



Memo

Project: SCDOT CLRB 2022-1

Subject: Preliminary Hydraulic Analysis

Route: U.S. Route 123 Bridge over Georges Creek (Asset ID 01548)

Date: Thursday, April 20, 2023

To: SCDOT

HDR is providing preliminary hydrologic and hydraulic assessment of the Georges Creek Bridge Replacement along U.S. Route 123 (Calhoun Memorial Hwy) in Pickens County, South Carolina. U.S. Route 123 in the vicinity of Georges Creek is designated as a Primary Route and provides access to commercial businesses between Greenville and Easley, SC. The Flood Insurance Study (FIS) for Pickens County and Flood Insurance Rate Map (FIRM) Panel No. 45077C0330D indicate the project is located within a Special Flood Hazard Area Zone AE without an established floodway.

Model Setup:

SCDOT requested the effective FEMA modeling and was provided a HEC-RAS model that included Georges Creek from approximately 6,000 feet downstream at the confluence of the Saluda River to 10 miles upstream of the project area. The effective FEMA modeling was the basis for this study.

The study (effective model) included one geometry file including the existing S.C. Route 124 and U.S. Route 123 bridges. The S.C. Route 124 is approximately 640 feet upstream of U.S. Route 123. The effective model also included one flow file including a 100-year single profile for various locations throughout the stream. Based on the FIS, the effective flows were initially developed using the 2006 South Carolina Rural Regression Equations. The USGS StreamStats application was used to estimate the 50-, 100- and 500-year events for the analysis with an approximate drainage area of 27.3 square miles at the project site. The drainage area and basin characteristics were also reviewed with current publicly available LiDAR and aerial imaging. The SCS Unit Hydrograph method was used for comparison of the watershed flows. Table 1 shows the comparison of project flows.

In general, the USGS Rural Streamstats application produces larger flows (approximately 25-40%) throughout the stream reach when compared to the effective FEMA flows.

Table 1: Flow Comparison

River Station	100-Year FEMA (1% AEP)	100-Year USGS (1% AEP) Design Flows
58431	528	245
53869	680	821
49997	1190	1020
43497	1395	1780
38685	1675	2060
27500	2989	2420
17500	2989	4210
17000	3518	4780
11396	4073	5530
3914	4483	6100



The USGS flows were used for determining the minimum low chord elevation based on the 50-year (2% AEP) design event, water surface elevations and required bridge length for the proposed bridge. The FEMA flows were used for determining if a finding of “No-Impact” is feasible.

The effective model includes a single bridge crossing for the U.S. Route 123 northbound and southbound bridges. The project will replace both the northbound and southbound bridges. The proposed conditions model assumes that both bridges will be replaced with the same span arrangement.

Corrected Effective Model:

The Corrected Effective model was built using HEC-RAS v6.1 to update the effective model. A summary of the revisions is listed below.

General

- Cross section data for RS 5588 and 5960 were updated based on project surveys.
- Cross section RS 5902 was added to improve calculations between the bridges.
- Flow data for the 50-, 100-, and 500-year events was added for comparison with the proposed bridge design.
- Overbank manning's n value revised from 10 to 0.1 at RS 1964

U.S. Route 123

- Cross section 5778 was moved upstream and renamed 5800 to accommodate a full realignment of U.S. Route 123 upstream of the existing alignment. The channel geometry was updated based on the project surveys.
- Cross sections 5758 and 5631 were added to the model based on project surveys to accommodate the bridge modeling.
- Deck/Roadway information for the U.S Route 123 bridge (RS 5677) was updated to reflect the survey data.
- The minimum bridge low chord was revised to 831.50 for the U.S. Route 123 bridge to reflect the survey data and existing plans.
- The pier width for the U.S. Route 123 bridge was revised to 2.33-ft to reflect field measurements. Sloping abutments were revised based on project surveys.
- Ineffective flow elevations revised to low point of surveyed roadway profile for the upstream section and bridge low chord for the downstream section.

The effective model extends approximately 6,000 feet downstream to the confluence with the Saluda River. Due to the downstream length of the model a sensitivity analysis was not completed on the natural conditions model to verify the extents of the model. Any fluctuations in the downstream boundary condition will have no effect on the water surface elevations at the project site. There are no other hydraulic structures that would impact flow conditions at the project site. No additional hydraulic structures were added to the model.

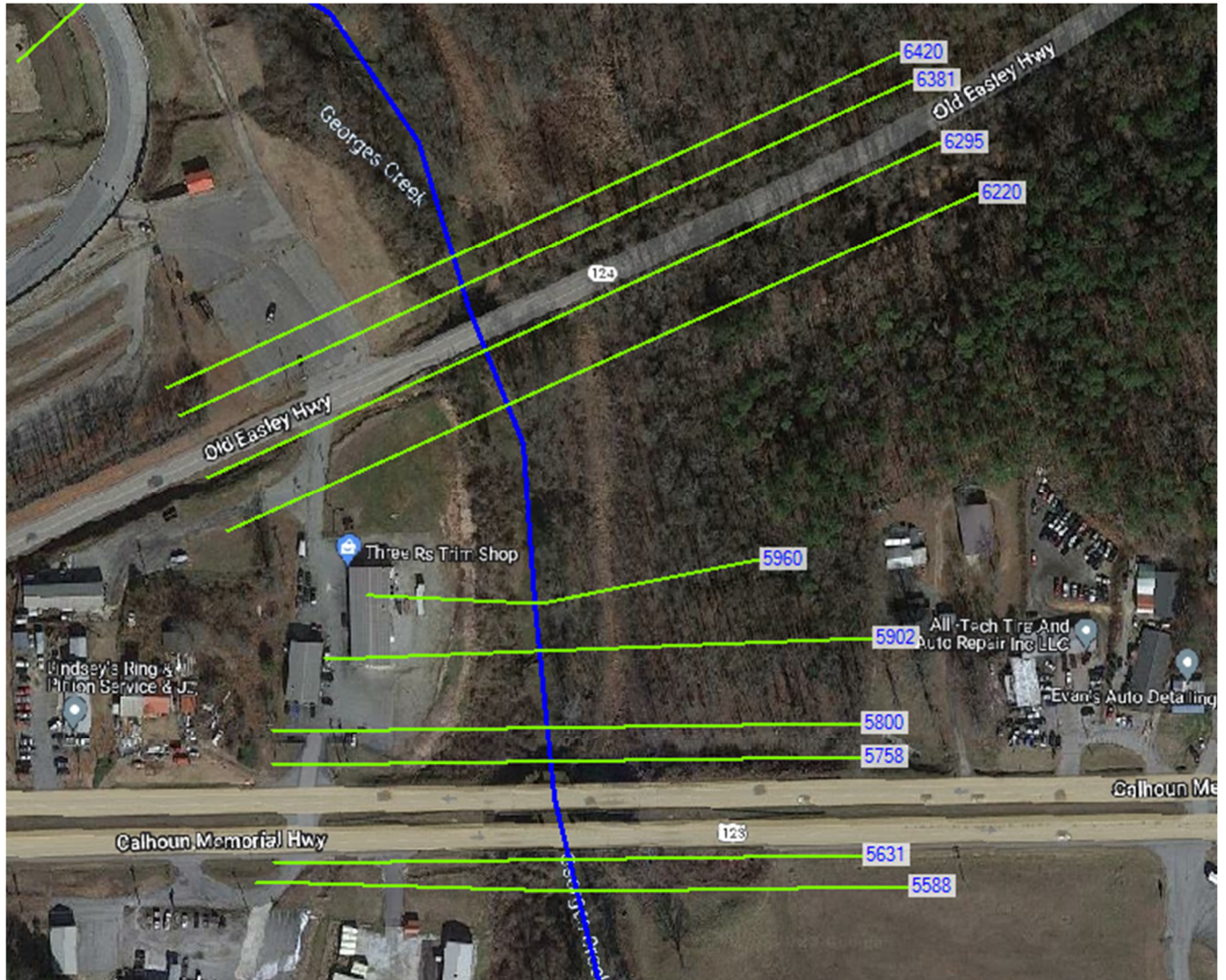


Figure 1: Georges Creek Model Layout (SC-124 & US-123)

Design Criteria:

U.S. Route 123 is classified as a primary route. Primary route crossings should be designed based on the 50-year design event as indicated in the *SCDOT Requirements for Hydraulic Design Studies*. Based on the Flood Insurance Study (FIS) for Pickens County and Flood Insurance Rate Map (FIRM) Panel No. 45077C0330D the projects are located within a Special Flood Hazard Area Zone AE without an established floodway. As such the bridge will be designed based on the following criteria:

1. The minimum low chord elevation shall be the 50-year (2% AEP) water surface elevation plus 2-ft of freeboard or existing low chord, whichever is higher.
2. The 100-year (1% AEP) should not overtop, while maintaining free-surface flow.
3. The proposed bridge should not create more backwater than the existing bridge.

Existing Bridge Analysis:

U.S. Route 123

The existing U.S. Route 123 bridges consist of 5 spans (5 @ 40-ft) for a total length of 200-ft with a superstructure depth of approximately 2-ft 9-1/8 inches resulting in a low chord elevation of 831.50. The existing channel in the vicinity of the bridge is uniform, approximately 40 feet in width, with sand/gravel bottom. Ineffective flows upstream and downstream of the proposed bridge were set based on assumed 1:1 expansion and 1:1 contraction ratio. Sloping abutments were included in the existing bridge model based on project surveys. Existing bridge bents consist of two square columns per bent with a width of 2.33- ft for the main structure.



Figure 2: U.S. Route 123 @ George's Creek Looking Downstream

The existing water surface elevations are presented in Table 3.

Preliminary Bridge Analysis:

U.S. Route 123

A three-span bridge was assumed for the preliminary analysis. The bridge consists of two 70-ft end spans and a main channel span of 105-ft for a total length of 245-ft with a total width of 46.25-ft. The spans are supported on one 5-ft diameter pier. The preliminary analysis assumes the bridge will be stage constructed to maintain two lanes of traffic during construction resulting in a 26-ft offset from the existing U.S. Route 123 southbound centerline to the upstream.



Ineffective flows upstream and downstream of the proposed bridge were set based at 1:1 expansion and 1:1 contraction ratios and 2:1 sloping abutments were included in the preliminary analysis. The roadway profile was raised to correct existing roadway design deficiencies. The proposed roadway profile and preliminary structure depth results in a low chord elevation of 837.53.

The table below shows the resulting water surface elevations in the project area for the existing and preliminary bridges for the 50-year (2% AEP) and the 100-year (1% AEP) events.

Table 2: Preliminary Bridge Analysis

RS	2% AEP Water Surface Elevations (ft)	1% AEP Water Surface Elevations (ft)
3500	802.24	803.27
3914	802.57	803.61
4500	803.23	804.27
5000	803.77	804.82
5588	805.06	806.08
5631	804.68	805.66
5677	U.S. Route 123	
5758	806.70	807.63
5800	806.93	807.84
5902	807.07	807.93
5960	808.03	808.81
6220	809.10	810.07
6295	810.47	811.52
6350	S.C. Route 124	
6381	810.67	811.74
6420	810.84	811.98
7000	811.44	812.53
7478	812.04	813.10
8000	812.66	813.72
8500	813.61	814.71
9002	814.66	815.80
9462	816.19	817.38
9900	816.87	818.02

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

U.S. Route 123

- Min. Low Chord (proposed) = $806.70 + 2.0\text{-ft freeboard} = 808.70 < \text{existing low chord of } 831.50$

The existing and proposed low chord for the U.S. Route 123 is above the required minimum low chord elevation. The proposed low chord elevation is controlled by the roadway design criteria and profile. At a minimum, it is recommended that the existing low chord elevation be maintained. The preliminary bridge also satisfies the requirement that the proposed bridge must not be subject to pressurized flow for the 100-year design event.

**Table 3: Water Surface Elevation Comparison (1% AEP) – Design Flows**

RS	Unrestricted Condition WSE (ft)	Existing Conditions WSE (ft)	Proposed Conditions WSE (ft)	Difference (ft)
3500	803.09	803.27	803.27	0.00
3914	803.45	803.61	803.61	0.00
4500	804.14	804.27	804.27	0.00
5000	804.70	804.82	804.82	0.00
5588	805.97	806.08	806.08	0.00
5631	805.14	805.66	805.66	0.00
5677	U.S. Route 123			
5758	807.07	808.08	807.63	-0.45
5800	807.33	808.24	807.84	-0.40
5902	807.20	808.29	807.93	-0.36
5960	808.34	809.01	808.81	-0.20
6220	809.69	810.20	810.07	-0.17
6295	811.05	811.60	811.52	-0.08
6350	S.C. Route 124*			
6381	811.17	812.07	811.74	-0.33
6420	811.50	812.48	811.98	-0.50
7000	811.97	812.84	812.53	-0.31
7478	812.69	813.34	813.10	-0.24
8000	813.38	813.92	813.72	-0.20
8500	814.44	814.87	814.71	-0.14
9002	815.60	815.92	815.80	-0.12
9462	817.25	817.46	817.38	-0.08
9900	817.92	818.09	818.02	-0.07

*S.C. Route 124 bridge is at RS 6315 for existing conditions and RS 6350 for proposed conditions.

Table 3 above shows that the proposed bridges reduce backwater from the existing conditions.

Table 4: Design Criteria Summary

Location	Design Criteria Summary (WSEs at RS 5758)							
	Prelim. Bridge (2% AEP) WSE (ft)	Minimum Required Freeboard (ft)	Prelim. Bridge Min. Low Chord (ft)	Existing Low Chord Elevation (ft)	Prelim. Bridge (1% AEP) WSE (ft)	Proposed (1% AEP) Backwater (ft)	Existing (1% AEP) Backwater (ft)	500-Year (0.2% AEP) WSE Check (ft)
U.S. Route 123	806.70	2.0	808.70	831.50	807.63	+0.56	+1.01	809.91 < LC

In addition to the SCDOT bridge criteria, the proposed conditions were evaluated using the FEMA effective flows for determining if a finding of “No-Impact” is feasible.



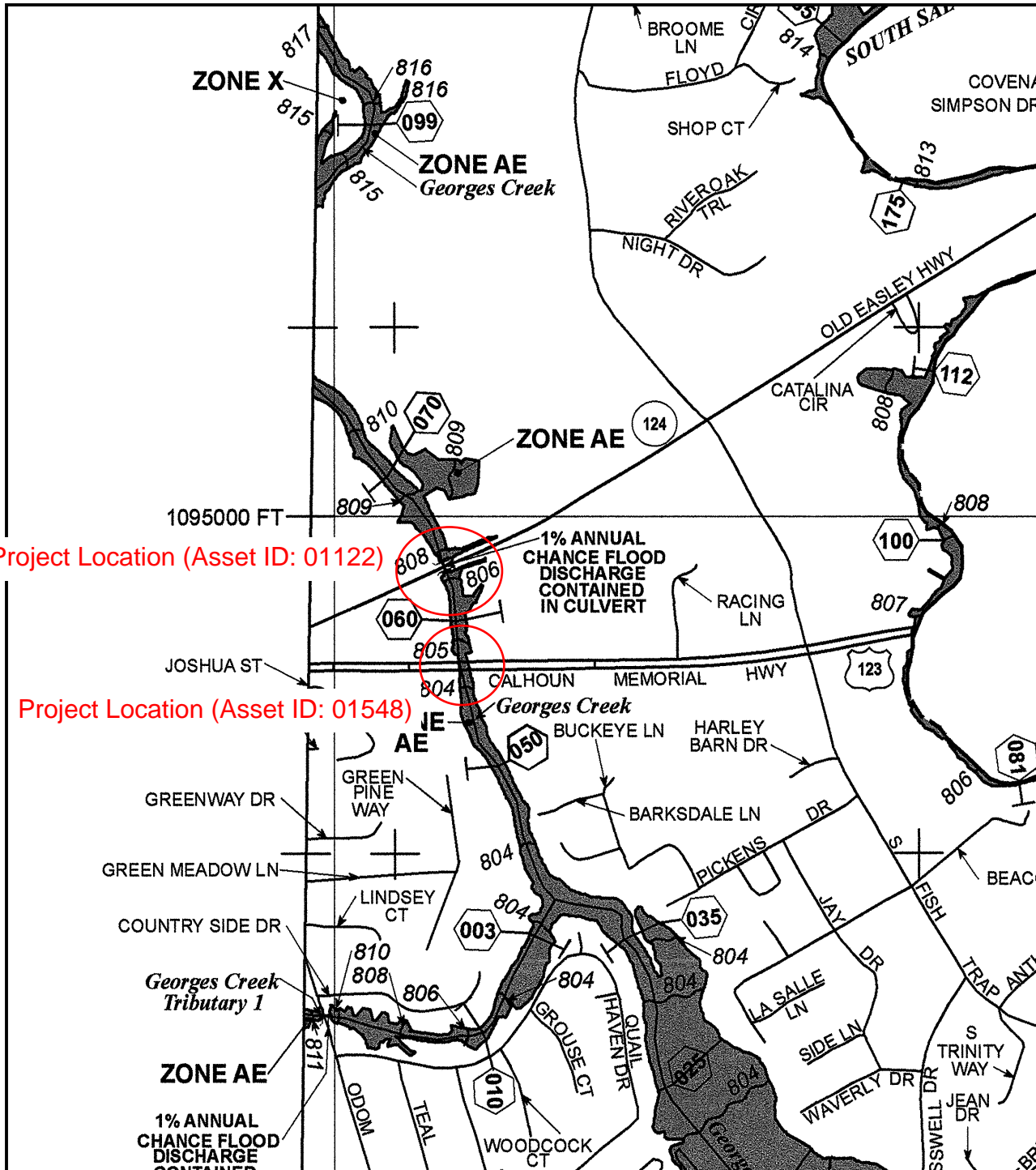
Table 5: Base Flood Elevation Comparison – FEMA Flows

RS	Corrected Conditions WSE (ft)	Proposed Conditions WSE (ft)	Difference (ft)
3500	801.05	801.05	0.00
3914	801.38	801.38	0.00
4500	802.03	802.03	0.00
5000	802.58	802.58	0.00
5588	803.91	803.91	0.00
5631	803.57	803.57	0.00
5677	U.S. Route 123		
5758	806.05	805.70	-0.35
5800	806.25	805.94	-0.31
5902	806.42	806.16	-0.26
5960	807.25	807.12	-0.13
6220	808.19	808.10	-0.09
6295	809.38	809.33	-0.05
6315	S.C. Route 124		
6381	809.83	809.52	-0.31
6420	809.94	809.61	-0.33
7000	810.51	810.26	-0.25
7478	811.09	810.89	-0.20
8000	811.67	811.50	-0.17
8500	812.56	812.43	-0.13
9002	813.56	813.47	-0.09
9462	814.98	814.92	-0.06
9900	815.71	815.66	-0.05

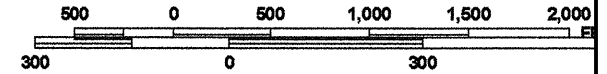
The preliminary bridge configurations meet all SCDOT design criteria for FEMA streams and the results support a finding of “No-Impact” in accordance with the *SCDOT Requirements for Hydraulic Design Studies and HDB 2019-4*. The proposed design should maintain the existing bridge low chord elevation.

Design Considerations:

Field reviews of the existing bridges indicate little scour in the overbank areas of the bridge. Both abutments are protected with rip rap and are in good condition. Existing velocities in the U.S. Route 123 bridge section are approximately 11.7 fps. The proposed velocities are reduced slightly by removal of the existing piers within the channel resulting in a velocity of approximately 11.5 fps. Abutments are largely located outside of the floodplain, but riprap protection is recommended to 2-ft above the design high water.



MAP SCALE 1" = 1000'



NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0330D

FIRM

FLOOD INSURANCE RATE MAP
PICKENS COUNTY,
SOUTH CAROLINA
AND INCORPORATED AREAS

PANEL 330 OF 430

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
PICKENS COUNTY	450166	0330	D

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
45077C0330D

EFFECTIVE DATE
APRIL 16, 2008

Federal Emergency Management Agency

This is an official FIRMette showing a portion of the above-referenced flood map created from the MSC FIRMette Web tool. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For additional information about how to make sure the map is current, please see the Flood Hazard Mapping Updates Overview Fact Sheet available on the FEMA Flood Map Service Center home page at <https://msc.fema.gov>.