

MAINTAINING MINIMUM FLOW IN THE STREAMS OF SOUTH CAROLINA

by
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DEPARTMENT OF NATURAL RESOURCES**

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Minimum flows for streams are established to protect public health, fish and other wildlife, and for recreation/aesthetic purposes. The minimum flow for a stream is the greatest of the minimum flows required for maintenance of water quality, for protection of fish and wildlife, or for navigability.

The equations for calculating the minimum flows in the South Carolina Water Plan are based on at least 20 percent of the average annual flows for the period 1938-1995. The minimum flows according to the State Water Plan are given in Figure 1 for selected streamflow gaging sites in the State. During average and high flow periods, natural flows are much higher than the minimum flows in the streams of South Carolina.

The minimum flow per square mile for selected streamflow measuring sites was calculated by dividing the minimum flow, in cubic feet per second, by the drainage area, in square miles, at each site. The minimum flows per square mile at those sites are given in Figure 2. The minimum flow at any stream site may be calculated by finding the nearest contour line to the site and multiplying it by the site's drainage area.

Analysis of the daily flow of streams in South Carolina indicates that flow is equal to or greater than the minimum about 95 percent of the time. Additional water is needed 5 percent of the time to maintain the minimum.

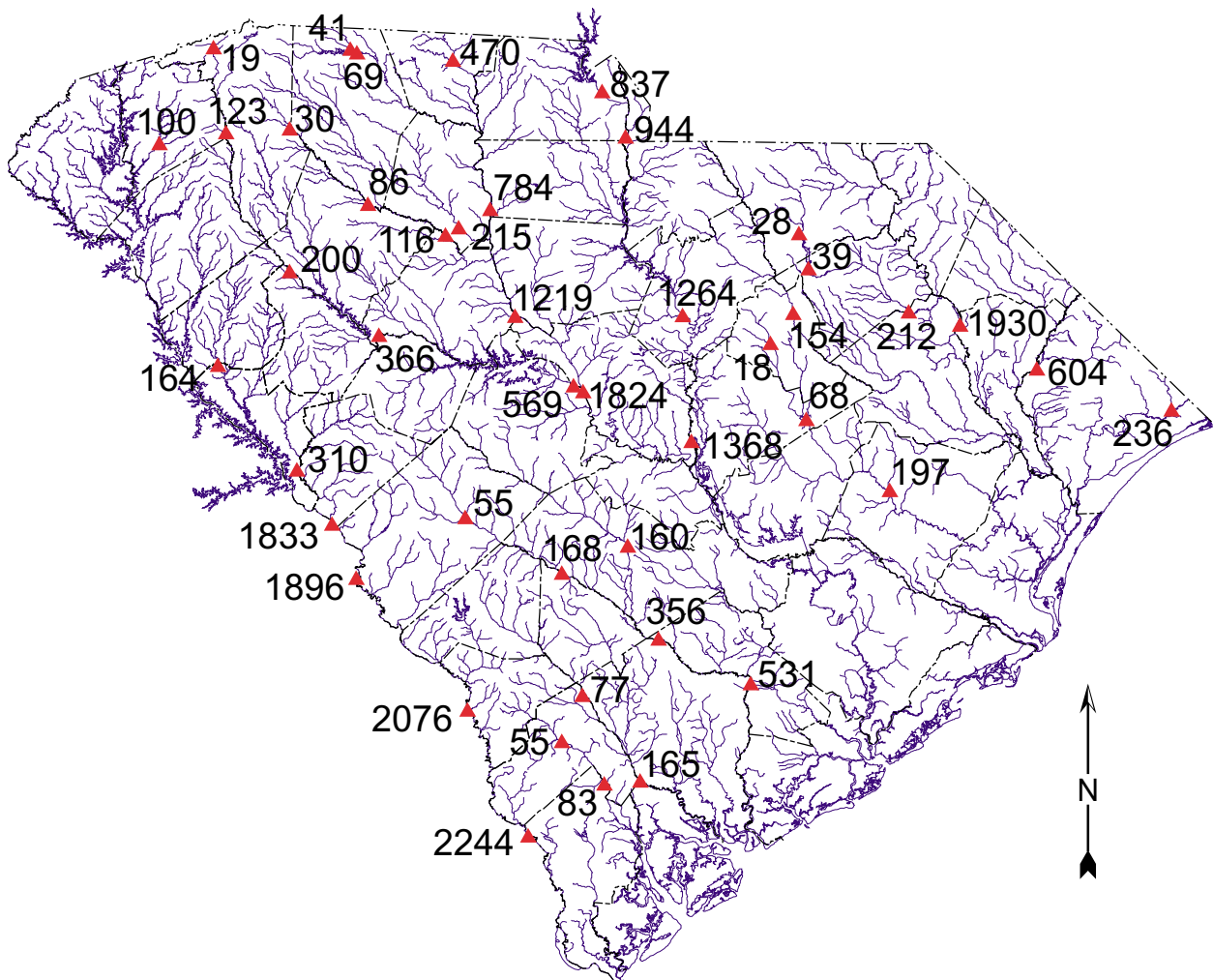


Figure 1. Minimum flow (cubic feet per second) for selected streamflow measuring sites according to the State Water Plan.

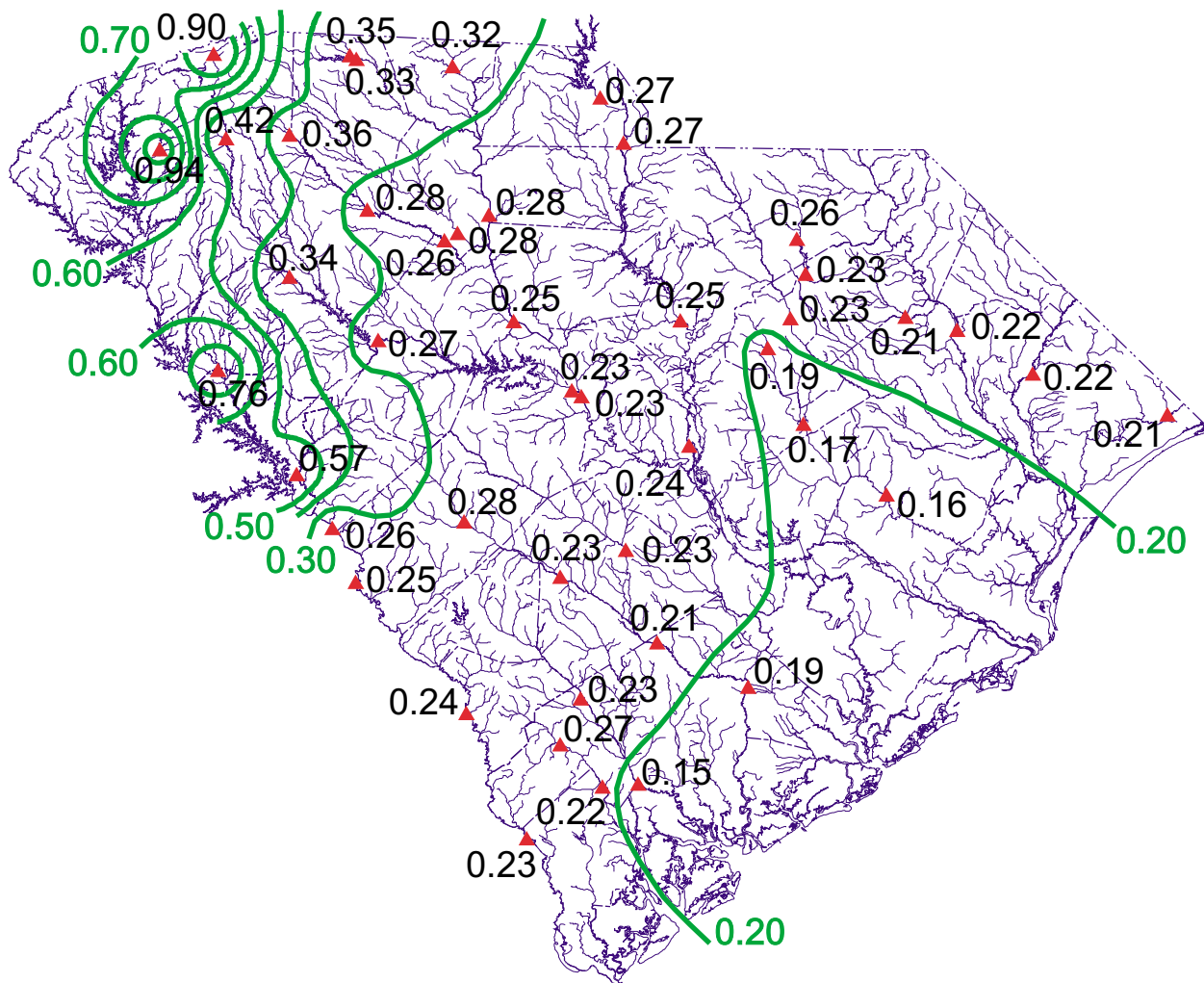


Figure 2. Minimum flow per square mile for selected streamflow measuring sites in South Carolina.

The time (5 percent) that water is not available to maintain minimum flow occurs mostly in the summer months, owing to high evapotranspiration. More water is available in the winter months when evaporation rates are low (Figure 3). Excess water stored during the winter months could be released in the summer months to maintain minimum flows.

The excess water could be stored in aquifers or surface reservoirs. In streams where existing storage facilities are available, releases of additional water could maintain minimum flow. Additional storage may be necessary at some existing facilities to meet all demands.

Reservoirs are built for multiple or single purposes, including hydropower generation,

flood management, water supply, and recreation/aesthetic use. The size of the reservoir depends on the reservoir purpose, the flow regime of the stream, topography at the reservoir site, and other variables.

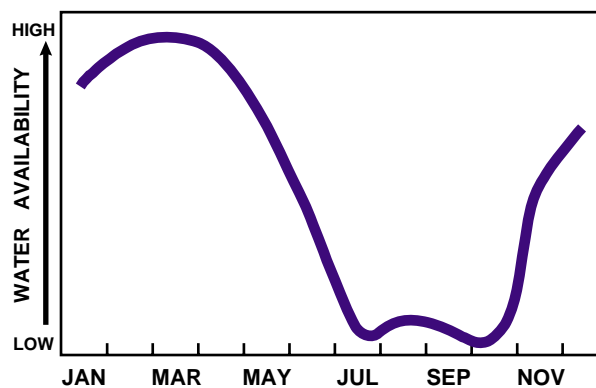


Figure 3. A typical stream hydrograph in South Carolina, showing water availability.

The following is an example illustrating the estimation of storage volume required to maintain minimum flow at a site on a stream. For this example, the minimum flow of the Pee Dee River at Pee Dee, S. C., is calculated from an equation presented in the State Water Plan:

$$\text{Minimum flow} = 0.487(8,830)^{0.912} = 1,930 \text{ cfs (cubic feet per second)}$$

where 8,830 is the drainage area of the Pee Dee River at Pee Dee, in square miles.

Estimating the storage volume required to maintain a flow of 1,930 cfs in the Pee Dee River at Pee Dee involves the following steps:

1. Select or determine the longest period with flow generally less than the minimum flow (1,930 cfs). The period August 9 through October 15, 1954 appears to be the longest period in which flows were generally less than 1,930 cfs for the Pee Dee River at Pee Dee (Figure 4).

During this 68-day period the flow was less than the minimum flow for 21 consecutive days, September 25 through October 15, 1954.

The summation of flows greater than and less than 1,930 cfs indicates a deficit flow of 38,400 cfsd (cfs days) for the 68-day period.

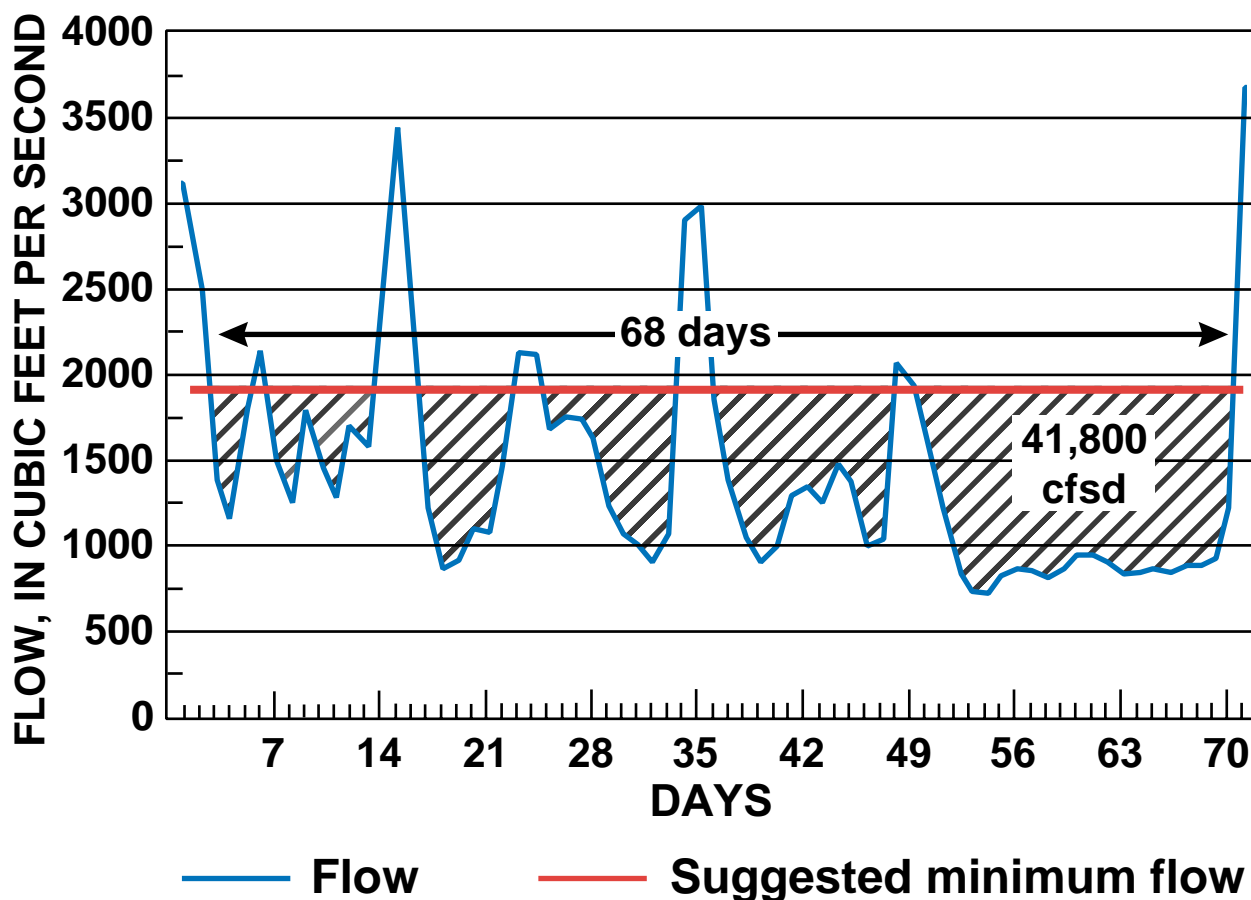


Figure 4. Daily flow of the Pee Dee River at the Pee Dee gaging station from August 8 through October 16, 1954, and the minimum flow based on the equation in the State Water Plan.

2. If a withdrawal of 50 cfs is added every day, then the anticipated withdrawal for the 68 days would be 3,400 cfsd:

$$50 \text{ cfs} \times 68 \text{ days} = 3,400 \text{ cfsd}$$

3. The summation of the deficit flow and the withdrawal for the 68 days is 41,800 cfsd:

$$38,400 \text{ cfsd} + 3,400 \text{ cfsd} = 41,800 \text{ cfsd}$$

4. The volume of storage to contain 41,800 cfsd is 83,000 acre-feet:

$$\frac{41,800 \text{ cfsd} \times 86,400 \text{ sec/day}}{43,560 \text{ ft}^2/\text{acre}} = 83,000 \text{ acre-feet}$$

5. If a surface reservoir contains 83,000 acre-feet and averages 10 feet in depth, the surface area of the reservoir would be 8,300 acres. If the surface reservoir averages 20 feet deep, the surface area of the reservoir is 4,150 acres.
6. If the storage facility is a surface reservoir, a volume of water to meet evaporation demands should be added to the designed storage facility. Assuming an evaporation rate of 47 inches per year, the 68-day evaporation loss from the reservoir is 9 inches:

$$\frac{68 \text{ days} \times 47 \text{ in/yr}}{365 \text{ days/yr}} = 9 \text{ inches}$$

In this example, an extra volume of water equal to 9 inches multiplied by the designed reservoir surface area should be added to the 83,000 acre-feet.

REFERENCE

Cherry, R.N., and Badr, A.W., 1998, South Carolina water plan: South Carolina Department of Natural Resources.