

Tropical Storm Florence in South Carolina

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State Climatology Office

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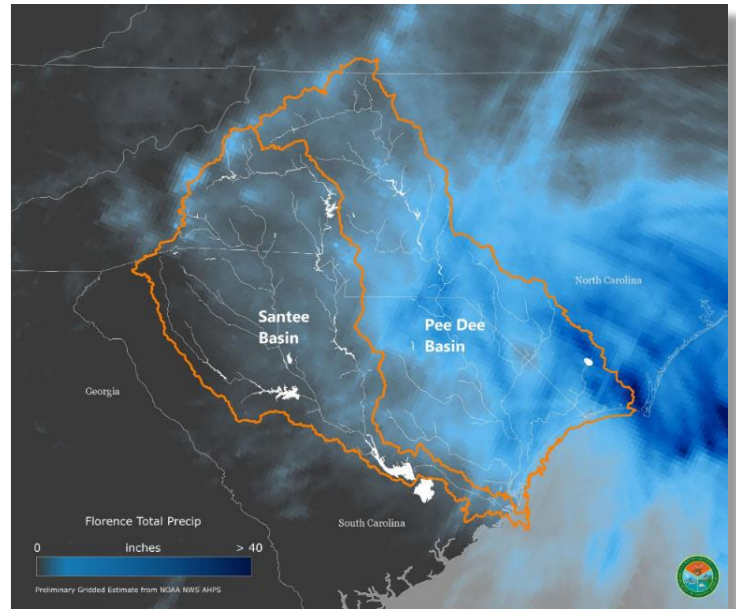


Introduction

Hurricane Florence made headlines in the Southeast United States nearly a week before making landfall near Wrightsville Beach, North Carolina. The storm made its official landfall at 7:15 AM ET on September 14, as a Category 1 Hurricane with maximum sustained winds of 90 mph.

Although the landfall occurred in North Carolina, the storm's slow forward movement of under 3 miles per hour and Florence's unique track brought **unprecedented rainfall across a large portion of North and South Carolina, causing extensive flooding** and requiring coordination and support from the Federal Emergency Management Agency (FEMA) and the American Red Cross, along with aid from state and local agencies.

Two of the major river basins in South Carolina, the Santee and Yadkin-Pee Dee Watersheds, start across the state line near the foothills of the Blue Ridge Mountains in North Carolina. **The most devastating impacts in South Carolina were not felt from Florence's initial impact but came from the extreme riverine flooding which lasted for several weeks following Florence's landfall.** The most extensive flooding was seen throughout the Yadkin-Pee Dee River Basin, as the up to three feet of rain that had fallen in North Carolina had to flow straight through major rivers in South Carolina to reach the Atlantic Ocean through Winyah Bay.



Impacts to South Carolina

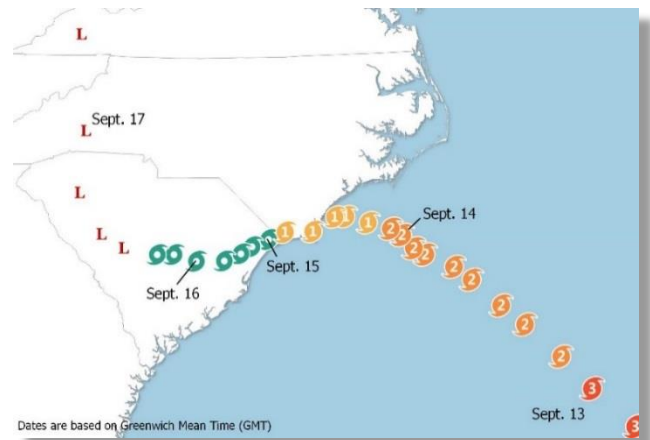
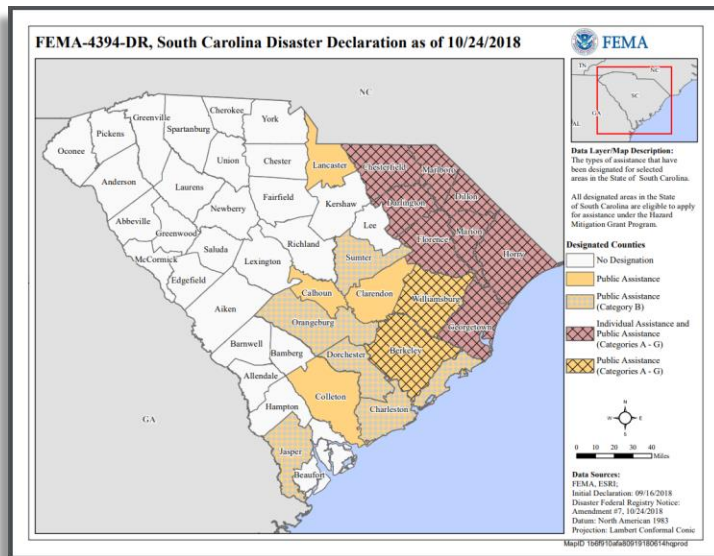


As major Hurricane Florence approached the East Coast, **a State of Emergency was declared for the entire state of South Carolina on September 8**, one week prior to landfall. Two days later, South Carolina Governor Henry McMaster ordered a mandatory evacuation for all South Carolina coastal counties. For the second time in the past three years, on September 11th, **a full reversal of Interstate-26 was completed to help residents and tourists leave the area ahead of the potentially dangerous storm.**

As Florence moved closer to the Carolina coast, the forecast models shifted the path of the storm's landfall farther north towards the NC/SC state line. This decreased the risk for the southern coastal counties of South Carolina, and Governor McMaster lifted the evacuation orders for Beaufort, Colleton, and Jasper counties. After Florence made landfall and conditions were improved, the remaining South Carolina coastal counties had their evacuation orders lifted.

SC Emergency Management Division Summary:

- 80 shelters were opened
- 129 water rescues
- 7,886 people used the provided shelters
- 233 road closures
- 187,000 power outages
- 1,063 assisted evacuations



Synoptic Discussion

The 2018 Hurricane Season got off to a rather slow start. Florence was the sixth named storm and formed from a tropical wave off the African Coast, near the Cape Verde Islands, on August 31. The storm rapidly intensified from a Category 1 to a Category 4 Hurricane in a 24-hour period starting on September 4. The forecast models had trouble initially with Florence's track, with some models having the storm turn out to sea, while others brought the storm closer to the United States. The track of the storm was unique, as past tropical cyclones that originated in the same area turned to the north and remained out to sea.

The uncertainty was based on the strength and placement of an upper-level ridge and how it would essentially direct the storm. Once the models had a better understanding of the atmospheric steering currents, it was obvious that the hurricane would make landfall somewhere along the Southeast coast. As it moved across the Atlantic, the storm went through a process of weakening and was downgraded to a tropical storm before re-strengthening back to a Category 4 hurricane. **Before landfall, the storm encountered wind shear, dry air and interacted with the continental shelf along the Carolina coast, causing it to weaken.**

Florence was a Category 1 Hurricane when it made landfall near Wrightsville Beach, North Carolina, on the morning of September 14. It proceeded to stall and remain nearly stationary for an entire day before it began a slow turn to the southwest, which is not a typical movement for tropical cyclones, and traveled across South Carolina at a speed of 2-3 mph. The storm continued to weaken during the 15 and the remnant circulation recurved and accelerated to the north-northeast and out of the state on September 16.

For more synoptic detail on Hurricane Florence, reference the following reports:

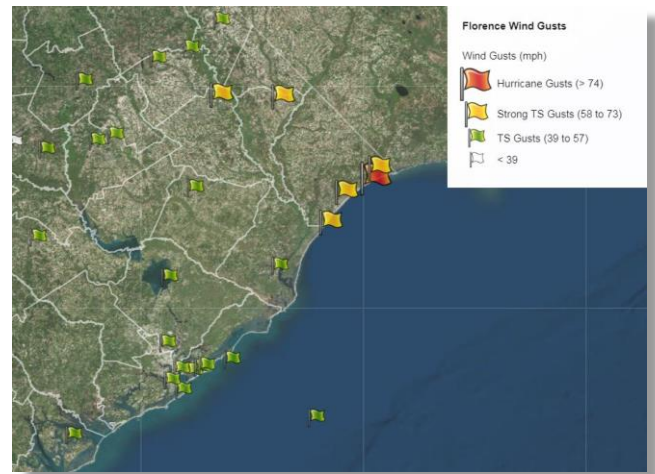
- [Florence Preliminary Open File Report](#)
- [Full Synoptic Analysis and Report](#)

Wind Gusts

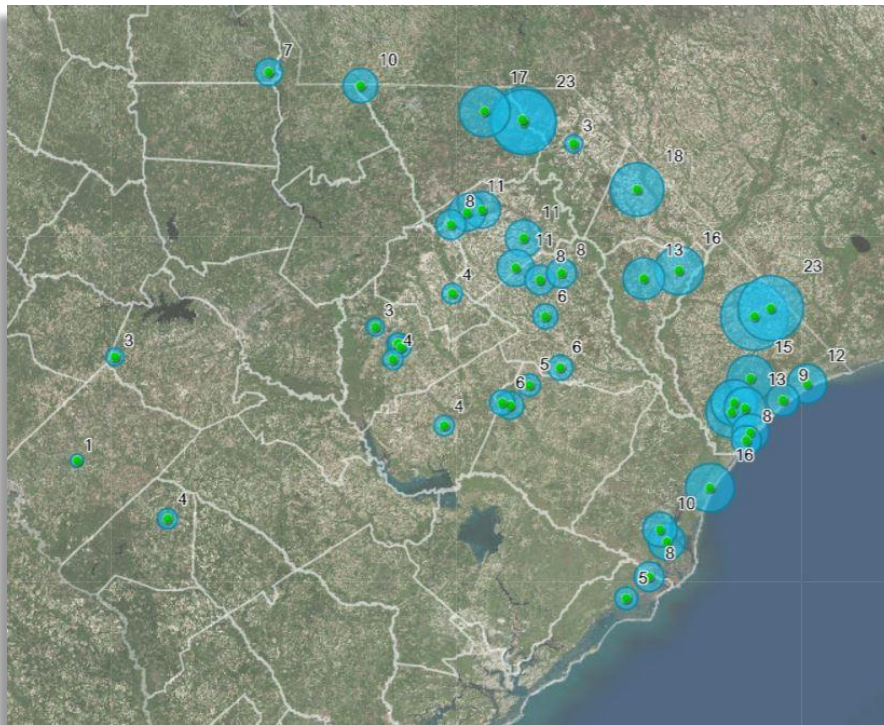
Over the Atlantic, Hurricane Florence had maximum sustained wind speeds of 138 mph, a Category 4 storm. Fortunately, Hurricane Florence weakened significantly prior to the storm's North Carolina landfall.

After making landfall as a Category 1 hurricane, Florence weakened further into a tropical storm with 38 miles per hour sustained winds and gusts of up to 70 miles per hour before crossing into Horry County, SC. Tropical storm-force wind gusts were observed along the South Carolina coast with one hurricane-force gust, 77 miles per hour, recorded at Cherry Grove Beach Pier on September 14.

Florence spawned 2 weak (EFO) tornadoes in the state, both of which touched down in Horry County. Despite the large diameter wind field of Florence (tropical storm-force winds were felt up to 200 miles away from the center), utility companies reported less than 200,000 outages across South Carolina, with most of those concentrated in Dillon, Horry and Marion counties. In contrast, Hurricane Matthew in 2016 caused 866,000 household power outages in the state.

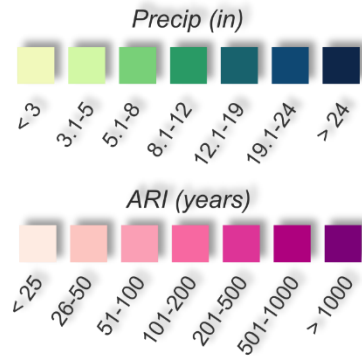
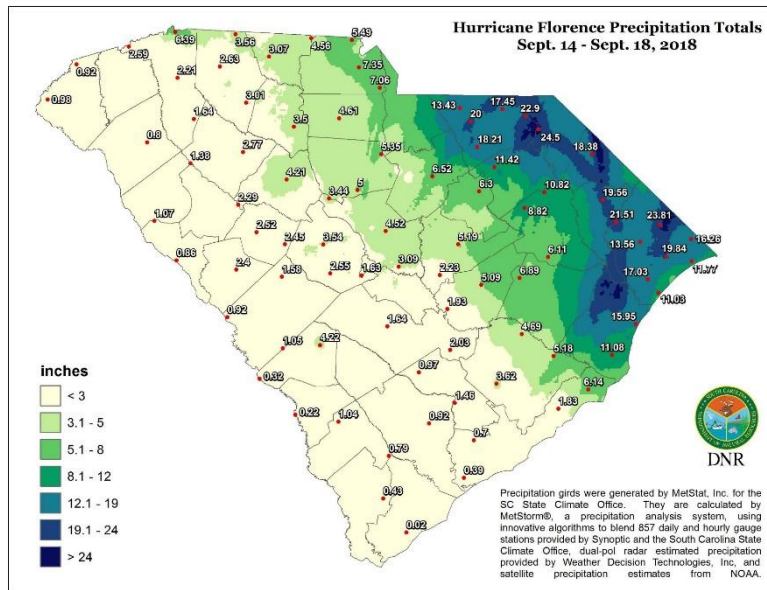


Rainfall Totals

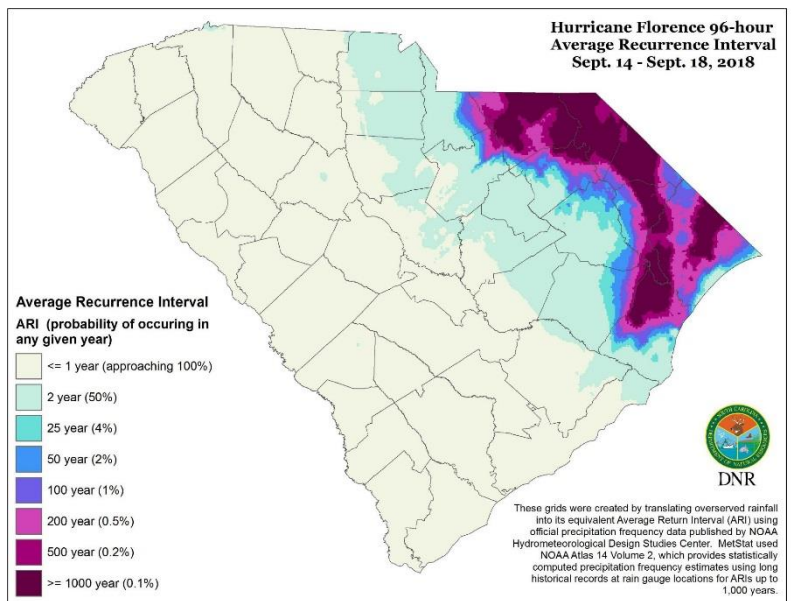


Many locations in South Carolina experienced four consecutive days of heavy rainfall due the slow movement of Hurricane Florence. This map shows the accumulation of rainfall at various locations throughout the state. The most widespread heavy rain fell in the Pee Dee River Basin in both North and South Carolina. The highest rainfall measured in South Carolina from Hurricane Florence was 23.63" from a CoCoRaHS station (Loris 2.9 WSW) in Horry County. This site exceeded the 1000-year return interval mark for 4-day rainfall accumulation.

Statewide Precipitation Analysis



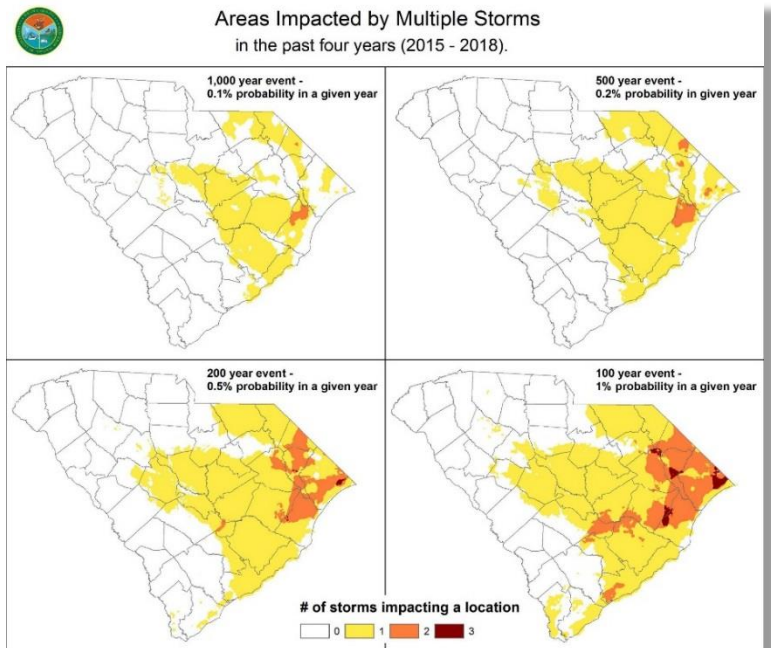
An analysis was completed to get Precipitation and Average Return Intervals (ARI) coverage across the state. These maps are helpful for seeing the areas of the state that received rainfall at very high ARI values. The percentage area of South Carolina that received rainfall within a given ARI range is below. **More than 8% of the state's land area received rainfall over 500-year ARI, most of which was within the Pee Dee River Basin.**



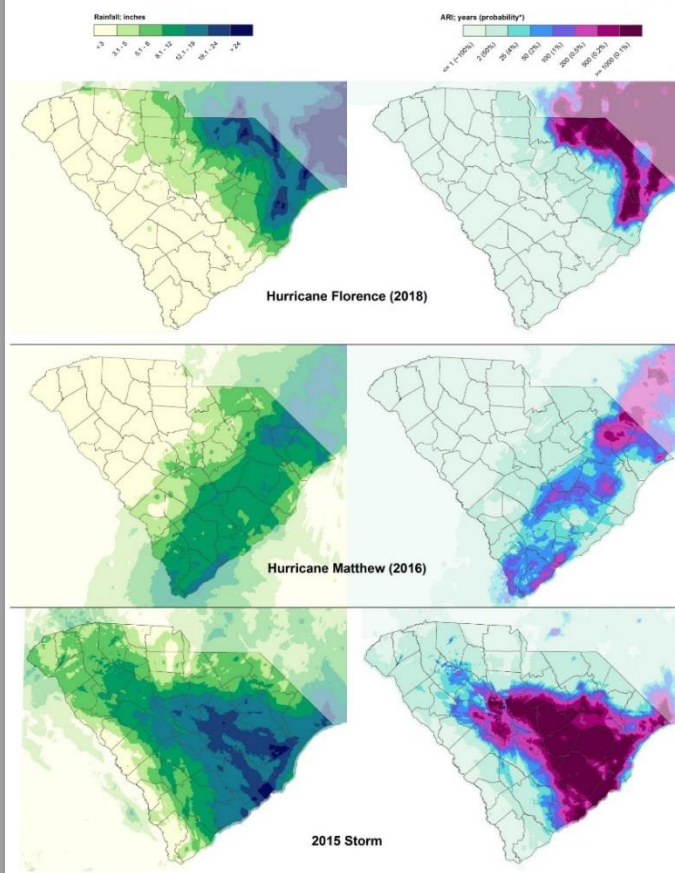
<u>ARI</u>	<u>72-hour</u>	<u>96-hour</u>
<= 10	79.03	80.19
11 to 25	3.55	3.00
26 to 50	2.03	2.02
51 to 100	1.76	1.62
101 to 500	5.22	5.14
501 to 1000	2.80	2.76
> 1000	5.62	5.28

Comparing Storms

Over the last four years, three separate weather events have caused destructive flooding across the state, and some of the same areas have been impacted by all three events. As communities in the Pee Dee still grappled with rebuilding after 2015 and 2016, Hurricane Florence's slow march across the region added insult to injury, as portions of Dillon, Florence, Georgetown, Horry, Marion, and Williamsburg counties experienced their third 100-year rainfall event since 2015.



Rainfall and ARI Comparison



2015

The widespread and excessive rainfall from the [October 2015 Flooding Event](#) lasted in some portions of the state up to seven consecutive days, with a **maximum rainfall total of 26.88 inches** reported by a [CoCoRaHS](#) observer in Mount Pleasant.

2016

The following fall, Hurricane Matthew dumped more rain across some of the same locations. The rain associated with [Matthew in 2016](#) fell within a two-day period, dropping **up to 17 inches in 48 hours** in some locations between the Interstate 95 corridor and the coast. The intensity and short duration of the rainfall from the storm caused extensive flooding in parts of the Pee Dee Basin.

2018

A CoCoRaHS observer near Loris, SC, in Horry County measured **23.63 inches** from Florence over the four-day period ending September 17. This

total is recognized as the highest rainfall total caused by a tropical cyclone in South Carolina, per the NOAA Weather Prediction Center, beating the previous record of 17.45 inches measured at the National Weather Service station near Jocassee from Tropical Storm Beryl in 1994. (The 2015 total does not meet [the requirements per the methodology of WPC](#) to be considered for the record).

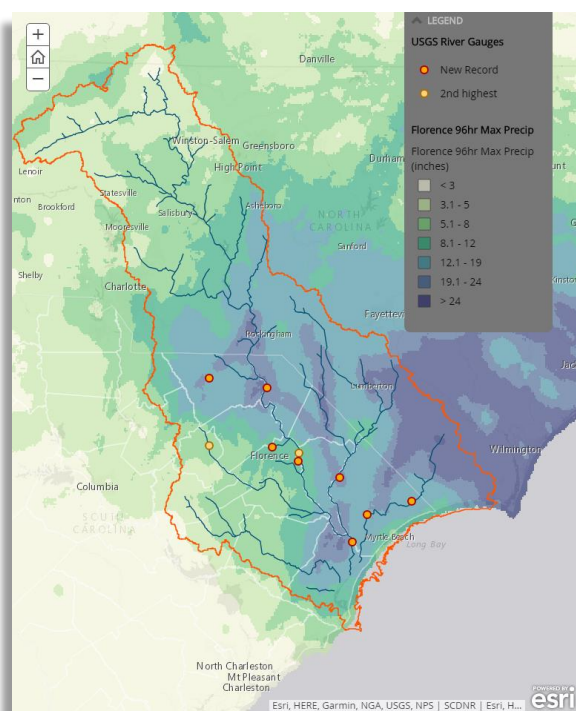
Peak River Flows

With widespread heavy rain in the Pee Dee Basin of South Carolina and North Carolina, several major rivers experienced major flooding, including the Pee Dee, Little Pee Dee, Lynches and Waccamaw rivers. Many of the areas damaged by these rivers were the same areas that saw extensive flooding during Hurricane Matthew.

The table and map show nine locations setting new record peaks and two others ranked second place with their peak flow levels from Florence. The historical record columns show the previous record, or the current record in the two cases where Florence's peak did not break the record. Florence brought record or near-record peaks to every USGS station in the Pee Dee Basin.

Interactive hydrographs show the streamflow for various sites along South Carolina's major affected rivers before, during, and after Hurricane Florence.

Some Northern portions of each river rose and fell faster than those located further down the watersheds.



Florence Peaks				Historical Record		
Stage (ft)	Flow (cfs)	Day (Sept)	Rank / POR*	Stage (ft)	Flow (cfs)	Year
Black Creek below Chesterfield						
11.99	3,690	17	1 / 13	10.07	1,480	2006
Note:						
Black Creek near Quinby						
17.37	6,880	17	1 / 17	16.81	6,530	2015
Note:						
Little Pee Dee at Galivants Ferry						
17.21	66,900	21	1 / 77	17.1	59,300	2016
Note: Based on a historic flood mark, the September 2018 peak is likely the largest at this location since at least 1928.						
Lynches River near Bishopville						
18.22	18,000	18	2 / 76	22.35	29,400	1945
Note:						
Pee Dee River near Bennettsville						
93.06	192,000	18	1 / 27	89.94	124,000	2003
Note:						
Pee Dee River at Pee Dee						
31.83	132,000	21	2 / 80	33.3	220,000	1945
Note: Streamflow regulated by six powerplants above station.						
Pee Dee River below Pee Dee						
36.96	139,000	21	1 / 22	33.96	99,000	2003
Note: Streamflow regulated by six powerplants above station.						
Pee Dee at Hwy 701 near Bucksport						
25	136,000	26	1 / 15	22.6	124,000	2016
Note: Note: Regulated; tidally influenced, which is overcome by basin runoff at high flows.						
Waccamaw River near Longs						
20.22	57,500	20	1 / 68	17.94	28,200	1999
Note:						
Waccamaw River at Conway Marina						
21.16	49,000	26	1 / 24	17.64	24,100	1999
Note: Tidally influenced, which is overcome by basin runoff at high flows.						

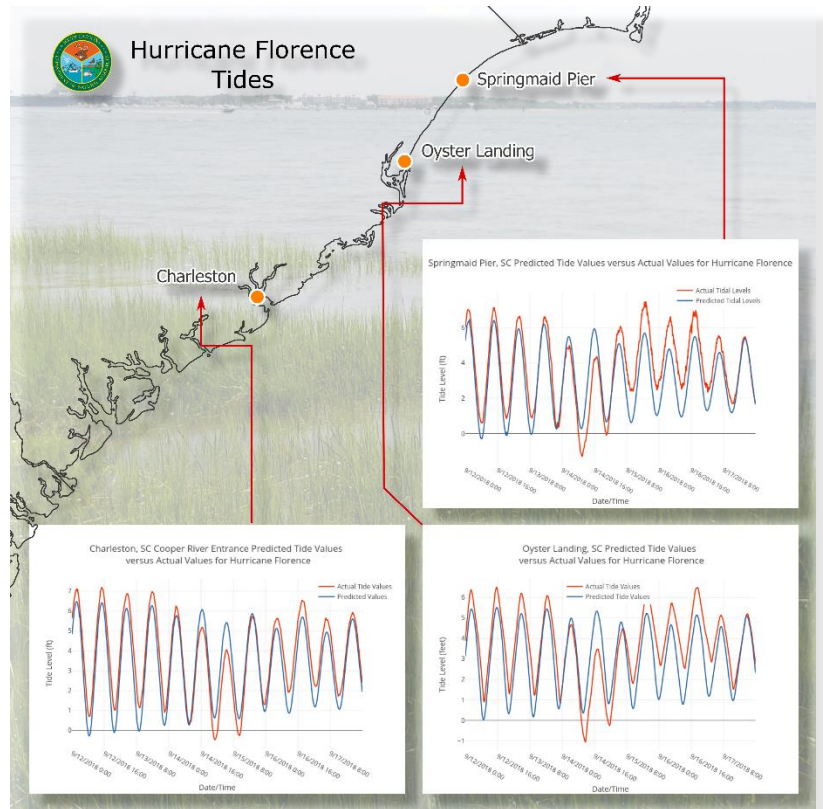
To view the interactive hydrographs for streamflow along the Pee Dee, Lynches, and Waccamaw river systems, explore the links below:

- [Pee Dee River System](#)
- [Lynches River System](#)
- [Waccamaw River System](#)

Storm Surge and Tides

Hurricane Florence's landfall and southwesterly tracks placed most of the South Carolina Coast on the southerly side of the circulation. On this side of the storm, prevailing wind direction is offshore, and because of the slow movement of the storm, **the winds persisted for hours and caused the water to retreat from the coastline**, including Charleston Harbor and near Winyah Bay. Due to the weather pattern, the NOAA Ocean Service tidal gauges along the South Carolina coast measured low-tidal water levels from September 13 to September 15.

Once the storm began its slow movement to the southwest and then across the state, **the wind direction changed to an onshore flow, and the water returned to normal levels before increasing as the wind continued to push more water toward the coast. A storm surge, combined with local tides, of less than 2.5 ft. was measured on September 16, and only Horry and Georgetown counties reported minor beach erosion.**



Resources

SCDNR

[SC State Climate Office](#)

[2015 Flood Interactive Story Journal](#)

[Hurricane Matthew \(2016\) Interactive Story Journal](#)

[SC State Climate Office Hurricane Florence Quick Report](#)

[SC State Climate Office Hurricane Florence Synoptic Report](#)

[SCDNR Flood Mitigation Program](#)

United States Geological Survey (USGS)

[USGS Hurricane Florence Portfolio](#)

[Preliminary Peak Stage and Streamflow Data Analysis](#)

[USGS Average Return Interval Statistical Analysis](#)

[USGS Water Data](#)

National Oceanic and Atmospheric Association (NOAA)

[South Carolina Tidal Data](#)

[Frequency Analysis \(ARI\) Glossary](#)

[Southeast River Forecast Center](#)

[Precipitation Frequency Estimates for ARI Analysis](#)

[Weather Prediction Center - Tropical Rainfall Estimates](#)

[NWS, Wilmington, NC - Hurricane Florence Report](#)

[NWS, Charleston, SC - Hurricane Florence Report](#)

[NWS, Columbia, SC - Fall/Winter 2018 Newsletter](#)

[NWS, Columbia, SC - Fall/Winter 2018 Newsletter](#)

SC ACIS

[AC ACIS Database of Precipitation Data](#)