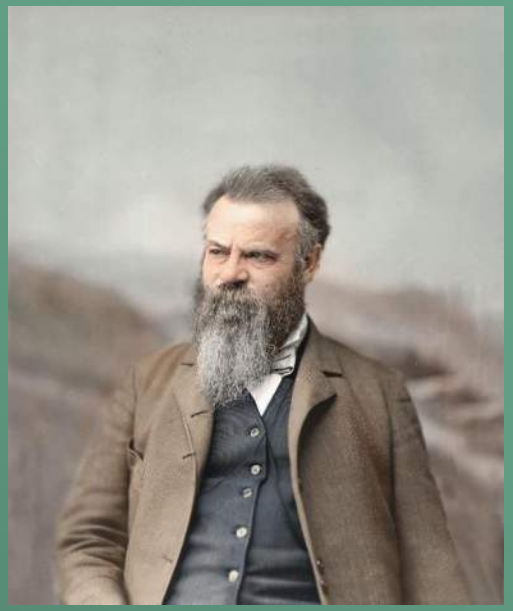
U.S. Geological Survey Streamflow Monitoring

Toby D. Feaster, P.E.
South Atlantic Water Science Center
Clemson, SC
November 8, 2023

USGS
science for a changing world

Institutional Overview: USGS History

USGS, which is part of the U.S. Department of Interior, was established on March 3, 1879.

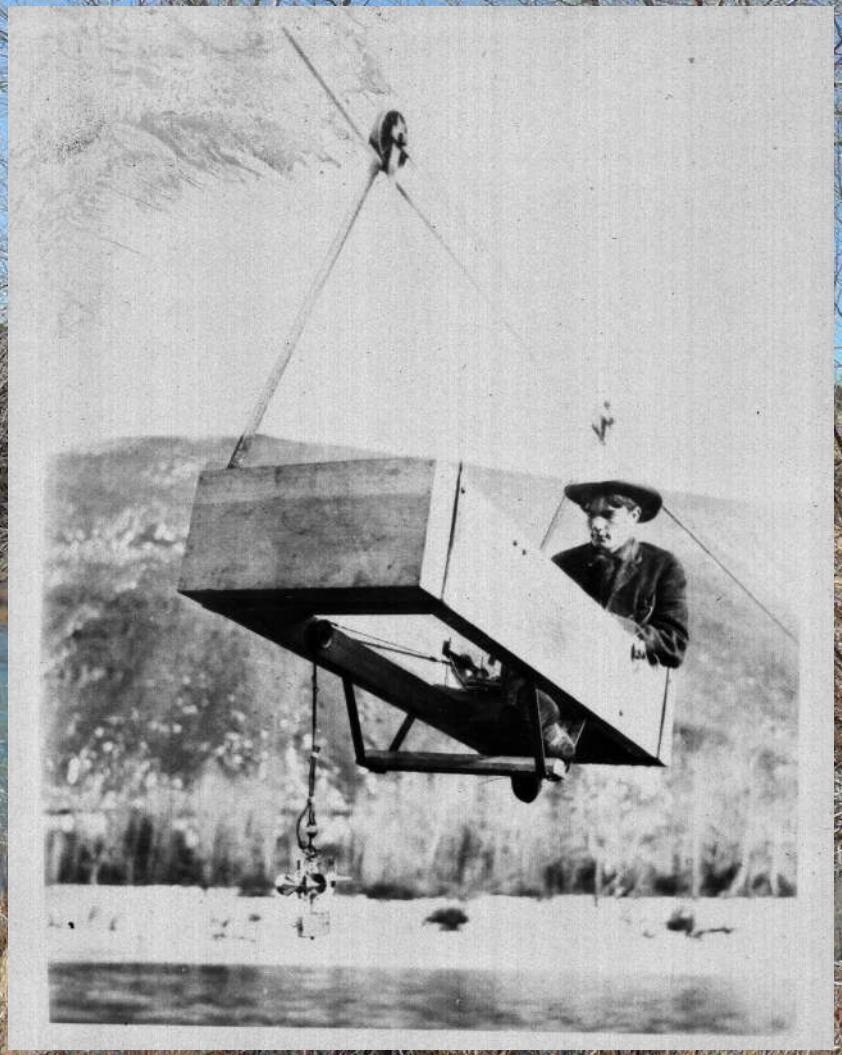


"classification of the public lands, and examination of the geological structure, mineral resources, and products of the national domain."

1889: USGS initiated the National Streamgaging Program with training and station installation on the Rio Grande River near Embudo, New Mexico.

USGS

The First USGS Streamgage on the Rio Grande at Embudo, NM



USGS
science for a changing world

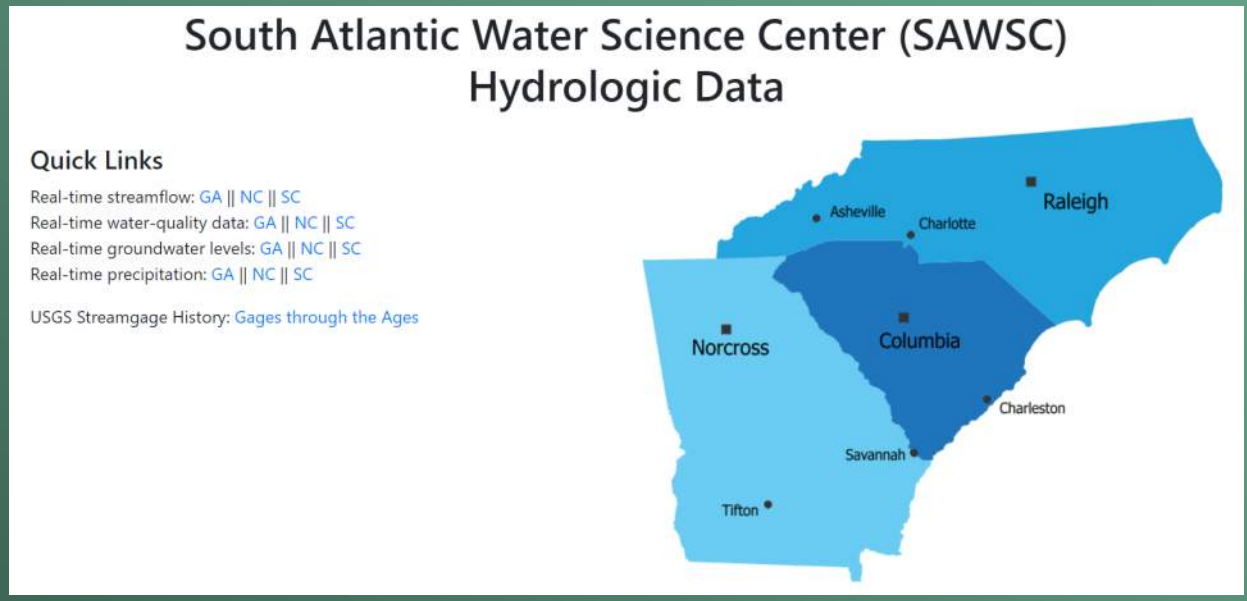
Institutional Overview:
USGS South Atlantic Water Science Center (SAWSC)

State Offices

- Georgia (GA)
- South Carolina (SC)
- North Carolina (NC)

Eight Field Offices

- Norcross, GA
  - Tifton, GA
  - Savannah, GA
- Columbia, SC
  - Charleston, SC
- Raleigh, NC
  - Asheville, NC
  - Charlotte, NC

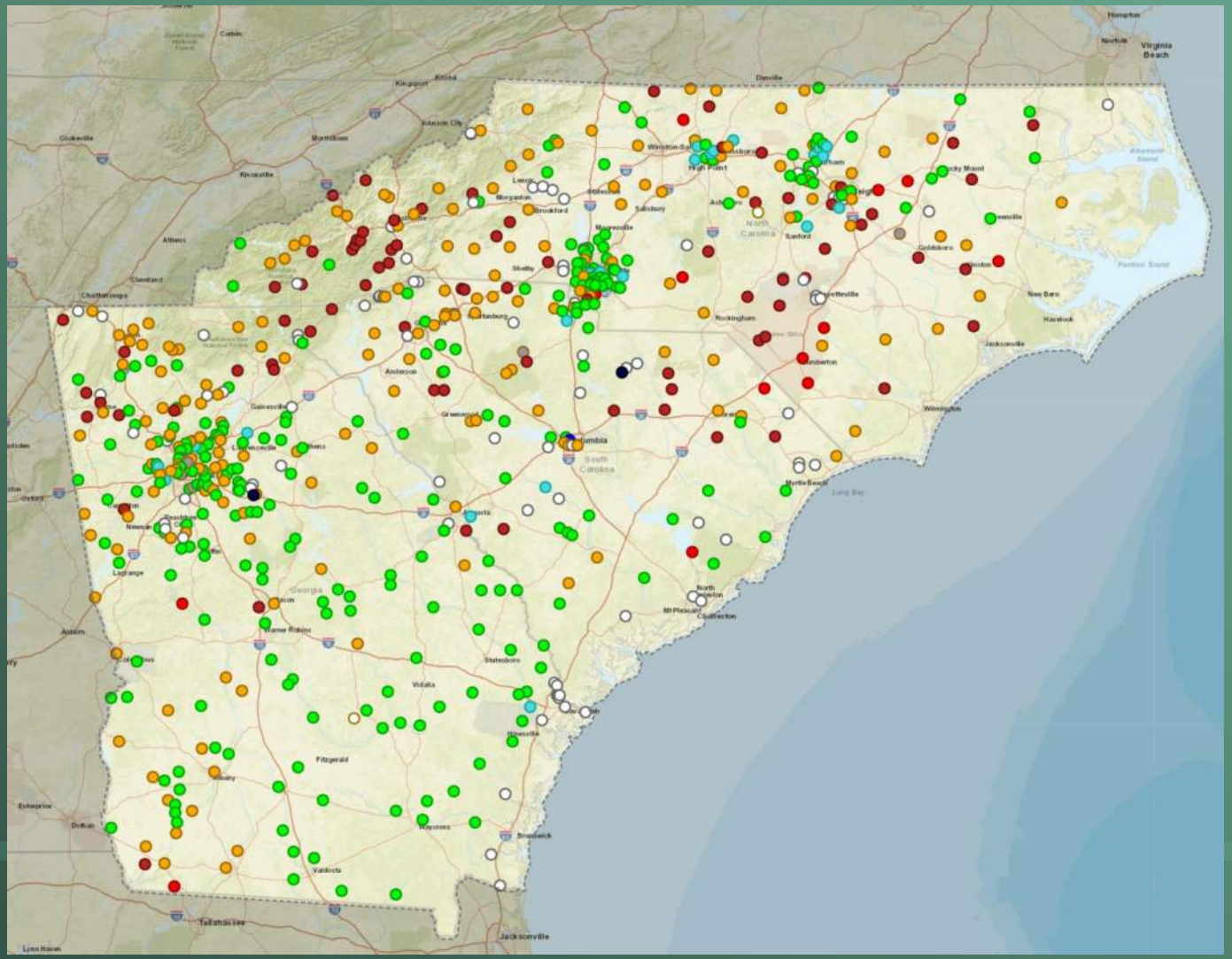


https://www2.usgs.gov/water/southatlantic/data/index.php

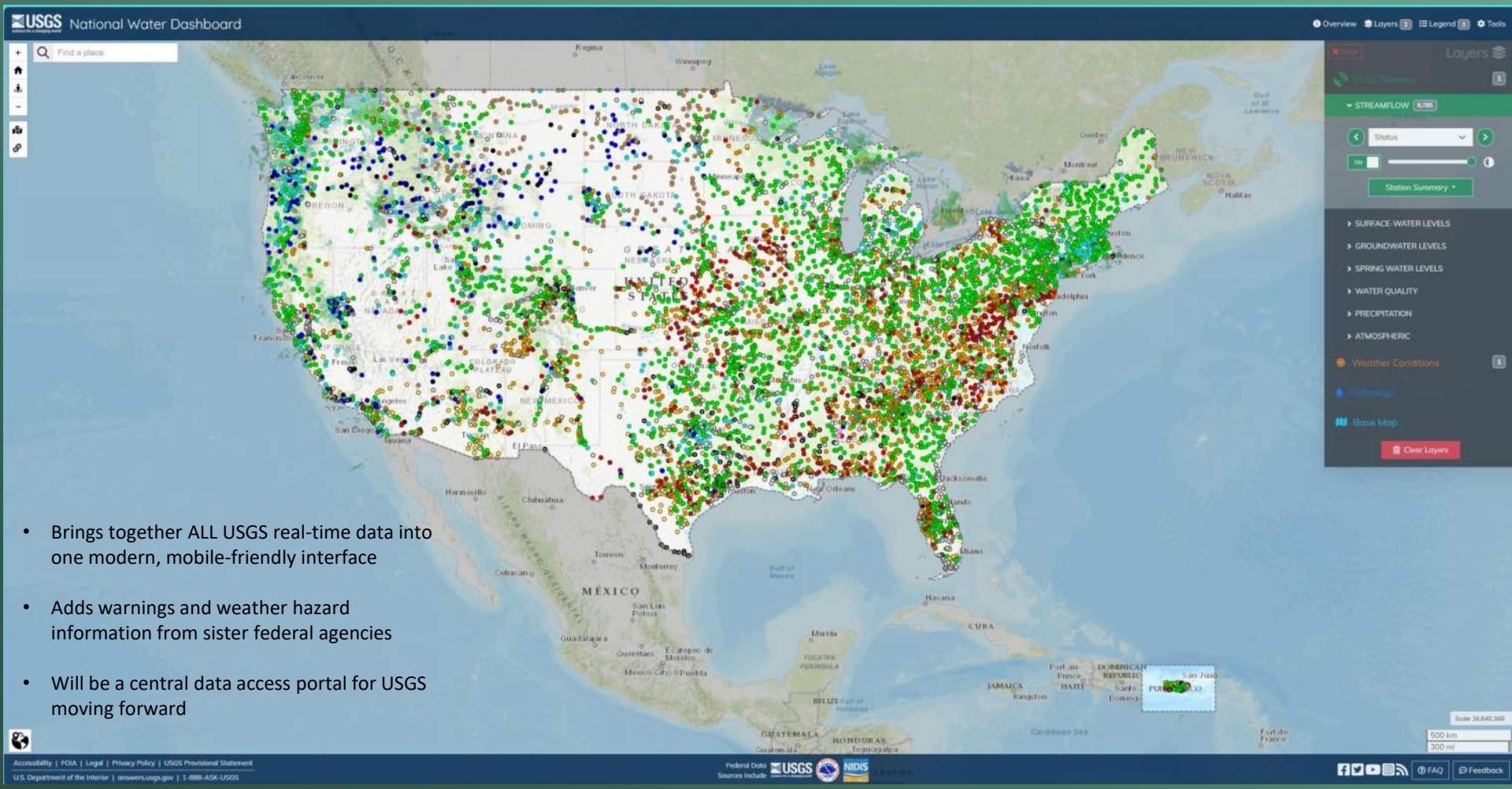
USGS

USGS South Atlantic Water Science Center (SAWSC)

USGS SAWSC operates about 1,100 real-time gaging stations monitoring SW, GW, and QW using satellite telemetry



USGS National Water Dashboard



- Brings together ALL USGS real-time data into one modern, mobile-friendly interface
- Adds warnings and weather hazard information from sister federal agencies
- Will be a central data access portal for USGS moving forward

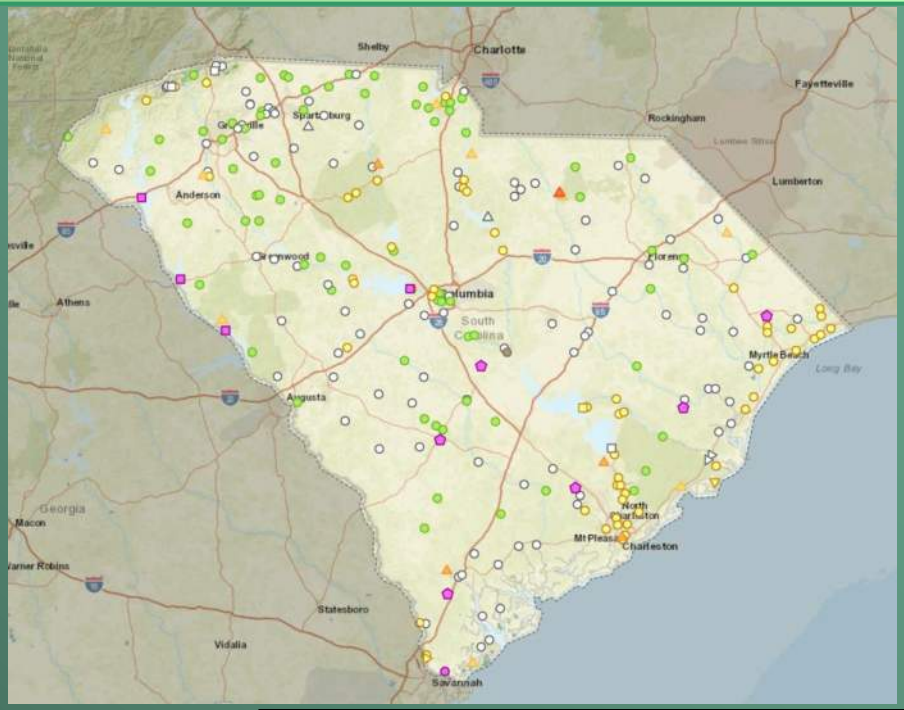
USGS

https://dashboard.waterdata.usgs.gov/

USGS in South Carolina

Continuous streamgages

- 216 surface-water stations (water level and/or streamflow)
- 62 rain gages
- 63 water-quality stations
- 21 groundwater levels



02135200 Pee Dee River at Highway 701 near Bucksport, SC

02164000 Reedy River near Greenville, SC

USGS

Streamgage Basics

A streamgage is a structure installed beside a stream or river that contains equipment that measures and records the water level (called gage height or stage) of the stream.

Streamflow (also called discharge) is computed from measured water levels using a site-specific relation (called a stage-discharge rating curve) developed from onsite water level and streamflow measurements made by USGS hydrologic technicians.

The water level and streamflow data are quality assured and made available online.

USGS

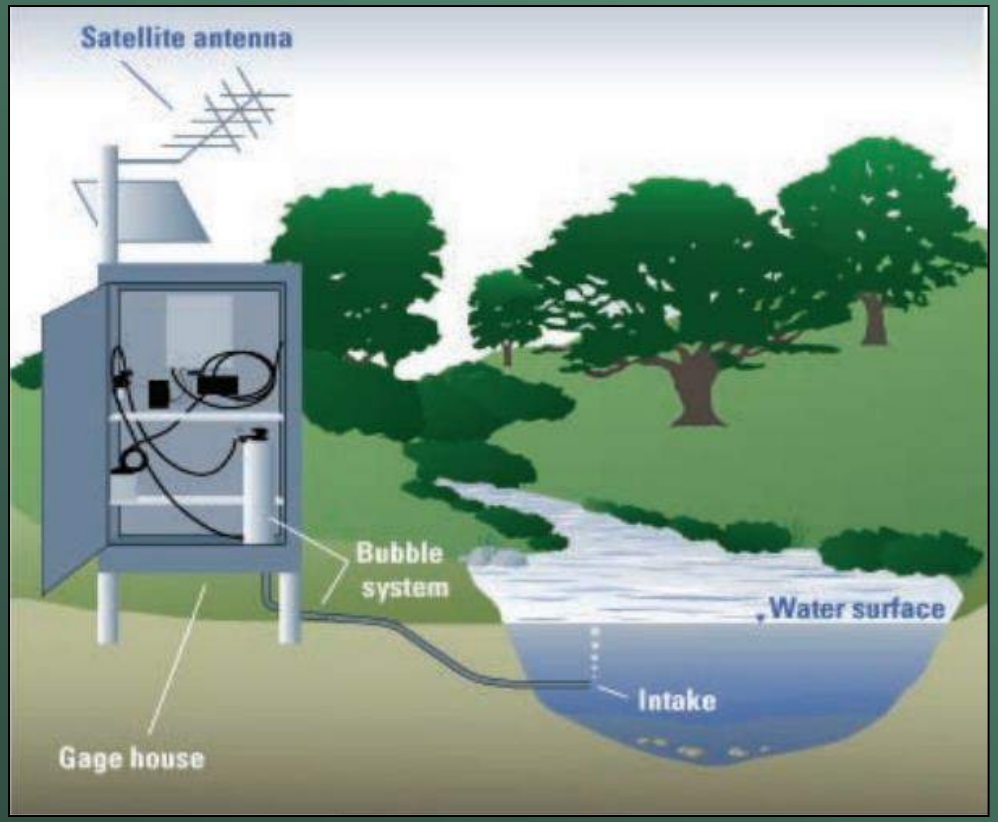
Streamgage Basics: Measuring Water Level

Stilling Well

- Uses float and weight suspended by steel tape.
- Intakes should be kept clean.
- Difficult and time-consuming installation.
- Reliable.

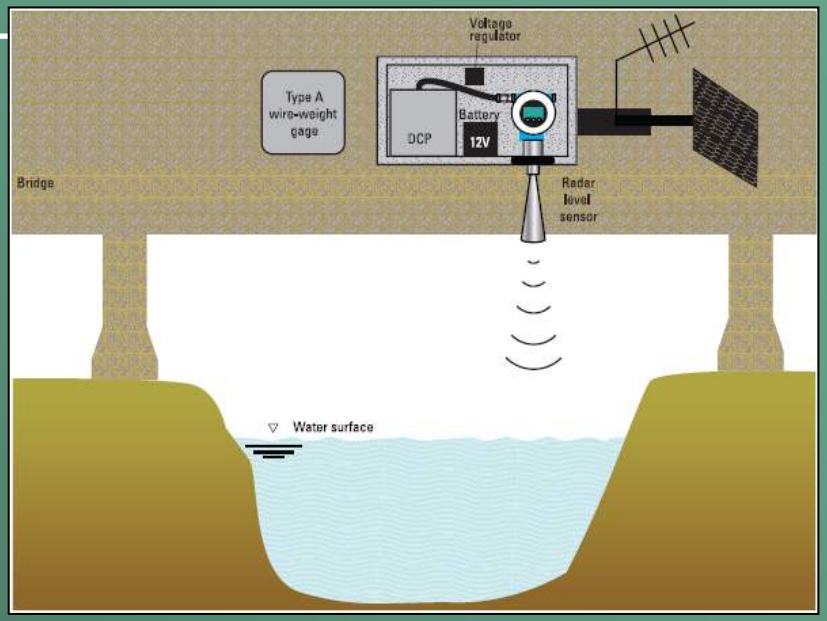
Many of these types of gage houses were constructed as part of the Civilian Conservation Corps.

Site Specific Installations: Bubbler/Pressure Sensor



USGS

Site Specific Installations: Non-Contact/Radar



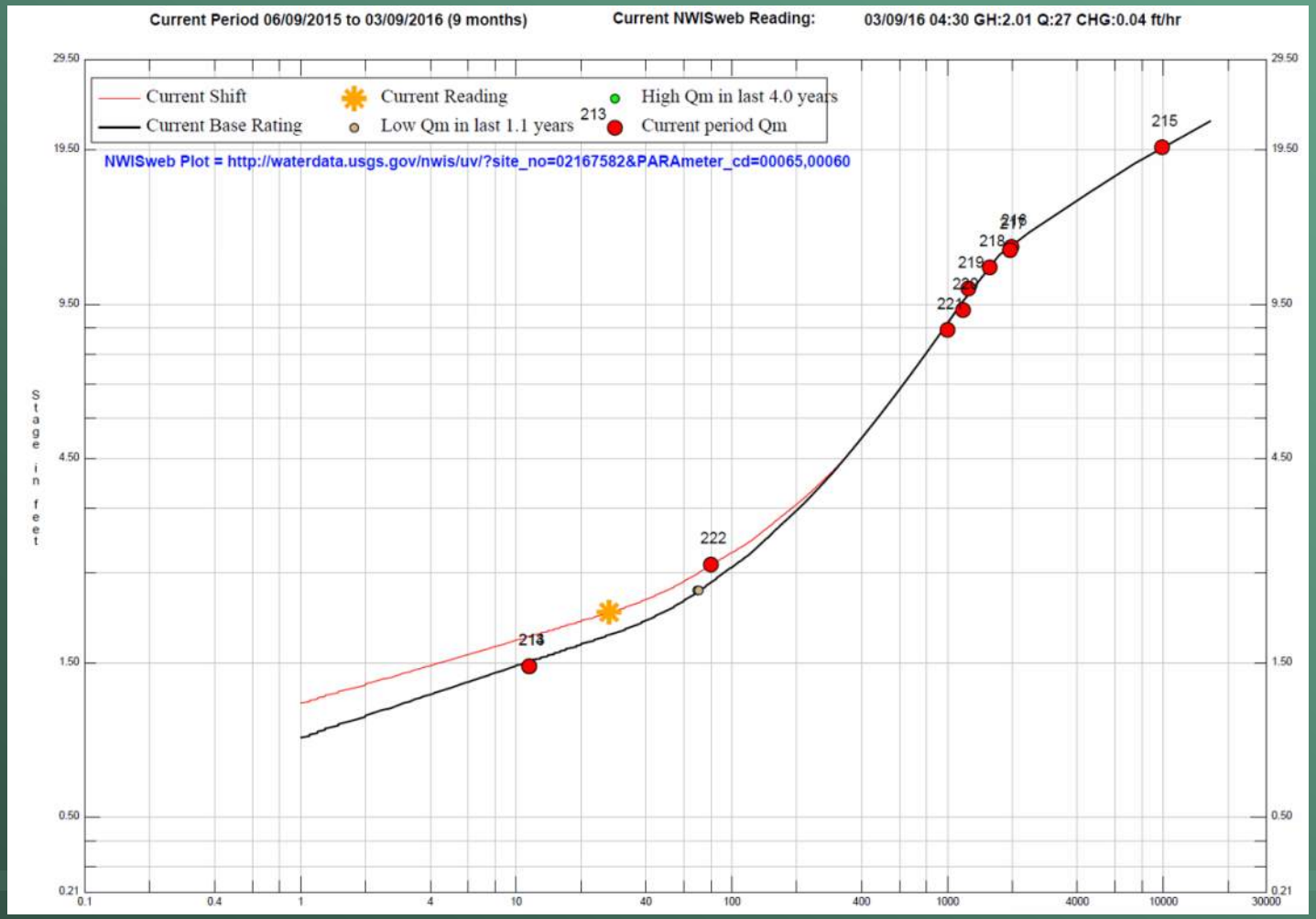
USGS

Site Specific Installations: Index Velocity

02135200 Pee Dee River at Highway 701 near Bucksport, SC

USGS

Streamgage Basics: Rating Curve



USGS

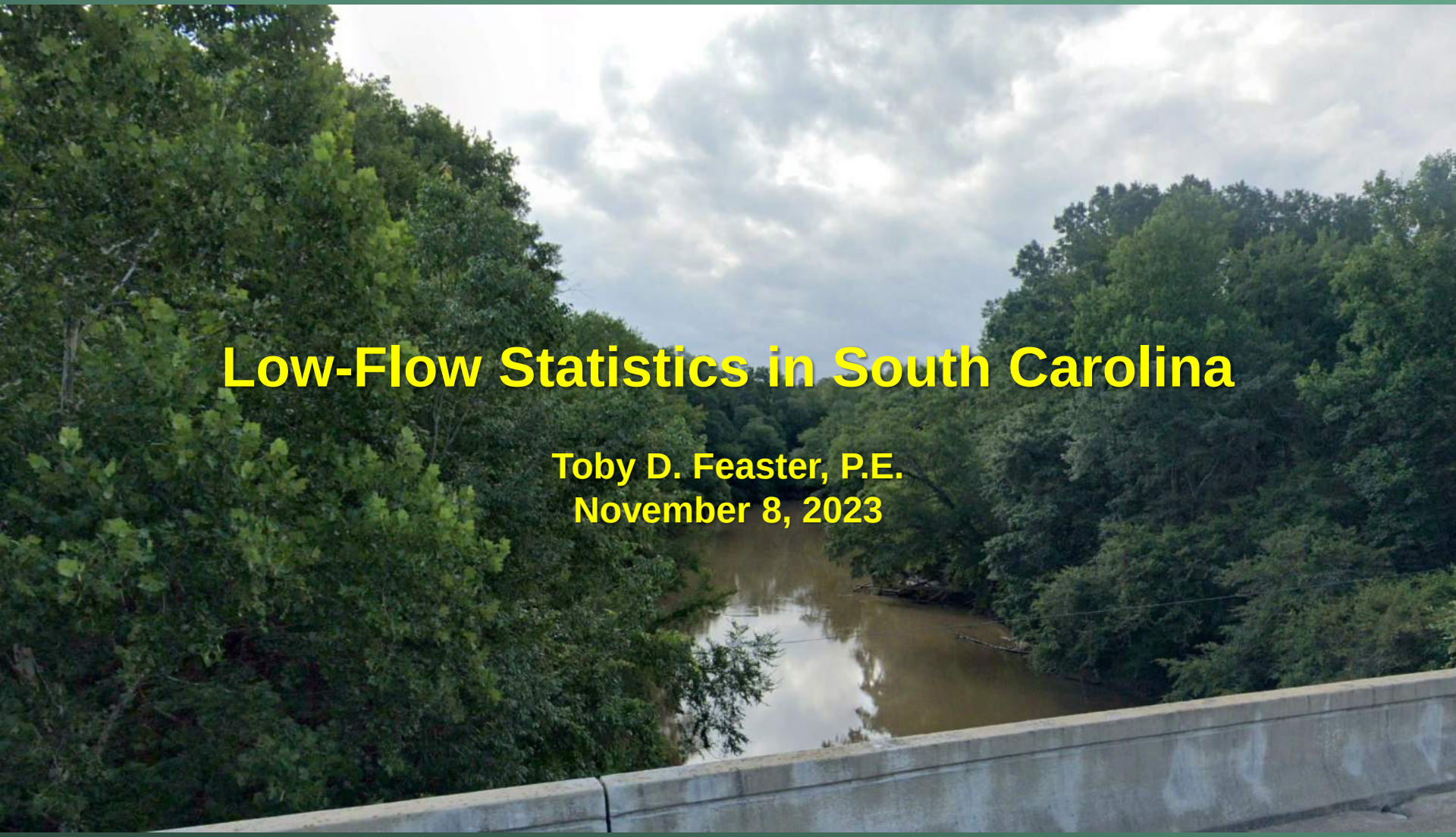
USGS in South Carolina

Why is a streamgage important?

- Flood warning/forecasting
- Flood control/mapping
- Drought monitoring
- State Water Planning
- Water supplies for continued growth
- Water effluent discharges
- Hurricane surge
- Hydroelectric power generation
- Navigation
- Safe bridge and roadway design
- Recreation
- Tourism
- Long-term climate analyses
- Modeling

USGS

Low-Flow Characterization of South Carolina Streams



Low-Flow Statistics in South Carolina

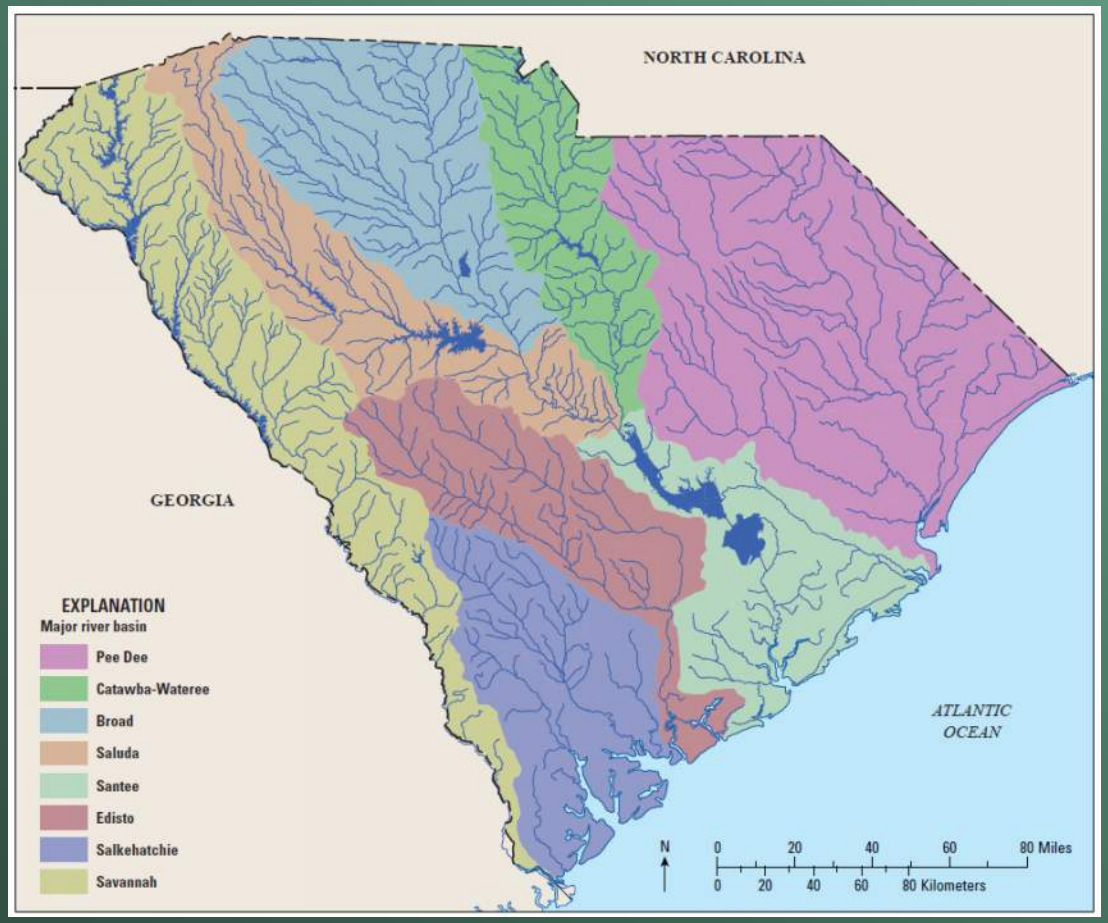
Toby D. Feaster, P.E.

November 8, 2023

USGS

Photo from Google Earth

Low-Flow Characterization of South Carolina Streams



South Carolina Low-Flow Updates

Between 2007 and 2014, the U.S. Geological Survey, in cooperation with the South Carolina Department of Health and Environmental Control, updated low-flow statistics at continuous-record streamgaging stations.

Prior to that, low-flow statistics had not been updated on a state-wide basis since 1987.

USGS

The USGS has been computing low-flow statistics in SC since the 1960s.

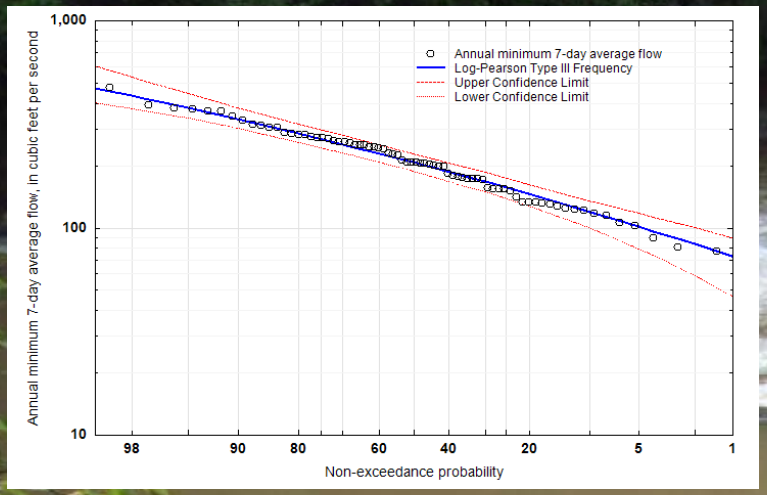
Low-Flow Characterization of South Carolina Streams

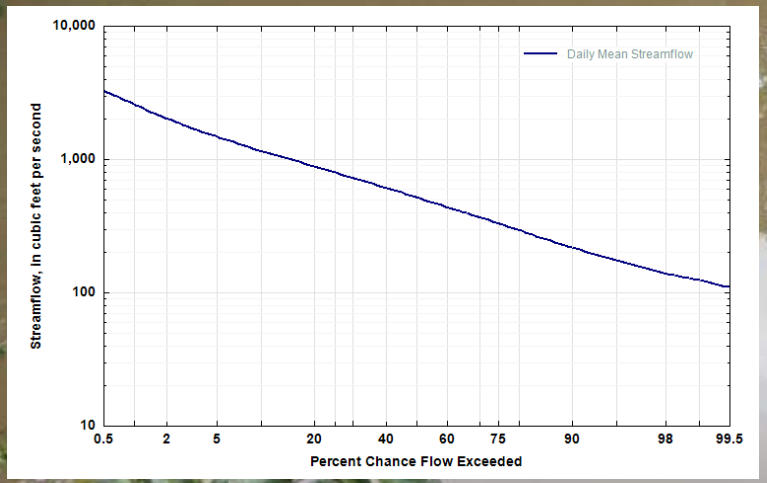
- Pee Dee River (March 2007)
- Broad River (March 2008)
- Saluda, Congaree, and Edisto Rivers (March 2009)
- Catawba-Wateree and Santee Rivers (March 2012)
- Savannah and Salkehatchie Rivers (March 2014)
- Summary report published in 2017

USGS

https://pubs.er.usgs.gov/

Low-Flow Characterization of South Carolina Streams



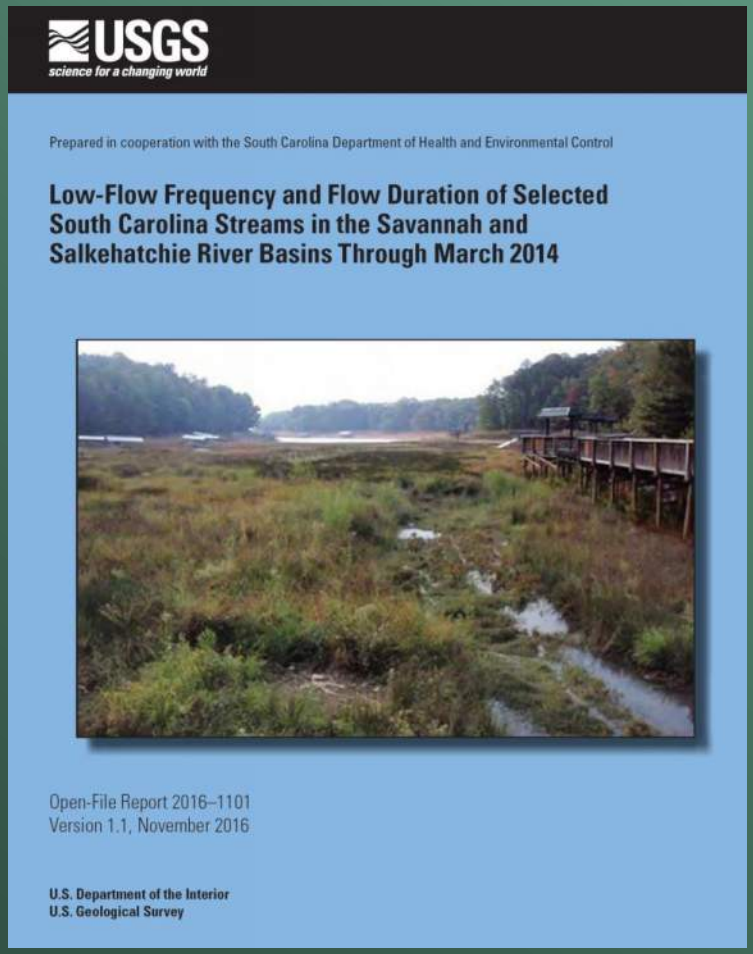


Low-Flow Statistics Published

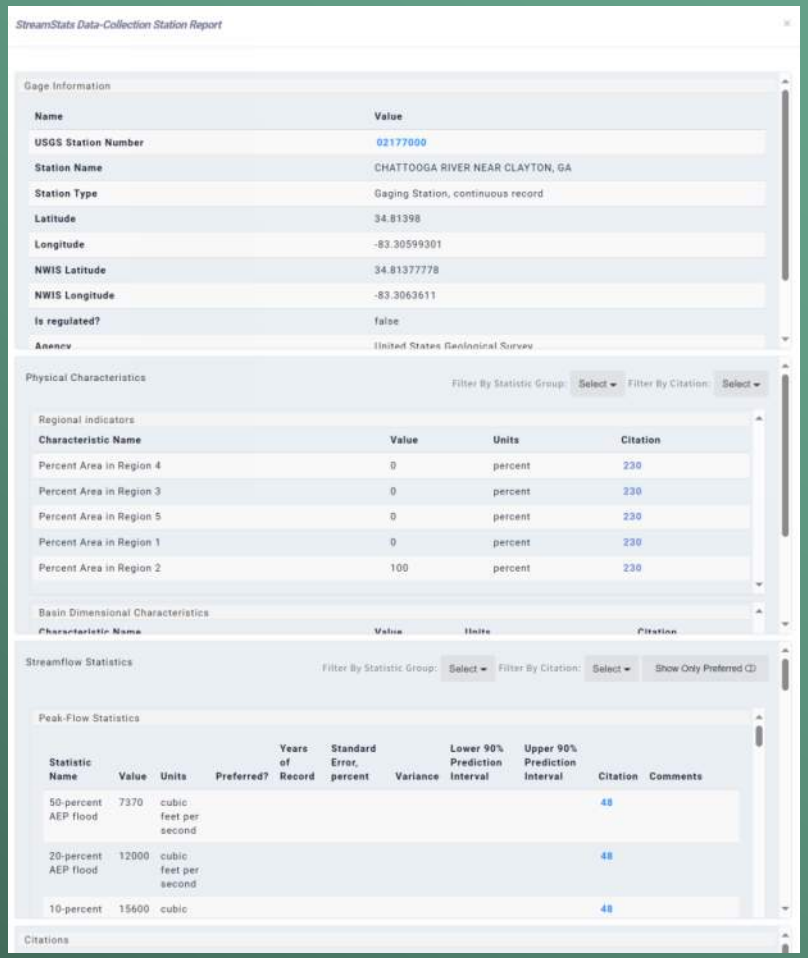
- **Annual minimum 1-, 3-, 7-, 14-, 30-, 60-, and 90-day average flows with a 2-, 5-, 10-, 20-, 30-, and 50-year recurrence interval (depending on the available length of record)**
- **Daily flow durations for the 5, 10, 25, 50, 75, 90, and 95 percentiles**

USGS
science for a changing world

Low-Flow Characterization of South Carolina Streams



https://pubs.er.usgs.gov/publication/ofr20161101



https://www.usgs.gov/tools/usgs-streamstats

USGS

Low-Flow Characterization of South Carolina Streams

USGS
science for a changing world

Prepared in cooperation with the South Carolina Department of Health and Environmental Control

Low-Flow Frequency and Flow Duration of Selected South Carolina Streams in the Savannah and Salkehatchie River Basins Through March 2014

Open-File Report 2016–1101
Version 1.1, November 2016

U.S. Department of the Interior
U.S. Geological Survey

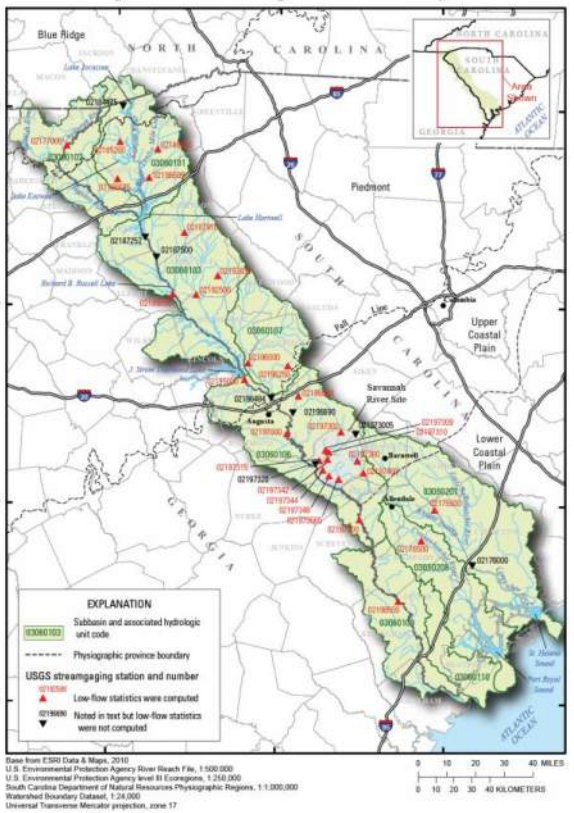
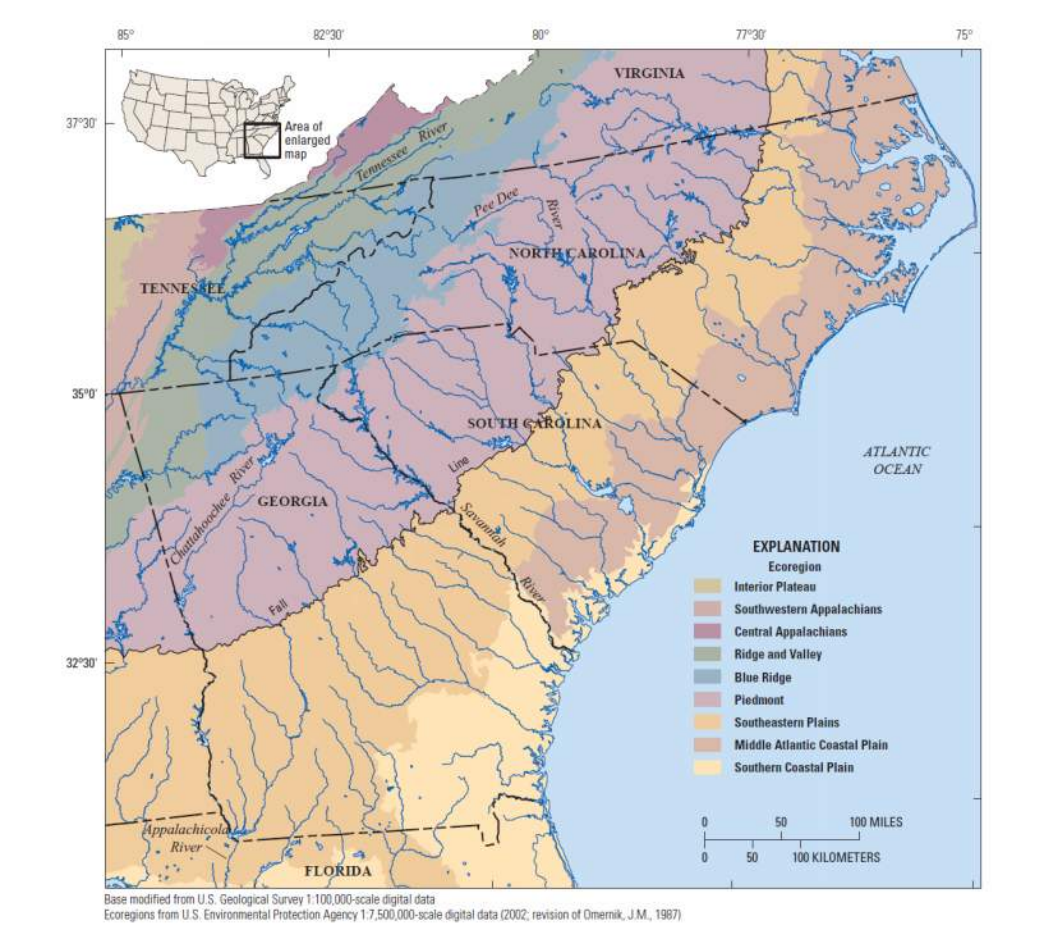


Figure 2. Eight-digit hydrologic unit code subbasins, subbasin name, and number of U.S. Geological Survey continuous-record streamgaging stations analyzed for the Savannah and Salkehatchie River Basins of South Carolina.

https://pubs.er.usgs.gov/publication/ofr20161101

USGS

Low-Flow Characterization of South Carolina Streams



As of April 2022, the USGS, in cooperation with SCDNR and SCDHEC, began a two-phase study to:

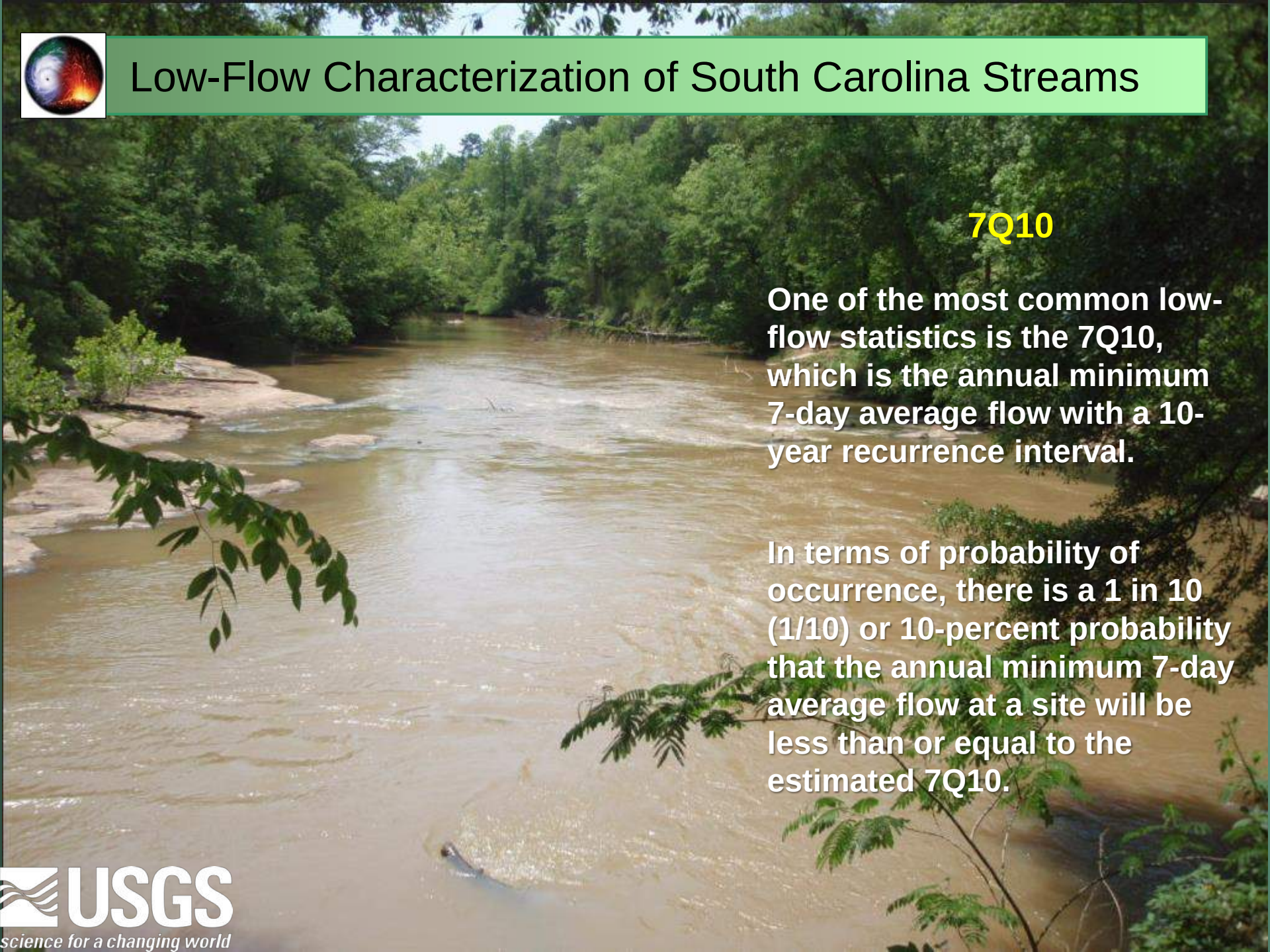
1) Update low-flow and mean annual flow statistics at USGS streamgages in SC, and

2) Develop regression equations that can be used to estimate low-flow and mean annual flow statistics at ungaged locations.

USGS

The USGS also has signed agreements with cooperators in NC and GA for concurrent projects in those states.

Low-Flow Characterization of South Carolina Streams



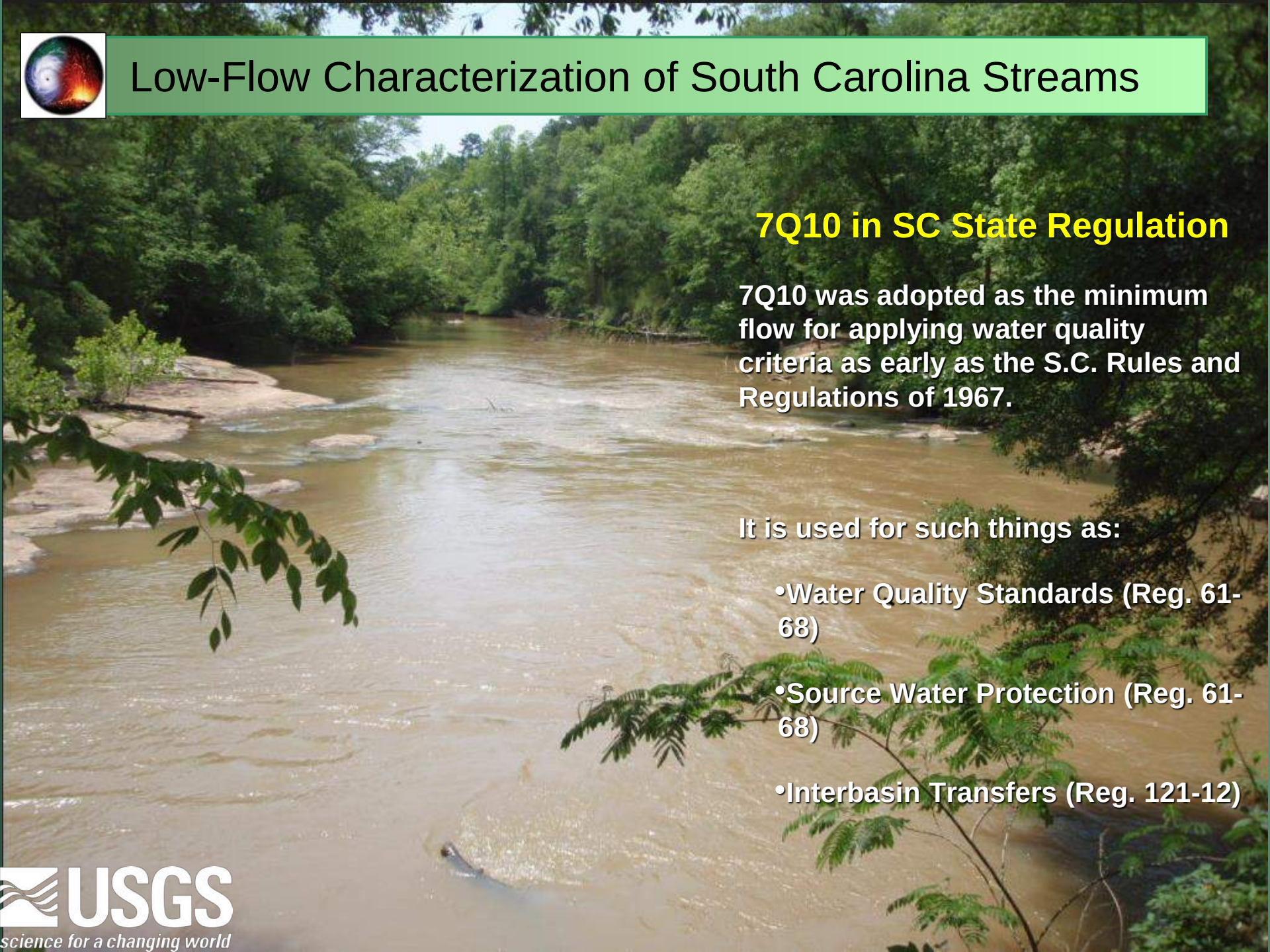
7Q10

One of the most common low-flow statistics is the 7Q10, which is the annual minimum 7-day average flow with a 10-year recurrence interval.

In terms of probability of occurrence, there is a 1 in 10 (1/10) or 10-percent probability that the annual minimum 7-day average flow at a site will be less than or equal to the estimated 7Q10.

USGS
science for a changing world

Low-Flow Characterization of South Carolina Streams



7Q10 in SC State Regulation

7Q10 was adopted as the minimum flow for applying water quality criteria as early as the S.C. Rules and Regulations of 1967.

It is used for such things as:

- **Water Quality Standards (Reg. 61-68)**
- **Source Water Protection (Reg. 61-68)**
- **Interbasin Transfers (Reg. 121-12)**

USGS
science for a changing world

Low-Flow Characterization of South Carolina Streams

How is the 7Q10 computed?

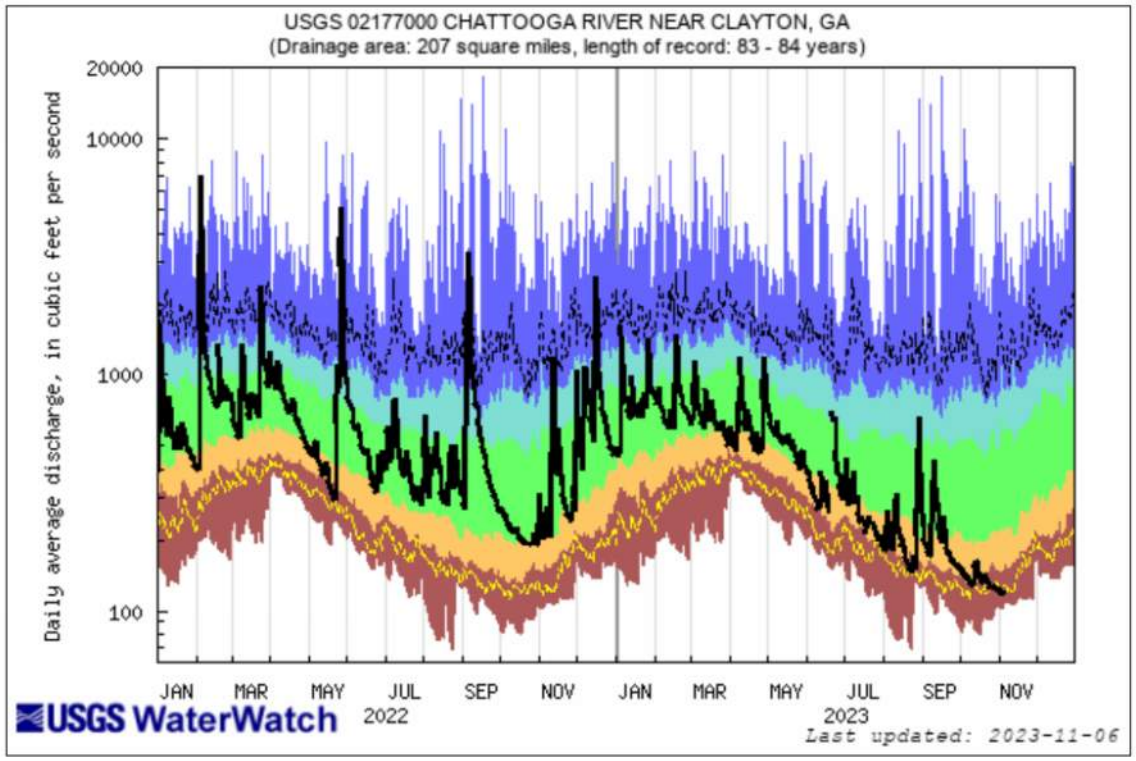
Let's look at an example at USGS station 02177000, Chattooga River near Clayton, GA, using climate years 1940-49 (first 10-years of record).

Note: A climate year begins on April 1 and ends on March 31 and is designated by the beginning year.

Why do we use the climate year as opposed to the water year, which begins on October 1 and ends on September 30 and is designated by the ending year?

USGS

Low-Flow Characterization of South Carolina Streams



Climate year

(Apr 1 to Mar 31)

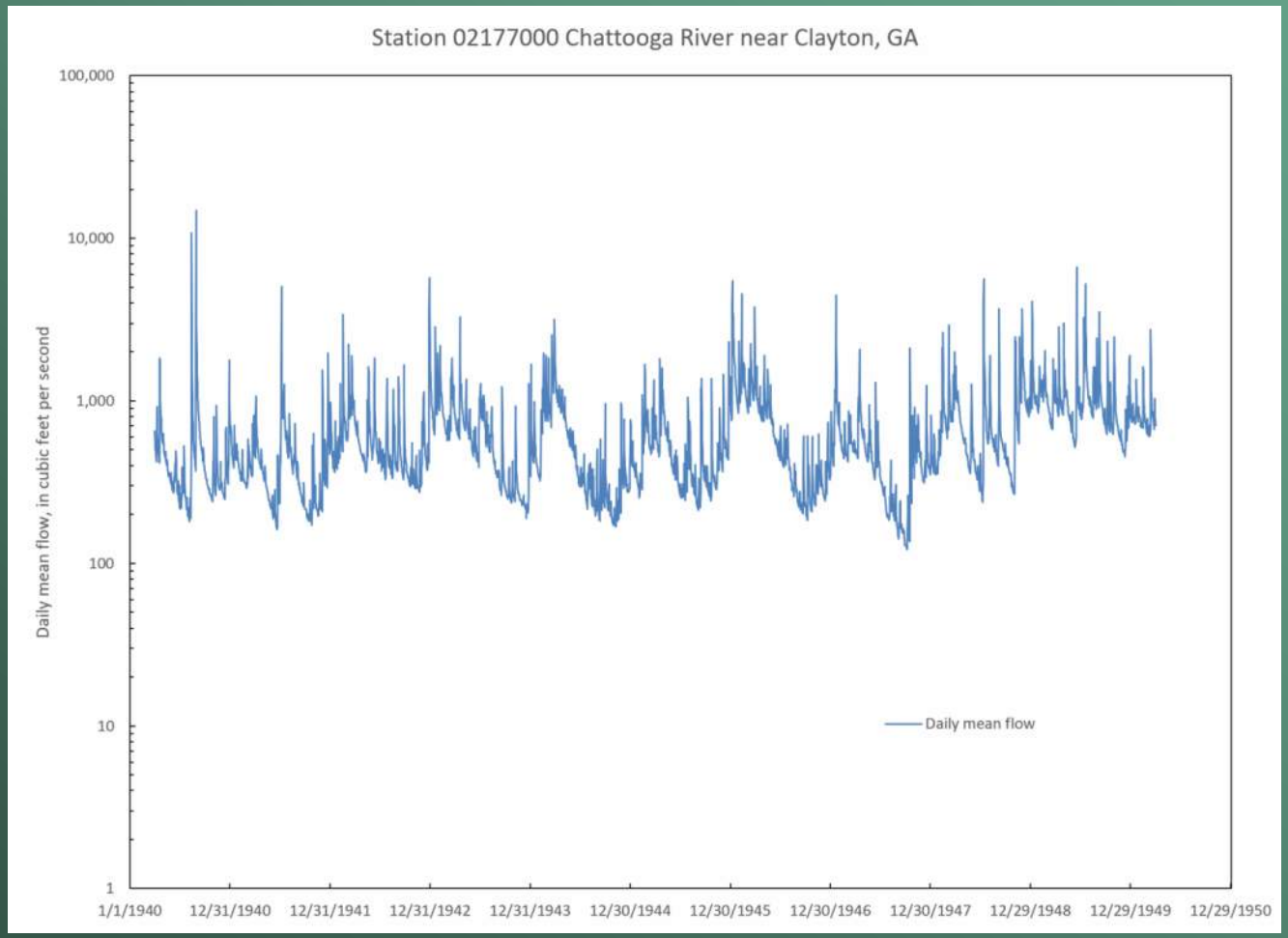
Water year

(Oct 1 to Sep 30)

USGS

https://waterwatch.usgs.gov/

Low-Flow Characterization of South Carolina Streams

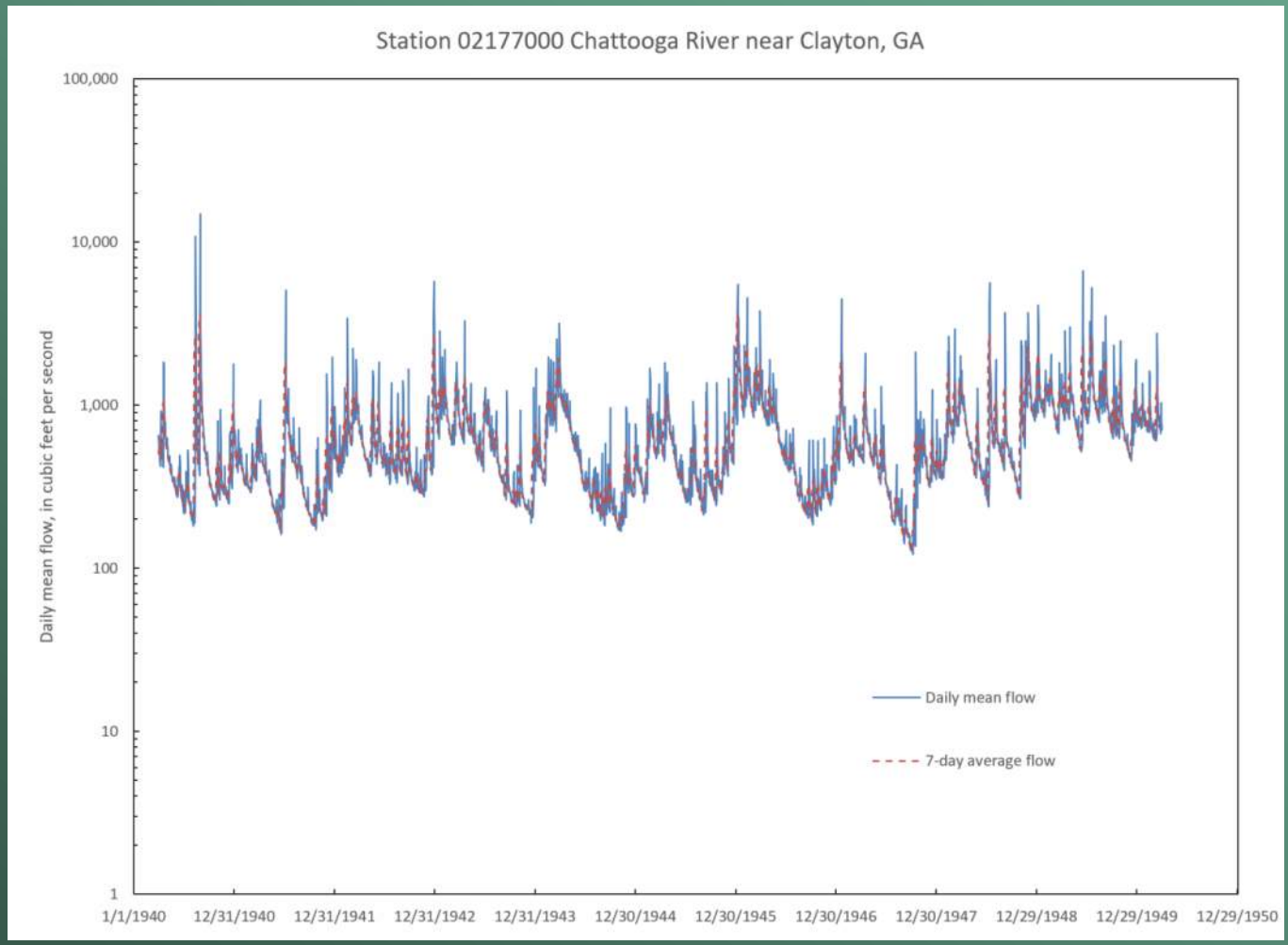


USGS

Low-Flow Characterization of South Carolina Streams

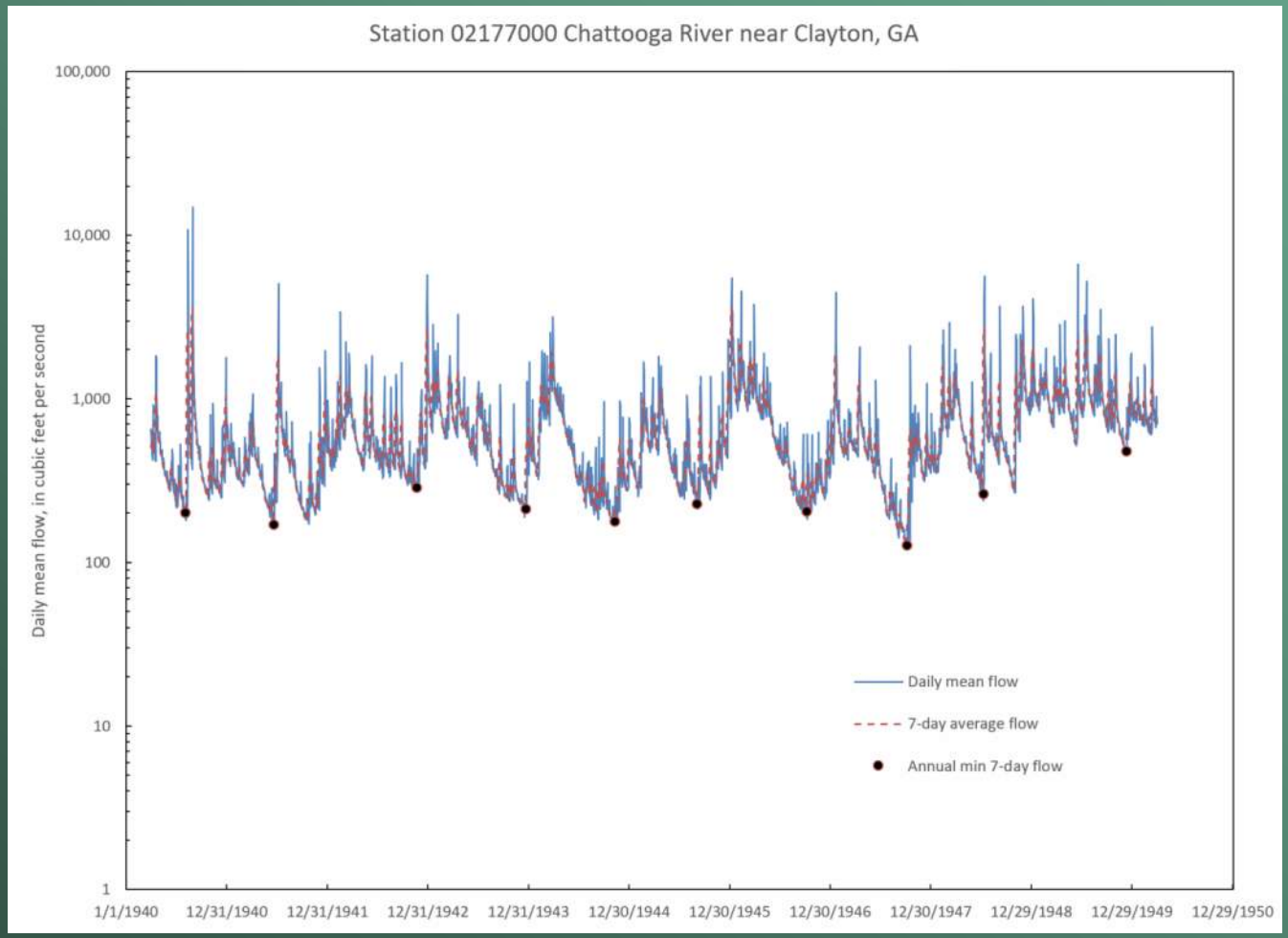
Station 02177000 Chattooga River near Clayton, GA

			Daily mean flow (ft^3/s)		7-day average (ft^3/s)
USGS	02177000	4/1/1940	650	A	
USGS	02177000	4/2/1940	561	A	
USGS	02177000	4/3/1940	505	A	
USGS	02177000	4/4/1940	486	A	
USGS	02177000	4/5/1940	466	A	
USGS	02177000	4/6/1940	421	A	
USGS	02177000	4/7/1940	428	A	502
USGS	02177000	4/8/1940	922	A	541
USGS	02177000	4/9/1940	794	A	575
USGS	02177000	4/10/1940	635	A	593
USGS	02177000	4/11/1940	568	A	605
USGS	02177000	4/12/1940	540	A	615
USGS	02177000	4/13/1940	498	A	626



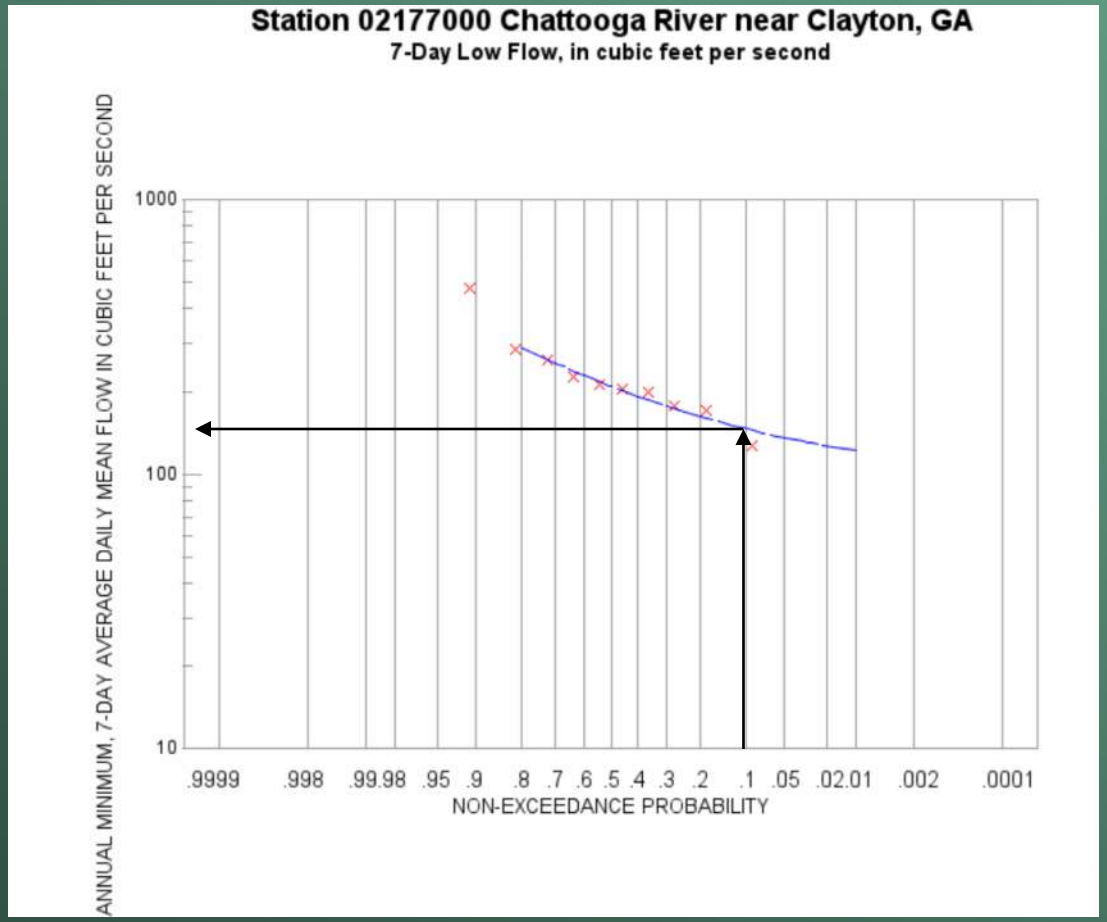
USGS

Low-Flow Characterization of South Carolina Streams



USGS

Low-Flow Characterization of South Carolina Streams



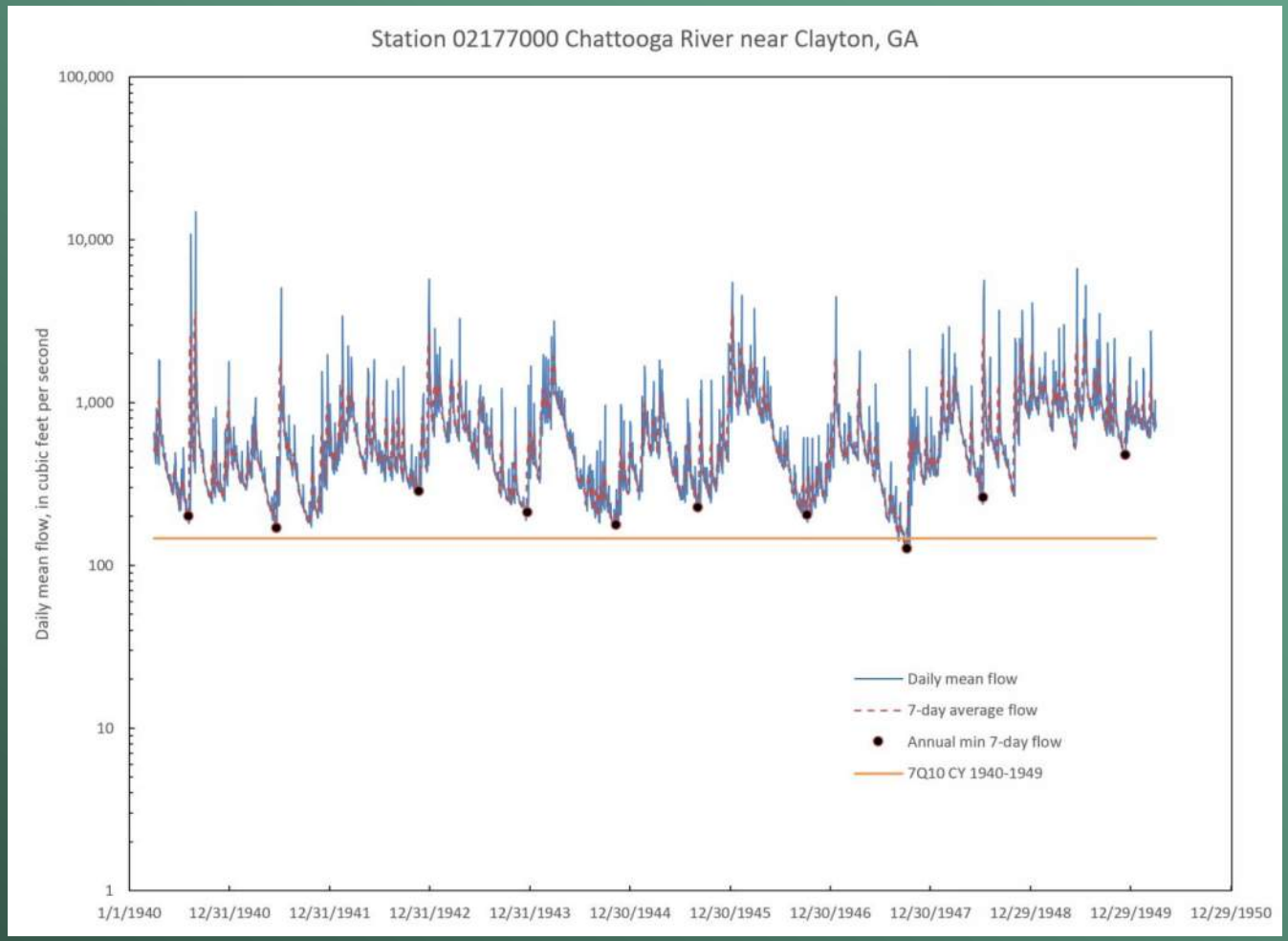
$$\log Q_T = \bar{X} + KS$$

From the log Pearson Type III statistical distribution, the 7Q10 for this period of record is 146 cubic feet per second (ft^3/s).

USGS

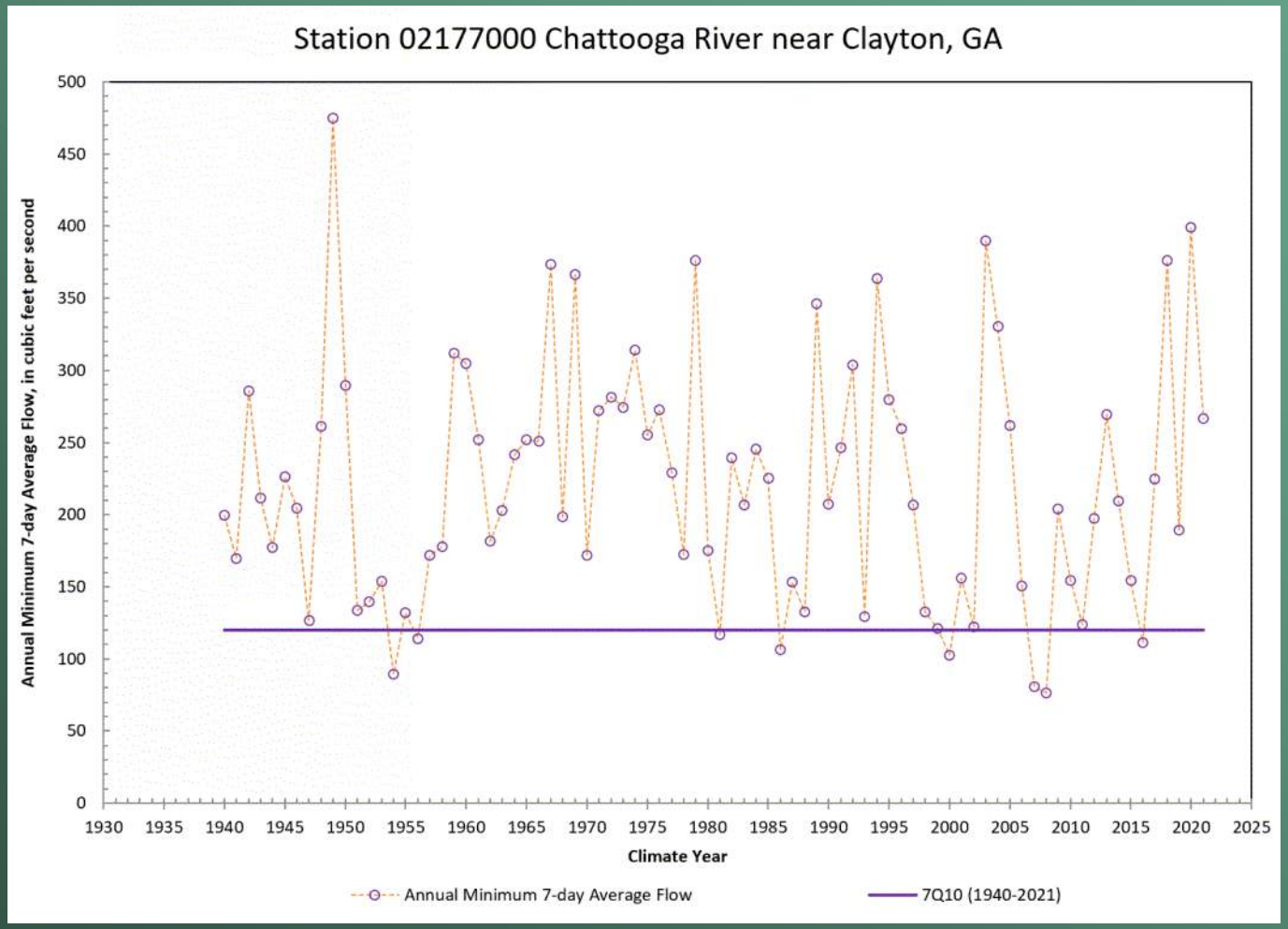
Low-Flow Characterization of South Carolina Streams

7Q10 = 146 ft^3/s



USGS

Low-Flow Characterization of South Carolina Streams



USGS

For the period from climate years 1940 to 2021 (82 years), the 7Q10 = 120 ft^3/s

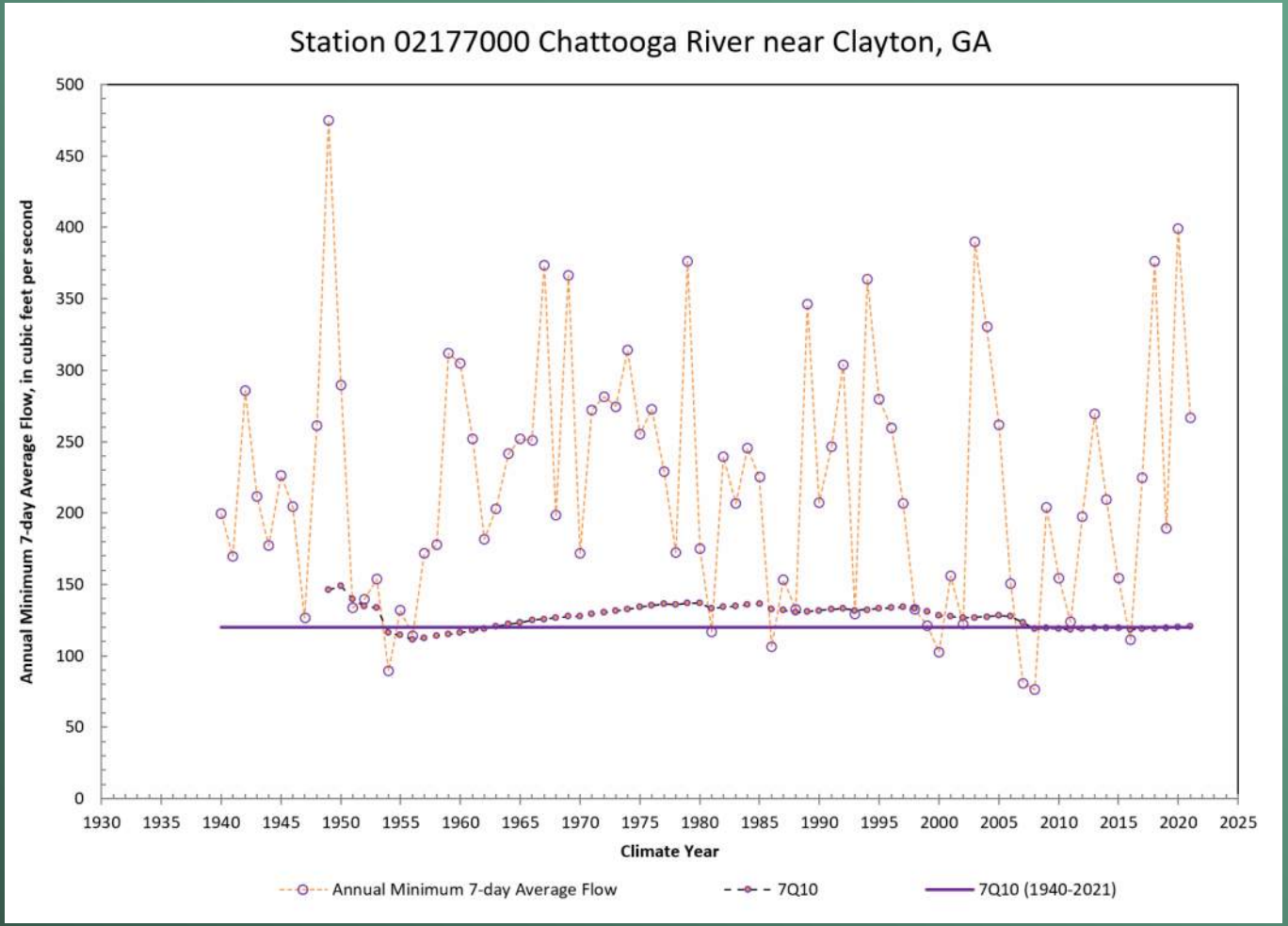
USGS

Streamflow statistics are not static values but are strongly influenced by length of record and hydrologic conditions captured in that record.

Low-Flow Characterization of South Carolina Streams

An example of how the 7Q10 has changed through time at 02177000.

CY	7Q10
1949	146
1956	111
1979	137
2011	118
2021	120

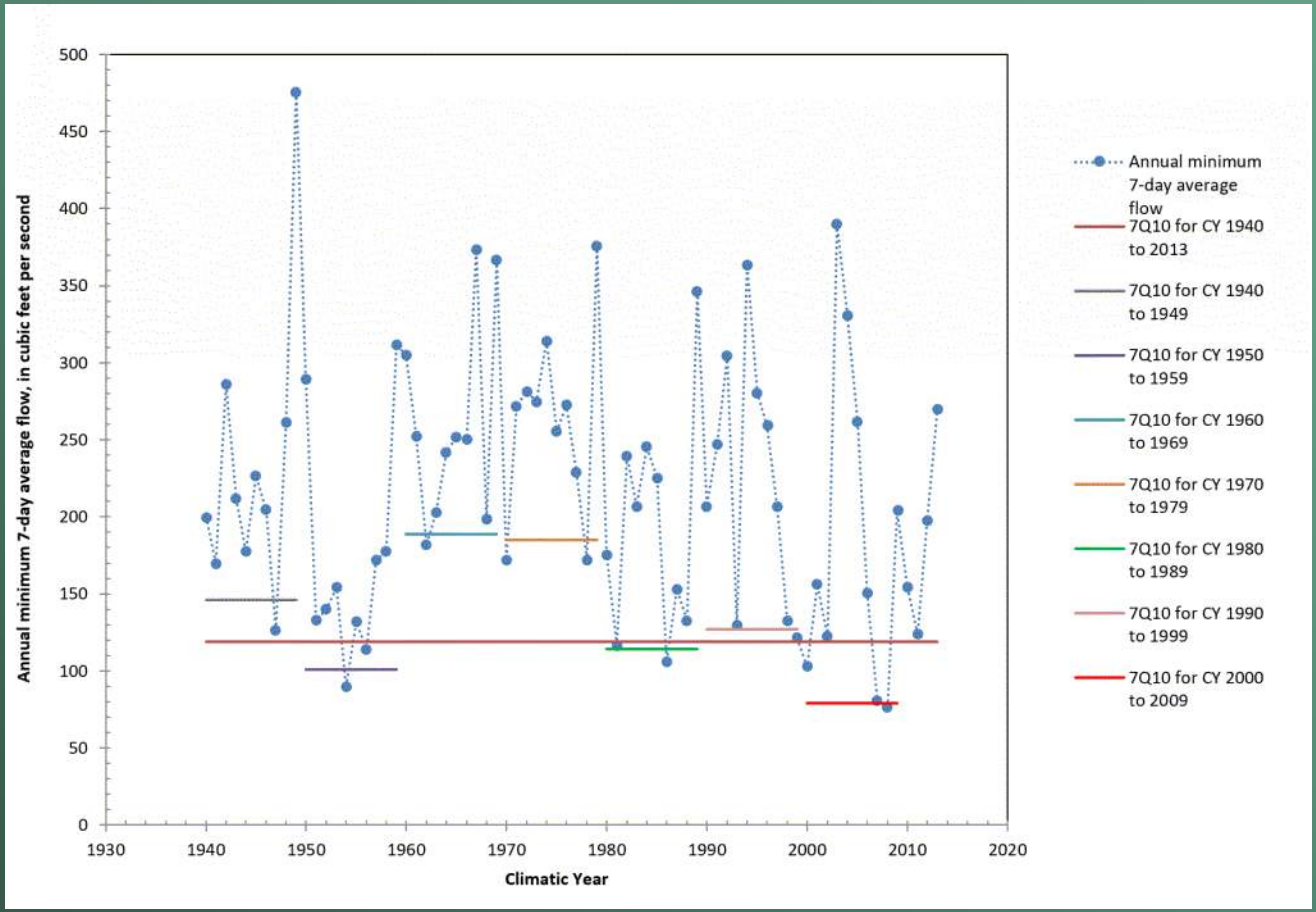


USGS

Low-Flow Characterization of South Carolina Streams

From the 2016 report, 7Q10 for seven different 10-year periods.

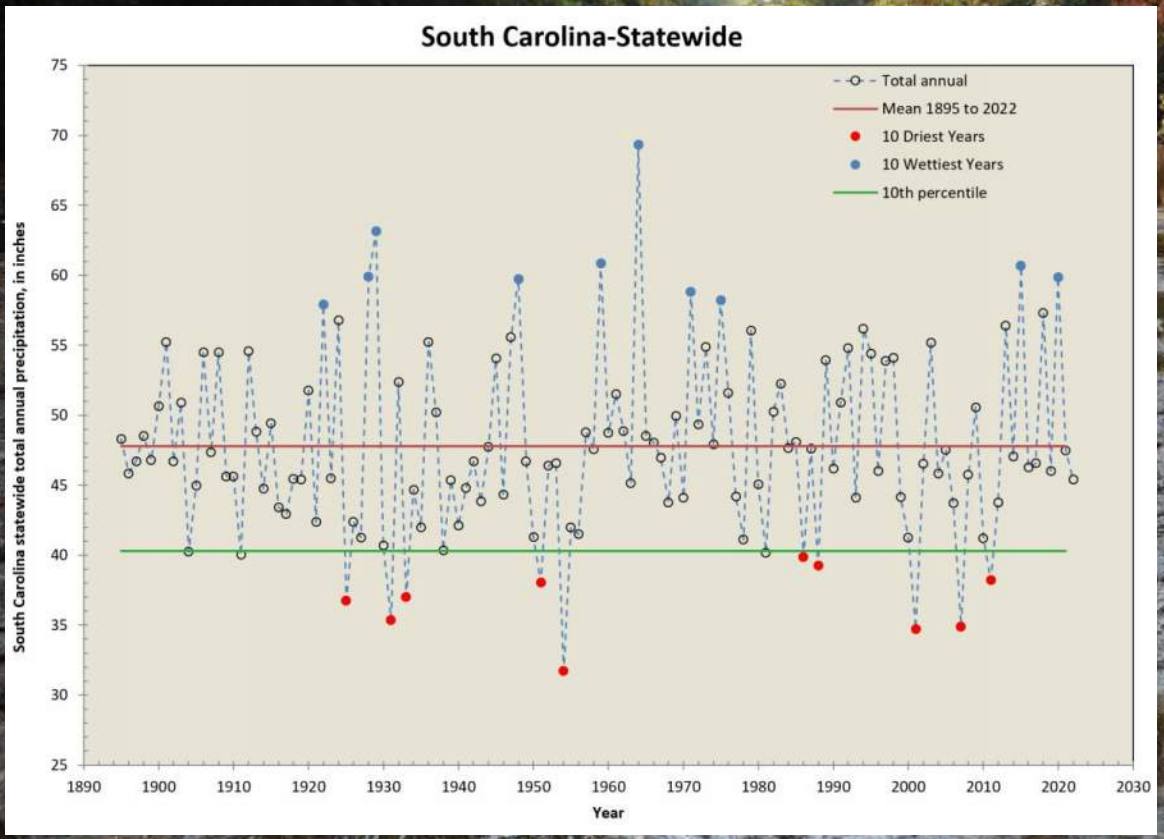
The range was 79 to 189 ft^3/s.



USGS

Low-Flow Characterization of South Carolina Streams

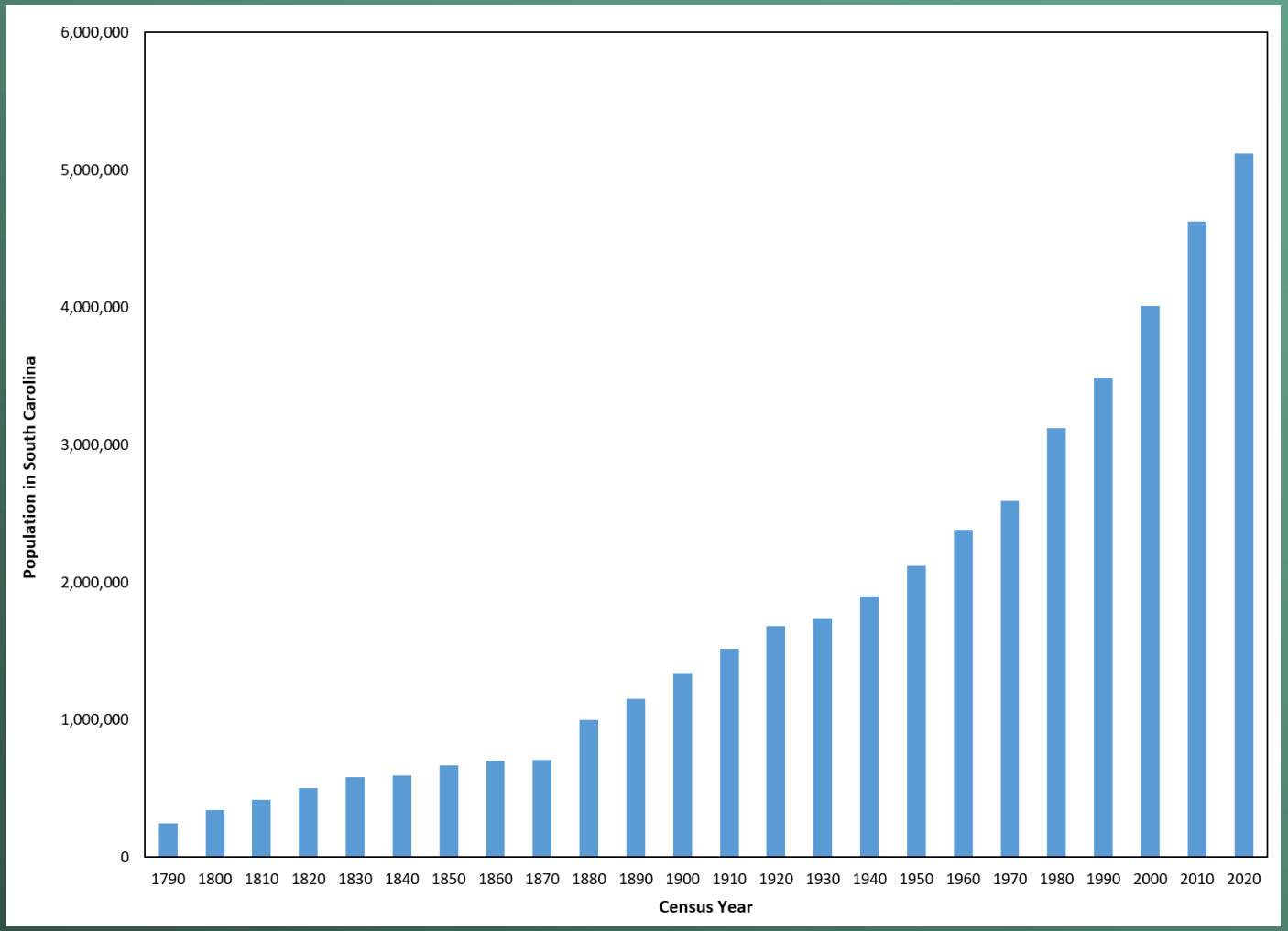
With respect to long-term statewide annual precipitation from 1895 to 2022



Wettest		Driest	
Year	Average total annual precipitation (inches)	Year	Average total annual precipitation (inches)
1964	69.32	1954	31.72
1929	63.14	2001	34.72
1959	60.86	2007	34.90
2015	60.66	1931	35.37
1928	59.89	1925	36.73
2020	59.87	1933	36.99
1948	59.74	1951	38.04
1971	58.82	2011	38.21
1975	58.23	1988	39.26
1922	57.90	1986	39.88

USGS

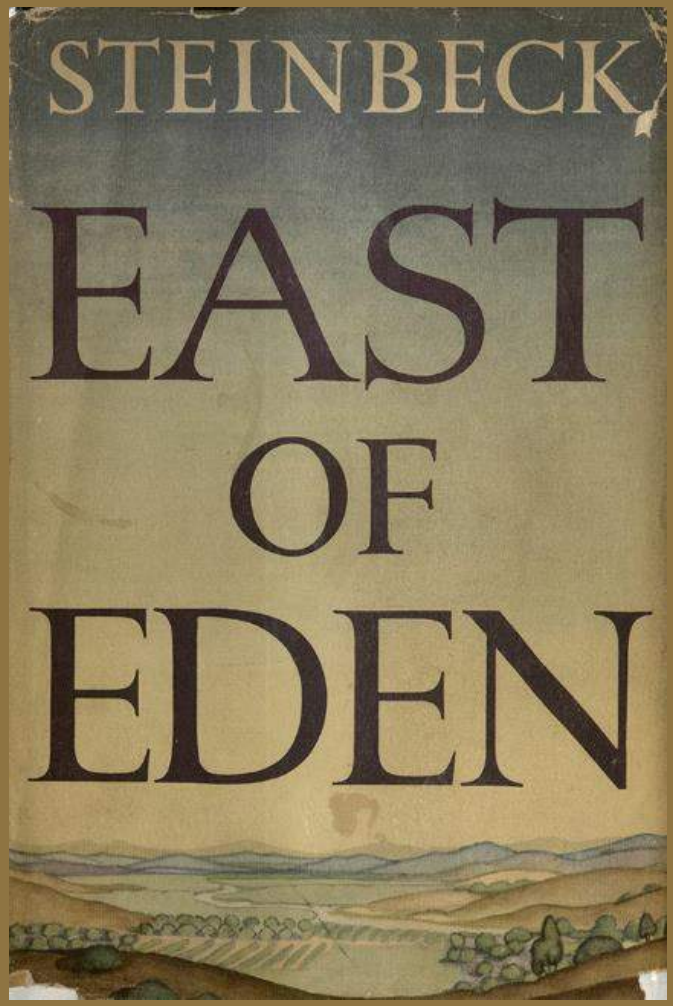
Low-Flow Characterization of South Carolina Streams



USGS

"And it never failed that during the dry years the people forgot about the rich years, and during the wet years, they lost all memory of the dry years. It was always that way."
–John Steinbeck *East of Eden*

"The reason we need long-term records is because we have short-term memories."--TDF



USGS

USGS
science for a changing world

tfeaster@usgs.gov