

MEMORANDUM

Project: SCDOT CLRB Package 27
Subject: Preliminary Hydraulic Analysis
Route: SC 83 over Little Pee Dee River (Asset ID 00814)
Date: March 14, 2025
To: SCDOT

Michael Baker International is providing a preliminary hydrologic and hydraulic assessment of the Little Pee Dee River Bridge Replacement along SC 83 in Marlboro County, South Carolina. SC 83 in the vicinity of the Little Pee Dee River is designated as a Primary Route and provides access to residential and rural areas. The Flood Insurance Study (FIS) for Marlboro County and Flood Insurance Rate Map (FIRM) Panel No's. 45069C0285C and 45069C0325C indicate the project is located within a Special Flood Hazard Area Zone A.

Model Setup:

An effective model was not provided for this stream and thus, *Hydrologic Engineering Center-River Analysis System* (HEC-RAS) Version 6.6 was used to construct the existing condition, unrestricted condition, and proposed condition models using the survey data provided by SCDOT and supplemented with *United States Geological Survey* (USGS) Light Detection and Ranging (LiDAR) data as appropriate. The model extends approximately 12,300 feet downstream and approximately 7,800 feet upstream of the project crossing. A Manning's "n" value of 0.04 was selected for use in the main channel, while a value of 0.12 was used for the overbank areas. The Manning's roughness values in the floodplain were determined based on review of aerial imagery.

The *USGS StreamStats* web application was used to determine a drainage area of 176 square miles for the project crossing. A USGS Streamgage, Station ID 02132500, is located on the Little Pee Dee River approximately 19.5 miles downstream of the SC 83 crossing. Per SCDOT's *Requirements for Hydraulic Design Studies*, a Log-Pearson Type III analysis is suggested. However, given the drainage area at the downstream gage station is 529 square miles, a Log-Pearson Type III analysis is not applicable according to the *Scientific Investigations Report 2023-5006, "Magnitude and Frequency of Floods for Rural Streams in Georgia, South Carolina, and North Carolina, 2017"*. This document requires the ratio of the drainage area at the gage station to drainage area at the project crossing to be between 0.5 and 1.5, and the ratio of the drainage areas for this project is 3.0. Therefore, the USGS Regression Equations presented in SIR 2023-5006 were used to determine the recurrence interval discharges for the project location.

Additionally, the SCS Unit Hydrograph method was used to develop recurrence interval discharges using land cover and soil data from the *National Land Cover Database* (NLCD) and the *United States Department of Agriculture* (USDA), respectively, to compare with the flowrates calculated using the USGS Regression Equations. **Table 1** below shows the comparison in flowrates at the project crossing.

Table 1: Comparison of Flowrates

Design Event (% AEP)	SCS Unit Hydrograph (cfs)	USGS StreamStats (cfs)
2 YR (50% AEP)	669	1,520
10 YR (10% AEP)	1,900	3,650
25 YR (4% AEP)	2,885	4,950
50 YR (2% AEP)	3,784	6,140
100 YR (1% AEP)	4,817	7,270
500 YR (0.2% AEP)	7,813	10,100

The recurrence interval discharges calculated using the USGS Regression Equations described above were ultimately selected for use in this analysis.

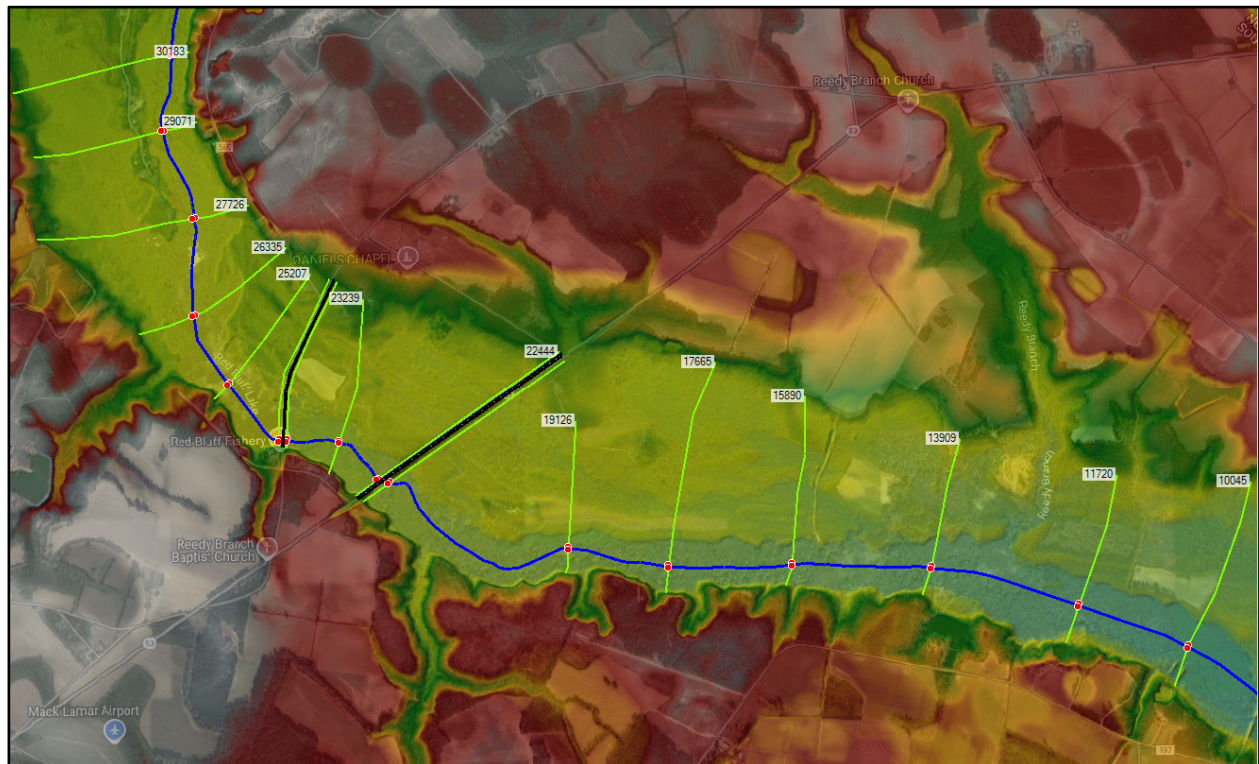


Figure 1: Little Pee Dee River Model Layout (SC 83)

Sensitivity Analysis:

A sensitivity analysis was completed on the natural conditions model to verify the downstream boundary extent of the model. First, the model was run using a normal depth as the downstream boundary condition which resulted in a water surface elevation of 126.94 ft for the 100-year storm at the downstream most cross section in the model. Next, subsequent runs were then initiated starting three (3) feet below and three (3) feet above 126.94 ft, and comparing the resulting water surface elevations near the bridge location (River Station 22379). The results of the sensitivity analysis are shown in **Table 2**, and indicate the model has sufficient downstream length to negate any effects of fluctuations in the downstream boundary condition on the water surface elevations at the project crossing.

Table 2: Sensitivity Analysis

River Station	100-Year (1% AEP) Normal Depth WSE (ft)	100-Year (1% AEP) +3 ft Profile WSE (ft)	100-Year (1% AEP) -3 ft Profile WSE (ft)
30183	140.69	140.69	140.69
29071	140.36	140.36	140.36
27726	140.11	140.11	140.11
26335	139.89	139.89	139.89
25207	139.61	139.62	139.61
24104	139.01	139.02	139.01
24045	Upstream Crossing - American Legion Road		
23996	136.73	136.74	136.73
23239	135.93	135.96	135.93
22444	135.66	135.70	135.66
22266	135.60	135.63	135.60
19126	134.00	134.13	134.00
17665	132.90	133.09	132.90
15890	131.75	132.12	131.76
13909	130.35	131.15	130.35
11720	128.51	130.27	128.53
10045	126.94	129.94	*124.26*
*Defaulted to Critical Depth *			

Design Criteria:

SC 83 is classified as a primary route. Primary route crossings should utilize the 50-year storm as the design event in accordance with the *SCDOT Requirements for Hydraulic Design Studies*. Based on the Flood Insurance Study (FIS) for Marlboro County and Flood Insurance Rate Map (FIRM) Panel No's. 45069C0285C and 45069C0325C, the project is located within a Special Flood Hazard Area Zone A. As such, the bridge will be designed based on the following criteria, unless differing criteria is presented in the Request for Proposals (RFP):

1. The minimum low chord elevation shall be the 50-year (2% AEP) water surface elevation plus 2 ft of freeboard.
2. The low chord of the replacement bridge should not be below the low chord of the existing bridge.
3. Free-surface flow should be maintained for the 100-year (1% AEP) event.
4. The backwater for the 100-year (1% AEP) design event is one (1) foot or less when compared to the unrestricted or natural condition.
5. The proposed bridge should not create more backwater than the existing bridge.

Existing Bridge Analysis:

The existing bridge consists of ten (10) - 25 ft spans, for a total length of 250 ft. The existing bridge has a gutter-to-gutter width of 22 ft, with an assumed superstructure depth of approximately 2.25 ft based on existing plans and survey data. The bridge is supported by 1 ft diameter timber piles. Ineffective flows upstream and downstream of the bridge were set based on assumed 1:1 contraction and 2:1 expansion ratios. Sloping abutments were estimated based on project surveys and visual observation. Based on the project surveys and existing bridge plans, the existing bridge low chord was estimated at elevation 139.52 ft.

Additionally, there is an SCDES Low Hazard dam (Red Bluff Lake, Dam Number D3455) approximately 1,500 feet upstream of the project bridge and is included in the hydraulic analysis. The primary control structure for this reservoir is a double 7' x 7' opening as shown in **Figure 2 (left)** below. A secondary overflow weir approximately 67' wide by 5' tall is located approximately 500 ft north of the primary control structure and is shown in **Figure 2 (right)**. During larger storm events, the northern portion of American Legion Rd is overtopped and therefore does not have a significant impact on the flowrates observed at the SC 83 crossing.



Figure 2: Upstream Face of Primary Control Structure (left) and Upstream Face of Secondary Control Structure (right) for the Red Bluff Lake Dam Upstream of SC 83

Preliminary Bridge Analysis:

A nine (9) span bridge was assumed for the preliminary analysis, and resulted in a bridge length of 420 ft. The bridge consists of a 40-40-30-40-110-40-40-40-40 span arrangement in order to provide the necessary pier setback requirements outlined in SCDOT's *Hydraulic Design Bulletin 2019-4* as well as to avoid conflicts with the existing bridge foundations. The preliminary bridge assumes a bridge width of 36.25 ft in width and will be skewed 10 degrees to better align with flood flows through the crossing. The 30 and 40 ft spans are 20-inch reinforced concrete flat slabs, while the 110 ft main span will be 54-inch Florida I Beams. The proposed roadway profile and preliminary structure depth results in a low chord elevation of 139.55 ft.

Ineffective flow areas upstream and downstream of the bridge were set based on assumed 1:1 contraction and 2:1 expansion ratios. Sloping abutments were also added in the model assuming 2:1 slopes. The existing roadway embankment within the preliminary bridge limits will be removed and restored back to natural elevations for increased hydraulic capacity.

Table 3 below summarizes the resulting water surface elevations in the project area for the existing and preliminary bridge for the 50-year (2% AEP) event.

Table 3: Design Event Water Surface Elevation Comparison

50-Year (2% AEP) Water Surface Elevation Comparison			
River Station	Existing 250' Bridge WSE (ft)	Preliminary 420' Bridge WSE (ft)	Difference (ft)
30183	140.29	140.29	0.00
29071	139.99	139.99	0.00
27726	139.77	139.77	0.00
26335	139.58	139.58	0.00
25207	139.34	139.34	0.00
24104	138.85	138.85	0.00
24045	Upstream Crossing - American Legion Road		
23996	137.56	137.09	-0.47
23239	137.24	136.62	-0.62
22444	136.63	136.11	-0.52
22379	SC 83 Bridge Crossing		
22266	136.09	135.76	-0.33
19126	133.53	133.53	0.00
17665	132.42	132.42	0.00
15890	131.23	131.23	0.00
13909	129.82	129.82	0.00
11720	128.03	128.03	0.00
10045	126.48	126.48	0.00

The resulting water surface elevation upstream of the bridge was used to check the required minimum low chord elevation for the preliminary bridge.

$$\text{Min Low Chord (Proposed)} = 136.11 + 2.0\text{-ft (Freeboard)} = 138.11$$

In addition to the freeboard requirement, SCDOT's *Hydraulic Design Bulletin 2019-4* states that free surface flow should be maintained through the bridge for the 100-year (1% AEP) event, and backwater should be limited to one (1) foot or less when compared to the unrestricted or natural conditions in the stream upstream of the proposed bridge. The resulting 100-year water surface elevations along the stream are provided in **Table 4** below.

Table 4: 100-Year Water Surface Elevations and Backwater Comparison

100-Year (1% AEP) Water Surface Elevation Comparison					
River Station	Unrestricted Conditions WSE (ft)	Existing 250' Bridge WSE (ft)	Existing Backwater (ft)	Preliminary 420' Bridge WSE (ft)	Preliminary Backwater (ft)
30183	140.69	140.69	0.00	140.69	0.00
29071	140.36	140.36	0.00	140.36	0.00
27726	140.11	140.11	0.00	140.11	0.00
26335	139.89	139.89	0.00	139.89	0.00
25207	139.61	139.61	0.00	139.61	0.00
24104	139.01	139.02	0.01	139.01	0.00
24045	Upstream Crossing - American Legion Road				
23996	136.73	138.30	1.57	137.73	1.00
23239	135.93	138.02	2.09	137.31	1.38
22444	135.66	137.37	1.71	136.77	1.11
22379	SC83 Bridge Crossing				
22266	135.60	136.71	1.11	136.35	0.75
19126	134.00	134.00	0.00	134.00	0.00
17665	132.90	132.90	0.00	132.90	0.00
15890	131.75	131.75	0.00	131.75	0.00
13909	130.35	130.35	0.00	130.35	0.00
11720	128.51	128.51	0.00	128.51	0.00
10045	126.94	126.94	0.00	126.94	0.00

The existing and proposed 100-year backwater along with the low chord criteria checks are summarized in **Table 5** below.

Table 5: Design Criteria Summary

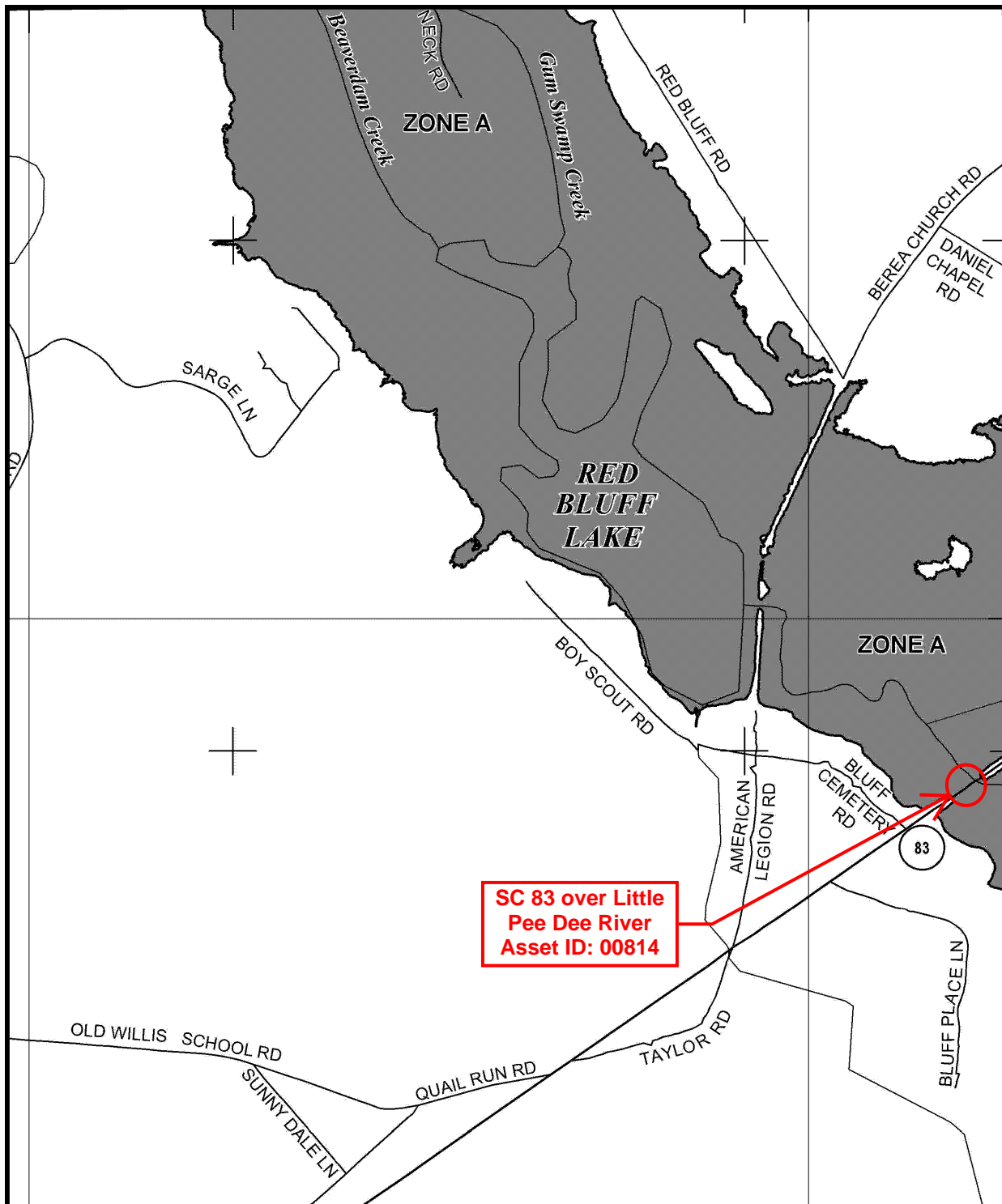
Design Criteria Summary							
Prelim. Bridge (2% AEP) WSE (ft)	Minimum Required Freeboard (ft)	Existing Low Chord Elevation (ft)	Prelim. Bridge Minimum Low Chord (ft)	Prelim. Bridge (1% AEP) WSE (ft)	Prelim. Bridge (1% AEP) Backwater (ft)	Existing (1% AEP) Backwater (ft)	Prelim. Bridge (0.2% AEP) WSE Check (ft)
136.11	2.0	139.52	139.55 > Exist.	136.77	+1.38	+2.09	138.18 < LC

The preliminary bridge configuration meets all SCDOT design criteria as previously specified, except for backwater as the preliminary bridge results in 1.38 ft of backwater and thus, **a design variance for backwater will be required**. Although the preliminary bridge does not meet the backwater requirement, upstream water surface elevations will be decreased compared to existing conditions by approximately 0.7 ft for the 100-year (1% AEP) event. The preliminary bridge low chord elevation was set to be no lower than the existing low chord and was ultimately determined by the roadway grade and superstructure depth. Additionally, the results of the preliminary bridge analysis supports the finding of “No-Impact” in accordance with SCDOT’s *Requirements for Hydraulic Design Studies* and *Hydraulic Design Bulletin 2019-4*.

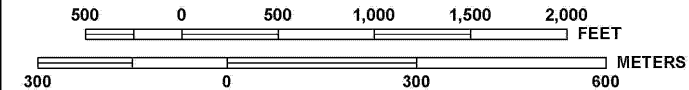
Design Considerations:

Field reviews indicate swampy conditions, likely due to the presence of small scour holes in the overbank areas. The existing scour at the bridge site is likely due to the relatively small bridge opening (251 ft) compared to the overall floodplain width of approximately 2,500 ft. The preliminary bridge reduces the average flow velocity through the bridge opening for the 100-year storm event from 3.83 ft/s in the existing conditions to 2.53 ft/s. Although the proposed abutments will be located further from the existing channel banks, riprap scour protection is recommended for abutment protection in accordance with SCDOT criteria. A design variance for backwater will be required as the preliminary 420 ft bridge results in 1.38 ft of backwater. However, the preliminary replacement structure will reduce water surface elevations upstream of the bridge approximately 0.7 ft for the 100-year (1% AEP) event.

The bridge is located within a FEMA Special Flood Hazard Area Zone A without established base flood elevations (BFEs), and the preliminary analysis supports a “No-Impact” finding. However, the final design should be verified to ensure this criterion is met.



MAP SCALE 1" = 1000'



NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0285C

FIRM

FLOOD INSURANCE RATE MAP

MARLBORO COUNTY, SOUTH CAROLINA

AND INCORPORATED AREAS

PANEL 285 OF 450

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
CLIO, TOWN OF	450149	0285	C
MARLBORO COUNTY	450146	0285	C

Notice to User: The Map Number shown below should be used when placing map orders; the Community Number shown above should be used on insurance applications for the subject community.



MAP NUMBER
45069C0285C

EFFECTIVE DATE
JUNE 16, 2011

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using FIRMette - Desktop version 3.0. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. Further information about National Flood Insurance Program flood hazard maps is available at <http://www.msc.fema.gov/>.