

THE 7Q10 IN SOUTH CAROLINA WATER-QUALITY REGULATION: NEARLY FIFTY YEARS LATER

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Abstract. The annual minimum 7-day average streamflow with a 10-year recurrence interval, often referred to as the 7Q10, has a long history of being an important low-flow statistic used in water-quality management in South Carolina as evidenced by its adoption into South Carolina law in 1967. State agencies, such as the South Carolina Department of Health and Environmental Control and the South Carolina Department of Natural Resources, use such low-flow statistics to determine Wasteload Allocations for National Pollutant Discharge Elimination System discharges, develop Total Maximum Daily Loads for streams, prepare the State Water Plan, and restrict the quantity of water that can be transferred out of basin.

The U.S. Geological Survey, working cooperatively with the South Carolina Department of Health and Environmental Control, is updating low-flow statistics at continuous-record streamflow gages in South Carolina on a basin-by-basin approach. Such statistics are influenced by length of record and hydrologic conditions under which the record was collected. Statewide low-flow statistics in South Carolina were last updated in 1987. Since that time several droughts have occurred with the most severe occurring from 1998-2002 and the most recent occurring from 2006-2009. The low-flow statistics for the Pee Dee River basin were the first to be completed in this ongoing investigation.

INTRODUCTION

South Carolina State agencies, such as the South Carolina Department of Health and Environmental Control (SCDHEC) and the South Carolina Department of Natural Resources (SCDNR), currently use low-flow statistics for many applications, including determining Wasteload Allocations (WLAs) for National Pollutant Discharge Elimination System (NPDES) discharges, development of Total Maximum Daily Loads for streams, restricting the quantity of water that can be transferred from one basin to another, and preparing the State Water Plan. In addition, low-flow statistics are

useful for improving the general level of understanding of natural (unregulated) and regulated stream systems. The two most recent droughts in South Carolina, during 1998–2002 and 2006–2009, have heightened the awareness of the importance of having up-to-date statistics for making such critical decisions.

Hydrologic information on the availability of streamflow under low-flow conditions is essential for the effective management of water resources. Low-flow statistics defining the magnitude and frequency of such low-flow events are provided as a minimum average streamflow over some designated time period. For example, one of the most common low-flow statistics is the annual minimum 7-day average streamflow with a 10-year recurrence interval (7Q10). In terms of probability of occurrence, there is a 1/10 or 10-percent probability that the annual minimum 7-day average flow in any 1 year will be less than the estimated 7Q10 value. Another example is the 1Q10 low-flow statistic, which is the annual minimum 1-day streamflow with a 10-year recurrence interval.

7Q10 in State Regulation

The common practice of using the 7Q10 statistical low flow in water-quality management has a long history, which almost certainly predates its widespread adoption in state's water-quality laws and regulations. South Carolina adopted the 7Q10 as the minimum stream flow for applying water-quality criteria as early as the S.C. Rules and Regulations of 1967, and it remains the applicable critical flow condition for most of the water-quality criteria today. S.C. Regulation 61-68, *Water Classifications and Standards*, includes the following definition for 7Q10:

7Q10 means the annual minimum seven day average flow rate that occurs with an average frequency of once in ten years as published or verified by the U.S. Geological Survey (USGS) or an estimate extrapolated from published or verified USGS data. (R. 61-68, Section B.2.)

The specific water-quality criteria applicable at the 7Q10 minimum flow condition includes the aquatic life

criteria dissolved oxygen (DO), pH, temperature, turbidity, and toxics as well as the human health criteria for noncarcinogens. The SCDHEC's NPDES permitting process includes development of WLAs and derivation of effluent permit limits designed to protect these criteria in the receiving stream at critical conditions including 7Q10 stream flow, plant design flow for Wastewater Treatment Facilities (WWTFs), and other parameters where appropriate. In addition, NPDES dischargers are required to pass Whole Effluent Toxicity tests based on 7Q10 dilution. It is important to note that Regulation 61-68 allows for alternatives to 7Q10 where appropriate, such as tidal waters and streams below dams due to the effects of reversing flows and altered low-flow patterns.

In addition to protecting for the water-quality criteria, the SCDHEC uses the 7Q10 flow to regulate Interbasin Transfers (IBTs) of water and to provide Source Water Protection (SWP) for municipal surface water supplies. Regulation 121-12 requires IBT permits for all new users who withdraw five percent or more of the 7Q10 from one basin and use or discharge any portion of it into a different basin. Under Regulation 121-12, IBT permits prohibit transfers of water that cause the remaining flow in the losing river basin to be less than the 7Q10. Existing regulation provides quantity restrictions only for IBT withdrawals. Surface-water withdrawals that do not involve transferring water to another basin do not have regulatory restrictions. Finally, the SCDHEC SWP and NPDES permitting program use 7Q10 to assess necessary protections at upstream WWTFs that have the potential to impact downstream water supplies at 7Q10 flow conditions.

UPDATING LOW-FLOW STATISTICS

Low-flow statistics such as the 7Q10 are not static values and are affected by such things as the number of years of record available for use in computing the statistic. Consequently, it is critical to effectively measure and document base-flow data for use in updating low-flow statistics on a regular basis, preferably about every 10 years, because of the importance of the applications previously discussed. Low-flow statistics in South Carolina have not been updated in a systematic way since 1987. In 2008, the USGS, in cooperation with the SCDHEC, initiated a study to update low-flow statistics at continuous-record (CR) streamgaging stations operated by the USGS in South Carolina. The investigation coincides with the SCDHEC Watershed Water Quality Management Strategy for monitoring, assessment, wasteload allocation, permitting and remediation in the eight major basins in South Carolina (fig. 1). The first basin to be assessed was the Pee Dee River basin. Complete details of the USGS investigation including tables of the low-flow statistics can be found in the USGS Open-File Report 2009-1171 (Feaster and Guimaraes, 2009).

Estimates of the annual minimum 1-, 3-, 7-, 14-, 30-, 60-, and 90-day average flows with recurrence intervals of 2, 5, 10, 20, 30, and 50 years were computed for the Pee Dee River basin depending on the length of record available at the CR station. In addition, daily flow duration statistics for the 5-, 10-, 25-, 75-, 90-, and 95-percent probabilities of exceedance also were provided.

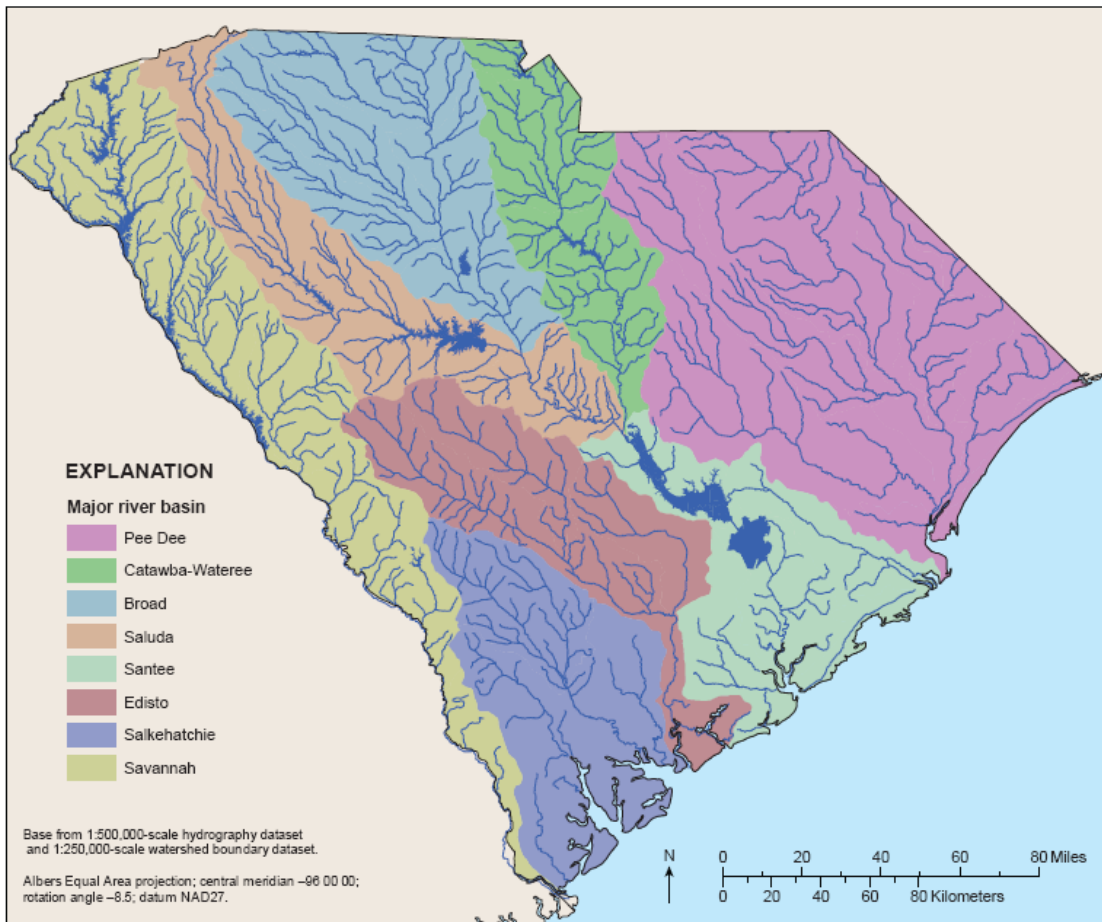


Figure 1. The eight major basins in South Carolina as defined by the SCDHEC.

Influence of Record Length on Low-Flow Statistics

Low-flow frequency statistics are often computed by fitting a series of annual minimum N-day average flows to some known statistical distribution, where N can equal any number from 1 to 365. For this investigation, the logarithms of the N-day flows mentioned previously were fit to a Pearson Type III distribution. The accuracy of such low-flow statistics is related to the lengths of records upon which the statistics are based. The longer the period of record at a streamgaging station that covers a broad range of hydrologic conditions, the more accurate or reflective of long-term conditions the low-flow statistics will be. The streamflow statistics for short records are much more sensitive to extreme hydrologic events than those for long-term records. As a result, streamflow statistics from one 10-year period may differ significantly from another 10-year period. Thus, a long-term record is always more desirable when computing streamflow statistics.

As an example of the effect that record length and hydrologic conditions can have on low-flow statistics, the 7Q10 for streamgaging station 02132000, Lynch River at Effingham, SC, was computed beginning with the first

10 years of record (April 1930–March 1940) and then updating on a 5-year basis through climatic year¹ 2006. Figure 2 shows the annual minimum 7-day average flow by climatic year for the period of record along with the computed 7Q10 estimates. The 7Q10 for the first 10 years of record was 143 cubic feet per second (ft³/s). By climatic year 1950, the 7Q10 had increased to 152 ft³/s due to the addition of data collected during a period when streamflow was fairly well sustained. With the drought of the 1950s, the 7Q10 decreased to 138 ft³/s in 1955. The 1960s and 1970s tended to be a relatively wet period, and the 7Q10 generally increased during that time. Lastly, the drought of 1998–2002 had a substantial effect on the 7Q10, with the value decreasing to 131 ft³/s in climatic year 2006. The difference between the highest and lowest 7Q10 computed in this analysis is 14 percent.

¹ A climatic year is the 12 month period from April 1 through March 31 and is designated by the year in which it begins.

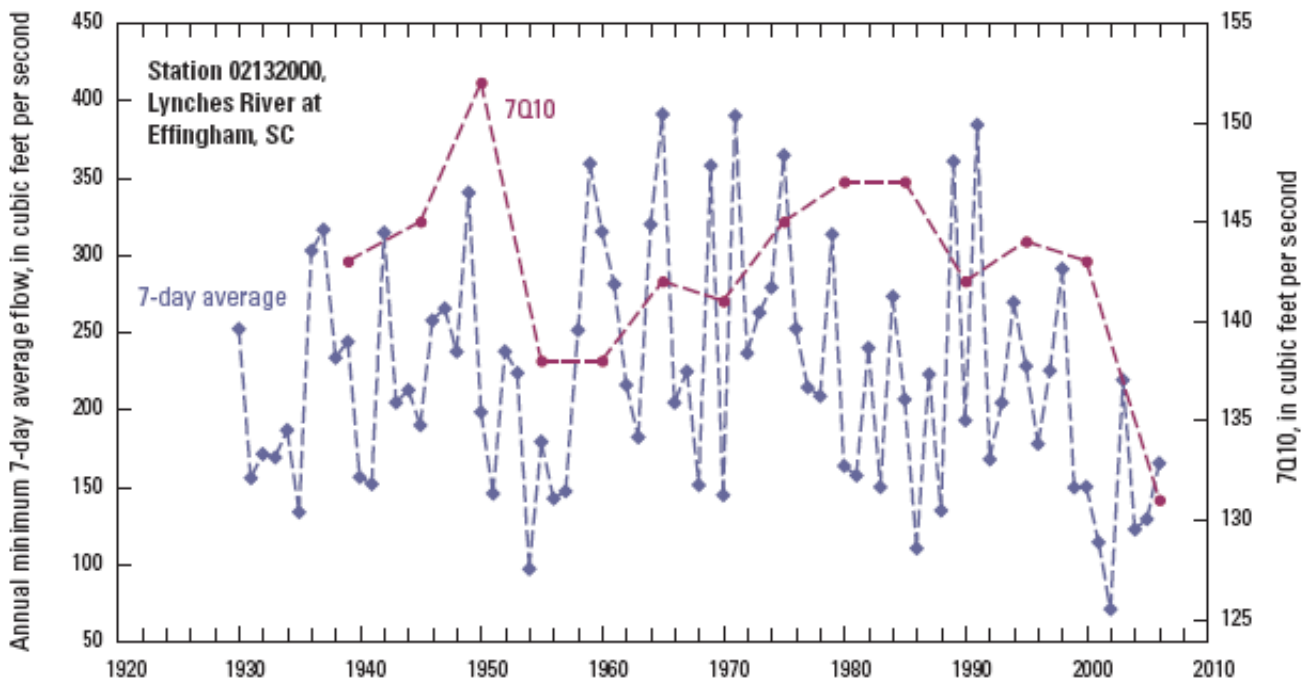


Figure 2. Annual minimum 7-day average flows and 7Q10 estimates at streamgaging station 02132000, Lynch River at Effingham, SC.

To show the effect of how the 7Q10 can be influenced under a different set of hydrologic conditions and the significant influence that period of record can have on streamflow statistics, a similar analysis was done using a synthesized record of annual minimum 7-day average flows. The synthesized flows were generated by reversing the annual minimum 7-day average flows from streamgaging station 02132000. Under these conditions, the streamflow record begins in a significant dry period. As can be seen in figure 3, the 7Q10 computed from the first 10 years of record is 89.9 ft³/s, which is 63 percent of the 7Q10 based on the first 10 years of record from the measured data at streamgaging station 02132000. Because the synthesized record began in a period that was the driest based on the next 68 years of record, the 7Q10 shows a pattern of continuing to increase until again, a value of 131 ft³/s was obtained in climatic year 2006. The difference between the highest and lowest 7Q10 computed in this analysis is 32 percent. This percent difference emphasizes that although the 7Q10 value at the end of the record was the same for both the measured data and the synthesized data; the intermittent values were sometimes significantly different based on a rearrangement of the hydrologic conditions (starting in a significant drought as opposed to starting in a relatively wet period). As the length of record at a streamgaging

station increases, the low-flow statistics are moving toward the values that would be expected to be obtained from the population. As the period of record increases, the streamflow statistics tend to be less influenced by extreme conditions, whether they are wet or dry.

SUMMARY

Broad-based streamflow monitoring data and up-to-date low-flow statistics are an important part of water-quality regulation and water-resource management in South Carolina, currently and for the foreseeable future. Streamflow monitoring data collected by the USGS and cooperating stakeholders and the current study by the USGS and the SCDHEC to update the low-flow statistics statewide help to ensure the best possible data and information are available to local, State, and Federal agencies, industries, environmental groups, and the general public.

South Carolina adopted the 7Q10 as the minimum streamflow for applying water-quality criteria as early as the S.C. Rules and Regulations of 1967. The 7Q10 remains the applicable critical flow condition for most of the water-quality criteria today and therefore, it is important that such statistics be updated on some

reasonable interval. Such updates allow for inclusion of new data and longer records, which are important due to the influence that extreme hydrologic conditions can have on short records.

REFERENCES

Feaster, T.D., and Guimaraes, W.B., 2009, Low-flow frequency and flow duration of selected South Carolina streams in the Pee Dee River basin through March

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S.C. Water Classifications and Standards Regulation 61-68, <http://www.scdhec.gov/environment/water/regs/r61-68.pdf>

S.C. Interbasin Transfer of Water Regulation 121-12, <http://www.scdhec.gov/environment/water/regs/r121-12.pdf>

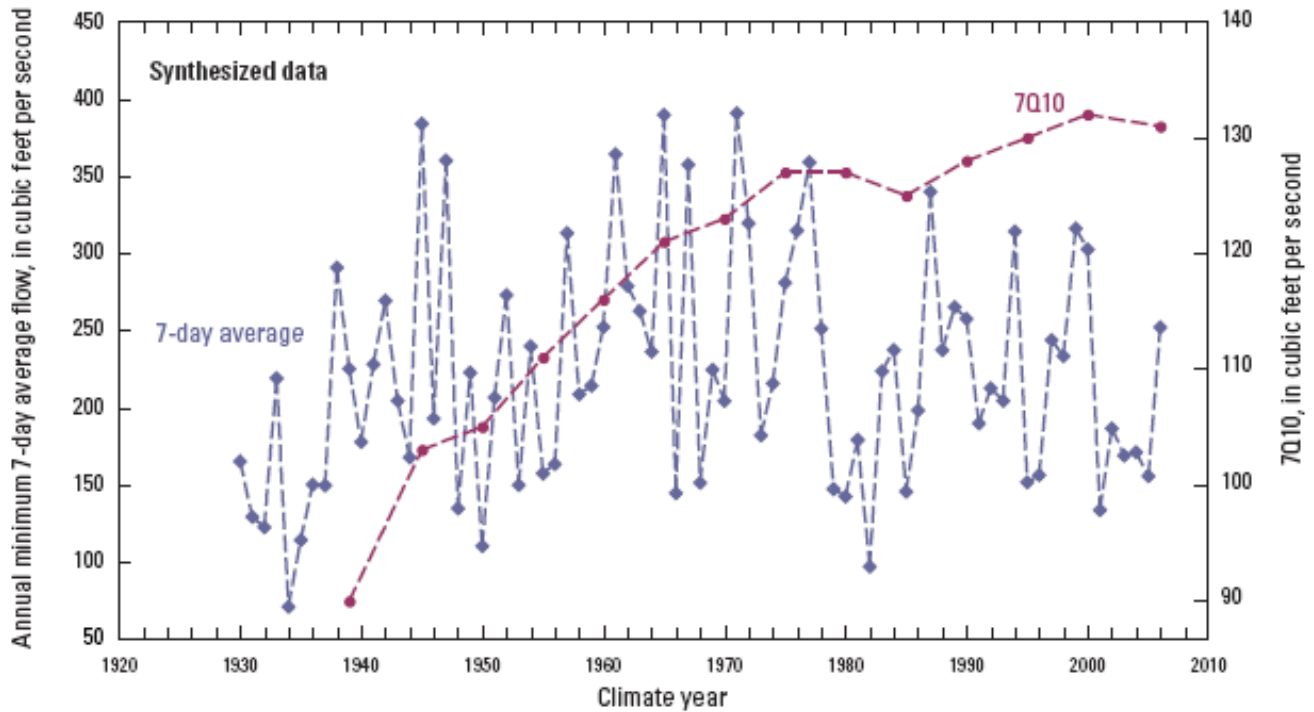


Figure 3. Annual minimum 7-day average flows and 7Q10 estimates from a synthesized dataset.