Summary of Floods in the United States During 1990 and 1991

United States Geological Survey Water-Supply Paper 2474

AVAILABILITY OF BOOKS AND MAPS OF THE U.S. GEOLOGICAL SURVEY

Instructions on ordering publications of the U.S. Geological Survey, along with prices of the last offerings, are given in the current-year issues of the monthly catalog "New Publications of the U.S. Geological Survey." Prices of available U.S. Geological Survey publications released prior to the current year are listed in the most recent annual "Price and Availability List." Publications that may be listed in various U.S. Geological Survey catalogs (**see back inside cover**) but not listed in the most recent annual "Price and Availability List" may be no longer available.

Order U.S. Geological Survey publications **by mail** or **over the counter** from the offices given below.

BY MAIL

Books

Professional Papers, Bulletins, Water-Supply Papers, Techniques of Water-Resources Investigations, Circulars, publications of general interest (such as leaflets, pamphlets, booklets), single copies of Preliminary Determination of Epicenters, and some miscellaneous reports, including some of the foregoing series that have gone out of print at the Superintendent of Documents, are obtainable by mail from

U.S. Geological Survey, Information Services
Box 25286, Federal Center, Denver, CO 80225

Subscriptions to Preliminary Determination of Epicenters can be obtained ONLY from the

Superintendent of Documents
Government Printing Office
Washington, DC 20402

(Check or money order must be payable to Superintendent of Documents.)

Maps

For maps, address mail orders to

U.S. Geological Survey, Information Services
Box 25286, Federal Center, Denver, CO 80225

OVER THE COUNTER

Books and Maps

Books and maps of the U.S. Geological Survey are available over the counter at the following U.S. Geological Survey Earth Science Information Centers (ESIC's), all of which are authorized agents of the Superintendent of Documents:

- **ANCHORAGE, Alaska**—Rm. 101, 4230 University Dr.
- **LAKEWOOD, Colorado**—Federal Center, Bldg. 810
- **MENLO PARK, California**—Bldg. 3, Rm. 3128, 345 Middlefield Rd.
- **RESTON, Virginia**—USGS National Center, Rm. 1C402, 12201 Sunrise Valley Dr.
- **SALT LAKE CITY, Utah**—Federal Bldg., Rm. 8105, 125 South State St.
- **SPOKANE, Washington**—U.S. Post Office Bldg., Rm. 135, West 904 Riverside Ave.
- **WASHINGTON, D.C.**—Main Interior Bldg., Rm. 2650, 18th and C Sts., NW.

Maps Only

Maps may be purchased over the counter at the following U.S. Geological Survey office:

- **ROLLA, Missouri**—1400 Independence Rd.

Summary of Floods in the United States During 1990 and 1991

Edited by P.R. JORDAN and L.J. COMBS

U.S. GEOLOGICAL SURVEY WATER-SUPPLY PAPER 2474

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, Director

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1996

For sale by the
U.S. Geological Survey
Branch of Information Services
Box 25286
Federal Center
Denver, CO 80225–0286

Library of Congress Cataloging in Publication Data

Summary of floods in the United States during 1990 and 1991 / edited by P.R. Jordan and L.J. Combs.
257 p. cm.— (U.S. Geological Survey water-supply paper ; 2474).
Includes bibliographical references (various pages).
Supt. of Docs. no.: I 19.13:W2474
1.Floods—United States. I. Jordan, Paul Robert, 1993–
II. Combs, L.J. III. Series
GB1399/3/S86 1996
551.48'9'0973—dc20

96–27535
CIP
ISBN 0–607–86217–3

CONTENTS

FIGURES

FIGURES—Continued

FIGURES—Continued

TABLES

TABLES—Continued

TABLES—Continued

CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
acre	4,047	square meter
acre-foot	1,233	cubic meter
cubic foot per second	0.02832	cubic meter per second
cubic yard	0.7646	cubic meter
foot	0.3048	meter
foot per mile	0.1894	meter per kilometer
foot per second	0.3048	meter per second
inch	25.4	millimeter
mile	1.609	kilometer
square mile	2.590	square kilometer
ton (short)	0.9072	megagram
ton per acre	0.0002241	megagram per square meter

Temperature can be converted to degrees Celsius (°C) or degrees Fahrenheit (°F) by the equations:

$$°C = 5/9\ (°F - 32)$$

$$°F = 9/5\ (°C) + 32.$$

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

GLOSSARY

Although much of the terminology used in this report is widely understood, some terms have specialized meanings in hydrology or are unfamiliar outside of hydrologic usage. The definitions given here are from Langbein and Iseri (1960), with slight modifications, and explain the terms as they are generally used by hydrologists in the U.S. Geological Survey.

Absorption The entrance of water into the soil or rocks by all natural processes. It includes the infiltration of precipitation or snowmelt.

Bank The margins of a channel. Banks are called right or left as viewed facing the direction of the flow.

Cubic feet per second A unit expressing rates of **discharge**. One cubic foot per second is equal to the **discharge** of a stream of rectangular cross section, 1 foot wide and 1 foot deep, flowing water an average velocity of 1 foot per second.

Current meter An instrument for measuring the speed of flowing water. The U.S. Geological Survey uses a rotating cup meter.

Discharge In its simplest concept, discharge means outflow; therefore, the use of this term is not restricted as to course or location, and it can be applied to describe the flow of water from a pipe or from a **drainage basin**. If the discharge occurs in some course or channel, it is correct to speak of the discharge of a canal or of a river.

Drainage area The drainage area of a stream at a specified location is that area, measured in a horizontal plane, that is enclosed by a drainage divide.

Drainage basin A part of the surface of the Earth that is occupied by a drainage system, which consists of a surface stream or a body of impounded **surface water** together with all tributary surface streams and bodies of impounded **surface water**.

Flood An overflow or inundation that comes from a river or other body of water (Barrows, 1948, p. 4) and causes or threatens damage. Any relatively high **streamflow** overtopping the natural or artificial banks in any reach of a stream (Leopold and Maddock, 1954, p. 249–251).

Flood plain The lowland that borders a river, usually dry but subject to flooding (Hoyt and Langbein, 1955, p. 12).

Flood stage The stage at which overflow of the natural banks of a stream begins to cause damage in the reach in which the elevation is measured (U.S. Weather Bureau).

Isohyetal map A map or chart showing lines that join points that received the same amount of precipitation.

Overland flow The flow of rainwater or snowmelt over the land surface toward stream channels.

Regulation The artificial manipulation of the flow of a stream.

Reservoir A pond, lake, or basin, either natural or artificial, for the storage, regulation, and control of water.

Runoff That part of the precipitation that appears in surface streams.

Stage The height of a water surface above an established datum plane (also gage height).

Stage/discharge curve A graph showing the relation between the gage height, usually plotted as ordinate, and the amount of water flowing (**discharge**) in a channel, expressed as volume per unit of time, usually plotted as abscissa.

Stage/discharge relation The relation expressed by the **stage/discharge curve**.

Streamflow The **discharge** that occurs in a natural channel. Although the term **discharge** can be applied to the flow of a canal, the word "streamflow" uniquely describes the **discharge** in a surface stream course. The term "streamflow" is more general than **runoff**, as streamflow may be applied to **discharge** whether or not it is affected by diversion or regulation.

Streamflow-gaging station A gaging station where a record of **discharge** of a stream is obtained.

Surface runoff That part of the **runoff** that travels over the soil surface to the nearest stream channel. It also is defined as that part of the **runoff** of a **drainage basin** that has not passed beneath the surface following precipitation.

Surface water Water on the surface of the Earth.

Water equivalent of snow The amount of water that would be obtained if the snow should be completely melted. Water content may be merely the amount of liquid water in the snow at the time of observation (Wilson, 1942, p. 153–154).

Summary of Floods in the United States During 1990 and 1991

Edited by P.R. Jordan *and* L.J. Combs

Abstract

This volume contains 50 articles describing severe, widespread, or unusual flooding in 28 of the 50 States during 1990 and 1991. Each flood is described to an extent commensurate with its significance and the availability of data on the hydrology and the damages. Each article includes one or more maps showing the general area of flooding and the sites for which data are presented. Most articles include tables of data that allow the reader to compare the described flood with past floods at selected flood-determination sites. The articles generally do not attempt to analyze floods or draw significant conclusions, except for a few cases in which the author had sufficient information for an analysis to be made.

Flooding was widespread in Oregon and Washington during January 1990 and also in Alabama, Georgia, and Florida during February and March 1990. Separate reports have been published for both areas of flooding.

Mississippi experienced severe flooding during January, February, March, May, and December 1990 and during February, April, May, and December 1991. Those floods resulted in loss of eight lives and hundreds of million dollars in damage.

The most widespread and destructive flooding of 1990–91 occurred in Oklahoma, Texas, Arkansas, and Louisiana during April and May 1990. Despite the reduction of maximum discharges at many sites by flood-control reservoirs, losses in the four-State region aggregated to 17 deaths and $1.3 billion.

Indiana, Iowa, Nebraska, and Ohio each experienced multiple floods during 1990, and Indiana and Nebraska also suffered flooding during 1991. Georgia experienced multiple floods during 1990 and 1991. Several other floods, from Hawaii to Maine, are reported in this volume. Flooding in the United States was more frequent and widespread during 1990 than during 1991.

INTRODUCTION

This report summarizes information on 50 floods in 28 of the 50 States during 1990 and 1991. The floods reported were unusual hydrologic events during which large areas were affected, great damage resulted, or record-high stages or discharges occurred and for which sufficient data were available for the preparation of an informative article. The States in which the floods described in this volume occurred are shown in figure 1. Also shown is the year of occurrence.

Many of the articles in this volume give the amount of rainfall and the duration of the storm associated with the flooding. Recurrence intervals of these storms may be determined from a rainfall-frequency atlas of the United States (Hershfield, 1961) or from a simplified set of equal-rainfall maps and charts contained in a report by Rostvedt (1965).

Flood damages frequently are difficult to assess. Dollar amounts given in this report should be used as a general indication of flood losses rather than as definite values. Even if detailed surveys and estimates have been made, there is little consistency among methods used and types of losses included. Some estimates may exclude certain locations (such as mountanous areas) or type of loss (either insured or

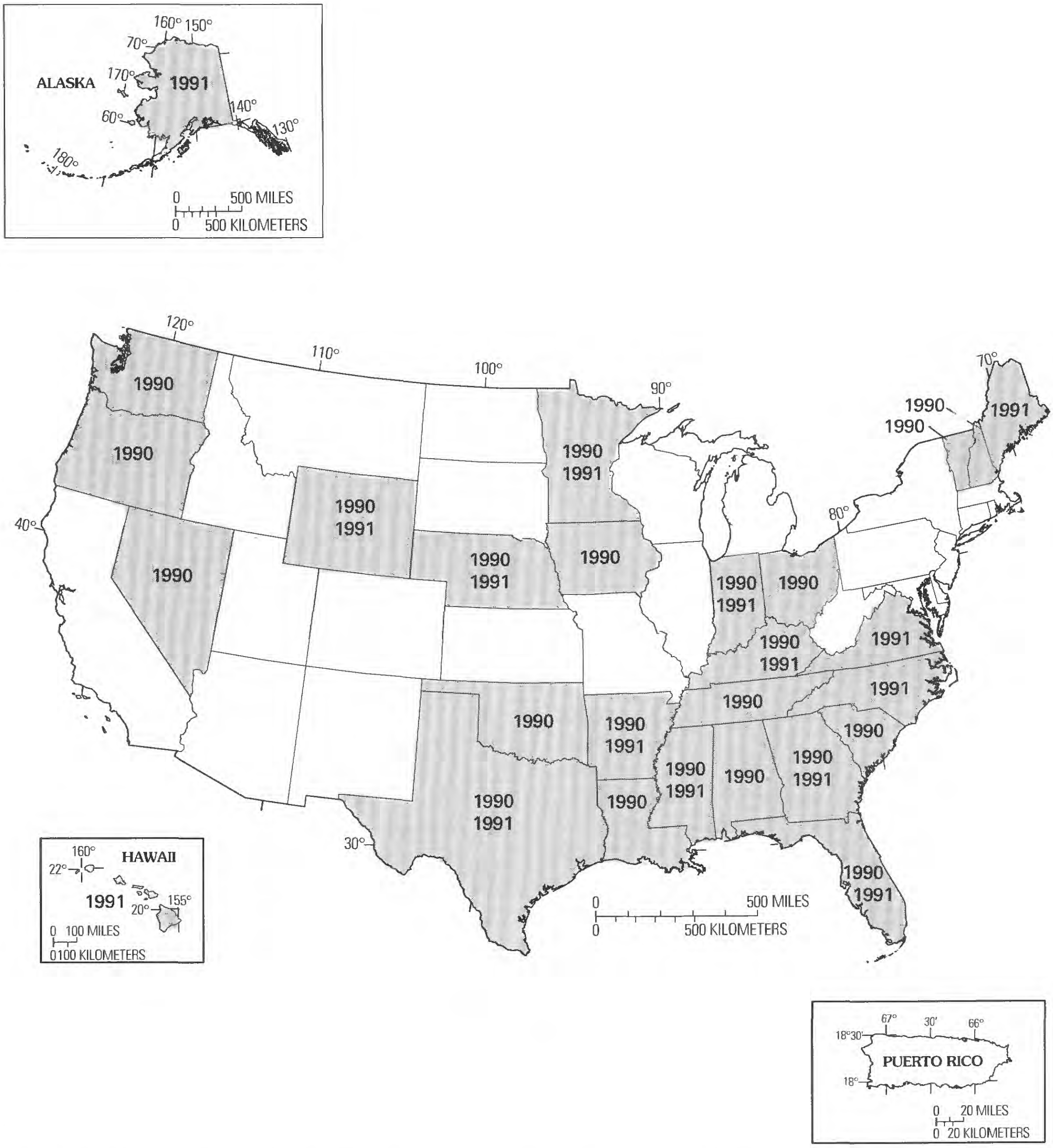


Figure 1. States and years in which floods reported in this volume occurred in the conterminous United States, Alaska, and Hawaii during 1990 and 1991.

uninsured) or type of property (either private or public). Some estimates include traffic-interruption and (or) flood-mitigation costs; others include strictly physical damage. Estimates may be based on replacement costs or on depreciated values. For floods not described in detailed published reports, the only damage estimates available usually are the preliminary figures contained in newspapers, climatological data from the National Oceanic and Atmospheric Administration (NOAA), or other sources published shortly after the flood.

Continuing investigation of surface-water resources in the flooded areas reported by this volume is performed by the U.S. Geological Survey (USGS) in cooperation with State agencies, the U.S. Army Corps of Engineers (USACE), the Bureau of

Reclamation (USBR), and other Federal or local agencies. NOAA, in addition to collecting and compiling data on meteorological phenomena, also collects data on stream stages in some areas. The data presented herein were collected, computations were made, and most of the text was written by USGS personnel located in offices in or near the flooded areas.

Previous Reports

During the 1950's and 1960's, the USGS summarized floods of each year in an annual series of Water-Supply Papers entitled, "Summary of Floods In the United States." A summary was published for each calendar year from 1950 through 1969. Water-Supply Paper 1137–I, the first in the series (U.S. Geological Survey, 1954), states the purpose of the series as being:

> To assemble in a single volume information relating to all known severe floods in the United States whether local or of wide areal extent. For floods that are described in ... other publications of the Geological Survey or in reports by other Federal and State agencies, only very brief mention including references to the reports containing detailed descriptions, will be given here. Local floods for which no individual reports have been prepared are described briefly.

In the first volume of that Water-Supply Paper series, each flood was described in a maximum of three or four paragraphs. Later volumes contained longer articles including maps.

The series was discontinued after the 1969 volume; however, in 1987 a program was begun to prepare and publish summaries for 1970 and succeeding years. Much of the following explanation is paraphrased from Byron N. Aldridge (U.S. Geological Survey, written commun., 1993) and from the published report for 1968 (Rostvedt, 1972).

Determination of Flood Discharges

The maximum elevation of the floodwater surface (stage) at a certain location along the stream often is used as a reference for comparison with other floods. However, stage is affected by changes in the shape and slope of the stream channel, which usually occur over time.

The usual method of determining stream discharges at a streamflow-gaging station is the application of a stage-discharge relation to a known stage. This relation usually is defined by current-meter measurements made through as wide a range of stage as possible (fig. 2). If the maximum discharge exceeds the range of the current-meter measurements, short extensions may be made to a graph of the stage-discharge relation by logarithmic extrapolation, by velocity-area studies, or by the use of other measurable hydraulic factors (Kennedy, 1983).

Maximum discharges that are greatly above the range of the defined stage/discharge relation at gaging stations and maximum discharges at miscellaneous sites that have no developed stage/discharge relation generally are determined by various types of indirect measurements. In addition, adverse conditions often make it impossible to obtain current-meter measurements at some sites during major floods. Maximum discharges at these sites are determined, after the floods have subsided, by indirect methods, which involve determining water-surface elevations from high-water marks, surveying cross sections, and computing discharge from hydraulic equations. Indirect methods are described by Dalrymple and Benson (1967), Hulsing (1967), Matthai (1967), Bodhaine (1968), and Benson and Dalrymple (1987).

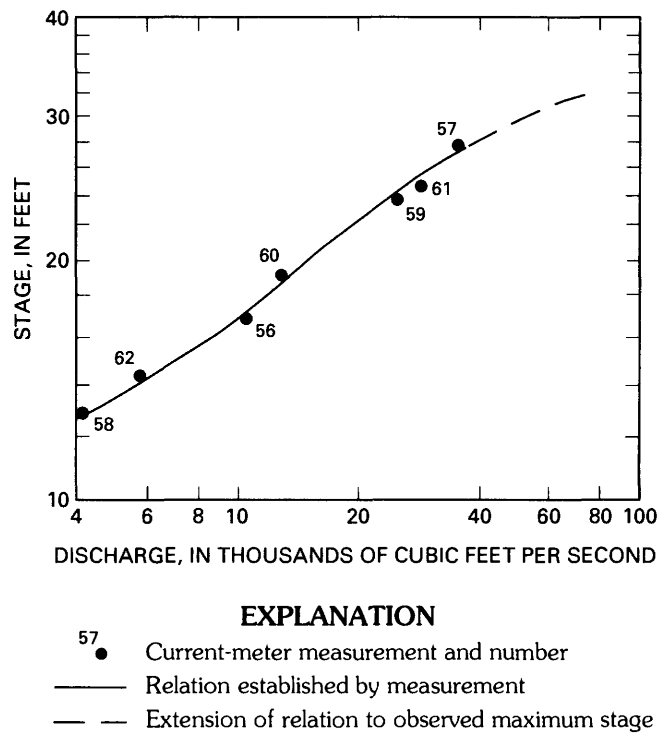


Figure 2. Example of a stage-discharge relation and upward extension.

The accuracy of indirect measurements depends on site conditions and the experience of personnel who select sites and make the surveys, and generally is poorer than for current-meter measurements. The indirect measurements used in determining maximum discharges for floods are not identified as such in this volume. Information as to the source and quality of discharge data in this volume can be obtained from the USGS office in the State in which the reported flood-determination site is located.

Explanation of Data

Floods are described in this volume in chronological order. Because the type and the amount of information differ for the floods, the form of reporting is not completely consistent for all the events.

The data provided for each flood include, if available and applicable: (1) descriptions of the storm, the flood, and the flood damage; (2) a map of the flood area showing flood-determination sites and, for some storms, precipitation data sites or lines of equal precipitation; (3) rainfall amounts and intensities; and (4) maximum stages and discharges for the streams affected. Stage and discharge data may be available for more sites than are included in this report. Such data are contained in USGS Water-Resources Data Reports for the respective States.

When ample rainfall data are available, they may be presented in tabular form and show daily or storm totals. When sufficient data are available to determine the pattern and distribution of rainfall, a map showing the distribution may be included.

A summary table of maximum stages and discharges is given for each flood, except where the number of flood-determination sites in the article is small and for which the information is included in the text description. In the table (an example is shown in table 1), the first three columns identify the site, which may be a continuous-record streamflow-gaging station, a partial-record station, or another site at which data have been obtained. The number in column 1 identifies the site on the map that appears in the article. The second column gives the USGS station number (downstream-order number) if such a number has been assigned. The third column gives the name of the gaging station or flood-determination site.

Drainage area in the summary table is the area, as measured on a flat projection map, that would contribute surface runoff to the indicated site on the stream. The given drainage area may be smaller than the total drainage area if the total area includes areas of extremely rapid infiltration rates that do not produce surface runoff, or closed subbasins that retain all their inflow.

The column headed "Period" shows the calendar years prior to the described flood for which the stage or discharge shown in the seventh and eighth columns are known to be a maximum. For most sites, this period corresponds to the period of systematic collection of streamflow data. For other sites, written or oral history may indicate that a flood stage was the highest since people have observed the stream or was the highest since some known date. For some sites, two or more periods are given. The use of two periods separated by a comma indicates a break in the period of record. Maximum stages or discharges during the intervening period are unknown. Two overlapping periods may be shown when the stage is the maximum for one period and the discharge is the maximum for a shorter period. This is the case when the stage for a large flood that occurred prior to the beginning of systematic data collection is known but the discharge is not.

The sixth column shows the calendar year in which the maximum stage and discharge for the indicated period occurred. The seventh and eighth columns show the stage and discharge of that maximum. Separate listings are made when maximum stage and maximum discharge did not occur concurrently. An effort was made to use stages that were measured relative to the datum in use at the time of the flood being described or to indicate by a footnote that a different datum was used.

The last four columns present data for the maximums during the described flood or floods. The data include the date on which the maximum occurred, maximum stage, maximum discharge, and, where available, the recurrence interval of the discharge.

The probability of a given discharge being equaled or exceeded in any given year frequently is used as an indication of a flood's relative magnitude and for comparison with floods at other sites. The relative magnitude also can be expressed in terms of recurrence interval, which is the reciprocal of the flood probability. A third way of expressing the relative flood magnitude is the percent chance of occurrence, which is 100 times the flood probability. A discharge that will be equaled or exceeded on an average (over a long period of time) of once in 10 years has a recurrence

Table 1. Example of summary table showing maximum stages and discharges

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined or not applicable; >, greater than; <, less than. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to [month] 1990				Maximum during [month] 1990			
Site no. (fig. __)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
1	88000002	Hypothetical Creek near Town	21	1971–90	1987	11.1	--	10	12.22	4,200	25
2	88000004	Hypothetical River at City	1,212	1939, 1955–90	1939	12.12	28,200	12	21.21	82,800	>100
3	99000001	Hypo River near Metropolis	3,333	1919–90	1943	33.33 --	-- 99,900	13	25.55	33,000	<2
4	--	Hypothetical Ditch at Village	--	--	--	--	--	10	--	3,800	--

interval of 10 years, is termed a "10-year flood," has a probability of 0.10, and has a 10-percent chance of occurring in any given year. A 100-year flood has a recurrence interval of 100 years, a probability of 0.01, and a 1-percent chance of occurrence in any given year. Because recurrence interval is most commonly used by Federal agencies (for example, in the context of flood insurance), it is used in this volume even though the use of percent chance would avoid the unintended connotations of regularity of occurrence that may accompany the term "recurrence interval."

Equivalence of flood probability and percent-chance values to selected recurrence-interval values are as follows:

Probability	Percent chance in given year	Recurrence interval (years)
0.50	50	2
.20	20	5
.10	10	10
.04	4	25
.02	2	50
.01	1	100

Recurrence intervals during any given flood may differ from site to site because of nonuniform distribution of runoff and uncertainty in the computed recurrence values. Operational patterns for reservoirs generally are not defined adequately to permit recurrence intervals to be computed for maximum discharges on regulated streams.

In addition to probability or percent chance of a given magnitude of discharge occurring in any 1 year, it is useful to know the probability or percent chance of occurrence during a given period of consecutive years. Results of such calculations for selected combinations of recurrence interval and length of period are as follows:

[* means greater than 99.9 but less than a 100-percent chance]

Recurrence interval (years)	Percent chance for indicated time period, in years				
	5	10	50	100	500
2	97	99.9	*	*	*
10	41	65	99.5	*	*
50	10	18	64	87	*
100	5	10	39	63	99.3

In addition to comparison of the magnitude of a flood at one site with earlier floods at the same site and comparison of a flood discharge at one site with those at other sites by comparison of recurrence intervals, it is possible to compare the magnitude of a flood with maximum known discharges in a large region. This type of comparison may be particularly useful for discharges whose recurrence intervals have not been determined or are so large that their recurrence intervals are shown in this volume as ">100" (greater than 100 years). Comparisons to maximum known discharges in a large region can be made by using the report by Crippen and Bue (1977), which contains graphs showing flood-envelope curves for the conterminous United States divided into 17 regions. A flood-envelope curve is drawn on a graph in which maximum known discharge is plotted against drainage area for stream sites having extremely large discharges; the graph and curve for one region are shown in figure 3. The envelope curve is a smooth curve drawn to exceed all the plotted discharges in relation to the drainage areas.

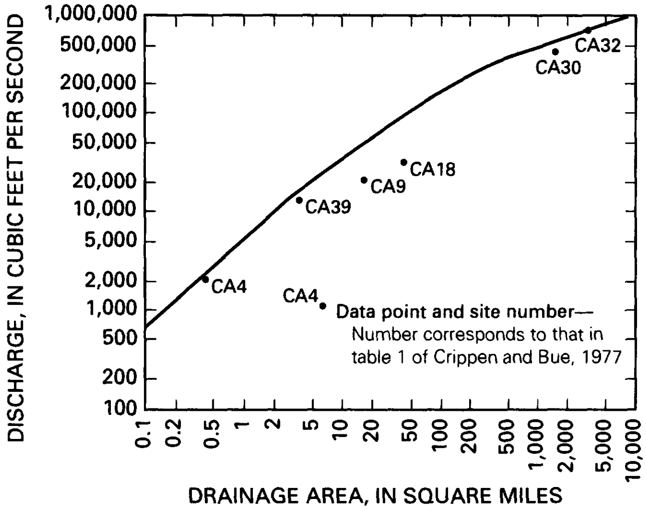


Figure 3. Maximum discharge versus drainage area and envelope curve for a region (modified from Crippen and Bue, 1977, p. 15).

REFERENCES

Barrows, H.K., 1948, Floods, their hydrology and control: New York, McGraw-Hill Book Co., 432 p.

Benson, M.A., and Dalrymple, Tate, 1967, General field and office procedures for indirect measurements: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A1, 29 p.

Bodhaine, G.L., 1968, Measurement of peak discharge at culverts by indirect methods: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A3, 60 p.

Crippen, J.R., and Bue, C.D., 1977, Maximum flood flows in the conterminous United States: U.S. Geological Survey Water-Supply Paper 1887, 52 p.

Dalrymple, Tate, and Benson, M.A., 1967, Measurement of peak discharge by slope-area methods: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A2, 12 p.

Hershfield, D.M., 1961, Rainfall frequency atlas of the United States: U.S. Department of Commerce, Weather Bureau, Technical Paper no. 40, 115 p.

Hoyt, W.G., and Langbein, W.B., 1955, Floods: Princeton, N.J., Princeton University Press, 469 p.

Hulsing, Harry, 1967, Measurement of peak discharge at dams by indirect methods: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A5, 29 p.

Kennedy, E.J., 1983, Computation of continuous records of streamflow: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A13, 53 p.

Langbein, W.B., and Iseri, K.T., 1960, General introduction and hydrologic definitions, *in* Manual of hydrology, part 1, General surface-water techniques: U.S. Geological Survey Water-Supply Paper 1541-A, 29 p.

Leopold, L.B., and Maddock, Thomas, Jr., 1954, The flood control controversy: New York, Ronald Press Co., 278 p.

Matthai, H.F., 1967, Measurement of peak discharge at width contractions by indirect methods: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A4, 44 p.

National Oceanic and Atmospheric Administration, 1990a, Climatological data (by States): Asheville, N.C., National Climatic Data Center (various months).

______1990b, Hourly precipitation data (by States): Asheville, N.C., National Climatic Data Center (various months).

______1990c, Storm data and unusual weather phenomena: Asheville, N.C., National Climatic Data Center, v. 32, nos. 1–12, (various pages).

______1991a, Climatological data (by States): Asheville, N.C., National Climatic Data Center (various months).

______1991b, Hourly precipitation data (by States): Asheville, N.C., National Climatic Data Center (various months).

______1991c, Storm data and unusual weather phenomena: Asheville, N.C., National Climatic Data Center, v. 33, no. 1–12 (various pages).

Rostvedt, J.O., 1965, Summary of floods in the United States during 1960: U.S. Geological Survey Water-Supply Paper 1790–B, 147 p.

______1972, Summary of floods in the United States during 1968: U.S. Geological Survey Water-Supply Paper 1970–B, 73 p.

U.S. Army Corps of Engineers, 1992, Annual flood damage report to Congress for fiscal year 1991: Washington, D.C., U.S. Army Corps of Engineers, Engineering Division, 26 p.

U.S. Geological Survey, 1954, Summary of floods in the United States during 1950: U.S. Geological Survey Water-Supply Paper 1137–I, p. 957–991.

Wilson, W.T., 1942, Melting characteristics of snow and its contribution to runoff, *in* June 30-July 2, 1941, Hydrology Conference Proceedings: University Park, Pennsylvania State College, School of Engineering Technical Bulletin 27, p. 153–165.

SUMMARY OF FLOODS OF 1990–91

Floods of January 9–11, 1990, in Northwestern Oregon and Southwestern Washington

By Larry L. Hubbard[1]

STORM SYSTEM

A major and complex storm system moved through northwestern Oregon and southwestern Washington during January 3–10, 1990. This storm system included high winds and excessive precipitation and was accompanied by high tides along the Oregon coast. The main storm passed over the extreme northwestern corner of Oregon and traveled in a northeasterly direction, passing over the south end of Puget Sound before decreasing in intensity near the summit of the Cascade Range. Large amounts of rain late in the storm period produced unusually large floods on January 9–11.

Precipitation in Oregon was most intense in the Nehalem and Wilson River Basins in Clatsop and Tillamook Counties (fig. 4). Eight-day precipitation totals for selected precipitation data sites are shown in table 2. The National Oceanic and Atmospheric Administration precipitation data site at Nehalem (site 3, fig. 4) recorded a total of 16.6 inches of rain during January 3–10 (table 2). This 8-day total precipitation is more than 15 percent of the mean annual precipitation at the site. The most rainfall recorded anywhere in the two States during the 8-day period was 18.4 inches at Lees Camp, Oregon (site 2, fig. 4) (National Oceanic and Atmospheric Administration, 1990c), where more than 5 inches of precipitation was recorded on January 9.

The daily precipitation record for Grays River Hatchery, Washington (fig. 5) illustrates the surging precipitation pattern of the storm system during the 8-day period. The greatest precipitation in the State of Washington during the storms occurred near the headwaters of the Skookumchuck, Deschutes, and Nisqually Rivers in Lewis County (U.S. Federal Emergency Management Agency Region X, 1990a).

FLOODS

Severe flooding occurred from Tillamook on the northern Oregon coast to eastern drainages of Puget Sound in western Washington. The excessive precipitation that occurred during the continuing rains of January 3–10 resulted in more than one maximum discharge on many of the rivers in the storm's path (fig. 6). The rivers did not return to base flow between storms. The early precipitation saturated the soils and added greatly to the runoff potential when the excessive rains arrived on January 9. The severity of flooding along the north Oregon coast was increased because the floodwaters of coastal rivers were backed up by high Pacific Ocean tides.

The major flooding in Oregon occurred in the Wilson River and Nehalem River Basins. The Wilson River maximum discharge (site 23, table 3) had only a 25-year recurrence interval, but the flooding of the Wilson River at the town of Tillamook was unusual because high tides created backwater and caused even higher stages than would have been experienced from the discharge alone. The Nehalem River maximum discharge (site 22, table 3) had a 100-year recurrence interval and exceeded the discharges of any previous known floods on the river (table 3).

The most severe flooding in Washington occurred in the Chehalis, Deschutes, Nisqually, and Puyallup River Basins. Maximum discharges at three flood-determination sites on the Chehalis River were estimated at the 100-year recurrence interval. The flood-determination site on the Deschutes River near Rainier, Washington (site 8, fig. 4) also recorded a 100-year recurrence interval. Maximum discharges of record were measured at Willapa River near Willapa (site 2), Chehalis River near Doty (site 3), Chehalis River near Grand Mound (site 6), Chehalis River at Porter (site 7), Deschutes River near Rainier (site 8), Mineral Creek near Mineral (site 10), South Prairie Creek at South Prairie (site 13), and Big Soos Creek above hatchery near Auburn (site 17).

DAMAGES

Floodwaters affected hundreds of homes, businesses, and farms in both States. Many public facilities, such as sewage and electrical facilities, sustained damage. "A hospital in Centralia [Wash.] was completely isolated as all the roads leading to it were inundated with water" (Federal Emergency Management

---

[1]This article is based on a previously published report (Hubbard, 1991).

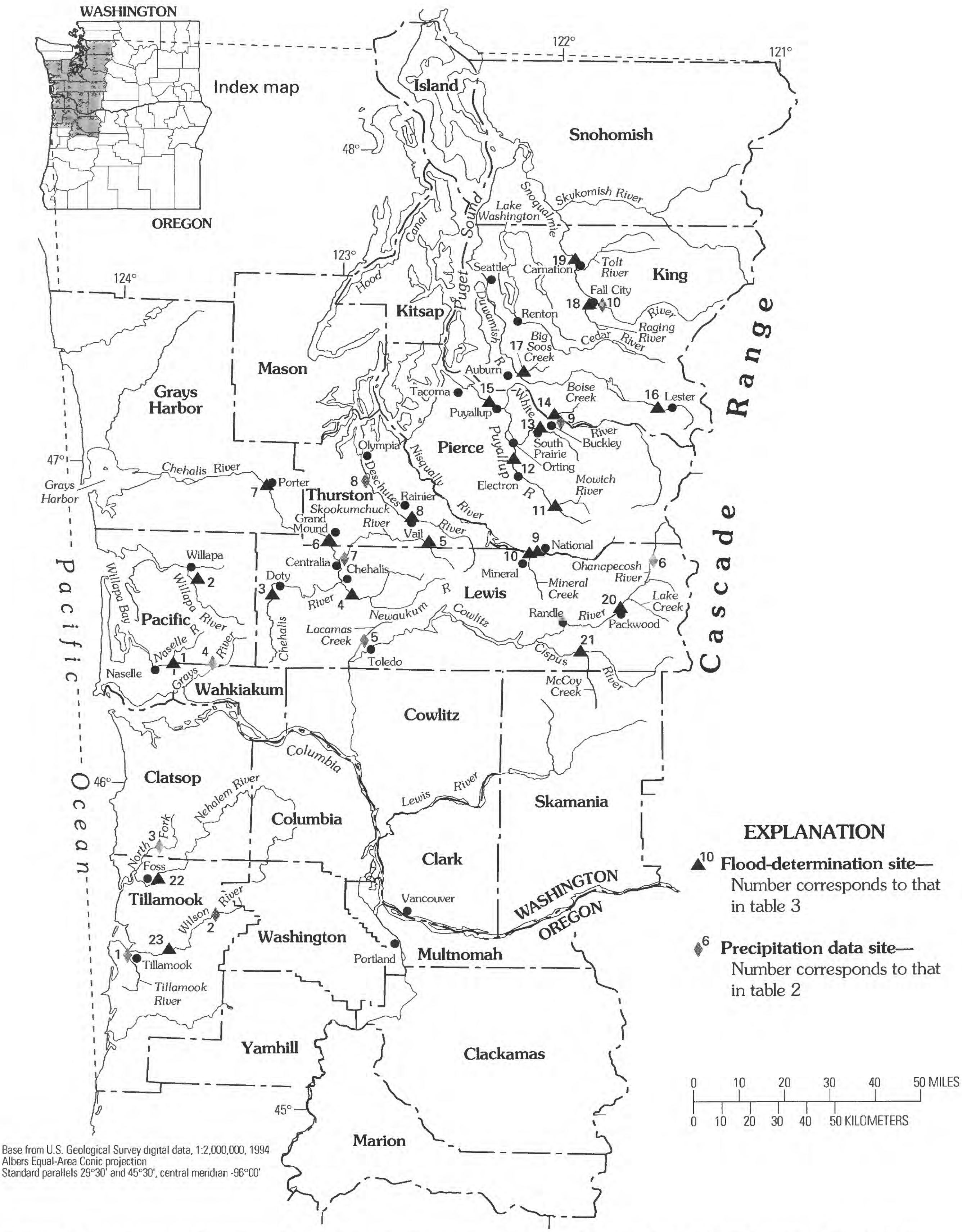


Figure 4. Flood area and location of flood-determination and precipitation data sites for floods of January 9–11, 1990, in northwestern Oregon and southwestern Washington.

Table 2. Precipitation totals for January 3–10, 1990, at selected precipitation data sites in northwestern Oregon and southwestern Washington

[Data from National Oceanic and Atmospheric Administration, 1990a,b]

Site no. (fig. 4)	Precipitation data site	Precipitation (inches)
1	Tillamook 1 W	10.3
2	Lees Camp	18.4
3	Nehalem 9 NE	16.6
4	Grays River Hatchery	14.3
5	Toledo	7.1
6	Rainier Ohanapecosh	12.4
7	Centralia	8.0
8	Olympia WSO AP	8.6
9	Buckley 1 NE	6.9
10	Snoqualmie Falls	9.7

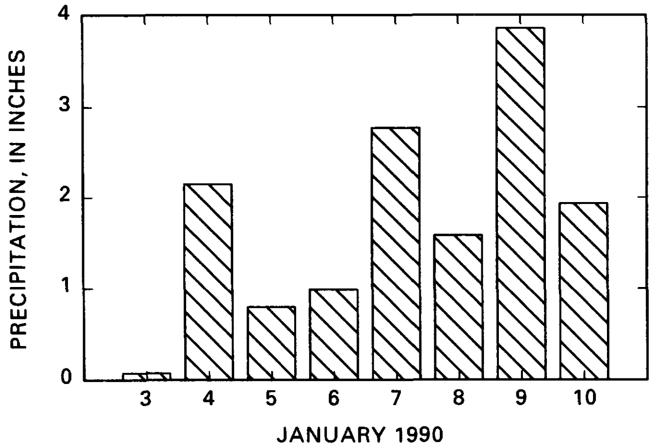


Figure 5. Daily precipitation at Grays River Hatchery, Washington (site 4, fig. 4), January 3–10, 1990 (data from National Oceanic and Atmospheric Administration, 1990b).

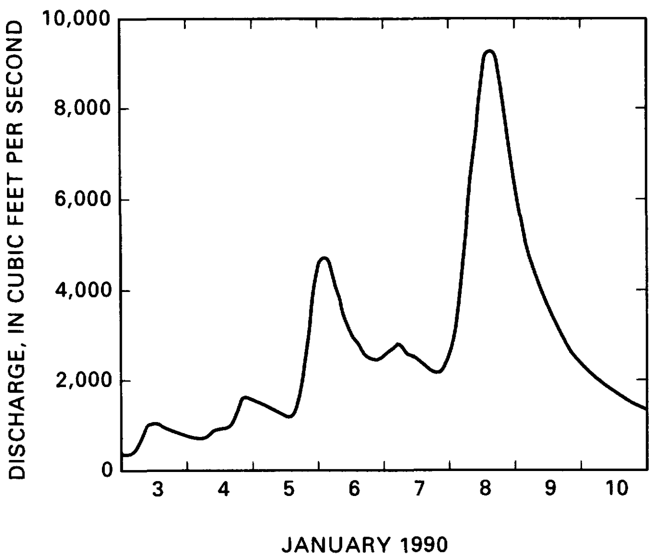


Figure 6. Instantaneous discharge of Naselle River near Naselle, Washington (site 1, fig. 4), January 3–10, 1990.

Agency Region X, 1990a). Damage to roads and railroads was extensive in both States. Interstate Highway 5 (I–5), the principal north-south highway in western Oregon and Washington, was closed for several days between Chehalis and Centralia, Washington, due to flooding. The highway was inundated with about 5 feet of water in that area. Four persons in the State of Washington lost their lives in the floods.

As a result of the flood damage, a disaster declaration was issued by the President of the United States for two counties in Oregon and six counties in Washington. The two counties in Oregon were Clatsop and Tillamook; the six counties in Washington were Grays Harbor, King, Lewis, Pierce, Thurston, and Wahkiakum. Damage figures recorded for those counties are shown in table 4. The values shown in table 4 were obtained from the Federal Emergency Management Agency Region X (1990a,b) and from Lora Murphy (Washington State Department of Emergency Management, written commun., 1990). Only those damages exceeding $50,000 are shown in the table, although there were many other damages of lesser amounts reported from other towns and utilities. Total flood damage for both States exceeded $19 million.

REFERENCES

Federal Emergency Management Agency Region X, 1990a, Hazard mitigation opportunities in the State of Washington: Report of the Interagency Hazard Mitigation Team, FEMA–852–DR–WA, 47 p.

______1990b, Interagency flood hazard mitigation report, 1990, In response to the January 18, 1990 disaster declaration, State of Oregon, Tillamook and Clatsop Counties: FEMA–853–DR–OR, 30 p.

Hubbard, L.L., 1991, Floods of January 9–11, 1990 in northwestern Oregon and southwestern Washington: U.S. Geological Survey Open-File Report 91–172, 10 p.

National Oceanic and Atmospheric Administration, 1990a, Climatological data, Oregon, January 1990: Asheville, N.C., National Climatic Data Center, v. 96, no. 1, 35 p.

______1990b, Climatological data, Washington, January 1990: Asheville, N.C., National Climatic Data Center, v. 94, no. 1, 25 p.

______1990c, Hourly precipitation data, Oregon, January 1990: Asheville, N.C., National Climatic Data Center, v. 40, no. 1, 36 p.

Table 3. Maximum stages and discharges prior to and during January 9–11, 1990, in northwestern Oregon and southwestern Washington

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined or not applicable; <, less than. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to January 1990				Maximum during January 1990			
Site no. (fig. 4)	Station no.	Stream and place determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence intervals (years)
				Naselle River Basin							
1	12010000	Naselle River near Naselle, Wash.	54.8	1929–89	1935	--	11,100	9	16.67	9,350	25
				Willapa River Basin							
2	12013500	Willapa River near Willapa, Wash.	130	1949–89	[1]1949	24.22	11,400	9	24.06	11,700	25
				Chehalis River Basin							
3	12020000	Chehalis River near Doty, Wash.	113	1939–89	1972	18.36	22,800	9	19.96	27,500	100
4	12025000	Newaukum River near Chehalis, Wash.	155	1942–89	1986	12.76	10,700	9	12.75	10,400	30
5	12025700	Skookumchuck River near Vail, Wash.	40.0	1967–89	1972	10.93	6,900	9	10.01	5,330	20
6	12027500	Chehalis River near Grand Mound, Wash.	895	1928–89	1986	18.41	51,600	10	19.34	68,700	100
7	12031000	Chehalis River at Porter, Wash.	1,294	1952–89	1972	23.88	55,600	11	24.52	60,400	100
				Deschutes River Basin							
8	12079000	Deschutes River near Rainier, Wash.	89.8	1949–82, 1987–89	1974	15.68	7,780	9	17.01	9,600	100
				Nisqually River Basin							
9	12082500	Nisqually River near National, Wash.	133	1942–89	1977	11.96	17,100	9	11.40	14,500	25
10	12083000	Mineral Creek near Mineral, Wash.	75.2	1942–89	1972	--	9,740	9	13.56	13,800	100
11	12092000	Puyallup river near Electron, Wash.	92.8	1908–25, 1945–48, 1957–89	1959	--	10,800	9	--	9,900	25
12	12093500	Puyallup River near Orting, Wash.	172	1931–89	1962	11.82	15,300	9	10.39	11,600	10
13	12095000	South Prairie Creek at South Prairie, Wash.	79.5	1950–71, 1988-89	1955	--	6,850	9	33.55	8,330	10
14	12099600	Boise Creek at Buckley, Wash.	15.4	1977–89	1984	5.18	972	9	3.76	673	<10
15	12101500	Puyallup river at Puyallup, Wash.	948	1914–89	1933	31.0	57,000	9	28.04	44,800	50

Table 3. Maximum stages and discharges prior to and during January 9–11, 1990, in northwestern Oregon and southwestern Washington—Continued

Site no. (fig. 4)	Station no.	Stream and place determination	Drainage area (mi^2)	Maximum prior to January 1990: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during January 1990: Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence intervals (years)
				Duwamish River Basin							
16	12104500	Green River near Lester, Wash.	96.2	1945–89	1959	--	22,000	9	8.28	4,000	20
17	12112600	Big Soos Creek above hatchery near Auburn, Wash.	66.7	1960–89	1972	6.17	1,090	9	7.55	1,750	100
				Snohomish River Basin							
18	12145500	Raging River near Fall City, Wash.	30.6	1945–89	1986	6.27	5,330	9	6.02	4,640	50
19	12149000	Snoqualmie River near Carnation, Wash.	603	1928–90	1932	--	59,500	9	59.06	48,900	10
					1932	59.93	--				
				Cowlitz River Basin							
20	14226500	Cowlitz River near Packwood, Wash.	287	1912–20, 1929–89	1933	13.00	36,600	9	11.34	22,800	<10
21	14232500	Cispus River near Randle, Wash.	321	1929–89	1974	12.58	21,700	9	12.26	20,100	50
				Nehalem River Basin							
22	14301000	Nehalem River near Foss, Ore.	667	1939–89	1972	23.11	46,900	9	25.07	[2]53,400	100
				Wilson River Basin							
23	14301500	Wilson River near Tillamook, Ore.	161	1932–89	1972	16.91	36,000	9	[2]16.54	[2]30,200	25

[1] A discharge of 11,400 ft^3/s also occurred in 1966 at a lower stage.
[2] Revised from value previously published.

Table 4. Storm damages in excess of $50,000 (rounded to the nearest thousand dollars) reported by towns, cities, counties, and utilities for floods of January 9–11, 1990, in northwestern Oregon and southwestern Washington

[Damages resulting from wind and landslides as well as flood damage are listed, but the majority of the damages are the result of flooding. Source: Federal Emergency Management Agency Region X, 1990a,b; Lora Murphy, Washington State Department of Emergency Management, written commun., 1990]

Location	Damages
Oregon	
Tillamook County	$8,000,000
Clatsop County	367,000
Washington	
Lewis County	966,000
City of Chehalis	149,000
City of Centralia	410,000
Lewis County Public Utility District #1	70,000
Thurston County	166,000
City of Montesano	91,000
Grays Harbor County	346,000
City of Puyallup	82,000
Pierce County	976,000
City of Tacoma	336,000
City of Sumner	74,000
City of Auburn	67,000
City of Tukwila	92,000
City of Renton	108,000
City of Issaquah	98,000
City of Kent	109,000
City of Bellevue	62,000
King County	4,609,000
Wahkiakum County	53,000
City of Pacific	76,000
Sammamish Plateau Water and Sewer District	85,000
Cedar River Water and Sewer District	71,000
Port of Seattle	53,000
Seattle Metro	115,000

Flood of January 25–February 1, 1990, in Southern Mississippi

By W. Trent Baldwin

Excessive rainfall occurred in a band from southwest to east-central Mississippi (fig. 7) beginning the morning of January 24 and ending the morning of January 25, 1990. At Liberty, in southwest Mississippi, 10.3 inches of rain were recorded on January 24. The 100-year, 24-hour rainfall at Liberty is about 10.5 inches according to a map by Hershfield (1961).

As a result of this storm, widespread flooding occurred in southern Mississippi. Maximum stages and discharges for 23 flood-determination sites (fig. 7) are summarized in table 5. Because the flood of January 25–February 1, 1990, and the flood of February 15–23, 1990, occurred within 1 month of each other and generally within the same part of the State, only one damage figure was available. The Federal Emergency Management Agency estimated the total damage caused by these two floods at more than $7 million (Larry Bowman, Federal Emergency Management Agency, oral commun., 1991).

REFERENCES

Hershfield, D.M., 1961, Rainfall frequency atlas of the United States: U.S. Department of Commerce, Weather Bureau, Technical Paper no. 40, 115 p.

National Oceanic and Atmospheric Administration, 1990, Climatological data, Mississippi, January 1990: Asheville, N.C., National Climatic Data Center, v. 95, no. 1, 23 p.

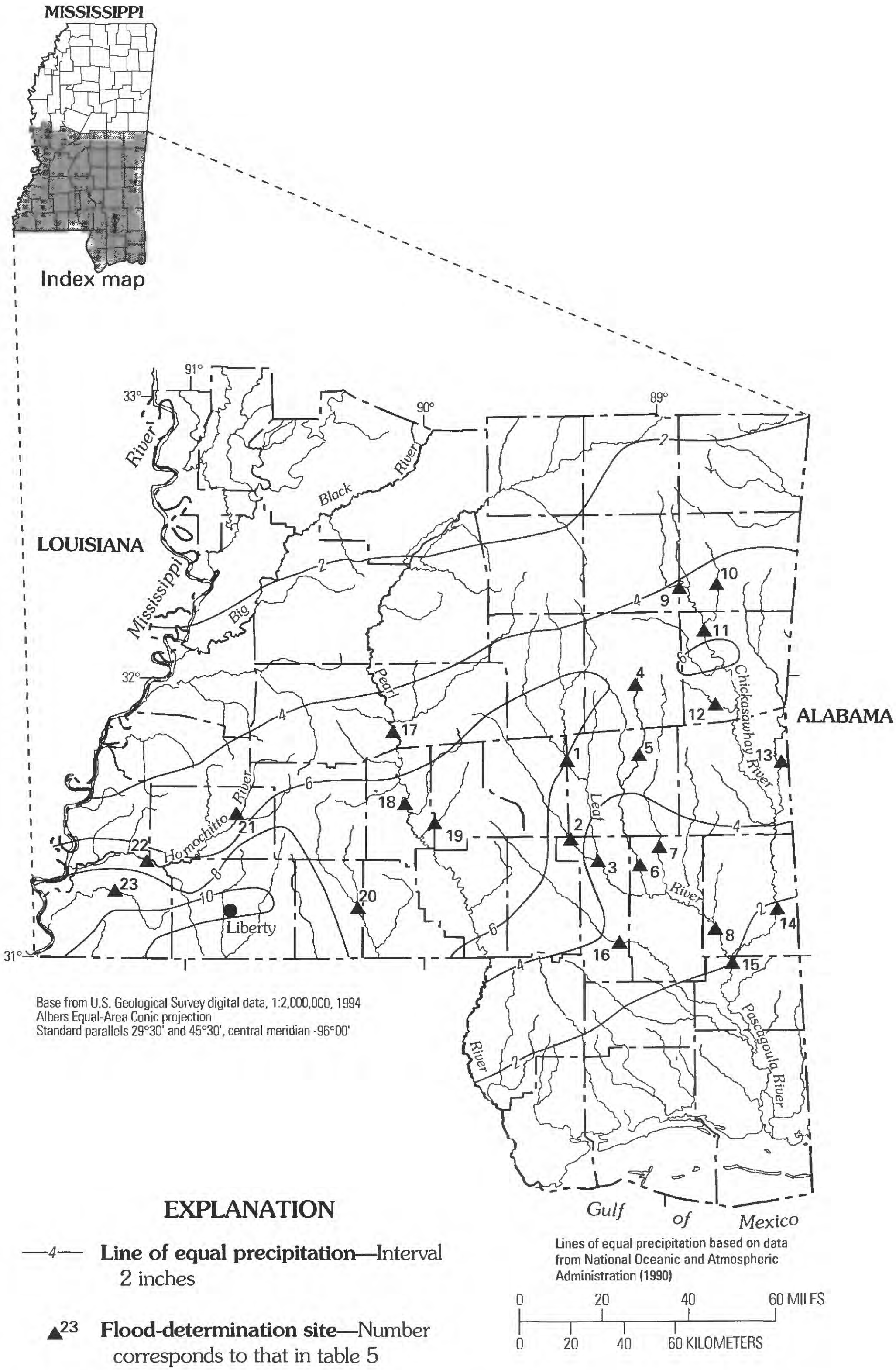


Figure 7. Location of flood determination sites for flood of January 25–February 1, 1990, and lines of equal precipitation for storms of January 24–25, 1990, in southern Mississippi.

Table 5. Maximum stages and discharges prior to and during flood of January 25–February 1, 1990, in southern Mississippi

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to January 1990				Maximum during January or February 1990			
Site no. (fig. 7)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Date (month/ day)	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Pascagoula River Basin							
1	02472000	Leaf River near Collins	743	1856–1989	1856	33.00	56,000	1/27	24.30	20,100	4
2	02472500	Bouie Creek near Hattiesburg	304	1900–89	1900	[1]33.50	[1]50,000	1/26	22.11	13,000	5
3	02473000	Leaf River at Hattiesburg	1,748	1900–89	1974	34.03	121,000	1/27	24.80	42,000	5
4	02473460	Tallahala Creek at Waldrup	102	1961–89	1974	23.18	17,900	1/25	20.38	6,750	4
5	02473500	Tallahala Creek at Laurel	238	1880–1989	1920	26.00	38,300	1/26	20.02	10,900	5
6	02474500	Tallahala Creek near Runnelstown	612	1885–1989	1900	[2]30.50	38,000	1/29	23.73	14,400	5
7	02474600	Bogue Homo near Richton	344	1971–89	1973	27.63	21,900	1/26	19.10	8,830	3
8	02475000	Leaf River near McLain	3,495	1900–89	1900	31.80	131,000	1/29	25.20	55,800	5
9	02475500	Chunky River near Chunky	369	1939–89	1979	26.64	40,900	1/26	19.34	10,900	3
10	02476600	Okatibee Creek at Arundel	342	1961–89	1961	[4]22.20	--	1/25	19.03	7,780	4
					1979	21.51	[3]20,500				
11	02477000	Chickasawhay River at Enterprise	918	1871–1989	1979	[2]37.94	61,700	1/27	30.98	18,800	3
12	02477330	Shubuta Creek near Shubuta	75.5	1963–89	1973	24.88	12,700	1/25	20.62	6,440	5
13	02477990	Buckatunna Creek near Denham	492	1972–89	1979	34.90	12,200	1/29	26.44	7,950	3
14	02478500	Chickasawhay River near Leakesville	2,690	1900–89	1900	38.00	125,000	2/1	28.02	29,200	3
15	02479000	Pascagoula River at Merrill	6,590	1852–1989	1900	32.50	230,000	1/30	24.96	84,400	4
16	02479130	Black Creek near Brooklyn	355	1961–89	1983	29.96	42,500	1/26	20.47	9,470	2
				Pearl River Basin							
17	02488000	Pearl River at Rockport	4,556	1874–1989	1979	42.83	[1]123,000	1/27	34.20	58,800	10
18	02488500	Pearl River near Monticello	4993	1874–1989	1874	34.50	--	1/25	29.24	73,400	20
					1979	[4]34.08	122,000				
19	02488700	White Sand Creek near Oak Vale	130	1966–89	1974	18.76	25,400	1/25	14.30	9,300	5
20	02490500	Bogue Chitto near Tylertown	492	1936–89	1936	34.70	[4]49,000	1/25	31.75	43,400	25
					1983	[4]34.62	64,200				
				Homochitto River Basin							
21	07291000	Homochitto River at Eddiceton	181	1939–89	1974	[2]19.53	55,400	1/25	17.99	21,800	3
22	07292500	Homcchitto River at Rosetta	787	1952–89	1964	29.30	[4]141,000	1/25	22.77	113,000	5
					1974	[4]28.60	150,000				
23	07295000	Buffalo River near Woodville	180	1942–89	1973	22.30	65,000	1/25	21.27	55,700	20

[1]Estimated.
[2]Stage at different site and (or) datum.
[3]Discharge affected by regulation.
[4]Less than maximum for period.

Flood of February 15–20, 1990, in Northwestern Georgia

By Timothy C. Stamey

Severe storms and torrential rains occurred over northwestern Georgia on February 15–16, 1990. Rainfall totals of as much as 11.27 inches were reported; however, most of the affected area received from 4.0 to 7.0 inches of rain for the 2-day period (National Oceanic and Atmospheric Administration, 1990). Significant flooding caused by excessive rainfall on already saturated ground occurred in the Chattooga, Conasauga, Oostanaula, and Toccoa River Basins. The most severely affected area of the State is shown in figure 8.

The severe storms occurred when a low-pressure system and an accompanying cold front stalled over northern Georgia. Unseasonably warm southerly winds carried moist air into Georgia from the Gulf of Mexico in advance of the low-pressure system. Upper level winds, at an altitude of about 18,000 feet, from the southwest and nearly parallel to the stalled surface front repeatedly carried storms over northwest Georgia. The net effect was a deluge of rain, lightning, and wind (National Oceanic and Atmospheric Administration, 1990).

The February 1990 flood was the first declared flood disaster in Georgia in several years. On February 23, 1990, the President of the United States declared 11 counties in northwestern Georgia major flood-disaster areas. Many roads and bridges were damaged during the flooding, and 876 private homes and other properties were damaged or destroyed. The result was several million dollars in damages (Federal Emergency Management Agency, written commun., 1990). The most severely affected areas were in the communities of Trion, where the Chattooga River forced the evacuation of an estimated 1,000 residents, and McCaysville, where the Toccoa River forced the evacuation of about 500 residents. Water and sanitary sewer systems were inoperable for several days, and much of the area was covered with silt and debris (Georgia Emergency Management Agency, written commun., 1990).

Maximum discharges on many streams in northwestern Georgia had recurrence intervals ranging from 2 to more than 100 years (table 6). The most severe flooding occurred on the Conasauga River and its tributaries and on the Chattooga River. The Conasauga River near Eton (site 17) peaked at a stage of 20.50 feet and had a maximum discharge of 33,200 cubic feet per second on February 16. This discharge was greater than that having a 100-year recurrence interval and about 32 percent greater than the previous maximum discharge recorded in 1973. Maximum discharges on two tributaries to the Conasauga River, Mill Creek near Crandall (site 18) and Holly Creek near Chatsworth (site 21), exceeded previous maximum discharges for these sites by more than 160 percent. The maximum discharge on Mill Creek had a recurrence interval of about 50 years, and the maximum discharge on Holly Creek was greater than the 100-year recurrence interval (table 6). Downstream, the Conasauga River at Tilton (site 22) peaked on February 17 at a stage of 29.89 feet and had a maximum discharge of 36,800 cubic feet per second with a recurrence interval of about 50 years.

On the Chattooga River at Summerville (site 35), the maximum discharge of 30,100 cubic feet per second exceeded the 1951 discharge by about 23 percent and was greater than the 100-year recurrence interval. The maximum discharge on the Oostanaula River at Resaca (site 25) was the second highest in 104 years of record, and near Rome (site 28), was the fourth highest in 52 years of record. Overall, record maximum discharges occurred at 15 of the 45 flood-determination sites listed in table 6.

REFERENCE

National Oceanic and Atmospheric Administration, 1990, Climatological data, Georgia, February 1990: Asheville, N.C., National Climatic Data Center, v. 94, no. 2, p. 6.

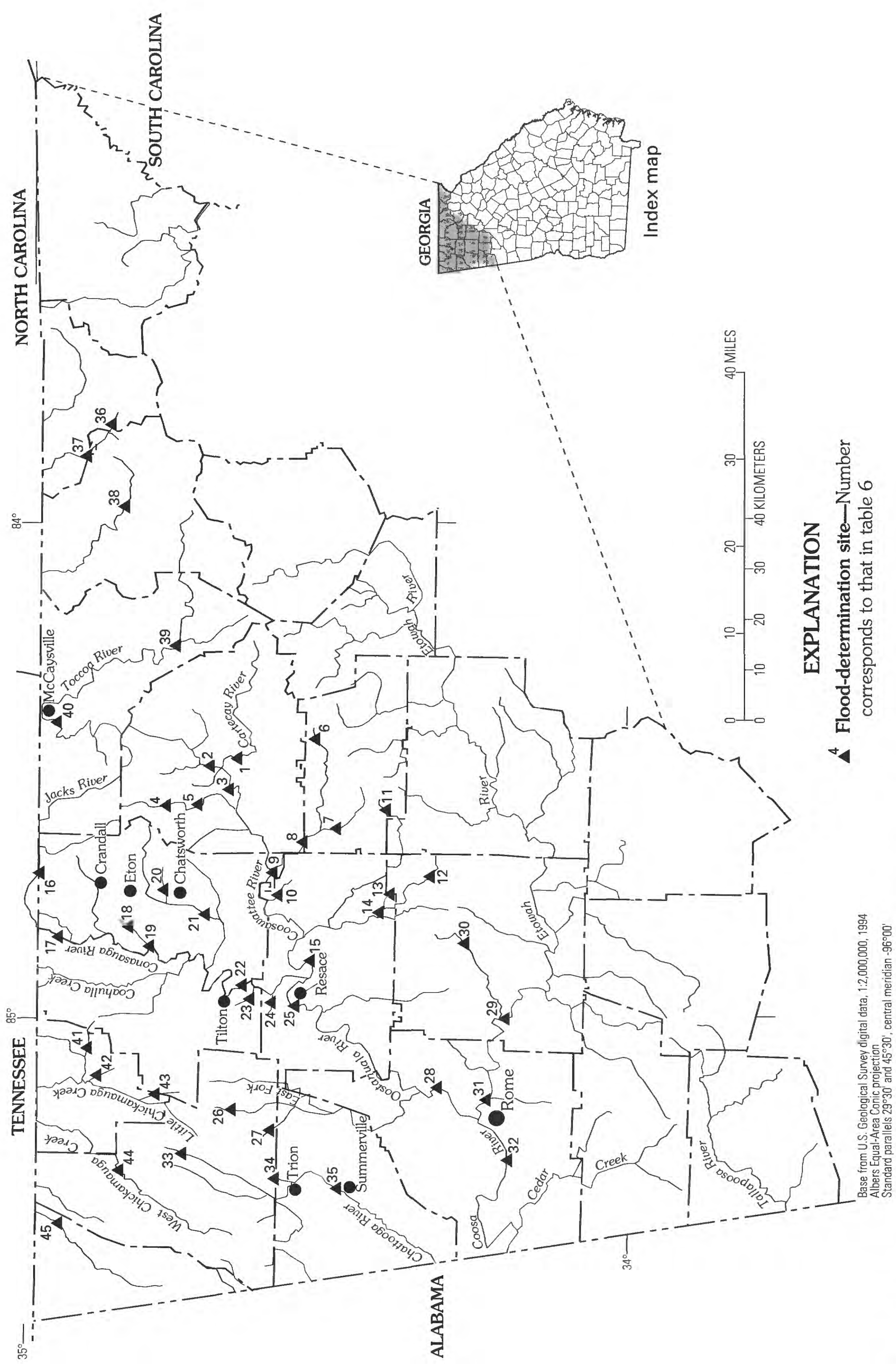


Figure 8. Location of flood-determination sites for flood of February 15–20, 1990, in northwestern Georgia.

Table 6. Maximum stages and discharges prior to and during flood of February 15–20, 1990, in northwestern Georgia

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined or not applicable; >, greater than. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to February 1990				Maximum during February 1990			
Site no. (fig. 8)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
		Mobile River Basin									
1	02379500	Cartecay River near Ellijay	134	1886–1990	1938	13.00	20,000	16	8.33	7,500	5
2	02380000	Ellijay River at Ellijay	87.7	1919–90	1964	17.90	15,300	16	17.22	12,000	50
3	02380500	Coosawattee River near Ellijay	236	1886–1990	1938	--	25,000	16	16.74	15,200	10
4	02381100	Mountaintown Creek tributary near Ellijay	2.41	1965–90	1973	7.20	822	16	5.53	485	5
5	02381300	Fir Creek near Ellijay	1.35	1966–90	1966	4.80	280	16	5.20	320	10
6	02381900	Ball Creek near Talking Rock	3.50	1965–90	1979	--	1,400	16	6.24	1,000	10
7	02381950	Scarecorn Creek above Hinton	6.40	1986–90	1986	2.83	241	16	3.28	333	--
8	02382200	Talking Rock Creek near Hinton	119	1951–90	1973	15.45	18,400	16	12.02	11,200	25
9	02382500	Coosawattee River at Carters	521	1886–1990	1951	36.00	57,000	16	18.94	8,370	--
10	02382600	Sugar Creek near Chatsworth	7.30	1965–90	1979	--	1,300	16	8.63	1,100	5
11	02382800	Dry Creek near Oakman	3.06	1951–90	1977	8.45	1,410	16	5.73	1,020	50
12	02382900	Pine Log Creek near Rydal	12.8	1951–90	1964	10.00	3,800	16	6.85	1,510	10
13	02383200	Redbud Creek near Ranger	1.97	1951–90	1977	6.20	1,210	16	3.74	370	2
14	02383220	Redbud Creek tributary near Ranger	.56	1951–90	1977	--	500	16	3.37	165	5
15	02383500	Coosawattee River near Pine Chapel	831	1938–90	1951	34.20	40,200	17	29.55	20,600	--
16	02384000	Conasauga River near Tennga	108	1930–90	1958	18.20	19,400	16	15.88	11,100	5
17	02384500	Conasauga River near Eton	252	1951–90	1973	18.59	25,200	16	20.50	33,200	>100
18	02384540	Mill Creek near Crandall	8.27	1985–90	1989	4.95	894	16	6.96	2,240	50
19	02384600	Pinhook Creek near Eton	4.28	1964–90	1967	7.30	960	16	6.86	768	5
20	02385700	Rock Creek near Chatsworth	3.46	1965–90	1979	5.63	750	16	9.42	2,300	>100
21	02385800	Holly Creek near Chatsworth	64	1961–90	1979	12.54	9,110	16	14.87	20,600	>100
22	02387000	Conasauga River at Tilton	687	1834–1990	1886	34.0	40,000	17	29.89	36,800	50
23	02387100	Polecat Creek near Spring Place	1.22	1964–90	1966	7.75	828	16	5.54	475	10
24	02387300	Dead Mans Branch near Resaca	.17	1965–90	1966	6.50	184	16	4.65	105	5
25	02387500	Oostanaula River at Resaca	1,602	1834–1990	1886	36.60	68,600	18	32.59	45,500	--

Table 6. Maximum stages and discharges prior to and during flood of February 15–20, 1990, in northwestern Georgia—Continued

Site no. (fig. 8)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to February 1990: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during February 1990: Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
		Mobile River Basin—Continued									
26	02388000	West Armuchee Creek near Sublingna	36.4	1951–90	1951	12.10	12,400	16	14.01	22,000	>100
27	02388200	Storey Mill Creek near Summerville	6.02	1951–90	1979	9.58	1,730	16	10.41	1,980	>100
28	02388500	Oostanaula River near Rome	2,115	1834–90	1834	--	70,000	20	35.70	42,600	--
29	02395000	Etowah River near Kingston	1,634	1916–90	1919	31.00	52,000	16	13.73	13,600	--
30	02395120	Two Run Creek near Kingston	33.1	1981–90	1982	7.91	3,180	16	7.57	2,720	5
31	02396000	Etowah River at Rome	1,819	1886–1990	1919	--	55,000	17	32.96	20,700	--
32	02397000	Coosa River near Rome	4,040	1834–1990	1886	43.00	100,000	17	34.38	58,800	--
33	02397750	Duck Creek near LaFayette	6.34	1965–90	1973	10.45	1,880	16	10.86	2,040	>100
34	02397830	Harrisburg Creek near Hawkins	13.3	1980–90	1988	11.20	4,260	16	12.00	5,530	>100
35	02398000	Chattooga River at Summerville	192	1938–90	1951	21.00	24,500	16	22.63	30,100	>100
		Tennessee River Basin									
36	03544947	Brier Creek near Hiawassee	1.67	1984–90	1986	3.19	185	16	3.57	372	5
37	03545000	Hiawassee River at Presley	45.5	1942–90	1952	15.24	5,700	16	9.78	2,100	2
38	03550500	Nottley River near Blairsville	74.8	1907–90	1967	21.04	12,900	16	11.84	4,600	5
39	03558000	Toccoa River near Dial	177	1841–1990	1906	18.50	28,000	16	10.13	8,790	10
40	03560000	Fightingtown Creek at McCaysville	70.9	1943–90	1951	11.92	5,420	16	17.30	12,200	>100
41	03566660	Sugar Creek near Ringgold	4.44	1951–90	1973	7.77	2,620	16	5.14	605	2
42	03566685	Little Chickamauga Creek tributary near Ringgold	3.36	1951–90	1973	9.13	1,970	16	4.96	886	25
43	03566700	South Chickamauga Creek at Ringgold	169	1867–1990	1973	27.39	33,400	16	22.80	19,500	25
44	03567200	West Chickamauga Creek near Kensington	73	1950–90	1951	18.50	12,000	16	19.34	14,000	>100
45	03568933	Lookout Creek near New England	149	1973–90	1982	20.73	20,000	16	18.76	14,300	25

Flood of February 15–23, 1990, in Southeastern Mississippi

By W. Trent Baldwin

From the afternoon of February 14 to the morning of February 16, 1990, excessive rainfall occurred in a band from southwest to east-central Mississippi (fig. 9). At Meridian, in east-central Mississippi, 7 inches of rain were recorded in a 6-hour period on February 15. The 100-year, 6-hour rainfall at Meridian is about 6.5 inches according to a map by Hershfield (1961). Cumulative rainfall of February 15 at selected precipitation data sites is shown in figure 10.

As a result of the storm, widespread flooding occurred. Maximum stages and discharges for 40 flood-determination sites in southeastern Mississippi are given in table 7. At nine of the sites, the February 15–23, 1990, flood was the largest in at least 16 years.

The flooding resulted in five deaths and caused extensive damage to roads, bridges, and homes. Because the flood of January 25–February 1, 1990, and this flood (February 15–23, 1990) occurred within 1 month of each other and generally within the same part of the State, only one damage figure was available. The Federal Emergency Management Agency estimated the total damage caused by these two floods at more than $7 million (Larry Bowman, Federal Emergency Management Agency, oral commun., 1991).

REFERENCES

Hershfield, D.M., 1961, Rainfall frequency atlas of the United States: U.S. Department of Commerce, Weather Bureau, Technical Paper no. 40, 115 p.

National Oceanic and Atmospheric Administration, 1990a, Climatological data, Mississippi, February 1990: Asheville, N.C., National Climatic Data Center, v. 95, no. 2, 23 p.

_____1990b, Hourly precipitation data, Mississippi, February 1990: Asheville, N.C., National Climatic Data Center, v. 40, no. 2, 19 p.

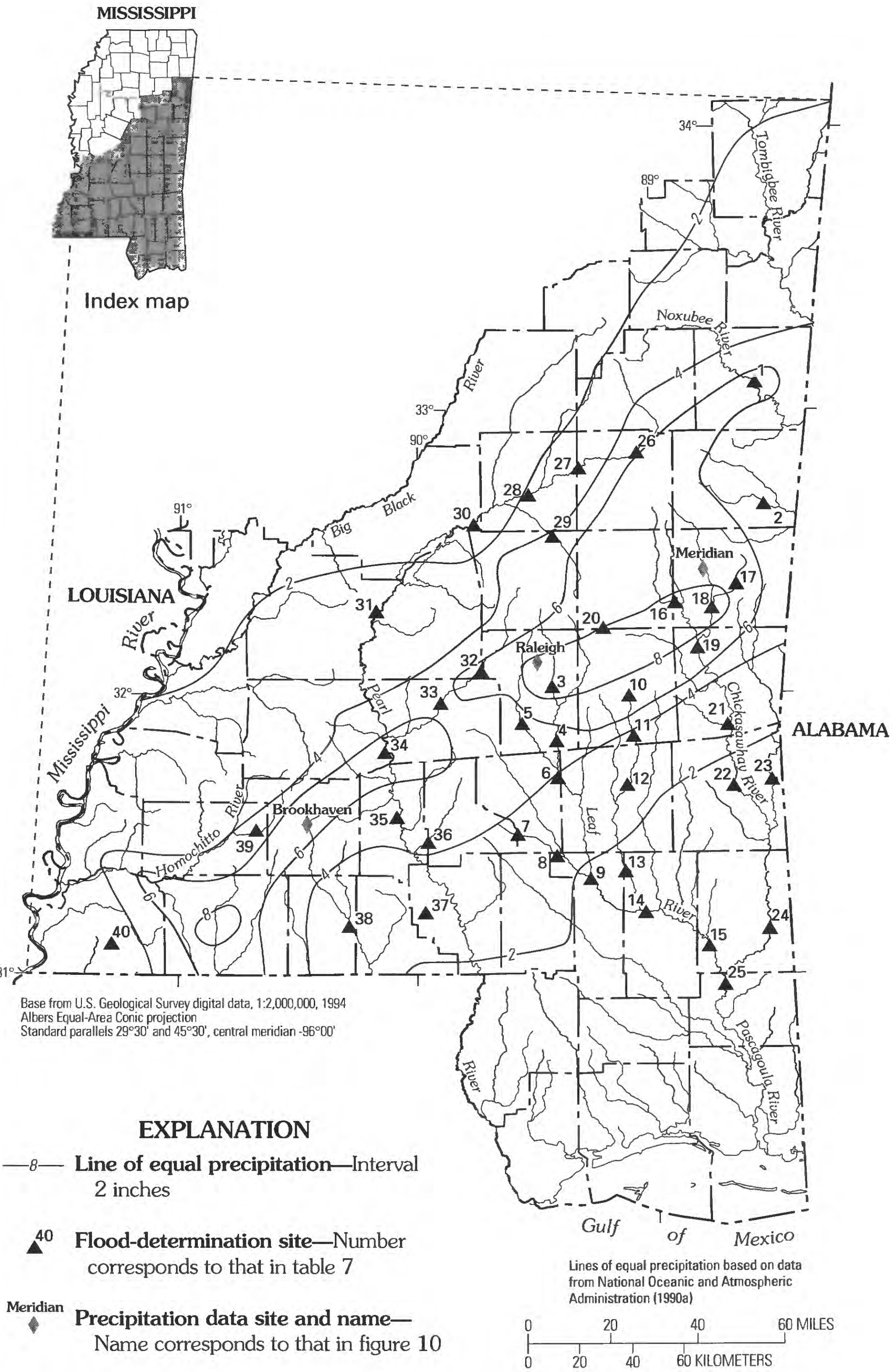


Figure 9. Location of flood-determination sites for flood of February 15–23, 1990, and lines of equal precipitation for storm of February 14–16, 1990, in southeastern Mississippi.

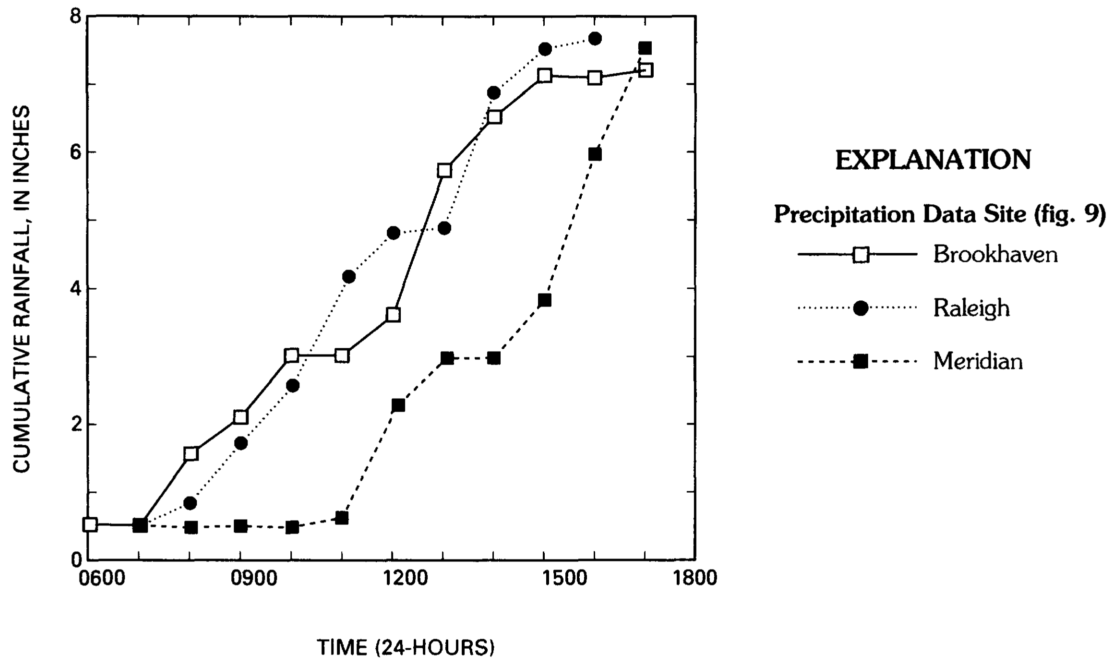


Figure 10. Cumulative rainfall of February 15, 1990, at selected precipitation data sites in southeastern Mississippi (data from National Oceanic and Atmospheric Administration, 1990b).

Table 7. Maximum stages and discharges prior to and during flood of February 15–23, 1990, in southeastern Mississippi

[mi², square miles; ft, feet above an arbitrary datum; ft³/s, cubic feet per second; >, greater than: --, not determined or not applicable. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to February 1990				Maximum during February 1990			
Site no. (fig. 9)	Station no.	Stream and place of determination	Drainage area (mi²)	Period	Year	Stage (ft)	Discharge (ft³/s)	Day	Stage (ft)	Discharge (ft³/s)	Discharge recurrence interval (years)
				Mobile River Basin							
1	02448000	Noxubee River at Macon	768	1892–1990	1979	38.97	125,000	16	28.84	13,500	2
2	02448620	Flat Scooba Creek tributary near Scooba	.44	1967–90	1979	8.87	427	16	6.30	205	5
				Pascagoula River Basin							
3	02471100	Leaf River near Raleigh	143	1856–1990	1856	--	[1]17,000	16	26.27	11,300	10
					1974	28.17	17,000				
4	02471250	Leaf River at Taylorsville	459	1856–1990	1856	--	[1]39,000	16	57.28	37,200	>100
					1974	57.44	[2]37,600				
5	02471500	Oakohay Creek at Mize	185	1942–90	1974	17.26	28,900	16	14.15	10,100	5
6	02472000	Leaf River near Collins	743	1856–1990	1856	33.00	56,000	17	31.44	46,700	40
7	02472420	Bouie Creek near Sanford	262	1961–90	1961	[2]32.02	33,200	17	26.66	14,000	5
					1974	32.22	[1,2]32,000				
8	02472500	Bouie Creek near Hattiesburg	304	1900–90	1900	[1]33.50	[1]50,000	17	21.05	10,700	4
9	02473000	Leaf River at Hattiesburg	1,748	1900–90	1974	34.03	121,000	19	27.09	54,900	10
10	02473460	Tallahala Creek at Waldrup	102	1961–90	1974	23.18	17,900	16	22.79	17,700	80
11	02473480	Tallahattah Creek near Waldrup	30.4	1965–90	1974	18.14	--	16	16.23	4,360	10
					1979	[2]17.20	7,200				
12	02473500	Tallahala Creek at Laurel	238	1880–1990	1919	26.00	38,300	17	21.34	14,800	10
13	02474500	Tallahala Creek near Runnelstown	612	1885–1990	1900	[3]30.50	38,000	20	24.94	16,900	5
14	02474560	Leaf River near New Augusta	2,542	1900–90	1900	36.00	120,000	20	30.15	69,300	20
15	02475000	Leaf River near McLain	3,495	1900–90	1900	31.80	131,000	22	26.23	71,700	10
16	02475500	Chunky River near Chunky	369	1939–90	1979	26.64	40,900	16	25.12	27,400	15
17	02476500	Sowashee Creek at Meridian	52.1	1900–90	1936	[3]26.50	--	15	20.85	5,250	5
					1964	[2]20.95	9,530				
18	02476600	Okatibee Creek at Arundel	342	1961–90	1961	22.20	--	16	22.65	[4]22,800	60
					1979	[2]21.51	[4]20,500				
19	02477000	Chickasawhay River at Enterprise	918	1871–90	1961	[3]37.94	61,700	17	41.56	47,300	20
20	02477050	Souenlovie Creek near Baxter	1.14	1964–90	1973	12.56	1,050	15	11.99	960	25
21	02477350	Chickasawhay River at Shubuta	1,458	1900–90	1900	[3]47.90	90,000	19	42.67	--	--
22	02477500	Chickasawhay River near Waynesboro	1,650	1900–90	1900	[3]50.30	[1]73,000	21	41.90	--	--

Table 7. Maximum stages and discharges prior to and during flood of February 15–23, 1990, in southeastern Mississippi—Continued

Site no. (fig. 9)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to February 1990: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during February 1990: Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
		Pascagoula River Basin—Continued									
23	02477990	Buckatunna Creek near Denham	492	1972–90	1979	34.90	12,200	20	31.02	10,300	5
24	02478500	Chickasawhay River at Leakesville	2,690	1900–90	1900	38.00	125,000	23	31.03	49,400	10
25	02479000	Pascagoula River at Merrill	6,590	1852–1990	1900	32.50	230,000	23	26.38	106,000	5
		Pearl River Basin									
26	02481880	Pearl River at Burnside	520	1874–1990	1979	23.31	70,600	17	16.51	14,900	4
27	02482000	Pearl River at Edinburg	904	1874–1990	1979	30.06	77,900	18	25.76	22,300	5
28	02482550	Pearl River near Carthage	1,346	1874–1990	1979	28.74	102,000	19	23.79	28,400	10
29	02483000	Tuscolameta Creek at Walnut Grove	411	1873–1990	1900	[2]34.50	--	17	30.12	27,000	20
					1950	[2]33.00	34,600				
30	02484630	Pearl River near Ratliff	2,595	1979–90	1979	26.50	--	18	21.20	--	--
31	02486000	Pearl River at Jackson	3,171	1874–1990	1979	43.28	128,000	19	32.90	[4]33,600	3
32	02487300	Strong River near Puckett	248	1950–90	1950	27.06	19,000	16	24.87	11,500	5
33	02487500	Strong River at D'Lo	425	1900–90	1983	33.48	26,400	16	30.50	17,300	10
34	02488000	Pearl River at Rockport	4,556	1874–1990	1979	42.83	[1]123,000	17	32.19	51,100	5
35	02488500	Pearl River near Monticello	4,993	1874–1990	1874	34.50	--	16	28.77	69,300	15
					1979	[2]34.08	122,000				
36	02488700	White Sand Creek near Oak Vale	130	1966–90	1974	18.76	25,400	16	11.49	5,580	3
37	02489030	Elmers Draw near Columbia	.91	1955–90	1983	16.22	1,620	15	8.86	550	4
38	02490500	Bogue Chitto near Tylertown	492	1936–90	1936	34.70	[2]49,000	17	25.07	22,200	4
					1983	[2]34.62	64,200				
		Homochitto River Basin									
39	07291250	McCall Creek near Lucien	60.8	1953–90	1974	92.70	23,000	15	85.27	10,300	3
		Thompson Creek Basin									
40	07373550	Moores Branch near Woodville	.21	1955–90	1973	9.90	455	15	5.45	235	3

[1]Estimated. [2]Less than maximum for period.
[3]Stage and different site and (or) datum. [4]Discharge affected by regulation.

Floods of February and March 1990 in Alabama, Georgia, and Florida

By J.L. Pearman, T.C. Stamey, G.W. Hess, *and* G.H. Nelson, Jr.[1]

Widespread flooding as a result of two separate storm systems occurred during February and March 1990 throughout large parts of Alabama, northwestern and west-central Georgia, and northwestern Florida. The February flood resulted from excessive rainfall on the 15th and 16th over west-central and northeastern Alabama and northwestern and north-central Georgia. The March flood resulted from nearly continuous rainfall that began in southwestern Alabama and northwestern Florida on the 15th and extended into central and southeastern Alabama and west-central Georgia on the 16th. Discharges having recurrence intervals in excess of 100 years occurred in areas of southeastern Alabama, northwestern and west-central Georgia, and northwestern Florida.

The February rainfall occurred primarily in north-central and northeastern Alabama and northwestern and north-central Georgia (fig. 11). Rainfall totals of 4 to 8 inches fell over the area, with some localized areas receiving more than 10 inches (Pearman and others, 1991). Streams in Alabama most affected were Mulberry Fork near Garden City, which had its highest discharge in 62 years of record, and Big Wills Creek near Reece City, which had a flood with a recurrence interval of 50 years. The most extreme flooding in Georgia occurred on the Chattooga River at Summerville, West Chickamauga Creek near Kensington, West Armuchee Creek near Subligna, Holly Creek near Chatsworth, and Fightingtown Creek at McCaysville, all of which had maximum discharges with recurrence intervals of 100 years or more.

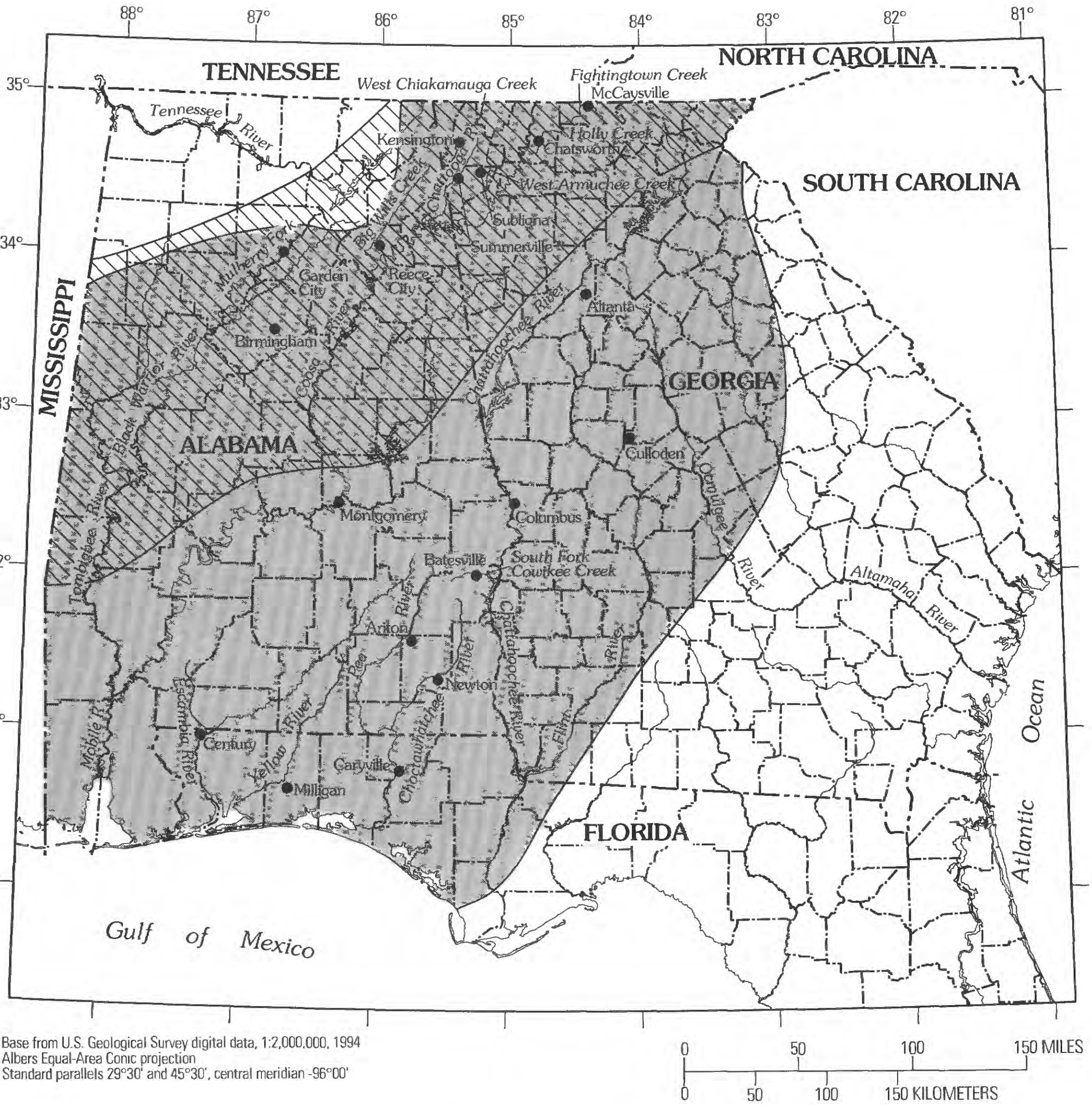
The March rainfall occurred in southern Alabama, west-central Georgia, and northwestern Florida. Rainfall in excess of 6 inches fell over the area, with a large part of southern Alabama receiving 8 to 14 inches. Maximum discharges with recurrence intervals in excess of 100 years occurred on numerous streams in southern Alabama, including the Choctawhatchee River at Newton, the Pea River near Ariton, and South Fork Cowikee Creek near Batesville. In Georgia, the Columbus area was the most severely affected as evidenced by maximum discharges exceeding 100-year recurrence intervals at flood-determination sites on four creeks having drainage areas of 47 to 342 square miles. The Flint River near Culloden had the second highest discharge since records began in 1913. Flooding in northwestern Florida occurred primarily on streams with headwaters in Alabama and just south of the Alabama-Florida State line. Notable floods occurred on Yellow River at Milligan, Escambia River near Century, and Choctawhatchee River at Caryville.

Pearman and others (1991) describe the storms and floods in detail. Included in the report are rainfall data for the area, maximum stages and discharges for 236 sites, and recurrence intervals for the sites.

[1]This article is based on a previously published report (Pearman and others, 1991).

REFERENCE

Pearman, J.L., Stamey, T.C., Hess, G.W., and Nelson, G.H., Jr., 1991, Floods of February and March 1990 in Alabama, Georgia, and Florida: U.S. Geological Survey Water-Resources Investigations Report 91–4089, 44 p.



EXPLANATION

- Area affected by excessive rainfall in February 1990 (hatched pattern)
- Area affected by excessive rainfall in March 1990 (shaded pattern)

Figure 11. Areas affected by excessive rainfall during February and March 1990 in Alabama, Georgia, and Florida.

Floods of March 16–21, 1990, in Northwestern and West-Central Georgia

By Timothy C. Stamey

Excessive rain occurred over northwestern and west-central Georgia on March 16–17, 1990. Rainfall amounts totaled as much as 9.60 inches, although most areas received from 5.0 to 7.0 inches for the 2-day period. The rain occurred when a low-pressure system and an accompanying cold front stalled over northwestern and central Georgia. Southerly winds carried moist air from the Gulf of Mexico into Georgia in advance of the low-pressure system. Upper level winds repeatedly carried storms along the stalled front over northwestern and west-central Georgia (National Oceanic and Atmospheric Administration, written commun., 1990). Severe flooding caused by intense rain on already saturated ground occurred in parts of the Chattahoochee, Coosa, Flint, Ocmulgee, Oconee, and Oostanaula River Basins. The most severely affected area of the State is shown in figure 12.

Just 3 weeks prior to the March 1990 floods, the President of the United States declared 11 counties in northwestern Georgia flood-disaster areas because of flooding on February 15–16. As a result of the floods during March 1990, 24 counties in west-central Georgia were added to the declaration as flood-disaster areas. At least four deaths were attributed to the flooding conditions in the Columbus area. Several million dollars in damages were reported to roads, bridges, and personal property, and more than 1,500 families were evacuated. (Georgia Emergency Management Agency, written commun., 1990).

Maximum discharges during the flood on many streams in northwestern and west-central Georgia had recurrence intervals ranging from 5 years to more than 100 years (table 8). The most severe flooding occurred in the Chattahoochee River Basin on Upatoi Creek near Columbus (site 41), where the maximum discharge was 3.1 times larger than the discharge having a 100-year recurrence interval. Maximum discharges on at least five other streams within about a 50-mile radius of Columbus equaled or exceeded the 100-year discharges (fig. 12, table 8). Discharges exceeding the previous maximum occurred at 15 sites in northwestern and west-central Georgia (table 8).

In the Rome area, the Coosa River (site 58) reached a maximum stage of 35.97 feet and had a maximum discharge of 65,500 cubic feet per second, which is the ninth largest flood recorded in 104 years at this site. In the Atlanta area, the Chattahoochee River (site 24) reached a record stage of 23.03 feet, the highest since the construction of Buford Dam in 1956, and Peachtree Creek (site 26) reached a maximum stage of 21.06 feet, the highest in 33 years of record (table 8).

In the Flint River Basin, Line Creek near Senoia (site 46) reached a maximum stage of 13.84 feet, which was the second highest peak in 26 years of record; Flint River near Culloden (site 52) reached a maximum stage of 38.00 feet, the second highest since 1913; and Flint River at Montezuma (site 54) reached a maximum stage of 26.05 feet, the second highest since 1905 (table 8).

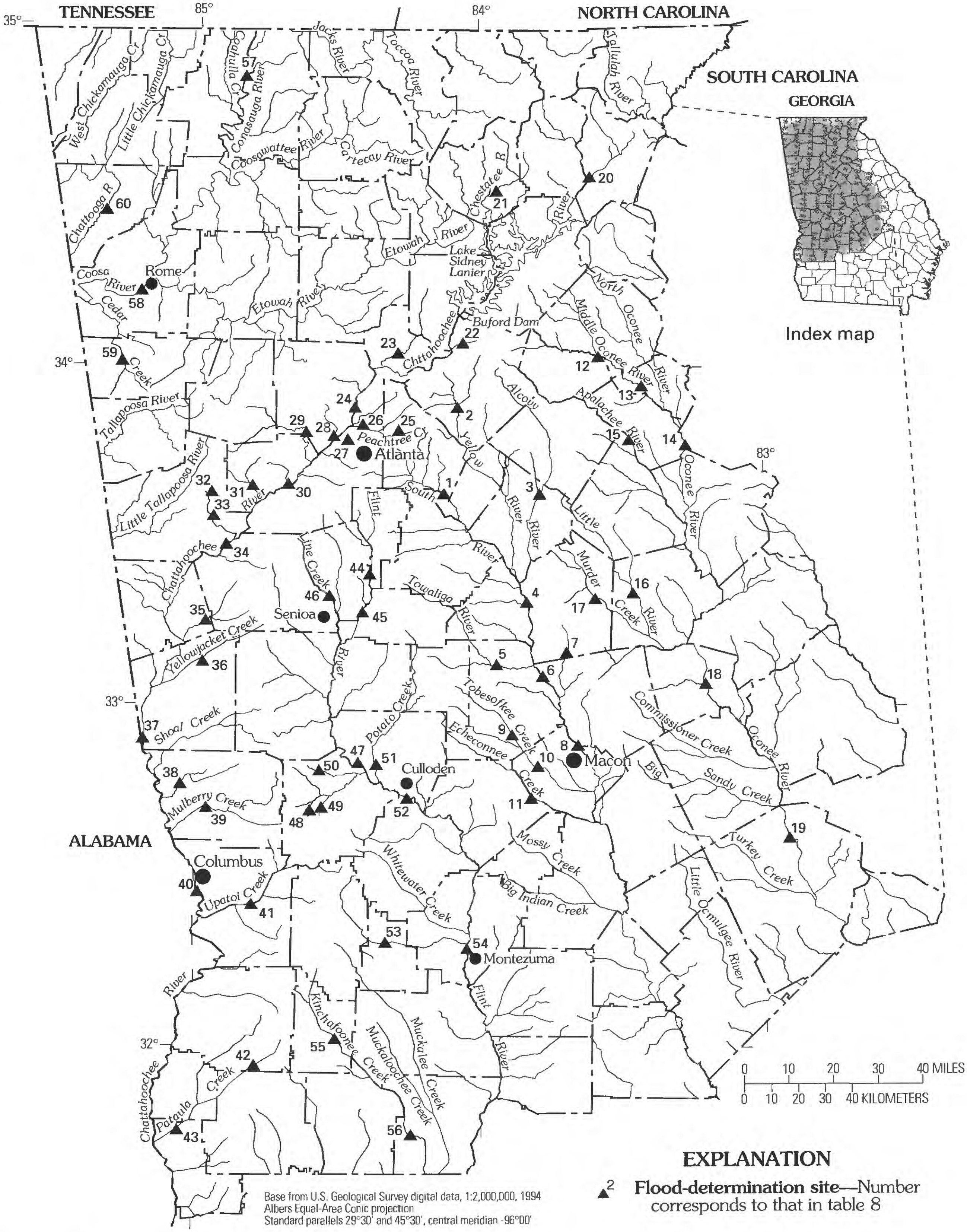


Figure 12. Location of flood-determination sites for floods of March 16–21, 1990, in northwestern and west-central Georgia.

Table 8. Maximum stages and discharges prior to and during floods of March 16–21, 1990, in northwestern and west-central Georgia

[mi^2, square miles; ft, feet above arbitrary datum; ft^3/s, cubic feet per second; --, not determined or not applicable; >, greater than. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to March 1990				Maximum during March 1990			
Site no. (fig. 12)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Altamaha River Basin							
1	02203965	South River near Lithonia	182	1961–90	1961	--	17,000	17	13.03	12,500	--
2	02206500	Yellow River near Snellville	134	1936–90	1948	19.40	9,500	17	19.67	12,600	--
3	02208450	Alcovy River above Covington	185	1972–90	1976	14.79	6,530	18	14.49	7,620	5
4	02210500	Ocmulgee River near Jackson	1,420	1887–1990	1919	26.80	69,000	18	20.96	46,300	25
5	02211300	Towaliga River near Jackson	105	1961–90	1971	17.17	7,470	18	19.05	9,300	50
6	02212500	Ocmulgee River at Juliette	1,960	1886–1990	1948	33.10	78,000	18	28.55	58,400	25
7	02212600	Falling Creek near Juliette	72.2	1965–90	1971	23.00	7,700	17	22.85	7,570	25
8	02213000	Ocmulgee River at Macon	2,240	1887–1990	1948	28.00	83,500	18	29.90	64,700	10
9	02213350	Tobesofkee Creek below Forsyth	53.4	1963–90	1971	10.10	9,160	17	5.20	7,000	25
10	02213470	Tobesofkee Creek above Macon	156	1967–78	1971	14.09	8,580	18	14.78	9,620	25
11	02214000	Echeconnee Creek near Macon	147	1929–90	1964	15.84	18,500	18	14.24	13,200	25
12	02217475	Middle Oconee River near Arcade	340	1987–90	1989	22.45	9,530	18	25.35	13,800	10
13	02217500	Middle Oconee River near Athens	398	1902–90	1902	25.50	19,600	18	20.84	13,700	10
14	02218300	Oconee River near Penfield	940	1902–90	1908	--	61,000	17	23.30	24,600	10
15	02219000	Apalachee River near Bostwick	176	1945–90	1946	8.90	11,200	17	7.54	7,910	5
16	02220900	Little River near Eatonton	262	1948–90	1948	30.80	15,000	18	28.78	12,500	10
17	02221000	Murder Creek near Monticello	24	1952–76	1971	9.64	3,240	17	8.51	2,550	10
18	02223000	Oconee River at Milledgeville	2,950	1886–1990	1886	46.70	140,000	18	36.50	70,300	10
19	02223500	Oconee River at Dublin	4,400	1886–1990	1936	33.00	96,700	21	27.14	46,200	5
				Apalachicola River Basin							
20	02331600	Chattahoochee River near Cornelia	315	1940–90	1949	--	27,000	17	15.07	18,900	5
21	02333500	Chestatee River near Dahlonega	153	1907–90	1967	25.17	22,700	17	16.76	11,600	5
22	02334885	Suwanee Creek near Suwanee	46.8	1985–90	1986	10.41	2,150	17	11.42	[1]3,760	10
23	02335700	Big Creek near Alpharetta	72.0	1961–90	1982	13.05	6,100	17	12.81	5,820	10

Table 8. Maximum stages and discharges prior to and during floods of March 16–21, 1990, in northwestern and west-central Georgia—Continued

Site no. (fig. 12)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to March 1990: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during March 1990: Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
		Apalachicola River Basin—Continued									
24	02336000	Chattahoochee River at Atlanta	1,450	1880–1990	1919	29.00	64,000	17	23.03	25,100	--
25	02336180	South Fork Peachtree at Willivee Drive near Decatur	11.0	1961–90	1973	--	2,200	17	11.54	1,450	--
26	02336300	Peachtree Creek at Atlanta	86.8	1898–1990	1920	--	21,000	17	21.06	9,650	--
27	02336360	Nancy Creek at Rickenbacker Way	26.6	1948–90	1973	14.84	4,500	17	12.93	3,200	--
28	02336490	Chattahoochee River near Atlanta	1,600	1961–90	1961	--	34,000	17	31.51	33,300	--
29	02337000	Sweetwater Creek near Austell	246	1905–90	1916	20.00	12,600	18	19.30	9,950	10
30	02337170	Chattahoochee River near Fairburn	2,060	1886–1990	1919	31.60	75,000	17	25.74	39,200	--
31	02337400	Dog River near Douglasville	43	1951–90	1961	16.15	9,910	16	14.68	7,220	10
32	02337448	Hurricane Creek tributary near Fairplay	.33	1977–90	1977	9.46	292	16	8.37	229	10
33	02337500	Snake Creek near Whitesburg	35.5	1955–90	1961	14.40	7,690	16	12.37	5,220	10
34	02338000	Chattahoochee River near Whitesburg	2,430	1886–1990	1919	--	95,000	18	25.90	48,700	--
35	02338660	New River near Corinth	127	1979–90	1979	13.92	7,450	17	17.17	10,000	25
36	02338775	Yellowjacket Creek at Hogansville	42.5	1919–90	1961	24.50	8,400	17	12.20	2,100	2
37	02339500	Chattahoochee River at West Point	3,550	1827–1990	1919	29.25	134,000	19	18.30	55,800	--
38	02340500	Mountain Oak Creek near Hamilton	61.7	1919–90	1948	16.60	11,800	17	6.06	4,750	10

Table 8. Maximum stages and discharges prior to and during floods of March 16–21, 1990, in northwestern and west-central Georgia—Continued

				Maximum prior to March 1990				Maximum during March 1990			
Site no. (fig. 12)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Dis-charge (ft^3/s)	Day	Stage (ft)	Dis-charge (ft^3/s)	Discharge recurrence interval (years)
			Apalachicola River Basin—Continued								
39	02341220	Mulberry Creek near Mulberry Grove	190	1983–90	1989	19.27	5,510	17	27.74	21,000	>100
40	02341500	Chattahoochee River at Columbus	4,670	1827–1990	1929	55.20	198,000	17	41.14	98,800	--
41	02341800	Upatoi Creek near Columbus	342	1968–90	1981	21.06	17,300	17	32.12	46,300	>100
42	02343200	Pataula Creek near Lumpkin	70	1929–78	1948	--	12,500	18	8.76	7,200	>100
43	02343225	Pataula Creek near Georgetown	295	1948–90	1948	11.80	42,000	18	7.43	7,540	10
44	02344350	Flint River near Lovejoy	130	1986–90	1989	16.26	6,350	17	17.76	8,090	10
45	02344500	Flint River near Griffin	272	1919–90	1929	17.90	15,300	17	16.20	11,500	10
46	02344700	Line Creek near Senoia	101	1965–90	1977	14.88	9,580	17	13.84	7,290	25
47	02346180	Flint River near Thomaston	1,220	1897–1990	1929	--	62,000	18	17.35	29,200	10
48	02346193	Scott Creek near Talbotton	3.36	1969–90	1981	8.07	1,960	16	8.01	1,880	25
49	02346210	Kimborough Creek near Talbotton	6.62	1969–90	1981	6.66	2,000	16	8.55	3,050	100
50	02346217	Coleoatchee Creek near Manchester	2.82	1969–90	1971	4.93	1,020	16	8.31	1,750	>100
51	02346500	Potato Creek near Thomaston	186	1938–90	1971	8.81	10,600	18	9.19	12,300	50
52	02347500	Flint River near Culloden	1,850	1897–1990	1929	38.40	92,000	17	38.00	80,000	50
53	02349350	Buck Creek near Ellaville	146	1979–90	1983	8.52	2,050	17	9.67	3,730	25
54	02349500	Flint River at Montezuma	2,900	1897–1990	1897	--	97,000	20	26.05	64,900	25
55	02350600	Kinchafoonee Creek at Preston	197	1900–90	1943	11.40	12,000	17	12.16	14,500	>100
56	02350900	Kinchafoonee Creek near Dawson	527	1900–90	1943	23.00	15,000	20	20.44	11,400	50
57	02384500	Conasauga River near Eton	252	1954–90	1990	20.50	33,200	17	16.68	16,500	5
58	02397000	Coosa River near Rome	4,040	1834–1990	1886	43.00	100,000	18	35.97	65,500	--
59	02397410	Cedar Creek at Cedartown	66.9	1886–1990	1979	21.10	16,500	16	18.36	7,910	25
60	02398000	Chattooga River at Summerville	192	1938–90	1990	22.63	30,100	17	18.25	13,300	5

Floods of April and May 1990 on the Arkansas, Red, and Trinity Rivers in Oklahoma, Texas, Arkansas, and Louisiana

By Robert L. Tortorelli

INTRODUCTION

Large quantities of rainfall in the spring of 1990 produced record or near-record floods during April and May 1990 in the Arkansas, Red, and Trinity River Basins. The affected area in Oklahoma, Texas, Arkansas, and Louisiana is shown in figure 13.

The flooding was the culmination of an extremely wet winter and early spring in the flooded area. By mid-March, streamflow was above average, soil-moisture conditions were wet, and flood potential was above average (U.S. Department of Commerce, 1991). Some streams were producing minor flooding. Rain continued to fall over the area until, by mid-April, conditions were conducive to serious flooding. Soils were saturated, flows in the principal rivers were near flood stage, and reservoirs were full or nearly full. Given these antecedent conditions, two major storm sequences in late April and early May produced widespread flooding, which generally was equal to or greater than the devasting floods of April and June 1957 that were reported by the U.S. Department of Commerce (1958).

New maximum stages and discharges of record occurred at many streamflow-gaging stations as a result of an early May storm. Where possible, U.S. Geological Survey hydrologists made streamflow measurements near times of maximum stages. Streams that originated in the areas of greatest precipitation had 50-year or greater floods; many streams had 100-year or greater floods.

Most major rivers and their tributaries in the flooded area are regulated by U.S. Army Corps of Engineers projects including flood-control reservoirs, many of which have been in operation for more than 25 years. The pool elevations and contents of many of these reservoirs reached new record maximums during 1990. Because these reservoirs were full or nearly full when the early May storm occurred, they were unable to contain all the runoff from the storm although they did reduce maximum discharges. Therefore, as runoff from tributary streams reached the major rivers, flood discharges that exceeded maximum discharges since completion of the major reservoirs were recorded.

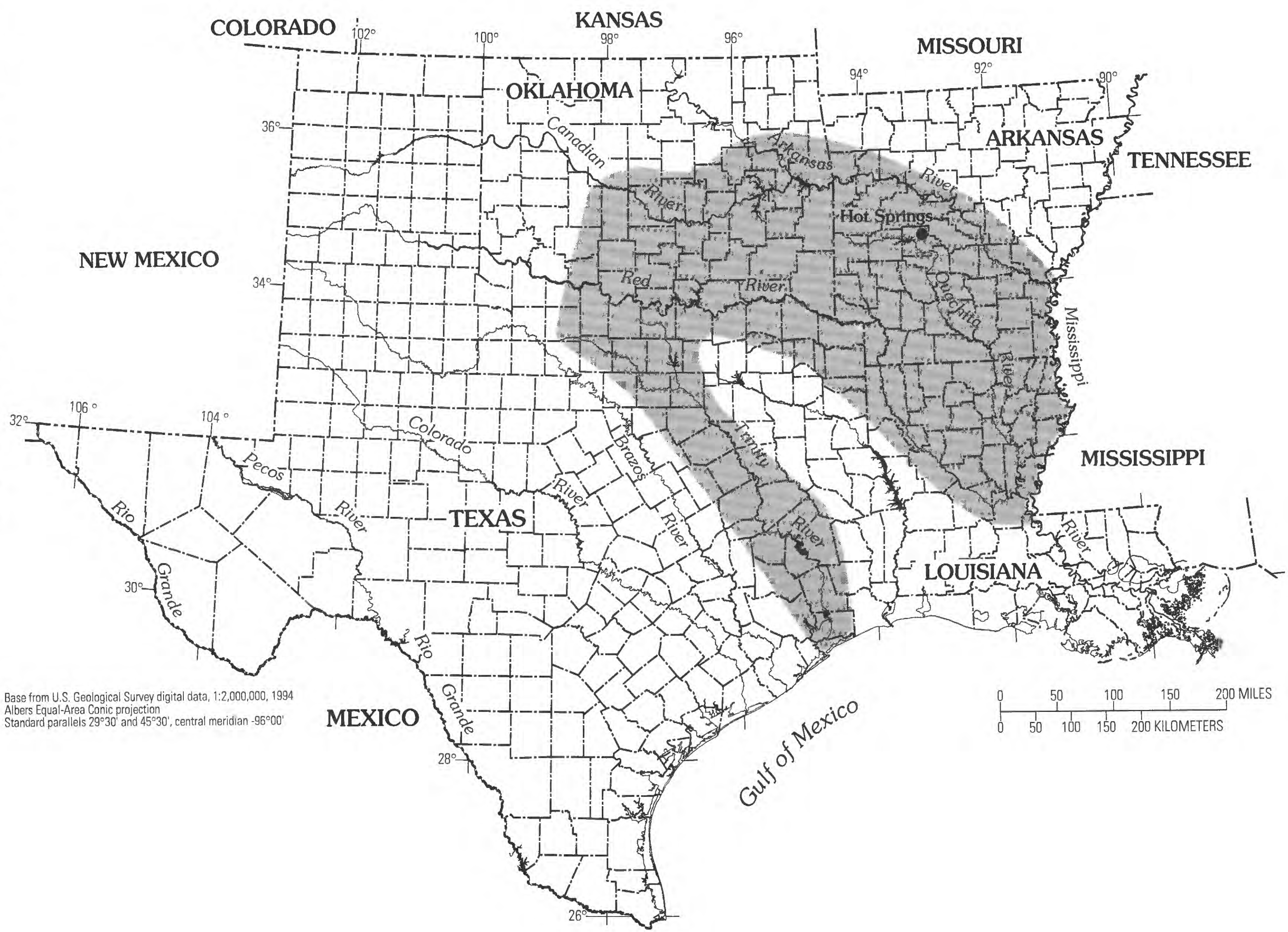
The flooding extended far downstream from the areas of excessive precipitation on the Arkansas, Red, and Trinity Rivers. The duration of flooding downstream was increased by reservoir releases prompted by the urgent need to decrease the record-high storage levels of the reservoirs.

A separate thunderstorm on May 19–20 produced 12.97 inches of rainfall in less than 24 hours and caused severe flooding in Hot Springs, Arkansas. The resulting maximum stage on the Ouachita River (tributary to the Red River) about 20 miles downstream from Hot Springs was the highest since 1923.

Seventeen deaths were attributed to the storms and subsequent flooding in the four-State area. In addition, economic losses were extensive; 131 counties were declared eligible for Federal disaster assistance totaling more than $53 million. Damages to public facilities, private property, and agricultural losses were estimated to be more than $1.3 billion. However, an estimated $4.5 billion in flood damages were prevented by U.S. Army Corps of Engineers flood-control projects (U.S. Army Corps of Engineers, 1991).

WEATHER SYNOPSIS

Two periods of excessive rainfall superimposed on the overall, wet-weather pattern provided the impetus for flooding. During the third week of April, a very strong low-pressure system entrenched itself over the Western United States. For several days, upper-level disturbances along and ahead of the center of the low pressure spawned thunderstorms in the region. During April 16–26, a series of slow-moving storms developed along a front that centered over southeastern Oklahoma and extended into northern Texas and western Arkansas. These storms delivered more than 8 inches of rainfall over the general area, the majority of which fell from April 18 through 20 and April 23 through 25. The late-April rains, falling on already



Base from U.S. Geological Survey digital data, 1:2,000,000, 1994
Albers Equal-Area Conic projection
Standard parallels 29°30' and 45°30', central meridian -96°00'

Figure 13. Location of area (shaded) affected by April–May 1990 flooding in the Arkansas, Red, and Trinity River Basins.

saturated soils, produced widespread flooding on many rivers and streams from April 18 through 19 and April 25 through 26.

On the morning of April 30, as the late-April floods were beginning to recede, another major storm system moved slowly through the region. The leading edge of an abnormal cold-air mass stalled on a line from northern Texas to southwestern Arkansas and remained stationary until May 3. During the 3-day period from May 1 through May 3, warm moist air that was lifted over the stationary cold front produced torrential rains, with some areas receiving more than 10 inches of rainfall. This caused record flooding in northern Texas, southeastern Oklahoma, and western Arkansas. Rain continued sporadically through mid-May. Cumulative daily rainfall from April 15 through May 19, 1990, averaged more than 16 inches in the flooded area and was more than 20 inches along the Arkansas-Oklahoma State line (figs. 14 and 15). Rainfall recorded at many individual precipitation data sites was even greater.

DESCRIPTION AND MEASUREMENT OF FLOODS

The description and measurement of floods are presented in two sections, "Stream Information" and "Reservoir Information," for each of the Arkansas, Red, and Trinity River Basins.

Arkansas River Basin

Unlike the flood of October 1986, which substantially affected most of eastern and north-central Oklahoma and eastern and south-central Kansas (Tortorelli and others, 1991), the floods of April and May 1990 in the Arkansas River Basin were confined primarily to east-central Oklahoma and central Arkansas (U.S. Army Corps of Engineers, 1990b,c).

Stream information

Several gaging stations on the Canadian and lower Arkansas Rivers and their tributaries recorded extremely high stages (table 9, fig. 16). The site at Baron Fork at Eldon (table 9, site 1) recorded a new maximum stage of record. The Canadian River at Calvin (site 3, above Eufaula Lake) and the Canadian River near Whitefield (site 5, below Eufaula Lake) nearly reached their maximum stages of record, which were established before Eufaula Lake (table 10, site 12) began storage in 1964.

The recorded stages of the Arkansas River near Van Buren, at Dardanelle, and at Little Rock (table 9, sites 7–9) were the highest since the completion of the McClellan-Kerr Navigation System in the late 1960's and were comparable to the 1957 Arkansas River flood (Lee, 1990; U.S. Army Corps of Engineers, 1990b,c).

Reservoir information

Flood-swollen streams contributed enormous inflow volumes to the reservoirs in the basin. The water-surface elevation of Tenkiller Ferry Lake (table 10, site 10) was the third highest since the May and June 1957 flood. Record-high elevations were recorded at Lake Thunderbird and Eufaula, Wister, Blue Mountain, and Nimrod Lakes (table 10, sites 11–15).

Water went over the Wister Lake spillway for the fourth time since the project's completion in 1949. The Eufaula Lake pool elevation rose into the induced surcharge storage (storage above the top of flood pool induced by regulating the opening of spillway gates) for the first time and lacked only 0.23 foot of completely filling that storage (U.S. Army Corps of Engineers, 1990c). The water surface rose above the 100-percent flood-pool storage level in Eufaula, Wister, Blue Mountain, and Nimrod Lakes (U.S. Army Corps of Engineers, 1990b,c). The flood storage of Eufaula Lake was at the 100-percent level on May 1, 1990, before the last rainstorm.

Red River Basin

Along most of the Red River main stem, from below Lake Texoma to just upstream of Alexandria (fig. 17), the floods of April and May 1990 exceeded those of 1957 (U.S. Army Corps of Engineers, 1990d) and were the largest since 1945 or earlier. This flood was the largest since 1987 in the upper Red River upstream of Lake Texoma and in the Washita River Basin.

Stream information

Red River tributaries including the Muddy Boggy Creek and the Little Wichita, Washita, Kiamichi, Mountain Fork, and Little Rivers, the upper Ouachita

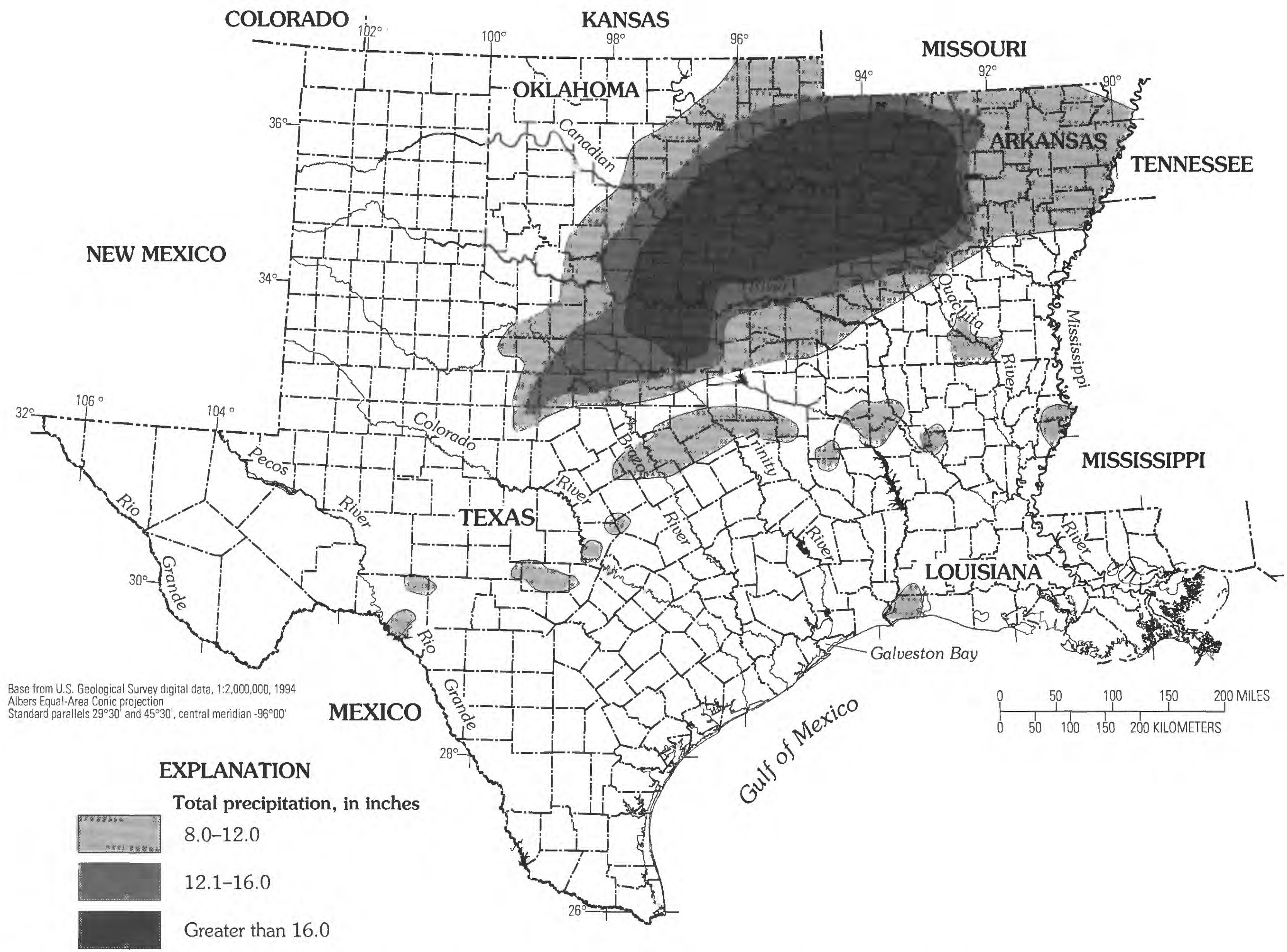


Figure 14. Total precipitation in and near flooded area for April 15 through May 19, 1990 (modified from Wahl, 1991).

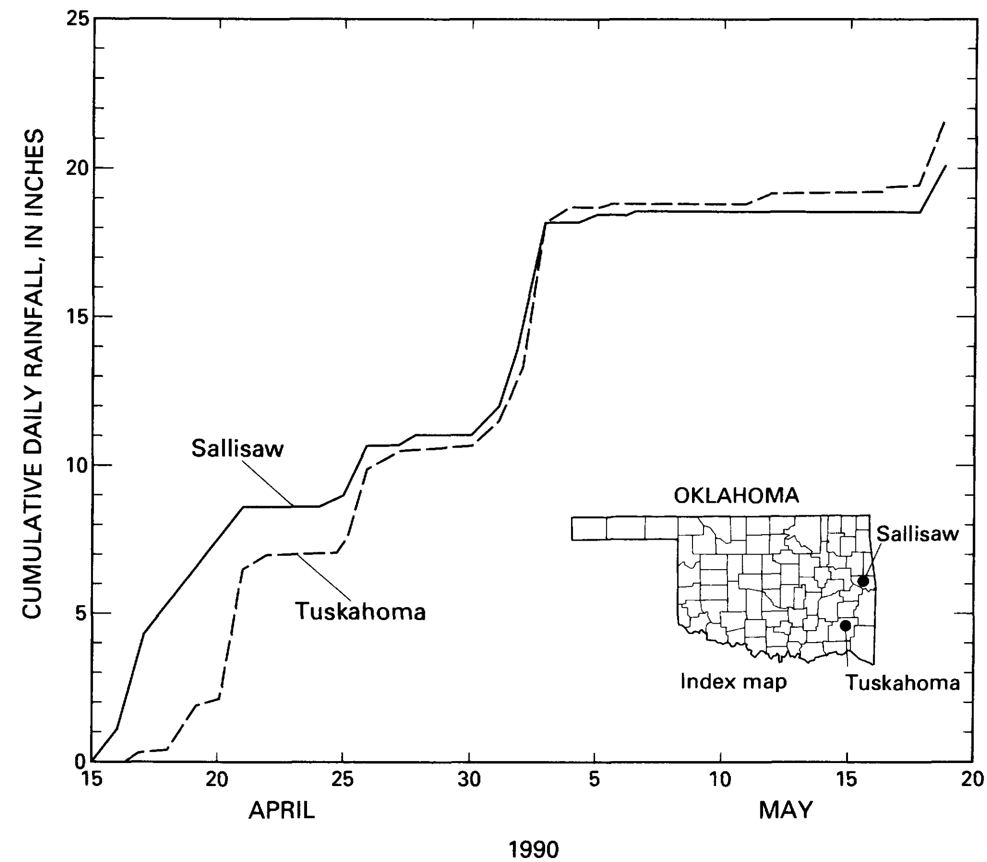


Figure 15. Cumulative daily rainfall for two southeastern Oklahoma precipitation data sites for April 15 through May 19, 1990 (data from National Oceanic and Atmospheric Administration, 1990a,b).

River, and the Red River main stem all had unusually high stages (table 11, sites 16–34). The flood-determination sites on the Washita River near Dickson, Muddy Boggy Creek at Unger, Kiamichi River near Clayton and near Antlers, and the Red River near DeKalb (table 11; sites 21, 23–24, 26–28) had new maximum stages and discharges of record. Flood-determination sites on the Red River downstream of Lake Texoma to Index, Arkansas, had the largest discharges since Lake Texoma was built in 1943 (table 11, sites 25, 28–29, 32–33).

Washita River near Dickson (site 21) also had the maximum discharge of record, despite several reservoirs and hundreds of U.S. Soil Conservation Service (SCS) floodwater-retarding structures (Federal Emergency Management Agency, 1990). The recorded stages of the Red River at Index (site 29), at Shreveport (site 32), and at Alexandria (site 33) were the highest since the April 1945 flood, which occurred shortly after Lake Texoma was built. The flood-determination site on the Ouachita River near Malvern (site 34) recorded the highest discharge for the period of record as a result of the mid-May rainstorm at and near Hot Springs, Arkansas.

Reservoir information

As in the Arkansas River Basin, the flood-swollen streams contributed enormous inflows to the reservoirs in the Red River Basin (fig. 17). Lake Texoma (table 12, site 37) had the highest flood-pool elevation since the May and June 1957 flood and established a new record. Record-high pool elevations also were experienced at Lake of the Arbuckles, McGee Creek Reservoir, and Sardis, Hugo, and Broken Bow Lakes (table 12, sites 36, 38, 40, 41, 43).

For the first time in the history of McGee Creek Reservoir and Sardis Lake, and for only the second time in the history of Lake Texoma, water went over the uncontrolled emergency spillways. Outflow from Lake Texoma was nearly 5 feet deep in the uncontrolled spillway and was a record outflow discharge. Hugo Lake crested only 0.5 foot below the uncontrolled spillway.

Table 9. Maximum stages and discharges prior to and during floods of April and May 1990 in the Arkansas River Basin, Oklahoma and Arkansas

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; >, greater than; --, not determined or not applicable. Source: Recurrence intervals calculated from U.S. Geological Survey data, except as noted. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to April 1990				Maximum during April and May 1990			
Site no. (fig. 16)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Date (month/day)	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
1	07197000	Baron Fork at Eldon, Okla.	307	1948–90	1986	25.78	55,500	5/3	25.91	57,600	100
2	07230500	Little River near Tecumseh, Okla.	456	1932–90	1932	25.58	60,000	5/3	18.28	14,000	[1]100
3	07231500	Canadian River at Calvin, Okla.	[2]27,952	1905–90	1950	17.35	174,000	5/3	18.97	146,000	25
4	07242000	North Canadian River near Wetumka, Okla.	[3]14,290	1937–90	1945	26.40	66,000	5/3	15.14	25,800	[1]10
5	07245000	Canadian River near Whitefield, Okla.	[4]47,576	1938–90	1943	25.50	281,000	5/3	25.32	241,000	[1]>100
6	07249413	Poteau River near Panama, Okla.	1,767	1935–90	1935	[5]44.6	--	5/3	41.59	74,600	--
7	07250550	Arkansas River at J.W. Trimble Lock and Dam near Van Buren, Ark	150,547	1833–1990	1943 1945	[6]38.0 [6]38.10	850,000	5/5	401.75	401,000	[5]50
8	07258000	Arkansas River at Dardanelle, Ark.	153,670	1933–90	1943	--	683,000	5/4	42.14	433,000	[5]55
9	07263450	Arkansas River at Murray Dam near Little Rock, Ark.	158,030	1833–1990	1933 1943	[6]34.6 [6]30.05	-- 536,000	5/7–8	256.97	406,000	[5]45

[1]Recurrence interval based on regulated period of record. [2]4,801 square miles noncontributing.
[3]4,899 square miles noncontributing. [4]9,700 square miles noncontributing.
[5]Estimated, U.S. Army Corps of Engineers. [6]At former site and datum.

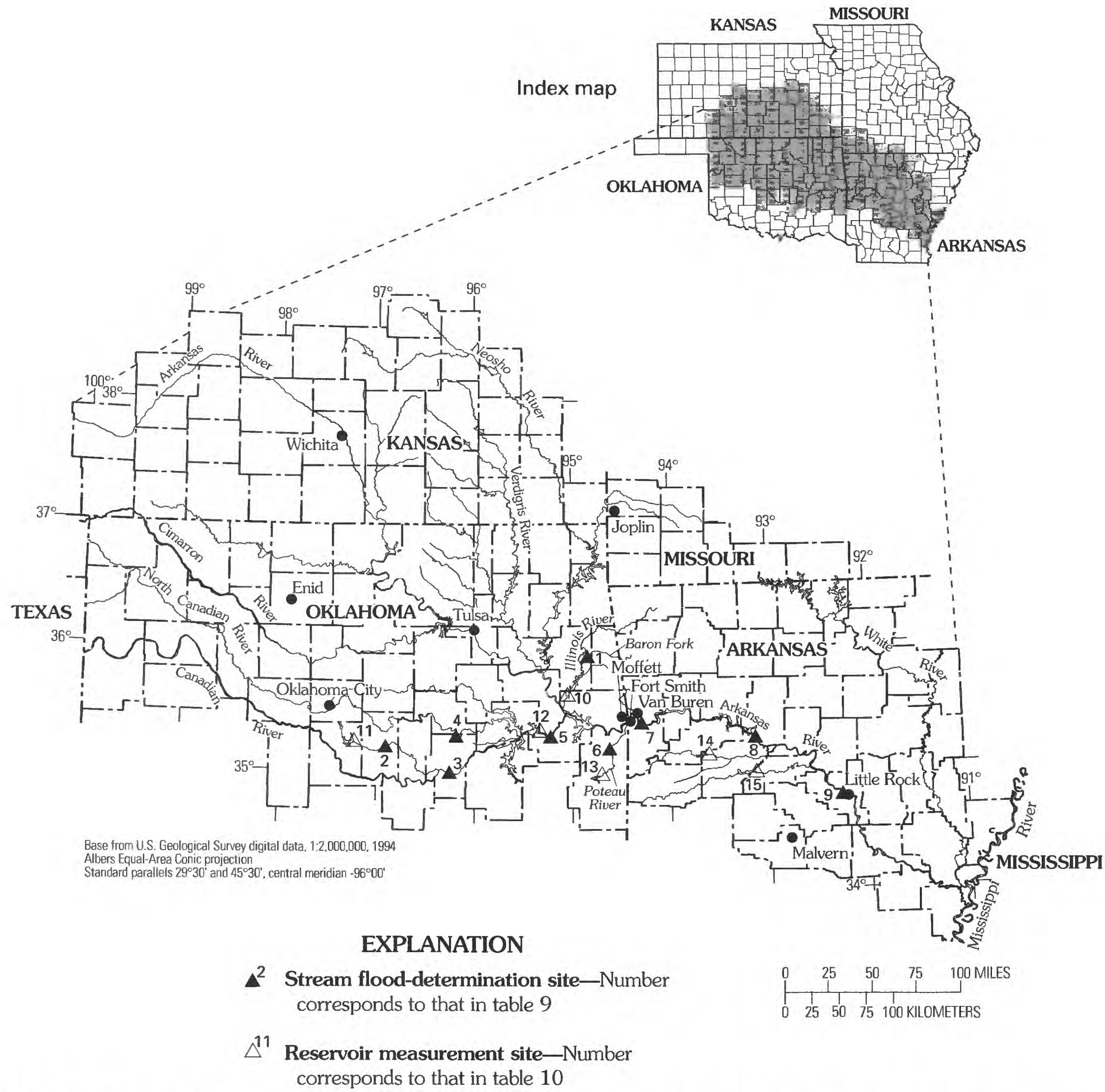


Figure 16. Location of flood-determination and reservoir measurement sites for floods of April and May 1990 in the Arkansas River Basin, Oklahoma and Arkansas.

Oklahoma has more than 2,500 SCS floodwater-retarding structures built to pass the 25-year, 10-day runoff through the principal spillway. During the floods of April and May 1990, more than 355 of the more than 600 structures in south-central and south-eastern Oklahoma had emergency spillway discharge. This exceeded the old record of 203 set during the May 1987 flood. The structures held back an estimated 0.5 million acre-feet of water (Federal Emergency Management Agency, 1990).

The flood-pool storage exceeded design quantities for Waurika Lake, Lake of the Arbuckles, McGee Creek Reservoir, and Sardis, Texoma, and Hugo Lakes (table 12, sites 35–38, 40–41) (U.S. Army Corps of Engineers, 1990b,c).

Table 10. Maximum elevations and contents of selected reservoirs prior to and during floods of April and May 1990 in the Arkansas River Basin, Oklahoma and Arkansas

[mi^2, square miles; ft, feet above sea level; acre-ft, acre-feet; --, not determined or not applicable. Source: Data from U.S. Geological Survey reports or data bases, except as noted]

					Maximum prior to April 1990			Maximum during April and May 1990			
Site no. (fig. 16)	Station no.	Reservoir name and location	Drainage area (mi^2)	Period	Year	Water-surface elevation (ft)	Contents (acre-ft)	Date (month /day)	Water-surface elevation (ft)	Contents (acre-ft)	Contents recurrence interval (years)
10	07197500	Tenkiller Ferry Lake near Gore, Okla.	1,610	1952–90	1957	666.36	1,218,000	5/6	662.52	1,140,000	--
11	07229900	Lake Thunderbird near Norman, Okla.	256	1965–90	1983	1,047.36	--	5/5	1,048.38	187,400	--
12	07244800	Eufaula Lake near Brooken, Okla.	[1]47,522	1964–90	1973	596.95	3,791,000	5/4	599.72	4,237,000	--
13	07248000	Wister Lake near Wister, Okla.	993	1949–90	1957	505.73	507,400	5/4	508.23	574,500	--
14	07259000	Blue Mountain Lake near Waveland, Ark.	488	1947–90	1957	422.53	298,430	5/4	425.19	331,460	[2]50
15	07262000	Nimrod Lake near Nimrod, Ark.	684	1942–90	1984	374.89	371,440	5/4	377.90	432,750	[2]50

[1]9,700 square miles noncontributing. [2]Estimated, U.S. Army Corps of Engineers.

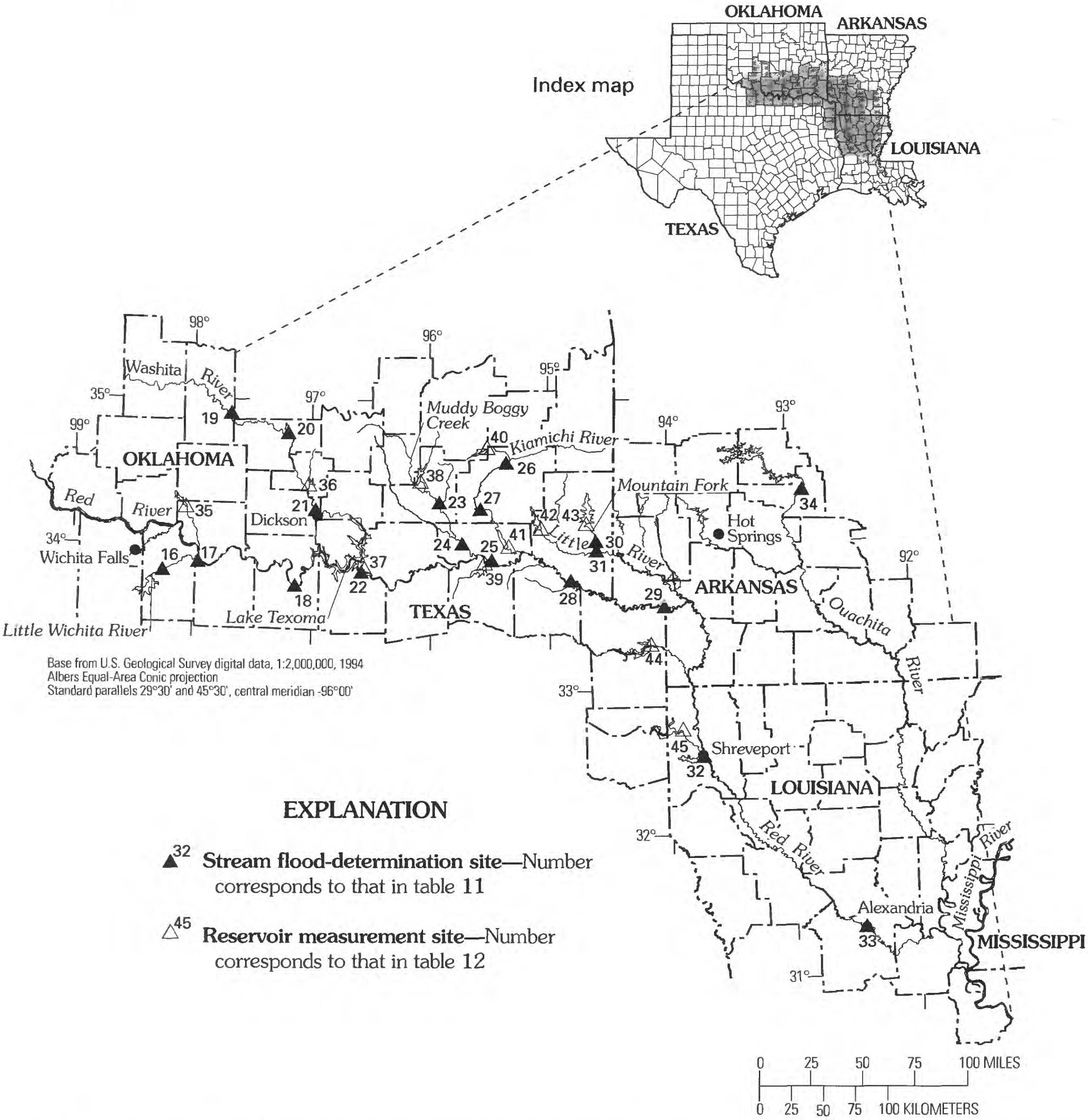


Figure 17. Location of flood-determination and reservoir measurement sites for floods of April and May 1990 in the Red River Basin.

Trinity River Basin

The floods of April and May 1990 in the Trinity River Basin (fig. 18) were among the three largest in this century at many measurement sites. The other largest floods occurred in May 1908 and April 1942 at those sites. The 1990 flood discharges in the Trinity River Basin were the largest since May 1957 or earlier at most sites in the basin.

Stream information

The upper Trinity River tributaries, including the West Fork, Elm Fork, and East Fork, and the Trinity River main stem all had large maximum discharges (table 13, sites 46–64). Discharges set new records at flood-determination sites on the West Fork of the Trinity River at Beach Street in Fort Worth and at Grand Prairie; the Elm Fork of the Trinity River at Gainesville and near Pilot Point; the East Fork of the Trinity

Table 11. Maximum stages and discharges prior to and during floods of April and May 1990 in the Red River Basin

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; >, greater than; --, not determined or not applicable. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to April 1990				Maximum during April and May 1990			
Site no. (fig. 17)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Date (month/day)	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
16	07314900	Little Wichita River above Henrietta, Tex.	1,037	1953–90	1966	--	7,630	5/3	24.96	14,200	>100
					1982	23.95	--				
17	07315500	Red River near Terral, Okla.	[1]28,723	1938–90	1987	32.65	225,000	5/4	23.78	115,000	15
18	07316000	Red River near Gainesville, Tex.	[1]30,782	1936–90	1987	40.08	265,000	5/5	33.13	134,000	[2]10
19	07328100	Washita River near Alex, Okla.	4,787	1964–90	1983	23.78	23,400	5/3	17.55	13,700	[2]10
20	07328500	Washita River near Pauls Valley, Okla.	5,330	1937–90	1987	28.72	43,600	5/3	20.35	28,000	[2]25
21	07331000	Washita River near Dickson, Okla.	7,202	1928–90	1987	45.24	105,000	5/3	44.26	118,000	[2]>100
22	07331600	Red River at Denison Dam, Tex.	[1]39,720	1923–90	1935	31.80	201,000	5/6	42.76	145,000	[2]>100
23	07334000	Muddy Boggy near Farris, Okla.	1,087	1937–90	1945	46.94	61,900	5/5	48.73	49,800	30
24	07335300	Muddy Boggy at Unger, Okla.	2,273	1982–90	1985	44.05	28,000	5/6	55.27	76,700	>100
25	07335500	Red River at Arthur City, Tex.	[1]44,531	1901–90	1908	43.20	400,000	5/4	34.21	275,000	[2]>100
26	07335790	Kiamichi River near Clayton, Okla.	708	1980–90	1981	20.21	24,800	5/4	22.23	40,200	[2]>100
27	07336200	Kiamichi River near Antlers, Okla.	1,138	1972–90	1977	38.33	50,000	5/3	42.65	62,300	[2]>100
28	07336820	Red River near DeKalb, Tex.	[1]47,348	1938–90	1957	32.20	205,000	5/6	34.42	279,000	[2]>100
29	07337000	Red River at Index, Ark.	[1]48,030	1918–90	1938	34.25	297,000	5/10	32.30	270,000	[3]100
30	07337900	Glover River near Glover, Okla.	315	1961–90	1971	29.72	98,600	5/3	26.27	70,100	20
31	07338500	Little River below Lukfata Creek near Idabel, Okla.	1,226	1946–90	1971	39.39	103,000	5/4	35.59	44,300	[2]25
32	07348500	Red River at Shreveport, La.	60,613	1928–90	1945	177.38	303,000	5/14	165.46	238,000	--
33	07355500	Red River at Alexandria, La.	67,500	1928–90	1945	89.46	233,000	5/20	83.56	[3]230,000	--
34	07359500	Ouachita River near Malvern, Ark.	1,585	1923–90	1923	30.3	140,000	5/20	29.0	[4]166,000	--

[1]5,936 square miles noncontributing. [2]Recurrence invertal based on period of regulated discharge.
[3]Estimated, U.S. Army Corps of Engineers. [4]Based on measurement 5.8 miles upstream, drainage area 1,549 square miles.

Table 12. Maximum elevations and contents of selected reservoirs prior to and during floods of April and May 1990 in the Red River Basin

[mi[2], square miles; ft, feet above sea level; acre-ft, acre-feet; --, not determined or not applicable. Source: Data from U.S. Geological Survey reports or data bases]

Site no. (fig. 17)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to April 1990				Maximum during April and May 1990		
				Period	Year	Water-surface elevation (ft)	Contents (acre-ft)	Date (month/day)	Water-surface elevation (ft)	Contents (acre-ft)
35	07313400	Waurika Lake near Waurika, Okla.	562	1977–90	1987	964.14	368,600	5/4	962.50	343,500
36	--	Lake of the Arbuckles near Dougherty, Okla.	126	1967–90	1976	885.80		5/3	888.99	--
37	07331500	Lake Texoma near Denison, Tex.	[1]39,719	1942–90	1957	643.18	5,991,300	5/6	644.76	6,028,000
38	--	McGee Creek Reservoir near Farris, Okla.	178	1987–90	1990	593.14	--	5/3	601.94	--
39	07335390	Pat Mayse Lake near Chicota, Tex.	175	1967–90	1971	462.87	208,000	5/5	459.73	183,000
40	07335775	Sardis Lake near Clayton, Okla.	275	1982–90	1984	603.84	345,400	5/3–4	612.14	489,300
41	07336600	Hugo Lake near Hugo, Okla.	1,709	1974–90	1982	425.00	577,800	5/6	440.05	1,056,000
42	07337300	Pine Creek Lake near Wright City, Okla.	835	1969–90	1984	473.13	356,000	5/7,8	472.84	352,300
43	07338900	Broken Bow Lake near Broken Bow, Okla.	754	1968–90	1984	620.40	1,244,000	5/23	622.64	1,283,000
44	07344200	Wright Patman Lake near Texarkana, Tex.	3,443	1953–90	1966	252.64	1,912,100	5/25	252.17	1,867,000
45	07345900	Lake O' the Pines near Jefferson, Tex.	850	1957–90	1966	245.41	694,360	5/21	237.38	452,300

[1]5,936 square miles noncontributing.

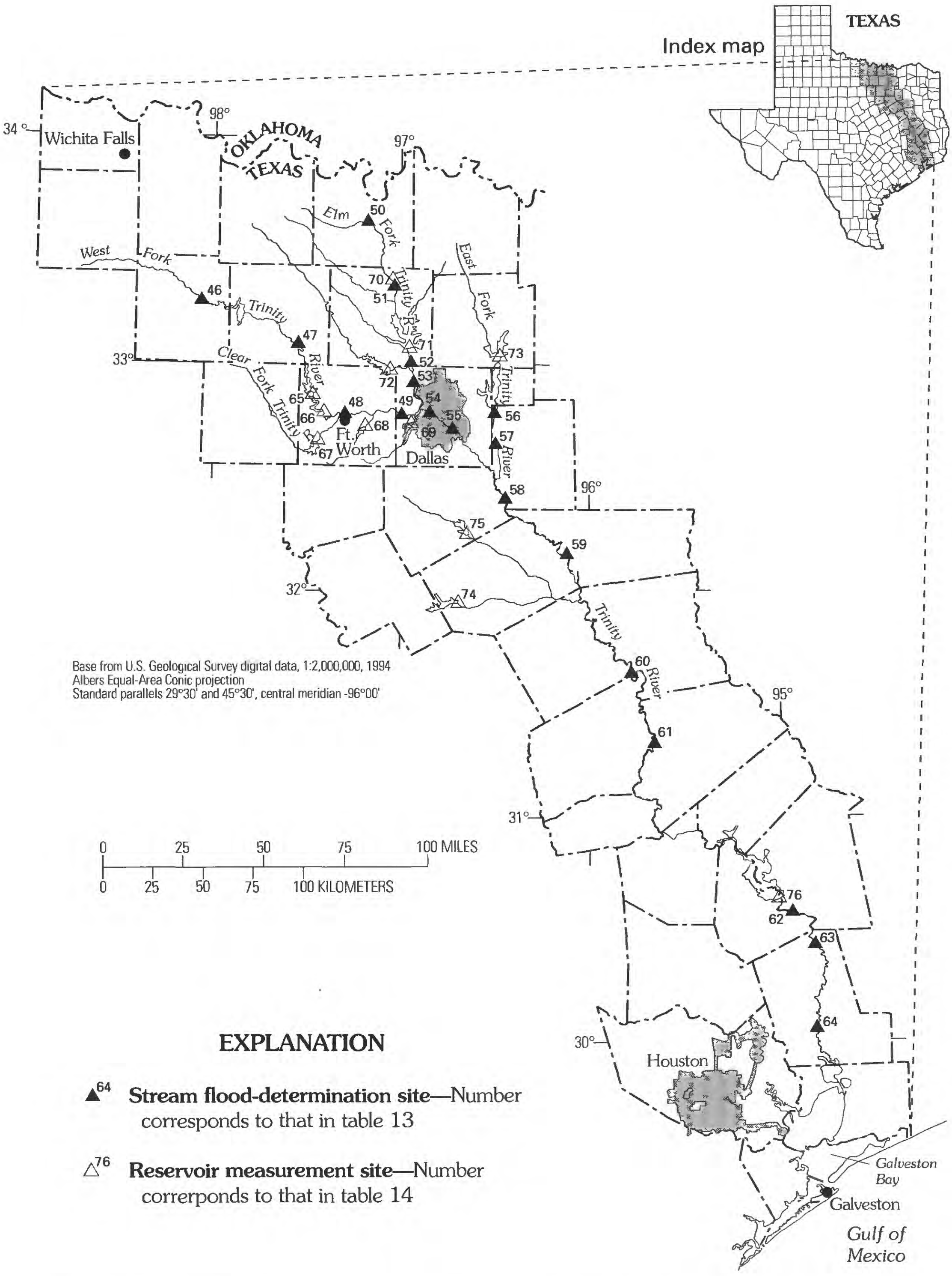


Figure 18. Location of flood-determination and reservoir measurement sites for floods of April and May 1990 in the Trinity River Basin, Texas.

River near Forney and near Crandall; and the Trinity River below Dallas, at Trinidad, near Crockett, and near Goodrich (table 13, sites 48–51, 55–57, 59, 61–62).

Reservoir information

The flood-swollen streams contributed enormous inflows to reservoirs in the basin (fig. 18). Record-high pool elevations were recorded at Lake Worth,

Table 13. Maximum stages and discharges prior to and during floods of April and May 1990 in the Trinity River Basin, Texas

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; >, greater than; --, not determined or not applicable. Source: Recurrence intervals calculated from U.S. Geological Survey, except as noted. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to April 1990				Maximum during April and May 1990			
Site no. (fig. 18)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Date (month/ day)	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
46	08042800	West Fork Trinity River near Jacksboro, Tex.	683	1900–90	1957	32.10	35,100	4/27	28.21	21,800	10
47	08044500	West Fork Trinity River near Boyd, Tex.	1,725	1947–90	1981	25.87	60,400	4/26	24.19	41,800	50
48	08048543	West Fork Trinity River at Beach Street, Ft. Worth, Tex.	2,685	1976–90	1981	36.26	26,700	5/2	38.02	46,600	[1]45
49	08049500	West Fork Trinity River at Grand Prairie, Tex.	3,065	1925–90	1949	28.00	62,000	5/3	33.88	64,400	[1]50–100
50	08050400	Elm Fork Trinity River at Gainesville, Tex.	174	1985–90	1989	25.33	24,000	5/2	22.80	21,300	--
51	08051130	Elm Fork Trinity River near Pilot Point, Tex.	692	1985–90	1987	15.76	3,290	5/3	27.33	8,190	--
52	08053000	Elm Fork Trinity River near Lewisville, Tex.	1,673	1949–90	1950	30.75	21,700	5/4	30.15	19,600	--
53	08055500	Elm Fork Trinity River near Carrollton, Tex.	2,459	1907–90	1908	19.0	[1]145,000	5/5	13.48	27,600	--
54	08057000	Trinity River at Dallas, Tex.	6,106	1840–1990	1908	52.6	184,000	5/3	47.10	82,300	[1]50–100
55	08057410	Trinity River below Dallas, Tex.	6,278	1961–90	1957	32.02	65,700	5/4	34.79	87,000	[1]50–100
56	08061750	East Fork Trinity River near Forney, Tex.	1,118	1973–90	1989	20.96	42,700	5/3	22.01	53,000	--
57	08062000	East Fork Trinity River near Crandall, Tex.	1,256	1949–90	1957	22.81	33,000	5/5	27.17	59,900	[1]>100
58	08062500	Trinity River near Rosser, Tex.	8,146	1938–90	1942	41.55	150,000	5/4	37.88	122,000	[1]50–100
59	08062700	Trinity River at Trinidad, Tex.	8,538	1964–90	1989	43.49	89,300	5/7	48.11	94,500	[1]50
60	08065000	Trinity River near Oakwood, Tex.	12,833	1890–1990	1890	51.64	180,000	5/7	49.61	107,000	[1]25
61	08065350	Trinity River near Crockett, Tex.	13,911	1964–90	1969	52.24	78,000	5/10	48.54	109,000	[1]25
62	08066250	Trinity River near Goodrich, Tex.	16,844	1965–90	1973	46.36	96,200	5/21	46.80	107,000	[1]50
63	08066500	Trinity River at Romayor, Tex.	17,186	1924–90	1942	35.80	111,000	5/21	41.58	105,000	[1]50
64	08067000	Trinity River at Liberty, Tex.	17,468	1903–90	1942	29.38	114,000	5/23	30.03	106,000	[1]50

[1]Estimated by U.S. Army Corps of Engineers.

Benbrook, Joe Pool, Ray Roberts, Lewisville, Lavon, and Bardwell Lakes, and Livingston Reservoir (table 14, sites 66–67, 69–71, 73, 75–76).

The flood-pool storage exceeded design quantities for four Dallas/Fort Worth area lakes—Ray Roberts, Lewisville, Grapevine, and Lavon (table 14, sites 70–73; U.S. Army Corps of Engineers, 1990a). The maximum stage of the Trinity River at Dallas was reduced about 13 feet by the operation of U.S. Army Corps of Engineers reservoirs in the upper Trinity River Basin (Jensen, 1990). Figure 19 shows a comparison of the April and May 1990 flood with other major floods in Dallas during this century and illustrates that the maximum discharge would have been about three times as great without flood-control reservoirs in place. About 250 SCS structures in Montague County also attenuated the flood discharges.

FLOOD DAMAGES

People and property in the flood areas suffered extensive individual, public facility, agricultural, and other damages. Individual damages included loss of life and damage to homes and businesses. Public-facility damages included damage to roads, bridges, and other public facilities, such as waste-treatment plants. Agricultural damages included loss of soil due to erosion, loss of crops, and loss of livestock. Other damages included items such as loss of tourism and damage to the environment.

Oklahoma

Three individuals died due to flood-related causes in Oklahoma (Federal Emergency Management Agency, 1990). The Federal Emergency Management Agency (FEMA) provided disaster assistance in 39 Oklahoma counties (table 15). FEMA provided $1.8 million for individuals and businesses and $6.0 million for public facilities (Smith, 1990c).

An estimate of damaged or destroyed private property is presented in table 16. The town of Moffett, Oklahoma, on the Arkansas River just upstream of Fort Smith, Arkansas, was inundated, with damage to more than 190 homes and damage to schools and businesses (Beard, 1990).

The Washita River, a Red River tributary, had record flows near Dickson. Just downstream from that site, the Burlington Railroad bridge near Ravia was in danger of being destroyed by floodwaters. The railroad parked fifteen 100-ton cars filled with granite boulders on its trestle over the Washita River to anchor the bridge; water reached 6 feet up on the cars (Beard, 1990).

Texas

Thirteen people died due to flood-related causes in Texas (McCartney, 1990). FEMA provided disaster assistance in 68 Texas counties (table 17)—$18 million for individuals and businesses and $12 million for public facilities (Smith, 1990a).

An estimated $500-700 million in flood-related agricultural losses occurred statewide as crops were flooded and livestock were drowned. With the addition of soil erosion, damage to the environment, losses to recreation, and property destruction, the total flood losses could be as high as $1 billion. Because the floods came just after farmers had plowed their fields to plant crops, erosion was especially extensive. As much as 5 tons of soil per acre (soil thickness of a dime) eroded from Texas croplands. Flooding near the Red River caused soil loss of as much as 30 tons per acre (Jensen, 1990). The effects of the flood reached far into Galveston Bay where floodwaters diluted the saline water so much that an estimated one-half of the oyster crop was lost, at an estimated cost of about $12 million (Jensen, 1990).

Flood losses to individuals and family services resulted in 1,150 approved grants for a total of $4.12 million. The storm runoff caused extensive damage to urban areas in the Trinity River Basin, especially in the Dallas/Fort Worth metroplex. Much of the worst flooding was in south Dallas areas that were not protected by levees. However, flood damages in the Dallas area could have been much worse if upstream flood-control reservoirs had not existed (fig. 19).

Arkansas

One person died of flood-related causes in Arkansas (Lee, 1990). FEMA provided disaster assistance in 24 Arkansas counties (table 18)—$10 million for individuals and businesses and $5.5 million for public facilities (Smith, 1990b). Total losses in Arkansas were estimated to exceed $250 million. Private-property damage (residential, commercial, farm facilities,

Table 14. Maximum elevations and contents of selected reservoirs prior to and during floods of April and May 1990 in the Trinity River Basin, Texas

[mi^2, square miles; ft, feet above sea level; acre-ft, acre-feet; >, greater than; --, not determined or not applicable. Source: Data from U.S. Geological Survey reports or data bases, except as noted]

				Maximum prior to April 1990				Maximum during April and May 1990			
Site no. (fig. 18)	Station no.	Reservoir and location	Drainage area (mi^2)	Period	Year	Water-surface elevation (ft)	Contents (acre-ft)	Date (month/day)	Water-surface elevation (ft)	Contents (acre-ft)	Contents recurrence interval (years)
65	08045000	Eagle Mountain Reservoir above Ft. Worth, Tex.	1,970	1934–90	1942	659.90	333,500	5/4	657.08	260,600	[1]90
66	08045400	Lake Worth above Ft. Worth, Tex.	2,064	1981–90	1981	598.23	53,900	5/3	598.70	56,040	[1]50
67	08046500	Benbrook Lake near Benbrook, Tex.	429	1952–90	1989	716.60	206,000	5/3	717.54	212,200	[1]>100
68	08049200	Lake Arlington at Arlington, Tex.	143	1957–90	1989	562.42	60,580	5/3	560.24	65,920	[1]20
69	08049800	Joe Pool Lake near Duncanville, Tex.	232	1985–90	1989	529.00	234,400	5/20	533.21	274,600	[1]30
70	08051100	Ray Roberts Lake near Pilot Point, Tex.	692	1987–90	1989	628.46	687,700	5/3	644.48	1,219,000	[1]250
71	08052800	Lewisville Lake near Lewisville, Tex.	1,660	1954–90	1981	536.46	1,168,000	5/4	536.73	1,181,000	[1]90
72	08054500	Grapevine Lake near Grapevine, Tex.	695	1952–90	1981	563.29	471,200	5/4	562.96	464,300	[1]60
73	08060500	Lavon Lake near Lavon, Tex.	770	1953–90	1989	503.62	751,600	5/3	504.93	791,000	[1]>100
74	08063050	Navarro Mills Lake near Dawson, Tex.	320	1962–90	1968	440.36	183,300	5/21	438.63	160,100	--
75	08063700	Bardwell Lake near Ennis, Tex.	178	1965–90	1969	432.35	103,300	5/22	434.54	112,100	--
76	08066190	Livingston Reservoir near Goodrich, Tex.	16,583	1968–90	1983	132.88	1,948,000	5/20	133.24	1,979,000	--

[1]Estimated by U.S. Army Corps of Engineers.

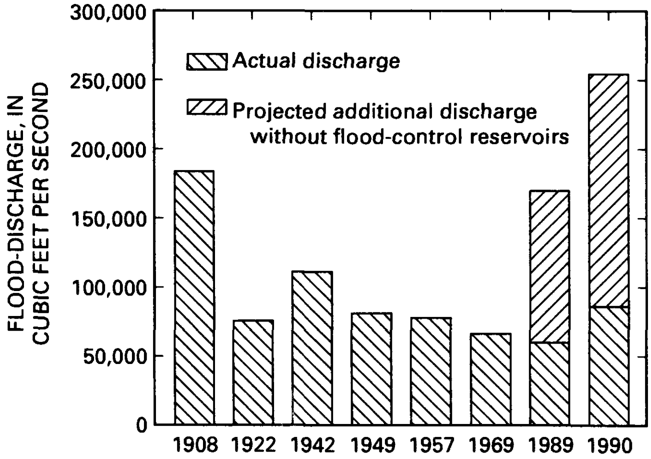


Figure 19. Significant flooding of the Trinity River at Dallas, with comparison of actual discharges and projected discharges without flood-control reservoirs (source: Jensen, 1990).

Table 15. Oklahoma counties and a city receiving disaster assistance for the floods of April and May 1990

[Information from U.S. Army Corps of Engineers, 1990c]

Adair	Haskell	McIntosh
Atoka	Hughes	Murray
Bryan	Jefferson	Okmulgee
Caddo	Johnston	Payne
Carter	Kingfisher	Pittsburg
Cherokee	Latimer	Pontotoc
Choctaw	LeFlore	Pottawatomie
Cleveland	Lincoln	Pushmataha
Coal	Logan	Roger Mills
Cotton	Love	Seminole
Delaware	Marshall	Sequoyah
Ellis	McClain	Stephens
Garvin	McCurtain	
The City of Bethany, Oklahoma County		

Table 16. Private-property damage in Oklahoma caused by the floods of April and May 1990

[Data from U.S. Army Corps of Engineers, 1990c]

	Number of		
	Houses	Mobile homes	Apartments
Destroyed	59	39	46
Major damage	290	32	107
Minor damage	437	15	169

Table 17. Texas counties receiving disaster assistance for the floods of April and May 1990

[Information from the U.S. Army Corps of Engineers, 1990a]

Anderson	Henderson	Pinto
Angelina	Hill	Polk
Archer	Hood	Raines
Bosque	Houston	Red River
Bowie	Hunt	San Jacinto
Callahan	Jack	Shackelford
Cass	Johnson	Somervell
Cherokee	Jones	Taylor
Clay	Kaufman	Tarrant
Collin	Knox	Throckmorton
Commanche	Lamar	Tom Green
Cooke	Leon	Trinity
Cottle	Liberty	Upton
Dallas	Limestone	Van Zandt
Denton	McLennon	Walker
Eastland	Maverick	Wharton
Ellis	Mills	Wichita
Erath	Montague	Wise
Fannin	Motley	Young
Foard	Navarro	Brown
Freestone	Palo	Hansford
Grayson	Parker	Ochiltree
Hamilton	Pecos	

crops, and livestock) in Arkansas was estimated at $35.4 million (U.S. Army Corps of Engineers, 1990b). Flood losses along the Red River were mostly agricultural—$5.4 million in land, $1.5 million in cattle, $1.8 million in levee damage, and about $750,000 to homes (Brown, 1991).

Louisiana

There were no serious injuries or deaths because of the flooding. Disaster assistance was requested from FEMA for 11 parishes affected by the flooding of the Red River in Lousiana (table 19). Agricultural and rural-development damages accounted for almost all of the flood losses in the State, and the Governor of Louisiana applied for an agricultural-disaster declaration from the U.S. Department of Agriculture for these 11 parishes in early May (Morning Advocate, 1990). In August, he requested an additional 16 parishes be added to the declaration (Buddy Roemer, Governor, State of Louisiana, written commun., 1990).

Table 18. Arkansas counties receiving disaster assistance for the floods of April and May 1990

[Information from U.S. Army Corps of Engineers, 1990b]

Benton	Jefferson	Pulaski
Boone	Johnson	Scott
Carroll	Little River	Sepastian
Clay	Logan	Yell
Columbia	Madison	
Crawford	Marion	
Faulker	Miller	
Franklin	Newton	
Garland	Perry	
Hot Springs	Polk	

Table 19. Louisiana parishes included in agricultural-disaster request following the floods of April and May 1990

[Information from Morning Advocate, 1990]

Avoyelles	Grant
Bossier	Natchitoches
Caddo	Rapides
Catahoula	Red River
Concordia	Winn
DeSoto	

The total area affected by flooding in Louisiana was about 700,000 acres, about 350,000 acres of which were cleared agricultural lands (U.S. Army Corps of Engineers, 1990d). More than $10 million in agricultural losses were attributed to the flood. Some parish roads were affected by the flooding; no interstate or major highways were damaged.

EFFECTIVENESS OF FLOOD-CONTROL RESERVOIRS

The flood-control systems in the four-State area were effective in reducing flood damages. Flows and releases from the complex reservoir systems were balanced and managed according to reservoir operations plans. This task required coordination among weather forecasters, onsite reservoir operators, and reservoir control engineers (U.S. Army Corps of Engineers, 1990c).

To illustrate the effectiveness of the reservoir operations during the April and May 1990 flood, the maximum inflows and the maximum outflows of nine critical reservoirs are listed below:

Site no. (fig. 16 or 17)	Reservoir	Flows (cubic feet per second): Maximum inflow[1]	Flows (cubic feet per second): Maximum outflow[1]
	Arkansas River Basin		
10	Tenkiller Ferry Lake, Okla.	70,000	12,000
12	Eufaula Lake, Okla.	430,000	230,000
13	Wister Lake, Okla.	100,000	25,000
	Red River Basin		
35	Waurika Lake, Okla.	23,000	2,600
36	Lake of the Arbuckles, Okla.	27,000	4,200
37	Lake Texoma, Tex.	300,000	132,000
38	McGee Creek Reservoir, Okla.	32,000	7,200
40	Sardis Lake, Okla.	114,000	5,500
41	Hugo Lake, Okla.	120,000	35,000

[1]Data from U.S. Army Corps of Engineers, 1990c.

Damages prevented by U.S. Army Corps of Engineers projects totalled about $220 million in Oklahoma, $4.2 billion in Texas, and $192 million in Arkansas (U.S. Army Corps of Engineers, 1991). The U.S. Army Corps of Engineers and local-interest levee systems protected 1.3 million acres of land in Louisiana during the flood on the Red River (U.S. Army Corps of Engineers, 1990d).

SELECTED REFERENCES

Arcement, G.J., Dantin, L.J., Garrison, C.R., and Lovelace, W.M., 1991, Water resources data, Louisiana, water year 1990: U.S. Geological Survey Water-Data Report LA–90–1, 419 p.

Beard, E.R., 1990, Monthly report of river and flood conditions—May 1990: Norman, Okla., National Weather Service, Hydrologic Service Office, 6 p.

Blazs, R.L., Walters, D.M., Coffey, D.K., and Boyle, D.L., 1991, Water resources data, Oklahoma, water year 1990: U.S. Geological Survey Water-Data Report OK–90–1, 517 p.

Brown, M.J., 1991, Rampaging Red cost Arkansans $14 million in '90: Little Rock, Ark., Arkansas Democrat, no. 170, March 20, 1991, p. 10B.

Buckler, H.D., and Shelby, W.J., 1991, Water resources data, Texas, water year 1990, volume 1. Arkansas River Basin, Red River Basin, Sabine River Basin, Neches River Basin, Trinity River Basin and intervening coastal basins: U.S. Geological Survey Water-Data Report TX–90–1, 453 p.

Ely, G.L., 1990, Monthly report of river and flood conditions—May 1990: Fort Worth, Tex., National Weather Service, Hydrologic Service Area, 2 p.

Ethridge, E.S., 1990, Monthly report of river and flood conditions—May 1990: Shreveport, La., National Weather Service, Hydrologic Service Area, 11 p.

Federal Emergency Management Agency, 1990, Interagency hazard mitigation report: Region VI, FEMA–866–OK, 29 p.

Fink, Jerry, 1990, State flood information already being compiled: Tulsa, Okla., Tulsa World, v. 85, no. 231, May 5, 1990, p. A–1.

Griffiths, J.F., 1990, Texas—May 1990, Special weather summary, *in* Climatological data—Texas, May 1990: Asheville, N.C., National Climatic Data Center, v. 95, no. 5, no pagination.

Jensen, Ric, 1990, Finding answers to flooding woes: Texas Water Resources Institute, Texas Water Resources, v. 16, no. 3, 6 p.

Jones, B.D., 1991, Texas—Floods and droughts, *in* National water summary 1988–89—Hydrologic events and floods and droughts: U.S. Geological Survey Water-Supply Paper 2375, p. 513–520.

Lee, A.B., 1990, Monthly report of river and flood conditions—May 1990: Little Rock, Ark., National Weather Service, Hydrologic Service Area, 2 p.

Lee, F.N., Muller, R.A., and Cox, R.R., 1991, Louisiana—Floods and droughts, *in* National water summary 1988–89—Hydrologic events and floods and droughts: U.S. Geological Survey Water-Supply Paper 2375, p. 303–310.

Louisiana Office of State Climatology, 1990, Louisiana—monthly climate review—May 1990: Baton Rouge, Louisiana State University, v. 10, no. 5, 5 p.

McCartney, S., 1990, Flood control projects spared urban areas, experts say: Oklahoma City, Okla., Daily Oklahoman, v. 99, no. 138, May 23, 1990, p. 1.

Morning Advocate, 1990, Farmland damage said $10 million: Baton Rouge, La., May 24, 1990, p. 1B–2B.

National Oceanic and Atmospheric Administration, 1990a, Climatological data, Oklahoma, April 1990: Asheville, N.C., National Climatic Data Center, v. 99, no. 4, p. 8–9.

_____1990b, Climatological data, Oklahoma, May 1990: Asheville, N.C., National Climatic Data Center, v. 99, no. 5, p. 8–9.

Neely, B.L., Jr., Hehr, J.G., and Young, J.R., 1991, Arkansas—Floods and droughts, *in* National water summary 1988–89—Hydrologic events and floods and droughts: U.S. Geological Survey Water-Supply Paper 2375, p. 189–196.

Oklahoma Climatogical Survey, 1991, Oklahoma annual summary 1990: Norman, Okla., Oklahoma Climatogical Survey, 31 p.

Porter, J.E., Westerfield, P.W., and Lambert, B.F., 1991, Water resources data, Arkansas, water year 1990: U.S. Geological Survey Water-Data Report AR–90–1, 585 p.

Radlein, R., 1990, Monthly report of river and flood conditions—May 1990: New Orleans, La., National Weather Service, River District Office, 2 p.

Southard, R.E., 1992, Flood of May 19–20, 1990, in the vicinity of Hot Springs, Arkansas: U.S. Geological Survey Water-Resources Investigations Report 92–4007, 22 p.

Smith, R., 1990a, Texas disaster office closes: Federal Emergency Management Agency, Region 6 News Release, August 16, 1990, 1 p.

_____1990b, Disaster assistance totals released—Arkansas: Federal Emergency Management Agency, Region 6 News Release, August 23, 1990, 1 p.

_____1990c, Disaster assistance totals released—Oklahoma: Federal Emergency Management Agency, Region 6 News Release, August 23, 1990, 1 p.

Tortorelli, R.L., Cooter, E.J., and Schulein, J.W., 1991, Oklahoma—Floods and droughts, *in* National water summary 1988–89—Hydrologic events and floods and droughts: U.S. Geological Survey Water-Supply Paper 2375, p. 451–458.

U.S. Army Corps of Engineers, 1990a, Report on flooding April–May 1990: Fort Worth District, 64 p.

_____1990b, After action flood report May 1990 event—Arkansas, White, and Red River Basins, Arkansas and Missouri: Little Rock District, 18 p.

_____1990c, After action flood report April–May 1990—Southeastern Oklahoma, northeastern Texas: Tulsa District, 28 p.

_____1990d, After action flood report, flood of May 1990—Red River Basin, Louisiana: Vicksburg District, 17 p.

_____1991, Annual report 1990: Southeastern Division, Reservoir Control Center, various pagination.

U.S. Department of Commerce, 1958, Rainfall and floods of April, May, June 1957 in the south-central States: Weather Bureau Technical Paper 33, 350 p.

_____1991, Disastrous floods on the Trinity, Red, and Arkansas Rivers May 1990: National Weather Service Natural Disaster Report, various pagination.

Wahl, K.L., 1991, Flooding in the Arkansas, Red, and Trinity River Basins in 1990: U.S. Geological Survey Yearbook 1990, p. 51–53.

Wright, J., 1990, April–May 1990 flood event at Bureau of Reclamation reservoirs (flood control): U.S. Bureau of Reclamation, Oklahoma-Texas Project Office Memorandum, 2 p.

Flood of May 12–17, 1990, in Southern Mississippi

By W. Trent Baldwin

From May 12 through May 13, 1990, a storm swept through southern Mississippi, producing rainfall totals in excess of 8 inches in some areas (fig. 20). Almost all of the rain fell in an 18-hour period beginning at noon on May 12. Collins, located in south-central Mississippi, recorded 9.5 inches of rain in a 12-hour period. The 100-year, 12-hour rainfall at Collins is about 8.5 inches according to a map by Hershfield (1961). Cumulative rainfall for May 12–13 at selected precipitation data sites is shown in figure 21.

As a result of the excessive rainfall, substantial flooding occurred. Maximum stages and discharges were documented at 25 flood-determination sites in southern Mississippi (fig. 20) and are summarized in table 20. At Bouie Creek near Hattiesburg (site 2), the flood that resulted from this storm was the largest since 1974 and the third largest in 52 years. At White Sand Creek near Oak Vale (site 20), the flood was the largest since 1974 and the second largest in 25 years.

Damage from the flood was extensive. Approximately 50 homes in Petal were virtually destroyed by floodwater from the Leaf River and Bouie Creek, more than 150 homes were affected by flooding in six counties in southern Mississippi, and total damage caused by this flood was estimated at more than $800,000 (Larry Bowman, Federal Emergency Management Agency, oral commun., 1991).

REFERENCES

Hershfield, D.M., 1961, Rainfall frequency atlas of the United States: U.S. Department of Commerce, Weather Bureau, Technical Paper no. 40, 115 p.

National Oceanic and Atmospheric Administration, 1990a, Climatological data, Mississippi, May 1990: Asheville, N.C., National Climatic Data Center, v. 95, no. 5, 23 p.

_____1990b, Hourly precipitation data, Mississippi, May 1990: Asheville, N.C., National Climatic Data Center, v. 40, no. 5, 16 p.

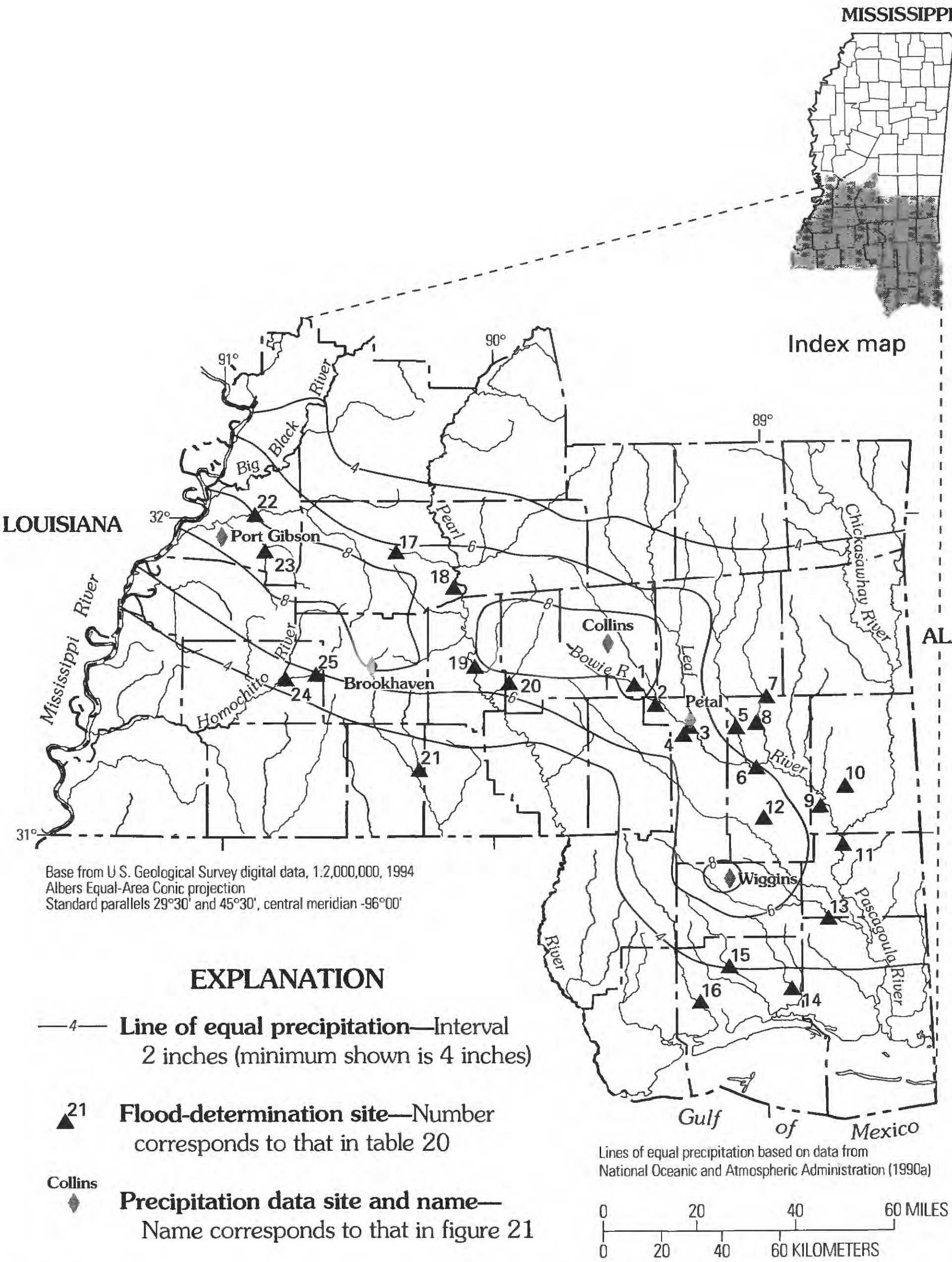


Figure 20. Location of flood-determination sites for flood of May 12–17, 1990, and lines of equal precipitation for storm of May 12–13, 1990, in southern Mississippi.

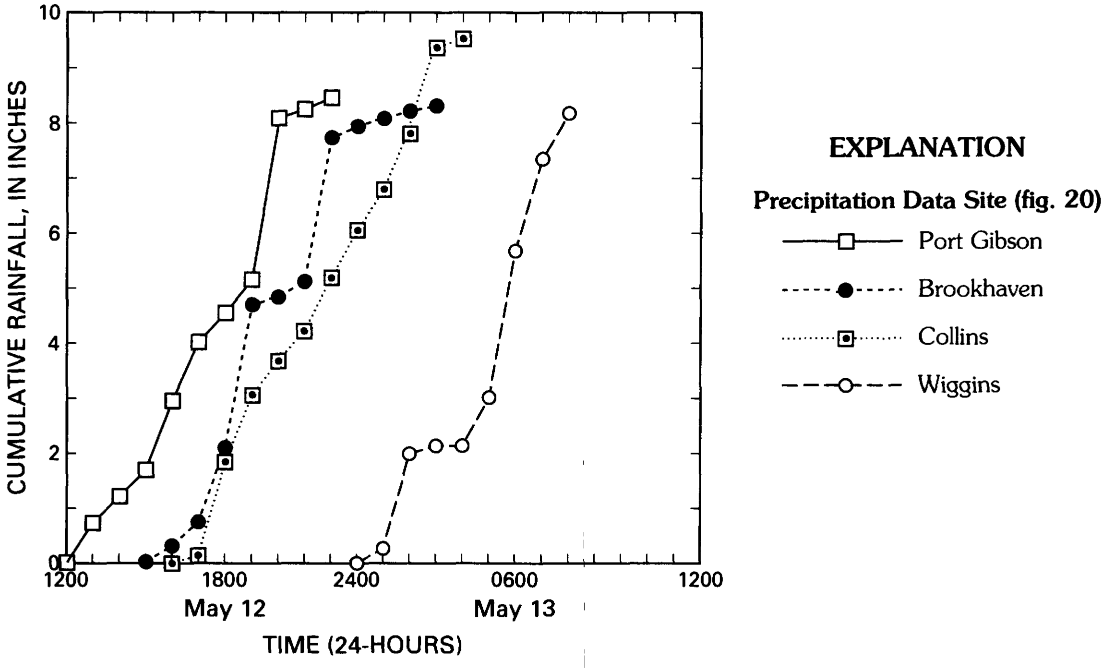


Figure 21. Cumulative rainfall of May 12–13, 1990, at selected precipitation data sites in southern Mississippi (data from National Oceanic and Atmospheric Administration, 1990b).

Table 20. Maximum stages and discharges prior to and during flood of May 12–17, 1990, in southern Mississippi

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined or not applicable. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

Site no. (fig. 20)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to May 1990: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during May 1990: Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Pascagoula River Basin							
1	02472420	Bouie Creek near Sanford	262	1961–90	1961 1974	32.02 32.22	33,200 [1,2]32,000	13	30.80	28,500	30
2	02472500	Bouie Creek near Hattiesburg	304	1900–90	1900	[2]33.50	[2]50,000	14	26.53	33,500	60
3	02473000	Leaf River at Hattiesburg	1,748	1900–90	1974	[2]34.03	121,000	14	27.31	56,300	10
4	02473047	Gordon Creek at Hattiesburg	8.83	1947–90	1983	61.89	6,920	13	13.05	2,390	4
5	02474500	Tallahala Creek near Runnelstown	612	1885–1990	1900	[3]30.50	38,000	15	22.01	11,500	3
6	02474560	Leaf River near New Augusta	2,542	1900–90	1900	36.00	120,000	15	[3]30.71	74,700	25
7	02474600	Bogue Homo near Richton	344	1971–90	1973	27.63	21,900	14	24.18	14,100	5
8	02474650	Buck Creek near Runnelstown	20.8	1951–90	1961 1979	[3]94.89 [1,3]91.41	[1]3,900 5,700	13	16.70	4,640	15
9	02475000	Leaf River near McLain	3,495	1900–90	1900	31.80	131,000	17	26.39	73,300	10
10	02475050	Waterfall Branch near McLain	.65	1955–90	1959	11.71	764	13	7.88	370	4
11	02479000	Pascagoula River at Merrill	6,590	1852–1990	1900	32.50	[1]230,000	17	24.60	79,500	3
12	02479155	Cypress Creek near Janice	52.6	1959–90	1959	32.06	16,700	13	22.43	4,070	3
13	02479300	Red Creek at Vestry	441	1959–90	1987	21.48	28,000	15	18.47	15,000	5
				Biloxi River Basin							
14	02480500	Tuxachanie Creek near Biloxi	92.4	1906–90	1906 1987	[1]23.20 23.63	21,000 [1]19,600	13	18.38	5,500	3
15	02481000	Biloxi River at Wortham	96.2	1916–90	1983	25.30	10,300	13	20.24	6,560	5
16	02481510	Wolf River near Landon	308	1971–90	1983	21.53	18,400	13	17.82	12,900	4
				Pearl River Basin							
17	02487900	Copiah Creek near Hazlehurst	47.4	1950–90	1980	25.11	32,000	12	18.60	6,200	3
18	02488000	Pearl River at Rockport	4,556	1874–1990	1979	42.83	[2]123,000	13	29.46	46,500	5
19	02488500	Pearl River near Monticello	4,993	1874–1990	1874 1979	34.50 34.08	-- 122,000	14	27.55	59,100	10
20	02488700	White Sand Creek near Oak Vale	130	1966–90	1974	18.76	25,400	13	17.60	19,900	40
21	02490500	Bogue Chitto near Tylertown	492	1936–90	1936 1983	34.70 [1]34.62	[1]49,000 64,200	14	22.68	17,700	3

Table 20. Maximum stages and discharges prior to and during flood of May 12–17, 1990, in southern Mississippi—Continued

				Maximum prior to May 1990				Maximum during May 1990			
Site no. (fig. 20)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Bayou Pierre River Basin							
22	07290650	Bayou Pierre near Willows	654	1959–90	1983	29.36	88,000	13	26.90	46,600	10
23	07290690	Clarks Creek near Pattison	75.0	1962–90	1980	27.90	31,000	12	26.46	22,800	40
				Homochitto River Basin							
24	07291000	Homochitto River at Eddiceton	181	1939–90	1974	[3]19.53	55,400	13	21.06	33,600	15
25	07291250	McCall Creek near Lucien	60.8	1953–90	1974	92.70	23,000	12	85.25	10,300	3

[1]Less than maximum for period. [2]Estimated. [3]Stage at different site and (or) datum.

Floods of May 17–June 7, 1990, in Southern Indiana

By Scott E. Morlock

Severe weather over parts of southern Indiana caused several damaging floods in late May and early June 1990. From May 12 to 13, 1 to 3 inches of rain fell over central and southern Indiana, causing isolated lowland flooding. The rain also resulted in saturated soils throughout much of southern Indiana.

On the morning of May 15, warm, moist air from the Gulf of Mexico, in combination with a warm front over southern Indiana and a weak weather system approaching from the west, caused the formation of thunderstorms. The storms continued to form and move across southern Indiana throughout the day and into the evening of May 15. More thunderstorms formed over southern Indiana during the morning and early afternoon of May 16. A final series of storms moved across southern Indiana the morning of the 17th, as a cold front traveled through the area.

Rainfall from the thunderstorms of May 15–17 ranged from 2 to nearly 10 inches in southern Indiana. The most excessive rains occurred in a 5- to 10-mile wide band that extended from Hazleton in southwest Indiana to Rising Sun in southeast Indiana (fig. 22).

The rains caused rapid rises in streams and rivers across south-central Indiana, most notably in Orange County. The Lost River near West Baden Springs in Orange County (site 03373700) reached a maximum stage of 26.21 feet on May 17 and had a maximum discharge of 14,000 cubic feet per second from 287 square miles of drainage area. These were the highest stage and discharge for the Lost River near West Baden Springs since March 1964.

Substantial flooding also occurred along reaches of the White River. The White River at Petersburg (site 03374000), which has a drainage area of 11,125 square miles, reached a maximum stage of 25.80 feet and had a maximum discharge of 120,000 cubic feet per second on May 22. These were the highest stage and discharge since February 1968. The recurrence interval of this flood was approximately 10 years.

Flood damage exceeded $80 million in south-central and southwestern Indiana, according to the National Oceanic and Atmospheric Administration (1990a). The cities of Orleans, French Lick, West Baden Springs, and Prospect in Orange County were flooded. Homes, businesses, and agricultural levees were damaged, and the public-water system for the city of Petersburg was rendered inoperable when floodwaters severed water-supply lines.

The pattern of severe weather experienced by southern Indiana continued into early June. On June 2, severe thunderstorms spawned more than 30 tornadoes, which killed 9 people and produced widespread damage in southern Indiana. During the week following the tornadoes, a weak atmospheric disturbance channeled moist air from the Gulf of Mexico into southern Indiana. A nearly stationary front extending from southern Missouri through central Kentucky provided a lifting mechanism that formed thunderstorms on June 6 and 7. The storms produced 6 to more than 8 inches of rain over six counties in south-central and southwestern Indiana.

The cities of Marengo and English in Crawford County experienced damaging floods. Whiskey Run at Marengo (site 03302849, fig. 22), with a drainage area of 7.02 square miles, reached a maximum stage of 12.39 feet and had a maximum discharge of 2,920 cubic feet per second on June 7. This was the highest stage recorded since the gaging station was established in October 1986.

A total of 31 counties in southern Indiana had significant damage from the May 17–22 flooding, the June 2 tornadoes, and the June 7 flooding. As a result, Indiana received a Federal disaster declaration. Although the property damage from May 17–June 7 was caused by individual storms, all damage during the period was covered by a single disaster declaration.

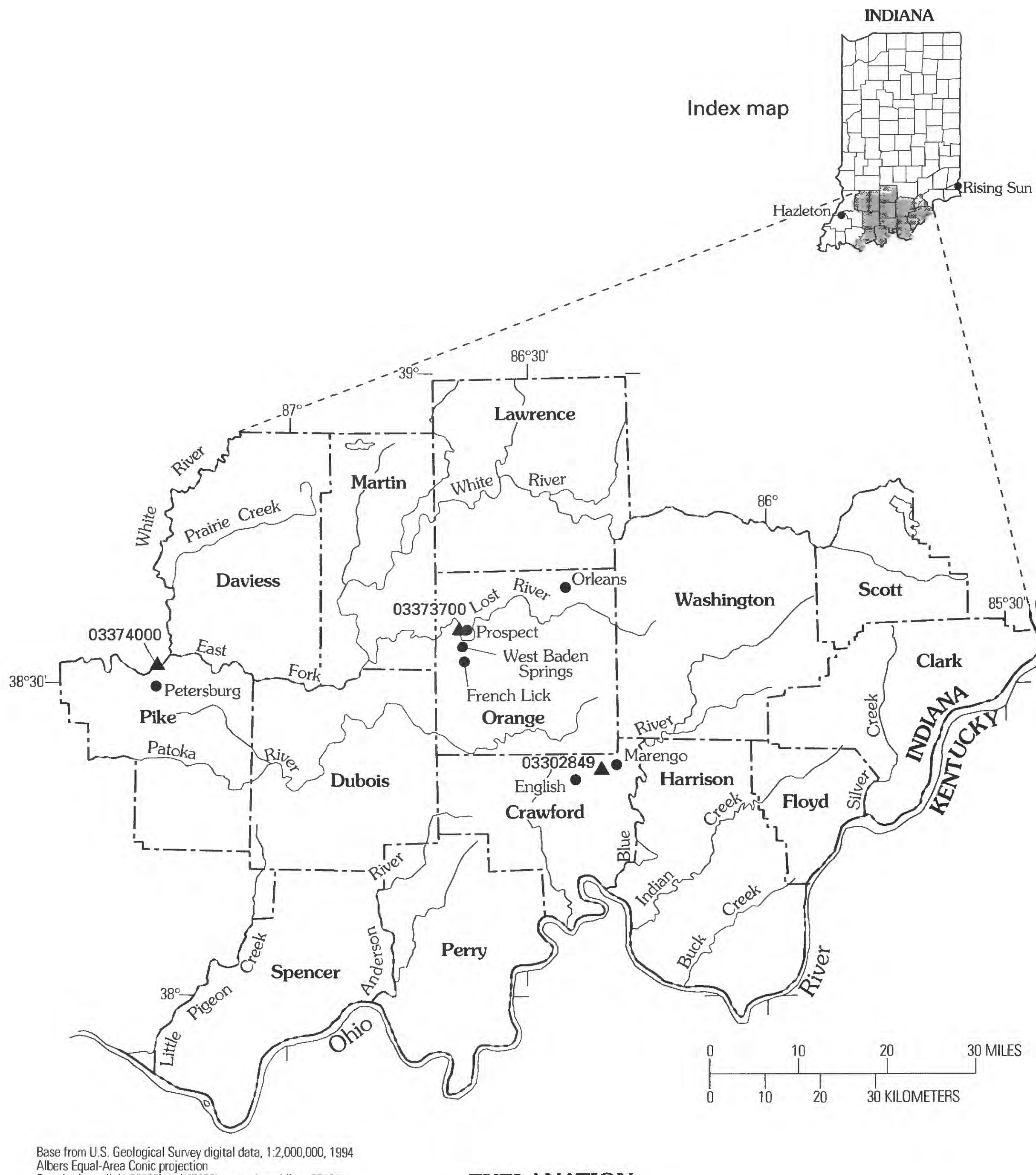
REFERENCES

Indiana Department of Natural Resources, Division of Water, 1986, Coordinated discharges of selected streams in Indiana: Indianapolis, Indiana [various pagination].

National Oceanic and Atmospheric Administration, 1990a, Monthly report of river and flood conditions for May 1990: Indianapolis, Indiana, 5 p.

_____1990b, Monthly report of river and flood conditions for June 1990: Indianapolis, Indiana, 5 p.

Stewart, J.A., and Nell, G.E., 1991, Water resources data, Indiana, water year 1990: U.S. Geological Survey Water-Data Report IN–90–1, 349 p.



EXPLANATION

03302849▲ **Flood-determination site**—Number is U.S. Geological Survey streamflow-gaging station number

Figure 22. Location of flood-determination sites for floods of May 17–June 7, 1990, in southern Indiana.

Flood of May 19–21, 1990, in West-Central Iowa

By B.D. Schaap

Excessive rains on May 18–19, 1990, caused flooding in west-central Iowa (fig. 23). The most severe flooding occurred in Sioux City where more than 4 inches of rain (table 21), with one unofficial report of 8 inches, caused Perry Creek to crest 7 to 8 feet above flood stage at 38th Street (table 22, site 10). Three bridges, more than 500 homes, and 80 businesses were damaged by the Perry Creek flood. About 60 miles southeast of Sioux City, severe livestock losses occurred when a barn rapidly filled with 8 to 10 feet of water. On the basis of information provided by the Iowa Disaster Services Division, flood damage to west-central Iowa was estimated at about $3 million. The flooded area was part of a larger area covered by a disaster declaration issued by the President of the United States for May 18 through July 6, 1990, for 33 counties.

REFERENCES

National Oceanic and Atmospheric Administration, 1990, Climatological data, Iowa, May 1990: Asheville, N.C., National Climatic Data Center, v. 101, no. 5, 30 p.

Table 21. Total precipitation, May 19–21, 1990, in west-central Iowa

[Data from National Oceanic and Atmospheric Administration, 1990]

Site no. (fig. 23)	Precipitation data site	Precipitation (inches)
	Iowa River Basin	
1	Williams	3.32
	Skunk River Basin	
2	Jewell	2.93
	Des Moines River Basin	
3	Carroll	3.71
4	Fort Dodge	3.21
5	Sac City	3.12
	Perry Creek Basin	
6	Sioux City Perry Creek	4.55
	Little Sioux River Basin	
7	Holstein	4.05
8	Ida Grove 5 NW	4.20
9	Galva	3.45
	Boyer River Basin	
10	Denison	4.32

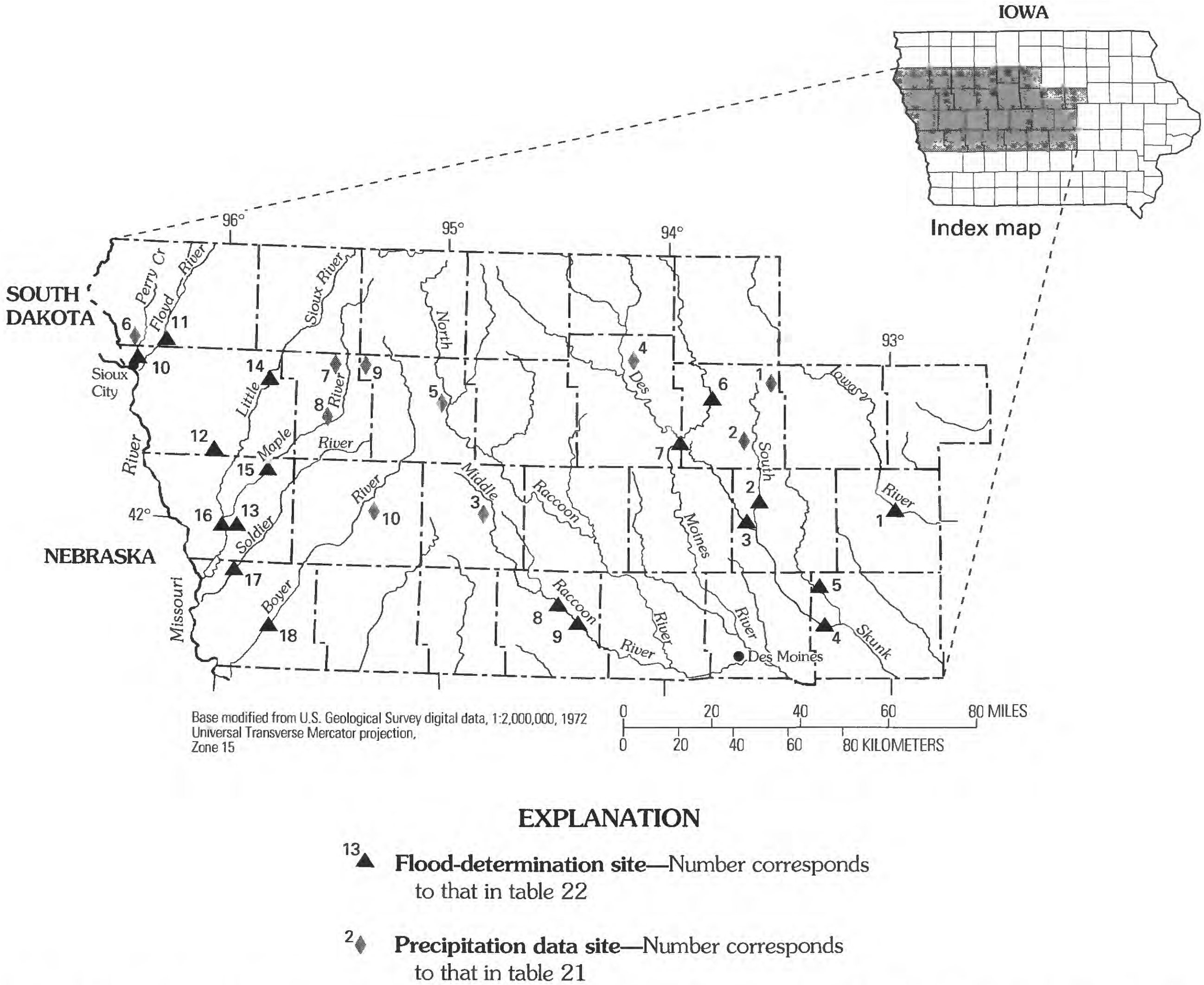


Figure 23. Location of flood-determination and precipitation data sites for flood of May 19–21, 1990, in west-central Iowa.

Table 22. Maximum stages and discharges prior to and during flood of May 19–21, 1990, in west-central Iowa

[mi², square miles; ft, feet above an arbitrary datum; ft³/s, cubic feet per second; <, less than; --, not determined or not applicable. Source: Recurrence intervals are calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum(s) prior to May 1990				Maximum during May 1990			
Site no. (fig. 23)	Station no.	Stream and place of determination	Drainage area (mi²)	Period of record	Year	Stage (ft)	Discharge (ft³/s)	Day	Stage (ft)	Discharge (ft³/s)	Discharge recurrence interval (years)
				Iowa River Basin							
1	05451500	Iowa River at Marshalltown	1,564	1915–27, 1932–90	1918	17.74	42,000	19	16.54	5,740	<2
				Skunk River Basin							
2	05470000	South Skunk River near Ames	315	1920–27, 1933–90	1954	13.66	8,630	20	7.37	3,250	2
3	05470500	Squaw Creek at Ames	204	1919–90	1975	14.00	11,300	19	10.61	4,200	5
4	05471050	South Skunk River at Colfax	803	1985–90	1987	17.35	6,850	21	16.61	5,750	--
5	05471200	Indian Creek near Mingo	276	1944–90,	1944	21.44	--	20	11.58	2,460	<2
				1958–90	1966	16.41	7,380				
				Des Moines River Basin							
6	05481000	Boone River near Webster City	844	1886–1990	1918	19.10	21,500	19	7.25	3,410	<2
7	05481300	Des Moines River near Stratford	5,452	1920–90	1954	25.35	57,400	20	13.65	10,000	<2
8	05483450	Middle Raccoon River near Bayard	375	1973–90	1973	[1]21.63	14,600	20	20.20	5,180	--
9	05483600	Middle Raccoon River at Panora	440	1958–90	1986	15.50	15,300	20	9.27	4,520	<2
				Perry Creek Basin							
10	06600000	Perry Creek at 38th Street, Sioux City	65.1	1939–69, 1981–90	1944	[1]25.50	9,600	19	28.54	8,670	30
				Floyd River Basin							
11	06600500	Floyd River at James	886	1892–1990	1953	25.3	71,500	19	20.70	8,090	5
				Monona-Harrison Ditch Basin							
12	06602020	West Fork Ditch at Hornick	403	1939–69, 1974–90	1962	[1]22.46	12,400	19	20.47	5,810	5
13	06602400	Monona-Harrison Ditch near Turin	900	1958–90	1971	28.03	19,900	19	20.28	8,600	3
				Little Sioux River Basin							
14	06606600	Little Sioux River at Correctionville	2,500	1918–25, 1928–32, 1936–90	1965	25.86	29,800	19	13.10	4,600	<2
15	06607200	Maple River at Mapleton	669	1941–90	1978	16.74	20,800	19	9.73	7,200	2
16	06607500	Little Sioux River near Turin	3,526	1958–90	1983	26.54	31,200	19	17.68	10,500	<2
				Soldier River Basin							
17	06608500	Soldier River at Pisgah	407	1940–90	1950	28.17	22,500	19	13.97	6,840	<2
				Boyer River Basin							
18	06609500	Boyer River at Logan	871	1881–1990,	1881	25.0	--	19	18.97	20,500	10
				1918–25, 1937–90	1971	[1]22.65	25,000				

[1]Measured from datum then in use.

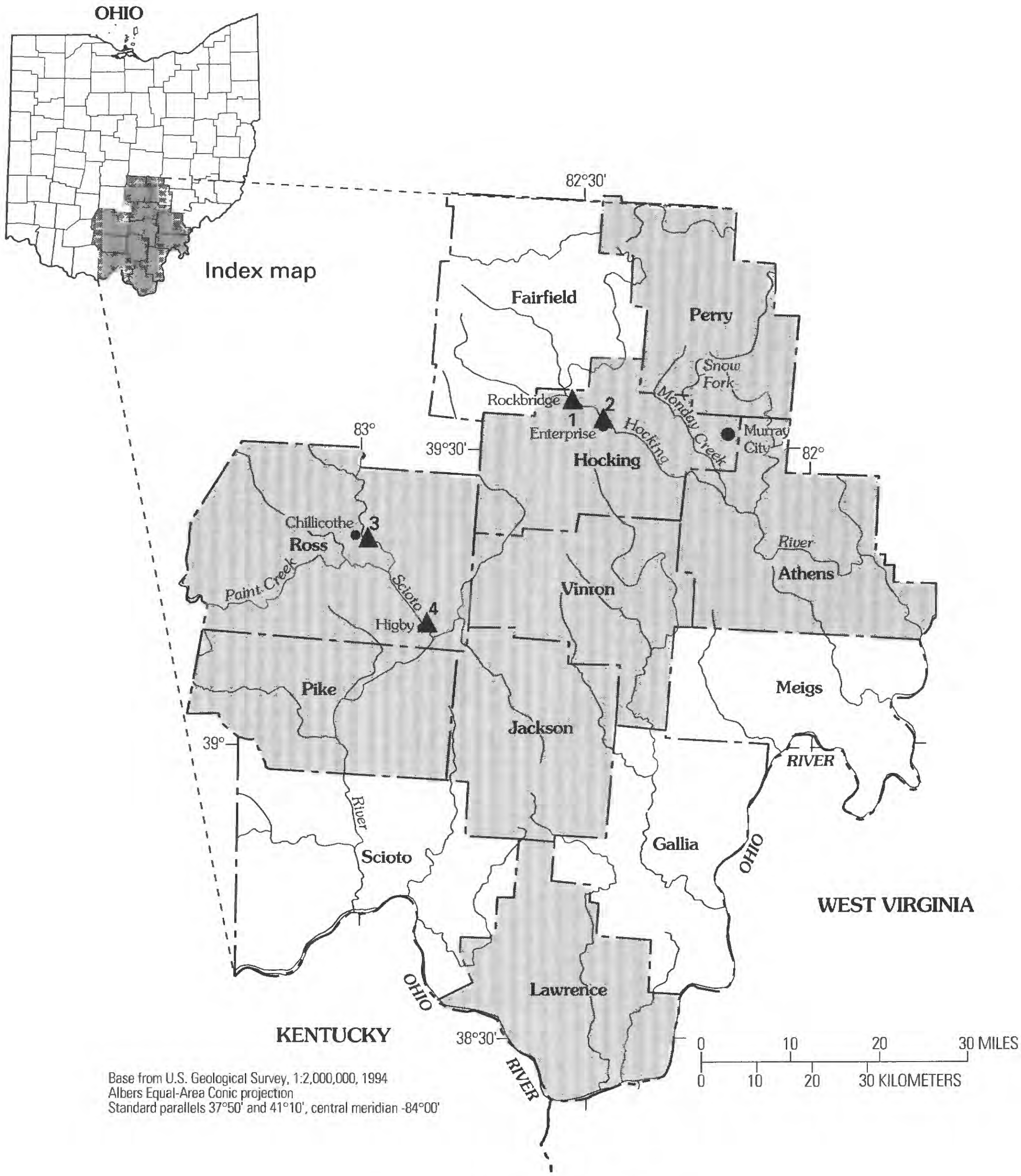
Floods of May 28–30, 1990, in South-Central Ohio

By G.F. Koltun

Two to three inches of rain fell in parts of south-central Ohio on May 28–29, 1990, causing flooding that severely affected eight Ohio counties (Athens, Hocking, Jackson, Lawrence, Perry, Pike, Ross, and Vinton) and resulted in three fatalities. The May 28–29 rain followed moderately excessive rain (1 to 2 inches) that occurred less than 2 weeks earlier. Moderate to locally severe flooding occurred in several areas along the Scioto and Hocking Rivers and their tributaries on May 28–30.

Flooding in the Hocking River Basin was notably severe. Flooding of Snow Fork of Monday Creek (fig. 24), a tributary to the Hocking River, resulted in damage to nine businesses and approximately 75 homes in the community of Murray City. Maximum discharges at two flood-determination sites in the Hocking River Basin had recurrence intervals of 5 to 25 years (table 23).

Athens, Hocking, Lawrence, and Perry Counties received disaster declarations from the President of the United States as a result of the flooding. In Athens County, more than 200 residents were evacuated from their homes. Twenty-nine Athens County residences were destroyed, and another 47 residences were damaged as a result of the flooding (Patricia Beck, Ohio Emergency Management Agency, written commun., 1992).



EXPLANATION

Counties affected by flooding

▲1 **Flood-determination site**—Number corresponds to that in table 23

Figure 24. Flood-determination sites and counties affected by flooding, May 28–30, 1990, in south-central Ohio.

Table 23. Maximum stages and discharges prior to and during floods of May 28–30, 1990, in south-central Ohio

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined or not applicable; <, less than. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

Site no. (fig. 24)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to May 1990: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during May 1990: Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Hocking River Basin							
1	03157000	Clear Creek near Rockbridge	89.0	1884–1990	1948	17.68	16,000	29	12.61	5,600	10–25
2	03157500	Hocking River at Enterprise	459	1884–1990	1907	22.00	36,000	29	16.51	11,300	5
				Scioto River Basin							
3	03234300	Paint Creek at Chillicothe[1]	1,136	1985–90	1986	17.66	11,700	29	24.67	30,100	--
4	03234500	Scioto River at Higby[1]	5,131	1913–90	1913	31.6	[2]--	30	19.12	46,000	[3]<2
					1937	[2]--	177,000				

[1]Streamflow at this site is regulated. [2] Less than maximum for period. [3]Recurrence interval is based on records of unregulated flow.

Flood of May 31, 1990, in Warren County, Mississippi

By W. Trent Baldwin

On May 31, 1990, a storm that stalled over Warren County in west-central Mississippi (fig. 25) produced intense rainfall. Several parts of the county received as much as 7 inches of rain in an 11-hour period ending at 5 p.m. Cumulative rainfall data from the National Oceanic and Atmospheric Administration precipitation data site at the Waterways Experiment Station, Vicksburg, are shown in figure 26. The most intense 3-hour and 6-hour rainfall recorded at this gage during the storm was 5.2 and 6.4 inches, respectively, having recurrence intervals between 50 and 100 years as reported by Hershfield (1961).

Hamilton Heights subdivision, which is located near the convergence of Hatcher Bayou and Durden Creek in south Vicksburg (fig. 25), experienced what many residents said was the worst flooding in the 20-year history of the neighborhood. The inundation resulted in 120 families being evacuated. The recurrence interval of the flood along Hatcher Bayou and Durden Creek was approximately 25 years (Blake Mendrop, U.S. Army Corps of Engineers, Vicksburg District, oral commun., 1991). Clear Creek near Bovina (fig. 25) experienced the largest flood since 1969 and the second largest in 37 years of record. This flood had a maximum discharge of 18,100 cubic feet per second at a stage of 29.37 feet at the flood-determination site shown in figure 25 and had a calculated 60-year recurrence interval.

As a result of the flooding, six county roads and two highways were closed. A total of 187 homes and businesses were evacuated. The bridge over Clear Creek near Bovina was closed due to shifted or damaged pilings. A bridge in Bovina was washed out. The Director of the Vicksburg-Warren County Emergency Management Agency estimated the total damage caused by the flood at $6 million (Luther Warnock, oral commun., 1994).

REFERENCES

Hershfield, D.M., 1961, Rainfall frequency atlas of the United States: U.S. Department of Commerce, Weather Bureau, Technical Paper no. 40, 115 p.

National Oceanic and Atmospheric Administration, 1990, Hourly precipitation data, Mississippi, May 1990: Asheville, N.C., National Climatic Data Center, v. 40, no, 5, 16 p.

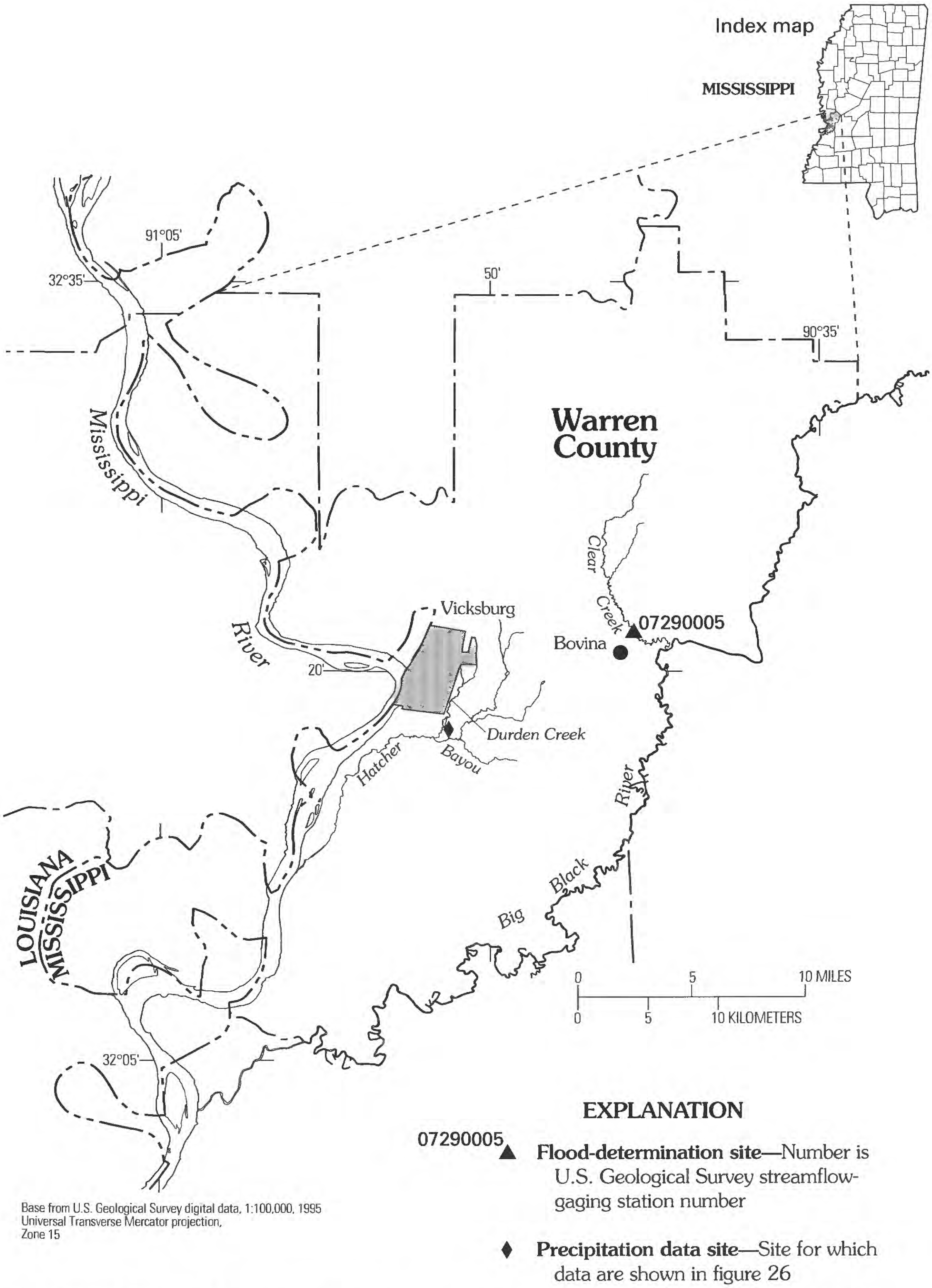


Figure 25. Location of flood-determination and precipitation data sites for flood of May 31, 1990, in Warren County, Mississippi.

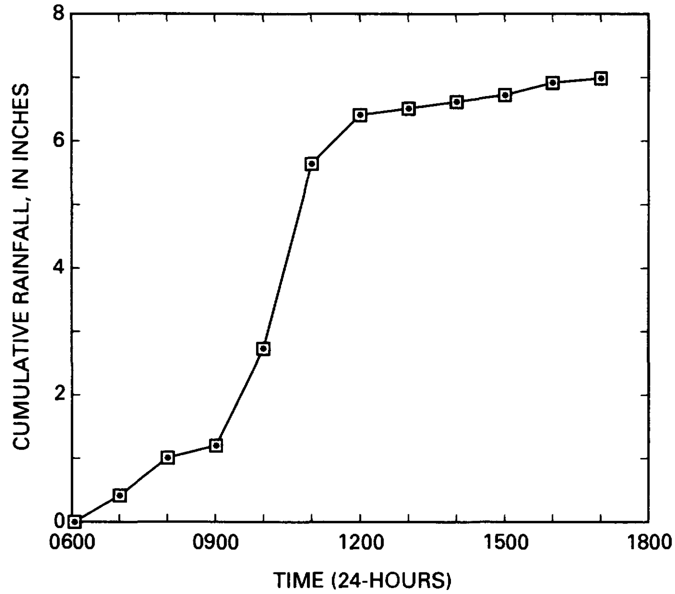


Figure 26. Cumulative rainfall of May 31, 1990, at precipitation data site located at the Waterways Experiment Station, Vicksburg, Mississippi (data from National Oceanic and Atmospheric Administration, 1990).

Floods of June 1990 in Iowa

By B.D. Schaap

Widespread flooding occurred across the southern two-thirds of Iowa from June 16–23, 1990, as excessive rains on June 16 and 17 were followed by additional rains during the next several days (fig. 27). There was one report of 5.5 inches of rainfall in about 90 minutes on June 16 in central Iowa and several unofficial reports from across Iowa of more than 12 inches of rainfall throughout a period of several days. Flooding was particularly severe along a line from west-central to east-central Iowa. In this area, new maximum discharges were established at six flood-determination sites (table 24). At eight sites, discharges equaled or exceeded the 100-year discharge. The discharge of Duck Creek in Davenport (site 3, fig. 27), as determined by the U.S. Army Corps of Engineers, Rock Island District, using indirect methods, was greater than the 100-year discharge.

Three deaths were attributed to the flooding. A young girl, who had been wading in the floodwaters, drowned when she was trapped below the water surface in a culvert (Des Moines Register, June 17, 1990). A second fatality occurred when a car dropped into a washed-out section of road and rolled into the ditch, killing the driver. In another car-related death, the driver was killed when the car left the road and landed upside down in a water-filled drainage ditch (Des Moines Register, June 19, 1990).

On the basis of information provided by the Iowa Disaster Services Division, more than $88 million in damages were attributed to the flooding. Agricultural losses accounted for more than $55 million of the estimated damages (E.M. Gordon, Iowa Disaster Service Division, written commun., 1991). In addition to reduced crop yields and property losses, many terraces were washed out, and soil erosion was severe. According to the U.S. Soil Conservation Service (Des Moines Register, June 22, 1990), at least 20 tons per acre of soil were lost from 2.8 million acres of central and eastern Iowa farmland, and more than 40 tons per acre were lost from 350,000 acres. The annual soil-replacement rate is only about 5 tons per acre (Des Moines Register, June 22, 1990).

More than 1,200 homes in Des Moines were affected by flooding in Walnut Creek (site 38), Fourmile Creek (site 40), and the Des Moines River (site 39) (Des Moines Register, June 18, 1990). Flooding in Clear Creek near Coralville (site 11) closed Interstate 80 for 14 hours (Barnes and Eash, 1994, p. 6), and many homes and businesses were damaged. More than 35 homes in the Bettendorf and Davenport area were destroyed by flooding in Crow Creek (site 2) and Duck Creek (site 3) (Des Moines Register, June 21, 1990). The maximum discharges in Crow Creek and Duck Creek were more than 1.5 times the discharges of their respective 100-year recurrence intervals. Duck Creek was 19 feet over flood stage.

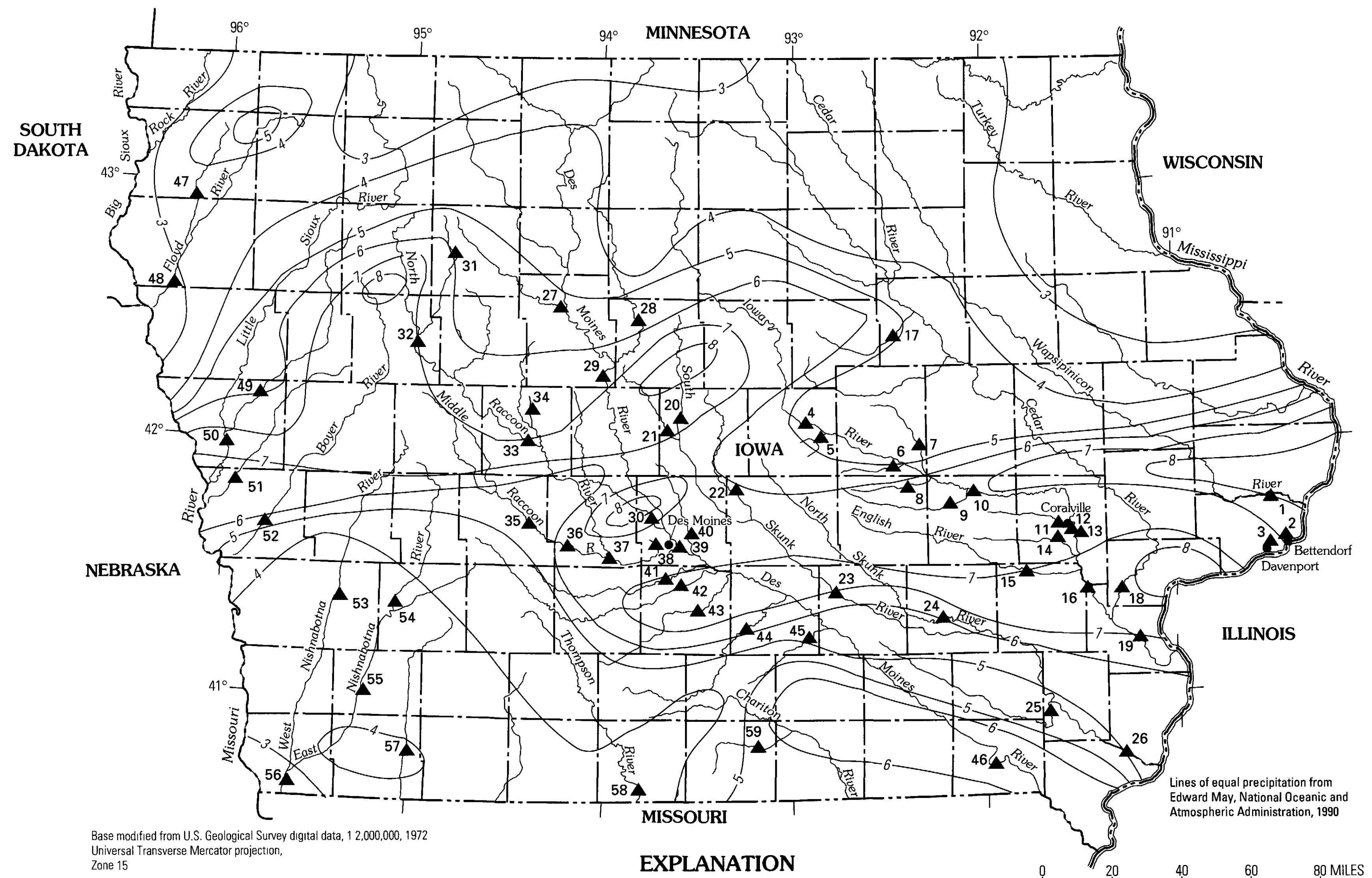
The floods of June 16–23 were the most damaging of the floods that affected Iowa from May 18 through July 6, 1990. Together, they resulted in 44 of Iowa's 99 counties being declared State disaster areas and 33 counties being declared Federal disaster areas.

Intense thunderstorms produced more than 3.5 inches of rain in 3 hours in the Davenport and Bettendorf area on June 29, 1990. This led to severe flooding of Duck Creek and Crow Creek for the second time in 2 weeks. Crow Creek at Bettendorf (site 2) reached a maximum stage of 10.42 feet and a maximum discharge of 6,690 cubic feet per second. Both values are second only to the maximums recorded just 2 weeks earlier when the discharge was 1.54 times the discharge for a 100-year recurrence interval. The June 29 maximum discharge was 1.34 times the discharge for a 100-year recurrence interval. The flooding hindered efforts to repair damages from the previous flood, caused additional damage including washed-out streets, and caused the loss of electric service to about 4,000 customers (Des Moines Register, June 30, 1990). Davenport and Bettendorf were declared a disaster area by the President of the United States because of the flooding on June 16–17 and 29.

REFERENCES

Baebenroth, R.W., and Schaap, B.D., 1992, Floods of 1986 and 1990 in the Raccoon River Basin, west-central Iowa: U.S. Geological Survey Open-File Report 92–94, 144 p.

Barnes, K.K., and Eash, D.A., 1994, Flood of June 17, 1990, in the Clear Creek Basin, east-central Iowa: U.S. Geological Survey Open-File Report 94–78, 21 p.



EXPLANATION

—5— **Line of equal precipitation, June 12-20**—Interval 1 inch

56▲ **Flood-determination site**—Number corresponds to that in table 24

Figure 27. Location of flood-determination sites for floods of June 1990 and lines of equal precipitation for June 12–20, 1990, in Iowa.

Table 24. Maximum stages and discharges prior to and during floods of June 1990 in Iowa

[mi², square miles; ft, feet above and arbitrary datum; ft³/s, cubic feet per second; >, greater than; --, not determined or not applicable. Source: Recurrence intervals calculated from U.S. Geological Survey data, except as noted. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to June 1990				Maximum during June 1990			
Site no. (fig. 27)	Station no.	Stream and place of determination	Drainage area (mi²)	Period	Year	Stage (ft)	Discharge (ft³/s)	Day	Stage (ft)	Discharge (ft³/s)	Discharge recurrence interval (years)
		Wapsipinicon River Basin									
1	05422000	Wapsipinicon River near De Witt	2,330	1934–90	1974	13.07	29,900	17	14.19	31,100	100
		Crow Creek Basin									
2	05422470	Crow Creek at Bettendorf	17.8	1977–90	1982	10.24	2,490	16	11.03	7,700	>100
3	--	Duck Creek at Kimberly Road, Davenport	59.0	--	--	--	--	16	--	17,200	[1]>100
		Iowa River Basin									
4	05451500	Iowa River at Marshalltown	1,564	1915–27, 1932–90	1918 1969	[2]17.74 19.37	42,000 [2]--	18	20.38	17,300	10
5	05451700	Timber Creek near Marshalltown	118	1949–90	1977	17.69	12,000	20	15.42	4,470	4
6	05451900	Richland Creek near Haven	56.1	1949–90	1974	24.00	7,000	19	21.54	2,740	5
7	05452000	Salt Creek near Elberon	201	1945–90	1947 1982	17.6 20.00	35,000 33,200	17	17.66	8,730	5
8	05452200	Walnut Creek near Hartwick	70.9	1947–90	1947 1983	17.7 [2]16.65	-- 7,100	17	15.79	6,850	20
9	05453000	Big Bear Creek at Ladora	189	1949–90	1960	14.60	10,500	17	23.65	5,640	4
10	05453100	Iowa River at Marengo	2,794	1956–90	1960 1969	[2]19.21 19.79	30,800 [2]--	21	18.68	18,100	4
11	05454300	Clear Creek near Coralville	98.1	1952–90	1982	14.61	[3]6,520	17	16.36	[3]10,200	>100
12	05454500	Iowa River at Iowa City	3,271	1851–1990	1851	24.1	70,000	17	23.29	13,500	3
13	05455010	South Branch Ralston Creek at Iowa City	2.94	1962–90 1963–90	1962 1972	10.5 9.47	-- 1,070	17	7.79	542	3
14	05455100	Old Mans Creek near Iowa City	201	1951–90	1962 1982	18.52 [2]17.25	[2]12,000 13,500	17	17.20	10,400	30
15	05455500	English River at Kalona	573	1939–90	1965	21.45	20,000	18	20.06	15,600	15
16	05455700	Iowa River near Lone Tree	4,293	1956–90	1965 1974	20.27 [2]18.97	-- 35,700	20	18.08	26,500	10
17	05463500	Black Hawk Creek at Hudson	303	1952–90	1969	18.23	19,300	17	17.32	13,800	40
18	0546500	Cedar River near Conesville	7,785	1939–90	1961 1965	[2]16.62 16.85	70,800 --	18	16.87	60,100	15
19	05465500	Iowa River at Wapello	12,499	1903–90	1947 1973	[4]16.10 28.63	94,000 92,000	19	28.91	86,600	30

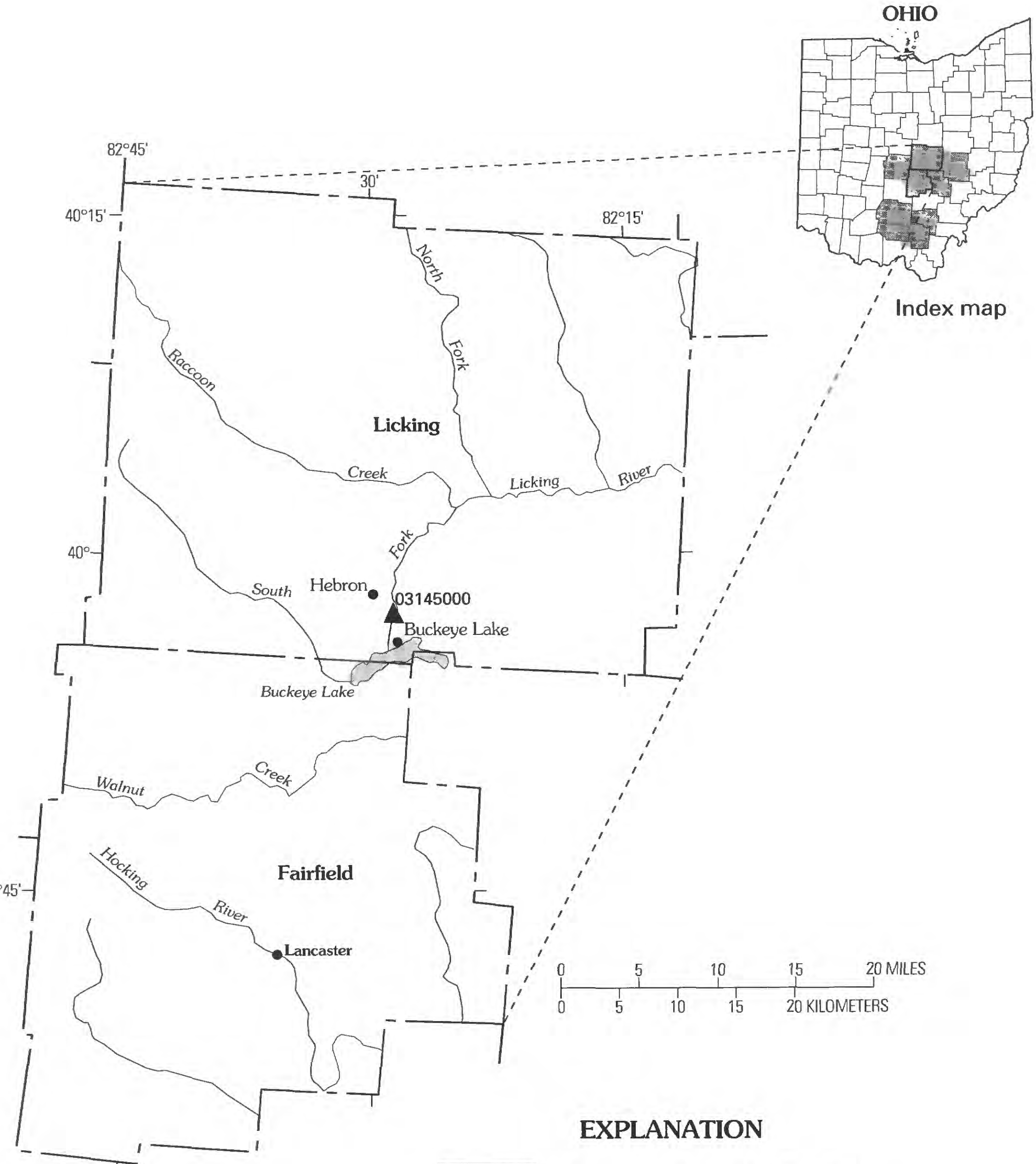
Table 24. Maximum stages and discharges prior to and during floods of June 1990 in Iowa—Continued

Site no. (fig. 27)	Station no.	Stream and place of determination	Drainage area (mi²)	Maximum prior to June 1990: Period	Year	Stage (ft)	Discharge (ft³/s)	Maximum during June 1990: Day	Stage (ft)	Discharge (ft³/s)	Discharge recurrence interval (years)
		Skunk River Basin									
20	05470000	South Skunk River near Ames	315	1920–27,	1944	13.90	--	17	11.84	6,600	20
				1933–90	1954	[2]13.66	8,630				
21	05470500	Squaw Creek at Ames	204	1918–90	1975	14.00	11,300	17	15.97	12,500	>100
22	05471200	Indian Creek near Mingo	276	1944–90	1944	21.4	--	18	16.11	6,550	10
				1958–90	1966	16.41	7,380				
23	05471500	South Skunk River near Oskaloosa	1,635	1944–90	1944	25.80	37,000	23	23.05	15,200	15
24	05472500	North Skunk River near Sigourney	730	1944–90	1960	25.33	27,500	20	25.18	21,300	40
25	05473400	Cedar Creek near Oakland Mills	530	1977–90	1983	19.68	[2]8,560	20	18.54	7,530	4
					1984	--	16,000				
26	05474000	Skunk River at Augusta	4,303	1851–1990	1973	27.05	66,800	23	22.34	44,200	25
		Des Moines River Basin									
27	05480500	Des Moines River at Fort Dodge	4,190	1914–27,	1965	[2]17.79	35,600	19	9.83	14,300	4
				1947–90	1947	19.62	--				
28	05481000	Boone River near Webster City	844	1896–1990	1918	19.10	21,500	17	9.40	5,670	2
29	05481300	Des Moines River near Stratford	5,452	1920–90	1954	25.35	57,400	18	19.01	18,600	3
30	05481950	Beaver Creek near Grimes	358	1960–90	1986	14.73	7,980	19	14.20	5,580	10
31	05482170	Big Cedar Creek near Varina	80.0	1959–90	1962	13.68	2,080	19	12.09	1,580	10
32	05482300	North Raccoon River near Sac City	700	1958–90	1979	18.02	13,100	17	20.14	9,930	10
33	05482500	North Raccoon River near Jefferson	1,619	1940–90	1947	22.3	29,100	19	18.61	18,400	15
34	05483000	East Fork Hardin Creek near Churdan	24.0	1952–90	1986	10.78	737	17	10.20	754	>100
35	05483600	Middle Raccoon River at Panora	440	1958–90	1986	15.50	15,300	18	12.77	9,000	10
36	05484000	South Raccoon River at Redfield	994	1940–90	1958	29.04	35,000	16	19.05	19,100	10
37	05484500	Raccoon River at Van Meter	3,441	1915–90	1947	[2]21.37	41,200	16	21.39	34,600	20
					1986	22.69	[2]40,200				
38	05484800	Walnut Creek at Des Moines	78.4	1971–90	1986	18.32	12,500	16	18.00	7,780	15
39	05485500	Des Moines River below Raccoon River at Des Moines	9,879	1893–1990	1947	32.0	77,000	19	26.95	45,200	5
40	05485640	Fourmile Creek at Des Moines	92.7	1971–90	1974	14.84	[2]5,340	16	14.18	4,410	5
					1977	[2]--	5,380				
41	05486000	North River near Norwalk	349	1940–90	1947	25.3	32,000	17	25.33	22,600	>100

Table 24. Maximum stages and discharges prior to and during floods of June 1990 in Iowa—Continued

Site no. (fig. 27)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to June 1990: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during June 1990: Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
		Des Moines River Basin—Continued									
42	05486490	Middle River near Indianola	503	1940–90	1947	26.40	34,000	17	23.03	12,800	10
43	05487470	South River near Ackworth	460	1940–90	1947	24.60	34,000	17	31.25	38,100	>100
44	05487980	White Breast Creek near Dallas	342	1962–90	1982	33.45	37,300	17	25.43	15,400	30
45	05489000	Cedar Creek near Bussey	374	1947–90	1982	34.61	96,000	17	24.74	13,000	4
46	05490500	Des Moines River at Keosauqua	14,038	1903–06, 1910–90	1903 1973	[2]27.85 28.02	146,000 [2]72,200	17	22.85	48,500	3
		Floyd River Basin									
47	06600300	West Branch Floyd River near Struble	180	1955–90	1962	15.63	8,060	17	14.57	3,940	4
48	06600500	Floyd River at James	886	1892–1990	1953	25.3	71,500	17	19.00	6,420	4
		Little Sioux River Basin									
49	06607200	Maple River at Mapleton	669	1941–90	1978	16.74	20,800	17	13.76	12,500	5
50	06607500	Little Sioux River near Turin	3,526	1958–90	1983	26.54	31,200	17	22.38	19,100	4
		Soldier River Basin									
51	06608500	Soldier River at Pisgah	407	1940–90	1950	28.17	22,500	17	24.42	17,200	10
		Boyer River Basin									
52	06609500	Boyer River at Logan	871	1918–25, 1937–90	1965 1971	25.22 [2]22.65	-- 25,000	17	22.54	30,800	>100
		Nishnabotna River Basin									
53	06807410	West Nishnabotna River at Hancock	609	1959–90	1972	22.12	26,400	17	18.33	16,400	5
54	06809210	East Nishnabotna River near Atlantic	436	1958–90	1958 1972	-- 22.81	34,200 [2]26,700	16	14.54	11,900	4
55	06809500	East Nishnabotna River at Red Oak	894	1918–25, 1936–90	1972	27.43	38,000	17	19.25	13,000	3
56	06810000	Nishnabotna River above Hamburg	2,806	1922–23, 1928–90	1947 1989	26.03 28.27	55,500 32,900	18	27.02	28,200	10
		Nodaway River Basin									
57	06817000	Nodaway River at Clarinda	762	1918–25, 1936–90	1947	25.3	31,100	17	17.26	15,900	4
		Grand River Basin									
58	06898000	Thompson River at Davis City	701	1885–1990	1885	22.4	30,000	18	12.55	12,700	5
59	06903700	South Fork Chariton River near Promise City	168	1967–90	1981	29.95	28,000	17	20.39	6,890	3

[1]Provided by U.S. Army Corps of Engineers, Rock Island District. [2]Less than maximum for period. [3]Revised from previously published value. [4]Measured from datum then in use.



Base from U.S. Geological Survey, 1:2,000,000, 1994
Albers Equal-Area Conic projection
Standard parallels 37°50' and 41°10', central meridian -84°00'

EXPLANATION

Counties affected by flooding

▲03145000 **Flood-determination site**—Number is U.S. Geological Survey streamflow-gaging station number

Figure 28. Location of flood-determination site for floods of June 8–9, 1990, in central and south-central Ohio, and counties affected by flooding.

Floods of June 8–9, 1990, in Central and South-Central Ohio

By G.F. Koltun

Scattered thunderstorms that occurred in central Ohio on June 7–9, 1990, produced cumulative rainfall amounts that ranged from 0.7 to nearly 4.9 inches. As a result, flooding occurred in at least nine central and south-central Ohio counties (Fairfield, Franklin, Jackson, Licking, Muskingum, Pike, Ross, Vinton, and Perry), causing minor to moderate damage. At least 250 residences sustained flood damages in Licking and Fairfield Counties alone.

On June 9, 1990, 3.18 inches of rain was recorded in the village of Buckeye Lake, which is located in Licking County (fig. 28). Residents of the village were ordered to evacuate because of fear that the 165-year-old earthen dam at the lake might fail. Lake levels rose to within 9 inches of overtopping the dam. Fortunately, several feet of an embankment on an upstream feeder canal collapsed, allowing floodwaters to be diverted and subsequently reducing the chance of dam failure. The flood-determination site on the South Fork Licking River near Hebron, Ohio (site 03145000), which is located downstream from Buckeye Lake, recorded a maximum discharge of 3,620 cubic feet per second, which was the largest discharge since 1970.

Floods of June 14–15, 1990, in Eastern Ohio

By G.F. Koltun

On June 14, 1990, a series of thunderstorms moved slowly from west to east across the southern two-thirds of Ohio causing minor to severe flooding. Twenty-four-hour rainfall totals for the period ending 7:00 a.m., June 15, 1990, ranged from approximately 0.25 to 5 inches along the path of the thunderstorms. Flooding was aggravated by unusually wet antecedent moisture conditions. Average rainfall in the State for May 1990 was 18.68 inches (3.04 inches above normal), making it the second wettest May on record. Unusually wet conditions continued into June and resulted in moderately severe localized flooding in some areas of the State during June 8–10.

Flooding during June 14–15 was most severe in Belmont, Jefferson, and Harrison Counties (fig. 29) where 26 people were killed and approximately $5 million in damage occurred. Twenty-four of the deaths occurred in the Wegee and Pipe Creek Basins, both of which lie within Belmont County. Unofficial estimates indicated that 3 to 4 inches of rain fell within a 75-minute period. The rain produced flash floods that were described by witnesses as a "wall of water" that rapidly traversed each valley. Fifty-eight residences were destroyed, and 145 residences were damaged in the Wegee and Pipe Creek Basins alone.

The Wegee and Pipe Creek Basins are located in the western foothills of the Appalachian Mountains and are characterized by small, steeply sloped hills, with narrow valleys. Because of the topography, many residences are located within the valleys and within close proximity to the streams. That proximity in conjuction with the rapidity and severity of flooding contributed significantly to the death toll. Historical accounts of floods that occurred in the late 1800's and early 1900's suggest that one or more floods of a similar or greater magnitude have occurred within the last 200 years (Shindel, 1991).

The National Oceanic and Atmospheric Administration (1991) reported that meteorological conditions on a large scale were conducive to excessive rainfall but concluded that it was the smaller scale features of the weather system that focused the excessive rainfall near the Wegee and Pipe Creek Basins. The dominance of the smaller scale features may explain the extreme variability in the recurrence intervals of floods in nearby basins (table 25).

The U.S. Geological Survey documented flood profiles and made indirect determinations of discharge in both the Wegee and Pipe Creek Basins. Further information about the June 14–15 flood as well as a discussion of the history of flooding in the Wegee and Pipe Creek Basins can be found in Shindel (1991).

REFERENCES

Koltun, G.F., and Roberts, J.W., 1990, Techniques for estimating flood-peak discharges of rural, unregulated streams in Ohio: U.S. Geological Survey Water-Resources Investigations Report 89–4126, 68 p.

National Oceanic and Atmospheric Administration, 1991, Shadyside, Ohio, flash floods, June 14, 1990: U.S. Department of Commerce, Natural Disaster Survey Report, various pagination.

Shindel, H.L., 1991, Flood of June 14–15, 1990, in Belmont, Jefferson, and Harrison Counties, Ohio, with emphasis on Pipe and Wegee Creek basins near Shadyside: U.S. Geological Survey Water-Resources Investigations Report 91–4147, 33 p.

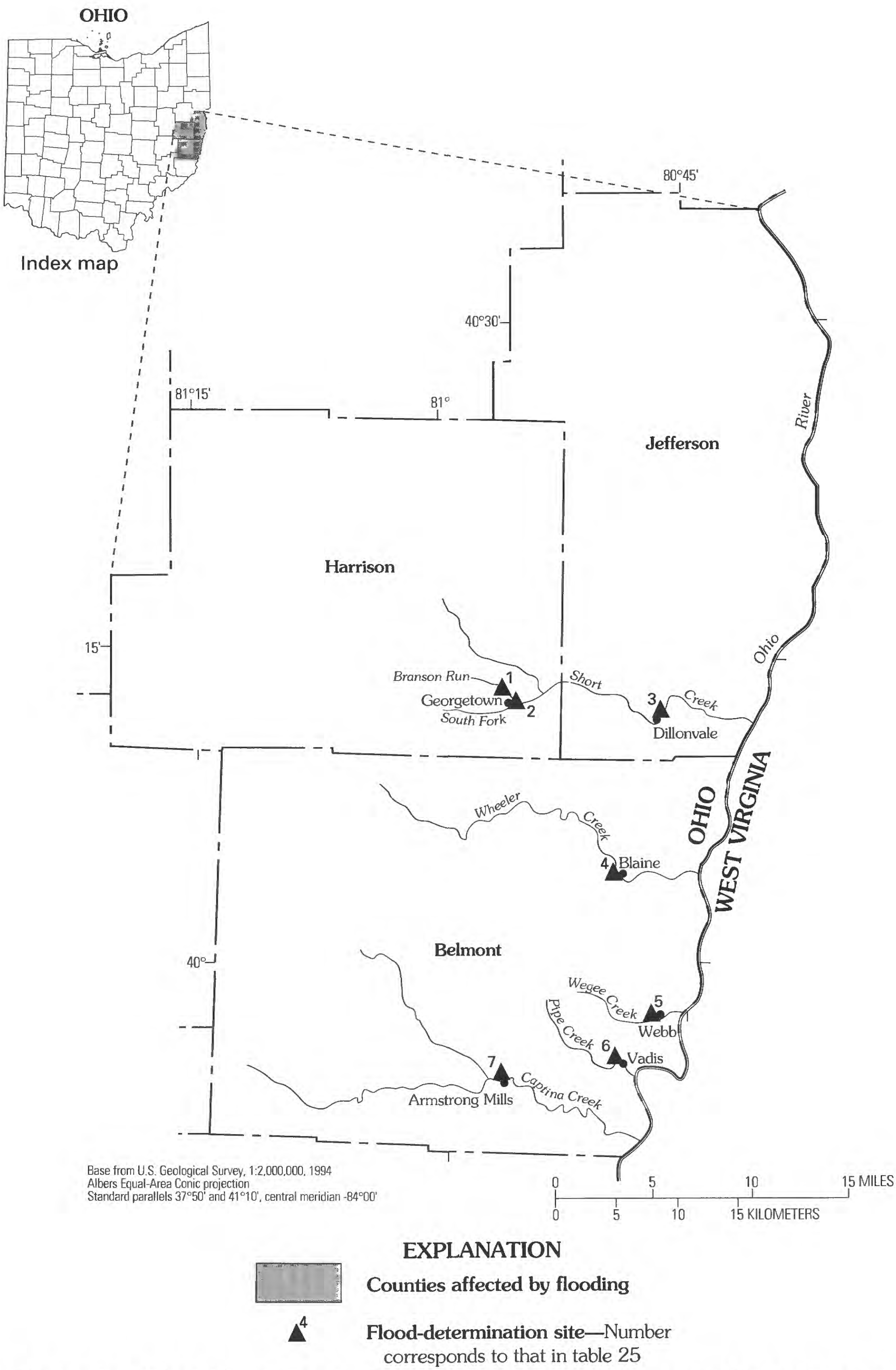


Figure 29. Location of flood-determination sites for floods of June 14–15, 1990, in eastern Ohio, and counties affected by flooding.

Table 25. Maximum stages and discharges prior to and during floods of June 14–15, 1990, in eastern Ohio

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; >, greater than; --, not determined or not applicable. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other information from U.S. Geological Survey reports or data bases]

				Maximum prior to June 1990				Maximum during June 1990			
Site no. (fig. 29)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Short Creek Basin							
1	03111450	Branson Run at Georgetown	1.31	1977–87	1978	96.89	134	14	97.87	190	25
2	03111455	South Fork Short Creek at Georgetown	10.9	1977–87	1980	87.65	380	14	88.76	620	25–50
3	03111500	Short Creek near Dillonvale	123	1941–90	1945 1963	[1]-- 10.17	6,500 [1]--	15	12.27	8,200	>100
				Wheeling Creek Basin							
4	03111548	Wheeling Creek below Blaine	97.7	1982–90	1989	6.85	3,780	15	7.63	4,720	5–10
				Wegee Creek Basin							
5	--	Wegee Creek near Webb	5.46	--	--	--	--	14	--	12,000	[2]>100
				Pipe Creek Basin							
6	--	Pipe Creek at Vadis	11.3	--	--	--	--	14	--	15,000	[2]>100
				Captina Creek Basin							
7	03114000	Captina Creek at Armstrong Mills	134	1926–35, 1958–90	1980	17.48	21,900	14	10.05	6,080	2

[1]Less than maximum for period.

[2]Estimated on the basis of regional-regression equations relating flood magnitude to frequency (Koltun and Roberts, 1990).

Floods of June and July 1990 in East-Central and Southeastern Nebraska

By J.A. Boohar

Severe thunderstorms during June 1990 caused damaging floods in east-central Nebraska along Shell Creek from Platte Center down to the confluence with the Platte River and in the Elkhorn River Basin from Norfolk to Waterloo. The excessive rainfall during June 1990 made it the 13th wettest June on record. Strong thunderstorms were concentrated in a six-county area (Colfax, Cuming, Dodge, Madison, Platte, and Stanton) in the east-central part of the State (fig. 30) during June 13–19, 1990. This area received rainfall totals of 8 to 9 inches, with more than 11 inches falling in a small area in northern Colfax County (National Oceanic and Atmospheric Administration, 1990a). The runoff volume from these storms was close to 100 percent of the rainfall.

East-central Nebraska has a topography that varies from steep bluffs to flat valley plains. Rolling hills and narrow tablelands between well-defined drainageways make up the Shell Creek drainage area. Major flooding occurred on Shell Creek on June 17, 1990, with the flood-determination site on Shell Creek near Columbus (site 1) recording a maximum stage of 22.76 feet at 4 a.m. (table 26). The discharge for this stage (8,000 cubic feet per second) exceeded the previous maximum in 40 years of record and has a recurrence interval of approximately 100 years.

The Elkhorn River originates in the northeast part of the Sandhills region and flows southeastward through rolling hills to join the Platte River about 30 miles from the Platte's confluence with the Missouri River. Three tributaries to the Elkhorn River—Union Creek, Pebble Creek, and Maple Creek—had major flooding as a result of thunderstorms during June. The maximum stage of Union Creek at Madison (site 3) was 25.72 feet at 4 a.m. on June 16, 1990. Discharge for this stage was 15,100 cubic feet per second and was a new maximum in 12 years of record. This discharge has a recurrence interval of approximately 60 years. The flood-determination site on Pebble Creek at Scribner (site 5) recorded a maximum stage of 23.90 feet at 5 a.m. on June 17. Discharge for this stage was 23,000 cubic feet per second and also was a new maximum in 12 years of record. This discharge has a recurrence interval of approximately 50 years. The flood-determination site on Maple Creek near Nickerson (site 6) recorded a maximum stage of 16.30 feet on June 17, time unknown. Discharge for this stage was 11,600 cubic feet per second and was a new maximum in 39 years of record. This discharge has a recurrence interval of approximately 50 years.

Lesser flooding occurred along the Elkhorn River main stem from Norfolk downstream to the confluence with the Missouri River, and on West Fork Big Blue River, where maximum discharges had recurrence intervals of 10 to 17 years (table 26).

According to assessments made by State, county, and city governments, intense rains from the series of storms during June 1990 resulted in contamination of numerous wells due to saturation of leaching areas of septic tanks; deposition of 4 to 8 inches of mud in some communities; rural bridges made impassable or washed out; and runoff that flooded one-third of the homes and businesses in Platte Center, a small village in Platte County. Eight injuries were reported along with one death that occurred in West Point on June 16, 1990.

Agricultural damages from soil erosion were severe with widespread losses of young row crops in the flooded areas. An interagency report (Interagency Hazard Mitigation Team, 1990, p. 13) indicated that almost 2 million acres of farmland were affected statewide. Crop losses amounted to about $57 million, with another $39 million in damages to livestock, farm equipment, and farm structures. Damages to public facilities amounted to about $5 million and include damages to roads, bridges, and culverts. The President of the United States issued a disaster declaration on July 4, 1990.

On July 19, 1990, a localized thunderstorm occurred in southeastern Nebraska (National Oceanic and Atmospheric Administration, 1990b, p. 89). This storm produced 6 inches of rain at Harvard and 9 inches near Sutton (fig. 30). However, Clay Center received no measurable precipitation on July 19 and only 0.58 inch on July 20. No measurable precipitation was reported at the Clay Center 6 ESE data site for July 19; 1.20 inches were reported for July 20. The

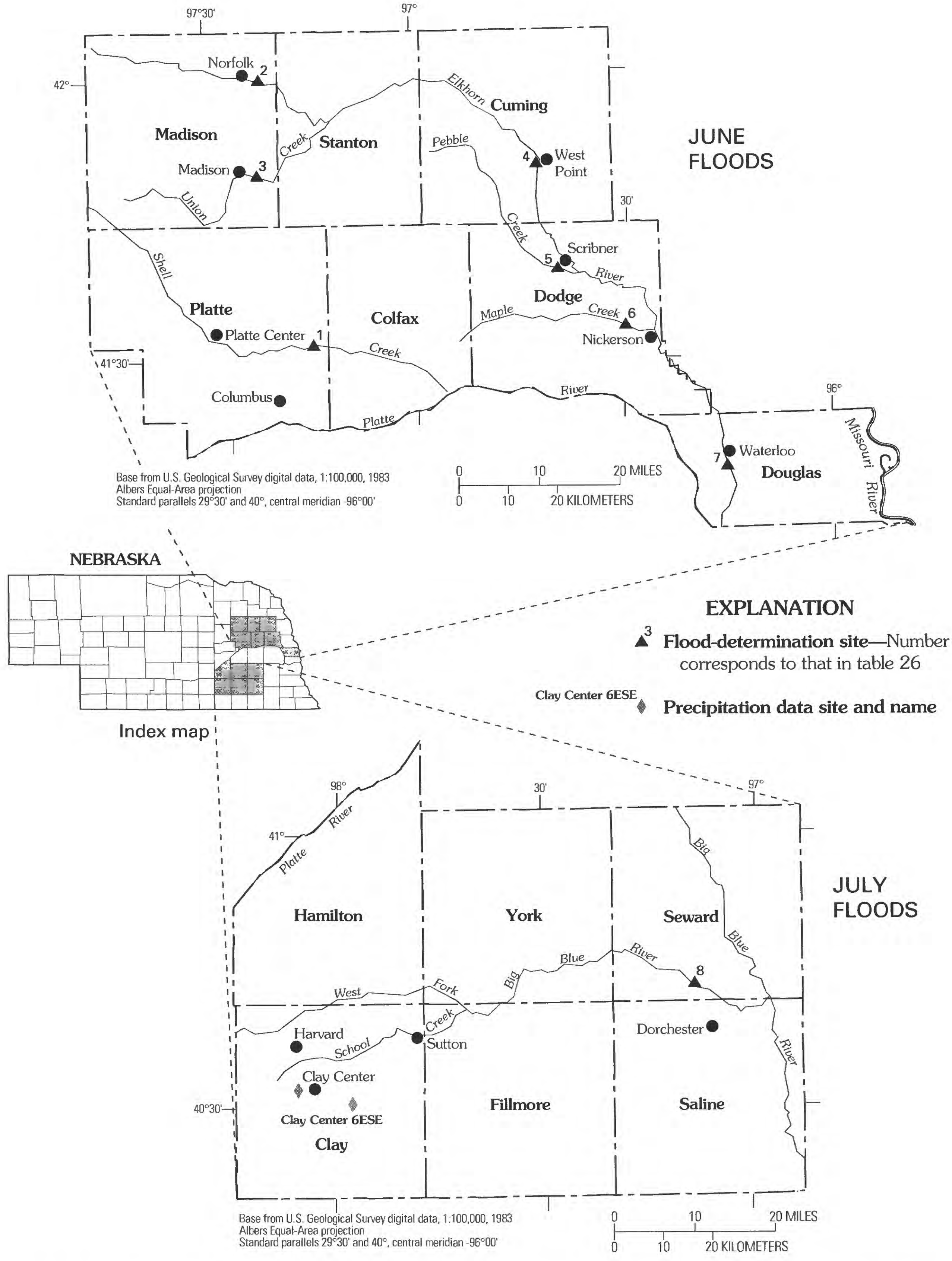


Figure 30. Location of flood-determination and precipitation data sites for floods of June and July 1990 in east-central and southeastern Nebraska.

Table 26. Maximum stages and discharges prior to and during floods of June and July 1990 in east-central and southeastern Nebraska

[mi^2, square miles; ft, feet above and arbitrary datum; ft^3/s, cubic feet per second; --, not determined or applicable. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to June and July 1990				Maximum during June and July 1990			
Site no. (fig. 30)	Station no.	Stream and point of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Date (month/day)	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Platte River Basin							
1	06795500	Shell Creek near Columbus	270	1947–90	1950	21.38	5,970	6/17	22.76	8,000	100
2	06799000	Elkhorn River at Norfolk	2,790	1897–1903, 1940–90	1967	--	16,900	6/16	9.25	10,500	10
3	06799230	Union Creek at Madison	174	1978–90	1984	22.90	7,630	6/16	25.72	15,100	60
4	06799350	Elkhorn River at West Point	5,100	1945–90	1967	--	44,000	6/17	14.71	30,300	10
					1982	16.37	--				
5	06799385	Pebble Creek at Scribner	204	1978–90	1984	23.75	20,300	6/17	23.90	23,000	50
6	06800000	Maple Creek near Nickerson	450	1944–90	1944	--	35,000	6/17	16.30	11,600	50
7	06800500	Elkhorn River at Waterloo	6,900	1880–1990	1944	--	100,000	6/19	17.30	37,000	15
				Kansas River Basin							
8	06880800	West Fork Big Blue River near Dorchester	1,206	1890–1990	1950	24.80	49,800	7/22	20.58	6,810	17

closest flood-determination site that recorded any stage increase during this time was the West Fork Big Blue River near Dorchester (site 8), 40 miles downstream from the confluence of School Creek and the West Fork Big Blue River. During the storm, School Creek overflowed its banks and flooded the Sutton city park. The flood-determination site near Dorchester recorded an increase in flow starting on July 21, with the maximum stage of 20.58 feet occurring at 9:30 p.m. on July 22. Discharge for this stage was 6,810 cubic feet per second and was determined to have a 17-year recurrence interval. Total damages in Clay County as a result of this storm were estimated to be more than $700,000 and involved businesses, private dwellings, public property, county roads, and rural areas.

REFERENCES

Interagency Hazard Mitigation Team, Region VII, 1990, Hazard mitigation opportunities in Nebraska: Federal Emergency Management Agency, Interagency Hazard Mitigation Report FEMA–873–DR–NEBRASKA, 40 p.

National Oceanic and Atmospheric Administration, 1990a, Climatological data, Nebraska, June 1990: Asheville, N.C., National Climatic Data Center, v. 95, no. 6, 33 p.

_____1990b, Storm data and unusual weather phenomena with late reports and corrections: Asheville, N.C., National Climatic Data Center, v. 32, no. 7, 170 p.

Floods of June and July 1990 in and near Las Vegas, Nevada

By Otto Moosburner

The most significant and intense storms of a rather "wet" summer in the Las Vegas metropolitan area occurred on June 10 and July 15–16, 1990. Although the mean annual precipitation in the area is about 4 inches, occasional floods, caused by intense rains in a rapidly urbanizing area, do occur.

Precipitation on June 10, from a moist unstable air mass associated with Tropical Depression Boris, totalled more than 1.5 inches in parts of Las Vegas immediately east and southeast of the downtown area. Most of the precipitation occurred within 1 hour. Maximum 15-minute intensities exceeded 3 inches per hour at several locations. Flooding was generated almost totally in and confined to the urbanized area as shown by the precipitation distribution (fig. 31).

The July 15–16 storm occurred west of the urbanized area in the headwaters and alluvial-fan areas of the Flamingo Wash drainage (fig. 32). Total rainfall in excess of 1.5 inches was recorded at a number of locations (an unofficial storm total of 2.5 inches was reported at one location). The storm generally lasted less than 2 hours.

Flamingo Wash is ephemeral, originates in the Spring Mountains west of Las Vegas, and drains generally eastward through central Las Vegas to join Las Vegas Wash in east Las Vegas. Las Vegas Wash flows to Lake Mead, an impoundment on the Colorado River. Since 1966, when flow records along Flamingo Wash began, five major floods have occurred—in 1975, 1983, 1984, and two in 1990. The magnitudes of major Flamingo Wash floods are listed in table 27. Because of changes in channel-measuring conditions, flood discharges have not been determined at consistent locations.

The maximum discharge in Flamingo Wash on June 10 was small west of the urbanized area (site 1, table 27), but it increased substantially through town (site 5, table 27). Discharge remained high in Las Vegas Wash at the outlet of Las Vegas Valley (4,050 cubic feet per second at site 6). On July 16, the maximum discharge west of Las Vegas was extremely high (site 1, table 27) but attenuated greatly to 512 cubic feet per second in Las Vegas Wash at the outlet of Las Vegas Valley.

Two deaths were attributed to the June 10 flooding—a woman drowned in her vehicle as she attempted to drive across a flood channel, and a man was swept into a manhole from which the cover reportedly had been removed. A woman died in the early morning hours of July 16 in Flamingo Wash when she was swept downstream from her vehicle while attempting to ford the flow. The June 10 and July 16 floods caused $8.7 million in damage to public facilities (Las Vegas Review-Journal, August 1990).

REFERENCES

National Oceanic and Atmospheric Administration, 1990a, Climatological data, Nevada, June 1990: Asheville, N.C., National Climatic Data Center, v. 105, no. 6, 18 p.

_____1990b, Climatological data, Nevada, July 1990: Asheville, N.C., National Climatic Data Center, v. 105, no. 7, 22 p.

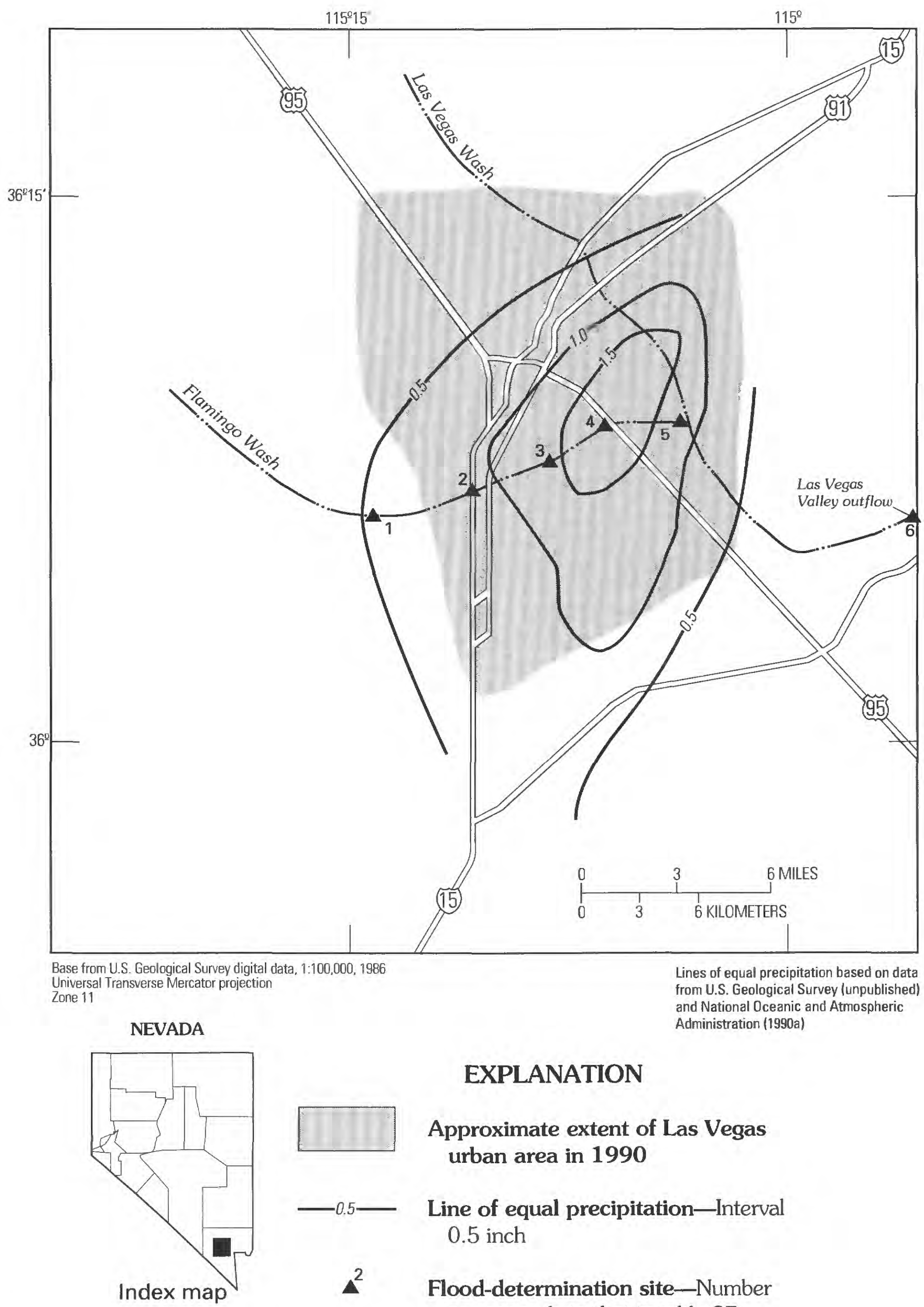
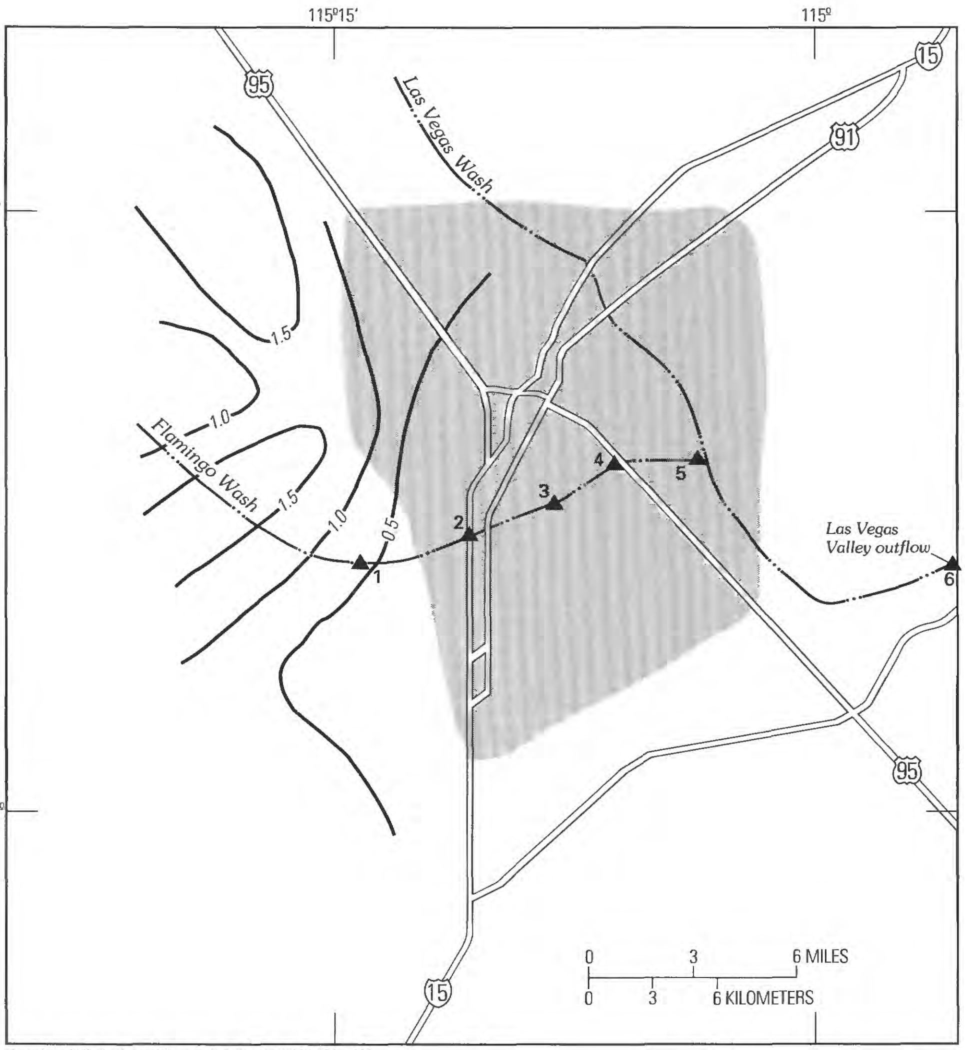


Figure 31. Location of flood-determination sites on Flamingo Wash, 1975–90, and lines of equal precipitation for storm of June 10, 1990, in and near Las Vegas, Nevada.



Base from U.S. Geological Survey digital data, 1:100,000, 1986
Universal Transverse Mercator projection
Zone 11

Lines of equal precipitation based on data from U.S. Geological Survey (unpublished) and National Oceanic and Atmospheric Administration (1990b)

EXPLANATION

Approximate extent of Las Vegas urban area in 1990

—0.5— **Line of equal precipitation**—Interval 0.5 inch

▲2 **Flood-determination site**—Number corresponds to that in table 27

Figure 32. Location of flood-determination sites on Flamingo Wash, 1975–90, and lines of equal precipitation for storm of July 15–16, 1990, in and near Las Vegas, Nevada.

Table 27. Maximum stages and discharges prior to and during floods of June and July 1990 in and near Las Vegas, Nevada

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined or not applicable. Source: Data from U.S. Geological Survey reports or data bases]

Site no. (figs. 31 and 32)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to June 1990: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximums during June and July 1990: Date (month/day)	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
1	09419673	Flamingo Wash near Torrey Pines Drive near Las Vegas	94	1988–90	1989	11.54	115	6/10 7/16	-- 21.41	357 3,920	-- --
2	09419675	Flamingo Wash at Las Vegas	[1]98	1966–81, 1985–89	1975	7.23	3,910	--	--	--	--
3	09419677	Flamingo Wash at Maryland Parkway at Las Vegas	106	1969–87	1983	12.15	4,700	--	--	--	--
4	09419678	Flamingo Wash near mouth at Las Vegas	117	1969–87	1984	--	4,000	--	--	--	--
5	09419678.1	Flamingo Wash at Nellis Blvd. near Las Vegas	215	--	--	--	--	6/10 7/16	15.90 --	4,100 3,260	-- --
6	09419753	Las Vegas Wash above Three Kids Wash below Henderson	[1]2,180	1988–90	1989	6.99	299	6/10 7/16	11.28 --	4,050 512	-- --

[1]Approximately.

Floods of July 1990 in Vermont

By M.F. Coakley *and* R.O. Brown

Severe thunderstorms in northern and central Vermont on July 4 and July 23, 1990, caused flooding on July 4–6 and July 23–24. As a result of the storm damage, the President of the United States declared the counties of Caledonia, Chittenden, Franklin, Lamoille, Washington, and Orange (fig. 33) flood-disaster areas eligible for public assistance. No injuries or loss of life because of either storm were reported (Federal Emergency Management Agency, 1990).

The steep topography of the Green Mountains in northern Vermont forces unstable air masses to rise up over the mountains and rapidly form into thunderstorms that release intense, localized precipitation and cause substantial runoff. Severe thunderstorms occurred along a front extending from Fairfax to Newbury in northern Vermont on July 4, 1990. A second series of severe thunderstorms developed within the western part of the same region on July 23, 1990, especially within Chittenden, Lamoille, and Washington Counties. The two July storms produced excessive precipitation over localized areas. Recorded rainfall amounts in the areas of excessive rainfall ranged from 2.7 to 5.3 inches as a result of the July 4 storm and from 4.5 to 5 inches in less than 12 hours as a result of the July 23 storm (Federal Emergency Management Agency, 1990; fig. 33).

Precipitation that is concentrated on the steep mountain slopes of northern Vermont often results in extreme discharges and velocities in streams that can cause erosion and damage to highway structures. Records for a flood-determination site on the East Orange Branch at East Orange, Vermont (site 5, fig. 34), indicate a rapid rise and large volume from the July 23 storm (U.S. Geological Survey, 1991). A new maximum instantaneous discharge of 800 cubic feet per second, which exceeded the previous maximum of 672 cubic feet per second recorded in 1973, was established at this site (table 28). Sites on the North Branch of the Winooski River at Wrightsville (site 14) and on the Jail Branch at East Barre (site 13) had maximum discharges on July 5 and July 23, respectively (table 28). Flood-control structures upstream of both sites contained the runoff effectively; however, the maximum discharge of 1,100 cubic feet per second measured at the North Branch Winooski site was a new maximum for the period following the construction of the flood-control structure in 1935 and exceeded the previous maximum of 1,040 cubic feet per second recorded in 1936. Other nearby flood-determination sites, for example Wells River at Wells River (site 4), had considerably less runoff.

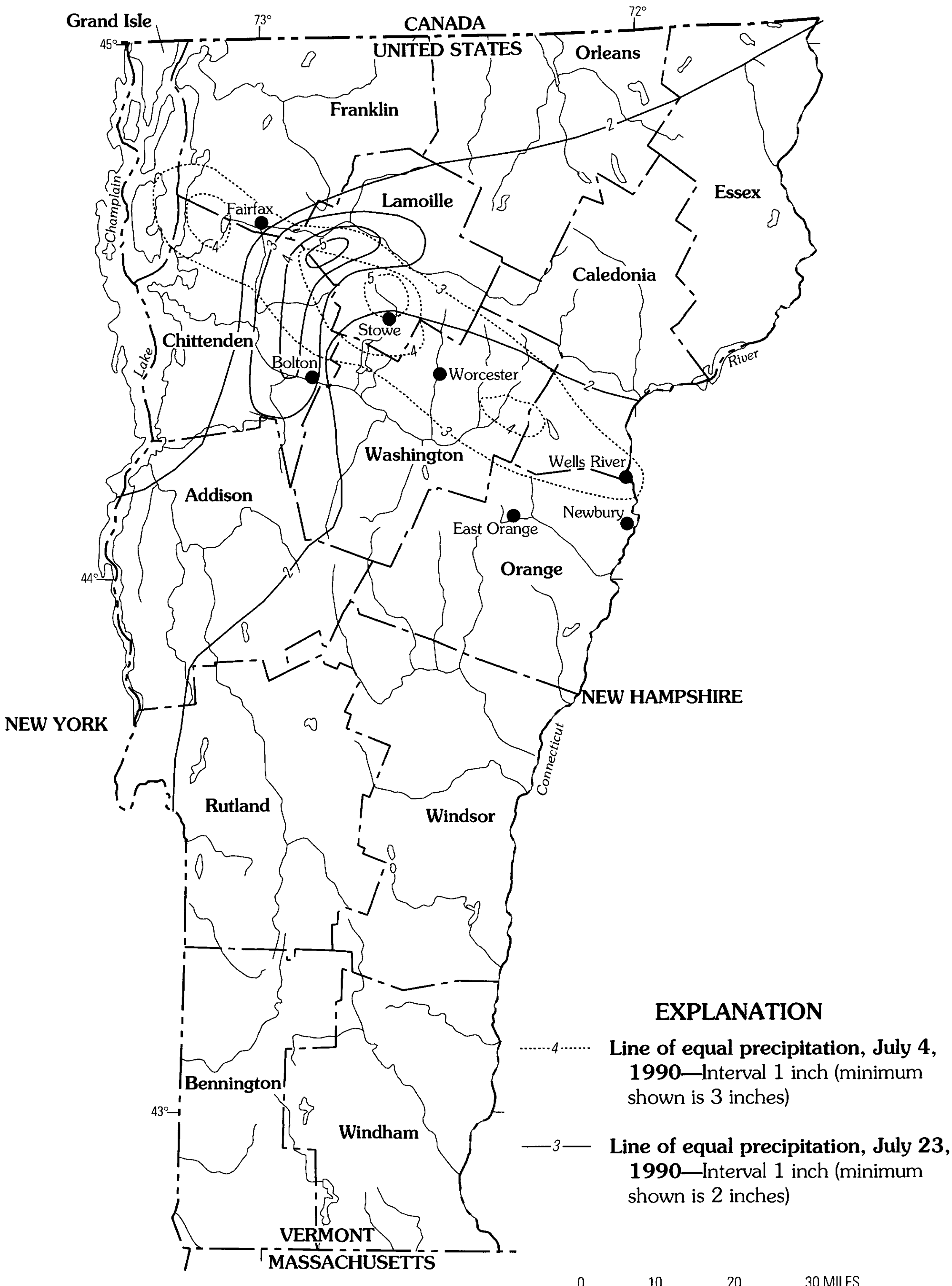
Storm damage was confined principally to roads, bridges, and culverts in the six-county disaster area. Towns experiencing the greatest damage were Bolton, Stowe, and Worcester. Flash floods on small streams washed out two bridges and several road culverts in these areas. Total storm damage was approximately $2.6 million and included damage to roads, bridges, culverts, and public facilities (Federal Emergency Management Agency, 1990).

REFERENCES

Federal Emergency Management Agency, 1990, Hazard mitigation survey team report: FEMA–875–DR–VT, August 1990, 22 p.

National Oceanic and Atmospheric Administration, 1990, Climatological data, New England, July 1990: Asheville, N.C., National Climatic Data Center, v. 102, no. 7, 64 p.

U.S. Geological Survey, 1991, Water resources data for New Hampshire and Vermont—Water year 1990: U.S. Geological Survey Water-Data Report NH–VT–90–1, 148 p.



Base from U S Geological Survey digital data, 1 2,000,000, 1994
Albers Equal-Area Conic projection
Standard parallels 29°30' and 45°30', central meridian -96°00'

Figure 33. Precipitation from storms of July 4 and July 23, 1990, in Vermont (modified from Federal Emergency Management Agency, 1990).

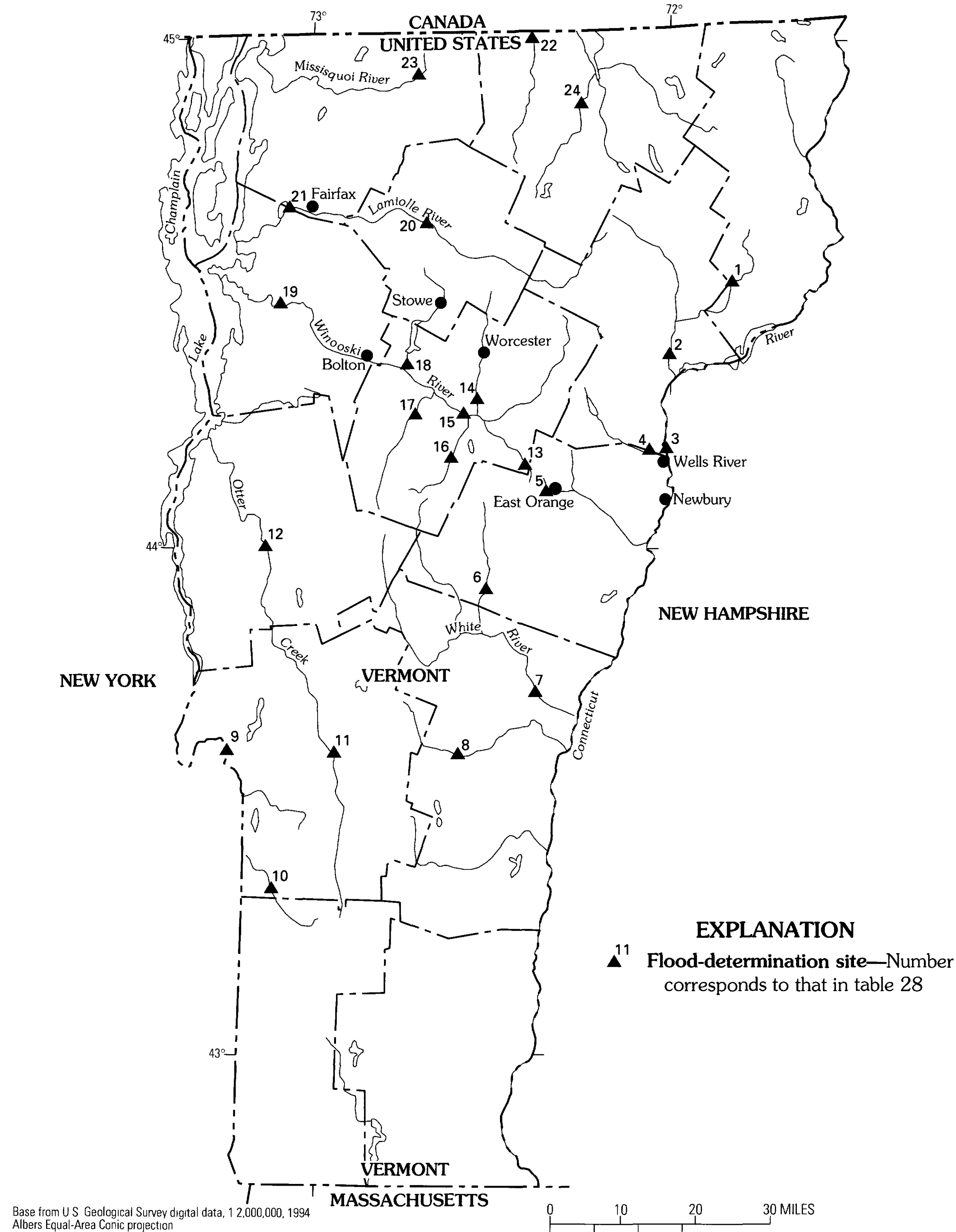


Figure 34. Location of flood-determination sites for floods of July 4 and July 23, 1990, in Vermont.

Table 28. Maximum stages and discharges prior to and during floods of July 4 and July 23, 1990, in Vermont

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; <, less than; >, greater than. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to July 1990				Maximum during July 1990			
Site no. (fig. 34)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Connecticut River Basin							
1	01134500	Moose River at Victory	75.2	1947–90	1973	12.04	4,340	5	6.23	566	<2
2	01135500	Passumpsic River at Passumpsic	436	1928–90	1973	23.49	18,200	24	6.94	3,170	<2
3	01138500	Connecticut River at Wells River	2,644	1949–90	1973	17.35	57,100	5	6.64	15,100	<2
4	01139000	Wells River at Wells River	98.4	1940–90	1973	9.82	5,970	5	6.13	2,160	5
5	01139800	East Orange Branch at East Orange	8.95	1958–90	1973	5.55	672	23	5.90	[1]800	>100
6	01142500	Ayers Brook at Randolph	30.5	1939–90	1973	10.37	2,600	23	4.44	172	<2
7	01144000	White River at West Hartford	690	1761–1990	1927	29.30	120,000	24	5.73	2,120	<2
8	01150900	Ottauquechee River near West Bridgewater	23.4	1984–90	1987	7.78	1,270	23	2.92	35	<2
				St. Lawrence River Basin							
9	04280000	Poultney River below Fair Haven	187	1928–90	1945	24.36	14,800	23	2.73	143	<2
10	04280350	Mettawee River near Pawlet	70.2	1984–90	1986	[1]5.22	3,310	23	2.45	121	<2
					1990	5.82	--				
11	04282000	Otter Creek at Center Rutland	307	1928–90	1938	12.45	13,700	4	2.37	287	<2
12	04282500	Otter Creek at Middlebury	628	1830–1990	1927	13.30	13,600	23	2.94	1,100	<2
13	04284000	Jail Branch at East Barre	38.9	[2]1935–90	1935	--	821	23	4.45	393	<2
					1973	9.48	--				
14	04285500	North Branch Winooski River at Wrightsville	69.2	[2]1935–90	1936	[1]4.32	1,040	5	3.96	1,100	<2
15	04286000	Winooski River at Montpelier	397	1830–1990	1927	27.10	57,000	5	9.07	4,770	<2
16	04287000	Dog River at Northfield Falls	76.1	1934–90	1973	11.57	10,600	23	2.29	380	<2
17	04288000	Mad River near Moretown	139	1830–1990	1927	19.40	23,000	23	5.87	2,170	<2
18	04289000	Little River near Waterbury	111	1935–90	1936	19.38	6,520	23	12.79	3,310	<2

Table 28. Maximum stages and discharges prior to and during floods of July 4 and July 23, 1990, in Vermont—Continued

Site no. (fig. 34)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to July 1990: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during July 1990: Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
			St. Lawrence River Basin—Continued								
19	04290500	Winooski River near Essex Junction	1,044	1830–1990	1927	50.40	113,000	23	8.05	10,400	<2
20	04292000	Lamoille River at Johnson	310	1928–90	1973	17.33	14,400	23	12.43	7,370	2
21	04292500	Lamoille River at East Georgia	686	1929–90	1982	--	23,700	5	8.64	9,100	<2
					1982	12.83	--				
22	04293000	Missisquoi River near North Troy	131	1931–90	1982	13.21	8,290	5	6.92	2,290	<2
23	04293500	Missisquoi River near East Berkshire	479	1830–1990	1927	23.10	45,000	6	5.89	2,640	<2
24	04296000	Black River at Coventry	122	1951–90	1976	7.91	3,740	5	4.95	896	<2

[1]Less than maximum for period. [2]Period of flow regulation.

Floods of July 12–15, 1990, in Central and Eastern Ohio

By G.F. Koltun

A slow-moving frontal system lingered in Ohio from July 9–16, 1990, causing excessive rains and flooding in the central and eastern parts of the State. Rainfall totals for the period were quite variable; however, most areas of the State received between 3 and 5 inches. Rainfall was greatest on July 12, 1990, in most areas of the State, with some reports of rainfall totals in excess of 4 inches. The National Oceanic and Atmospheric Administration reported that 2.2 inches of rain fell in the Columbus area in Franklin County during a 3-hour period, causing flooding of city streets.

Flooding in Licking County was widespread, with the communities of Granville, Heath, Marne, and Newark being the most seriously affected (fig. 35). Small stream and urban flooding also occurred in Belmont, Columbiana, Jefferson, Mahoning, and Trumbull Counties in extreme eastern Ohio. Maximum discharges for selected flood-determination sites are reported in table 29.

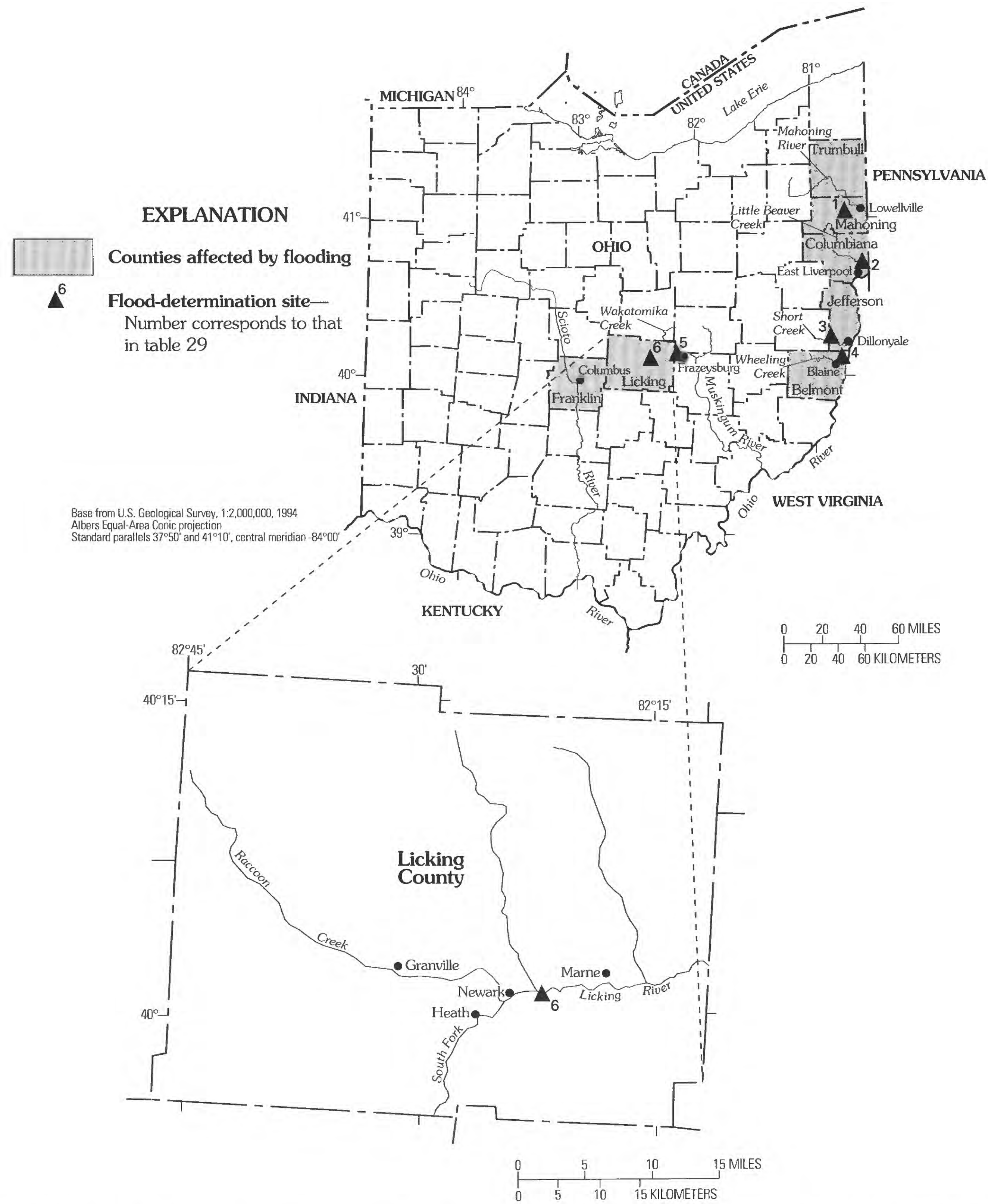


Figure 35. Location of flood-determination sites for floods of July 12–15, 1990, in central and eastern Ohio, and counties affected by flooding.

Table 29. Maximum stages and discharges prior to and during floods of July 12–15, 1990, in central and eastern Ohio

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined or not applicable. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

Site no. (fig. 35)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to July 1990: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during July 1990: Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (year)
				Mahoning River Basin							
1	[1]03099500	Mahoning River at Lowellville	1,073	1913, 1944–90	1959 1913	[2]-- 17.8	21,000 [2]--	15	11.91	16,300	--
				Little Beaver Creek Basin							
2	03109500	Little Beaver Creek near East Liverpool	496	1915–90	1941	17.40	25,000	15	15.89	20,600	25
				Short Creek Basin							
3	03111500	Short Creek near Dillonvale	123	1941–90	1990	12.27	8,200	12	9.75	4,200	5
				Wheeling Creek Basin							
4	03111548	Wheeling Creek below Blaine	97.7	1982–90	1989	6.85	3,780	12	7.72	4,840	5–10
				Muskingum River Basin							
5	03144000	Wakatomika Creek near Frazeysburg	140	1936–90	1979	14.07	16,800	13	10.15	7,250	5–10
6	03146500	Licking River near Newark	537	1939–90	1959	20.30	45,000	12	15.05	19,800	5–10

[1]Streamflow at this gaging station is regulated.
[2]Less than maximum for period.

Flood of July 27–August 2, 1990, in Central Iowa

By B.D. Schaap

Widespread flooding occurred in central Iowa from July 27 to August 2, 1990, as several thunderstorms produced excessive rains in the area (fig. 36). Most of the rain fell on July 27. Four-day total rainfall amounts of more than 5 inches were common (table 30), with as much as 9 inches unofficially reported 55 miles northwest of Waterloo. Although thousands of homes were affected by flooding and some roads were closed, most of the damages, an estimated $400,000 on the basis of information provided by the Iowa Disaster Services Division (Ellen M. Gordon, Administrator, written commun., 1991), were agricultural losses. An earthen dam on the West Fork Cedar River, about 25 miles upstream of Waterloo, was threatened but did not fail. Unprecedented amounts of water overflowed the 30-year-old dam, which is part of a system of structures retaining the Big Marsh wetland. About 15 miles closer to Waterloo, the stage of the West Fork Cedar River at Finchford (site 14, fig. 36) was more than 1 foot above the previous maximum stage (table 31). The President of the United States declared 17 counties affected by this flood and a flood later in August a disaster area.

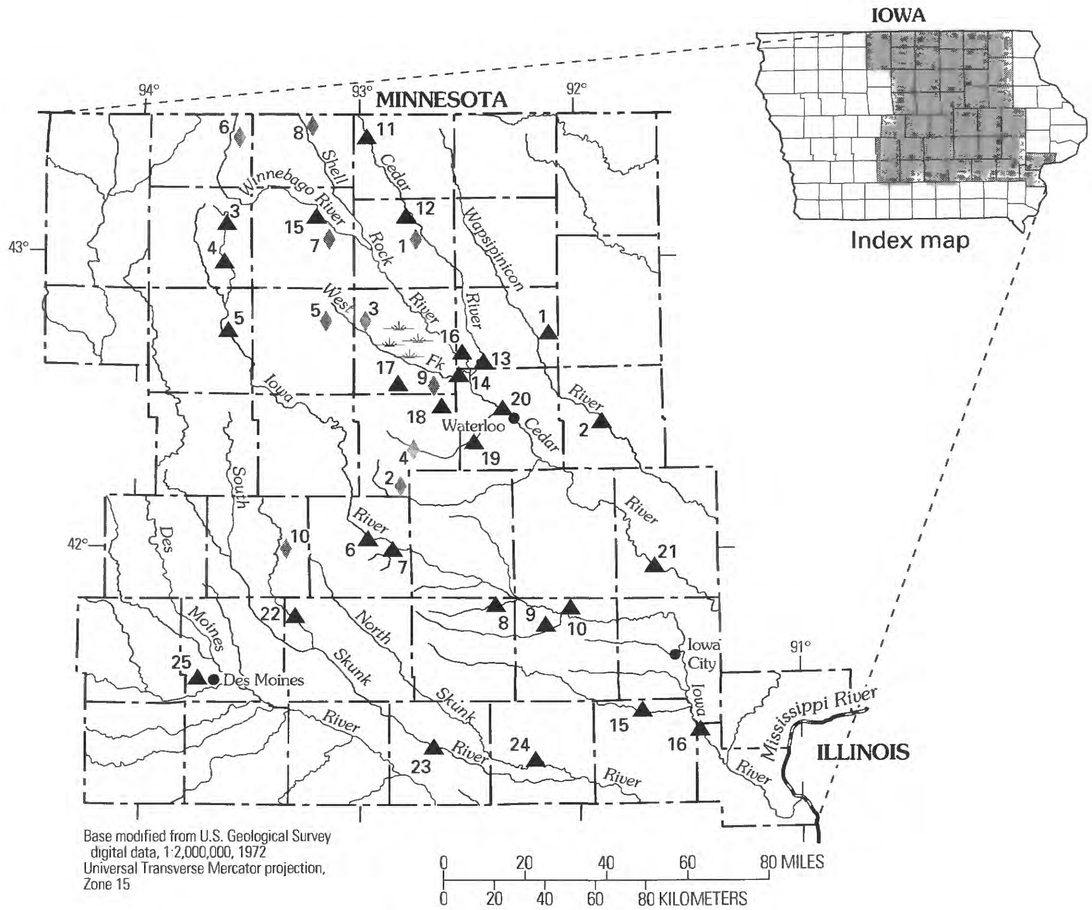
REFERENCE

National Oceanic and Atmospheric Administration, 1990, Climatological data, Iowa, July 1990: Asheville, N.C., National Climatic Data Center, v. 101, no. 7, 34 p.

Table 30. Total precipitation, July 27–30, 1990, in central Iowa

[Data from National Oceanic and Atmospheric Administration, 1990]

Site no. (fig. 36)	Precipitation data site	Precipitation (inches)
	Iowa River Basin	
1	Charles City	5.11
2	Conrad 2 SSE	5.55
3	Dumont	5.53
4	Grundy Center	5.41
5	Hampton	5.35
6	Lake Mills	5.16
7	Mason City	5.68
8	Northwood	6.43
9	Parkersburg	5.73
	Skunk River Basin	
10	Colo	6.10



EXPLANATION

Big Marsh wetland

22 ▲ **Flood-determination site**—Number corresponds to that in table 31

2 ♦ **Precipitation data site**—Number corresponds to that in table 30

Figure 36. Location of flood-determination and precipitation data sites for flood of July 27–August 2, 1990, in central Iowa.

Table 31. Maximum stages and discharges prior to and during flood of July 27–August 2, 1990, in central Iowa

[mi², square miles; ft, feet above an arbitrary datum; ft³/s, cubic feet per second; --, not determined or not applicable; <, less than. Source: Recurrence intervals are calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum(s) prior to July 1990				Maximum during July 27–August 2, 1990			
Site no. (fig. 36)	Station no.	Stream and place of determination	Drainage area (mi²)	Period	Year	Stage (ft)	Discharge (ft³/s)	Date (month/day)	Stage (ft)	Discharge (ft³/s)	Discharge recurrence interval (years)
			Wapsipinicon River Basin								
1	05420855	Buck Creek near Oran	37.9	1966–90	1979	90.00	1,460	7/29	90.06	1,500	--
2	05421000	Wapsipinicon River at Independence	1,048	1901–90	1968	21.11	26,800	7/31	10.15	7,260	2
			Iowa River Basin								
3	05448800	East Branch Iowa River near Garner	45.1	1952–90	1961	12.81	1,120	7/29	9.36	371	--
4	05449000	East Branch Iowa River near Klemme	133	1948–76, 1977–90	1954	11.2	5,960	7/29	8.51	804	<2
5	05449500	Iowa River near Rowan	429	1940–76,	1954	14.88	8,460	7/29	10.84	1,760	<2
				1977–90	1984	15.00	--				
6	05451500	Iowa River at Marshalltown	1,564	1915–27, 1932–90	1918	17.74	42,000	7/28	18.78	10,900	3
7	05451700	Timber Creek near Marshalltown	118	1949–90	1977	17.69	12,000	7/29	14.57	3,360	3
8	05452200	Walnut Creek near Hartwick	70.9	1947–90	1947	17.7	--	7/28	15.72	6,500	15
				1949–90	1983	16.65	7,100				
9	05453000	Big Bear Creek at Ladora	189	1945–90	1960	14.60	10,500	7/29	21.06	3,570	<2
10	05453100	Iowa River at Marengo	2,794	1956–90	1960	19.21	30,800	8/1	17.42	12,500	<2
11	05457440	Deer Creek near Carpenter	91.6	1966–90	1979	83.40	3,900	7/29	85.01	3,800	--
12	05457700	Cedar River at Charles City	1,054	1961–90	1961	21.53	29,200	7/30	14.24	11,300	3
13	05458500	Cedar River at Janesville	1,661	1904–06, 1914–27, 1932–42, 1945–90	1961	16.33	37,000	7/30	10.30	12,800	3
14	05458900	West Fork Cedar River at Finchford	846	1945–90	1951	17.28	31,900	7/29	18.45	23,300	30
15	05459500	Winnebago River at Mason City	526	1932–90	1933	15.7	10,800	7/27	7.62	2,620	<2
16	05462000	Shell Rock River at Shell Rock	1,746	1856, 1953–90	1856	17.7	45,000	7/29	13.43	12,800	4
17	05462750	Beaver Creek tributary near Aplington	11.6	1966–90	1983	94.27	3,000	7/29	93.65	1,270	--

Table 31. Maximum stages and discharges prior to and during flood of July 27–August 2, 1990, in central Iowa—Continued

				Maximum(s) prior to July 1990				Maximum during July 27–August 2, 1990			
Site no. (fig. 36)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Date (month/day)	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
		Iowa River Basin—Continued									
18	05463000	Beaver Creek at New Hartford	347	1945–90	1947	13.5	18,000	7/29	11.19	6,310	4
19	05463500	Black Hawk Creek at Hudson	303	1952–90	1969	18.23	19,300	7/29	16.38	7,900	10
20	05464000	Cedar River at Waterloo	5,146	1940–90	1961	21.86	76,700	7/30	17.38	47,100	5
21	05464500	Cedar River at Cedar Rapids	6,510	1902–90	1961	19.66	73,000	8/2	14.57	46,300	5
		Skunk River Basin									
22	05471200	Indian Creek near Mingo	276	1944–90	1944	21.4	--	7/28	16.34	6,980	15
				1958–90	1966	16.41	7,380				
23	05471500	South Skunk River near Oskaloosa	1,635	1944–90	1944	25.80	37,000	7/31	19.71	8,170	<2
24	05472500	North Skunk River near Sigourney	730	1945–90	1960	25.33	27,500	7/31	18.49	4,800	<2
		Des Moines River Basin									
25	05484800	Walnut Creek at Des Moines	78.4	1971–90	1986	18.32	12,500	7/27	10.97	1,640	<2

Floods of August 7–14, 1990, in New Hampshire

By K.E. McKenna

Excessive precipitation from storms between August 7 and 11, 1990, resulted in flooding in the central and northern parts of New Hampshire. As a result of the storm damage, the President of the United States declared the counties of Belknap, Carroll, Cheshire, Coos, Grafton, Hillsborough, Merrimack, and Sullivan (fig. 37) flood-disaster areas eligible for public assistance (Federal Emergency Management Agency, 1990).

The precipitation was associated with a low-pressure system in the lower Great Lakes Region and with a slow-moving cold front that began moving into New England on August 6. A convergence zone of air masses formed between an area of high pressure in the Canadian Maritime Provinces and a low-pressure system and associated cold front in the lower Great Lakes Region. The convergence zone extended from northern New Hampshire to western Massachusetts and moved very slowly eastward during the next 36 to 48 hours. Thunderstorms with intense rain developed and moved northward along the convergence zone (Federal Emergency Management Agency, 1990).

By 7 a.m., August 7, the town of Glencliff, New Hampshire, reported 3.18 inches of rain; the largest amount reported in New Hampshire for the 24-hour period beginning at 7 a.m. on August 6. Precipitation in most areas ranged from 2 to 2.5 inches. During the daytime of August 7, rain fell at a moderate to intense rate. The National Oceanic and Atmospheric Administration issued a flood watch at 12:40 p.m., and flood warnings by 6:53 p.m. Maximum rainfall totals for August 7–8 were as follows: 7.65 inches at Bristol, 7.10 inches at Bradford, and 7.06 inches at Plymouth. Most of this rain fell in one 24-hour period from 7 a.m. August 7 to 7 a.m. August 8 (fig. 37).

A high-pressure area over the Great Lakes moved into New England on August 8 and 9, pushing the cold front eastward into Maine and bringing relief from the rain in New Hampshire. On August 10, the maritime high-pressure system strengthened and pushed the cold front back westward into New Hampshire. The cold front became nearly stationary and extended from southwestern New Hampshire to Berlin in the northeast. On August 10, an area of low pressure formed over the Middle Atlantic States and moved northeastward along the front bringing additional rain to New Hampshire. Rainfall amounts (fig. 38) were approximately equal to or less than the 10-year frequency rainfall; amounts in isolated small areas exceeded the 100-year frequency rainfall (Federal Emergency Management Agency, 1990).

Stream-discharge data correlated with basinwide rainfall data for the August storms. Records for the flood-determination sites on the Smith River near Bristol (site 7, fig. 39) and West Branch Warner River near Bradford (site 11) indicated discharges of a 5-year recurrence interval as a result of the August 6–8 rainfall and runoff. Records for the Lucy Brook near North Conway flood-determination site (site 2) indicated a new maximum instantaneous discharge of 2,660 cubic feet per second on August 11, which exceeded the previous maximum of 1,320 cubic feet per second recorded in 1979 (table 32). The recurrence interval for the Lucy Brook flood of August 11 was greater than 100 years. On the same day on the nearby Ellis River near Jackson (site 1), runoff was considerably less than in Lucy Brook, indicating that only a small isolated area in the upland area near Lucy Brook was affected by the August 10–11 rainfall. Discharges from most other flood-determination sites (table 32) had recurrence intervals of about 2 years or less for the August storms.

Damage principally was confined to gravel roads, bridges, culverts, and shoulders of paved roads. A railroad bridge in Meredith suffered substantial erosional damage. No unregulated flood-determination sites were in the area near Meredith, so the recurrence interval of the flood in Meredith could not be determined. Total estimated damage to public facilities was about $1.2 million (Federal Emergency Management Agency, 1990).

REFERENCE

Federal Emergency Management Agency, 1990, Hazard mitigation survey team report: FEMA–876–DR–NH, September 1990, 19 p.

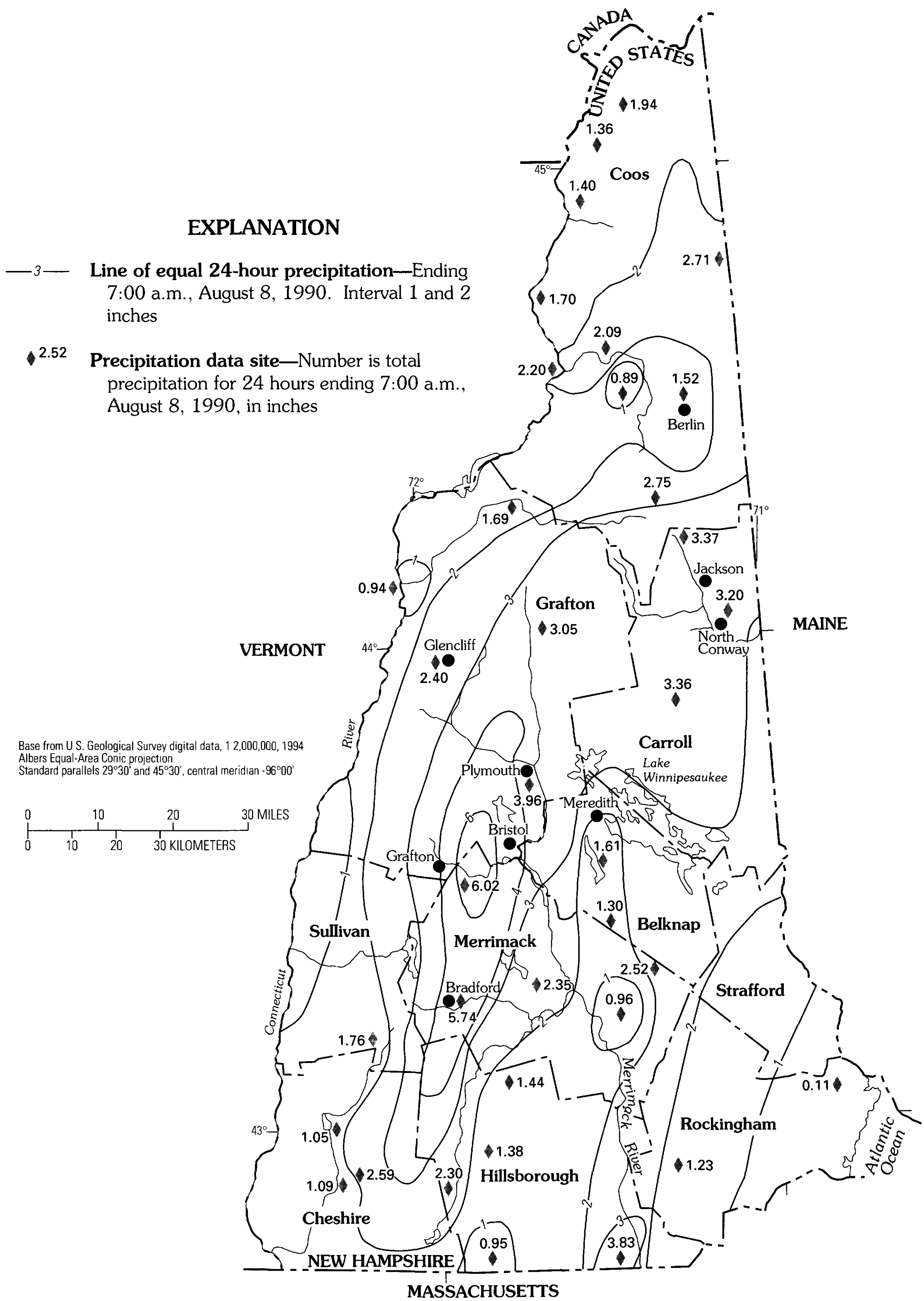


Figure 37. Precipitation for storm of August 7–8, 1990, in New Hampshire (Federal Emergency Management Agency, 1990).

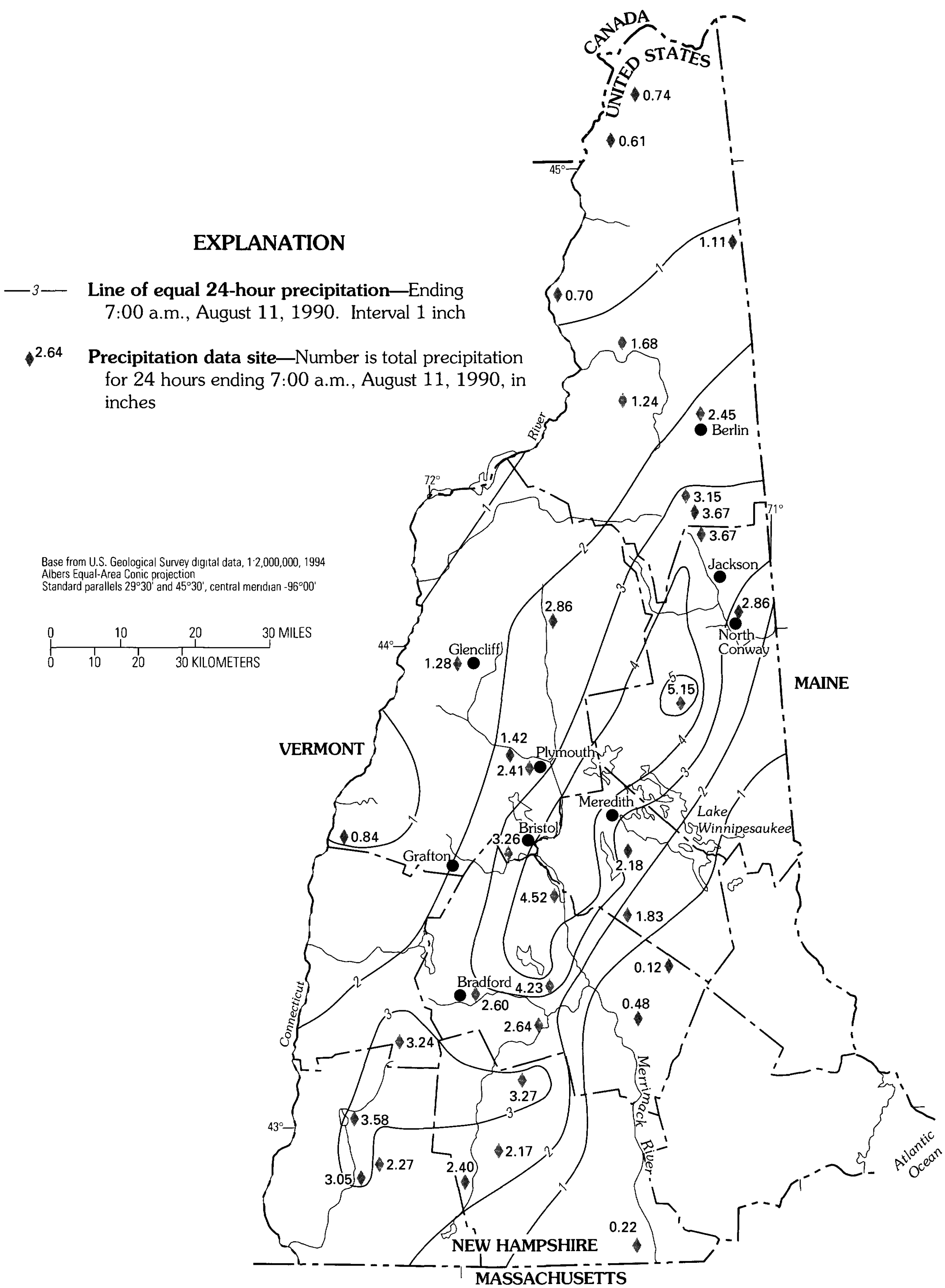


Figure 38. Precipitation for storm of August 10–11, 1990, in New Hampshire (Federal Emergency Management Agency, 1990).

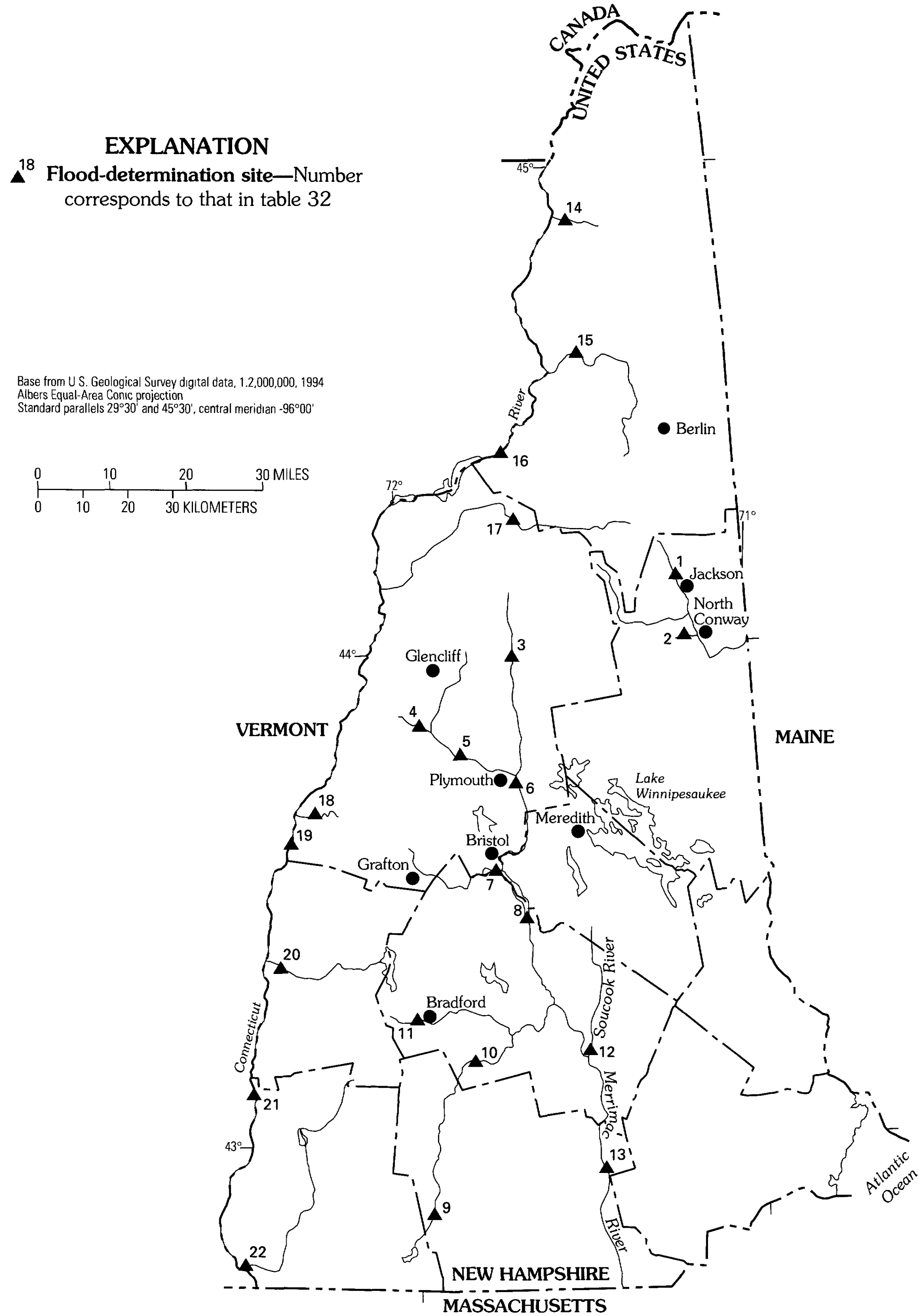


Figure 39. Location of flood-determination sites for floods of August 7–14, 1990, in New Hampshire.

Table 32. Maximum stages and discharges prior to and during floods of August 7–14, 1990, in New Hampshire

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; >, greater than; <, less than; --, not determined. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to August 1990				Maximum during August 1990			
Site no. (fig. 39)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Dis-charge (ft^3/s)	Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Saco River Basin							
1	01064300	Ellis River near Jackson	10.9	1963–90	1966	10.34	4,500	11	4.76	1,140	2
2	01064400	Lucy Brook near North Conway	4.60	1964–90	1979	8.49	1,320	11	9.67	2,660	>100
				Merrimack River Basin							
3	01075000	Pemigewasset River at Woodstock	193	1940–90	1959	16.13	47,000	11	9.14	9,990	<2
4	01075800	Stevens Brook near Wentworth	2.94	1963–90	1973	6.36	1,120	7	3.35	208	2
5	01076000	Baker River near Rumney	143	1929–90	1942	15.50	21,400	8	7.88	4,980	<2
6	01076500	Pemigewasset River at Plymouth	622	1903–90	1936	29.00	65,400	11	15.63	22,100	2
7	01078000	Smith River near Bristol	85.8	1918–90	1936	16.09	8,100	8	8.54	2,720	5
8	01081500	Merrimack River at Franklin Junction	1,507	1903–90	1936	36.40	83,000	--	--	--	--
9	01082000	Contoocook River at Peterborough	68.1	1964–90	1950	6.35	2,640	--	2.89	367	<2
10	01080500	Contoocook River near Henniker	368	1938–90	1944	13.13	9,460	--	9.95	3,670	<2
11	01085800	West Branch Warner River near Bradford	5.75	1962–90	1984	--	800	7	8.24	470	5
12	01089100	Soucook River Pembroke Road near Concord	81.9	1951–90	1977	14.50	3,700	12	5.32	183	<2
13	01092000	Merrimack River near Goffs Falls, below Manchester	3,092	1722–1990	1936	35.19	150,000	12	9.76	24,000	<2

Table 32. Maximum stages and discharges prior to and during floods of August 7–14, 1990, in New Hampshire—Continued

				Maximum prior to August 1990				Maximum during August 1990			
Site no. (fig. 39)	Station no.	Stream and place of determination	Drainage area (mi²)	Period	Year	Stage (ft)	Dis-charge (ft³/s)	Day	Stage (ft)	Discharge (ft³/s)	Discharge recurrence interval (years)
				Connecticut River Basin							
14	01129440	Mohawk River near Colebrook	36.7	1986–90	1987	8.93	7,630	8	6.27	635	<2
15	01130000	Upper Ammonoosuc River near Groveton	232	1940–90	1969	12.01	24,100	11	4.77	1,930	<2
16	01131500	Connecticut River at Dalton	1,514	1927–90	1936	25.60	48,300	8	13.87	9,790	<2
17	01137500	Ammonoosuc River at Bethlehem Junction	87.6	1939–90	1959	12.09	10,800	14	7.87	4,300	2
18	01141800	Mink Brook near Etna	4.6	1962–90	1986	3.93	629	7	2.80	167	<2
19	01144500	Connecticut River at West Lebanon	4,092	1760–1990	1927	35.00	136,000	7	12.85	25,000	<2
20	01152500	Sugar River at West Claremont	269	1928–90	1936 1981	[1]10.92 12.19	14,000 --	14	6.02	4,580	<2
21	01154500	Connecticut River at North Walpole	5,493	1942–90	1953	30.37	97,000	14	16.38	34,900	<2
22	01161000	Ashuelot River at Hinsdale	420	1907–90	1936	20.20	16,600	11	7.62	5,310	3

[1]Less than maximum for period.

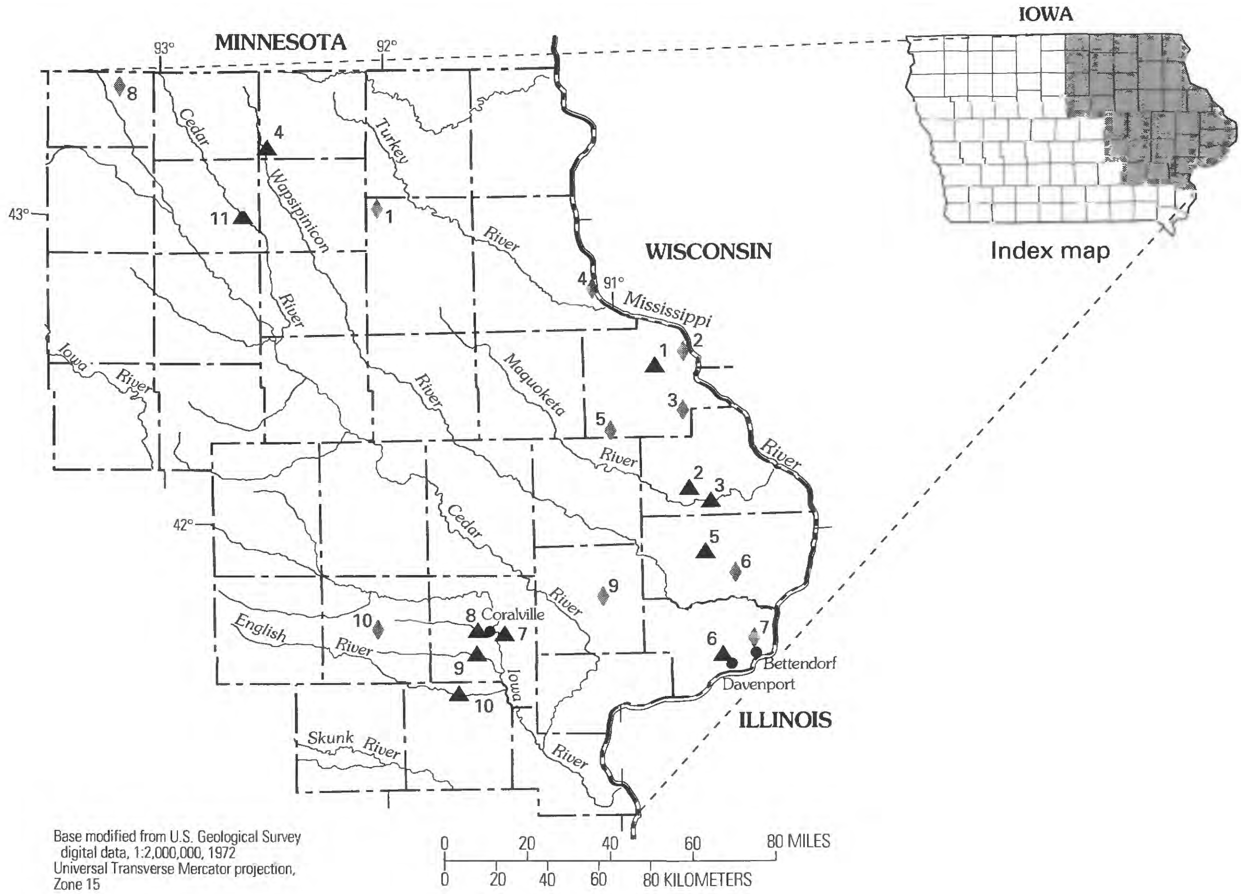
Flood of August 17–22, 1990, in Eastern Iowa

By B.D. Schaap

During August 17–22, 1990, parts of eastern Iowa (fig. 40) experienced flooding as several severe thunderstorms moved through the area bringing lightning, high winds, a possible tornado, and excessive rains. Although there was one report of more than 6.5 inches of rain in 1 day, the large rainfall totals over much of the area were the result of rains continuing for several days (table 33). The maximum discharge of Old Mans Creek near Iowa City (site 9, fig. 40) had a 20-year recurrence interval (table 34). Flood damages were estimated by the Iowa Disaster Services Division at $14.65 million, including more than $12 million in agricultural losses. The severe damages resulted in the region being designated a disaster area by the President of the United States.

REFERENCE

National Oceanic and Atmospheric Administration, 1990, Climatological data, Iowa, August 1990: Asheville, N.C., National Climatic Data Center, v. 101, no. 8, 30 p.



EXPLANATION

10 ▲ **Flood-determination site**—Number corresponds to that in table 34

2 ◆ **Precipitation data site**—Number corresponds to that in table 33

Figure 40. Location of flood-determination and precipitation data sites for flood of August 17–22, 1990, in eastern Iowa.

Table 33. Total precipitation, August 17–22, 1990, in eastern Iowa

[Data from National Oceanic and Atmospheric Administration, 1990]

Site no. (fig. 40)	Precipitation data site	Precipitation (inches)
	Turkey River Basin	
1	Waucoma	4.87
	Little Maquoketa River Basin	
2	Dubuque Lock and Dam 11	5.17
3	Dubuque WSO AP	6.23
4	Guttenberg Lock and Dam 10	5.88
	Maquoketa River Basin	
5	Cascade	5.40
	Wapsipinicon River Basin	
6	De Witt	4.78
	Crow Creek Basin	
7	Le Claire Lock and Dam 14	8.10
	Iowa River Basin	
8	Northwood	7.07
9	Tipton	6.62
10	Williamsburg	4.96

Table 34. Maximum stages and discharges prior to and during flood of August 17–22, 1990, in eastern Iowa

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined or not applicable; <, less than. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

Site no. (fig. 40)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to August 1990: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during August 1990: Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
		Little Maquoketa River Basin									
1	05414350	Little Maquoketa River near Graf	39.6	1951–90	1951	15.78	7,220	17	12.32	4,090	--
		Maquoketa River Basin									
2	05418450	North Fork Maquoketa River at Fulton	516	1977–90	1981	17.26	10,700	18	12.26	6,120	<2
3	05418500	Maquoketa River near Maquoketa	1,553	1913–90	1944	24.70	48,000	20	23.50	11,300	<2
		Wapsipinicon River Basin									
4	05420560	Wapsipinicon River near Elma	95.2	1958–90	1974	14.94	10,100	21	11.55	750	<2
5	05421890	Silver Creek at Welton	9.03	1966–90	1974	89.77	4,820	19	89.43	1,630	--
		Crow Creek Basin									
6	05422470	Crow Creek at Bettendorf	17.8	1977–90	1990	11.03	7,700	19	9.28	2,190	10
		Iowa River Basin									
7	05454000	Rapid Creek near Iowa City	25.3	1937–90	1965	14.10	6,100	20	13.61	3,480	5
8	05454300	Clear Creek near Coralville	98.1	1952–90	1990	16.36	[1]10,200	20	13.09	4,050	5
9	05455100	Old Mans Creek near Iowa City	201	1951–90	1982	19.25	13,500	21	16.88	8,440	20
10	05455500	English River at Kalona	573	1939–90	1965	21.45	20,000	22	16.57	6,480	2
11	05457700	Cedar River at Charles City	1,054	1961–90	1961	21.53	29,200	20	11.78	8,520	<2

[1]Revised from previously published value.

Flood of August 20, 1990, in Southeastern Wyoming

By George F. Ritz

An intense local thunderstorm during the afternoon and early evening of August 20, 1990, caused extensive flooding in South Sybille and Sybille Creeks, damaging bridges, roads, culverts, irrigation systems, and pasturelands along 9 miles of State Highway 34 and adjacent areas near Wheatland in southeastern Wyoming (fig. 41). Precipitation measured by local ranchers ranged from 2.75 to 3.10 inches during slightly more than 1 hour, while hail accompanying the rainfall reportedly accumulated several feet deep along roadways at a number of locations. Larger amounts of precipitation might have occurred in isolated parts of the drainage basins, although actual amounts were not determined. No human lives were lost, however, and no disaster declarations were issued by State or local authorities.

Maximum discharges at three sites along South Sybille and Sybille Creeks were determined by U.S. Geological Survey personnel using indirect methods. Streamflow at site 1, the State Highway 34 crossing over South Sybille Creek (fig. 41), completely submerged the bridge and inundated about 1,000 feet of roadway. Maximum discharge was calculated as 15,500 cubic feet per second. Channel banks incurred extensive erosion, riprap structures failed, debris blocked half of the bridge opening, and the channel was scoured to bedrock, yet no structural damage to the bridge was detected by subsequent engineering analysis conducted by the Wyoming State Highway Department. Average flow velocities at maximum discharge were 5.38 feet per second upstream from the bridge and 11.66 feet per second through the bridge opening.

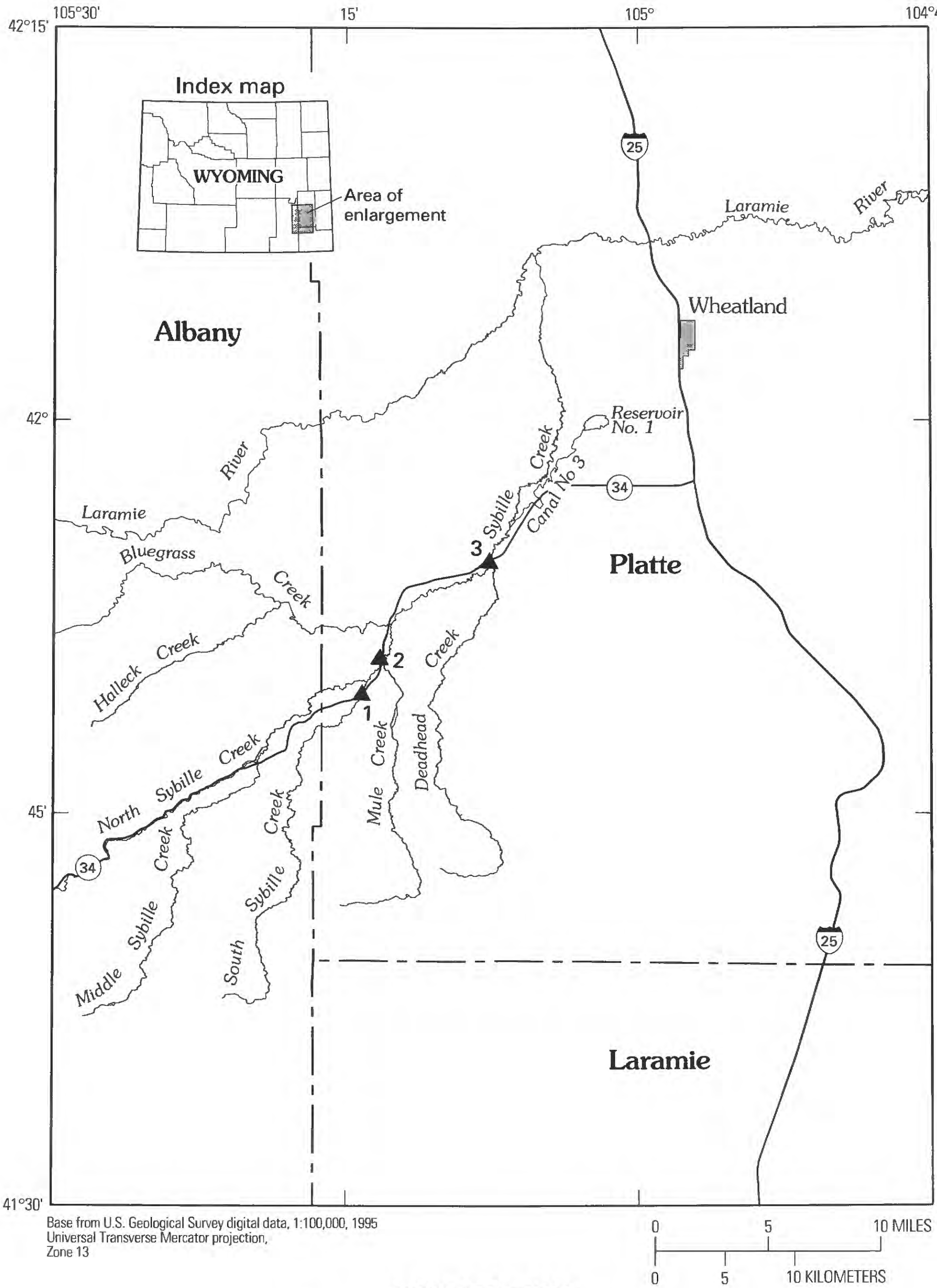
Maximum discharge at site 2, Sybille Creek above Mule Creek (fig. 41), was 19,900 cubic feet per second. The gage shelter was almost completely submerged, and two motorists were nearly swept away when they attempted to cross the submerged bridge of State Highway 34, about 150 feet downstream from the gage. Water levels rose very rapidly as stage increased from 1.49 to 15.6 feet in about 90 minutes (fig. 42). Debris blocked much of the channel in the vicinity of the gage and bridge, but there was no structural damage to the bridge. About 700 feet of the roadway was submerged at the maximum stage.

No significant damage was observed downstream at site 3, Sybille Creek above Canal No. 3 (fig. 41). Maximum discharge at this site was determined by indirect methods to be 6,900 cubic feet per second. No bridge submergence occurred at this site, and riprap structures generally were undisturbed. The stream reached maximum stage in about 2 hours at this site (fig. 42).

Flood damages along South Sybille and Sybille Creeks were estimated by local agencies to be about $324,000. Along the 9 miles of State Highway 34 between sites 1 and 3, the Wyoming State Highway Department reported that costs to repair or replace fencelines, riprap structures, and culverts, in addition to stabilizing channel banks, would total about $175,000. Repair costs to the highway bridge and surrounding channel at South Sybille Creek accounted for more than $83,000 of this amount. In addition, the Wheatland Irrigation District reported that four bridges were washed out and one irrigation dam on private property was destroyed. Replacement costs for these structures and several stretches of fenceline were estimated at $85,000. Stabilization of damaged creek banks required 6,000 cubic yards of riprap at an additional cost of $64,000.

Estimates of flood damage to private property generally were unavailable. Agricultural losses were minor as floodwaters were confined mostly to the stream channel and adjacent pastureland. About 10 head of cattle were reported killed in the flood, but no dollar estimates for these livestock losses were available. One house was known to have sustained damage from the flood.

Because of short-term or nonexistent records at each of the flood-determination sites, estimates of recurrence intervals were made by comparing discharges determined by indirect methods to characteristics developed for streams in Wyoming (Lowham, 1988). Results indicated that the maximum discharge at the State Highway 34 bridge over South Sybille Creek greatly exceeded the 100-year recurrence-interval discharge (table 35) and was 1.5 times the 500-year discharge. Similarly, the maximum discharge at site 2 was about 1.4 times the 500-year discharge. Floodflow was attenuated significantly by the time it



EXPLANATION

▲[1] **Flood-determination site**—Number corresponds to that in table 35

Figure 41. Location of flood-determination sites for flood of August 20, 1990, in southeastern Wyoming.

reached Sybille Creek above Canal No. 3 (site 3), where the maximum discharge approximated that of a 50-year flood.

REFERENCE

Lowham, H.W., 1988, Streamflows in Wyoming: U.S. Geological Survey Water-Resources Investigations Report 88–4045, 78 p.

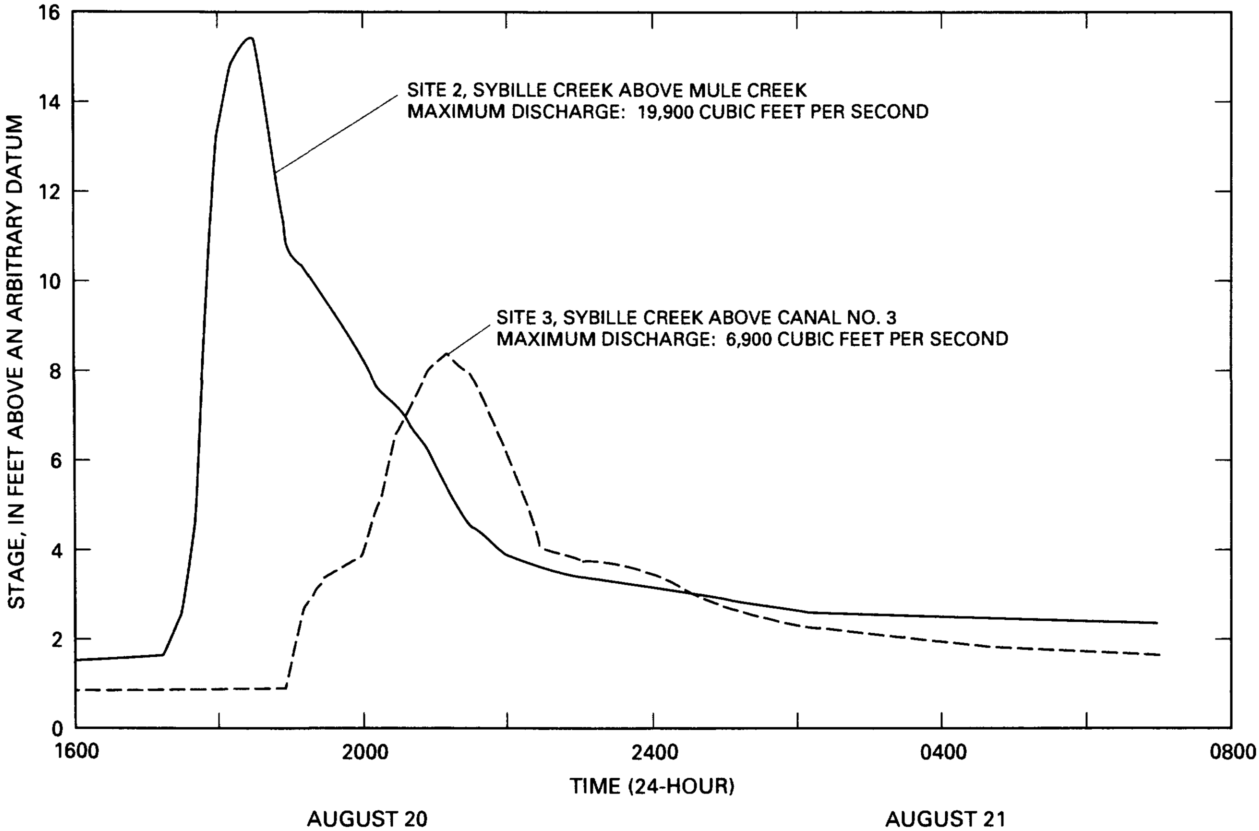


Figure 42. Stage hydrograph of Sybille Creek on August 20–21, 1990, southeastern Wyoming.

Table 35. Maximum stages and discharges prior to and during flood of August 20, 1990, in southeastern Wyoming

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined or not applicable; >, greater than. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to August 20, 1990				Maximum during August 20, 1990		
Site no. (fig. 41)	Station	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Stage (ft)	Dis-charge (ft^3/s)	Discharge recur-rence interval (years)
1	--	South Sybille Creek at State Highway 34, near Wheatland	72.5	--	--	--	--	--	15,500	>100
2	06664400	Sybille Creek above Mule Creek, near Wheatland	194	1974–90	1984	6.77	1,100	15.6	19,900	>100
3	06665790	Sybille Creek above Canel No. 3, near Wheatland	395	1980–90	1984	4.26	1,400	8.35	6,900	50

Flood of September 5–6, 1990, in Northeastern Minnesota and Extreme Northwestern Wisconsin

By G.H. Carlson

The storm of September 5–6, 1990, resulted in severe flooding in the cities of Cloquet and Duluth, Minnesota, and the surrounding area. Rainfall amounts of more than 9 inches occurred between about 5 p.m. on September 5, and 6 a.m. on September 6 (13 hours). Reports from the National Oceanic and Atmospheric Administration (NOAA), the Minnesota Department of Natural Resources, Division of Forestry (DNR), and County Soil and Water Conservation Districts (SWCD) document the rainfall. In the western part of the storm area, the greatest rainfall amount reported at the SWCD station near Floodwood was 6.93 inches, whereas in the eastern part of the storm area, 9.03 inches were reported at the DNR station near Cloquet. This is nearly twice the 100-year, 12-hour rainfall of 4.7 inches for the Cloquet area (Hershfield, 1961) and exceeds the 100-year, 24-hour rainfall of 5.4 inches by more than 3 inches. The path of greatest rainfall generally followed the St. Louis River southeastward from Floodwood to Cloquet, Minnesota, and continued into Wisconsin (fig. 43).

The area of excessive rainfall is drained by the downstream reaches of the St. Louis River and tributaries, the Nemadji River, and a number of small tributaries to Lake Superior. The St. Louis River is gaged at Scanlon (site 1), downstream of one of the five hydropower dams located in the steep drop to Lake Superior. Two sites are operated within the Nemadji River Basin in Minnesota (sites 2 and 3), and one on the Nemadji River in Wisconsin (site 4, table 36). Flow changes in the St. Louis River illustrate the rapid rate of runoff that resulted in the area of greatest rainfall. The St. Louis River was flowing at about 315 cubic feet per second on September 5, prior to the storm; the maximum discharge occurred the following afternoon at 19,500 cubic feet per second at the Scanlon site. A short distance downstream of the confluence with the Midway River, the maximum discharge at the dam at Thomson was reported in the Duluth News-Tribune to be more than 28,000 cubic feet per second (Hertzel, Sept. 7, 1990). Flow in the St. Louis River was confined within the channel, and flood damages were caused by local runoff and overflow of small streams, not from overflow of the St. Louis River.

Runoff within the storm area varied considerably because of variations in topography. In Minnesota, the eastern part of the storm area included steeply sloping terrain where the land surface drops about 600 feet in 12 miles from a high plain to the level of Lake Superior. The communities of Cloquet, Scanlon, Thomson, Carlton, and Duluth are built along, and below, this slope. Here, rapid rates of runoff resulted in general devastation, with severe damage to roads, homes, and other buildings. In contrast, the western part of the storm area included large areas of flat marshland in southwestern St. Louis County and northeastern Aitkin County. The antecedent moisture condition in this part of the storm area was generally dry, and no reports of significant flooding were received from that area. In Superior, Wisconsin, the topography also is flat, and resulting damages from the flood were not extensive.

Severe damages occurred throughout the Cloquet-Duluth area. Floodwaters overloaded the Western Lake Superior Sanitary District's treatment plant in Duluth and millions of gallons of untreated runoff and sewage went into the St. Louis River. A sewer pipeline in eastern Duluth broke, sending untreated sewage into Lake Superior. Two boys in Carlton were injured, although not severely, when floodwater pulled them through a road culvert. Several major highways were severely damaged. About 0.25 mile of the westbound lanes of Miller Trunk Highway in Duluth was washed away. Minnesota Trunk Highway 23 was damaged in several locations, as was Minnesota Route 210 in Jay Cooke State Park, with holes 25 feet deep reported. Concern over the integrity of the dam at Thomson and safety for the campers in Jay Cooke State Park downstream of the dam led to the evacuation of residents of Thomson and the campers from the park to a Carlton school in the early morning hours of September 6. Two businesses that experienced considerable damage

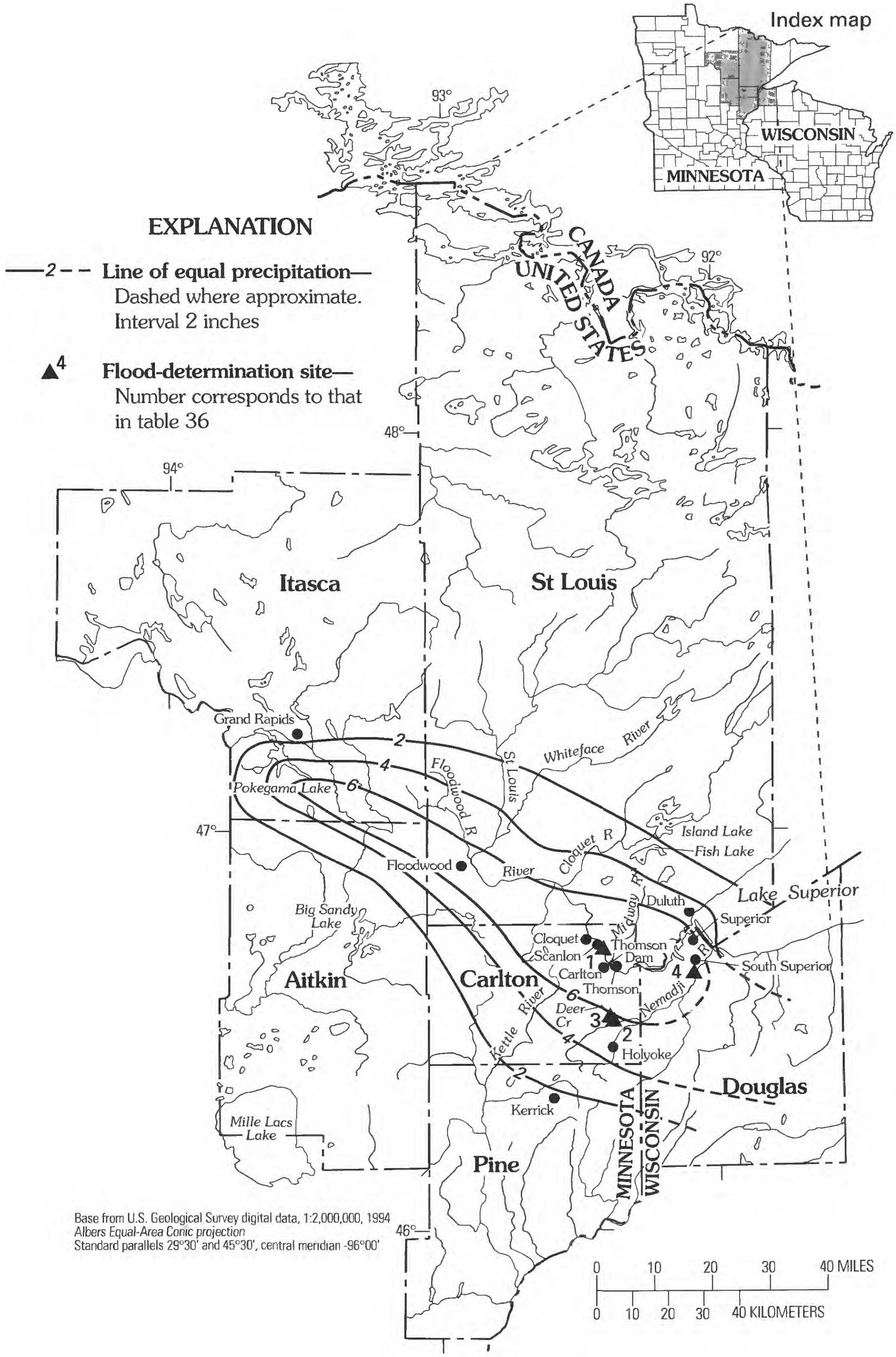


Figure 43. Location of flood-determination sites and lines of equal precipitation for flood of September 5–6, 1990, in northeastern Minnesota and extreme northwestern Wisconsin (lines of equal precipitation modified from Minnesota Department of Natural Resources, September 1990).

Table 36. Maximum stages and discharges prior to and during flood of September 5–6, 1990, in northeastern Minnesota and extreme northwestern Wisconsin

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second. Source: Recurrence intervals from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to September 1990				Maximum during September 1990			
Site no. (fig. 43)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				St. Louis River Basin							
1	04024000	St. Louis River at Scanlon, Minn.	3,430	1908–90	1950	15.80	37,900	6	10.33	19,500	3
				Nemadji River Basin							
2	04024095	Nemadji River near Holyoke, Minn.	118	1972–90	1985	17.38	4,420	6	15.83	3,600	56
3	04024098	Deer Creek near Holyoke, Minn.	7.77	1977–90	1985	32.76	2,000	6	29.43	1,730	13
4	04024430	Nemadji River near South Superior, Wisc.	420	1974–90	1979	23.83	10,700	6	25.97	13,700	38

were the Potlatch Company paper mill in Cloquet and Luigino's Pasta plant in Duluth, which was being readied for starting operations when floodwaters arrived. At these companies, large electric motors and other machines were submerged when buildings were flooded by local runoff. Palmer Peterson (Carlton County Emergency Management Coordinator, oral commun., 1991) reported total damages of $325,000 to 78 homes, 12 of which had structural damage. Damage to the roadway system maintained by Carlton County was estimated at $1,025,000. In addition, the Minnesota Department of Transportation estimated cost to repair damage to the State Trunk Highway System from this storm at $331,000 (Steve Bayer, Minnesota Department of Transportation, oral commun., 1991). No dollar estimates were released for the damages to the Potlatch Company in Cloquet or to the Luigino's Pasta plant in Duluth, but indications are that those damages were more than $1 million.

REFERENCES

Hershfield, D.M., 1961, Rainfall frequency atlas of the United States: U.S. Department of Commerce, Weather Bureau, Technical Paper no. 40, 115 p.

Hertzel, Laurie, Sept. 7, 1990, Storm wreaks havoc on Carlton County: Duluth News-Tribune, v. 121, no. 152, p. 1A.

Minnesota Department of Natural Resources, September 1990, Flash flood in Duluth area, September 5–6, 1990: State Climatology Office, 1 p.

Floods of October 10–15, 1990, in South Carolina

By Curtis L. Sanders, Jr.

Excessive rains during October 1990 in central and western South Carolina resulted from the passage of two cold fronts that were combined with remnants of Tropical Storms Klaus and Marco. For October 10–12, an unofficial rainfall total of nearly 17 inches was reported for Rembert, South Carolina. In the Pee Dee and Santee River Basins, the 2- to 4-hour rainfall ending at 7:00 a.m. on October 11 was the most intense for the period. Rainfall amounts officially reported for October 11 were: Camden, 9.62 inches; Catawba, 4.36 inches; Kershaw, 9.85 inches; and Orangeburg, 9.99 inches. Rainfall reported for October 12 at Spartanburg was 8.40 inches. Rainfall for the Savannah River Basin was the most intense for the period 7 to 8 a.m. October 11 through 7 to 8 a.m. October 13. Rainfall amounts for selected sites for this period were: Aiken, 8.00 inches; Clarks Hill, 10.80 inches; Edgefield, 6.57 inches; Greenwood, 4.85 inches; and McCormick, 8.25 inches (National Oceanic and Atmospheric Administration, 1990).

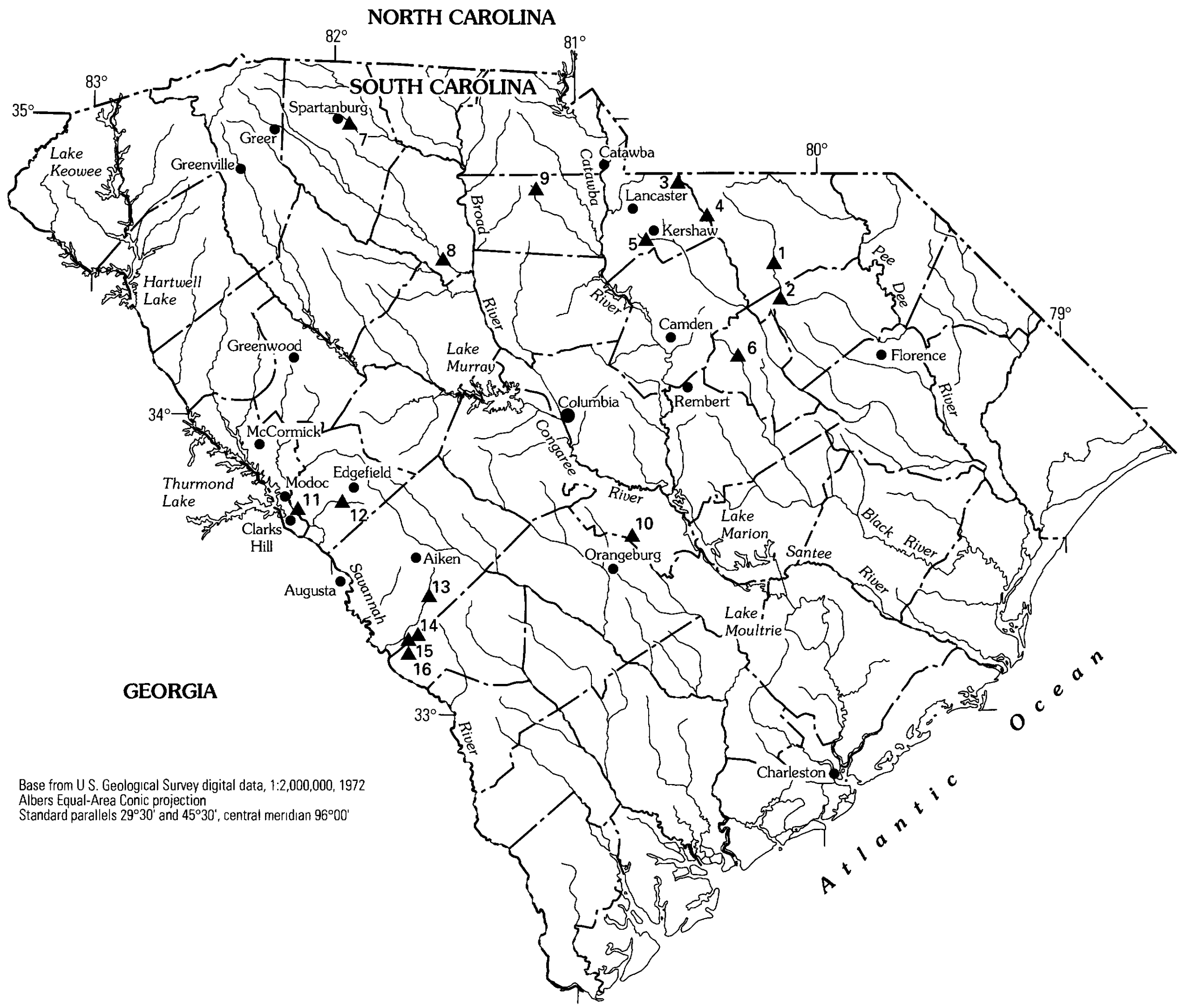
The most intense rainfall was very localized and caused record discharges on streams with small drainage basins. Streams with drainage areas greater than 200 square miles did not have discharges exceeding those of a 50-year recurrence interval.

Flood data for selected sites (fig. 44) in the Pee Dee, Santee, and Savannah River Basins are shown in table 37. The most extreme flooding occurred on Antley Spring Branch at Southern Railroad near St. Matthews (site 10, fig. 44), where the ratio of maximum discharge to the 100-year recurrence-interval discharge was 3.0. Ratios for four other sites equalled or exceeded 2.0 (sites 1, 2, 4, and 6).

In the Pee Dee and Santee River Basins, the floods caused five deaths (four of them in one automobile near Camden) and washed out or caused the closing of more than 120 bridges on secondary road systems. Seventeen earthen dams failed, and 81 were damaged from overtopping. Thirteen counties were declared Federal disaster areas (George Ballentine, South Carolina Department of Health and Environmental Control, oral commun., 1994).

REFERENCE

National Oceanic and Atmospheric Administration, 1990, Climatological data, South Carolina, October 1990: Asheville, N.C., National Climatic Data Center, v. 93, no. 10, 15 p.



EXPLANATION

▲8 **Flood-determination site**—Number corresponds to that in table 37

0 20 40 60 80 MILES

0 20 40 60 80 KILOMETERS

Figure 44. Location of flood-determination sites for floods of October 10–15, 1990, in South Carolina.

Table 37. Maximum stages and discharges prior to and during floods of October 10–15, 1990, in South Carolina

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; >, great than; --, not determined. Source: Recurrence intervals from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to October 1990				Maximum during October 1990			
Site no. (fig. 44)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Date (month/day /year)	Stage (ft)	Dis-charge (ft^3/s)	Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Pee Dee River Basin							
1	02130900	Black Creek near McBee	108	1959–90	7/16/75	11.29	1,770	12	13.07	4,500	>100
								15	13.10		
2	02130910	Black Creek near Hartsville	173	1960–90	8/18/71	10.08	2,010	13	12.35	4,550	>100
3	--	Lynches River at Secondary Road 39 near Tradesville	28	--	--	--	--	10	99.90	6,400	
4	02131309	Fork Creek near Jefferson	24.3	1976–90	2/24/79	7.89	1,560	11	13.32	8,960	>100
5	02131472	Hanging Rock Creek near Kershaw	23.9	1980–90	10/2/89	9.64	1,370	10	10.69	1,770	2
6	02135300	Scape Ore Swamp near Bishopville	96.0	1968–90	9/7/79	8.54	1,700	12	11.80	4,540	>100
				Santee River Basin							
7	02156301	Lawsons Fork Creek at treatment plant at Spartanburg	75.6	1989–90	3/18/90	10.37	1,490	12	12.51	2,360	--
8	02160105	Tyger River near Delta	759	1973–90	10/11/76	26.31	30,300	14	24.01	24,400	16
9	--	Conrad Creek at Secondary Road 192 near Rodman	45	--	--	--	--	10	95.40	4,700	18
10	--	Antley Spring Branch at Southern Railroad near St. Matthews	2.86	--	--	--	--	12	100.34	890	>100
				Savannah River Basin							
11	02196000	Stevens Creek near Modoc	545	1929–90	8/14/40	41.08	35,100	12	37.50	27,800	25
12	02196250	Horn Creek near Colliers	13.9	1980–90	10/02/85	15.29	3,680	12	14.80	2,900	16
13	02197300	Upper Three Runs near New Ellenton	87.0	1966–90	6/13/73	8.37	472	12	8.49	635	--
14	02197338	Site No. 5 at Savannah River Site	.28	1967–90	8/5/74	7.94	406	12	8.07	410	--
15	02197342	Site No. 7 at Savannah River Site	12.5	1967–90	8/22/90	5.90	1,230	12	6.47	1,740	--
16	021973426	C–004 at Savannah River Site	.83	1983–90	5/28/84	5.10	570	12	4.69	355	--

Flood of October 11–20, 1990, in East-Central Georgia

By Timothy C. Stamey

Torrential rain occurred in east-central Georgia on October 10–12, 1990. In places, rainfall totaled as much as 19.89 inches for the 3-day period, although most areas received from 7.0 to 10.0 inches of rain. The largest 24-hour rainfall amount recorded was 16.42 inches at Louisville, about 50 miles southwest of Augusta (National Oceanic and Atmospheric Administration, written commun., 1990). Severe flooding caused by the intense rain on already saturated ground occurred in several tributaries to the Ogeechee, Ohoopee, and Savannah Rivers. The most severely affected flood area is shown in figure 45.

The rains were the result of the convergence of a slow-moving cold front from the northwest, Tropical Storm Klaus from the east, and Tropical Storm Marco from the south. The resulting excessive rains approached or exceeded several long-standing rainfall records in Georgia. The most notable record was a 3-day rainfall of 19.89 inches in Louisville (National Oceanic and Atmospheric Administration, written commun., 1990).

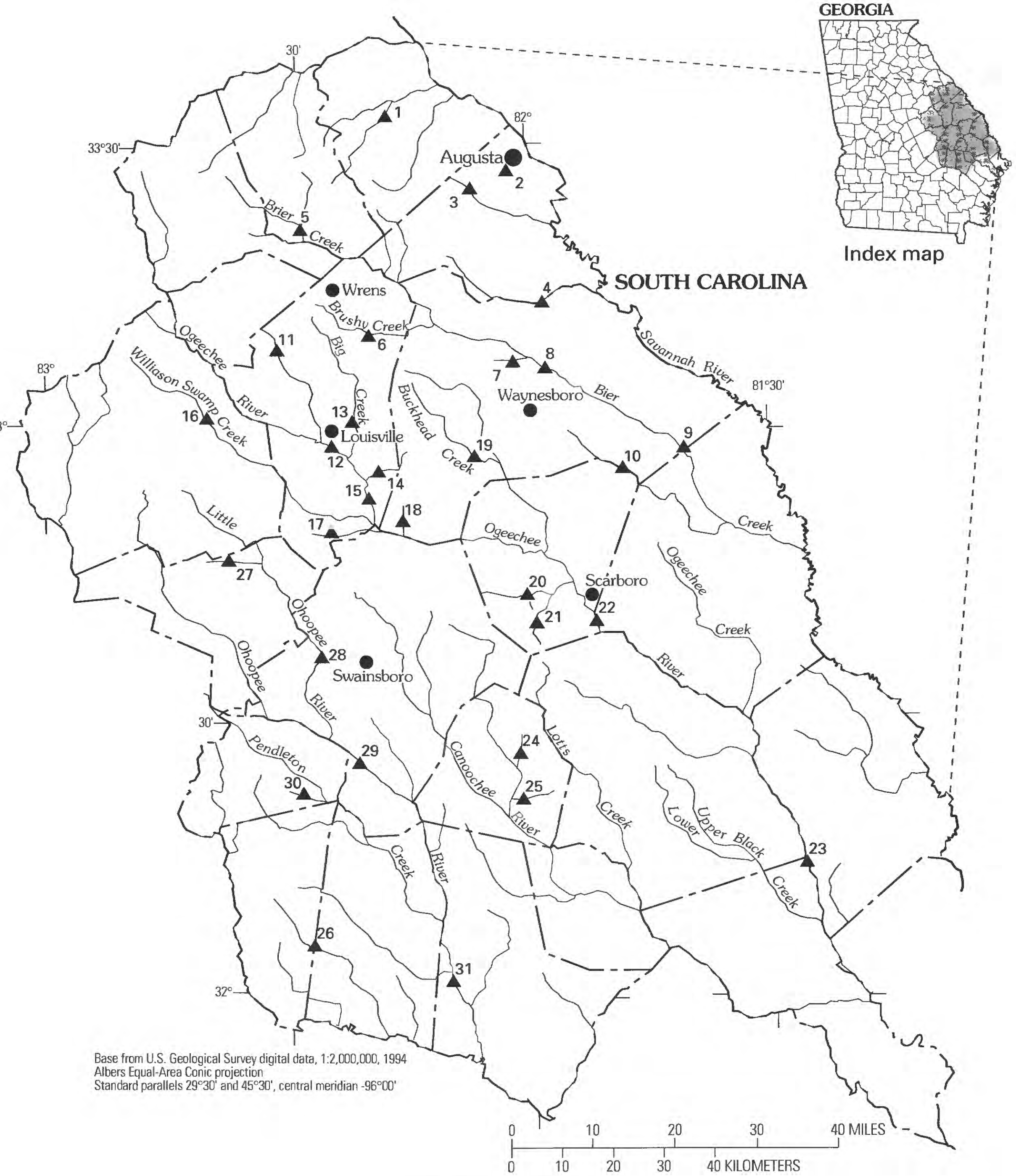
The flood of October 11–20 was the third severe flood to occur in Georgia in 1990, and the President of the United States declared nine counties in east-central Georgia flood-disaster areas. At least four people lost their lives after being swept away by floodwaters. Damage to roads and bridges was substantial and resulted in millions of dollars in damages to public and private property. Numerous dam failures were reported, and several hundred residents were evacuated (Federal Emergency Management Agency, written commun., 1990).

Maximum discharges of streams in east-central Georgia had recurrence intervals ranging from 2 years to more than 100 years. Record-high stages and discharges occurred at 14 sites in east-central Georgia where stage and discharge data were collected during October 1990 (table 38).

The most severe flooding occurred on Big Creek near Louisville (site 13), Brushy Creek near Wrens (site 6), and Buckhead Creek near Waynesboro (site 19), where the maximum discharges were much greater than the respective 100-year discharges. Known dam failures upstream of the gaged sites on Big Creek and Brushy Creek contributed to the severity of the flooding at these two sites. Also, there were at least six other streams within about a 50-mile radius of Augusta that experienced maximum discharges equal to or greater than those having a 100-year recurrence interval (fig. 45, table 38).

All sites where discharge equalled or exceeded the 100-year discharge within this 50-mile radius had drainage areas of less than 100 square miles, except sites on the Ogeechee River. The Ogeechee River experienced maximum discharges having recurrence intervals ranging from 10 to more than 100 years. The maximum discharge of 27,000 cubic feet per second for the Ogeechee River near Louisville (site 12) was the largest since 1929 at that site. The maximum stage for Ogeechee River at Scarboro (site 22) was 13.42 feet, which is the highest since March 1944 and the third highest stage since 1935 (flood stage is 8 feet). Maximum discharges attenuated as the flood progressed downstream (table 38).

The upstream reaches of the Ohoopee and Little Ohoopee Rivers and some small tributaries in the Swainsboro area also had maximum discharges equal to or in excess of the 100-year discharge. The maximum discharges on these streams also attenuated as the flood progressed downstream (table 38).



EXPLANATION

▲[2] **Flood-determination site**—Number corresponds to that in table 38

Figure 45. Location of flood-determination sites for flood of October 11–20, 1990, in east-central Georgia.

Table 38. Maximum stages and discharges prior to and during flood of October 11–20, 1990, in east-central Georgia

[mi^2, square mile; ft, feet above arbitrary datum; ft^3/s, cubic feet per second; >, greater than; <, less than; --, not determined. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to October 1990				Maximum during October 1990			
Site no. (fig. 45)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Savannah River Basin							
1	02195150	Kiokee Creek at Appling	43.9	1984–90	1985	10.27	1,900	12	15.53	11,500	>100
2	02196760	Rocky Creek tributary at Augusta	1.56	1979–90	1988	6.31	519	12	9.60	1,110	100
3	02196820	Butler Creek at Fort Gordon	7.5	1929–90	1929	12.40	2,300	12	13.30	4,700	--
4	02197190	McBean Creek near McBean	41.4	1929–90	1929	14.80	4,300	12	7.52	3,160	100
5	02197520	Brier Creek near Thomson	55.0	1797–1990	1929	--	12,000	12	13.53	2,210	10
6	02197600	Brushy Creek near Wrens	28.0	1959–90	1971	8.03	1,200	12	14.02	[1]11,400	>100
7	02197810	Walnut Branch near Waynesboro	11.9	1796–1990	1966	8.89	598	12	11.48	2,300	>100
8	02197830	Brier Creek near Waynesboro	473	1796–1990	1929	23.00	48,000	13	14.24	14,200	50
9	02198000	Brier Creek near Millhaven	646	1929–90	1929	25.10	64,000	15	15.58	14,600	50
10	02198100	Beaverdam Creek near Sardis	30.8	1987–90	1987	6.64	600	13	7.60	1,850	5
				Ogeechee River Basin							
11	02200400	Rocky Comfort Creek near Grange	188	1979–90	1980	14.82	4,020	12	12.08	1,840	5
12	02200500	Ogeechee River near Louisville	800	1840–1990	1929	21.30	46,000	13	16.82	27,000	>100
13	02200900	Big Creek near Louisville	95.8	1948–90	1948	12.00	19,000	12	12.70	[1]28,400	>100
14	02200930	Spring Creek near Louisville	14.2	1961–90	1980	7.35	1,130	12	10.38	2,200	>100
15	02200950	Ogeechee River near Wadley	990	1840–1990	1929	--	50,000	13	17.33	29,500	100
16	02201000	Williamson Swamp Creek at Davisboro	109	1929–90	1929	15.0	9,200	12	9.74	2,110	10
17	02201110	Nails Creek near Bartow	8.36	1964–90	1972	4.21	654	12	9.36	3,260	>100
18	02201250	Seals Creek tributary near Midville	.99	1964–74	1964	2.44	82	12	3.56	165	50

Table 38. Maximum stages and discharges prior to and during flood of October 11–20, 1990, in east-central Georgia—Continued

Site no. (fig. 45)	Station no.	Stream and place of determination	Drainage area (mi²)	Maximum prior to October 1990: Period	Year	Stage (ft)	Discharge (ft³/s)	Maximum during October 1990: Day	Stage (ft)	Discharge (ft³/s)	Discharge recurrence interval (years)
		Ogeechee River Basin—Continued									
19	02201350	Buckhead Creek near Waynesboro	64.0	1929–90	1929	11.60	9,000	12	13.33	13,000	>100
20	02201800	Richardson Creek near Millen	43.0	1963–84	1980	6.04	2,400	12	2.02	100	<2
21	02201830	Sculls Creek near Millen	4.38	1965–90	1966	3.73	278	12	2.92	20	<2
22	02202000	Ogeechee River at Scarboro	1,940	1840–84	1929	17.00	75,000	15	13.42	37,300	25
23	02202500	Ogeechee River near Eden	2,650	1840–90	1929	20.00	78,000	20	14.41	26,800	10
24	02202820	Reedy Creek near Metter	3.41	1965–80	1966	6.74	278	12	4.18	20	<2
25	02202910	Ten Mile Creek tributary at Pulaski	1.14	1963–90	1966	7.67	599	12	4.32	140	2
		Altamaha River Basin									
26	02225100	Cobb Creek near Lyons	69	1929–90	1966	9.90	3,500	12	3.50	300	<2
27	02225210	Hurricane Branch near Wrightsville	3.53	1965–90	1973	4.28	650	12	6.52	1,100	>100
28	02225250	Little Ohoopee River near Swainsboro	216	1925–90	1929	14.00	13,500	13	13.40	15,800	>100
29	02225320	Ohoopee River near Aline	698	1925–90	1980	17.25	15,200	12	18.81	22,000	100
30	02225350	Pendleton Creek tributary no. 2 near Soperton	1.68	1965–90	1973, 1984	3.47	290	12	3.00	210	5
31	02225500	Ohoopee River near Reidsville	1,110	1886–1990	1925	28.40	47,000	16	20.34	16,400	25

[1]Discharge affected by dam failure.

Floods of November 1990 in Western Washington

By Larry L. Hubbard[1]

STORM SYSTEMS

Above-average precipitation over western Washington during October and early November 1990 resulted in saturated soils that contributed to flooding potential when major storms arrived on November 7–11 and November 21–25. The daily precipitation record for the National Oceanic and Atmospheric Administration precipitation data site at Mud Mountain Dam in Pierce County (site 5, fig. 46) illustrates the large amount of precipitation that fell during October and November (fig. 47). The above-normal precipitation in western Washington during October and November 1990 is documented by the 1990 annual records of the National Oceanic and Atmospheric Administration (1990c). For example, the total precipitation for October and November at Mud Mountain Dam was 23.42 inches. This precipitation was 12.06 inches greater than the normal precipitation of 11.36 inches for these months (about 200 percent of normal) and was typical of the climatological records reviewed for this article. For the same period, recorded precipitation at Grays River Hatchery (site 1) was about 140 percent of normal, and at Lake Wenatchee, the easternmost precipitation data site (site 9), about 250 percent of normal.

Throughout most of western Washington, the largest amounts of precipitation fell during the second storm, November 21–25. The precipitation data site at Diablo Dam on the Skagit River (site 10) recorded about 2 inches more during the second storm (table 39) than during the first storm, but the most intense rain was recorded November 10 when 7.32 inches fell in the 24-hour period (fig. 48).

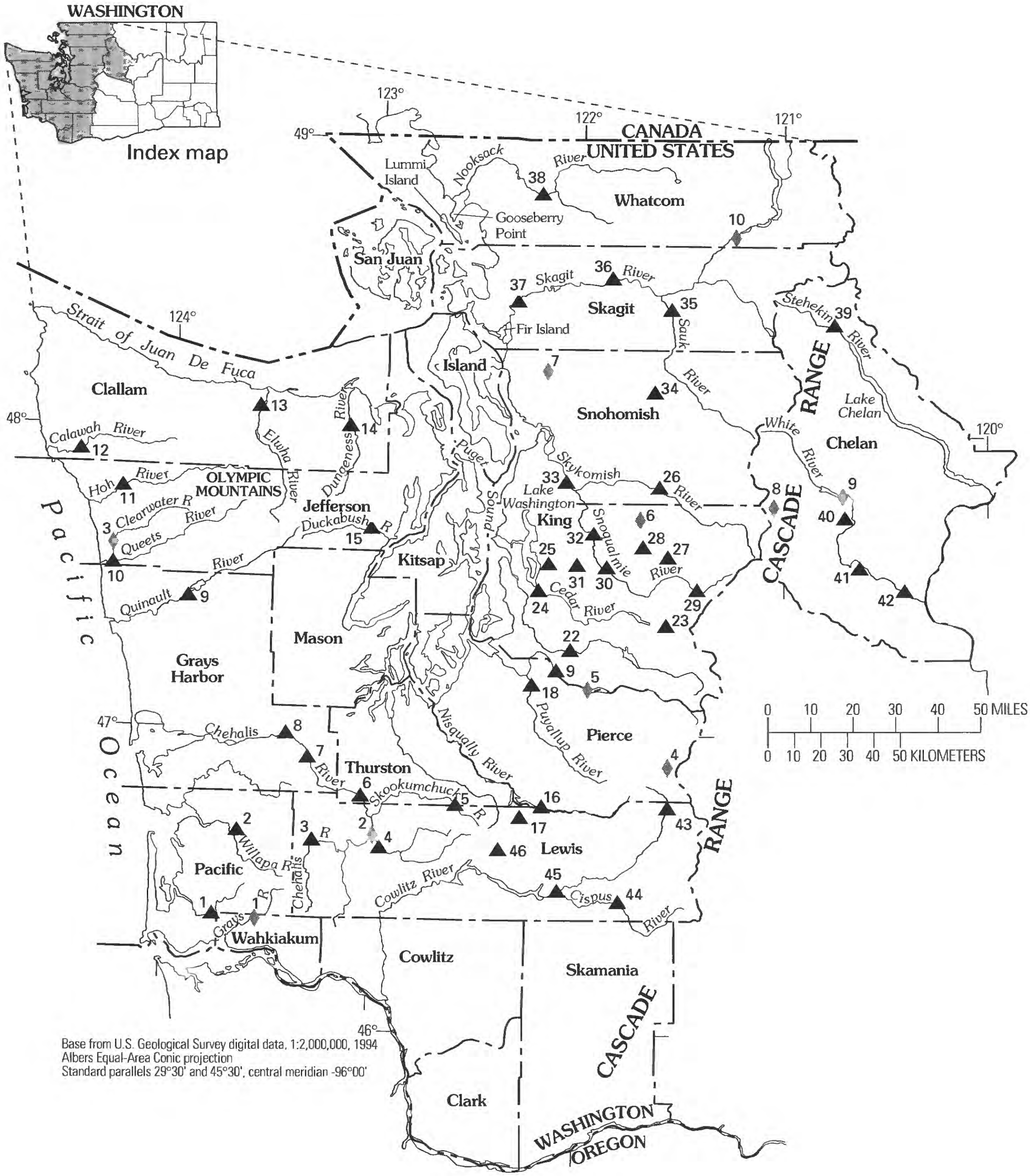
During the period between the major November storms, wet weather accompanied by cool temperatures continued, and snow levels dropped to about the 1,000-foot land-surface altitude. By November 21, general snow depths in the Cascade Range were 6 inches at altitudes of 1,000 to 2,000 feet; 12 inches from 2,000 to 3,000 feet; and 12 to 18 inches from 3,000 to 4,000 feet. Water content of the snowpack was generally 10 percent or more (U.S. Department of Agriculture, 1992). A warm front moved through western Washington on Wednesday, November 21. Snow changed to rain as temperatures rose, and melting occurred at altitudes below about 7,500 feet in the northern part of the State and below about 5,500 feet in the southern part of the State. During the next 3 days, intense rains fell on drainages where rivers already were swollen with snowmelt runoff; disastrous flooding resulted. A cold front that moved in from the north on November 26, 1990, lowered temperatures and diminished precipitation, finally ending the severe flooding.

FLOODS

As a result of the October–November 1990 storms, the western half of Washington experienced two major floods during November. The November 9–11 flooding affected streams in most of the northern half of western Washington, and the November 23–26 flooding affected streams in most of western Washington. The highest stages ever observed were recorded on November 25 in the Wenatchee River on the eastern slopes of the Cascade Range. With the exception of some rivers in the Skagit and Nooksack River Basins, most rivers in western Washington and along the eastern slope of the Cascade Range experienced more severe flooding during November 23–26 than during November 9–11.

The November 9–11 flooding was most prevalent in the northern parts of western Washington. The most severe flooding occurred in the Quinault, Queets, Snohomish, Skagit, and Nooksack River Basins (flood-determination sites 9, 10, 26–38 in table 40 and fig. 46). The recurrence intervals for floods in these basins generally ranged from 10 to 50 years. On November 10, the maximum discharge for the Nooksack River at Deming (site 38) was 37,900 cubic feet per second (fig. 49). Appreciable flooding occurred on rivers that drain the eastern and western slopes of the

[1]This article is based on a previously published report (Hubbard, 1994).



EXPLANATION

▲10 **Flood-determination site**—Number corresponds to that in table 40

◆6 **Precipitation data site**—Number corresponds to that in table 39

Figure 46. Location of flood-determination and precipitation data sites for floods of November 1990 in western Washington.

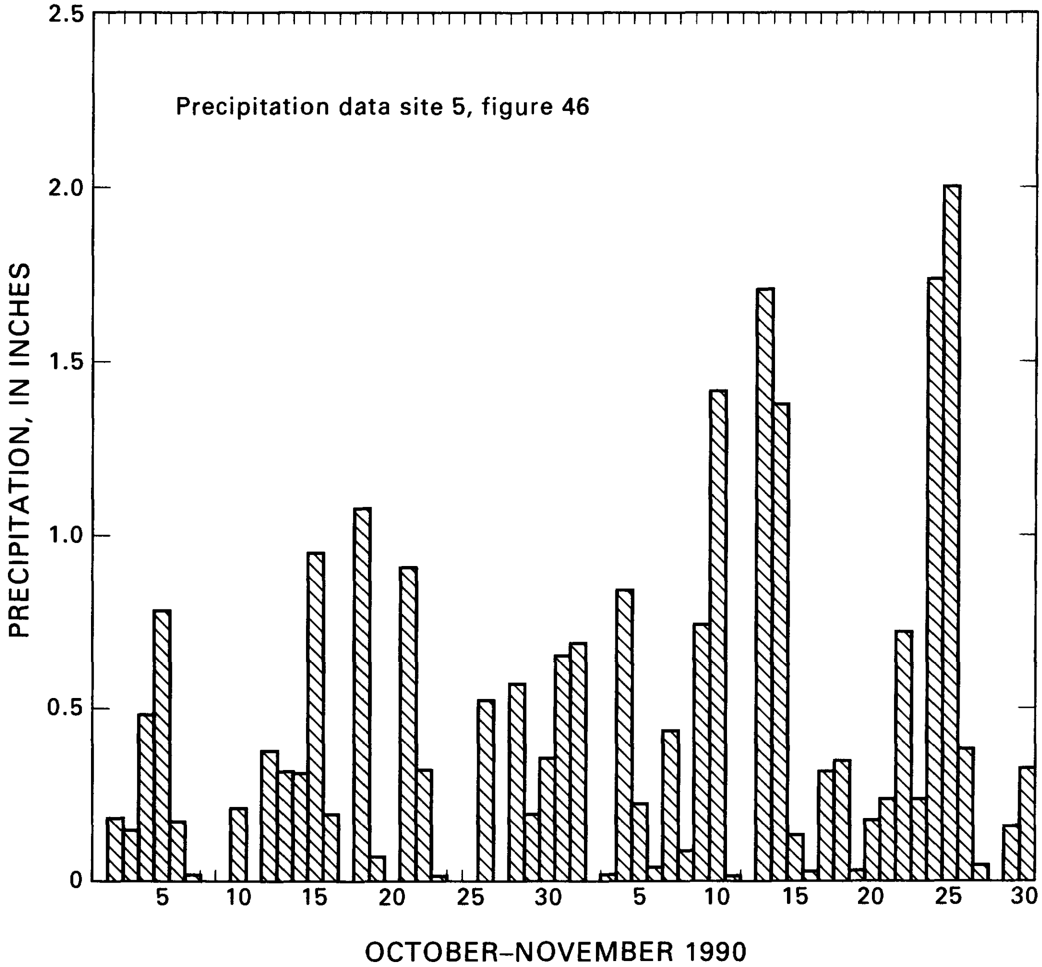


Figure 47. Daily precipitation at Mud Mountain Dam, Washington, October and November 1990. (data from National Oceanic and Atmospheric Administration, 1990a,b).

Table 39. Precipitation totals for November 7–11 and November 21–25, 1990, at precipitation data sites in western Washington

[Data from National Oceanic and Atmospheric Administration, 1990b]

Site no. (fig. 46)	Precipitation data site	Precipitation, in inches November 7–11	November 21–25
1	Grays River Hatchery	3.12	8.10
2	Centralia	1.15	6.06
3	Clearwater	6.59	8.05
4	Rainer Ohanapecosh	2.59	4.51
5	Mud Mountain Dam	2.70	4.96
6	Tolt South Fork Reservoir	6.24	7.30
7	Arlington	2.41	4.86
8	Stevens Pass	8.75	14.40
9	Lake Wenatchee	3.16	7.53
10	Diablo Dam	13.25	15.44

Olympic Mountains. The maximum discharge of November 10 on the Quinault River (site 9) slightly exceeded that of November 24.

The November 23–26 flooding generally was more severe and more widespread than the flooding earlier in the month. The most severe November 23–26 flooding in Washington occurred in the Duwamish, Lake Washington, Snohomish, and Wenatchee River Basins. The flood hydrograph for the Wenatchee River at Plain (site 40) is shown in figure 50. Maximum discharges on the Snohomish River near Monroe (site 33) and on three rivers in the Wenatchee Basin (site 40–42) equalled or exceeded the 100-year discharge. The floodflow of the Wenatchee River at Plain was 1.3 times greater than the discharge having a 100-year recurrence interval. The largest discharges known occurred November 24 or 25 at 12 flood-determination sites (table 40).

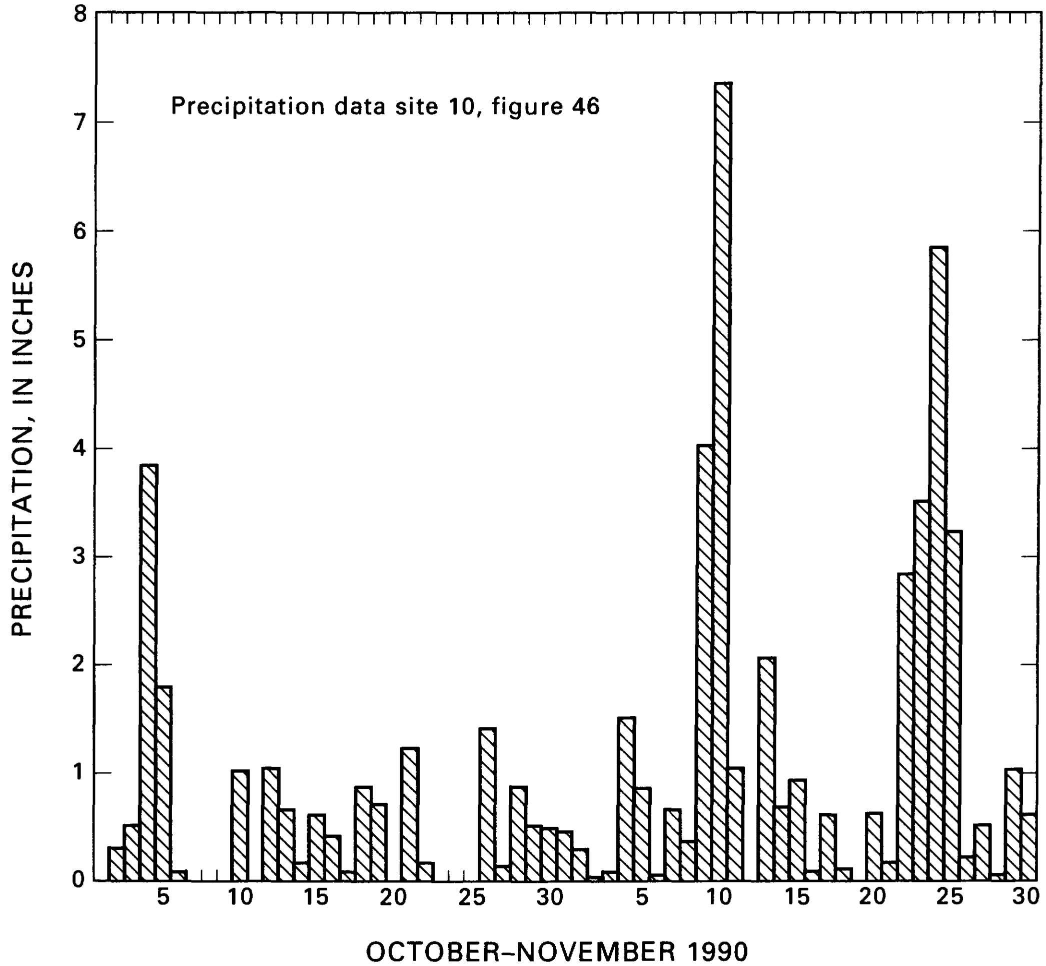


Figure 48. Daily precipitation at Diablo Dam, Washington, October and November 1990 (data from National Oceanic and Atmospheric Administration, 1990a,b).

DAMAGES

No final damage figures were available for the November 1990 flooding. All damage figures discussed are based on preliminary estimates as presented by the National Oceanic and Atmospheric Administration (1991).

Extensive damages occurred as a result of the flooding on November 9–11, 1990. The Governor of Washington declared a state of emergency in Grays Harbor, King, Skagit, Snohomish, and Whatcom Counties. The floodwaters of the Skagit River breached levees on Fir Island at the mouth of the river; approximately 500 people were evacuated, and about 170 homes and farms were flooded. In Snohomish County, about 200 people were displaced from their homes. In Whatcom County, more than 1,000 people on Gooseberry Point and Lummi Island were isolated for a week. The Governor of Washington estimated total flood damages at about $42 million. Total damages to homes in Skagit, Snohomish, and Whatcom Counties were $14 million, and damage to public works was about $24 million. Damages to homes in Skagit County were about $8 million and in Whatcom County about $4 million.

Two lives were lost as a direct result of the flooding on November 23–26, 1990. Large amounts of resources were expended for rescuing and evacuating about 2,000 residents from flooded areas. Some residents of Fir Island on the Skagit River were evacuated to escape rising floodwaters for the second time during the month of November. Thousands of homes were flooded in the affected areas; 42 homes were totally destroyed. Early estimates of damages to homes, farm structures, farm crops, livestock, roads, dikes, high-

Table 40. Maximum stages and discharges prior to and during floods of November 1990 in western Washington

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined or applicable; <, less than; e, estimated; >, greater than. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to November 1990				Maximum during November 1990			
Site no. (fig. 46)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Naselle River Basin							
1	12010000	Naselle River near Naselle	54.8	1929–90	1935	--	11,100	24	18.45	11,300	50
				Willapa River Basin							
2	12013500	Willapa River near Willapa	130	1948–90	1990	24.06	11,700	24	24.21	11,800	15
				Chehalis River Basin							
3	12020000	Chehalis River near Doty	113	1939–90	1990	19.96	27,500	24	17.45	20,600	25
4	12025000	Newaukum River near Chehalis	155	1942–90	1986	12.76	10,700	24	12.73	10,300	25
5	12025700	Skookumchuck River near Vail	40.0	1967–90	1972	10.93	6,900	24	10.30	5,820	20
6	12027500	Chehalis River near Grand Mound	895	1928–90	1990	19.34	68,700	25	18.12	48,000	20
7	12031000	Chehalis River at Porter	1,294	1952–90	1990	24.52	60,400	26	23.17	43,000	10
8	12035000	Satsop River near Satsop	299	1929–90	1935	38.9	46,600	24	35.75	38,200	10
				Quinault River Basin							
9	12039500	Quinault River at Quinault Lake	264	1909–90	1909	--	52,600	10	18.35	41,400	15
				Queets River Basin							
10	12040500	Queets River near Clearwater	445	1930–67, 1974–90	1935	27.0	130,400	23	25.44	112,000	25
				Hoh River Basin							
11	12041200	Hoh River at U.S. Highway 101 near Forks	253	1960–90	1979	19.08	51,600	24	19.61	54,500	15
				Quillavute River Basin							
12	12043000	Calawah River near Forks	129	1897–1901, 1976–80, 1984–90	1979	18.98	28,900	23	20.58	34,500	20
				Elwha River Basin							
13	12045500	Elwah River at McDonald Bridge near Port Angeles	269	1897–1901, 1918–90	1897 1949	-- 24.20	41,600 [1]30,000	23	23.71	28,700	15

Table 40. Maximum stages and discharges prior to and during floods of November 1990 in western Washington—Continued

				Maximum prior to November 1990				Maximum during November 1990			
Site no. (fig. 46)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Dungeness River Basin							
14	12048000	Dungeness River near · Sequim	156	1923–30, 1937–90	1949	7.30	6,820	24	8.35	[1]7,120	25
				Duckabush River							
15	12054000	Duckabush River near Brinnon	66.5	1938–90	1949	10.06	8,960	23	8.04	5,500	5
				Nisqually River Basin							
16	12082500	Nisqually River near National	133	1942–90	1977	11.96	17,100	24	10.23	11,000	10
17	12083000	Mineral Creek near Mineral	75.2	1942–90	1990	13.56	13,800	24	12.78	10,000	25
				Puyallup River Basin							
18	12093500	Puyallup River near Orting	172	1931–90	1962	11.82	15,300	24	10.19	10,300	5
19	12095000	South Prairie Creek at South Prairie	79.5	1950–79, 1988–90	1990	33.55	8,330	24	32.45	5,560	10
20	12099600	Boise Creek at Buckley	15.4	1977–90	1984	5.18	972	24	3.38	571	2
21	12101500	Puyallup River at Puyallup	948	1914–90	1933	31.0	57,000	24	27.19	41,900	15
				Duwamish River Basin							
22	12112600	Big Soos Creek above hatchery near Auburn	66.7	1960–90	1990	7.55	1,750	25	7.16	1,570	30
				Lake Washington Basin							
23	12117500	Cedar River near Landsburg	121	1895–1990	1911	--	14,200	24	10.38	10,800	70
24	12119000	Cedar River at Renton	184	1945–90	1975	14.14	8,800	24	17.13	[1]10,600	100
25	12121600	Issaquah Creek near mouth near Issaquah	56.6	1963–90	1990	13.50	3,200	24	13.43	2,410	5
				Snohomish River Basin							
26	12134500	Skykomish River near Gold Bar	535	1928–90	1980	21.34	90,100	24	22.49	102,000	50
27	12141300	Middle Fork Snoqualmie River near Tanner	154	1961–90	1959	18.7	49,900	24	14.97	30,100	25
28	12141300	North Fork Snoqualmie River near Snoqualmie Falls	64.0	1929–90	1932	17.5	15,800	24	12.05	12,000	10
29	12143400	South Fork Snoqualmie River above Alice Creek near Garcia	41.6	1960–90	1986	18.33	8,450	24	18.26	8,000	15
30	12144500	Snoqualmie River near Snoqualmie	375	1958–90	1959	19.78	61,000	24	21.55	78,800	50

Table 40. Maximum stages and discharges prior to and during floods of November 1990 in western Washington—Continued

Site no. (fig. 46)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to November 1990: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during November 1990: Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Snohomish River Basin—Continued							
31	12145500	Raging River near Fall City	30.6	1945–90	1986	6.27	5,330	24	6.56	6,220	100
32	12149000	Snoqualmie River near Carnation	603	1928–90	1932 1932	[1]59.88 59.93	59,500	24	60.70	65,200	25
33	12150800	Snohomish River near Monroe	1,537	1921, 1963–90	1921 1975	-- 22.92	180,000e 115,000	25	25.30	150,000	100
				Skagit River Basin							
34	12186000	Sauk River above White Chuck River near Darrington	152	1917–22, 1928–90	1980	16.03	40,100	24	12.56	24,600	20
35	12189500	Sauk River near Sauk	714	1928–90	1980	18.24	98,600	24	16.99	83,400	40
36	12194000	Skagit River near Concrete	2,737	1815–1990	1815	69.3	500,000	10	40.20	149,000	30
37	12200500	Skagit River near Mt. Vernon	3,093	1906–90	1906	37.0	180,000	25	37.37	152,000	75
				Nooksack River Basin							
38	12210500	Nooksack River at Deming	584	1932, 1935–90	1932	16.8	49,300	10	15.40	37,900	10
				Chelan River Basin							
39	12451000	Stehekin River near Stehekin	321	1910–35, 1929–90	1948	29.00	18,900	24	27.45	14,700	10
				Wenatchee River Basin							
40	12457000	Wenatchee River at Plain	591	1910–79, 1989–90	1948	12.48	22,700	25	14.39	33,200	>100
41	12459000	Wenatchee River at Peshastin	1,000	1929–90	1948	15.88	32,300	25	17.58	40,000	>100
42	12462500	Wenatchee River at Monitor	1,301	1962–90	1980	27.23	29,600	25	30.00 [1]29.80	-- 45,900	-- >100
				Cowlitz River Basin							
43	14226500	Cowlitz River near Packwood	287	1912–20, 1929–30	1933	13.00	36,600	24	12.48	28,700	15
44	14232500	Cispus River near Randle	321	1929–90	1974	12.58	21,700	25	10.21	11,500	5
45	14233400	Cowlitz River near Randle	1,030	1947–90	1977	26.54	89,300	25	23.60	66,300	25
46	14236200	Tilton River above Bear Canyon Creek near Cinebar	141	1956–90	1977	17.00	22,500	24	14.44	17,600	10

[1]Less than maximum for period.

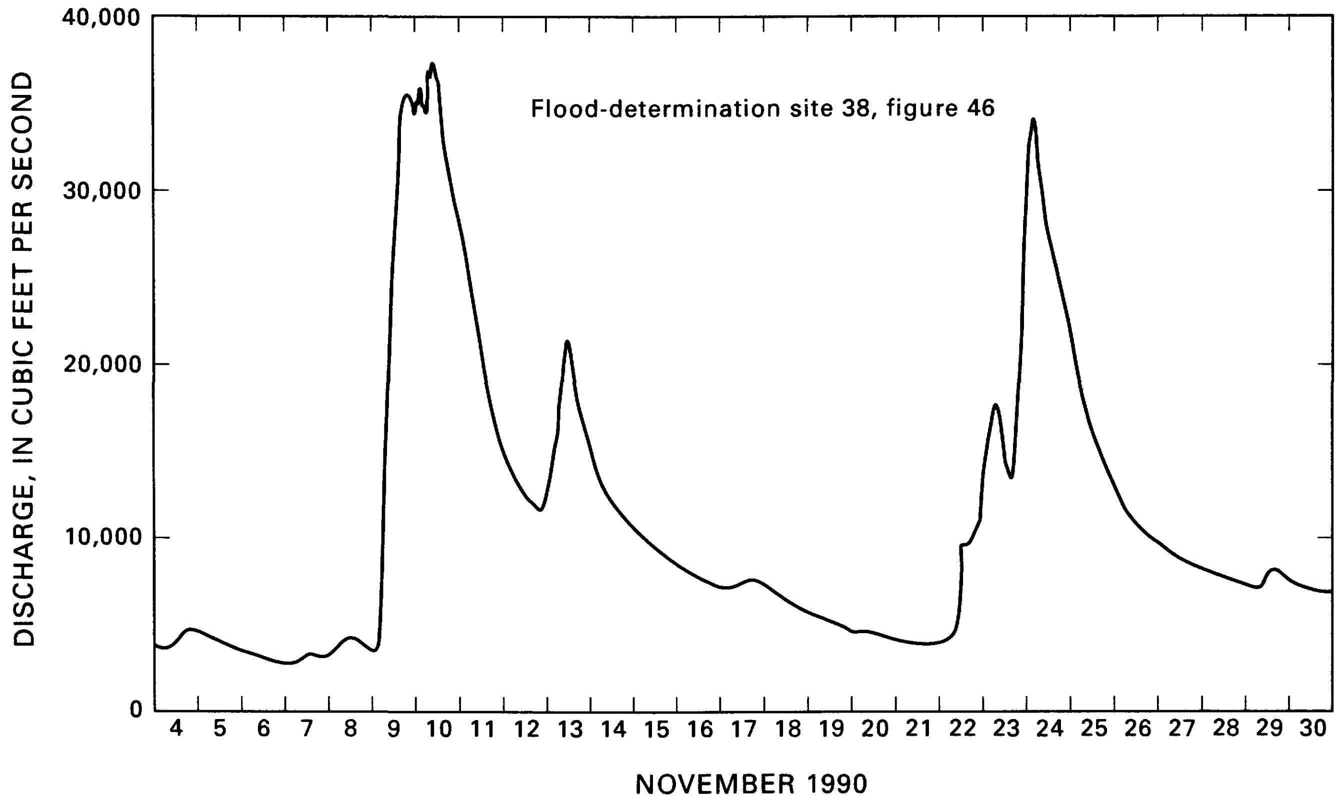


Figure 49. Discharge of Nooksack River at Deming, Washington, November 4–30, 1990.

way structures, and other utilities totalled $100 million.

REFERENCES

Hubbard, L.L., 1994, Floods of November 1990 in western Washington: U.S. Geological Survey Open-File Report 93–631, 14 p.

National Oceanic and Atmospheric Administration, 1990a, Climatological data, Washington, October 1990: Asheville, N.C., National Climatic Data Center, v. 94, no. 10, 27 p.

_____1990b, Climatological data, Washington, November 1990: Asheville, N.C., National Climatic Data Center, v. 94, no. 11, 34 p.

_____1990c, Climatological data, Washington, annual summary 1990: Asheville, N.C., National Climatic Data Center, v. 94, no. 13, 40 p.

_____1991, Western Washington floods, November 21–26, 1990: Asheville, N.C., National Climatic Data Center, Natural Disaster Survey Report, 76 p.

U.S. Department of Agriculture, U.S. Forest Service, Mt. Baker-Snoqualmie National Forest, 1992, Flooding in West Cascade Mountain River Basins—A perspective on the November 1990 flooding in western Washington: 28 p.

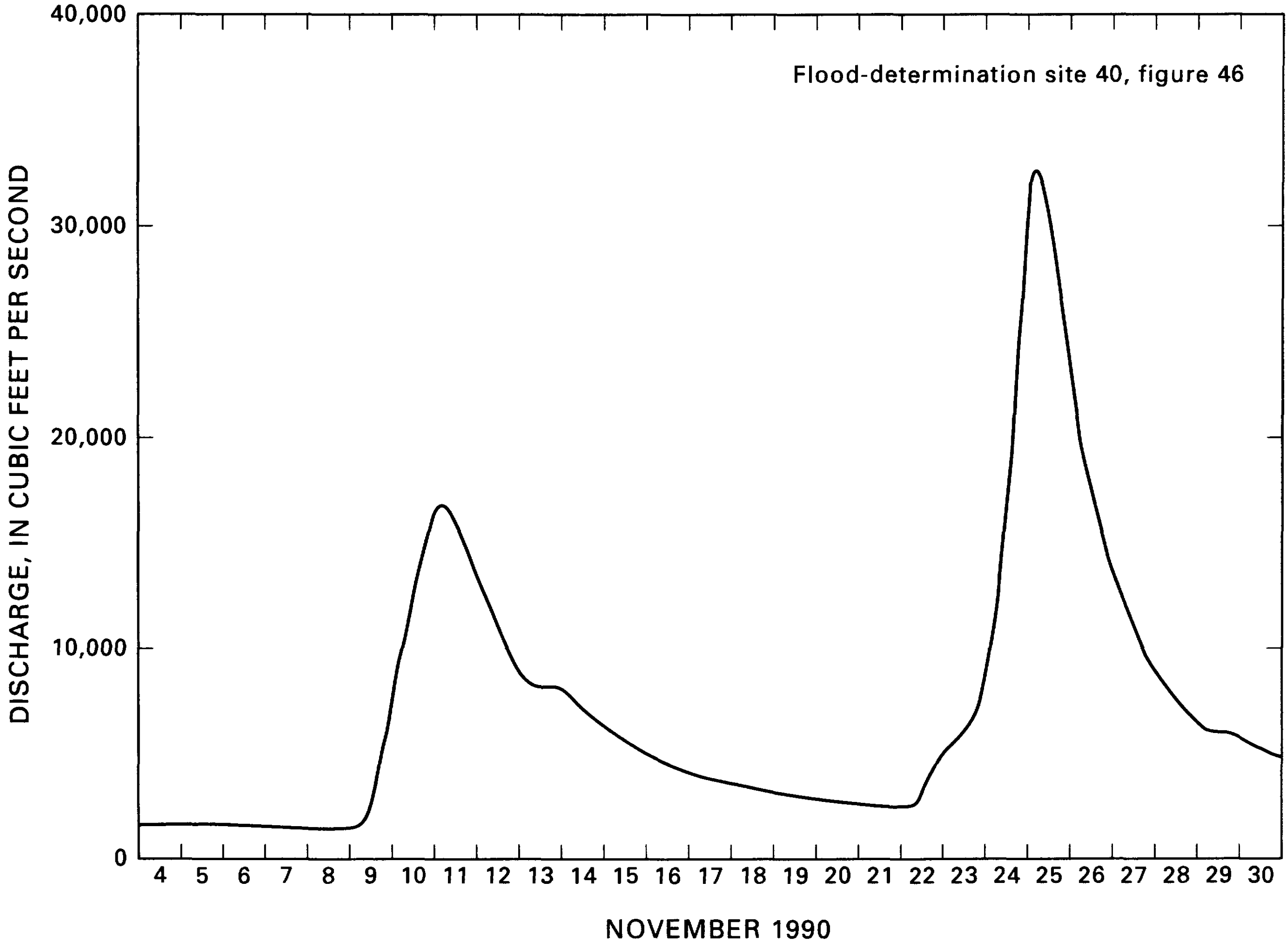


Figure 50. Discharge of Wenatchee River at Plain, Washington, November 4–30, 1990.

Flood of November 28, 1990, in Lake County, Northwestern Indiana

By Scott E. Morlock

During the night of November 27 and morning of November 28, 1990, large concentrations of atmospheric moisture from the Gulf of Mexico and the movement of a cold front through Illinois and Indiana produced 5 to 6.25 inches of rain over Lake County in northwestern Indiana. The excessive rainfall caused flooding on the Little Calumet River and its tributaries in northwestern Lake County. Maximum stages for the period of record occurred on the Hart Ditch at Munster (site 2) and the Little Calumet River at Munster (site 3) on November 28 (fig. 51). Maximum stages and discharges for Hart Ditch at Dyer and Munster and Little Calumet River at Munster are given in table 41.

The flooding caused the evacuation of at least 400 people from their homes. On November 28, the American Red Cross sheltered 358 persons. One man lost his life while trying to build an emergency berm near the Little Calumet River. He was electrocuted when the bed of his dump truck contacted a powerline.

Many residences received substantial flood damages. Much of this damage occurred from the flooding of a single large subdivision. Flood depths within some parts of the subdivision exceeded 8 feet. Sanitary-sewer backups damaged some structures. Several commercial structures also received damages.

Petroleum products from a flooded gasoline station and from residential heating tanks leaked into floodwaters. Polychlorinated biphenyls (PCB's) were detected in concentrations as large as 1,200 milligrams per liter in some petroleum products cleaned from the flooded areas.

Total property damage from the flooding was estimated at more than $7.2 million, according to the Federal Emergency Management Agency (1990). On December 6, 1990, the President of the United States declared a major disaster due to the flood damage in Lake County.

REFERENCES

Federal Emergency Management Agency, 1990, Interagency hazard mitigation report for Indiana, Disaster Declaration FEMA–885–DR–IN: Chicago, Illinois, 36 p.

Indiana Department of Natural Resources, Division of Water, 1986, Coordinated discharges of selected streams in Indiana: Indianapolis, Indiana [various pagination].

Stewart, J.A., and Diewert, C.E., 1992, Water resources data, Indiana, water year 1991: U.S. Geological Survey Water-Data Report IN–91–1, 369 p.

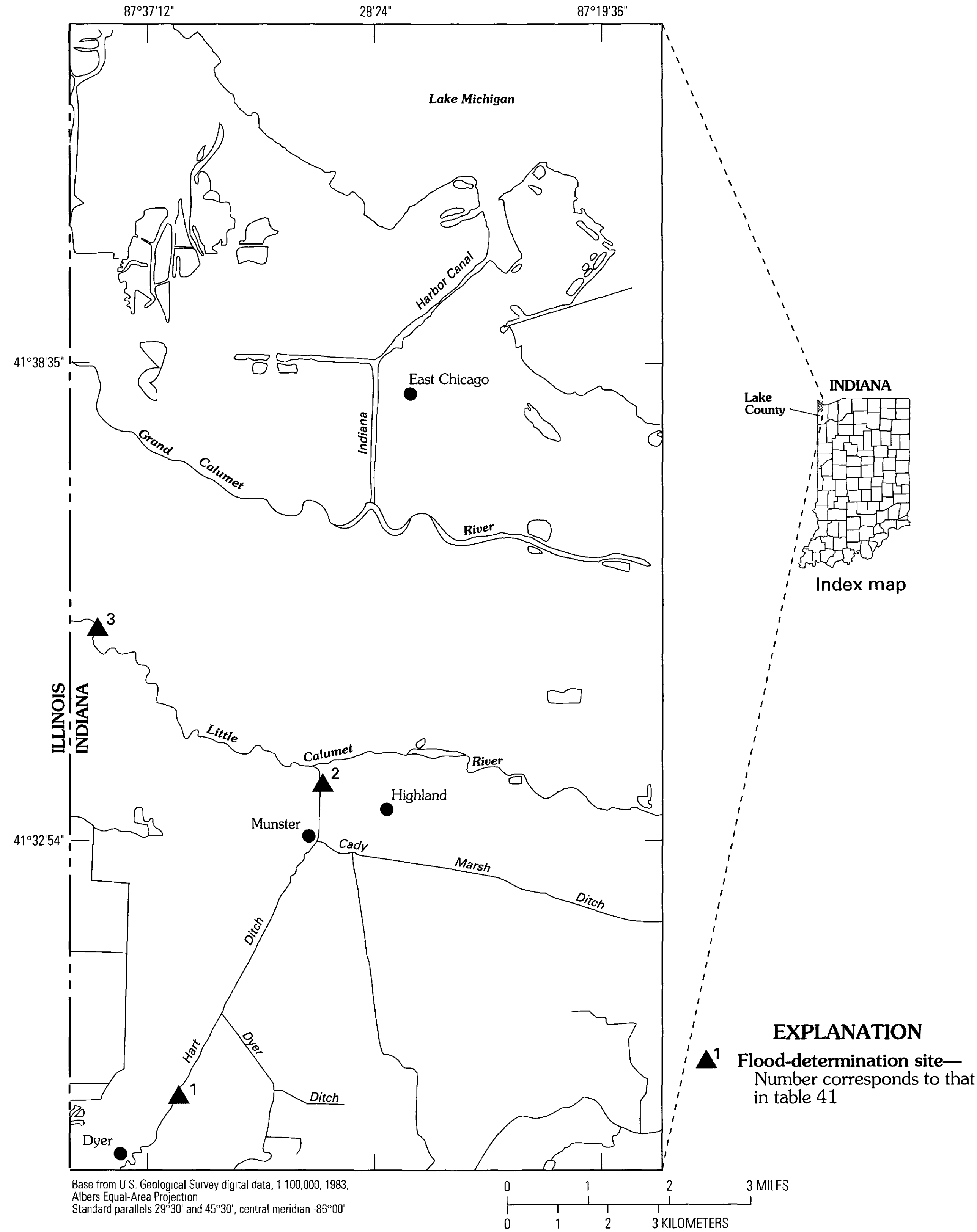


Figure 51. Location of flood-determination sites for flood of November 28, 1990, in Lake County, northwestern Indiana.

Table 41. Maximum stages and discharges prior to and during flood of November 28, 1990, in Lake County, northwestern Indiana

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined or not applicable. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to November 28, 1990				Maximum during November 28, 1990		
Site no. (fig. 51)	Station	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Stage (ft)	Discharge (ft^3/s)	Discharge, recurrence interval (years)
1	05536179	Hart Ditch at Dyer	37.6	1989–90	--	--	--	15.33	3,010	--
2	05536190	Hart Ditch at Munster	70.7	1943–90	1959	--	2,670	8.72	3,010	--
					1989	8.10	--			
3	05536195	Little Calumet River at Munster	90.0	1958–90	1959	--	1,510	17.03	1,200	--

Floods of December 20–30, 1990, in Alabama, Mississippi, and Tennessee

By J. Brian Atkins

Severe flooding occurred in north Alabama, northeast Mississippi, and south-central Tennessee as a result of excessive rainfall that fell December 20–23, 1990. Thunderstorms associated with a strong cold front produced rainfall amounts of 12 inches or more in some areas, as indicated in figure 52.

Maximum stages for periods of record ranging from 3 to 158 years in length were exceeded at 19 flood-determination sites, of which 12 sites were located in the Tennessee River Basin (table 42). Flood discharges equaled or exceeded the 100-year recurrence interval at 9 sites, the 50-year recurrence interval at 13 sites, and the 10-year recurrence interval at 37 sites.

Flash flooding resulted in deaths, injuries, and evacuations, and in damage to roads, bridges, homes, and businesses. Damage caused by the flooding in Alabama was estimated at $15 millon (National Oceanic and Atmospheric Administration, 1991d, p. 19). In Mississippi, more than 500 homes and about 100 businesses were damaged or destroyed (National Oceanic and Atmospheric Administration, 1991d, p. 49, 55–56). Flooding in Tennessee was responsible for eight deaths and more than $8 million in damage (National Oceanic and Atmospheric Administration, 1991d, p. 84–86).

REFERENCES

National Oceanic and Atmospheric Administration, 1991a, Climatological data, Alabama, December 1990: Asheville, N.C., National Climatic Data Center, v. 96, no. 12.

_____1991b, Climatological data, Mississippi, December 1990: Asheville, N.C., National Climatic Data Center, v. 95, no. 12.

_____1991c, Climatological data, Tennessee, December 1990: Asheville, N.C., National Climatic Data Center, v. 95, no. 12.

_____1991d, Storm data and unusual weather phenomena with late reports and corrections, December 1990: Asheville, N.C., National Climatic Data Center, v. 32, no. 12, 101 p.

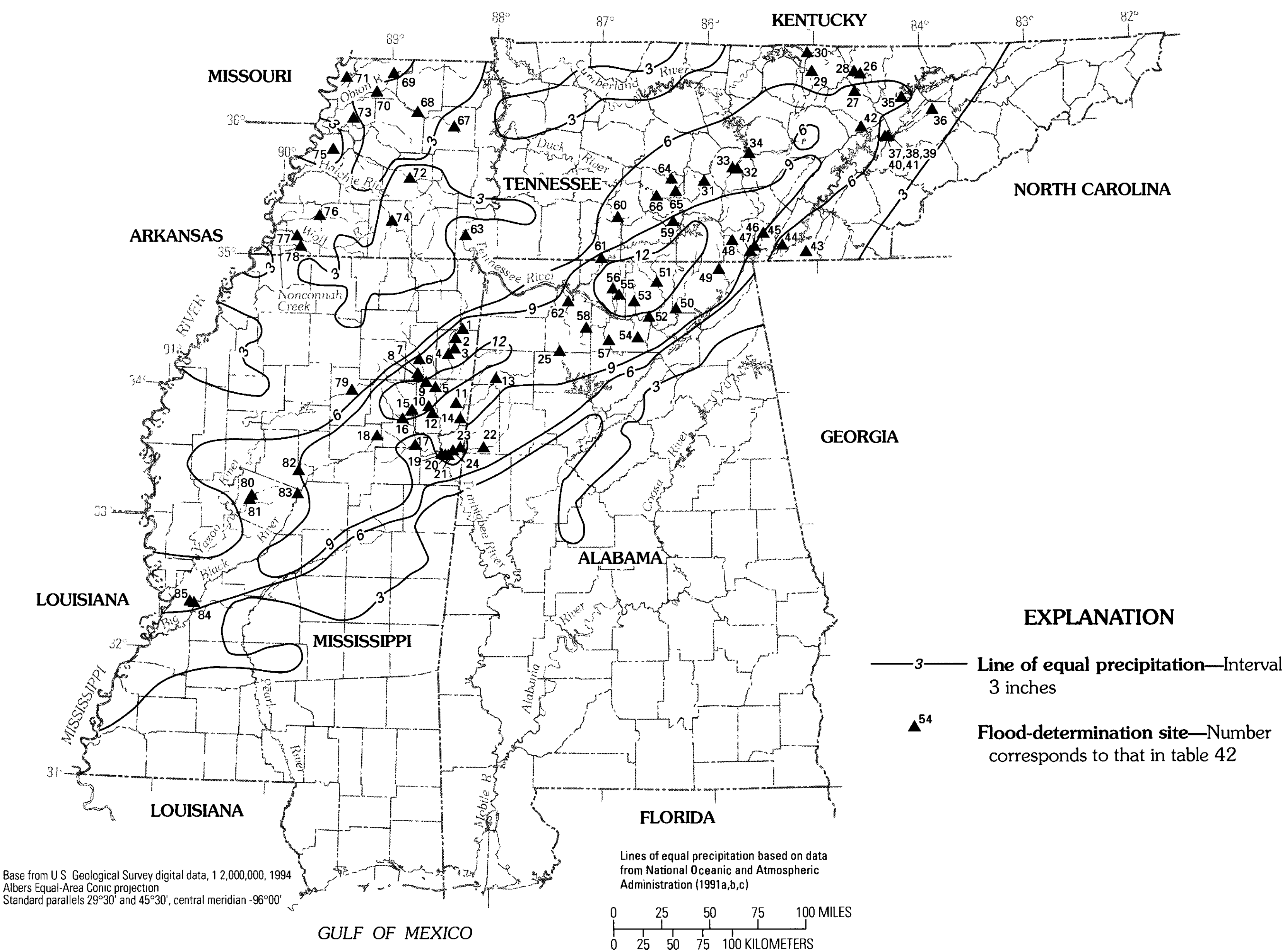


Figure 52. Location of flood-determination sites for floods of December 20–30, 1990, and lines of equal precipitation for storm of December 20–23, 1990, in Alabama, Mississippi, and Tennessee.

Table 42. Maximum stages and discharges prior to and during floods of December 20–30, 1990, in Alabama, Mississippi, and Tennessee

[mi², square miles; ft, feet above an arbitrary datum; ft³/s, cubic feet per second; >, greater than; <, less than; --, not determined or not applicable. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to December 1990				Maximum during December 1990			
Site no. (fig. 52)	Station no.	Stream and place of determination	Drainage area (mi²)	Period	Year	Stage (ft)	Discharge (ft³/s)	Day	Stage (ft)	Discharge (ft³/s)	Discharge recurrence interval (years)
				Mobile River Basin							
1	02430085	Red Bud Creek near Moores Mill, Miss.	15.7	1975–90	1983 1989	[1]12.25 12.46	1,690 [1]1,370	20	12.40	1,320	8
2	02430615	Mud Creek near Fairview, Miss.	11.1	1976–90	1986	9.83	778	21	9.85	[1]1,020	12
3	02430880	Cummings Creek near Fulton, Miss.	19.1	1975–90	1983	11.03	1,570	20	11.77	1,420	5
4	02431000	Tombigbee River near Fulton, Miss.	612	1929–90	1955	25.75	82,200	23	20.03	[2]21,100	2
5	02433500	Tombigbee River at Bigbee, Miss.	1,226	1890–1990	1973	27.64	112,000	23	25.99	[2]78,600	25
6	02435020	Town Creek at Eason Boulevard at Tupelo, Miss.	233	1955–90	1983	27.39	26,100	22	23.03	13,700	3
7	02435800	Coonewah Creek at Shannon, Miss.	53.1	1927–90	1962	19.57	22,400	21	16.81	--	--
8	02436000	Chiwapa Creek at Shannon, Miss.	145	1927–90	1955 1962	[1]15.72 15.90	35,500 [1]32,400	22	12.12	[3]18,900	5
9	02436500	Town Creek near Nettleton, Miss.	620	1892–1990	1955	33.88	151,000	22	29.15	41,300	6
10	02437300	Mattubby Creek near Aberdeen, Miss.	92.2	1925–90	1937	96.40	[4]15,500	21	95.27	14,600	25
11	02437550	Nichols Creek tributary near Quincy, Miss.	.54	1966–90	1973	7.03	338	20	4.98	155	2
12	02437600	James Creek at Aberdeen, Miss.	28.4	1948, 1961, 1963–90	1948, 1961	19.29	7,500	21	23.79	4,630	5
13	02438000	Buttahatchee River below Hamilton, Ala.	277	1916–90	1973	35.49	49,500	22	28.87	29,000	20
14	02439400	Buttahatchee River near Aberdeen, Miss.	798	1916–90	1973	23.48	80,000	24	20.55	46,700	20
15	02440000	Chuquatonchee Creek near Eqypt, Miss.	167	1927–90	1973	16.61	36,300	21	15.39	21,900	20
16	02440400	Houlka Creek near McCondy, Miss.	189	1963–90	1973	18.65	40,000	22	17.43	26,800	30
17	02440500	Chuquatonchee Creek near West Point, Miss.	505	1927–90	1973	24.58	57,100	23	23.26	44,300	25
18	02440600	Line Creek near Maben, Miss.	4.76	1952–90	1983	28.33	7,540	21	21.64	2,240	5
19	02441000	Tibbee Creek near Tibbee, Miss.	926	1892–1990	1973	32.26	81,600	23	30.24	57,800	9
20	02441390	Tombigbee River near Columbus, Miss.	4,440	1981–90	1983 1983	-- 71.09	[3]136,000 [1,3]124,000	26	69.52	[3]164,000	25

Table 42. Maximum stages and discharges prior to and during floods of December 20–30, 1990, in Alabama, Mississippi, and Tennessee—Continued

				Maximum prior to December 1990				Maximum during December 1990			
Site no. (fig. 52)	Station no.	Stream and place of determination	Drainage area (mi²)	Period	Year	Stage (ft)	Discharge (ft³/s)	Day	Stage (ft)	Discharge (ft³/s)	Discharge recurrence interval (years)
				Mobile River Basin—Continued							
21	02441500	Tombigbee River at Columbus, Miss.	4,463	1833–1990	1892 1973	[5]40.09 42.22	[4]268,000 [1]194,000	25	37.22	--	--
22	02442500	Luxapallila Creek near Millport, Ala.	247	1955–59 1981–90	1961 1983	14.21 [1]13.74	-- 13,300	24	14.07	15,500	--
23	02443000	Luxapallila Creek at Steens, Miss.	309	1916–90	1949	19.20	16,000	24	18.83	15,500	25
24	02443500	Luxapallila Creek near Columbus, Miss.	715	1892–1990	1892 1979	35.30 [1]32.35	-- 40,400	24	31.04	35,100	12
25	02450250	Sipsey Fork near Grayson, Ala.	92.1	1961–90	1973	44.27	20,300	23	33.66	11,300	5
				Cumberland River Basin							
26	03408500	New River at New River, Tenn.	382	1909–90	1929	41.20	74,700	23	32.14	46,800	20
27	03409000	White Oak Creek near Sunbright, Tenn.	13.5	1934, 1955–82, 1985–90	1973	17.24	5,560	23	10.80	--	--
28	03409500	Clear Fork near Robbins, Tenn.	272	1929–90	1929 1973	22.10 [1]18.92	-- 35,700	23	17.58	30,200	20
29	03414500	East Fork Obey River near Jamestown, Tenn.	202	1929–90	1929 1973	30.70 [1]30.46	-- 44,800	23	27.77	35,800	30
30	03416000	Wolf River near Byrdstown, Tenn.	106	1929–90	1982	17.14	23,500	23	11.08	12,200	5
31	03420360	Mud Creek tributary No. 2 near Summitville, Tenn.	2.28	1967–90	1973	5.60	1,760	22	5.87	2,870	>100
32	03421000	Collins River near McMinnville, Tenn.	640	1854–1990	1929	39.10	75,300	23	38.70	74,300	50
33	03421200	Charles Creek near McMinnville, Tenn.	31.1	1955–90	1989	17.03	24,800	22	11.99	6,780	20
34	03422500	Caney Fork near Rock Island, Tenn.	1,678	1912–90	1929	43.60	210,000	23	33.88	[2]140,000	--
				Tennessee River Basin							
35	03534000	Coal Creek at Lake City, Tenn.	24.5	1929, 1932–34, 1955–90	1929	--	8,400	23	9.77	7,110	50
36	03535180	Willow Fork near Halls Crossroads, Tenn.	3.23	1967–90	1973	8.08	878	23	7.08	528	5
37	03536440	Northwest tributary near Oak Ridge, Tenn.	.67	1987–90	1990	3.70	175	23	3.73	182	10
38	03536450	First Creek near Oak Ridge, Tenn.	.33	1987–90	1990	3.37	133	23	4.10	295	>100

Table 42. Maximum stages and discharges prior to and during floods of December 20–30, 1990, in Alabama, Mississippi, and Tennessee—Continued

Site no. (fig. 52)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to December 1990: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during December 1990: Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
		Tennessee River Basin—Continued									
39	03536550	Whiteoak Creek below Melton Valley Drive near Oak Ridge, Tenn.	3.28	1985–90	1990	6.31	629	23	6.51	711	14
40	03537100	Melton Branch near Melton Hill, near Oak Ridge, Tenn.	.52	1985–90	1988	9.92	109	23	10.64	238	25
41	03537200	Melton Branch tributary (Center Seven) near Oak Ridge, Tenn.	.07	1987–90	1990	3.64	29	23	3.71	35.0	8
42	03540500	Emory River at Oakdale, Tenn.	764	1857–1990	1929	41.20	195,000	23	38.71	170,000	>100
43	03566420	Wolftever Creek near Ooltewah, Tenn.	18.8	1964–90	1973	9.75	7,300	22	6.58	1,200	<2
44	03569168	Stringers Branch at Red Bank, Tenn.	1.54	1980–90	1987	25.70	--	22	22.85	--	--
45	03571000	Sequatchie River near Whitwell, Tenn.	[5]402	1867–1990 1921–90	1867 1973	19.0 17.65	-- 32,500	23	18.02	35,400	100
46	03571500	Little Sequatchie River at Sequatchie, Tenn.	116	1979–90	1980	11.29	--	22	11.78	--	--
47	03571730	Standifer Branch at Jasper, Tenn.	15.3	1982–90	1980	16.80	--	22	19.59	--	--
48	03571800	Battle Creek near Monteagle, Tenn.	50.4	1903–90	1963	12.20	10,200	22	12.03	9,800	>100
49	03572110	Crow Creek near Bass, Ala.	131	1975–90	1980	17.17	12,600	23	18.68	22,400	--
50	03574500	Paint Rock River near Woodville, Ala.	320	1867–1990	1973	24.40	74,200	23	23.42	56,900	>100
51	03575000	Flint River near Chase, Ala.	342	1867–1990	1973	[6]29.52	104,000	23	31.04	87,300	>100
52	03575500	Tennessee River at Whitesburg, Ala.	25,610	1925–90	1973	26.06	323,000	24	24.75	304,000	--
53	03575830	Indian Creek near Madison, Ala.	49.0	1959–90	1973	12.70	16,500	22	11.76	11,600	50
54	03576148	Cotaco Creek at Florette, Ala.	136	1963–90	1973	17.89	19,500	23	19.50	23,300	100
55	03576250	Limestone Creek near Athens, Ala.	119	1939–90	1973	17.28	45,800	23	15.20	26,700	50
56	03576400	Piney Creek near Athens, Ala.	55.8	1951–90	1963	13.38	12,900	22	10.80	4,700	4
57	03576500	Flint Creek near Falkville, Ala.	86.3	1953–90	1973	15.85	12,500	23	19.28	--	--
58	03577000	West Flint Creek near Oakville, Ala.	87.6	1941–90	1941, 1950	--	7,800	23	28.00	7,900	25

Table 42. Maximum stages and discharges prior to and during floods of December 20–30, 1990, in Alabama, Mississippi, and Tennessee—Continued

				Maximum prior to December 1990				Maximum during December 1990			
Site no. (fig. 52)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
		Tennessee River Basin—Continued									
59	03580995	East Fork Mulberry Creek below Jack Daniel Distillery at Lynchburg, Tenn.	23.4	1988–90	1989 1989	7.95 --	2,520 2,610	23	10.01	5,370	7
60	03583300	Richland Creek near Cornersville, Tenn.	47.5	1962–90	1989	16.58	11,400	22	13.16	6,010	4
61	03584600	Elk River at Prospect, Tenn.	1,805	1902–08, 1919–90	1902	--	130,000	24	30.25	55,500	5
62	03586500	Big Nance Creek at Courtland, Ala.	166	1935–90	1973	24.97	27,200	23	24.21	21,900	>100
63	03593500	Tennessee River at Savannah, Tenn.	33,140	1867–1990	1973	96.11	585,000	26 27	-- 91.04	[2]417,000 --	-- --
64	03597300	Wartrace Creek above Bell Buckle, Tenn.	4.99	1966–90	1973	12.64	3,220	21	7.30	1,060	<2
65	03597590	Wartrace Creek below County Road at Wartrace, Tenn.	35.7	1989–90	1989	11.04	3,330	21	13.00	5,400	4
66	03598000	Duck River near Shelbyville, Tenn.	481	1902–90	1902	--	87,000	23	29.88	26,100	5
		Obion River Basin									
67	07024300	Beaver Creek at Huntingdon, Tenn.	55.5	1954–90	1970	13.96	8,350	21	14.48	5,910	12
68	07024500	South Fork Obion River near Greenfield, Tenn.	383	1929–90	1937	17.82	25,600	22	18.10	20,000	20
69	07026004	Obion River at Highway 51 near Obion, Tenn.	1,876	1929–58, 1967–90	1937	40.40	99,500	24	39.10	45,000	11
70	07027000	Reelfoot Lake near Tiptonville, Tenn.	240	1940–90	1973	15.65	--	30	14.12	--	--
71	07027500	South Fork Forked Deer River at Jackson, Tenn.	495	1929–73, 1988–90	1935	24.00	43,600	23	18.34	7,540	<2
72	07029090	Lewis Creek near Dyersburg, Tenn.	25.5	1955–78, 1980–83, 1985–90	1964	19.31	5,450	21	18.00	2,650	2
		Hatchie River Basin									
73	07029500	Hatchie River at Bolivar, Tenn.	1,480	1929–90	1973	21.66	61,600	30	15.71	9,780	<2
74	07030100	Cane Creek at Ripley, Tenn.	33.9	1957–70, 1986–90	1989	23.16	6,360	21	20.87	4,790	30
		Loosahatchie River Basin									
75	07030240	Loosahatchie River near Arlington, Tenn.	262	1970–90	1987	25.27	27,400	22	21.16	14,400	10

Table 42. Maximum stages and discharges prior to and during floods of December 20–30, 1990, in Alabama, Mississippi, and Tennessee—Continued

Site no. (fig. 52)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to December 1990: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during December 1990: Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
		Wolf River Basin									
76	07031660	Wolf River at Walnut Grove Road at Memphis, Tenn.	709	1970–90	1975	27.98	33,400	22	17.05	10,900	<2
		Yazoo River Basin									
77	07283000	Skuna River at Bruce, Miss.	254	1892–1990	1955	[5]24.11	61,400	22	26.28	[3]22,000	3
78	07287350	Fannegusha Creek near Tchula, Miss.	103	1947–90	1947	25.10	32,000	22	21.33	10,200	2
79	07287355	Fannegusha Creek near Howard, Miss.	103	1953–66, 1987–90	1961	[5]142.87	24,000	22	19.23	12,500	4
		Big Black River Basin									
80	07289265	Hays Creek tributary no. 1 near Vaiden, Miss.	14.0	1960–90	1973	26.68	3,500	22	26.33	2,900	5
81	07289350	Big Black River at West, Miss.	1,027	1892–1990	1983	26.08	71,200	23	22.87	33,900	5
82	07290000	Big Black River near Bovina, Miss.	2,812	1927–90	1983	40.77	92,300	30	36.80	32,800	3
83	07290005	Clear Creek near Bovina, Miss.	32.0	1953–90	1969	30.03	21,000	22	27.36	10,900	8

[1]Less than maximum for period. [2]Discharge affected by regulation or diversion. [3]Discharge affected by channelization. [4]Estimated.
[5]Stage at different site and (or) datum. [6]Includes 18 square miles without surface drainage. [7]At site 0.2 mile downstream at same datum.

Floods of December 23–31, 1990, in Southeastern Kentucky

By Kevin J. Ruhl

A series of frontal systems produced rainfall over much of Kentucky and Tennessee from December 17–31, 1990. Widespread flooding occurred in the Cumberland River Basin in Kentucky and Tennessee, and minor flooding occurred in the Levisa Fork, upper Kentucky, and upper Licking River Basins in Kentucky. Flooding in the Cumberland River Basin affected mostly stream reaches along the Kentucky-Tennessee border.

Maximum discharges of streams in the Cumberland River Basin occurred mainly on December 22 or 23, 1990. Rain had fallen throughout the previous week, saturating the soil. The greatest rainfall occurred during a 24-hour period ending on December 23 and included 4.25 inches at Pineville, 4.20 inches at Middlesboro, and 4.03 inches at Stearns (fig. 53). Flood-determination sites are shown in figure 53, and the maximum stages and discharges are given in table 43. The maximum discharge of the South Fork Cumberland River near Stearns (site 10) had a recurrence interval of 17 years, and the maximum stage was the highest since 1973. Much of the drainage areas contributing runoff to the sites near Middlesboro (site 8) and Stearns (site 10) are located in Tennessee.

The upper Kentucky River Basin experienced minor flooding from this series of storm systems. Maximum discharges at the flood-determination sites occurred on different days in each of the three major Kentucky River subbasins (North, Middle, and South Forks). The discharges and dates of occurrence are given in table 43. On the main stem of the Kentucky River at Lock 14 at Heidelberg (site 7), three peak discharges of similar magnitude occurred during December 1990. On December 19, 23, and 31, the peak discharges were 40,800, 40,600, and 39,600 cubic feet per second, respectively. Precipitation was widespread and sporadic as indicated by the values given in table 44.

The Levisa Fork Basin and the upper Licking River Basin experienced minor flooding near the end of this period. Maximum discharges at the flood-determination sites at Paintsville (site 1) and near Salyersville (site 2) occurred on December 31 and had recurrence intervals of less than 2 years (table 43). Rainfall amounts at Paintsville and Salyersville on December 30 were 1.64 and 1.87 inches, respectively (National Oceanic and Atmospheric Administration, 1991).

Damages due to water inundating structures were experienced throughout southeastern Kentucky during the period. Ten counties in Kentucky were declared eligible for public assistance from the Federal government.

REFERENCES

Choquette, A.F., 1988, Regionalization of peak discharges for streams in Kentucky: U.S. Geological Survey Water-Resources Investigations Report 87–4209, 105 p., 1 pl.

Hannum, C.H., 1976, Technique for estimating magnitude and frequency of floods in Kentucky: U.S. Geological Survey Water-Resources Investigations Report 76–62, 70 p.

National Oceanic and Atmospheric Administration, 1991, Climatological data, Kentucky, December 1990: Asheville, N.C., National Climatic Data Center, v. 85, no. 12, 27 p.

EXPLANATION

▲1 **Flood-determination site**—Number corresponds to that in table 43

♦1 **Precipitation data site**—Number corresponds to that in table 44

Figure 53. Location of flood-determination and precipitation data sites for floods of December 23–31, 1990, in southeastern Kentucky.

Table 43. Maximum stages and discharges prior to and during floods of December 23–31, 1990, in southeastern Kentucky

[mi^2, square miles; ft, feet an arbitrary datum; ft^3/s, cubic feet per second; <, less than. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

Site no. (fig. 53)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to December 1990: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during December 1990: Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Big Sandy River Basin							
1	03212500	Levisa Fork at Paintsville	2,144	1915–16, 1928–90	1957	45.92	69,700	31	18.65	13,800	<2
				Licking River Basin							
2	03248500	Licking River near Salyersville	140	1939–90	1939	25.4	14,300	31	20.03	3,240	<2
				Kentucky River Basin							
3	03277500	North Fork Kentucky River at Hazard	466	1940–90	1957	37.54	47,800	28	11.98	8,230	<2
4	03280000	North Fork Kentucky River at Jackson	1,101	1929–31, 1939–90	1957	43.10	53,500	28	20.48	14,800	<2
5	03281000	Middle Fork Kentucky River at Tallega	537	1931, 1940–90	1957	43.33	52,700	31	23.31	8,050	<2
6	03281500	South Fork Kentucky River at Booneville	722	1926–31, 1939–90	1957	43.40	66,100	24	30.73	22,600	<2
7	03282000	Kentucky River at Lock 14 at Heidelberg	2,657	1926–90	1939	35.60	120,000	19	19.70	40,800	<2
				Cumberland River Basin							
8	03402000	Yellow Creek near Middlesboro	60.6	1940–90	1977	23.35	11,700	23	17.91	6,960	9
9	03403000	Cumberland River near Pineville	809	1939–90	1977	54.86	80,500	23	39.27	30,800	2
10	03410500	South Fork Cumberland River near Stearns	954	1942–90	1973	45.31	93,200	23	40.12	74,300	17

Table 44. Rainfall amounts at selected precipitation data sites in the upper Kentucky River Basin for December 17–28, 1990

[Data from National Oceanic and Atmospheric Administration, 1991]

Site no (fig. 53)	Precipitation data site	Precipitation (inches)		
		December 17–18	December 22–23	December 27–28
1	Hazard[1]	1.10	1.50	1.76
2	Jackson[2]	4.26	1.83	1.48
3	Hyden[1]	1.04	1.87	1.78
4	Manchester[2]	1.48	2.68	1.50

[1]Observation time 7:00 a.m. [2]Observation time midnight.

Floods of December 28, 1990–January 2, 1991, in Ohio

By G.F. Koltun

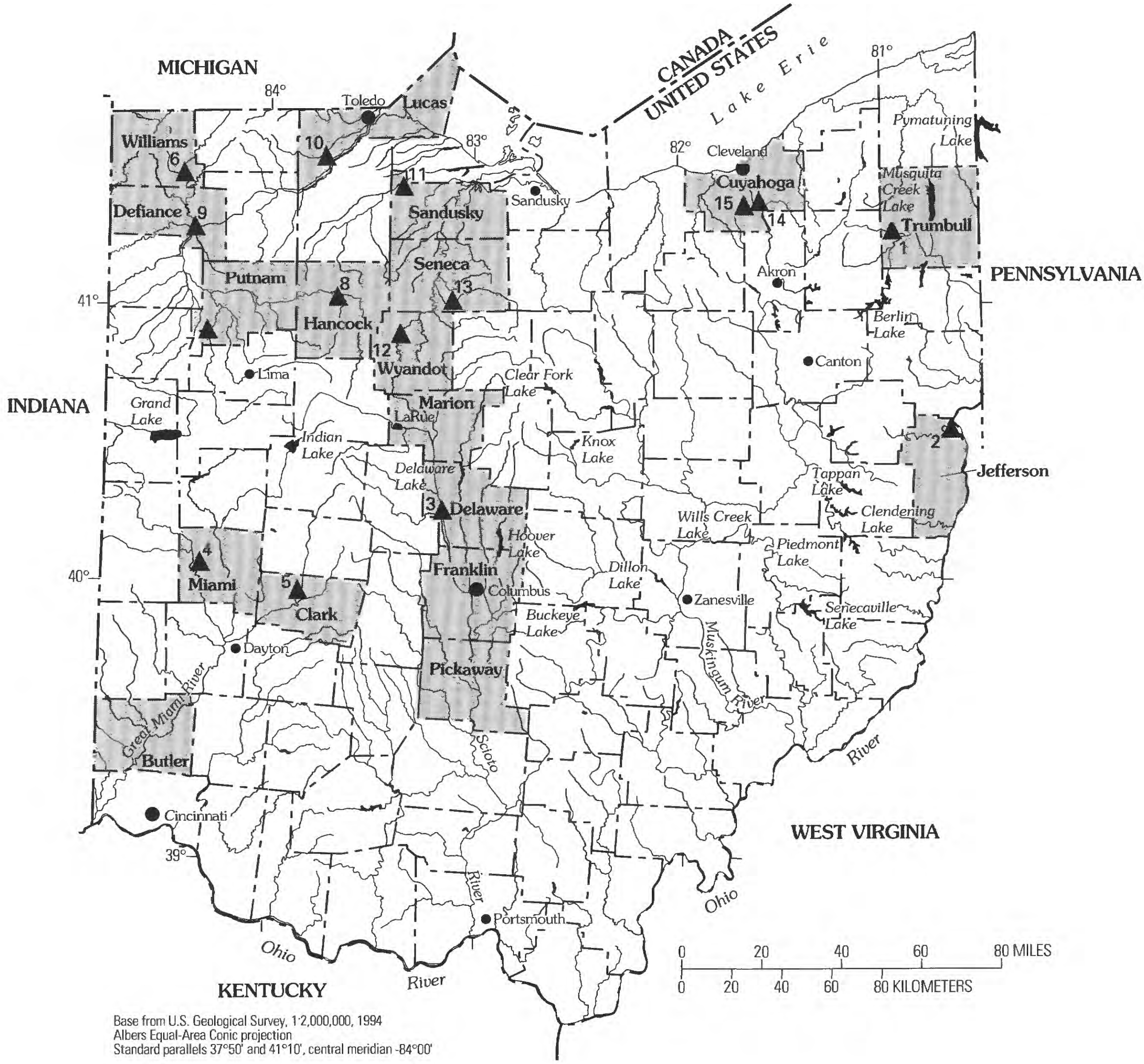
Two to three inches of rain falling on snow-covered ground caused flooding in many areas of Ohio from December 28, 1990, to January 2, 1991. Flooding conditions were aggravated by significantly above-normal precipitation before December 28. Average precipitation in Ohio for the month of December was 7.78 inches (5.20 inches above normal), making it the wettest December in at least 60 years of record keeping (National Oceanic and Atmospheric Administration, 1991, p. 24).

Flooding was reported in at least 18 counties scattered throughout Ohio (fig. 54). Rising floodwaters forced the evacuation of residents in Butler, Cuyahoga, Franklin, Marion, and Pickaway Counties. County commissioners declared Marion County a disaster area, primarily as a result of flooding in the village of LaRue.

Maximum discharges at flood-determination sites in the Lake Erie drainage had recurrence intervals that generally ranged from 5 to 25 years. In contrast, maximum discharges at flood-determination sites in the Ohio River drainage had recurrence intervals that generally ranged from 2 to 10 years. Table 45 shows maximum discharges for selected flood-determination sites that recorded relatively large flood discharges. Most flood-determination sites had the annual maximum discharge during December 30–31, 1990; however, maximum discharges recorded at flood-determination sites located on streams with large contributing drainage areas generally occurred during January 1–2, 1991.

REFERENCE

National Oceanic and Atmospheric Administration, 1991, Climatological data, Ohio, December 1990: Asheville, N.C., National Climatic Data Center, v. 95, no. 12, 27 p.



EXPLANATION

Counties affected by flooding

▲6 **Flood-determination site**—Number corresponds to that in table 45

Figure 54. Location of flood-determination sites for floods of December 28, 1990–January 2, 1991, in Ohio, and counties affected by flooding.

Table 45. Maximum stages and discharges prior to and during floods of December 28, 1990–January 2, 1991, in Ohio

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined or not applicable. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

Site no. (fig. 54)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to December 1990				Maximum during December 1990 through January 1991			
				Period	Year	Stage (ft)	Discharge (ft^3/s)	Date (month/day)	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Beaver River Basin							
1	03093000	Eagle Creek at Phalanx Station	97.6	1926–34, 1937–90	1979	13.71	8,150	12/31	12.98	5,050	10–25
				Yellow Creek Basin							
2	03110000	Yellow Creek near Hammondsville	147	1940–90	1952	12.17	9,580	12/31	11.49	8,170	50–100
				Scioto River Basin							
3	03220000	Mill Creek near Bellepoint	178	1913–90	1959	[3]--	20,300	12/30	10.28	8,210	10–25
					1913	18.0	[3]--				
				Great Miami River Basin							
4	03265000	Stillwater River at Pleasant Hill	503	1884–1990	1913	[1]17.5	[2]51,400	12/30	17.93	20,700	10–25
5	03267900	Mad River at St. Paris Pike at Eagle City	310	1913–90	1971	[3]--	9,700	12/30	16.68	8,980	10–25
					1913	19.8	[3]--				
				Tiffin River Basin							
6	04185000	Tiffin River at Stryker	410	1913, 1921–28, 1937, 1940–90	1982	18.36	7,800	12/31	16.1	5,280	5–10
				Auglaize River Basin							
7	04186500	Auglaize River near Ft. Jennings	332	1921–35, 1940–90	1959	20.30	12,000	12/31	18.18	9,980	25
8	04189000	Blanchard River near Findlay	346	1884–1990	1913	18.50	22,000	12/31	14.85	9,670	10–25
				Maumee River Basin							
9	04192500	Maumee River near Defiance	5,545	1924–35, 1939–74, 1978–90	1982	15.87	104,000	01/01	13.28	83,700	25–50
10	04193500	Maumee River at Waterville	6,330	1884–1990	1913	19.9	180,000	01/01	15.31	90,700	10–25
				Portage River Basin							
11	04195500	Portage River at Woodville	428	1913, 1928–35, 1939–90	1913	17.0	17,000	12/31	13.67	10,400	10–25

Table 45. Maximum stages and discharges prior to and during floods of December 28, 1990–January 2, 1991, in Ohio—Continued

				Maximum prior to December 1990				Maximum during December 1990 through January 1991			
Site no. (fig. 54)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Date (month/day)	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Sandusky River Basin							
12	04196800	Tymochtee Creek at Crawford	229	1959–90	1978	[3]--	6,390	12/31	9.77	6,700	25–50
					1959	12.9	[3]--				
13	04197100	Honey Creek at Melmore	149	1961–90	1981	11.00	4,440	12/30	10.89	4,290	10–25
				Cuyahoga River Basin							
14	04207200	Tinkers Creek at Bedford	83.9	1962–90	1969	10.10	7,220	12/30	8.05	4,030	10–25
15	04208000	Cuyahoga River at Independence	707	1913–90	1959	22.41	24,800	12/30	21.77	15,000	10–25

[1]Stage not comparable to 1990 stage because of failure of levee in 1913.
[2]Determined by the Miami Conservancy District for location 3 miles upstream.
[3]Less than maximum for period.

Floods of December 29, 1990–January 7, 1991, in Indiana

By Scott E. Morlock

Major flooding occurred throughout Indiana during late December 1990 and early January 1991. All major drainage basins within Indiana were affected by the flooding.

Meteorological conditions and events that occurred during December led to the flooding. Above-normal rainfall was prevalent for the first 3 weeks of December. Snow and sleet fell over the entire State from December 22 to 24. On December 25, an arctic air mass caused the ground to freeze. A storm system produced 1 to 8 inches of snowfall across Indiana on December 27. This storm was followed by the arrival of warm, moist air, which melted the snow and produced continuous rain from December 28 through December 30 (National Oceanic and Atmospheric Administration, 1991).

The snowmelt produced as much as 0.75 inch of water. Rainfall amounts across Indiana ranged from 1.25 to 4.5 inches (National Oceanic and Atmospheric Administration, 1991). The runoff from the snowmelt and rain caused rivers and streams to begin rising on December 28. Flooding occurred in the drainage basins of the Wabash River, Lake Michigan, streams tributary to Lake Erie to the northeast in Ohio, and streams tributary to the Illinois River to the west in Illinois (fig. 55). Most small streams peaked on December 29. Larger streams and rivers reached maximum stages from December 30 through January 2. The Wabash River in southwest Indiana did not peak until January 7. An arctic air mass, which produced bitter cold across Indiana from December 31 through January 4, compounded the damage caused by flooding. Ponded floodwaters in many locations froze, caused additional structural damage, and hampered cleanup efforts.

Many streams and rivers peaked at the highest stages since 1913. Recurrence intervals for maximum discharges on streams and rivers across Indiana ranged from less than 10 to more than 100 years. Peak stages and discharges for selected streams are given in table 46.

Two people were killed as a result of the flooding, and at least 33 were injured. Approximately 4,000 people were evacuated from more than 2,000 homes. Damage from the flooding in Indiana was widespread. More than 1,700 structures were damaged; there was major damage to 565 homes, and 16 mobile homes were completely destroyed. There was significant damage to roads, bridges, and water- and wastewater-treatment facilities (Federal Emergency Management Agency, 1991). Major levee breaks were reported in many locations. The U.S. Army Corps of Engineers estimated flood damages of $50–100 million throughout the State. Of 92 counties in Indiana, 72 received substantial flood damages. On January 5, 1991, the President of the United States declared a major disaster for Indiana due to the flooding.

REFERENCES

Federal Emergency Management Agency, 1991, Interagency hazard mitigation report for Indiana, disaster declaration FEMA–885–DR–IN: Chicago, Illinois, 36 p.

Indiana Department of Natural Resources, Division of Water, 1986, Coordinated discharges of selected streams in Indiana: Indianapolis, Indiana [various pagination].

National Oceanic and Atmospheric Administration, 1991, Climatological data, Indiana, December 1990: Asheville, N.C., National Climatic Data Center, v. 95, no. 12, 21 p.

Stewart, J.A., and Diewert, C.E., 1992, Water resources data, Indiana, water year 1991: U.S. Geological Survey Water-Data Report IN–91–1, 369 p.

EXPLANATION

▲13 **Flood-determination site**—Number corresponds to that in table 46

Figure 55. Location of flood-determination sites for floods of December 29, 1990–January 7, 1991, in Indiana.

Table 46. Maximum stages and discharges prior to and during floods of December 29, 1990–January 7, 1991, in Indiana

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined or not applicable; >, greater than Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to December 1990				Maximum during December 1990–January 1991			
Site no. (fig. 55)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Date (mont h/day)	Stage (ft)	Dis-charge (ft^3/s)	Discharge recurrence interval (years)
				Great Miami River Basin							
1	03276500	Whitewater River at Brookville	1,224	1913–90, 1923–90	1913, 1959	39.00 27.78	-- 81,800	12/30	20.44	43,200	15–20
				Wabash River Basin							
2	03324000	Little River near Huntington	263	1943–90	1950	16.90	5,900	12/31	18.98	5,230	25
3	03324300	Salamonie River near Warren	425	1924–90	1959	17.05	13,200	12/30	16.21	11,700	15–20
4	03325500	Mississinewa River near Ridgeville	133	1927–90	1958	16.25	13,900	12/30	15.14	9,420	15–20
5	03326070	Big Lick Creek near Hartford City	29.2	1971–90	1981	16.14	1,940	12/30	15.45	1,640	--
6	03327520	Pipe Creek near Bunker Hill	159	1968–90	1985	16.59	4,390	12/31	17.91	5,140	--
7	03328500	Eel River near Logansport	789	1913–90	1943 1985	13.20 --	-- 17,700	12/31	11.75	14,700	25–30
8	03330241	Tippecanoe River at North Webster	49.3	1986–90	1986	5.64	294	1/2	6.49	364	15–20
9	03333050	Tippecanoe River near Delphi	1,869	1905–90	1959	15.1	22,600	12/30	12.87	22,100	25
10	03333450	Wildcat Creek near Jerome	146	1913–90 1916–90	1913 1980	18.00 13.34	-- 6,140	12/30	13.71	6,890	30–40
11	03333700	Wildcat Creek at Kokomo	242	1955–90	1959	--	8,100	12/30	16.95	8,070	25
12	03334000	Wildcat Creek at Owasco	396	1944–90	1950 1980	13.30 --	-- 10,800	12/31	12.04	9,650	15–20
13	03335690	Mud Pine Creek near Oxford	39.4	1971–90	1990	13.22	5,710	12/29	11.45	3,100	--
14	03339500	Sugar Creek at Crawfordsville	509	1913–90	1913	17.30	36,000	12/30	13.19	21,200	15–20
15	03340500	Wabash River at Montezuma	11,118	1828–1990	1913	34.00	230,000	1/1	29.98	104,000	15–20
16	03340800	Big Racoon Creek near Fincastle	139	1857–1990	1957	19.10	39,900	12/30	16.10	16,000	--
17	03341500	Wabash River at Terre Haute	12,263	1828–1990	1913	31.1	245,000	1/2	26.08	108,000	15–20
18	03347000	White River at Muncie	241	1828–1990	1913	22.6	20,000	12/31	12.96	10,400	10–15

Table 46. Maximum stages and discharges prior to and during floods of December 29, 1990–January 7, 1991, in Indiana—Continued

Site no. (fig. 55)	Station no.	Stream and place of determination	Drainage area (mi²)	Maximum prior to December 1990				Maximum during December 1990–January 1991			
				Period	Year	Stage (ft)	Discharge (ft³/s)	Date (mont h/day)	Stage (ft)	Dis-charge (ft³/s)	Discharge recurrence interval (years)
				Wabash River Basin—Continued							
19	03348000	White River at Anderson	406	1828–1990	1913	23.60	28,000	1231	18.83	17,900	25
20	03348350	Pipe Creek at Frankton	113	1958–90	1958	15.50	--	12/30	14.38	4,550	--
					1989	--	4,920				
21	03349000	White River at Noblesville	858	1913–90	1913	23.80	--	12/31	21.29	27,000	25
				1946–90	1964	21.31	26,800				
22	03350500	Cicero Creek at Noblesville	216	1913–90	1913	19.50	--	12/30	14.77	8,240	25
23	03351500	Fall Creek near Fortville	169	1913–90	1913	12.0	--	12/31	9.83	8,450	50
24	03353000	White River at Indianapolis	1,635	1828–1990	1913	36.00	70,000	12/31	20.51	38,000	15–20
25	03354000	White River near Centerton	2,444	1828–1990	1913	--	90,000	12/31	18.38	48,600	15–20
26	03360500	White River at Newberry	4,688	1847–1990	1913	27.50	130,000	1/2	25.36	94,800	50
27	03377500	Wabash River at Mount Carmel, Illinois	28,635	1828–1990	1913	33.00	428,000	1/7	31.75	225,000	15–20
				Streams tributary to Lake Michigan							
28	04099808	Little Elkhart River at Middlebury	97.6	1913–90	1985	10.52	2,470	12/30	9.88	1,910	40–50
29	04100252	Forker Creek near Burr Oak	19.2	1913–90	1985	7.00	480	12/30	7.03	323	>100
30	04100500	Elkhart River at Goshen	594	1913–90	1985	--	6360	12/30	11.03	5,530	30–40
				Streams tributary to Lake Erie							
31	04180000	Cedar Creek near Cedarville	270	1946–90	1982	12.98	5,340	12/30	13.38	5,580	50
32	04180500	St. Joseph River near Ft. Wayne	1,060	1950–90	1989	17.86	13,200	12/31	17.51	12,800	25
				Illinois River Basin							
33	05515500	Kankakee River at Davis	537	1913–90	1982	--	1,920	12/30	13.48	1,610	25
34	05516500	Yellow River at Plymouth	294	1948–90	1954	17.13	5,390	1/1	15.30	3,930	100
35	05517890	Cobb Ditch near Kouts	30.3	1968–90	1985	17.95	--	12/29	15.72	906	--
					1990	--	1,160				
36	05518000	Kankakee River at Shelby	1,779	1922–90	1982	12.98	7,650	1/2	11.91	5,660	10–15
37	05521000	Iroquois River at Rosebud	35	1948–90	1987	6.76	504	12/30	7.93	656	>100
38	05522000	Iroquois River near North Marion	144	1910–90	1958	15.09	2,040	12/31	14.60	1,730	30–40
39	05522 .500	Iroquois River at Rensselaer	203	1910–90	1958	16.54	2,550	12/31	15.79	2,390	80–90
40	05524500	Iroquois River near Foresman	449	1948–90	1958	24.42	5,930	12/31	22.19	5,670	50

Flood of January 3–7, 1991, on the Ohio River Main Stem in Kentucky

By Kevin J. Ruhl

A series of frontal systems moved through the Ohio and Cumberland River Basins between December 17 and 31, 1990, causing widespread rainfall throughout Kentucky, Tennessee, Ohio, and southern Indiana. Most flooding on the main stem of the Ohio River in Kentucky occurred in the reach from just south of Cincinnati, Ohio, to Paducah, Kentucky (fig. 56). The flooding in this reach occurred between January 3–7, 1991.

Flooding on the Ohio River from Cincinnati, Ohio, to just above the confluence with the Cumberland River resulted from the contribution of flow from several major tributaries in Kentucky. These included Levisa Fork (east of the area shown in figure 56) and the Licking and Kentucky Rivers. Flow from streams in southern Indiana also contributed to main-stem flooding. Flooding on the reach downstream of the confluence with the Cumberland River resulted from the previously mentioned tributary contributions and the contributions of flow from the Cumberland and Tennessee Rivers.

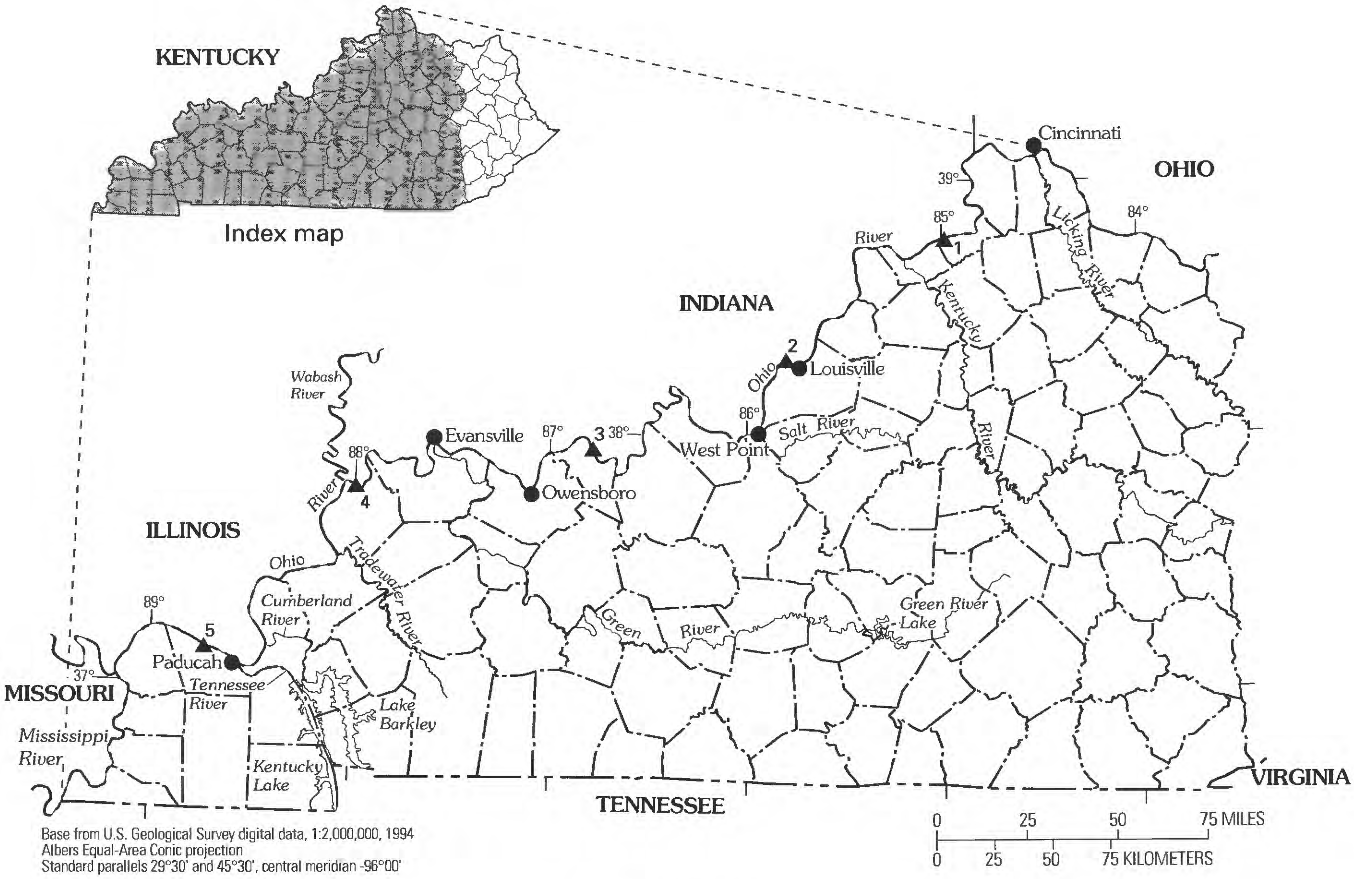
The flood-determination sites on the Ohio River are shown in figure 56, and the maximum stages and discharges are listed in table 47. The maximum discharges for the three most upstream sites—the Ohio River at Markland Dam (site 1), Louisville (site 2), and Cannelton Dam (site 3)—were less than the discharge for the 10-year recurrence interval. However, the stage at these three sites was the highest since December 1978 when major flooding also occurred along the main stem of the Ohio River downstream of Cincinnati. Because of inflows from streams in southern Indiana, the discharge of the Ohio River near Uniontown (site 4) was slightly larger than the discharge for the 10-year recurrence interval. For the river reach downstream of the confluence with the Cumberland and Tennessee Rivers, the discharge increased substantially because of inflows from those streams. The maximum discharge at Metropolis, Illinois (site 5), was slightly less than the discharge for a 30-year recurrence interval, and the stage was 0.21 foot higher than that recorded in 1978.

Numerous roads and businesses in low-lying areas in the Louisville metropolitan area were closed due to the flooding. In West Point, Kentucky, a small community located adjacent to the Ohio River approximately 10 miles southwest of Louisville, several houses were flooded, and more than 150 people were evacuated. In Paducah, Kentucky, in McCracken County, flooding in low-lying areas caused some evacuations. McCracken County was declared eligible for public assistance by the Federal government. Several other cities along this reach of the Ohio River experienced minor damage as a result of the flooding.

REFERENCES

Choquette, A.F., 1988, Regionalization of peak discharges for streams in Kentucky: U.S. Geological Survey Water-Resources Investigations Report 87–4209, 105 p., 1 pl.

Hannum, C.H., 1976, Technique for estimating magnitude and frequency of floods in Kentucky: U.S. Geological Survey Water-Resources Investigations Report 76–62, 70 p.



EXPLANATION

▲1 **Flood-determination site**—Number corresponds to that in table 47

Figure 56. Location of flood-determination sites for flood of January 3–7, 1991, in Kentucky.

Table 47. Maximum stages and discharges prior to and during flood of January 3–7, 1991, on the Ohio River main stem in Kentucky

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not applicable. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

Site no. (fig. 56)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to January 1991: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during January 1991: Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
1	03277200	Ohio River at Markland Dam, Ky.	83,170	1970–90	1978	55.25	542,000	3	52.89	491,000	7
2	03294500	Ohio River at Louisville, Ky.	91,170	1928–90	1937	85.44	1,110,000	4	60.30	535,000	7
3	03303280	Ohio River at Cannelton Dam, Ky.	97,000	1975–90	1978	49.08	617,000	5	46.85	572,000	9
4	03322420	Ohio River near Uniontown, Ky.	108,000	1984–90	1989	45.12	583,000	6	--	720,000	11
								9	51.54	--	--
5	03611500	Ohio River at Metropolis, Ill.	203,000	1928–90	1937	66.60	1,850,000	7	56.89	1,190,000	30

Floods of January 30–February 3, 1991, in East-Central Georgia

By Timothy C. Stamey

Moderate to severe rains occurred over most of east-central Georgia on January 29–31, 1991. Rainfall totaled as much as 5.7 inches, although most areas received from 2.5 to 4.5 inches for the 3-day period (National Oceanic and Atmospheric Administration, written commun., 1991). Rain developed as a low-pressure system and an accompanying cold front moved slowly over the southern half of the State. Unseasonably warm, southerly winds carried large amounts of moist air from the Gulf of Mexico into east-central Georgia in advance of the cold front (National Oceanic and Atmospheric Administration, written commun., 1991), resulting in periods of moderate to excessive rain on January 29–31.

Flooding caused by rainfall on ground already saturated by earlier storms occurred in parts of the Canoochee, Ocmulgee, Oconee, and Ogeechee River Basins (fig. 57). Several small streams having drainage areas of less than 50 square miles flooded earlier in January, but the most severe and widespread flooding occurred from January 30 to February 3. High water in east-central Georgia resulted in flooding of agricultural and timberland in the lowland areas adjacent to creeks and rivers but did not produce severe or extensive damage to property or livestock.

Maximum discharges on many streams in east-central Georgia had recurrence intervals ranging from 2 to 50 years. The most severe flooding occurred at flood-determination sites 4, 6, 14, 15, 17, and 18 (fig. 57, table 48). Maximum discharges at these sites had recurrence intervals ranging from 25 to 50 years (table 48).

The maximum discharge of 750 cubic feet per second at Crooked Creek near Kite (site 17) was the second largest recorded in 27 years. The maximum discharge of 18,300 cubic feet per second for the Ohoopee River near Reidsville (site 20) was the largest recorded since 1966. The maximum discharge of 750 cubic feet per second for Reedy Creek near Twin City (site 6) was the third largest recorded since 1929.

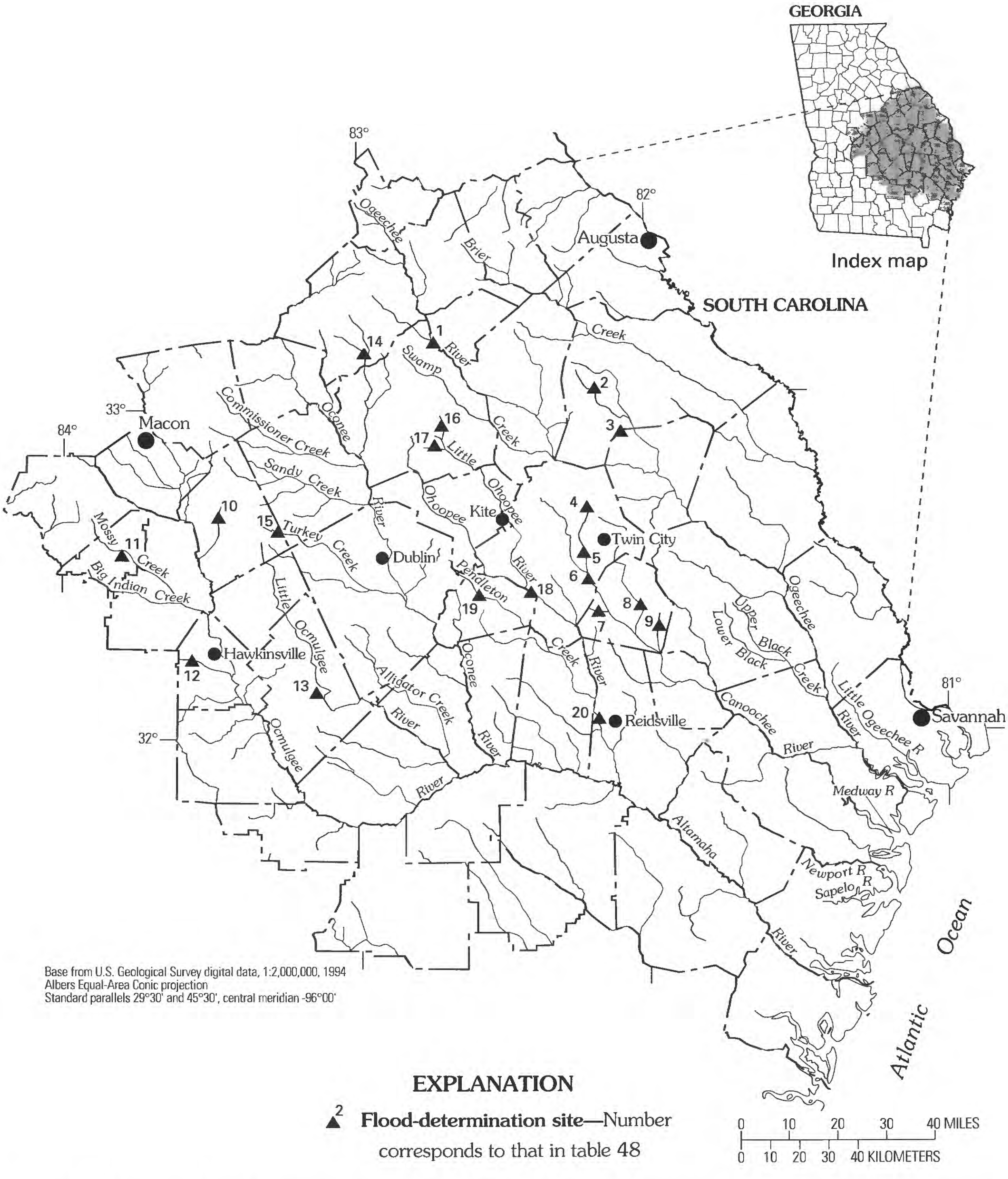


Figure 57. Location of flood-determination sites for floods of January 30–February 3, 1991, in east-central Georgia.

Table 48. Maximum stages and discharges prior to and during floods of January 30–February 3, 1991, in east-central Georgia

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined or not applicable; <, less than. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or or data bases]

Site no. (fig. 57)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to January 1991: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during January–February 1991: Date (month/day)	Stage (ft)	Discharge (ft^3/s)	Dischargerecurrence interval (years)
		Ogeechee River Basin									
1	02200000	Ogeechee River at Jewell	242	1888–1990	1888	34.12	27,000	01/31	14.75	4,000	5
2	02201800	Richardson Creek near Millen	43.0	1963–90	1980	6.04	2,400	01/31	5.02	1,000	5
3	02201830	Hooker Branch tributary near Millen	4.38	1965–90	1966	3.73	278	01/30	2.92	100	<2
4	02202800	Canoochee River near Swainsboro	46	1929–90	1929	9.40	2,820	01/31	9.88	2,100	50
5	02202810	Rock Creek near Swainsboro	5.05	1929–90	1929	5.60	1,000	01/30	3.34	200	2
6	02202820	Reedy Creek near Twin City	9.36	1929–90	1929	7.70	2,400	01/30	4.91	750	25
7	02202850	Reedy Branch near Metter	3.41	1965–90	1966	6.74	2,400	01/30	6.67	250	5
8	02202900	Fifteen Mile Creek near Metter	147	1948–90	1966	8.96	6,400	01/31	6.53	2,160	5
9	02202910	Ten Mile Creek tributary at Pulaski	1.14	1948–90	1966	7.67	599	01/30	3.63	75	<2
		Altamaha River Basin									
10	02214280	Savage Creek near Bullard	33.0	1979–90	1980	11.49	2,700	01/31	10.55	1,520	10
11	02214820	Mossy Creek near Perry	92.9	1979–90	1981	8.27	788	01/31	6.85	495	<2
12	02215100	Tucsawhatchee Creek near Hawkinsville	163	1984–90	1987	11.94	2,760	02/01	11.25	2,320	5
13	02215800	Gum Swamp Creek near Chauncey	221	1984–90	1987	9.33	4,740	01/31	9.32	3,980	5
14	02223082	Buffalo Creek near Linton	92.9	1961–90	1961	20.00	5,400	01/30	19.49	5,010	50
15	02224100	Turkey Creek near Dublin	316	1929, 1984–90	1929	--	19,000	01/31	16.85	10,500	50
16	02225210	Hurricane Branch near Wrightsville	3.53	1965–90	1990	6.52	1,100	01/30	3.52	450	10
17	02225240	Crooked Creek near Kite	7.22	1965–90	1990	8.49	1,200	01/30	6.45	750	25
18	02225320	Ohoopee River near Aline	698	1925–90	1990	18.81	22,000	01/31	17.60	16,500	50
19	02225350	Pendleton Creek tributary no. 2 near Soperton	1.68	1965–90	1973, 1984	3.47	290	01/30	2.27	93	<2
20	02225500	Ohoopee River near Reidsville	1,110	1886–1990	1925	28.40	47,000	02/03	21.01	18,300	10

Flood of February 18–26, 1991, in Mississippi

By W. Trent Baldwin

Severe flooding occurred in the northern half of Mississippi as a result of rainfall on February 17–23, 1991. According to the National Oceanic and Atmospheric Administration (1991), rainfall of 6 to 12 inches fell across the area during that period (fig. 58). Ten precipitation data sites in northern Mississippi set new records for total rainfall for the month of February.

As a result of the excessive rains, severe flooding occurred in northern and central Mississippi. Maximum stages and discharges at 56 flood-determination sites (fig. 58) are summarized in table 49. Maximum discharges equaled or exceeded the 10-year recurrence-interval discharges at 17 sites and exceeded maximums of record at 6 sites. Minor flooding occurred in the Pascagoula River Basin in the southeastern part of the State.

Two teenage boys drowned on February 20 when their boat capsized on a flooded creek in northeastern Mississippi. Damage caused by this flood was extensive. More than 1.2 million acres of land were inundated by floodwater in northwestern Mississippi. More than 350 homes were damaged in 10 counties. The total damage caused by this flood was estimated at more than $5 million (William V. Thompson, National Oceanic and Atmospheric Administration, written commun., 1991).

REFERENCES

National Oceanic and Atmospheric Administration, 1991, Climatological data, Mississippi, February 1991: Asheville, N.C., National Climatic Data Center, v. 96, no. 2, 23 p.

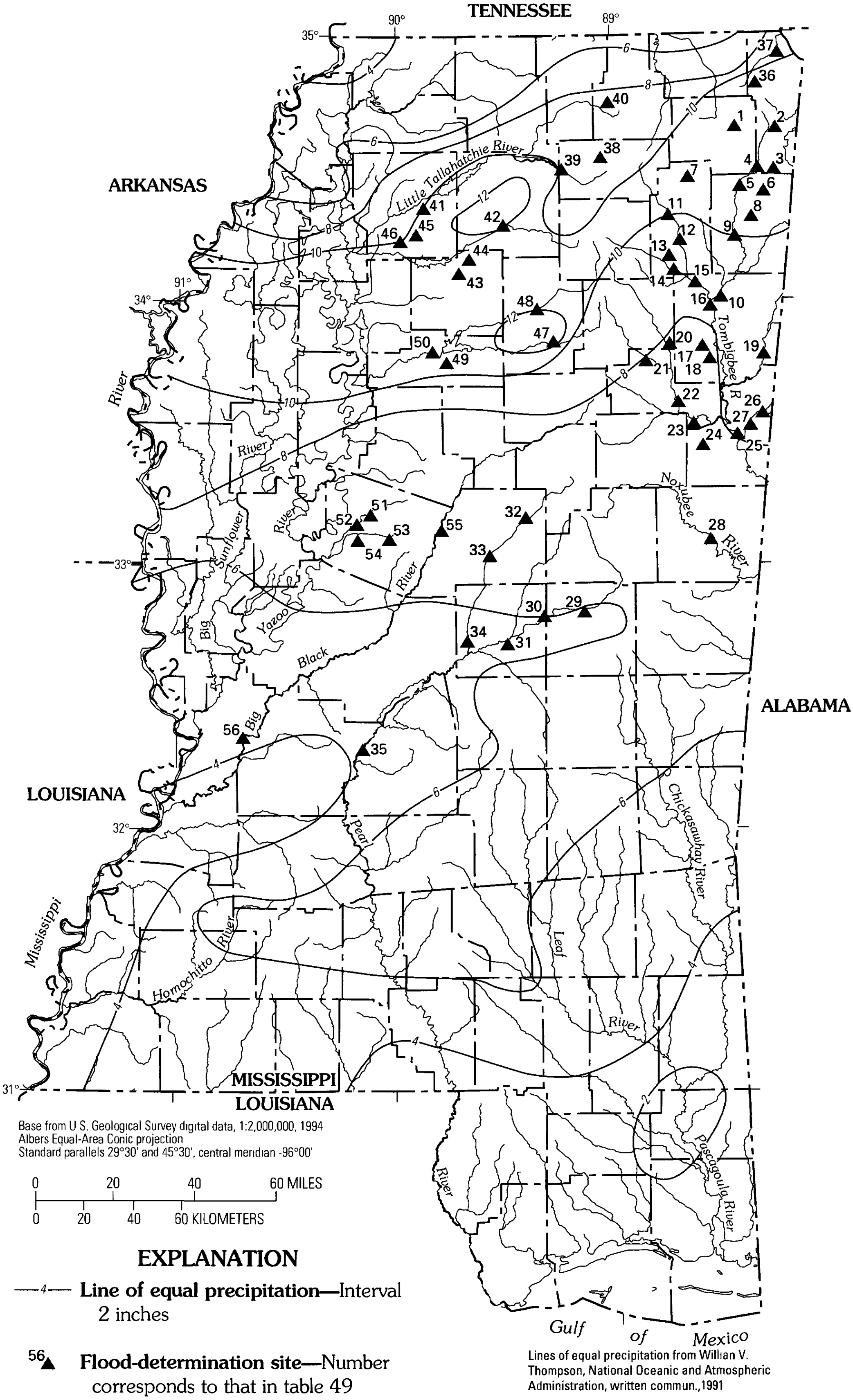


Figure 58. Location of flood-determination sites for flood of February 18–26, 1991, and lines of equal precipitation for storm of February 17–23, 1991, in Mississippi.

Table 49. Maximum stages and discharges prior to and during flood of February 18–26, 1991, in Mississippi

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined or not applicable. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

Site no. (fig. 58)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to February 1991				Maximum during February 1991			
				Period	Year	Stage (ft)	Discharge (ft^3/s)	Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Mobile River Basin							
1	02429900	Big Brown Creek near Booneville	27.1	1916–91	1970	[1]99.97	3,900	18	19.22	2,040	2
2	02429980	Pollard Mill Branch at Paden	2.01	1967–91	1983	6.07	524	19	6.81	688	15
3	02430085	Red Bud Creek near Moores Mill	15.7	1975–91	1990	12.40	1,700	19	12.35	1,660	10
4	02430100	Mackeys Creek near Moores Mill	118	1983–91	1983	--	[2]2,500	19	7.67	545	--
5	02430500	Tombigbee River near Marietta	308	1892–1977	1955	13.50	--	19	14.05	--	--
6	02430615	Mud Creek near Fairview	11.1	1976–91	1990	9.85	1,020	19	9.84	1,010	10
7	02430680	Twentymile Creek near Guntown	131	1965–91	1983	28.86	[3]32,400	19	28.72	[3]21,500	3
8	02430880	Cummings Creek near Fulton	19.1	1975–91	1989	11.74	1,840	19	11.61	1,290	4
9	02431000	Tombigbee River near Fulton	612	1929–91	1955	25.75	[2]82,200	20	24.39	[4]49,900	20
10	02433500	Tombigbee River at Bigbee	1,226	1890–1991	1973	27.64	112,000	20	25.77	[4]74,300	20
11	02434000	Town Creek at Tupelo	111	1927–91	1955	27.72	23,000	19	23.70	15,500	10
12	02435020	Town Creek at Tupelo	233	1955–91	1983	27.39	26,100	19	26.19	27,100	20
13	02435800	Coonewah Creek at Shannon	53.1	1927–91	1962	19.57	22,400	19	17.13	--	--
14	02436000	Chiwapa Creek at Shannon	145	1927–91	1955 1962	15.72 15.90	35,500 32,400	19	12.55	[3]20,000	5
15	02436500	Town Creek near Nettleton	620	1892–1991	1955	33.88	151,000	19	30.85	56,600	15
16	02437000	Tombigbee River near Amory	1,928	1892–1991	1973	34.65	162,000	20	32.29	[2]106,000	20
17	02437300	Mattubby Creek near Aberdeen	92.2	1925–91	1937	96.40	[2]15,500	19	93.54	10,200	5
18	02437600	James Creek at Aberdeen	28.4	1948, 1961, 1963–91	1948, 1961	[1]19.29	7,500	19	23.90	4,790	5
19	02439400	Buttahatchee River near Aberdeen	798	1916–91	1973	23.48	80,000	20	20.23	43,700	15
20	02440000	Chuquatonchee Creek near Egypt	167	1927–91	1973	16.61	36,300	19	14.30	12,300	3

Table 49. Maximum stages and discharges prior to and during flood of February 18–26, 1991, in Mississippi—Continued

Site no. (fig. 58)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to February 1991: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during February 1991: Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
		Mobile River Basin—Continued									
21	02440400	Houlka Creek near McCondy	189	1963–91	1973	18.65	40,000	19	16.10	17,300	5
22	02440500	Chuquatonchee Creek near West Point	505	1927–91	1973	24.58	57,100	19	21.87	33,200	10
23	02441000	Tibbee Creek near Tibbee	926	1892–1991	1973	32.26	81,600	20	29.66	52,000	5
24	02441300	Catalpa Creek at Mayhew	98.0	1963–91	1979	21.52	19,800	19	21.05	--	--
25	02441500	Tombigbee River at Columbus	4,463	1833–1991	1892 1973	[1,5]40.09 42.22	[2]268,000 [5]194,000	21	36.75	[4]162,000	25
26	02443000	Luxapallila Creek at Steens	309	1916–91	1949 1990	[5]19.20 19.41	16,000 [5]8,700	21	18.34	11,500	5
27	02443500	Luxapallila Creek near Columbus	715	1892–1991	1892 1979	35.30 [5]32.35	-- 40,400	21	29.46	29,000	5
28	02448000	Noxubee River at Macon	768	1892–1991	1979	38.97	125,000	23	30.42	21,000	4
		Pearl River Basin									
29	02481880	Pearl River at Burnside	520	1874–1991	1979	23.31	70,600	21	16.38	14,200	4
30	02482000	Pearl River at Edinburg	904	1874–1991	1979	30.06	77,900	22	25.23	18,800	5
31	02482550	Pearl River at Carthage	1,346	1874–1991	1979	28.74	102,000	24	23.41	24,600	5
32	02483890	Yockanookany River tributary near McCool	.34	1965–91	1980	6.76	415	20	7.73	540	90
33	02484000	Yockanookany River near Kosciusko	303	1933, 1938–91	1979	23.06	40,700	21	16.46	10,200	4
34	02484500	Yockanookany River near Ofahoma	469	1938–91	1979	[1]23.27	46,500	22	22.96	11,000	4
35	02486000	Pearl River at Jackson	3,170	1874–1991	1979	43.28	[4]128,000	26	32.82	[4]36,200	3
		Tennessee River Basin									
36	03592718	Little Yellow Creek near Burnsville	24.7	1974–91	1983	19.83	5,180	19	18.85	2,990	4
37	03592824	Tennessee-Tombigbee Waterway at Cross Roads	--	1980–91	1984	18.24	--	20	19.02	--	--
		Yazoo River Basin									
38	07267000	Hell Creek near New Albany	27.3	1939, 1942, 1952–91	1982	13.50	[3]8,420	20	12.91	[3]7,760	25
39	07268000	Little Tallahatchie River at Etta	526	1937, 1939–91	1955 1983	29.32 [5]29.02	[5]79,000 85,200	19	29.27	59,000	15

Table 49. Maximum stages and discharges prior to and during flood of February 18–26, 1991, in Mississippi—Continued

Site no. (fig. 58)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to February 1991: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during February 1991: Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
		Yazoo River Basin—Continued									
40	07269000	North Tippah Creek near Ripley	20.0	1939-42, 1948, 1952–66, 1968–80, 1983–85, 1988–91	1968 1979	[5]21.17 21.60	[3]7,100 --	18	17.97	[3]4,200	2
41	07273100	Hotopha Creek near Batesville	35.1	1986–91	1990	15.12	9,430	19	16.83	10,400	--
42	07274000	Yocona River near Oxford	262	1947–91	1955	[1]23.72	44,100	19	28.02	24,300	10
43	07274250	Otoucalofa Creek at Water Valley	84.1	1952–91	1983	28.07	15,900	19	25.62	7,900	5
44	07274251	Town Creek at Water Valley	2.25	1985–91	1990	11.00	1,800	19	10.17	1,480	--
45	07275500	Long Creek at Courtland	66.2	1907–91	1954	25.02	38,300	19	--	[2]23,000	40
46	07275530	Peters (Long) Creek near Pope	79.2	1986–91	1990	19.86	26,500	19	21.13	25,600	--
47	07282000	Yalobusha River at Calhoun City	305	1949–91	1982	25.75	[3]70,100	19	23.63	[3]31,600	3
48	07283000	Skuna River at Bruce	254	1892–1991	1955	[1]24.11	61,400	19	30.43	[3]33,700	5
49	07285400	Batupan Bogue at Grenada	240	1985–91	1989	15.33	14,500	19	18.02	21,800	--
50	07285510	Yalobusha River at Grenada	1,570	1989–90	1989	24.68	[4]14,100	19	26.87	[4]18,700	--
51	07287350	Fannegusha Creek near Tchula	103	1947–91	1947	25.10	32,000	19	23.26	14,600	5
52	07287355	Fannegusha Creek near Howard	107	1953–60, 1962–66, 1987–91	1955	[1]142.10	[2]20,000	19	19.18	12,300	4
53	07287400	Black Creek at Lexington	88.1	1987–91	1987	22.31	7,230	18	22.20	7,150	--
54	07287404	Harland Creek near Howard	62.1	1987–91	1987	21.36	7,440	18	21.70	5,700	--
		Big Black River Basin									
55	07289350	Big Black River at West	1,027	1892–1991	1983	26.08	71,200	21	22.90	29,900	4
56	07290000	Big Black River near Bovina	2,812	1927–91	1983	40.77	92,300	26	38.15	38,400	5

[1]Stage at different site and (or) datum. [2]Estimated. [3]Discharge affected by channelization.
[4]Discharge affected by regulation or diversion. [5]Less than maximum for period.

Floods of March 2–20, 1991, in Northern Florida

By M.A. Franklin

Because of rainfall in excess of 7 inches on March 2–3, 1991 (National Oceanic and Atmospheric Administration, 1991c), following wet antecedent conditions, areas of northern Florida were flooded during March 2–20. The official rainfall at Tallahassee was 9.41 inches in 26 hours on March 2–3 (National Oceanic and Atmospheric Administration, 1991d), and unofficial reports indicated as much as 18 inches of rain fell in Madison County during the same period. Prior to January 1991 the area had been experiencing a major drought. However, as much as 20 inches of general rain fell in January; an additional 1 to 3 inches fell in February (National Oceanic and Atmospheric Administration, 1991a,b).

Counties with significant flooding were Calhoun, Gadsden, Leon, and Wakulla, and parts of Bay, Franklin, Gulf, Hamilton, Jackson, Jefferson, Madison, Suwannee, and Taylor (fig. 59). Maximum stages and discharges for selected flood-determination sites in northern Florida are shown in table 50.

In and around the Tallahassee urban area in Leon County, 270 homes were damaged or isolated by high water or washed-out roads. In Wakulla County, additional homes were damaged or isolated. In rural areas, most of the damage was confined to washed-out roads, bridges, and culverts, and some homes were damaged or isolated.

REFERENCES

Bridges, W.C., 1982, Technique for estimating magnitude and frequency of floods on natural-flow streams in Florida: U.S. Geological Survey Water-Resources Investigations Report 82–4012, 44 p.

National Oceanic and Atmospheric Administration, 1991a, Climatological data, Florida, January 1991: Asheville, N.C., National Climatic Data Center, v. 95, no. 1, 17 p.

_____1991b, Climatological data, Florida, February 1991: Asheville, N.C., National Climatic Data Center, v. 95, no. 2, 18 p.

_____1991c, Climatological data, Florida, March 1991: Asheville, N.C., National Climatic Data Center, v. 95, no. 3, 19 p.

_____1991d, Hourly precipitation data, Florida, March 1991: Asheville, N.C., National Climatic Data Center, v. 41, no. 3, 14 p.

Figure 59. Location of flood-determination sites for floods of March 2–20, 1991, in northern Florida.

Table 50. Maximum stages and discharges prior to and during floods of March 2–20, 1991, in northern Florida

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second, <, less than; >, greater than; --, not determined. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

Site no (fig. 59)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to March 1991: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during March 1991: Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval[1] (years)
		Suwannee River Basin									
1	02315000	Suwannee River near Benton	2,090	1948–91	1973	102.80	27,700	13	97.30	12,100	6
2	02315500	Suwannee River at White Springs	2,430	1927–91	1973	88.56	38,100	20	79.79	12,900	<5
3	02315550	Suwannee River at Suwannee Springs	2,630	1961–91	1973	78.91	30,100	18	68.45	12,500	<5
4	02319000	Withlacoochee River near Pinetta	2,120	1931–91	1948	38.64	79,400	8	36.98	37,900	20
5	02319500	Suwannee River at Ellaville	6,970	1927–91	1948	40.88	95,300	12	33.62	53,300	19
6	02320500	Suwannee River at Branford	7,880	1928–91	1948	34.07	83,900	18	27.85	37,700	12
7	02323500	Suwannee River near Wilcox	9,640	1941–91	1948	22.32	84,700	19	15.44	38,800	9
		Aucilla River Basin									
8	02326500	Aucilla River at Lamont	747	1950–91	1973	16.57	11,500	8	14.86	8,170	13
9	02326512	Aucilla River near Scanlon	805	1976–91	1984	20.47	7,460	10	20.21	6,310	18
		St. Marks River Basin									
10	02326900	St. Marks River near Newport	535	1957–91	1973	11.81	4,750	5	11.18	4,490	10
		Ochlockonee River Basin									
11	02327100	Sopchoppy River near Sopchoppy	102	1961–91	1975	34.47	5,260	4	33.47	4,710	13
12	02329000	Ochlockonee River near Havana	1,140	1926–91	1948	35.08	55,900	6	31.38	22,800	15
13	02329500	Little River near Quincy	237	1950–91	1969	24.65	45,600	3	18.80	18,700	18
14	02329534	Quincy Creek at Quincy	16.8	1969–91	1969	12.18	3,170	3	11.83	2,920	>100
15	02329600	Little River near Midway	305	1965–91	1969	86.25	49,200	4	81.70	19,000	13
16	02330100	Telogia Creek near Bristol	126	1950–91	1969	16.65	20,600	4	13.72	12,800	50

Table 50. Maximum stages and discharges prior to and during floods of March 2–20, 1991, in northern Florida—Continued

				Maximum prior to March 1991				Maximum during March 1991			
Site no (fig. 59)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval[1] (years)
				Apalachicola River Basin							
17	02359000	Chipola River near Altha	781	1920–91	1926	33.55	25,000	4	28.43	11,800	12
18	02359170	Apalachicola River near Sumatra	19,200	1977–91	1990	13.82	179,000	10	10.60	105,000	--
				Econfina Creek Basin							
19	02359500	Econfina Creek near Bennett	122	1927–91	1948	12.46	3,720	3	14.37	5,850	>100

[1]Estimated by method of Bridges (1982).

Floods of March 3–11, 1991, in Southern Georgia

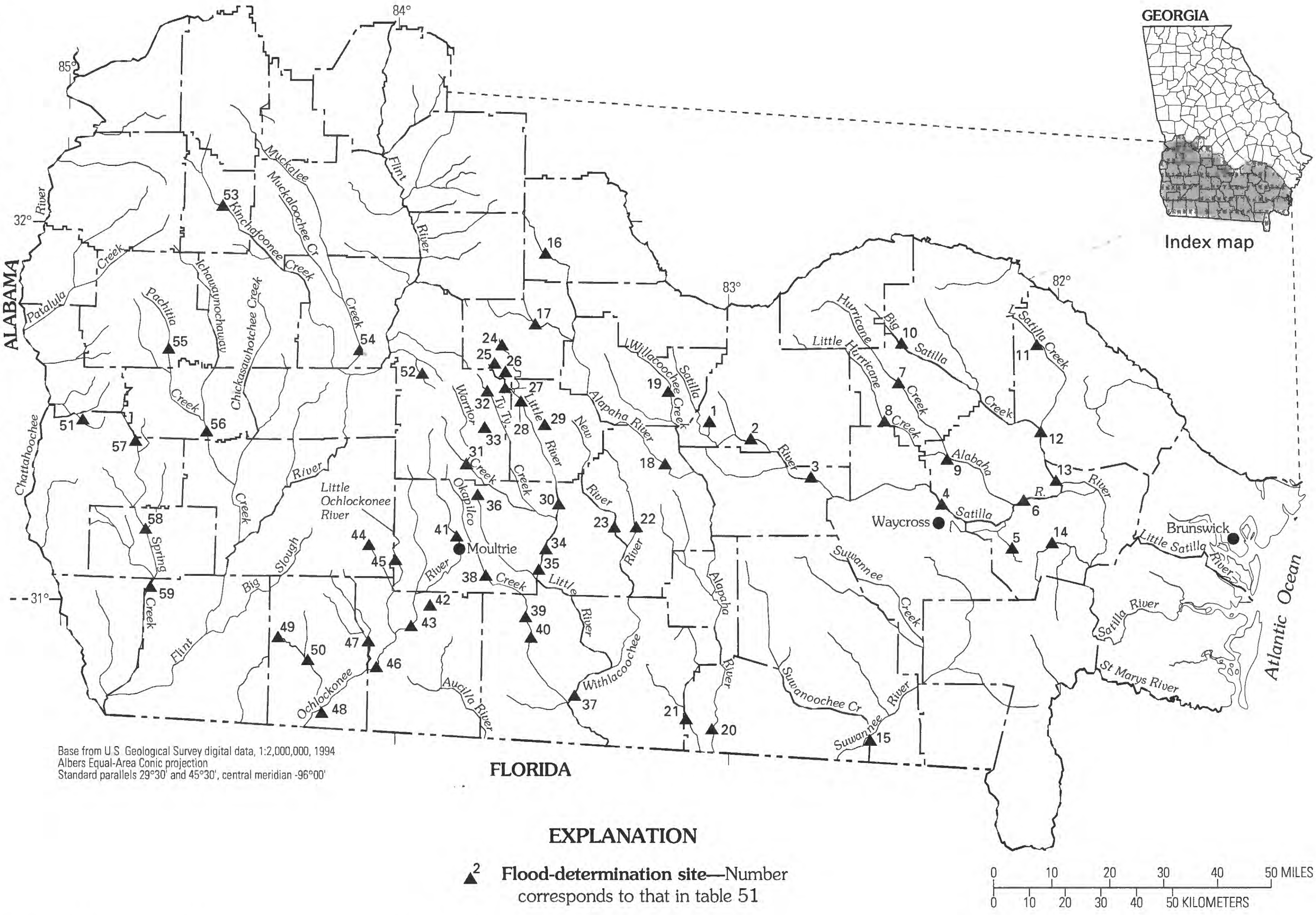
By Timothy C. Stamey

Periods of excessive rain began across southern Georgia on March 1 and continued until early on March 3. Rainfall amounts totaled as much as 9.2 inches for the 3-day period; however, most areas in southern Georgia received from 4.5 to 6.0 inches of rain. The rain resulted from a slow-moving low-pressure system with an accompanying cold front that extended across Georgia. Southerly winds preceding the front carried moist, unstable air from the Gulf of Mexico into southern Georgia. The low-pressure system intensified as it moved across the southern half of the State (National Oceanic and Atmospheric Administration, written commun., 1991).

The excessive rain on ground saturated by previous rainfall resulted in significant flooding on March 3–11 (fig. 60). As a result of extensive flood damage to public and private property, the President of the United States declared 15 counties in southern Georgia as flood-disaster areas on March 15. Damages of $6.3 million were reported to have occurred to at least 183 homes and 27 businesses. A few flood-related injuries were reported by the Georgia Emergency Management Agency (written commun., 1991).

Maximum discharges on many streams in southern Georgia had recurrence intervals ranging from 5 to 50 years. The most severe flooding occurred in the Satilla and Ochlockonee River Basins. Maximum discharges at most sites in these basins generally had recurrence intervals ranging from 25 to 50 years (fig. 60, table 51).

The maximum discharge of 31,800 cubic feet per second for the Satilla River near Waycross (site 4) was the third largest on record for the period 1928–91 and the largest since 1948. The maximum discharge of 14,200 cubic feet per second for the Little Satilla River near Offerman (site 12) was the largest recorded since 1953. The Ochlockonee River at Moultrie (site 41) reached a maximum discharge of 5,000 cubic feet per second, which is the second largest on record for the period 1948–91. New maximum discharges occurred at four sites (table 51) where discharge data were collected for the March 3–11 floods.



EXPLANATION

▲2 **Flood-determination site**—Number corresponds to that in table 51

Figure 60. Location of flood-determination sites for floods of March 3–11, 1991, in southern Georgia.

Table 51. Maximum stages and discharges prior to and during floods of March 3–11, 1991, in southern Georgia

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined or not applicable. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports and data bases]

Site no. (fig. 60)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to March 1991: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during March 1991: Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Satilla River Basin							
1	02226190	Little Creek near Willacoochee	6.38	1965–91	1970	5.93	945	3	6.00	1,000	50
2	02226200	Satilla River near Douglas	235	1862–1991	1948	15.40	15,500	5	11.72	7,680	25
3	02226300	Satilla River near Pearson	355	1862–1991	1948	20.60	19,500	5	19.53	15,500	50
4	02226500	Satilla River near Waycross	1,200	1862–1991	1948	22.40	39,000	6	21.52	31,800	50
5	02226580	Big Creek near Hoboken	60	1966–91	1984	12.96	3,130	4	12.32	2,740	25
6	02226582	Satilla River near Hoboken	1,350	1929–91	1948	--	42,000	7	16.80	29,000	50
7	02227000	Hurricane Creek near Alma	139	1929–91	1948	--	13,000	5	9.90	5,400	50
8	02227200	Little Hurricane Creek below Alma	102	1928–91	1948	--	7,500	5	9.39	4,800	25
9	02227290	Alabaha River near Blackshear	414	1929–91	1948	--	21,500	6	15.90	10,200	25
10	02227400	Big Satilla Creek near Alma	112	1862–1991	1929	--	17,000	5	9.87	5,800	50
11	02227430	Little Satilla Creek near Odum	49	1862–1991	1929	12.90	9,500	6	7.19	1,820	5
12	02227500	Little Satilla River near Offerman	646	1862–1991	1929	--	38,000	6	13.76	14,200	25
13	02227520	Little Satilla River near Patterson	695	1970–91	1984	17.84	13,400	7	18.10	15,500	25
14	02228050	Buffalo Creek near Hickox	62	1966–91	1976	10.69	4,430	4	8.23	1,800	5
				Suwannee River Basin							
15	02314500	Suwannee River at Fargo	1,260	1925–91	1928	19.50	13,800	11	15.35	7,180	5
16	02315700	Alapaha River near Rebecca	112	1951–91	1960	6.51	3,400	5	6.41	3,270	10
17	02315900	Deep Creek near Ashburn	137	1951–91	1970	13.84	4,600	5	13.57	4,400	10
18	02316000	Alapaha River near Alapaha	663	1862–1991	1928	19.00	16,000	5	16.02	8,360	10
19	02316200	Willacoochee River near Ocilla	90	1928–91	1948	11.90	7,000	4	9.39	3,700	25
20	02317500	Alapaha River at Statenville	1,400	1862–1991	1948	29.80	27,300	10	28.28	14,800	25
21	02317600	Little River near Statenville	199	1984–91	1984	17.36	11,000	5	16.69	9,430	50
22	02317700	Withlacoochee River near Nashville	132	1928–91	1948	14.80	8,500	5	11.13	3,980	10
23	02317734	New River near Nashville	146	1970–91	1984	12.50	6,350	5	13.76	6,800	50
24	02317760	Little River near Ashburn	8.54	1965–91	1975	5.01	787	3	3.12	536	5

Table 51. Maximum stages and discharges prior to and during floods of March 3–11, 1991, in southern Georgia—Continued

Site no. (fig. 60)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to March 1991: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during March 1991: Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
		Suwannee River Basin—Continued									
25	02317775	Daniels Creek near Ashburn	1.11	1965–91	1983	3.60	231	3	2.90	165	5
26	02317780	Lime Sink Creek near Sycamore	.68	1965–91	1982	6.08	252	3	3.63	110	5
27	02317795	Mill Creek near Tifton	6.21	1965–91	1986	11.06	1,400	3	6.33	884	25
28	02317800	Little River near Tifton	145	1951–91	1961	9.89	3,630	5	10.25	3,900	10
29	02317810	Arnold Creek tributary near Tifton	.47	1965–91	1986	4.46	160	3	3.47	109	5
30	02317830	Little River near Lenox	208	1862–1991	1948	--	15,000	5	14.39	7,000	25
31	02317870	Warrior Creek near Sumner	109	1966–91	1986	14.42	4,440	5	13.54	3,050	10
32	02317900	Ty Ty Creek at Ty Ty	47	1928–91	1948	9.30	3,500	4	7.86	2,410	25
33	02317905	Little Creek near Omega	4.22	1965–91	1986	5.28	820	3	4.82	590	25
34	02317980	Little River near Sparks	555	1862–1991	1948	14.70	28,000	6	14.31	17,800	50
35	02318000	Little River near Adel	577	1862–1991	1948	21.00	30,800	6	20.16	20,000	50
36	02318020	Bull Creek tributary near Ellenton	.27	1960–91	1961	5.63	181	3	4.32	119	10
37	02318500	Withlacoochee River near Quitman	1,480	1862–1991	1948	31.70	52,000	7	29.12	35,900	50
38	02318600	Okapilco Creek near Berlin	101	1862–1991	1948	--	12,500	4	13.38	7,740	50
39	02318700	Okapilco Creek near Quitman	269	1980–91	1986	18.75	18,500	5	17.15	13,300	50
40	02318725	Okapilco Creek at Quitman	278	1862–1991	1948	--	37,000	5	16.46	13,500	50
		Ochlockonee River Basin									
41	02327200	Ochlockonee River at Moultrie	96	1862–1991	1948	15.50	11,000	4	10.83	5,000	50
42	02327350	Ochlockonee River tributary near Coolidge	1.81	1948–91	1964	6.14	789	3	3.24	330	5
43	02327355	Ochlockonee River near Coolidge	260	1948, 1981–91	1948	--	35,000	4	16.89	11,000	50
44	02327400	Sallys Branch tributary near Sale City	3.70	1966–91	1986	--	1,400	4	5.56	570	25
45	02327415	Little Ochlockonee River near Moultrie	44.8	1981–91	1986	10.22	5,860	3	9.78	4,750	50
46	02327500	Ochlockonee River near Thomasville	550	1862–1991	1948	29.10	66,000	5	21.47	22,500	25
47	02327700	Barnetts Creek near Thomasville	104	1948–91	1964	20.40	17,700	5	15.92	7,200	50
48	02327810	Ochlockonee River near Cairo	747	1862–1991	1948	--	60,000	5	28.33	29,000	50
49	02327860	Popple Branch near Whigham	1.71	1977–91	1986	6.92	609	3	4.56	316	10
50	02328000	Tired Creek near Cairo	60	1862–1991	1948	16.30	28,100	4	11.04	8,500	25

Table 51. Maximum stages and discharges prior to and during floods of March 3–11, 1991, in southern Georgia—Continued

Site no. (fig. 60)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to March 1991: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during March 1991: Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
		Apalachicola River Basin									
51	02343267	Temple Creek near Blakley	2.78	1978–91	1978	2.03	110	3	2.50	102	5
52	02350520	Abrams Creek tributary near Doles	3.77	1965–91	1967	5.99	652	3	3.98	335	5
53	02350600	Kinchafoonee Creek at Preston	197	1900–91	1900	12.16	14,500	4	7.82	3,490	5
54	02351890	Muckalee Creek near Leesburg	362	1900–91	1900	- -	18,000	4	13.48	5,270	5
55	02353400	Pachitla Creek near Edison	188	1900–91	1916	11.88	11,800	3	8.27	4,580	10
56	02353500	Ichawaynochaway Creek at Milford	620	1900–91	1916	17.20	15,500	5	13.43	9,710	10
57	02356100	Spring Creek near Arlington	49	1951–91	1978	9.15	4,880	4	8.73	3,820	50
58	02356640	Spring Creek at Colquitt	281	1981–91	1982	11.23	6,240	5	10.90	6,010	25
59	02357000	Spring Creek near Iron City	485	1938–91	1948	19.90	--	5	18.04	9,120	25
					1975	--	17,700				

Flood of April 1991 in Northern Maine

By Joseph P. Nielsen

Snowmelt and ice breakup caused by warm weather combined with rainfall to cause severe ice-jam flooding along the St. John and Aroostook Rivers in Aroostook County in northern Maine during April 1991. The ice jams initially formed in late December 1990 when rain broke up the recently formed ice cover. This broken ice jammed at several locations along the St. John River, most notably at the former site of Ninemile Bridge (site 1, fig. 61) (Ninemile Bridge was destroyed by ice in 1953) and near the settlement of Dickey. Throughout the remainder of the winter, ice and packed slush built up behind these initial jams, until, by April, accumulations were estimated to be more than 30 feet thick (Federal Emergency Management Agency, 1991, p. 5). Warm weather and precipitation between April 5 and 11 increased streamflow and loosened the accumulated ice. This ice, augmented by the increased streamflow, damaged bridges, roads, and houses as it moved downriver.

Most of the damage occurred along the St. John River at Dickey (fig. 61). The St. John River is one of the largest rivers in Maine. Beginning at Little St. John Pond along the border between Maine and Quebec, it flows northward through remote, primarily uninhabited timberlands for about 140 miles until reaching Dickey, the first settlement along the river. From Dickey it continues eastward for another 100 miles, forming the international boundary between Maine and New Brunswick, Canada, until entering New Brunswick at Hamlin, Maine. Throughout the entire 240-mile length in Maine, the St. John River is unregulated and unobstructed, the longest such length of river in New England. Because of the remote location, records of previous floods are rare. However, serious flooding has occurred in the past, most notably during May 1974, April 1979, and April 1983. Ice, combined with various combinations of rainfall and snowmelt, is the most common cause of flooding on the river. There have been 31 ice jams recorded at Dickey since the installation of the U.S. Geological Survey (USGS) gaging station (site 3, fig. 61) in 1946 (Federal Emergency Management Agency, 1991, p. 23).

On April 9, 1991, the ice from Big Rapids began to move through the town of Allagash, destroying a 720-foot bridge over the St. John River and the nearby USGS streamflow-gaging station (site 3, fig. 61). Water and ice behind the jam also backed up the Little Black River, a tributary to the St. John, destroying a 211-foot bridge and pushing it several hundred feet upriver. On April 10, 1,000 feet of State Highway 161 in Allagash was destroyed as the ice continued downriver. Also on April 10, the USGS streamflow-gaging station upriver on the St. John River at Ninemile Bridge (site 1, fig. 61) was destroyed by ice-jam movement. In addition to the two bridges and streamflow-gaging stations, 11 homes in Allagash were destroyed, and 22 others were damaged by the ice and water (Federal Emergency Management Agency, 1991, p. 6). Almost 200 of the 359 people in the town were forced to evacuate (U.S. Geological Survey, 1993). As the ice moved downstream it continued to jam at islands and other constrictions in the river for the next several days. At Fort Kent, Maine, ice striking the bottom of the International Bridge on the afternoon of April 11 caused officials to close the bridge for 6 hours. Damage in other communities along the St. John River in Maine was minor, except at Grand Isle where three homes were extensively damaged (U.S. Army Corps of Engineers, 1993, p. 29). Residual ice along the river bank remained for several months, forming sheer walls more than 30 feet high in many locations along the St. John River. Along the Aroostook River, ice jams between April 12–16 caused flooding and evacuations in Fort Fairfield, Caribou, and Washburn. Thirteen homes were damaged.

Rainfall totals as reported by the National Oceanic and Atmospheric Administration for April 5–11 averaged 1.4 to 1.9 inches throughout the St. John and Aroostook River Basins. Temperatures were about 30 to 60 ^{o}F throughout the same period (National Oceanic and Atmospheric Administration, 1991). Snow surveys on April 3 showed 2 to 3 feet of snow in the basins, with water content ranging from 8 to 10 inches (Saint John River Forecast Centre, 1991). By April 15, snow cover had decreased to 1.5 to 2 feet and

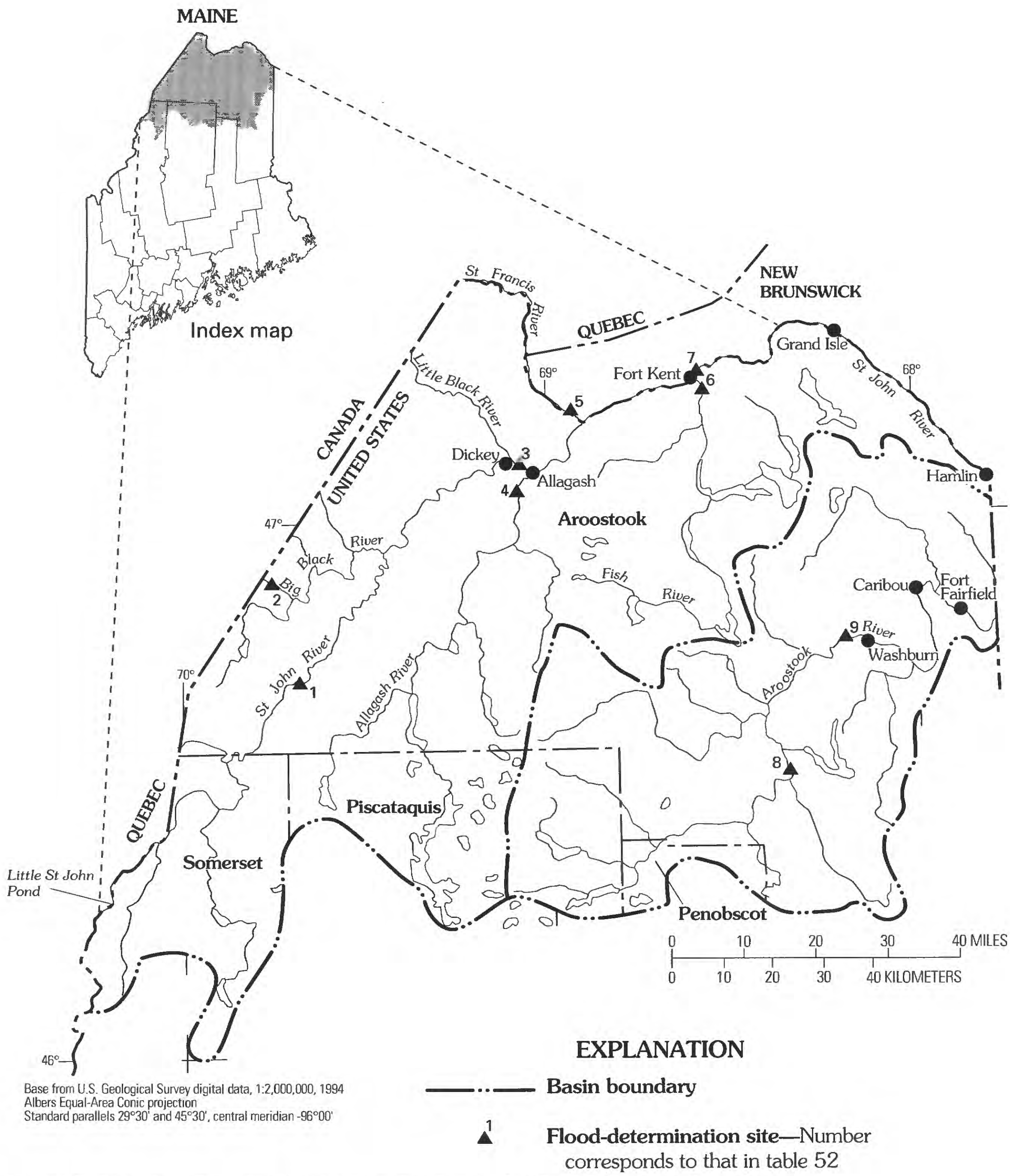


Figure 61. Location of flood-determination sites for flood of April 1991 in northern Maine.

water content to 4 to 8 inches, indicating that rainfall totals were augmented by as much as 2 to 4 inches of meltwater from the snowpack during the flood period.

Maximum discharges for the flood were less than those having a 5-year recurrence interval throughout the affected area (table 52). Several discharges could not be determined, however, due to the presence of ice jams and the destruction of streamflow-gaging stations. Maximum stages had recurrence intervals of 100 years or greater at three gaging stations in the St. John River Basin. The stage of 37.89 feet at the gaging station on the St. John River at Dickey (site 3, fig. 61), in use since 1947, exceeded the previous maximum stage, recorded in 1974, by 8.73 feet and was 12.89 feet above flood stage. The maximum stage of 19.78 ft at the streamflow-gaging station on the

Table 52. Maximum stages and discharges prior to and during flood of April 1991 in northern Maine

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined; <, less than. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases except as noted]

Site no. (fig. 61)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum stage prior to April 1991: Period	Year	Stage (ft)	Maximum stage during April 1991: Day	Stage (ft)	Recurrence interval[1] (years)	Maximum discharge during April 1991: Day	Discharge (ft^3/s)	Recurrence interval (years)
1	01010000	St. John River at Ninemile Bridge, Maine	1,341	1951–91	1976	[2]20.01	11	[2,3]23	100	11	[4]26,500	--
2	01010070	Big Black River near Depot Mountain, Maine	171	1984–91	1987	[5]15.62	10	[2]13.69	--	10	[4]3,600	--
3	01010500	St. John River at Dickey, Maine	2,680	1947–91	1974	[2]29.16	9	[2,3]37.89	>100	12	[4]53,000	--
4	01011000	Allagash River near Allagash, Maine	1,229	1932–91	1983	[2]19.48	10	[2]19.78	>100	11	[4]13,700	--
5	01011500	St. Francis River at outlet of Glasier Lake near Conners, New Brunswick	524	1952–91	1979	[5]15.39	12	[5]7.64	--	12	3,940	<2
6	01013500	Fish River near Fort Kent, Maine	873	1930–91	1973	[5]12.43	11	[5]7.11	--	11	5,670	<2
7	01014000	St. John River below Fish River at Fort Kent, Maine	5,665	1927–91	1979	[5]27.31	11	[2]25.59	15	12	85,800	2
8	01015800	Aroostook River near Masardis, Maine	892	1958–91	1983	[5]17.70	11	[2]15.29	3	12	[4]13,200	--
9	01017000	Aroostook River at Washburn, Maine	1,654	1931–91	1973	[2]20.91	12	[2]17.47	35	12	[4]30,000	--

[1]From U.S. Army Corps of Engineers (1993, plates 5–6). [2]Ice jam. [3]From high-water marks.
[4]Estimated daily mean discharge. [5]Open water.

Allagash River near Allagash (site 4, fig. 61) was the highest since at least 1932 and had a recurrence interval greater than 100 years. The maximum stage on the St. John River at Ninemile Bridge (site 1, fig. 61) could not be immediately determined due to the site's remote location and the destruction of the streamflow-gaging station; however, from later surveys of high-water marks, the stage was estimated to be approximately 23 feet, which was the highest since the gage was established in 1951 and represents a recurrence interval of 100 years. The gaging station on the St. John River at Fort Kent (site 7, fig. 61) had a maximum stage of 25.59 feet, 5.59 feet above flood stage; the recurrence interval of such a stage is 15 years. The maximum discharge of 85,800 cubic feet per second at the same gaging station had a recurrence interval of about 2 years. Flood damage in Fort Kent was minimized by the presence of a flood-control dike built by the U.S. Army Corps of Engineers in 1977. The dike protects most of the central business district to a stage of approximately 32 feet.

Maximum stages along the Aroostook River were generally not as extreme as on the St. John River. The gaging station on the Aroostook River at Washburn (site 9, fig. 61) had a maximum stage of 17.47 feet, which has a recurrence interval of 35 years. This was 3.47 feet above flood stage but 3.44 feet below the maximum stage of 20.91 feet recorded during an ice jam in 1973. The gaging station on the Aroostook River near Masardis (site 8, fig. 61) recorded a maximum stage of 15.29 feet, 1.71 feet below flood stage.

On April 13, 1991, the Governor of Maine requested that a flood disaster be declared for Aroostook County. On April 19, 1991, the President of the United States issued a formal disaster declaration. Damages to public facilities as a result of the ice jams were estimated at more than $14 million, of which approximately $13.5 million was to bridges and roads (Federal Emergency Management Agency, 1991). Total damages to private property were estimated at $920,000 (Lynette Miller, Maine Emergency Management Agency, oral commun., 1994). Damages in New Brunswick, Canada, were estimated at more than $1.1 million (Canadian dollars). Ninety-six homes were damaged, and 178 people were evacuated from communities along the Canadian side of the St. John River downriver of Fort Kent, Maine (Brian Burrell, New Brunswick Department of the Environment, written commun., 1994).

The ice jams also affected the habitat of the Federally endangered plant species Furbish's lousewort (*Pedicularis furbishiae*), which grows only along the banks of the St. John River in Maine and New Brunswick. The perennial herb generally is found on the north- or west-facing riverbank in a narrow band at the spring high-water level, preferring environments as they exist 3–10 years after the time of last severe disturbance (U.S. Fish and Wildlife Service, 1991). The scour and slumping caused by ice jams clears the riverbank of vegetation, including the Furbish's lousewort. However, the removal of vegetation from the bank along parts of the river allows the plant to colonize other locations, whereas without the clearing caused by the ice the plant soon would be overcome by successional forces. Thus, the species is entirely dependent on the dynamic action of ice jams for survival (U.S. Fish and Wildlife Service, 1991, p. 17). In the summer following the flood of April 1991, the population of Furbish's lousewort was estimated to have decreased 56 percent as a result of the ice jams (Gregory and Gawler, 1992, p. 2); however, many of the areas scoured will become new habitat for the endangered species within the next decade.

REFERENCES

Federal Emergency Management Agency, 1991, Hazard mitigation survey team report: Federal Emergency Management Agency, Region 1 Hazard Mitigation Survey Team, FEMA–901–DR–ME, 43 p.

Gregory, L.L., and Gawler, S.C., 1992, Population sizes of Furbish's lousewort (*Pedicularis furbishiae*), along the St. John River, Maine, 1991 census results: Report to the Critical Areas Program and the U.S. Fish and Wildlife Service, Maine State Planning Office, 15 p.

National Oceanic and Atmospheric Administration, 1991, Climatological data, New England, April 1991: Asheville, N.C., National Climatic Data Center, v. 103, no. 4, 59 p.

Saint John River Forecast Centre, April 3 and 15, 1991, Saint John River basin cooperative snow survey: Fredericton, New Brunswick, 7 p.

U.S. Army Corps of Engineers, 1993, Saint John River, Maine, ice damage control—general investigation study reconnaissance report: Waltham, Mass., 375 p.

U.S. Fish and Wildlife Service, 1991, Revised Furbish lousewort recovery plan: Newton Corner, Mass., 62 p.

U.S. Geological Survey, 1993, National water summary 1990–91—Hydrologic events and stream water quality: U.S. Geological Survey Water-Supply Paper 2400, p. 50.

Floods of April and May 1991 in Southern Arkansas

By C.S. Barks

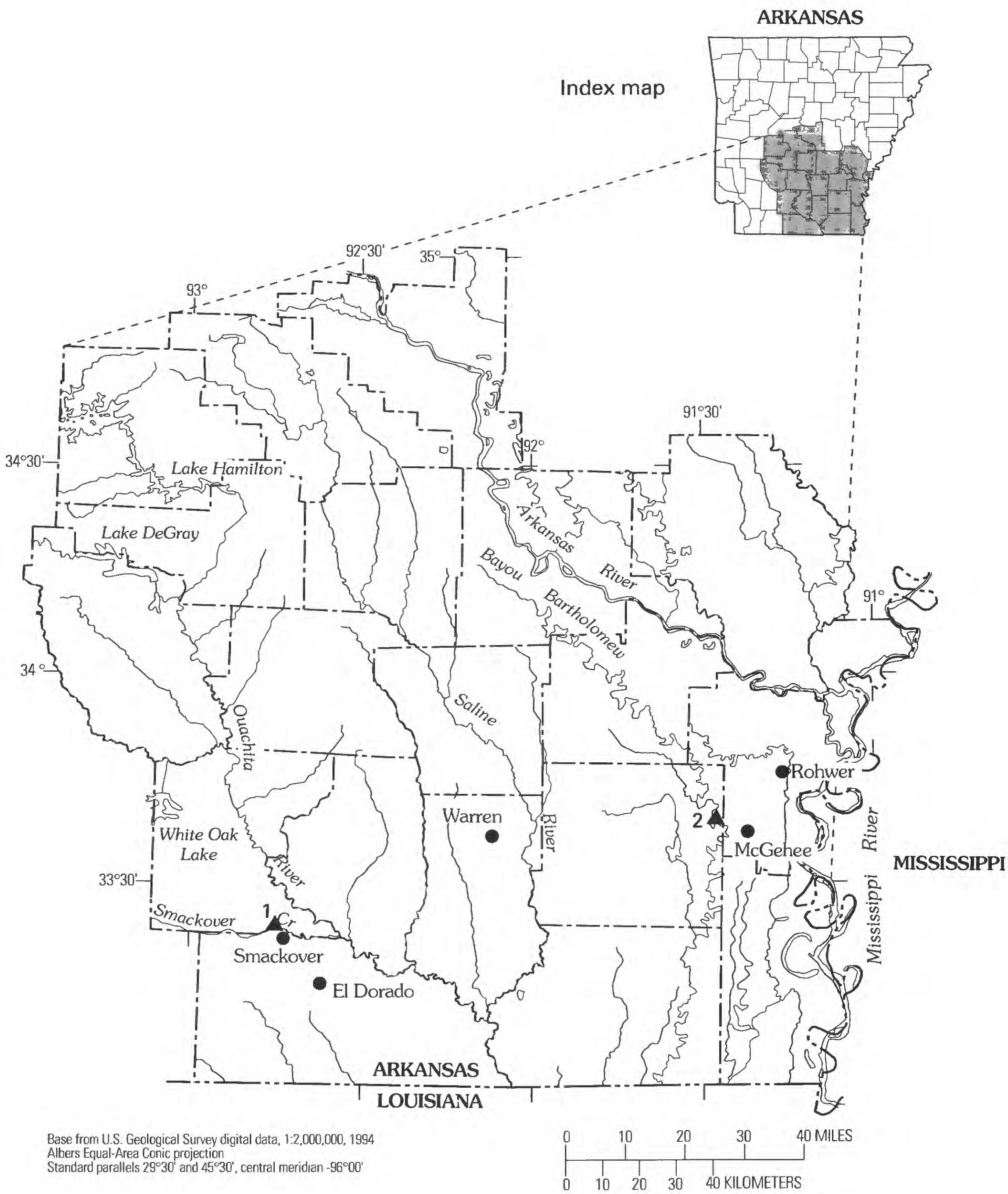
Flooding in southern Arkansas during April and May 1991 resulted in 15 counties being declared Federal disaster areas. One life was lost when floodwaters forced a vehicle off a state highway south of Warren (fig. 62). The State Office of Emergency Services (oral commun., 1991) estimated that damage to roads, bridges, culverts, and agriculture exceeded $3 million.

Storms on April 28 and 29 produced 6 to 11 inches of rain in southern Arkansas. National Oceanic and Atmospheric Administration (1991) records indicated that several cities in southern Arkansas experienced one of the wettest Aprils on record. At Rohwer, Arkansas (fig. 63), 20.19 inches of rain were recorded for the month. This is nearly four times the average rainfall of 5.46 inches for April.

The maximum discharge of 28,600 cubic feet per second of Smackover Creek near Smackover (site 1) occurred on April 29 and exceeded the discharge for a 40-year recurrence interval. The maximum stage of 22.6 feet was the third highest since at least 1938. The maximum discharge of 6,020 cubic feet per second for Bayou Bartholomew near McGehee (site 2) occurred on May 5 and exceeded the discharge for a 37-year recurrence interval. Its maximum stage of 25.25 feet was the second highest stage since at least 1930.

REFERENCE

National Oceanic and Atmospheric Administration, 1991, Climatological data, Arkansas, April 1991: Asheville, N.C., National Climatic Data Center, v. 96, no. 4, 28 p.



EXPLANATION

▲1 **Flood-determination site**—Number corresponds to that used in text

Figure 62. Location of flood-determination sites for floods of April and May 1991 in southern Arkansas.

Floods of April and May 1991 in Mississippi

By W. Trent Baldwin

April and May 1991 were two of the wettest months on record in Mississippi. For the most part, the record rainfall was not a result of one very intense storm system but rather a persistent pattern of storms. Rainfall totals for the 2 months in the State ranged from 16 to 38 inches. The April 1991 rainfall totals ranged from 6.5 to 22.8 inches, whereas the normal rainfall in April ranges from 5.2 to 6.4 inches (William V. Thompson, National Oceanic and Atmospheric Administration, written commun., 1991). At 18 precipitation data sites, April 1991 was the wettest month on record; at 56 sites, it was the wettest April on record. Although the northeastern part of the State received from 8 to 12 inches of rain from May 25 to May 27, it was the persistent pattern of storms that resulted in the excessive rainfall. The rainfall totals in this region for May 1991 ranged from 5.9 to 23.4 inches, whereas normal rainfall ranges from 3.8 to 5.8 inches (William V. Thompson, National Oceanic and Atmospheric Administration, written commun., 1991). At four precipitation data sites, May 1991 was the wettest month on record; at 22 sites, it was the wettest May on record.

As a result of the record-breaking rainfall during April and May, flooding occurred in every major drainage basin in the State. Maximum stream stages and discharges for 109 flood-determination sites (fig. 63) are summarized in table 53. Maximum discharges equaled or exceeded the discharge for the 100-year recurrence interval at 7 sites, the 50-year recurrence interval at 13 sites, and the 10-year recurrence interval at 35 sites.

Flooding was more severe in the Yazoo River Basin in northwestern Mississippi and the Mobile River Basin in northeastern Mississippi than in other drainage basins in the State. The U.S. Army Corps of Engineers operates flood-retarding structures on the Little Tallahatchie, Yocona, Coldwater, and Yalobusha Rivers in the Yazoo River Basin. These structures experienced the largest floods since at least 1973 and had emergency-spillway flows for more than 70 consecutive days. In the Mobile River Basin, floods on the Tombigbee River were also the largest since at least 1973.

The U.S. Army Corps of Engineers supplied more than 1 million sandbags and 30 pumps for flood control in northwestern Mississippi. Inmates from the State Penitentiary and guardsmen from the Mississippi National Guard participated in the sandbagging effort. At least one death was attributed to the floods—a 9-year old boy drowned while swimming in the swift current of a creek. The State Highway 6 bridge over the Tombigbee River was closed when one of the piers settled about 1 foot. More than 2 million acres of land were inundated by floodwater, and 1,700 homes were damaged. Damage caused by these floods was estimated in the hundreds of millions of dollars (William V. Thompson, National Oceanic and Atmospheric Administration, written commun., 1991).

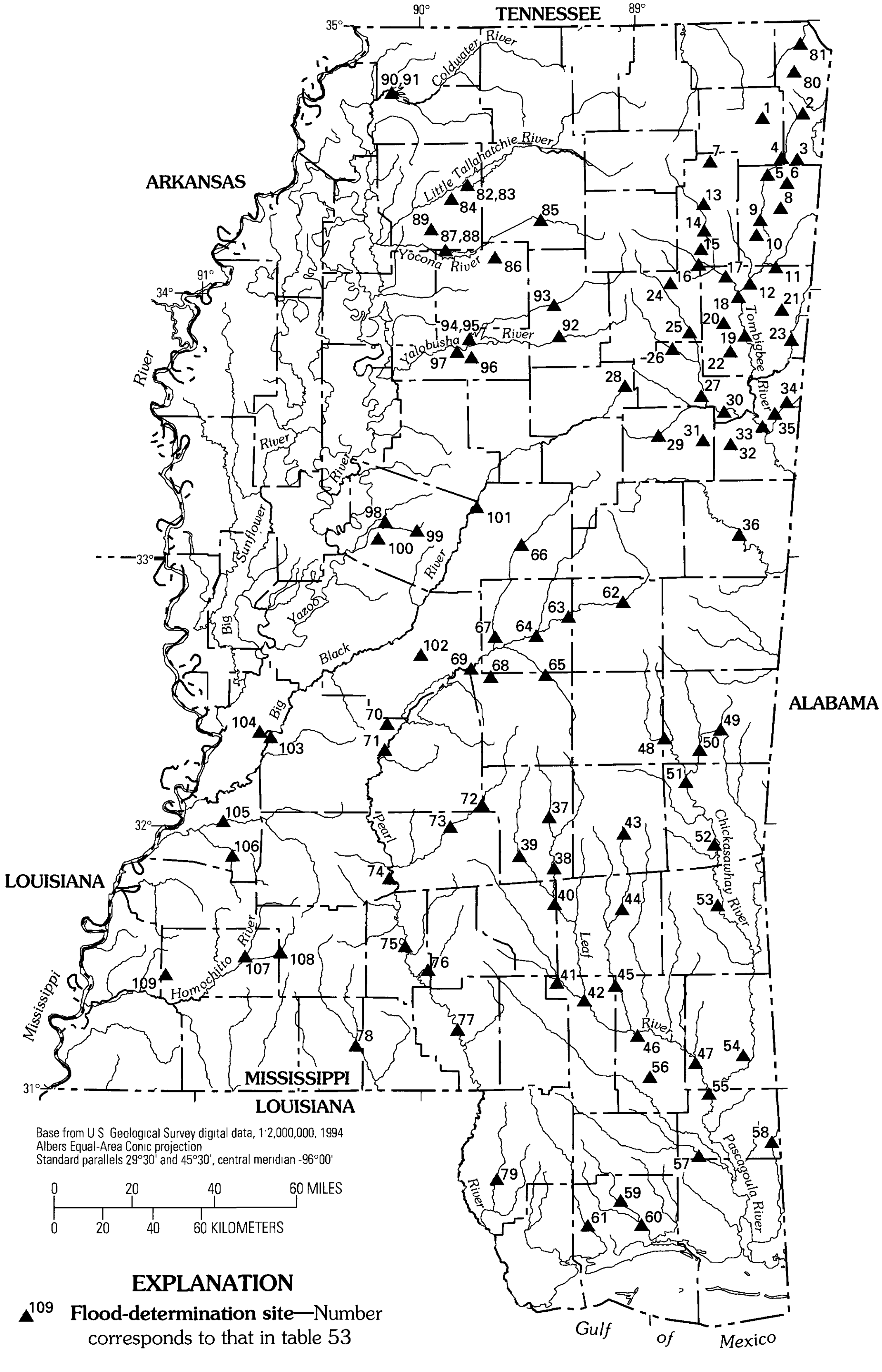


Figure 63. Location of flood-determination sites for floods of April and May 1991 in Mississippi.

Table 53. Maximum stages and discharges prior to and during floods of April and May 1991 in Mississippi

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined or not applicable; > greater than. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to April 1991				Maximum during April and May 1991			
Site no. (fig. 63)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Date (month/day)	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Mobile River Basin							
1	02429900	Big Brown Creek near Booneville	27.1	1953–91	1970	[1]99.97	3,900	5/27	21.56	3,140	5
2	02429980	Pollard Mill Branch at Paden	2.01	1967–91	1991	6.81	688	5/26	9.02	1,200	100
3	02430085	Red Bud Creek near Moores Mill	15.7	1975–91	1990	12.40	1,700	5/26	13.13	2,330	20
4	02430100	Mackeys Creek near Moores Mill	118	1983–91	1983	--	[2]2,500	5/26	9.12	780	--
5	02430500	Tombigbee River near Marietta	308	1892–1977, 1991	1991	14.05	--	5/27	15.24	--	--
6	02430615	Mud Creek near Fairview	11.1	1976–91	1990	9.85	1,020	5/27	10.48	1,390	50
7	02430680	Twentymile Creek near Guntown	131	1965–91	1983	28.86	[3]32,400	5/27	30.88	2,341,500	>100
8	02430880	Cummings Creek near Fulton	19.1	1975–91	1989	11.74	1,840	5/27	12.71	2,350	10
9	02431000	Tombigbee River near Fulton	612	1929–91	1955	25.75	82,200	5/27	27.72	[4]73,800	80
10	02431410	Mantachie Creek below Dorsey	66.9	1988–91	1990	15.64	7,030	5/27	17.96	10,500	--
11	02433000	Bull Mountain Creek near Smithville	336	1916–91	1973	18.26	44,400	5/27	15.18	21,700	10
12	02433500	Tombigbee River at Bigbee	1,226	1890–1991	1973	27.64	112,000	5/28	27.49	4101,000	50
13	02434000	Town Creek at Tupelo	111	1927–91	1955	27.72	23,000	5/27	26.67	20,100	40
14	02435020	Town Creek at Eason Boulevard at Tupelo	233	1955–91	1983	27.39	26,100	5/27	27.80	237,900	100
15	02435800	Coonewah Creek at Shannon	53.1	1927–91	1962	19.57	22,400	5/27	17.78	--	--
16	02436000	Chiwapa Creek at Shannon	145	1927–91	1955 1962	[5]15.72 15.90	35,500 532,400	5/27	12.88	320,900	5
17	02436500	Town Creek near Nettleton	620	1892–1991	1955	33.88	151,000	5/27	31.48	62,200	25
18	02437000	Tombigbee River near Amory	1,928	1892–1991	1973	34.65	162,000	5/28	33.83	4141,000	50
19	02437100	Tombigbee River at Aberdeen	2,050	1892–1991	1973	45.02	123,000	5/28	40.22	4103,000	--
20	02437300	Mattubby Creek near Aberdeen	92.2	1925–91	1937	96.40	215,500	5/27	94.52	12,700	10
21	02437550	Nichols Creek tributary near Quincy	.54	1966–91	1973	7.03	338	5/27	7.10	340	15
22	02437600	James Creek at Aberdeen	28.4	1948, 1961, 1963–91	1948, 1961	[1]19.29	7,500	5/27	24.82	6,280	10
23	02439400	Buttahatchee River near Aberdeen	798	1916–91	1973	23.48	80,000	4/16	18.57	27,500	4
24	02439980	Chuquatonchee Creek near Okalona	68.5	1911–91	1951 1973	-- 16.93	16,500 [5]15,000	5/27	14.85	5,170	3
25	02440000	Chuquatonchee Creek near Egypt	167	1927–91	1973	16.61	36,300	5/27	15.14	19,500	10
26	02440400	Houlka Creek near McCondy	189	1963–91	1973	18.65	40,000	5/27	17.91	32,200	90
27	02440500	Chuquatonchee Creek near West Point	505	1927–91	1973	24.58	57,100	5/27	23.74	48,600	40
28	02440600	Line Creek near Maben	4.76	1952–91	1983	28.33	7,540	5/27	25.12	4,240	100

Table 53. Maximum stages and discharges prior to and during floods of April and May 1991 in Mississippi—Continued

Site no. (fig. 63)	Station no.	Stream and place of determination	Drainage area (mi²)	Maximum prior to April 1991: Period	Year	Stage (ft)	Discharge (ft³/s)	Maximum during April and May 1991: Date (month/day)	Stage (ft)	Discharge (ft³/s)	Discharge recurrence interval (years)
		Mobile River Basin—Continued									
29	02440800	Trim Cane Creek near Starkville	44.9	1926–91	1983	28.10	9,980	5/27	27.31	7,950	10
30	02441000	Tibbee Creek near Tibbee	926	1892–1991	1973	32.26	81,600	5/27	31.16	68,000	20
31	02441220	Sand Creek tributary near Mayhew	.44	1966–91	1984	8.75	395	5/27	7.58	320	10
32	02441300	Catalpa Creek at Mayhew	98.0	1963–91	1979	21.52	19,800	4/15	20.73	--	--
33	02441500	Tombigbee River at Columbus	4,463	1833–1991	1892	[1,5]40.09	[2]268,000	5/29	37.01	[4]172,000	30
					1973	42.22	[5]194,000				
34	02443000	Luxapallila Creek at Steens	309	1916–91	1949	[5]19.20	16,000	4/15	17.90	9,800	4
					1990	19.41	[5]8,700				
35	02443500	Luxapallila Creek near Columbus	715	1892–1991	1892	35.30	--	4/16	28.47	25,700	5
					1979	[5]32.35	40,400				
36	02448000	Noxubee River at Macon	768	1892–1991	1979	38.97	125,000	5/1	30.69	22,600	4
		Pascagoula River Basin									
37	02471100	Leaf River near Raleigh	143	1856–1991	1856	--	[2]17,000	4/30	23.08	6,240	3
					1974	28.17	17,000				
38	02471250	Leaf River near Taylorsville	459	1856–1991	1856	--	[2]39,000	4/30	50.16	12,900	4
					1974	57.44	[5]37,600				
39	02471500	Oakohay Creek at Mize	185	1942–91	1974	17.26	28,900	4/30	13.39	7,400	3
40	02472000	Leaf River near Collins	743	1856–1991	1856	33.00	56,000	5/1	24.50	22,600	5
41	02472500	Bouie Creek near Hattiesburg	304	1900–91	1900	[2]33.50	[2]50,000	4/30	19.35	8,540	3
42	02473000	Leaf River at Hattiesburg	1,750	1900–91	1974	34.03	121,000	5/2	22.44	33,100	3
43	02473460	Tallahala Creek at Waldrup	102	1961–91	1974	23.18	17,900	4/30	19.92	7,080	4
44	02473500	Tallahala Creek at Laurel	238	1880–1991	1919	26.00	38,300	5/2	18.32	7,110	3
45	02474500	Tallahala Creek near Runnelstown	612	1885–1991	1900	[1]30.50	38,000	5/4	21.53	10,900	3
46	02474560	Leaf River near New Augusta	2,542	1900–91	1900	36.00	120,000	5/3	26.48	41,300	5
47	02475000	Leaf River near McLain	3,495	1900–91	1900	31.80	131,000	5/6	24.21	48,200	3
48	02475500	Chunky River near Chunky	369	1939–91	1979	26.64	40,900	4/30	22.66	15,700	5
49	02476500	Sowashee Creek at Meridian	49.0	1900–91	1936	26.50	--	4/29	8.90	4,250	4
					1964	[5]20.95	9,530				
50	02476600	Okatibee Creek at Arundel	342	1961, 1969–91	1990	22.65	[4]22,800	4/30	19.85	[4]10,100	5
51	02477000	Chickasawhay River at Enterprise	918	1871–1991	1961	37.94	61,700	5/1	34.31	25,100	4

Table 53. Maximum stages and discharges prior to and during floods of April and May 1991 in Mississippi—Continued

Site no. (fig. 63)	Station no.	Stream and place of determination	Drainage area (mi²)	Maximum prior to April 1991: Period	Year	Stage (ft)	Discharge (ft³/s)	Maximum during April and May 1991: Date (month/day)	Stage (ft)	Discharge (ft³/s)	Discharge recurrence interval (years)
				Mobile River Basin—Continued							
52	02477350	Chickasawhay River at Shubuta	1,458	1900–91	1900	47.90	90,000	5/5	33.50	--	--
53	02477500	Chickasawhay River near Waynesboro	1,650	1900–91	1900	50.30	[2]73,000	5/6	33.30	--	--
54	02478500	Chickasawhay River at Leakesville	2,690	1900–91	1900	38.00	125,000	5/8	28.32	30,800	3
55	02479000	Pascagoula River at Merrill	6,590	1852–1991	1900	32.50	230,000	5/7	24.72	81,100	3
56	02479155	Cypress Creek near Janice	52.6	1959–91	1959	32.06	[6]16,700	5/11	23.19	4,580	3
57	02479300	Red Creek at Vestry	441	1959–91	1987	21.48	28,000	5/12	16.23	8,770	2
58	02479560	Escatawpa River near Agricola	562	1974–91	1983	22.39	33,700	5/11	19.91	22,500	10
				Biloxi River Basin							
59	02481000	Biloxi River at Wortham	96.2	1916–91	1983	25.30	10,300	5/18	20.85	6,990	5
60	02481130	Biloxi River near Lyman	251	1957–91	1957	[2]21.50	[2]35,000	5/18	19.17	14,600	4
				Wolf River Basin							
61	02481510	Wolf River near Landon	308	1971–91	1983	21.53	18,400	5/18	22.63	12,600	4
				Pearl River Basin							
62	02481880	Pearl River at Burnside	520	1874–1991	1979	23.31	70,600	4/30	17.29	19,300	5
63	02482000	Pearl River at Edinburg	904	1874–1991	1979	30.06	77,900	5/1	26.29	25,900	10
64	02482550	Pearl River near Carthage	1,346	1874–1991	1979	28.74	102,000	5/2	24.48	32,900	10
65	02483000	Tuscolameta Creek at Walnut Grove	411	1874–1991	1950	[3]33.00	34,600	4/15	28.47	14,900	4
66	02484000	Yockanookany River near Kosciusko	303	1933, 1938–91	1979	23.06	40,700	5/28	17.80	14,300	5
67	02484500	Yockanookany River near Ofahoma	469	1938–91	1979	[1]23.27	46,500	5/2	23.48	13,200	5
68	02484600	Coffee Bogue near Ludlow	77.0	1971–91	1983	15.36	7,900	4/29	14.09	5,030	4
69	02484630	Pearl River at Coal Bluff near Ratliff	2,595	1979–91	1979	26.50	--	5/4	23.11	--	--
70	02485700	Hanging Moss Creek at Jackson	16.8	1953–91	1953	99.60	5,320	4/28	17.97	3,250	5
71	02486000	Pearl River at Jackson	3,171	1874–1991	1979	43.28	[4]128,000	5/4	35.12	[4]46,200	5
72	02487300	Strong River near Puckett	248	1950–91	1950	27.06	19,000	4/30	25.35	13,400	5
73	02487500	Strong River at D'Lo	425	1900, 1929–91	1983	33.48	26,400	5/1	29.17	14,000	5
74	02488000	Pearl River at Rockport	4,556	1874–1991	1979	42.83	[2]123,000	5/5	35.66	65,000	15
75	02488500	Pearl River near Monticello	4,993	1874–1991	1874	34.50	--	5/6	29.59	76,500	25
					1979	[5]34.08	122,000				
76	02488700	Whitesand Creek near Oak Vale	130	1966–91	1974	18.76	25,400	4/30	10.91	4,920	2

Table 53. Maximum stages and discharges prior to and during floods of April and May 1991 in Mississippi—Continued

Site no. (fig. 63)	Station no.	Stream and place of determination	Drainage area (mi²)	Maximum prior to April 1991: Period	Maximum prior to April 1991: Year	Maximum prior to April 1991: Stage (ft)	Maximum prior to April 1991: Discharge (ft³/s)	Maximum during April and May 1991: Date (month/day)	Maximum during April and May 1991: Stage (ft)	Maximum during April and May 1991: Discharge (ft³/s)	Maximum during April and May 1991: Discharge recurrence interval (years)
Pearl River Basin—Continued											
77	02489000	Pearl River near Columbia	5,720	1874–1991	1874	[2]31.00	165,000	5/6	24.55	--	--
78	02490500	Bogue Chitto near Tylertown	492	1936–91	1936	34.70	[5]49,000	4/30	21.52	18,200	3
					1983	[5]34.62	64,200				
79	02492360	West Hobolochitto Creek near McNeill	175	1966–91	1983	23.25	18,000	5/10	18.66	6,200	2
Tennessee River Basin											
80	03592718	Little Yellow Creek East near Burnsville	24.7	1973–91	1982	21.74	--	5/27	20.14	3,900	5
					1983	[5]19.83	5,180				
81	03592824	Tennessee-Tombigbee Waterway at Cross Roads	--	1980–91	1991	19.02	--	5/27	18.77	--	--
Yazoo River Basin											
82	07272000	Little Tallahatchie River (Sardis Lake) at Sardis Dam	1,545	1939–91	1973	[6]285.83	--	5/29	[6]285.5	--	100
83	07272500	Little Tallahatchie River at Sardis Dam (outlet)	1,545	1939–91	1973	[6]213.80	[4,8]11,900	5/29	[6]211.0	[4,8]10,400	---
84	07273100	Hotopha Creek near Batesville	35.1	1986–91	1991	16.83	10,400	5/28	14.52	7,320	---
85	07274000	Yocona River near Oxford	262	1947–91	1955	[1]23.72	44,100	4/29	27.33	17,900	5
86	07274252	Otoucalofa Creek Canal at Water Valley	97.1	1985–91	1990	17.11	17,500	5/1	20.10	--	--
87	07274500	Yocona River (Enid Lake) at Enid Dam	560	1951–91	1973	[6]271.17	--	5/1	[6]271.7	--	[7]70
88	07275000	Yocona River at Enid Dam (outlet)	560	1951–91	1951	[5,6]197.2	[4,8]6,060	5/1	[6]193.9	[4,8]5,200	--
					1952	[6]198.5	[4,8]4,440				
89	07275530	Peters (Long) Creek near Pope	79.2	1986–91	1990	19.86	26,500	4/28	19.08	20,200	---
90	07278000	Coldwater River (Arkabutla Lake) at Arkabutla Dam	1,000	1941–91	1973	[6]243.08	--	4/30	[6]244.0	--	[7]>100
91	07278500	Coldwater River at Arkabutla Dam (outlet)	1,000	1941–91	1973	[5,6]191.5	[4,8]10,200	4/30	[8]193.2	[2,5,8]13,500	--
					1984	[6]202.6	[4,5,8]5,150				
92	07282000	Yalobusha River at Calhoun City	305	1949–91	1982	25.75	[3]70,100	5/27	24.32	43,600	5
93	07283000	Skuna River at Bruce	254	1948–91	1955	[1]24.11	61,400	4/29	28.12	[4]26,800	4
94	07284500	Yalobusha River (Grenada Lake) at Grenada Dam	1,320	1953–91	1983	[6]236.3	--	5/29	[6]237.3	--	[7]100
95	07285000	Yalobusha River at Grenada Dam (outlet)	1,320	1953–91	1982	[6]181.4	--	5/1	[6]177.0	[4,5,8]10,500	--
					1983	[5,6]175.1	[4,8]9,000		[5,6]176.0	[4,8]11,500	
96	07285400	Batupan Bogue at Grenada	240	1985–91	1991	18.02	21,800	4/29	19.65	30,400	--

Table 53. Maximum stages and discharges prior to and during floods of April and May 1991 in Mississippi—Continued

Site no. (fig. 63)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to April 1991: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during April and May 1991: Date (month/day)	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Yazoo River Basin—Continued							
97	07285510	Yalobusha River at Grenada	1,570	1989–91	1991	26.87	[4]18,700	4/29	27.54	[4]23,000	--
98	07287355	Fannegusha Creek near Howard	107	1953–60, 1962–66, 1987–91	1955	[1]142.10	[2]20,000	4/29	21.27	20,800	25
99	07287400	Black Creek at Lexington	88.1	1987–91	1987	22.31	7,230	4/29	23.92	8,290	--
100	07287404	Harland Creek near Howard	62.1	1987–91	1987	21.36	7,440	4/29	22.08	5,920	--
				Big Black River Basin							
101	07289350	Big Black River at West	1,027	1892–1991	1983	26.08	71,200	4/30	24.39	49,400	15
102	07289600	Tilda Bogue near Canton	24.4	1948–91	1953	[5]19.00	8,800	4/29	18.27	3,200	3
					1983	19.44	--				
103	07290000	Big Black River at Bovina	2,812	1927–91	1983	40.77	92,300	5/5	39.21	56,200	15
104	07290005	Clear Creek near Bovina	32.0	1953, 1955–91	1969	30.03	21,000	4/29	26.00	7,350	3
105	07290650	Bayou Pierre near Willows	654	1959–91	1983	29.36	88,000	4/30	25.97	36,000	4
106	07290690	Clarks Creek near Pattison	75.0	1962–91	1980	27.90	31,000	4/29	20.05	10,500	3
107	07291000	Homochitto River at Eddiceton	181	1939–91	1974	[1]19.53	55,400	4/14	17.65	20,800	3
108	07291250	McCall Creek near Lucien	60.8	1953–91	1974	92.70	23,000	4/14	84.66	9,450	3
109	07292500	Homochitto River at Rosetta	787	1949–91	1949	37.80	--	4/15	19.32	[3]56,900	2
					1974	[5]28.60	150,000				

[1]Stage at different site and (or) datum. [2]Estimated
[3]Discharge affected by channelization. [4]Discharge affected by regulation or diversion.
[5]Less than maximum for period. [6]Stage is a maximum daily average.
[7]Based on stage-frequency values furnished by U.S. Army Corps of Engineers (oral commun., 1992). [8]Discharge is a maximum daily average.

Floods of May 10,1991, in Northwestern Nebraska and June 4–5, 1991, in East-Central Nebraska

By J.A. Boohar

Record flooding occurred on May 10, 1991, on the White River in Sioux and Dawes Counties, northwestern Nebraska (fig. 64). This area received almost 7 inches of rain accompanied by hail of as much as 5 inches in diameter (National Oceanic and Atmospheric Administration, 1991a, p. 142–143). The excessive rain resulted in flooding of the White River, with extensive damage to the town of Crawford and to Fort Robinson State Park. A stage of 16.32 feet was obtained from a high-water mark at the flood-determination site at Crawford (site 1). Discharge for this stage was based on the rating extended by slope-area, bridge-opening, and road-overflow measurements. The discharge was computed to be 13,300 cubic feet per second and established a new maximum for 56 years of record at this site. This discharge was calculated to be four times the discharge for a 100-year recurrence interval and was more than seven times greater than the previous maximum.

One fatality, a drowning, resulted from the flood. Damages to Crawford included the destruction of the town's water-collecting system, a new golf course, the State fish hatchery, a cattle sale barn, and a mobile-home park. Bridges and roads also were destroyed or damaged throughout the area. Total damages were estimated by the Civil Defense and Emergency Management agencies to be as much as $15 million, and Crawford was declared a disaster area by the Governor of Nebraska.

Flooding on June 4–5, 1991, in east-central Nebraska (fig. 64) resulted from 3 to 5 inches of rainfall. Floodwaters from the East Fork Maple Creek topped a 15-foot dike and flooded downtown Howells to a depth of 4 to 6 feet (National Oceanic and Atmospheric Administration, 1991b, p. 116). One man died when the walls of his basement collapsed. The library housed in the Community Center lost most of its 12,300 books. The flood-determination site on Maple Creek near Nickerson (site 2) recorded a stage of 16.10 feet. A discharge of 8,690 cubic feet per second was computed, which was calculated to have a 15-year recurrence interval. Damages were estimated by the Civil Defense and Emergency Management agencies to be about $28 million.

The maximum stage that occurred on June 5, 1991, at Pebble Creek at Scribner (site 3) located in Dodge County (fig. 64) was 24.15 feet, 0.25 foot higher than the record for this site established just the previous year. Discharge for this stage was 27,900 cubic feet per second, also exceeding the previous maximum, and was calculated to have a 100-year recurrence interval. Flooding also occurred along the Elkhorn River, and 11 miles of U.S. Highway 275 near Scribner was closed.

REFERENCES

National Oceanic and Atmospheric Administration, 1991a, Storm data and unusual weather phenomena with late reports and corrections, May 1991: Asheville, N.C., National Climatic Data Center, v. 33, no. 5, 260 p.

_____1991b, Storm data and unusual weather phenomena with late reports and corrections, June 1991: Asheville, N.C., National Climatic Data Center, v. 33, no. 6, 218 p.

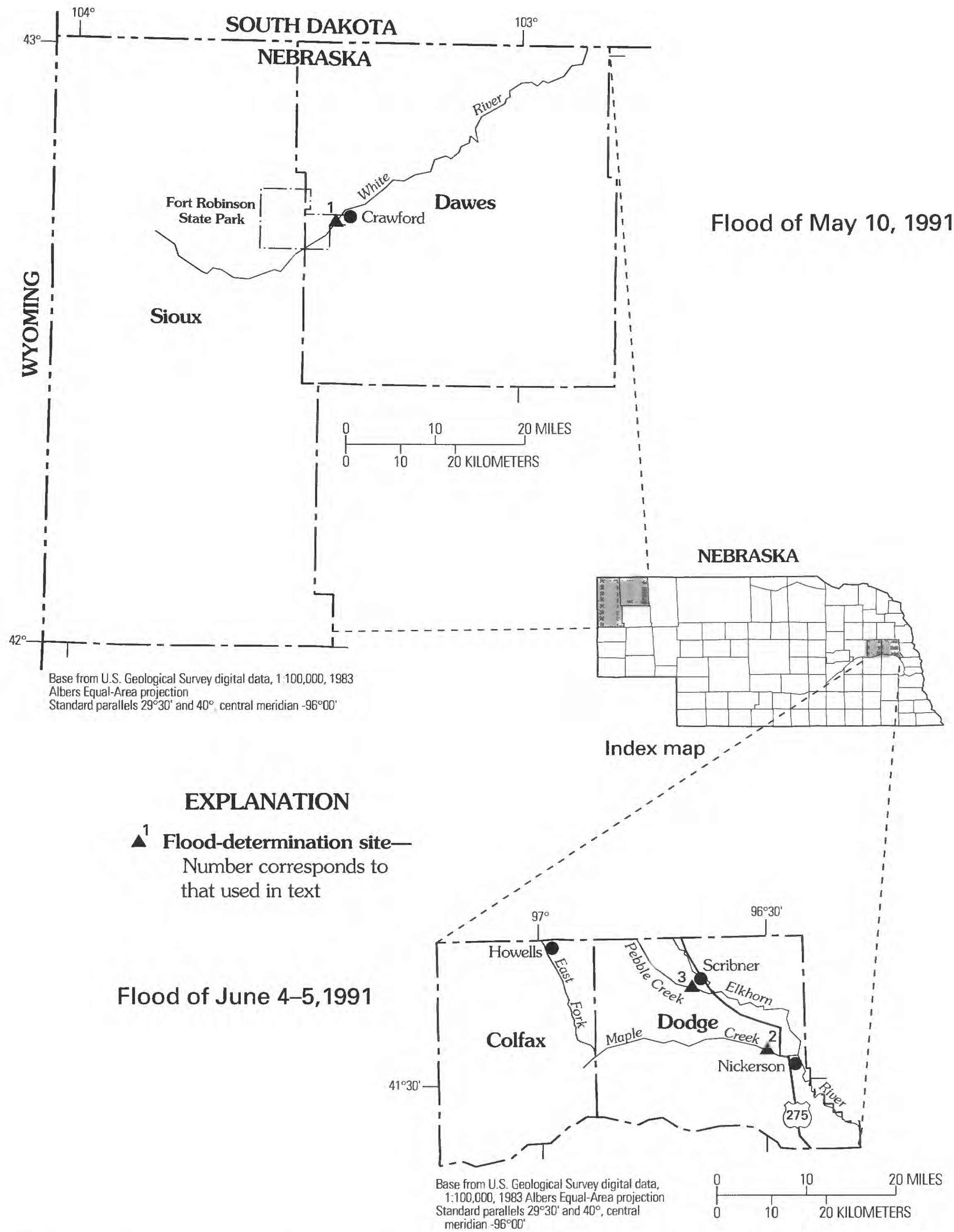


Figure 64. Location of flood-determination sites for floods of May 10 and June 4–5, 1991, in Nebraska.

Floods of June 1991 in Central Wyoming

By W.J. Sadler

Floods occurred on many streams in the Wind River Basin of central Wyoming during the first half of June 1991 (fig. 65). Rapid melting of mountain snowpack, in combination with rainfall and additional late-May and early-June snowfall in the Wind River Mountains, produced substantial runoff that lasted, in general, from June 2 through June 15. Damaging floods occurred intermittently in the Riverton area and on the Wind River Indian Reservation throughout the 2-week period.

In the Wind River watershed upstream of Boysen Reservoir, which encompasses most of the Wind River Basin, snowpack was 126 percent of average. Of particular note, snowpack in the Little Wind River drainage was 206 percent of average. Snowmelt runoff had already begun when a cool, wet period resulted in additional accumulation of wet snow in the mountains and rain at the lower elevations (tables 54 and 55). These conditions caused direct runoff in the already saturated lower elevations and accelerated snowmelt at middle elevations; some streams, mainly in the Lander and Fort Washakie area, experienced substantial floodflows on June 2–3 (table 56).

Intermittent rains continued through June 7 (tables 54 and 55), followed by a warming trend. The rains and warming trend accelerated high mountain snowmelt, and sustained high flows continued throughout the basin for the next several days. A warm, rainy period that began on June 13 (tables 54 and 55) caused rapid melting of the remaining snowpack in the mountains. Record or near-record floods occurred June 13 on many of the larger tributaries of the upper Wind River, the Wind River west of Riverton, and the North and South Forks of the Little Wind River near Fort Washakie (table 56).

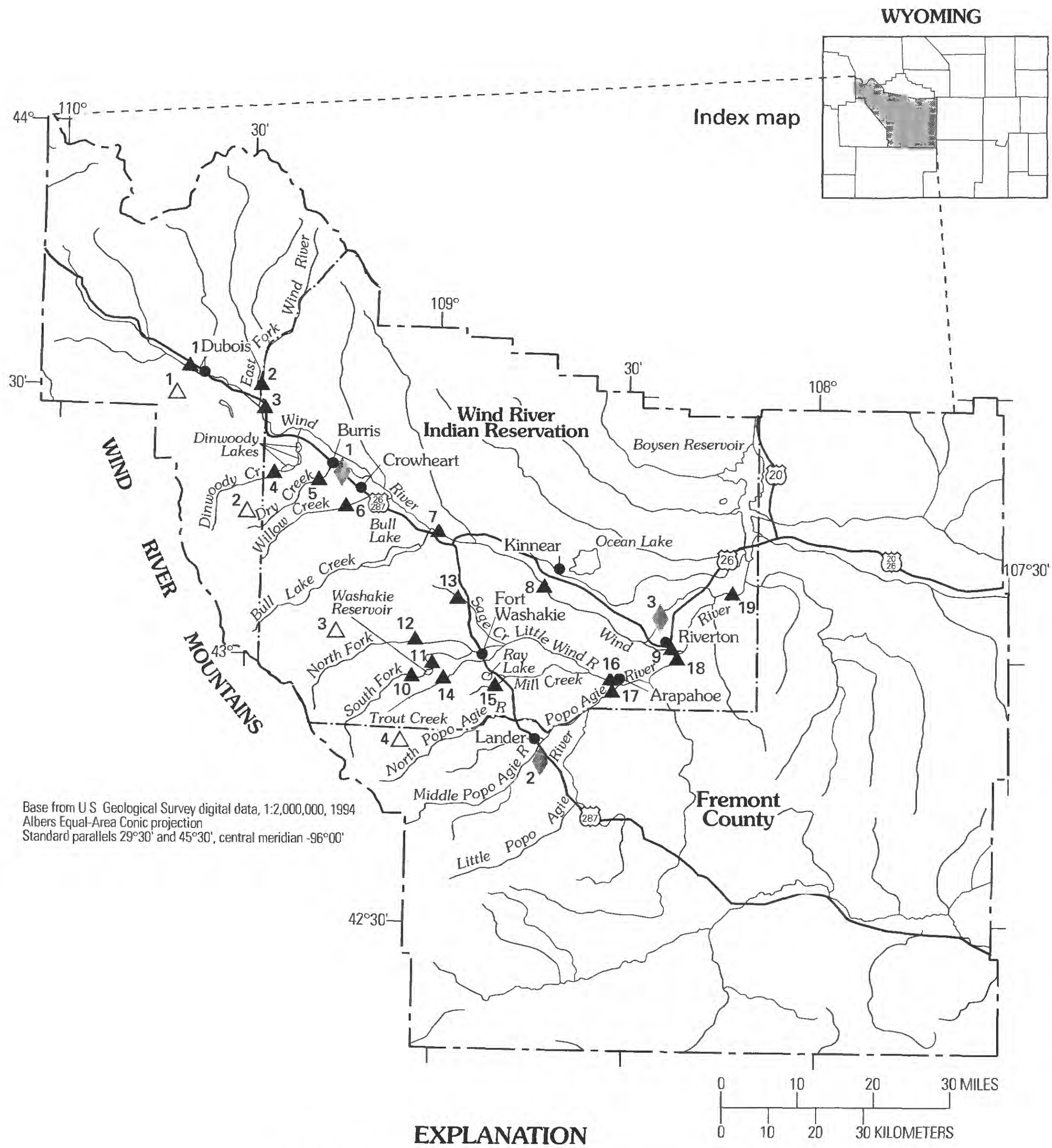
By June 14 and 15, the flood crest reached Riverton, and the area around the confluence of the Wind and Little Wind Rivers experienced perhaps the most severe flooding of the month. Record or near-record stages and discharges were recorded on the Wind River at Riverton (site 9), which reached record stage, the Little Wind River above Arapahoe (site 16), the Popo Agie River near Arapahoe (site 17), and the Little Wind River near Riverton (site 18). Near the downstream end of the basin, the Wind River above Boysen Reservoir (site 19) reached a maximum discharge of 18,700 cubic feet per second, and some flooding occurred in the area. Maximum stages and discharges for June 2–15, and comparisons with previous record maximums in the Wind River Basin, are shown in table 56. Recurrence intervals for maximum discharges were 10 to 25 years at several sites (table 56), and the recurrence interval was 40 years for the Wind River near Crowheart (site 7).

Damage estimates from Fremont County Emergency Management (Ken Lee, oral commun., 1993) for the floods near Riverton and on the Wind River Indian Reservation totalled $80,000, which included damage to public facilities and private property. In addition, 30 people required evacuation, approximately 1,000 man-hours were expended on sandbagging and related activities, and 100 emergency relief workers were on hand June 1–18.

REFERENCES

National Oceanic and Atmospheric Administration, 1991, Climatological data, Wyoming, June 1991: Asheville, N.C., National Climatic Data Center, v. 100, no. 6, 28 p.

U.S. Soil Conservation Service, 1991, Wyoming basins outlook report, June 1, 1991 and July 1, 1991: U.S. Department of Agriculture, 26 p.



EXPLANATION

▲17 **Flood-determination site**—Number corresponds to that in table 56

◆2 **Precipitation data site**—Number corresponds to that in table 55

△4 **Soil Conservation Service snow survey site**—Number corresponds to that in table 54

Figure 65. Location of flood-determination, precipitation data, and snow survey sites for floods of June 1991 in central Wyoming.

Table 54. Average May 1991 snowpack, last accumulation of snow, and total precipitation for May 31–June 15, 1991, at selected Soil Conservation Service snow survey sites in the Wind River Mountains, central Wyoming

[Source: Data from U.S. Soil Conservation Service, 1991]

Site no. (fig. 65)	Site name and elevation	Average May 1991 snowpack, in inches of water equivalence	Last additional snow accumulation: Date	Last additional snow accumulation: Amount, in inches of water equivalence	Total precipitation, in inches: May 31–June 8	Total precipitation, in inches: June 13–15
1	Little Warm Springs, 9,370 feet	9.7	May 28	0.2	1.0	0.5
2	Cold Springs 9,630 feet	5.5	June 1	1.1	2.0	.2
3	St. Lawrence Basin 8,960 feet	10.0	June 1	1.2	4.1	0
4	Hobbs Park 10,100 feet	21.1	May 28	.5	4.1	.3

Table 55. Precipitation, in inches, for May 31–June 7 and June 13 and 14, 1991, at selected precipitation data sites in the Wind River Basin, central Wyoming

[Source: National Oceanic and Atmospheric Administration, 1991]

Date	Precipitation data site (fig. 65): Site 1 Burris	Site 2 Lander	Site 3 Riverton
May 31	0.15	0.96	0.59
June 1	.20	.39	0
2	.01	.20	.55
3	.20	Trace	0
4	.07	Trace	0
5	.57	.06	.12
6	.07	Trace	.09
7	.06	Trace	.07
June 13	0	.05	0
14	.22	.01	.15
Totals for May 31–June 14	1.55	1.67	1.57

Table 56. Maximum stages and discharges prior to and during floods of June 1991 in central Wyoming

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined or not applicable. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

Site no. (fig. 65)	Station no.	Stream and place of determination	Drainage area (mi^2)	Maximum prior to June 1991: Period	Year	Stage (ft)	Discharge (ft^3/s)	Maximum during June 1991: Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
1	06218500	Wind River near Dubois	232	1945–91	1972	5.48	1,940	7, 13	5.11	1,440	4
2	06220500	East Fork Wind River near Dubois	427	1950–57, 1975–91	1954 1981	7.72 [1]7.69	-- 5,980	13	6.33	3,210	2
3	06220800	Wind River above Red Creek, near Dubois	1,073	--	--	--	--	13	6.60	4,900	--
4	06221400	Dinwoody Creek above lakes, near Burris	88.2	1957–77, 1988–91	1971 1977	4.57 [1]4.44	-- 1,450	13	4.03	913	2
5	06222500	Dry Creek near Burris	57	1921–40, 1988–91	1921	[2]3.9	1,400	13	5.59	931	10
6	06223500	Willow Creek near Crowheart	55.4	1909, 1921–23, 1925–40, 1988–91	1939	[2]5.40	1,100	12	5.15	802	20
7	06225500	Wind River near Crowheart[3]	1,891	1945–91	1963	9.16	13,000	13	11.04	14,300	40
8	06227600	Wind River near Kinnear[3]	2,194	1974–79	1974	7.23	8,540	13	8.03	13,900	--
9	06228000	Wind River at Riverton[3]	2,309	1906–08, 1911–91	1935	10.15	13,300	14	10.50	8,470	--
10	06228350	South Fork Little Wind River above Washakie Reservoir, near Ft. Washakie	90.3	1979–91	1981	8.21	2,080	13	8.48	2,230	20
11	06228450	South Fork Little Wind River below Washakie Reservoir, near Ft. Washakie[4]	93.5	1988–91	1989	4.39	879	13	6.43	2,120	--
12	06228800	North Fork Little Wind River near Ft. Washakie	112	1988–91	1989	4.14	744	13	6.20	2,360	--
13	06229680	Sage Creek above Norkok Meadows Creek, near Ft. Washakie	118	1990–91	1990	2.98	27	3	7.02	624	--
14	06229900	Trout Creek near Ft. Washakie	16.1	1961–68, 1970–84, 1990–91	1978	[2]5.56	470	2	7.49	500	25
15	06230190	Mill Creek above Ray Lake, near Ft. Washakie	15.8	1990–91	1990	2.30	33	3	4.20	426	--

Table 56. Maximum stages and discharges prior to and during floods of June 1991 in central Wyoming—Continued

				Maximum prior to June 1991				Maximum during June 1991			
Site no. (fig. 65)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
16	06231000	Little Wind River above Arapahoe[3]	660	1906–09, 1911–18, 1979–91	1911	[2]6.60	3,840	15	13.39	4,190	20
17	06233900	Popo Agie River near Arapahoe	796	1979–91	1983	9.93	4,240	3	9.91	4,600	15
18	06235500	Little Wind River near Riverton[3]	1,904	1941–91	1963	10.85	14,700	13	9.54	9,160	15
19	06236100	Wind River above Boysen Reservoir near Shoshoni[3]	4,390	1990–91	1990	5.94	5,010	14	9.31	18,700	--

[1]Less than maximum for period. [2]Site and datum then in use.
[3]Affected by diversions or storage upstream or both. [4]Regulated by reservoirs.

Flood of July 4–5, 1991, in and near Charlottesville, Virginia

By B.J. Prugh, Jr.

Moderate to severe flooding occurred on streams in the upper Rivanna and South Anna River Basins in the vicinity of Charlottesville, Virginia, on July 4–5, 1991. Major flooding was restricted to small tributaries of the Rivanna River and to the headwaters of the South Anna River in an area extending from west of Charlottesville to near Louisa (fig. 66).

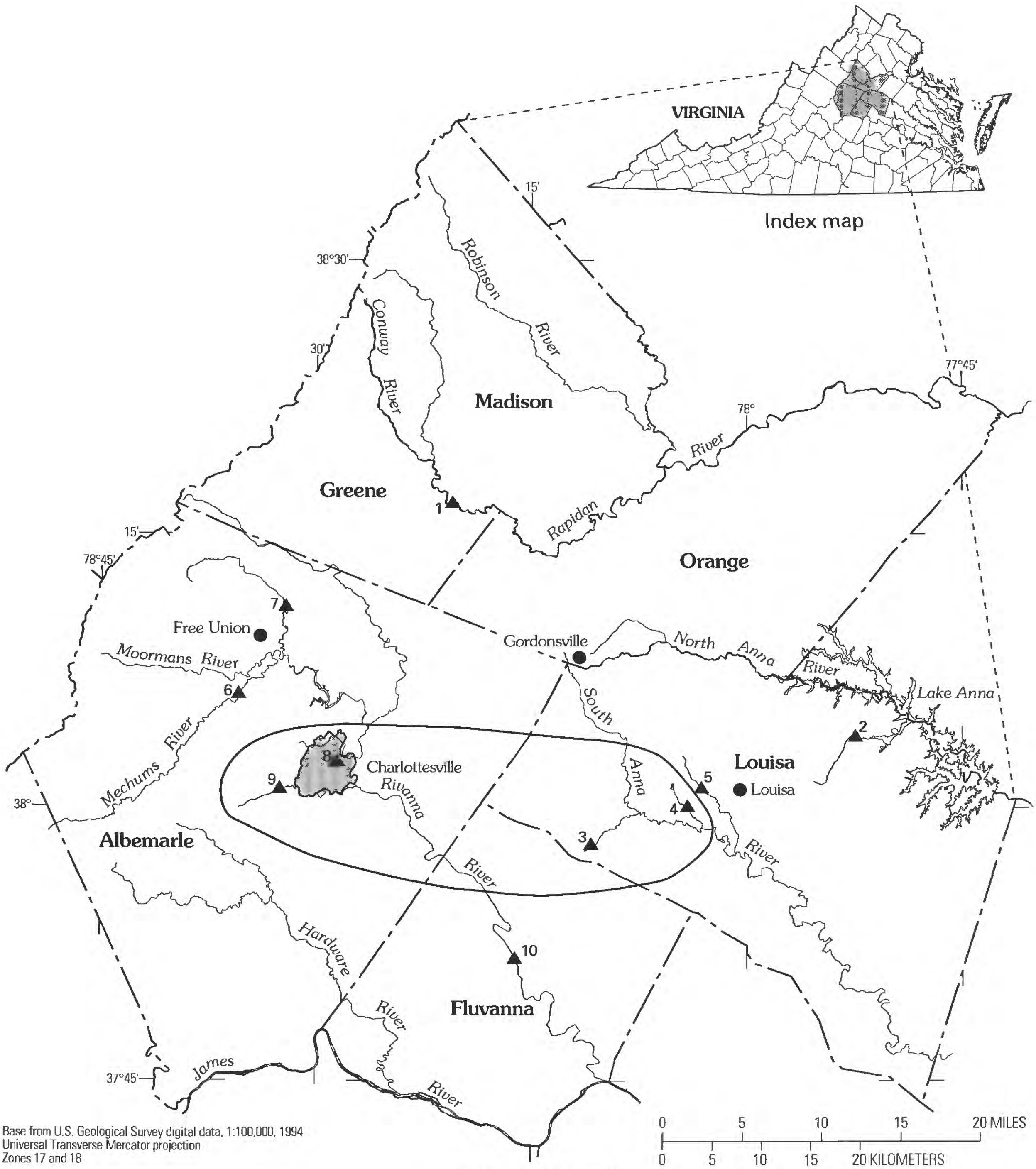
A new maximum stage and discharge for the period of record was recorded at Fosters Creek near Ferncliff (site 3). On other nearby streams, the flooding was less extreme than on Fosters Creek, but it was the largest on record since at least September 1987 (table 57).

The flooding was caused by runoff from precipitation associated with a complex weather system that developed over central Virginia in early July. A cold front moved into the State early in the month and became stationary. Precipitation associated with this front resulted in wet antecedent soil-moisture conditions that affected runoff from subsequent storms. Meanwhile, the remnants of Tropical Storm Anna were moving northeastward along the eastern seaboard and creating an intensified flow of moisture-laden air against the eastern slope of the Blue Ridge Mountains. This sequence of events culminated in total precipitation amounts for the July 2–5 period of 3 inches at Gordonsville, 4.9 inches at Louisa, 5.7 inches at Free Union, and 8.1 inches at Charlottesville (National Oceanic and Atmospheric Administration, 1991). Precipitation amounts decreased significantly away from the Charlottesville area. Just east of this area, Richmond, Virginia, and Washington, D.C., received less than 0.5 inch, while Fredericksburg, Virginia, recorded about 0.7 inch for the same period (National Oceanic and Atmospheric Administration, 1991).

The staggered and prolonged nature of the precipitation resulted in multiple maximum stages on area streams, with the largest occurring on July 4 and early July 5. In the Rivanna River Basin, both headwater streams (sites 6 and 7) and the lower basin main stem of the Rivanna River (site 10) had maximum discharges that were less than those for a 2-year recurrence interval (table 57). On smaller tributary streams to the Rivanna River in the vicinity of Charlottesville, the recurrence interval was about 20 years at flood-determination sites on Schenks Branch (an urbanized watershed, site 8) and Moores Creek (site 9). The largest recurrence intervals for the flooding were observed about 30 miles to the east in the headwaters of the South Anna River Basin where maximum discharges on Fosters Creek (site 3) and Waldrop Creek (site 4) had calculated recurrence intervals of 70 and 25 years, respectively.

REFERENCE

National Oceanic and Atmospheric Administration, 1991, Climatological data, Viriginia, July 1991: Asheville, N.C., National Climatic Data Center, v. 101, no. 7, 20 p.



EXPLANATION

——— **Approximate extent of 10-year recurrence-interval flooding on smaller streams**

▲10 **Flood-determination site**—Number corresponds to that in table 57

Figure 66. Location of flood-determination sites for flood of July 4–5, 1991, in and near Charlottesville, Virginia, and approximate extent of 10-year recurrence-interval flooding on smaller streams.

Table 57. Maximum stages and discharges prior to and during flood of July 4–5, 1991, in and near Charlottesville, Virginia

[mi2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; <, less than. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to July 1991				Maximum during July 1991			
Site no. (fig. 66)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Rappahook River Basin							
1	01665500	Rapidan River near Ruckersville	114	1942–91	1942	20.80	30,700	4	3.65	916	<2
				York River Basin							
2	01670300	Contrary Creek near Mineral	5.53	1976–91	1985	4.70	2,280	4	2.49	286	<2
3	01671615	Fosters Creek near Ferncliff	.61	1960–91	1969	10.55	1,000	4	10.60	1,020	70
4	01671650	Waldrop Creek near Louisa	2.85	1969–91	1969	21.00	2,500	4	15.40	1,440	25
5	01671750	Harris Creek near Trevilians	3.31	1969–91	1969	16.70	3,300	4	7.21	742	7
				James River Basin							
6	02031000	Mechums River near White Hall	95.4	1942–51, 1959, 1979–91	1942	[1]30.3	20,000	5	11.16	2,380	<2
7	02032400	Buck Mountain Creek near Free Union	37.0	1979–91	1979	11.12	6,600	4	3.05	273	<2
8	02032700	Schenks Branch at Charlottesville	1.34	1950–91	1987	12.54	1,670	4	8.48	1,050	20
9	02033300	Moores Creek near Charlottesville	3.52	1967–91	1979	18.74	(2)	4	16.92	2,270	20
10	02034000	Rivanna River at Palmyra	664	1934–91	1969	39.85	86,000	4	16.78	10,200	<2

[1]At different datum. [2]Not determined but known to be greater than 2,000 cubic feet per second.

Flood of July 21, 1991, at Stockton, Southeastern Minnesota

By G. H. Carlson

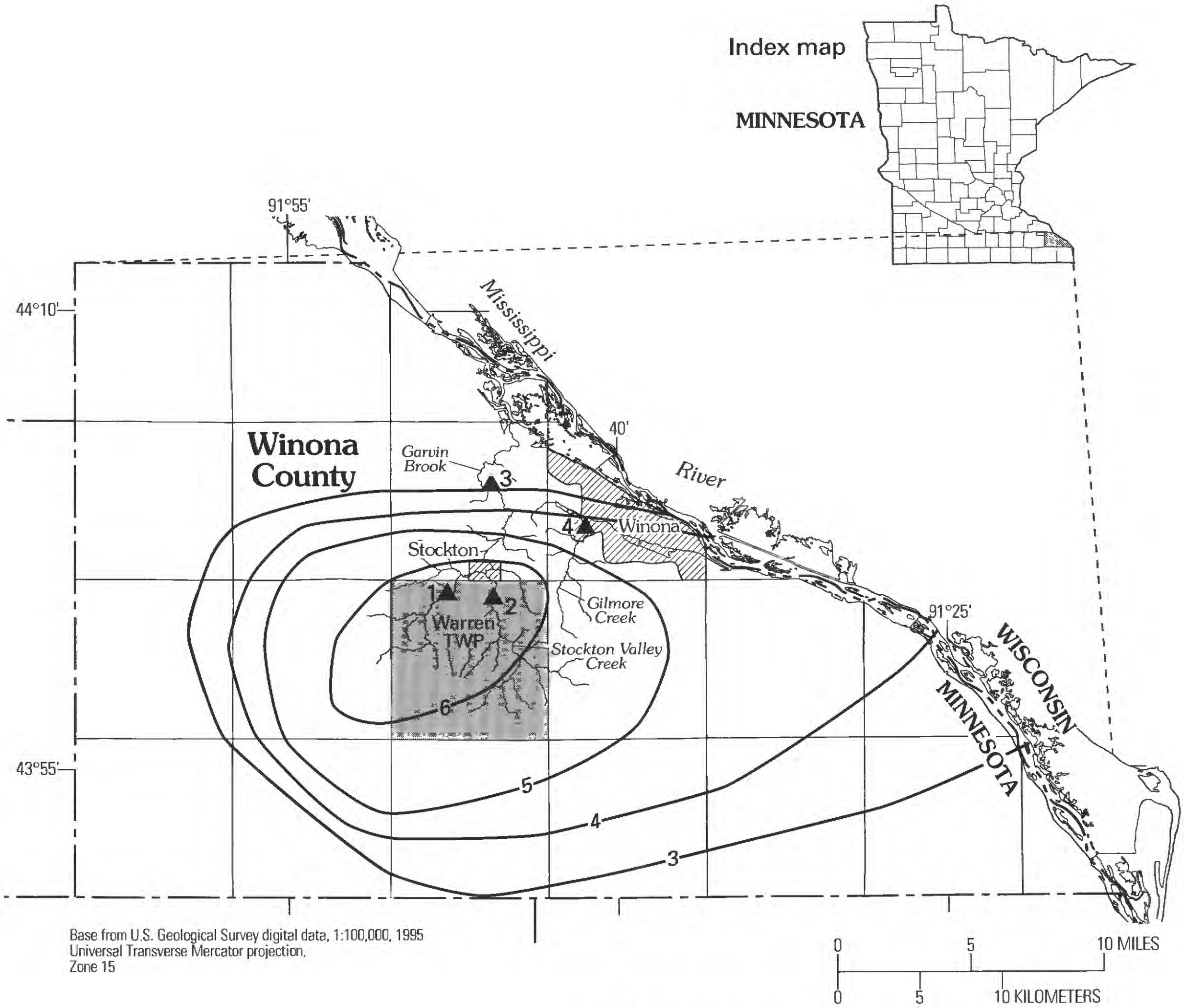
During the early evening hours of July 21, 1991, a thunderstorm with torrential rain caused extensive flooding in the small community of Stockton in southeastern Minnesota. Stockton is in Winona County about 4 miles southwest of the town of Winona (fig. 67). Unofficial reports indicate that the headwaters of Garvin Brook and the drainage area of Stockton Valley Creek, a major tributary of Garvin Brook, received 5.5 inches of rain between 6 and 7 p.m. (State Climatology Office, 1991), which is about 1.9 times the 100-year, 1-hour rainfall of 2.9 inches for that area (Hershfield, 1961, p. 35). Another thunderstorm between 2 and 4 a.m. on July 22 added 1.45 inches of rain, making the total 24-hour rainfall 6.95 inches (State Climatology Office, 1991). This exceeds the 6.1 inches for a 24-hour rainfall with a 100-year recurrence interval (Hershfield, 1961, p. 105). The largest rainfall amounts occurred in Warren Township in the Stockton Valley Creek area. The Gilmore Creek Basin, adjacent to Garvin Brook on the east, also had flooding.

The topography of the land near Stockton is steep, with deeply incised bedrock valleys carved in a plateau that has an elevation of about 1,240 feet above sea level. Although the slopes of the Garvin Brook and Stockton Valley Creek channels are 49 and 62 feet per mile, respectively, the slope of the valley walls that make up much of the land surface varies from a few hundred feet per mile to about 1,800 feet per mile. Differences in basin shape and the effects of roadway embankments along the valley of Garvin Brook may account for the large differences in maximum discharges generated from this storm by the two streams (table 58). The valley of Garvin Brook upstream from Stockton is long and narrow, with a narrow valley floor. A railroad and a trunk highway extend up the valley on separate embankments. Each embankment has several crossings over the stream and its tributaries. Restrictive openings through the embankments create small ponding areas that attenuate large floodflows. In contrast, the valley of Stockton Valley Creek is fan shaped and has a wide valley floor with no high embankments crossing the valley or other constrictions to impede the flow. At the flood-determination site on Stockton Valley Creek (site 2), a roadway crosses the valley on a low embankment that forms a weir 900 feet long. Flow approaching the roadway on July 21 was about 4 feet higher than the roadway for most of the valley width and was as much as 6.5 feet higher than the roadway at the low point in the road.

The small community of Stockton (population about 500) is situated on a flat area of the valley floor directly downstream of the confluence of Stockton Valley Creek and Garvin Brook. No one was killed or seriously injured, but virtually the entire town was inundated to depths of 5 feet or more by 10 p.m. on July 21. By 10:30 p.m., floodwaters had receded to below the level of the main highways through town, a decline of about 4 feet from the maximum stage. News reports indicated that two homes destroyed in the flood had floated off their foundations; one of them was carried across a street where it collided with another house (Doyle, 1991). The mayor of Stockton indicated this was the worst flood since 1951 (Doyle, 1991). Damages within Stockton resulting from this flood include 3 homes destroyed and 112 homes damaged, 20 of them extensively. When damage to businesses and sewer systems is included, total damage from this flood in Stockton was estimated at $1.5 million (Joseph Gibson, Minnesota Department of Natural Resources, oral commun., 1993).

There was severe damage to agricultural crops on the valley floor and to farm homes and farm machinery throughout the valley. Tall lush corn was flattened. Farm tractors and other heavy machines were submerged, while lighter machines and pickup trucks either floated or were rolled down the valley by the rushing floodwaters. Complete large trees eroded from creek banks were deposited in fields. The stage at Garvin Brook near Minnesota City (site 3), 4 miles downstream from Stockton, rose 17 feet, and the gage house at this site was carried away.

Maximum discharges (table 58) on Garvin Brook were determined by indirect measurement at former gaging stations on Garvin Brook near Minnesota City (site 3), and Garvin Brook at Stockton (site 1), a short distance upstream from the confluence with Stockton Valley Creek. The maximum discharge in Stockton



EXPLANATION

——3—— **Line of equal precipitation—** Interval 1 inch

▲4 **Flood-determination site—**Number corresponds to that in table 58

Figure 67. Location of flood-determination sites and lines of equal precipitation for flood of July 21, 1991, at Stockton, southeastern Minnesota (lines of equal precipitation modified from State Climatology Office, 1991).

Valley Creek was determined at a road crossing 1.3 miles upstream from its junction with Garvin Brook in Stockton (site 2).

Lengths of streamflow records for sites in the Garvin Brook Basin are too short to permit realistic estimates of the flood-frequency curves for these sites. Estimates using methods described in the most recent flood-frequency report for Minnesota (Jacques and Lorenz, 1988) indicate that the discharges having 100-year recurrence intervals are approximately 5,000 cubic feet per second for Stockton Valley Creek (site 2) and Garvin Brook at Stockton (site 1) and approximately 9,000 cubic feet per second for Garvin Brook near Minnesota City (site 3). On that basis, the recurrence interval of the July 21 flood in the Garvin Brook Basin is estimated at more than 100 years throughout the basin. Gilmore Creek was less affected by large rainfall amounts (fig. 67), and this stream's maximum discharge had an estimated 50-year recurrence interval (table 58).

Table 58. Maximum stages and discharges prior to and during flood of July 21, 1991, at Stockton, southeastern Minnesota

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; >, greater than; --, not determined or not applicable. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to July 1991				Maximum during July 1991			
Site no. (fig. 67)	Station no.	Stream	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Day	Stage (ft)	Dis-charge (ft^3/s)	Discharge recurrence interval (years)
					Garvin Brook Basin						
1	05378220	Garvin Brook at Stockton	14.4	1982–83	1983	4.15	168	21	12.58	11,000	>100
2	05378230	Stockton Valley Creek at Stockton	19.4	1982–85	1985	7.69	731	21	--	42,300	>100
3	05378235	Garvin Brook near Minnesota City	45.2	1982–91	1986	6.63	1,580	21	17.79	11,200	>100
					Gilmore Creek Basin						
4	05379000	Gilmore Creek at Winona	8.95	1940–65	1951	9.47	5,360	21	8.74	4,400	50

REFERENCES

Doyle, Pat, July 23, 1991, Flash flood ravages Stockton: Minneapolis Star Tribune, v. X, no. 110, p. 1B.

Hershfield, D.M., 1961, Rainfall frequency atlas of the United States: U.S. Department of Commerce, Weather Bureau, Technical Paper 40, 115 p.

Jacques, J.E., and Lorenz, D.L., 1988, Techniques for estimating the magnitude and frequency of floods in Minnesota: U.S. Geological Survey Water-Resources Investigations Report 87–4170, 48 p.

State Climatology Office, 1991, Flash floods in southeastern Minnesota July 21, 1991: Minnesota Department of Natural Resources, Division of Waters, 1 p.

Floods of July and August 1991 in South-Central North Carolina

By Thomas J. Zembrzuski, Jr.

Waves of intermittent, but locally intense, thunderstorms moved slowly across North Carolina's south-central coastal plain during late July and early August 1991, producing from 5 to 11 inches of rain in Duplin, Greene, Johnston, Lenoir, Sampson, Wayne, and Wilson Counties. Individual storms occurred almost daily and caused flash floods in several small streams in the Neuse and lower Cape Fear River Basins (fig. 68). The floods overtopped dozens of roads, damaged or destroyed several bridges, culverts, and small dams, forced the evacuation of residents in low-lying areas, and inundated hundreds of acres of cropland. Even after the storms ended on August 3, floodwaters continued to rise in the lower reaches of the Neuse River and in some of the larger tributaries of the Neuse and Cape Fear Rivers.

Most of the rain fell during 9 days beginning July 26. Rainfall amounts were quite variable throughout the seven counties, but most of the area received at least 5 inches of rain during the period. The largest rainfall amounts totaled 11.22 inches in Goldsboro, 9.67 inches in Clinton, and 7.80 inches in Wilson (National Oceanic and Atmospheric Administration, 1991a,b).

During the rainy period, different locales experienced flood problems almost daily. On July 27, a storm over Goldsboro produced more than 4.5 inches of rain in 3 hours, resulting in extensive flooding of urban streets and small streams. During July 29–31, more than 6 inches of rain fell in parts of Johnston and Wilson Counties. In addition to urban flooding in the town of Wilson, hundreds of acres of cropland were inundated, and 32 rural secondary roads were inundated or washed out along Little River, Contentnea Creek, and their tributaries. The period's last and most intense storms affected Sampson County during July 30–31, when nearly 8 inches of rain fell at Clinton. The resulting floods washed out or inundated 21 secondary roads in Sampson County and closed a 10-mile stretch of Interstate 40 for 13 hours. Four homes were flooded, and eight were evacuated after a small dam failed on a tributary to Six Runs Creek near Clinton (National Oceanic and Atmospheric Administration, 1991c).

Most of the smaller streams had crested by August 1 (table 59). As the floodwaters from these streams slowly drained into larger ones, water levels continued to rise for several days on the larger streams. The Neuse River, Contentnea Creek, Black River, and Northeast Cape Fear River did not crest until several days after the last storms. The Neuse River was above flood stage at Goldsboro from July 31 to August 5 and at Kinston from August 3 to 8 (Barker and others, 1992).

In spite of rather large rainfall amounts recorded at some precipitation data sites, severe flooding was not widespread. The highly variable and protracted nature of the thunderstorm period generally limited the magnitude and extent of flooding. Most flood-determination sites in the seven-county area recorded maximum discharges less than the discharge for a 5-year recurrence interval (Gunter and others, 1987). An exception was at flood-determination site 13 on Six Runs Creek at Clinton, where a maximum discharge of 9,100 cubic feet per second was determined. The recurrence interval of this discharge exceeded 100 years, but the discharge may have been augmented by the release of ponded floodwaters after the failure of a small dam.

REFERENCES

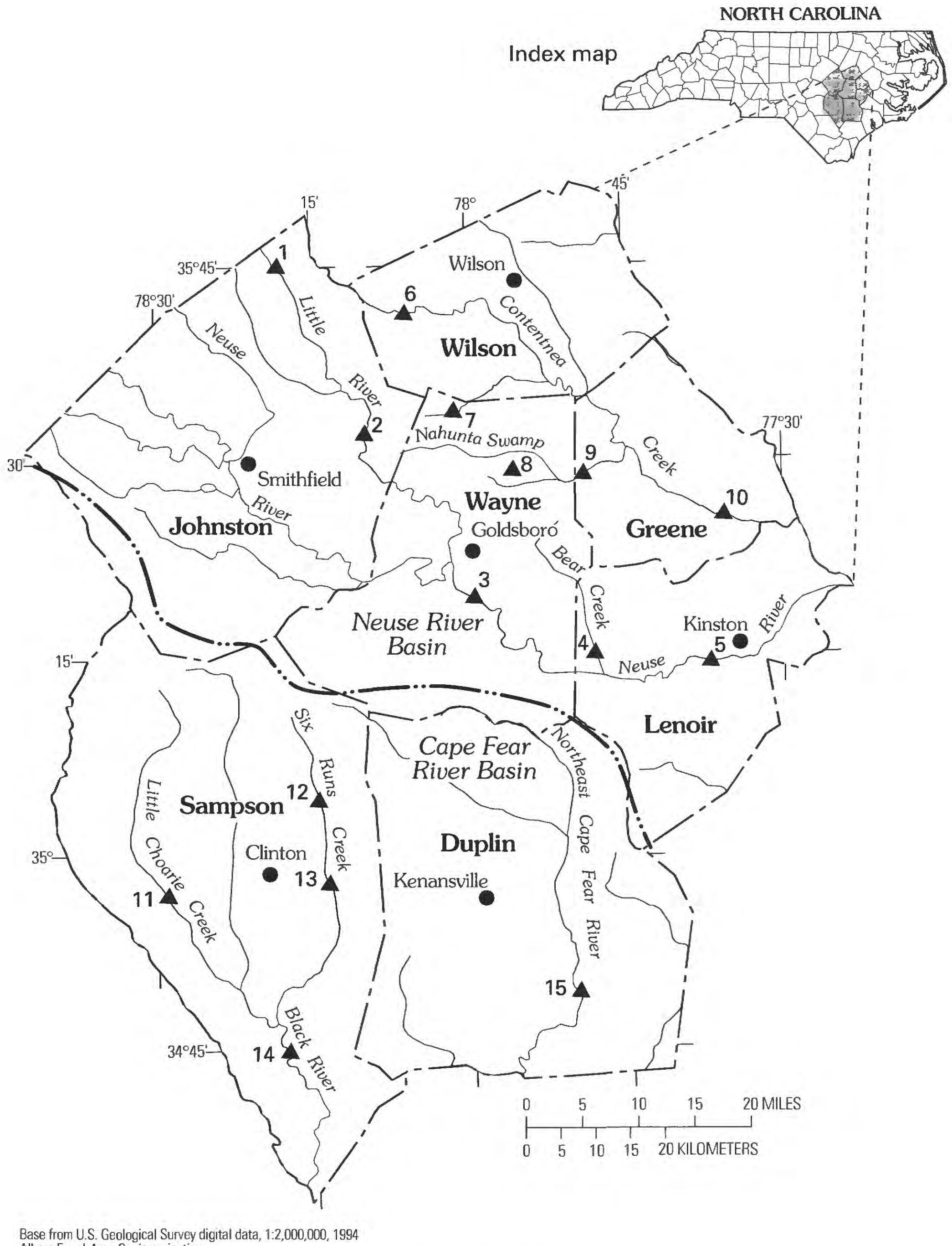
Barker, R.G., Ragland, B.C., Rinehardt, J.F., and Eddins, W.H., 1992, Water resources data for North Carolina, water year 1991: U.S. Geological Survey Water-Data Report NC–91–1, 349 p.

Gunter, H.C., Mason, R.R., and Stamey, T.C., 1987, Magnitude and frequency of floods in rural and urban basins of North Carolina: U.S. Geological Survey Water-Resources Investigations Report 87–4096, 52 p.

National Oceanic and Atmospheric Administration, 1991a, Climatological data, North Carolina, July 1991: Asheville, N.C., National Climatic Data Center, v. 96, no. 7, 36 p.

_____1991b, Climatological data, North Carolina, August 1991: Asheville, N.C., National Climatic Data Center, v. 96, no. 8, 32 p.

_____1991c, Storm data and unusual weather phenomena with late reports and corrections, July 1991: Asheville, N.C., National Climatic Data Center, v. 33, no. 7, 191 p.



Base from U.S. Geological Survey digital data, 1:2,000,000, 1994
Albers Equal-Area Conic projection
Standard parallels 29°30' and 45°30', central meridian -96°00'

EXPLANATION

Basin boundary

Flood-determination site—Number corresponds to that in table 59

Figure 68. Location of flood-determination sites for floods of July and August 1991 in south-central North Carolina.

Table 59. Maximum stages and discharges prior to and during floods of July and August 1991 in south-central North Carolina

[mi², square miles; ft, feet above an arbitrary datum; ft³/s, cubic feet per second; --, not determined or not applicable; <, less than; >, greater than. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to July 1991				Maximum during July and August 1991			
Site no. (fig. 68)	Permanent station no.	Stream and place of determination	Drainage area (mi²)	Period	Year	Stage (ft)	Discharge (ft³/s)	Date (month/day)	Stage (ft)	Discharge (ft³/s)	Discharge recurrence interval (years)
				Neuse River Basin							
1	02088470	Little River near Kenly	191	1964–89	1964	16.30	5,030	8/1	14.40	2,110	3
2	02088500	Little River near Princeton	232	1930–91	1964	13.94	7,150	8/1	11.83	2,860	3
3	02089000	Neuse River near Goldsboro	2,399	[1]1929–91	1929	27.3	38,600	8/3	17.43	8,760	--
4	02089252	Bear Creek near May's Store	57.7	1988–91	1990	9.25	1,220	7/31	6.22	322	<2
5	02089500	Neuse River at Kinston	2,692	[1]1919 1929–91	1919	25.0	39,000	8/6	15.09	8,530	--
6	02090380	Contentnea Creek near Lucama	161	1964–91	1964	16.28	5,860	7/30	13.10	2,920	4
7	0209058290	Great Swamp near Pinkney	9.46	--	--	--	--	7/31	--	490	4
8	0209096970	Moccasin Run near Patetown	1.89	1988–91	1989	4.23	79	8/3	4.00	82	<2
9	02091000	Nahunta Swamp near Shine	80.4	1954–91	1964	14.14	5,470	8/3	9.24	943	<2
10	02091500	Contentnea Creek at Hookerton	733	1929–91	1964	22.11	17,200	8/5	14.49	5,330	4
				Cape Fear River Basin							
11	02106000	Little Coharie Creek near Roseboro	92.8	1950–91	1964 1984	-- 10.34	3,400 --	8/1	9.01	1,750	4
12	02106087	Six Runs Creek at Hargroves	28.9	--	--	--	--	7/30	--	1,000	5
13	0210636025	Six Runs Creek at Clinton	115	--	--	--	--	7/30	--	[2]9,100	>100
14	02106500	Black River near Tomahawk	676	1952–91	1984	22.08	17,500	8/4	18.84	7,160	7
15	02108000	Northeast Cape Fear River at Chinquapin	599	1940–91	1962	20.16	20,400	8/4	13.01	4,520	2

[1]Flow regulated by Falls Lake (about 18 miles northwest of western boundary of area shown in figure 68) since December 1983. [2]Affected by dam failure.

Flood of September 1991 in the Crow River Basin, South-Central Minnesota

By G.H. Carlson

Excessive rains, mostly between 2 and 10 p.m. on September 7, 1991, and totaling more than 6 inches (State Climatology Office, 1991a), resulted in flooding along Buffalo Creek at Glencoe and on other tributaries to the South Fork Crow River in south-central Minnesota. Another storm during the evening of September 8 added 2 inches or more of rain to the already saturated area (State Climatology Office, 1991a). Additional rains of from 1 to 2 inches during September 10–16 (State Climatology Office, 1991b) aggravated agricultural losses by prolonging the time fields remained flooded.

The largest rainfall amounts on September 7 occurred along a line from near Hector to Glencoe and from near Paynesville in Stearns County toward the northwest (fig. 69). Rainfall amounts exceeding the 7 inches shown in figure 69 included 11.00 inches in the Buffalo Creek Basin just west of Glencoe. Other amounts exceeding 7 inches in the Buffalo Creek Basin included 9.50 inches at Glencoe and 8.21 inches in northwestern Sibley County (State Climatology Office, 1991b). The 100-year, 12-hour rainfall is about 5 inches for that area (Huff and Angel, 1992, p. 83). Thus, the area of greatest rainfall received about twice the 100-year, 12-hour rainfall amount in about 8 hours during the afternoon and evening of September 7. The area around Hector and Glencoe that received 6 inches or more of rain during the first storm consisted of about 12 townships (about 430 square miles). The area is gently rolling farmland having numerous depressions and many small lakes and marshes. Maximum discharges occurred in small drainage areas shortly after the intense rain of September 7 (table 60). On larger streams, however, the discharge continued to increase for several days. In Crow River at Rockford (site 8), the flow continued to increase for 9 days, reaching a maximum on September 17.

In the area of greatest rainfall, maximum discharges in the smaller basins, including sites 2 and 5 (fig. 69 and table 60), exceeded those of 100-year recurrence intervals, as estimated by techniques described by Jacques and Lorenz (1988). Maximum discharges were the largest of record at sites 2, 5, and 6 (table 60). In Glencoe, flooding along Buffalo Creek threatened several buildings, and a sandbag dike was hastily constructed to protect them. The rising floodwaters reached maximum stage near the base of the dike about the time the dike was completed, and the buildings were not damaged. Damage to crops was extensive, however, because many acres of cropland include depressions or are adjacent to small lakes and wetlands that flooded far beyond their normal boundaries. Several weeks were required for the water to drain from some fields. As a result, many acres of corn and soybeans were ruined by prolonged submergence. No dollar estimate of damage was compiled for this flood.

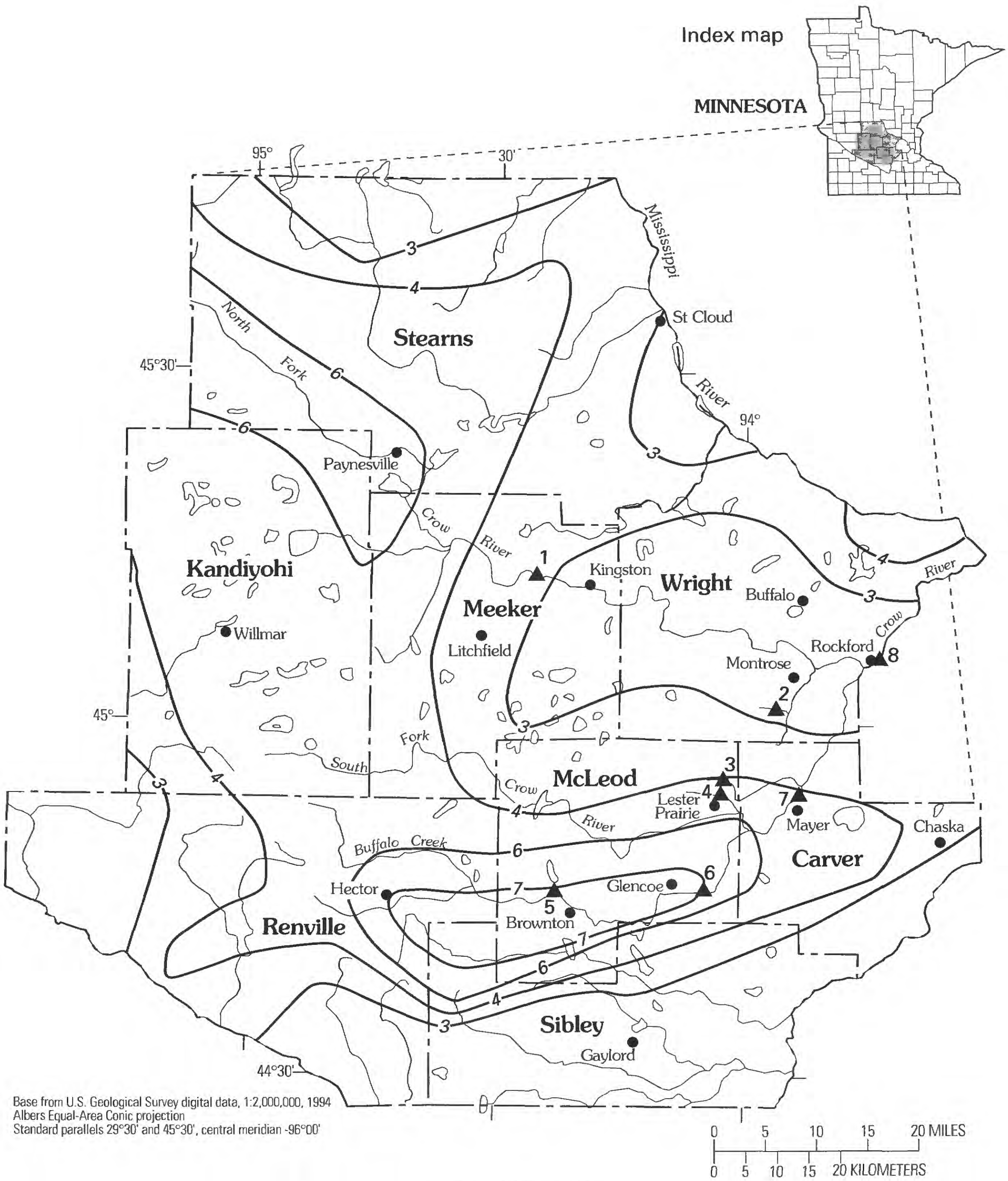
REFERENCES

Huff, F.A., and Angel, J.R., 1992, Rainfall frequency atlas of the Midwest: Illinois State Water Survey Bulletin 71, 141 p.

Jacques, J.E., and Lorenz, D.L., 1988, Techniques for estimating magnitude and frequency of floods in Minnesota: U.S. Geological Survey Water-Resources Investigations Report 87–4170, 48 p.

State Climatology Office, 1991a, Flash flood on September 7, 1991: Minnesota Department of Natural Resources, Division of Waters, 1 p.

_____1991b, Weekly precipitation map, September 10–September 16, 1991 (as of 8 a.m.): Minnesota Department of Natural Resources, Division of Waters, 1 p.



EXPLANATION

—3— **Line of equal precipitation**—Interval, in inches, variable

▲4 **Flood-determination site**—Number corresponds to that in table 60

Figure 69. *Location of flood-determination sites and lines of equal precipitation for flood of September 1991 in Crow River Basin, south-central Minnesota (lines of equal precipitation modified from State Climatology Office, 1991a,b).*

Table 60. Maximum stages and discharges prior to and during flood of September 1991 in the Crow River Basin, south-central Minnesota

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined or not applicable. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to September 1991				Maximum during September 1991			
Site no. (fig. 69)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Dis-charge (ft^3/s)	Day	Stage (ft)	Dis-charge (ft^3/s)	Discharge recur-rence interval (years)
1	05278120	North Fork Crow River near Kingston	--	1985–91	1986	17.82	4,850	16	15.70	2,750	--
2	05278350	Fountain Creek near Montrose	6.73	1962–85	1978	7.91	132	7	9.15	202	>100
3	05278700	Otter Creek near Lester Prairie	30.2	1961–89	1965	9.24	525	10	7.21	162	3
4	05278750	Otter Creek tributary near Lester Prairie	1.54	1962–86	1965	11.14	87	8	10.39	58	11
5	05278850	Buffalo Creek tributary near Brownton	9.45	1961–87	1965	17.39	124	8	16.84	175	>100
6	05278930	Buffalo Creek near Glencoe	374	1973–80	1979	9.75	2,590	12	11.78	4,300	18
7	05279000	South Fork Crow River near Mayer	1,170	1934–84, 1986–91	1965	19.23	16,100	13	15.37	6,760	11
8	05280000	Crow River at Rockford	2,520	1909–17, 1929–91	1965	19.27	22,400	17	12.26	8,740	8

Floods of October 31, 1991, on Kodiak Island, Alaska

By Bruce B. Bigelow

On October 31, 1991, Kodiak Island, Alaska, received a record 7.44 inches of rain. According to the National Oceanic and Atmospheric Administration (Arthur Armour, oral commun., 1994), Kodiak's previous maximum 24-hour rainfall was 4.53 inches, on February 25, 1947. The large quantity of precipitation on October 31 resulted in saturated and unstable soils, with subsequent slumping and landslides in the city of Kodiak. Mudslides destroyed at least two homes and damaged several others. At least 50 homes were evacuated. Flooding on the Buskin River and its tributaries caused washouts that closed the highway between the city of Kodiak and Kodiak Airport. People arriving and departing Kodiak from the airport had to be ferried across the river either by the U.S. Coast Guard or by local fishermen. On November 2, 1991, Alaska Governor Walter J. Hickel declared Kodiak a disaster area. No lives were lost, but damage to city streets, power, sewer and water lines, and other public facilities was estimated at $5 million. Damage to private property was not estimated.

Myrtle Creek (site 1, fig. 70, table 61), the closest gaged stream to Kodiak, is about 13 miles south of the city. The gaging station has operated since 1963. The maximum discharge on October 31 was 970 cubic feet per second, which has only a 5-year recurrence interval. However, because of the damage involved, indirect measurements were made at two ungaged sites. A measurement was made on the Buskin River at Bridge No. 6 (site 2), which is 2.0 miles upstream from the mouth and was 0.6 mile upstream from a road washout. About 1 square mile of drainage area is gained between the measurement site and the point that was washed out. An indirect measurement of maximum discharge also was made on Devils Creek near its mouth (site 3). Devils Creek is a tributary to the Buskin River about 1 mile upstream from its mouth. The measurement site was just above a point where a culvert had failed under an airport access road. In addition to flooding at these two locations, damage also was caused by mudslides in the residential areas, primarily on the steep hillsides northwest of the city of Kodiak (fig. 70).

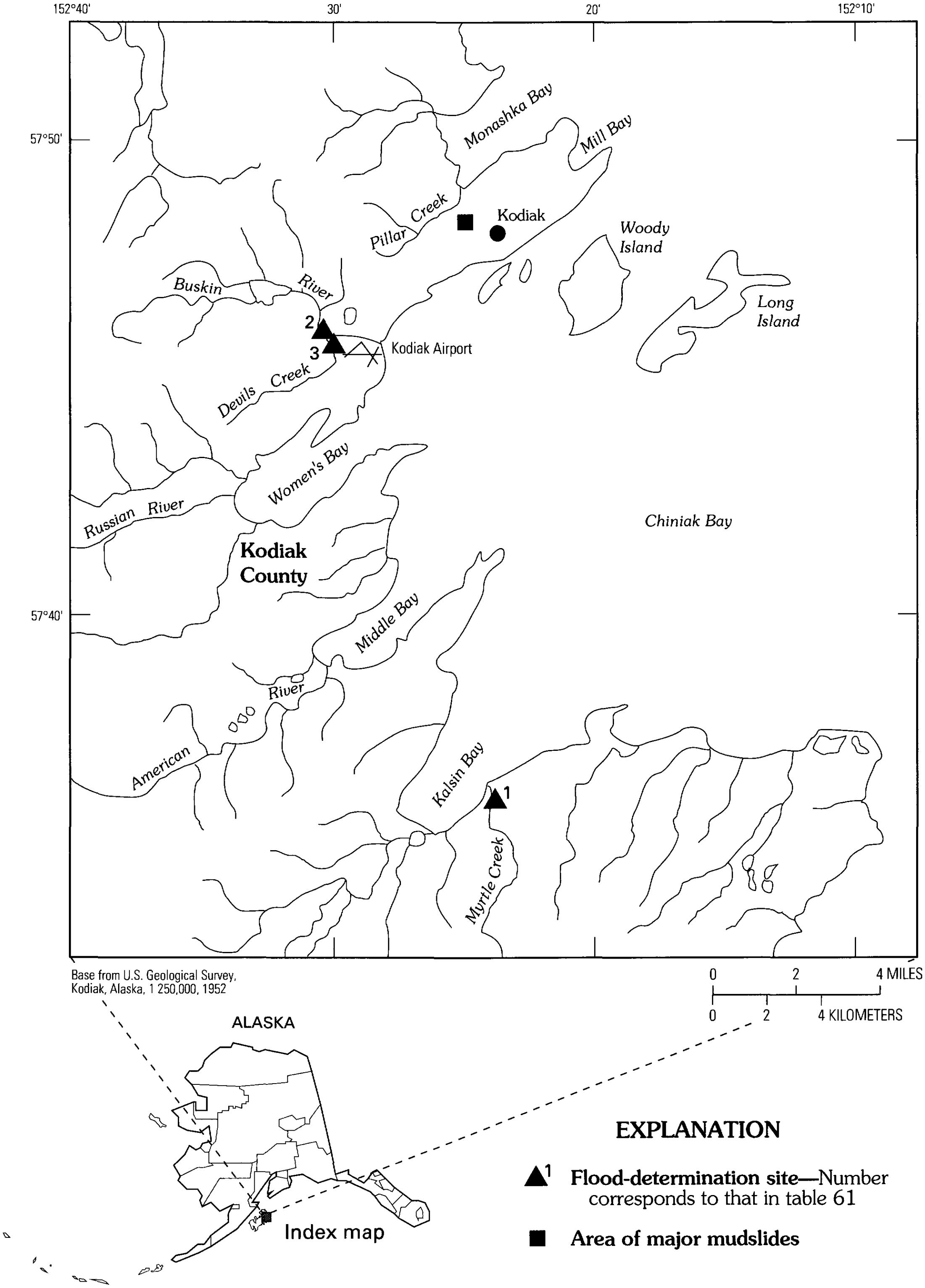


Figure 70. Location of flood-determination sites and areas of mudslides for floods of October 31, 1991, on Kodiak Island, Alaska.

Table 61. Maximum stages and discharges prior to and during floods of October 31, 1991, on Kodiak Island, Alaska

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined or not applicable. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to October 1991				Maximum during October 1991			
Site no. (fig. 70)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
1	15297200	Myrtle Creek near Kodiak	4.74	1963–91	1977	6.93	1,350	31	5.87	970	5
2	--	Buskin River at Bridge No. 6 near Kodiak	[1]18.2	--	--	--	--	31	--	[2]3,510	--
3	--	Devils Creek below runway near mouth near Kodiak	4.04	--	--	--	--	31	--	[2]840	--

[1]Approximate.
[2]Indirect measurement of maximum discharge.

Flood of December 1–5, 1991, in Northeastern Mississippi

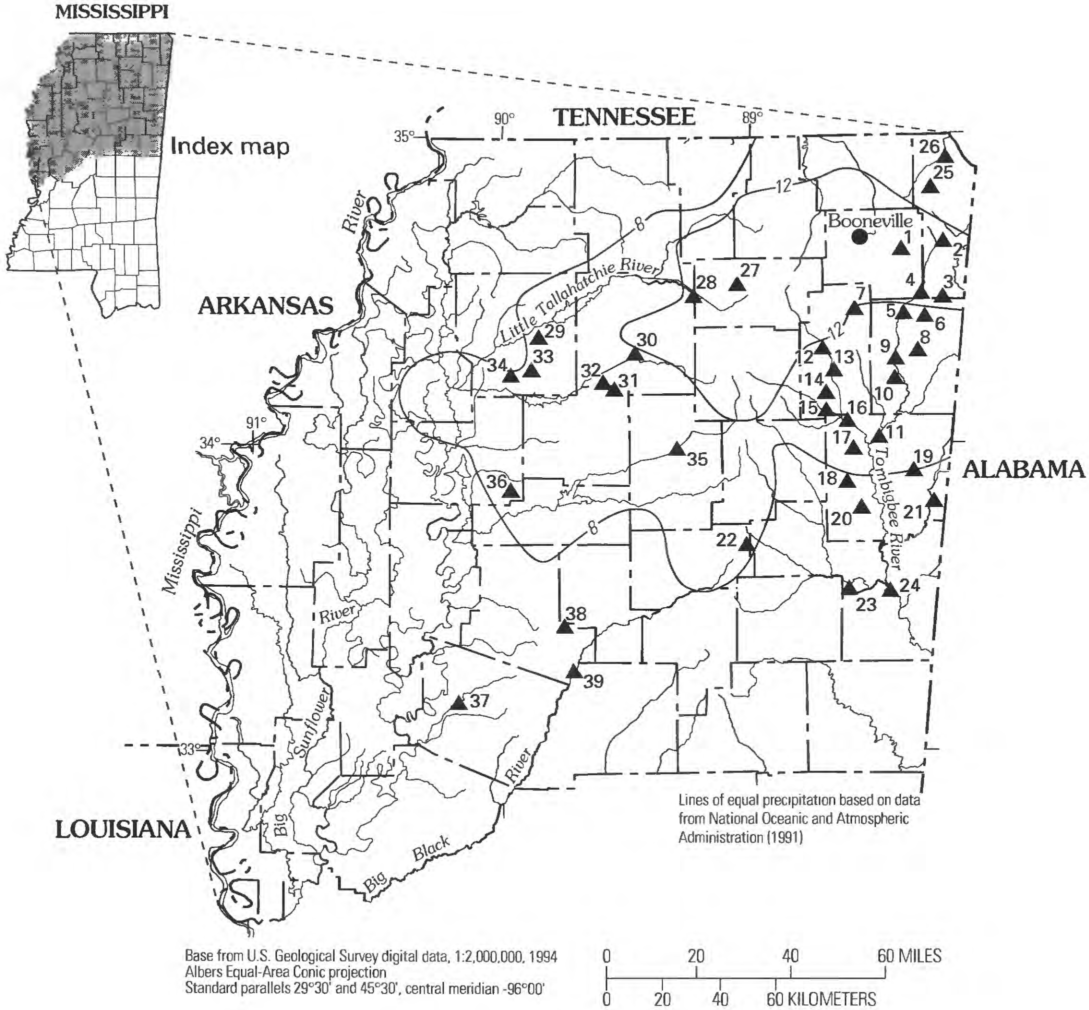
By W. Trent Baldwin

Northeastern Mississippi experienced flooding as a result of rainfall from November 30 through December 2, 1991. According to the National Oceanic and Atmospheric Administration (1992), rainfall in excess of 8 inches fell across the area (fig. 71). The largest amount of rainfall during the 3-day period was 15.8 inches at Booneville.

Maximum stages and discharges at 39 sites (fig. 71) are summarized in table 62. Maximum discharges equaled or exceeded the discharges for a 10-year recurrence interval at 15 of the sites. On the Little Tallahatchie River at Etta (site 28), the flood crested within 0.03 foot of the highest measured in 55 years. Damage from the flood was minor and limited mainly to low-lying roads and bridges.

REFERENCE

National Oceanic and Atmospheric Administration, 1992, Climatological data, Mississippi, December 1991: Asheville, N.C., National Climatic Data Center, v. 96, no. 12, 27 p.



EXPLANATION

—8— **Line of equal precipitation**—Interval 4 inches (minimum shown is 8 inches)

▲38 **Flood-determination site**—Number corresponds to that in table 62

Figure 71. Location of flood-determination sites for flood of December 1–5, 1991, and lines of equal precipitation for storm of November 30–December 2, 1991, in northeastern Mississippi.

Table 62. Maximum stages and discharges prior to and during flood of December 1–5, 1991, in northeastern Mississippi

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined or not applicable. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to December 1991				Maximum during December 1991			
Site no. (fig. 71)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Mobile River Basin							
1	02429900	Big Brown Creek near Booneville	27.1	1953–91	1970	[1]99.97	3,900	1	19.93	2,030	2
2	02429980	Pollard Mill Branch at Paden	2.01	1967–91	1991	9.02	1,200	1	5.19	361	4
3	02430085	Red Bud Creek near Moores Mill	15.7	1975–91	1991	13.13	2,330	1	12.92	2,130	15
4	02430100	Mackeys Creek near Moores Mill	118	1984–91	1983	--	[2]2,500	1	8.59	689	--
5	02430500	Tombigbee River near Marietta	308	1892–1977, 1991	1991	15.24	--	2	14.02	--	--
6	02430615	Mud Creek near Fairview	11.1	1976–91	1991	10.48	1,390	1	9.84	1,010	10
7	02430680	Twentymile Creek near Guntown	131	1965–91	1991	30.88	[2,3]41,500	1	28.79	[3]22,000	3
8	02430880	Cummings Creek near Fulton	19.1	1975–91	1991	12.71	2,350	1	11.18	967	3
9	02431000	Tombigbee River near Fulton	612	1929–91	1955 1991	[5]25.75 27.72	82,200 [4,5]73,800	2	24.18	46,500	15
10	02431410	Mantachie Creek below Dorsey	66.9	1988–91	1991	17.96	10,500	1	16.25	[4]7,200	--
11	02433500	Tombigbee River at Bigbee	1,226	1890–1991	1973	27.64	112,000	3	25.89	[4]75,400	20
12	02434000	Town Creek at Eason Boulevard at Tupelo	111	1927–91	1955	27.72	23,000	1	24.52	16,700	15
13	02435020	Town Creek at Tupelo	233	1955–91	1991	27.80	37,900	1	25.48	23,200	10
14	02435800	Coonewah Creek at Shannon	53.1	1927–91	1962	19.57	22,400	1	17.53	--	--
15	02436000	Chiwapa Creek at Shannon	145	1927–91	1955 1962	[5]15.72 15.90	35,500 [5]32,400	1	13.93	[3]24,100	10
16	02436500	Town Creek near Nettleton	620	1892–1991	1955	33.88	151,000	2	--	55,000	15
17	02437000	Tombigbee River near Amory	1,928	1892–1991	1973	34.65	162,000	3	32.44	[4]110,000	25
18	02437300	Mattubby Creek near Aberdeen	92.2	1925–91	1937	96.40	[2]15,500	3	93.35	9,650	4
19	02437550	Nichols Creek tributary near Quincy	.54	1966–91	1991	7.10	340	2	6.12	208	4
20	02437600	James Creek at Aberdeen	28.4	1948–61, 1963–91	1948, 1961	[1]19.29	7,500	2	24.13	5,140	5

Table 62. Maximum stages and discharges prior to and during flood of December 1–5, 1991, in northeastern Mississippi—Continued

Site no. (fig. 71)	Station no.	Stream and place of determination	Drainage area (mi²)	Maximum prior to December 1991: Period	Year	Stage (ft)	Discharge (ft³/s)	Maximum during December 1991: Day	Stage (ft)	Discharge (ft³/s)	Discharge recurrence interval (years)
				Mobile River Basin—Continued							
21	02439400	Buttahatchee River near Aberdeen	798	1916–91	1973	23.48	80,000	3	20.33	44,700	15
22	02440600	Line Creek near Maben	4.76	1952–91	1983	28.33	7,540	2	22.43	2,630	5
23	02441000	Tibbee Creek near Tibbee	926	1892–1991	1973	32.26	81,600	4	25.91	34,300	3
24	02441390	Tombigbee River at Columbus Lock and Dam	4,440	1833–1991	1892	--	278,000	5	63.88	[4]126,000	10
				Tennessee River Basin							
25	03592718	Little Yellow Creek near Burnsville	24.7	1974–91	1983	19.83	5,180	1	18.57	2,790	4
26	03592824	Tennessee-Tombigbee Waterway at Cross Roads	--	1980–91	1991	19.02	--	3	18.51	--	--
				Yazoo River Basin							
27	07267000	Hell Creek near New Albany	27.3	1939–42, 1952–91	1982	13.50	[3]8,420	2	10.50	[3]5,270	4
28	07268000	Little Tallahatchie River at Etta	526	1937–91	1955 1983	29.32 [5]29.02	[5]79,000 85,200	2	29.29	59,100	15
29	07273100	Hotopha Creek near Batesville	35.1	1986–91	1991	16.83	10,400	2	12.36	4,890	--
30	07274000	Yocona River near Oxford	262	1947–91	1955	[1]23.72	44,100	2	27.15	16,100	4
31	07274250	Otoucalofa Creek at Water Valley	84.1	1952–91	1983	28.07	15,900	1	24.86	10,600	15
32	07274251	Town Creek at Water Valley	2.25	1985–91	1990	11.00	1,800	1	9.71	1,330	--
33	07275500	Long Creek at Courtland	66.2	1907–91	1954	25.02	38,300	2	18.12	11,000	3
34	07275530	Peters (Long) Creek near Pope	79.2	1986–91	1990 1991	[5]19.86 21.13	26,500 [5]25,600	2	15.15	11,600	--
35	07283000	Skuna River at Bruce	254	1892–1991	1955	[1]24.11	61,400	1	30.09	[3]32,600	5
36	07285700	Long Creek near Cascilla	1.64	1965–91	1984	12.70	1,860	2	11.92	1,350	10
37	07287350	Fannegusha Creek near Tchula	103	1947–91	1947	25.10	32,000	2	20.62	9,400	2
				Big Black River Basin							
38	07289265	Hays Creek tributary No. 1 near Vaiden	14.0	1960–91	1973	26.68	3,500	2	26.14	3,540	10
39	07289350	Big Black River at West	1,030	1892–1991	1983	26.08	71,200	4	22.42	30,000	4

[1]Stage at different site and (or) datum. [2]Estimated. [3]Discharge affected by channelization.
[4]Discharge affected by regulation or diversion. [5]Less than maximum for period.

Flood of December 13–14, 1991, in Northeastern Kauai, Hawaii

By Richard A. Fontaine

During early December 1991, an atmospheric low-pressure trough developed west of the Hawaiian Islands. Such low-pressure troughs increase the potential for intense rains in the islands (Hawaii Division of Water and Land Development, 1992, p. 11). A few days after the trough developed, a winter-type storm brought intense rains to the island of Kauai. Although rain fell over most of Kauai, the storm was particularly severe in the northeast corner of the island. For the 24-hour period from noon on December 13 to noon on December 14, all precipitation recording stations on Kauai showed at least 3.0 inches (National Oceanic and Atmospheric Administration, 1992). Rainfall totals greater than 10 inches were recorded over the entire northeast corner of the island (fig. 72*A*). More than 22 inches of rain fell during the 24-hour storm period at Kaneha Reservoir. Precipitation gages at Anahola and Kapaa Stables recorded in excess of 18 inches before the gages overflowed while large quantities of rain were still falling. Total storm precipitation data for selected precipitation data sites located in northeastern Kauai are given in table 63. Maximum rainfall intensities during the storm were recorded at the Anahola site where as much as 6.7 inches of rain fell in 1 hour, and 11.6 inches fell in 2 hours (table 64). Maximum recorded rainfall depths at Anahola for durations from 1 to 12 hours were 17 to 66 percent greater than those estimated for 100-year recurrence-interval storms of corresponding durations (table 64).

In northeastern Kauai, the extreme rainfall intensities caused record maximum discharges on several streams having small drainage areas and steep basin slopes (table 65). Discharges recorded at sites located on Kapaa Stream (site 5), Akulikuli Stream (site 6), Anahola Stream (site 8), and Halaulani Stream (site 9) had recurrence intervals in excess of 100 years. Discharges at six sites exceeded any discharges previously determined at the sites (Matsuoka and others, 1993). The maximum discharge of 1,550 cubic feet per second at Akulikuli Stream near Kapaa (site 6) was almost twice that of the previous maximum discharge at the site. Maximum discharges at Halaulani Stream near Kilauea (site 9) and Kapaa Stream near Kealia (site 7) were 66 and 72 percent higher than previous maximums.

The flooding in northeastern Kauai was particularly tragic in that four lives were lost. The timing of the intense rain in the early morning hours of December 14 (table 64) and resulting rapid runoff in the streams were factors that contributed to the loss of life. In addition, flood damages in excess of $7 million were sustained. The greatest residential property damages occurred in the areas surrounding Kapaa and Anahola (Hawaii Division of Water and Land Development, 1992, p. 11). On December 16, 1991, the Governor of Hawaii declared Kauai a major disaster area.

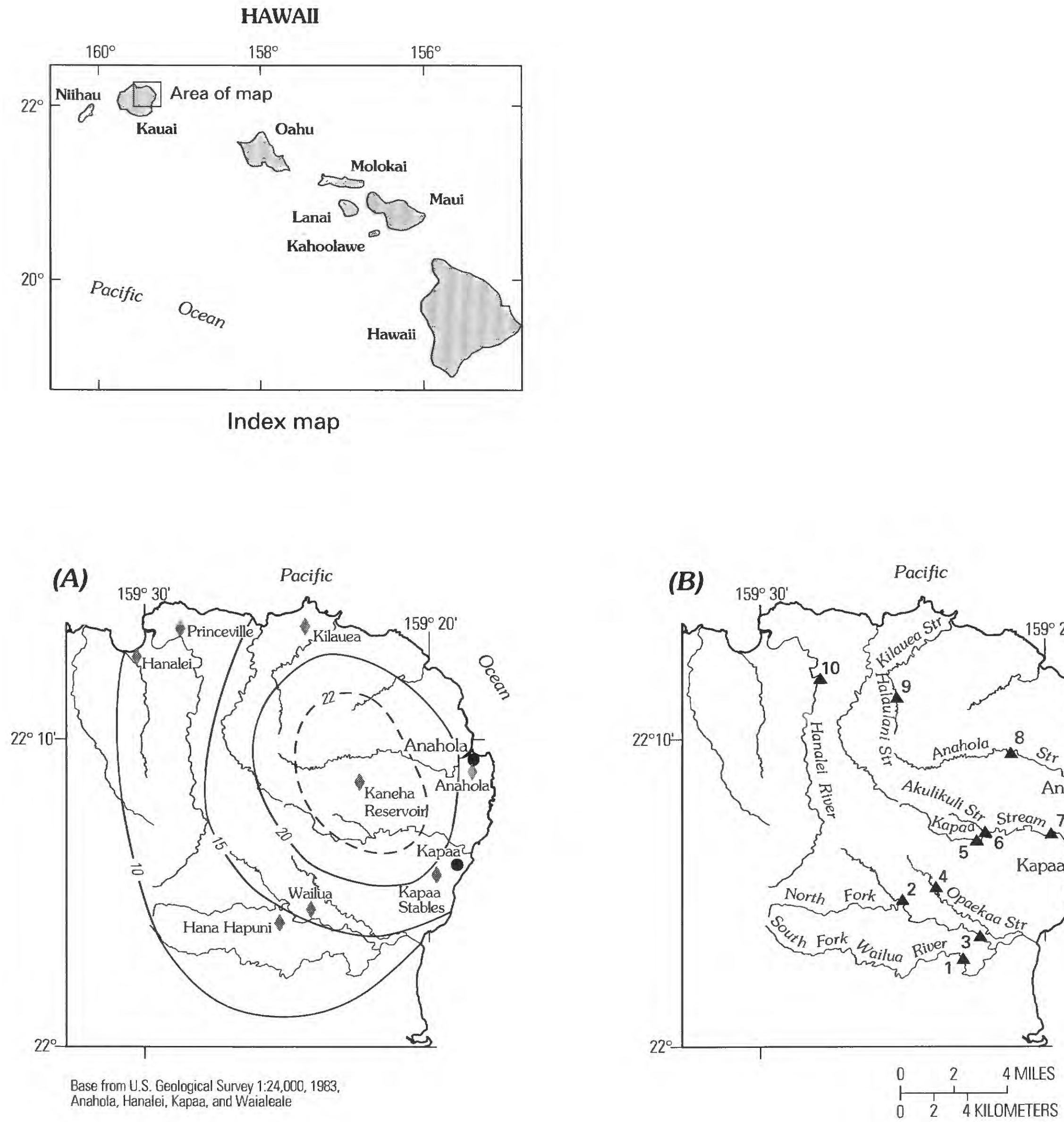
REFERENCES

Hawaii Division of Water and Land Development, 1992, Storm of December 14, 1991, northeast Kauai: Hawaii Department of Land and Natural Resources Circular C121, 35 p.

Matsuoka, Iwao, Kunishige, V.E., and Lum, M.G., 1993, Water resources data Hawaii and other Pacific areas, water year 1992, volume 1: U.S. Geological Survey Water-Data Report HI–92–1, 999 p.

National Oceanic and Atmospheric Administration, 1992, Hourly precipitation data, Hawaii and Pacific, December 1991: Asheville, N.C., National Climatic Data Center, v. 27, no. 12, 30 p.

U.S. Weather Bureau, 1962, Rainfall-frequency atlas of the Hawaiian Islands: U.S. Department of Commerce, Weather Bureau Technical Paper 43, 60 p.



EXPLANATION

— 22 — **Line of equal precipitation**—Dashed where inferred. Intervals 2 and 5 inches

Hanalei ♦ **Precipitation station and name**—Used in table 63

EXPLANATION

▲3 **Flood-determination site**—Number corresponds to that in table 65

Figure 72. (*A*) Distribution of precipitation for the storm of December 13–14, 1991, and (*B*) location of flood-determination sites, northeastern Kauai, Hawaii (precipitation distribution modified from Hawaii Division of Water and Land Development, 1992, fig. 2).

Table 63. Total precipitation for the 24-hour period from noon December 13 to noon December 14, 1991, northeastern Kauai, Hawaii

[Data from National Oceanic and Atmospheric Administration, 1992]

Precipitation data site (fig. 72*A*)	Precipitation (inches)
Anahola	[1]18.0
Hana Hapuni	12.7
Hanalei	10.9
Kaneha Reservoir	[2]22.3
Kapaa Stables	[3]18.2
Kilauea	18.4
Princeville	12.5
Wailua	15.3

[1]Gage overflowed at 5:45 a.m., December 14, 1991.
[2]Estimated from a nonrecording gage at site.
[3]Gage overflowed between 8:00 a.m. and 9:00 a.m., December 14, 1991.

Table 64. Maximum recorded rainfall depths and recurrence-interval data for selected durations and times of occurrence, December 13 to 14, 1991, at the National Oceanic and Atmospheric Administration precipitation data site at Anahola, Kauai, Hawaii

[Recurrence-interval data from U.S. Weather Bureau, 1962]

Duration (hours)	Depth[1] (inches)	Time of occurrence (24-hour)	100-year recurrence interval depth (to nearest inch)
0.5	3.5	0400 to 0430 hours, December 14	4
1.0	6.7	0400 to 0500 hours, December 14	5
2.0	11.6	0315 to 0515 hours, December 14	7
3.0	14.1	0245 to 0545 hours, December 14	9
6.0	16.7	2345 hours, December 13 to 0545 hours, December 14	12
12.0	17.5	1745 hours, December 13 to 0545 hours, December 14	15

[1]Gage overflowed at 0545 hours on December 14; depths given are only for the period when the gage was in operation.

Table 65. Maximum stages and discharges prior to and during flood of December 13–14, 1991, on northeastern Kauai, Hawaii

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; <, less than; >, greater than; --, not determined or applicable. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to December 1991				Maximum during December 1991			
Site number (fig. 72B)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence imterval (years)
1	16060000	South Fork Wailua River near Lihue	22.4	1914–90	1963	22.90	87,300	14	18.92	28,800	<10
2	16068000	East Branch of North Fork Wailua River near Lihue	6.27	1916–90	1955	14.70	18,400	14	10.84	9,070	50
3	16071000	North Fork Wailua River near Kapaa	17.9	1953–90	1955	19.88	53,200	14	16.02	30,100	40
4	16071500	Left Branch Opaekaa Stream near Kapaa	.65	1961–90	1975	5.58	724	14	6.60	1,060	50
5	16080000	Kapaa Stream at Kapahi Ditch intake near Kapaa	3.86	1937–90	1956	5.34	7,670	14	5.66	9,660	>100
6	16081200	Akulikuli Stream near Kapaa	.40	1964–90	1982	7.64	780	14	10.40	1,550	>100
7	16084500	Kapaa Stream at old highway crossing near Kealia	14.0	1962–90	1982	18.02	17,600	14	3.11	30,300	65
8	16089000	Anahola Stream near Kealia	4.27	1914–90	1956	14.60	19,600	14	16.34	18,400	>100
9	16097500	Halaulani Stream at altitude of 400 ft near Kilauea	1.90	1958–90	1959	8.30	--	14	9.64	4,030	>100
					1989	7.69	2,420				
10	16103000	Hanalei River near Hanalei	19.1	1962–90	1974	14.28	24,900	14	14.45	25,800	<10

Floods of December 20–26, 1991, in Central Texas

By H.R. Hejl, Jr., R.M. Slade, Jr., *and* M.E. Jennings

Rainfall on a large area of central Texas during December 18–23, 1991, caused extensive flooding in many locations. Record maximum discharges occurred in December 1991 at U.S. Geological Survey flood-determination sites located throughout this area.

On December 18, a warm, moist, unstable air mass began spreading northward from the Gulf of Mexico, overrunning a cold surface ridge that had settled over Texas. Simultaneously, a deep, cold, upper-level trough over the southwestern United States and northern Mexico was pumping tropical moisture into central and northern Texas from low latitudes across Mexico. Embedded thunderstorms began producing intense rain over south-central Texas, expanding northward late on December 18. This combination of moisture movement persisted until December 23, with thunderstorm activity producing intense rains throughout central Texas during the period. Lines of equal precipitation in figure 73 represent the total precipitation during this 6-day period. The maximum known 24-hour rainfall total, 8.60 inches 60 miles west of Waco, had a recurrence interval of about 50 years (Hershfield, 1961, p. 103). The monthly precipitation for December 1991 was 100 percent or more above normal (Larkin and Bomar, 1983) in central Texas.

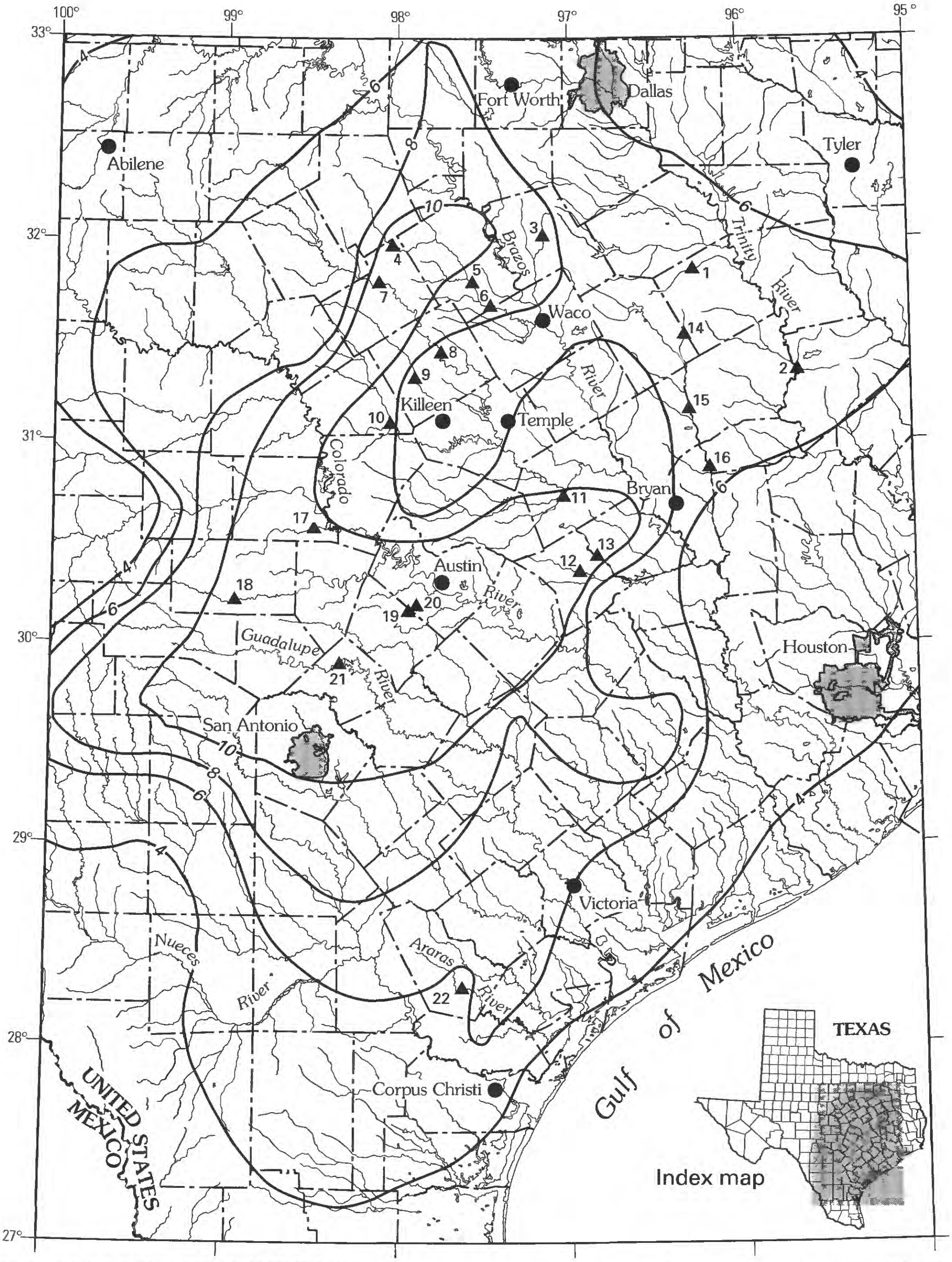
Flood data are shown in table 66 for sites on streams in central Texas where the December 1991 maximum discharges were equal to or greater than those for a 10-year recurrence interval and for other sites having large discharges. Nine of the 22 sites listed in table 66 had discharges exceeding previously known maximums. Four of these sites had maximum discharges with recurrence intervals greater than 100 years.

Because of the flooding, central Texas was declared a Federal disaster area on December 26, 1991. Ten deaths were attributed to the flooding throughout the area. The Federal Emergency Management Agency (written commun., 1993) distributed more than $43 million in Federal funds for public assistance, temporary housing, individual and family grants, disaster unemployment, and home and business loans.

REFERENCES

Hershfield, D.M., 1961, Rainfall frequency atlas of the United States: U.S. Department of Commerce, Weather Bureau, Technical Paper 40, 115 p.

Larkin, T.J., and Bomar, A., 1983, Climatic atlas of Texas: Texas Department of Water Resources L.P.–192, 151 p.



Base from U.S. Geological Survey digital data, 1:2,000,000, 1994
Albers Equal-Area Conic projection
Standard parallels 29°30' and 45°30', central meridian -96°00'

0 25 50 75 100 MILES

0 25 50 75 100 KILOMETERS

EXPLANATION

——4—— **Lines of equal precipitation—** Interval 2 inches

▲22 **Flood-determination site—**Number corresponds to that in table 66

Figure 73. Location of flood-determination sites and lines of equal precipitation for storms of December 18–23, 1991, in central Texas (lines of equal precipitation based on data compiled by National Oceanic and Atmospheric Administration).

Table 66. Maximum stages and discharges prior to and during floods of December 20–26, 1991, in central Texas

[mi^2, square miles; ft, feet above an arbitrary datum; ft^3/s, cubic feet per second; --, not determined or not applicable; >, greater than. Source: Recurrence intervals calculated from U.S. Geological Survey data. Other data from U.S. Geological Survey reports or data bases]

				Maximum prior to December 1991				Maximum during December 1991			
Site no. (fig. 73)	Station no.	Stream and place of determination	Drainage area (mi^2)	Period	Year	Stage (ft)	Discharge (ft^3/s)	Day	Stage (ft)	Discharge (ft^3/s)	Discharge recurrence interval (years)
				Trinity River Basin							
1	08064700	Tehuacana Creek near Streetman	142	1932–91	1989	30.2	85,700	21	26.4	34,700	45
2	08065350	Trinity River near Crockett	13,911	1964–91	1990	48.54	109,000	26	48.5	109,000	--
				Brazos River Basin							
3	08093250	Hackberry Creek at Hillsboro	57.9	1887–1991	1981	18.95	12,050	20	18.44	10,700	20
4	08094800	North Bosque River at Hico	359	1880–1991	1952	27.60	[1]87,800	20	23.27	27,000	--
5	08095000	North Bosque River near Clifton	968	1854–1991	1959	34.88	[1]92,800	20	38.3	[2]200,000	>100
6	08095200	North Bosque River at Valley Mills	1,146	1868–1991	1908	43	--	21	44.6	[2]220,000	>100
7	08100000	Leon River near Hamilton	1,891	1858–1991	1908	38.4	--	20	35.02	32,100	--
8	08100500	Leon River at Gatesville	2,342	1854–1991	1908	35	70,000	21	35.00	68,000	--
9	08101000	Cowhouse Creek at Pidcoke	455	1882–1991	1959	40.1	66,200	20	44.3	110,000	>100
10	08103800	Lampasas River near Kempner	818	1960–91	1965	32.98	[1]71,000	20	35.00	[2]78,000	>100
11	08106310	San Gabriel River near Rockdale	1,359	1975–91	1979	32.91	15,600	21	35.74	39,000	--
12	08109700	Middle Yegua Creek near Dime Box	236	1914–91	1975	15.16	11,400	22	15.39	12,500	30
13	08109800	East Yegua Creek near Dime Box	244	1958–91	1975	13.91	14,000	22	12.94	8,910	10
14	08110430	Big Creek near Freestone	57.1	1980–91	1989	15.37	5,950	21	16.33	17,500	65
15	08110500	Navasota River near Easterly	968	1845–1991	1899	24.0	[1]90,000	22	27.22	61,800	--
16	08111000	Navasota River near Bryan	1,454	1951–91	1966	16.57	38,200	23	19.97	66,600	--
				Colorado River Basin							
17	08152000	Sandy Creek near Kingsland	346	1881–1991	1952	34.2	163,000	20	17.62	39,500	25
18	08152900	Pedernales River near Fredericksburg	369	1979–91	1979	34.4	64,000	20	32.09	49,900	10
19	08158810	Bear Creek near Driftwood	12.2	1924–91	1981	16.2	13,500	20	14.23	10,200	15
20	08158840	Slaughter Creek near Austin	8.24	1980–91	1981	10.79	4,080	20	10.68	6,330	20
				Guadalupe River Basin							
21	08167500	Guadalupe River near Spring Branch	1,315	1923–91	1978	45.25	160,000	21	36.00	79,300	20
				Aransas River Basin							
22	08189700	Aransas River near Skidmore	247	1914–91	1967	42.22	82,800	22	29.4	14,700	10

[1]Discharge occurred prior to regulation of streamflow by reservoir(s).
[2]Partially regulated by flood-detention reservoirs; recurrence intervals based on unregulated period.

INDEX

I

J

K

L

M

N

O

P

Q

R