

MEMORANDUM

Project: SCDOT CLRB Package 27
Subject: Preliminary Hydraulic Analysis
Route: S-17-58 (Gaddys Mill Road) over Beaverdam Creek (Asset ID 06474)
Date: March 14, 2025, Revised April 8, 2025
To: SCDOT

Michael Baker International is providing a preliminary hydrologic and hydraulic assessment of the Beaverdam Creek Bridge Replacement along S-17-58 (Gaddys Mill Road) in Dillon County, South Carolina. Gaddys Mill Road in the vicinity of Beaverdam Creek is designated as a Secondary Route and provides access to residential and rural areas. The Flood Insurance Study (FIS) for Dillon County and Flood Insurance Rate Map (FIRM) Panel No. 45033C0175C indicates 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 11,000 feet downstream and approximately 9,000 feet upstream of the project crossing. A Manning's "n" value of 0.05 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, along with *Scientific Investigations Report 2023-5006, "Magnitude and Frequency of Floods for Rural Streams in Georgia, South Carolina, and North Carolina, 2017"*, was utilized to estimate the recurrence interval discharges for the reach. In particular, the project crossing has an approximate drainage area of 16.2 square miles. Next, 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 Flowrate

Design Event (% AEP)	SCS Unit Hydrograph (cfs)	USGS StreamStats (cfs)
2 YR (50% AEP)	583	399
10 YR (10% AEP)	1,232	1,080
25 YR (4% AEP)	1,699	1,530
50 YR (2% AEP)	2,111	1,940
100 YR (1% AEP)	2,567	2,350
500 YR (0.2% AEP)	3,833	3,400

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



Figure 1: Beaverdam Creek Model Layout (S-17-58)

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 82.92 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 82.92 ft, and comparing the resulting water surface elevations near the bridge location (River Station 18548). 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)
27715	95.79	95.79	95.79
27002	95.41	95.41	95.41
26198	94.95	94.95	94.95
25551	94.54	94.55	94.54
24583	93.94	93.94	93.94
23857	93.57	93.57	93.57
23104	93.20	93.20	93.20
22049	92.67	92.67	92.67
21039	92.13	92.13	92.13
20026	91.68	91.68	91.68
19300	91.35	91.36	91.35
18722	90.76	90.76	90.76
18653	90.48	90.49	90.48
18617	90.58	90.59	90.58
18464	90.54	90.55	90.54
18078	90.31	90.32	90.31
17618	89.64	89.66	89.64
17102	89.09	89.13	89.09
16265	88.41	88.50	88.41
15643	87.99	88.14	87.99
15041	87.67	87.88	87.67
14361	87.33	87.61	87.33
13684	86.90	87.29	86.89
12794	86.26	86.89	86.25
11328	85.15	86.38	85.12
9924	84.23	86.12	84.13
8647	83.49	85.99	83.23
7647	82.92	85.92	*80.84*
*Defaulted to Critical Depth *			

Design Criteria:

Gaddys Mill Road is classified as a secondary route and meets the requirements for Low Volume Bridge Replacement Projects. The 25-year storm event is to be used as the design event in accordance with this document. Based on the Flood Insurance Study (FIS) for Dillon County and Flood Insurance Rate Map (FIRM) Panel No. 45033C0175C, 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 25-year (4% AEP) water surface elevation plus 1 ft of freeboard.
2. Free-surface flow should be maintained for the 100-year (1% AEP) event.
3. The hydraulic design shall maintain or improve the existing backwater for the 100-year (1% AEP) event.

Existing Bridge Analysis:

The existing bridge consists of seven (7) - 15 ft spans, for a total length of 105 ft. The existing bridge has a gutter-to-gutter width of 26 ft, with an assumed superstructure depth of approximately 1 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 90.47 ft.

Additionally, there is an abandoned bridge approximately 125 ft upstream of the project bridge and was thus included in the hydraulic analysis. This existing structure is approximately 57 ft in length and 10.5 ft in width. The existing roadway fill on the western end of the bridge is no longer present which has resulted in a secondary conveyance area at this location, see **Figure 2** below. The earthen embankment on the eastern side of this crossing essentially serves as a dam as elevations along this embankment are higher than the 100-year flood elevations.



Figure 2: Secondary Conveyance Area West of Abandoned Bridge Crossing Upstream



Figure 3: Abandoned Bridge Crossing Upstream of S-58 Bridge

Preliminary Bridge Analysis:

The preliminary bridge consists of three (3) 50 ft spans with a total bridge length of 150 ft. The spans are 21-inch prestressed concrete cored slabs supported on pile bents. The bridge has a total width of 36 ft and will be skewed 15 degrees to better align with flood flows through the crossing. The preliminary bridge has a minimum low chord elevation of 91.40 ft. The span arrangement and beam types were selected in accordance with SCDOT's *Supplemental Design*

Criteria for Low Volume Bridge Replacement Projects (PCDM-11) and SCDOT's Bridge Design Manual.

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.

Table 3 below summarizes the resulting water surface elevations in the project area for the existing and preliminary bridge for the 25-year (4% AEP) event.

Table 3: Design Event Water Surface Elevation Comparison

25-Year (4% AEP) Water Surface Elevation Comparison			
River Station	Existing 105' Bridge WSE (ft)	Preliminary 150' Bridge WSE (ft)	Difference (ft)
27715	94.89	94.89	0.00
27002	94.54	94.54	0.00
26198	94.13	94.13	0.00
25551	93.77	93.77	0.00
24583	93.18	93.18	0.00
23857	92.79	92.79	0.00
23104	92.36	92.36	0.00
22049	91.81	91.80	-0.01
21039	91.28	91.25	-0.03
20026	90.83	90.79	-0.04
19300	90.50	90.43	-0.07
18722	90.28	90.20	-0.08
18689	Abandoned Bridge Crossing Upstream		
18653	90.20	90.13	-0.07
18617	90.21	90.14	-0.07
18548	S-17-58 Bridge Crossing		
18464	89.89	89.88	-0.01
18078	89.60	89.60	0.00
17618	88.97	88.97	0.00
17102	88.41	88.41	0.00
16265	87.66	87.66	0.00
15643	87.22	87.22	0.00
15041	86.88	86.88	0.00
14361	86.54	86.54	0.00
13684	86.10	86.10	0.00
12794	85.44	85.44	0.00
11328	84.38	84.38	0.00
9924	83.49	83.49	0.00
8647	82.71	82.71	0.00
7647	82.09	82.09	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.

$$\text{Min Low Chord (Proposed)} = 90.14 + 1.0\text{-ft (Freeboard)} = 91.14$$

In addition to the freeboard requirement, SCDOT's *Supplemental Design Criteria for Low Volume Bridge Replacement Projects (PCDM-11)* states that free surface flow should be maintained through the bridge for the 100-year (1% AEP) event, and backwater shall be maintained or improved when compared to existing conditions. 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 105' Bridge WSE (ft)	Existing Backwater (ft)	Preliminary 150' Bridge WSE (ft)	Preliminary Backwater (ft)
27715	95.79	95.79	0.00	95.79	0.00
27002	95.41	95.42	0.01	95.41	0.00
26198	94.95	94.97	0.02	94.96	0.01
25551	94.54	94.56	0.02	94.55	0.01
24583	93.94	93.98	0.04	93.96	0.02
23857	93.57	93.63	0.06	93.59	0.02
23104	93.20	93.28	0.08	93.23	0.03
22049	92.67	92.80	0.13	92.73	0.06
21039	92.13	92.33	0.20	92.22	0.09
20026	91.68	91.97	0.29	91.81	0.13
19300	91.35	91.73	0.38	91.53	0.18
18722	90.76	91.45	0.69	91.22	0.46
18689	Abandoned Bridge Crossing Upstream				
18653	90.48	91.33	0.85	91.09	0.61
18617	90.58	91.35	0.77	91.12	0.54
18548	S-17-58 Bridge Crossing				
18464	90.54	90.66	0.12	90.66	0.12
18078	90.31	90.31	0.00	90.31	0.00
17618	89.64	89.64	0.00	89.64	0.00
17102	89.09	89.09	0.00	89.09	0.00
16265	88.41	88.41	0.00	88.41	0.00
15643	87.99	87.99	0.00	87.99	0.00
15041	87.67	87.67	0.00	87.67	0.00
14361	87.34	87.34	0.00	87.34	0.00
13684	86.90	86.90	0.00	86.90	0.00
12794	86.26	86.26	0.00	86.26	0.00
11328	85.15	85.15	0.00	85.15	0.00
9924	84.21	84.21	0.00	84.21	0.00
8647	83.45	83.45	0.00	83.45	0.00
7647	82.85	82.85	0.00	82.85	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 (4% AEP) WSE (ft)	Minimum Required Freeboard (ft)	Prelim. Bridge Minimum Low Chord (ft)	Existing Low Chord Elevation (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)
90.14	1.0	91.40 > Exist.	90.47	91.12	+0.61	+0.85	92.14

The preliminary bridge configuration proposed meets all SCDOT design criteria as previously specified. The preliminary bridge low chord elevation is controlled by the hydraulic freeboard criteria, 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 a scour hole is present in the existing channel at the bridge crossing. The preliminary bridge reduces the average flow velocity through the bridge opening for the 100-year storm event from 4.37 ft/s in the existing conditions to 3.46 ft/s. However, riprap scour protection is recommended for abutment protection in accordance with SCDOT criteria. 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.