

## South Carolina Southeastern Plains, Ecoregion 65 Stream Morphology Results

In the South Carolina Southeastern Plains, Ecoregion 65, geomorphic data were collected from 15 streams during January and February 2020 (Figure 1 and Table 1). Twelve of these streams (all except sites 2, 10, and 11) are located within Level IV Ecoregion 65c (Sand Hills). Three sites are at USGS gage stations with drainage areas ranging from 14.7 to 51.9 square miles, while the remaining 12 are ungaged reference streams in forested watersheds with drainage areas ranging from 0.25 to 20.0 square miles. Several other streams were visited to evaluate their potential for inclusion in this study but were rejected due to local instability or other factors affecting their geomorphic conditions.

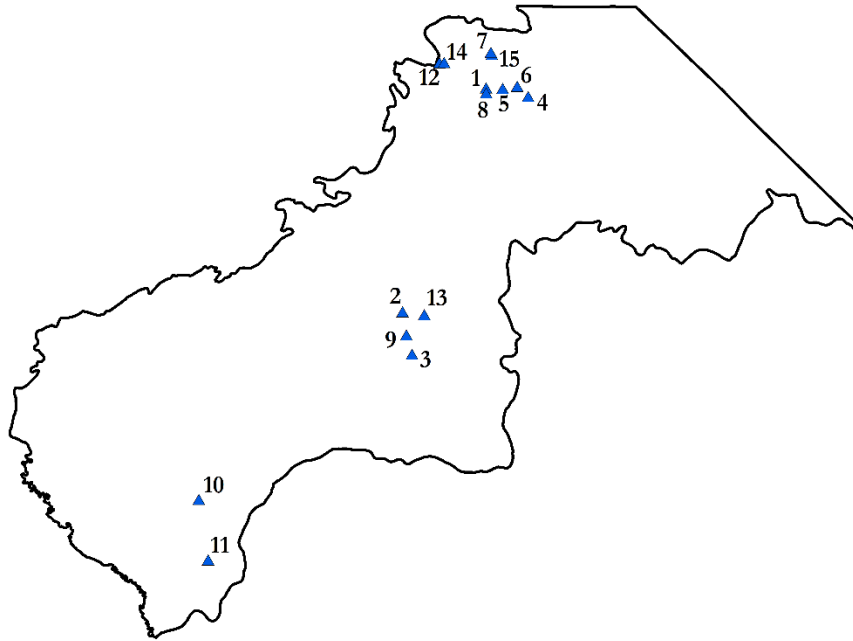


Figure 1. Reference Stream Sites in Ecoregion 65, South Carolina.

Table 1. Reference Stream Sites.

ID	Stream name	Source/Location	Latitude	Longitude	Drainage area (mile <sup>2</sup> )
1	Poplar Branch	Carolina Sandhills NWR	34.559874	-80.234442	0.25
2	UT Beech Creek	Manchester State Forest	33.873469	-80.548092	0.38
3	Mill Creek	Manchester State Forest	33.742333	-80.513768	0.39
4	UT Mill Creek	Sand Hills State Forest	34.532336	-80.078090	0.42
5	UT Black Creek	Carolina Sandhills NWR	34.558225	-80.172544	0.81
6	Middle Prong Juniper Creek	Sand Hills State Forest	34.563947	-80.118820	1.32
7	Canal Branch	Carolina Sandhills NWR	34.669100	-80.215719	1.40
8	Cow Branch	Carolina Sandhills NWR	34.544613	-80.233883	1.86
9	Shanks Creek	Poinsett State Park	33.802784	-80.534618	3.61
10	Toby Creek	SCDNR Fish Site	33.296829	-81.297025	10.7
11	Wells Branch	SCDNR Fish Site	33.111540	-81.261873	13.5
12	Little Fork Creek	USGS Gage	34.638271	-80.406705	14.7
13	Brunson Swamp	Manchester State Forest	33.864224	-80.467757	20.0
14	Fork Creek	USGS Gage	34.638528	-80.389503	24.4
15	Black Creek	USGS Gage	34.663060	-80.211803	51.9

The USGS gage stations were included in this study because long-term records for flow stage and discharge can be used to quantify the specific channel-forming discharge exceedance probability for bankfull conditions. Discharge can be reported in terms of exceedance probability (or return period) to assist in determining channel-forming discharges and morphological indicators in ungaged watersheds. The chosen gage sites are at stable stream locations in relatively undisturbed watersheds with field indicators of bankfull stage near the gages.

The ungaged reference streams in this ecoregion were selected through consultation with SCDNR and other local stream professionals, as well as extensive field reconnaissance. Reference reaches were identified generally based on the following criteria:

- Streams with drainage areas ranging between approximately 0.1 and 20 square miles (with the exception of USGS gage stations)
- Watersheds with stable land use and mostly forested over the past several decades
- Stream channels and floodplains in equilibrium with active bankfull stage indicators (i.e., bank height ratios near 1.0)
- Single-thread stream channels with freely-formed meander patterns in low-gradient valleys (less than 2% longitudinal slope)
- No valley restrictions throughout the reference reach or upstream/downstream that may influence channel form
- Healthy riparian forest buffers
- Accessible for data collection and protected for future access

Field measurements of stream geomorphological characteristics were collected to establish hydraulic geometry relationships following the methods outlined in the most current version of the North Carolina SQT Field User Manual<sup>1</sup>. All stream assessments included collection of bankfull riffle dimension (cross-section) data. As conditions allowed, pattern data were collected for a subset of the reference sites.

Data collected for all reference sites included:

- Rosgen stream type
- drainage area (DA)
- bankfull riffle cross-section area ( $A_{bkr}$ )
- bankfull riffle width ( $W_{bkr}$ ) and mean depth ( $d_{bkr}$ ) for calculating width-to-depth ratio (WDR)
- width of floodprone area ( $W_{fpa}$ ) for calculating entrenchment ratio (ER)
- maximum depth at top of bank and bankfull stage for calculating bank height ratio (BHR)
- channel water surface slope (S)
- sinuosity (k)
- median substrate size classification
- estimated Manning roughness coefficient (n)

The subset of reference sites with pattern data included collection of:

- meander wavelengths ( $L_{meander}$ )
- belt widths ( $W_{blr}$ )
- radius of curvature of meander bends ( $R_c$ )

Profile data were also collected for the subset of reference sites that appeared to have variations in streambed elevations within the reach. However, field observations and data analyses did not result in discernable riffle-pool sequences. Rather than riffles and pools, variations in bedform were generally due to tree roots, vegetation in the channel, woody debris, and accumulations of sand. This is typical of low-slope, sand bed streams in coastal plain ecoregions. As a result, profile data (i.e., riffle slopes and lengths, pool lengths, and pool spacings) could not effectively be measured.

Large woody debris (LWD) information was collected in accordance with the most current version of the Application of the Large Woody Debris Index Field User Manual developed by Stream Mechanics and Ecosystem Planning & Restoration<sup>2</sup>.

Field measurement results are presented in the appendix and in the tables and graphs below. Table 2 summarizes riffle cross-section dimension geomorphic parameters used for Rosgen stream classification. Four of the streams measured in Ecoregion 65 are C streams, while the remaining 11 are E streams. Sand was the dominant bed material in all streams, with the exception of two of the larger streams (Little Fork Creek and Fork Creek), whose streambeds were predominantly gravel. Entrenchment ratios are typically very high. Nine of the valleys were so wide that they precluded exact measurement; in these cases, entrenchment ratios are reported as >10.0. Width/depth ratios are highly variable, and range from 6.1 to 25.1.

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<sup>1</sup> NC SQT [https://stream-mechanics.com/wp-content/uploads/2017/09/Data-Collection-and-Analysis-Manual\\_NC-SQT-v3.0.pdf](https://stream-mechanics.com/wp-content/uploads/2017/09/Data-Collection-and-Analysis-Manual_NC-SQT-v3.0.pdf); currently under revision.

<sup>2</sup> Large Woody Debris Assessment [https://stream-mechanics.com/wp-content/uploads/2017/12/LWDI-Manual\\_V1.pdf](https://stream-mechanics.com/wp-content/uploads/2017/12/LWDI-Manual_V1.pdf)

Table 2. Morphology Dimensions.

Site	Drainage area (mile <sup>2</sup> )	Channel slope (ft/ft)	Cross-section area (ft <sup>2</sup> )	Bankfull width (ft)	Bankfull mean depth (ft)	Width/depth ratio	Entrenchment ratio	Rosgen Stream Class
1	0.25	0.0113	2.0	5.9	0.3	17.7	7.6	C5
2	0.38	0.0082	3.8	6.3	0.6	10.2	3.2	E5
3	0.39	0.0041	6.9	11.0	0.6	17.4	>10.0	C5
4	0.42	0.0077	2.9	5.3	0.5	9.8	>10.0	E5
5	0.81	0.0047	5.2	7.8	0.7	11.6	5.4	E5
6	1.32	0.0079	7.8	6.9	1.1	6.1	>10.0	E5
7	1.40	0.0012	8.3	9.4	0.9	10.5	>10.0	E5
8	1.86	0.0100	4.7	7.8	0.6	13.1	>10.0	C5
9	3.61	0.0043	11.3	10.5	1.1	9.9	>10.0	E5
10	10.7	0.0015	40.7	20.4	2.0	10.2	9.5	E5
11	13.5	0.0013	41.1	32.1	1.3	25.1	>10.0	C5
12	14.7	0.0016	103.9	30.9	3.4	9.2	4.9	E4
13	20.0	0.0007	51.1	18.7	2.7	6.8	>10.0	E5
14	24.4	0.0038	93.7	29.1	3.2	9.0	9.1	E4
15	51.9	0.0004	154.1	35.3	4.4	8.1	>10.0	E5

Table 3 summarizes estimated bankfull hydraulic parameters (velocity and discharge) for each stream based on the Manning equation. The Manning equation, in English units, is:

$$v = \frac{1.486 * (R^{2/3}) * (S^{1/2})}{n}$$

where  $v$  is average velocity (feet/second),  $R$  is the hydraulic radius (feet),  $S$  is average water surface slope (feet/feet), and  $n$  is a dimensionless coefficient describing channel roughness, known as Manning's  $n$ , which ranges from 0.033 to 0.150 for natural channels. The Cowan (1956) method was used to estimate the Manning's  $n$  values based on sediment size, irregularity within a cross-section, variation among cross-sections, obstructions, vegetation, and sinuosity. The bankfull discharge is estimated as the product of average velocity and riffle bankfull cross-section area.

For these streams, Manning's  $n$  values range from 0.045 to 0.063, which match expected values for natural alluvial streams in this ecoregion. Estimated bankfull average velocities for the study streams are generally between 1 and 2 feet per second, though range from 0.7 to 3.7 with variations due to slope, cross-section dimensions, and channel roughness.

Table 3. Estimated Bankfull Hydraulic Parameters.

Site	Drainage area (mile <sup>2</sup> )	Manning's n	Estimated Bankfull Velocity (ft/s)	Estimated Bankfull Discharge (cfs)
1	0.25	0.060	1.2	2.3
2	0.38	0.045	1.9	7.4
3	0.39	0.055	1.2	8.2
4	0.42	0.055	1.4	4.0
5	0.81	0.055	1.3	6.7
6	1.32	0.055	2.2	17
7	1.40	0.063	0.7	5.7
8	1.86	0.060	1.6	7.5
9	3.61	0.058	1.6	18
10	10.7	0.050	1.6	66
11	13.5	0.055	1.1	45
12	14.7	0.047	2.5	260
13	20.0	0.045	1.4	73
14	24.4	0.047	3.7	348
15	51.9	0.063	1.1	166

The graphs in Figures 2 through 5 show riffle bankfull morphological parameters and estimated discharge related to watershed drainage area (i.e., regional curves). These graphs include data points measured in Ecoregion 65 of both South Carolina and North Carolina. North Carolina stream data points are shown for comparison only and should not be used for assessment or design in South Carolina. The North Carolina data represent eight streams, as published by Doll, et al. (2003). North Carolina data are not included in Figure 5 due to minor differences in the methodologies used to estimate bankfull discharge. Figures 2 through 5 also include best-fit regression lines for each data set in addition to the regression equations and coefficients of determination.

Figures 2 through 4 demonstrate that measured bankfull cross-section area, width, and depth are often smaller in the South Carolina streams than in the assessed North Carolina streams. One reason for this result may be that many of the sites measured in South Carolina were in protected, forested watersheds with little or no impervious surface (e.g., Carolina Sandhills National Wildlife Refuge, Manchester State Forest). These undisturbed, forested watersheds tend to dampen peak flow responses to rainfall, producing equilibrium channels with little to no incision. The cross-section dimensions for South Carolina streams are validated by most streams having a bankfull elevation equal to the top of bank (i.e., Bank Height Ratio = 1.0).

Twelve of the 15 South Carolina data points (all except sites 2, 10, and 11) in Figures 2 through 5 represent data collected from streams located within Level IV Ecoregion 65c (Sand Hills). As a result, these regional curves could be considered representative of both Level III Ecoregion 65 and Level IV Ecoregion 65c.

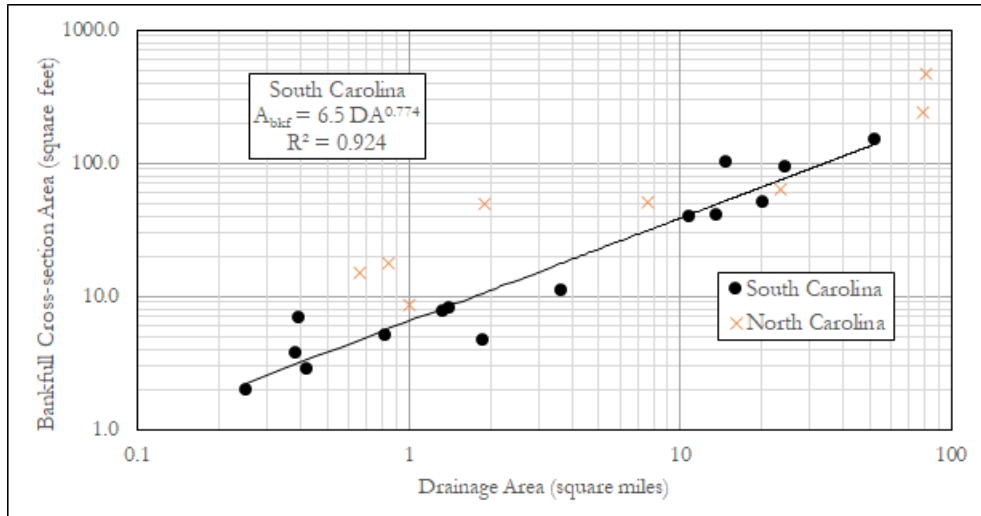


Figure 2. Bankfull riffle cross-section area related to drainage area for Ecoregion 65 streams with best-fit regression equations for South Carolina data. (Note: North Carolina stream data points are shown for comparison only and should not be used for assessment or design in South Carolina.)

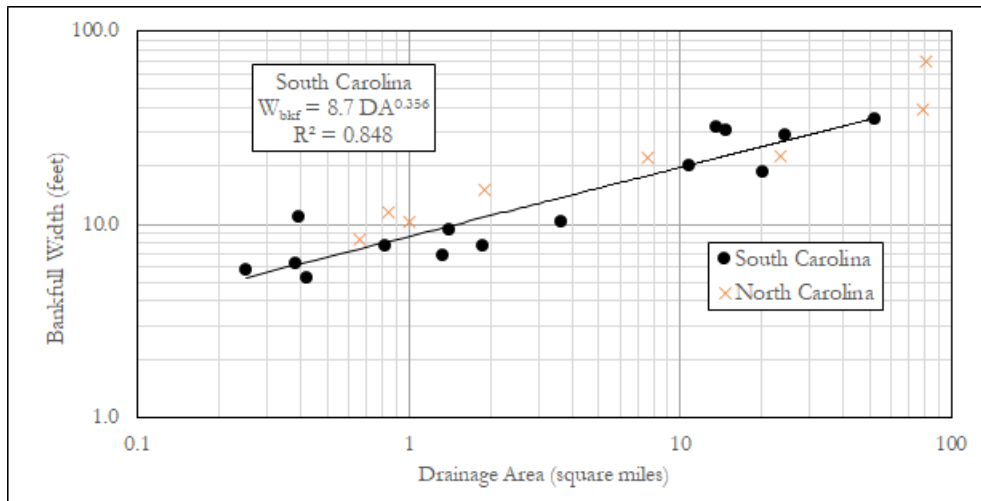


Figure 3. Bankfull riffle cross-section width related to drainage area for Ecoregion 65 streams with best-fit regression equations for South Carolina data. (Note: North Carolina stream data points are shown for comparison only and should not be used for assessment or design in South Carolina.)

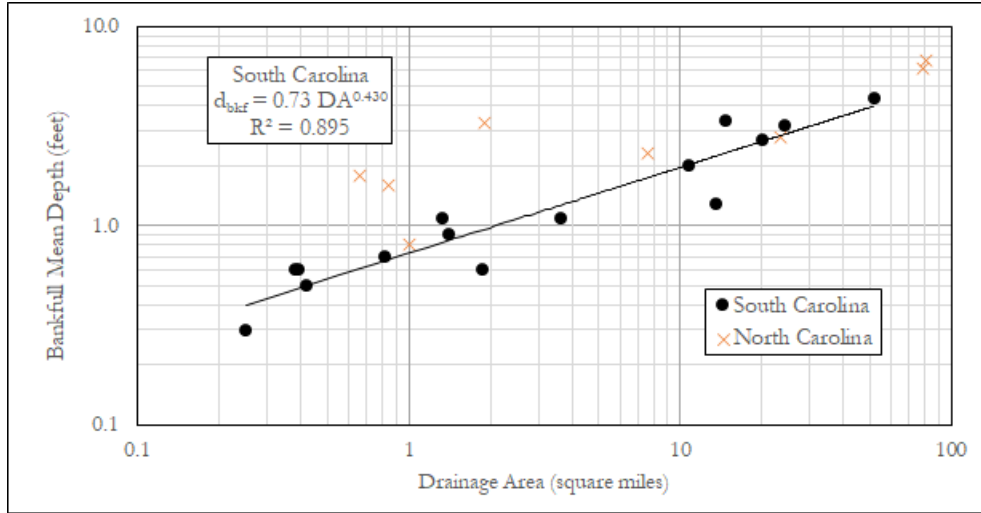


Figure 4. Bankfull riffle mean depth related to drainage area for Ecoregion 65 streams with best-fit regression equations for South Carolina data. (Note: North Carolina stream data points are shown for comparison only and should not be used for assessment or design in South Carolina.)

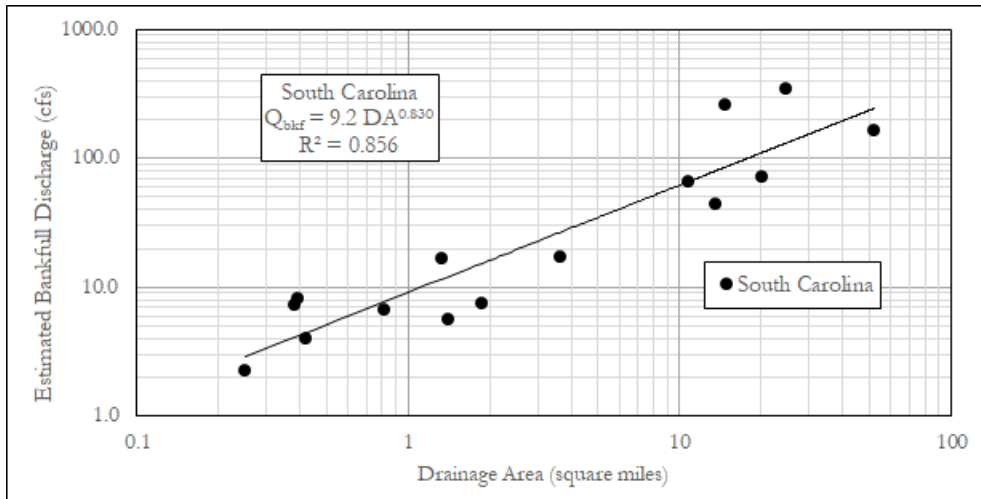


Figure 5. Estimated bankfull discharge related to drainage area for Ecoregion 65 streams.

Table 4 summarizes stream pattern data for the meandering reference streams with discernable planform parameters that could be assessed in the field. For each stream, the median pattern parameters and the median dimensionless ratios are listed. Median meander wavelength ratios range from 3.6 to 8.5, belt width ratios range from 1.9 to 3.5, and radius of curvature ratios range from 1.4 to 4.8.

Table 5 summarizes Large Woody Debris (LWD) assessments for each stream, including the numbers of LWD pieces, number of dams, and the LWD Index scores.

Table 4. Stream Morphology Pattern Parameters.

Site	Drainage area (mile <sup>2</sup> )	Sinuosity (ft/ft)	Median meander wavelength [ratio to bankfull width] (ft [none])	Median belt width [ratio to bankfull width] (ft [none])	Median radius of curvature [ratio to bankfull width] (ft [none])
2	0.38	1.06	53 [8.5]	14 [2.2]	30 [4.8]
5	0.81	1.19	37 [4.8]	15 [1.9]	21 [2.7]
7	1.40	1.45	34 [3.6]	31 [3.3]	13 [1.4]
9	3.61	1.33	88 [8.4]	37 [3.5]	35 [3.3]

Table 5. Large Woody Debris Assessment Results.

Site	Number of Pieces	Number of Dams	Piece Score	Dam Score	LWDI
1	10	0	202	0	202
2	8	0	154	0	154
3	7	0	125	0	125
4	11	0	214	0	214
5	16	0	326	0	326
6	7	1	139	15	214
7	7	0	139	0	139
8	8	0	160	0	160
9	10	0	201	0	201
10	14	1	310	12	370
11	17	2	349	33	514
12	9	1	185	16	265
13	8	0	158	0	158
14	6	0	117	0	117
15	18	0	401	0	401



## **APPENDIX**

### **ECOREGION 65, SOUTH CAROLINA**

# 1. Poplar Branch Ecoregion 65, South Carolina

**Latitude:** 34.559874

**Longitude:** -80.234442

**Drainage area:** 0.25 square miles

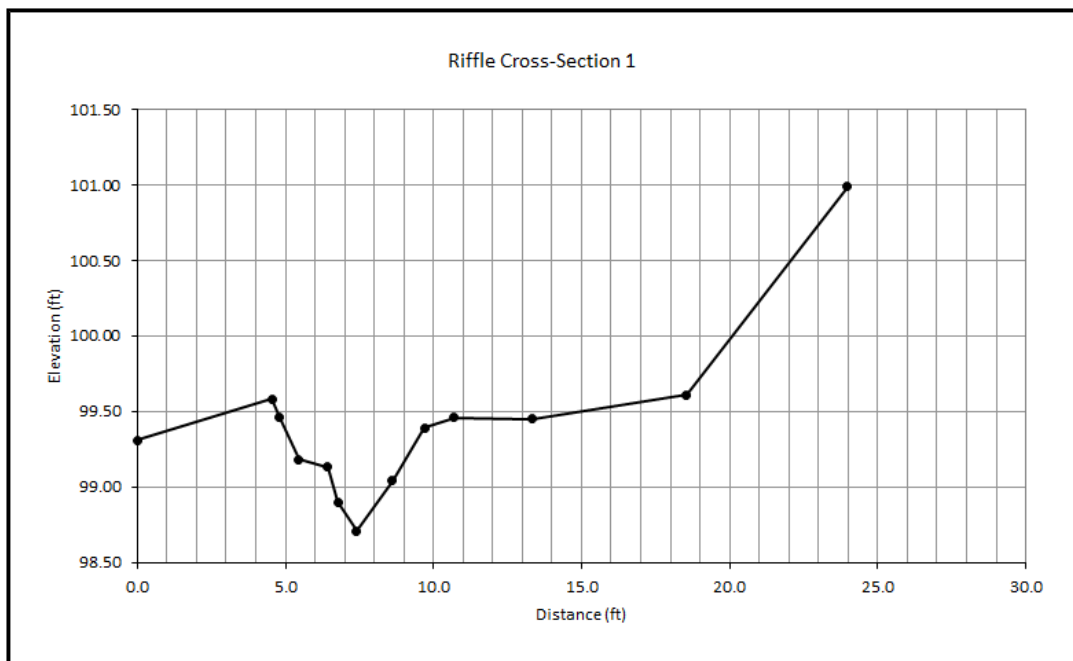
**Median particle size:** sand

**Longitudinal slope:** 0.0113 feet/foot

**Stream classification:** C5



Area (square feet) =	2.0
Width (feet) =	5.9
Mean depth =	0.3
Max depth =	0.8
Width/depth ratio =	17.7
Entrenchment ratio =	7.6



## 2. UT Beech Creek Ecoregion 65, South Carolina

**Latitude:** 33.873469

**Longitude:** -80.548092

**Drainage area:** 0.38 square miles

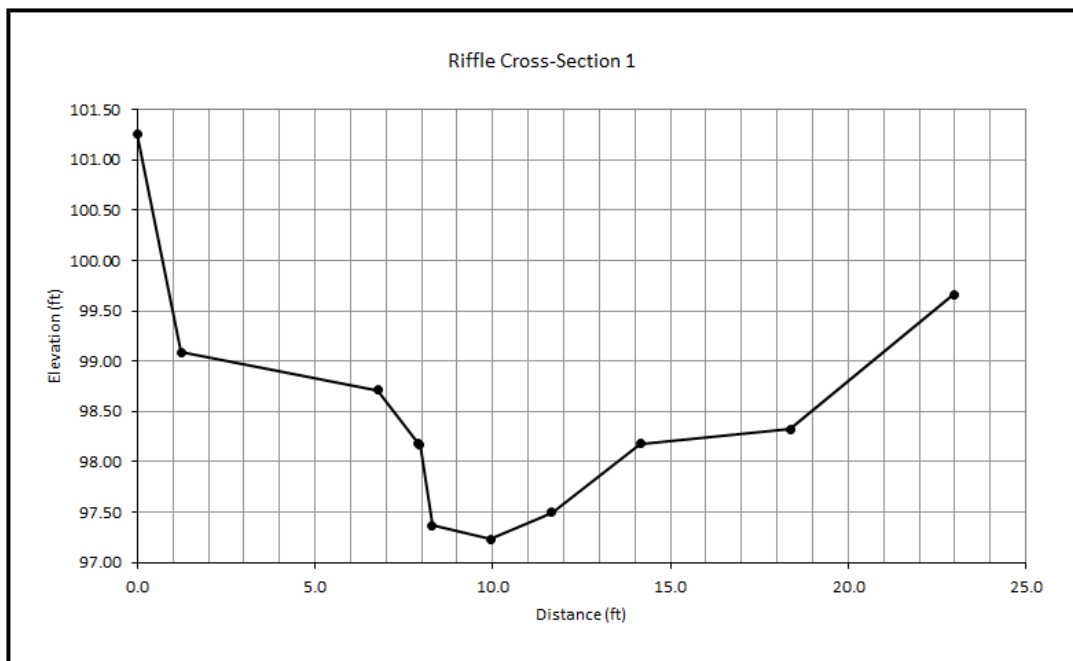
**Median particle size:** sand

**Longitudinal slope:** 0.0082 feet/foot

**Stream classification:** E5



Area (square feet) =	3.8
Width (feet) =	6.3
Mean depth =	0.6
Max depth =	1.0
Width/depth ratio =	10.2
Entrenchment ratio =	3.2



### 3. Mill Creek Ecoregion 65, South Carolina

**Latitude:** 33.742333

**Longitude:** -80.513768

**Drainage area:** 0.39 square miles

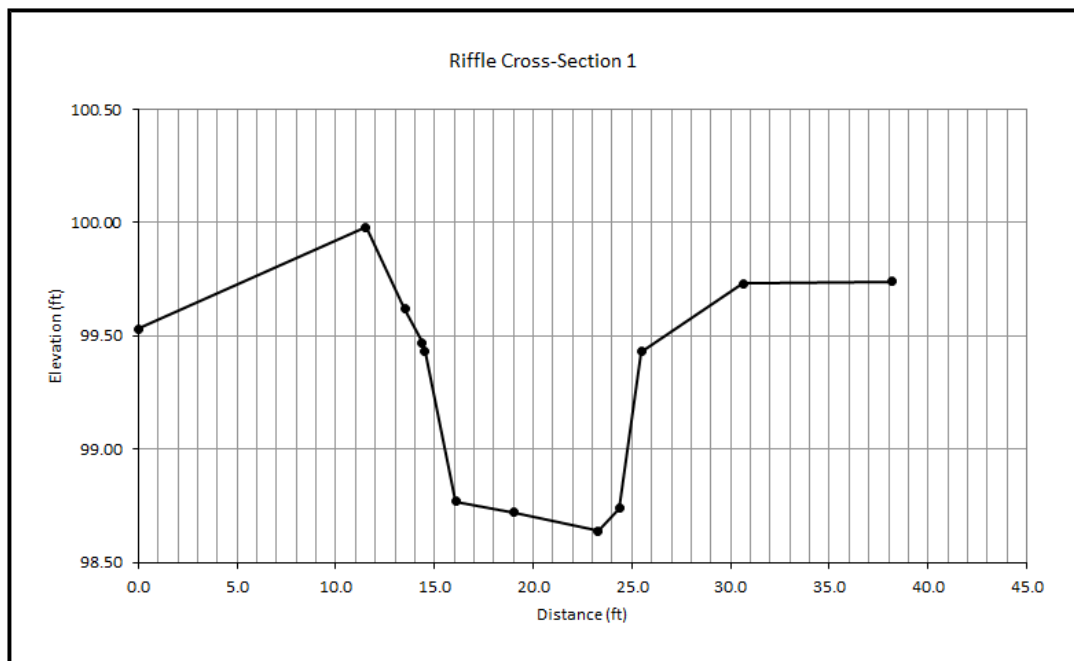
**Median particle size:** sand

**Longitudinal slope:** 0.0041 feet/foot

**Stream classification:** C5



Area (square feet) =	6.9
Width (feet) =	11.0
Mean depth =	0.6
Max depth =	0.8
Width/depth ratio =	17.4
Entrenchment ratio =	>10.0





## 4. UT Mill Creek Ecoregion 65, South Carolina

**Latitude:** 34.532336

**Longitude:** -80.078090

**Drainage area:** 0.42 square miles

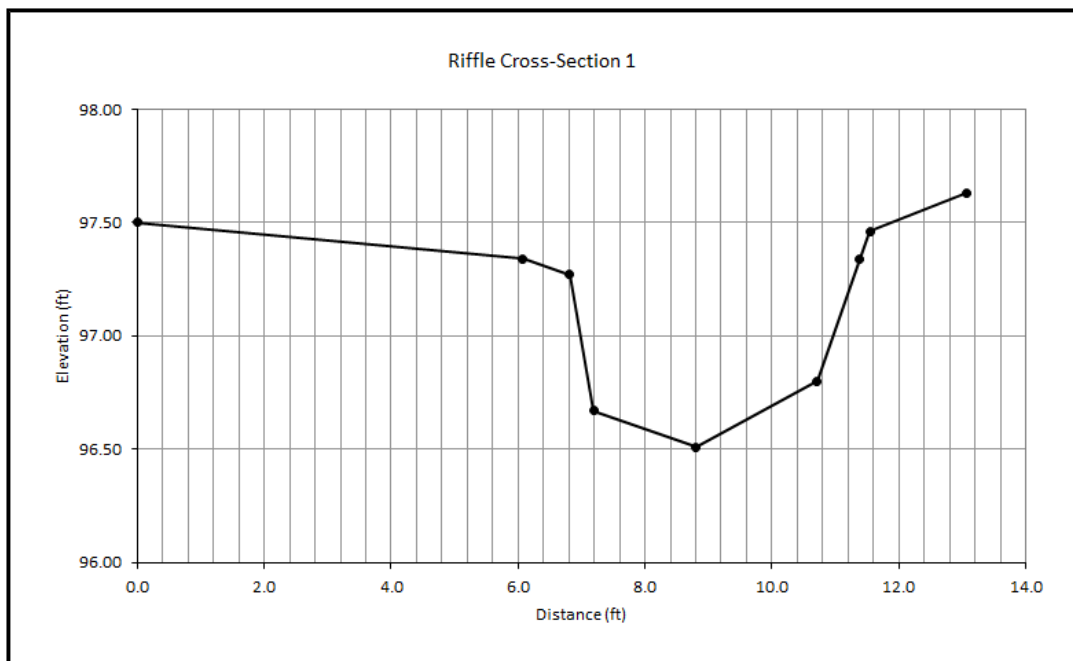
**Median particle size:** sand

**Longitudinal slope:** 0.0077 feet/foot

**Stream classification:** E5



Area (square feet) =	2.9
Width (feet) =	5.3
Mean depth =	0.5
Max depth =	0.8
Width/depth ratio =	9.8
Entrenchment ratio =	>10.0



## 5. UT Black Creek Ecoregion 65, South Carolina

**Latitude:** 34.558225

**Longitude:** -80.172544

**Drainage area:** 0.81 square miles

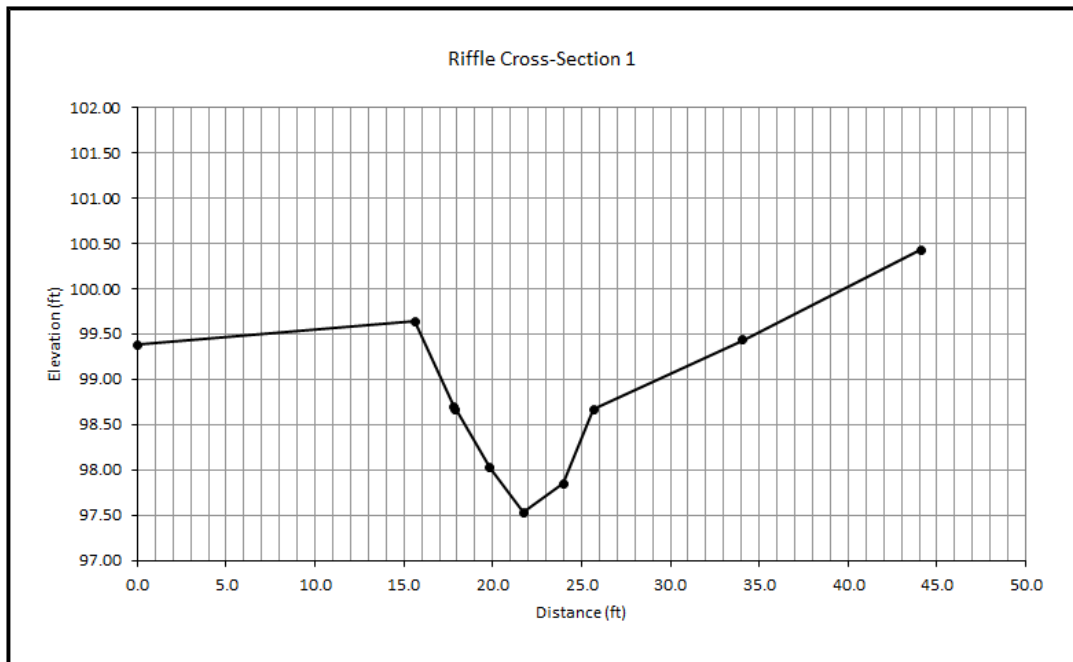
**Median particle size:** sand

**Longitudinal slope:** 0.0047 feet/foot

**Stream classification:** E5



Area (square feet) =	5.2
Width (feet) =	7.8
Mean depth =	0.7
Max depth =	1.1
Width/depth ratio =	11.6
Entrenchment ratio =	5.4



## 6. Middle Prong Juniper Creek Ecoregion 65, South Carolina

**Latitude:** 34.563947

**Longitude:** -80.118820

**Drainage area:** 1.32 square miles

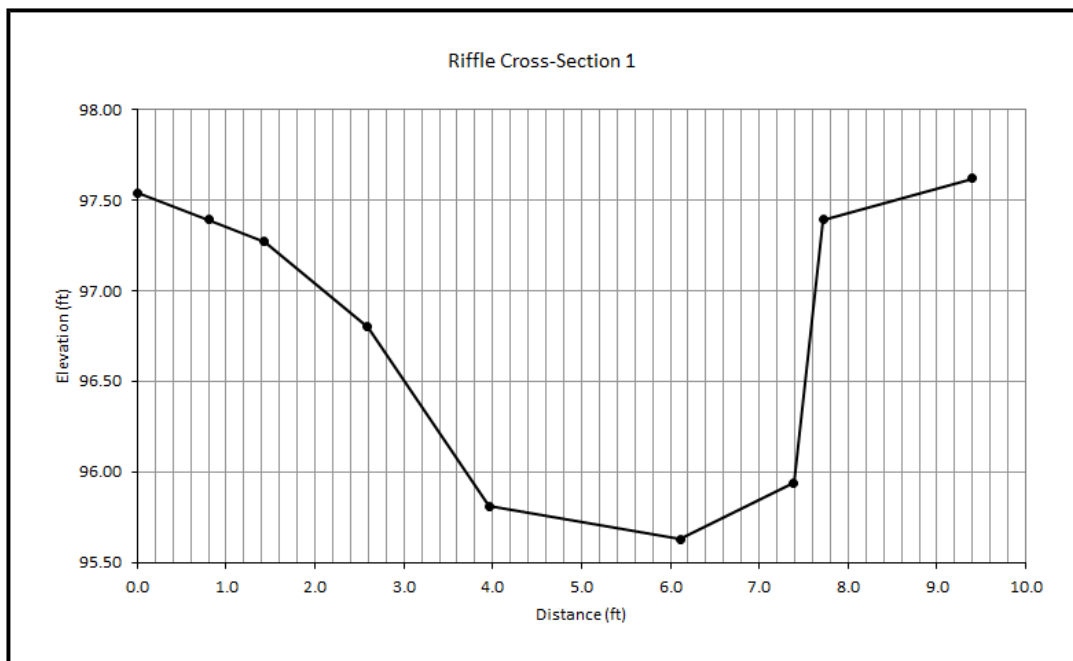
**Median particle size:** sand

**Longitudinal slope:** 0.0079 feet/foot

**Stream classification:** E5



Area (square feet) =	7.8
Width (feet) =	6.9
Mean depth =	1.1
Max depth =	1.8
Width/depth ratio =	6.1
Entrenchment ratio =	>10.0





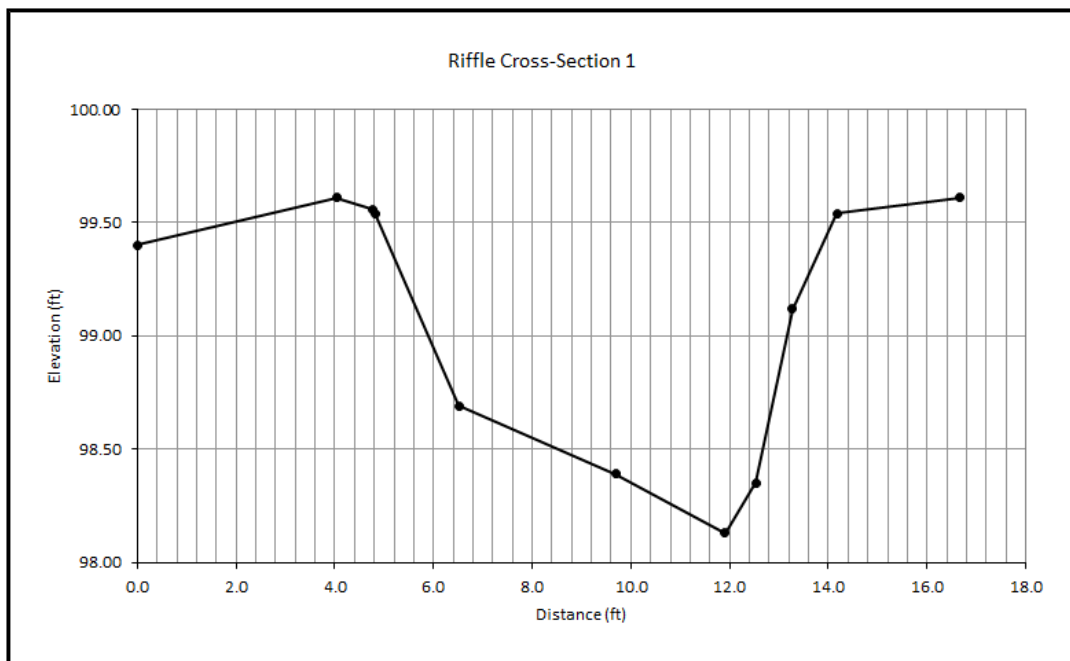
# 7. Canal Branch

## Ecoregion 65, South Carolina

**Latitude:** 34.669100  
**Longitude:** -80.215719  
**Drainage area:** 1.40 square miles  
**Median particle size:** sand  
**Longitudinal slope:** 0.0012 feet/foot  
**Stream classification:** E5



Area (square feet) =	8.3
Width (feet) =	9.4
Mean depth =	0.9
Max depth =	1.4
Width/depth ratio =	10.5
Entrenchment ratio =	>10.0





## 8. Cow Branch Ecoregion 65, South Carolina

**Latitude:** 34.544613

**Longitude:** -80.233883

**Drainage area:** 1.86 square miles

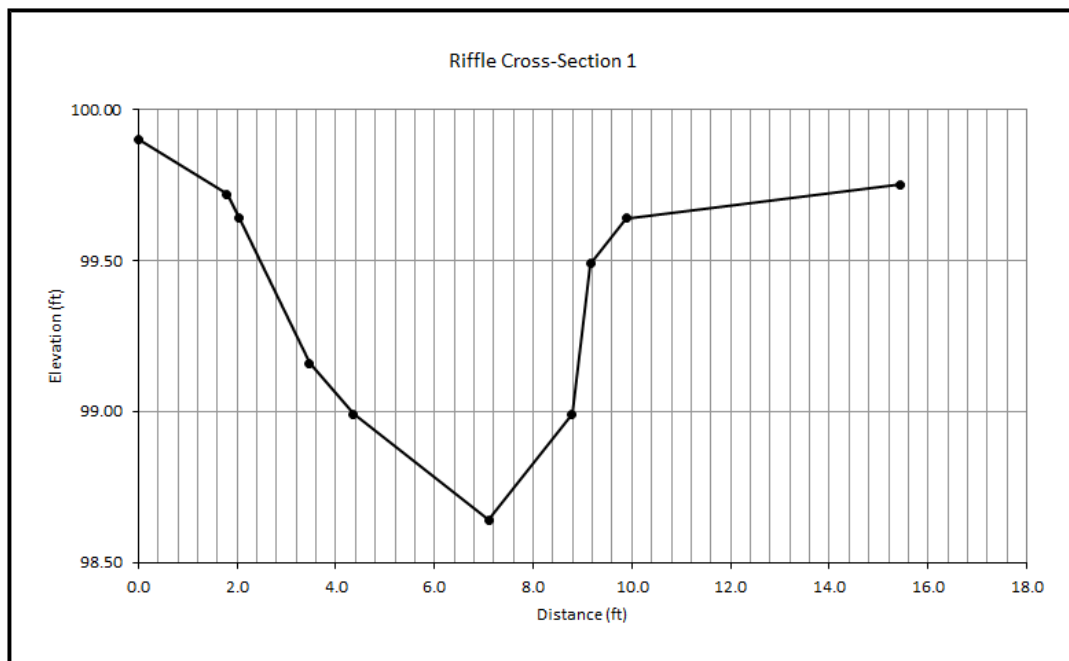
**Median particle size:** sand

**Longitudinal slope:** 0.0100 feet/foot

**Stream classification:** C5



Area (square feet) =	4.7
Width (feet) =	7.8
Mean depth =	0.6
Max depth =	1.0
Width/depth ratio =	13.1
Entrenchment ratio =	>10.0

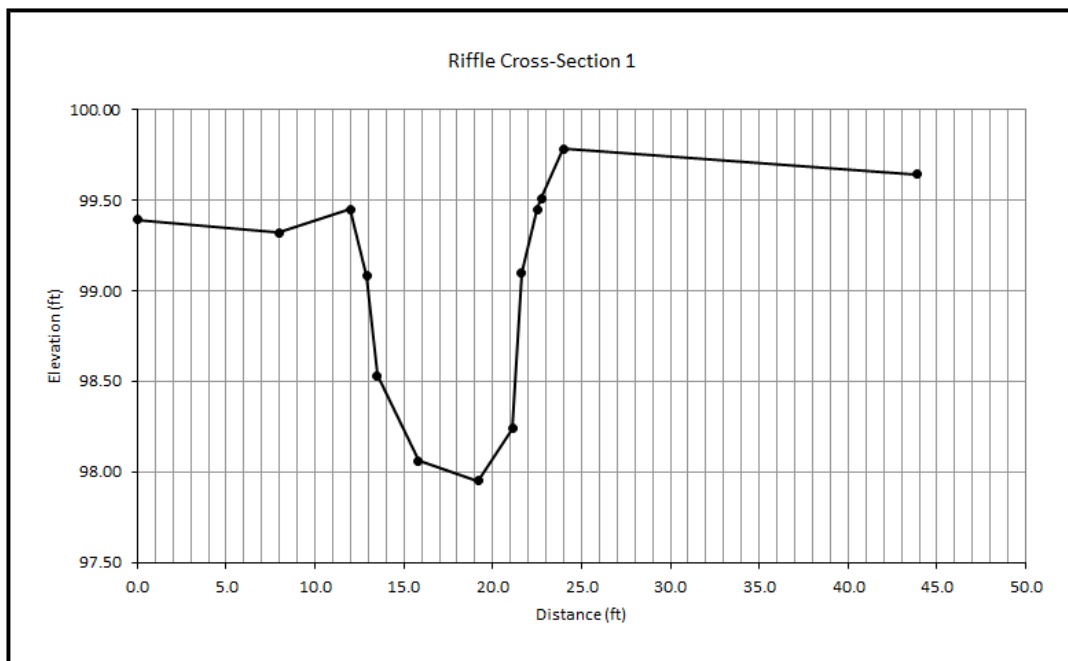


# 9. Shanks Creek Ecoregion 65, South Carolina

**Latitude:** 33.802784  
**Longitude:** -80.534618  
**Drainage area:** 3.61 square miles  
**Median particle size:** sand  
**Longitudinal slope:** 0.0043 feet/foot  
**Stream classification:** E5



Area (square feet) =	11.3
Width (feet) =	10.5
Mean depth =	1.1
Max depth =	1.5
Width/depth ratio =	9.9
Entrenchment ratio =	>10.0



# 10. Toby Creek Ecoregion 65, South Carolina

**Latitude:** 33.296829

**Longitude:** -81.297025

**Drainage area:** 10.7 square miles

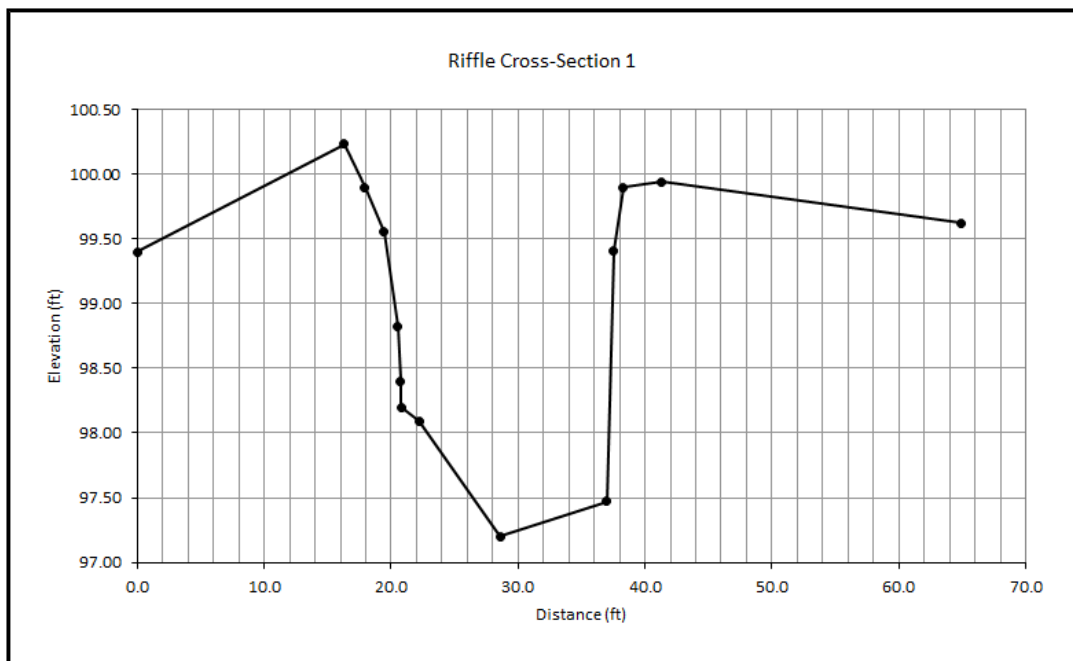
**Median particle size:** sand

**Longitudinal slope:** 0.0015 feet/foot

**Stream classification:** E5



Area (square feet) =	40.7
Width (feet) =	20.4
Mean depth =	2.0
Max depth =	2.7
Width/depth ratio =	10.2
Entrenchment ratio =	9.5



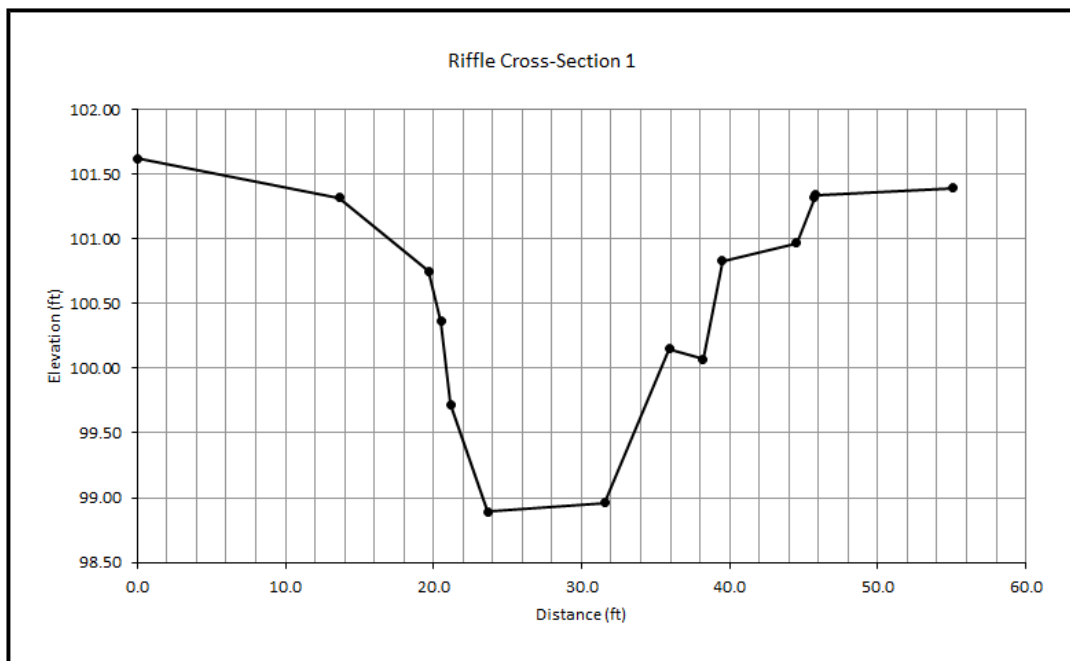


# 11. Wells Branch Ecoregion 65, South Carolina

**Latitude:** 33.111540  
**Longitude:** -81.261873  
**Drainage area:** 13.5 square miles  
**Median particle size:** sand  
**Longitudinal slope:** 0.0013 feet/foot  
**Stream classification:** C5



Area (square feet) =	41.1
Width (feet) =	32.1
Mean depth =	1.3
Max depth =	2.4
Width/depth ratio =	25.1
Entrenchment ratio =	>10.0



## 12. Little Fork Creek Ecoregion 65, South Carolina

**Latitude:** 34.638271

**Longitude:** -80.406705

**Drainage area:** 14.7 square miles

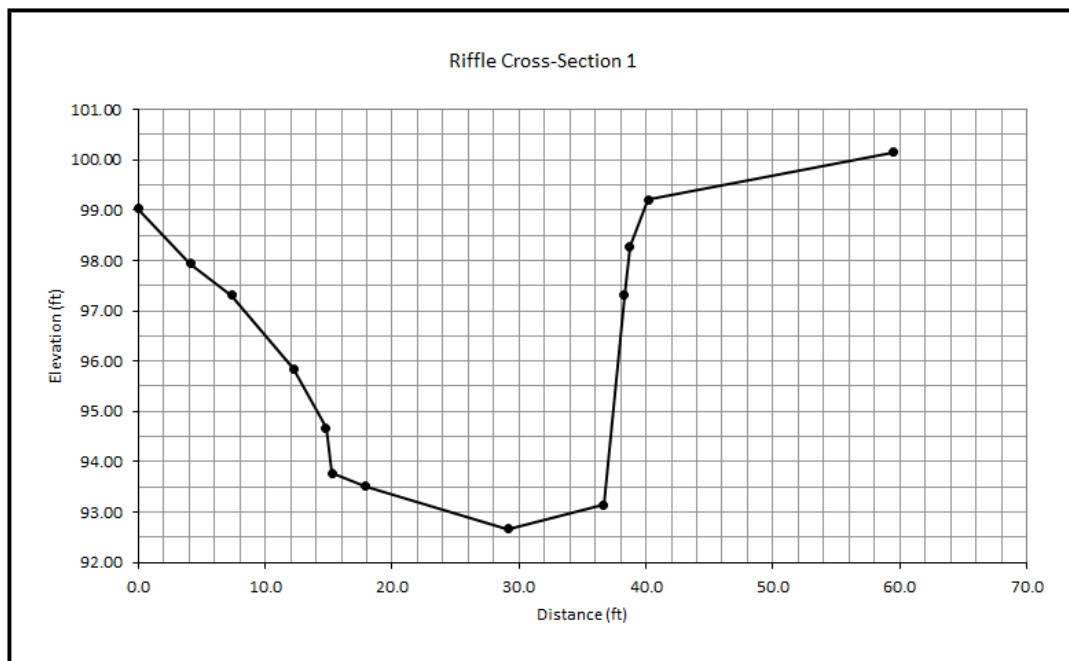
**Median particle size:** gravel

**Longitudinal slope:** 0.0016 feet/foot

**Stream classification:** E4



Area (square feet) =	103.9
Width (feet) =	30.9
Mean depth =	3.4
Max depth =	4.6
Width/depth ratio =	9.2
Entrenchment ratio =	4.9



# 13. Brunson Swamp Ecoregion 65, South Carolina

**Latitude:** 33.864224

**Longitude:** -80.467757

**Drainage area:** 20.0 square miles

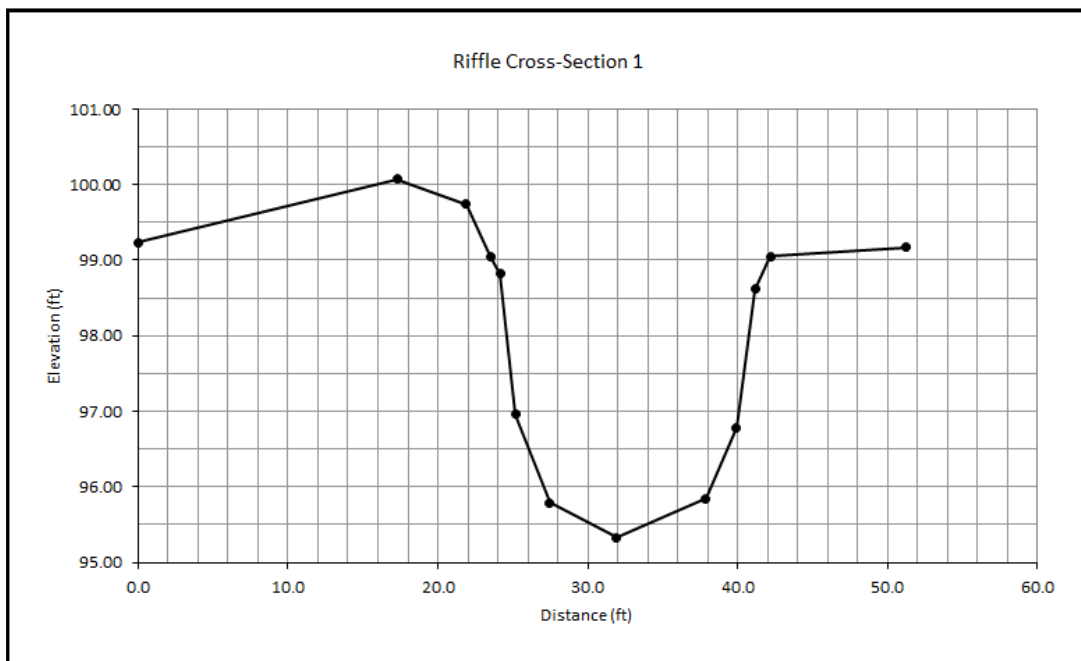
**Median particle size:** sand

**Longitudinal slope:** 0.0007 feet/foot

**Stream classification:** E5



Area (square feet) =	51.1
Width (feet) =	18.7
Mean depth =	2.7
Max depth =	3.7
Width/depth ratio =	6.8
Entrenchment ratio =	>10.0





# 14. Fork Creek

## Ecoregion 65, South Carolina

**Latitude:** 34.638528

**Longitude:** -80.389503

**Drainage area:** 24.4 square miles

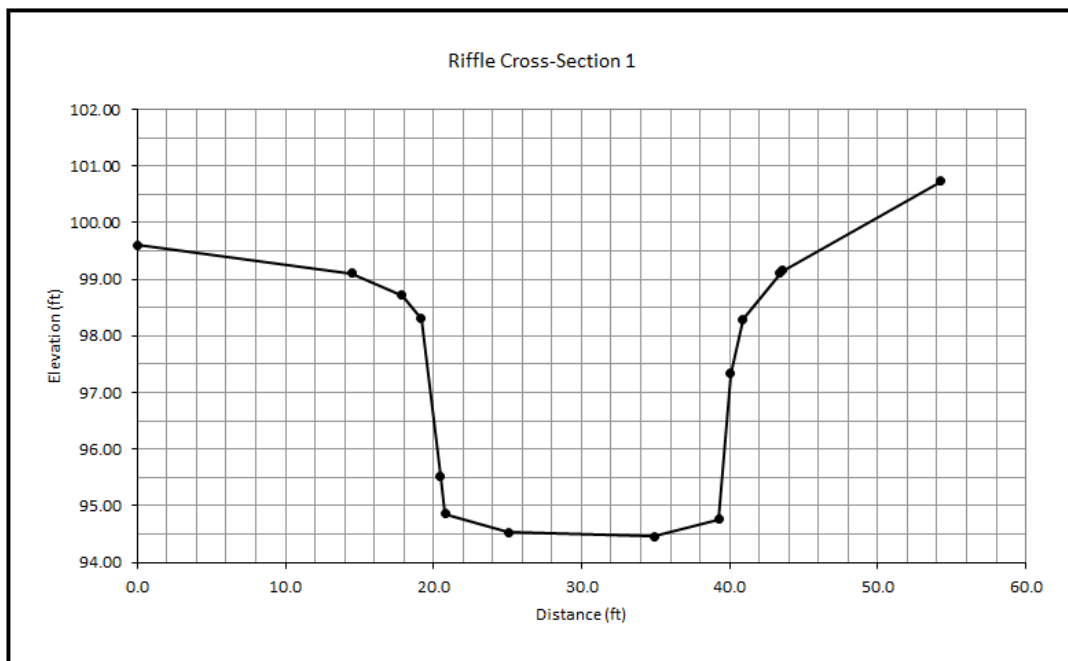
**Median particle size:** gravel

**Longitudinal slope:** 0.0038 feet/foot

**Stream classification:** E4



Area (square feet) =	93.7
Width (feet) =	29.1
Mean depth =	3.2
Max depth =	4.6
Width/depth ratio =	9.0
Entrenchment ratio =	9.1



# 15. Black Creek Ecoregion 65, South Carolina

**Latitude:** 34.663060  
**Longitude:** -80.211803  
**Drainage area:** 51.9 square miles  
**Median particle size:** sand  
**Longitudinal slope:** 0.0004 feet/foot  
**Stream classification:** E5



Area (square feet) =	154.1
Width (feet) =	35.3
Mean depth =	4.4
Max depth =	5.6
Width/depth ratio =	8.1
Entrenchment ratio =	>10.0

