STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

HYDRAULIC ANALYSIS REPORT

Cape Fear Crossing
Brunswick and New Hanover Counties
North Carolina

STIP Project No. U-4738

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1.0 INTRODUCTION

The North Carolina Department of Transportation (NCDOT) proposes to construct a new location project in Brunswick and New Hanover Counties (Figure 1). The project is included in the 2016-2025 State Transportation Improvement Program (STIP) as Cape Fear Crossing (STIP Project U-4738). The project would be a fully controlled access facility extending from the vicinity of US 17 Bypass and I-140 in Brunswick County to US 421 in New Hanover County, including a crossing of the Cape Fear River. NCDOT has selected 12 alternatives for detailed study. These alternatives include two alternatives that will upgrade existing US 17, four alternatives on new location, and six "hybrid" alternatives that incorporate components of new location and upgrades to existing roadway. Individual descriptions of the 12 alternatives are included below and are shown on Figure 2:

- **Upgrade Existing Alternatives:**
  - Alternative F/P: These two alternatives include upgrading US 17 from the I-140/US 17 interchange, to US 421 in the City of Wilmington. The alternatives will be designed as a freeway (Alternative F) and as a standard widening (Alternative P).
- **New Location Alternatives:**
  - Alternative B: This alternative begins at I-140 and crosses US 17, travels between the Brunswick Forest and Mallory Creek developments, and crosses the Cape Fear River to terminate at Shipyard Boulevard.
  - Alternative C: This alternative begins at I-140 and crosses US 17, travels parallel to Wire Road, and crosses the Cape Fear River to terminate at Independence Boulevard.
  - Alternatives M Avoidance and N Avoidance: These alternatives begin at the I-140/US 17 interchange, avoid the Snee Farm/Stoney Creek subdivisions, travel south of Brunswick Forest, and cross the Cape Fear River to terminate at either Independence Boulevard (Alternative M Avoidance) or Shipyard Boulevard (Alternative N Avoidance).
- **"Hybrid" Alternatives:**
  - Alternative G/Q: These two alternatives begin at the I-140/US 17 interchange, upgrade existing US 17 for approximately two miles, then continue on new location between the Brunswick Forest and Mallory Creek developments, and cross the Cape Fear River to terminate at Independence Boulevard. Alternative G and Alternative Q follow the same alignment, but Alternative G will be designed as a freeway for its entire length, while Alternative Q will be designed as a standard widening along US 17 and a freeway on its new location portion.
  - Alternative J/T: These two alternatives begin at the I-140/US 17 interchange, upgrade existing US 17 for approximately two miles, then continue on new location parallel to Wire Road, and cross the Cape Fear River to terminate at Shipyard Boulevard. Alternative J and Alternative T follow the same alignment, but Alternative J will be designed as a freeway for its entire length, while Alternative T will be designed as a standard widening along US 17 and a freeway on its new location portion.
  - Alternative V (freeway and standard widening option): This alternative will include upgrading US 17 to the US 17/US 421 interchange, then travel south along Eagle Island on new location, and cross the Cape Fear River to terminate at US 421 just north of the Port of Wilmington. This alternative will have two options: it will be

designed as a freeway with service roads and interchanges, and as a standard widening with access remaining similar to its current function.

The hydraulic analysis has been prepared to assist in the preparation of an Environmental Impact Statement (EIS) for the project. This document follows the NCDOT Guidelines for Drainage Studies and Hydraulic Design guidance where possible; however, when a preferred alternative has been selected and designs have been refined, a more detailed Hydraulic Aspects Report will be prepared.

2.0 HYDRAULIC ANALYSIS

In order to aid in the evaluation of the DSAs, the hydraulic analysis utilized available GIS and CAD data to identify hydraulic crossing locations along 12 DSAs. Data collection for the hydraulic analysis included base mapping composed of GIS data, effective flood maps, topographic data, aerial photography, and functional designs of DSAs. Jurisdictional areas identified during field investigations were verified by Brad Shaver of the U.S. Army Corps of Engineers (USACE) and Mason Herndon of the NC Division of Water Resources (NCDWR) during numerous field visits held between December 17, 2013 and March 19, 2014. Field work to identify jurisdictional areas within extended study areas added to the project was conducted between April 13, 2015 and June 30, 2015.

Surface water and wetland data, obtained from field survey information dated August 26, 2015, was used to identify 48 hydraulic crossing locations with drainage areas (DA) greater than 80 acres. United States Geological Survey (USGS) StreamStats was utilized to delineate the contributing DA of each crossing identified. Each crossing is categorized into one of three hydraulic structure types based on DA and calculated peak flow discharge (Q) as follows:

- Conveyance less than or equal to (≤) 72" pipe
- Box Culvert
- Bridge

2.1 Study Area Characteristics

The study area lies in the coastal plain physiographic province of North Carolina. Topography in the project vicinity is characterized as nearly level, with wide upland surfaces. Elevations in the study area range from sea level to 75 feet above mean sea level. Land use within the project vicinity includes a mixture of residential, commercial, industrial, agriculture, and forested woodland areas.

2.2 Design Criteria

Through coordination with the NCDOT Hydraulics Unit, the hydraulic analysis methodology criterion was developed using the following:

- 50-year design storm frequency
- USGS Urban equations, assuming an impervious area of 20% to account for potential future development, will be used to calculate discharges

- Inlet control for culvert sizing
- Headwater depth to culvert height (HW/D) of 1.2 (HW/D = 1 for culvert crossings located within the Federal Emergency Management Agencies (FEMA) floodway boundaries)
- Reinforced concrete pipe/culvert material
- FEMA floodway crossings default to bridge structure
- Minimum 10' offset from top of bank for bridge structure lengths

Design criteria are listed in Appendix B.

Inlet control culvert nomographs were used to determine a maximum flow capacity for a 72" reinforced concrete pipe (RCP) and a single 6'x6' reinforced concrete box culvert (RCBC). Utilizing the regional USGS urban flood-frequency equations (2001), a maximum contributing drainage area for the 50-year storm flow was calculated for each of three hydraulic crossing categories. The flow capacity, maximum DA, and number of crossings identified for each category are shown in Table 1.

Peak discharge calculations, inlet computations, and additional evaluation criteria, along with other calculations and/or references used or developed for the analysis, are provided in Appendix C.

Table 1. Hydraulic Crossing Categories

Category	Structure Type	Q Capacity (cfs)	Maximum Drainage Area (ac.)	Maximum Drainage Area (sq. mi.)	No. of Crossings
≤72" pipe [1]	≤72" pipe	280	< 80	< 0.13	3
Box Culvert [2, 3]	Single 6'x6' RCBC	330	< 100	< 0.16	26
	Double 8'x6' RCBC	900	< 640	< 1.0	
	Triple 8'x6' RCBC	1300	< 992	< 1.55	
Bridge	Bridge	N/A	> 992	>1.55	18

Notes:

1. Drainage areas estimated to require a structure less than or equal to a 72" pipe are not included in the hydraulic analysis unless located within a FEMA regulated floodway.
2. Crossing locations with drainage areas estimated to require conveyance larger than a 72" pipe but less than the capacity of a triple box culvert will be evaluated for an approximate box culvert opening size based on inlet control hydraulics unless located in a FEMA regulated floodway.
3. Culvert crossing locations within FEMA regulated floodway boundaries utilize a HW/D = 1 for the 100-year storm for sizing.

2.3 Hydraulic Crossings

Major hydraulic crossings are those with a contributing DA requiring conveyance greater than a 72" pipe. Hydraulic crossings requiring less than or equal to the conveyance of a 72" pipe are considered minor crossings and have been screened out from the analysis of this report. For DAs requiring a triple box culvert, estimated bridge lengths were calculated for structure size comparison. A summary table of the box culvert and bridge crossings is listed in Table 2. Appendix A contains the Hydraulic Crossing Summary Table, a complete list of all identified hydraulic crossings, as well as Figures 3 and 4, location maps for culvert and bridge hydraulic crossings.

Site maps showing plan and profile views have been generated for proposed bridge crossing locations and are included in Appendix D. Bridge crossing maps show functional design alignments; preliminary proposed bridge length; surrounding wetland areas; floodplain and floodway limits; and aerial imagery.

Table 2. Major Hydraulic Crossings

Alternatives	Crossing No.	Structure Type	Structure Size	Surface Water
M, N	1 *	Culvert	Triple 8x6 RCBC	Bishop Branch
M, N	2	Culvert	Triple 8x6 RCBC	Bishop Branch
M, N	2A	Culvert	Triple 8x6 RCBC	Bishop Branch
M, N	3	Bridge		Morgan Branch
M, N	4	Culvert	Triple 6x6 RCBC	Goodland Branch
M, N	5	Culvert	Double 6x6 RCBC	UT to Goodland Branch
M, N	6	Culvert	6x6 RCBC	UT to Goodland Branch
M, N	7	Culvert	6x6 RCBC	UT to Town Creek
M, N	8	Culvert	8x6 RCBC	Little Mallory Creek (Beaverdam Branch)
M, N	10	Bridge		Mallory Creek
M, N	11	Culvert	Triple 6x6 RCBC	UT to Mallory Creek
B, C, G, Q, J, T, M, N	11A	Culvert	Triple 6x6 RCBC	UT to Mallory Creek
C, G, Q, M	12	Bridge		Cape Fear River
C, G, Q, M	13	Culvert	7x6 RCBC	Unnamed Tributary
C, G, Q, M	14	Culvert	Triple 6x6 RCBC	Unnamed Tributary
C, G, Q, M	15	Culvert	Double 6x6 RCBC	East Fork Creek
C, G, Q, M	16 *	Culvert	Double 6x6 RCBC	East Fork Creek
F, G, J, M, N, VF	18 *	Culvert	Triple 8x6 RCBC	UT to Morgan Creek
F, P, G, Q, J, T, VF, VA	19 *	Culvert	Triple 8x6 RCBC	Morgan Branch
M, N	20 *	Widen Bridge		UT to Morgan Branch
M, N	21 *	Widen Bridge		UT to Morgan Branch
B, C	22	Culvert	8x6 RCBC	UT to Morgan Branch
B, C	23	Culvert	8x6 RCBC	UT to Morgan Branch
B, C	24	Bridge		Jackeys Creek Tributary
B, C, G, Q, J, T	25	Culvert	6x6 RCBC	UT to Piney Branch
B, C, G, Q, J, T	26	Culvert	7x6 RCBC	UT to Piney Branch
B, C, G, Q, J, T	27	Culvert	Triple 7x6 RCBC	Piney Branch
B, G, Q	28	Bridge		Mallory Creek Tributary
B, G, Q	29	Bridge		Mallory Creek
C, J, T	30	Bridge		Mallory Creek
B, C, G, Q, J, T, M, N	33 *	Bridge		Mallory Creek
B, C, G, Q, J, T	34	Bridge		Mallory Creek
B, J, T, N	35	Bridge		Cape Fear River
B, C, F, P, G, Q, J, T, VF, VA	36 *	Bridge		Jackeys Creek
F, P, VF, VA	37	Culvert	Triple 6x6 RCBC	UT to Jackeys Creek

Table 2. Major Hydraulic Crossings (cont.)

Alternatives	Crossing No.	Structure Type	Structure Size	Surface Water
F, P, VF, VA	38 *	Bridge		Brunswick River
F, P, VF, VA	39 *	Bridge		Alligator Creek
F, P	40	Bridge		Cape Fear River
VF, VA	41	Bridge		Cape Fear River
VF, VA	42	Culvert	Double 6x6 RCBC	UT to Greenfield Creek
VF, VA	43	Bridge		Greenfield Creek
F, P, VF, VA	44 *	Culvert	Triple 8x6 RCBC	Greenfield Creek
C, G, Q, M	45	Culvert	8x6 RCBC	Unnamed Tributary
C, G, Q, M	46 *	Culvert	Double 6x6 RCBC	East Fork Creek

* Denotes crossing with existing major hydraulic structure.

Notes:

1. All dimensions in feet. Culvert size shown as width x height.

3.0 DISCLAIMER

The analysis and results included in this report are based on GIS data and are intended to be used to assist in facilitating the Section 404/National Environmental Policy Act Merger Process Concurrence Point (CP) 2A: Bridging Decisions and Alignment Review. Recommendations received from the CP 2A meeting will be incorporated into the functional designs to assist in evaluating DSAs within the Draft Environmental Impact Statement.

All delineations, calculations, and design elements are based on the available data. For this report, no field investigation was performed to verify existing hydraulic structures listed in the NCDOT Bridge Database. Hydraulic analysis includes the best available information on existing crossing structure sizes per NCDOT Bridge Database. Hydraulic crossing locations and corresponding analysis is based on 12 functional design roadway alignments (current as of April 28, 2016), stream data, and FEMA flood mapping, and associated GIS data. Functional designs may be revised per CP 2A meeting recommendations.

Following selection of the Least Environmentally Damaging Practicable Alternative /Preferred Alternative, a standard Hydraulic Aspects Report will be prepared. Crossing locations within FEMA boundaries will require comparison of published FEMA discharge values to other discharge calculation methodologies prior to the finalization of preliminary recommendations.

Due to the limited scope of field work and hydraulic analysis performed in this study, final design recommendations should not rely on data contained within this report and should rather be based on a thorough field investigation and independent hydraulic analysis, given the most current information available at that time.

4.0 REFERENCES

North Carolina Department of Transportation
Bridge Policy, 2012. Website: https://connect.ncdot.gov/projects/.../Bridge%20Policy.pdf

Guidelines for Drainage Studies and Hydraulic Design, 1999. Website:
https://connect.ncdot.gov/resources/hydro/Pages/Guidelines-Drainage-Studies.aspx

State Mapping Resources , 2012, County Maps. Website:
http://www.ncdot.gov/travel/statemapping/

Structures Management Unit Manual, 2012. Website:
https://connect.ncdot.gov/resources/Structures/Pages/default.aspx

North Carolina Floodplain Mapping Program
Floodplain Mapping Information System website: http://www.ncfloodmaps.com/fact_sheets.htm

United States Geological Survey
The StreamStats program for North Carolina website:
http://water.usgs.gov/osw/streamstats/north_carolina.html

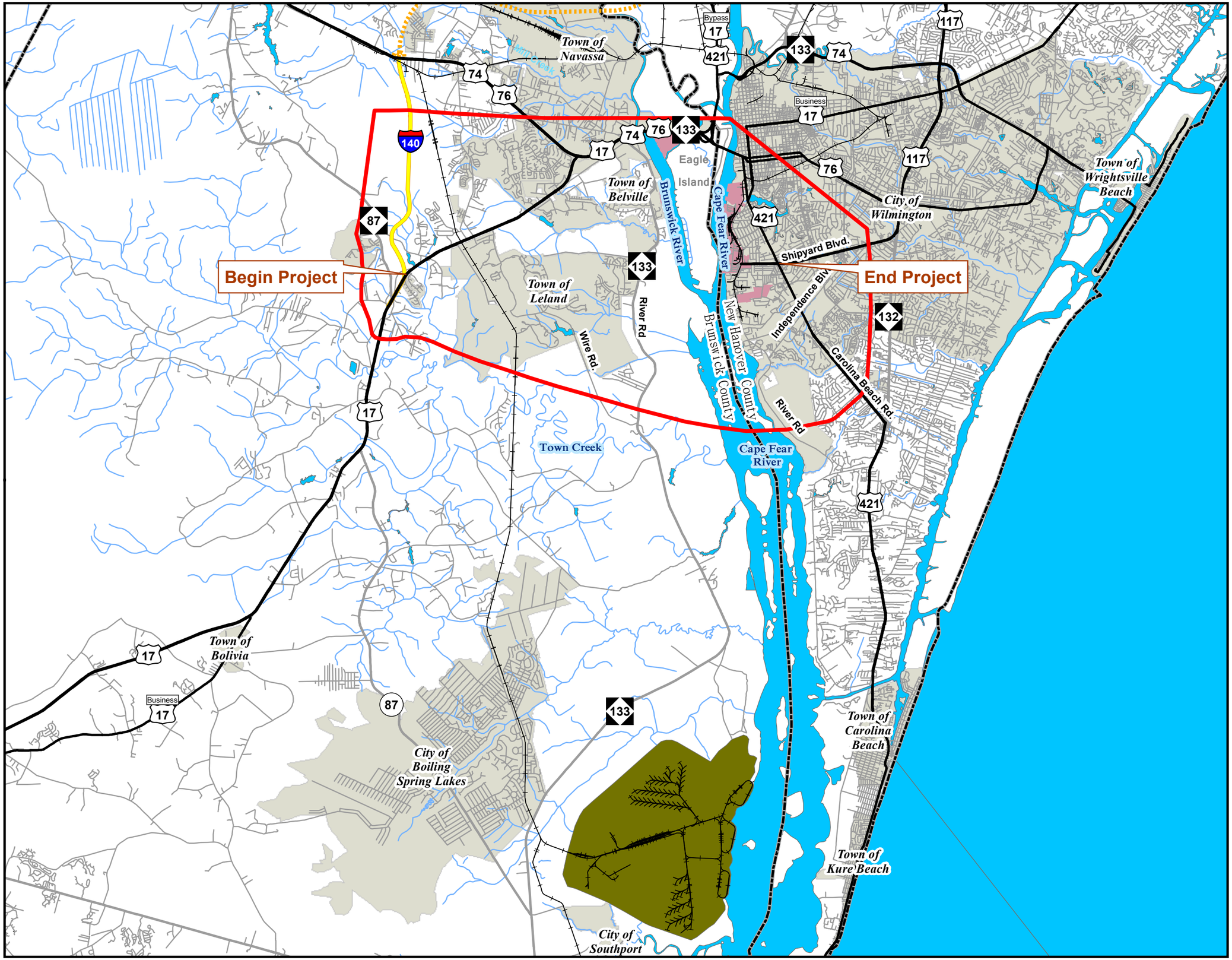
Appendix A

CAPE FEAR CROSSING

State Transportation Improvement Program
Project No. U-4738

Hydraulic Analysis

Figure 1 - Project Vicinity



Legend

- Project Study Area
- Interstate
- US Highway
- NC Highway
- Local Roads
- Railroad
- Future Wilmington Bypass (I-140)
- Creek/Stream
- Water
- Municipality
- County Boundary
- Port of Wilmington
- Sunny Point Military Ocean Terminal

N

0 1 2 4
Miles

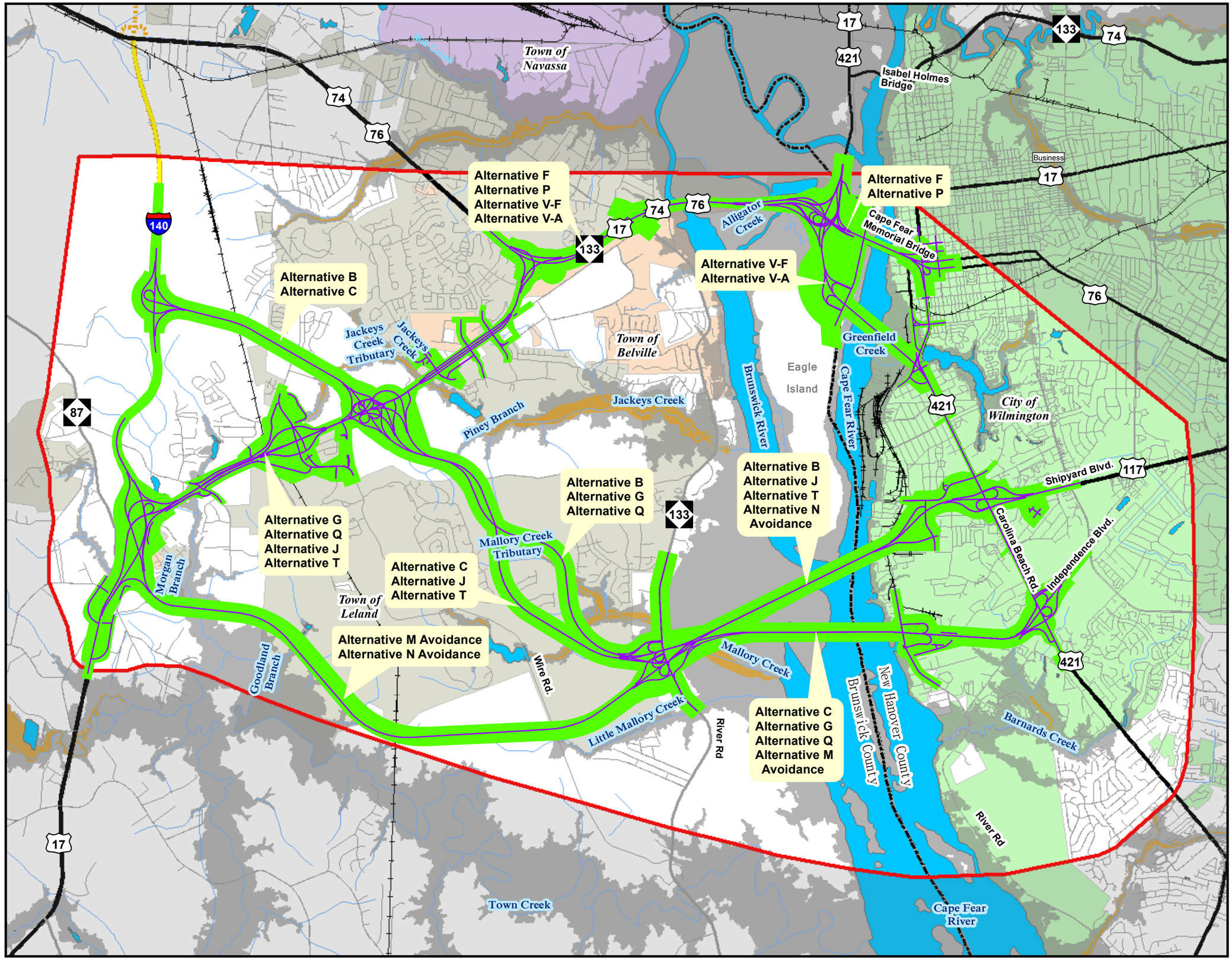
Date: May 2016
This map is for reference only.
Sources: ESRI Inc., CGIA, NCDOT, and URS.

CAPE FEAR CROSSING

State Transportation Improvement Program
Project No. U-4738

Hydraulic Analysis

Figure 2 - Project Study Area Map



Legend

- Project Study Area
- Alternative Alignment
- Detailed Study Corridor
- Interstate
- US Highway
- NC Highway
- Local Road
- Railroad
- Future Wilmington Bypass (I-140)
- Creek/Stream
- Floodway
- Floodplain
- Water
- Belville
- Leland
- Navassa
- Wilmington
- County Boundary

N

0 0.5 1 2
Miles

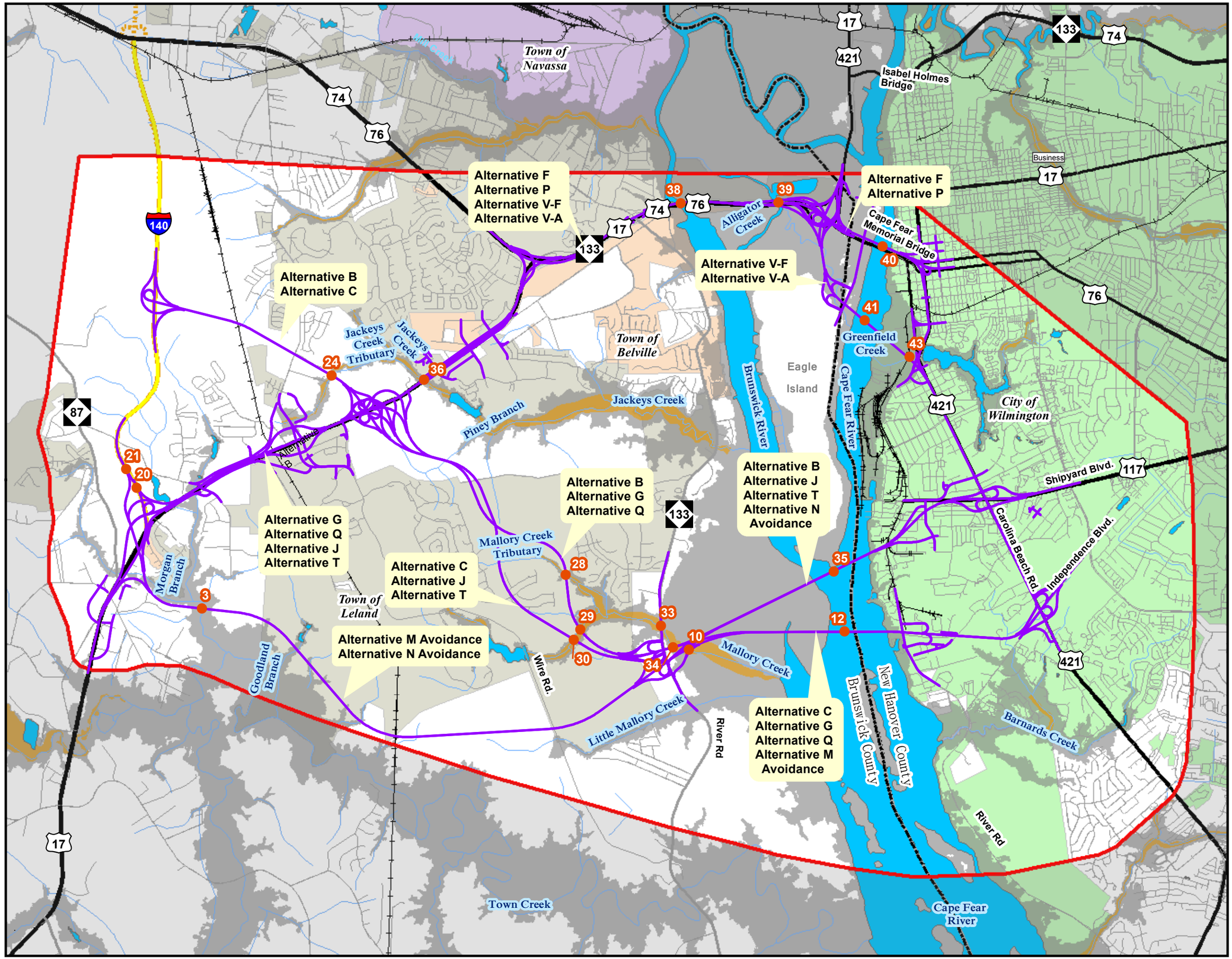
Date: May 2016
This map is for reference only.
Sources: ESRI Inc., CGIA, NCDOT, and URS.

CAPE FEAR CROSSING

State Transportation Improvement Program
Project No. U-4738

Hydraulic Analysis

Figure 3 - Bridge Locations



Legend

- Project Study Area
- Proposed Bridge Crossing
- Alternative Alignment
- Interstate
- US Highway
- NC Highway
- Local Road
- Railroad
- Future Wilmington Bypass (I-140)
- Creek/Stream
- Floodway
- Floodplain
- Water
- Belville
- Leland
- Navassa
- Wilmington
- County Boundary

N

0 0.5 1 2
Miles

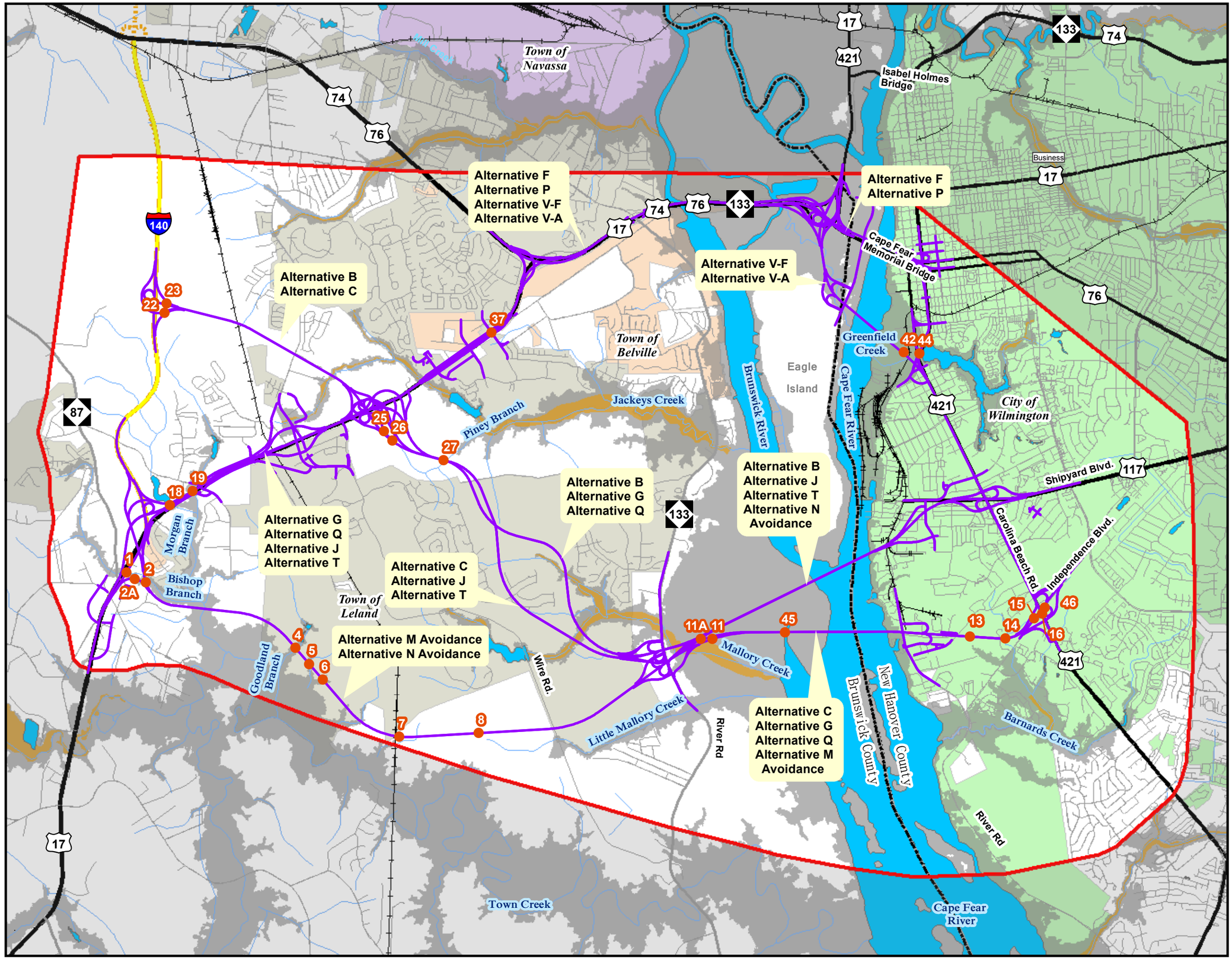
Date: May 2016
This map is for reference only.
Sources: ESRI Inc., CGIA, NCDOT, and URS.

CAPE FEAR CROSSING

State Transportation Improvement Program
Project No. U-4738

Hydraulic Analysis

Figure 4 - Culvert Locations



Legend

- Project Study Area
- Alternative Alignment
- Proposed Box Culvert Crossing
- Interstate
- US Highway
- NC Highway
- Local Road
- Railroad
- Future Wilmington Bypass (I-140)
- Creek/Stream
- Floodway
- Floodplain
- Water
- Belville
- Leland
- Navassa
- Wilmington
- County Boundary

N

0 0.5 1 2
Miles

Date: May 2016
This map is for reference only.
Sources: ESRI Inc., CGIA, NCDOT, and URS.

U-4738 Cape Fear Crossing
Hydraulic Crossing Summary

Crossing No.	Drainage Area		Alternatives
	acres	sq. mi.	
1	832	1.3	M, N
2	864	1.35	M, N
2A	864	1.35	M, N
3	4166.4	6.51	M, N
4	652.8	1.02	M, N
5	204.8	0.32	M, N
6	96	0.15	M, N
7	76.8	0.12	M, N
8	140.8	0.22	M, N
9	1337.6	2.09	M, N
10	3040	4.75	M, N
11	665.6	1.04	M, N
11A	665.6	1.04	B, C, G, Q, J, T, M, N
12	5664000	8850	C, G, Q, M
13	89.6	0.14	C, G, Q, M
14	768	1.2	C, G, Q, M
15	320	0.5	C, G, Q, M
16	300.8	0.47	C, G, Q, M
17	59.52	0.093	M, N
18	998.4	1.56	F, G, J, M, N, VF
19	1049.6	1.64	F, P, G, Q, J, T, VF, VA
20	32.64	0.051	M, N
20A	32.64	0.051	M, N
21	58.816	0.0919	M, N
22	172.8	0.27	B, C
23	166.4	0.26	B, C
24	460.8	0.72	B, C
25	96	0.15	B, C, G, Q, J, T
26	134.4	0.21	B, C, G, Q, J, T
27	947.2	1.48	B, C, G, Q, J, T
28	454.4	0.71	B, G, Q
29	1811.2	2.83	B, G, Q
30	1728	2.7	C, J, T
33	2988.8	4.67	B, C, G, Q, J, T, M, N
34	3001.6	4.69	B, C, G, Q, J, T
35	5664000	8850	B, J, T, N
36	1772.8	2.77	B, C, F, P, G, Q, J, T, VF, VA
37	588.8	0.92	F, P, VF, VA
38	10560	16.5	F, P, VF, VA
39	422.4	0.66	F, P, VF, VA
40	5638400	8810	F, P
41	5638400	8810	VF, VA
42	198.4	0.31	VF, VA
43	2528	3.95	VF, VA
44	2508.8	3.92	F, P, VF, VA
45	147.2	0.23	C, G, Q, M
46	300.8	0.47	C, G, Q, M

Appendix B

U-4738 (CAPE FEAR CROSSING) HYDRAULIC ANALYSIS APPROACH AND DESIGN CRITERIA

General Design Criteria and Approach

- Crossings will be analyzed using standard analysis methodologies; however available GIS data will be used instead of field investigation data.
- Hydraulic crossing locations to be identified based on functional roadway design alignments.
- Drainage area delineation will utilize GIS data such as the USGS StreamStats website or USGS Quad Maps.
- 50-year design storm.
- USGS Urban equations assuming an impervious area of 20% will be used to calculate discharges. (The project is in close proximity to the City of Wilmington and in viewing aerial photography, there are residential subdivisions in the surrounding area.)
- Only crossings with drainage areas of 80 acres (0.12 sq mi.) or more will be considered in this report.
    - The Q50 for a 72" pipe with a HW/D of 1.2 is approximately 280 cfs. Using the USGS Urban Regression equations, assuming an impervious area of 20% and backing into a drainage area, it takes approximately 80 acres to produce a discharge of 280 cfs.

Conveyance less than or equal to 72" pipe

- Categorized as a minor structure and therefore not included in hydraulic analysis.

Box Culvert (conveyance larger than 72" pipe)

- Inlet control
- HW/D = 1.2
- Reinforced concrete box culvert
- Box height to be used will be standard 6'. Minimum cell width of 6' and maximum cell width of 8'.
- Single 6'x 6' box capacity = 330 cfs
    - DA < 100 ac or 0.16 sq. mi.
- Single 8' x 6' box capacity = 450 cfs
    - DA < 180 ac or 0.28 sq. mi.
- Double 6' x 6' box capacity = 650 cfs
    - DA < 365 ac or 0.57 sq. mi.
- Double 8' x 6' box capacity = 900 cfs
    - DA < 640 ac or 1.0 sq. mi.
- Triple 6' x 6' box capacity = 1000 cfs
    - DA < 768 ac or 1.20 sq. mi.
- Triple 8'x 6' box capacity = 1300 cfs
    - DA < 992 ac or 1.55 sq. mi.
- Box Culvert size recommendations will be summarized in a tabular format.

Bridge

- Conveyance larger than triple 8' x 6' RCBC or drainage area greater than 1.55 sq. miles.
- Bridge structure lengths to be determined based on combination of functional roadway alignment profile, FEMA floodway/non-encroachment limits, 10' setback from existing channel top of bank or 5' minimum setback behind the end of the structure for existing bridge crossings.
- 1.5:1 abutment slope
- Low chord of bridge to be placed 2' above the 100 year WSEL.
- Superstructure depth to follow NCDOT Structure Design Manual Figure 6-1.

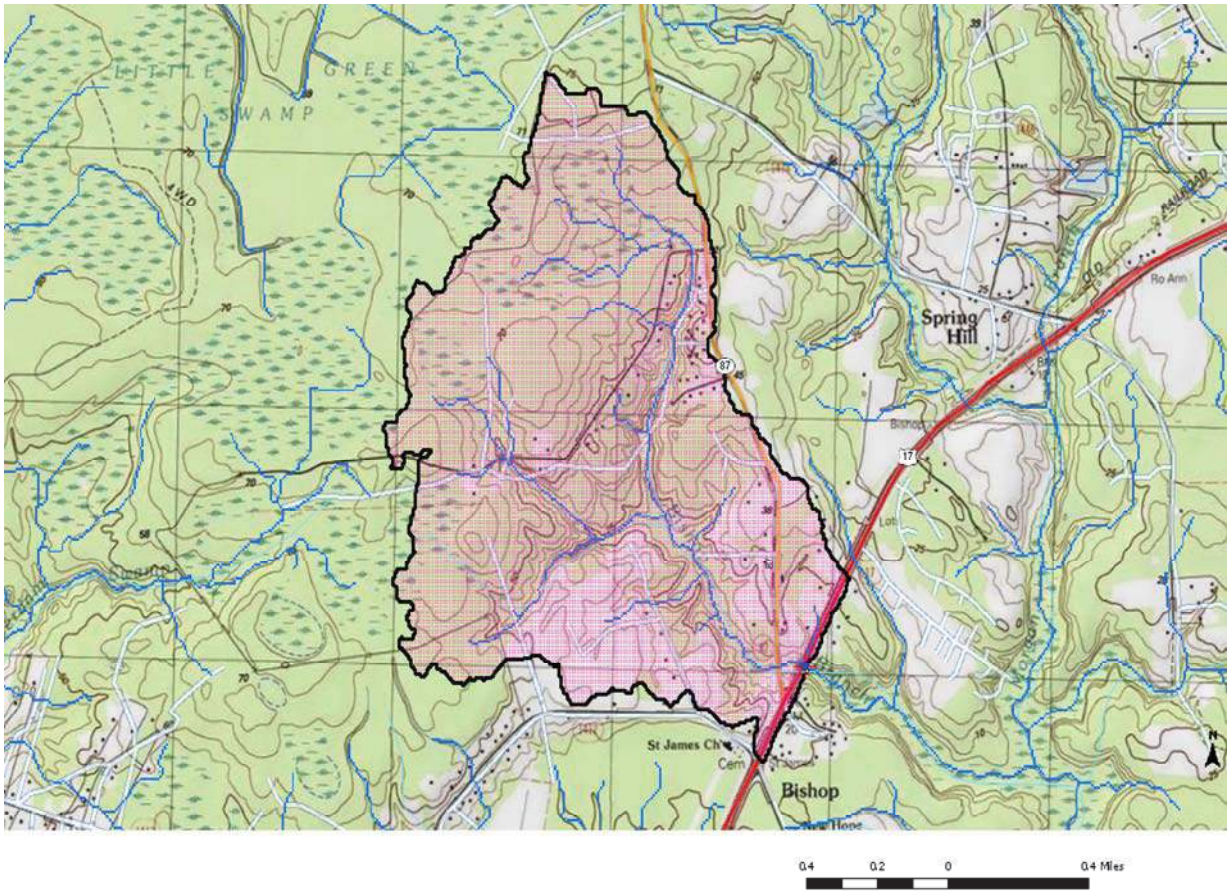
- Minimum longitudinal bridge slope = 0.3%
- An estimated bridge length will also be calculated for crossings with a triple box culvert.
- Site maps with plan and profile view will be generated showing the proposed bridge structure in reference to surrounding areas of environmental concern.

Appendix C

USGS
North Carolina StreamStats

U-4738

Crossing 1



Explanation
- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

9/9/2014 1:43:04 PM

Crossing 1

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Tue Sep 9 2014 13:38:15 Mountain Daylight Time
NAD27 Latitude: 34.1823 (34 10 56)
NAD27 Longitude: -78.0827 (-78 04 58)
NAD83 Latitude: 34.1824 (34 10 57)
NAD83 Longitude: -78.0824 (-78 04 57)

Parameter	Value
Area in square miles	1.3
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	7.49
Mean basin slope, based on slope percent grid	2.42
Percent of area covered by barren rock using 2006 NLCD	1.512
Percent of area in cultivation using 2006 NLCD	10.196
Percent of area covered by all densities of developed land using 2006 NLCD	7.533
Percent of area covered by forest using 2006 NLCD	31.520
Percent of area covered by grassland/herbaceous using 2006 NLCD	15.746
Percent impervious of basin area 2006 NLCD	1.12
Mean annual precipitation in inches	57.8
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	14.553
Percent of area hydrologic soil 'A' defined by SSURGO	33.5
Percent of area hydrologic soil 'B' defined by SSURGO	62.6
Percent of area hydrologic soil 'C' defined by SSURGO	3.91
Percent of area hydrologic soil 'D' defined by SSURGO	0
Percent of area covered by water using 2006 NLCD	0.130
Percent of area covered by wetland using 2006 NLCD	18.810

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 01

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 1.3 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	70
5	$123 * DA^{0.627}$	140
10	$174 * DA^{0.617}$	200
25	$245 * DA^{0.606}$	290
50	$309 * DA^{0.600}$	360
100	$832 * DA^{0.594}$	950
200	$447 * DA^{0.589}$	500
500	$550 * DA^{0.583}$	650

North Carolina Urban Flood-Frequency Equations [3]

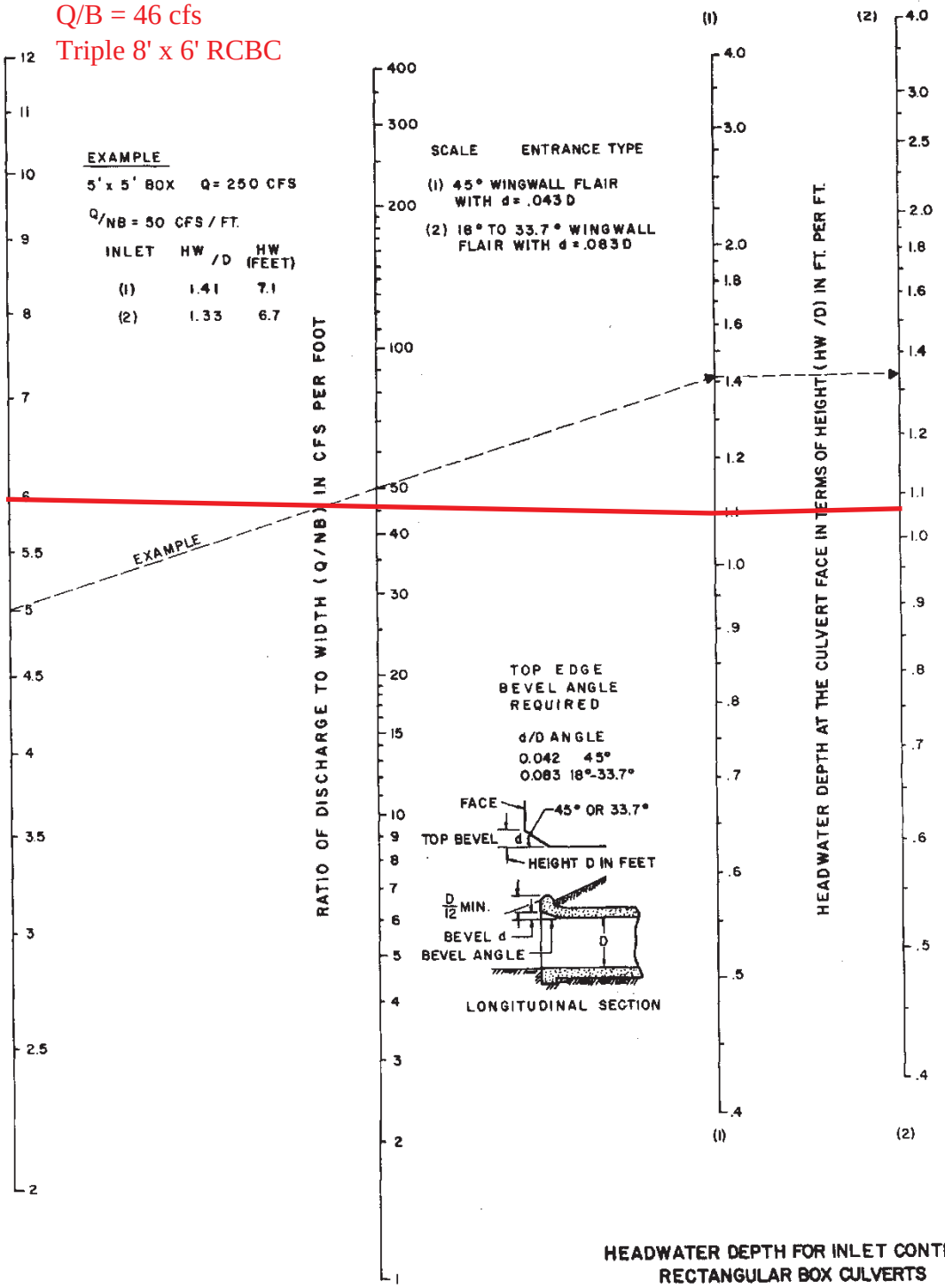
Drainage Area = 1.3 sq. mi.
Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	250
5	$68.2 * DA^{0.655} * IA^{0.572}$	450
10	$109 * DA^{0.625} * IA^{0.515}$	600
25	$209 * DA^{0.570} * IA^{0.436}$	900
50	$280 * DA^{0.558} * IA^{0.396}$	1,100
100	$363 * DA^{0.547} * IA^{0.358}$	1,200
200 [4]	UQ100 / RQ100 * RQ200	650
500 [4]	UQ100 / RQ100 * RQ500	800

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

U-4738
Crossing 1
DA = 832 ac.(1.3 sq.mi.)
Q50 = 1,100 cfs
FEMA Crossing
Q/B = 46 cfs
Triple 8' x 6' RCBC

CHART 9B

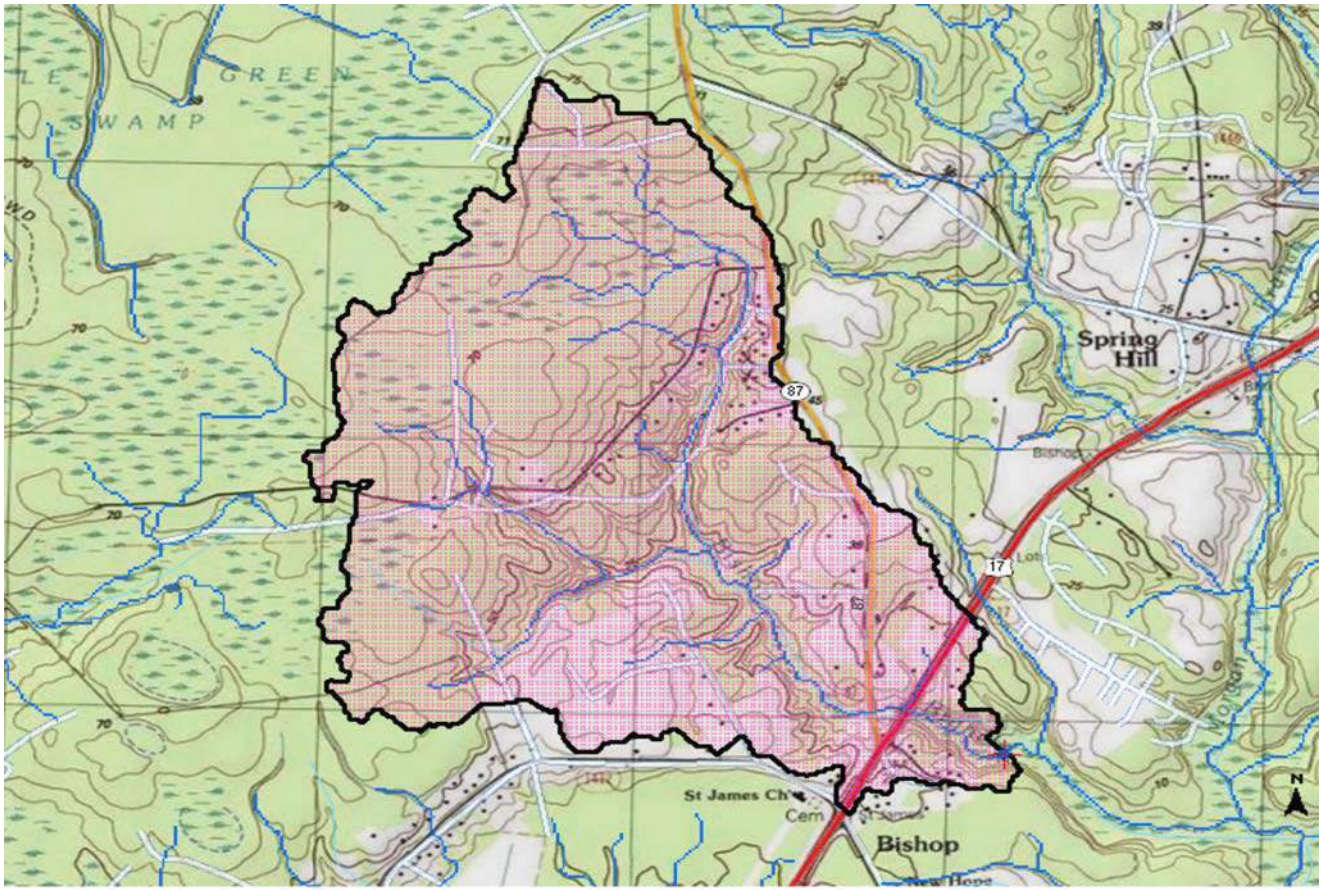


HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

USGS
North Carolina StreamStats

U-4738

Crossing 2
& 2A



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.4 0.2 0 0.4 Miles

9/11/2014 12:32:03 PM

Crossing 2 & 2A

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Tue Sep 9 2014 13:51:48 Mountain Daylight Time
NAD27 Latitude: 34.1809 (34 10 51)
NAD27 Longitude: -78.0794 (-78 04 46)
NAD83 Latitude: 34.1811 (34 10 52)
NAD83 Longitude: -78.0791 (-78 04 45)

Parameter	Value
Area in square miles	1.35
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	7.93
Mean basin slope, based on slope percent grid	2.47
Percent of area covered by barren rock using 2006 NLCD	1.456
Percent of area in cultivation using 2006 NLCD	9.819
Percent of area covered by all densities of developed land using 2006 NLCD	7.885
Percent of area covered by forest using 2006 NLCD	31.093
Percent of area covered by grassland/herbaceous using 2006 NLCD	15.305
Percent impervious of basin area 2006 NLCD	1.20
Mean annual precipitation in inches	57.8
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	14.797
Percent of area hydrologic soil 'A' defined by SSURGO	34.8
Percent of area hydrologic soil 'B' defined by SSURGO	61
Percent of area hydrologic soil 'C' defined by SSURGO	3.83
Percent of area hydrologic soil 'D' defined by SSURGO	0.36
Percent of area covered by water using 2001 NLCD	0.125
Percent of area covered by water using 2006 NLCD	0.125
Percent of area covered by wetland using 2006 NLCD	19.520

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 02 & 2A

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 1.4 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	75
5	$123 * DA^{0.627}$	150
10	$174 * DA^{0.617}$	210
25	$245 * DA^{0.606}$	290
50	$309 * DA^{0.600}$	370
100	$380 * DA^{0.594}$	450
200	$447 * DA^{0.589}$	550
500	$550 * DA^{0.583}$	650

North Carolina Urban Flood-Frequency Equations [3]

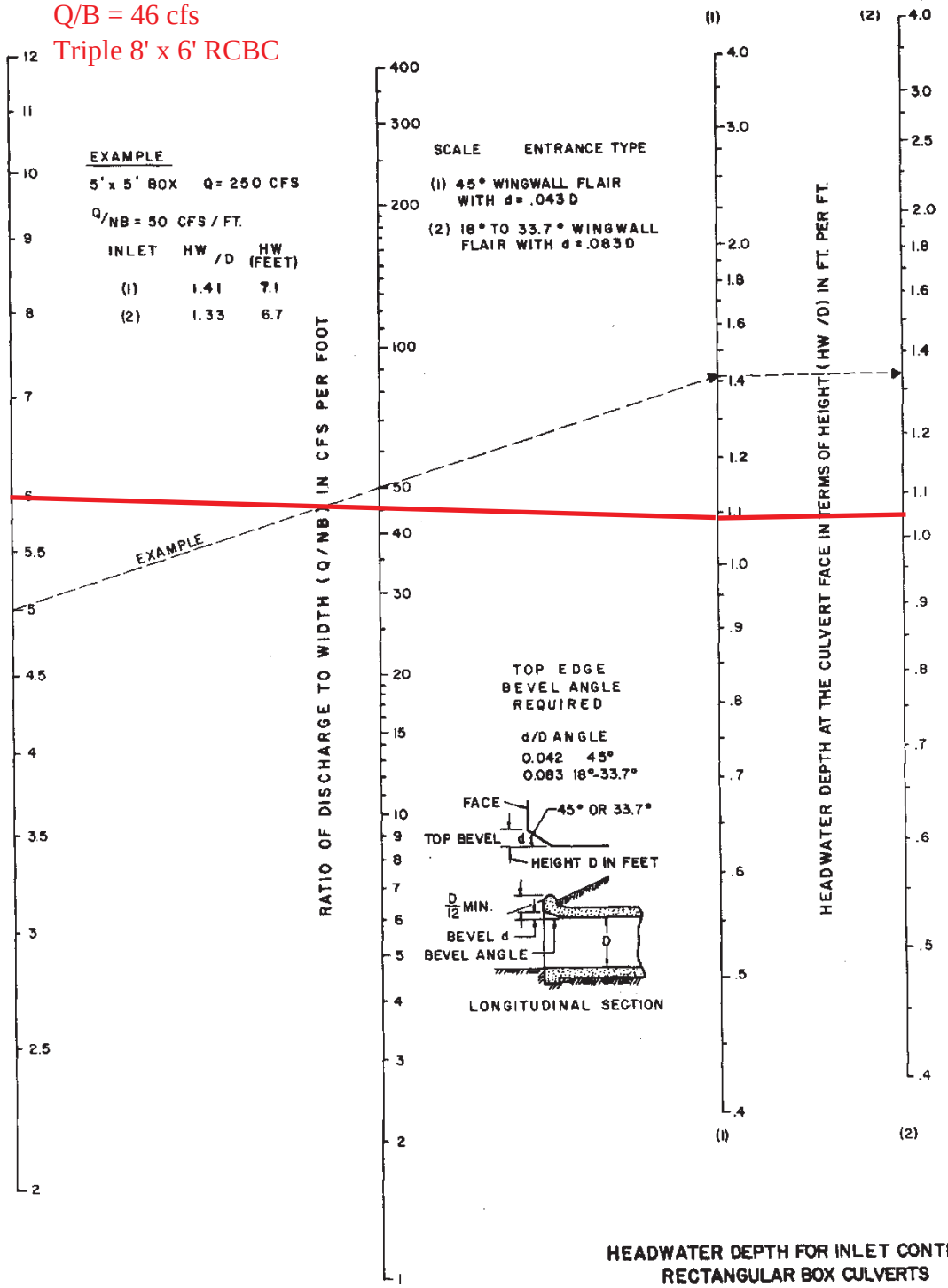
Drainage Area = 1.4 sq. mi.
Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	260
5	$68.2 * DA^{0.655} * IA^{0.572}$	460
10	$109 * DA^{0.625} * IA^{0.515}$	600
25	$209 * DA^{0.570} * IA^{0.436}$	900
50	$280 * DA^{0.558} * IA^{0.396}$	1,100
100	$363 * DA^{0.547} * IA^{0.358}$	1,300
200 [4]	UQ100 / RQ100 * RQ200	1,600
500 [4]	UQ100 / RQ100 * RQ500	1,900

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

U-4738
Crossing 2 & 2A
DA = 864 ac.
Q50 = 1,100 cfs
FEMA Crossing
Q/B = 46 cfs
Triple 8' x 6' RCBC

CHART 9B

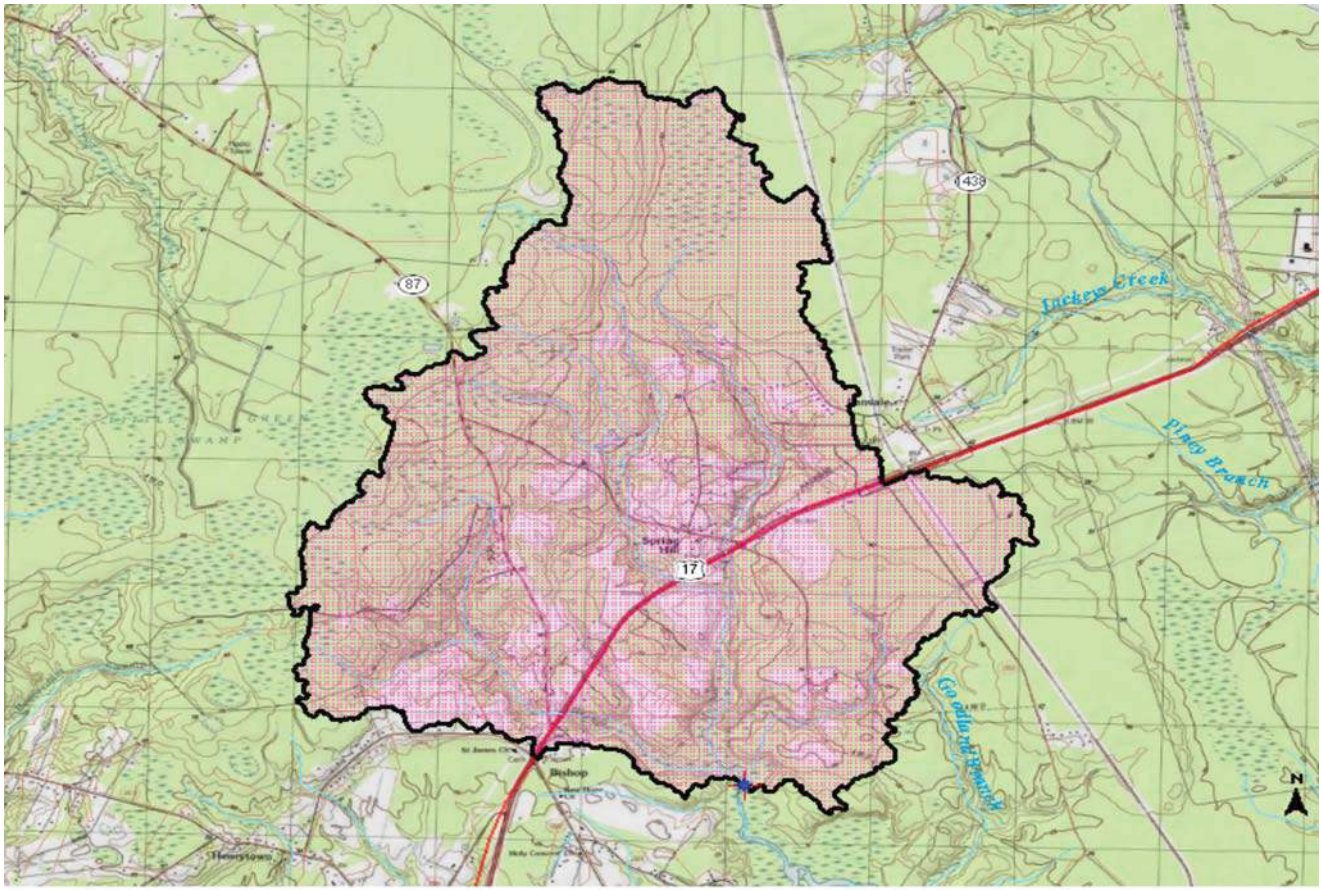


HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

USGS
North Carolina StreamStats

U-4738

Crossing 3



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.9 0.45 0 0.9 Miles

9/11/2014 12:34:48 PM

Crossing 3

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Fri Sep 12 2014 12:22:40 Mountain Daylight Time
NAD27 Latitude: 34.1769 (34 10 37)
NAD27 Longitude: -78.0694 (-78 04 10)
NAD83 Latitude: 34.1771 (34 10 37)
NAD83 Longitude: -78.0692 (-78 04 09)

Parameter	Value
Area in square miles	6.51
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	19.8
Mean basin slope, based on slope percent grid	2.3
Percent of area covered by barren rock using 2006 NLCD	0.906
Percent of area in cultivation using 2006 NLCD	3.054
Percent of area covered by all densities of developed land using 2006 NLCD	7.748
Percent of area covered by forest using 2006 NLCD	41.155
Percent of area covered by grassland/herbaceous using 2006 NLCD	9.421
Percent impervious of basin area 2006 NLCD	1.26
Mean annual precipitation in inches	57.9
Percent of area of protected Federal and State owned land	0.00167
Percent of area covered by shrubland using 2006 NLCD	16.440
Percent of area hydrologic soil 'A' defined by SSURGO	32
Percent of area hydrologic soil 'B' defined by SSURGO	47.7
Percent of area hydrologic soil 'C' defined by SSURGO	14.7
Percent of area hydrologic soil 'D' defined by SSURGO	5.37
Percent of area covered by water using 2006 NLCD	0.234
Percent of area covered by wetland using 2006 NLCD	21.042

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 03

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 6.5 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	200
5	$123 * DA^{0.627}$	400
10	$174 * DA^{0.617}$	550
25	$245 * DA^{0.606}$	750
50	$309 * DA^{0.600}$	950
100	$380 * DA^{0.594}$	1,200
200	$447 * DA^{0.589}$	1,300
500	$550 * DA^{0.583}$	1,600

North Carolina Urban Flood-Frequency Equations [3]

Drainage Area = 6.5 sq. mi.
Impervious Area = 20 % (greater than 10%)

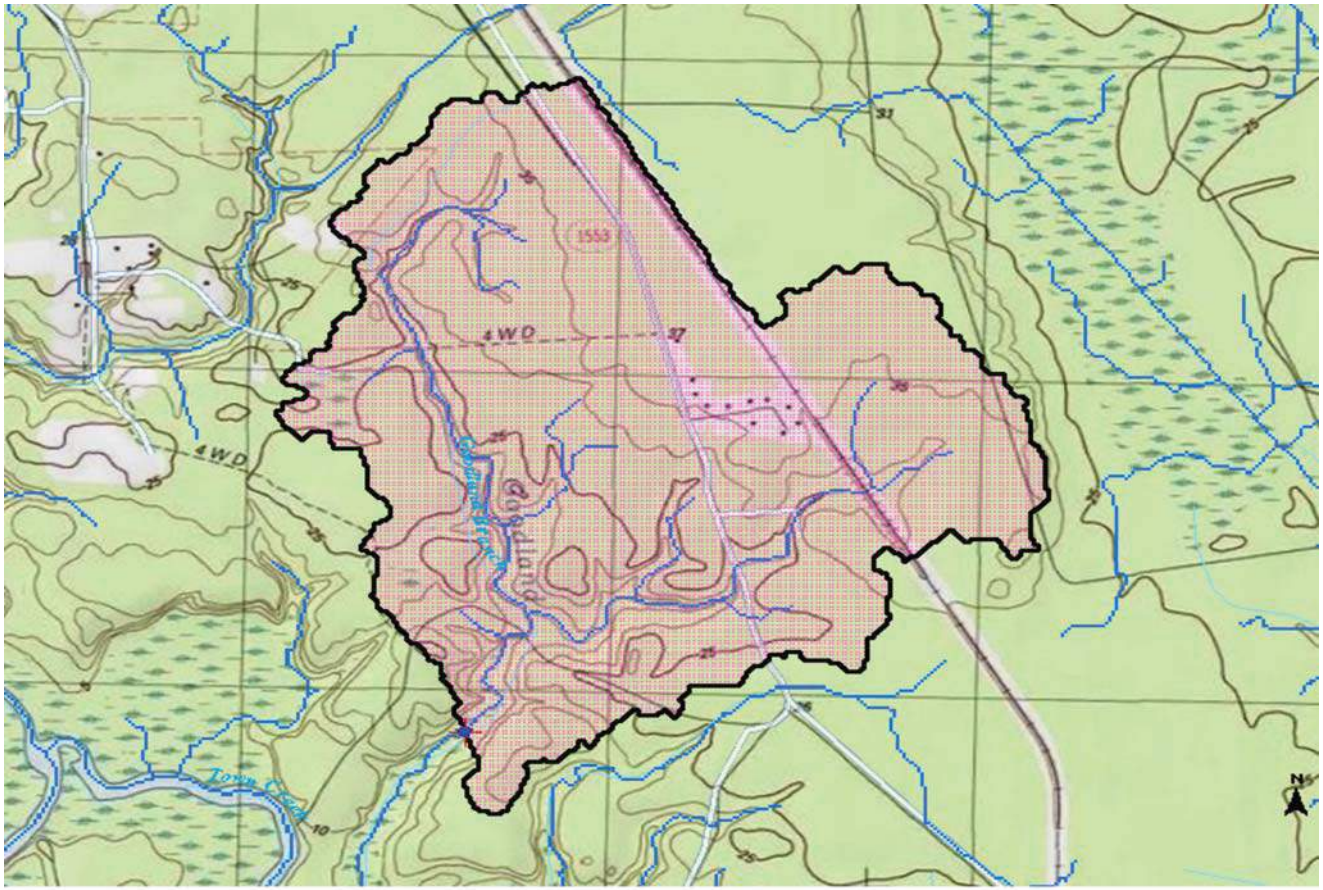
Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	800
5	$68.2 * DA^{0.655} * IA^{0.572}$	1,300
10	$109 * DA^{0.625} * IA^{0.515}$	1,600
25	$209 * DA^{0.570} * IA^{0.436}$	2,200
50	$280 * DA^{0.558} * IA^{0.396}$	2,600
100	$363 * DA^{0.547} * IA^{0.358}$	3,000
200 [4]	UQ100 / RQ100 * RQ200	3,300
500 [4]	UQ100 / RQ100 * RQ500	4,000

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

USGS
North Carolina StreamStats

U-4738

Crossing 4



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

9/11/2014 12:37:21 PM

Crossing 4

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Tue Sep 9 2014 14:07:26 Mountain Daylight Time
NAD27 Latitude: 34.1711 (34 10 16)
NAD27 Longitude: -78.0534 (-78 03 12)
NAD83 Latitude: 34.1713 (34 10 17)
NAD83 Longitude: -78.0532 (-78 03 11)

Parameter	Value
Area in square miles	1.02
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	6.92
Mean basin slope, based on slope percent grid	1.89
Percent of area covered by barren rock using 2006 NLCD	0.000
Percent of area in cultivation using 2006 NLCD	2.394
Percent of area covered by all densities of developed land using 2006 NLCD	3.711
Percent of area covered by forest using 2006 NLCD	30.008
Percent of area covered by grassland/herbaceous using 2006 NLCD	28.519
Percent impervious of basin area 2006 NLCD	0.36
Mean annual precipitation in inches	58.5
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	31.255
Percent of area hydrologic soil 'A' defined by SSURGO	12.1
Percent of area hydrologic soil 'B' defined by SSURGO	79.7
Percent of area hydrologic soil 'C' defined by SSURGO	6.04
Percent of area hydrologic soil 'D' defined by SSURGO	2.22
Percent of area covered by water using 2006 NLCD	0.234
Percent of area covered by wetland using 2006 NLCD	3.879

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 04

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 1.0 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	60
5	$123 * DA^{0.627}$	120
10	$174 * DA^{0.617}$	180
25	$245 * DA^{0.606}$	250
50	$309 * DA^{0.600}$	310
100	$380 * DA^{0.594}$	380
200	$447 * DA^{0.589}$	450
500	$550 * DA^{0.583}$	550

North Carolina Urban Flood-Frequency Equations [3]

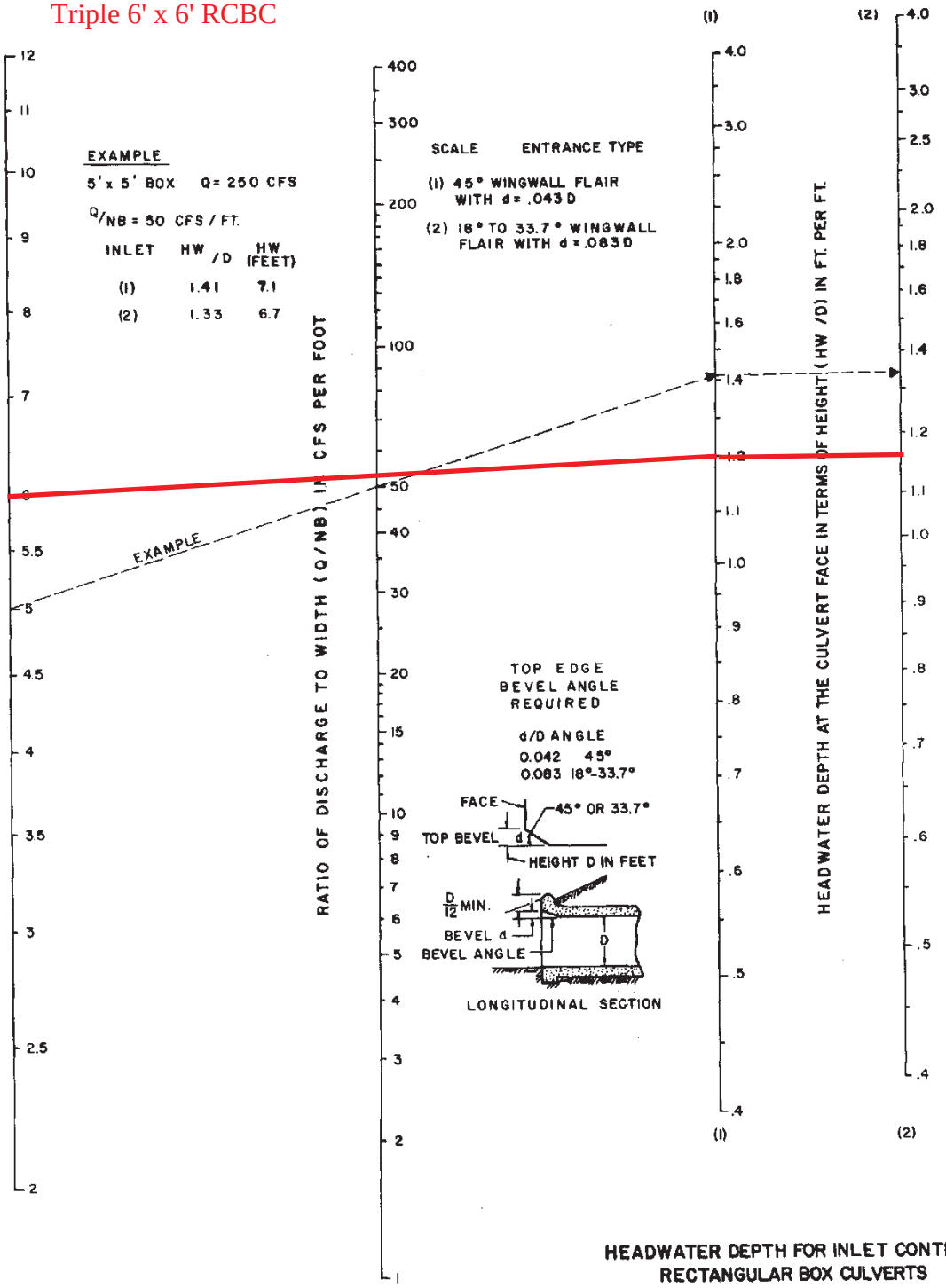
Drainage Area = 1.0 sq. mi.
Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	210
5	$68.2 * DA^{0.655} * IA^{0.572}$	380
10	$109 * DA^{0.625} * IA^{0.515}$	500
25	$209 * DA^{0.570} * IA^{0.436}$	800
50	$280 * DA^{0.558} * IA^{0.396}$	950
100	$363 * DA^{0.547} * IA^{0.358}$	1,100
200 [4]	UQ100 / RQ100 * RQ200	1,300
500 [4]	UQ100 / RQ100 * RQ500	1,600

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

U-4738
Crossing 4
DA = 653 ac.
Q50 = 950 cfs
Q/B = 53 cfs
Triple 6' x 6' RCBC

CHART 9B

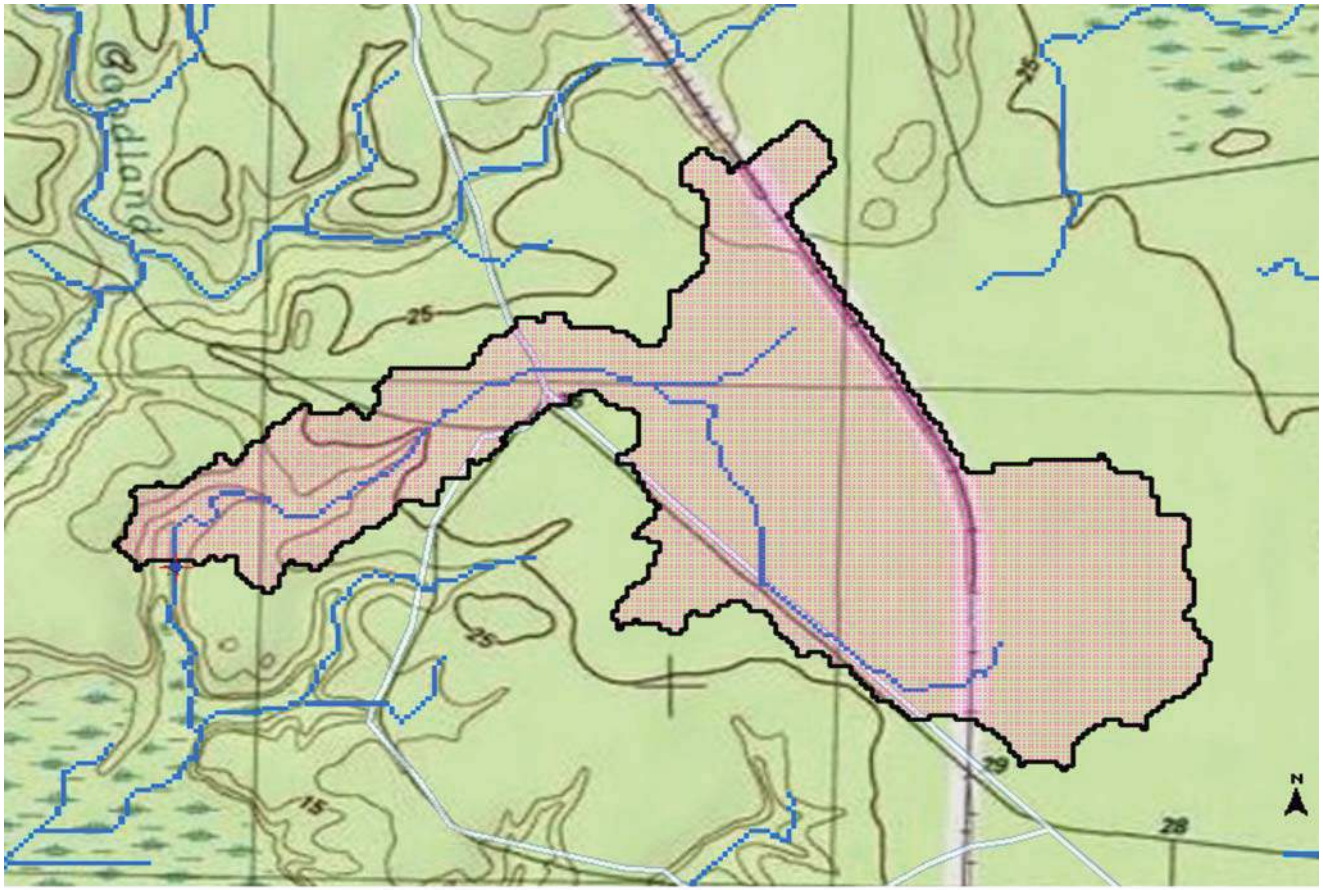


HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

USGS
North Carolina StreamStats

U-4738

Crossing 5



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.2 0.1 0 0.2 Miles

9/11/2014 12:44:45 PM

Crossing 5

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Tue Sep 9 2014 14:12:57 Mountain Daylight Time
NAD27 Latitude: 34.1688 (34 10 08)
NAD27 Longitude: -78.0509 (-78 03 03)
NAD83 Latitude: 34.1690 (34 10 08)
NAD83 Longitude: -78.0506 (-78 03 02)

Parameter	Value
Area in square miles	0.32
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	5.49
Mean basin slope, based on slope percent grid	1.22
Percent of area covered by barren rock using 2006 NLCD	10.310
Percent of area in cultivation using 2006 NLCD	19.203
Percent of area covered by all densities of developed land using 2006 NLCD	3.329
Percent of area covered by forest using 2006 NLCD	27.863
Percent of area covered by grassland/herbaceous using 2006 NLCD	4.563
Percent impervious of basin area 2006 NLCD	0.22
Mean annual precipitation in inches	58.7
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	30.929
Percent of area hydrologic soil 'A' defined by SSURGO	5.32
Percent of area hydrologic soil 'B' defined by SSURGO	81.4
Percent of area hydrologic soil 'C' defined by SSURGO	12.8
Percent of area hydrologic soil 'D' defined by SSURGO	0.44
Percent of area covered by water using 2006 NLCD	0.000
Percent of area covered by wetland using 2006 NLCD	3.804

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 05

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 0.32 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	29
5	$123 * DA^{0.627}$	60
10	$174 * DA^{0.617}$	85
25	$245 * DA^{0.606}$	120
50	$309 * DA^{0.600}$	160
100	$380 * DA^{0.594}$	190
200	$447 * DA^{0.589}$	230
500	$550 * DA^{0.583}$	280

North Carolina Urban Flood-Frequency Equations [3]

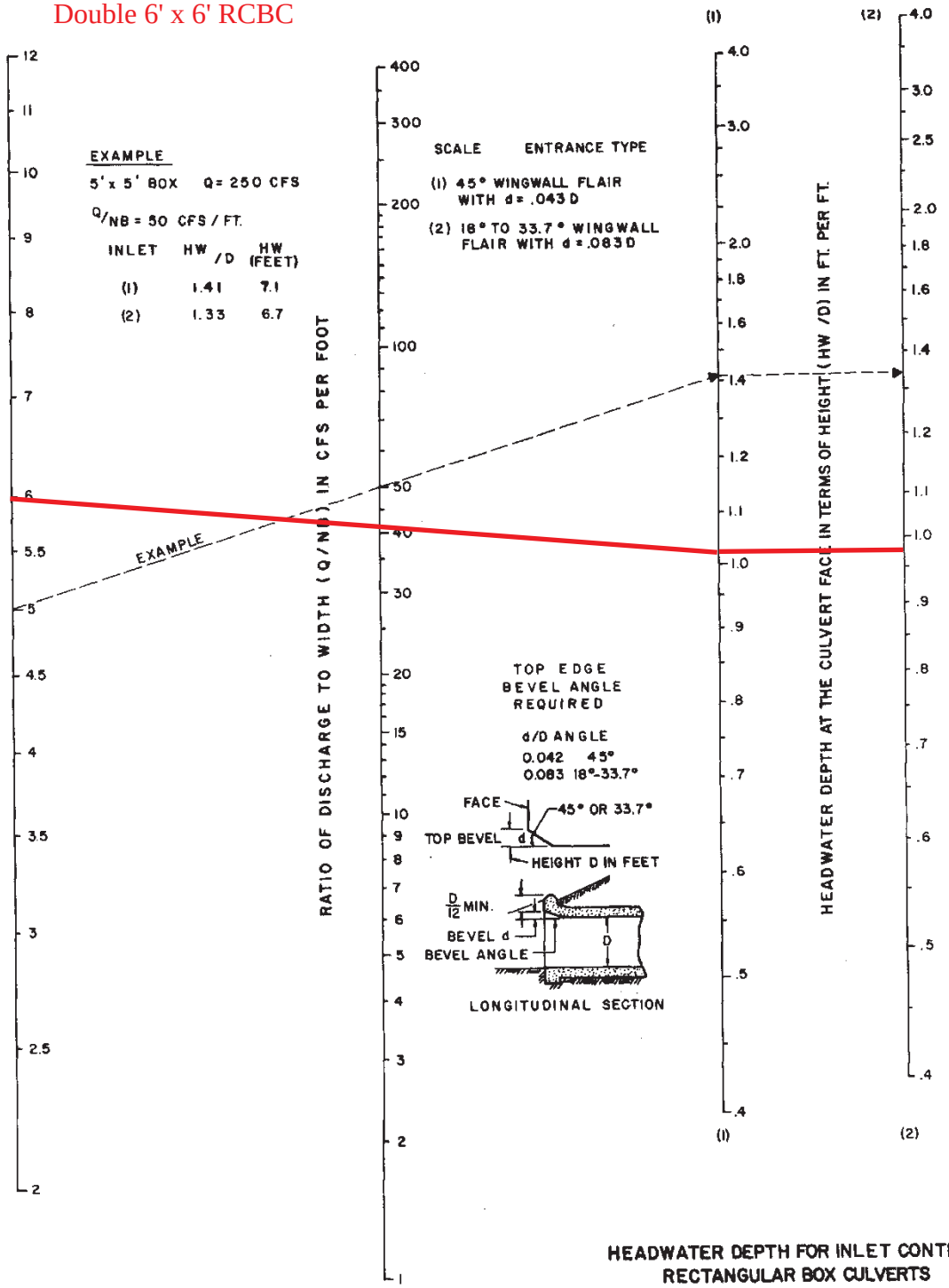
Drainage Area = 0.32 sq. mi.
Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	90
5	$68.2 * DA^{0.655} * IA^{0.572}$	180
10	$109 * DA^{0.625} * IA^{0.515}$	250
25	$209 * DA^{0.570} * IA^{0.436}$	400
50	$280 * DA^{0.558} * IA^{0.396}$	490
100	$363 * DA^{0.547} * IA^{0.358}$	550
200 [4]	UQ100 / RQ100 * RQ200	650
500 [4]	UQ100 / RQ100 * RQ500	800

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

U-4738
Crossing 5
DA = 205 ac.
Q50 = 490 cfs
Q/B = 41 cfs
Double 6' x 6' RCBC

CHART 9B

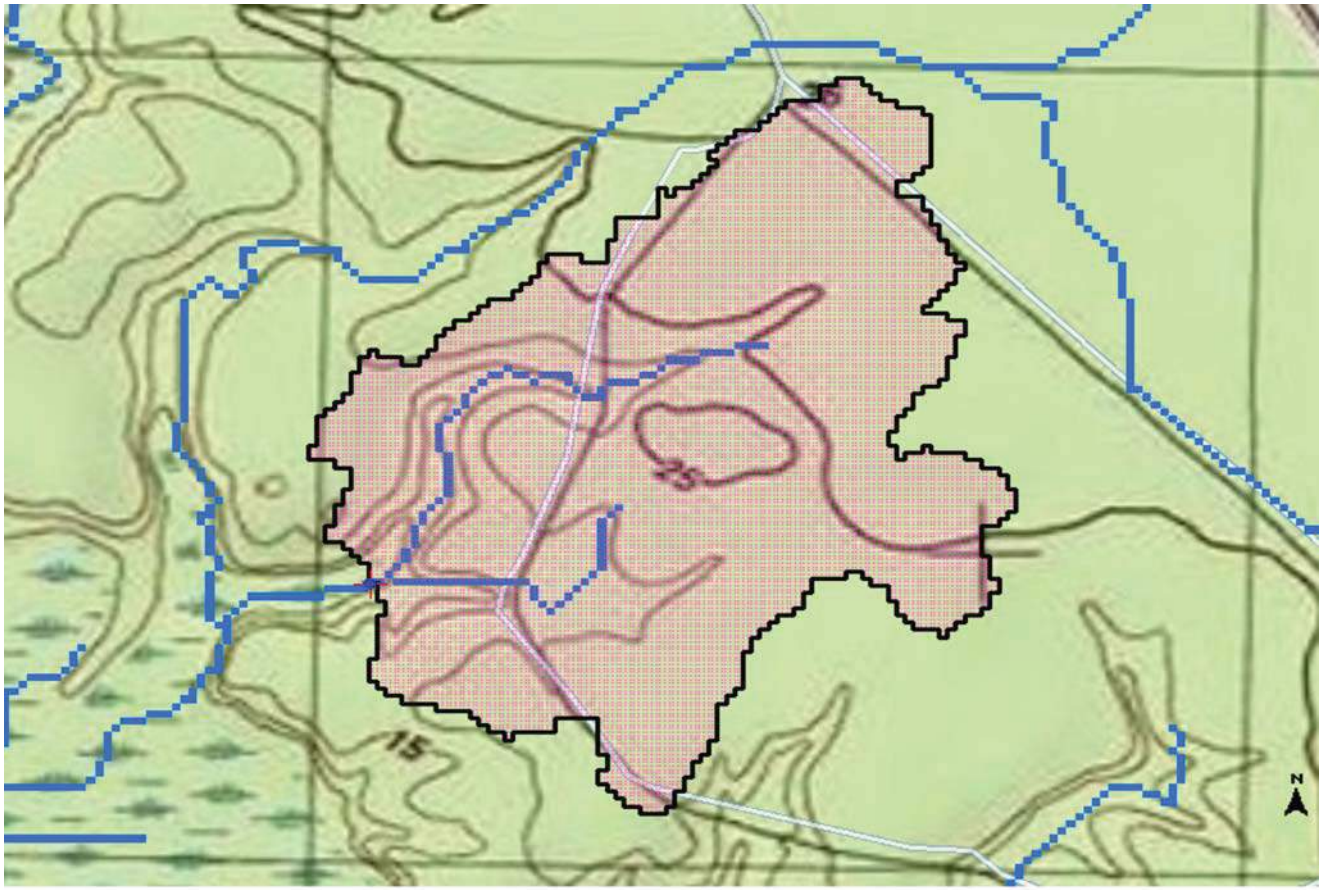


HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

USGS
North Carolina StreamStats

U-4738

Crossing 6



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.1 0.05 0 0.1 Miles

9/11/2014 12:48:27 PM

Crossing 6

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Tue Sep 9 2014 14:17:36 Mountain Daylight Time
NAD27 Latitude: 34.1663 (34 09 59)
NAD27 Longitude: -78.0487 (-78 02 55)
NAD83 Latitude: 34.1665 (34 09 59)
NAD83 Longitude: -78.0485 (-78 02 54)

Parameter	Value
Area in square miles	0.15
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	2.59
Mean basin slope, based on slope percent grid	1.94
Percent of area covered by barren rock using 2006 NLCD	0.000
Percent of area in cultivation using 2006 NLCD	7.694
Percent of area covered by all densities of developed land using 2006 NLCD	3.043
Percent of area covered by forest using 2006 NLCD	61.921
Percent of area covered by grassland/herbaceous using 2006 NLCD	0.000
Percent impervious of basin area 2006 NLCD	0.13
Mean annual precipitation in inches	58.7
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	22.821
Percent of area hydrologic soil 'A' defined by SSURGO	19.8
Percent of area hydrologic soil 'B' defined by SSURGO	73
Percent of area hydrologic soil 'C' defined by SSURGO	0
Percent of area hydrologic soil 'D' defined by SSURGO	7.19
Percent of area covered by water using 2006 NLCD	0.000
Percent of area covered by wetland using 2006 NLCD	4.521

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 06

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 0.15 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	18
5	$123 * DA^{0.627}$	37
10	$174 * DA^{0.617}$	55
25	$245 * DA^{0.606}$	80
50	$309 * DA^{0.600}$	100
100	$380 * DA^{0.594}$	120
200	$447 * DA^{0.589}$	150
500	$550 * DA^{0.583}$	180

North Carolina Urban Flood-Frequency Equations [3]

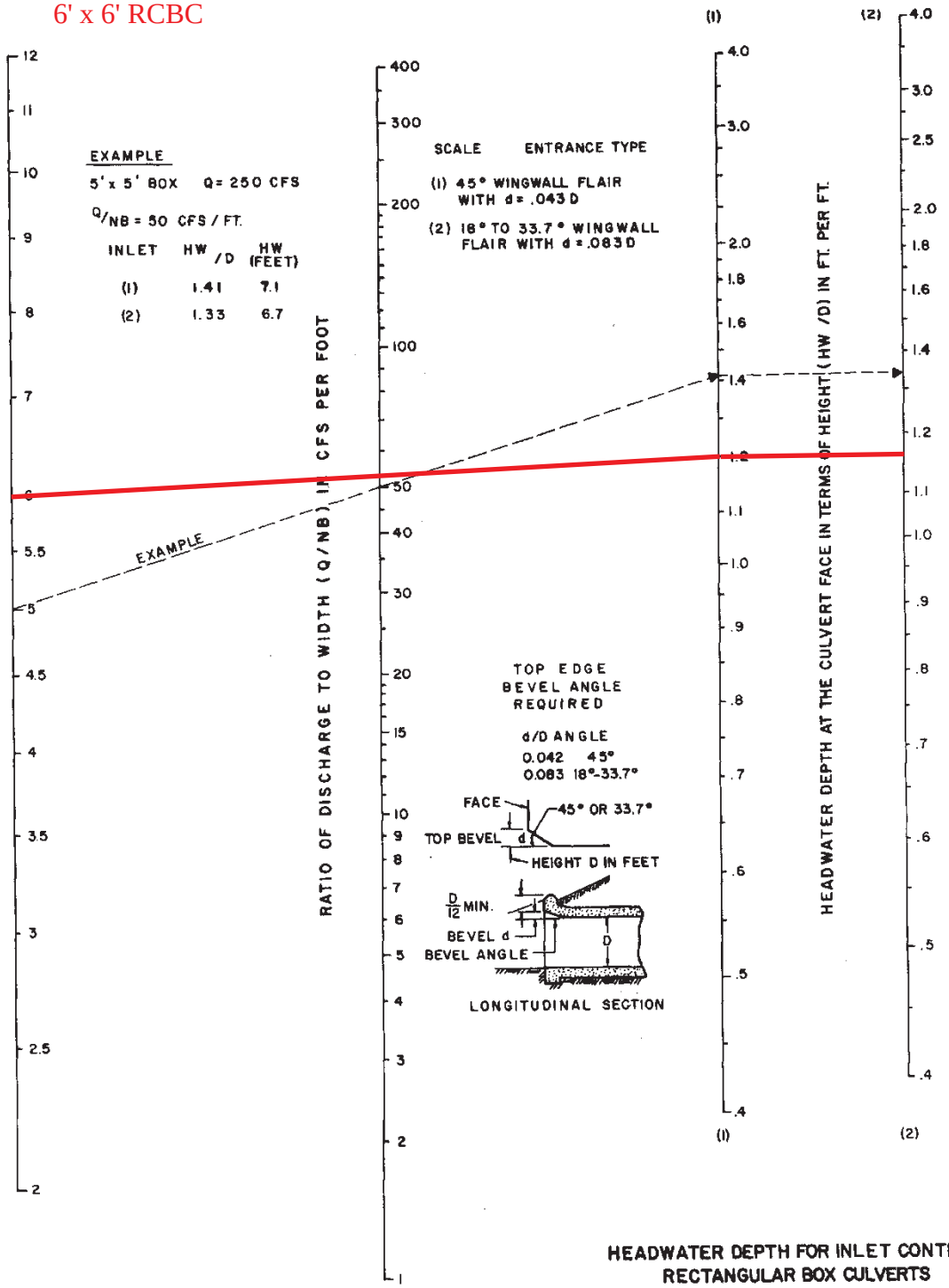
Drainage Area = 0.15 sq. mi.
Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	55
5	$68.2 * DA^{0.655} * IA^{0.572}$	110
10	$109 * DA^{0.625} * IA^{0.515}$	160
25	$209 * DA^{0.570} * IA^{0.436}$	260
50	$280 * DA^{0.558} * IA^{0.396}$	320
100	$363 * DA^{0.547} * IA^{0.358}$	380
200 [4]	UQ100 / RQ100 * RQ200	480
500 [4]	UQ100 / RQ100 * RQ500	550

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

U-4738
Crossing 6
DA = 96 ac.
Q50 = 320 cfs
Q/B = 53 cfs
6' x 6' RCBC

CHART 9B

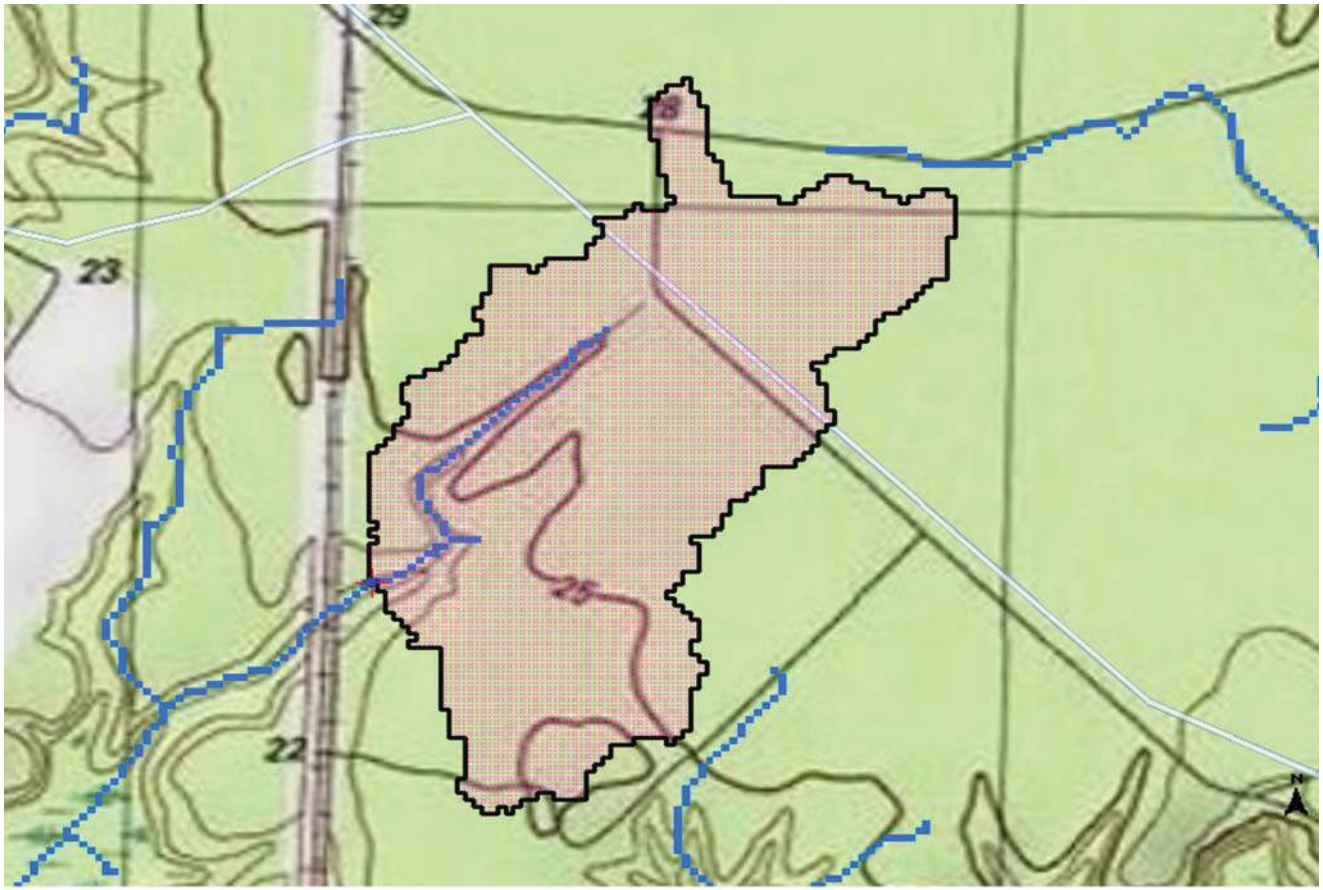


HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

USGS
North Carolina StreamStats

U-4738

Crossing 7



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.1 0.05 0 0.1 Miles

9/11/2014 12:50:40 PM

Crossing 7

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Tue Sep 9 2014 14:23:18 Mountain Daylight Time
NAD27 Latitude: 34.1584 (34 09 30)
NAD27 Longitude: -78.0358 (-78 02 09)
NAD83 Latitude: 34.1586 (34 09 31)
NAD83 Longitude: -78.0356 (-78 02 08)

Parameter	Value
Area in square miles	0.12
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	2.39
Mean basin slope, based on slope percent grid	1.51
Percent of area covered by barren rock using 2006 NLCD	21.697
Percent of area in cultivation using 2006 NLCD	0.000
Percent of area covered by all densities of developed land using 2006 NLCD	0.027
Percent of area covered by forest using 2006 NLCD	45.988
Percent of area covered by grassland/herbaceous using 2006 NLCD	20.805
Percent impervious of basin area 2006 NLCD	0.16
Mean annual precipitation in inches	58.9
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	2.486
Percent of area hydrologic soil 'A' defined by SSURGO	34.9
Percent of area hydrologic soil 'B' defined by SSURGO	49.9
Percent of area hydrologic soil 'C' defined by SSURGO	15.2
Percent of area hydrologic soil 'D' defined by SSURGO	0
Percent of area covered by water using 2006 NLCD	0.000
Percent of area covered by wetland using 2006 NLCD	8.998

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 07

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 0.12 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	15
5	$123 * DA^{0.627}$	33
10	$174 * DA^{0.617}$	47
25	$245 * DA^{0.606}$	70
50	$309 * DA^{0.600}$	85
100	$380 * DA^{0.594}$	110
200	$447 * DA^{0.589}$	130
500	$550 * DA^{0.583}$	160

North Carolina Urban Flood-Frequency Equations [3]

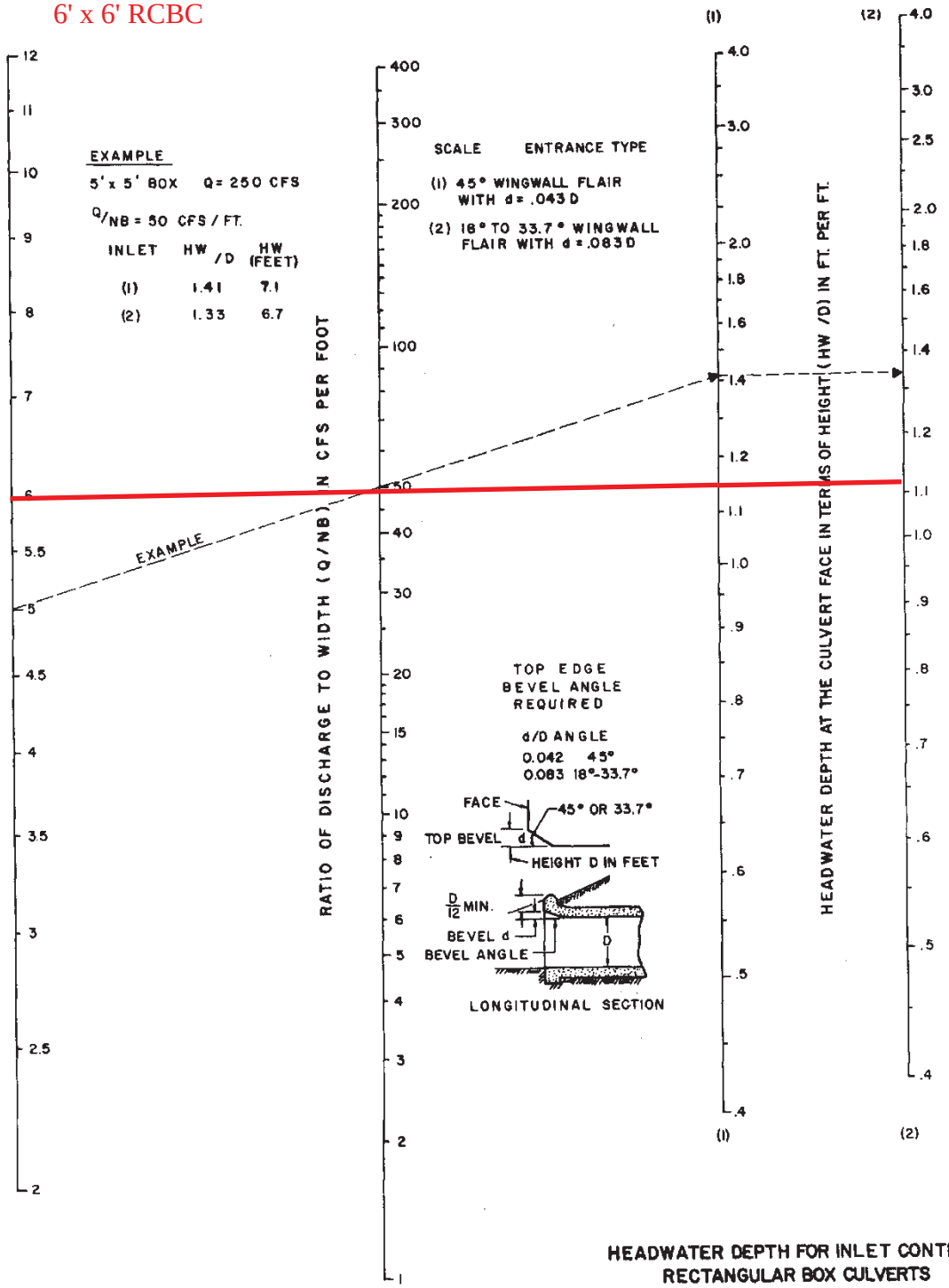
Drainage Area = 0.12 sq. mi.
Impervious Area = 22 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	48
5	$68.2 * DA^{0.655} * IA^{0.572}$	100
10	$109 * DA^{0.625} * IA^{0.515}$	140
25	$209 * DA^{0.570} * IA^{0.436}$	240
50	$280 * DA^{0.558} * IA^{0.396}$	290
100	$363 * DA^{0.547} * IA^{0.358}$	340
200 [4]	UQ100 / RQ100 * RQ200	400
500 [4]	UQ100 / RQ100 * RQ500	490

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

U-4738
Crossing 7
DA = 77 ac.
Q50 = 290 cfs
Q/B = 48 cfs
6' x 6' RCBC

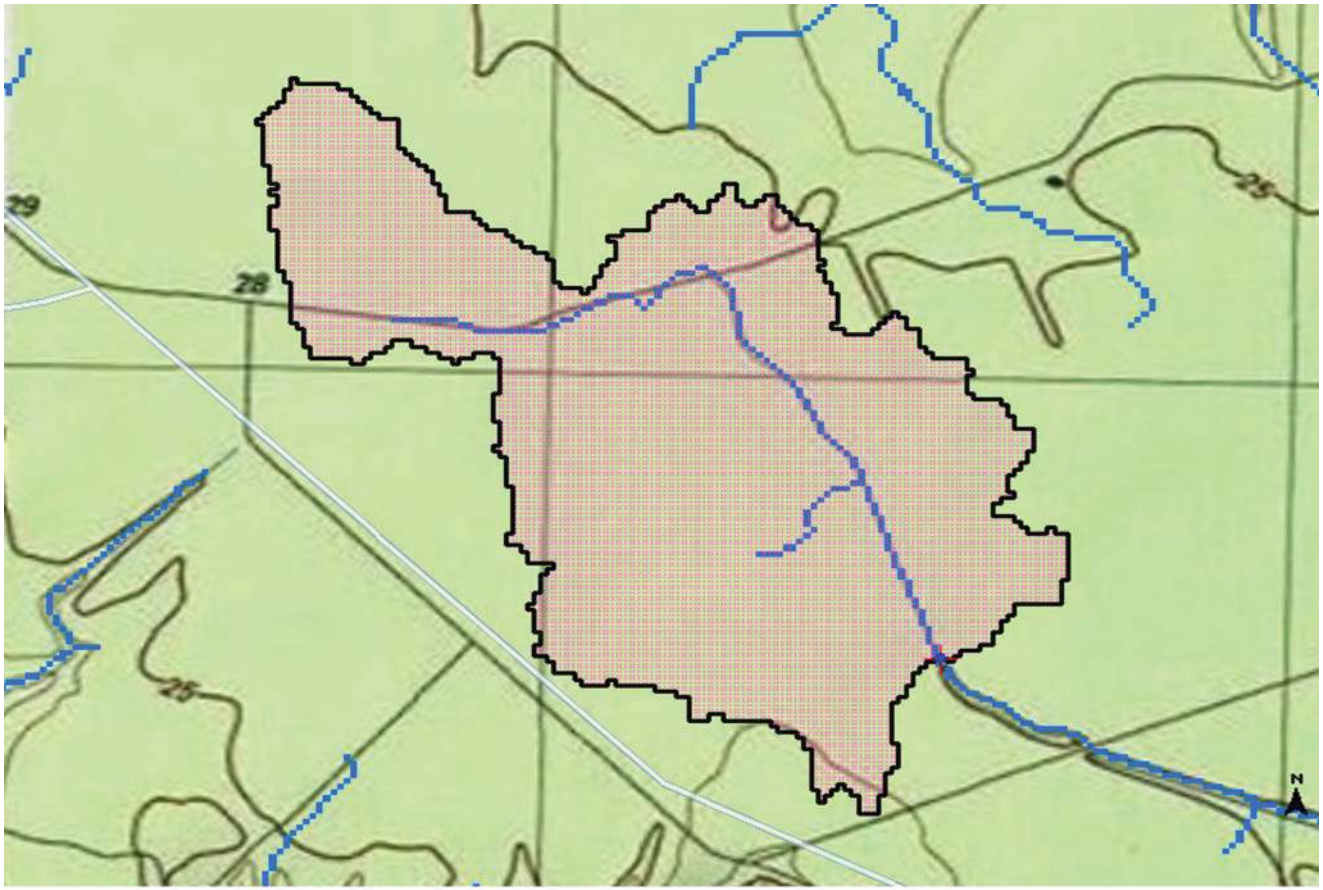
CHART 9B



HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

U-4738

Crossing 8



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.1 0.05 0 0.1 Miles

9/11/2014 12:55:04 PM

Crossing 8

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Thu Sep 11 2014 12:57:27 Mountain Daylight Time
NAD27 Latitude: 34.1586 (34 09 31)
NAD27 Longitude: -78.0222 (-78 01 20)
NAD83 Latitude: 34.1588 (34 09 32)
NAD83 Longitude: -78.0219 (-78 01 19)

Parameter	Value
Area in square miles	0.22
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	3.5
Mean basin slope, based on slope percent grid	0.79
Percent of area covered by barren rock using 2006 NLCD	6.405
Percent of area in cultivation using 2006 NLCD	2.234
Percent of area covered by all densities of developed land using 2006 NLCD	0.000
Percent of area covered by forest using 2006 NLCD	32.781
Percent of area covered by grassland/herbaceous using 2006 NLCD	18.698
Percent impervious of basin area 2006 NLCD	0.00
Mean annual precipitation in inches	58.9
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	13.994
Percent of area hydrologic soil 'A' defined by SSURGO	2.31
Percent of area hydrologic soil 'B' defined by SSURGO	87.3
Percent of area hydrologic soil 'C' defined by SSURGO	10.4
Percent of area hydrologic soil 'D' defined by SSURGO	0
Percent of area covered by water using 2006 NLCD	0.000
Percent of area covered by wetland using 2006 NLCD	25.888

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 08

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 0.22 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	23
5	$123 * DA^{0.627}$	48
10	$174 * DA^{0.617}$	70
25	$245 * DA^{0.606}$	100
50	$309 * DA^{0.600}$	120
100	$380 * DA^{0.594}$	150
200	$447 * DA^{0.589}$	180
500	$550 * DA^{0.583}$	230

North Carolina Urban Flood-Frequency Equations [3]

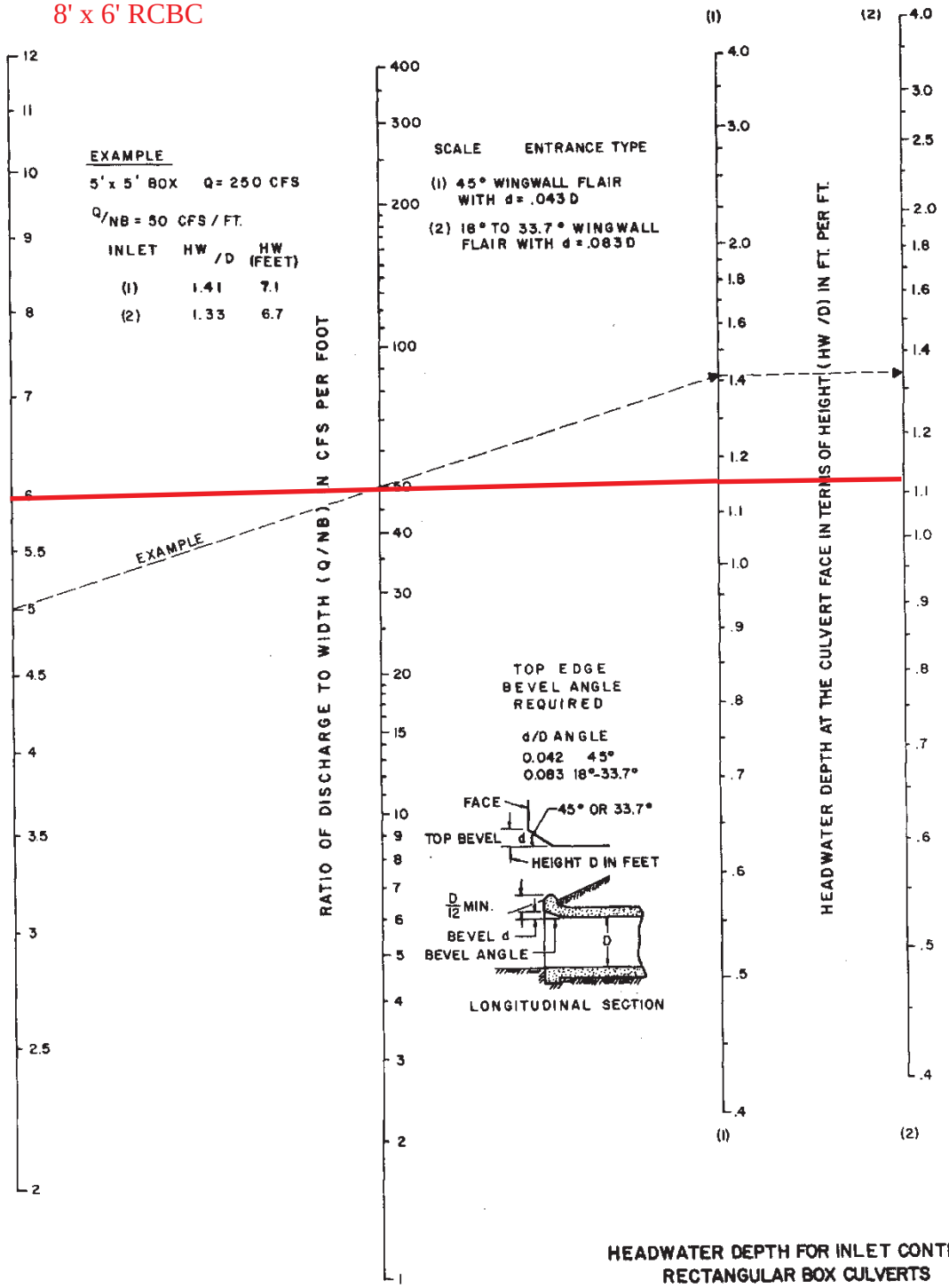
Drainage Area = 0.22 sq. mi.
Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	70
5	$68.2 * DA^{0.655} * IA^{0.572}$	140
10	$109 * DA^{0.625} * IA^{0.515}$	200
25	$209 * DA^{0.570} * IA^{0.436}$	330
50	$280 * DA^{0.558} * IA^{0.396}$	390
100	$363 * DA^{0.547} * IA^{0.358}$	460
200 [4]	UQ100 / RQ100 * RQ200	550
500 [4]	UQ100 / RQ100 * RQ500	700

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

U-4738
Crossing 8
DA = 141 ac.
Q50 = 390 cfs
Q/B = 49 cfs
8' x 6' RCBC

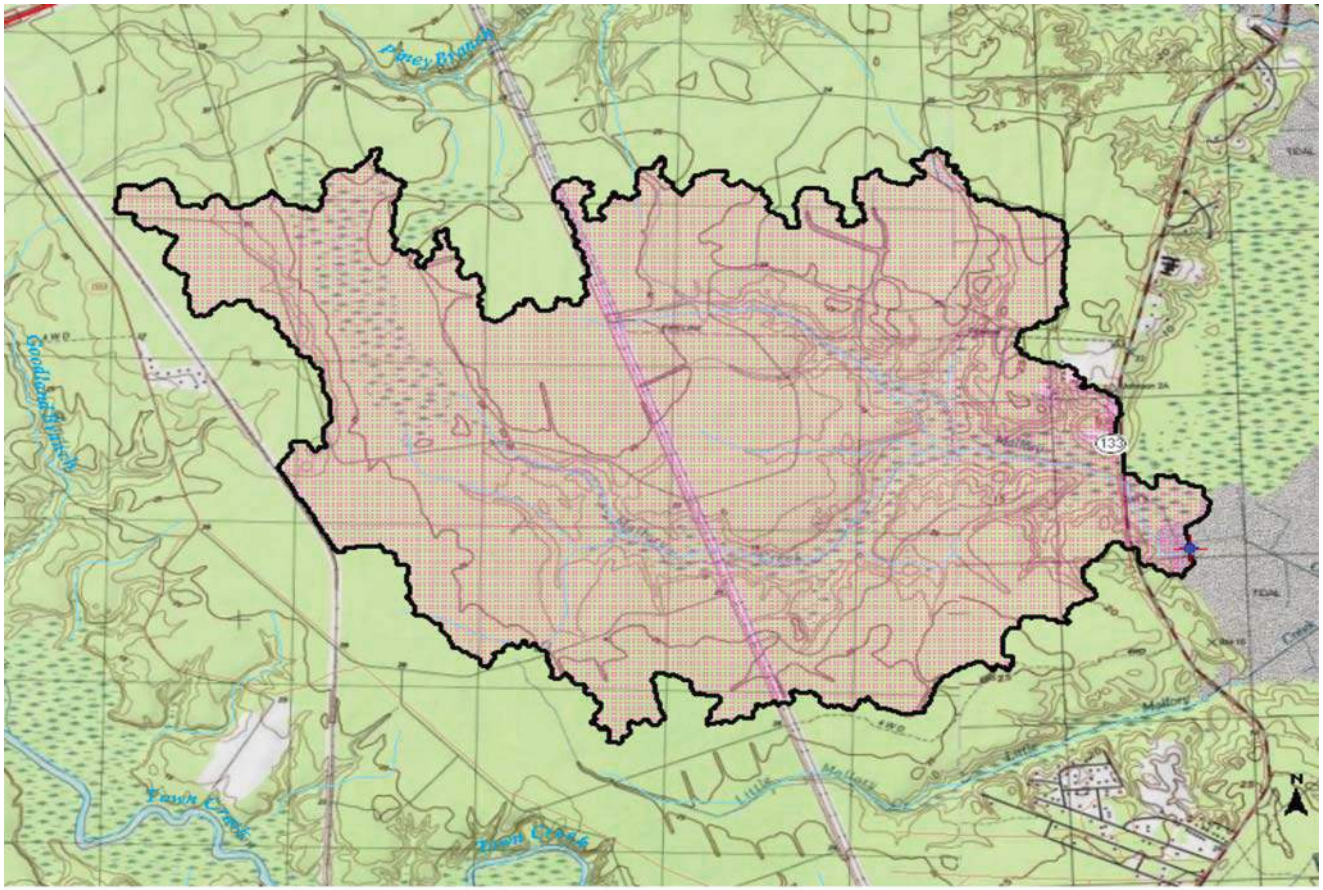
CHART 9B



HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

U-4738

Crossing 10



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.7 0.35 0 0.7 Miles

9/11/2014 1:03:22 PM

Crossing 10

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Tue Sep 9 2014 14:40:32 Mountain Daylight Time
NAD27 Latitude: 34.1701 (34 10 12)
NAD27 Longitude: -77.9866 (-77 59 12)
NAD83 Latitude: 34.1703 (34 10 13)
NAD83 Longitude: -77.9863 (-77 59 11)

Parameter	Value
Area in square miles	4.75
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	21.1
Mean basin slope, based on slope percent grid	1.42
Percent of area covered by barren rock using 2006 NLCD	7.086
Percent of area in cultivation using 2006 NLCD	0.171
Percent of area covered by all densities of developed land using 2006 NLCD	26.680
Percent of area covered by forest using 2006 NLCD	20.107
Percent of area covered by grassland/herbaceous using 2006 NLCD	9.401
Percent impervious of basin area 2006 NLCD	3.46
Mean annual precipitation in inches	58.6
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	14.375
Percent of area hydrologic soil 'A' defined by SSURGO	23.8
Percent of area hydrologic soil 'B' defined by SSURGO	49.2
Percent of area hydrologic soil 'C' defined by SSURGO	15.4
Percent of area hydrologic soil 'D' defined by SSURGO	11.7
Percent of area covered by water using 2006 NLCD	0.823
Percent of area covered by wetland using 2006 NLCD	21.355

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 10

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 4.75 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	170
5	$123 * DA^{0.627}$	330
10	$174 * DA^{0.617}$	460
25	$245 * DA^{0.606}$	650
50	$309 * DA^{0.600}$	800
100	$380 * DA^{0.594}$	950
200	$447 * DA^{0.589}$	1,100
500	$550 * DA^{0.583}$	1,400

North Carolina Urban Flood-Frequency Equations [3]

Drainage Area = 4.75 sq. mi.
Impervious Area = 20 % (greater than 10%)

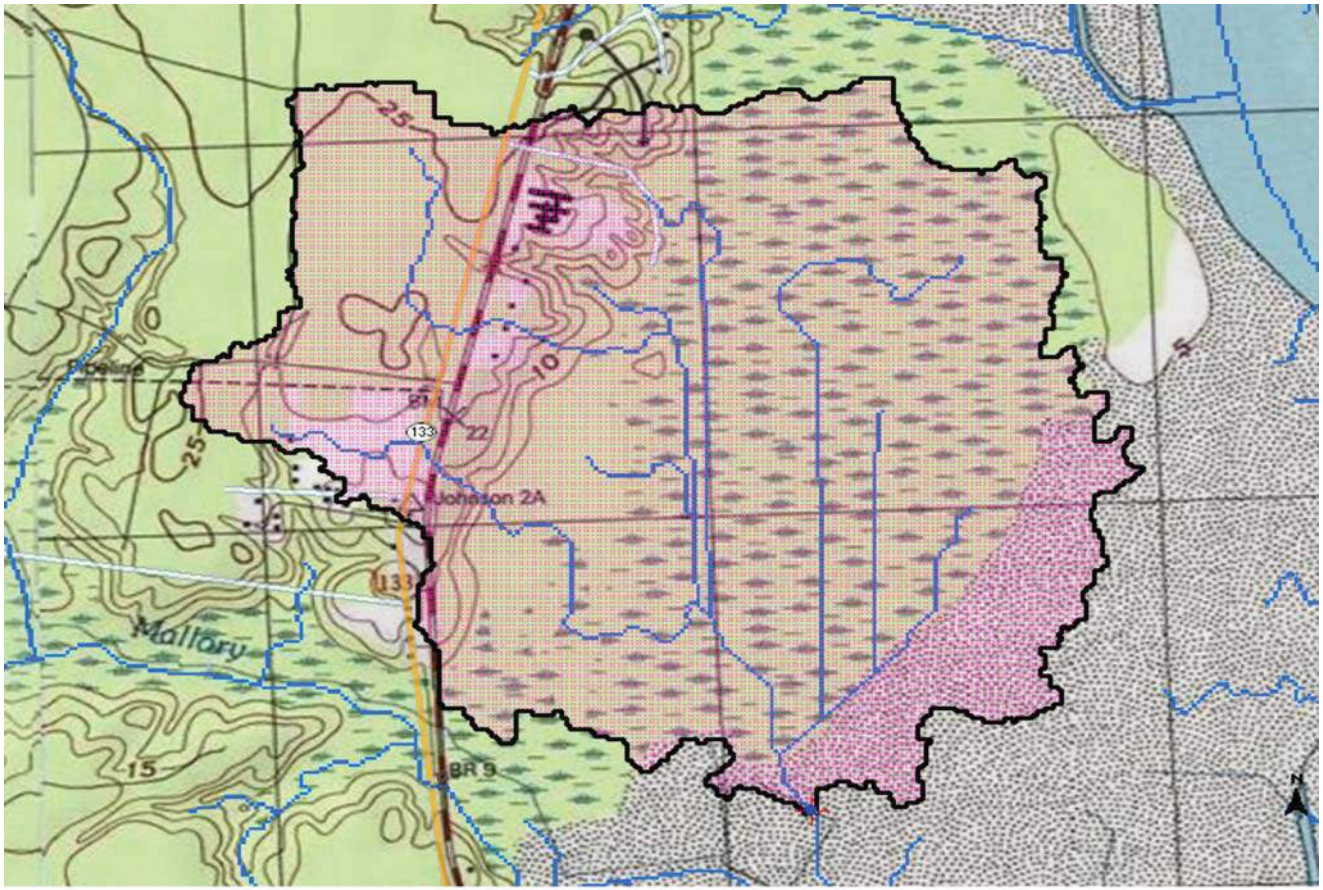
Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	650
5	$68.2 * DA^{0.655} * IA^{0.572}$	1,100
10	$109 * DA^{0.625} * IA^{0.515}$	1,400
25	$209 * DA^{0.570} * IA^{0.436}$	1,900
50	$280 * DA^{0.558} * IA^{0.396}$	2,200
100	$363 * DA^{0.547} * IA^{0.358}$	2,500
200 [4]	UQ100 / RQ100 * RQ200	2,900
500 [4]	UQ100 / RQ100 * RQ500	3,700

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

USGS
North Carolina StreamStats

U-4738

Crossing 11



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.3 0.15 0 0.3 Miles

9/11/2014 1:05:45 PM

Crossing 11

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Tue Sep 9 2014 14:52:14 Mountain Daylight Time
NAD27 Latitude: 34.1719 (34 10 19)
NAD27 Longitude: -77.9814 (-77 58 53)
NAD83 Latitude: 34.1720 (34 10 19)
NAD83 Longitude: -77.9811 (-77 58 52)

Parameter	Value
Area in square miles	1.04
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	6.78
Mean basin slope, based on slope percent grid	1.28
Percent of area covered by barren rock using 2006 NLCD	0.894
Percent of area in cultivation using 2006 NLCD	1.346
Percent of area covered by all densities of developed land using 2006 NLCD	10.910
Percent of area covered by forest using 2006 NLCD	12.893
Percent of area covered by grassland/herbaceous using 2006 NLCD	1.485
Percent impervious of basin area 2006 NLCD	2.38
Mean annual precipitation in inches	58.4
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	5.050
Percent of area hydrologic soil 'A' defined by SSURGO	13.6
Percent of area hydrologic soil 'B' defined by SSURGO	13
Percent of area hydrologic soil 'C' defined by SSURGO	5.69
Percent of area hydrologic soil 'D' defined by SSURGO	67.7
Percent of area covered by water using 2006 NLCD	0.000
Percent of area covered by wetland using 2006 NLCD	67.422

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 11

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 1.04 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	60
5	$123 * DA^{0.627}$	130
10	$174 * DA^{0.617}$	180
25	$245 * DA^{0.606}$	250
50	$309 * DA^{0.600}$	320
100	$380 * DA^{0.594}$	390
200	$447 * DA^{0.589}$	460
500	$550 * DA^{0.583}$	550

North Carolina Urban Flood-Frequency Equations [3]

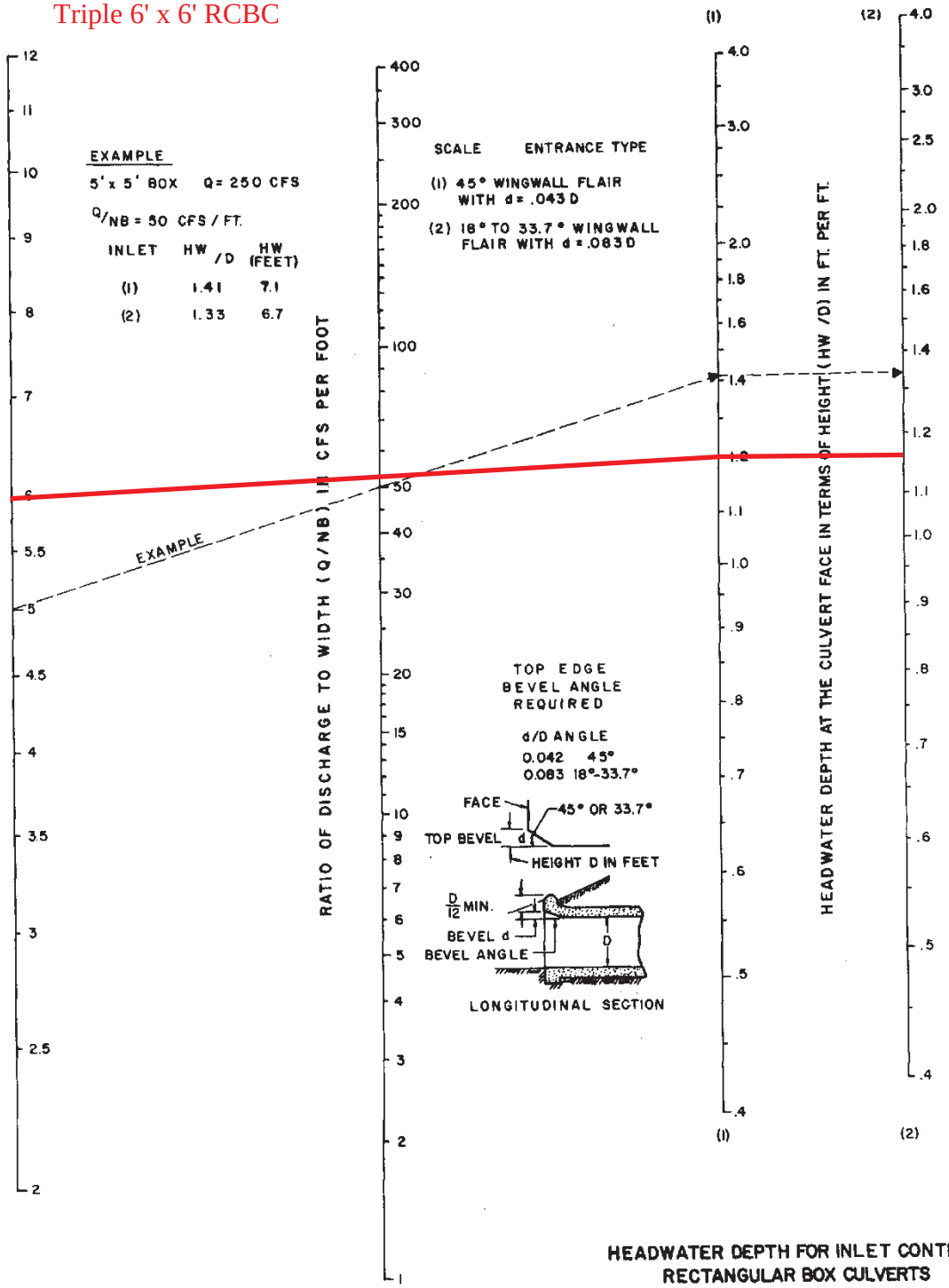
Drainage Area = 1.04 sq. mi.
Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	220
5	$68.2 * DA^{0.655} * IA^{0.572}$	390
10	$109 * DA^{0.625} * IA^{0.515}$	500
25	$209 * DA^{0.570} * IA^{0.436}$	800
50	$280 * DA^{0.558} * IA^{0.396}$	950
100	$363 * DA^{0.547} * IA^{0.358}$	1,100
200 [4]	UQ100 / RQ100 * RQ200	1,300
500 [4]	UQ100 / RQ100 * RQ500	1,600

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

U-4738
Crossing 11
DA = 665 ac.
Q50 = 950 cfs
Q/B = 53 cfs
Triple 6' x 6' RCBC

CHART 9B

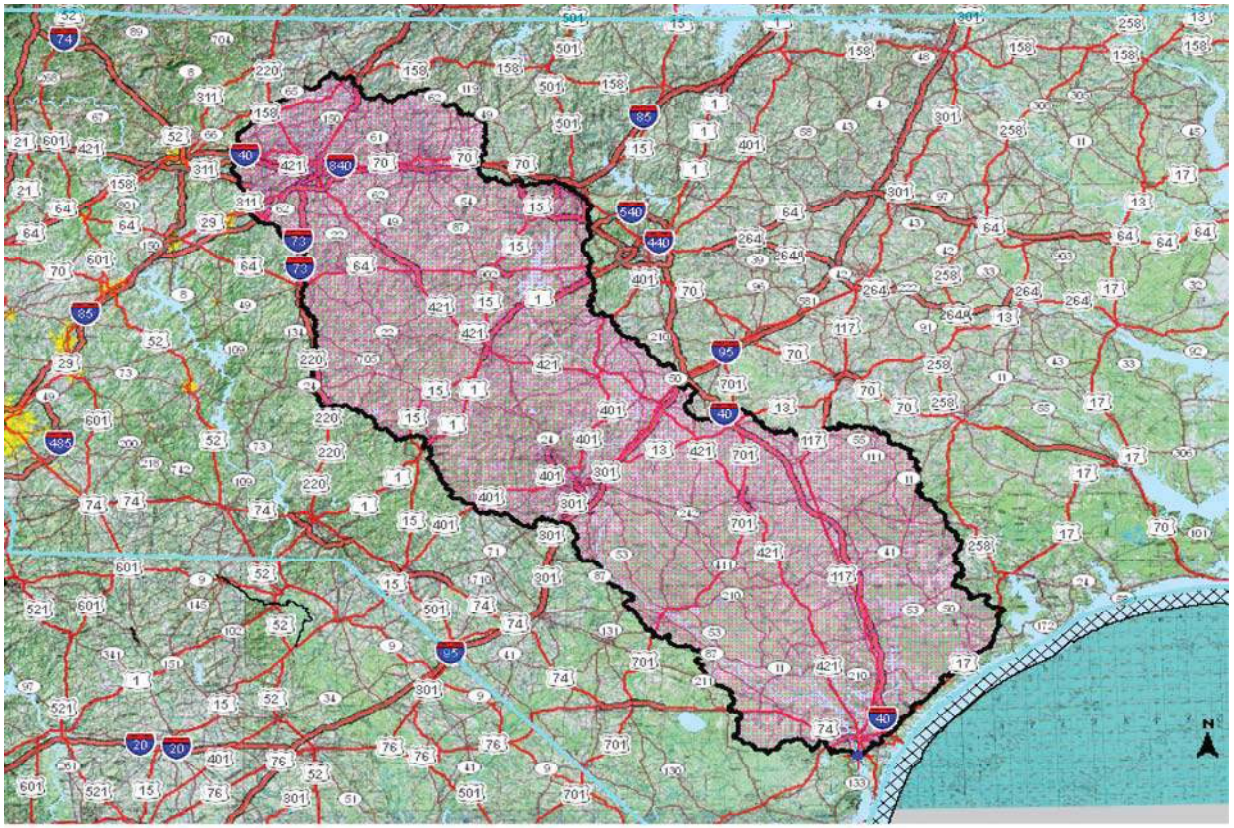


HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

USGS
North Carolina StreamStats

U-4738

Crossing 12



Explanation
- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

40 20 0 40 Miles

9/10/2014 7:41:48 AM

Crossing 12

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 08:25:35 Mountain Daylight Time
NAD27 Latitude: 34.1723 (34 10 20)
NAD27 Longitude: -77.9574 (-77 57 27)
NAD83 Latitude: 34.1725 (34 10 21)
NAD83 Longitude: -77.9571 (-77 57 26)

Parameter	Value
Area in square miles	8850
Percent of area covered by hydrologic region 1	38.011
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	8.771
Percent of area covered by hydrologic region 4	53.218
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	1070
Mean basin slope, based on slope percent grid	4.32
Percent of area covered by barren rock using 2006 NLCD	0.367
Percent of area in cultivation using 2006 NLCD	23.004
Percent of area covered by all densities of developed land using 2001 NLCD	10.367
Percent of area covered by all densities of developed land using 2006 NLCD	10.789
Percent of area covered by forest using 2006 NLCD	37.372
Percent of area covered by grassland/herbaceous using 2006 NLCD	5.248
Percent impervious of basin area 2006 NLCD	2.48
Mean annual precipitation in inches	49.3
Percent of area of protected Federal and State owned land	5.68
Percent of area covered by shrubland using 2006 NLCD	7.654
Percent of area hydrologic soil 'A' defined by SSURGO	13.8
Percent of area hydrologic soil 'B' defined by SSURGO	48.1
Percent of area hydrologic soil 'C' defined by SSURGO	24.8
Percent of area hydrologic soil 'D' defined by SSURGO	11.4
Percent of area covered by water using 2006 NLCD	1.324
Percent of area covered by wetland using 2006 NLCD	14.241

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 12

Total Drainage Area = 8850 sq. mi.
Impervious Area = 20 %

Recurrence Interval (years)	Total Q (cfs)
2	170,000
5	170,000
10	180,000
25	170,000
50	180,000
100	190,000
200	210,000
500	240,000

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 12c (Region 1)

North Carolina Urban Flood-Frequency Equations [3]

Drainage Area = 8850 sq. mi.

Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$33.3 * DA^{0.739} * IA^{0.686}$	210,000
5	$78.9 * DA^{0.681} * IA^{0.572}$	210,000
10	$122 * DA^{0.655} * IA^{0.515}$	220,000
25	$228 * DA^{0.611} * IA^{0.436}$	220,000
50	$296 * DA^{0.602} * IA^{0.396}$	230,000
100	$374 * DA^{0.593} * IA^{0.358}$	240,000
200 [4]	UQ100 / RQ100 * RQ200	270,000
500 [4]	UQ100 / RQ100 * RQ500	300,000

3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.

4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 12b (Region 3)

North Carolina Urban Flood-Frequency Equations [3]

Drainage Area = 8850 sq. mi.

Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$21 * DA^{0.752} * IA^{0.686}$	150,000
5	$49.6 * DA^{0.700} * IA^{0.572}$	160,000
10	$75.6 * DA^{0.677} * IA^{0.515}$	170,000
25	$128 * DA^{0.644} * IA^{0.436}$	160,000
50	$170 * DA^{0.637} * IA^{0.396}$	180,000
100	$217 * DA^{0.630} * IA^{0.358}$	190,000
200 [4]	UQ100 / RQ100 * RQ200	220,000
500 [4]	UQ100 / RQ100 * RQ500	250,000

3. Robbins, J.C., and Pope, B.F., 1996, Estimation of Flood-Frequency Characteristics of Small Urban Streams in North Carolina: U.S. Geological Survey Water-Resources Investigations Report 96-4084.

4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 12a (Region 4)

North Carolina Urban Flood-Frequency Equations [3]

Drainage Area = 8850 sq. mi.

Impervious Area = 20.0 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	150,000
5	$68.2 * DA^{0.655} * IA^{0.572}$	150,000
10	$109 * DA^{0.625} * IA^{0.515}$	150,000
25	$209 * DA^{0.570} * IA^{0.436}$	140,000
50	$280 * DA^{0.558} * IA^{0.396}$	150,000
100	$363 * DA^{0.547} * IA^{0.358}$	150,000
200 [4]	UQ100 / RQ100 * RQ200	170,000
500 [4]	UQ100 / RQ100 * RQ500	200,000

3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.

4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

U-4738

Crossing 13

Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.1 0.05 0 0.1 Miles

9/11/2014 1:08:35 PM

Crossing 13

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 08:29:15 Mountain Daylight Time
NAD27 Latitude: 34.1717 (34 10 18)
NAD27 Longitude: -77.9372 (-77 56 14)
NAD83 Latitude: 34.1718 (34 10 19)
NAD83 Longitude: -77.9369 (-77 56 13)

Parameter	Value
Area in square miles	0.14
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	2.75
Mean basin slope, based on slope percent grid	1.99
Percent of area covered by barren rock using 2006 NLCD	0.000
Percent of area in cultivation using 2001 NLCD	0.000
Percent of area in cultivation using 2006 NLCD	0.000
Percent of area covered by all densities of developed land using 2006 NLCD	58.424
Percent of area covered by forest using 2006 NLCD	22.396
Percent of area covered by grassland/herbaceous using 2006 NLCD	0.000
Percent impervious of basin area 2006 NLCD	23.98
Mean annual precipitation in inches	58.3
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	8.356
Percent of area hydrologic soil 'A' defined by SSURGO	31.4
Percent of area hydrologic soil 'B' defined by SSURGO	14.9
Percent of area hydrologic soil 'C' defined by SSURGO	0
Percent of area hydrologic soil 'D' defined by SSURGO	0
Percent of area covered by water using 2006 NLCD	0.000
Percent of area covered by wetland using 2006 NLCD	10.824

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 13

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 0.14 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	17
5	$123 * DA^{0.627}$	36
10	$174 * DA^{0.617}$	50
25	$245 * DA^{0.606}$	75
50	$309 * DA^{0.600}$	95
100	$380 * DA^{0.594}$	120
200	$447 * DA^{0.589}$	140
500	$550 * DA^{0.583}$	170

North Carolina Urban Flood-Frequency Equations [3]

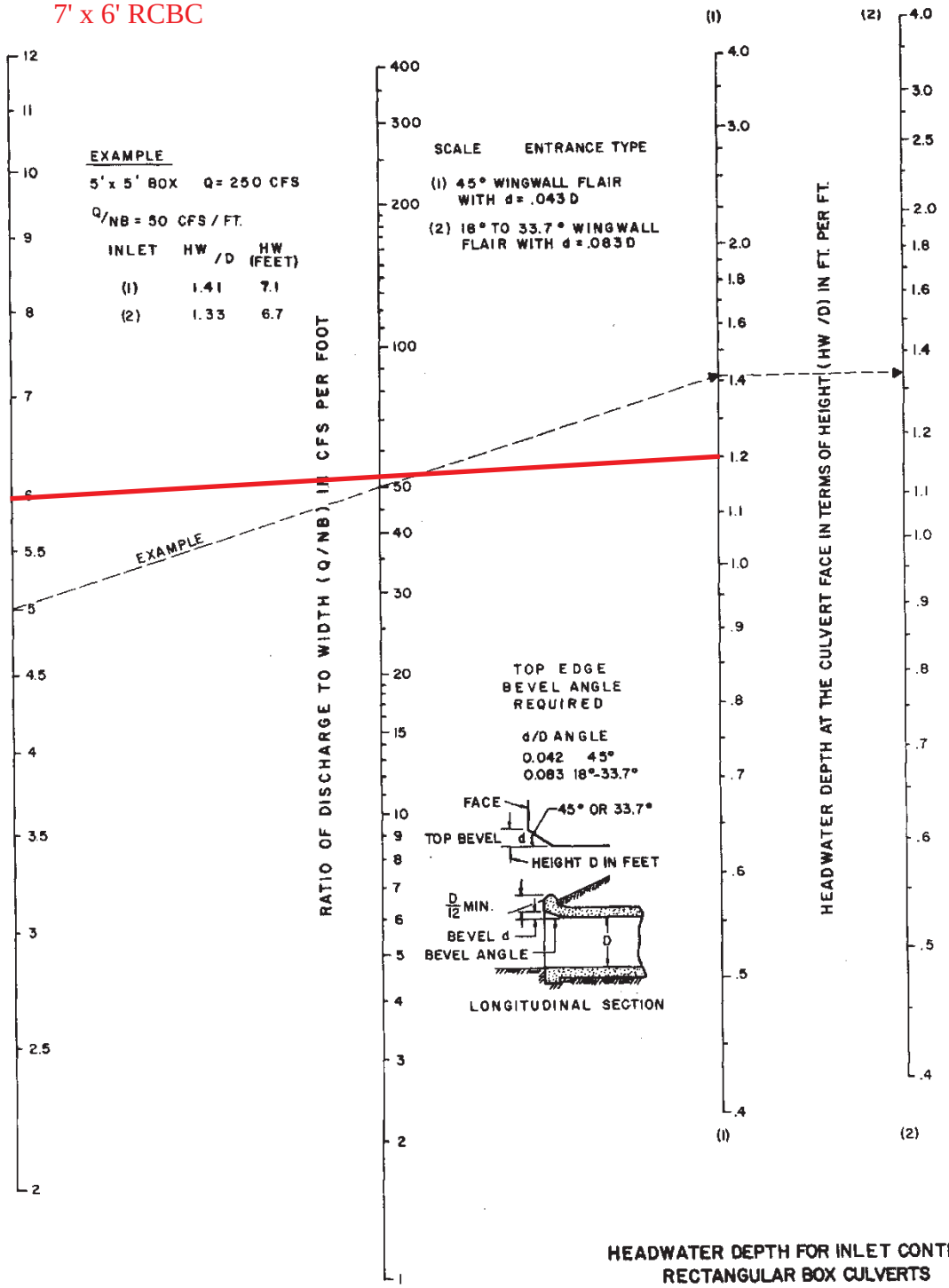
Drainage Area = 0.14 sq. mi.
Impervious Area = 25 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	60
5	$68.2 * DA^{0.655} * IA^{0.572}$	120
10	$109 * DA^{0.625} * IA^{0.515}$	170
25	$209 * DA^{0.570} * IA^{0.436}$	280
50	$280 * DA^{0.558} * IA^{0.396}$	330
100	$363 * DA^{0.547} * IA^{0.358}$	390
200 [4]	UQ100 / RQ100 * RQ200	460
500 [4]	UQ100 / RQ100 * RQ500	550

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

R-4738
Crossing 13
DA = 90 ac.
Q50 = 330 cfs
Q/B = 53 cfs
7' x 6' RCBC

CHART 9B

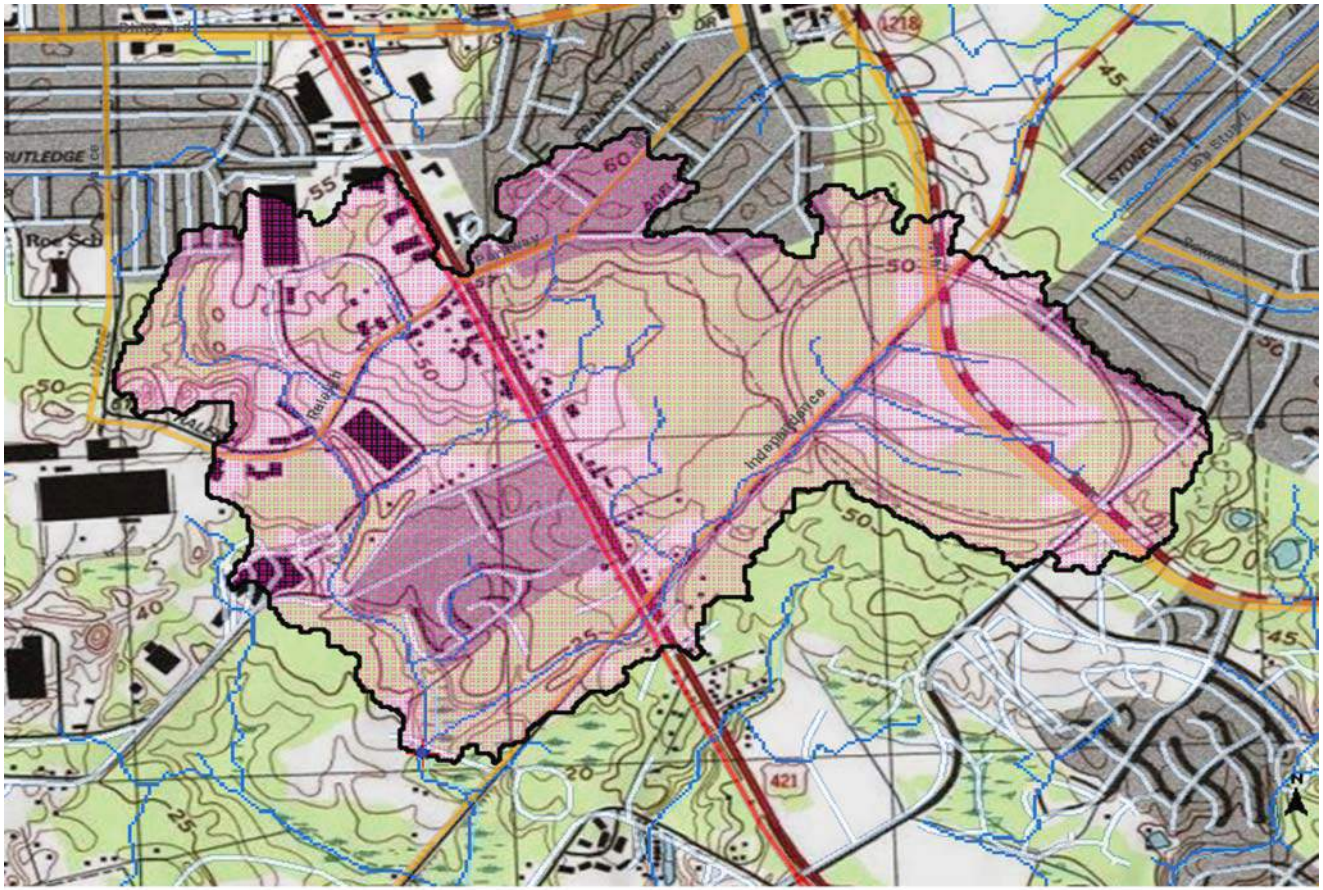


HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

USGS
North Carolina StreamStats

U-4738

Crossing 14



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Crossing 14

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 08:32:42 Mountain Daylight Time
NAD27 Latitude: 34.1714 (34 10 17)
NAD27 Longitude: -77.9318 (-77 55 54)
NAD83 Latitude: 34.1716 (34 10 18)
NAD83 Longitude: -77.9315 (-77 55 53)

Parameter	Value
Area in square miles	1.2
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	8.83
Mean basin slope, based on slope percent grid	2.05
Percent of area covered by barren rock using 2006 NLCD	0.000
Percent of area in cultivation using 2006 NLCD	0.000
Percent of area covered by all densities of developed land using 2006 NLCD	56.113
Percent of area covered by forest using 2006 NLCD	23.574
Percent of area covered by grassland/herbaceous using 2006 NLCD	2.157
Percent impervious of basin area 2006 NLCD	19.97
Mean annual precipitation in inches	58.2
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	7.266
Percent of area hydrologic soil 'A' defined by SSURGO	59.2
Percent of area hydrologic soil 'B' defined by SSURGO	37.4
Percent of area hydrologic soil 'C' defined by SSURGO	0
Percent of area hydrologic soil 'D' defined by SSURGO	1.3
Percent of area covered by water using 2006 NLCD	0.000
Percent of area covered by wetland using 2006 NLCD	10.889

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 14

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 1.20 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	70
5	$123 * DA^{0.627}$	140
10	$174 * DA^{0.617}$	190
25	$245 * DA^{0.606}$	270
50	$309 * DA^{0.600}$	340
100	$380 * DA^{0.594}$	420
200	$447 * DA^{0.589}$	500
500	$550 * DA^{0.583}$	600

North Carolina Urban Flood-Frequency Equations [3]

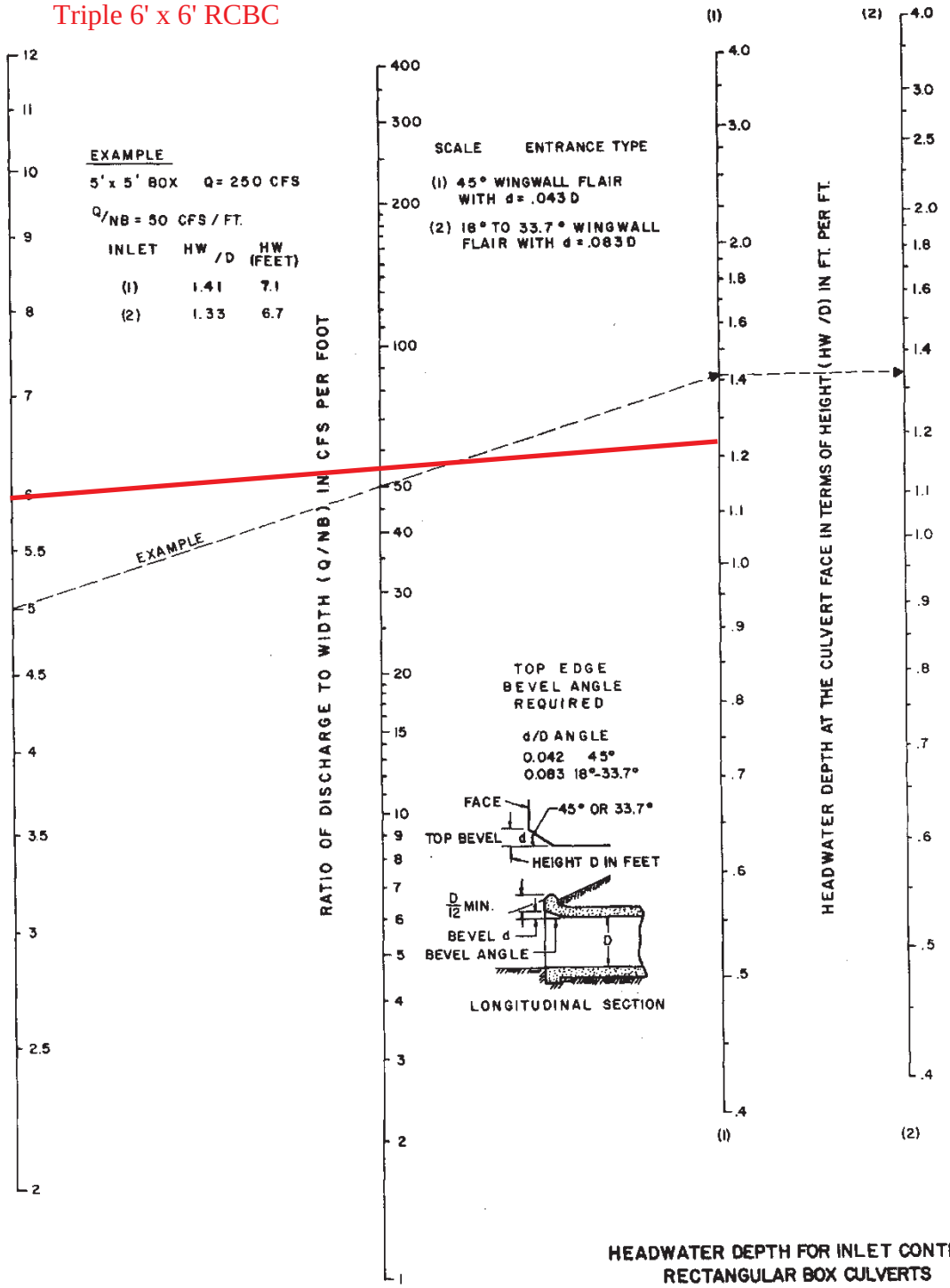
Drainage Area = 1.20 sq. mi.
Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	240
5	$68.2 * DA^{0.655} * IA^{0.572}$	430
10	$109 * DA^{0.625} * IA^{0.515}$	550
25	$209 * DA^{0.570} * IA^{0.436}$	850
50	$280 * DA^{0.558} * IA^{0.396}$	1,000
100	$363 * DA^{0.547} * IA^{0.358}$	1,200
200 [4]	UQ100 / RQ100 * RQ200	1,400
500 [4]	UQ100 / RQ100 * RQ500	1,700

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

R-4738
Crossing 14
DA = 768 ac.
Q50 = 1,000 cfs
Q/B = 55 cfs
Triple 6' x 6' RCBC

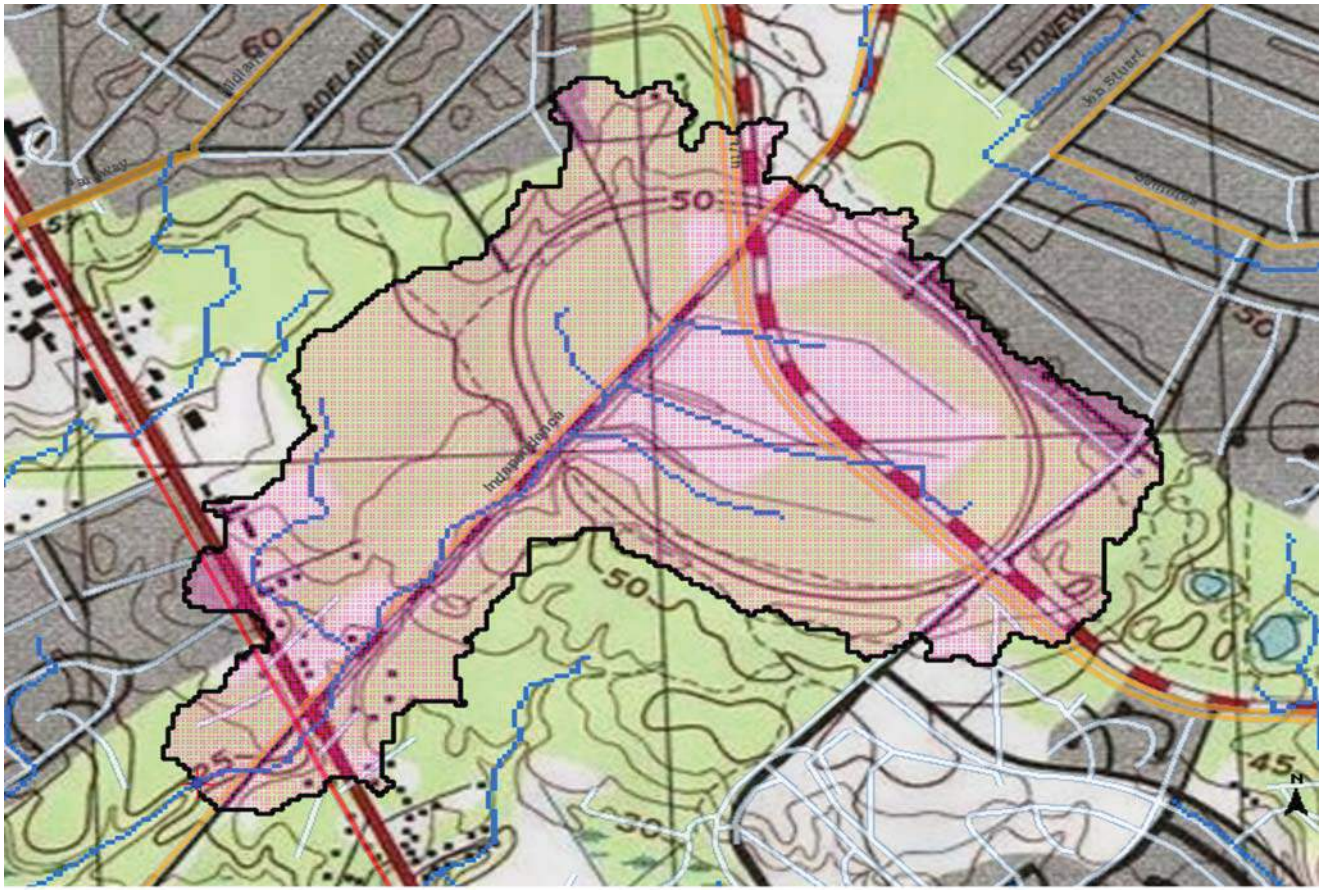
CHART 9B



HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

U-4738

Crossing 15



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

9/11/2014 1:28:54 PM

Crossing 15

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 08:37:34 Mountain Daylight Time
NAD27 Latitude: 34.1742 (34 10 27)
NAD27 Longitude: -77.9274 (-77 55 38)
NAD83 Latitude: 34.1744 (34 10 28)
NAD83 Longitude: -77.9271 (-77 55 37)

Parameter	Value
Area in square miles	0.5
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	5.4
Mean basin slope, based on slope percent grid	1.77
10-85 slope in feet per mile based on preprocessed elevation data	11.7
Percent of area covered by barren rock using 2006 NLCD	0.000
Percent of area in cultivation using 2006 NLCD	0.000
Percent of area covered by all densities of developed land using 2006 NLCD	35.680
Percent of area covered by forest using 2006 NLCD	33.335
Percent of area covered by grassland/herbaceous using 2006 NLCD	0.870
Percent impervious of basin area 2006 NLCD	11.41
Mean annual precipitation in inches	58.2
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	11.454
Percent of area hydrologic soil 'A' defined by SSURGO	65.2
Percent of area hydrologic soil 'B' defined by SSURGO	34.8
Percent of area hydrologic soil 'C' defined by SSURGO	0
Percent of area hydrologic soil 'D' defined by SSURGO	0
Percent of area covered by water using 2006 NLCD	0.000
Percent of area covered by wetland using 2006 NLCD	18.661

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 15

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 0.50 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	38
5	$123 * DA^{0.627}$	80
10	$174 * DA^{0.617}$	110
25	$245 * DA^{0.606}$	160
50	$309 * DA^{0.600}$	200
100	$380 * DA^{0.594}$	250
200	$447 * DA^{0.589}$	300
500	$550 * DA^{0.583}$	370

North Carolina Urban Flood-Frequency Equations [3]

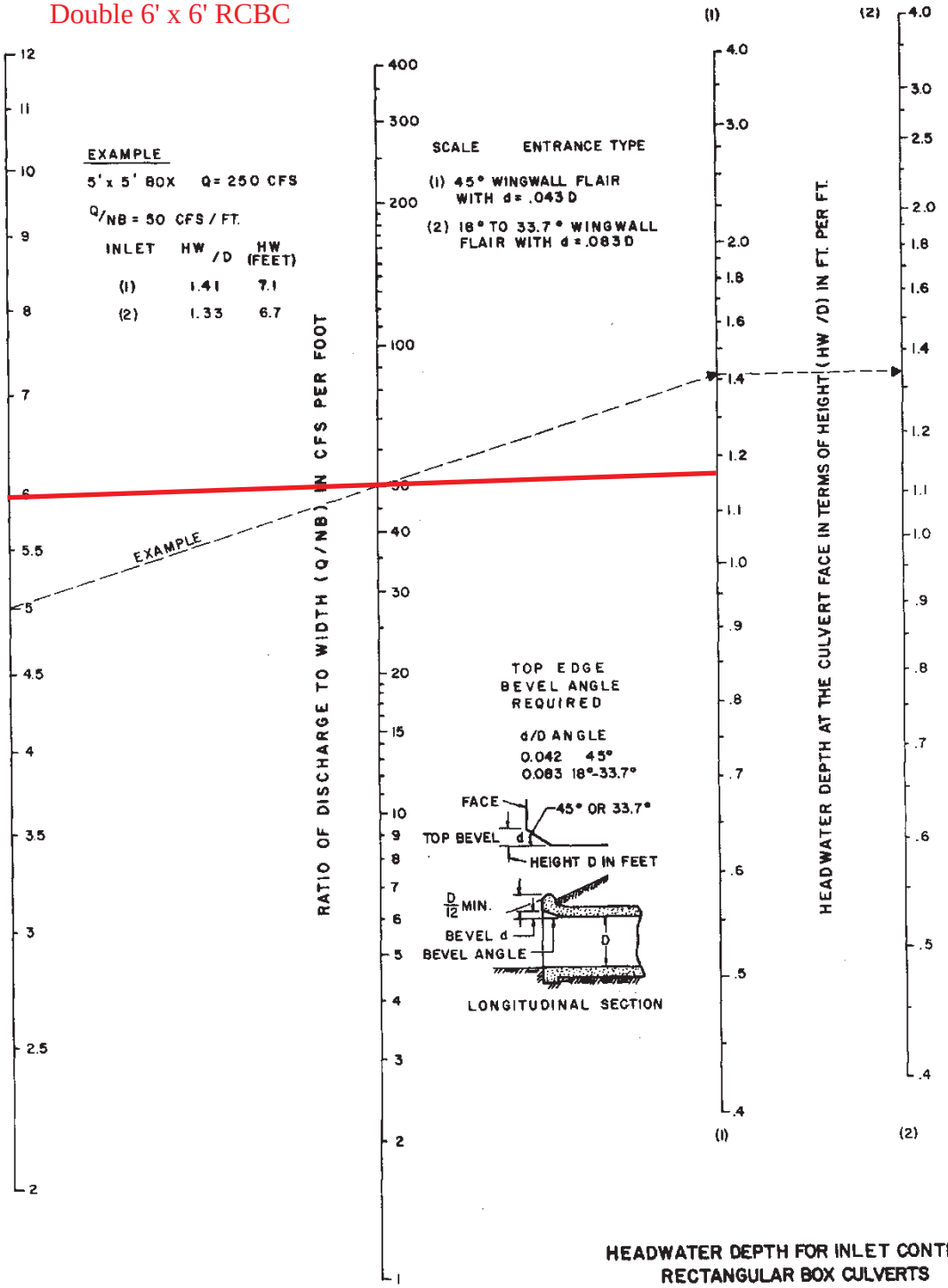
Drainage Area = 0.50 sq. mi.
Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	130
5	$68.2 * DA^{0.655} * IA^{0.572}$	240
10	$109 * DA^{0.625} * IA^{0.515}$	330
25	$209 * DA^{0.570} * IA^{0.436}$	500
50	$280 * DA^{0.558} * IA^{0.396}$	600
100	$363 * DA^{0.547} * IA^{0.358}$	750
200 [4]	UQ100 / RQ100 * RQ200	900
500 [4]	UQ100 / RQ100 * RQ500	1,100

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

R-4738
Crossing 15
DA = 320 ac.
Q50 = 600 cfs
Q/B = 50 cfs
Double 6' x 6' RCBC

CHART 9B

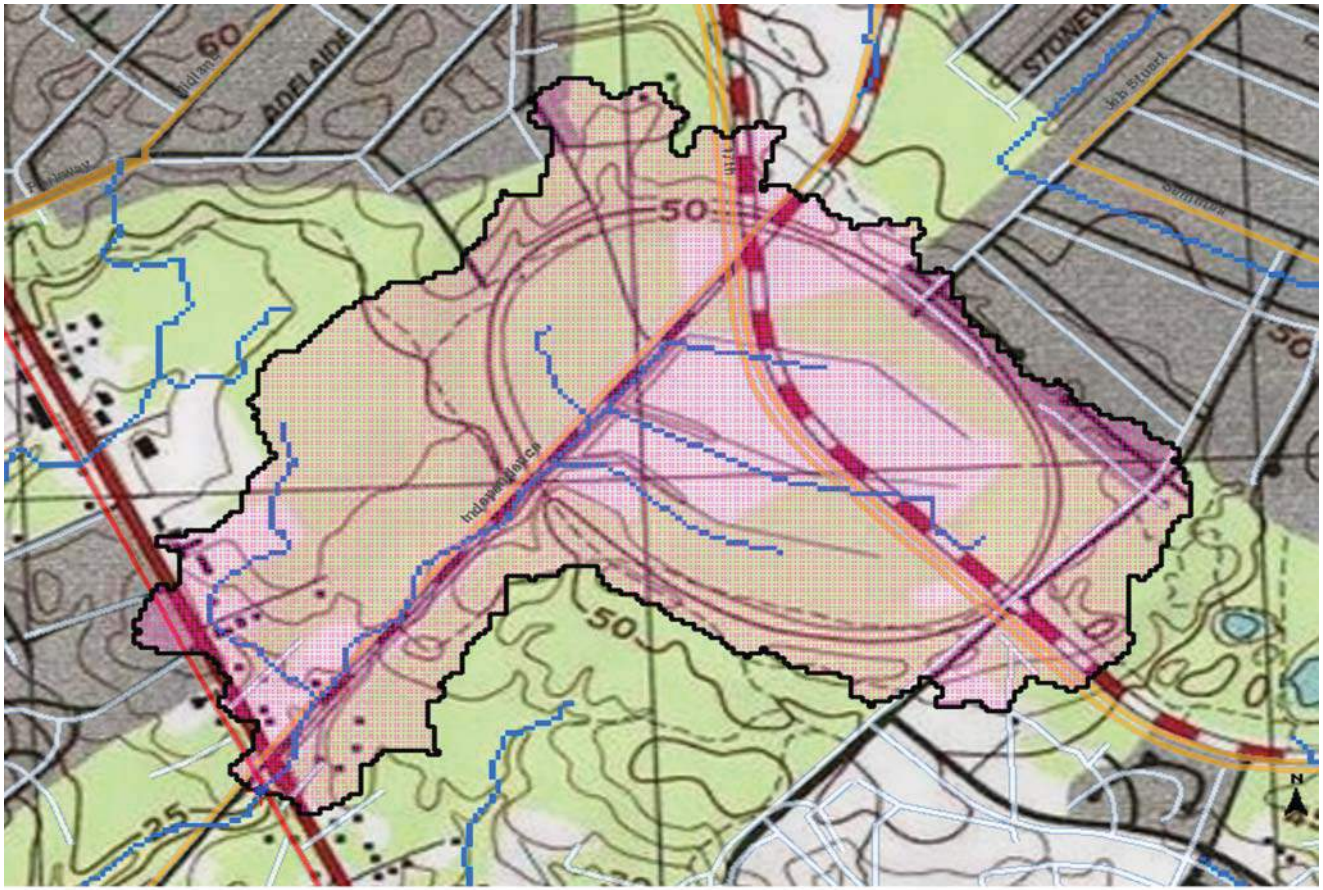


HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

USGS
North Carolina StreamStats

U-4738

Crossing 16



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.2 0.1 0 0.2 Miles

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Crossing 16

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 08:41:21 Mountain Daylight Time
NAD27 Latitude: 34.1750 (34 10 30)
NAD27 Longitude: -77.9254 (-77 55 31)
NAD83 Latitude: 34.1752 (34 10 31)
NAD83 Longitude: -77.9251 (-77 55 30)

Parameter	Value
Area in square miles	0.47
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	5.02
Mean basin slope, based on slope percent grid	1.74
Percent of area covered by barren rock using 2006 NLCD	0.000
Percent of area in cultivation using 2006 NLCD	0.000
Percent of area covered by all densities of developed land using 2006 NLCD	34.292
Percent of area covered by forest using 2006 NLCD	33.117
Percent of area covered by grassland/herbaceous using 2006 NLCD	0.915
Percent impervious of basin area 2006 NLCD	11.14
Mean annual precipitation in inches	58.2
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	12.048
Percent of area hydrologic soil 'A' defined by SSURGO	66.1
Percent of area hydrologic soil 'B' defined by SSURGO	33.9
Percent of area hydrologic soil 'C' defined by SSURGO	0
Percent of area hydrologic soil 'D' defined by SSURGO	0
Percent of area covered by water using 2006 NLCD	0.000
Percent of area covered by wetland using 2006 NLCD	19.628

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 16

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 0.47 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	37
5	$123 * DA^{0.627}$	75
10	$174 * DA^{0.617}$	110
25	$245 * DA^{0.606}$	160
50	$309 * DA^{0.600}$	200
100	$380 * DA^{0.594}$	240
200	$447 * DA^{0.589}$	290
500	$550 * DA^{0.583}$	350

North Carolina Urban Flood-Frequency Equations [3]

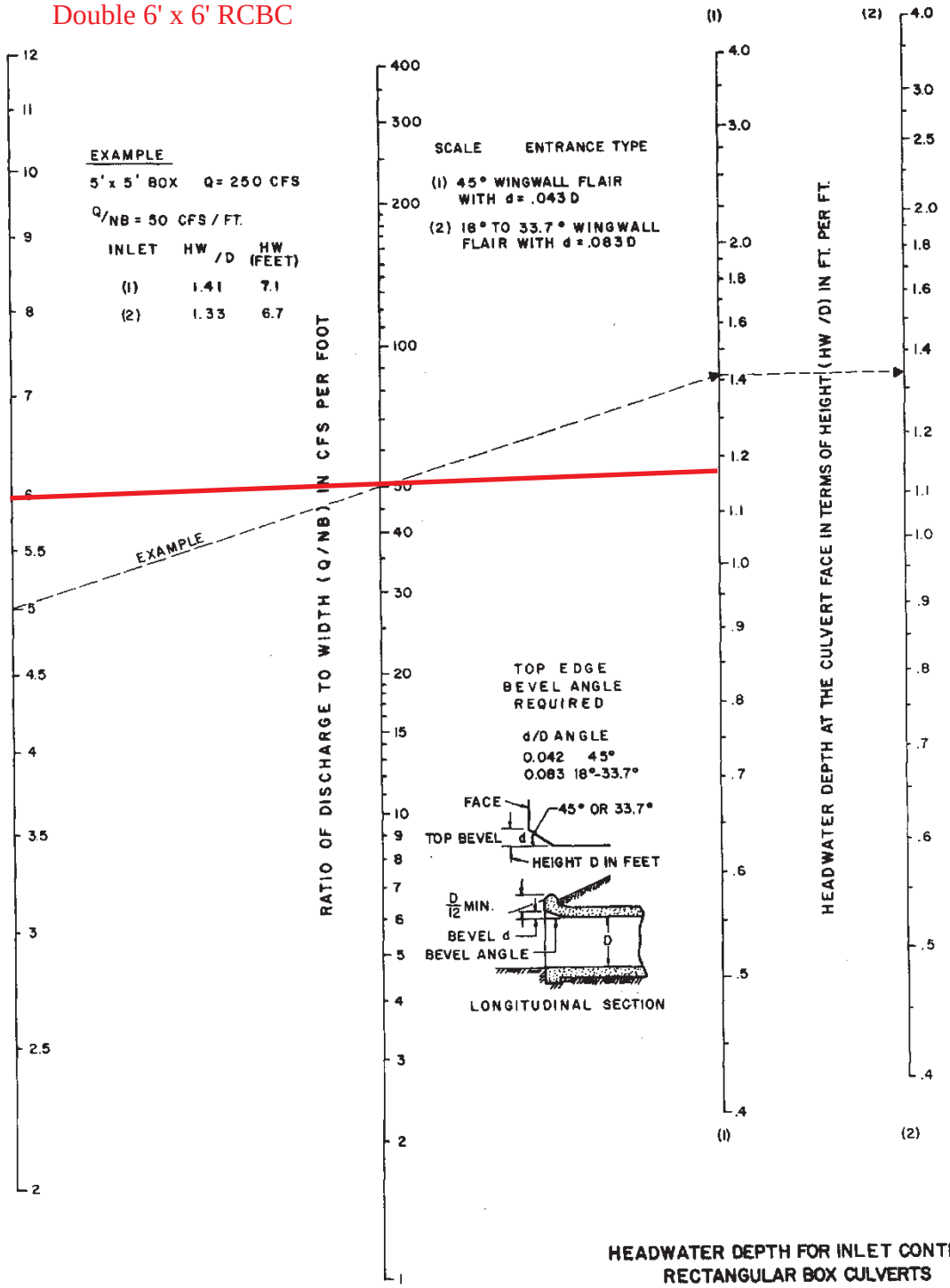
Drainage Area = 0.47 sq. mi.
Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	120
5	$68.2 * DA^{0.655} * IA^{0.572}$	230
10	$109 * DA^{0.625} * IA^{0.515}$	320
25	$209 * DA^{0.570} * IA^{0.436}$	500
50	$280 * DA^{0.558} * IA^{0.396}$	600
100	$363 * DA^{0.547} * IA^{0.358}$	700
200 [4]	UQ100 / RQ100 * RQ200	850
500 [4]	UQ100 / RQ100 * RQ500	1,000

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

R-4738
Crossing 16
DA = 301 ac.
Q50 = 600 cfs
Q/B = 55 cfs
Double 6' x 6' RCBC

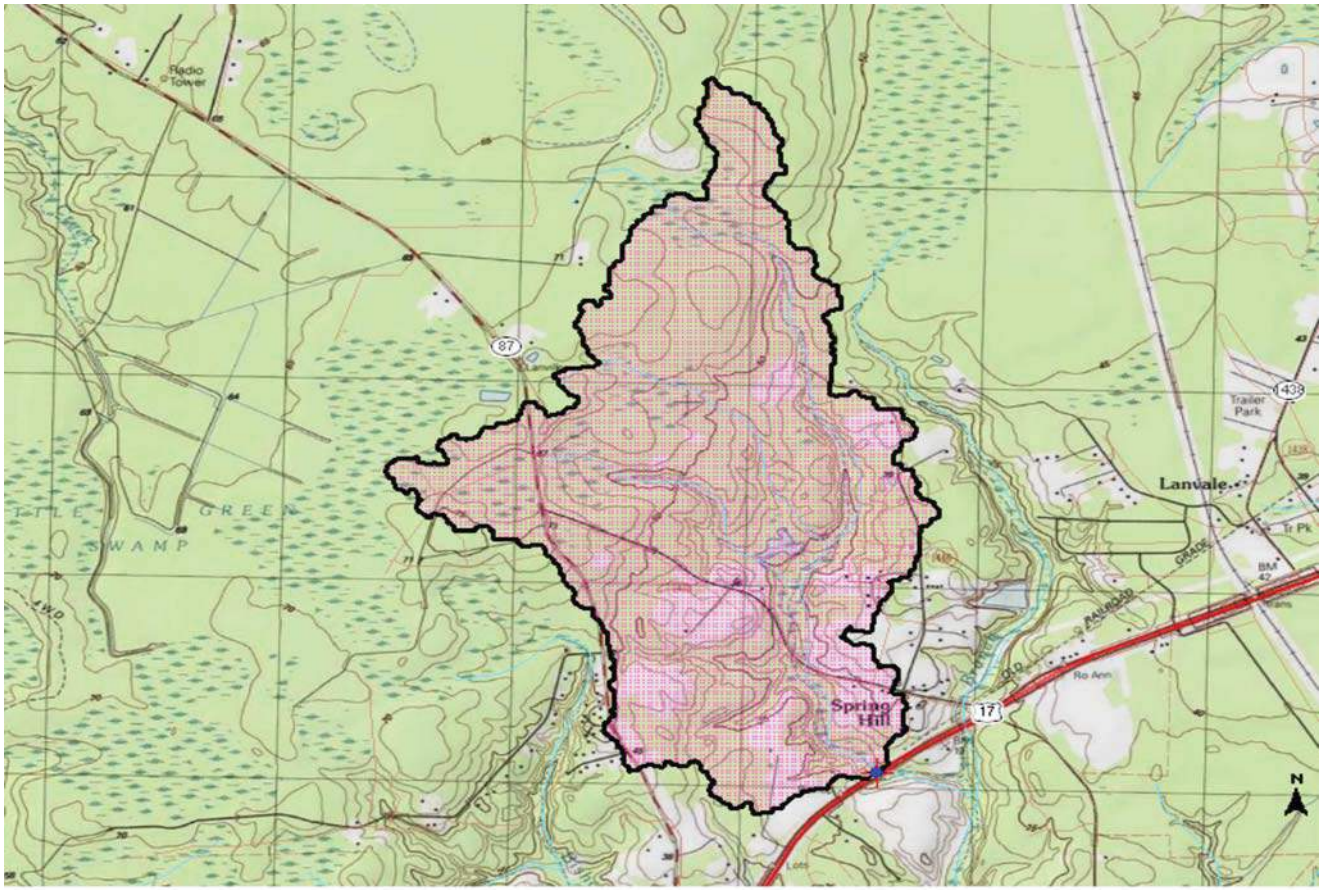
CHART 9B



HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

U-4738

Crossing 18



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.6 0.3 0 0.6 Miles

9/11/2014 1:38:40 PM

Crossing 18

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 08:52:36 Mountain Daylight Time
NAD27 Latitude: 34.1916 (34 11 30)
NAD27 Longitude: -78.0747 (-78 04 29)
NAD83 Latitude: 34.1918 (34 11 30)
NAD83 Longitude: -78.0744 (-78 04 28)

Parameter	Value
Area in square miles	1.56
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	9.67
Mean basin slope, based on slope percent grid	2.28
Percent of area covered by barren rock using 2006 NLCD	0.000
Percent of area in cultivation using 2006 NLCD	0.145
Percent of area covered by all densities of developed land using 2006 NLCD	4.000
Percent of area covered by forest using 2006 NLCD	55.308
Percent of area covered by grassland/herbaceous using 2006 NLCD	7.737
Percent impervious of basin area 2006 NLCD	0.64
Mean annual precipitation in inches	57.8
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	10.675
Percent of area hydrologic soil 'A' defined by SSURGO	31.2
Percent of area hydrologic soil 'B' defined by SSURGO	58.5
Percent of area hydrologic soil 'C' defined by SSURGO	2.31
Percent of area hydrologic soil 'D' defined by SSURGO	7.66
Percent of area covered by water using 2006 NLCD	0.220
Percent of area covered by wetland using 2006 NLCD	21.914

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 18

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 1.56 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	80
5	$123 * DA^{0.627}$	160
10	$174 * DA^{0.617}$	230
25	$245 * DA^{0.606}$	320
50	$309 * DA^{0.600}$	400
100	$380 * DA^{0.594}$	490
200	$447 * DA^{0.589}$	600
500	$550 * DA^{0.583}$	700

North Carolina Urban Flood-Frequency Equations [3]

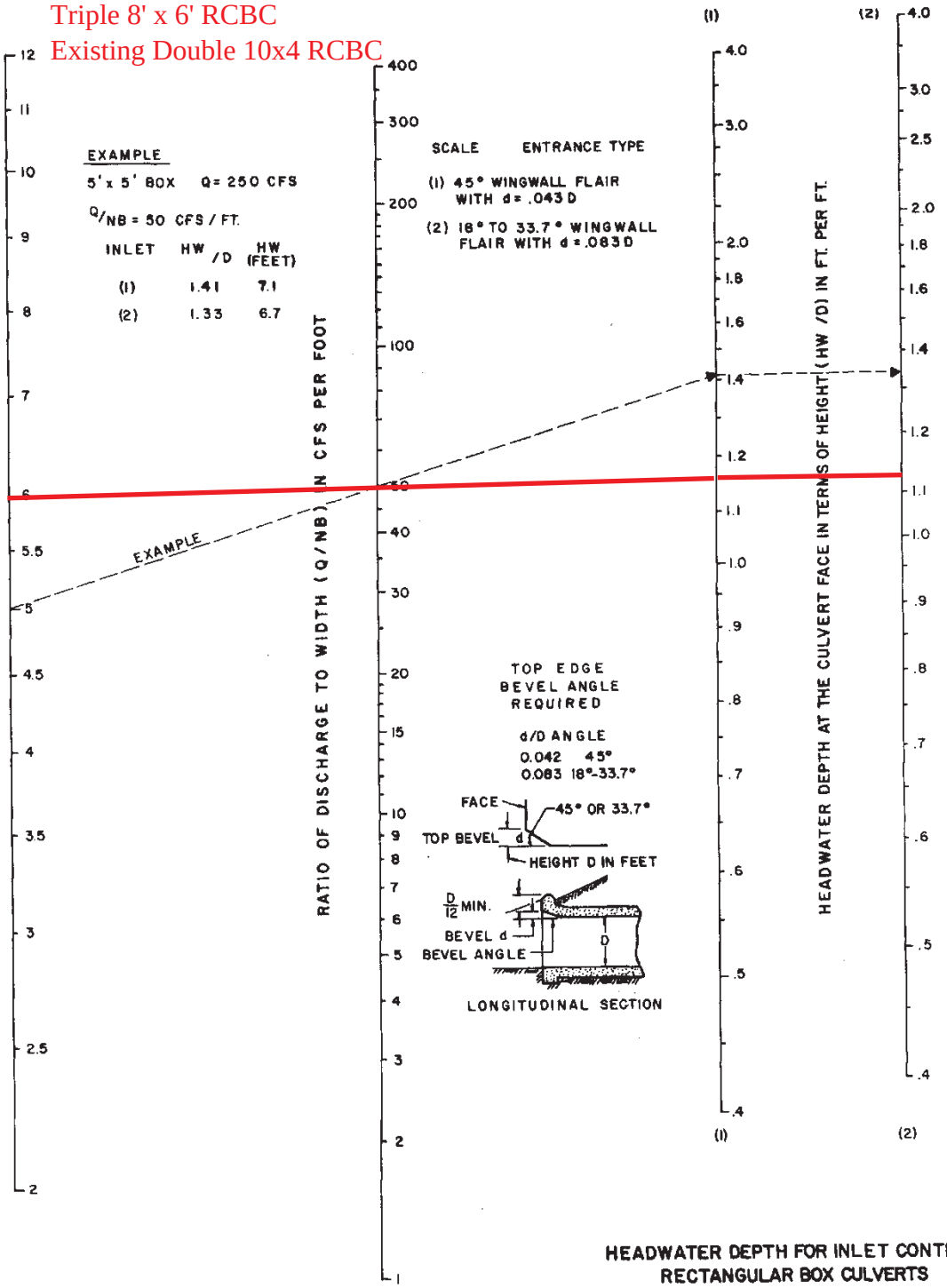
Drainage Area = 1.56 sq. mi.
Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	290
5	$68.2 * DA^{0.655} * IA^{0.572}$	500
10	$109 * DA^{0.625} * IA^{0.515}$	650
25	$209 * DA^{0.570} * IA^{0.436}$	1,000
50	$280 * DA^{0.558} * IA^{0.396}$	1,200
100	$363 * DA^{0.547} * IA^{0.358}$	1,400
200 [4]	UQ100 / RQ100 * RQ200	1,700
500 [4]	UQ100 / RQ100 * RQ500	2,000

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

U-4738
Crossing 18
DA = 998 ac.
Q50 = 1,200 cfs
Q/B = 50 cfs
Triple 8' x 6' RCBC
Existing Double 10x4 RCBC

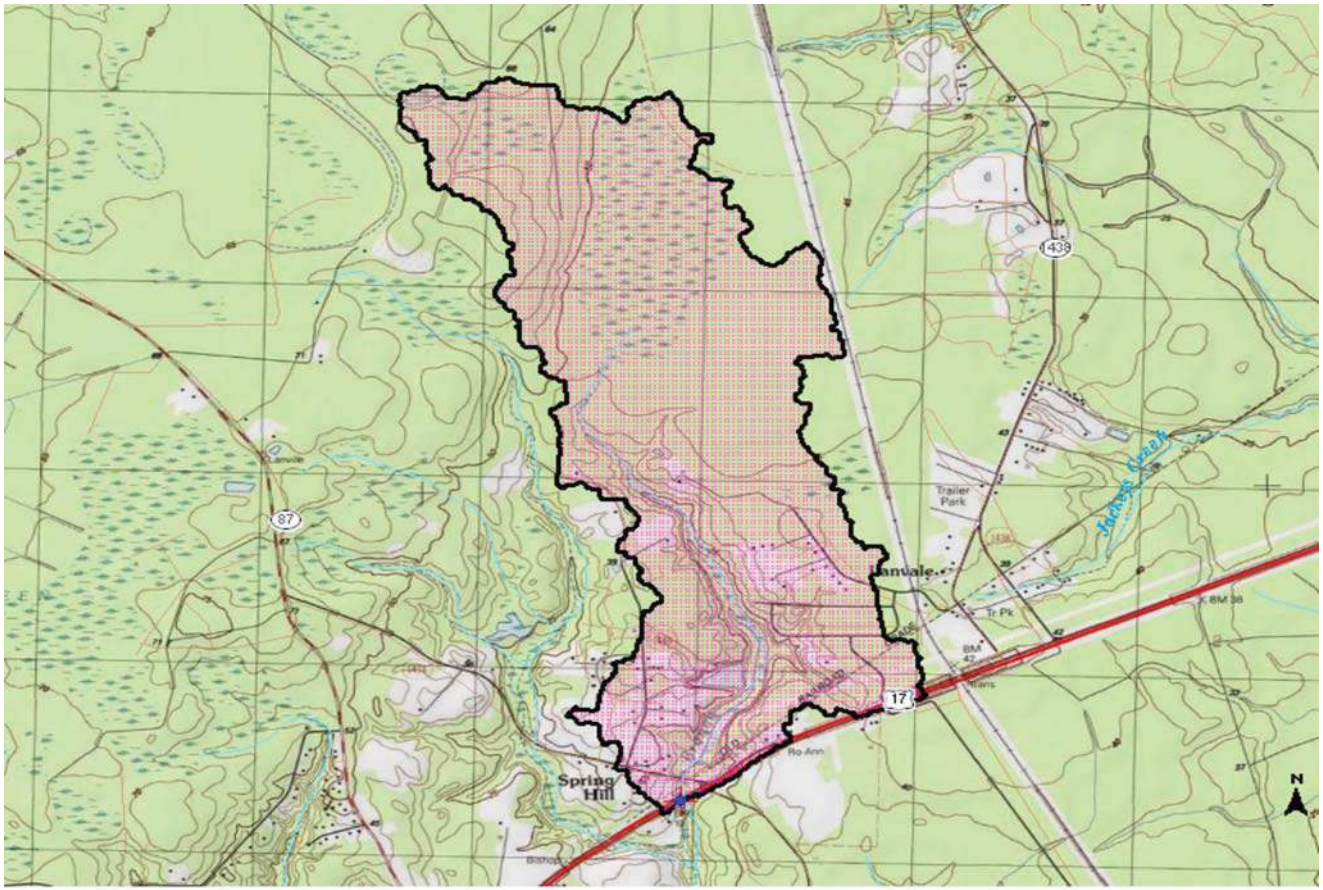
CHART 9B



HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

U-4738

Crossing 19



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.6 0.3 0 0.6 Miles

9/11/2014 1:41:47 PM

Crossing 19

USGS
North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 08:55:51 Mountain Daylight Time
NAD27 Latitude: 34.1936 (34 11 37)
NAD27 Longitude: -78.0708 (-78 04 15)
NAD83 Latitude: 34.1938 (34 11 38)
NAD83 Longitude: -78.0706 (-78 04 14)

Parameter	Value
Area in square miles	1.64
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	10.7
Mean basin slope, based on slope percent grid	2.09
Percent of area covered by barren rock using 2006 NLCD	1.818
Percent of area in cultivation using 2006 NLCD	0.022
Percent of area covered by all densities of developed land using 2006 NLCD	4.270
Percent of area covered by forest using 2006 NLCD	44.875
Percent of area covered by grassland/herbaceous using 2006 NLCD	9.459
Percent impervious of basin area 2006 NLCD	0.74
Mean annual precipitation in inches	57.9
Percent of area of protected Federal and State owned land	0.00662
Percent of area covered by shrubland using 2006 NLCD	15.814
Percent of area hydrologic soil 'A' defined by SSURGO	11.4
Percent of area hydrologic soil 'B' defined by SSURGO	40.8
Percent of area hydrologic soil 'C' defined by SSURGO	41.2
Percent of area hydrologic soil 'D' defined by SSURGO	5.89
Percent of area covered by water using 2006 NLCD	0.615
Percent of area covered by wetland using 2006 NLCD	23.127

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 19

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 1.64 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	85
5	$123 * DA^{0.627}$	170
10	$174 * DA^{0.617}$	240
25	$245 * DA^{0.606}$	330
50	$309 * DA^{0.600}$	420
100	$380 * DA^{0.594}$	500
200	$447 * DA^{0.589}$	600
500	$550 * DA^{0.583}$	750

North Carolina Urban Flood-Frequency Equations [3]

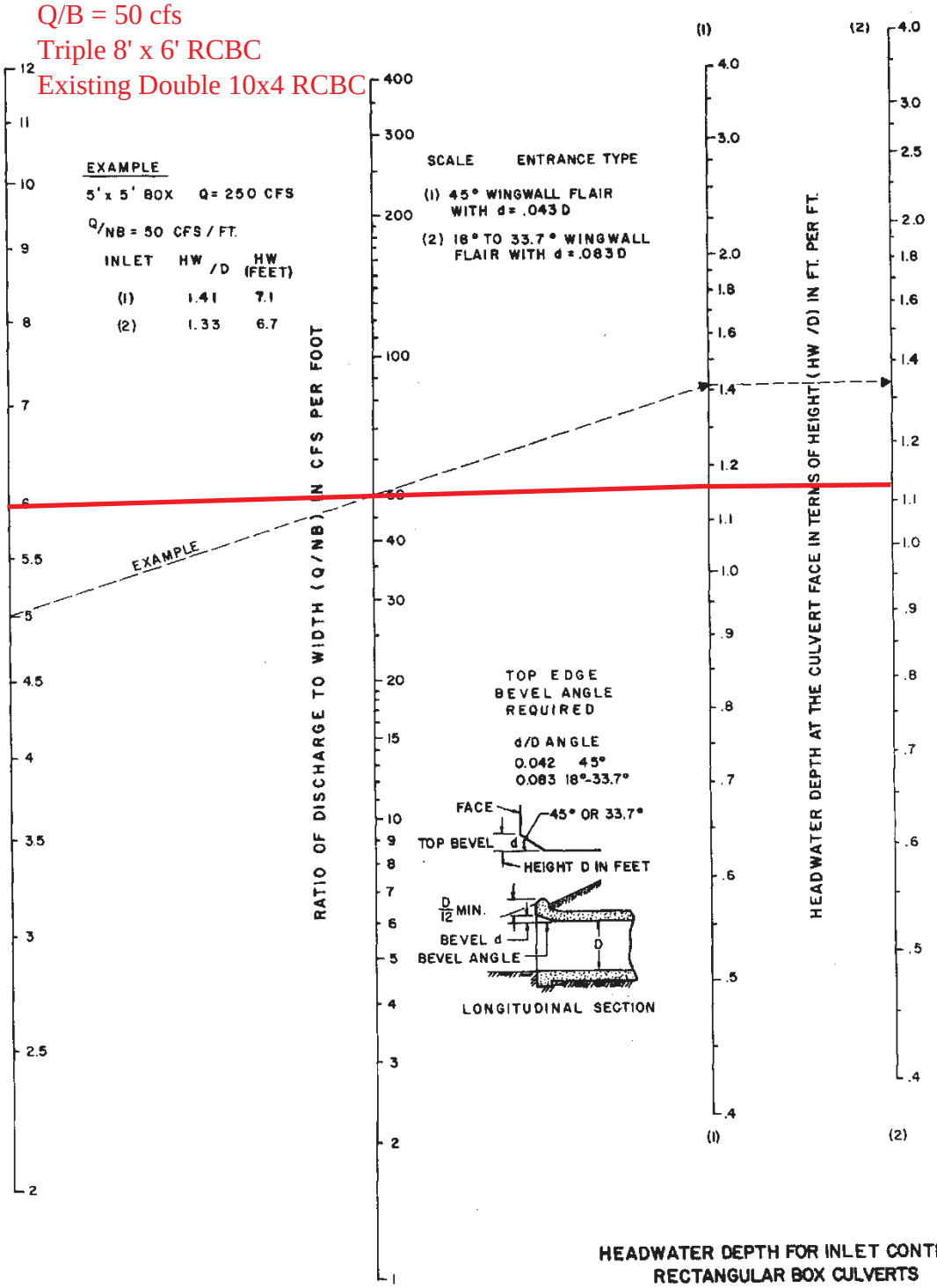
Drainage Area = 1.64 sq. mi.
Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	300
5	$68.2 * DA^{0.655} * IA^{0.572}$	500
10	$109 * DA^{0.625} * IA^{0.515}$	700
25	$209 * DA^{0.570} * IA^{0.436}$	1,000
50	$280 * DA^{0.558} * IA^{0.396}$	1,200
100	$363 * DA^{0.547} * IA^{0.358}$	1,400
200 [4]	UQ100 / RQ100 * RQ200	1,700
500 [4]	UQ100 / RQ100 * RQ500	2,100

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

U-4738
Crossing 19
DA = 1050 ac.
Q50 = 1,200 cfs
FEMA Crossing
Q/B = 50 cfs
Triple 8' x 6' RCBC
Existing Double 10x4 RCBC

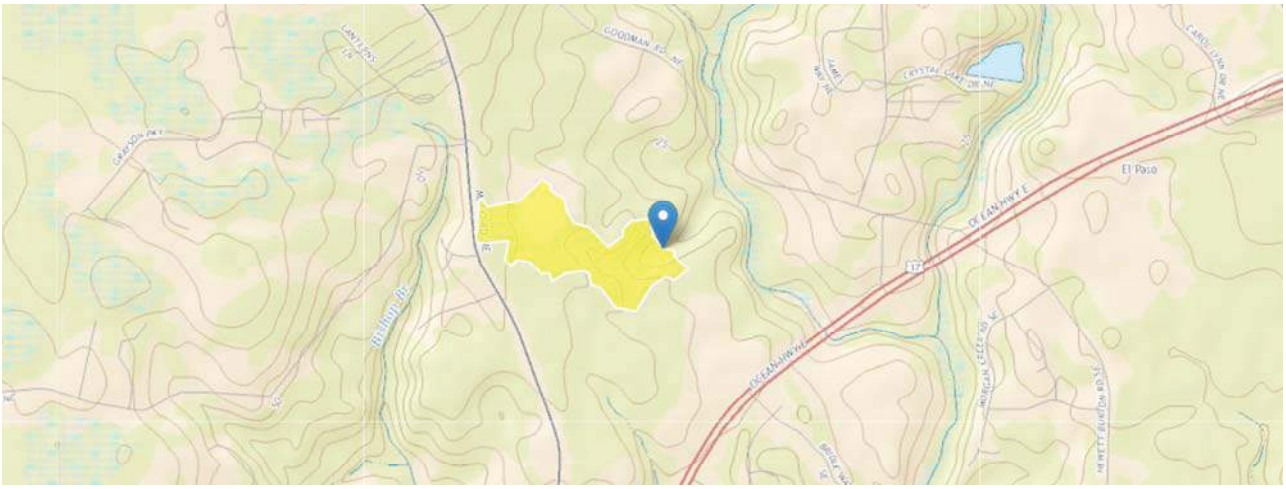
CHART 9B



HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

U-4738 Crossing 20

Region ID: NC
Workspace ID: NC20160615064546717000
Clicked Point (Latit... 34.19418,-78.08017
Time: 2016-06-15 08:46:31 -0400



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	0.051	square miles
BASINPERIM	Perimeter of the drainage basin as defined in SIR 2004-5262	1.67	miles
PCTREG1	Percentage of drainage area located in Region 1	0	percent
PCTREG2	Percentage of drainage area located in Region 2	0	percent
PCTREG3	Percentage of drainage area located in Region 3	0	percent
PCTREG4	Percentage of drainage area located in Region 4	100	percent
PCTREG5	Percentage of drainage area located in Region 5	0	percent
PRECIP	Mean Annual Precipitation	57.9	inches
I24H50Y	Maximum 24-hour precipitation that occurs on average once in 50 years	10.6	inches
SSURGOA	Percentage of area of Hydrologic Soil Type A from SSURGO	12.8	percent
SSURGOB	Percentage of area of Hydrologic Soil Type B from SSURGO	86.7	percent
SSURGOC	Percentage of area of Hydrologic Soil Type C from SSURGO	0	percent
SSURGOD	Percentage of area of Hydrologic Soil Type D from SSURGO	0.51	percent
PROTECTED	Percent of protected Federal and State owned land within the basin	0	percent
LC11BARE	Percentage of barren from NLCD 2011 class 31	0	percent
LC11CRPHAY	Percentage of cultivated crops and hay, classes 81 and 82, from NLCD 2011	0	percent
LC11DEV	Percentage of land-use from NLCD 2011 classes 21-24	0.44	percent
LC11FOREST	Percentage of forest from NLCD 2011 classes 41-43	65.949	percent
LC11GRASS	Percentage of grassland from NLCD 2011 class 71	10.253	percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	0.0266	percent
LC11SHRUB	Percentage of shrub scrub from NLCD 2011 class 52	21.013	percent
LC11WATER	Percent of open water, class 11, from NLCD 2011	0	percent
LC11WETLND	Percentage of wetlands, classes 90 and 95, from NLCD 2011	2.342	percent

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 20

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 0.05 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	9
5	$123 * DA^{0.627}$	19
10	$174 * DA^{0.617}$	28
25	$245 * DA^{0.606}$	40
50	$309 * DA^{0.600}$	50
100	$380 * DA^{0.594}$	65
200	$447 * DA^{0.589}$	75
500	$550 * DA^{0.583}$	95

North Carolina Urban Flood-Frequency Equations [3]

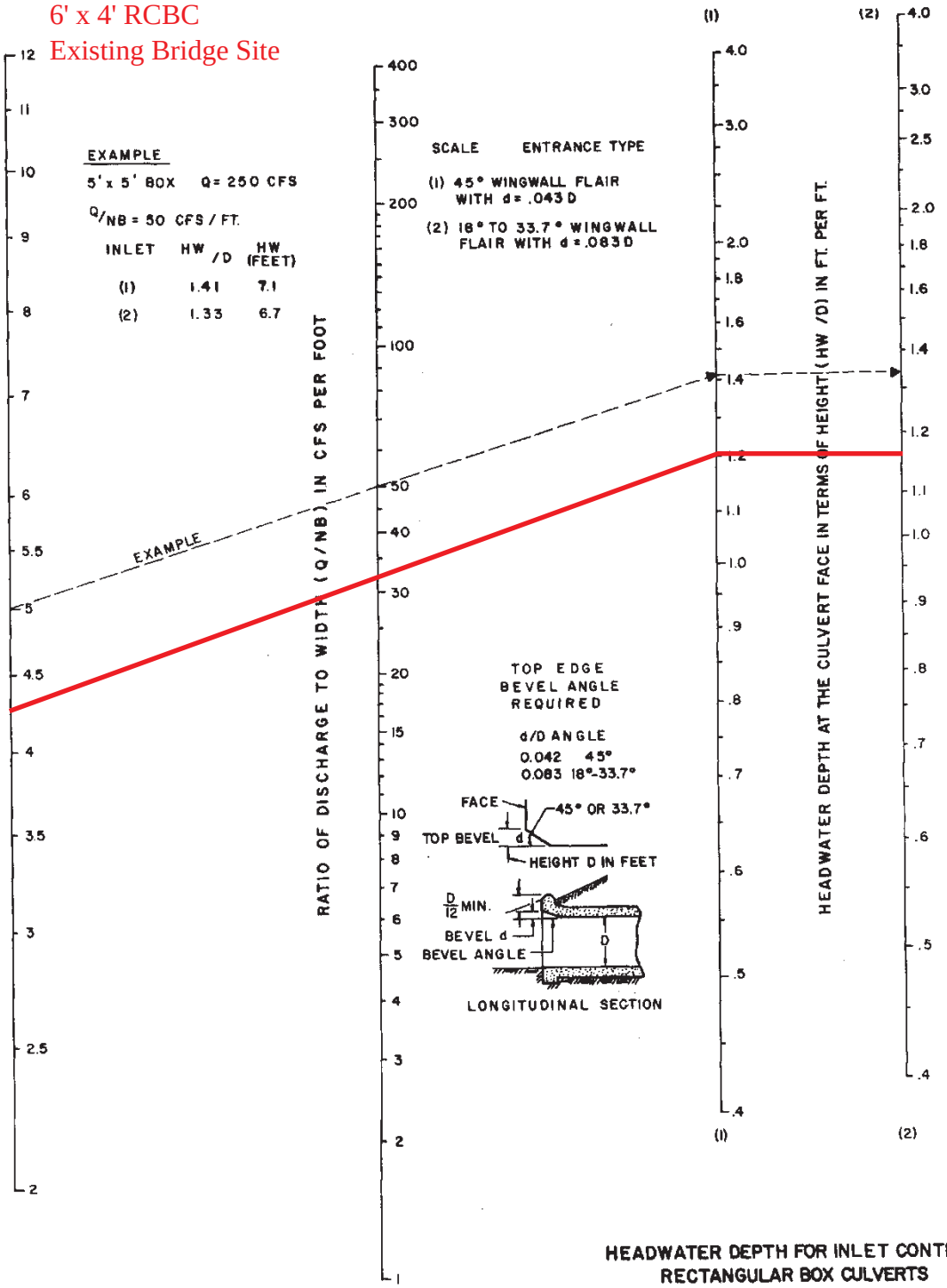
Drainage Area = 0.05 sq. mi.
Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	24
5	$68.2 * DA^{0.655} * IA^{0.572}$	55
10	$109 * DA^{0.625} * IA^{0.515}$	80
25	$209 * DA^{0.570} * IA^{0.436}$	140
50	$280 * DA^{0.558} * IA^{0.396}$	170
100	$363 * DA^{0.547} * IA^{0.358}$	210
200 [4]	UQ100 / RQ100 * RQ200	240
500 [4]	UQ100 / RQ100 * RQ500	310

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

R-4738
Crossing 20
DA = 33 ac.
Q50 = 170 cfs
Q/B = 29 cfs
6' x 4' RCBC
Existing Bridge Site

CHART 9B

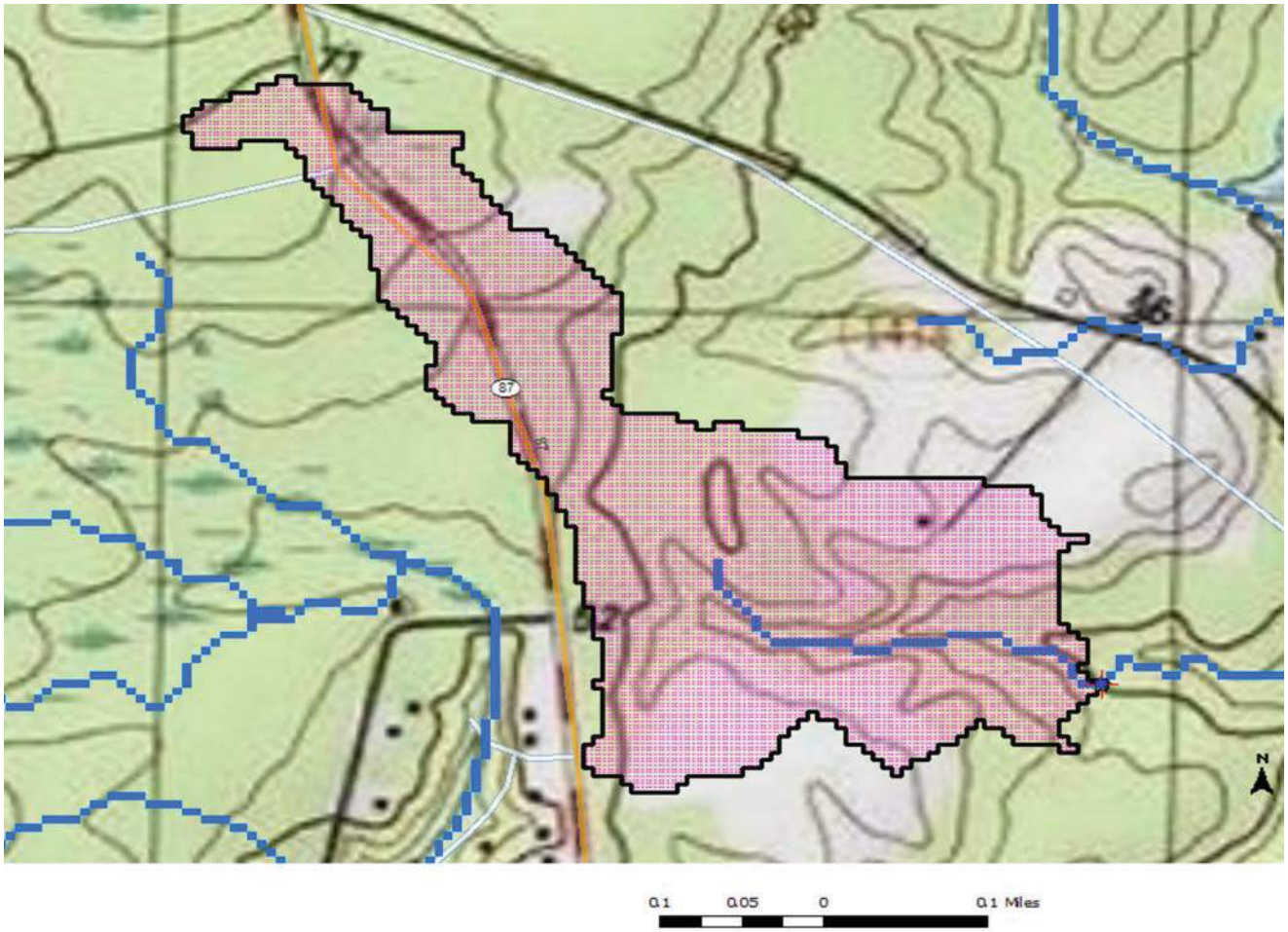


HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

USGS
North Carolina StreamStats

U-4738

Crossing 21



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

7/1/2015 8:12:44 AM

USGS
North Carolina StreamStats

Basin Characteristics Report

Date: Wed Jul 1 2015 08:10:29 Mountain Daylight Time
NAD27 Latitude: 34.1963 (34 11 47)
NAD27 Longitude: -78.0817 (-78 04 54)
NAD83 Latitude: 34.1965 (34 11 47)
NAD83 Longitude: -78.0814 (-78 04 53)

Parameter	Value
Area in square miles	0.0919
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	2.44
Mean basin slope, based on slope percent grid	2
Percent of area covered by barren rock using 2006 NLCD	0.000
Percent of area in cultivation using 2006 NLCD	2.459
Percent of area covered by all densities of developed land using 2006 NLCD	13.523
Percent of area covered by forest using 2006 NLCD	58.658
Percent of area covered by grassland/herbaceous using 2006 NLCD	1.897
Percent impervious of basin area 2006 NLCD	1.48
Mean annual precipitation in inches	57.8
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	7.376
Percent of area hydrologic soil 'A' defined by SSURGO	9.13
Percent of area hydrologic soil 'B' defined by SSURGO	90.9
Percent of area hydrologic soil 'C' defined by SSURGO	0
Percent of area hydrologic soil 'D' defined by SSURGO	0
Percent of area covered by water using 2006 NLCD	0.000
Percent of area covered by wetland using 2006 NLCD	16.087

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 21

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 0.09 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	13
5	$123 * DA^{0.627}$	28
10	$174 * DA^{0.617}$	40
25	$245 * DA^{0.606}$	60
50	$309 * DA^{0.600}$	75
100	$380 * DA^{0.594}$	90
200	$447 * DA^{0.589}$	110
500	$550 * DA^{0.583}$	140

North Carolina Urban Flood-Frequency Equations [3]

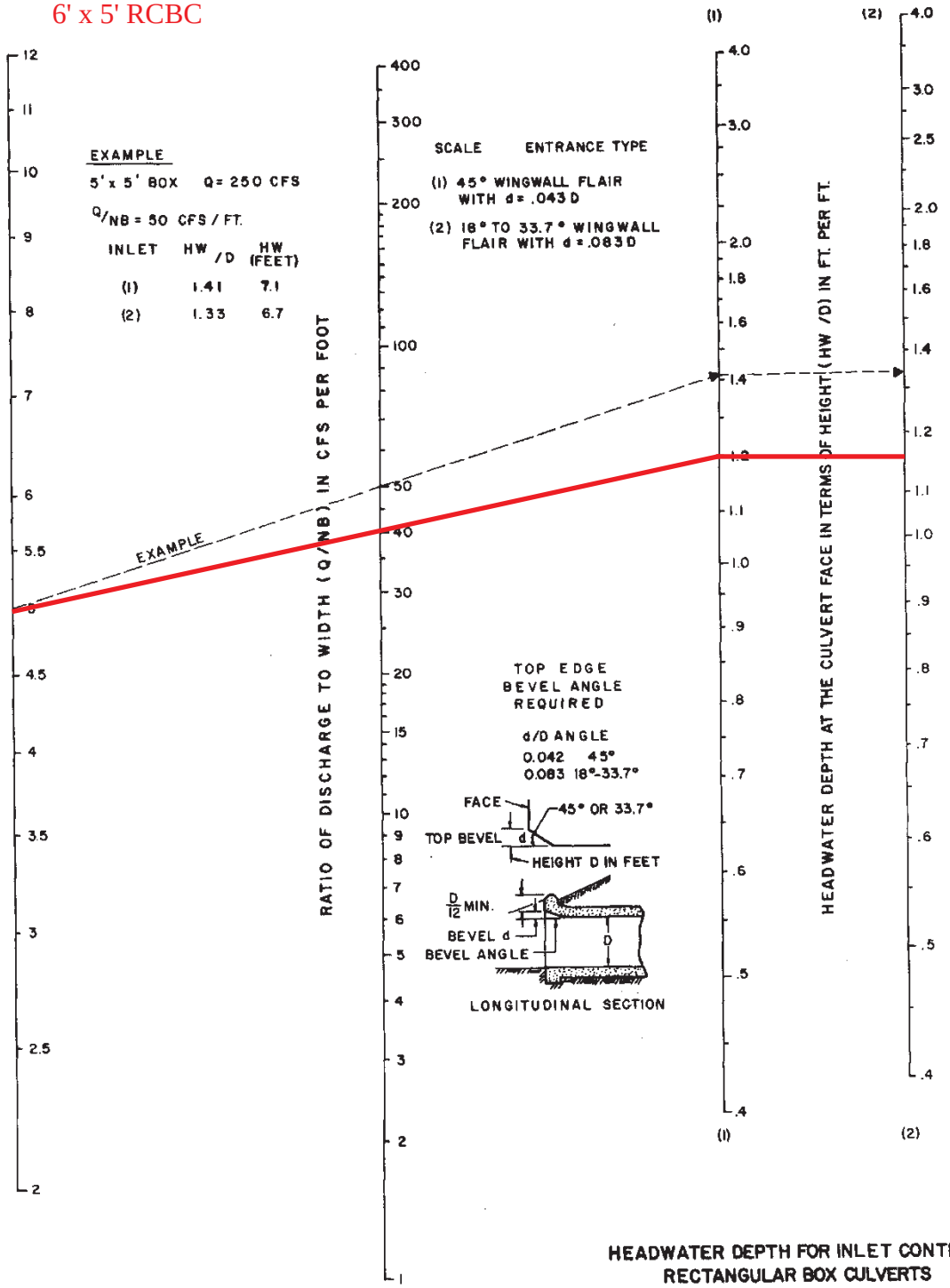
Drainage Area = 0.09 sq. mi.
Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	37
5	$68.2 * DA^{0.655} * IA^{0.572}$	80
10	$109 * DA^{0.625} * IA^{0.515}$	110
25	$209 * DA^{0.570} * IA^{0.436}$	200
50	$280 * DA^{0.558} * IA^{0.396}$	240
100	$363 * DA^{0.547} * IA^{0.358}$	290
200 [4]	UQ100 / RQ100 * RQ200	350
500 [4]	UQ100 / RQ100 * RQ500	450

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

R-4738
Crossing 21
DA = 59 ac.
Q50 = 240 cfs
Q/B = 40 cfs
6' x 5' RCBC

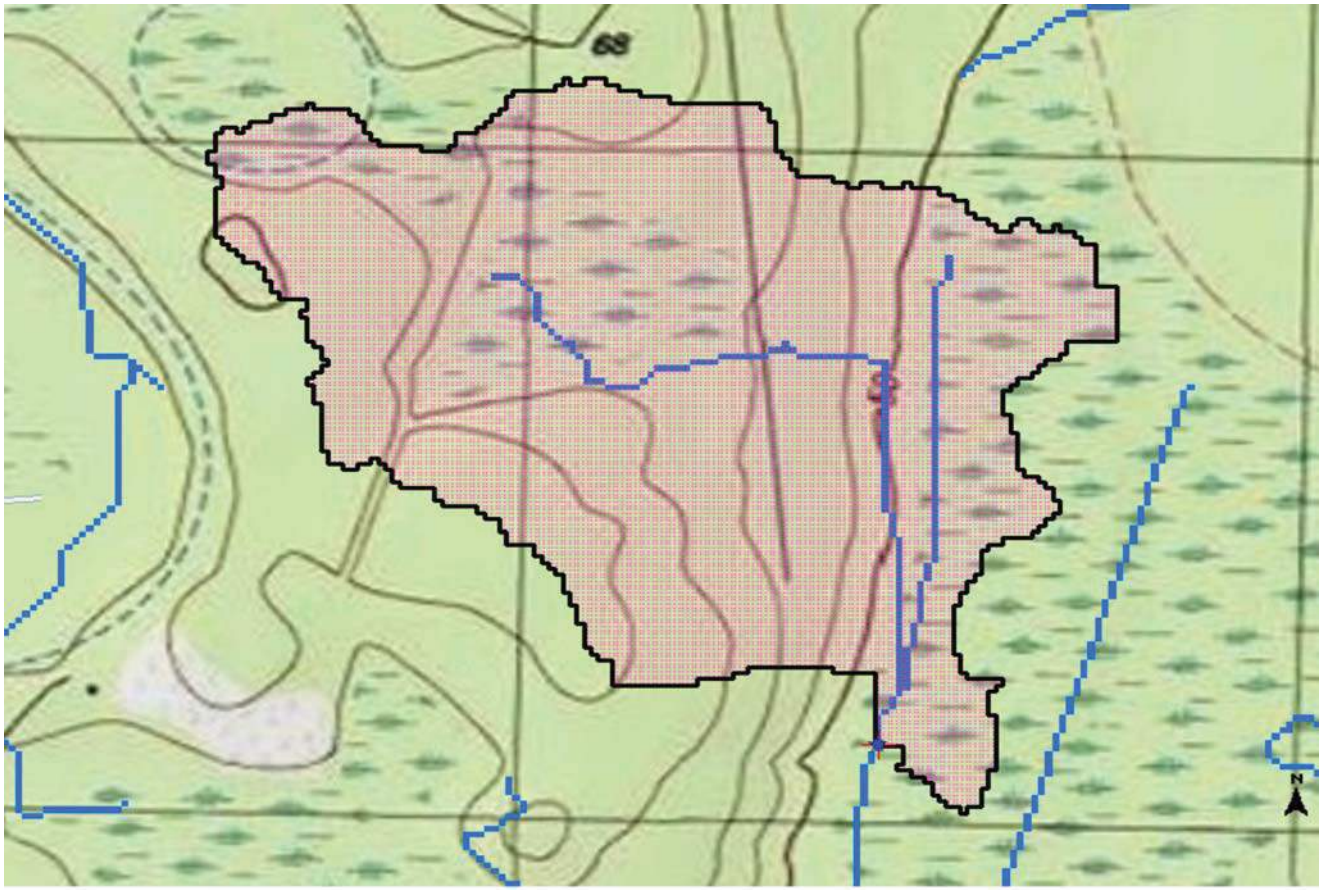
CHART 9B



HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

U-4738

Crossing 22



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.1 0.05 0 0.1 Miles

9/11/2014 1:58:50 PM

Crossing 22

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 09:30:17 Mountain Daylight Time
NAD27 Latitude: 34.2190 (34 13 09)
NAD27 Longitude: -78.0751 (-78 04 30)
NAD83 Latitude: 34.2192 (34 13 09)
NAD83 Longitude: -78.0748 (-78 04 29)

Parameter	Value
Area in square miles	0.27
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Elevation at outlet, in feet	50
Perimeter in miles	3.3
Mean basin slope, based on slope percent grid	1.5
Percent of area covered by barren rock using 2006 NLCD	0.000
Percent of area in cultivation using 2006 NLCD	0.131
Percent of area covered by all densities of developed land using 2006 NLCD	0.000
Percent of area covered by forest using 2006 NLCD	54.491
Percent of area covered by grassland/herbaceous using 2006 NLCD	8.626
Percent impervious of basin area 2006 NLCD	0.00
Mean annual precipitation in inches	57.6
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	24.881
Percent of area hydrologic soil 'A' defined by SSURGO	7.22
Percent of area hydrologic soil 'B' defined by SSURGO	75.2
Percent of area hydrologic soil 'C' defined by SSURGO	17.5
Percent of area hydrologic soil 'D' defined by SSURGO	0
Percent of area covered by water using 2006 NLCD	0.000
Percent of area covered by wetland using 2006 NLCD	11.870

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 22

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 0.27 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	26
5	$123 * DA^{0.627}$	55
10	$174 * DA^{0.617}$	80
25	$245 * DA^{0.606}$	110
50	$309 * DA^{0.600}$	140
100	$380 * DA^{0.594}$	170
200	$447 * DA^{0.589}$	210
500	$550 * DA^{0.583}$	260

North Carolina Urban Flood-Frequency Equations [3]

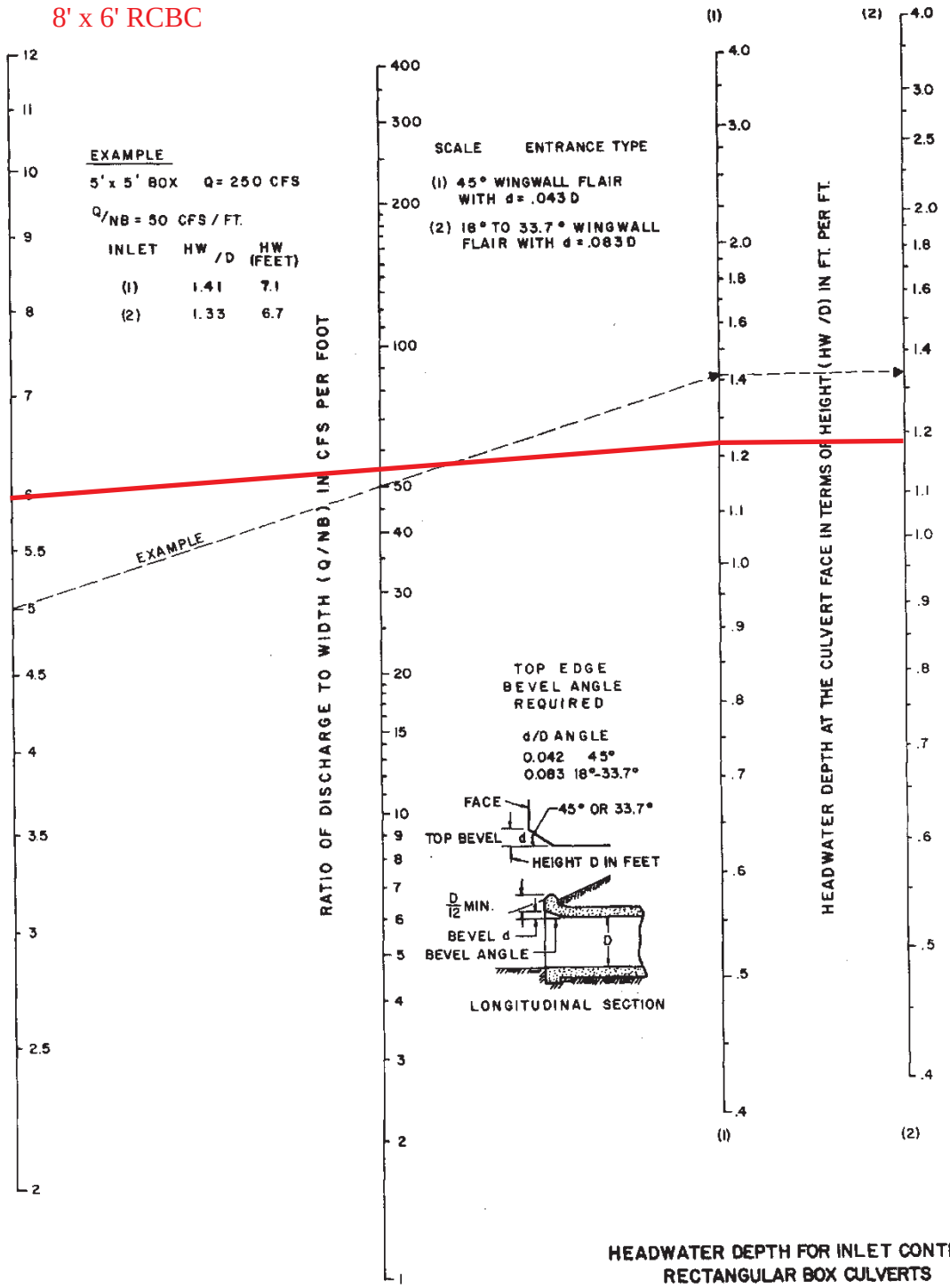
Drainage Area = 0.27 sq. mi.
Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	80
5	$68.2 * DA^{0.655} * IA^{0.572}$	160
10	$109 * DA^{0.625} * IA^{0.515}$	220
25	$209 * DA^{0.570} * IA^{0.436}$	370
50	$280 * DA^{0.558} * IA^{0.396}$	440
100	$363 * DA^{0.547} * IA^{0.358}$	500
200 [4]	UQ100 / RQ100 * RQ200	600
500 [4]	UQ100 / RQ100 * RQ500	750

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

U-4738
Crossing 22
DA = 173 ac.
Q50 = 440 cfs
Q/B = 55 cfs
8' x 6' RCBC

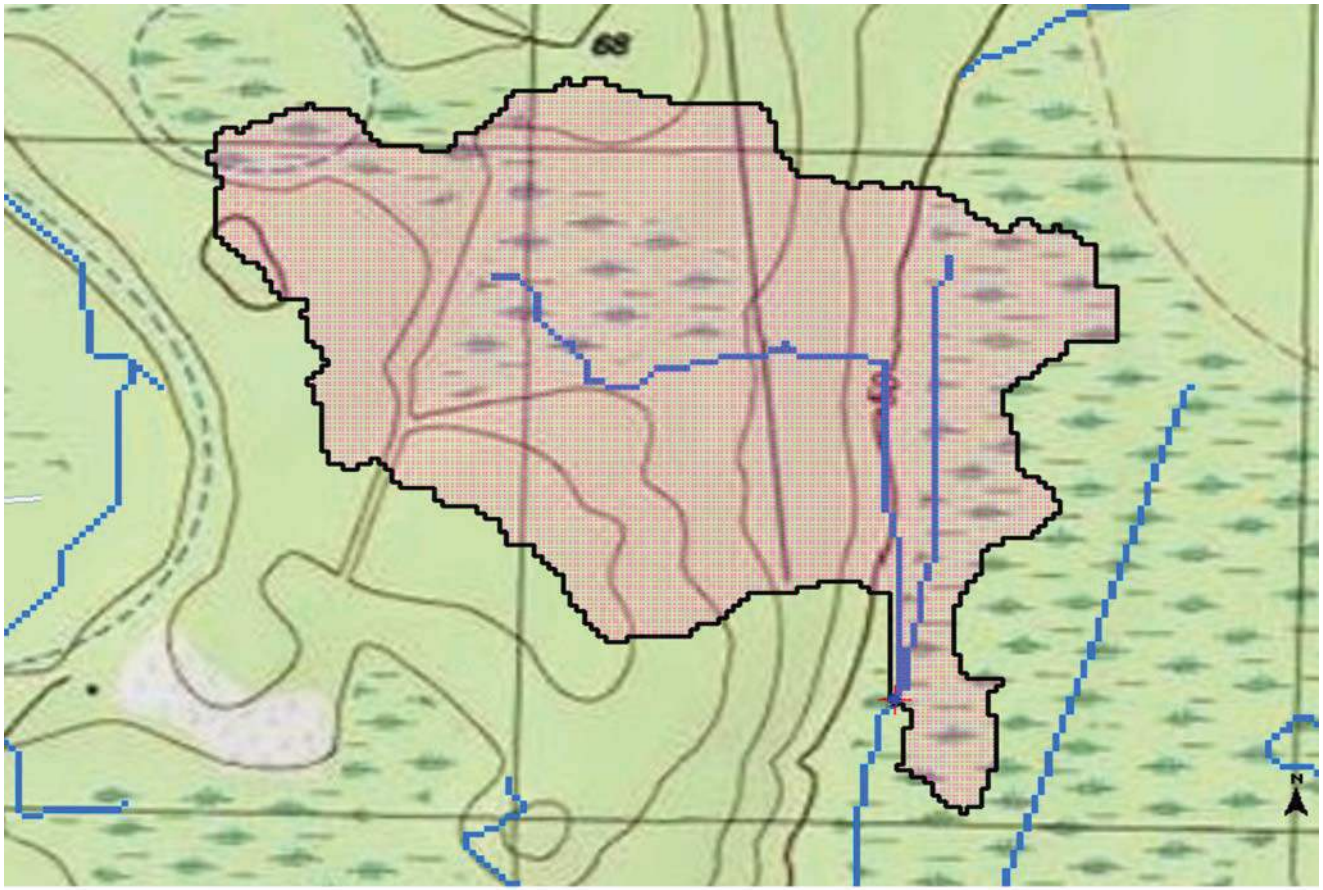
CHART 9B



HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

U-4738

Crossing 23



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.1 0.05 0 0.1 Miles

9/11/2014 2:05:10 PM

Crossing 23

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 09:37:42 Mountain Daylight Time
NAD27 Latitude: 34.2196 (34 13 11)
NAD27 Longitude: -78.0749 (-78 04 30)
NAD83 Latitude: 34.2198 (34 13 11)
NAD83 Longitude: -78.0746 (-78 04 29)

Parameter	Value
Area in square miles	0.26
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	3.39
Mean basin slope, based on slope percent grid	1.48
Percent of area covered by barren rock using 2006 NLCD	0.000
Percent of area in cultivation using 2006 NLCD	0.139
Percent of area covered by all densities of developed land using 2006 NLCD	0.000
Percent of area covered by forest using 2006 NLCD	54.453
Percent of area covered by grassland/herbaceous using 2006 NLCD	9.157
Percent impervious of basin area 2006 NLCD	0.00
Mean annual precipitation in inches	57.6
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	23.676
Percent of area hydrologic soil 'A' defined by SSURGO	7.67
Percent of area hydrologic soil 'B' defined by SSURGO	74.2
Percent of area hydrologic soil 'C' defined by SSURGO	18.1
Percent of area hydrologic soil 'D' defined by SSURGO	0
Percent of area covered by water using 2006 NLCD	0.000
Percent of area covered by wetland using 2006 NLCD	12.576

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 23

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 0.26 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	25
5	$123 * DA^{0.627}$	55
10	$174 * DA^{0.617}$	75
25	$245 * DA^{0.606}$	110
50	$309 * DA^{0.600}$	140
100	$380 * DA^{0.594}$	170
200	$447 * DA^{0.589}$	200
500	$550 * DA^{0.583}$	250

North Carolina Urban Flood-Frequency Equations [3]

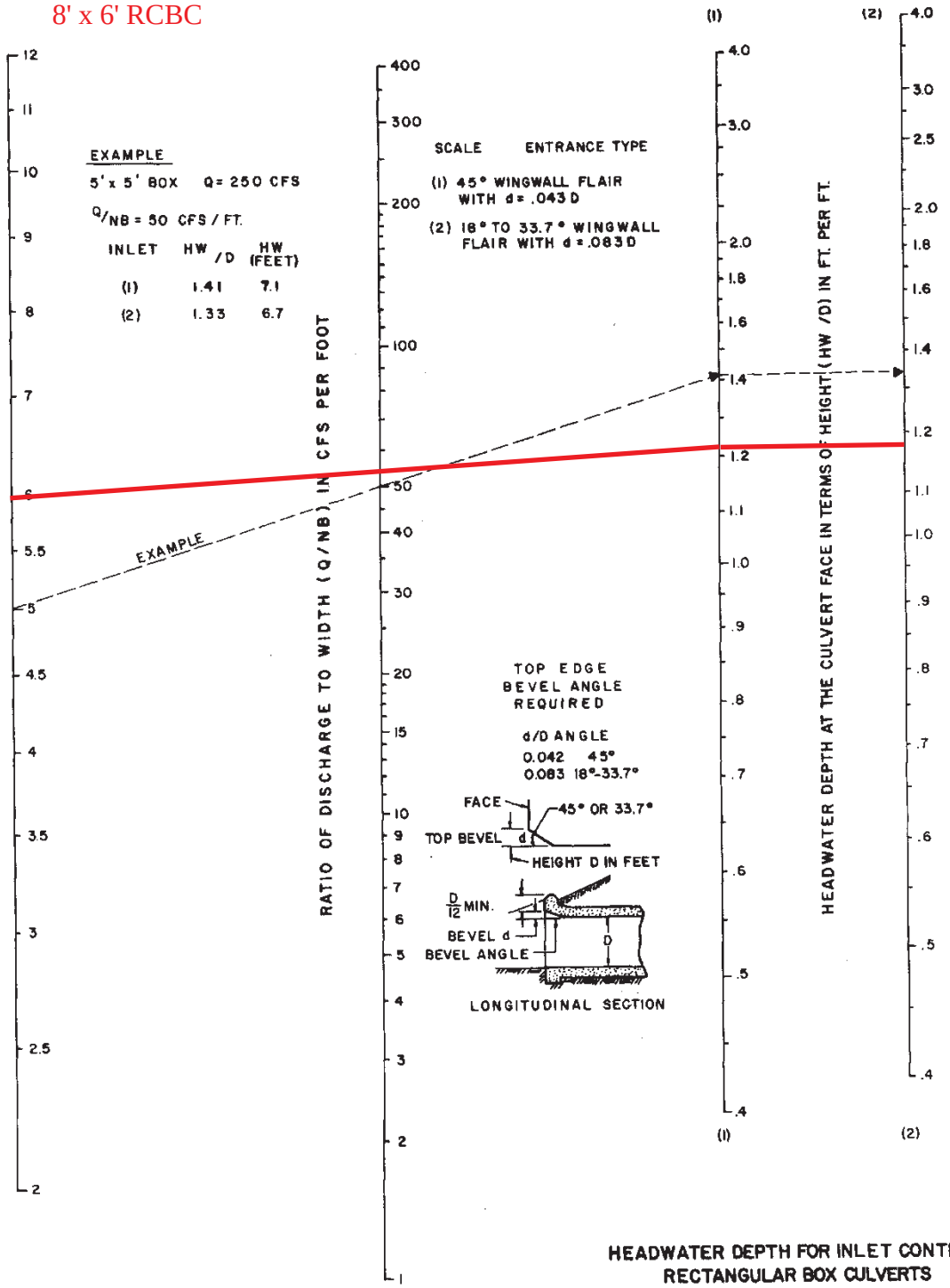
Drainage Area = 0.26 sq. mi.
Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	80
5	$68.2 * DA^{0.655} * IA^{0.572}$	160
10	$109 * DA^{0.625} * IA^{0.515}$	220
25	$209 * DA^{0.570} * IA^{0.436}$	360
50	$280 * DA^{0.558} * IA^{0.396}$	430
100	$363 * DA^{0.547} * IA^{0.358}$	500
200 [4]	UQ100 / RQ100 * RQ200	600
500 [4]	UQ100 / RQ100 * RQ500	750

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

U-4738
Crossing 23
DA = 166 ac.
Q50 = 430 cfs
Q/B = 54 cfs
8' x 6' RCBC

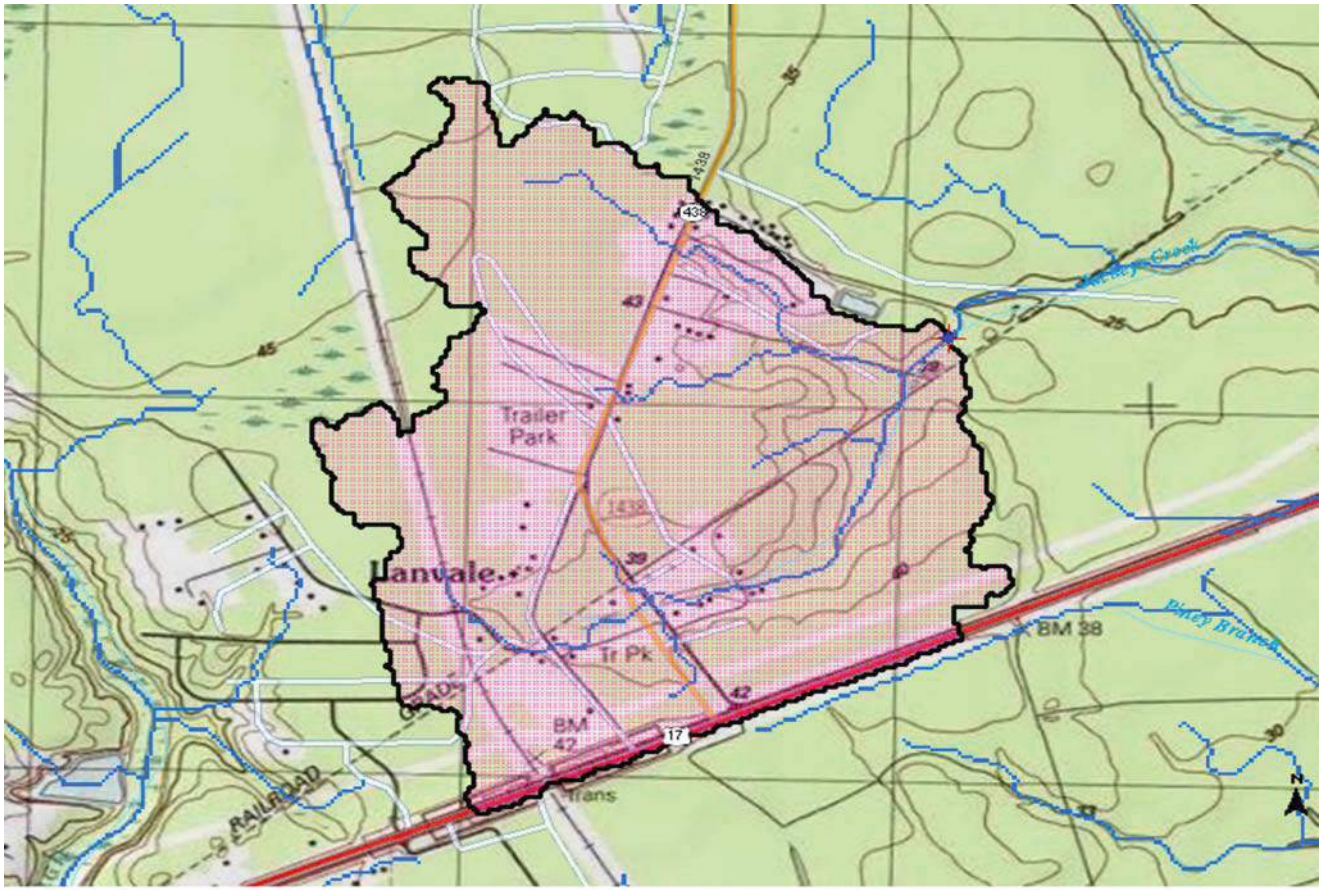
CHART 9B



HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

U-4738

Crossing 24



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.3 0.15 0 0.3 Miles

9/11/2014 2:07:30 PM

Crossing 24

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 09:43:25 Mountain Daylight Time
NAD27 Latitude: 34.2100 (34 12 36)
NAD27 Longitude: -78.0467 (-78 02 48)
NAD83 Latitude: 34.2102 (34 12 37)
NAD83 Longitude: -78.0465 (-78 02 47)

Parameter	Value
Area in square miles	0.72
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	5.7
Mean basin slope, based on slope percent grid	1.51
Percent of area covered by barren rock using 2006 NLCD	0.000
Percent of area in cultivation using 2006 NLCD	0.099
Percent of area covered by all densities of developed land using 2006 NLCD	12.701
Percent of area covered by forest using 2006 NLCD	44.758
Percent of area covered by grassland/herbaceous using 2006 NLCD	11.405
Percent impervious of basin area 2006 NLCD	2.51
Mean annual precipitation in inches	58.1
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	21.156
Percent of area hydrologic soil 'A' defined by SSURGO	3.03
Percent of area hydrologic soil 'B' defined by SSURGO	59.7
Percent of area hydrologic soil 'C' defined by SSURGO	31.3
Percent of area hydrologic soil 'D' defined by SSURGO	5.93
Percent of area covered by water using 2006 NLCD	0.000
Percent of area covered by wetland using 2006 NLCD	9.881

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 24

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 0.72 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	49
5	$123 * DA^{0.627}$	100
10	$174 * DA^{0.617}$	140
25	$245 * DA^{0.606}$	200
50	$309 * DA^{0.600}$	250
100	$380 * DA^{0.594}$	310
200	$447 * DA^{0.589}$	370
500	$550 * DA^{0.583}$	450

North Carolina Urban Flood-Frequency Equations [3]

Drainage Area = 0.72 sq. mi.
Impervious Area = 20 % (greater than 10%)

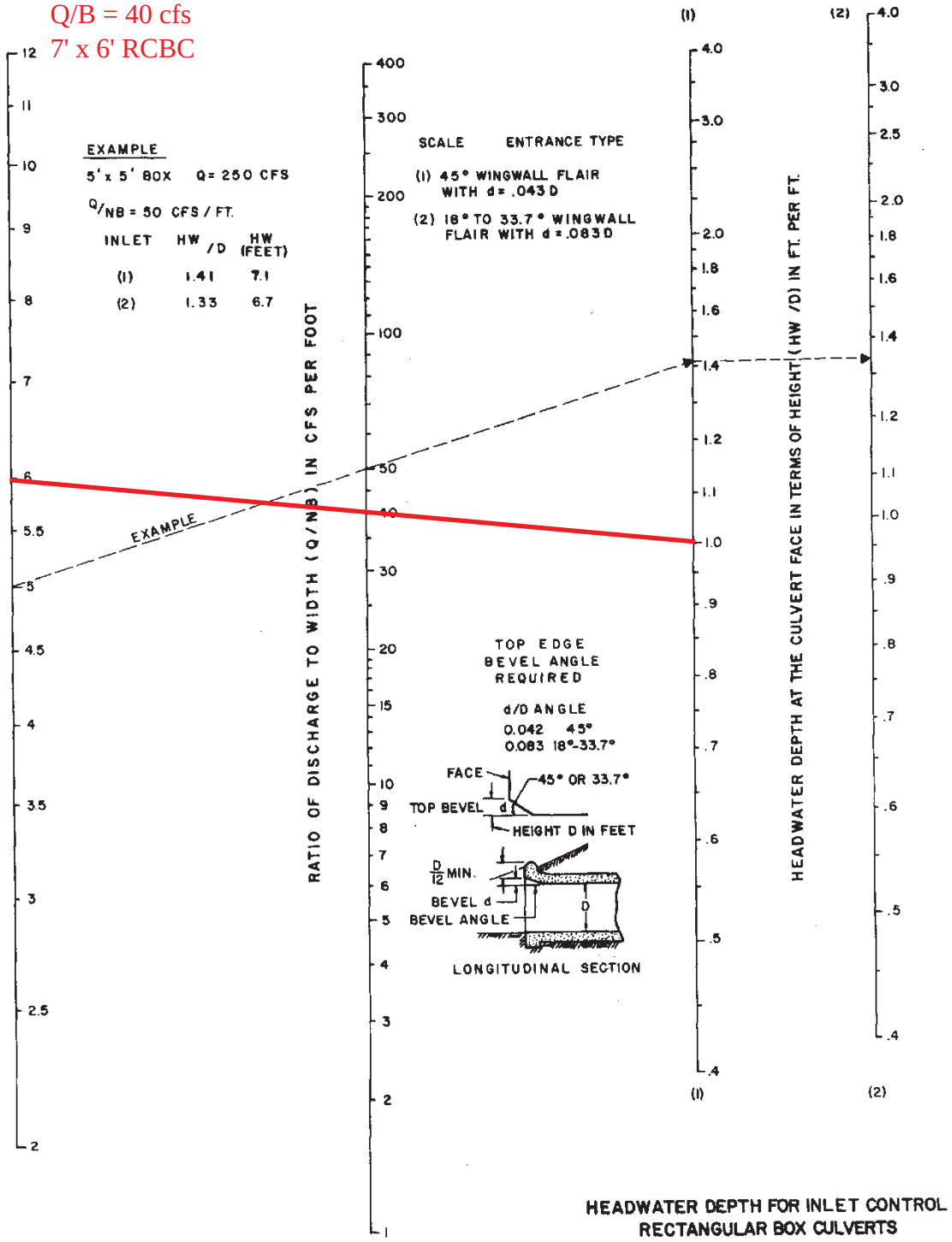
Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	170
5	$68.2 * DA^{0.655} * IA^{0.572}$	310
10	$109 * DA^{0.625} * IA^{0.515}$	420
25	$209 * DA^{0.570} * IA^{0.436}$	650
50	$280 * DA^{0.558} * IA^{0.396}$	750
100	$363 * DA^{0.547} * IA^{0.358}$	900
200 [4]	UQ100 / RQ100 * RQ200	1,100
500 [4]	UQ100 / RQ100 * RQ500	1,300

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

R-4738
Crossing 24
DA = 461 ac.
Q50 = 250 cfs
FEMA Crossing
Q/B = 40 cfs
7' x 6' RCBC

CHART 9B

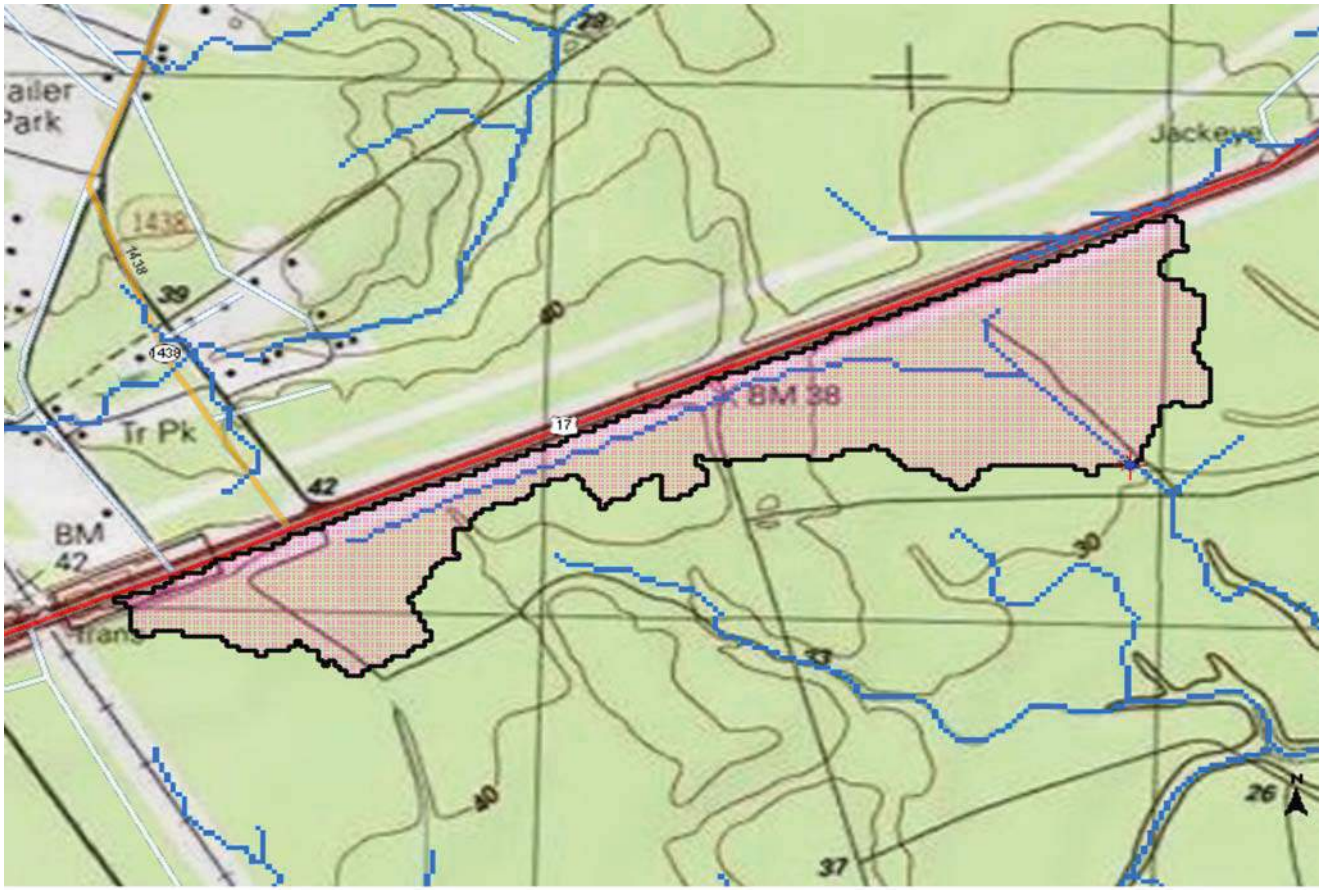
DETAILED STUDY = BRIDGE



HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

U-4738

Crossing 25



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.2 0.1 0 0.2 Miles

9/11/2014 2:10:01 PM

Crossing 25

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 09:51:18 Mountain Daylight Time
NAD27 Latitude: 34.2018 (34 12 06)
NAD27 Longitude: -78.0379 (-78 02 16)
NAD83 Latitude: 34.2019 (34 12 07)
NAD83 Longitude: -78.0376 (-78 02 15)

Parameter	Value
Area in square miles	0.15
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	3.8
Mean basin slope, based on slope percent grid	1.98
Percent of area covered by barren rock using 2006 NLCD	0.000
Percent of area in cultivation using 2006 NLCD	0.000
Percent of area covered by all densities of developed land using 2006 NLCD	48.973
Percent of area covered by forest using 2006 NLCD	18.862
Percent of area covered by grassland/herbaceous using 2006 NLCD	0.000
Percent impervious of basin area 2006 NLCD	5.50
Mean annual precipitation in inches	58.2
Percent of area of protected Federal and State owned land	0
Percent of area hydrologic soil 'A' defined by SSURGO	19.7
Percent of area hydrologic soil 'B' defined by SSURGO	32.5
Percent of area hydrologic soil 'C' defined by SSURGO	47.8
Percent of area hydrologic soil 'D' defined by SSURGO	0
Percent of area covered by water using 2006 NLCD	0.000
Percent of area covered by wetland using 2006 NLCD	30.796

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 25

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 0.15 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	18
5	$123 * DA^{0.627}$	37
10	$174 * DA^{0.617}$	55
25	$245 * DA^{0.606}$	80
50	$309 * DA^{0.600}$	100
100	$380 * DA^{0.594}$	120
200	$447 * DA^{0.589}$	150
500	$550 * DA^{0.583}$	180

North Carolina Urban Flood-Frequency Equations [3]

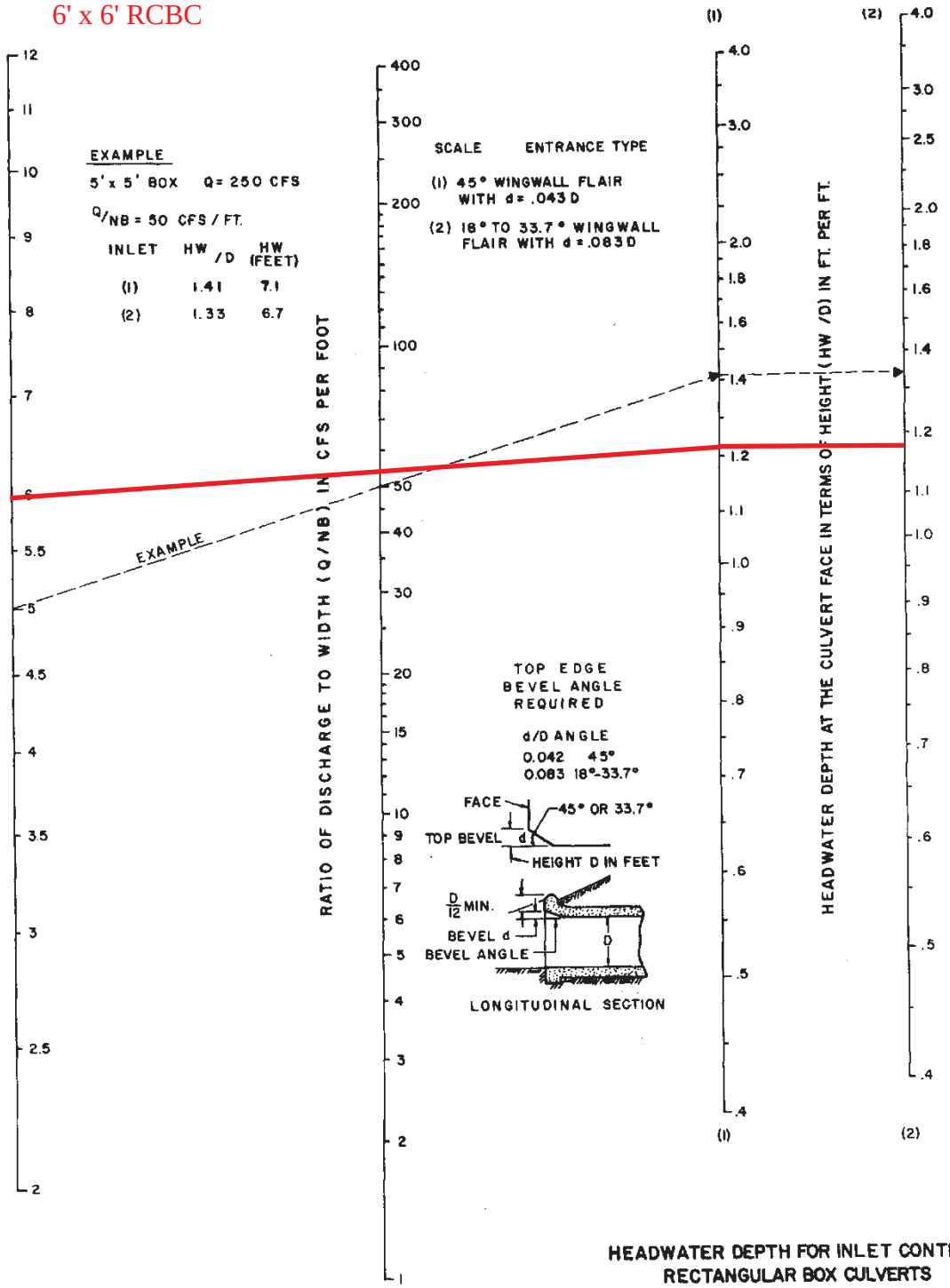
Drainage Area = 0.15 sq. mi.
Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	55
5	$68.2 * DA^{0.655} * IA^{0.572}$	110
10	$109 * DA^{0.625} * IA^{0.515}$	160
25	$209 * DA^{0.570} * IA^{0.436}$	260
50	$280 * DA^{0.558} * IA^{0.396}$	320
100	$363 * DA^{0.547} * IA^{0.358}$	380
200 [4]	UQ100 / RQ100 * RQ200	480
500 [4]	UQ100 / RQ100 * RQ500	550

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

R-4738
Crossing 25
DA = 96 ac.
Q50 = 320 cfs
Q/B = 54 cfs
6' x 6' RCBC

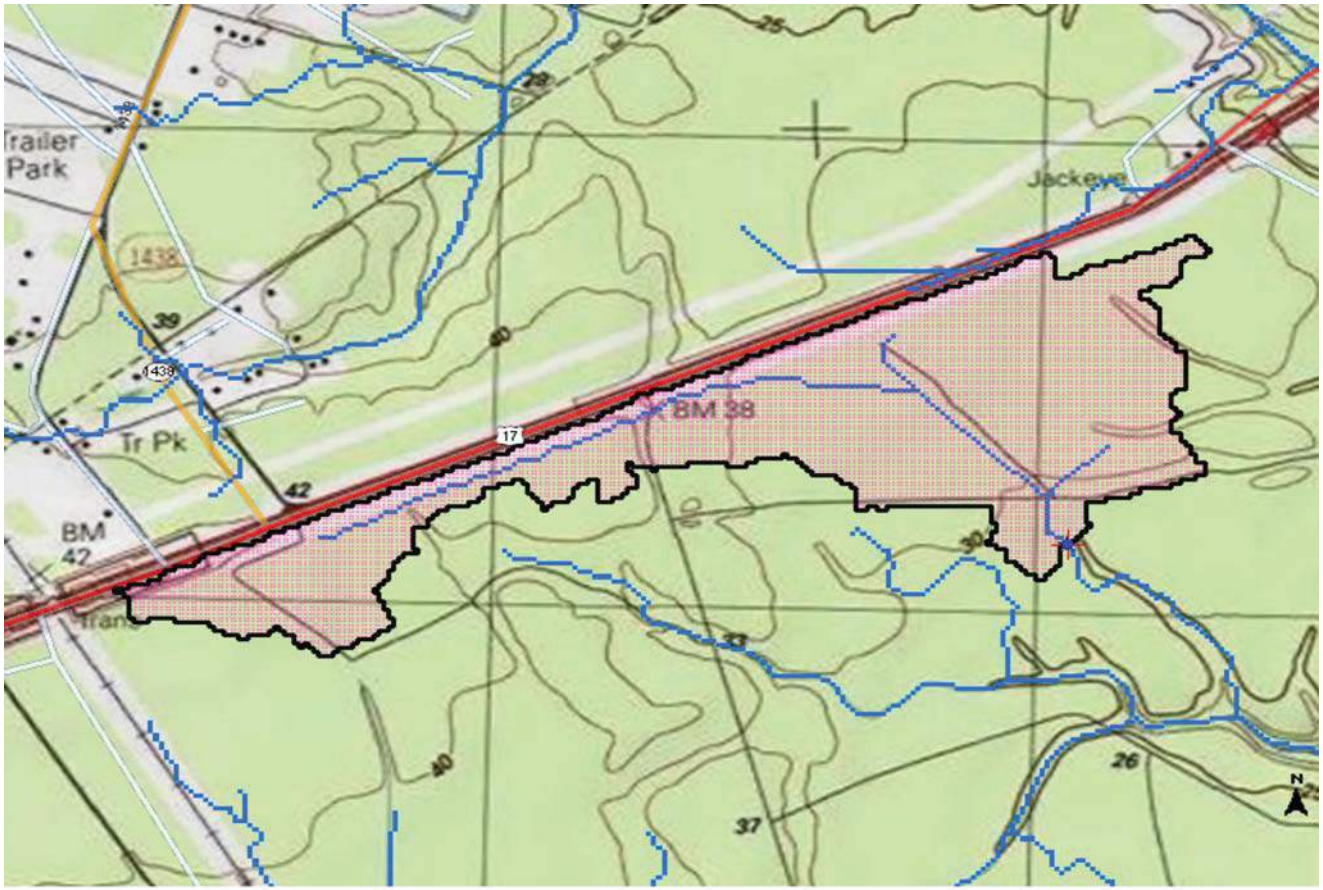
CHART 9B



HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

U-4738

Crossing 26



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.25 0.125 0 0.25 Miles

9/12/2014 9:28:12 AM

Crossing 26

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 09:55:06 Mountain Daylight Time
NAD27 Latitude: 34.2004 (34 12 01)
NAD27 Longitude: -78.0367 (-78 02 12)
NAD83 Latitude: 34.2005 (34 12 02)
NAD83 Longitude: -78.0364 (-78 02 11)

Parameter	Value
Area in square miles	0.21
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	4.58
Mean basin slope, based on slope percent grid	1.76
Percent of area covered by barren rock using 2006 NLCD	0.000
Percent of area in cultivation using 2006 NLCD	0.000
Percent of area covered by all densities of developed land using 2006 NLCD	34.909
Percent of area covered by forest using 2006 NLCD	27.896
Percent of area covered by grassland/herbaceous using 2006 NLCD	0.000
Percent impervious of basin area 2006 NLCD	3.92
Mean annual precipitation in inches	58.2
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	1.082
Percent of area hydrologic soil 'A' defined by SSURGO	15.3
Percent of area hydrologic soil 'B' defined by SSURGO	23.7
Percent of area hydrologic soil 'C' defined by SSURGO	61
Percent of area hydrologic soil 'D' defined by SSURGO	0
Percent of area covered by water using 2006 NLCD	0.000
Percent of area covered by wetland using 2006 NLCD	36.113

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 26

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 0.21 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	22
5	$123 * DA^{0.627}$	46
10	$174 * DA^{0.617}$	65
25	$245 * DA^{0.606}$	95
50	$309 * DA^{0.600}$	120
100	$380 * DA^{0.594}$	150
200	$447 * DA^{0.589}$	180
500	$550 * DA^{0.583}$	220

North Carolina Urban Flood-Frequency Equations [3]

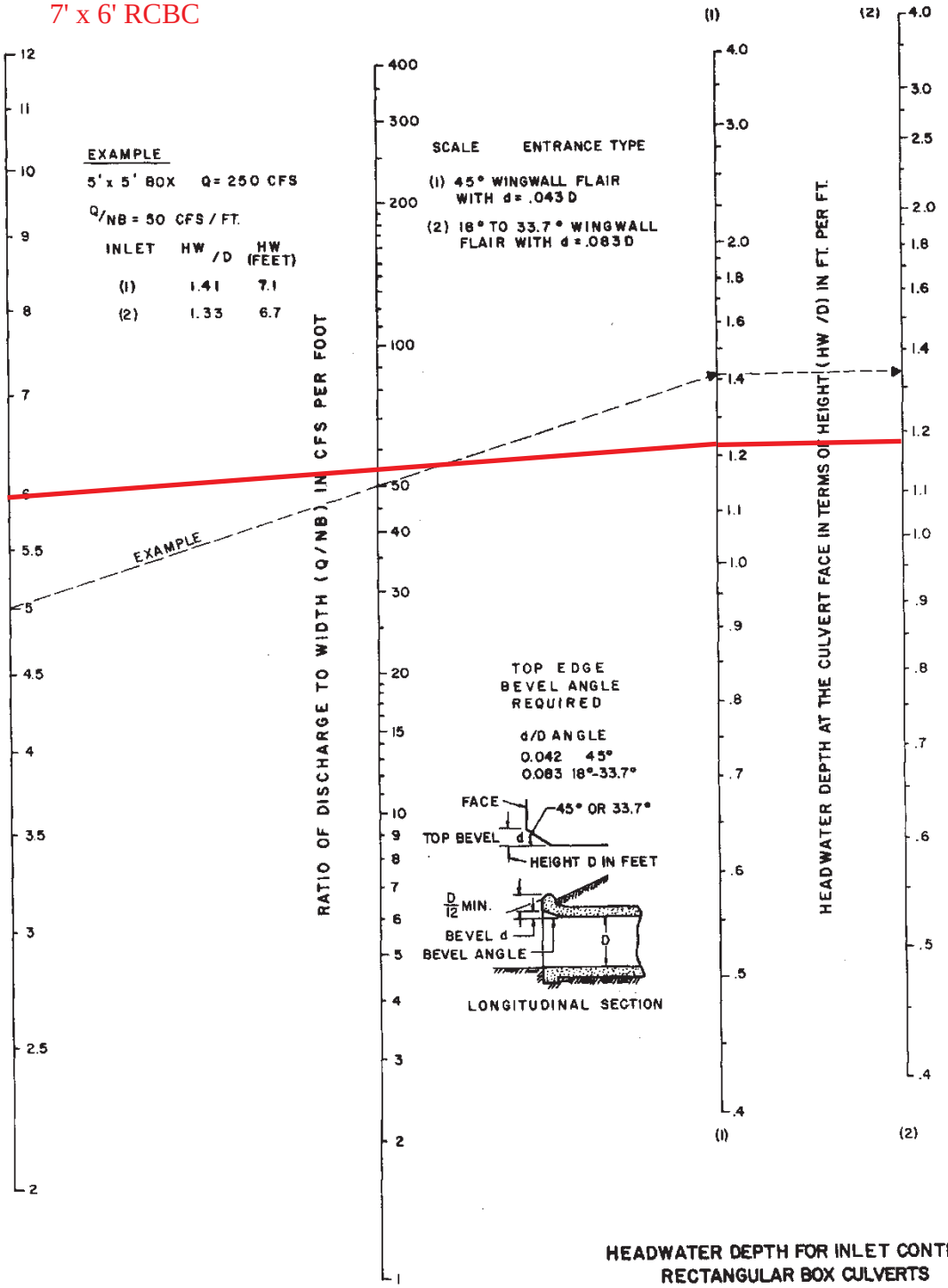
Drainage Area = 0.21 sq. mi.
Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	70
5	$68.2 * DA^{0.655} * IA^{0.572}$	140
10	$109 * DA^{0.625} * IA^{0.515}$	190
25	$209 * DA^{0.570} * IA^{0.436}$	320
50	$280 * DA^{0.558} * IA^{0.396}$	380
100	$363 * DA^{0.547} * IA^{0.358}$	450
200 [4]	UQ100 / RQ100 * RQ200	550
500 [4]	UQ100 / RQ100 * RQ500	650

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

U-4738
Crossing 26
DA = 134 ac.
Q50 = 380 cfs
Q/B = 54 cfs
7' x 6' RCBC

CHART 9B

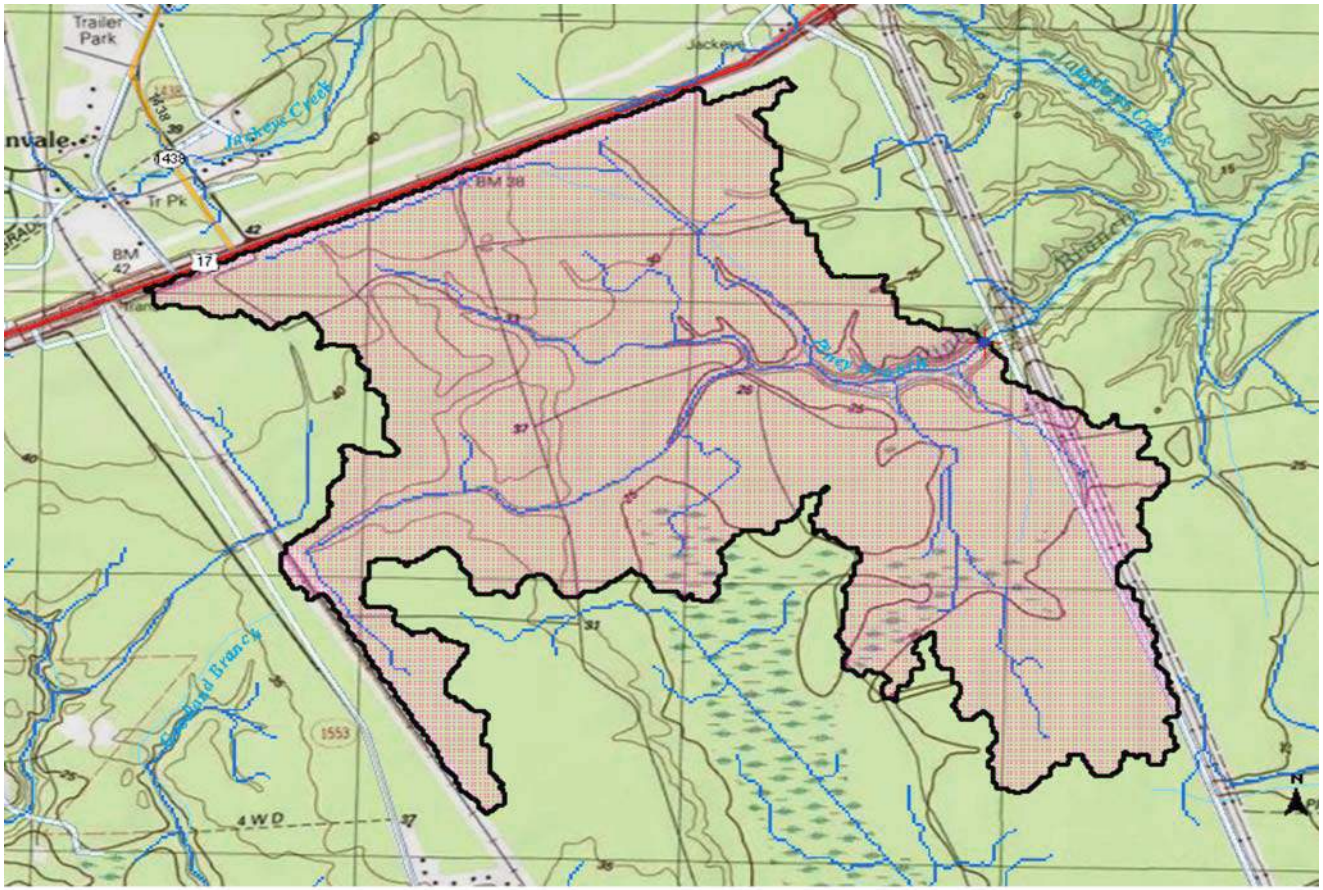


HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

USGS
North Carolina StreamStats

U-4738

Crossing 27



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.4 0.2 0 0.4 Miles

9/12/2014 9:30:36 AM

Crossing 27

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 10:36:08 Mountain Daylight Time
NAD27 Latitude: 34.1976 (34 11 52)
NAD27 Longitude: -78.0275 (-78 01 39)
NAD83 Latitude: 34.1978 (34 11 52)
NAD83 Longitude: -78.0273 (-78 01 38)

Parameter	Value
Area in square miles	1.48
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	12.4
Mean basin slope, based on slope percent grid	1.42
Percent of area covered by barren rock using 2006 NLCD	0.756
Percent of area in cultivation using 2006 NLCD	0.000
Percent of area covered by all densities of developed land using 2006 NLCD	49.358
Percent of area covered by forest using 2006 NLCD	24.449
Percent of area covered by grassland/herbaceous using 2006 NLCD	1.114
Percent impervious of basin area 2006 NLCD	10.13
Mean annual precipitation in inches	58.3
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	5.743
Percent of area hydrologic soil 'A' defined by SSURGO	8.58
Percent of area hydrologic soil 'B' defined by SSURGO	35.2
Percent of area hydrologic soil 'C' defined by SSURGO	56.2
Percent of area hydrologic soil 'D' defined by SSURGO	0
Percent of area covered by water using 2006 NLCD	0.000
Percent of area covered by wetland using 2006 NLCD	18.580

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 27

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 1.48 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	80
5	$123 * DA^{0.627}$	160
10	$174 * DA^{0.617}$	220
25	$245 * DA^{0.606}$	310
50	$309 * DA^{0.600}$	390
100	$380 * DA^{0.594}$	480
200	$447 * DA^{0.589}$	550
500	$550 * DA^{0.583}$	700

North Carolina Urban Flood-Frequency Equations [3]

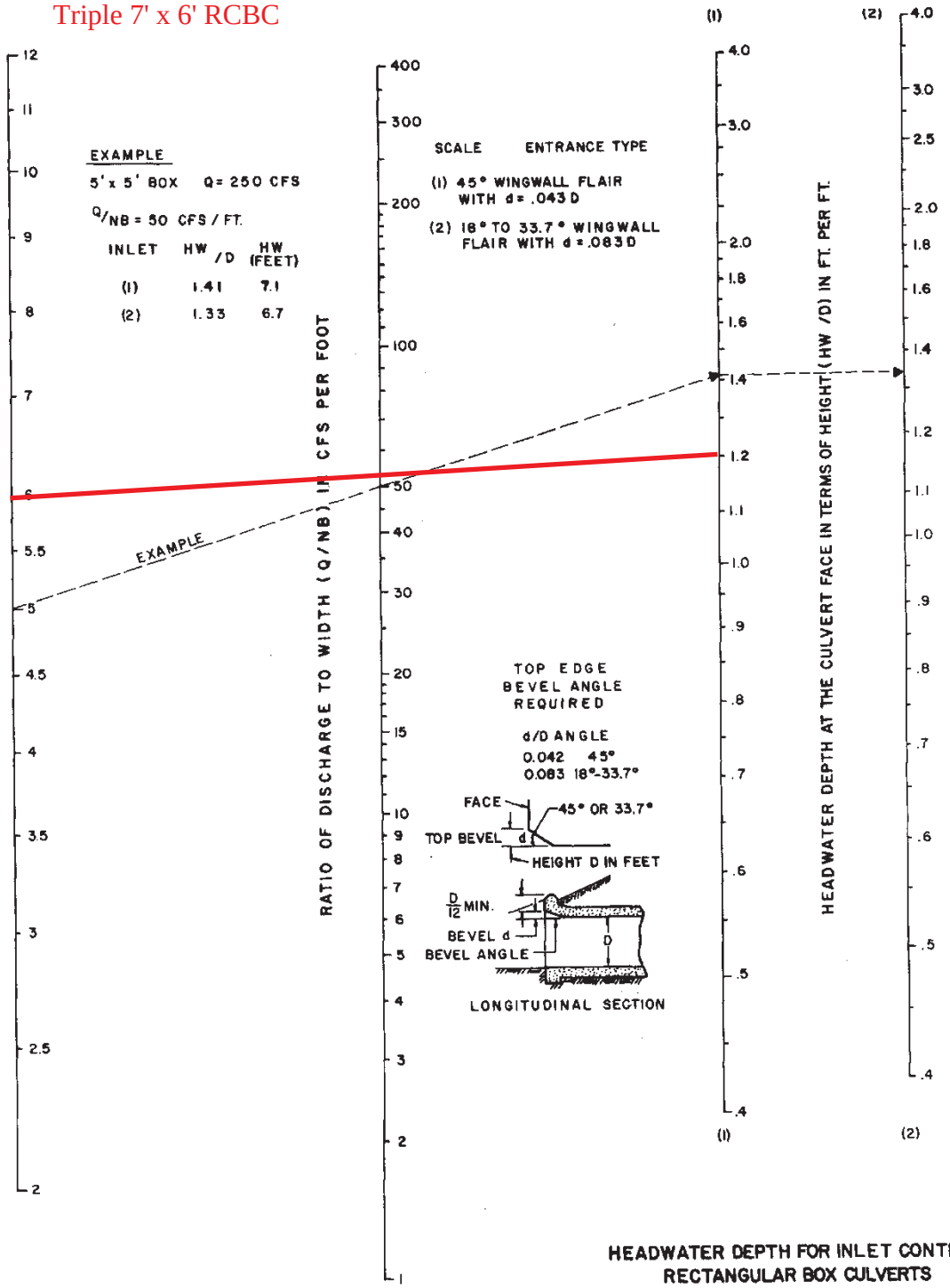
Drainage Area = 1.48 sq. mi.
Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	280
5	$68.2 * DA^{0.655} * IA^{0.572}$	490
10	$109 * DA^{0.625} * IA^{0.515}$	650
25	$209 * DA^{0.570} * IA^{0.436}$	950
50	$280 * DA^{0.558} * IA^{0.396}$	1,100
100	$363 * DA^{0.547} * IA^{0.358}$	1,300
200 [4]	UQ100 / RQ100 * RQ200	1,500
500 [4]	UQ100 / RQ100 * RQ500	1,900

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

R-4738
Crossing 27
DA = 947 ac.
Q50 = 1100 cfs
Q/B = 53 cfs
Triple 7' x 6' RCBC

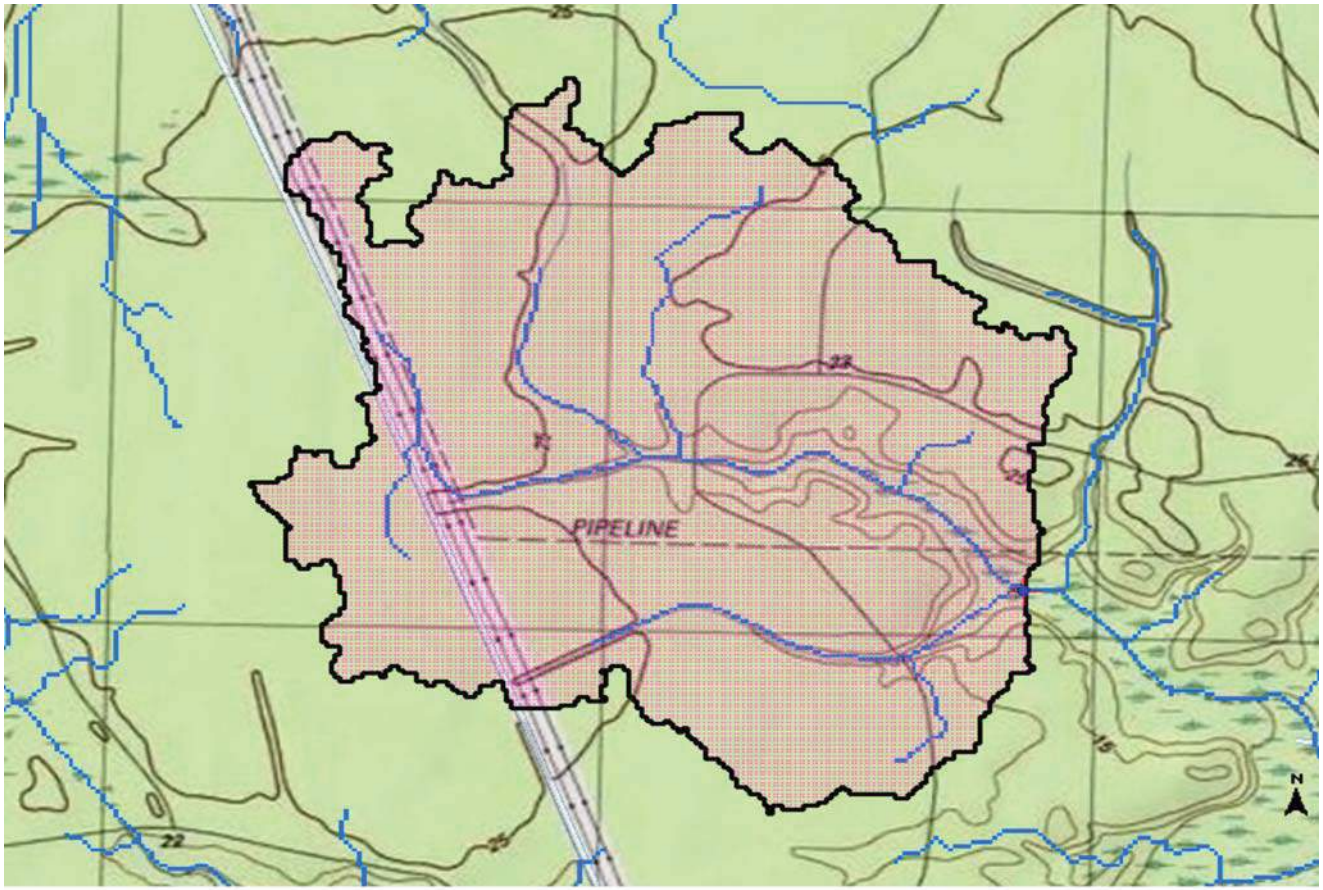
CHART 9B



HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

U-4738

Crossing 28



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.25 0.125 0 0.25 Miles

9/12/2014 10:05:44 AM

Crossing 28

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 10:39:44 Mountain Daylight Time
NAD27 Latitude: 34.1812 (34 10 52)
NAD27 Longitude: -78.0071 (-78 00 26)
NAD83 Latitude: 34.1814 (34 10 53)
NAD83 Longitude: -78.0068 (-78 00 25)

Parameter	Value
Area in square miles	0.71
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	6.17
Mean basin slope, based on slope percent grid	1.27
Percent of area covered by barren rock using 2006 NLCD	0.000
Percent of area in cultivation using 2006 NLCD	0.000
Percent of area covered by all densities of developed land using 2006 NLCD	17.105
Percent of area covered by forest using 2006 NLCD	37.010
Percent of area covered by grassland/herbaceous using 2006 NLCD	14.111
Percent impervious of basin area 2006 NLCD	2.45
Mean annual precipitation in inches	58.5
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	24.047
Percent of area hydrologic soil 'A' defined by SSURGO	20.6
Percent of area hydrologic soil 'B' defined by SSURGO	66
Percent of area hydrologic soil 'C' defined by SSURGO	7.81
Percent of area hydrologic soil 'D' defined by SSURGO	5.58
Percent of area covered by water using 2006 NLCD	0.290
Percent of area covered by wetland using 2006 NLCD	7.436

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 28

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 0.71 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	48
5	$123 * DA^{0.627}$	100
10	$174 * DA^{0.617}$	140
25	$245 * DA^{0.606}$	200
50	$309 * DA^{0.600}$	250
100	$380 * DA^{0.594}$	310
200	$447 * DA^{0.589}$	370
500	$550 * DA^{0.583}$	450

North Carolina Urban Flood-Frequency Equations [3]

Drainage Area = 0.71 sq. mi.
Impervious Area = 20 % (greater than 10%)

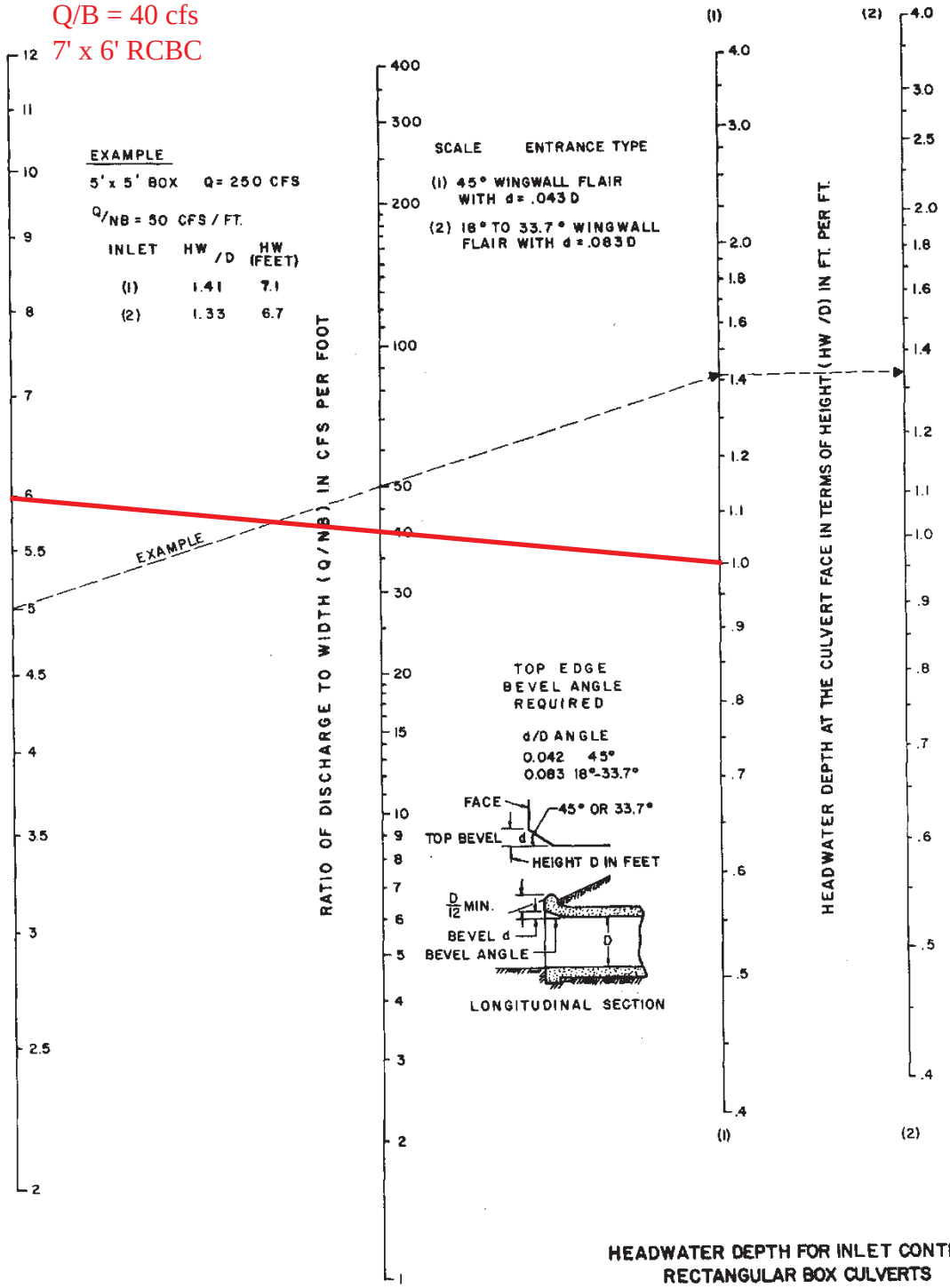
Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	160
5	$68.2 * DA^{0.655} * IA^{0.572}$	300
10	$109 * DA^{0.625} * IA^{0.515}$	410
25	$209 * DA^{0.570} * IA^{0.436}$	650
50	$280 * DA^{0.558} * IA^{0.396}$	750
100	$363 * DA^{0.547} * IA^{0.358}$	900
200 [4]	UQ100 / RQ100 * RQ200	1,100
500 [4]	UQ100 / RQ100 * RQ500	1,300

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

R-4738
Crossing 28
DA = 454 ac.
Q50 = 250 cfs
FEMA Crossing
Q/B = 40 cfs
7' x 6' RCBC

CHART 9B

DETAILED STUDY = BRIDGE

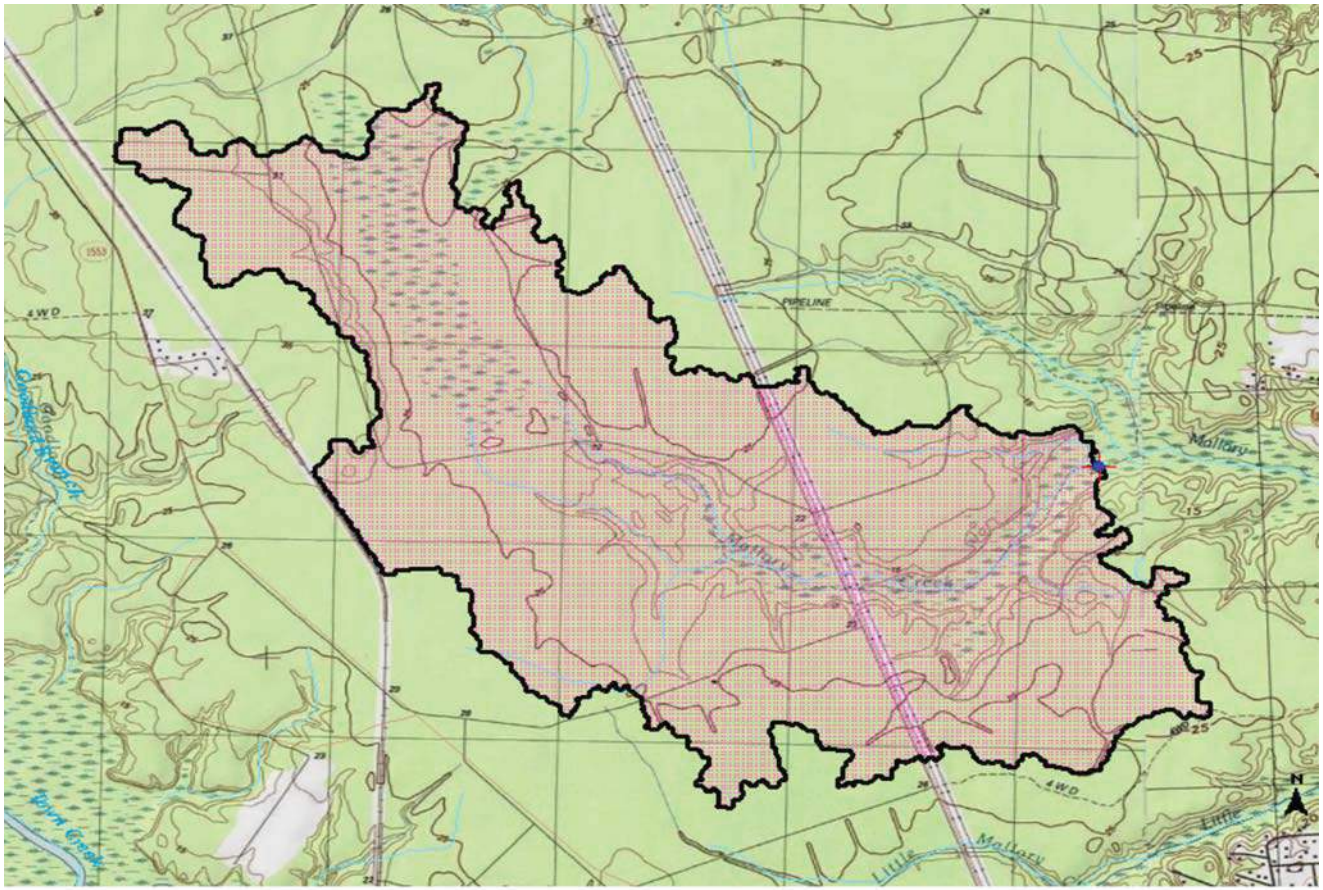


HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

USGS
North Carolina StreamStats

U-4738

Crossing 29



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- huc poly

0.6 0.3 0 0.6 Miles

9/12/2014 10:10:52 AM

Crossing 29

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 10:45:13 Mountain Daylight Time
NAD27 Latitude: 34.1750 (34 10 30)
NAD27 Longitude: -78.0021 (-78 00 08)
NAD83 Latitude: 34.1752 (34 10 31)
NAD83 Longitude: -78.0018 (-78 00 07)

Parameter	Value
Area in square miles	2.83
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Mean basin slope, based on slope percent grid	1.26
10-85 slope in feet per mile based on preprocessed elevation data	7.36
Percent of area covered by barren rock using 2006 NLCD	11.254
Percent of area in cultivation using 2006 NLCD	0.000
Percent of area covered by all densities of developed land using 2006 NLCD	27.637
Percent of area covered by forest using 2006 NLCD	17.933
Percent of area covered by grassland/herbaceous using 2006 NLCD	9.730
Percent impervious of basin area 2006 NLCD	2.72
Mean annual precipitation in inches	58.6
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	10.952
Percent of area hydrologic soil 'A' defined by SSURGO	20.5
Percent of area hydrologic soil 'B' defined by SSURGO	51.3
Percent of area hydrologic soil 'C' defined by SSURGO	19.5
Percent of area hydrologic soil 'D' defined by SSURGO	8.77
Percent of area covered by water using 2006 NLCD	1.309
Percent of area covered by wetland using 2006 NLCD	21.185

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 29

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 2.83 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	120
5	$123 * DA^{0.627}$	240
10	$174 * DA^{0.617}$	330
25	$245 * DA^{0.606}$	460
50	$309 * DA^{0.600}$	600
100	$380 * DA^{0.594}$	700
200	$447 * DA^{0.589}$	800
500	$550 * DA^{0.583}$	1,000

North Carolina Urban Flood-Frequency Equations [3]

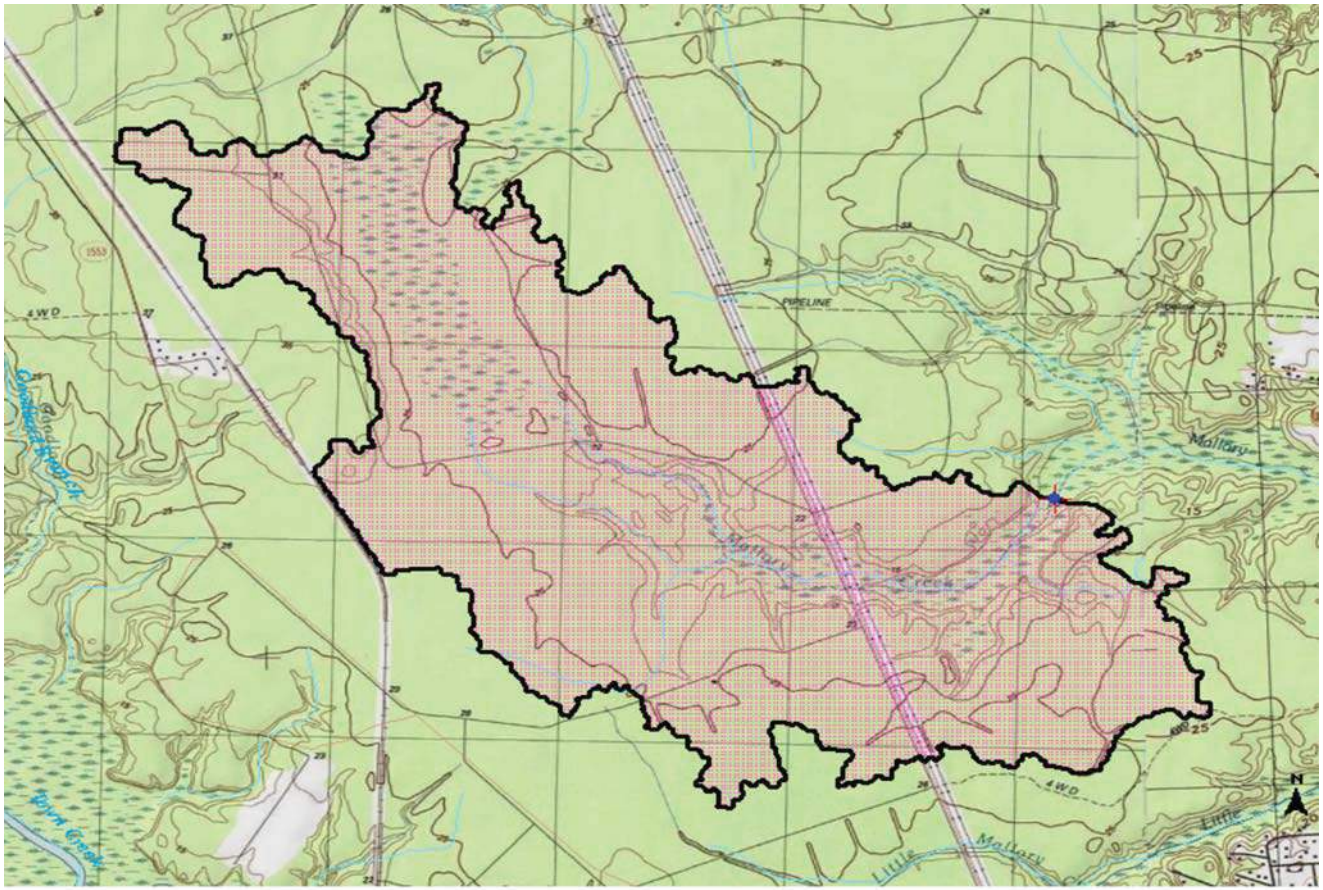
Drainage Area = 2.83 sq. mi.
Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	450
5	$68.2 * DA^{0.655} * IA^{0.572}$	750
10	$109 * DA^{0.625} * IA^{0.515}$	1,000
25	$209 * DA^{0.570} * IA^{0.436}$	1,400
50	$280 * DA^{0.558} * IA^{0.396}$	1,600
100	$363 * DA^{0.547} * IA^{0.358}$	1,900
200 [4]	UQ100 / RQ100 * RQ200	2,200
500 [4]	UQ100 / RQ100 * RQ500	2,700

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

U-4738

Crossing 30



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.6 0.3 0 0.6 Miles

9/12/2014 10:46:22 AM

Crossing 30

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 10:48:11 Mountain Daylight Time
NAD27 Latitude: 34.1736 (34 10 25)
NAD27 Longitude: -78.0042 (-78 00 15)
NAD83 Latitude: 34.1737 (34 10 25)
NAD83 Longitude: -78.0039 (-78 00 14)

Parameter	Value
Area in square miles	2.7
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	16.1
Mean basin slope, based on slope percent grid	1.23
Percent of area covered by barren rock using 2006 NLCD	11.770
Percent of area in cultivation using 2006 NLCD	0.000
Percent of area covered by all densities of developed land using 2006 NLCD	28.284
Percent of area covered by forest using 2006 NLCD	17.836
Percent of area covered by grassland/herbaceous using 2006 NLCD	9.097
Percent impervious of basin area 2006 NLCD	2.77
Mean annual precipitation in inches	58.6
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	11.027
Percent of area hydrologic soil 'A' defined by SSURGO	19.1
Percent of area hydrologic soil 'B' defined by SSURGO	52.3
Percent of area hydrologic soil 'C' defined by SSURGO	20.4
Percent of area hydrologic soil 'D' defined by SSURGO	8.24
Percent of area covered by water using 2006 NLCD	1.369
Percent of area covered by wetland using 2006 NLCD	20.617

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 30

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 2.70 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	110
5	$123 * DA^{0.627}$	230
10	$174 * DA^{0.617}$	320
25	$245 * DA^{0.606}$	450
50	$309 * DA^{0.600}$	550
100	$380 * DA^{0.594}$	700
200	$447 * DA^{0.589}$	800
500	$550 * DA^{0.583}$	1,000

North Carolina Urban Flood-Frequency Equations [3]

Drainage Area = 2.70 sq. mi.
Impervious Area = 20 % (greater than 10%)

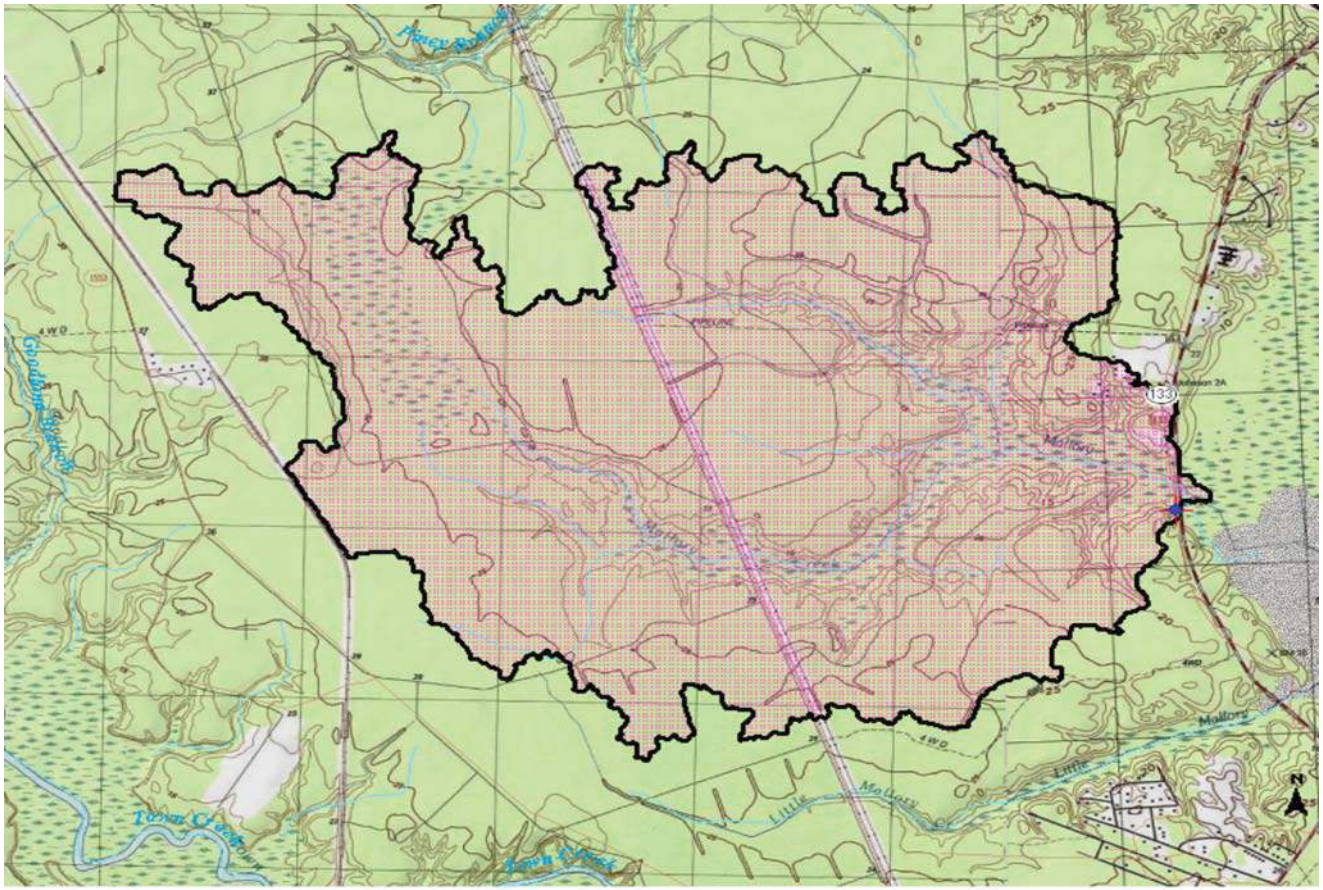
Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	430
5	$68.2 * DA^{0.655} * IA^{0.572}$	750
10	$109 * DA^{0.625} * IA^{0.515}$	950
25	$209 * DA^{0.570} * IA^{0.436}$	1,400
50	$280 * DA^{0.558} * IA^{0.396}$	1,600
100	$363 * DA^{0.547} * IA^{0.358}$	1,800
200 [4]	UQ100 / RQ100 * RQ200	2,100
500 [4]	UQ100 / RQ100 * RQ500	2,600

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

USGS
North Carolina StreamStats

U-4738

Crossing 33



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.7 0.35 0 0.7 Miles

9/12/2014 10:53:36 AM

Crossing 33

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 10:58:58 Mountain Daylight Time
NAD27 Latitude: 34.1724 (34 10 21)
NAD27 Longitude: -77.9905 (-77 59 26)
NAD83 Latitude: 34.1726 (34 10 21)
NAD83 Longitude: -77.9903 (-77 59 25)

Parameter	Value
Area in square miles	4.67
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	20.3
Mean basin slope, based on slope percent grid	1.41
Percent of area covered by barren rock using 2006 NLCD	7.204
Percent of area in cultivation using 2006 NLCD	0.174
Percent of area covered by all densities of developed land using 2006 NLCD	27.026
Percent of area covered by forest using 2006 NLCD	20.247
Percent of area covered by grassland/herbaceous using 2006 NLCD	9.557
Percent impervious of basin area 2006 NLCD	3.51
Mean annual precipitation in inches	58.6
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	14.613
Percent of area hydrologic soil 'A' defined by SSURGO	23.9
Percent of area hydrologic soil 'B' defined by SSURGO	49.7
Percent of area hydrologic soil 'C' defined by SSURGO	15.6
Percent of area hydrologic soil 'D' defined by SSURGO	10.7
Percent of area covered by water using 2006 NLCD	0.837
Percent of area covered by wetland using 2006 NLCD	20.342

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 33

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 4.67 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	160
5	$123 * DA^{0.627}$	320
10	$174 * DA^{0.617}$	450
25	$245 * DA^{0.606}$	600
50	$309 * DA^{0.600}$	800
100	$380 * DA^{0.594}$	950
200	$447 * DA^{0.589}$	1,100
500	$550 * DA^{0.583}$	1,400

North Carolina Urban Flood-Frequency Equations [3]

Drainage Area = 4.67 sq. mi.
Impervious Area = 20 % (greater than 10%)

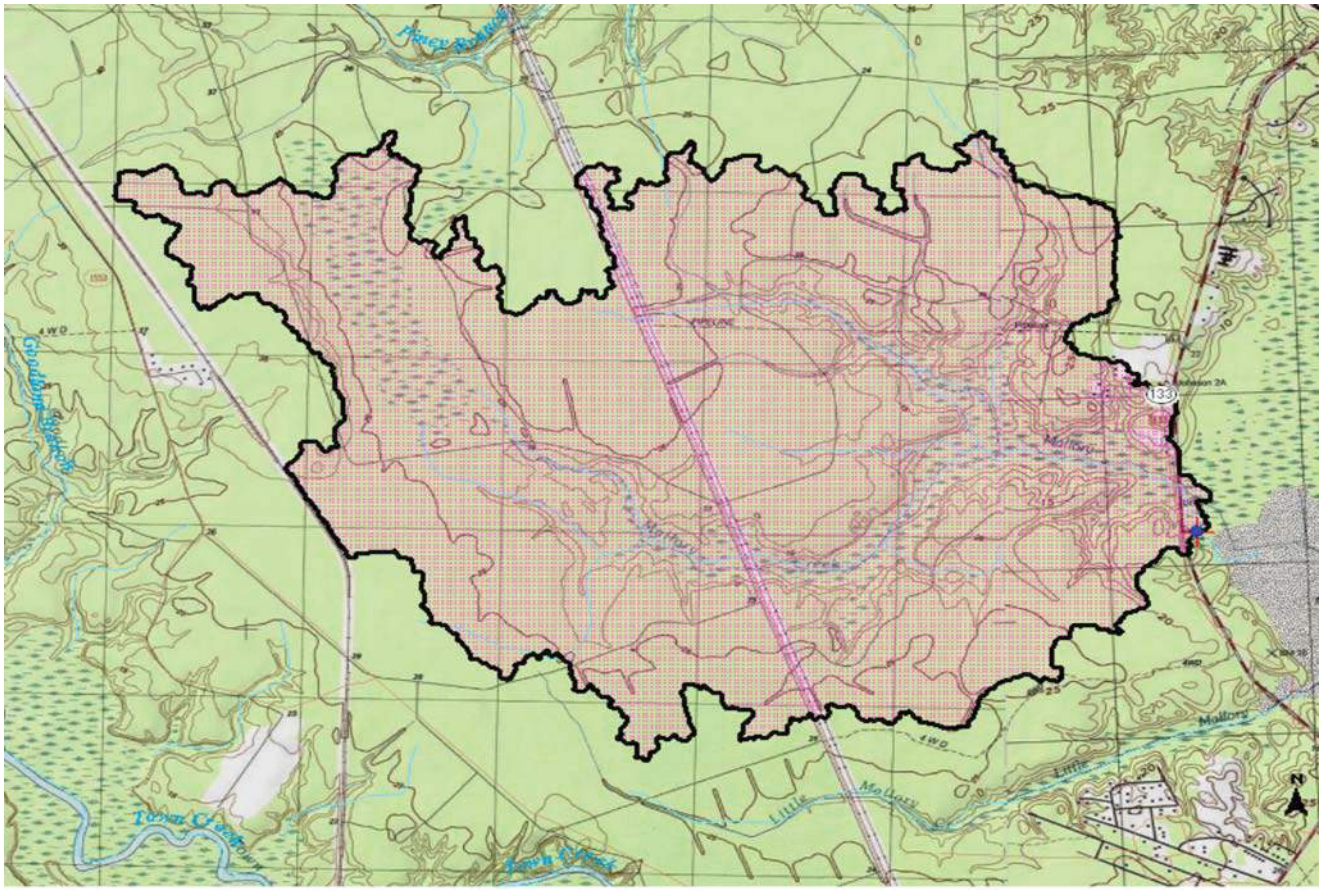
Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	650
5	$68.2 * DA^{0.655} * IA^{0.572}$	1,000
10	$109 * DA^{0.625} * IA^{0.515}$	1,300
25	$209 * DA^{0.570} * IA^{0.436}$	1,900
50	$280 * DA^{0.558} * IA^{0.396}$	2,200
100	$363 * DA^{0.547} * IA^{0.358}$	2,500
200 [4]	UQ100 / RQ100 * RQ200	2,900
500 [4]	UQ100 / RQ100 * RQ500	3,700

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

USGS
North Carolina StreamStats

U-4738

Crossing 34



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.7 0.35 0 0.7 Miles

9/12/2014 10:55:59 AM

Crossing 34

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 11:03:03 Mountain Daylight Time
NAD27 Latitude: 34.1713 (34 10 17)
NAD27 Longitude: -77.9894 (-77 59 22)
NAD83 Latitude: 34.1715 (34 10 17)
NAD83 Longitude: -77.9891 (-77 59 21)

Parameter	Value
Area in square miles	4.69
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	20.4
Mean basin slope, based on slope percent grid	1.41
Percent of area covered by barren rock using 2006 NLCD	7.178
Percent of area in cultivation using 2006 NLCD	0.174
Percent of area covered by all densities of developed land using 2006 NLCD	27.026
Percent of area covered by forest using 2006 NLCD	20.248
Percent of area covered by grassland/herbaceous using 2006 NLCD	9.523
Percent impervious of basin area 2006 NLCD	3.50
Mean annual precipitation in inches	58.6
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	14.562
Percent of area hydrologic soil 'A' defined by SSURGO	24
Percent of area hydrologic soil 'B' defined by SSURGO	49.6
Percent of area hydrologic soil 'C' defined by SSURGO	15.6
Percent of area hydrologic soil 'D' defined by SSURGO	10.8
Percent of area covered by water using 2006 NLCD	0.834
Percent of area covered by wetland using 2006 NLCD	20.456

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 34

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 4.69 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	160
5	$123 * DA^{0.627}$	320
10	$174 * DA^{0.617}$	450
25	$245 * DA^{0.606}$	650
50	$309 * DA^{0.600}$	800
100	$380 * DA^{0.594}$	950
200	$447 * DA^{0.589}$	1,100
500	$550 * DA^{0.583}$	1,400

North Carolina Urban Flood-Frequency Equations [3]

Drainage Area = 4.69 sq. mi.
Impervious Area = 20 % (greater than 10%)

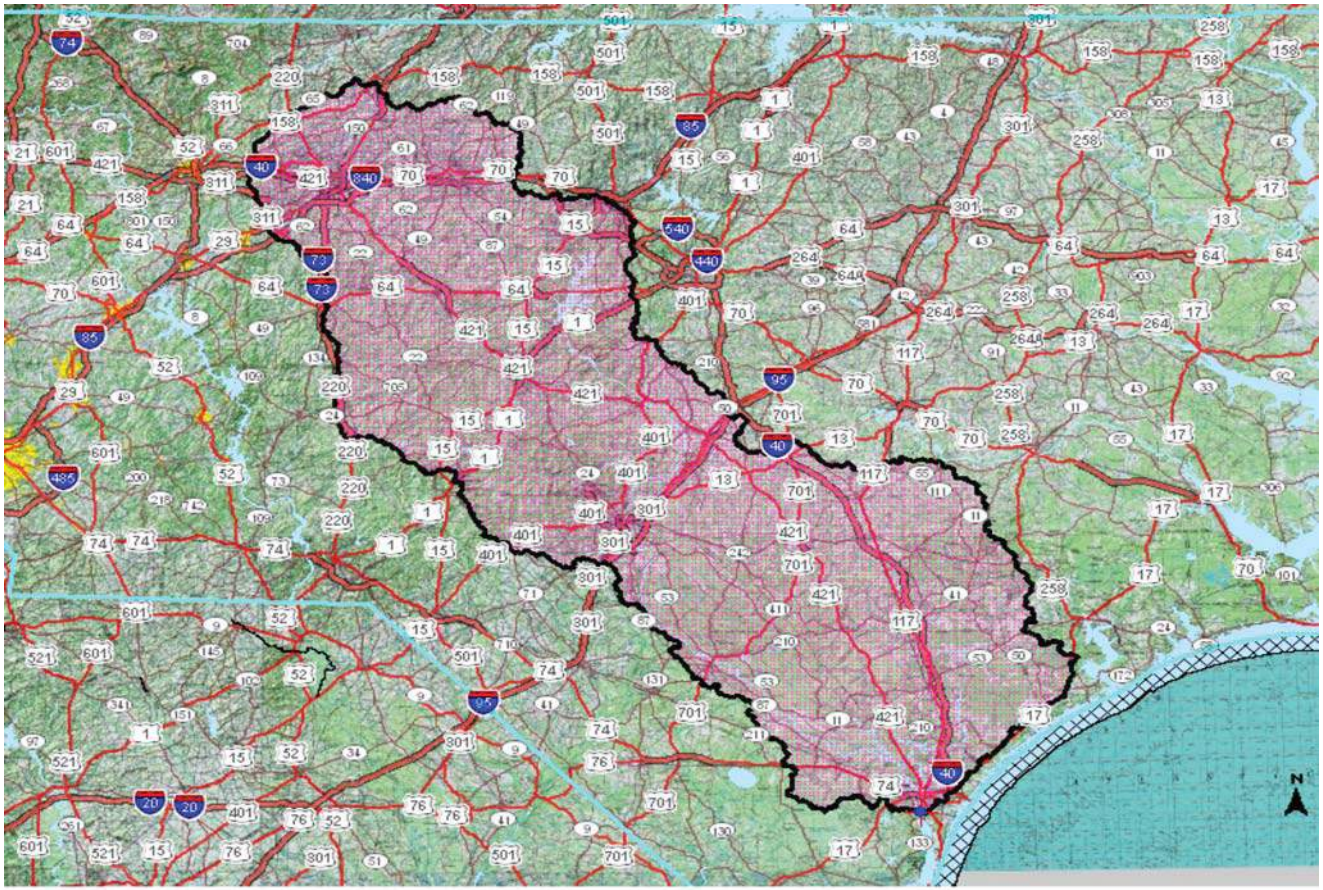
Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	650
5	$68.2 * DA^{0.655} * IA^{0.572}$	1,000
10	$109 * DA^{0.625} * IA^{0.515}$	1,300
25	$209 * DA^{0.570} * IA^{0.436}$	1,900
50	$280 * DA^{0.558} * IA^{0.396}$	2,200
100	$363 * DA^{0.547} * IA^{0.358}$	2,500
200 [4]	UQ100 / RQ100 * RQ200	2,900
500 [4]	UQ100 / RQ100 * RQ500	3,700

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

USGS
North Carolina StreamStats

U-4738

Crossing 35



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

40 20 0 40 Miles

9/12/2014 10:59:11 AM

Crossing 35

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 11:12:32 Mountain Daylight Time
NAD27 Latitude: 34.1789 (34 10 44)
NAD27 Longitude: -77.9587 (-77 57 31)
NAD83 Latitude: 34.1790 (34 10 44)
NAD83 Longitude: -77.9584 (-77 57 30)

Parameter	Value
Area in square miles	8850
Percent of area covered by hydrologic region 1	38.011
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	8.771
Percent of area covered by hydrologic region 4	53.218
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	1070
Mean basin slope, based on slope percent grid	4.32
Percent of area covered by barren rock using 2006 NLCD	0.367
Percent of area in cultivation using 2006 NLCD	23.004
Percent of area covered by all densities of developed land using 2006 NLCD	10.789
Percent of area covered by forest using 2006 NLCD	37.372
Percent of area covered by grassland/herbaceous using 2006 NLCD	5.248
Percent impervious of basin area 2006 NLCD	2.48
Mean annual precipitation in inches	49.3
Percent of area of protected Federal and State owned land	5.68
Percent of area covered by shrubland using 2006 NLCD	7.654
Percent of area hydrologic soil 'A' defined by SSURGO	13.8
Percent of area hydrologic soil 'B' defined by SSURGO	48.1
Percent of area hydrologic soil 'C' defined by SSURGO	24.8
Percent of area hydrologic soil 'D' defined by SSURGO	11.4
Percent of area covered by water using 2006 NLCD	1.324
Percent of area covered by wetland using 2006 NLCD	14.242

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 35

Total Drainage Area = 8850 sq. mi.
Impervious Area = 20 %

Recurrence Interval (years)	Total Q (cfs)
2	170,000
5	170,000
10	180,000
25	170,000
50	180,000
100	190,000
200	210,000
500	240,000

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 35c (Region 1)

North Carolina Urban Flood-Frequency Equations [3]

Drainage Area = 8850 sq. mi.

Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$33.3 * DA^{0.739} * IA^{0.686}$	210,000
5	$78.9 * DA^{0.681} * IA^{0.572}$	210,000
10	$122 * DA^{0.655} * IA^{0.515}$	220,000
25	$228 * DA^{0.611} * IA^{0.436}$	220,000
50	$296 * DA^{0.602} * IA^{0.396}$	230,000
100	$374 * DA^{0.593} * IA^{0.358}$	240,000
200 [4]	UQ100 / RQ100 * RQ200	270,000
500 [4]	UQ100 / RQ100 * RQ500	300,000

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 35b (Region 3)

North Carolina Urban Flood-Frequency Equations [3]

Drainage Area = 8850 sq. mi.

Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$21 * DA^{0.752} * IA^{0.686}$	150,000
5	$49.6 * DA^{0.700} * IA^{0.572}$	160,000
10	$75.6 * DA^{0.677} * IA^{0.515}$	170,000
25	$128 * DA^{0.644} * IA^{0.436}$	160,000
50	$170 * DA^{0.637} * IA^{0.396}$	180,000
100	$217 * DA^{0.630} * IA^{0.358}$	190,000
200 [4]	UQ100 / RQ100 * RQ200	220,000
500 [4]	UQ100 / RQ100 * RQ500	250,000

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. Robbins, J.C., and Pope, B.F., 1996, Estimation of Flood-Frequency Characteristics of Small Urban Streams in North Carolina: U.S. Geological Survey Water-Resources Investigations Report 96-4084.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 35a (Region 4)

North Carolina Urban Flood-Frequency Equations [3]

Drainage Area = 8850 sq. mi.

Impervious Area = 20 % (greater than 10%)

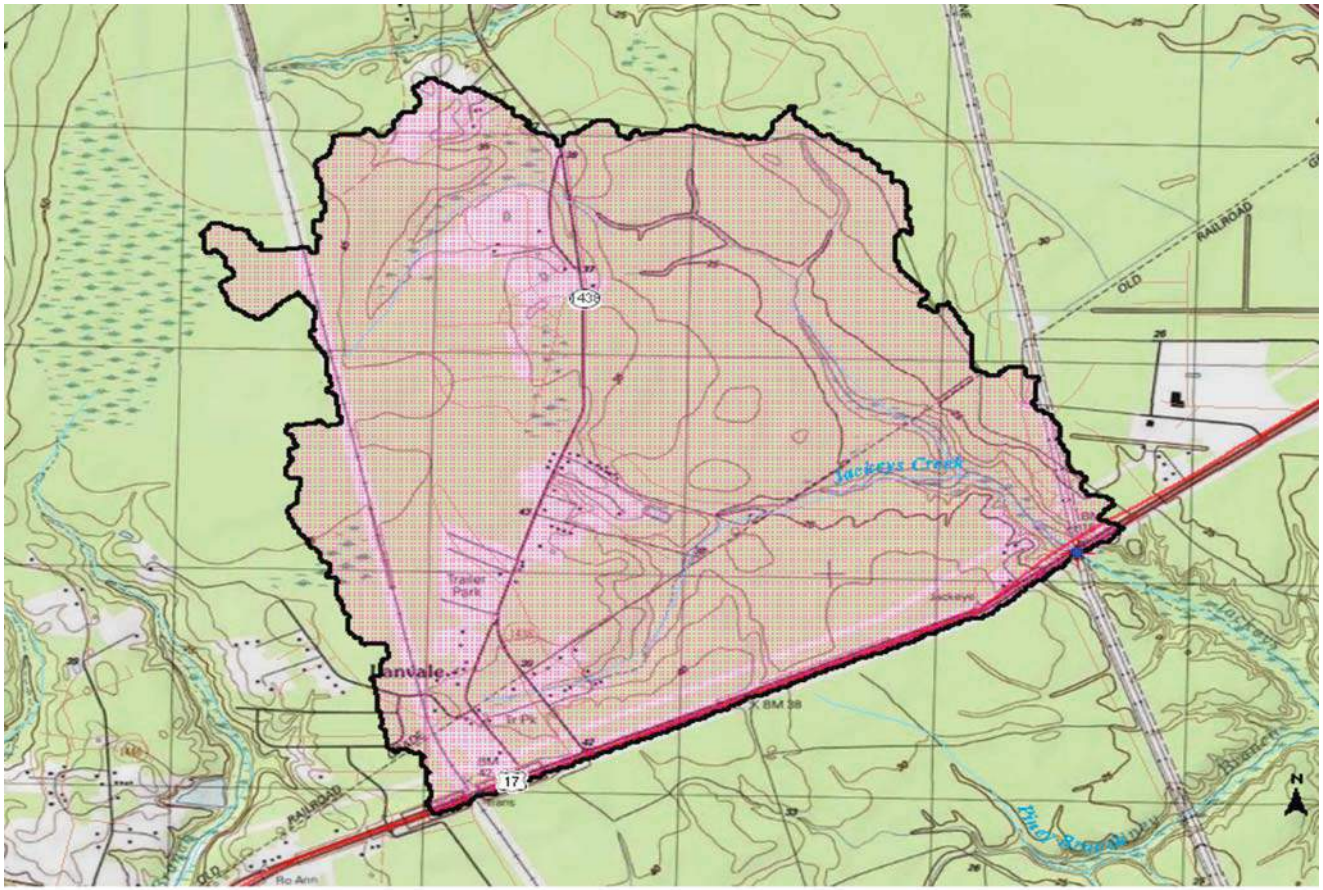
Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	150,000
5	$68.2 * DA^{0.655} * IA^{0.572}$	150,000
10	$109 * DA^{0.625} * IA^{0.515}$	150,000
25	$209 * DA^{0.570} * IA^{0.436}$	140,000
50	$280 * DA^{0.558} * IA^{0.396}$	150,000
100	$363 * DA^{0.547} * IA^{0.358}$	150,000
200 [4]	UQ100 / RQ100 * RQ200	170,000
500 [4]	UQ100 / RQ100 * RQ500	200,000

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

USGS
North Carolina StreamStats

U-4738

Crossing 36



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.5 0.25 0 0.5 Miles

9/12/2014 11:02:01 AM

Crossing 36

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 11:23:28 Mountain Daylight Time
NAD27 Latitude: 34.2091 (34 12 33)
NAD27 Longitude: -78.0311 (-78 01 52)
NAD83 Latitude: 34.2093 (34 12 34)
NAD83 Longitude: -78.0308 (-78 01 51)

Parameter	Value
Area in square miles	2.77
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	10.9
Mean basin slope, based on slope percent grid	1.68
Percent of area covered by barren rock using 2006 NLCD	0.000
Percent of area in cultivation using 2006 NLCD	4.501
Percent of area covered by all densities of developed land using 2006 NLCD	25.956
Percent of area covered by forest using 2006 NLCD	27.840
Percent of area covered by grassland/herbaceous using 2006 NLCD	4.008
Percent impervious of basin area 2006 NLCD	5.56
Mean annual precipitation in inches	58
Percent of area of protected Federal and State owned land	0.00839
Percent of area covered by shrubland using 2006 NLCD	10.558
Percent of area hydrologic soil 'A' defined by SSURGO	24.5
Percent of area hydrologic soil 'B' defined by SSURGO	36.3
Percent of area hydrologic soil 'C' defined by SSURGO	35.9
Percent of area hydrologic soil 'D' defined by SSURGO	2.93
Percent of area covered by water using 2006 NLCD	0.109
Percent of area covered by wetland using 2006 NLCD	27.028

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 36

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 2.77 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	120
5	$123 * DA^{0.627}$	230
10	$174 * DA^{0.617}$	330
25	$245 * DA^{0.606}$	450
50	$309 * DA^{0.600}$	550
100	$380 * DA^{0.594}$	700
200	$447 * DA^{0.589}$	800
500	$550 * DA^{0.583}$	1,000

North Carolina Urban Flood-Frequency Equations [3]

Drainage Area = 2.77 sq. mi.
Impervious Area = 20 % (greater than 10%)

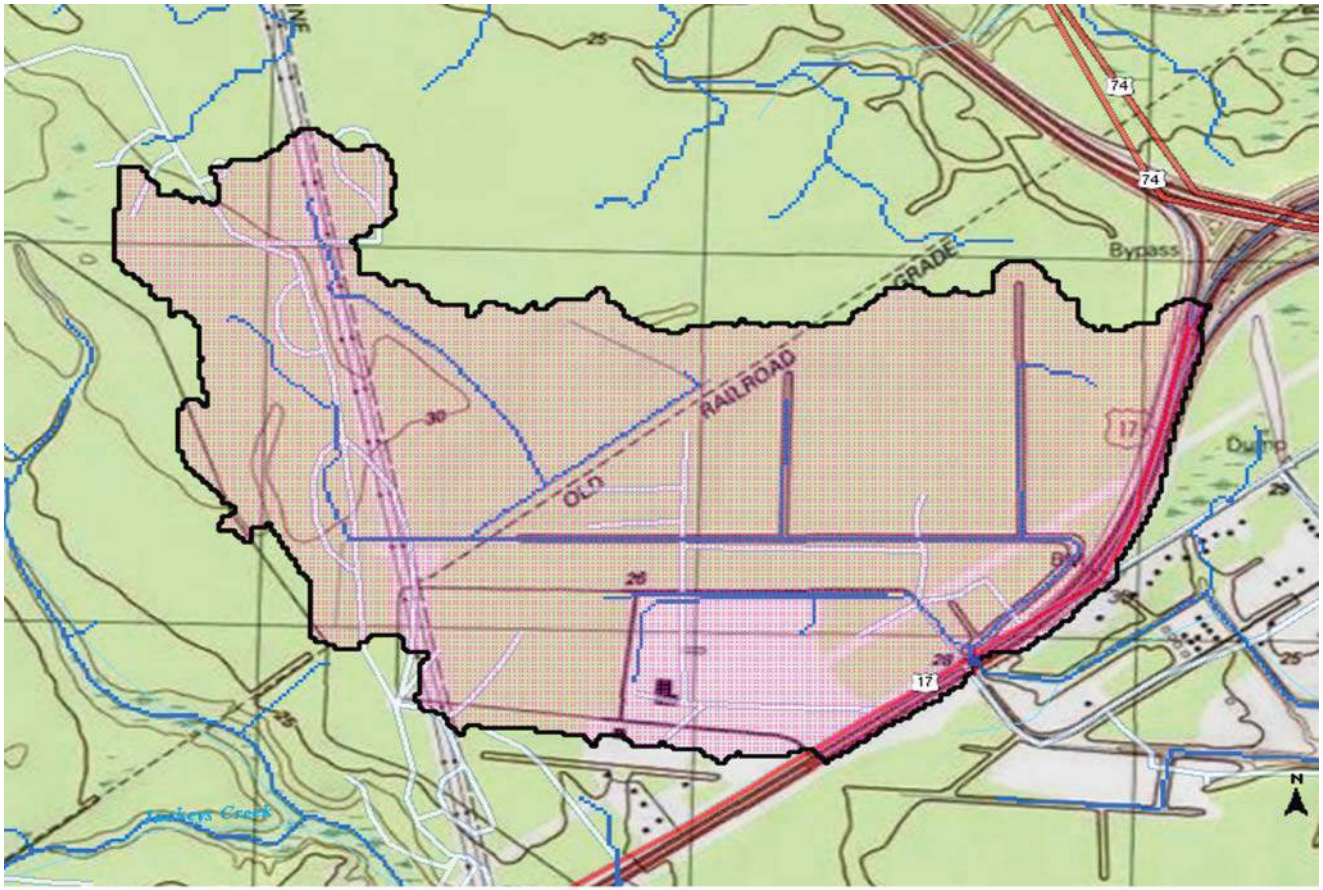
Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	440
5	$68.2 * DA^{0.655} * IA^{0.572}$	750
10	$109 * DA^{0.625} * IA^{0.515}$	950
25	$209 * DA^{0.570} * IA^{0.436}$	1,400
50	$280 * DA^{0.558} * IA^{0.396}$	1,600
100	$363 * DA^{0.547} * IA^{0.358}$	1,900
200 [4]	UQ100 / RQ100 * RQ200	2,200
500 [4]	UQ100 / RQ100 * RQ500	2,700

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

USGS
North Carolina StreamStats

U-4738

Crossing 37



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- huc poly

0.3 0.15 0 0.3 Miles

9/12/2014 11:04:16 AM

Crossing 37

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 11:31:29 Mountain Daylight Time
NAD27 Latitude: 34.2160 (34 12 58)
NAD27 Longitude: -78.0191 (-78 01 09)
NAD83 Latitude: 34.2162 (34 12 58)
NAD83 Longitude: -78.0188 (-78 01 08)

Parameter	Value
Area in square miles	0.92
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	6.58
Mean basin slope, based on slope percent grid	1.4
Percent of area covered by barren rock using 2006 NLCD	7.105
Percent of area in cultivation using 2006 NLCD	2.754
Percent of area covered by all densities of developed land using 2006 NLCD	78.615
Percent of area covered by forest using 2006 NLCD	6.658
Percent of area covered by grassland/herbaceous using 2006 NLCD	3.068
Percent impervious of basin area 2006 NLCD	24.21
Mean annual precipitation in inches	58.1
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	1.800
Percent of area hydrologic soil 'A' defined by SSURGO	37.7
Percent of area hydrologic soil 'B' defined by SSURGO	22.7
Percent of area hydrologic soil 'C' defined by SSURGO	39.6
Percent of area hydrologic soil 'D' defined by SSURGO	0
Percent of area covered by water using 2006 NLCD	0.000
Percent of area covered by wetland using 2006 NLCD	0.000

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 37

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 0.92 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	55
5	$123 * DA^{0.627}$	120
10	$174 * DA^{0.617}$	170
25	$245 * DA^{0.606}$	230
50	$309 * DA^{0.600}$	290
100	$380 * DA^{0.594}$	360
200	$447 * DA^{0.589}$	430
500	$550 * DA^{0.583}$	500

North Carolina Urban Flood-Frequency Equations [3]

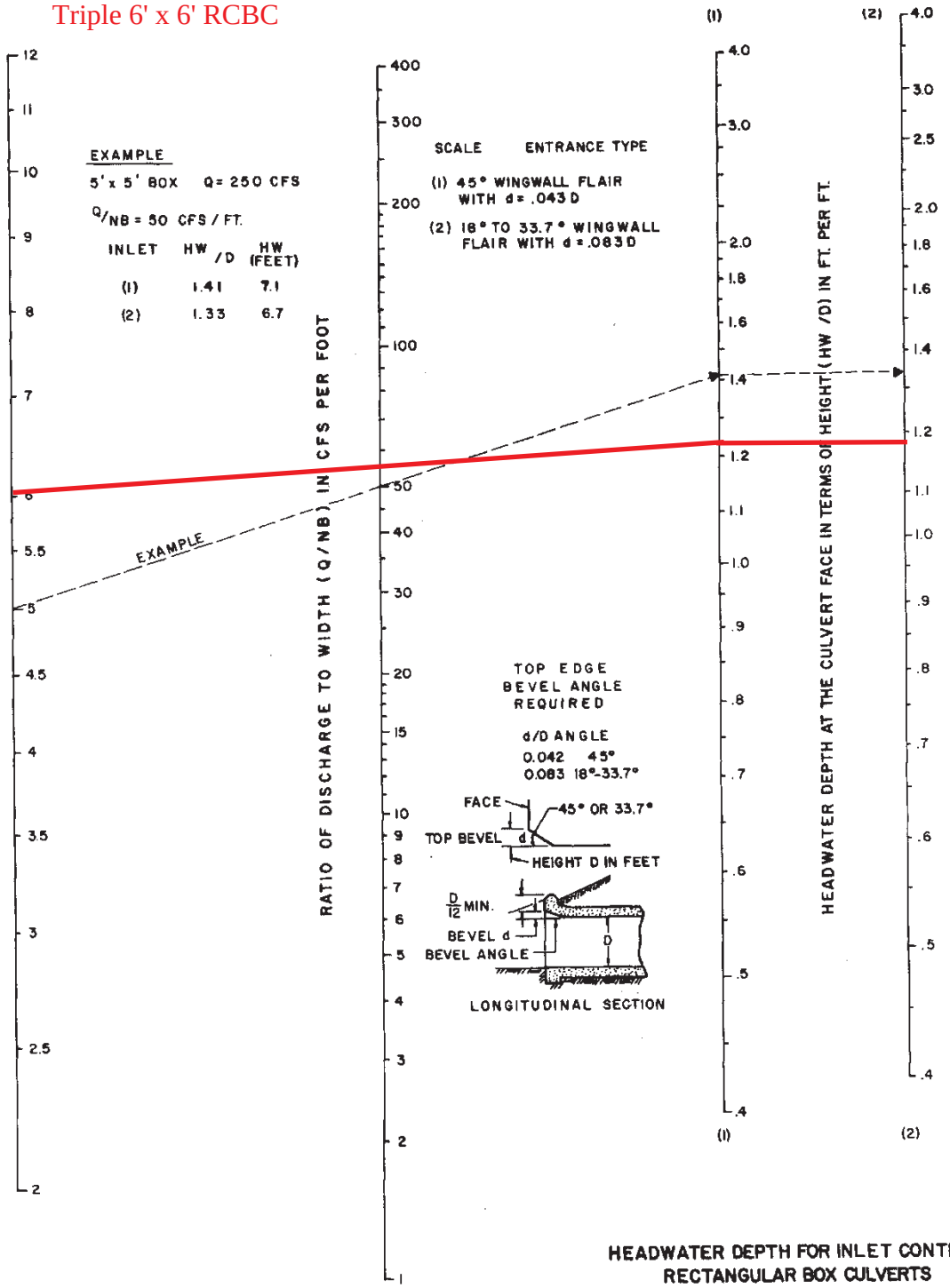
Drainage Area = 0.92 sq. mi.
Impervious Area = 31 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	270
5	$68.2 * DA^{0.655} * IA^{0.572}$	460
10	$109 * DA^{0.625} * IA^{0.515}$	600
25	$209 * DA^{0.570} * IA^{0.436}$	900
50	$280 * DA^{0.558} * IA^{0.396}$	1,000
100	$363 * DA^{0.547} * IA^{0.358}$	1,200
200 [4]	UQ100 / RQ100 * RQ200	1,400
500 [4]	UQ100 / RQ100 * RQ500	1,700

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

R-4738
Crossing 37
DA = 589 ac.
Q50 = 1000 cfs
Q/B = 55 cfs
Triple 6' x 6' RCBC

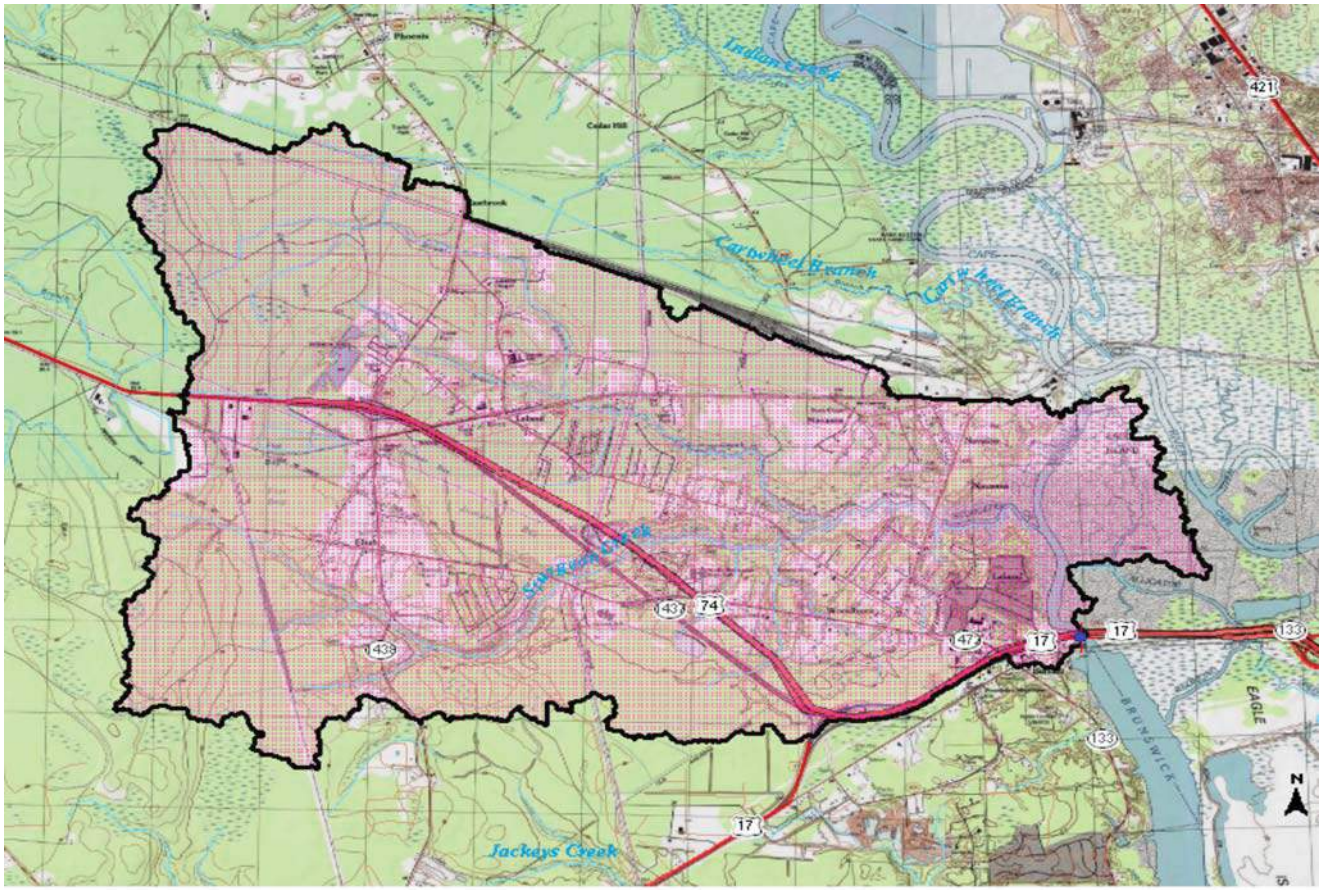
CHART 9B



HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

U-4738

Crossing 38



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

1 0.5 0 1 Miles

9/12/2014 11:06:27 AM

Crossing 38

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 11:35:19 Mountain Daylight Time
NAD27 Latitude: 34.2338 (34 14 02)
NAD27 Longitude: -77.9862 (-77 59 10)
NAD83 Latitude: 34.2340 (34 14 02)
NAD83 Longitude: -77.9859 (-77 59 09)

Parameter	Value
Area in square miles	16.5
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	32.1
Mean basin slope, based on slope percent grid	1.77
Percent of area covered by barren rock using 2006 NLCD	0.192
Percent of area in cultivation using 2006 NLCD	4.937
Percent of area covered by all densities of developed land using 2006 NLCD	27.492
Percent of area covered by forest using 2006 NLCD	25.446
Percent of area covered by grassland/herbaceous using 2006 NLCD	2.672
Percent impervious of basin area 2006 NLCD	6.91
Mean annual precipitation in inches	57.8
Percent of area of protected Federal and State owned land	0.0598
Percent of area covered by shrubland using 2006 NLCD	15.188
Percent of area hydrologic soil 'A' defined by SSURGO	44.1
Percent of area hydrologic soil 'B' defined by SSURGO	35
Percent of area hydrologic soil 'C' defined by SSURGO	8.23
Percent of area hydrologic soil 'D' defined by SSURGO	10.9
Percent of area covered by water using 2006 NLCD	1.290
Percent of area covered by wetland using 2006 NLCD	22.783

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 38

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 16.5 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	370
5	$123 * DA^{0.627}$	700
10	$174 * DA^{0.617}$	1,000
25	$245 * DA^{0.606}$	1,300
50	$309 * DA^{0.600}$	1,700
100	$380 * DA^{0.594}$	2,000
200	$447 * DA^{0.589}$	2,300
500	$550 * DA^{0.583}$	2,800

North Carolina Urban Flood-Frequency Equations [3]

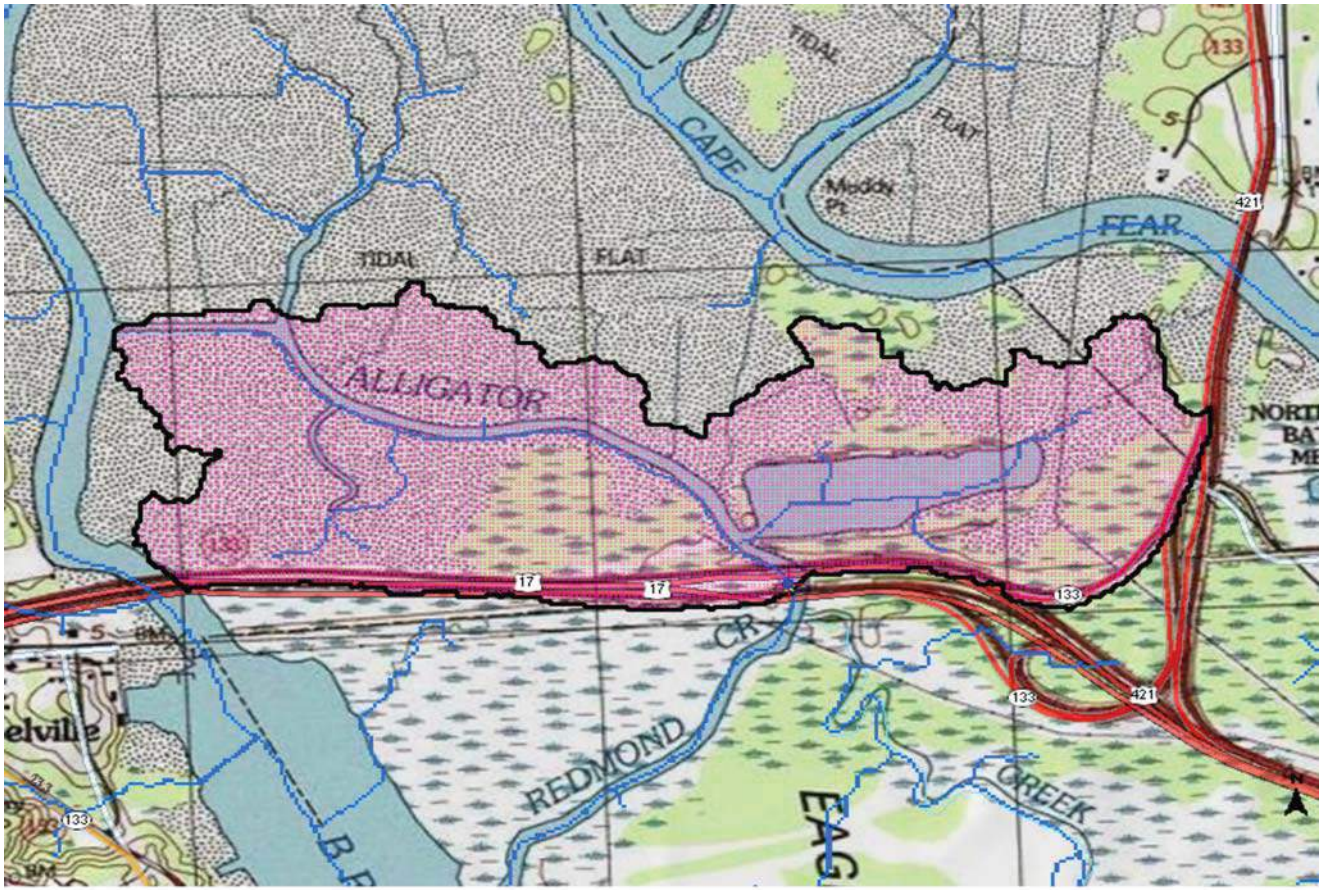
Drainage Area = 16.5 sq. mi.
Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	1,600
5	$68.2 * DA^{0.655} * IA^{0.572}$	2,400
10	$109 * DA^{0.625} * IA^{0.515}$	2,900
25	$209 * DA^{0.570} * IA^{0.436}$	3,800
50	$280 * DA^{0.558} * IA^{0.396}$	4,400
100	$363 * DA^{0.547} * IA^{0.358}$	4,900
200 [4]	UQ100 / RQ100 * RQ200	5,600
500 [4]	UQ100 / RQ100 * RQ500	6,900

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

U-4738

Crossing 39



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.3 0.15 0 0.3 Miles

9/12/2014 11:08:57 AM

Crossing 39

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 11:39:09 Mountain Daylight Time
NAD27 Latitude: 34.2341 (34 14 03)
NAD27 Longitude: -77.9696 (-77 58 11)
NAD83 Latitude: 34.2343 (34 14 03)
NAD83 Longitude: -77.9694 (-77 58 10)

Parameter	Value
Area in square miles	0.66
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	6.24
Mean basin slope, based on slope percent grid	1.2
Percent of area covered by barren rock using 2006 NLCD	0.000
Percent of area in cultivation using 2006 NLCD	0.000
Percent of area covered by all densities of developed land using 2006 NLCD	9.906
Percent of area covered by forest using 2006 NLCD	0.000
Percent of area covered by grassland/herbaceous using 2006 NLCD	0.000
Percent impervious of basin area 2006 NLCD	1.46
Mean annual precipitation in inches	58
Percent of area of protected Federal and State owned land	0.00844
Percent of area covered by shrubland using 2006 NLCD	0.249
Percent of area hydrologic soil 'A' defined by SSURGO	2.19
Percent of area hydrologic soil 'B' defined by SSURGO	0
Percent of area hydrologic soil 'C' defined by SSURGO	0
Percent of area hydrologic soil 'D' defined by SSURGO	83.3
Percent of area covered by water using 2006 NLCD	7.526
Percent of area covered by wetland using 2006 NLCD	82.320

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 39

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 0.66 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	46
5	$123 * DA^{0.627}$	95
10	$174 * DA^{0.617}$	130
25	$245 * DA^{0.606}$	190
50	$309 * DA^{0.600}$	240
100	$380 * DA^{0.594}$	300
200	$447 * DA^{0.589}$	350
500	$550 * DA^{0.583}$	430

North Carolina Urban Flood-Frequency Equations [3]

Drainage Area = 0.66 sq. mi.
Impervious Area = 20 % (greater than 10%)

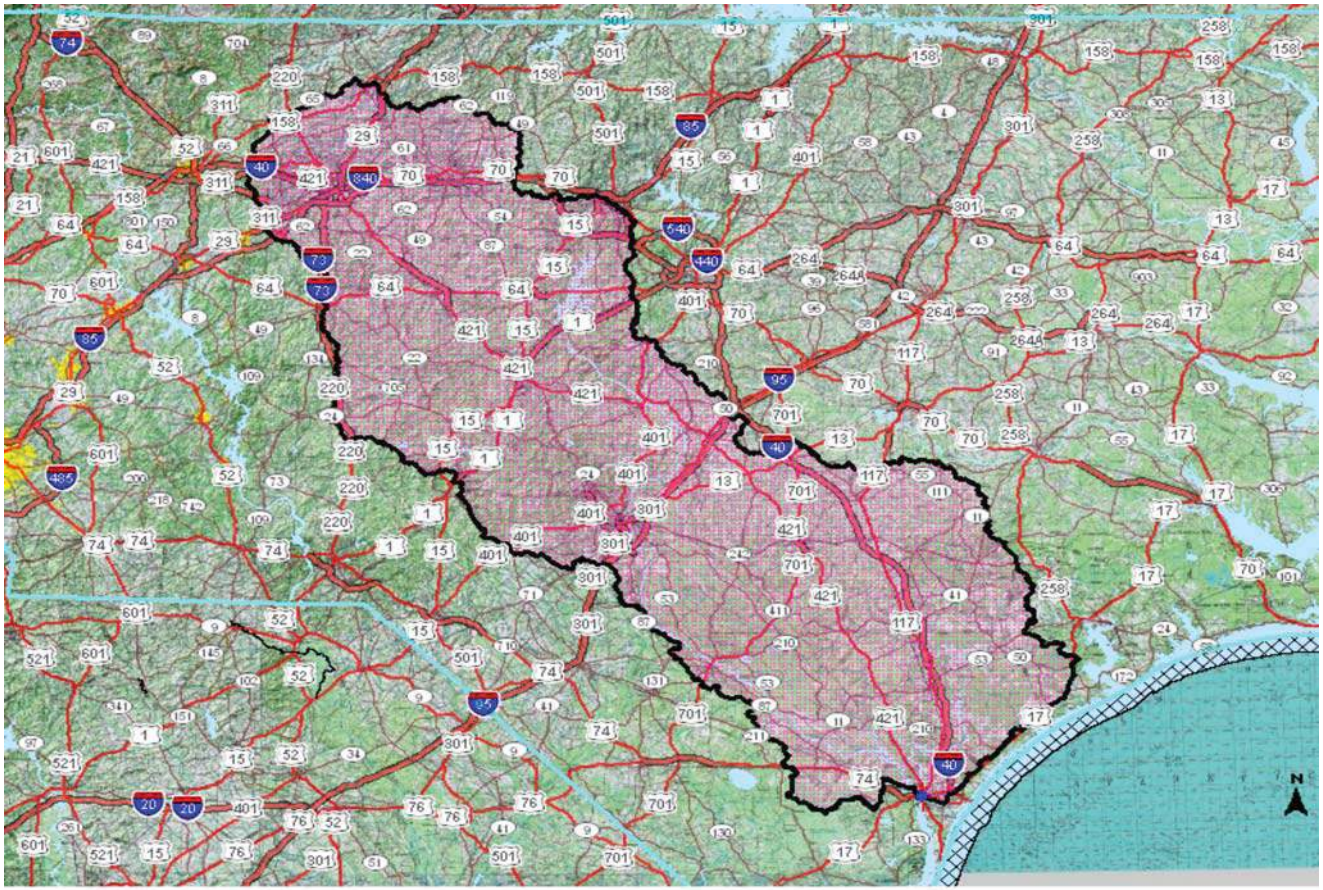
Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	160
5	$68.2 * DA^{0.655} * IA^{0.572}$	290
10	$109 * DA^{0.625} * IA^{0.515}$	390
25	$209 * DA^{0.570} * IA^{0.436}$	600
50	$280 * DA^{0.558} * IA^{0.396}$	750
100	$363 * DA^{0.547} * IA^{0.358}$	850
200 [4]	UQ100 / RQ100 * RQ200	1,000
500 [4]	UQ100 / RQ100 * RQ500	1,200

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

USGS
North Carolina StreamStats

U-4738

Crossing 40



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

40 20 0 40 Miles

9/12/2014 11:11:59 AM

Crossing 40

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 11:49:26 Mountain Daylight Time
NAD27 Latitude: 34.2274 (34 13 39)
NAD27 Longitude: -77.9523 (-77 57 08)
NAD83 Latitude: 34.2276 (34 13 39)
NAD83 Longitude: -77.9520 (-77 57 07)

Parameter	Value
Area in square miles	8810
Percent of area covered by hydrologic region 1	38.188
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	8.812
Percent of area covered by hydrologic region 4	53.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	1060
Mean basin slope, based on slope percent grid	4.33
Percent of area covered by barren rock using 2006 NLCD	0.357
Percent of area in cultivation using 2006 NLCD	23.098
Percent of area covered by all densities of developed land using 2006 NLCD	10.679
Percent of area covered by forest using 2006 NLCD	37.461
Percent of area covered by grassland/herbaceous using 2006 NLCD	5.262
Percent impervious of basin area 2006 NLCD	2.44
Mean annual precipitation in inches	49.3
Percent of area of protected Federal and State owned land	5.71
Percent of area covered by shrubland using 2006 NLCD	7.638
Percent of area hydrologic soil 'A' defined by SSURGO	13.7
Percent of area hydrologic soil 'B' defined by SSURGO	48.2
Percent of area hydrologic soil 'C' defined by SSURGO	24.8
Percent of area hydrologic soil 'D' defined by SSURGO	11.4
Percent of area covered by water using 2006 NLCD	1.302
Percent of area covered by wetland using 2006 NLCD	14.203

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 40

Total Drainage Area = 8850 sq. mi.
Impervious Area = 20 %

Recurrence Interval (years)	Total Q (cfs)
2	170,000
5	170,000
10	180,000
25	170,000
50	180,000
100	190,000
200	210,000
500	240,000

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 40a (Region 4)

North Carolina Urban Flood-Frequency Equations [3]

Drainage Area = 8810 sq. mi.

Impervious Area = 20.0 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	150,000
5	$68.2 * DA^{0.655} * IA^{0.572}$	150,000
10	$109 * DA^{0.625} * IA^{0.515}$	150,000
25	$209 * DA^{0.570} * IA^{0.436}$	140,000
50	$280 * DA^{0.558} * IA^{0.396}$	150,000
100	$363 * DA^{0.547} * IA^{0.358}$	150,000
200 [4]	UQ100 / RQ100 * RQ200	170,000
500 [4]	UQ100 / RQ100 * RQ500	200,000

3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.

4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 40b (Region 3)

North Carolina Urban Flood-Frequency Equations [3]

Drainage Area = 8810 sq. mi.

Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$21 * DA^{0.752} * IA^{0.686}$	150,000
5	$49.6 * DA^{0.700} * IA^{0.572}$	160,000
10	$75.6 * DA^{0.677} * IA^{0.515}$	170,000
25	$128 * DA^{0.644} * IA^{0.436}$	160,000
50	$170 * DA^{0.637} * IA^{0.396}$	180,000
100	$217 * DA^{0.630} * IA^{0.358}$	190,000
200 [4]	UQ100 / RQ100 * RQ200	220,000
500 [4]	UQ100 / RQ100 * RQ500	250,000

3. Robbins, J.C., and Pope, B.F., 1996, Estimation of Flood-Frequency Characteristics of Small Urban Streams in North Carolina: U.S. Geological Survey Water-Resources Investigations Report 96-4084.

4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 40c (Region 2)

North Carolina Urban Flood-Frequency Equations [3]

Drainage Area = 8810 sq. mi.

Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$33.3 * DA^{0.739} * IA^{0.686}$	210,000
5	$78.9 * DA^{0.681} * IA^{0.572}$	210,000
10	$122 * DA^{0.655} * IA^{0.515}$	220,000
25	$228 * DA^{0.611} * IA^{0.436}$	220,000
50	$296 * DA^{0.602} * IA^{0.396}$	230,000
100	$374 * DA^{0.593} * IA^{0.358}$	240,000
200 [4]	UQ100 / RQ100 * RQ200	270,000
500 [4]	UQ100 / RQ100 * RQ500	300,000

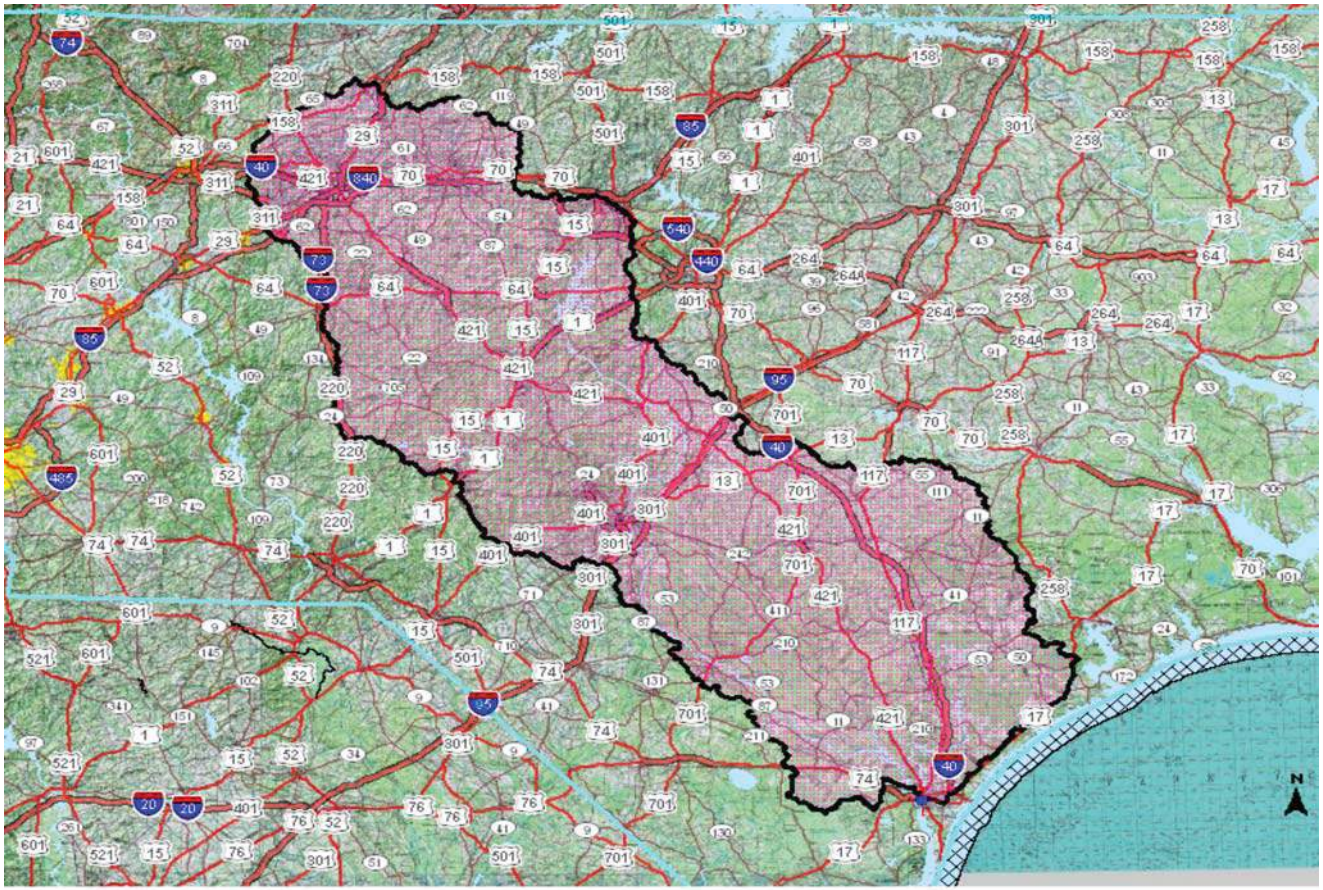
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.

4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

USGS
North Carolina StreamStats

U-4738

Crossing 41



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

40 20 0 40 Miles

9/12/2014 11:26:03 AM

Crossing 41

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 11:57:18 Mountain Daylight Time
NAD27 Latitude: 34.2170 (34 13 01)
NAD27 Longitude: -77.9550 (-77 57 18)
NAD83 Latitude: 34.2172 (34 13 02)
NAD83 Longitude: -77.9547 (-77 57 17)

Parameter	Value
Area in square miles	8810
Percent of area covered by hydrologic region 1	38.186
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	8.811
Percent of area covered by hydrologic region 4	53.003
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	1060
Mean basin slope, based on slope percent grid	4.33
Percent of area covered by barren rock using 2006 NLCD	0.357
Percent of area in cultivation using 2006 NLCD	23.097
Percent of area covered by all densities of developed land using 2006 NLCD	10.683
Percent of area covered by forest using 2006 NLCD	37.458
Percent of area covered by grassland/herbaceous using 2006 NLCD	5.261
Percent impervious of basin area 2006 NLCD	2.45
Mean annual precipitation in inches	49.3
Percent of area of protected Federal and State owned land	5.71
Percent of area covered by shrubland using 2006 NLCD	7.637
Percent of area hydrologic soil 'A' defined by SSURGO	13.7
Percent of area hydrologic soil 'B' defined by SSURGO	48.2
Percent of area hydrologic soil 'C' defined by SSURGO	24.8
Percent of area hydrologic soil 'D' defined by SSURGO	11.4
Percent of area covered by water using 2006 NLCD	1.304
Percent of area covered by wetland using 2006 NLCD	14.203

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 41

Total Drainage Area = 8850 sq. mi.
Impervious Area = 20 %

Recurrence Interval (years)	Total Q (cfs)
2	170,000
5	170,000
10	180,000
25	170,000
50	180,000
100	190,000
200	210,000
500	240,000

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 41a (Region 4)

North Carolina Urban Flood-Frequency Equations [3]

Drainage Area = 8810 sq. mi.

Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	150,000
5	$68.2 * DA^{0.655} * IA^{0.572}$	150,000
10	$109 * DA^{0.625} * IA^{0.515}$	150,000
25	$209 * DA^{0.570} * IA^{0.436}$	140,000
50	$280 * DA^{0.558} * IA^{0.396}$	150,000
100	$363 * DA^{0.547} * IA^{0.358}$	150,000
200 [4]	UQ100 / RQ100 * RQ200	170,000
500 [4]	UQ100 / RQ100 * RQ500	200,000

3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.

4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 41b (Region 3)

North Carolina Urban Flood-Frequency Equations [3]

Drainage Area = 8810 sq. mi.

Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$21 * DA^{0.752} * IA^{0.686}$	150,000
5	$49.6 * DA^{0.700} * IA^{0.572}$	160,000
10	$75.6 * DA^{0.677} * IA^{0.515}$	170,000
25	$128 * DA^{0.644} * IA^{0.436}$	160,000
50	$170 * DA^{0.637} * IA^{0.396}$	180,000
100	$217 * DA^{0.630} * IA^{0.358}$	190,000
200 [4]	UQ100 / RQ100 * RQ200	220,000
500 [4]	UQ100 / RQ100 * RQ500	250,000

3. Robbins, J.C., and Pope, B.F., 1996, Estimation of Flood-Frequency Characteristics of Small Urban Streams in North Carolina: U.S. Geological Survey Water-Resources Investigations Report 96-4084.

4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 41c (Region 1)

North Carolina Urban Flood-Frequency Equations [3]

Drainage Area = 8810 sq. mi.

Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$33.3 * DA^{0.739} * IA^{0.686}$	210,000
5	$78.9 * DA^{0.681} * IA^{0.572}$	210,000
10	$122 * DA^{0.655} * IA^{0.515}$	220,000
25	$228 * DA^{0.611} * IA^{0.436}$	220,000
50	$296 * DA^{0.602} * IA^{0.396}$	230,000
100	$374 * DA^{0.593} * IA^{0.358}$	240,000
200 [4]	UQ100 / RQ100 * RQ200	270,000
500 [4]	UQ100 / RQ100 * RQ500	300,000

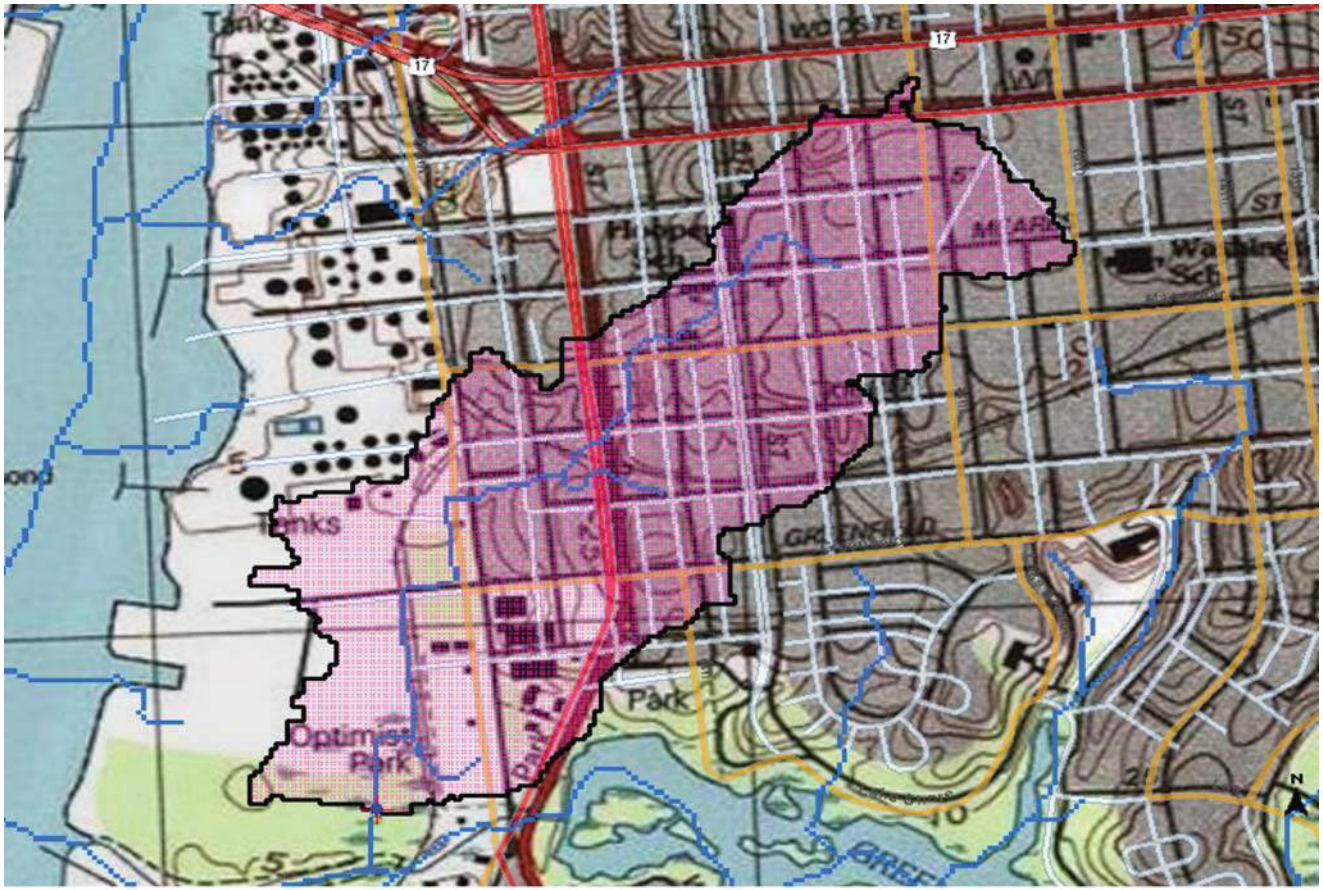
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.

4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

USGS
North Carolina StreamStats

U-4738

Crossing 42



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.2 0.1 0 0.2 Miles

9/12/2014 11:35:53 AM

Crossing 42

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 12:04:30 Mountain Daylight Time
NAD27 Latitude: 34.2124 (34 12 45)
NAD27 Longitude: -77.9484 (-77 56 54)
NAD83 Latitude: 34.2126 (34 12 45)
NAD83 Longitude: -77.9481 (-77 56 53)

Parameter	Value
Area in square miles	0.31
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	4.24
Mean basin slope, based on slope percent grid	2.36
Percent of area covered by barren rock using 2006 NLCD	0.000
Percent of area in cultivation using 2006 NLCD	1.937
Percent of area covered by all densities of developed land using 2006 NLCD	88.304
Percent of area covered by forest using 2006 NLCD	0.694
Percent of area covered by grassland/herbaceous using 2006 NLCD	0.000
Percent impervious of basin area 2006 NLCD	37.35
Mean annual precipitation in inches	57.9
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	4.009
Percent of area hydrologic soil 'A' defined by SSURGO	41.3
Percent of area hydrologic soil 'B' defined by SSURGO	18.3
Percent of area hydrologic soil 'C' defined by SSURGO	0
Percent of area hydrologic soil 'D' defined by SSURGO	7.41
Percent of area covered by water using 2006 NLCD	0.000
Percent of area covered by wetland using 2006 NLCD	5.055

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 42

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 0.31 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	28
5	$123 * DA^{0.627}$	60
10	$174 * DA^{0.617}$	85
25	$245 * DA^{0.606}$	120
50	$309 * DA^{0.600}$	150
100	$380 * DA^{0.594}$	190
200	$447 * DA^{0.589}$	220
500	$550 * DA^{0.583}$	280

North Carolina Urban Flood-Frequency Equations [3]

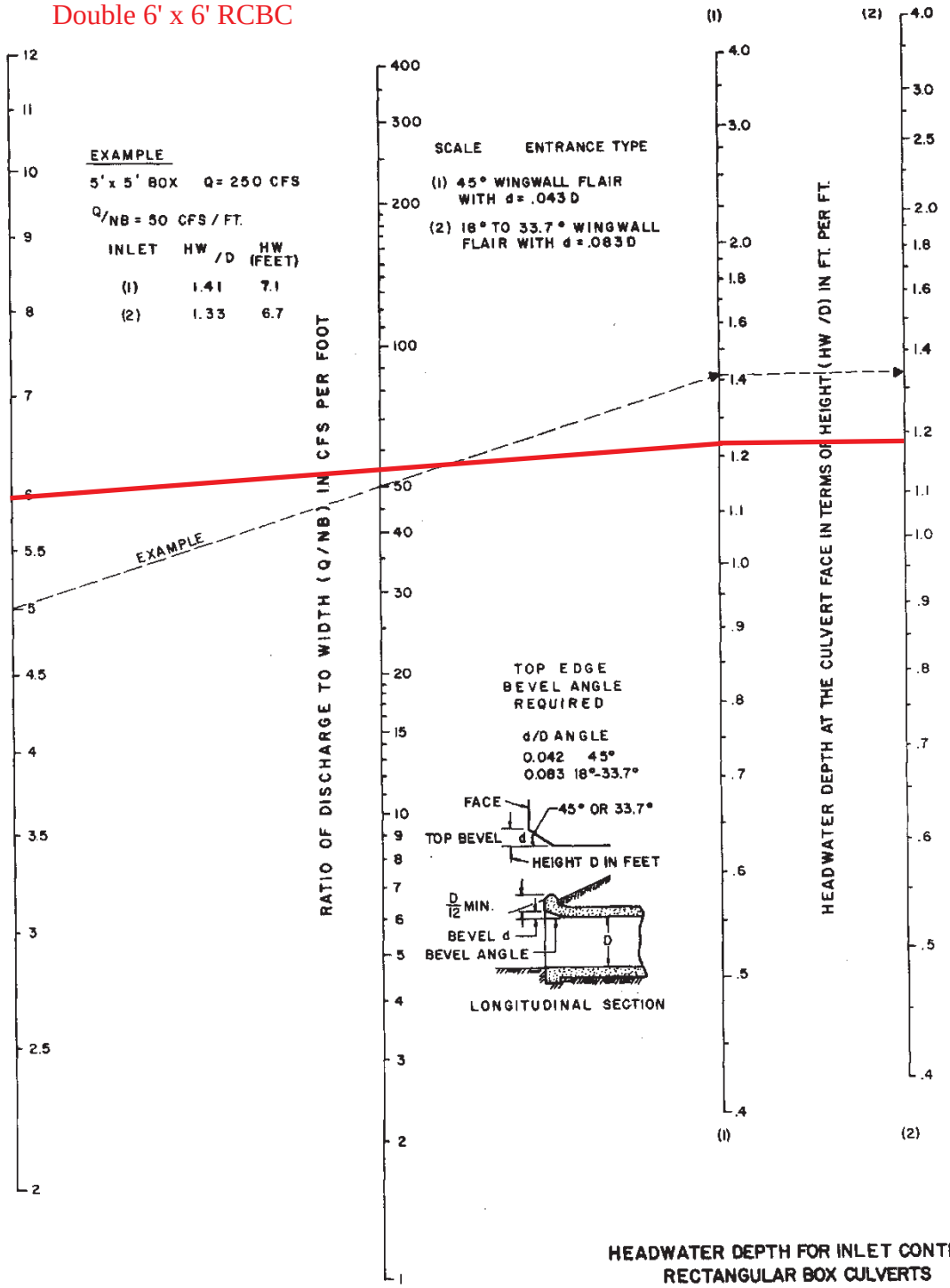
Drainage Area = 0.31 sq. mi.
Impervious Area = 40 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	150
5	$68.2 * DA^{0.655} * IA^{0.572}$	260
10	$109 * DA^{0.625} * IA^{0.515}$	350
25	$209 * DA^{0.570} * IA^{0.436}$	550
50	$280 * DA^{0.558} * IA^{0.396}$	650
100	$363 * DA^{0.547} * IA^{0.358}$	700
200 [4]	UQ100 / RQ100 * RQ200	800
500 [4]	UQ100 / RQ100 * RQ500	1,000

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

R-4738
Crossing 42
DA = 198 ac.
Q50 = 650 cfs
Q/B = 55 cfs
Double 6' x 6' RCBC

CHART 9B

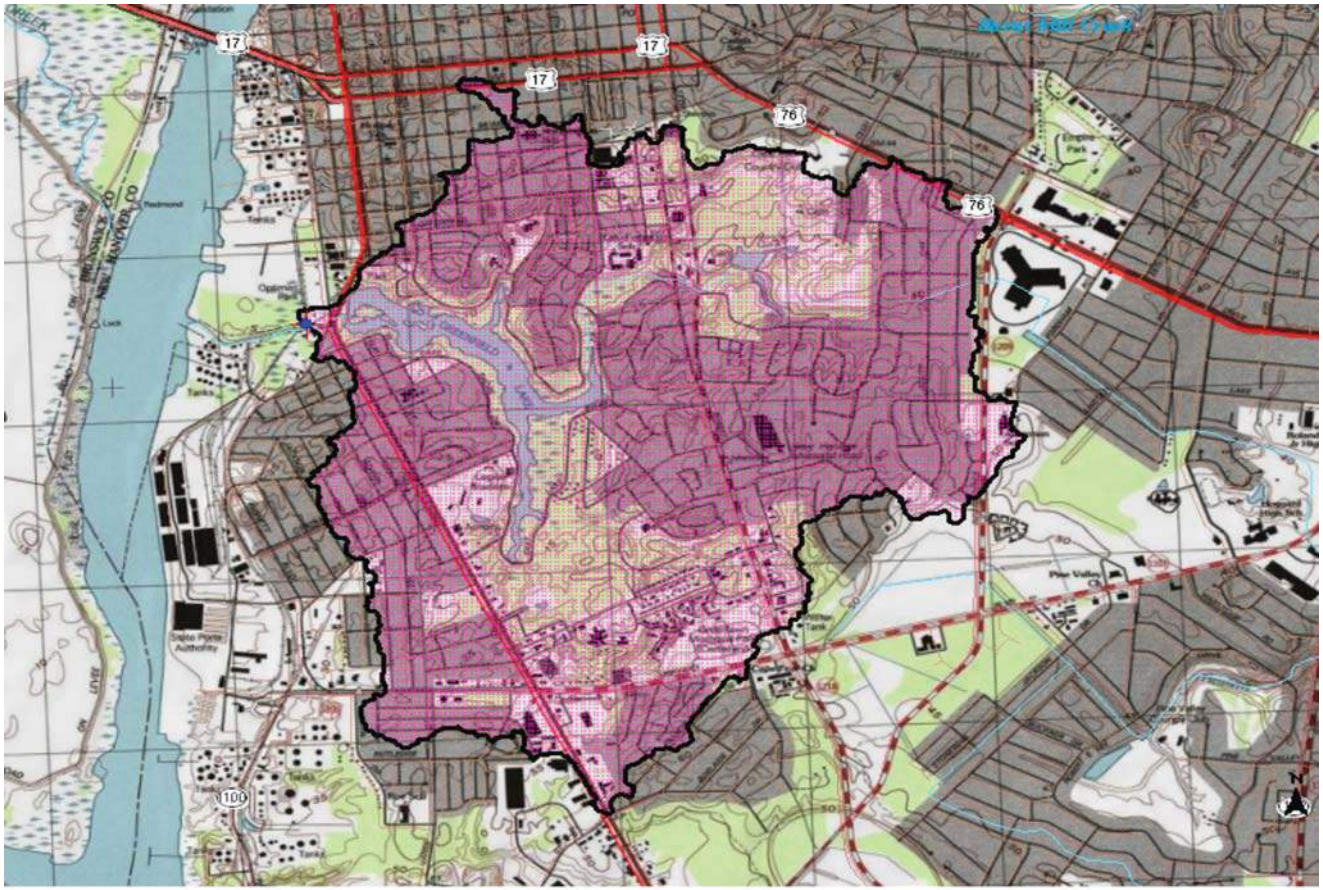


HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

USGS
North Carolina StreamStats

U-4738

Crossing 43



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.7 0.35 0 0.7 Miles

9/12/2014 11:38:54 AM

Crossing 43

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 12:08:13 Mountain Daylight Time
NAD27 Latitude: 34.2117 (34 12 42)
NAD27 Longitude: -77.9473 (-77 56 50)
NAD83 Latitude: 34.2119 (34 12 43)
NAD83 Longitude: -77.9470 (-77 56 49)

Parameter	Value
Area in square miles	3.95
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	14.8
Mean basin slope, based on slope percent grid	2.48
Percent of area covered by barren rock using 2006 NLCD	0.130
Percent of area in cultivation using 2006 NLCD	0.718
Percent of area covered by all densities of developed land using 2006 NLCD	84.726
Percent of area covered by forest using 2006 NLCD	5.892
Percent of area covered by grassland/herbaceous using 2006 NLCD	0.211
Percent impervious of basin area 2006 NLCD	29.33
Mean annual precipitation in inches	58
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	1.817
Percent of area hydrologic soil 'A' defined by SSURGO	63
Percent of area hydrologic soil 'B' defined by SSURGO	20.7
Percent of area hydrologic soil 'C' defined by SSURGO	0.32
Percent of area hydrologic soil 'D' defined by SSURGO	2.77
Percent of area covered by water using 2006 NLCD	3.907
Percent of area covered by wetland using 2006 NLCD	2.599

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 43

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 3.95 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	150
5	$123 * DA^{0.627}$	290
10	$174 * DA^{0.617}$	410
25	$245 * DA^{0.606}$	550
50	$309 * DA^{0.600}$	700
100	$380 * DA^{0.594}$	850
200	$447 * DA^{0.589}$	1,000
500	$550 * DA^{0.583}$	1,200

North Carolina Urban Flood-Frequency Equations [3]

Drainage Area = 3.95 sq. mi.
Impervious Area = 30 % (greater than 10%)

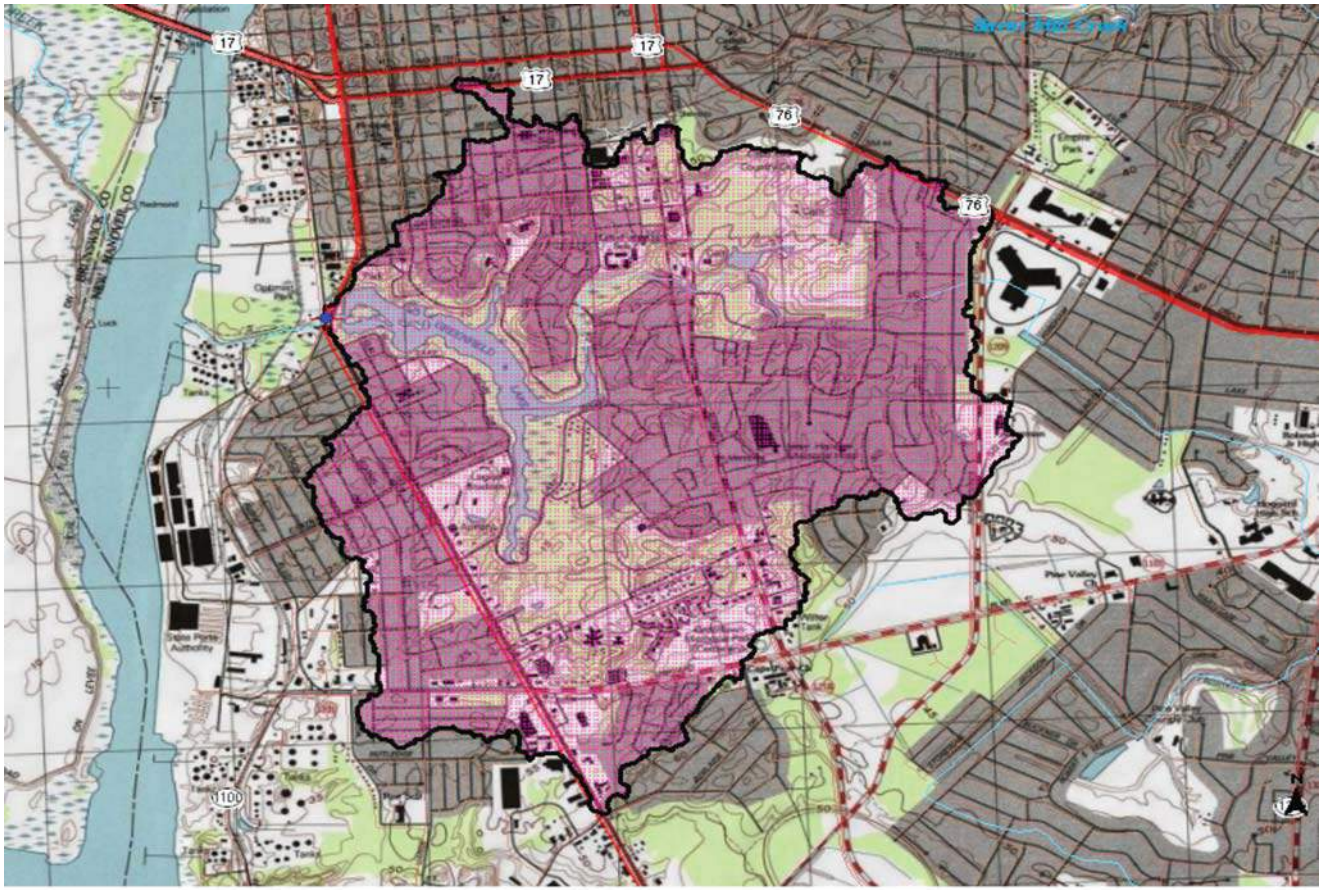
Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	750
5	$68.2 * DA^{0.655} * IA^{0.572}$	1,200
10	$109 * DA^{0.625} * IA^{0.515}$	1,500
25	$209 * DA^{0.570} * IA^{0.436}$	2,000
50	$280 * DA^{0.558} * IA^{0.396}$	2,300
100	$363 * DA^{0.547} * IA^{0.358}$	2,600
200 [4]	UQ100 / RQ100 * RQ200	3,100
500 [4]	UQ100 / RQ100 * RQ500	3,700

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

USGS
North Carolina StreamStats

U-4738

Crossing 44



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.7 0.35 0 0.7 Miles

9/12/2014 11:43:48 AM

Crossing 44

USGS North Carolina StreamStats

Basin Characteristics Report

Date: Wed Sep 10 2014 12:10:59 Mountain Daylight Time
NAD27 Latitude: 34.2120 (34 12 43)
NAD27 Longitude: -77.9459 (-77 56 45)
NAD83 Latitude: 34.2122 (34 12 44)
NAD83 Longitude: -77.9456 (-77 56 44)

Parameter	Value
Area in square miles	3.92
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	14.6
Mean basin slope, based on slope percent grid	2.48
Percent of area covered by barren rock using 2006 NLCD	0.131
Percent of area in cultivation using 2006 NLCD	0.723
Percent of area covered by all densities of developed land using 2006 NLCD	84.627
Percent of area covered by forest using 2006 NLCD	5.934
Percent of area covered by grassland/herbaceous using 2006 NLCD	0.213
Percent impervious of basin area 2006 NLCD	29.16
Mean annual precipitation in inches	58
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	1.830
Percent of area hydrologic soil 'A' defined by SSURGO	63.1
Percent of area hydrologic soil 'B' defined by SSURGO	20.8
Percent of area hydrologic soil 'C' defined by SSURGO	0.33
Percent of area hydrologic soil 'D' defined by SSURGO	2.75
Percent of area covered by water using 2006 NLCD	3.935
Percent of area covered by wetland using 2006 NLCD	2.609

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 44

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 3.92 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	150
5	$123 * DA^{0.627}$	290
10	$174 * DA^{0.617}$	400
25	$245 * DA^{0.606}$	550
50	$309 * DA^{0.600}$	700
100	$380 * DA^{0.594}$	850
200	$447 * DA^{0.589}$	1,000
500	$550 * DA^{0.583}$	1,200

North Carolina Urban Flood-Frequency Equations [3]

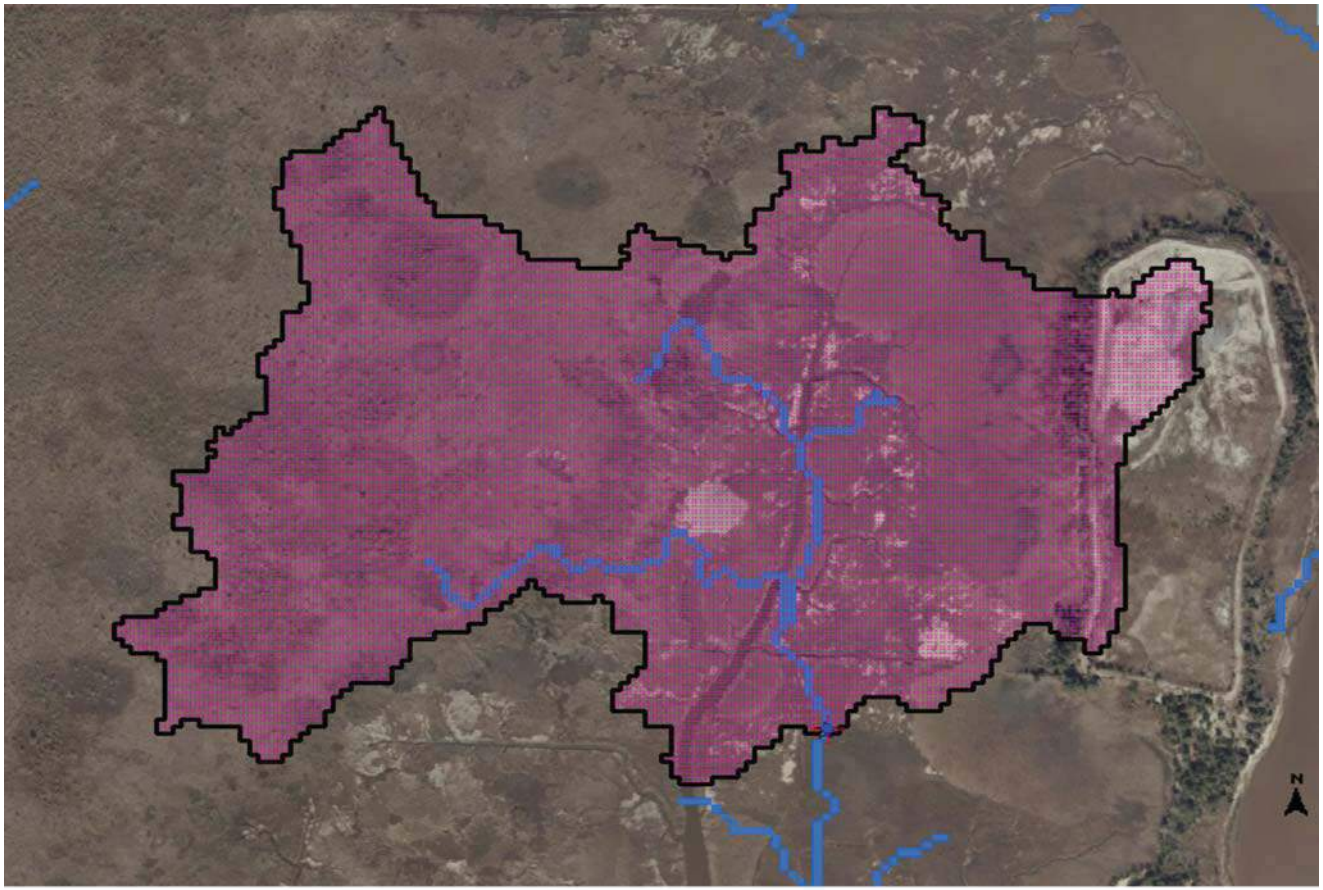
Drainage Area = 3.92 sq. mi.
Impervious Area = 30 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	750
5	$68.2 * DA^{0.655} * IA^{0.572}$	1,200
10	$109 * DA^{0.625} * IA^{0.515}$	1,500
25	$209 * DA^{0.570} * IA^{0.436}$	2,000
50	$280 * DA^{0.558} * IA^{0.396}$	2,300
100	$363 * DA^{0.547} * IA^{0.358}$	2,600
200 [4]	UQ100 / RQ100 * RQ200	3,100
500 [4]	UQ100 / RQ100 * RQ500	3,700

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

U-4738

Crossing 45



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.1 0.05 0 0.1 Miles

5/22/2015 10:01:10 AM

USGS
North Carolina StreamStats

Basin Characteristics Report

Date: Fri May 22 2015 09:59:39 Mountain Daylight Time
NAD27 Latitude: 34.1726 (34 10 21)
NAD27 Longitude: -77.9681 (-77 58 05)
NAD83 Latitude: 34.1728 (34 10 22)
NAD83 Longitude: -77.9678 (-77 58 04)

Parameter	Value
Area in square miles	0.23
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	3.68
Mean basin slope, based on slope percent grid	0.94
Percent of area covered by barren rock using 2006 NLCD	3.792
Percent of area in cultivation using 2006 NLCD	0.000
Percent of area covered by all densities of developed land using 2006 NLCD	0.000
Percent of area covered by forest using 2006 NLCD	0.000
Percent of area covered by grassland/herbaceous using 2006 NLCD	0.000
Percent impervious of basin area 2006 NLCD	0.00
Mean annual precipitation in inches	58.4
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	3.384
Percent of area hydrologic soil 'A' defined by SSURGO	4.09
Percent of area hydrologic soil 'B' defined by SSURGO	0
Percent of area hydrologic soil 'C' defined by SSURGO	0
Percent of area hydrologic soil 'D' defined by SSURGO	90.9
Percent of area covered by water using 2006 NLCD	0.000
Percent of area covered by wetland using 2006 NLCD	92.824

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 45

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 0.23 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	23
5	$123 * DA^{0.627}$	49
10	$174 * DA^{0.617}$	70
25	$245 * DA^{0.606}$	100
50	$309 * DA^{0.600}$	130
100	$380 * DA^{0.594}$	160
200	$447 * DA^{0.589}$	190
500	$550 * DA^{0.583}$	230

North Carolina Urban Flood-Frequency Equations [3]

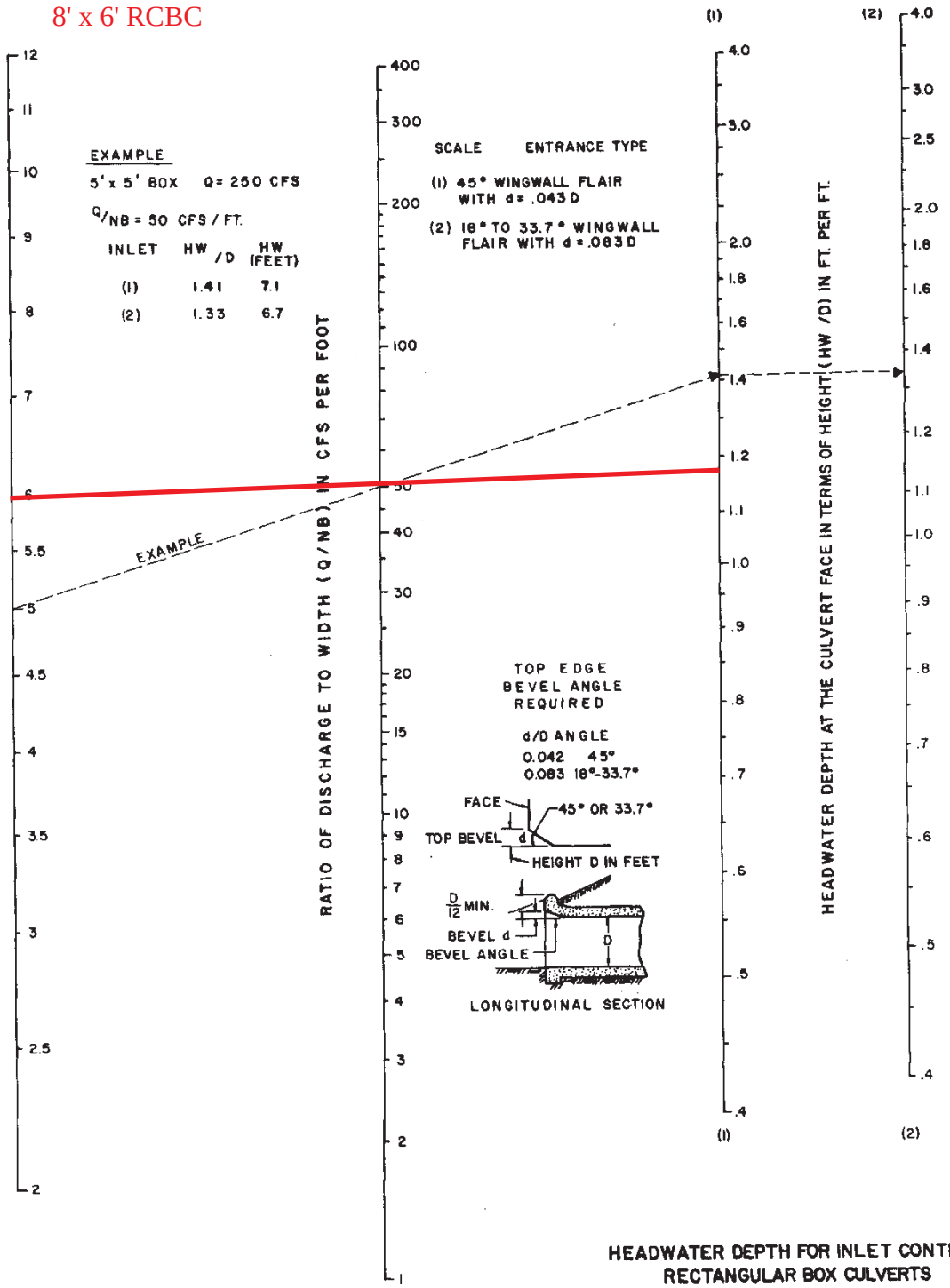
Drainage Area = 0.23 sq. mi.
Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	75
5	$68.2 * DA^{0.655} * IA^{0.572}$	140
10	$109 * DA^{0.625} * IA^{0.515}$	200
25	$209 * DA^{0.570} * IA^{0.436}$	330
50	$280 * DA^{0.558} * IA^{0.396}$	400
100	$363 * DA^{0.547} * IA^{0.358}$	470
200 [4]	UQ100 / RQ100 * RQ200	550
500 [4]	UQ100 / RQ100 * RQ500	700

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

R-4738
Crossing 45
DA = 147 ac.
Q50 = 400 cfs
Q/B = 50 cfs
8' x 6' RCBC

CHART 9B

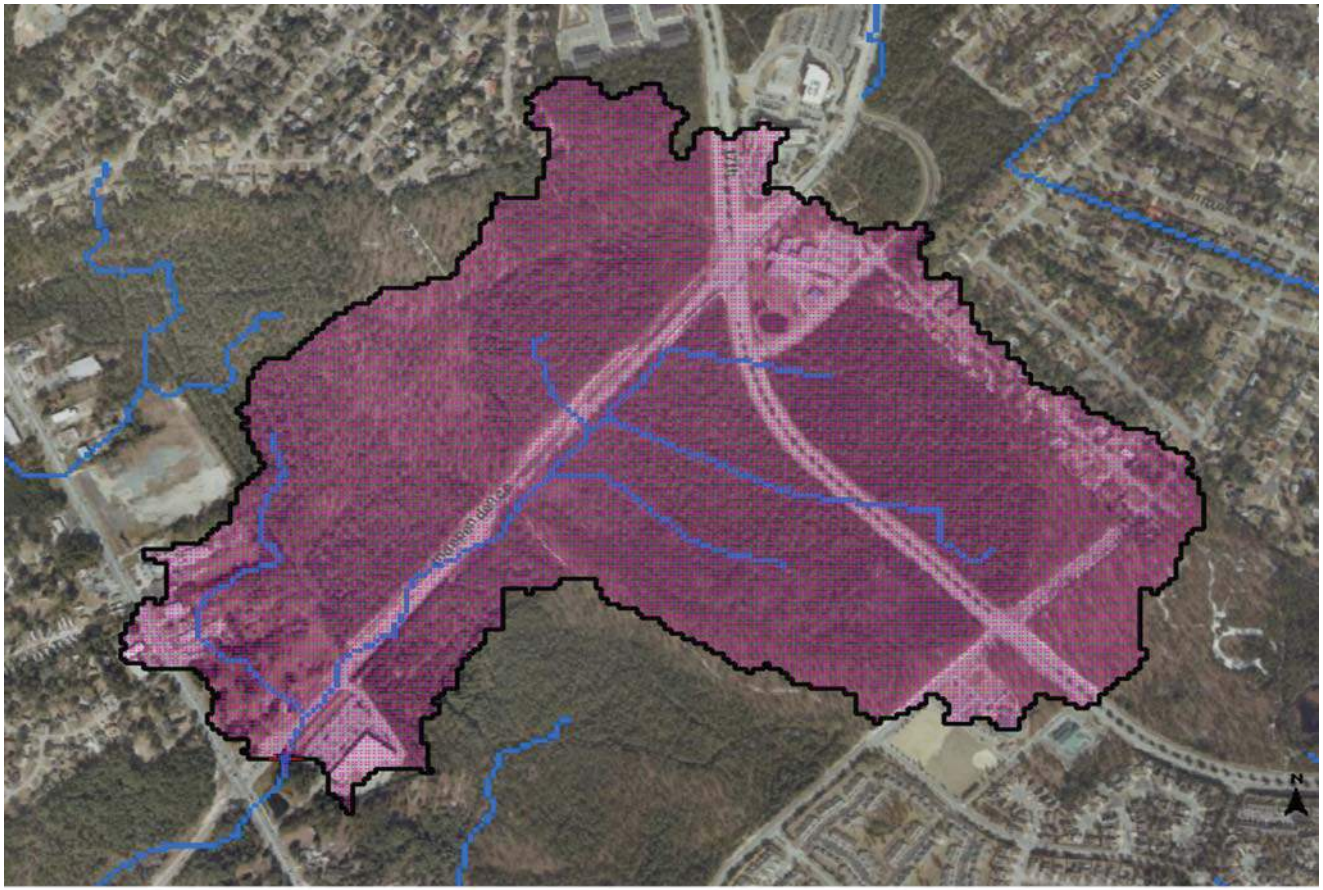


HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

USGS
North Carolina StreamStats

U-4738

Crossing 46



Explanation

- GlobalWatershedPoint
- Slp1085Point
- NCDOT Points
- LocalGages
- Gaging Station, Continuous Record
- Low Flow, Partial Record
- Peak Flow, Partial Record
- Peak and Low Flow, Partial Record
- Stage Only
- Low Flow, Partial Record, Stage
- Miscellaneous Record
- Unknown
- LocalNHD2
- LongestFlowpath3D
- Stream Grid
- GlobalWatershed
- Pilot Study Area
- hucpoly

0.2 0.1 0 0.2 Miles

6/1/2015 1:00:16 PM

USGS
North Carolina StreamStats

Basin Characteristics Report

Date: Mon Jun 1 2015 13:02:38 Mountain Daylight Time
NAD27 Latitude: 34.1759 (34 10 33)
NAD27 Longitude: -77.9248 (-77 55 29)
NAD83 Latitude: 34.1761 (34 10 34)
NAD83 Longitude: -77.9245 (-77 55 28)

Parameter	Value
Area in square miles	0.47
Percent of area covered by hydrologic region 1	0.000
Percent of area covered by hydrologic region 2	0.000
Percent of area covered by hydrologic region 3	0.000
Percent of area covered by hydrologic region 4	100.000
Percent of area covered by hydrologic region 5	0.000
Perimeter in miles	4.93
Mean basin slope, based on slope percent grid	1.73
Percent of area covered by barren rock using 2006 NLCD	0.000
Percent of area in cultivation using 2006 NLCD	0.000
Percent of area covered by all densities of developed land using 2006 NLCD	33.289
Percent of area covered by forest using 2006 NLCD	33.622
Percent of area covered by grassland/herbaceous using 2006 NLCD	0.929
Percent impervious of basin area 2006 NLCD	10.77
Mean annual precipitation in inches	58.2
Percent of area of protected Federal and State owned land	0
Percent of area covered by shrubland using 2006 NLCD	12.231
Percent of area hydrologic soil 'A' defined by SSURGO	66.1
Percent of area hydrologic soil 'B' defined by SSURGO	33.9
Percent of area hydrologic soil 'C' defined by SSURGO	0
Percent of area hydrologic soil 'D' defined by SSURGO	0
Percent of area covered by water using 2006 NLCD	0.000
Percent of area covered by wetland using 2006 NLCD	19.928

USGS Flood-Frequency Equations

Project Name:	U-4738 Cape Fear Crossing

CROSSING 46

North Carolina Rural Flood-Frequency Equations [1,2]

Drainage Area = 0.47 sq. mi.

Rural Flood-Recurrence Interval (years)	Region 4 - Coastal Plain	RQ (cfs)
2	$60.3 * DA^{0.649}$	37
5	$123 * DA^{0.627}$	75
10	$174 * DA^{0.617}$	110
25	$245 * DA^{0.606}$	160
50	$309 * DA^{0.600}$	200
100	$380 * DA^{0.594}$	240
200	$447 * DA^{0.589}$	290
500	$550 * DA^{0.583}$	350

North Carolina Urban Flood-Frequency Equations [3]

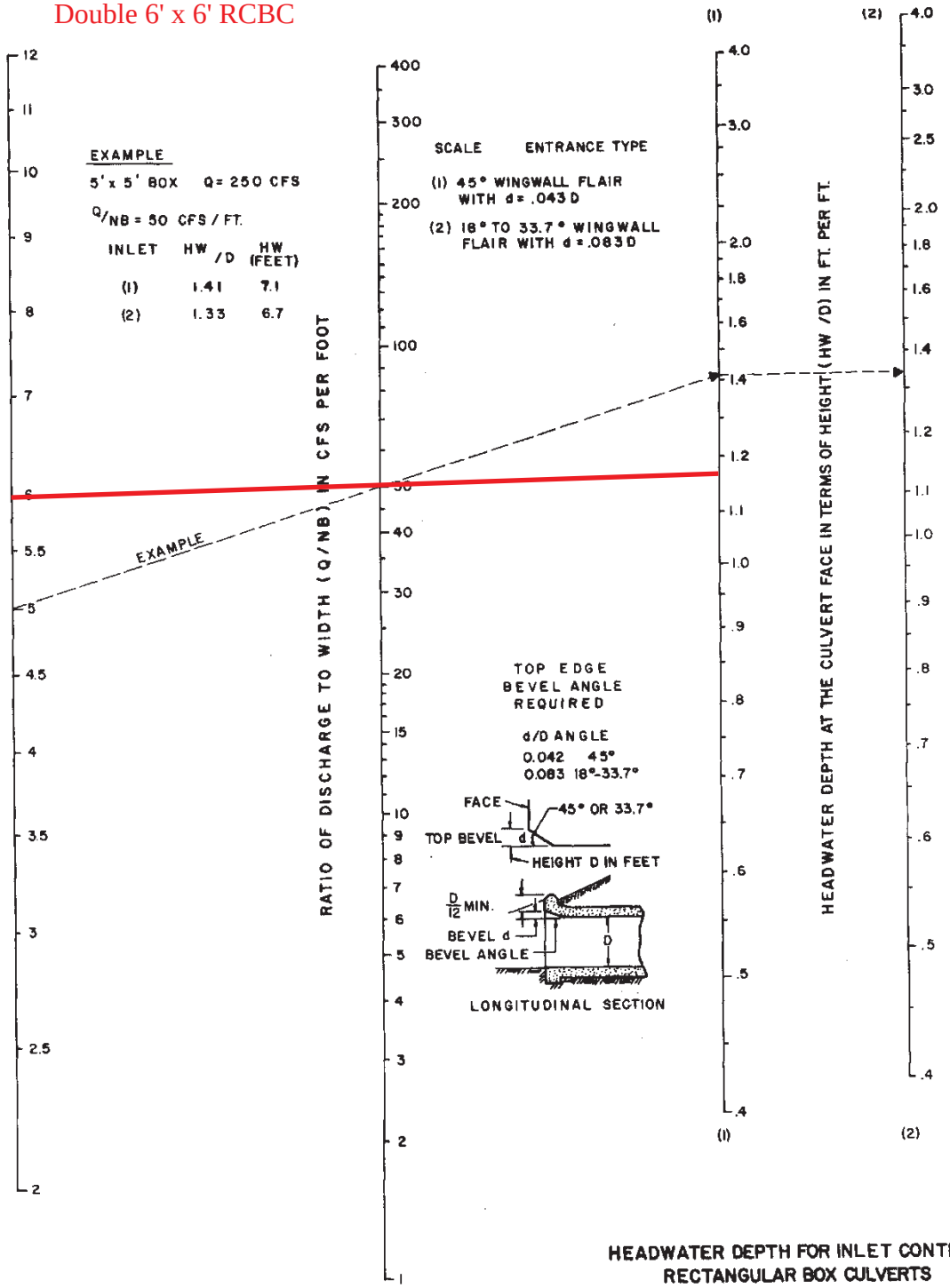
Drainage Area = 0.47 sq. mi.
Impervious Area = 20 % (greater than 10%)

Recurrence Interval (years)	Urban Flood-Frequency Equation	UQ (cfs)
2	$26.9 * DA^{0.722} * IA^{0.686}$	120
5	$68.2 * DA^{0.655} * IA^{0.572}$	230
10	$109 * DA^{0.625} * IA^{0.515}$	320
25	$209 * DA^{0.570} * IA^{0.436}$	500
50	$280 * DA^{0.558} * IA^{0.396}$	600
100	$363 * DA^{0.547} * IA^{0.358}$	700
200 [4]	UQ100 / RQ100 * RQ200	850
500 [4]	UQ100 / RQ100 * RQ500	1,000

1. Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.
2. Rural Flood-Frequency Equations not applicable for areas with greater than 10% impervious area.
3. USGS, 2001, The National Flood-Frequency Program - Methods for Estimating Flood Magnitude and Frequency In Rural and Urban Areas in North Carolina: U.S. Geological Survey Fact Sheet 007-00, January, 2002.
4. No equations published for storms greater than the 100-year. Therefore, the ratio between the 100-year urban and rural Q used to estimate the urban Q200 and Q500 value.

R-4738
Crossing 46
DA = 301 ac.
Q50 = 600 cfs
Q/B = 50 cfs
Double 6' x 6' RCBC

CHART 9B



HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

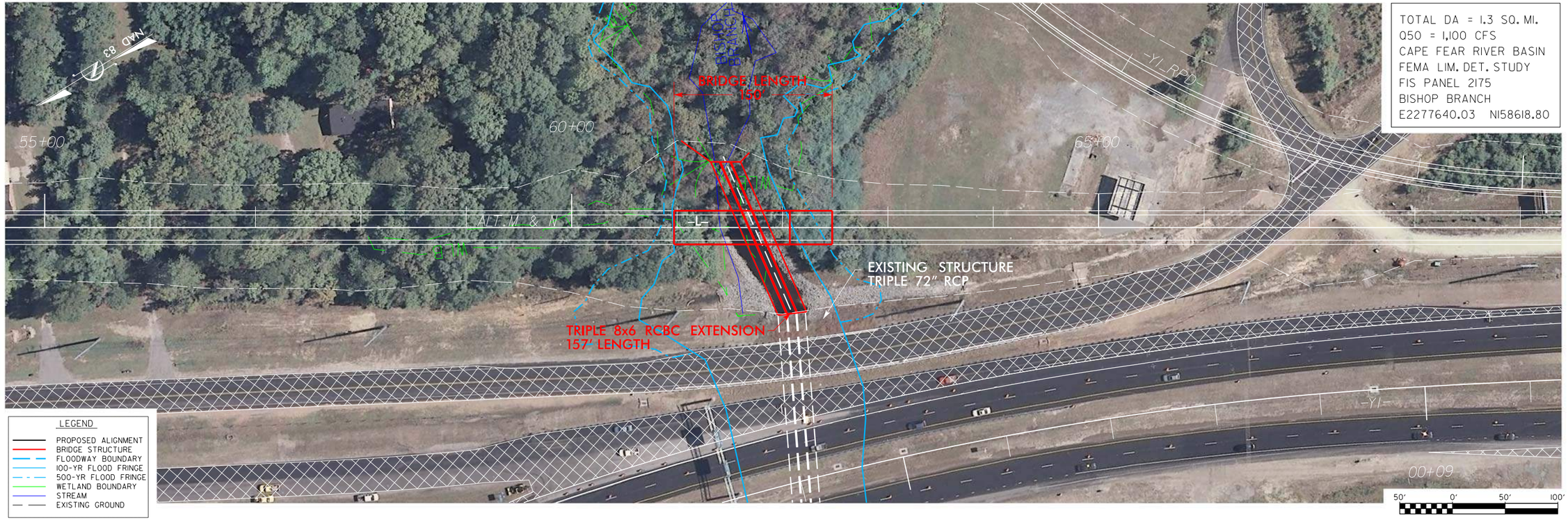
Appendix D

8/17/99

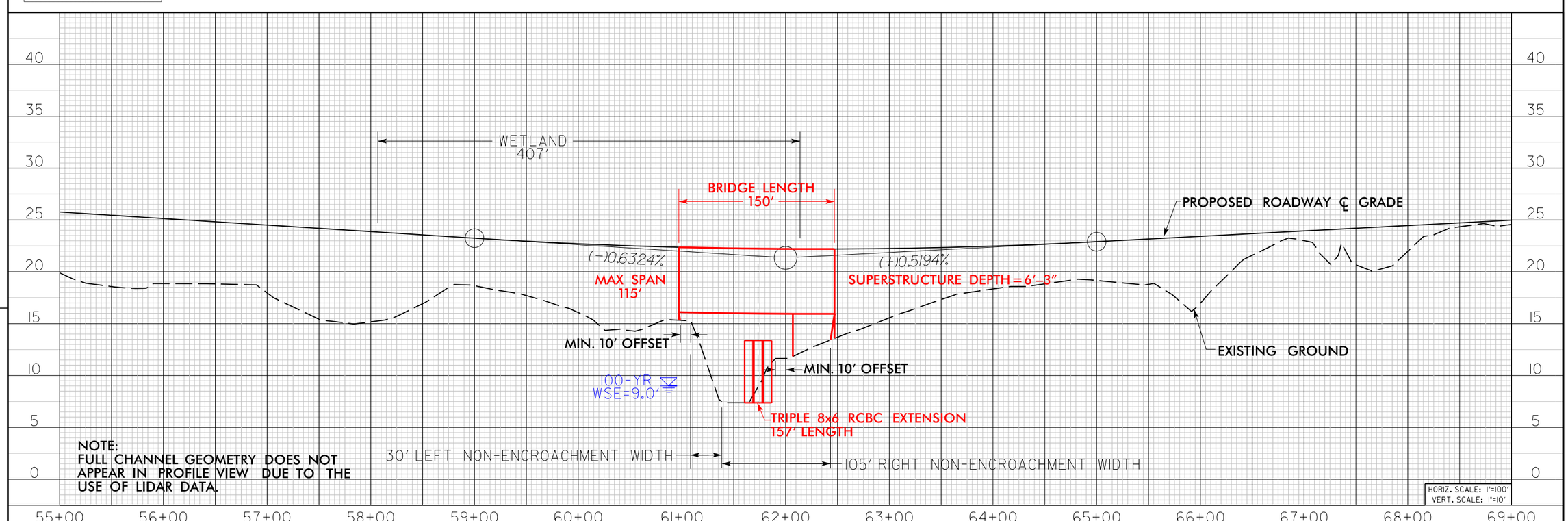
REVISIONS

ALTERNATIVES M, N - CROSSING 1 (BISHOP BRANCH)

PROJECT REFERENCE NO.	SHEET NO.
U-4738	
	DATE: MAY 2016



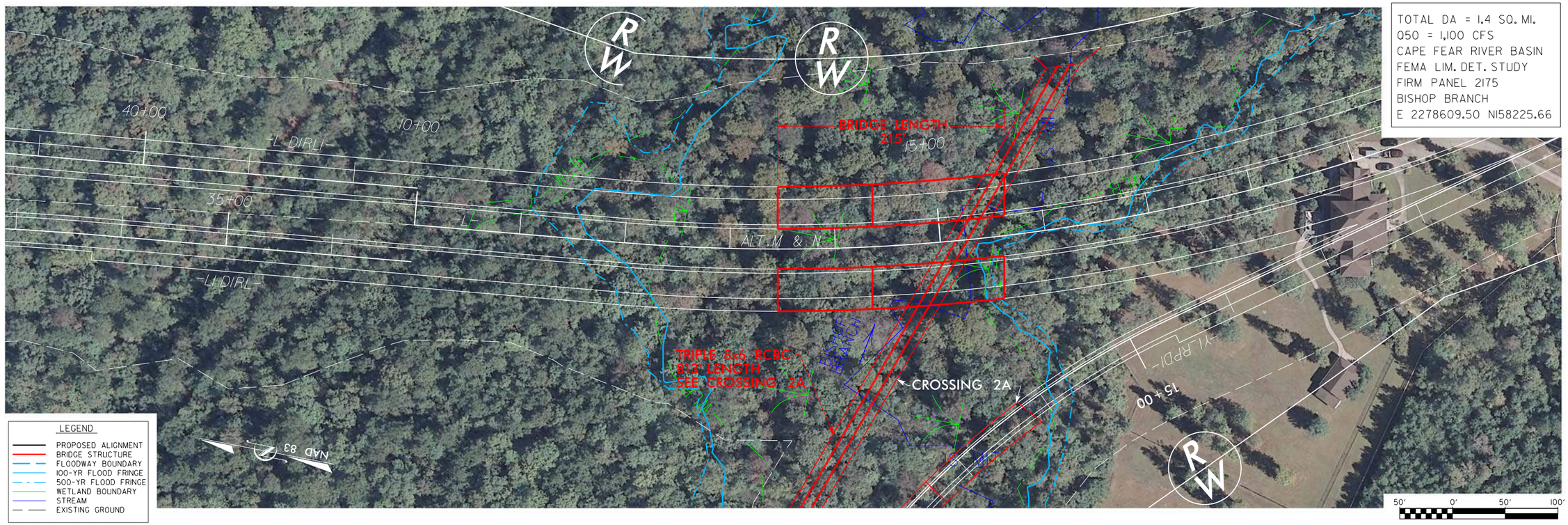
TOTAL DA = 1.3 SQ. MI.
Q50 = 1,100 CFS
CAPE FEAR RIVER BASIN
FEMA LIM. DET. STUDY
FIS PANEL 2175
BISHOP BRANCH
E2277640.03 N158618.80

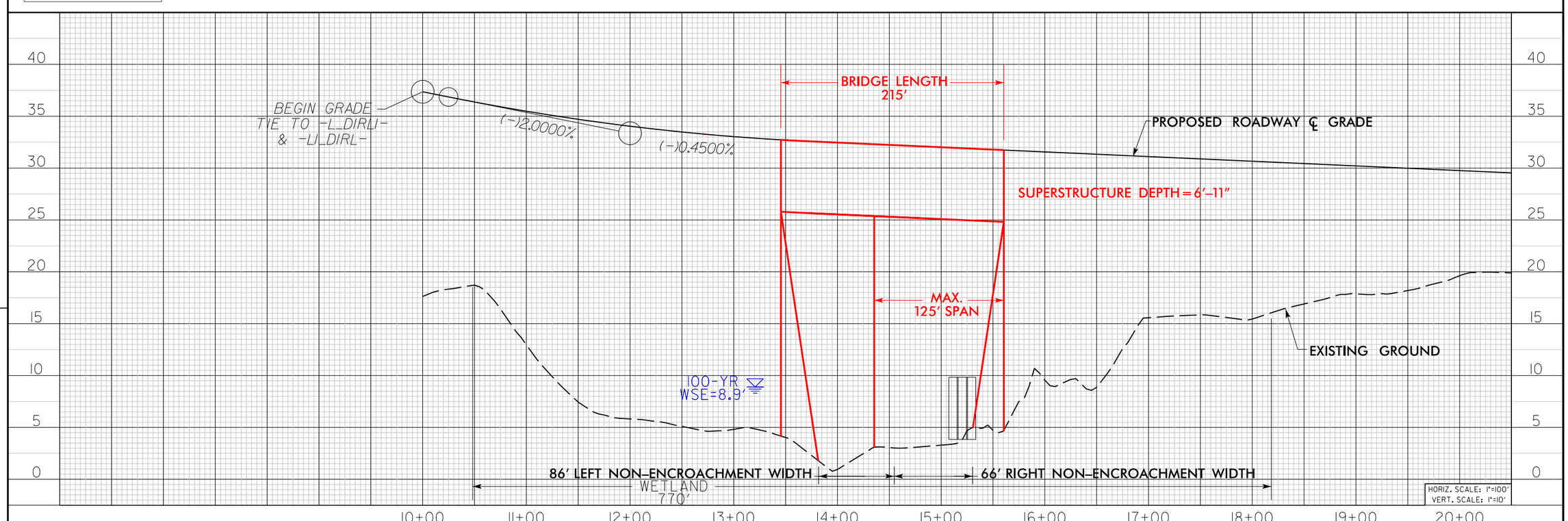


NOTE:
FULL CHANNEL GEOMETRY DOES NOT APPEAR IN PROFILE VIEW DUE TO THE USE OF LIDAR DATA.

PROJECT REFERENCE NO.	SHEET NO.
U-4738	
	DATE: MAY 2016

ALTERNATIVES M, N - CROSSING 2 (BISHOP BRANCH)





REVISIONS

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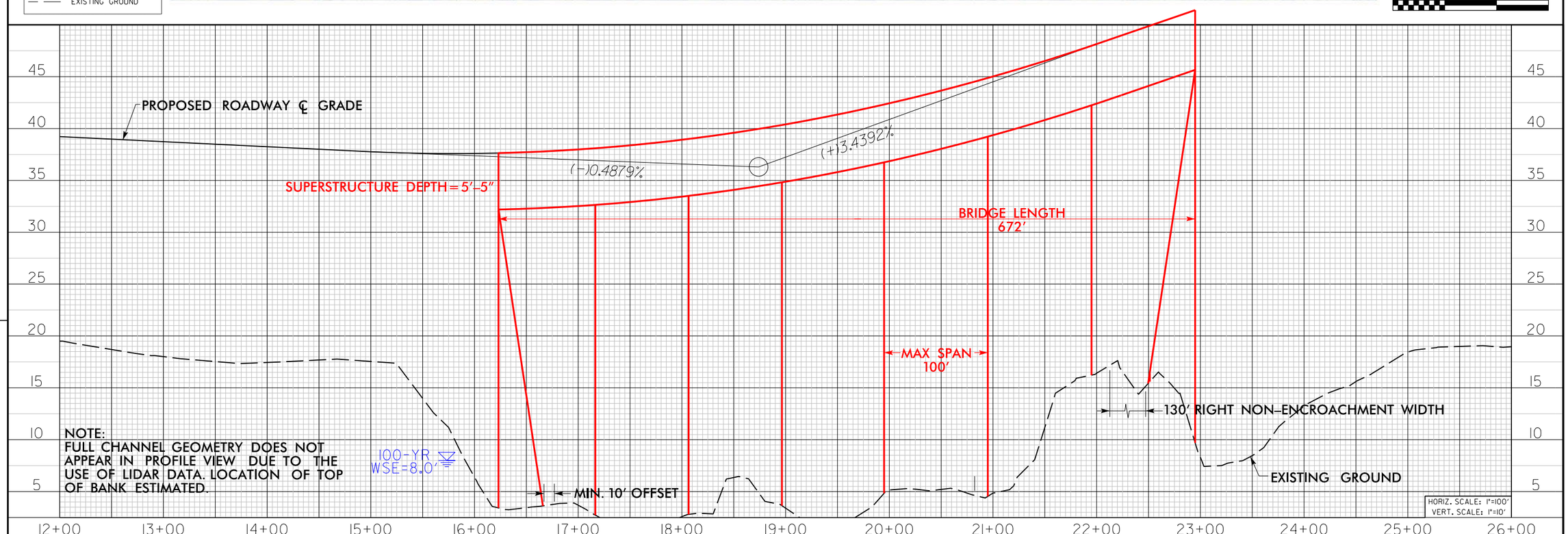
PROJECT REFERENCE NO.	SHEET NO.
U-4738	
	DATE: MAY 2016

ALTERNATIVES M, N - CROSSING 2A (BISHOP BRANCH)

TOTAL DA = 1.4 SQ. MI.
Q50 = 1,100 CFS
CAPE FEAR RIVER BASIN
FEMA LIM. DET. STUDY
FIRM PANEL 2175
BISHOP BRANCH
E 2278609.50 N 158225.66



NOTE:
FULL CHANNEL GEOMETRY DOES NOT APPEAR IN PROFILE VIEW DUE TO THE USE OF LIDAR DATA. LOCATION OF TOP OF BANK ESTIMATED.

REVISIONS

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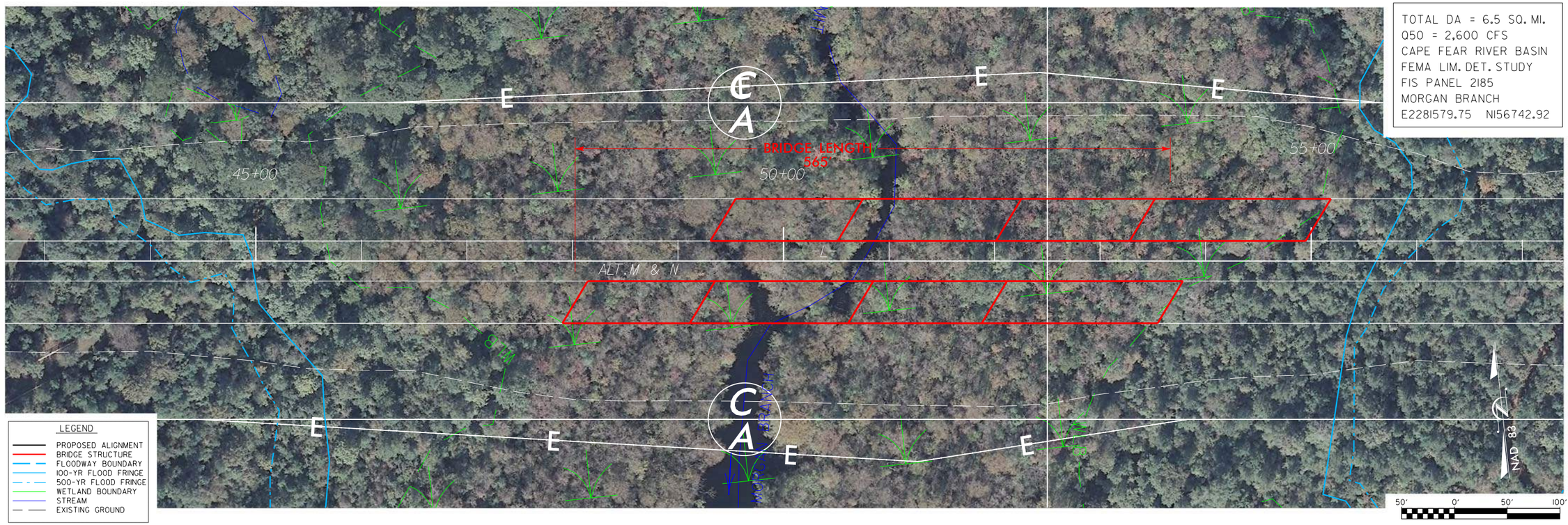
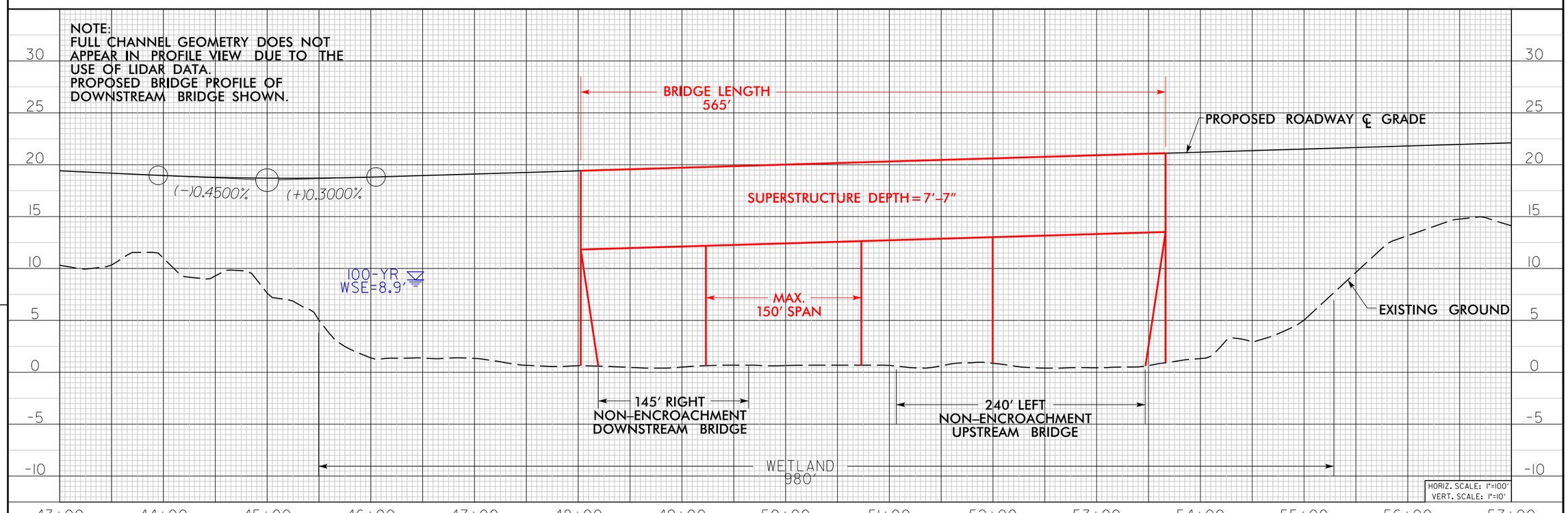
PROJECT REFERENCE NO.	SHEET NO.
U-4738	
	DATE: MAY 2016

ALTERNATIVES M, N - CROSSING 3 (MORGAN BRANCH)





REVISIONS

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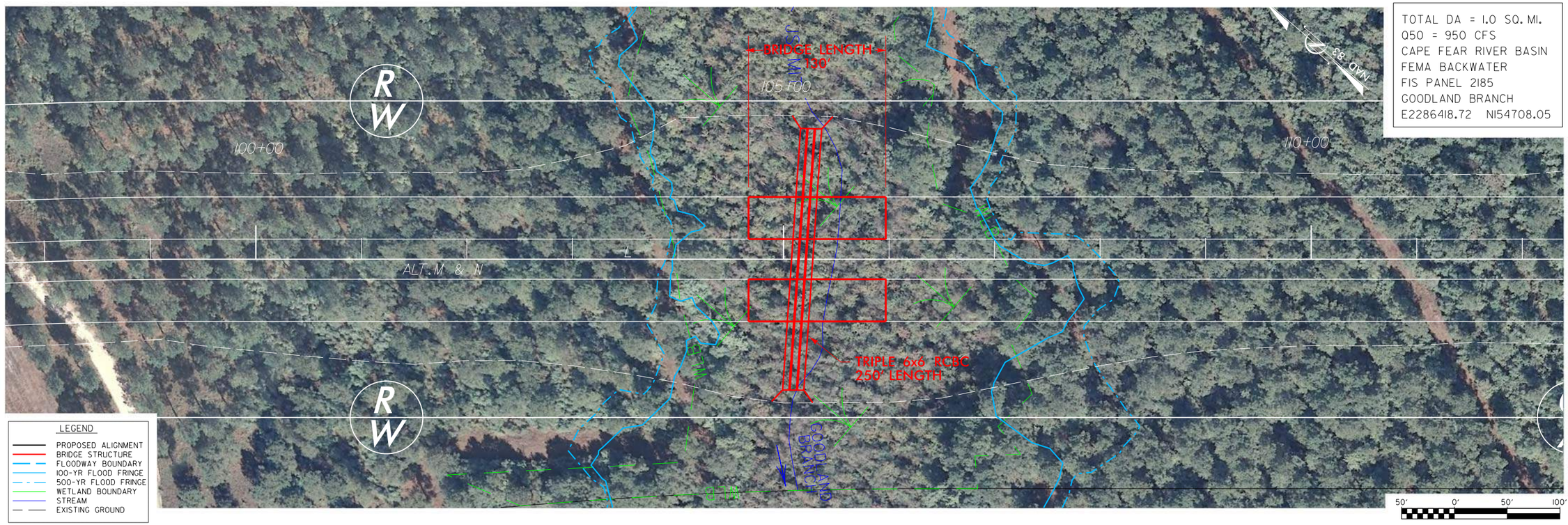
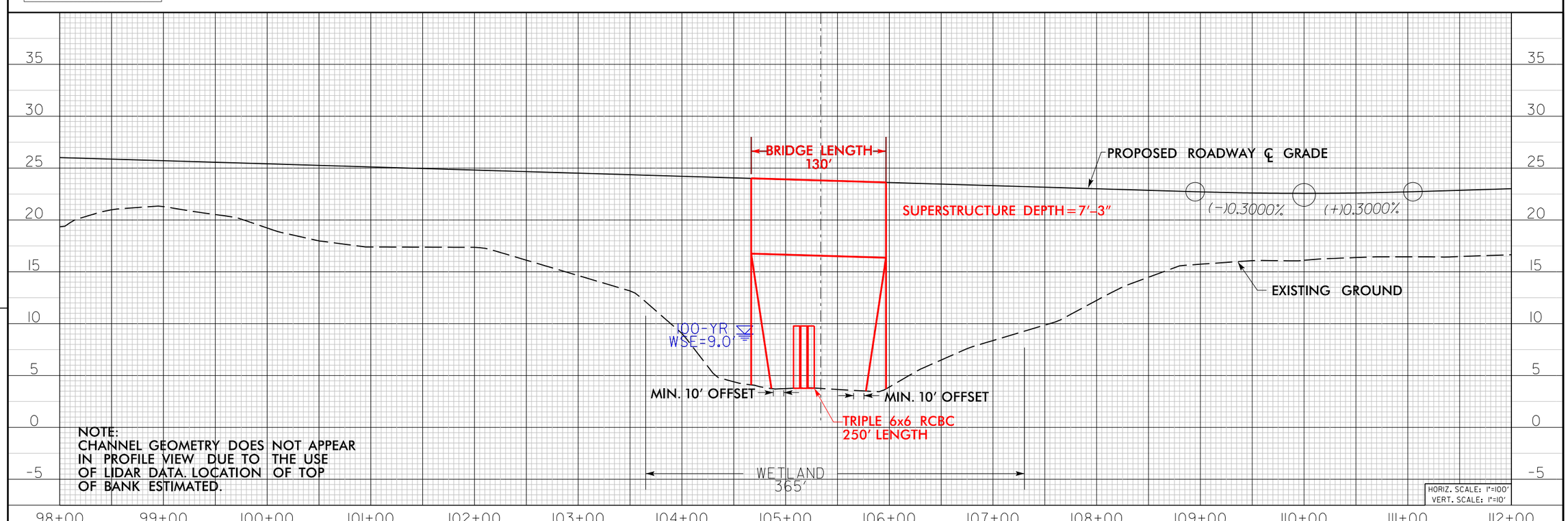
REVISIONS

PROJECT REFERENCE NO.	SHEET NO.
U-4738	
	DATE: MAY 2016

ALTERNATIVES M, N - CROSSING 4 (GOODLAND BRANCH)



TOTAL DA = 1.0 SQ. MI.
Q50 = 950 CFS
CAPE FEAR RIVER BASIN
FEMA BACKWATER
FIS PANEL 2185
GOODLAND BRANCH
E2286418.72 N154708.05



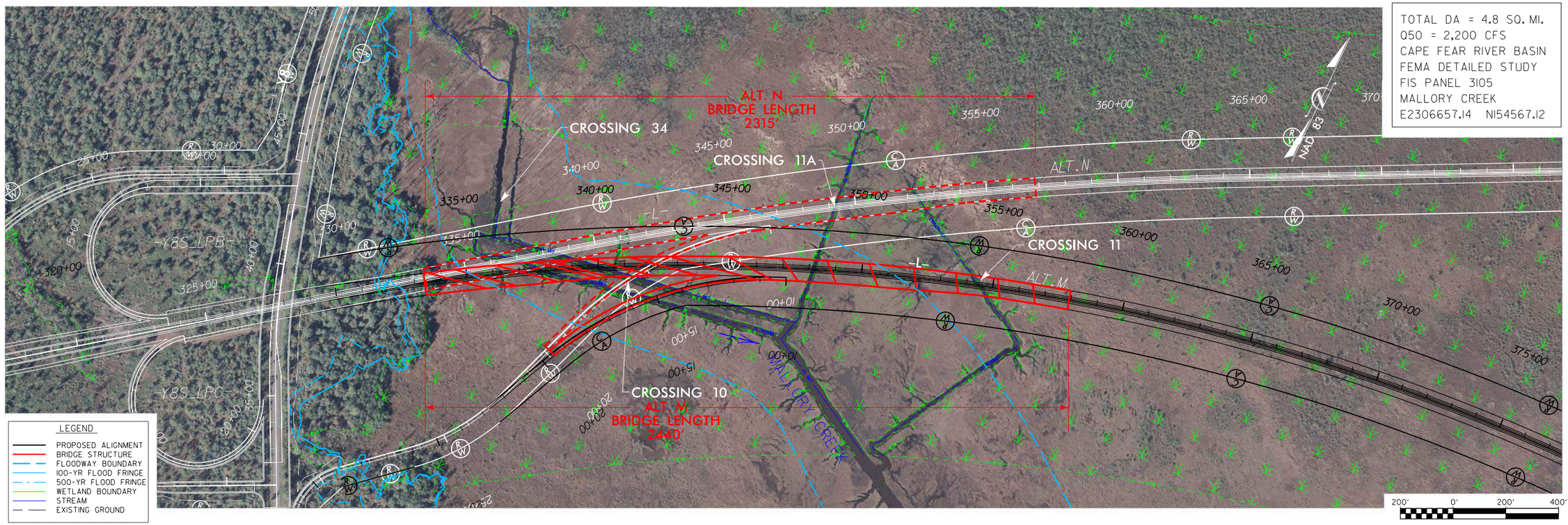
NOTE:
CHANNEL GEOMETRY DOES NOT APPEAR IN PROFILE VIEW DUE TO THE USE OF LIDAR DATA. LOCATION OF TOP OF BANK ESTIMATED.

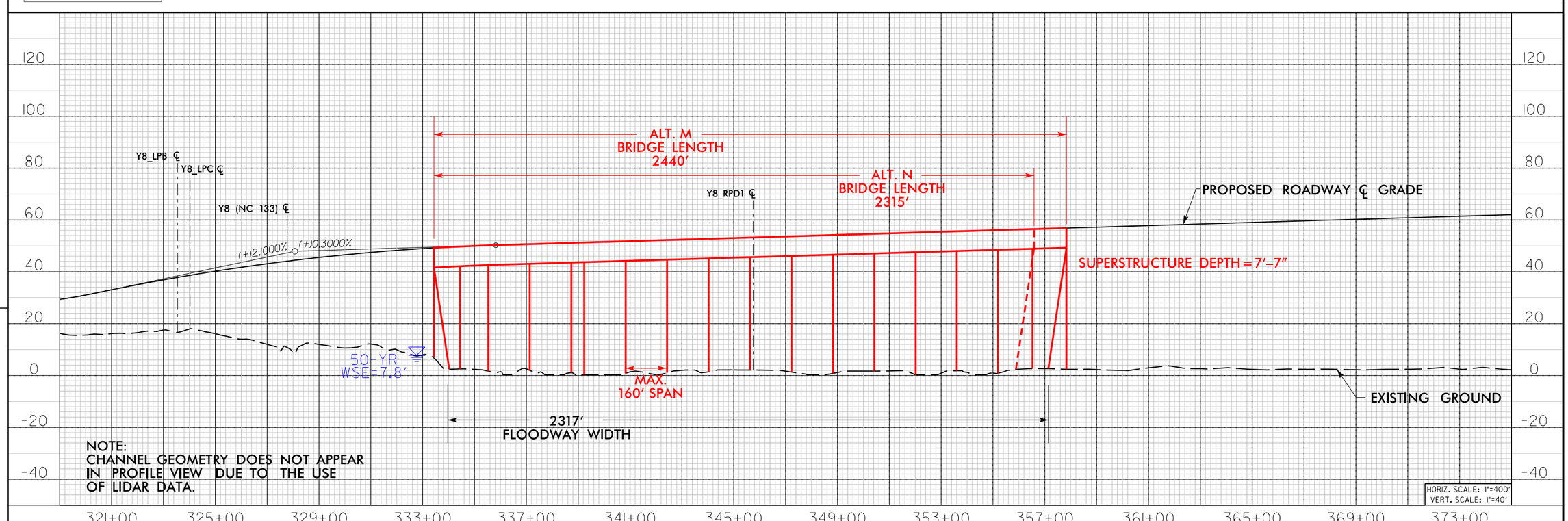
PROJECT REFERENCE NO.	SHEET NO.
U-4738	
	DATE: MAY 2016

ALTERNATIVES M, N - CROSSING 10, 11, 11A (MALLORY CREEK)

8/17/99

REVISIONS





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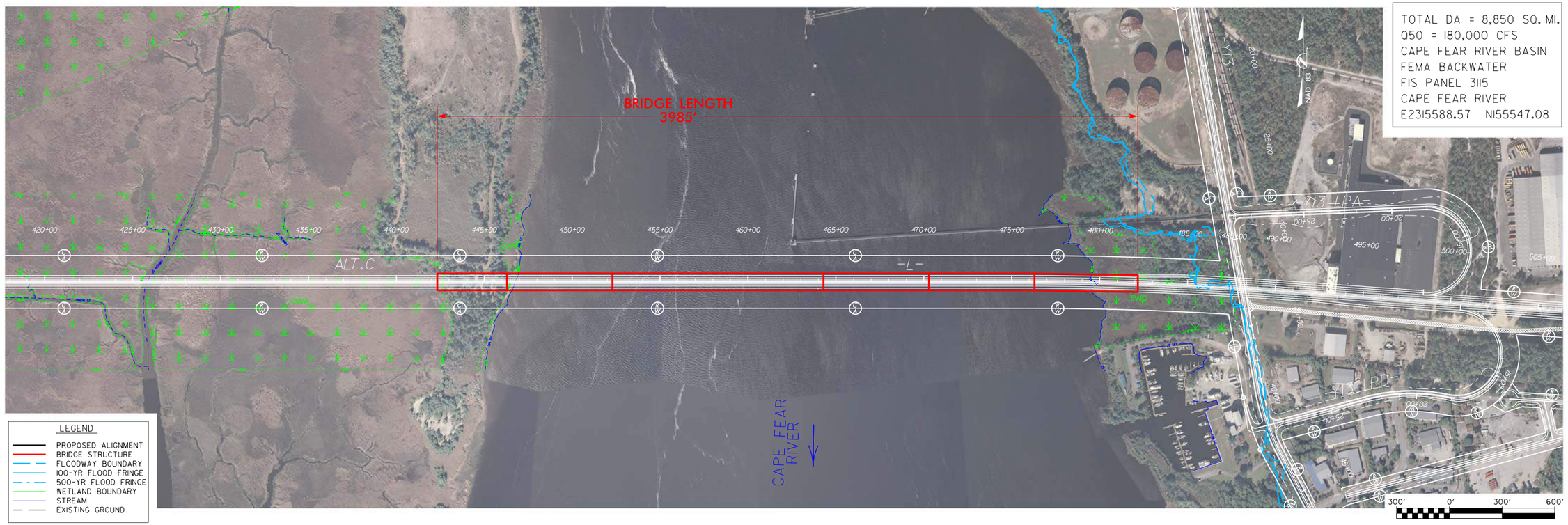
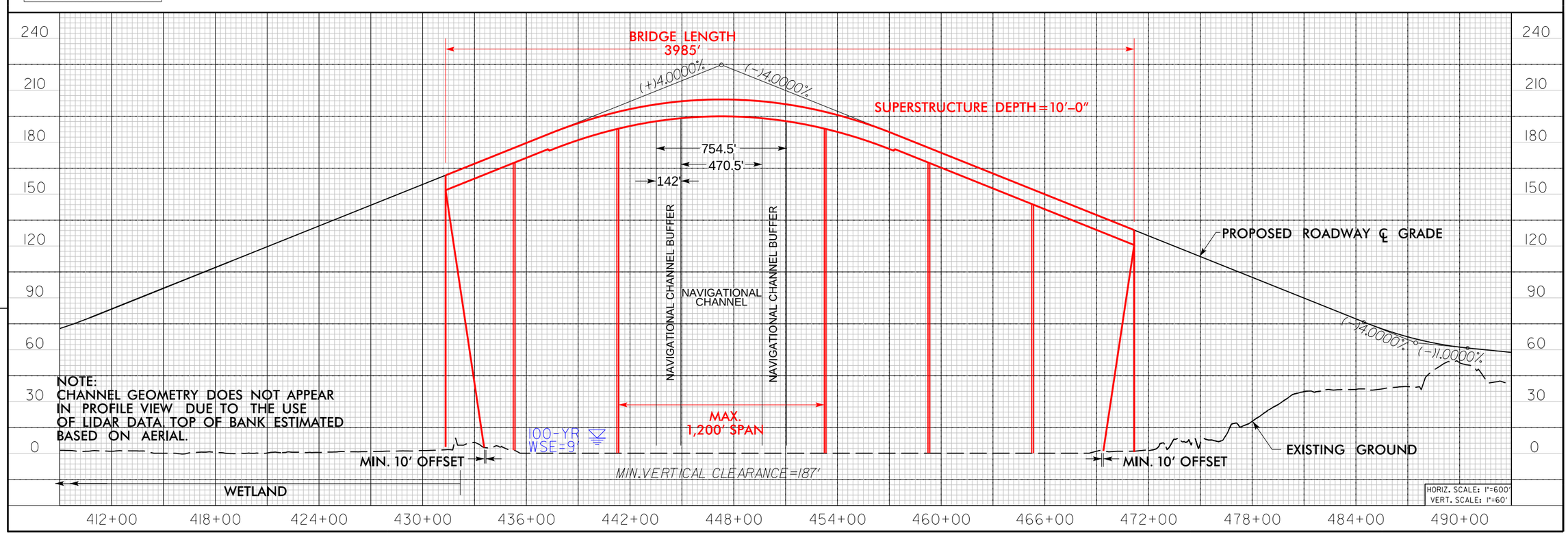
REVISIONS

PROJECT REFERENCE NO.	SHEET NO.
U-4738	
	DATE: MAY 2016

ALTERNATIVES C, G, Q, M - CROSSING 12 (CAPE FEAR RIVER)



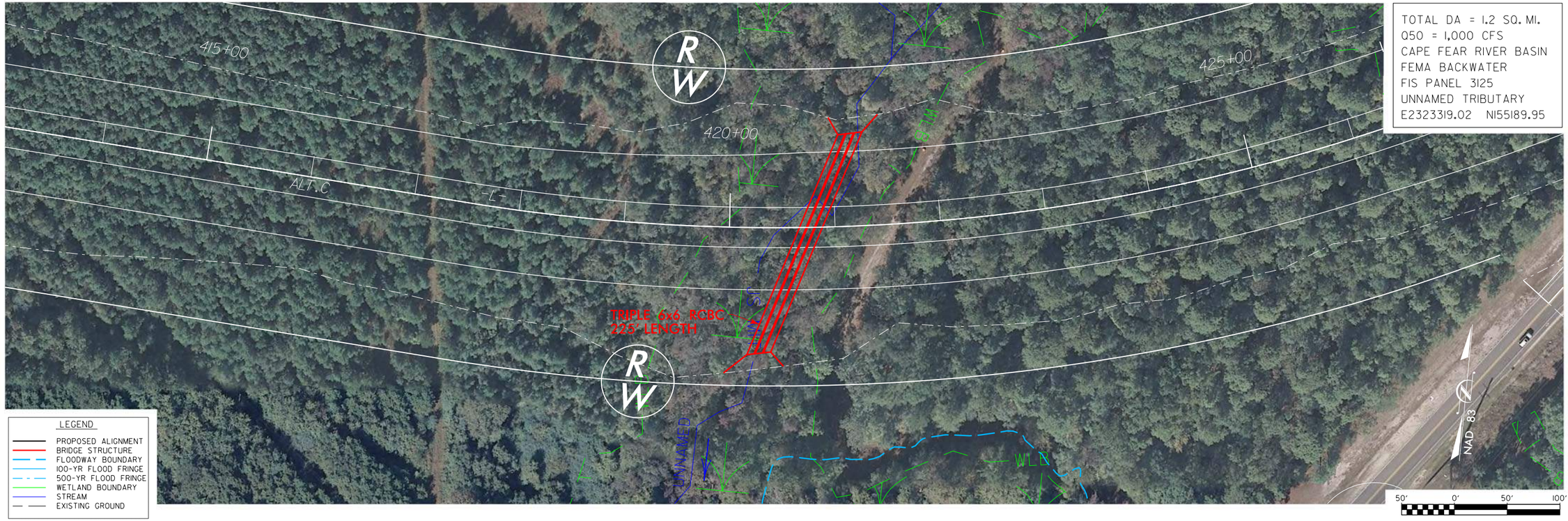


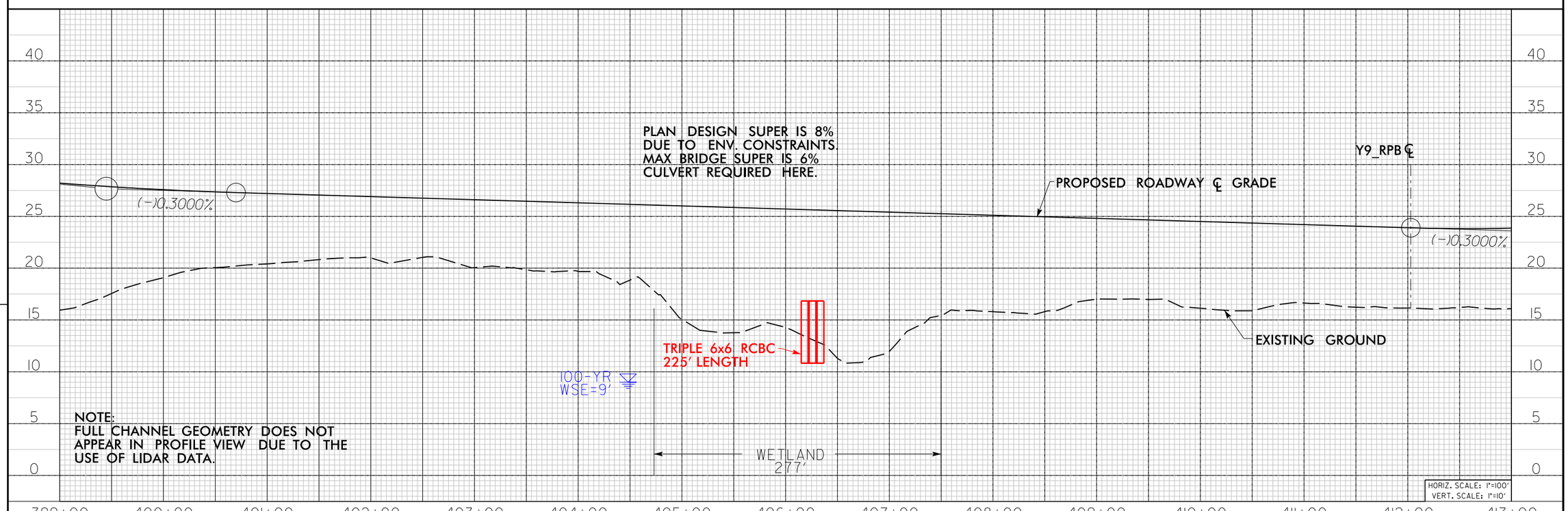
PROJECT REFERENCE NO.	SHEET NO.
U-4738	
	DATE: MAY 2016

ALTERNATIVES C, G, Q, M - CROSSING 14 (UNNAMED TRIBUTARY)

8/17/99

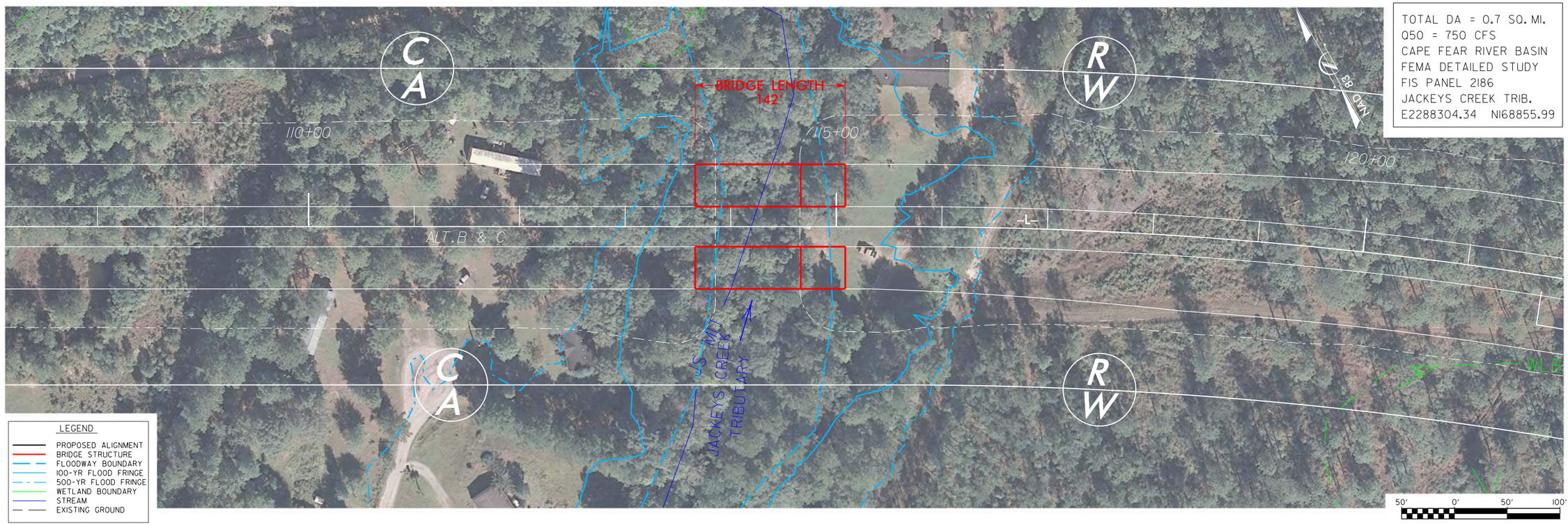
REVISIONS





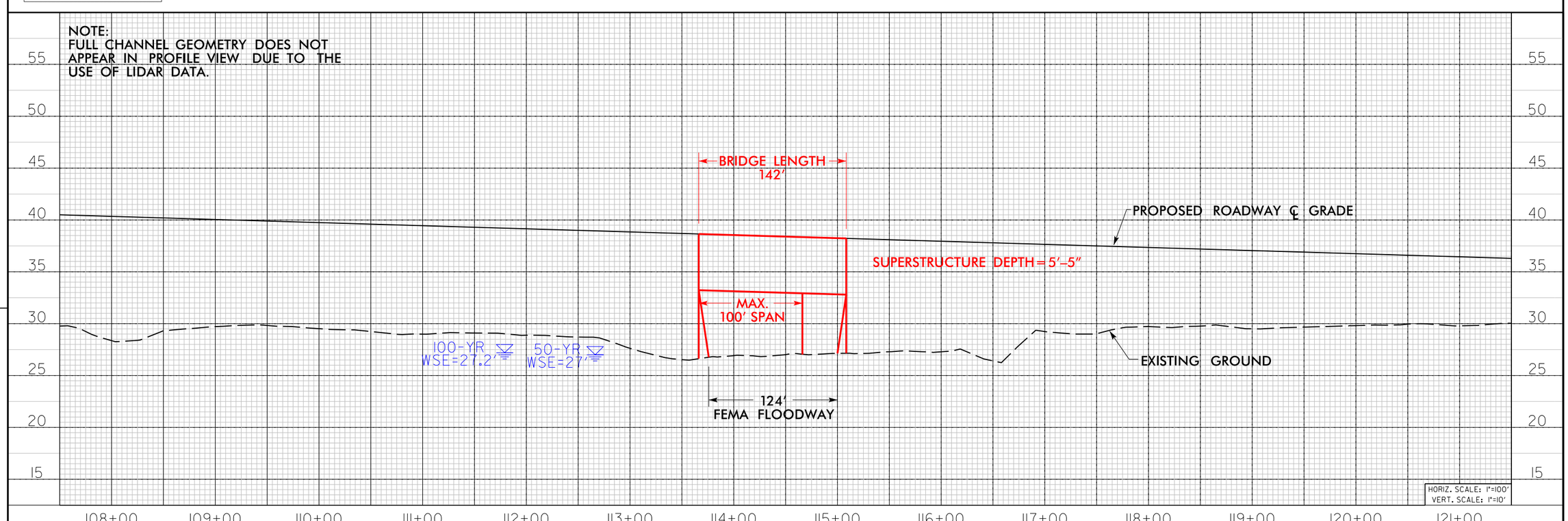
PROJECT REFERENCE NO.	SHEET NO.
U-4738	
	DATE: MAY 2016

ALTERNATIVES B, C - CROSSING 24 (JACKEYS CREEK TRIBUTARY)



TOTAL DA = 0.7 SQ. MI.
Q50 = 750 CFS
CAPE FEAR RIVER BASIN
FEMA DETAILED STUDY
FIS PANEL 2186
JACKEYS CREEK TRIB.
E2288304.34 N168855.99

NOTE:
FULL CHANNEL GEOMETRY DOES NOT APPEAR IN PROFILE VIEW DUE TO THE USE OF LIDAR DATA.



REVISIONS

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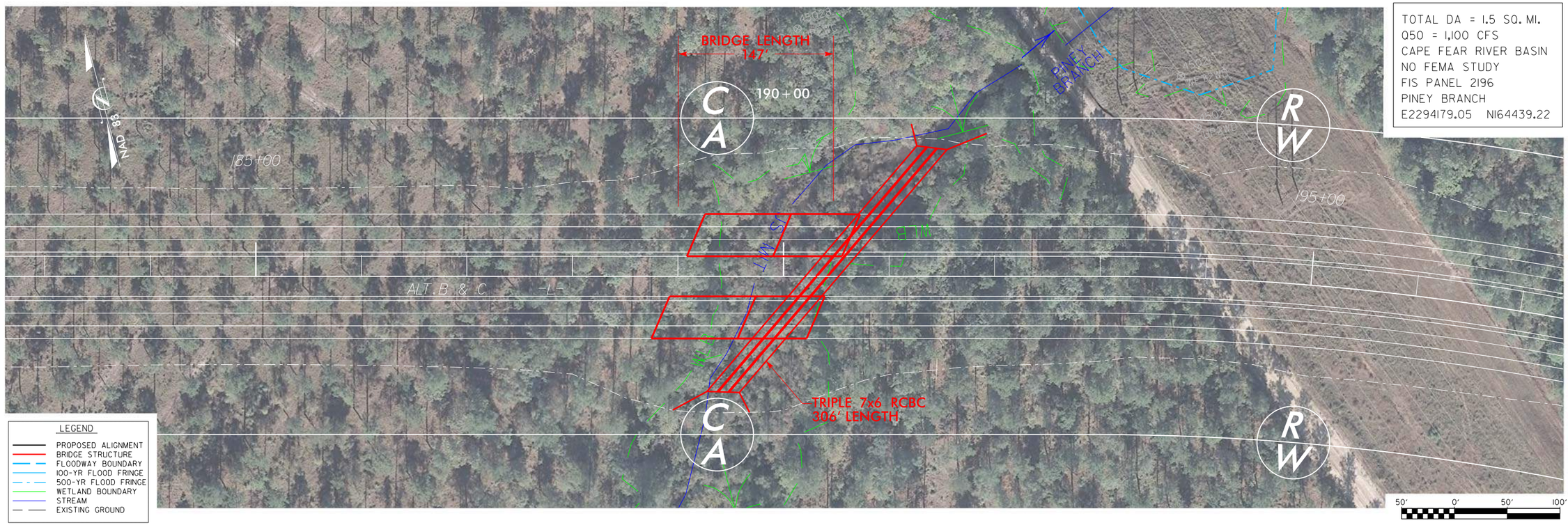
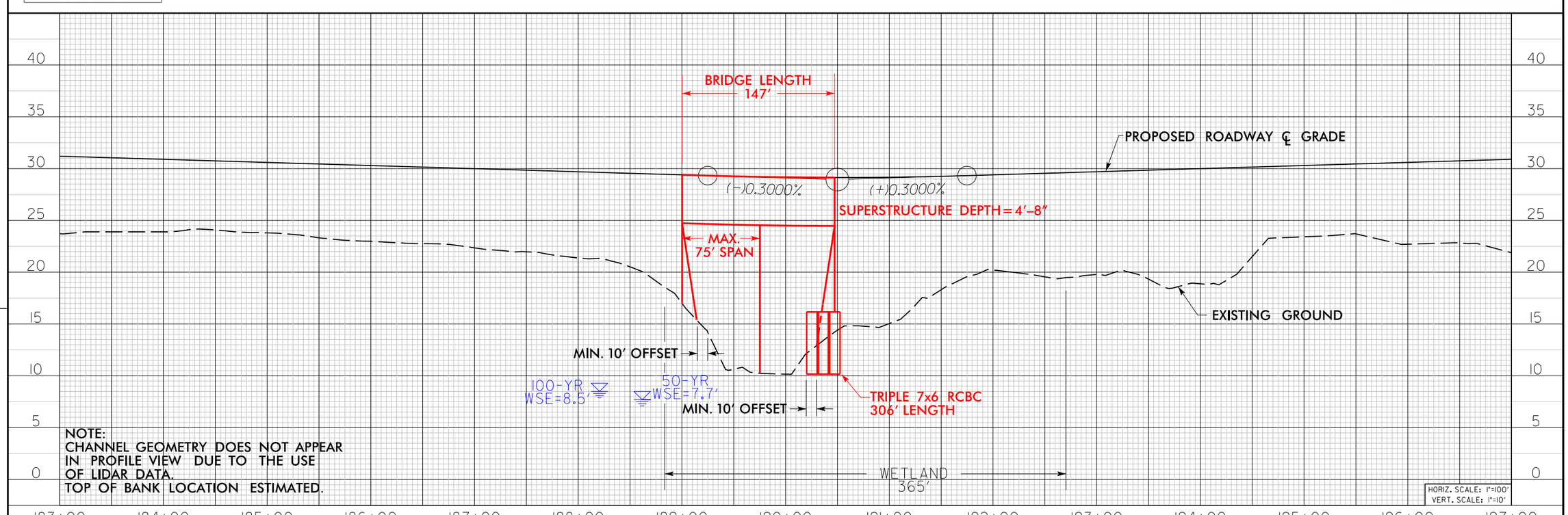
PROJECT REFERENCE NO.	SHEET NO.
U-4738	
	DATE: MAY 2016

ALTERNATIVES B, C, G, Q, J, T - CROSSING 27 (PINEY BRANCH)



TOTAL DA = 1.5 SQ. MI.
Q50 = 1,100 CFS
CAPE FEAR RIVER BASIN
NO FEMA STUDY
FIS PANEL 2196
PINEY BRANCH
E2294179.05 N164439.22



NOTE:
CHANNEL GEOMETRY DOES NOT APPEAR IN PROFILE VIEW DUE TO THE USE OF LIDAR DATA.
TOP OF BANK LOCATION ESTIMATED.

REVISIONS

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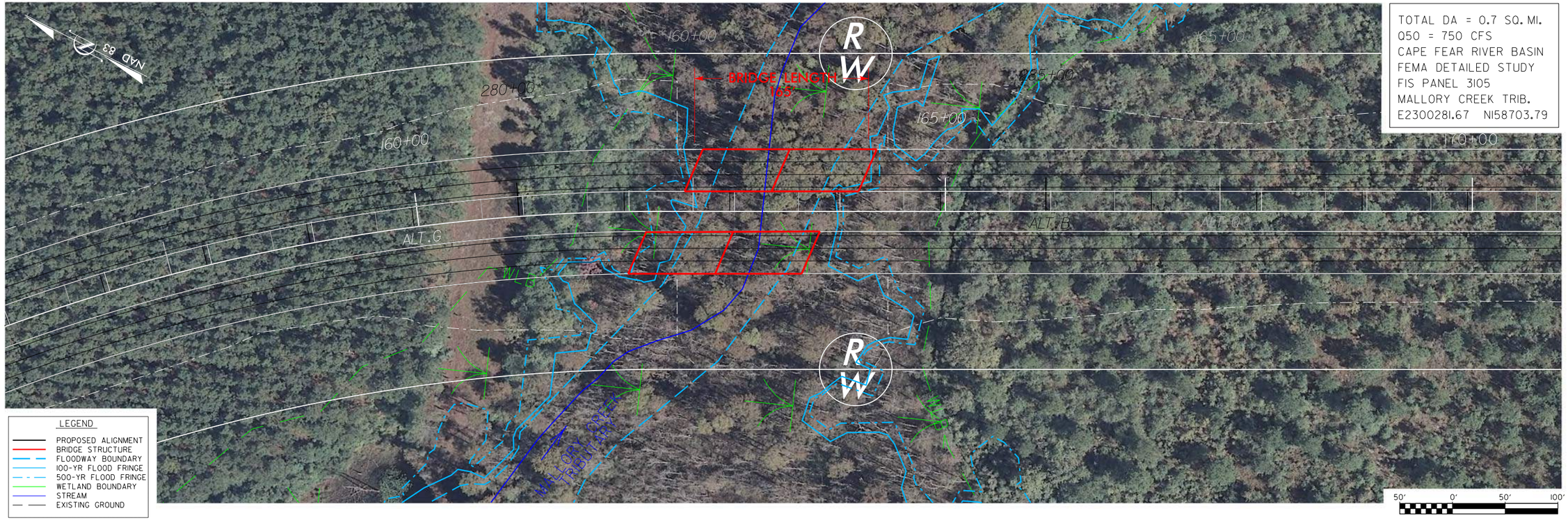
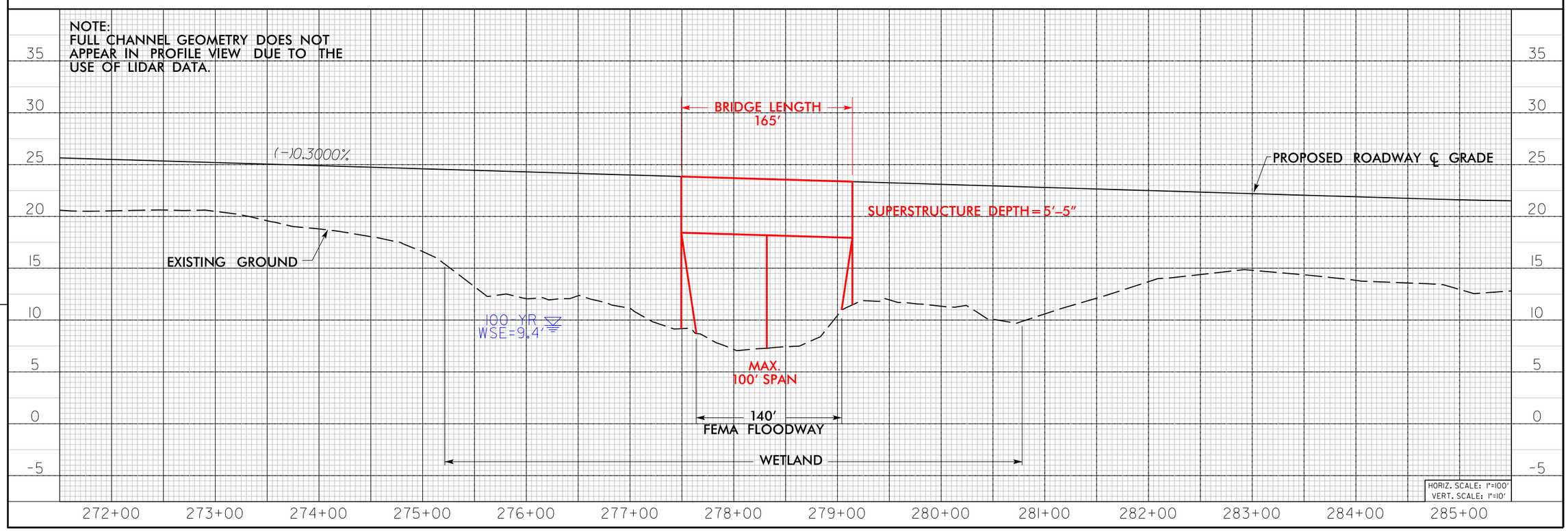
REVISIONS

PROJECT REFERENCE NO.	SHEET NO.
U-4738	
	DATE: MAY 2016

ALTERNATIVES B, G, Q - CROSSING 28 (MALLORY CREEK TRIBUTARY)

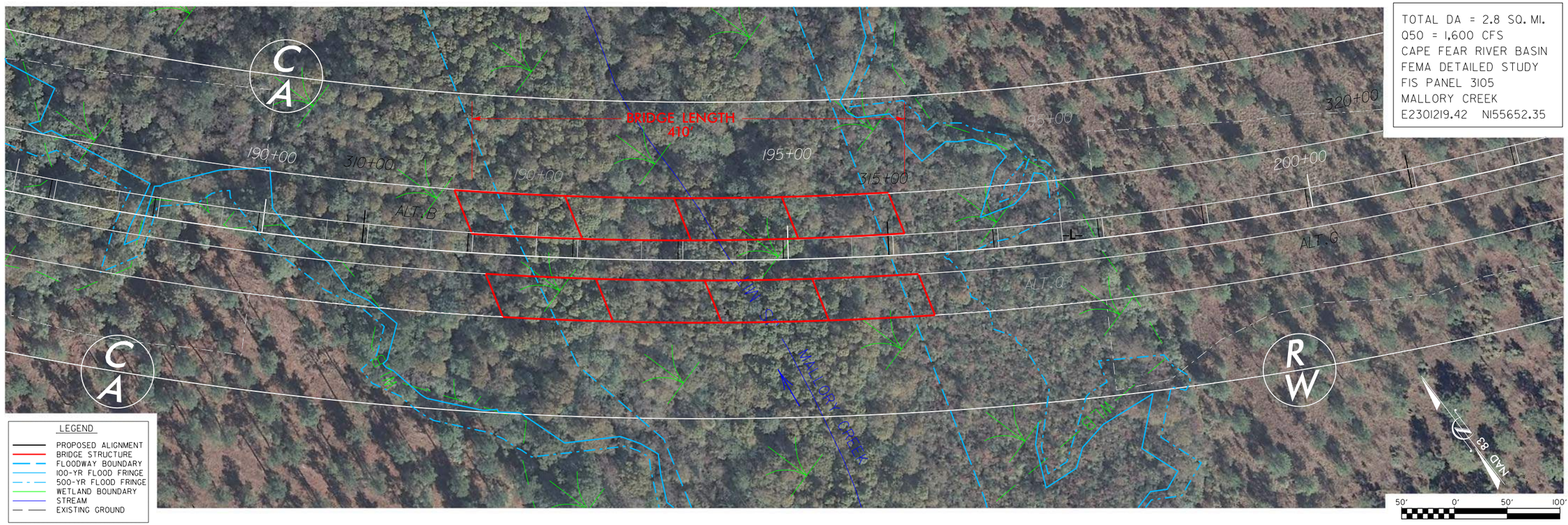


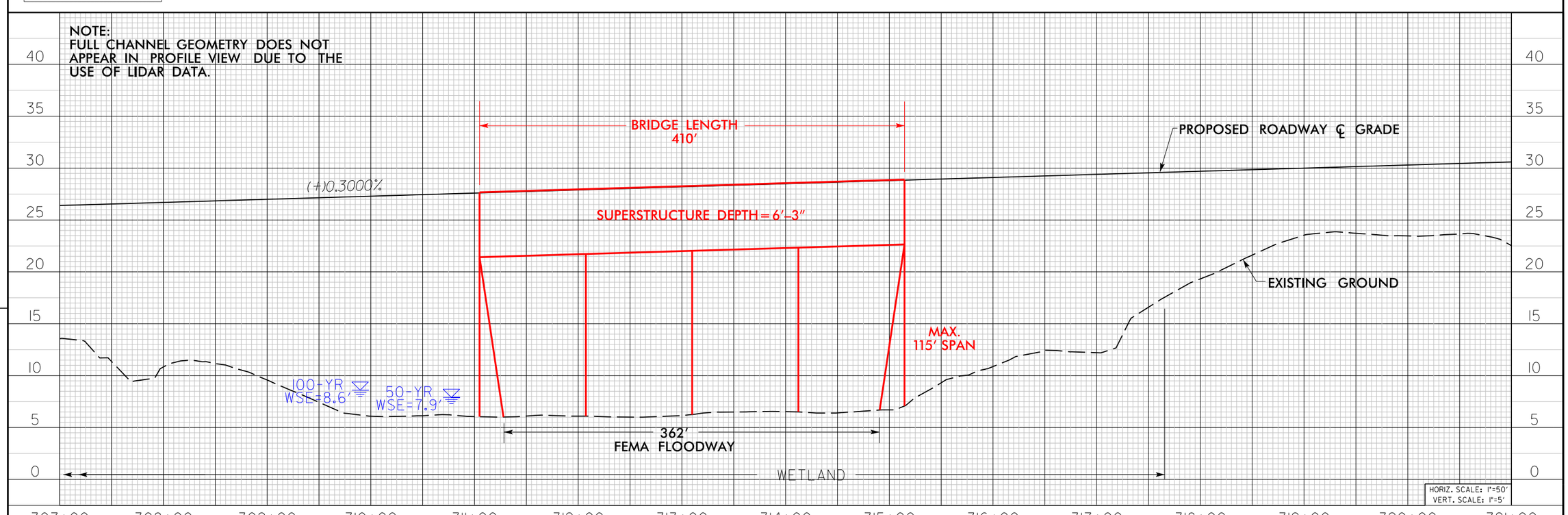
TOTAL DA = 0.7 SQ. MI.
Q50 = 750 CFS
CAPE FEAR RIVER BASIN
FEMA DETAILED STUDY
FIS PANEL 3105
MALLORY CREEK TRIB.
E2300281.67 N158703.79



PROJECT REFERENCE NO.	SHEET NO.
U-4738	
	DATE: MAY 2016

ALTERNATIVES B, G, Q - CROSSING 29 (MALLORY CREEK)





REVISIONS

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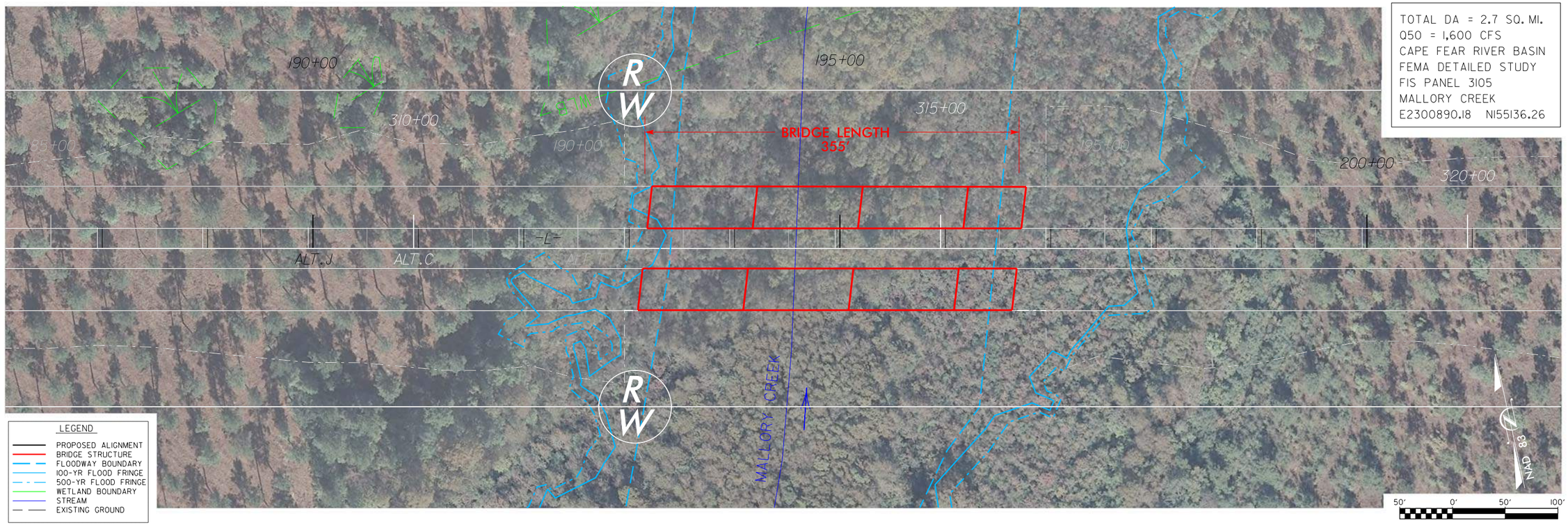
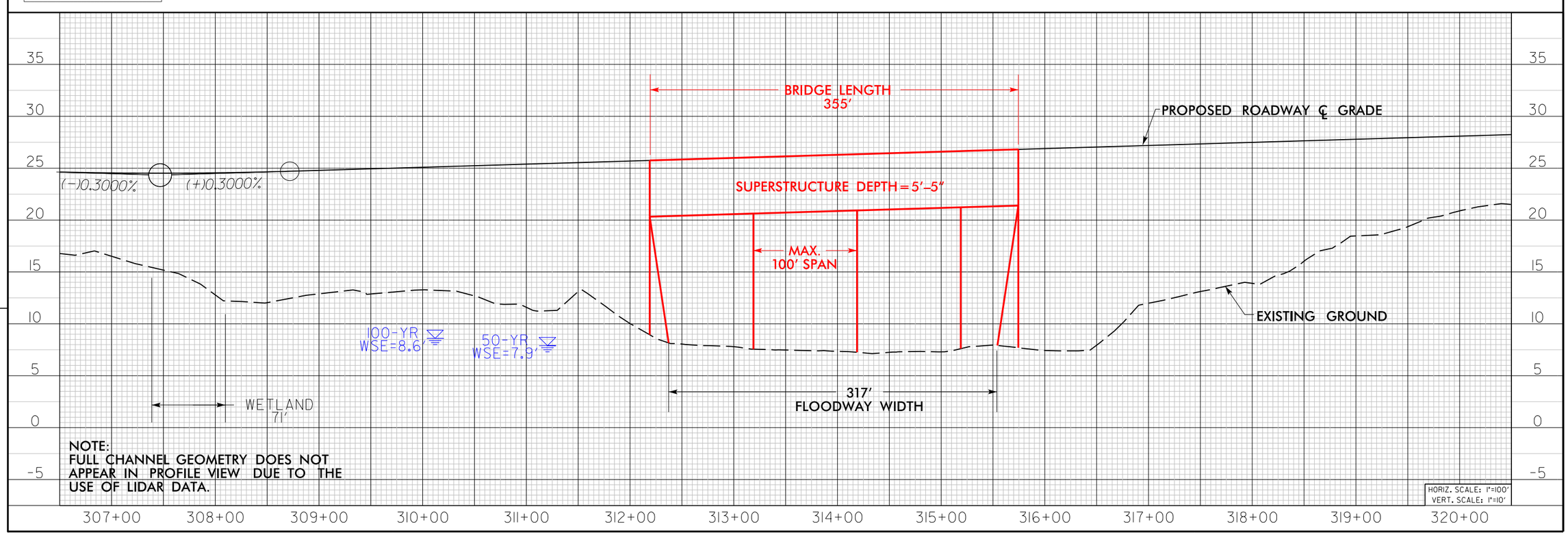
PROJECT REFERENCE NO.	SHEET NO.
U-4738	
	DATE: MAY 2016

ALTERNATIVES C, J, T - CROSSING 30 (MALLORY CREEK)

TOTAL DA = 2.7 SQ. MI.
Q50 = 1,600 CFS
CAPE FEAR RIVER BASIN
FEMA DETAILED STUDY
FIS PANEL 3105
MALLORY CREEK
E2300890.18 N155136.26





NOTE:
FULL CHANNEL GEOMETRY DOES NOT APPEAR IN PROFILE VIEW DUE TO THE USE OF LIDAR DATA.

REVISIONS

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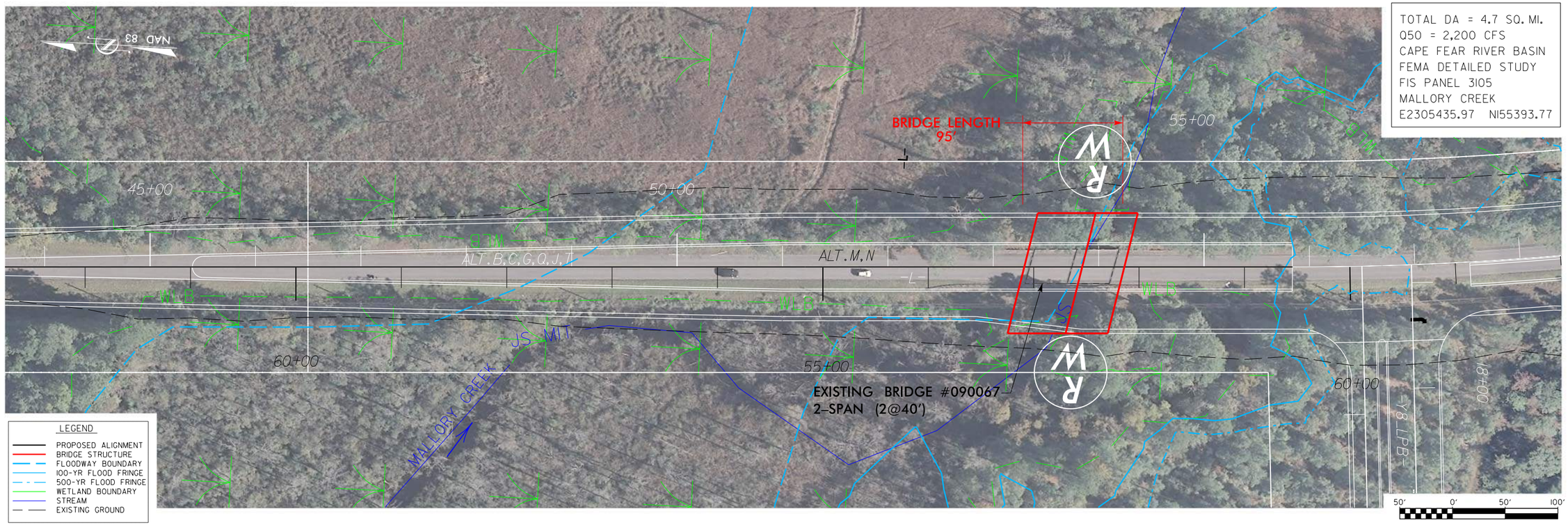
PROJECT REFERENCE NO.	SHEET NO.
U-4738	
	DATE: MAY 2016

ALTERNATIVE B, C, G, Q, J, T, M, N - CROSSING 33 (MALLORY CREEK)

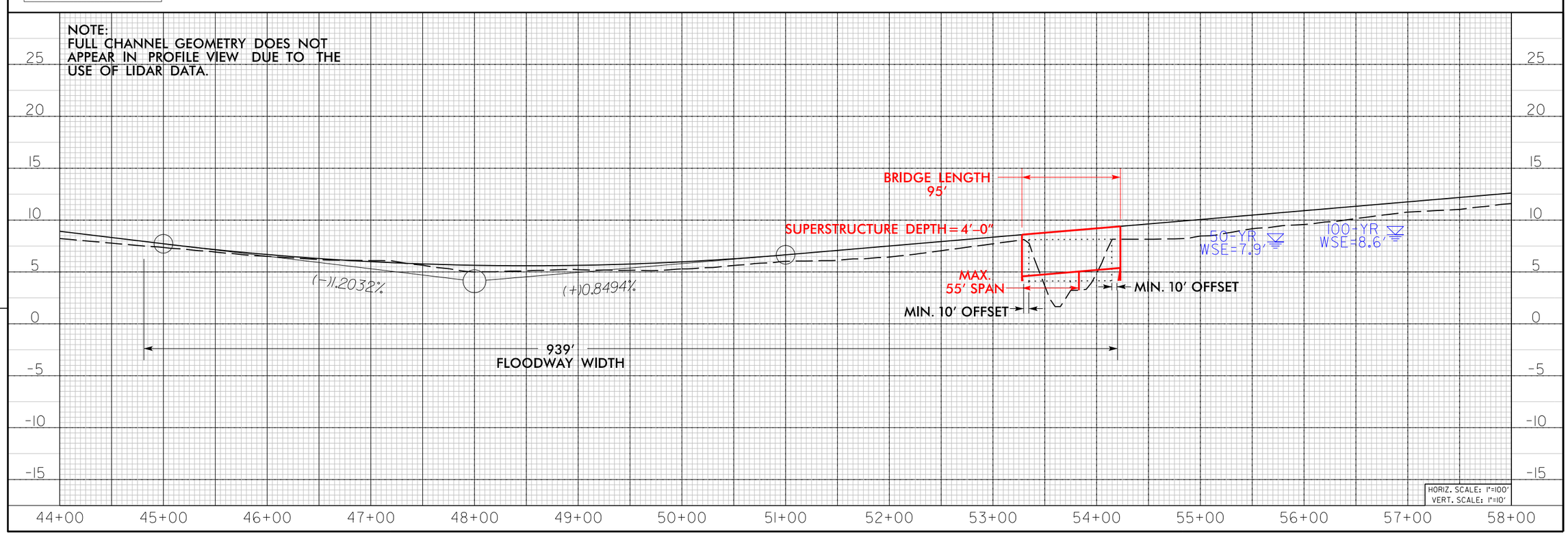
8/17/99

REVISIONS

TOTAL DA = 4.7 SQ. MI.
Q50 = 2,200 CFS
CAPE FEAR RIVER BASIN
FEMA DETAILED STUDY
FIS PANEL 3105
MALLORY CREEK
E2305435.97 N155393.77



NOTE:
FULL CHANNEL GEOMETRY DOES NOT APPEAR IN PROFILE VIEW DUE TO THE USE OF LIDAR DATA.



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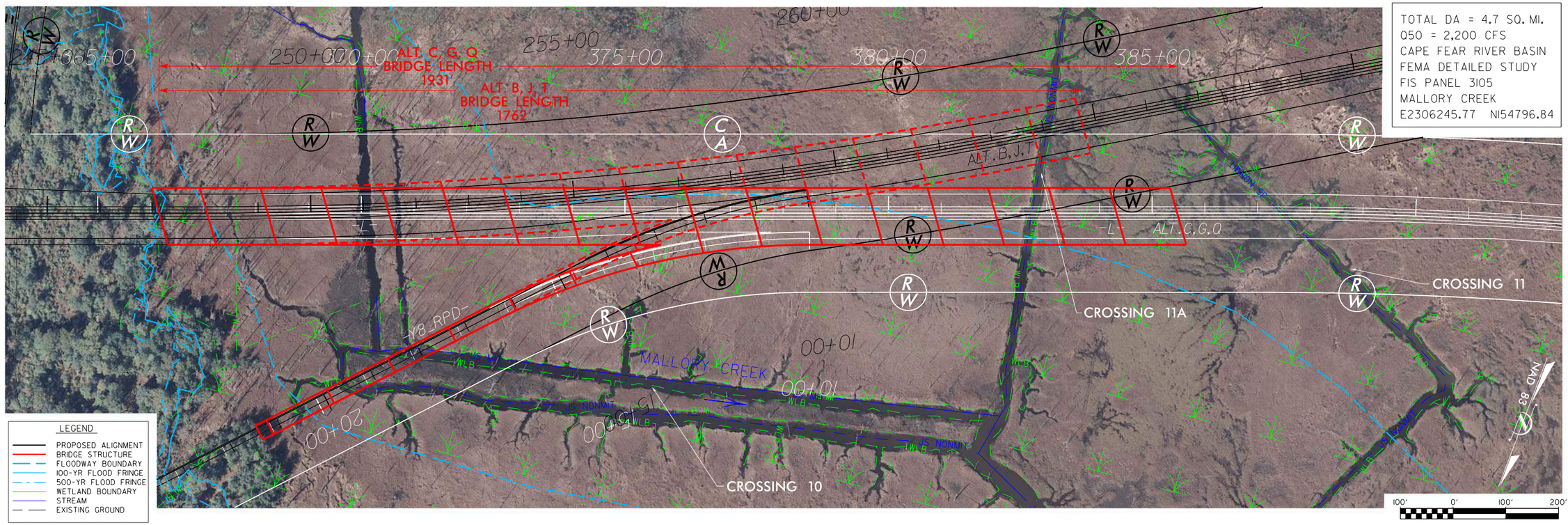
	DATE: MAY 2016

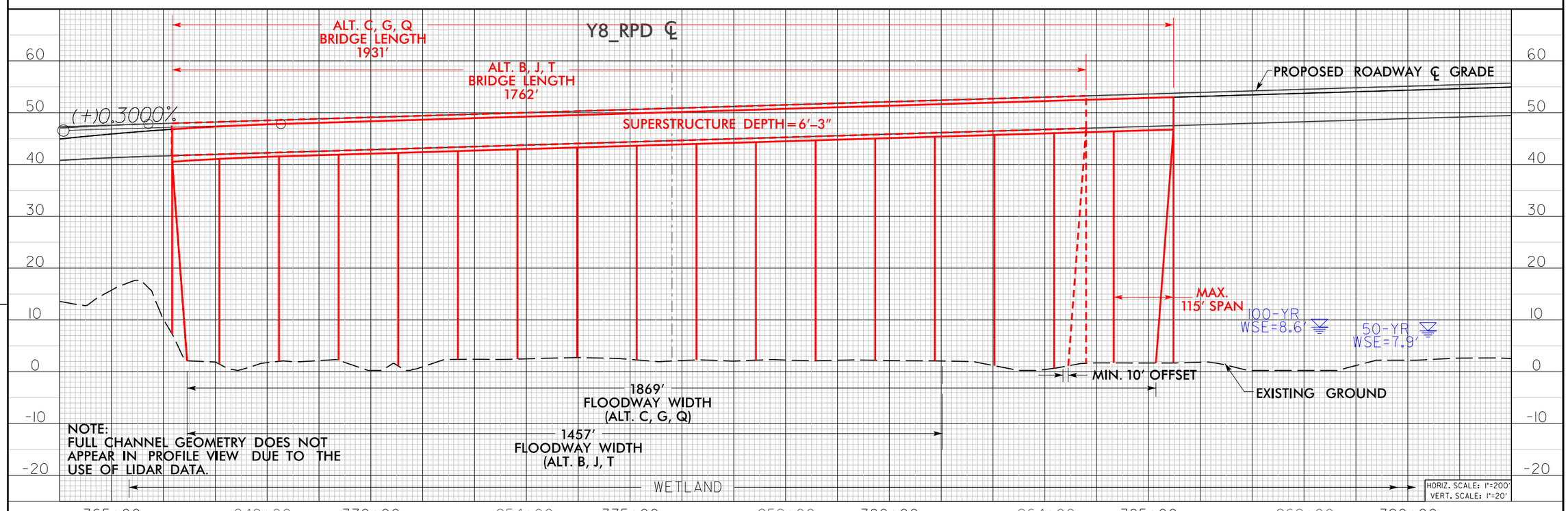
ALTERNATIVES B, C, G, Q, J, T - CROSSING 34 (MALLORY CREEK)

8/17/99

REVISIONS

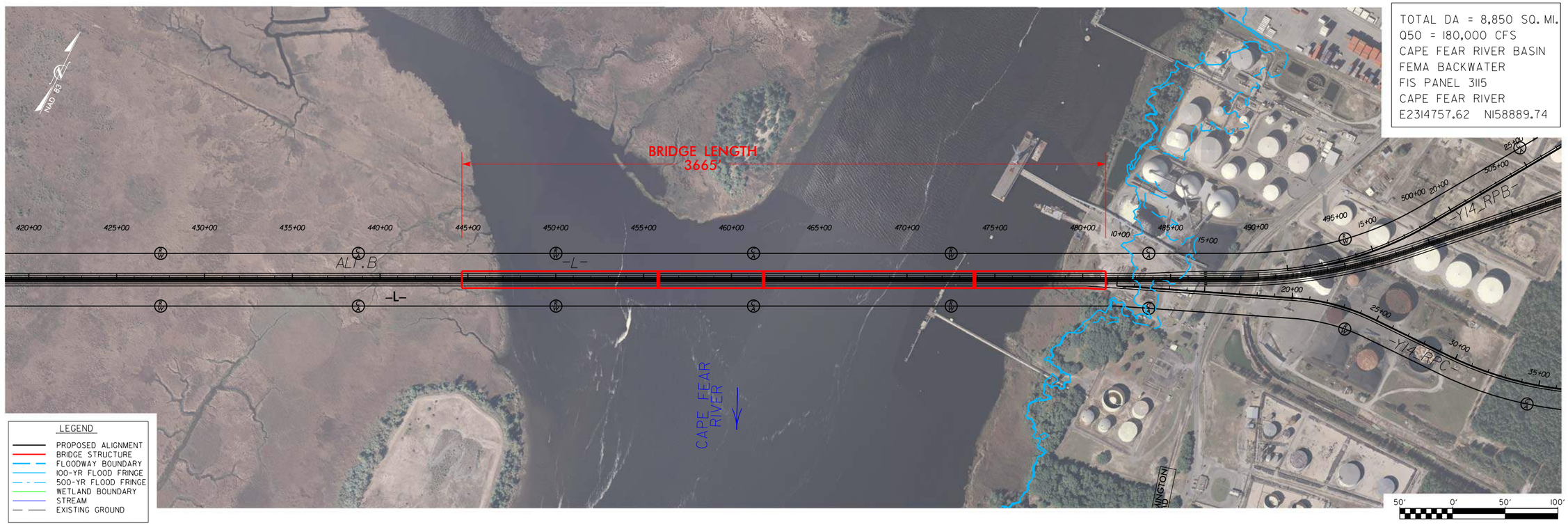
TOTAL DA = 4.7 SQ. MI.
Q50 = 2,200 CFS
CAPE FEAR RIVER BASIN
FEMA DETAILED STUDY
FIS PANEL 3105
MALLORY CREEK
E2306245.77 N154796.84





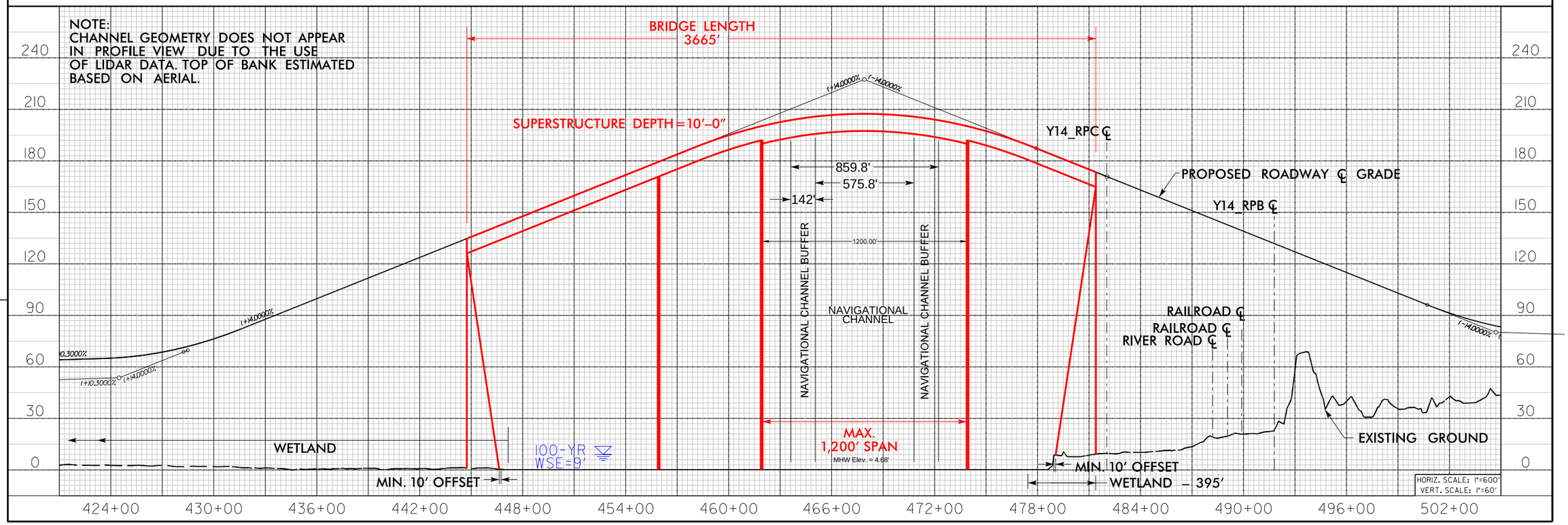
PROJECT REFERENCE NO.	SHEET NO.
U-4738	
	DATE: MAY 2016

ALTERNATIVE B, J, T, N - CROSSING 35 (CAPE FEAR RIVER)



TOTAL DA = 8,850 SQ. MI.
Q50 = 180,000 CFS
CAPE FEAR RIVER BASIN
FEMA BACKWATER
FIS PANEL 3115
CAPE FEAR RIVER
E2314757.62 N158889.74

NOTE:
CHANNEL GEOMETRY DOES NOT APPEAR IN PROFILE VIEW DUE TO THE USE OF LIDAR DATA. TOP OF BANK ESTIMATED BASED ON AERIAL.



REVISIONS

8/17/99

PROJECT REFERENCE NO.	SHEET NO.
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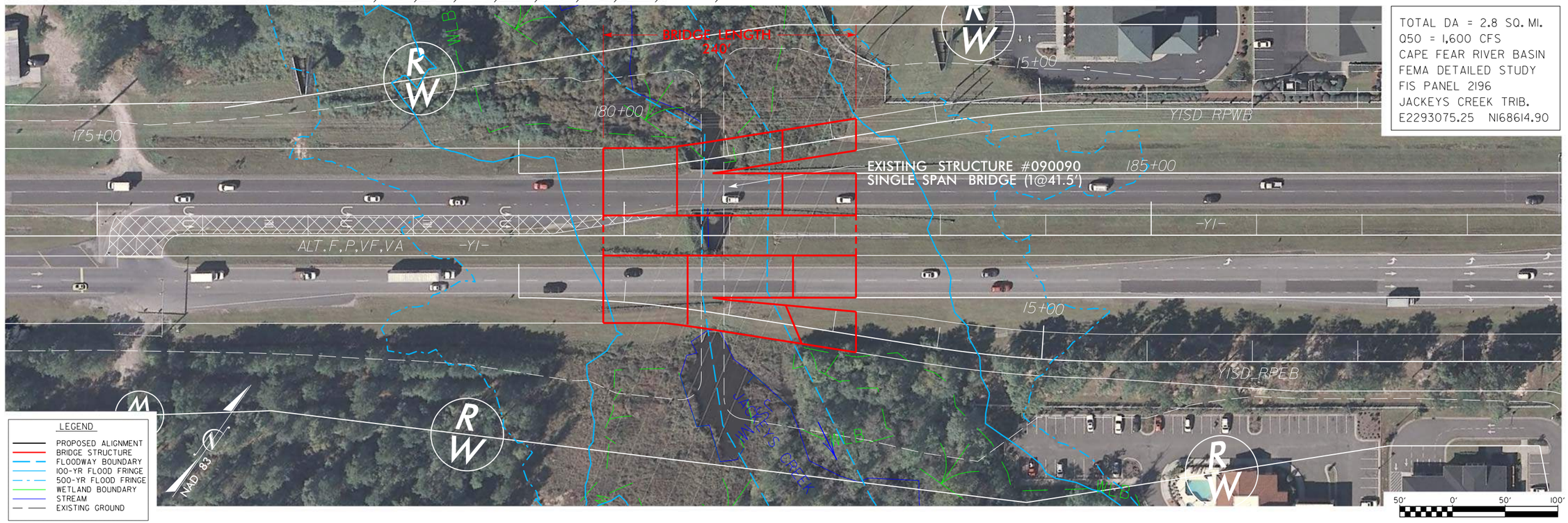
	DATE: MAY 2016

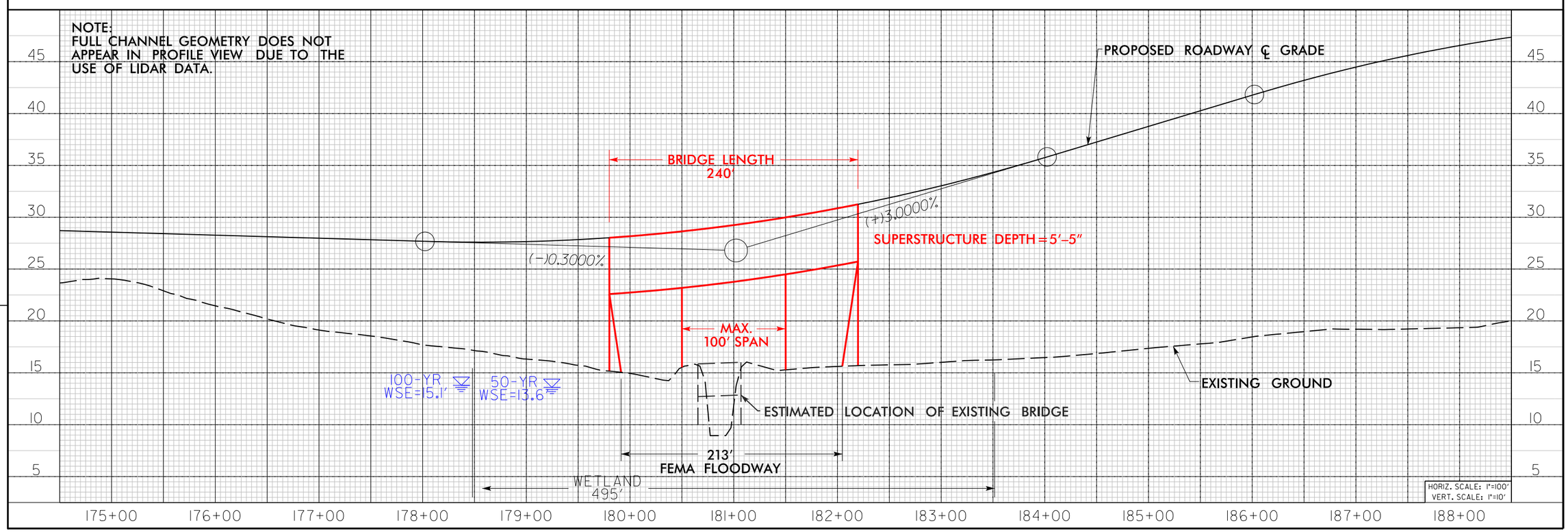
8/17/99

REVISIONS

ALTERNATIVES B, C, F, P, G, Q, J, T, VF, VA - CROSSING 36 (JACKEYS CREEK)



TOTAL DA = 2.8 SQ. MI.
Q50 = 1,600 CFS
CAPE FEAR RIVER BASIN
FEMA DETAILED STUDY
FIS PANEL 2196
JACKEYS CREEK TRIB.
E2293075.25 N168614.90



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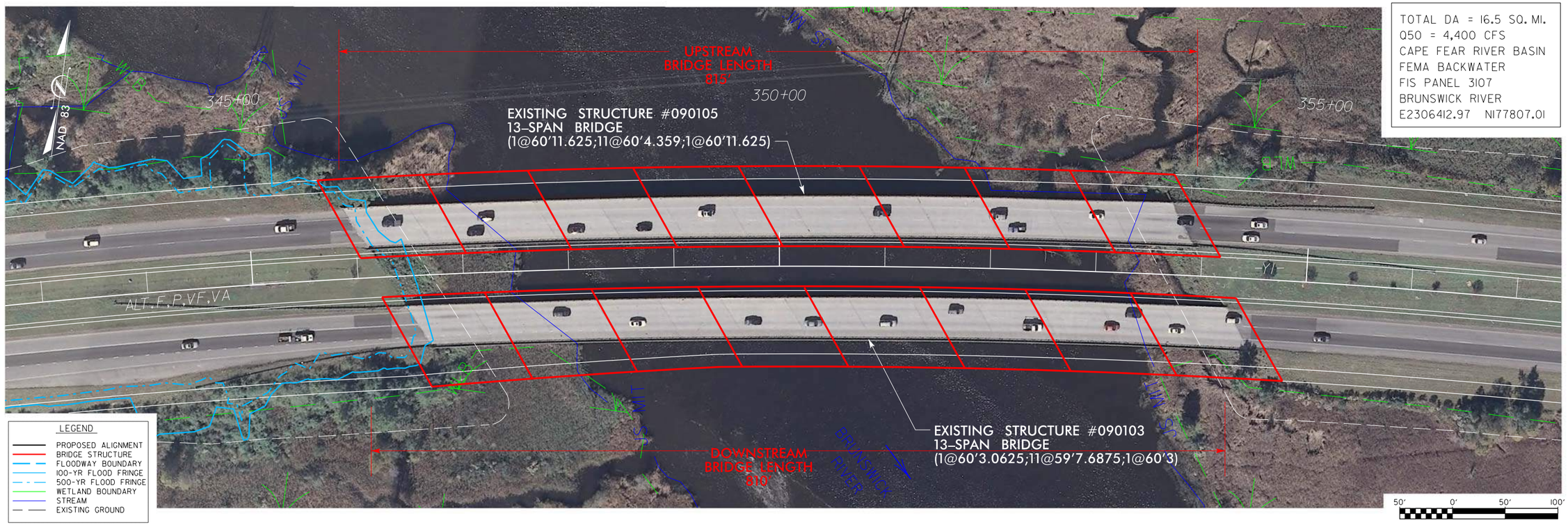
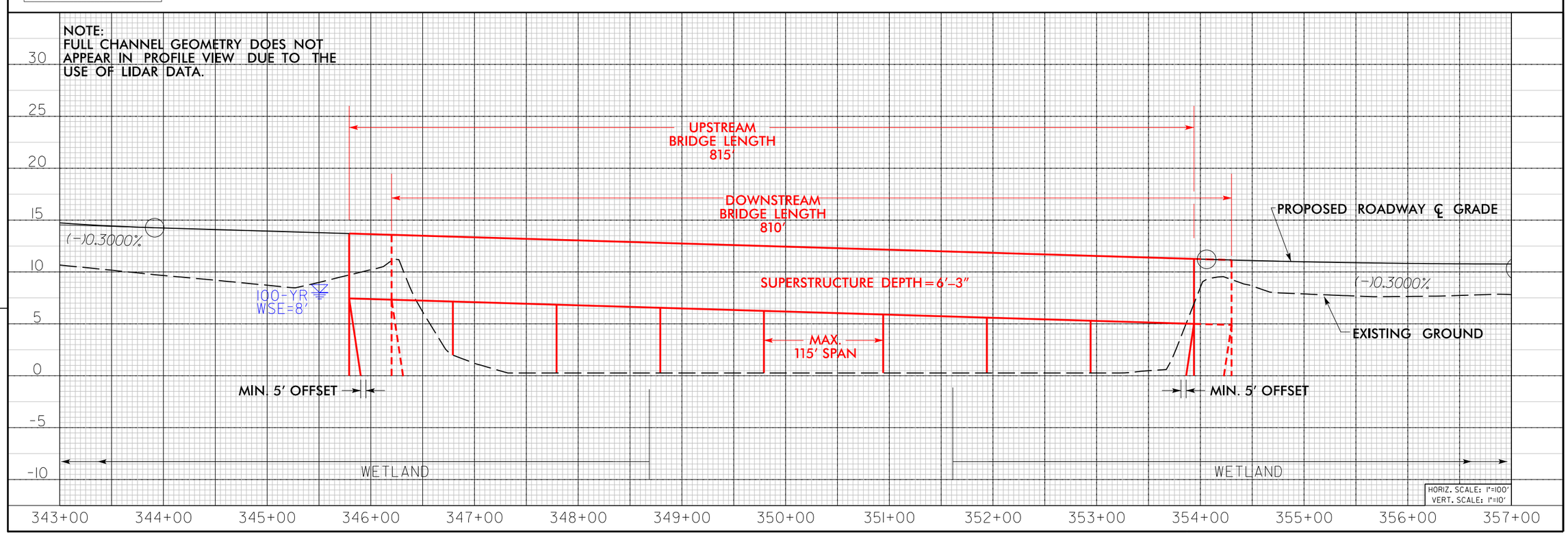
	DATE: MAY 2016

ALTERNATIVES F, P, VF, VA - CROSSING 38 (BRUNSWICK RIVER)



TOTAL DA = 16.5 SQ. MI.
Q50 = 4,400 CFS
CAPE FEAR RIVER BASIN
FEMA BACKWATER
FIS PANEL 3107
BRUNSWICK RIVER
E2306412.97 N177807.01

NOTE:
FULL CHANNEL GEOMETRY DOES NOT APPEAR IN PROFILE VIEW DUE TO THE USE OF LIDAR DATA.



REVISIONS

8/17/99

ALTERNATIVES F, P, VF, VA - CROSSING 39 (ALLIGATOR CREEK)

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	DATE: MAY 2016

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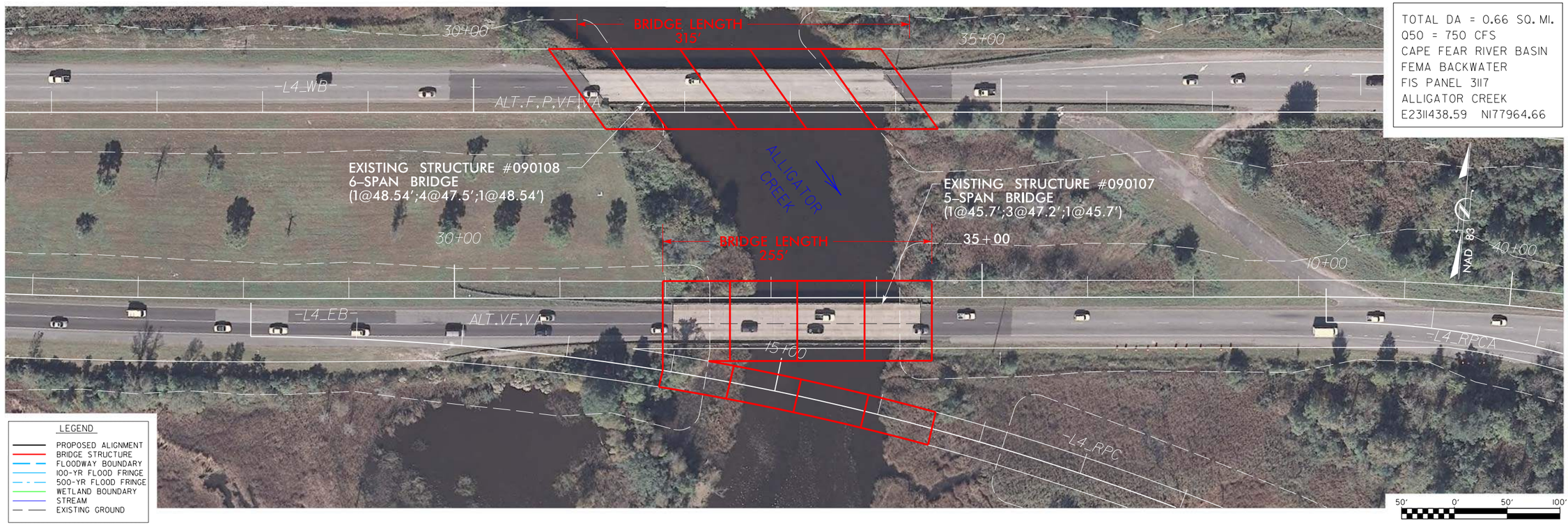
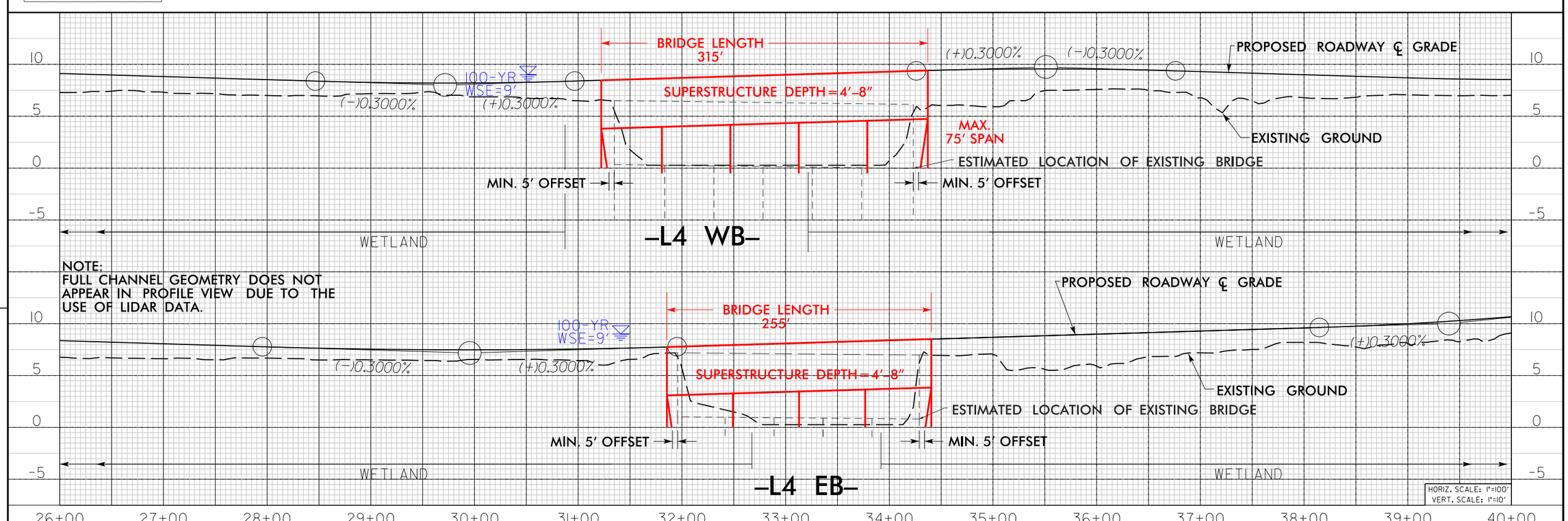
REVISIONS



TOTAL DA = 0.66 SQ. MI.
Q50 = 750 CFS
CAPE FEAR RIVER BASIN
FEMA BACKWATER
FIS PANEL 3117
ALLIGATOR CREEK
E2311438.59 N177964.66



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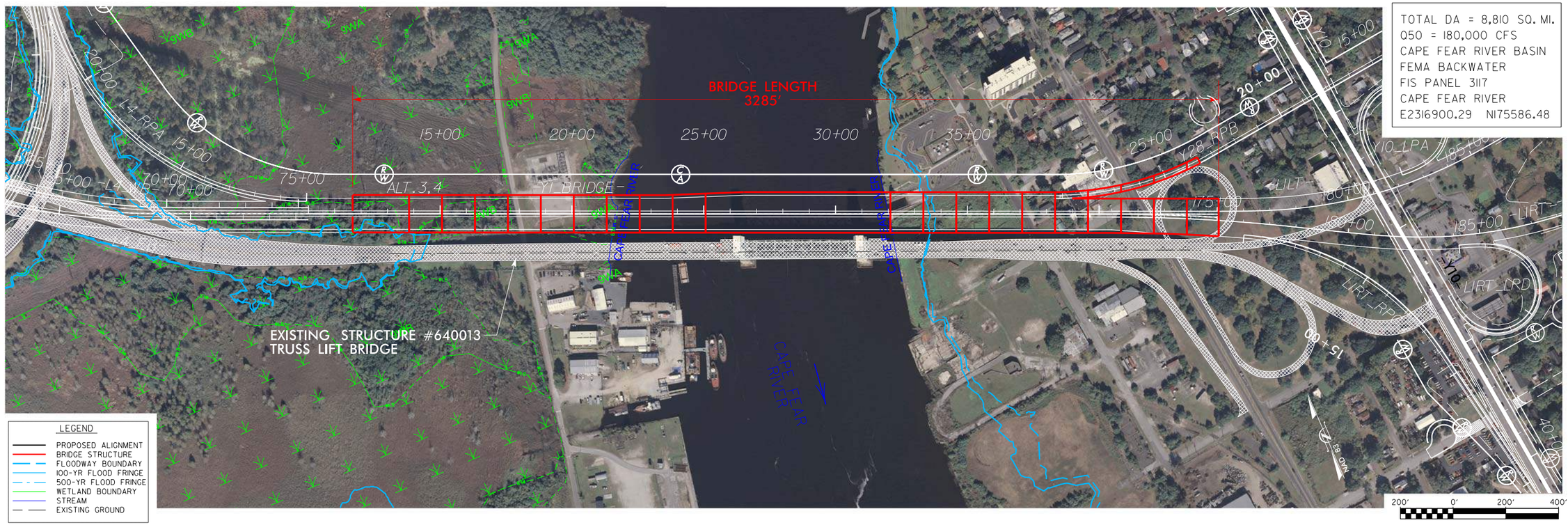
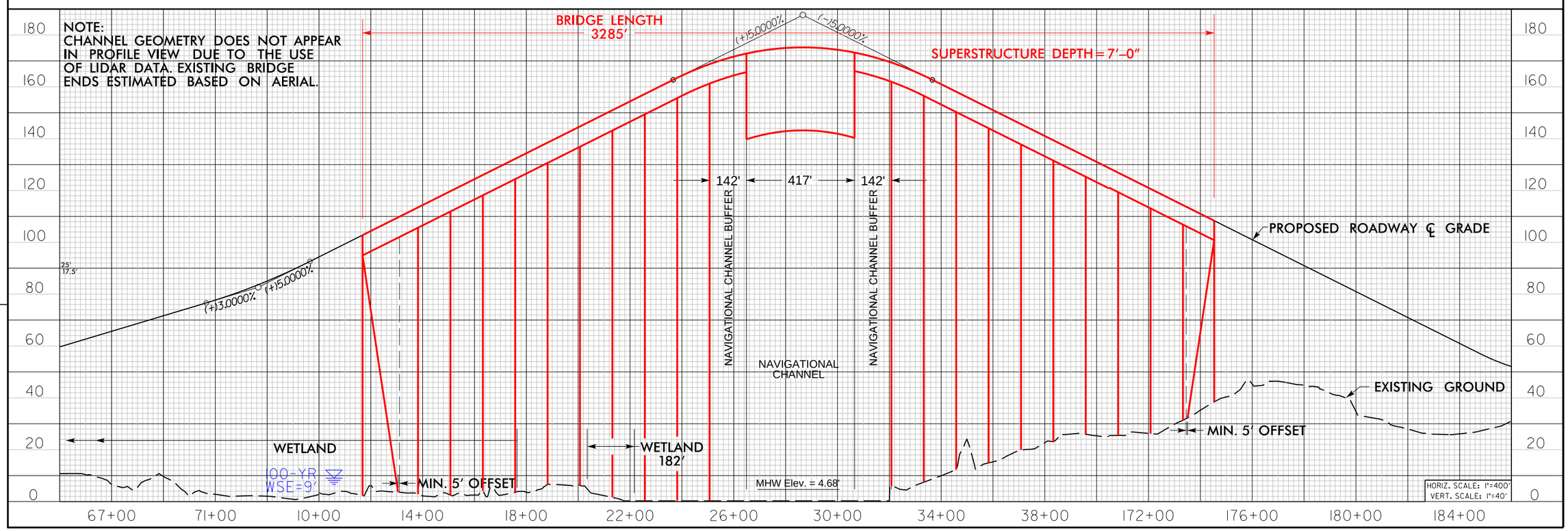
	DATE: MAY 2016

ALTERNATIVES F, P - CROSSING 40 (CAPE FEAR RIVER)



TOTAL DA = 8,810 SQ. MI.
Q50 = 180,000 CFS
CAPE FEAR RIVER BASIN
FEMA BACKWATER
FIS PANEL 3117
CAPE FEAR RIVER
E2316900.29 N175586.48



REVISIONS

8/17/99

8/17/99

REVISIONS

ALTERNATIVES VF, VA - CROSSING 41 (CAPE FEAR RIVER)

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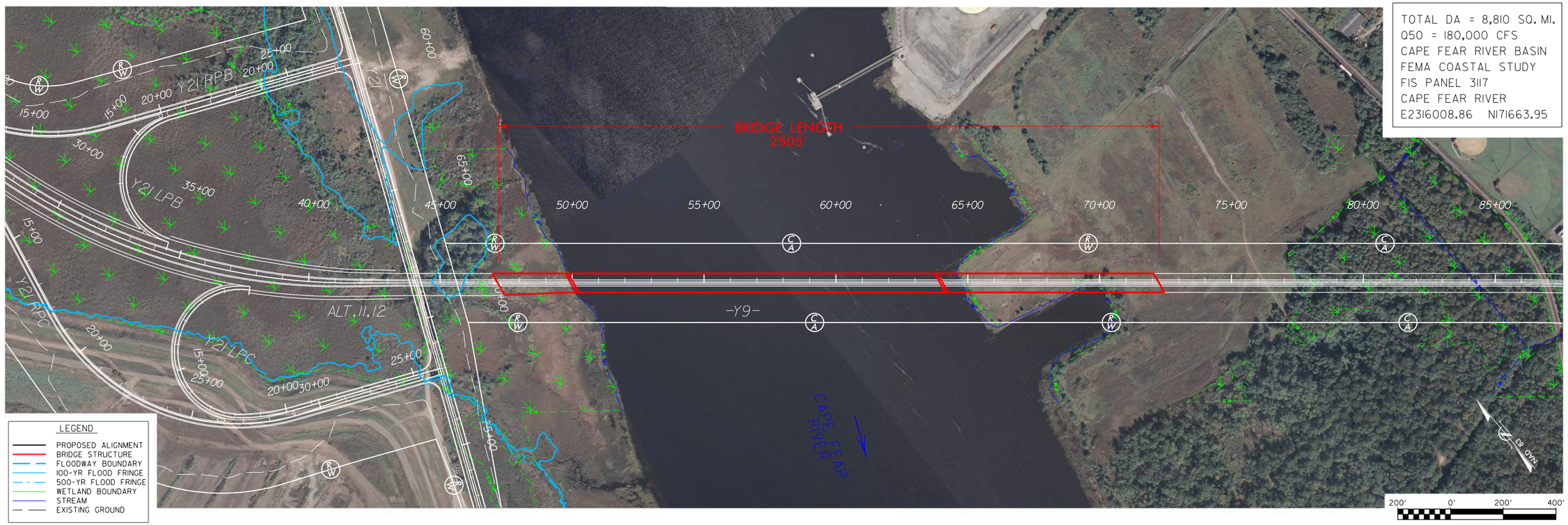
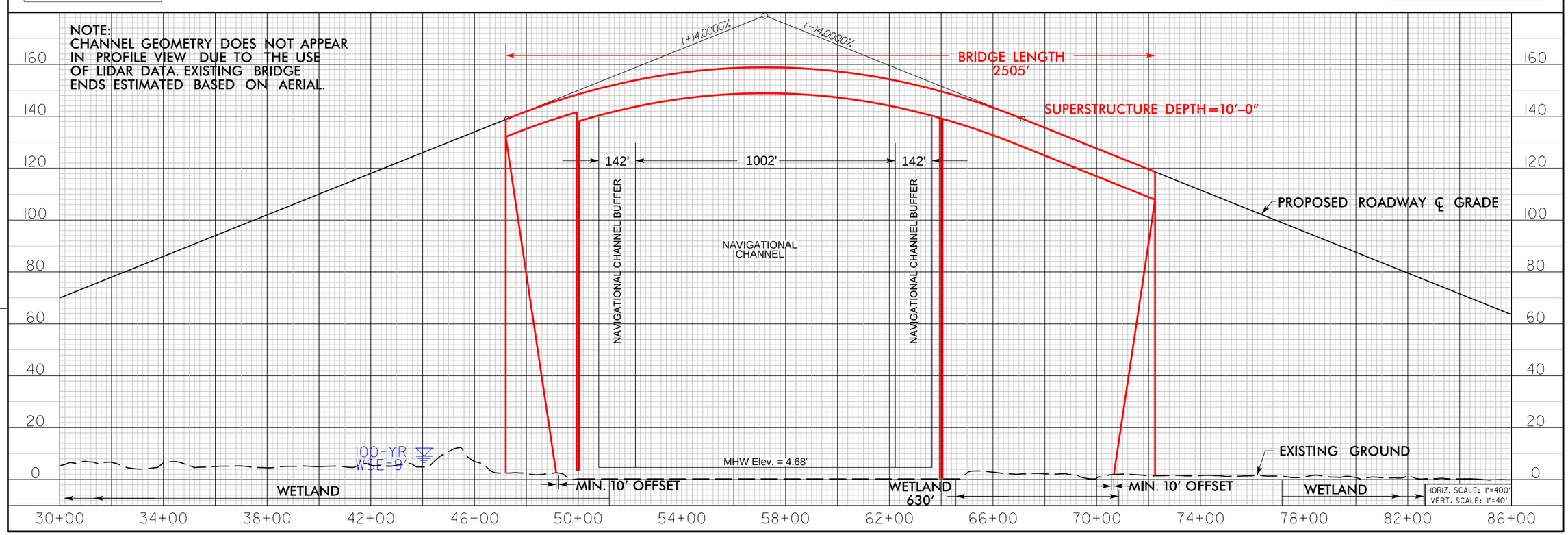
	DATE: MAY 2016





8/17/99

REVISIONS

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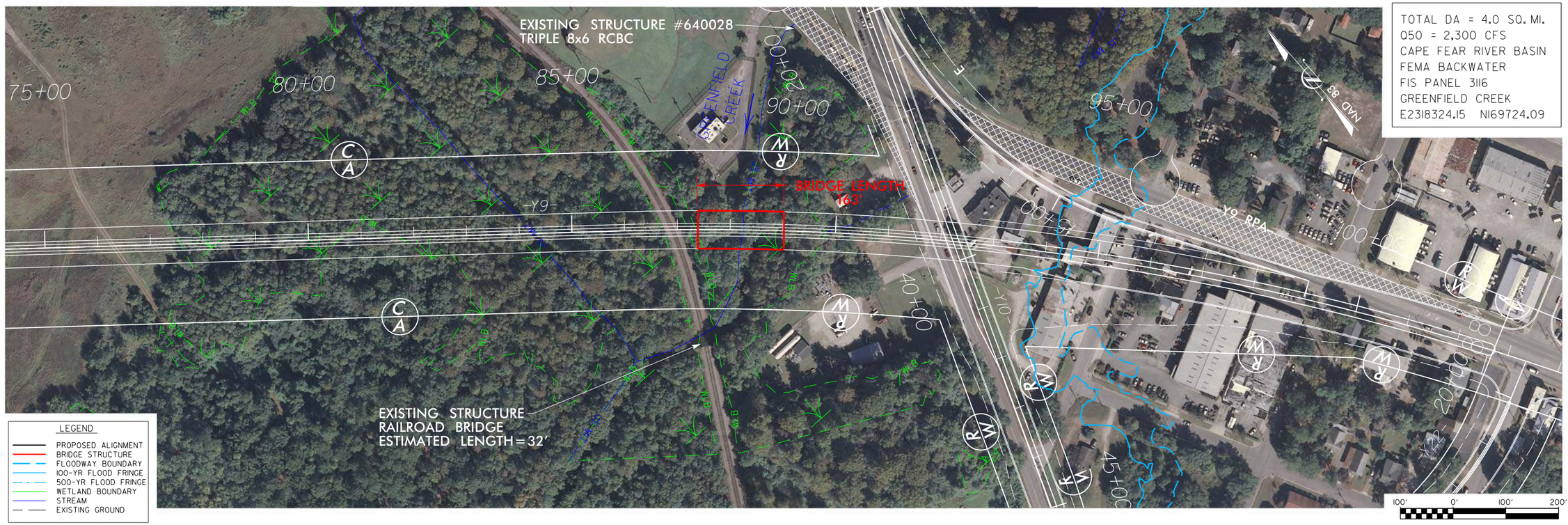
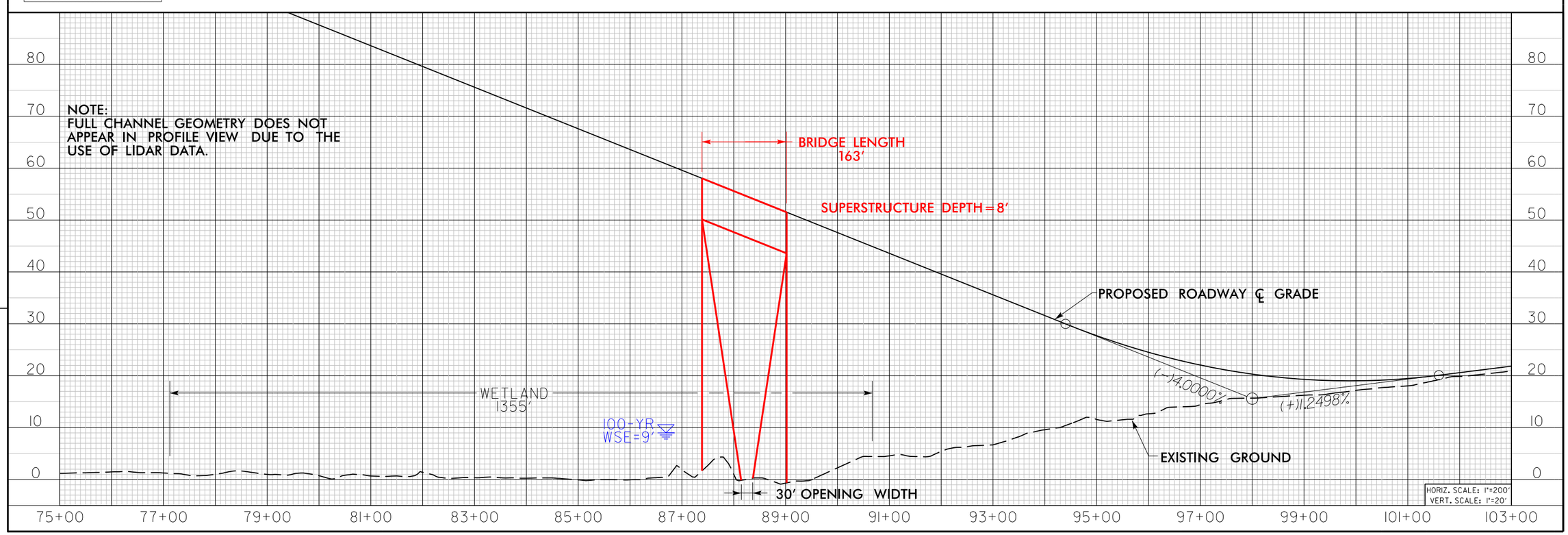
U-4738	
	DATE: MAY 2016

ALTERNATIVE VF, VA - CROSSING 43 (GREENFIELD CREEK)



TOTAL DA = 4.0 SQ. MI.
Q50 = 2,300 CFS
CAPE FEAR RIVER BASIN
FEMA BACKWATER
FIS PANEL 3116
GREENFIELD CREEK
E2318324.15 N169724.09