USGS
science for a changing world

Prepared in cooperation with the South Carolina Department of Transportation, Office of Materials and Research, and the North Carolina Department of Transportation, Division of Highways (Hydraulics Unit)

Estimating Flood Magnitude and Frequency for Urban and Small, Rural Streams in Georgia, South Carolina, and North Carolina, 2011

Introduction

Reliable estimates of the magnitude and frequency of floods are essential for the design of transportation and water-conveyance structures, flood insurance studies, and flood-plain management. Flood-frequency estimates are particularly important in densely populated urban areas. The U.S. Geological Survey (USGS) used a multistate approach to update methods for determining the magnitude and frequency of floods in urban and small, rural streams that are not substantially affected by regulation or tidal fluctuations in Georgia, South Carolina, and North Carolina (Feaster and others, 2014). The multistate approach has the advantage over a single state approach of increasing the number of streamflow-gaging stations (streamgages) available for analysis, expanding the geographical coverage that would allow for application of regional regression equations across state boundaries, and building on a previous flood-frequency investigation of rural streamgages in the Southeastern United States. This investigation was funded as part of a cooperative program of water-resources investigations between the USGS, the South Carolina Department of Transportation, and the North Carolina Department of Transportation. In addition, much of the data and information for the Georgia streamgages was funded through a similar cooperative program with the Georgia Department of Transportation.

Overview

Building on the success of a multistate approach for developing regional flood-frequency equations to estimate the magnitude and frequency of floods at ungaged rural streams in the Southeast (Feaster and others, 2009; Gotvald and others, 2009; Weaver and others, 2009), a similar approach was applied to urban and small, rural streams (Feaster and others, 2014). For this investigation, "Southeast" refers specifically to Georgia, South Carolina, and North Carolina. The analytical techniques used incorporate both urban and rural streamgages and, therefore, can be applied to urban and small, rural streams. The lower limit of drainage area for basins included in the Southeast rural flood-frequency study was 1 square mile (mi^2). The lower limit of drainage area for rural basins included in the current investigation was 0.1 mi^2. Consequently, in this study, small, rural streams refer to those with drainage areas less than 1 mi^2. Some of the benefits of including both urban and rural streamgages in the regression analysis are (1) smoother transition between urban and rural flood-frequency estimates, (2) larger database than would be available with urban streamgages alone, and (3) larger geographical coverage in the hydrologic regions, which will represent a broader range of hydrologic conditions likely to occur at ungaged locations.

The focus of the investigation was on three hydrologic regions (HR) in the Southeast (fig. 1): HR1, Piedmont–Ridge and Valley; HR3, Sand Hills; and HR4, Coastal Plain. The Blue Ridge (HR2) was not included due to the lack of urban streamgages having sufficient record lengths to include in a regional regression analysis. Regression equations for HR5, which is contained solely in southwest Georgia, were previously developed and published by Gotvald and Knaak (2011).

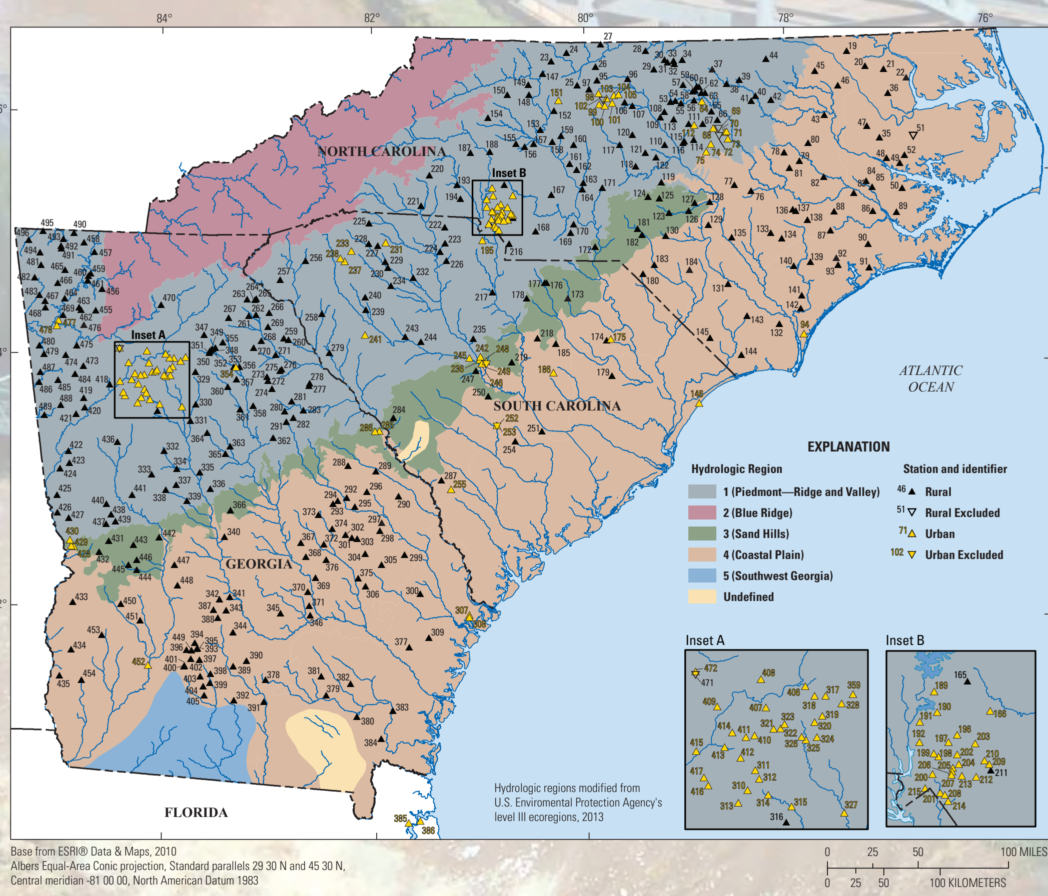

Figure 1. Locations of hydrologic regions and U.S. Geological Survey streamgages with 10 or more years of record that were included in the Southeast regional-regression analysis for urban and small, rural streams.

Regression Analysis

The regression analysis included flood-frequency estimates generated for 488 USGS streamgages: 340 rural; 32 small, rural; and 116 urban. The flood-frequency data for the rural streamgages were taken from the previously published Southeastern rural study (Feaster and others, 2009). The flood-frequency estimates for the remaining streamgages were completed by using a modified version of the methods described in Bulletin 17B of the Hydrology Subcommittee of the Interagency Advisory Committee on Water Data (1982) by including the expected moments algorithm, which allows for a more generalized approach to representing observed annual peak-flow information by using an interval range as compared to the conventional method of using point data (Cohn and others, 1997), and a generalized Grubbs-Becks test, which allows for the detection of multiple potentially influential low outliers (Cohn and others, 2013).

The regional-regression analysis resulted in predictive equations that can be used to estimate the 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent annual exceedance probability (AEP) flows at urban and small, rural ungaged locations in the Southeast. Explanatory variables included in the equations are as follows: HR1, drainage area (DA) and percentage of impervious area (IA); HR3, DA and percentage of developed land; and HR4, DA, IA, and the 24-hour, 50-year maximum precipitation. Incorporation of urban streamgages from the inner Coastal Plain of New Jersey allowed for an increase in DA size from 3.5 to 53.5 mi^2 for which the predictive equations for the Southeast Coastal Plain are applicable (fig. 2). Average standard error of prediction for the predictive equations, which is a measure of the average accuracy of the regression equations when predicting flood estimates for ungaged sites, ranged from 25 percent for the 10-percent AEP regression equation for the Piedmont–Ridge and Valley region to 73 percent for the 0.2-percent AEP regression equation for the Sand Hills region.

References

Cohn, T.A., England, J.F., Berenbrock, C.E., Mason, R.R., Stedinger, J.R., and Lamontagne, J.R., 2013, A generalized Grubbs-Beck test statistic for detecting multiple potentially-influential low outliers in flood series: Water Resources Research, v. 49, no. 8, p. 5047–5058, doi: 10.1002/wrcr.20392.

Cohn, T.A., Lane, W.L., and Baier, W.G., 1997, An algorithm for computing moments-based flood quantile estimates when historical flood information is available: Water Resources Research, v. 33, no. 9, p. 2089–2096.

Feaster, T.D., Gotvald, A.J., and Weaver, J.C., 2014, Methods for estimating the magnitude and frequency of floods for urban and small, rural streams in Georgia, South Carolina, and North Carolina, 2011 (ver 1.1, March 2014): U.S. Geological Survey Scientific Investigations Report 2014–5030, 104 p.

Feaster, T.D., Gotvald, A.J., and Weaver, J.C., 2009, Magnitude and frequency of rural floods in the Southeastern United States, 2006—Volume 3, South Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5156, 226 p.

Fenneman, N.M., and Johnson, D.W., 1946, Physical divisions of the United States: U.S. Geological Survey map, scale 1:7,000,000.

Gotvald, A.J., Feaster, T.D., and Weaver, J.C., 2009, Magnitude and frequency of rural floods in the Southeastern United States, 2006—Volume 1, Georgia: U.S. Geological Survey Scientific Investigations Report 2009–5043, 120 p.

Gotvald, A.J., and Knaak, A.E., 2011, Magnitude and frequency of floods for urban and small rural streams in Georgia: U.S. Geological Survey Scientific Investigations Report 2011–5042, 39 p.

Interagency Advisory Committee on Water Data, 1982, Guidelines for determining flood flow frequency: Hydrology Subcommittee Bulletin 17B, 28 p., 14 app., 1 pl.

Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the Southeastern United States, 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p.

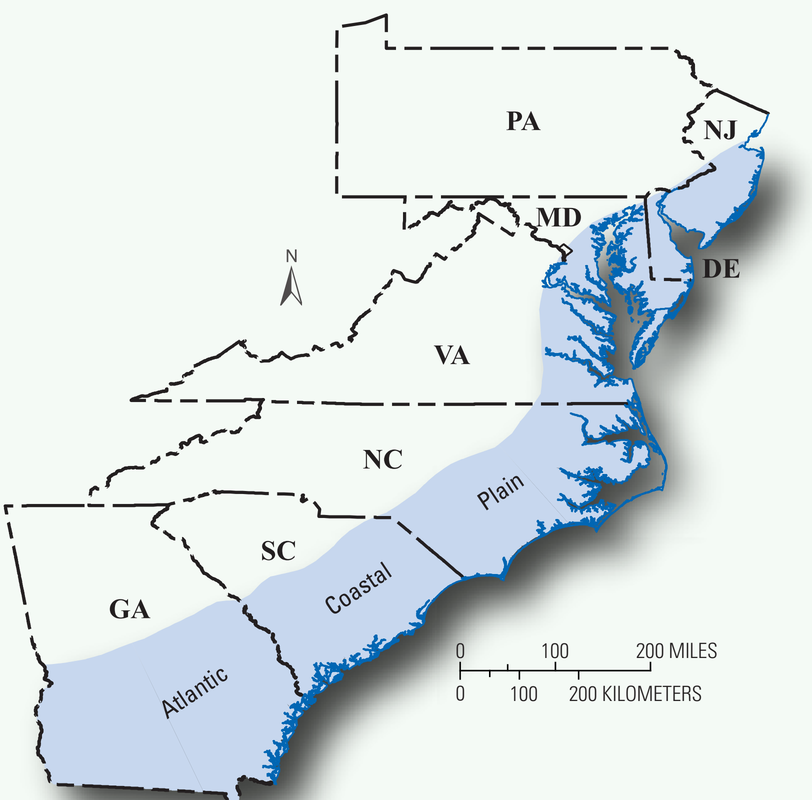

Figure 2. The Atlantic Coastal Plain from Georgia to New Jersey.

By Toby D. Feaster (tfeaster@usgs.gov)
Anthony J. Gotvald (gotvald@usgs.gov)
J. Curtis Weaver (jcweaver@usgs.gov)

The information in this Fact Sheet is based on USGS Scientific Investigations Report 2014–5030, available at *http://pubs.usgs.gov/sir/2014/5030/.*

For additional information, please contact:
Director
U.S. Geological Survey
South Carolina Water Science Center
Stephenson Center, Suite 129
720 Gracern Road
Columbia, SC 29210-7651
(803) 750-6100
http://sc.water.usgs.gov

ISSN 2327-6932 (online)
http://dx.doi.org/10.3133/fs20143015