Summary of Floods in the United States During 1964

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1840-C

Prepared in cooperation with Federal, State, and local agencies

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By J. O. ROSTVEDT and others

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CONTENTS

ILLUSTRATIONS

TABLES

SUMMARY OF FLOODS IN THE UNITED STATES DURING 1964

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ABSTRACT

This report describes the most outstanding floods in the United States during 1964. The four most damaging floods during the year were in December in the Far Western States, in March along the Ohio River, in September in central and northern Florida and southern Georgia, and in June in northwestern Montana.

The floods of December in the Far Western States were the most damaging in the history of the area. Record-breaking discharges occurred in an unusually large area—Oregon, northern California, western Nevada and Idaho, and southern Washington. Forty-seven lives were lost, and damage amounted to several hundred million dollars.

Two storms in early March along the Ohio River caused maximum discharges of record on many streams in Ohio, Kentucky, and Indiana and also high discharges in parts of Illinois, West Virginia, and Pennsylvania. Eighteen lives were lost, and flood damage was about $100 million.

In September, Hurricane Dora, the first hurricane of record to cross northeastern Florida from the Atlantic Ocean, caused outstanding floods in northern Florida and southern Georgia. Flood damage exceeded $100 million.

The most severe floods of record in northwestern Montana occurred on both sides of the Continental Divide following heavy rains in early June. Thirty lives were lost, and flood damage was about $55 million.

About $6 million damage resulted from severe flooding in a small area in the Papillion Creek basin, in eastern Nebraska, in early June.

In the last half of September, floods from torrential rains in three areas in Texas caused about $1 million damage.

In addition to the floods mentiond above, 21 others of lesser magnitude are considered important enough to be included in this annual summary.

INTRODUCTION

This report summarizes information on outstanding floods in the United States during 1964. The floods reported were unusual hydrologic events in which large areas were affected, great damage resulted, or record-high discharges or stages occurred, and sufficient data were available for the preparation of a report.

Three U.S. Geological Survey Water-Supply Papers—1840–A, "Floods of March 1964 Along the Ohio River" (Beaber and Rostvedt, 1965); 1840–B, "Floods of June in Northwestern Montana" (Boner and Stermitz, 1967); and 1866, "Floods of December 1964–January 1965 in the Far-Western States" (Waananen and others, 1970a, b)—are special reports that describe the 1964 floods in detail in their respective areas. The areas for which flood reports have been prepared for 1964 are shown in figure 1. The areas discussed in the individual reports are indicated by a solid pattern, and other areas discussed in this summary chapter are shown by a line pattern. The months in which the floods occurred are shown; the map thereby gives both the location and the time distributions of floods during the year.

A flood may be defined as any abnormally high streamflow that overtops natural or artificial banks of a stream; a great number of these events occur every year in the United States, but many may be unreported.

Each flood in this report was selected as an outstanding or comparatively rare event. A rare flood is not necessarily an impressive flood, but it is one whose probability of being duplicated at any one site is very small. A rare flood in an isolated area or in a sparsely inhabited area could possibly be a more outstanding hydrologic event than a much publicized flood in a developed area.

Many variable factors of meteorology and physiography in innumerable combinations produce floods of all degrees of severity. Some meteorological factors influencing floods are the form, the amount, and the intensity of precipitation; moisture condition of the soil before the storm; the temperature, which may cause frozen soil or may determine the rate of snowmelt; and the direction of the storm movement. The principal physiographic features of a basin that affect floodflows are drainage area, altitude, geology, shape, slope, aspect, and vegetation cover. With the exception of vegetation cover, which varies seasonally, the physiographic features are fixed for any given area. The combination of the magnitude and intensity of meteorologic factors, antecedent moisture conditions, and the effect of inherent physiographic features on runoff determine the magnitude of a flood.

Losses from floods in the United States during 1964 ($652 million) were 3.7 times those in 1963 ($176 million) and 8.7 times those in 1962 ($75 million). The 1964 flood losses were the highest since those of 1955 ($995 million) and were about 1.9 times the national average of $340 million, based on the 10-year period 1951–60, adjusted to the 1960 price index.

Total loss of life due to floods in 1964 was 100, compared with 39 in 1963 and 19 in 1962, and was considerably greater than the national annual average of 79 lives lost during the 40-year period 1925–64.

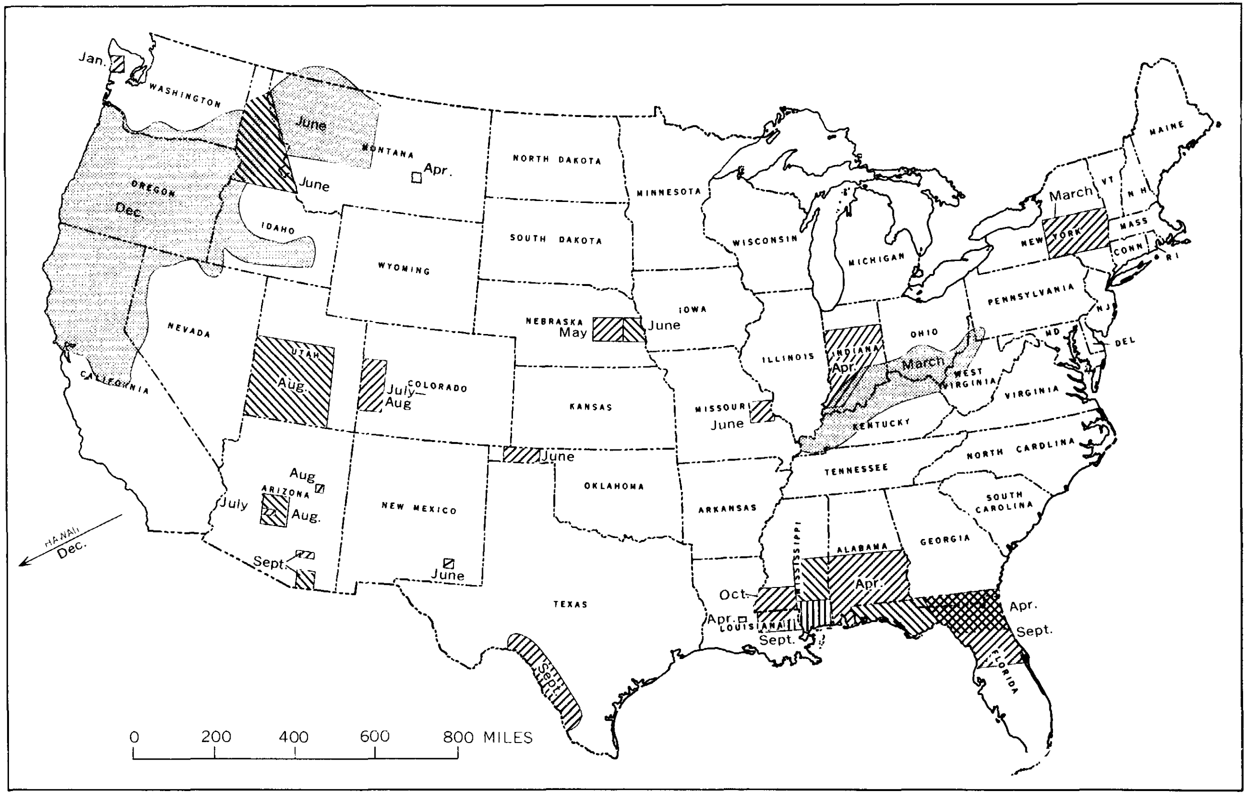

FIGURE 1.—Areas and months of occurrence of outstanding floods in 1964 for which reports are presented in this summary. Solid pattern indicates the areas for which special reports were prepared.

Many of the flood reports give the amount of rainfall and the duration of the storm causing the flood. Recurrence intervals of these storms may be determined from the U.S. Weather Bureau (1961) or from a simplified set of isopluvial maps and charts contained in a report by Rostvedt (1965).

Continuing investigation of surface-water resources in the areas included in this report is performed by the U.S. Geological Survey in cooperation with State agencies, the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, and other Federal or local agencies. Some data were obtained from U.S. Weather Bureau publications.

Collection of data, computations, and most of the text were made by the district offices in whose district the floods occurred.

DETERMINATION OF FLOOD STAGES AND DISCHARGES

Data of peak stages and peak discharges at discharge stations in this report are those obtained and compiled in the regular procedures of surface-water investigation by the Geological Survey.

The usual method of determining stream discharges at a gaging station is the application of a stage-discharge relation to a known stage. The relation at a station is usually defined by current-meter measurements through as much of the range of stage as possible. If the peak discharge at a station is above the range of the computed stage-discharge relation, short extension may be made to the graph of relation by logarithmic extrapolation, by velocity-area studies, or by use of other measurable hydraulic factors.

Peak discharges that are greatly above the range of the stage-discharge relation at gaging stations, and peak discharges at miscellaneous sites (which have no developed stage-discharge relation) are generally determined by various types of indirect measurements. During major floods adverse conditions often make it impossible to obtain current-meter measurements at some sites. Peak discharges are then measured, after the flood has subsided, by indirect methods based on detailed surveys of selected channel reaches. A general description of the indirect methods used by the Geological Survey is given by Corbett and others (1943), Johnson (1936), and Dalrymple and others (1937). More detailed information concerning the latest techniques is available in recent reports by Kindsvater and others (1953), Bodhaine (1963), and Tracy (1957).

EXPLANATION OF DATA

The floods are described in chronological order. Because the type and the amount of information differ for the floods, no consistent form is used to report the events.

The data for each flood include: A description of the storm, the flood, and the flood damage; a map of the flood area showing flood-determination points, and, for some storms, precipitation stations or isohyets; rainfall amounts and intensities; and peak stages and discharges of the streams affected.

Where considerable rainfall data are available, they are presented in tabular form and show daily or storm totals. Where sufficient data are available to determine the pattern and distribution of rainfall, an isohyetal map is shown for some areas.

A summary table of peak stages and discharges is given for each flood unless the number of stations in the report is small. For these floods the information is included in the text description.

In the summary table the first column under maximum floods gives the period of known floods prior to the 1964 floods. This period does not necessarily correspond to that of gaging-station operation; rather, the period may extend back to an earlier date. More than one period of known floods are shown for some stations. A period is shown whenever it can be associated with a maximum stage, even though the corresponding discharge may not be known. A second, shorter period of floods is then given in which maximums of both discharge and stage are known.

The second column under maximum floods shows the year—within the period of known floods—in which the maximum stage or discharge occurred. The third column gives the date of the peak stage or discharge of the 1964 flood.

The last column gives the recurrence interval for the 1964 peak discharge. The recurrence interval, as obtained from data published in the U.S. Geological Survey reports on flood magnitude and frequency, is the average interval, in years, within which a flood of a given magnitude will be equaled or exceeded once as an annual maximum. A flood having a recurrence interval of 20 years can be expected to occur, on the average, once in 20 years. In other words, the flood has a 5-percent chance of occurring in any year. In nearly all flood-frequency reports used, data limit the determination of recurrence intervals to 50 years. The severity of a flood whose recurrence interval exceeds the limit of determination is expressed as the ratio of its peak discharge to the discharge of the flood that has a recurrence interval equal to the limits of determination (usually the 50-year flood).

SUMMARY OF FLOODS

FLOODS OF JANUARY 25 IN NORTH COASTAL OREGON

By J. M. Abbott

On January 25, 1964, a flood in the north coastal area of Oregon, in the Nehalem, Wilson, and Trask River basins (fig. 2), resulted from a series of storms that moved across that area on January 5, 17, and 24. During January, precipitation occurred almost every day in northwestern Oregon. Heavy snowfall occurred during the series of storms, in the higher elevations of the north coastal river basins. A total of 35.75 inches of rain fell at Tillamook during January (fig. 3) compared with a normal January rainfall there of 10.11 inches Streams had just begun to recede on January 24, when the combined surge of runoff from rain and melted snow poured into the swollen streams and caused major flooding along the coast from Tillamook to Seaside.

The peak discharge in Nehalem River near Foss was 43,200 cfs

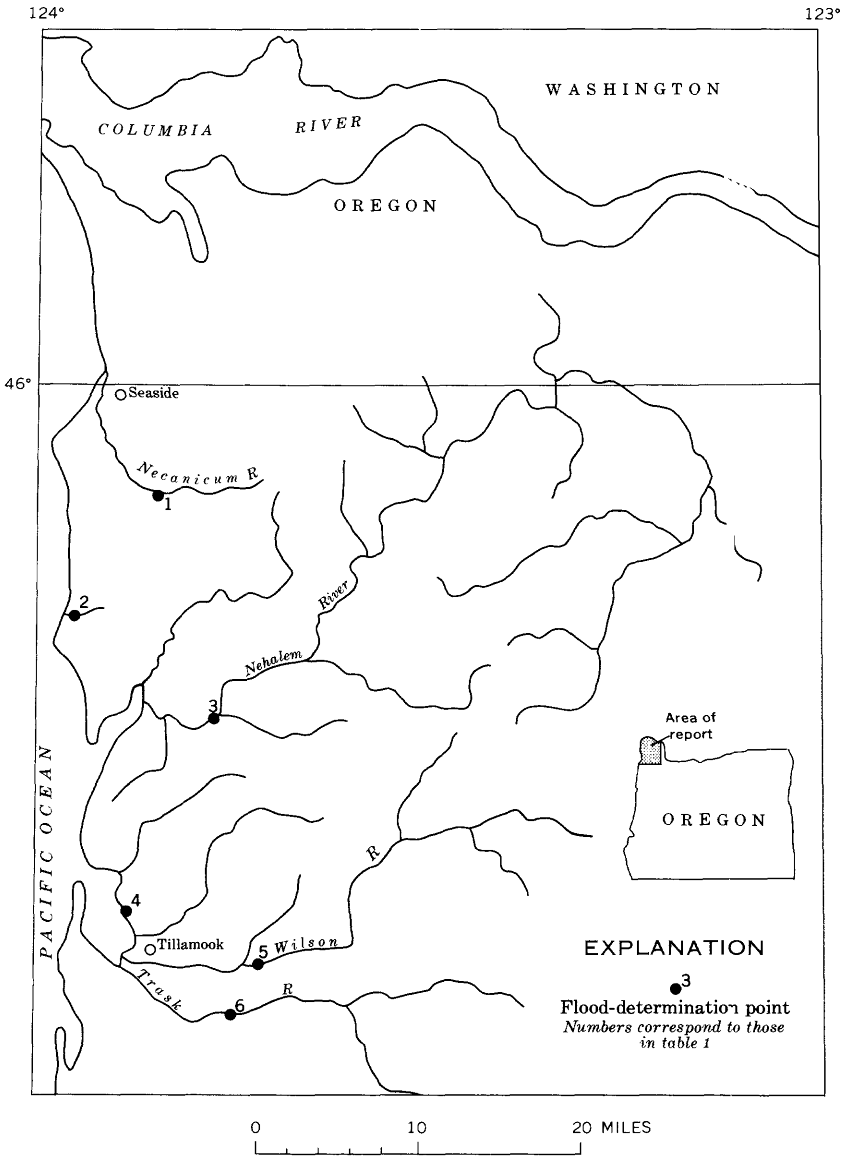

FIGURE 2.—Flood area; location of flood-determination points, floods of January 25 in north coastal Oregon.

(cubic feet per second) (fig. 4), which is the maximum for the period of record that began in 1939. Peak discharges and their recurrence intervals at the sites shown in figure 2 are listed in table 1.

The flood damage was localized in the flatlands surrounding Nehalem Bay and Tillamook Bay. Damage to agricultural lands was inundation of pastures, deposition of silt and debris, and loss of land through streambank erosion. Residential and commercial damage occurred along the lower Nehalem River and in the lowland area in and around the city of Tillamook. North and south of

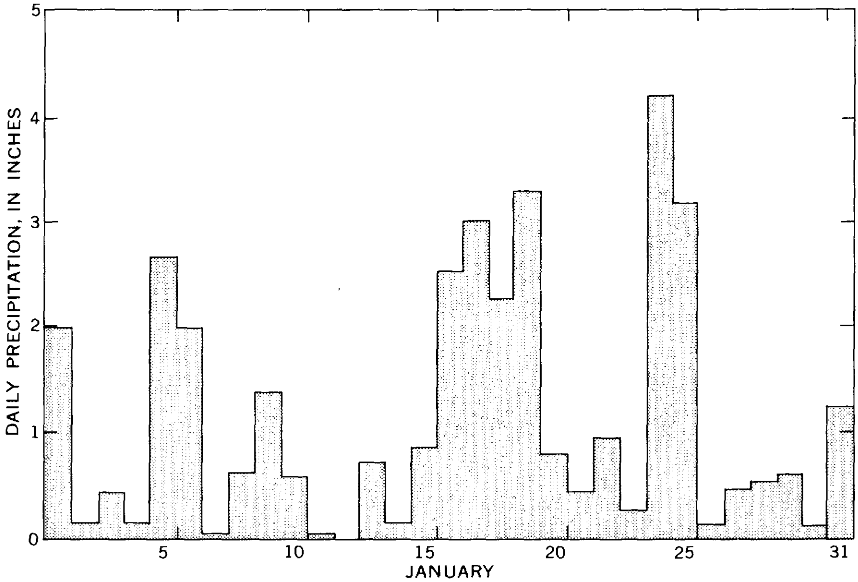

FIGURE 3.—Daily precipitation for January at Tillamook, Oreg.

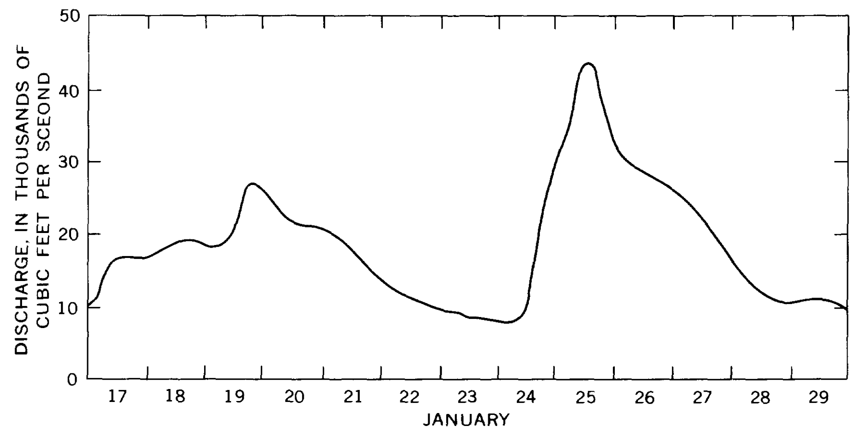

FIGURE 4.—Discharge, January 17–29, on Nehalem River near Foss, Oreg.

TABLE 1.—*Flood stages and discharges, January 25 in north coastal Oregon*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Jan. 1964: Period	Year	Jan. 1964 (day)	Gage height (ft)	Discharge: Cubic feet per second	Recurrence interval (years)
	Necanicum River basin							
1	South Fork Necanicum River near Seaside.	7.99	1952–63	1955		[1] 8.85	3,020	
					25	8.86	3,040	[2] 1.78
	Asbury Creek basin							
2	Asbury Creek near Cannon Beach.	1.97	1952–63	1961		9.66	314	
					25	9.07	267	5
	Nehalem River basin							
3	Nehalem River near Foss.	667	1939–63	1955		19.67	39,300	
					25	21.10	43,200	
	Patterson Creek basin							
4	Patterson Creek at Bay City.	1.87	1952–63	1955		13.08	207	
					25	13.06	205	3
	Wilson River basin							
5	Wilson River near Tillamook.	161	1914–16, 1931–63	1933		[3] 19.28	30,000	
					25	17.35	25,000	6
	Trask River basin							
6	Trask River near Tillamook.	145	1921	1921		17	30,000	
			1931–55, 1961–63	1955		13.09	20,200	
					25	11.43	18,100	5

[1] Affected by backwater from debris.
[2] Ratio of peak discharge to 50-yr flood.
[3] At site 100 ft downstream at datum 0.93 ft higher.

Tillamook U.S. Highway 101 was inundated, and traffic was halted. Many cattle of Tillamook County and hundreds of sheep in northwestern Oregon were drowned in low-lying pastures. There was no loss of human life in this area due to the flood.

FLOODS OF MARCH ALONG THE OHIO RIVER

The floods of March 1964 in the Ohio River basin caused widespread damage in six States adjacent to the Ohio River (fig. 5). Flood damage was estimated at more than $100 million, of which about 75 percent was along the main stem of the Ohio River. More than 21,000 homes were damaged or destroyed, and more than 29,000 families suffered losses. Eighteen lives were lost.

Floods were caused by two storms, on March 2–5 and March 8–10. Both storms approximately paralleled the Ohio River in a belt that extended from western Kentucky, through northern Kentucky, southern Indiana, and central Ohio, to western Pennsylvania. In most localities the storm of March 8–10 was the more severe. Total rainfall from the storms exceeded 14 inches in western Kentucky. The greatest 24-hour precipitation recorded was 8.00 inches at Paducah, Ky., on March 4.

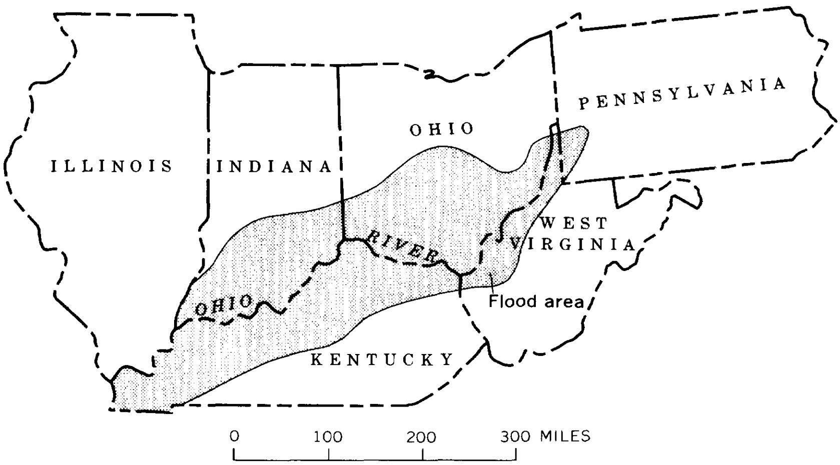

FIGURE 5.—Flood area ; in March along the Ohio River.

Maximum discharges previously known were exceeded at many points in Ohio, Kentucky, and Indiana. Peak discharges of the March floods exceeded the 50-year flood at many localities. The Licking River at Catawba, Ky., reached the highest stage since 1888. The Ohio River in Kentucky reached stages which were second or third highest since the maximum known flood in 1937.

These floods are fully described in a report by Beaber and Rostvedt (1965) that presents a general description of the storm precipitation, the floods, the flood damage, and recurrence intervals of the peak discharges. Maximum stages and discharges for the March 1964 flood and for the period of station record, at 150 continuous-record gaging stations, crest-stage stations, miscellaneous sites, and reservoir stations are listed in a summary table. Station descriptions are given for all stations listed in the summary table. A table of daily mean discharges for March 1964 and a table of stages and discharges at selected intervals during most of the days of floodflow are given for each continuous-record gaging station.

FLOODS OF MARCH 5–10 IN NEW YORK

By F. LUMAN ROBISON

February 1964 was a cold month in New York, with temperatures throughout most of the State averaging from 1° to 6° below normal. On the last day of the month, temperatures began to moderate, especially in the eastern and south-central areas, until on March 5 high readings of 71°F were recorded at Albany and New York, 72°F at Poughkeepsie, and 75°F at Westerleigh, on Staten Island.

Snow cover in the eastern part of the State was moderately heavy, with a measured water equivalent on March 2–4 of as much as 6 inches in the lower Adirondacks and in the south-central counties and 12 inches in the Tug Hill area, east of Lake Ontario (fig. 6).

In the late afternoon of March 4, rain began to fall on most of the State and continued until early evening of March 5. The heaviest measured rainfall totaled 4 inches at Piseco, in the Sacandaga River basin, and 3.80 inches at Hoffmeister, in the West Canada Creek basin. The distribution and amounts of rainfall for this storm are shown on the isohyetal map, figure 7.

The combination of unseasonably warm temperatures and of rain falling on water-laden snow resulted in widespread, but moderate, flooding across the south-central part of the State during March 5–6.

Table 2 lists streams where maximum discharges of record were recorded with exception of the Hudson River. Also shown for comparison are the previous maximum discharges for the same streams. The last column in the table gives the recurrence intervals for the 1964 flood discharges. The site numbers in this tabulation correspond to those in figure 7.

The data for several of the stations where record peak discharges were recorded (table 3) show that the warm temperatures and asso-

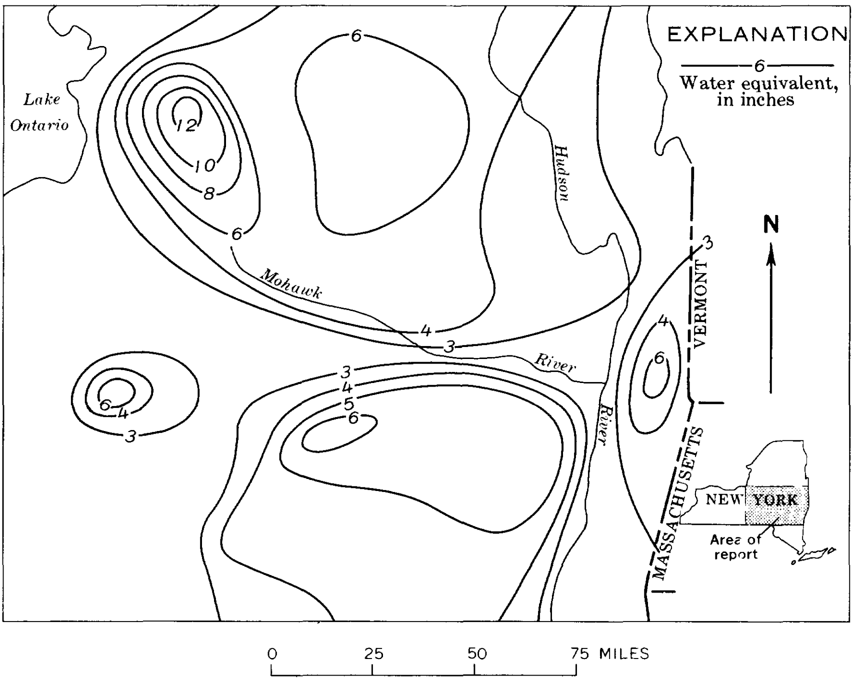

FIGURE 6.—Water equivalent of snow on ground, March 2–4 in southeastern New York, floods of March 5–10 in New York.

ciated snowmelt were more important factors than rainfall in causing flooding.

Peak discharges on some of the streams probably would have been greater had it not been for storage in upstream reservoirs. Table 4 shows the mean and maximum inflow to reservoirs in the report area, as computed from the observed changes in contents. Also listed are the associated daily and momentary maximum discharges at the nearest downstream gaging stations. Sacandaga, Delta, and Hinckley are primarily river-regulating reservoirs that are refilled by spring runoff. Schoharie is a unit of the New York City reservoir system that is also dependent on spring runoff. East Sidney and Whitney Point Reservoirs serve flood-control purposes.

As frequently happens, the Mohawk River became jammed with ice on March 5–6 in the constriction below the bridge on State Highway 146 at Rexford. When the main jam broke free on March 6, a tremendous mass of water and ice was released to the stream below, and the gaging station at Cohoes (sta. 10) recorded the greatest discharge since the record began in 1917.

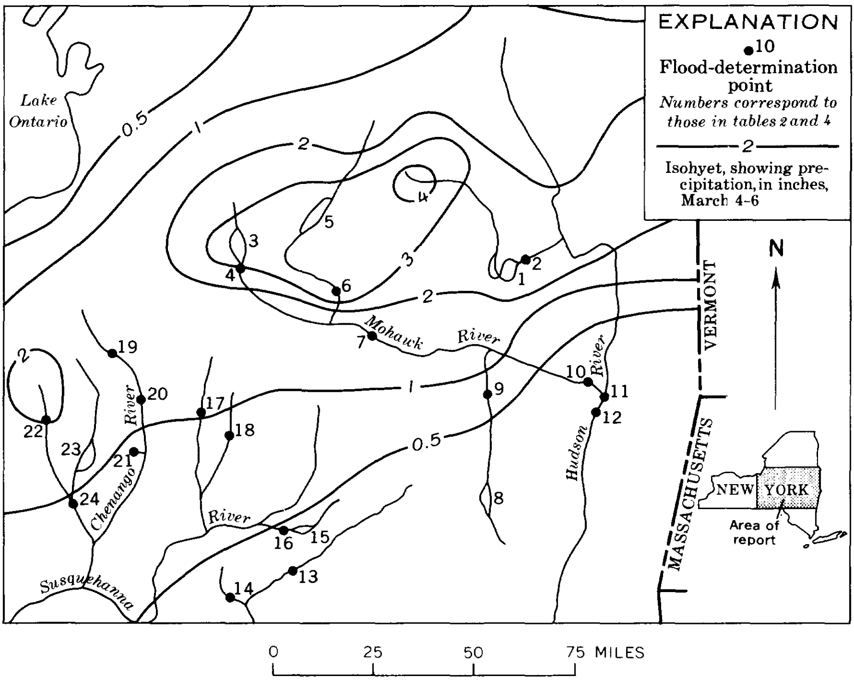

FIGURE 7.—Flood area; location of flood-determination points and isohyets for March 4–6, floods of March 5–10 in New York.

TABLE 2.—*Flood stages and discharges, March 5–10 in New York*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Mar. 1964: Period	Year	Mar. 1964 (date)	Gage height (ft)	Discharge: Cubic feet per second	Recurrence interval (years)
	Hudson River basin							
7	Mohawk River near Little Falls.	1,348	1927–64	1945		17.80	25,300	
					5	18.33	27,200	3
10	Mohawk River at Cohoes	3,456	1917–64	1936		22.57	130,000	
					6	23.15	[1] 143,000	[2] 1.23
11	Hudson River at Green Island	8,090	1946–64	1948		27.05	181,000	
					6	24.82	141,000	17
12	Hudson River at Albany							
	Delaware River basin							
13	West Branch Delaware River at Walton.	331	1950–64	1959		13.76	15,700	
					5	13.66	15,800	20
14	Oquaga Creek at Deposit	66	1940–64	1959		6.42	4,500	
					10	7.07	5,850	[2] 1.07
	Susquehanna River basin							
17	Unadilla River near New Berlin.	196	1924–64	1950		9.95	6,600	
					5	10.12	6,940	4
18	Butternut Creek at Morris	59.6	1938–64	1959		7.74	3,240	
					5	8.47	4,260	22
19	Chenango River at Eaton	24.3			6		2,570	50
20	Chenango River at Sherburne	264	1936–64	1936		10.6	(3)	
			1938–64	1961		9.77	8,980	
					5	9.80	9,200	5
21	Clark Creek at Oxford	2.55			5		152	
22	Tioughnioga River at Cortland.	296	1938–64	1950		10.82	10,000	
					5	12.49	13,000	12

[1] From release of upstream ice jam.
[2] Ratio of peak discharge to 50-yr flood.
[3] Not determined.

TABLE 3.—*Measured snow-water equivalent, rainfall, and runoff March 4–8 in New York*

No.	Stream	Drainage area (sq. mi.)	Water equivalent in snow (in.)	Rainfall Mar. 4–5 (in.)	Total (in.)	Recorded runoff Mar. 5–8: Cubic feet per second-days (cfs-days)	Inches
13	West Branch Delaware River at Walton	331	5	0.3	5.3	21.320	2.40
17	Unadilla River near New Berlin	196	4	1.6	5.6	11.780	2.24
18	Butternut Creek at Morris	59.6	4	1.4	5.4	4.194	2.62
20	Chenago River at Sherburne	264	2	1.6	3.6	13 960	1.97
22	Tioughnioga River near Cortland	296	3	1.4	4.4	21.340	2.68

Figure 8 is a stage hydrograph for the Mohawk River at Cohoes (sta. 10) and for the Hudson River at Green Island, above Troy (sta. 11) and at Albany (sta. 12). It shows the rise and the recession resulting from the ice-jam release.

TABLE 4.—*Reservoir inflow and discharge, March 4–9 in New York*

No.	Name and location	Drainage area (sq mi)	Mean reservoir inflow		Maximum 24-hour inflow		Mean discharge		Maximum mean daily discharge		Momentary maximum discharge	
			Date in March	Cubic feet per second	Date in March	Cubic feet per second	Date in March	Cubic feet per second	Date in March	Cubic feet per second	Date in March	Cubic feet per second
1	Sacandaga Reservoir at Conklingville	1,044	5–7	21,200	5–6	28,200						
2	Sacandaga River at Stewarts Bridge near Hadley	1,055					5–6	386	5	744	5	4,030
3	Delta Reservoir near Rome	145	4–7	3,850	5–6	7,380						
4	Mohawk River below Delta Dam	150					5–6	318	5	460	5	708
5	Hinckley Reservoir	373	5–7	10,200	6–7	14,900						
6	West Canada Creek at Kast Bridge	556					5–6	7,020	5	10,400	5	13,400
8	Schoharie Reservoir	314	4–7	4,400	5–6	9,730						
9	Schoharie Creek at Burtonsville	883					5–6	11,500	6	14,000	5	29,400
15	East Sidney Reservoir	102	4–7	1,890	4–5	3,650						
16	Onleout Creek at East Sidney	102					8–9	1,700	9	1,720	8	1,850
23	Whitney Point Reservoir	255	4–7	6,030	5–6	9,390						
24	Tioughnioga River at Itaska	735					5–6	12,200	6	13,500	5	17,500

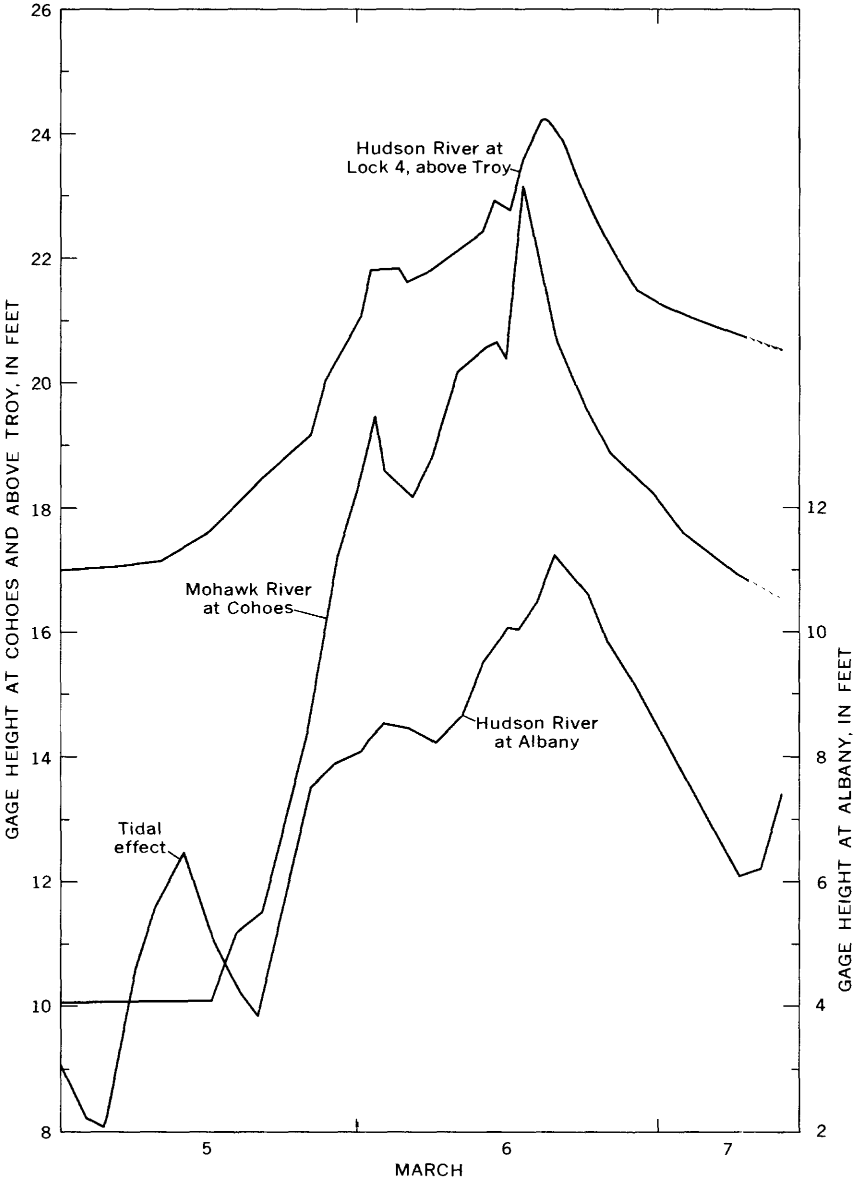

Figure 8.—Stage of the Mohawk River at Cohoes and the Hudson River at Lock 4, above Troy and at Albany, N.Y., March 5–7.

Figure 9 is a stage hydrograph for Butternut Creek at Morris (sta. 18); it shows the rise and recession of this flood caused by a moderate amount of rain falling on a snowpack that had about a 3.5-inch water equivalent.

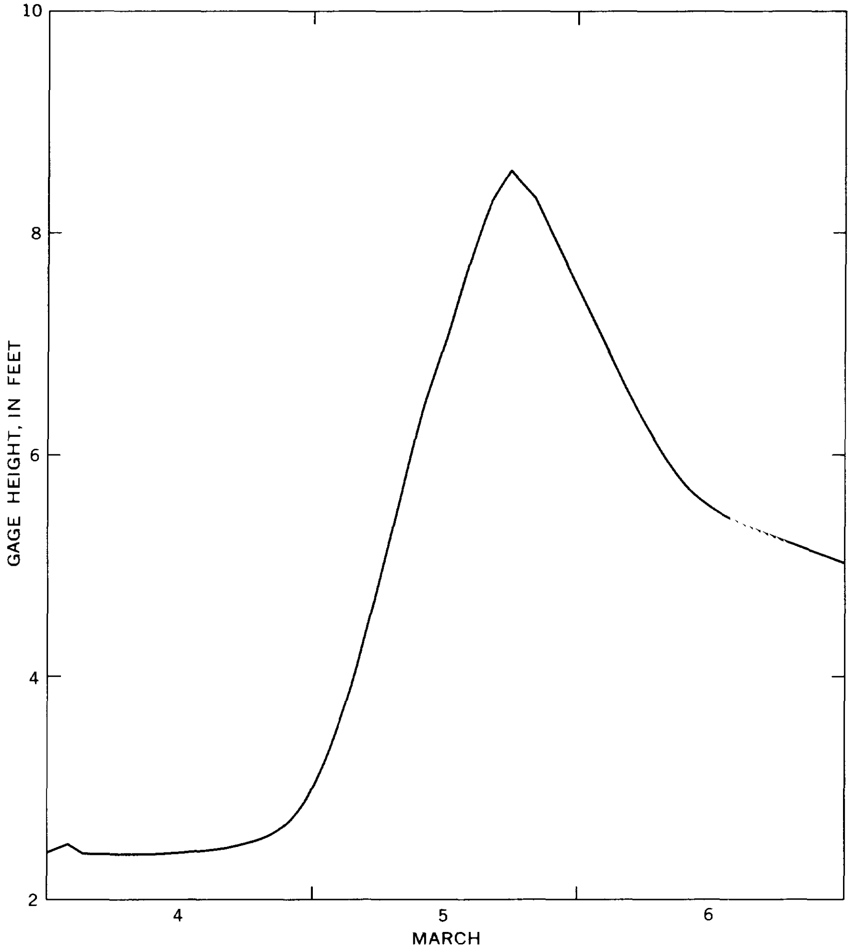

FIGURE 9.—Stage of Butternut Creek at Morris, N.Y., March 4–6.

Two indirect measurements of peak discharge were made at ungaged sites in the Chenango River basin (stas. 19 and 20).

The monetary damage resulting from this widespread flood is very difficult to assess. Although a significant area was affected by floodwaters, most of the damage consisted of water-filled cellars and of minor street and highway washouts. Three small highway bridges on secondary roads in the Mohawk basin were damaged or lost owing to erosion of the earth fill at the abutments. It was estimated that replacement of a bridge lost near the village of Ohio in Herkimer County would cost $40,000. An earthen dam on the Electric Light Stream and a bridge on the Chenango River at Eaton in Madison County were destroyed, but no estimates of damage are available.

On March 10 a complex, low-pressure weather system, moving from the lower Mississippi Valley toward the New Jersey–Delaware coast, brought heavy snow to the Mohawk Valley and Adirondacks, and rain to the Southern Tier counties. Discharges of many streams increased considerably, but a new record peak was established at only one New York stream-gaging station, Oquaga Creek at Deposit (table 2). Damage from this flood was minor.

FLOODS OF APRIL 6–10 IN EAST-CENTRAL MISSISSIPPI

After WILSON and ELLISON (1968)

Heavy rains of as much as 12 inches in a 12-hour period fell during the night of April 5–6 in a narrow band in east-central Mississippi, from Stringer, through Waldrup, Paulding, and Enterprise, and on into Alabama near Kewanee. Residents in the Rose Hill–Paulding area reported uniformly intense rain for the entire night. The greatest rainfalls recorded were 11.70 inches at Paulding, and 10.27 inches at Enterprise. The band in which rainfall exceeded 10 inches is estimated to have had a maximum width of about 10 miles in the Rose Hill–Paulding area (fig. 10). The band of 6-inch rainfall was about 25 miles wide in the same area. This rainfall produced unusually high floods on streams draining 20 to 500 square miles. The greatest floods were on Souinlovey, Tallahala, Tallahoma, and Etehoma Creeks, and floods on upper Buckatunna and Sowashee Creeks were somewhat less extreme.

Additional rains fell in the Laurel area from 10 p.m. on April 7 to 7 a.m. on April 8. The reported total at Laurel was 2.26 inches, and at Shubuta, 30 miles northeast, it was 3.72 inches. The rain fell during the initial cresting of Tallahala and Buckatunna Creeks and greatly increased the flood wave as it moved downstream. Isohyetal lines of the April 7–8 rainfall are shown in figure 10.

Peak discharges at gaged sites (fig. 10) where unusual floods occurred are shown in table 5.

Nuakfuppa and East Tallahala Creeks on State Highway 528 (stas. 5 and 4, respectively) near Bay Springs overtopped the highway and crested above their estimated 50-year flood levels. The extreme floods on upper Tallahala and Tallahoma Creeks moved downstream into the Laurel area as a flash flood. Residents, railroads, and businesses had little warning. The peak stage on Tallahala Creek at Interstate Highway 59 (sta. 6) exceeded that of February 1961 by 1 foot. As the crest reached the vicinity of State Highway 15S (sta. 7) near midnight of April 7, almost 3 inches more rain fell. This caused a buildup of the flood wave, which also exceeded that of February 1961 at State Highway 29 near Ellisville (sta. 10). The flood wave decreased as it moved downstream, and at Runnelstown (sta. 11) it was considerably below that of February 1961.

The peak discharge in Sowashee Creek was the maximum in 24 years of record. At the U.S. Highway 45 gage (sta. 15), the peak stage was 1.3 feet higher than that of the flood of February 21, 1961, and the peak discharge was 25 percent greater. This flood caused heavy damage in Meridian.

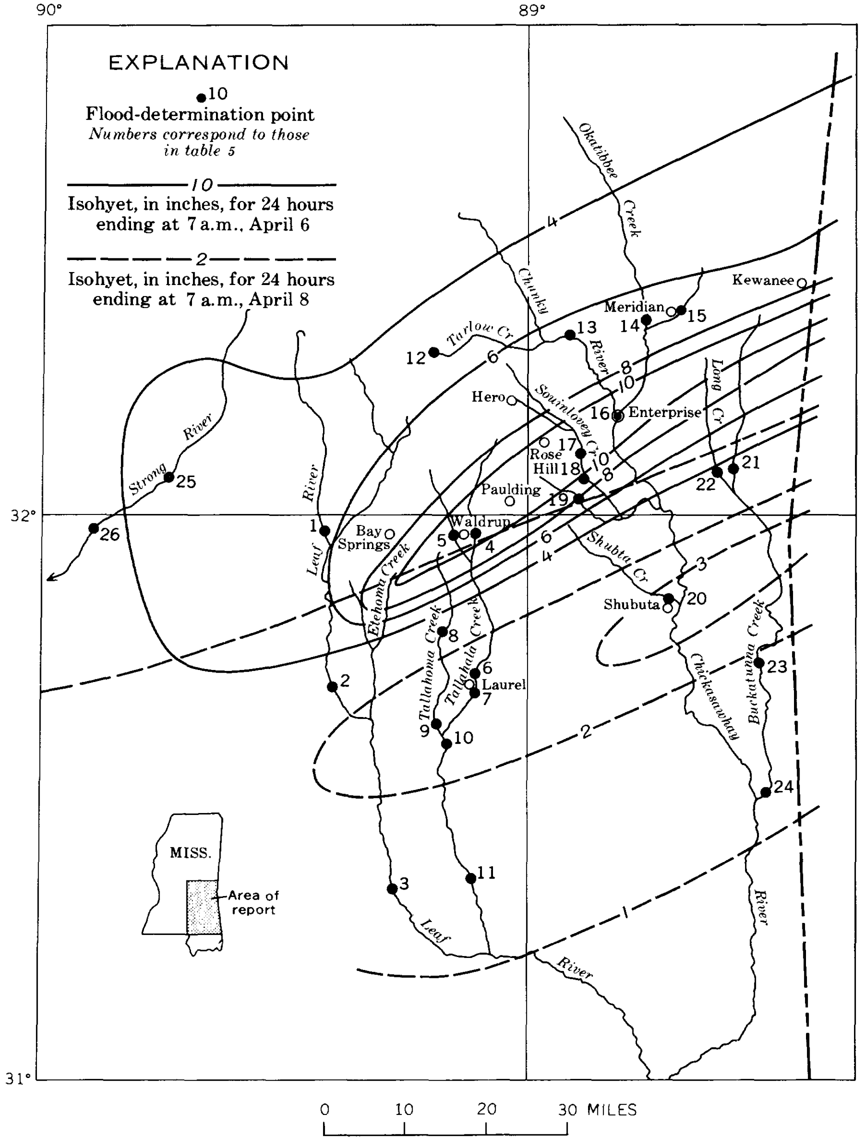

FIGURE 10.—Flood area; location of flood-determination points and isohyets for April 6–8, floods of April 6–10 in east-central Mississippi.

TABLE 5.—*Flood stages and discharges, April 6–10 in east-central Mississippi*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Apr. 1964: Period	Year	Apr. 1964 (date)	Gage height (ft)	Discharge (cfs)
	Pascagoula River basin						
1	Leaf River near Raleigh	143	1940–43, 1957–64	1961		301.93	14,500
					6	299.59	6,600
2	Leaf River near Collins	752	1856	1856		33	(1)
			1939–64	1961		31.85	48,500
					8	26.00	23,000
3	Leaf River at Hattiesburg	1,760	1900	1900		33.6	(1)
			1904–64	1961		31.53	72,200
					10	23.80	29,500
4	East Tallahala Creek near Bay Springs.	100	1961–64	1961		311.61	11,200
					6	313.4	22,000
5	Nuakfuppa Creek near Bay Springs.	25			6	316.48	5,530
6	Tallahala Creek at Interstate 59 at Laurel.	224	1880–1964	1919		233	(1)
			1961	1961		230.5	18,700
					7	231.4	22,600
7	Tallahala Creek at State Highway 15S at Laurel.	233	1880–1964	1919		26	(1)
			1938–64	1961		22.32	19,100
					8	23.13	21,100
8	Tallahoma Creek near Laurel	149	1940–48, 1961–64	1961		248.71	12,600
					7	248.7	12,600
9	Tallahoma Creek at Ellisville	210	1900	1900		206	(1)
			1961–64	1961		203.58	13,600
					8	203.53	13,000
10	Tallahala Creek at Ellisville	466	1900	1900		200	(1)
			1961–64	1961		196.73	27,200
					8	197.41	31,100
11	Tallahala Creek near Runnelstown.	612	1865–1964	1900		30.5	(1)
			1940–64	1961		25.07	32,800
					10	22.88	23,700
12	Tarlow Creek near Newton	15.9	1952–64	1961		18.29	4,300
					6	17.95	3,000
13	Chunky River near Chunky	368	1938–64	1961		25.75	30,800
					7	21.37	12,700
14	Okatibbee Creek near Meridian	239	1938–64	1961		26.14	27,000
					6	22.20	7,120
15	Sowashee Creek at Meridian	51.9	1900–64	1936		[2] 29.5	(1)
			1939–45, 1949–64	1951		[3] 23.09	8,030
					6	20.95	9,530
16	Chickasawhay River at Enterprise.	913	1900	1900		37.2	(1)
			1905–64	1961		37.94	61,700
					8	30.70	27,500
17	Souinlovey Creek near Rose Hill.	104	1961–64	1961		295.79	14,100
					6	297.74	18,400
18	Souinlovey Creek near Pachuta	174	1938	1938		256.2	(1)
			1956–64	1961		255.66	18,500
					7	256.35	20,000
19	Pachuta Creek at Pachuta	23	1938	1938		268.6	(1)
			1949, 1952–64	1961		268.32	6,000
					6	270.91	7,200
20	Shubuta Creek near Shubuta	95	1961	1961		202.8	8,040
					6	204.19	15,000
21	Buckatunna Creek near Sykes	120	1961–64	1961		40.76	9,300
					6	42.1	15,800
22	Long Creek near Quitman	75	1961–64	1961		44.54	5,710
					6	45.7	9,400
23	Buckatunna Creek near Waynesboro.	411	1900	1900		189.0	(1)
			1961–64	1961		186.41	20,500
					9	186.22	20,000
24	Buckatunna Creek near Buckatunna.	600	1938	1938		130.9	(1)
			1961–64	1961		130.0	26,000
					10	126.7	17,000
	Pearl River basin						
25	Strong River near Puckett	260	1950	1950		27.06	19,300
			1955–64	1961		26.35	15,500
					6	25.53	9,300
26	Strong River at Dlo	429	1900	1900		33+	(1)
			1929–64	1950		33.0	24,800
					7	25.55	8,800

[1] Unknown.
[2] At site 0.5 mile upstream; same datum.
[3] At site 0.4 mile upstream; same datum.

The flood on upper Souinlovey Creek was probably the most unusual in the flood area. The new crossing of State Highway 503 near Hero was overtopped, and more than 100 feet of fill was completely removed. The drainage area at that point is about 20 square miles, and the estimated peak discharge greatly exceeded the 50-year flood. At State Highway 504 (sta. 17) the peak stage was 2 feet higher than that of February 1961 and was higher than any other flood of record. At Interstate 59, U.S. Highway 11 (sta. 18), and State Highway 512, the Souinlovey Creek flood exceeded those of February and December 1961, and it was about as high as the historic flood of 1900.

Pachuta Creek at Pachuta (sta. 19), with a drainage area of 23 square miles, had the maximum flood of record which began in 1951. Tarlow Creek near Newton (sta. 12) was not in the area of heaviest rainfall, but its flood was the second greatest since records began in 1951. Shubuta Creek near Shubuta (sta. 20) had a severe flood.

Upper Buckatunna and Long Creeks had severe floods that crested higher than the floods of February 1961 at State Highway 18 (stas. 21 and 22). As the flood wave moved downstream, it began to decrease, but on the night of April 7, about 4 inches of rain fell in the Buckatunna basin near Shubuta. This increased the flood, and at proposed U.S. Highway 84 (sta. 23), it almost equaled that of February 1961. It again began to decrease as it moved south, and at U.S. Highway 45 (sta. 24), it was 3 feet lower than that of the flood of February 1961.

The crest at Chickasawhay River at Enterprise (sta. 16) was moderate because rains in the upper basin probably did not exceed 4 inches. The drainage basin of Chunky River near Chunky (sta. 13) also was north of the heavy rains, and its flood was moderate.

The amount of flood damage was considerable. Hundreds of families in Meridian were driven from their homes on the morning of April 6 by the rising waters of Sowashee Creek. The floodwaters covered hundreds of lawns in heavily populated residential areas on the north side of Sowashee Creek and endangered business areas on the south side, according to local news media. Damage from floodwaters of Gallagher Creek, which flows through much of northern and western Meridian, was reported to have been heavy.

The U.S. Army Corps of Engineers reported that damage amounted to $457,000, and that 2,000 persons were evacuated from Laurel during the flood of April 6–7.

Elevations of floodmarks were determined at many highway, county road, and railroad crossings on the streams most affected by the floods. Floodmarks were surveyed on Etehoma, Tallahala, Tallahoma, Sowashee, Souinlovey, Pachuta, Buckatunna, and Long Creeks. Floodmarks were obtained at most highway and railroad crossings to show differentials in water-surface elevation across fills at the main-channel bridge and at each edge of the valley. Detailed descriptions of floodmarks and permanent reference marks, referenced to mean sea level at most crossings, and historical flood elevations and those corresponding to the 50-year flood on flood profiles at highway and railroad crossings are given in a report by Wilson and Ellison (1968).

FLOODS OF APRIL IN ALABAMA

By Jerald F. McCain

Weather throughout Alabama during the entire month of April was distinguished by numerous thunderstorms, tornadoes, and heavy rainfall, resulting in local flash floods that caused widespread damage. The greatest total monthly rainfall recorded in the State was 18.70 inches at Prattville. The total monthly rainfall of 15.64 inches at Montgomery was the second greatest amount recorded during April for more than 90 years of record. The monthly rainfall of 16.82 inches at Meridian, Miss., near the west-central Alabama border was a record for April.

During the period of April 6–8, several thunderstorms over the central part of the State produced heavy rains. Rainfall amounts of 9 inches or more were recorded along a line from Meridian, Miss., through Montgomery to Auburn. Percipitation for April 6–8 is shown on the isohyetal map (fig. 11). Several rainfall stations reported 7 inches or more on April 6. Pushmataha in west-central Alabama reported 10.10 inches. Other notable rainfall amounts were 7.98 inches at Dayton, 7.63 inches at Marion Junction, and 7.09 inches at Prattville.

The intense rainfall of April 6–8 caused several streams in south-central Alabama to have record-breaking floods (table 6). Tuckabum Creek near Butler (sta. 32) in the western part of the State had a peak discharge on April 6 that was more than five times greater than the previous maximum in a 10-year record. At Uchee Creek near Fort Mitchell (sta. 4), near the Georgia State line, the peak stage on April 9 was 4.5 feet higher than the previous maximum stage in an 18-year record. The peak discharges at Tuckabum Creek and Uchee Creek were 2.31 and 1.65 times the 50-year floods, respectively. The outstanding flood peaks at Alamuchee Creek near Cuba (sta. 30), Kinterbish Creek near York (sta. 31), and Uchee Creek near Seale (sta. 2) were approximately 1.1 times the 50-year flood at each site. The peak discharge at Uphapee Creek near Tuskegee (sta. 19) was the maximum during 25 years of record and has an estimated recurrence interval of 32 years. The April 9 peak stage at Uphapee Creek was about 1 foot lower than the historic 1929 flood peak. Floods of record also occurred at Phelps Creek near Opelika (sta. 3) and Ivy Creek at Mulberry (sta. 22).

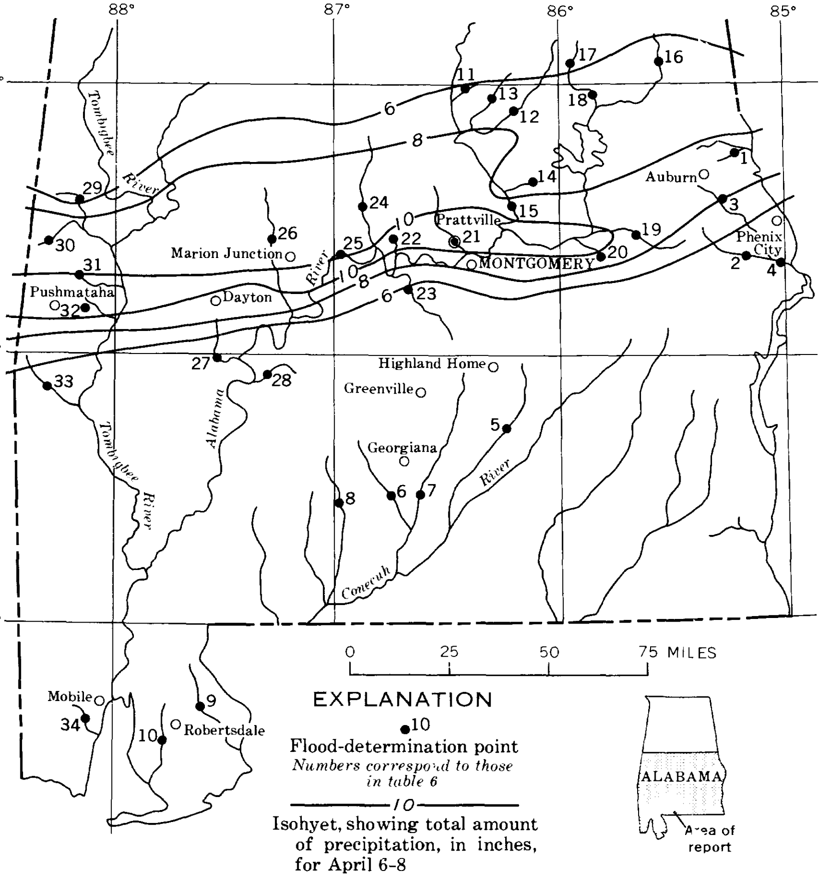

FIGURE 11.—Flood area; location of flood-determination points and isohyets for April 6–8, floods of April in Alabama.

Damage to public facilities in the flood area was reported by the Alabama Civil Defense Department as about $215,000.

Heavy rains fell over most of southern Alabama again or April 27, producing significant floods on many streams. Heaviest rainfall amounts were 9.30 inches at Georgiana, 8.38 inches at Greenville, 7.57 inches at Highland Home, and 7.89 inches at Robertsdale.

Record floods occurred at two gaging stations—Pigeon Creek near Thad (sta. 7) and Montlimar Creek at U.S. Highway 90 at Mobile (sta. 34). The peak discharge at Pigeon Creek was the maximum for 28 years of record. Two other streams in the area of heavy rainfall, Patsaliga Creek at Luverne (sta. 5) and Sepulga River near McKenzie (sta. 6), had peak discharges with estimated recurrence intervals of

TABLE 6.—*Flood stages and discharges, April in Alabama*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Apr. 1964: Period	Maximum floods: Prior to Apr. 1964: Year	Maximum floods: Apr. 1964 (date)	Maximum floods: Gage height (ft)	Maximum floods: Discharge: Cubic feet per second	Maximum floods: Discharge: Recurrence interval (year)
	Apalachicola River basin							
1	Osanippa Creek near Fairfax.	101	1953–64	1961		16.08	12,800	
					8	8.18	3,860	2
2	Uchee Creek near Seale	134	1951–64	1958		13.1	([1])	
					9	14.06	19,500	[2] 1.11
3	Phelps Creek near Opelika.	7.47	1959–64	1961		8.81	690	
					8	9.85	3,090	([1])
4	Uchee Creek near Fort Mitchell.	325	1947–64	1958		22.0	21,100	
					9	26.45	55,100	[2] 1.65
	Escambia River basin							
5	Patsaliga Creek at Luverne.	249	1944–64	1948		16.8	16,700	
					28	16.16	14,500	13
6	Sepulga River near McKenzie.	464	1929	1929		33	([1])	
			1938–64	1938			28,100	
				1961		24.70		
					29	24.34	22,200	12
7	Pigeon Creek near Thad.	296	1929	1929		30	([1])	
			1938–64	1948			17,100	
				1961		27.27		
					29	27.85	17,300	12
8	Murder Creek near Evergreen.	170	1929	1929		26.6	([1])	
			1938–64	1938		16.65		
				1961			22,000	
					27	13.80	10,800	8
	Perdido River basin							
9	Styx River near Loxley	93.2	1926	1926		22.2	([1])	
			1951–64	1953		19.73	14,000	
					27	17.91	7,820	8
	Fish River basin							
10	Fish River near Silver Hill.	55.1	1953–64	1953		17.04	8,570	
					27	15.00	5,470	7
	Mobile River basin							
11	Paint Creek near Marble Valley.	13.5	1959–64	1961		10.78	1,660	
					6	13.49	3,940	([1])
12	Hatchet Creek near Rockford.	244	1944–64	1946		[3] 25.9	22,800	
					6	[3] 23.52	20,700	15
13	Weogufka Creek near Weogufka.	73.6	1951–64	1951		16.8	24,200	
					6	13.62	8,260	7
14	Paterson Creek near Central.	5.1	1954–64	1961		9.10	1,100	
					6	7.82	943	([1])
15	Coosa River at Jordan Dam near Wetumpka.	10,200	1912–14, 1926–64	1938		46.4	[4] 298,000	
					6	37.6	[4] 205,000	
16	Tallapoosa River at Wadley.	1,660	1923–64	1936		[5] 27.9	52,800	
					7	21.50	35,300	2
17	Harbuck Creek near Hackneyville.	6.7	1951–64	1955		8.9	([1])	
			1958–64	1961		6.34	2,170	
					6	7.95	1,950	([1])
18	Hillabee Creek near Hackneyville.	196	1952–64	1957		25.7	15,600	
					6	23.74	12,800	5
19	Uphapee Creek near Tuskegee.	330	1929	1929		29.2	([1])	
			1940–64	1943		27.33	29,600	
					9	28.18	32,200	32
20	Calabee Creek near Tuskegee.	126	1952–64	1961		16.54	14,200	
					9	16.97	17,700	7

See footnotes at end of table.

TABLE 6.—*Flood stages and discharges, April in Alabama*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Apr. 1964: Period	Year	Apr. 1964 (date)	Gage height (ft)	Discharge: Cubic feet per second	Recurrence interval (year)
	Mobile River basin—Continued							
21	Autauga Creek at Prattville.	109	1919	1919		18.8	23,000	
			1939–64	1939		18.35	21,800	
					6	8.38	6,390	3
22	Ivy Creek at Mulberry	10.5	1960–64	1961		14.20	2,120	
					6	15.81	2,440	(1)
23	Big Swamp Creek near Lowndesboro.	247	1940–64	1948		21.3	37,000	
					8	17.93	12,300	2
24	Mulberry Creek at Jones	208	1938–64	1938		33.6	48,000	
					6	18.13	11,600	4
25	Alabama River at Selma	17,100	1899, 1900–13, 1928–64.	1961		57.97	284,000	
					12	53.33	199,000	14
26	Boguechitto Creek near Browns.	104	1944–58, 1960–64	1951		19.0	14,200	
					8	17.51	10,200	7
27	Turkey Creek at Kimbrough.	114	1959–64	1961		25.02	39 600	
					8	18.33	6 210	2
28	Pursley Creek near Camden.	60.2	1951, 1953–64	1961		25.90	11,400	
					8	19.03	6 260	2
29	Sucarnoochee River at Livingston.	606	1939–64	1961		29.35	31,500	
					8	24.44	11,300	2
30	Alamuchee Creek near Cuba.	63	1954–64	1961		18.03	12,000	
					6	18.35	12,700	[2] 1.14
31	Kinterbish Creek near York.	91.4	1954–64	1961		22.23	14 400	
					6	23.0	15 000	[2] 1.11
32	Tuckabum Creek near Butler.	112	1955–64	1961		20.13	6 830	
					6	22.9	35 100	[2] 2.31
33	Okatuppa Creek at Gilbertown.	151	1956–64	1961		(1)	[6] 4 200	
					7	14.50	3 970	2
	Dog River basin							
34	Montlimar Creek at U.S. Highway 90, at Mobile.	8.26	1962–64	1962		5.00	894	
					27	8.60	4,000	(1)

[1] Not determined.
[2] Ratio of peak discharge to 50-yr flood.
[3] Datum in use 1966; 1944–64 datum 1 ft lower.
[4] Regulated.
[5] At site 0.2 mile upstream, at datum 1.46 ft higher.
[6] Daily discharge.

13 and 12 years, respectively. At the Montlimar Creek gaging station, which is equipped with a continuous-recording rain gage, more than 10 inches of rainfall was recorded in a 36-hour period. During one intense burst, 1.9 inches fell in a 15-minute period. (See fig. 12.)

Overtaxed or clogged drainage channels overflowed in several areas of Mobile and the resultant flooding damaged many houses. The city of Mobile estimated the total damage to streets and bridges to be about $60,000. In addition to damage to streets and bridges, an estimated $150,000 would be required to dredge Montlimar Creek, which was partly clogged by sediment from headwater bank erosion.

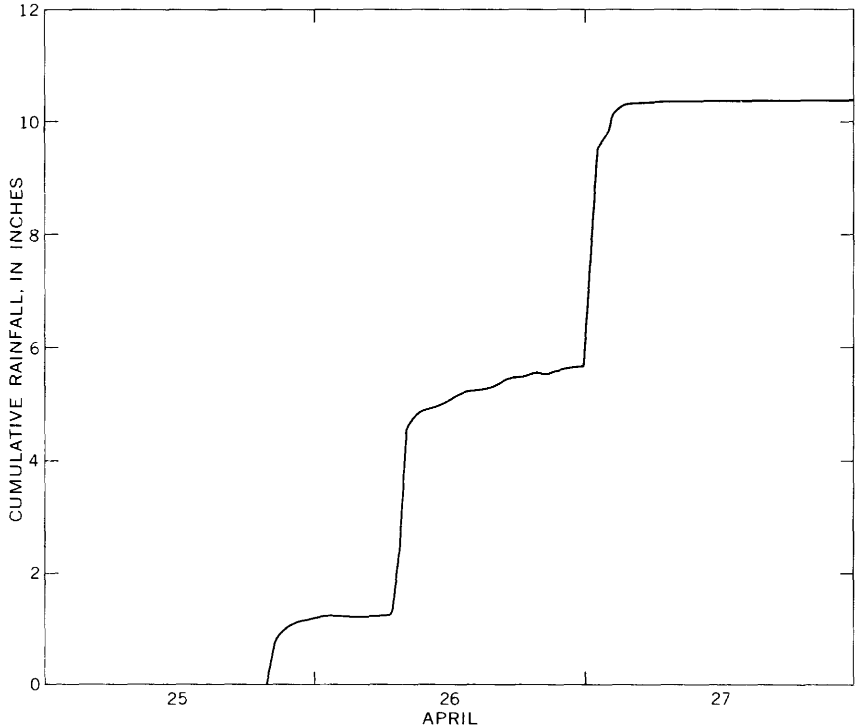

FIGURE 12.—Cumulative rainfall on April 25–27 at Montlimar Creek at U.S. Highway 90 at Mobile, Ala.

FLOODS OF APRIL 18–20 NEAR VILLE PLATTE, LA.

By VERNON B. SAUER

A small area in south-central Louisiana, mainly the northern part of Evangeline Parish, received torrential rains on the night of April 17 and the early morning of April 18. Official U.S. Weather Bureau reports for Ville Platte, a community of about 8,000 persons, indicated that 14.55 inches of rain fell during the 14-hour period from 5 p.m. on April 17 to 7 a.m. on April 18, and a total of 14.61 inches fell during a 16-hour period. This storm produced the third greatest 24-hour precipitation recorded in Louisiana in any April. The real extent of the storm was small, as indicated by rainfall recorded at nearby stations. Eunice, about 15 miles southwest of Ville Platte, received 0.89 inch of rainfall, and Bunkie, about 19 miles north-northeast, received 1.45 inches. As a result, flooding was not extensive, even though some streams in the immediate area rose to record heights. The locations of flood-determination points and precipitation gages are shown in figure 13.

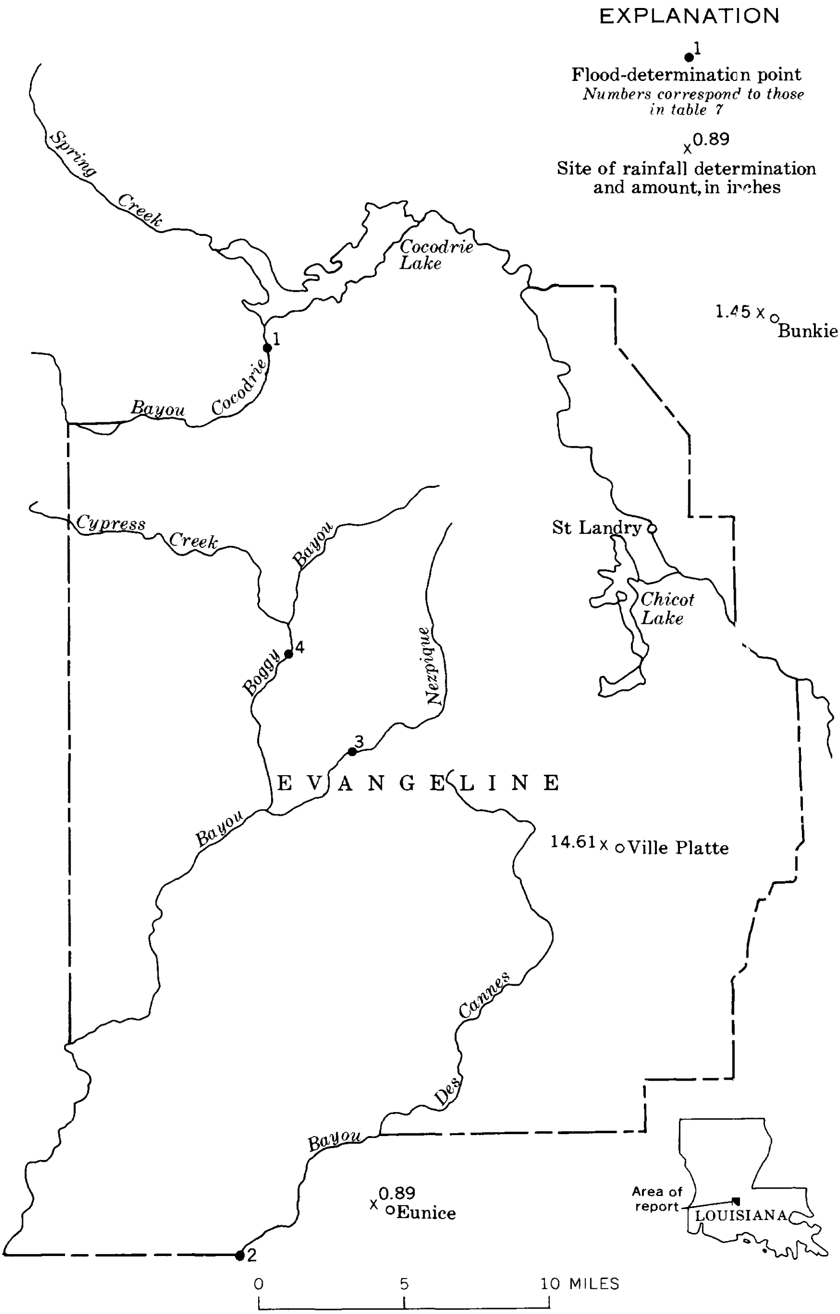

Figure 13.—Flood area; location of flood-determination points and precipitation stations, floods of April 18–20 near Ville Platte, La.

The most outstanding flood occurred at Boggy Bayou, near Pine Prairie (51.3 sq mi), which had a peak discharge of 17,400 cfs, a flood equivalent to 2.3 times the 50-year flood. Peak stages and discharges at gaging stations in the area are given in table 7.

TABLE 7.—*Flood stages and discharges, April 18–20 near Ville Platte, La.*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Apr. 1964: Period	Maximum floods: Prior to Apr. 1964: Year	Apr. 1964 (date)	Gage height (ft)	Discharge: Cubic feet per second	Discharge: Recurrence interval (years)
	Mississippi River Delta							
1	Bayou Cocodrie near Glenmora.	72.1	1954–64	1955		12.50	(1)	
					20	15.54	(1)	
	Mermentau River basin							
2	Bayou des Cannes near Eunice.	131	1938–64	1953		22.36	11,900	
					20	20.70	8,680	8
3	East Fork Bayou Nezpique near Reddell.	40.0	1953–64	1953		18.93	(1)	
					19	17.68	(1)	
4	Boggy Bayou near Pine Prairie.	51.3	1948–58, 1962–64	1953		18.50	16,000	
					19	18.78	17,400	[2] 2.3

[1] Not determined.
[2] Ratio of peak discharge to 50-yr flood.

Flash flooding from local drainage and small streams in or near Ville Platte and St. Landry caused damage to homes and business establishments. Half of Ville Platte was flooded by 4 a.m. on April 18 with water as much as 3 feet deep in some areas. About 250 persons were forced to evacuate their homes in Ville Platte and St. Landry. The deluge resulted in extensive damage to levees in rice fields and to newly planted rice and cotton. Some highways were closed, and some powerlines were down. Lake Chicot, a 2,000 acre-foot reservoir, overflowed during the night of April 18, causing danger to an earth dam near its north end.

FLOODS OF APRIL 20–24 IN CENTRAL INDIANA

By ARCHIE A. MCCOLLAM

Severe flooding occurred in central Indiana on April 20–24 as the result of heavy rains on April 18–22. Precipitation in the flood area ranged from 3 to 7 inches. The isohyetal map (fig. 14) was compiled from U.S. Weather Bureau data.

Peak discharges were great in the upper drainage basins in areas of heavy rainfall (fig. 14). At 10 gaging stations the peak stages equaled or exceeded previous maximums for periods of record ranging from 3 to 40 years. Thirty-eight flood-determination points are listed in table 8. The known recurrence intervals of the flood peaks equaled or exceeded 50 years at five stations, exceeded 25 years at 11 stations, and exceeded 10 years at 21 stations.

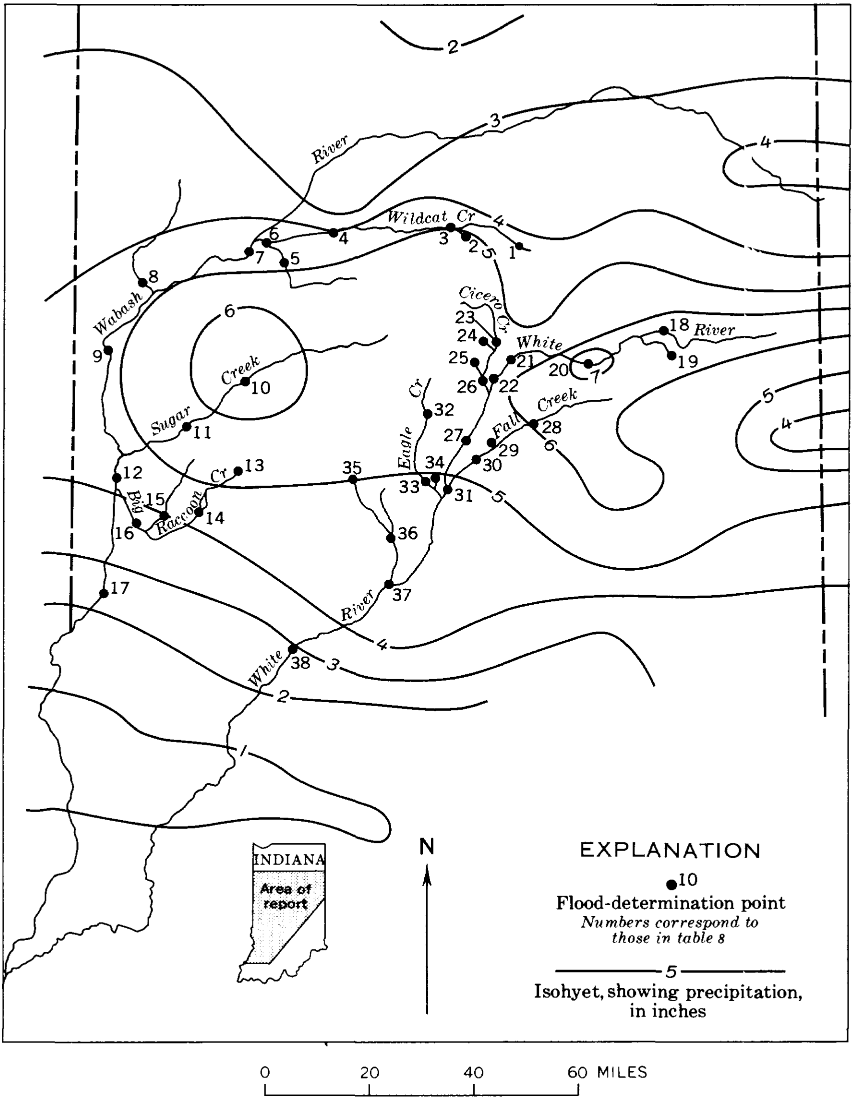

FIGURE 14.—Flood area; location of flood-determination points and isohyets for April 18–22, floods of April 20–24 in central Indiana.

TABLE 8.—*Flood stages and discharges, April 20–24 in central Indiana*

Wabash River basin

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Apr. 1964: Period	Prior to Apr. 1964: Year	Apr. 1964 (date)	Gage height (ft)	Discharge: Cubic feet per second	Discharge: Recurrence interval (years)
1	Wildcat Creek near Jerome.	148	1913	1913		18	(1)	
			1961–64	1962		11.98	3,990	
					20	11.80	4,160	36
2	Kokomo Creek near Kokomo.	24.3	1959–64	1962		[2] 8.63		
				1963			513	
					20	9.88	1,040	(1)
3	Wildcat Creek at Kokomo.	245	1955–64	1959		10.83	8,100	
					21	11.77	6,900	50
4	Wildcat Creek at Owasco.	390	1943–64	1943		14.0	(1)	
				1950		13.3	10,200	
					21	11.75	10,000	25
5	South Fork Wildcat Creek near Lafayette.	246	1943–64	1943		16.8	17,900	
					20	14.64	10,800	22
6	Wildcat Creek near Lafayette.	791	1954–64	1958		21.52	25,000	
					21	18.36	18,300	9
7	Wabash River at Lafayette.	7,247	1901–02, 1904, 1907–64.	1913		32.9	190,000	
					23	20.89	58,300	3
8	Big Pine Creek near Williamsport.	329	1955–64	1959		16.00	12,600	
					20	13.25	7,980	6
9	Wabash River at Covington.	8,208	1913, 1927–64	1913		35.1	200,000	
					24	25.10	62,500	2
10	Sugar Creek at Crawfordsville.	509	1913	1913		17.3	36,000	
			1927, 1937, 1939–64.	1957		14.48	26,300	
					21	13.40	21,800	22
11	Sugar Creek near Byron.	668	1941–64	1957		22.98	32,200	
					21	18.71	24,000	14
12	Wabash River at Montezuma.	11,100	19313	1913		34.0	230,000	
			1925–64	1943		32.83	184,000	
					24	26.43	76,700	2
13	Big Raccoon Creek near Fincastle.	132	1957–64	1957		19.10	39,900	
					21	15.15	11,600	42
14	Big Raccoon Creek at Ferndale.	215	1957–64	1957		19.87	40,500	
					20		[3, 4] 424	
15	Little Raccoon Creek near Catlin.	133	1957–64	1957		18.27	53,400	
					21	14.00	6,600	7
16	Big Raccoon Creek at Coxville.	440	1957–64	1957		21.23	108,000	
					21	14.55	[4] 13,100	
17	Wabash River at Terre Haute.	12,200	1828, 1858, 1867, 1875, 1883, 1892–97, 1902–64.	1913		31.1	245,000	
					25	24.39	82,400	3
18	White River at Muncie.	242	1904, 1913, 1924–29, 1931–64.	1913		22.6	20,000	
					21	14.98	14,300	42
19	Buck Creek near Muncie.	36.7	1955–64	1959		12.64	1,7[illegible]0	
					21	13.96	1,780	3
20	White River at Anderson.	401	1904, 1911–64	1913		23.6	28,000	
					21	19.41	18,700	24
21	White River near Noblesville.	814	1914–64	1927			27,200	
				1958		16.35		
					22	16.35	26,600	13
22	White River at Noblesville.	837	1913	1913		23.8	(1)	
			1947–64	1958		20.55	24,000	
					22	21.31	26,800	10
23	Cicero Creek near Arcadia.	131	1937	1937		15.6	(1)	
			1955–64	1957		11.86	6,720	
					21	10.65	3,680	7
24	Little Cicero Creek near Arcadia.	44.7	1956–64	1957		8.69	3,980	
					20	7.63	2,210	(1)
25	Hinkle Creek near Cicero.	16.3	1956–64	1957		8.45	4,920	
					20	7.80	3,290	(1)
26	Cicero Creek at Noblesville.	219	1913	1913		19.5	(1)	
			1951–64	1957		15.26	9,800	
					20	14.50	7,800	20
27	White River near Nora	1,200	1913, 1926, 1930–64.	1913		22.4	58.500	
					23	18.65	30,400	30

See footnotes at end of table.

TABLE 8.—*Flood stages and discharges, April 20–24 in central Indiana*—Continued

Wabash River basin—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Apr. 1964: Period	Prior to Apr. 1964: Year	Apr. 1964 (date)	Gage height (ft)	Discharge: Cubic feet per second	Discharge: Recurrence interval (years)
28	Fall Creek near Fortville.	172	1913	1913		12	(1)	
			1942–64	1943		9.77	8,240	
					21	9.88	8,750	[5] 1.09
29	Mud Creek at Indianapolis.	42.5	1958–64	1963		8.05	1,600	
					21	8.37	2,010	(1)
30	Fall Creek at Millersville.	313	1913, 1926, 1930–64.	1913		16.3	22,000	
					21	12.78	10,100	20
31	White River at Indianapolis.	1,627	1904–06, 1912–64	1913		30.0	70,000	
					22	19.88	35,600	23
32	Eagle Creek at Zionsville.	102	1957	1957		19.20	(1)	
			1958–64	1958		13.22	9,100	
					20	14.64	12,400	[5] 1.17
33	Eagle Creek at Indianapolis.	179	1913, 1938–64	1957		16.38	28,800	
					21	11.05	14,700	[5] 1.21
34	Little Eagle Creek at Speedway.	18.6	1960–64	1961		7.44	1,940	
					21	7.31	1,880	(1)
35	West Fork White Lick Creek at Danville.	28.9	1957–64	1957		16.0	6,660	
					21	8.77	2,170	(1)
36	White Lick Creek at Mooresville.	212	1957–64	1963		22.95	18,000	
					20	20.94	13,600	50
37	White River near Centerton.	2,435	1913	1913		(1)	90,000	
			1926–32, 1947–64	1950		17.2	43,000	
					22	17.57	50,500	
38	White River at Spencer.	2,980	1913, 1926–46	1913		28.5	100,000	
					23	23.33	48,900	14

[1] Not determined.
[2] Affected by ice backwater.
[3] Daily discharge.
[4] Regulated by reservoir.
[5] Ratio of peak discharge to 50-yr flood.

At least one life was lost as a result of the floods, and many families were evacuated from their homes. Widespread damage occurred to levees, bridges, utilities, homes, and personal possessions. Damage in Delaware, Henry, and Madison Counties was more than $1.3 million, according to Civil Defense officials.

FLOODS OF APRIL 25–28 IN SOUTHERN MISSISSIPPI

After WILSON and ELLISON (1968)

Moderate to heavy rains fell over all of Mississippi on April 24–27. The rains were especially heavy along the coast, where a total of 12.01 inches fell at Gulfport in the 3-day period. At Gulfport, 11.69 inches fell in the 29 hours from April 26 (1 a.m.) to April 27 (6 a.m.). A total of 10.85 inches was reported to have fallen in 24 hours at Bay St. Louis, which is a record 24-hour rainfall for any April in the coastal area of Mississippi. An isohyetal map of southern Mississippi (fig. 15) shows that the rainfall diminished rapidly northward from the coast, with only about 4 inches of rainfall recorded 50 miles north of Gulfport.

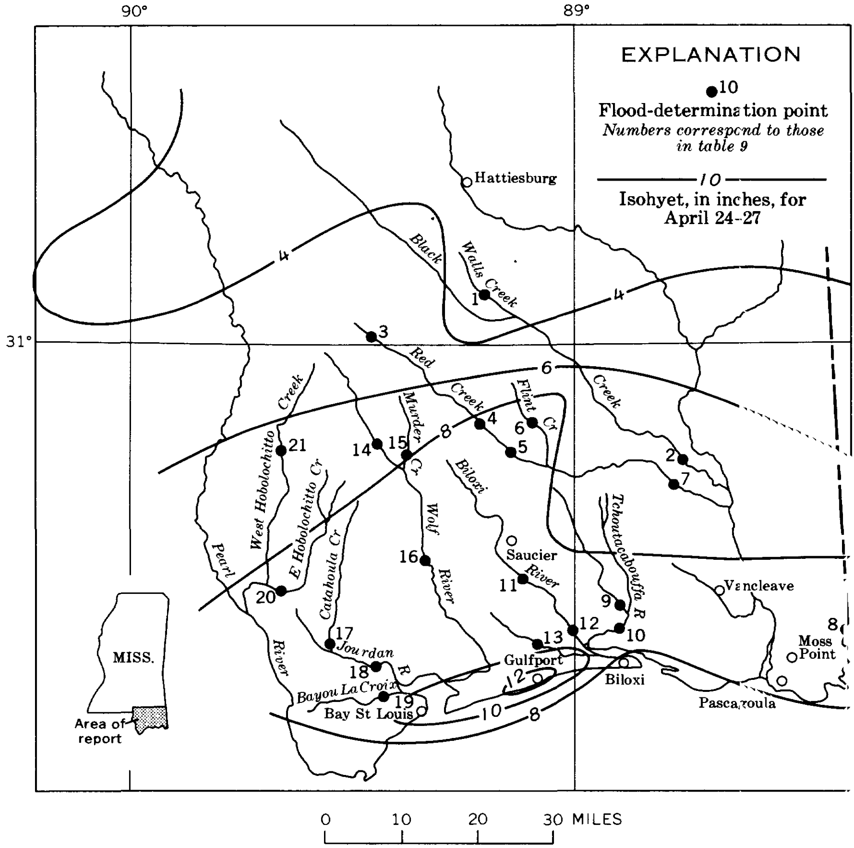

FIGURE 15.—Flood area; location of flood-determination points and isohyets for April 24–27, floods of April 25–28 in southern Mississippi.

The rains caused major flooding on small streams in the coastal area and on the lower reaches of the larger streams draining into the gulf. According to local news media, the low-lying areas in Gulfport were covered with water, and approximately 2,000 persons in the Gulfport-Biloxi area were evacuated from their homes. Brickyard Bayou, a primary drainage outlet in Gulfport, flooded and backed water into homes in the western section of the city. Some areas in Bayou View were flooded by the water from both Brickyard Bayou and Bayou Bernard.

Several highways in the coastal area were overtopped by the floodwater. Bluff Creek crested only 1.0 foot below the peak of the record flood of September 1957, and its water overtopped State Highway 57 by about 3 feet at Vancleve. U. S. Highway 90 was overtopped in several places between Biloxi and the Mississippi-Alabama State line.

Peak stages and discharges at 21 selected sites (fig. 15) in the areas of heavy rainfall are listed in table 9.

TABLE 9.—*Flood stages and discharges, April 25–28 in southern Mississippi*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Apr. 1964, Period	Prior to Apr. 1964, Year	Apr. 1964 (date)	Gage height (ft)	Discharge (cfs)
	Pascagoula River basin						
1	Walls Creek near Brooklyn	22.3	1951–64	1959		98.16	6,000
					26	95.00	2,500
2	Black Creek near Benndale	760	1949, 1959–64	1949		41.7	32,000
					26	37.84	13,500
3	Red Creek at Lumberton	15.6	1951–64	1961		98.7	3,500
					26	95.16	850
4	Red Creek near Wiggins	168	1850–1964	1916		(1)	(2)
			1952–64	1961		148.82	17,000
					26	146.51	10,300
5	Red Creek near Perkinston	218	1952–64	1960		118.7	14,000
					27	119.82	16,500
6	Flint Creek near Wiggins	24.8	1948, 1953–54, 1957–64.	1957		16.17	3,320
					27	16.39	3,670
7	Red Creek near Vestry	416	1958–64	1961		18.56	21,500
					28	18.78	20,200
8	Franklin Creek near Grand Bay, Ala.	16.4	1959–64	1961		16.54	2,750
					26	16.08	1,920
	Tchoutacabouffa River basin						
9	Tuxachanie Creek near Biloxi	92.4	1907–09	1907–09		23	(2)
			1952–64	1957		22.22	17,700
					27	19.72	11,200
10	Tchoutacabouffa River near Biloxi.	220	1957–64	1957		13.08	36,000
					27	10.40	26,400
	Biloxi River basin						
11	Biloxi River at Wortham	98.3	1948	1948		22.3	(2)
			1952–64	1957		21.08	7,740
					27	20.94	8,420
12	Biloxi River at Lorraine	264	1957–64	1957		9.03	35,000
					27,28	7.09	23,400
	Bayou Bernard basin						
13	Bayou Bernard near Landon	30.0	1957–64	1957		16.5	9,900
					27	12.11	5,900
	Wolf River basin						
14	Wolf River near Poplarville	71	1952–64	1961		193.42	12,800
					26	188.68	3,800
15	Murder Creek near Poplarville	21.6	1952–64	1961		19.20	7,000
					26	16.56	2,900
16	Wolf River near Lyman	253	1945–48	1947		22.1	18,500
					27	21.9	20,000
	Jourdan River basin						
17	Catahoula Creek near Santa Rosa.	155	1961–64	1961		21.5	(2)
			1962–64	1964		19.36	4,360
					27	25.05	16,600
18	Jourdan River near Bay St. Louis.	215	1916	1916		13.7	(2)
			1959–64	1961		7.85	26,300
					27	7.43	22,400
19	Bayou La Croix near Clearmont Harbor.	43	1959–64	1961		23.65	2,900
					27	23.90	3,200

See footnotes at end of table.

TABLE 9.—*Flood stages and discharges, April 25–28 in southern Mississippi*—Con.

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods				
			Prior to Apr. 1964		Apr. 1964 (date)	Gage height (ft)	Discharge (cfs)
			Period	Year			
	Pearl River basin						
20	East Hobolochitto Creek at Picayune.	108	1956–64	1961		87.54	6,800
					26	88.58	8,000
21	West Hobolochitto Creek near Poplarville.	92	1928–64	1961		133.89	19,900
					26	129.82	6,000

[1] Between 152.5 ft and 153.5 ft.
[2] Unknown.

The lower reaches of the Jourdan, Biloxi, and Tchoutacabouffa Rivers had severe flooding, and the smaller gaged streams, such as Bayou La Croix (sta. 19), Bayou Bernard (sta. 13), and Franklin Creek (sta. 8), had floods of much less severity. The heavy rainfall diminished north of the coastal area, and Catahoula Creek (sta. 17) had only a moderate flood.

The flood on Red Creek was minor near its headwaters at Lumberton (sta. 3), but it grew progressively more severe in the lower reaches, and when it reached Perkinston (sta. 5), it had the greatest peak discharge in the period of record, which began in 1952.

FLOODS OF APRIL 25–MAY 3 IN NORTHERN FLORIDA AND SOUTHERN GEORGIA

By JAMES W. RABON

Heavy general rains fell over the panhandle and northern peninsula of Florida and in southern Georgia during late April and early May. These rains caused significant flooding on many streams, principally those draining basins of less than 500 square miles.

Streamflow preceding the storms was considerably above normal in the entire area. In the panhandle of Florida, streamflow for the first half of the water year (October 1963–March 1964) was 20 percent above normal for Econfina Creek near Bennett (sta. 45), 65 percent above normal for Shoal River near Crestview (sta. 54), and three times normal for Ochlockonee River near Havana (sta. 39). (See fig. 16.)

The excess of runoff above normal ranged from 5.8 inches for Econfina Creek near Bennett to 9.4 inches for Ochlockonee River near Havana. In the northern peninsula, streamflow for the preceding 6 months ranged from 2¾ times normal for North Fork Black Creek near Middleburg (sta. 11) to five times normal for St. Marys River near Macclenny (sta. 5). The excess of runoff above normal ranged from 6.7 inches for North Fork Black Creek to 9.1 inches for St. Marys River.

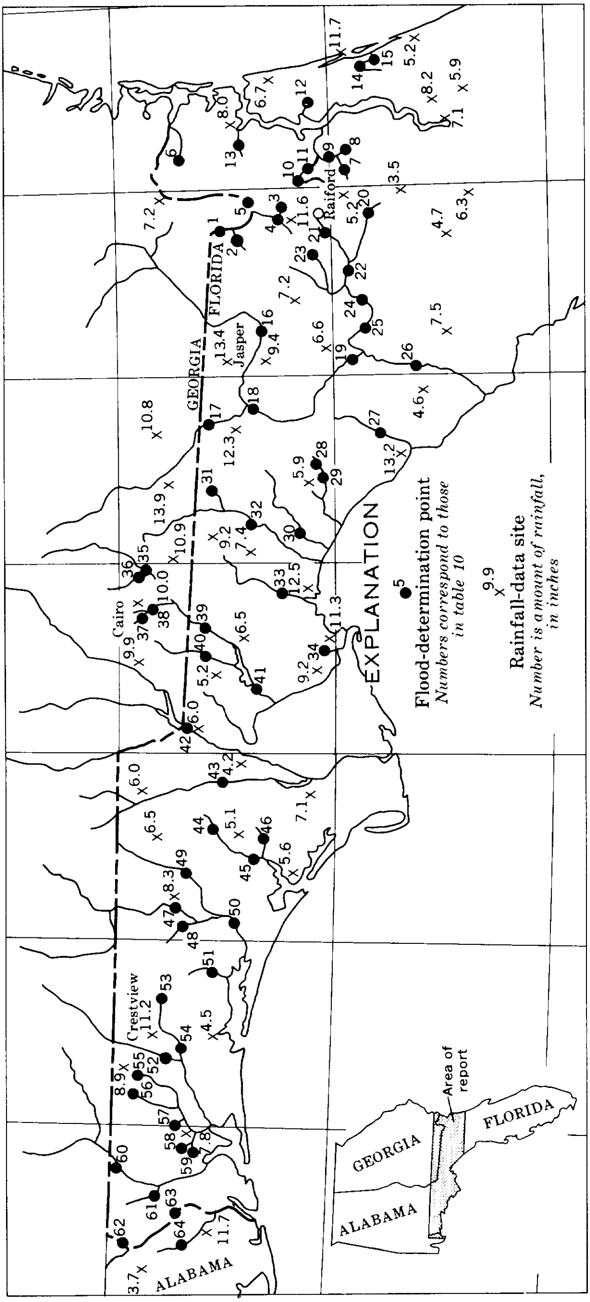

Figure 16.—Flood area; location of flood-determination points and total rainfall, April 25–May 3, floods of April 25–May 3 in northern Florida and southern Georgia.

The greatest amounts of rainfall in the panhandle area cf Florida occurred April 26–28. The greatest 1-day rainfall (9.01 in.) occurred at the Crestview weather station on April 27, and total rainfall for the period April 25–May 3 was 11.16 inches. A total of less than half an inch was measured on 7 of the 9 days. At Cairo, Ga., in the headwaters of the Ochlockonee River, 3.80 inches rainfall was measured on April 27 and 4.92 inches on May 2. Total rainfall measured at this station for the 9-day flood period was 9.97 inches. In the northern peninsula, the greatest 1-day rainfall, 7.03 inches, occurred on May 2 at the Jasper weather station, and 6.41 inches fell at the Glen St. Mary station. Total rainfall amounts for the flood period at these two stations were 13.37 inches and 11.61 inches, respectively. Figure 17 shows the rainfall depth-duration curve for the recording-gage weather station at Raiford State Prison.

Maximum discharges of record occurred at three gaging stations in the St. Marys River basin, where the peak discharges at Turkey Creek at Macclenny (sta. 3) and South Prong St. Marys River at Glen St. Mary (sta. 4) slightly exceeded those for 50-year floods (table 10).

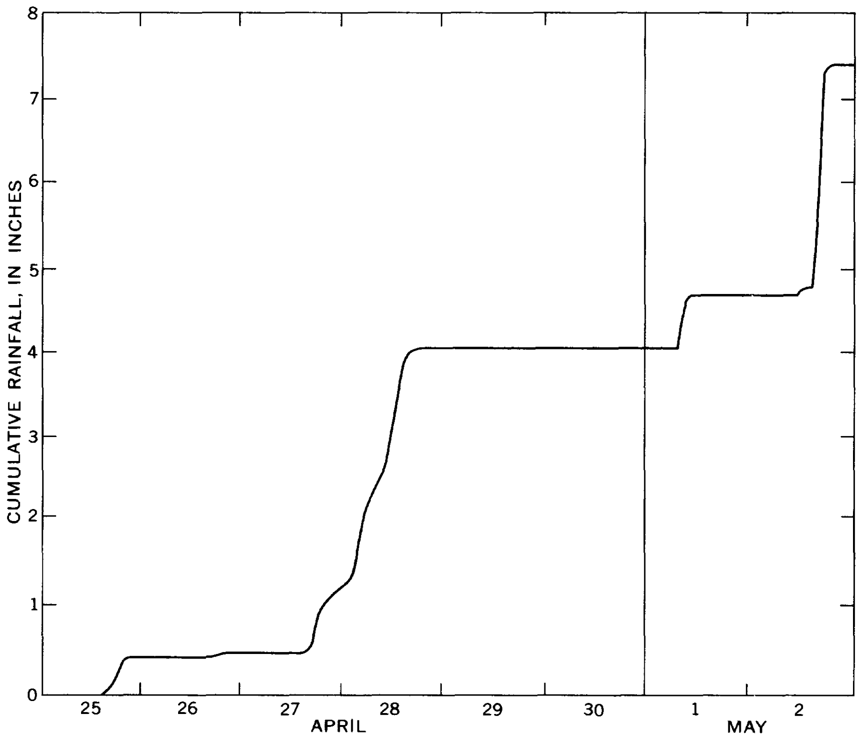

FIGURE 17.—Cumulative rainfall, April 25–May 2 at Raiford State Prison weather station, Florida.

In the St. Johns River basin, three crest-stage partial-record stations had peak discharges that were maximums in short periods of record. The peak discharge at one of these stations (Yellow Water Creek near Maxville, sta. 10) exceeded that for a 50-year flood. At one coastal-basin station, Moultrie Creek near St. Augustine (sta. 15), the peak discharge was about 16 percent greater than that for a 50-year flood. Peak discharges of streams in the Suwannee River basin were generally less than those for 10-year floods.

TABLE 10.—*Flood stages and discharges, April–May in northern Florida and southern Georgia*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Apr. 1964: Period	Maximum floods: Prior to Apr. 1964: Year	Maximum floods: Apr.–May 1964 (date)	Maximum floods: Gage height (ft)	Maximum floods: Discharge: Cubic feet per second	Maximum floods: Discharge: Recurrence interval (years)
	St. Marys River basin							
1	North Prong St. Marys River at Moniac, Ga.	160	1921–23, 1927–34, 1951–64.	1928		[1] 16.7	[1] 6,060	
					May 3, 4	15.41	2,760	4
2	Middle Prong St. Marys River at Taylor, Fla.	127	1955–64	1958		12.0	1,790	
					May 3	13.96	3,590	13
3	Turkey Creek at Macclenny, Fla.	20.9	1955–64	1963		7.10	1,270	
					May 2	8.40	2,600	[2] 1.04
4	South Prong St. Marys River at Glen St. Mary, Fla.	150	1947	1947		13.0	6,000	
			1950–64	1950		12.71	6,200	
					May 3	13.26	6,340	[2] 1.11
5	St. Marys River near Macclenny, Fla.	720	1926–64	1947		22.29	[1] 28,100	
					May 4	20.72	16,500	13
6	Little St. Marys River near Hilliard, Fla.	18.1	1961–64	1962		6.03	768	
					May	5.58	521	7
	St. Johns River basin							
7	South Fork Black Creek near Camp Blanding, Fla.	34.8	1958–64	1959		11.24	3,240	
					May	7.68	697	1
8	Greens Creek near Penney Farms, Fla.	14.9	1958–64	1960		6.00	1,360	
					May	5.20	900	5
9	South Fork Black Creek near Penney Farms, Fla.	134	1939–64	1944		26.33	13,900	
					May 3	16.48	3,090	2
10	Yellow Water Creek near Maxville, Fla.	25.7	1958–64	1963		8.64	1,000	
					May 3	10.55	3,220	[2] 1.10
11	North Fork Black Creek near Middleburg, Fla.	174	1919	1919		25.3	15,000	
			1931–64	1944		23.76	10,400	
					May 3	23.91	12,600	18
12	Durbin Creek near Durbin, Fla.	36.7	1961–64	1963		5.45	332	
					May	8.66	1,350	22
13	Trout River at Dinsmore, Fla.	20	1961–64	1963		7.18	522	
					May	7.41	564	7
	Coastal basins between St. Johns River and Lake Okeechobee and the Everglades							
14	Moultrie Creek at State Highway 207, near St. Augustine, Fla.	22.1	1961–64	1963		8.47	682	
					May 3	8.77	766	([3])
15	Moultrie Creek near St. Augustine, Fla.	23.3	1939–64	1941		9.31	1,370	
					May 3	8.73	1,280	[2] 1.16

See footnotes at end of table.

TABLE 10.—*Flood stages and discharges, April–May in northern Florida and southern Georgia*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Apr. 1964: Period	Year	Apr.-May 1964 (date)	Gage height (ft)	Discharge: Cubic feet per second	Recurrence interval (years)
	Suwannee River basin							
16	Suwannee River at White Springs, Fla.	1,990	1927–64	1948		36.65	28,500	
					May 5	31.52	13,500	5
17	Withlacoochee River near Pinetta, Fla.	2,220	1928–64	1948		38.64	79,400	
					May 7	33.01	21,600	5
18	Suwannee River at Ellaville, Fla.	6,580	1927–64	1948		40.88	95,300	
					May 11	29.67	33,800	8
19	Suwannee River at Branford, Fla.	7,090	1931–64	1948		34.07	83,900	
					May 15	25.29	28,600	7
20	Santa Fe River near Graham, Fla.	135	1957–64	1959		13.39	1,120	
					May 6	6.80	98	([3])
21	New River near Lake Butler, Fla.	212	1950–64	1950		12.02	6,470	
					May 4	11.61	5,190	10
22	Santa Fe River at Worthington, Fla.	630	1931–64	1934			[1] 17,500	
				1944		24.94		
					May 6	19.84	4,960	2
23	Swift Creek near Lake Butler, Fla.	27	1957–64	1960		8.61	913	
					May	6.89	442	([3])
24	Santa Fe River near High Springs, Fla.	950	1931–64	1948		15.71	12,700	
					May 8, 9	6.08	2,820	2
25	Santa Fe River near Fort White, Fla.	1,080	1927–29,	1948			12,300	
			1932–64.	1948		[4] 13.70		
					May 9		3,170	2
26	Suwanee River near Wilcox, Fla.	9,500	1930–31, 1941–64.	1948		22.32	84,700	
					May 18	13.04	29,300	5
	Steinhatchee River basin							
27	Steinhatchee River near Cross City, Fla.	350	1950–64	1957		15.84	4,320	
					May 3	12.90	1,760	1
	Coastal basins between Steinhatchee River and Aucilla River							
28	Fenholloway River near Foley, Fla.	70	1955–64	1957		14.08	1,620	
					Apr. 29	10.75	465	1
29	Fenholloway River at Foley, Fla.	80	1946–64	1948		16.03	2,640	
					May 1	14.34	797	2
30	Econfina River near Perry, Fla.	192	1950–61	1957		12.78	2,540	
					May 2	10.99	866	2
	Aucilla River basin							
31	Little Aucilla River near Greenville, Fla.	20	1963					
					May 6	5.72	765	([3])
32	Aucilla River at Lamont, Fla.	680	1950–64	1957		14.93	6,580	
					May 8	13.29	5,860	([3])
	Coastal basins between Aucilla River and Ochlockonee River							
33	St. Marks River near Newport, Fla.	540	1956–64	1957		10.01	4,010	
					May 2	6.76	1,530	([3])
34	Sopchoppy River near Sopchoppy, Fla.	104	1961–64	1962		19.90	2,980	
					May 2	14.68	1,730	2
35	Ochlockonee River near Thomasville, Ga.	550	1937–64	1948		29.1	72,000	
					May 3	18.8	14,800	11
36	Barnetts Creek near Thomasville, Ga.	104	1951–64	1959		16.8	10,400	
					May 3	19.04	14,600	[2] 1.45
37	Wolf Creek near Whigham, Ga.	19	1929–64	1948		15	([3])	
			1951–64	1959		8.2	2,000	
					May 2	9.32	3,720	27

See footnotes at end of table.

TABLE 10.—*Flood stages and discharges, April–May in northern Florida and southern Georgia*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Apr. 1964: Period	Maximum floods: Prior to Apr. 1964: Year	Maximum floods: Apr.–May 1964 (date)	Maximum floods: Gage height (ft)	Maximum floods: Discharge: Cubic feet per second	Maximum floods: Discharge: Recurrence interval (years)
	Coastal basins between Aucilla River and Ochlockonee River—Continued							
38	Tired Creek near Cairo, Ga.	60	1943–64	1948		16.3	28,100	
					May 2	13.0	14,600	[2] 1.93
39	Ochlockonee River near Havana, Fla.	1,020	1926–64	1948		35.08	55,900	
					May 5	30.11	17,400	8
40	Little River near Quincy, Fla.	250	1950–64	1960		20.45	23,200	
					May 3	15.13	6,660	5
41	Ochlockonee River near Bloxham, Fla.	1,660	1926–64	1948		28.50	50,200	
				1957		32.64	[5] 55,000	
					May 6	21.94	17,900	([3])
	Apalachicola River basin							
42	Apalachicola River at Chattahoochee, Fla.	17,100	1928–64	1929		38.97	293,000	
					May 6	27.04	111,000	3
43	Chipola River near Altha, Fla.	781	1912–13, 1921–27, 1929–31, 1943–64.	1926		33.55	25,000	
					May 7	26.05	8,960	6
	Econfina Creek basin							
44	Econfina Creek near Compass Lake, Fla.	40.5	1962–64	1962		11.58	1,050	
					May 3	7.67	474	2
45	Econfina Creek near Bennett, Fla.	122	1935–64	1948		12.46	4,860	
					Apr. 28	8.05	1,090	1
46	Bear Creek near Youngstown, Fla.	67.2	1962–64	1963		12.68	2,260	
					Apr. 28	11.12	1,360	7
	Choctawhatchee River basin							
47	Choctawhatchee River at Caryville, Fla.	3,499	1929–64	1929		27.1	206,000	
					May 4	13.52	33,200	2
48	Sandy Creek at Ponce de Leon, Fla.	115	1961–64	1962		10.94	3,910	
					Apr. 28	14.21	9,120	[2] 1.07
49	Holmes Creek at Vernon, Fla.	386	1950–64	1960		23.35	10,900	
					Apr. 30	21.12	8,120	32
50	Choctawhatchee River near Bruce, Fla.	4,384	1929–64	1929		[1] 25.0	[1] 220,000	
					May 2	13.11	40,900	3
	Coastal basins between Choctawhatchee River and Yellow River							
51	Alaqua Creek near De Funiak Springs, Fla.	65.6	1951–64	1953		18.47	9,020	
					Apr. 28	16.15	2,020	2
	Yellow River basin							
52	Yellow River at Milligan, Fla.	624	1929	1929		26.2	([3])	
			1938–64	1953		15.13	28,000	
					Apr. 30	10.51	8,830	2
53	Shoal River near Mossy Head, Fla.	123	1951–64	1953		21.86	8,690	
					Apr. 27	23.64	10,500	[2] 1.08
54	Shoal River near Crestview, Fla.	474	1938–64	1940		14.26	12,700	
					Apr. 29	12.11	15,300	10

See footnotes at end of table.

TABLE 10.—*Flood stages and discharges, April–May in northern Florida and southern Georgia*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Apr. 1964: Period	Maximum floods: Prior to Apr. 1964: Year	Maximum floods: Apr.-May 1964 (date)	Maximum floods: Gage height (ft)	Maximum floods: Discharge: Cubic feet per second	Maximum floods: Discharge: Recurrence interval (years)
	Blackwater River basin							
55	Blackwater River near	205	1950-64	1953		20.80	17,200	
	Baker, Fla.				Apr. 28	15.56	5,760	2
56	Big Juniper Creek near	36	1958-64	1961		12.34	3,900	
	Munson, Fla.				Apr. 27	10.14	1,850	2
57	Big Coldwater Creek	237	1938-64	1939		17.33	23,100	
	near Milton, Fla.				Apr. 28	12.12	9,240	3
58	Pond Creek near	58.7	1958-64	1960		11.52	3,380	
	Milton, Fla.				Apr. 27	9.75	1,940	1
59	Hurricane Branch near	2.95	1960-64	1961		4.60	272	
	Milton, Fla.				Apr. 27	5.69	1,680	(3)
	Escambia River basin							
60	Escambia River near	3,817	1929-64	1929		37.8	315,000	
	Century, Fla.				May 4	18.92	49,500	3
61	Pine Barron Creek	75.3	1952-64	1955		18.0	24,800	
	near Barth, Fla.				Apr. 27	15.08	7,980	11
	Perdido River basin							
62	Brushy Creek near	49	1958-64	1962		14.96	9,680	
	Walnut Hill, Fla.				Apr. 27	11.37	2,620	2
63	Perdido River at	394	1929	1929		25.7	(3)	
	Barrineau Park, Fla.		1941-64	1955		23.94	39,000	
					Apr. 28	16.30	10,600	3
64	Styx River near	93.2	1926	1926		22.2	(3)	
	Loxley, Ala.		1951-64	1953		19.73	14,000	
					Apr. 27	17.91	7,820	8

1 At different site or datum.
2 Ratio of peak discharge to 50-yr. flood.
3 Not determined.
4 Affected by backwater.
5 Affected by dam failure upstream.

Peak discharges at seven gaging stations in the panhandle area are of special interest. At three stations in the upper Ochlockonee River basin in Georgia, peak discharges were the greatest since the record floods of 1948. At two of these three stations, Barnetts Creek near Thomasville (sta. 36) and Tired Creek near Cairo (sta. 38), peak discharges were about 1.5 to 2 times those for 50-year floods. Outstanding floods occurred on two streams in the Choctawhatchee River basin. Sandy Creek at Ponce de Leon (sta. 48) had a peak discharge slightly exceeding that for a 50-year flood, and Holmes Creek at Vernon (sta. 49) had a 32-year flood. The maximum discharge of record occurred on Shoal River near Mossy Head (sta. 53) and was about 8 percent greater than that for a 50-year flood. Hurricane Branch near Milton (sta. 59), a crest-stage partial-record station draining only 2.95 square miles, had a peak discharge of 569 cfs per sq mi (cubic feet per second per square mile). The frequency of this flood has not been determined.

Damage from rains and flooding were light.

FLOOD OF APRIL 26–27 NEAR BILLINGS, MONT.

By MELVIN V. JOHNSON

Intense rainfall on April 25–26 caused local flooding in the Pryor Creek basin, southeast of Billings, Mont. (fig. 18). Precipitation at the U.S. Weather Bureau station at Pryor was 2.20 inches on April 25 and 2.44 inches on April 26.

Peak stages and discharges, determined by indirect measurements, of the April 26–27 flood are compared with stages and discharges from prior maximum know floods in table 11.

TABLE 11.—*Flood stages and discharges, April 26–27 in Pryor Creek basin, near Billings, Mont.*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Apr. 1964: Period	Maximum floods: Prior to Apr. 1964: Year	Maximum floods: Apr. 1964 (date)	Maximum floods: Gage height (ft)	Maximum floods: Discharge: Cubic feet per second	Maximum floods: Discharge: Recurrence interval (years)
1	Wets Creek near Billings	8.14	1955–64	1963		2.7	125	
					26	6.9	565	25
2	West Buckeye Creek near Billings.	1.54	1955–64	1957		[1] 1.81	185	
					26	4.48	215	25
3	Pryor Creek near Billings.	435	1912–24, 1938–64	1960		9.9	1,700	
					26	15.04	3,720	[2] 1.1
4	Pryor Creek at Huntley	606	1904–16	1905		16.0	2,300	
					27		3,860	50

[1] At site 2,000 ft downstream.
[2] Ratio of peak discharge to 50-yr flood.

The peak discharges from this storm were relatively large. The recurrence interval for the peak discharge on each of the tributaries to Pryor Creek was 25 years, and that for each of the two stations on Pryor Creek was about 50 years.

Flood damage was estimated by the U.S. Weather Bureau to be more than $100,000. A mainline railroad bridge at Huntley was destroyed by the flood.

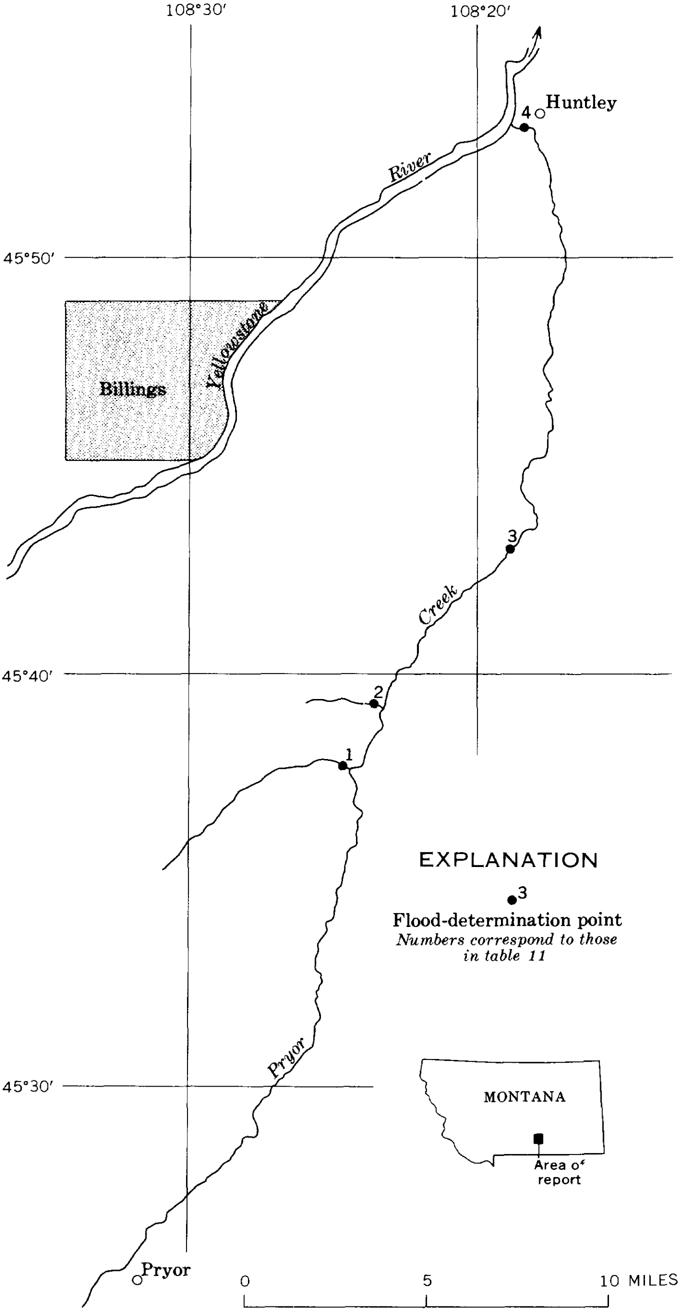

FIGURE 18.—Flood area; location of flood-determination points, floods of April 26–27 near Billings, Mont.

FLOODS OF MAY AND JUNE IN NEBRASKA

By H. D. Brice

Severe flooding in parts of Nance County in east-central Nebraska (fig. 19) occurred as a result of heavy, localized rainfall, May 25–26. The time and intensity of the rain were not recorded, but in Nebraska such local storms usually last less than 12 hours. A total of 5.98 inches was observed at the U.S. Weather Bureau nonrecording rain gage 2 miles west of Genoa, and the May 28 edition of the Nance County Journal reported that amounts greater than 10 inches fell in some areas of the county during the night of May 25–26. According to the U.S. Weather Bureau (1961), this amount in 12 hours is almost twice the 100-year, 12-hour rainfall for the Genoa vicinity.

Skeedee Creek basin, northwest of Genoa, is in the area believed to have been hit hardest by the storm. Runoff from an area of 0.59 square mile, 7¼ miles west and 3¼ miles north of Genoa, indicates that the heaviest concentration of rainfall was in the upper part of the basin. The unit discharge from that small area was 1,670 cfs per sq. mi., about three times as great as the present-day concept of a 50-year peak discharge from a drainage area of that size in that vicinity. Farther downstream, and on the mainstem of Skeedee Creek (at a county

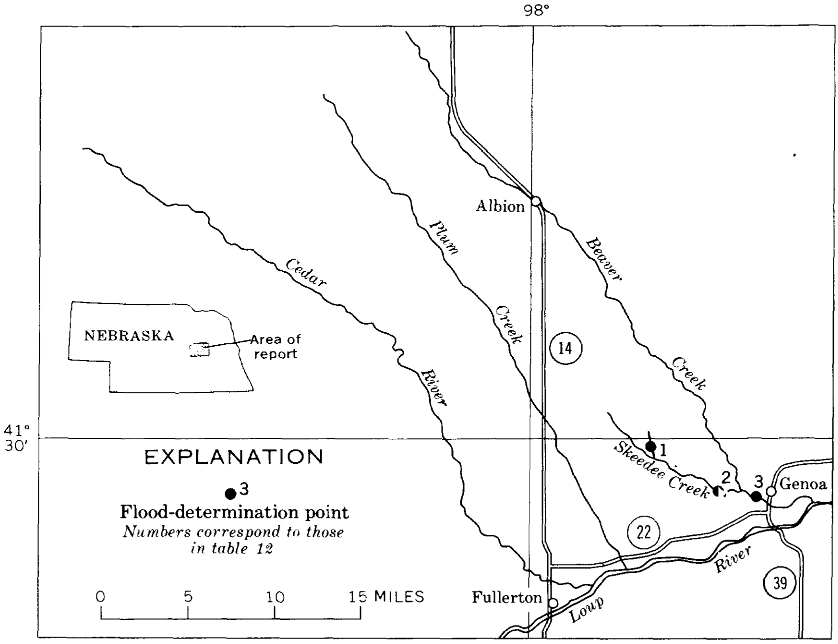

FIGURE 19.—Flood area; location of flood-determination points, flood of May 25–26 in east-central Nebraska.

road bridge 3 miles west of Genoa; drainage area, 18.0 sq. mi. a peak discharge of 21,300 cfs occurred (table 12), which is about 12 times as large as a 50-year flood discharge at the point.

The peak discharge (18,500 cfs) in Beaver Creek below the mouth of Skeedee Creek was slightly less than the peak in Skeedee Creek. This unusually high peak in the small tributary stream was about two times the size of that for a 50-year flood after it entered the much larger Beaver Creek.

During the height of the flooding in the Genoa area on May 26, State Highway 22 was closed to traffic just west of the village, and several families were evacuated from their homes along Beaver Creek. Damage to highways, bridges, and culverts in Nance County was estimated at $200,000. Other damage, including crop losses, livestock losses, farm building and machinery damage probably reached several hundred thousand dollars.

Rainfall of from 5 to 7 inches between June 8 and 15, followed by a torrential downpour of as much as 6 inches on June 16, resulted in extremely severe flooding in Papillion Creek basin in eastern Nebraska during the night of June 16–17 (fig. 20).

Hundreds of residents were evacuated from their homes in West Omaha, Elkhorn, Ralston, Millard, and Papillion. Many lives were saved by heroic rescue efforts, but nine lives were lost by drowning or heart attacks.

Damage was estimated to be more than $6 million. This is more than that sustained during any previous flood in this area because of recent additional urbanization of the flood plains.

Three determinations of peak flood discharges were made in this basin, and their magnitude in relation to the recurrence interval and to the 50-year flood is shown in table 12.

TABLE 12.—*Flood stages and discharges, May 25–26 and June 16 in east-central and eastern Nebraska*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to May 1964: Period	Year	May–June 1964 (date)	Gage height (ft)	Discharge: Cubic feet per second	Ratio to a 50-year flood
1	Skeedee Creek tributary near Genoa.	0.59			May 25		985	3
2	Skeedee Creek near Genoa	18.0			May 25		21,300	12
3	Beaver Creek at Genoa	627	1940–64	1950			21,200	
		[1] 410			May 26	20.75	18,500	2.1
4	West Papillion Creek near Millard.	60.2			June 16		45,200	2
5	Hell Creek near Millard	4.13			June 16		4,920	1.1
6	Big Papillion Creek at Ralston.	148			June 16		15,400	[2] 9

[1] Contributing area.
[2] Recurrence interval, in years.

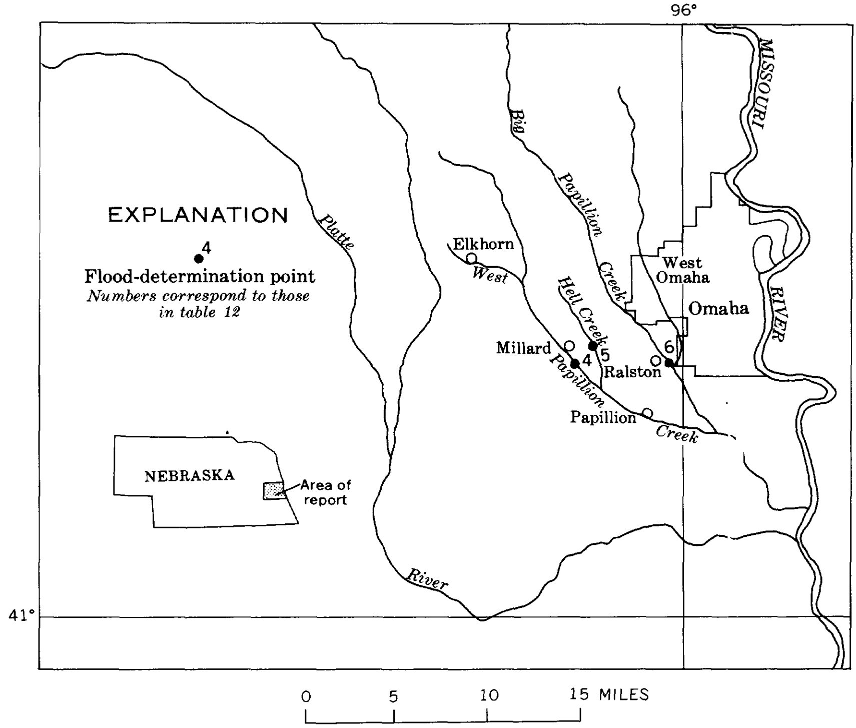

FIGURE 20.—Flood area; location of flood-determination points, flood of June 16 in eastern Nebraska.

FLOODS OF JUNE IN NORTHWESTERN MONTANA

Northwestern Montana had the most severe floods of record on both sides of the Continental Divide (fig. 21) after the heavy rains of June 7–8. Precipitation during the 36-hour-storm period was much as 14 inches. Streams were high from late snowmelt runoff and soil moisture was favorable for high runoff rates.

The principal streams affected by the floods were the St. Mary, Belly, and Waterton Rivers in the Hudson Bay basin; the Dearborn, Sun, Teton, and Marias Rivers in the Missouri River basin; and the Flathead River upstream from Flathead Lake in the Columbia River basin.

Peak discharges on streams in the flood area ranged in magnitude from about 2 to 11.5 times the probable 50-year flood. The peak discharge (5,740 cfs) of Street Creek at international boundary, from 6.0 square miles of drainage area, was 10.3 times the 50-year flood. The peak discharge (54,600 cfs) of Teton River near Farmington was 11.5 times the 50-year flood from a drainage area of 105 square miles.

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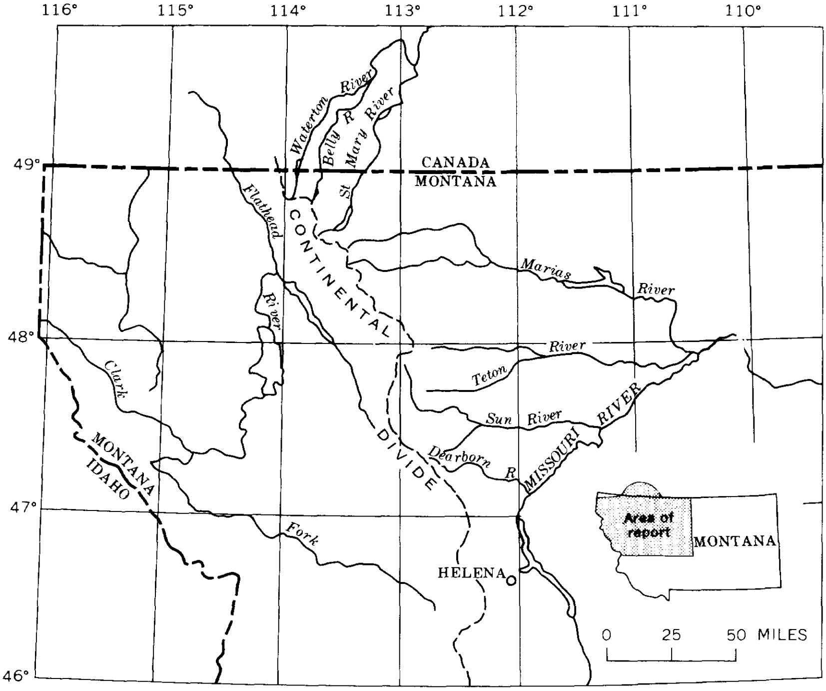

FIGURE 21.—Flood area ; in June in northwestern Montana.

The peak discharge (75,300 cfs) of Middle Fork Flathead River at Essex was 3.9 times the 50-year flood and was four times the maximum discharge during the previous 25 years of record.

The operation of irrigation and flood-control reservoirs did much to reduce flood peaks and damages. However, the failure of Swift Dam on Birch Creek and Lower Two Medicine Lake Dam on Two Medicine Creek caused destruction of numerous buildings and bridges downstream.

Flood damage within the United States was estimated at $55 million. Thirty lives were lost, 350 persons were injured, and about 8,700 persons were evacuated from their homes during the high-water period. Damage in Canada was reported at more than $1 million.

These floods are fully described in Geological Survey Water-Supply Paper 1840–B, by Boner and Stermitz (1967).

The above-mentioned Water-Supply Paper presents discussions of the antecedent hydrology and of the meteorology of the flood-producing storm; a description of the floods; information on flood damage; maps of principal urban inundation; flood profiles; discussions of storage regulation, previous floods, flood frequency, and deposition and degradation of stream channels; and detailed information on the stage, discharge, and reservoir contents for the May–June period. Maximum stages and discharges for the June 1964 flood and for the period of station record at 204 continuous-record gaging stations, crest-stage stations, miscellaneous sites, and reservoir stations are listed in a summary table. Station descriptions are given for all stations listed in the summary table of that report.

FLOODS OF JUNE 8 IN NORTHERN IDAHO

By C. A. Thomas

Flooding occurred in northern Idaho on June 8 as a result of persistent, widespread rains on above-normal snowpacks that were already melting at fairly high rates. The fringe of the severe storm that caused the great flood in northwestern Montana extended into Idaho. The area of flooding in northern Idaho is shown in figure 22. The heaviest rain was on June 8, and most of the peak discharges occurred on that date. Figure 23 shows weather conditions typical for the area during May and June. Figure 24 shows isohyets for June 5–8, and location of snow courses and water equivalent of the snow on June 1.

The most noteworthy floods occurred in Clearwater, Coeur d'Alene, and Salmon River basins. (See table 13.) However, flooding extended also into other basins.

In the Clearwater River basin, peak discharges in several large tributaries exceeded previous maximums of record. The June 1 snow surveys showed the water equivalent in the snowpacks to be considerable. Of 11 snow courses surveyed, the highest measured 69 inches of water, the lowest, 10 inches, and the average was 40 inches. Rainfall June 5–8 was about equal to a 25-year storm according to U.S. Weather Bureau (1964a). On June 2, when there was little precipitation, daily discharge at Lochsa River near Lowell (sta. 12) was 18.4 cfs per sq mi or an average of 0.68 inch of runoff per day, from the basin. By June 8, the average daily temperature had dropped 15°–20°, but the surcharge from the heavy rainfall increased the peak runoff to 29.8 cfs per sq mi or a rate of 1.10 inches per day for the basin.

The major runoff from snow in the Coeur d'Alene River basin occurred prior to June 8. Peak discharges were not unusual in the Coeur d'Alene River main stem or major tributaries. However, the intense rain on June 8 caused flooding on several small tributaries near the headwaters. A total of 3.86 inches of precipitation was reported at Burke June 5–8, of which 2.66 inches fell on June 8. Rainfall was probably at least this heavy over a considerable area near the summit, and melting of the remaining snow probably contributed to the runoff.

Flooding in the Salmon River basin was limited to small tributaries adjacent to the Clearwater River basin (table 13). Because of the

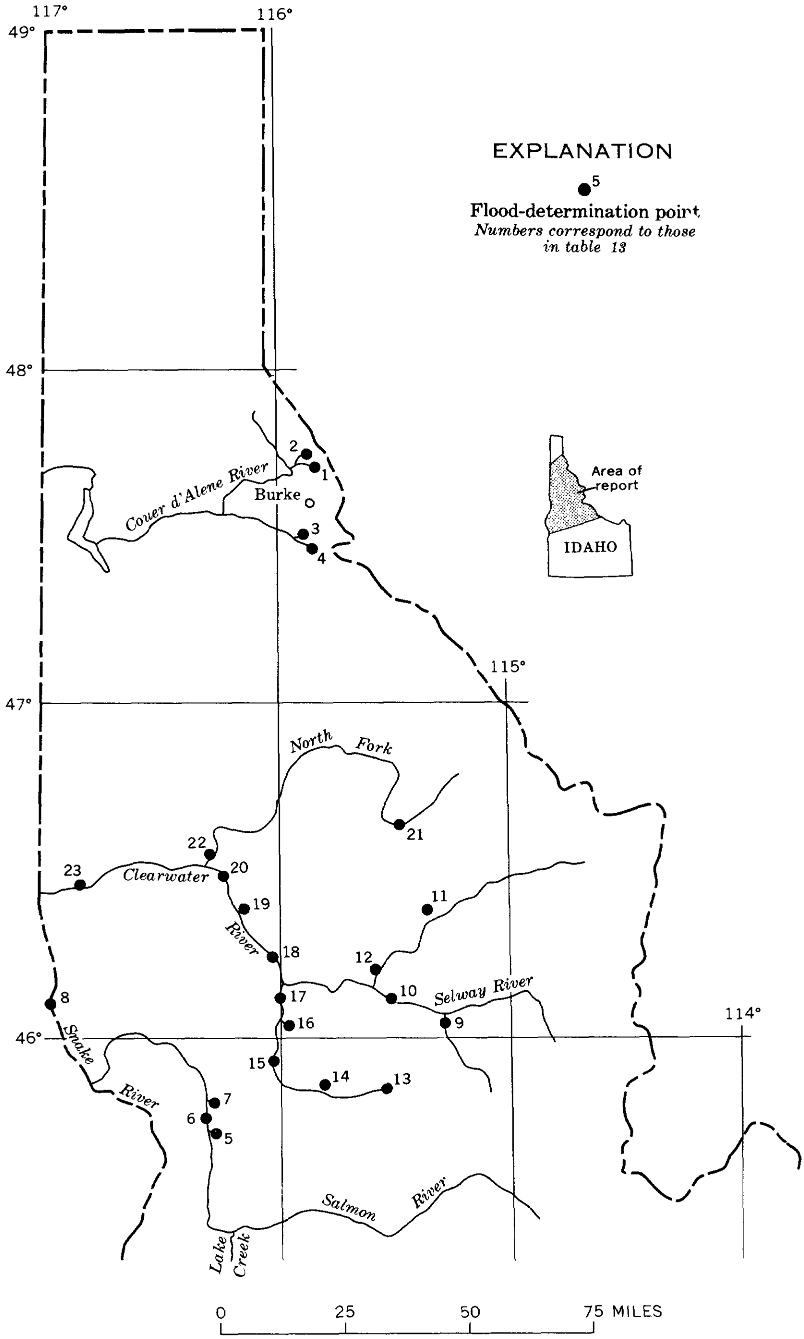

FIGURE 22.—Flood area; location of flood-determination points, floods of June 8 in northern Idaho.

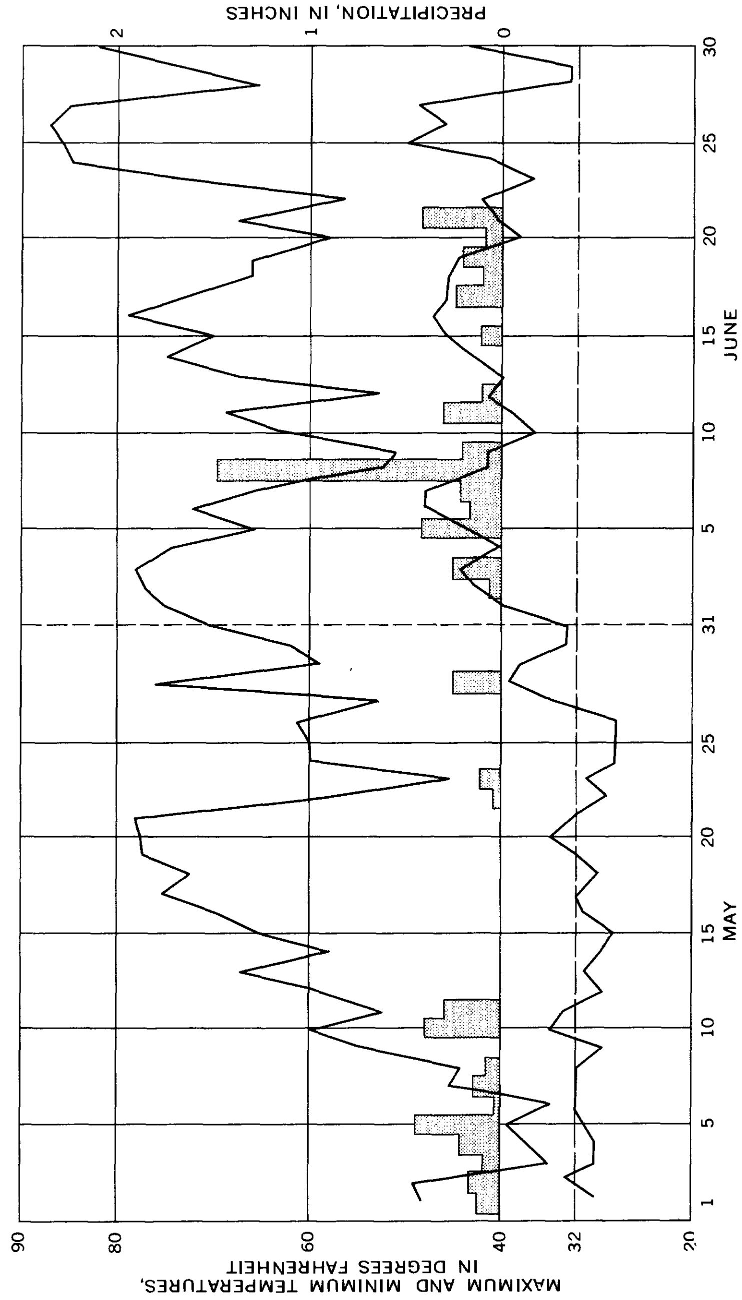

FIGURE 23.—Weather conditions for May and June at Powell, Idaho.

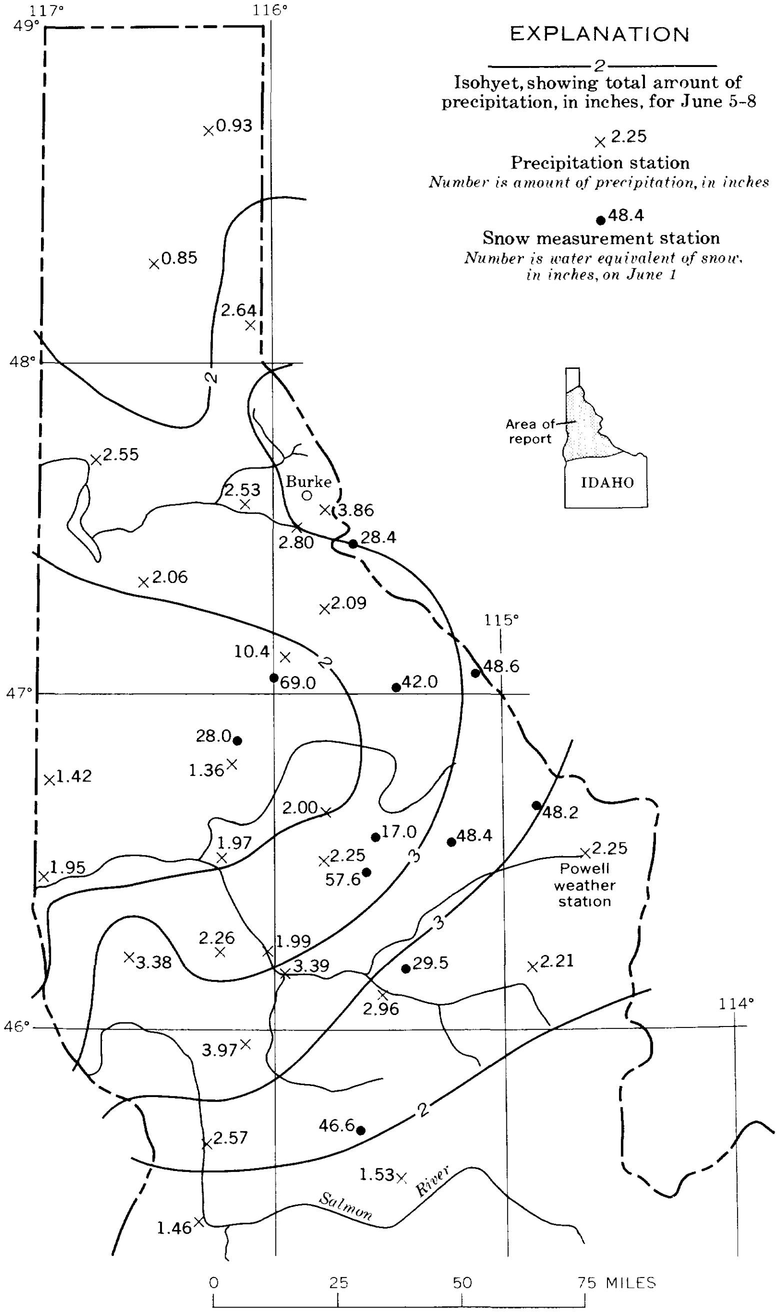

FIGURE 24.—Precipitation amounts and water equivalent of snow prior to floods of June 8 in northern Idaho.

TABLE 13.—*Flood stages and discharges, June 8 in northern Idaho*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to June 1964: Period	Prior to June 1964: Year	June 1964 (date)	Gage height (ft)	Discharge: Cubic feet per second	Discharge: Recurrence interval (years)
	Coeur d'Alene River basin							
1	East Fork Eagle Creek near Murray.	9.13			8		457	50+
2	Cottonwood Creek near Murray.	2.05			8		328	50+
3	Boulder Creek at Mullan.	3.13	1961–64	1961		15.32	136	
					8	15.53	144	
4	Canyon Creek at Gem	18.1			8		817	50+
	Salmon River basin							
5	North Fork Skookumchuck Creek near White Bird.	15.6	1959–64	1962		3.72	113	
					8	4.46	471	15
6	Salmon River at White Bird.	13,550	1894–1964	1894		37.5	120 000	
					8	29.98	79 000	5
7	White Bird Creek at White Bird.	96	1948	1948			3 500	
					8		1,840	
	Snake River, main stem							
8	Snake River near Anatone.	92,960	1958–64	1963		15.55	102,000	
					17	17.27	119,000	
	Clearwater River basin							
9	Meadow Creek near Lowell.	241			8	7.26	5,650	25
10	Selway River near Lowell.	1,910	1929–64	1948		16.04	48,900	
					8	14.39	43,400	25
11	Fish Creek near Lochsa ranger station.	89.2	1957–64	1964		5.54	2,280	
					8	5.42	2,160	
12	Lochsa River near Lowell.	1,180	1910–12, 1929–64	1933		13.44	34,800	
					8	13.50	35,100	40
13	South Fork Clearwater River near Elk City.	261	1944–64	1948		[1] 13.06	3,700	
					8	7.48	4,040	50
14	Peasley Creek near Golden.	14.5	1962–64	1962		10.04	103	
					8	11.11	240	
15	South Fork Clearwater River near Grangeville.	865	1911–64	1917		13.6	15,000	
					8	13.0	13,700	35
16	Sally Ann Creek near Stites.	[2] 15	1961–64	1963		9.17	255	
					8	9.99	328	
17	South Fork Clearwater River at Stites.	[2] 1,150	1911–12	1912		[1] 6.00	10,700	
					8	10.3	17,500	
18	Clearwater River at Kamiah.	[2] 4,850	1910–64	1948		19.22	99,000	
					8	19.16	103 000	55
19	Lolo Creek near Greer	243	1912	1912		7.8	3,410	
					8		3,430	
20	Clearwater River at Orofino.	[2] 5,580	1931–38	1933		[1] 20.87	8[illegible] 500	
					8	20.32	99,700	50
21	North Fork Clearwater River at Bungalow ranger station.	996	1944–64	1948		11.13	27,400	
					8	9.24	2[illegible],400	5
22	North Fork Clearwater River near Ahsahka.	[2] 2,440	1926–64	1933		35.5	100,000	
					8	21.90	41,800	5
23	Clearwater River at Spalding.	[2] 9,570	1910–13, 1924–64	1948		23.76	177,000	
				1963		[3] 27.77		
					8	20.70	14[illegible],000	10

[1] Site and datum then in use.
[2] Approximately.
[3] Due to ice jam.

persistent rains and continuing high water, a small dam broke on West Fork Lake Creek. Lake Creek is a small tributary to Salmon River, upstream from Riggins. Although only an estimated 70 acre-feet of water was released in the steep channel, the deluge destroyed several buildings and severely eroded the West Fork channel in a reach about 1 mile long. The enormous load of debris dammed the main channel of Salmon River, which overtopped and washed out the north approach to a bridge across the Salmon River just below the mouth of Lake Creek.

Damage to roads, bridges, railroads, sawmills, and other improvements was sizable, and there was considerable erosion in forested areas. No estimate of damage is available, but the potential seriousness of the flood was lessened because of the sparse population and the few improvements in large parts of the flood area.

FLOOD OF JUNE 13 AT ARTESIA, N. MEX.

By George L. Haynes, Jr.

A thunderstorm of rare occurrence and wide coverage centered about 5 miles west of Artesia, N. Mex. (fig. 25) from 4 p.m. to 7 p.m. on June 13. According to data gathered by the Soil Conservation Service, at least 4.5 inches of rain fell at the storm center, of which about three-fourths of the total fell in 1 hour. The storm covered an elliptical area of about 80 square miles. Of the total drainage area of 185 square miles of the Eagle Draw drainage basin above Artesia, roughly only 25 square miles was covered by the storm.

Artesia suffered its worst flooding from Eagle Draw since 1911, when an estimated $1 million damage occurred. The worst flood of record occurred in 1905 and caused $1.33 million damage. The floods come principally from Eagle Draw, but some of the 1964 flooding was caused by water from an unnamed arroyo draining an area near the municipal airport, where 4.40 inches of rain fell. Total damage from the 1964 flood was estimated by the Soil Conservation Service at $1,214,000. Damage in Artesia was estimated at $819,000, and agricultural damage was estimated at $395,000. No lives were lost, but approximately 130 persons were evacuated from their homes

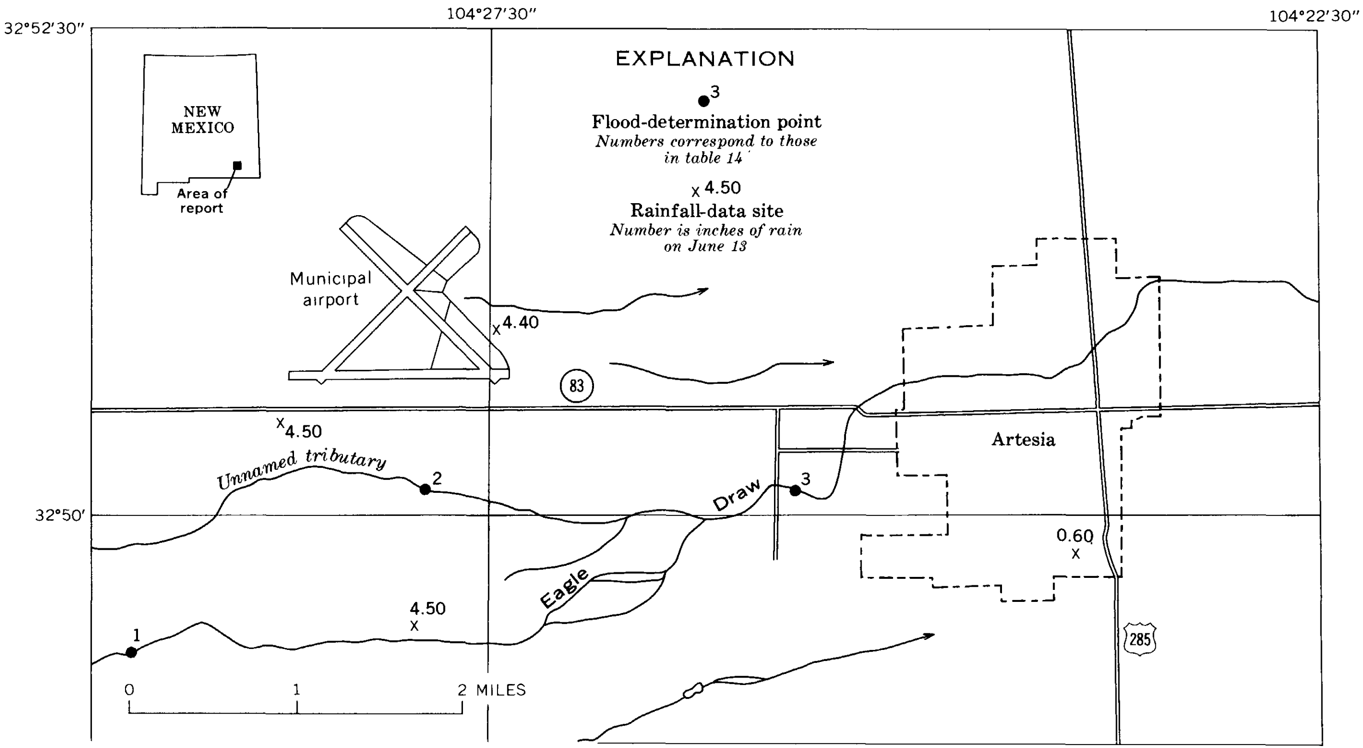

Figure 25.—Flood area; location of flood-determination points and rainfall-data sites, flood of June 13 at Artesia, N. Mex.

Two flood crests struck the town, the first at about 7:30 p.m. The time of the second crest is unknown, but it was probably several hours later. The first crest came from the unnamed tributary that joins Eagle Draw at the west edge of Artesia.

Peak discharges at two sites on Eagle Draw and at one site on the unnamed tributary over which the storm centered are given in table 14. The peak discharge of Eagle Draw about 5 miles west of Artesia had a recurrence interval of 22 years. The recurrence interval for the peak discharge of the 1954 flood 2 miles upstream from this site was considerably greater and the discharge was 1.3 times that of the 50-year flood. The 1954 flood caused less damage in Artesia ($310,000) than the 1964 flood, but several persons were drowned. The storm that produced the 1954 flood occurred over the upper part of the basin, whereas much of heaviest precipitation during the 1964 storm occurred downstream from this area.

A peak discharge of 10,700 cfs was measured on the unnamed tributary about 3 miles west of Artesia. As much as 4.5 inches of rain fell over most of the drainage basin area of 4.3 square miles. Flood-frequency relations are not defined in this area for small drainage basins. The unit discharge of 2,490 cfs per sq mi is outstanding; the 50-year flood on Eagle Draw (drainage area, 174 sq mi) is about 10,000 cfs.

TABLE 14.—*Flood stages and discharges, June 13 at Artesia, N. Mex.*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to June 13, 1964 — Period	Prior to June 13, 1964 — Year	June 1964 (date)	Gage height (ft)	Discharge — Cubic feet per second	Discharge — Recurrence interval (years)
	Rio Grande basin							
1	Eagle Draw	174			13		7,170	22
		[1] 166	1954	1954			12,500	
2	Unnamed tributary	4.3			13		10,700	(2)
3	Eagle Draw	(2)			13		7,020	(2)

[1] At site about 2 miles upstream from site 1.
[2] Unknown.

A peak discharge of 7,020 cfs was measured on Eagle Draw just downstream from the unnamed tributary at the west edge of Artesia. The crests from the unnamed tributary and Eagle Draw did not synchronize, and the peak on Eagle Draw attenuated considerably because of extensive spreading of the flow between the measuring sites. A small amount of flow from Eagle Draw may have crossed the divide into an arroyo to the south.

FLOOD OF JUNE 15 ON THE NORTH CANADIAN RIVER NEAR GUYMON, OKLA.

By L. L. Laine

A record high discharge occurred on the North Canadian River near Guymon in the central Oklahoma Panhandle on June 15 from high-intensity rains over a relatively small drainage basin (fig. 26). The peak discharge of 55,400 cfs was 26 percent greater than the previously known maximum of September 1941 and was the greatest peak discharge since records began in 1937.

Volume of discharge on the North Canadian River on June 15–16 was extremely great (fig. 27) and was about equal to the average yearly runoff (21,500 acre-ft) during a 27-year period of record at this site.

At 5:30 a.m. on June 15, a major flood on Beaver (Sand) Creek and a minor rise on Tepee Creek were observed at the State Highway 95 bridge crossings of these creeks. The two tributary creeks enter the North Canadian River a few miles upstream from the gaging station near Guymon. High-water marks showed that no significant flow had occurred on the North Canadian River a short distance upstream from the tributaries.

Most of the floodwater originated in the 220-square-mile basin of Beaver Creek, which is only a small part of the total contributing area of 1,175 square miles of the North Canadian River near Guymon.

The probability of occurrence of a flood similar to that of June 15 is very small, for the peak discharge has a recurrence interval of 50 years at the Guymon gaging station.

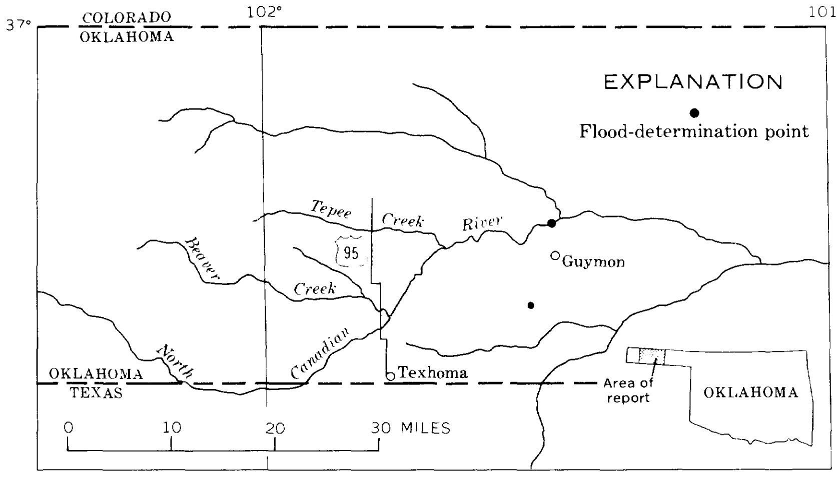

Figure 26.—Flood area; location of flood-determination point, flood of June 15 on the North Canadian River near Guymon, Okla.

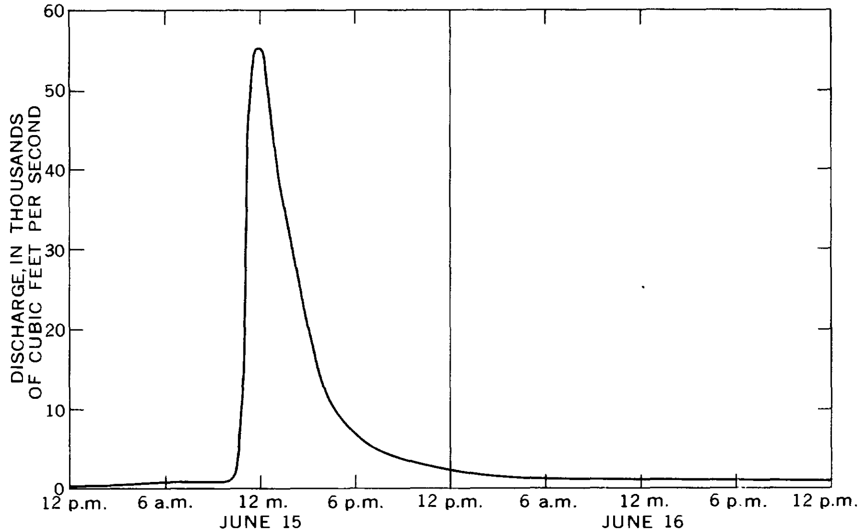

FIGURE 27.—Discharge for the North Canadian River near Guymon, Okla., June 15–16.

Precipitation data are not available for either Beaver Creek or Tepee Creek basins, and records for nearby basins do not indicate the amount or intensity of the rain that caused the flood. A Guymon newspaper reported an unofficial rainfall of 5.3 inches in 2 days at Texhoma, a few miles southeast of the Beaver Creek basin.

Flood damage to pasture land, livestock, and residential property was small.

FLOODS OF JUNE 17–18 IN CENTRAL-EASTERN MISSOURI

After M. S. PETERSEN (1965)

Floods of June 17–18 on several small creeks in Jefferson, Ste. Genevieve, and St. Francois Counties in central-eastern Missouri were among the most outstanding floods ever recorded in Missouri. The intensity of the rainfall and the magniture of the peak discharges were outstanding in a small area of about 200 square miles.

Short bursts of rain began at 8 p.m. on June 17, and by 10 p.m. the intensity began to increase and soon became unusually great. The rains were decreasing rapidly by 12 p.m. and stopped soon thereafter. Most of the rain fell in a 2-hour period, and intensities of 3 inches in 1 hour were reported. The greatest amount of storm rainfall reported was 7.30 inches at Prairie du Rocher, Ill. Rainfall was also intense in the Isle du Bois Creek basin, in Kinsey Creek basin, and in the upper part of Plattin Creek basin (fig. 28).

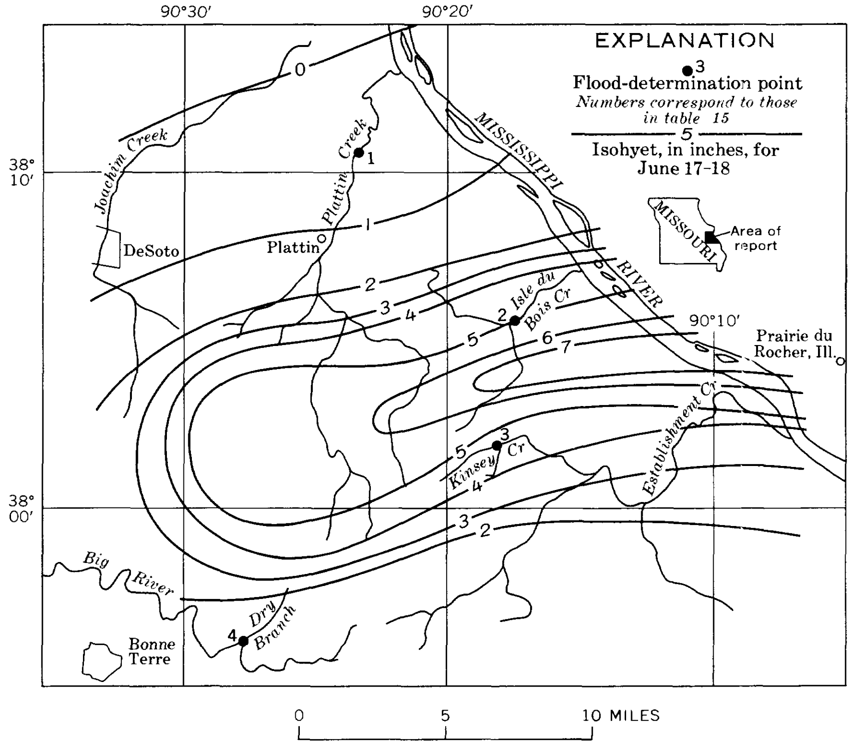

FIGURE 28.—Flood area; location of flood-determination points and isohyets for June 17–18, floods of June 17–18 in central-eastern Missouri.

The area is characterized generally by rolling hills. The steep slopes of the uplands are heavily wooded, and croplands dominate the flood plains. The streambed, typical of this type of terrain, is very steep in the headwater reaches, becomes less steep as the tributaries join to form a main channel, and flattens considerably on reaching the Mississippi River alluvium.

The floods were the highest and the most damaging headwater floods in the memory of residents; one resident said the floods were the highest in 80 years. Peak discharges, measured at three sites, were extremely high and were much greater than 50-year floods (table 15). Those on Isle du Bois Creek and Kinsey Creek were each about 5.5 times the magnitude of a 50-year flood and had the highest Myers rating of any recorded peaks in Missouri. Figure 29 is a discharge hydrograph of Dry Branch near Bonne Terre. Although this stream is small and did not have an outstanding flood, the shape of the hydrograph is representative of the discharge pattern for other streams in the area.

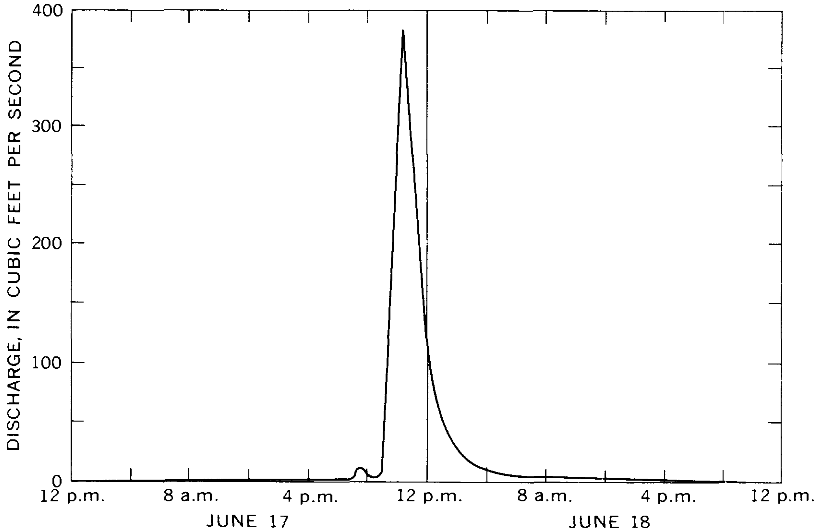

Figure 29.—Typical flood hydrograph, Dry Branch near Bonne Terre, Mo., floods of June 17–18 in central-eastern Missouri.

Table 15.—*Flood stages and discharges, June 17–18 in central-eastern Missouri*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to June 1964, Period	Maximum floods: Prior to June 1964, Year	Maximum floods: June 1964 (date)	Maximum floods: Gage height (ft)	Maximum floods: Discharge, Cubic feet per second	Maximum floods: Discharge, Ratio to a 50-year flood
1	Plattin Creek near Crystal City	83.4	------	------	17	24.06	30,100	2.3
2	Isle du Bois Creek near Ste. Genevieve	16.4	------	------	17	31.08	28,400	5.5
3	Kinsey Creek at Kinsey	3.18	------	------	17	------	11,600	5.6
4	Dry branch near Bonne Terre	3.65	------	------	17	2.89	372	.17

The floods caused many thousand dollars' damage. The areas affected were almost all rural, and damage was confined mostly to crops and agricultural equipment. Automobiles and farm machinery were swept down the creeks. Private roads and fields were badly scoured. Several county bridges were damaged or destroyed, and 500 feet of blacktop surface was washed away from one section of road. A county road engineer reported that $15,000 was spent to replace gravel and road fill and to clean out culverts. One major bridge on U.S. Highway 61 was damaged. Numerous homes were damaged, and their contents were swept away by the swift current. About 5,000 acres of cropland was covered with water, and huge piles of debris were lodged against trees, rocks, posts, and buildings.

A U.S. Armp Corps of Engineers report (1964a) of Plattin Creek shows a water-surface profile and the estimated inundated area of a 200-year flood. The stage of the rare flood of June 1964 was significantly higher than that for the estimated 200-year flood of the report.

FLOODS FROM THUNDERSTORMS OF JULY-SEPTEMBER IN ARIZONA

By Otto Moosburner and B. N. Aldridge

Frequent thunderstorms in Arizona on July 14–15, July 24–25, July 29–August 2, August 13–14, August 26, September 6, and September 13–14 caused major flooding in some areas. Unofficial estimates of damage from these major floods totaled more than $2 million, and several smaller floods each caused tens of thousands of dollars' damage. Much of the flood damage resulted from runoff from steep slopes and from overloaded storm-drainage facilities. High unit rates of runoff, in cubic feet per second per square mile, and minor damage occurred in several small remote areas not included in this report. The floods are discussed in chronological order. Significant flood data are tabulated, in downstream order, in table 16, and flood-determination points are shown in figure 30.

Moderate to heavy thunderstorm activity on July 14–15 caused flooding and property damage in Wickenburg, Phoenix, and Tucson. The most severe damage reported was in Wickenburg on July 15. A flash flood in Powder House Wash—a tributary of the Hassayampa River—caused from $50,000 to $75,000 damage to residences and motels on the alluvial fan at the mouth of the wash. A rancher, whose home is in the drainage basin of Powder House Wash, reported 2½ inches of rain in a 45-minute period; the U.S. Weather Bureau reported 1.30 inches of rain at Wickenburg on July 15. A peak discharge of 1,980 cfs was measured, by use of the slope-area method, about half a mile upstream from the damaged area (sta. 26, fig. 30). The rate of runoff was 1,080 cfs per sq mi from a drainage area of 1.83 square miles.

On July 25, a flood from the steep slopes west of Jerome washed out U.S. Highway 89A and deposited large amounts of rock debris in and around business buildings in Jerome. The steep stream gradients and lack of defined channels made measurements of peak discharge infeasible.

July 30 to August 2 was a period of widespread thunderstorm activity. Rain fell througout most of the State, and severe flooding occurred in several areas. Eight persons drowned, and unofficial estimates of damage were about $1 million. The estimates included damage from direct rainfall, hail, ponding, and failure of local drainage structures.

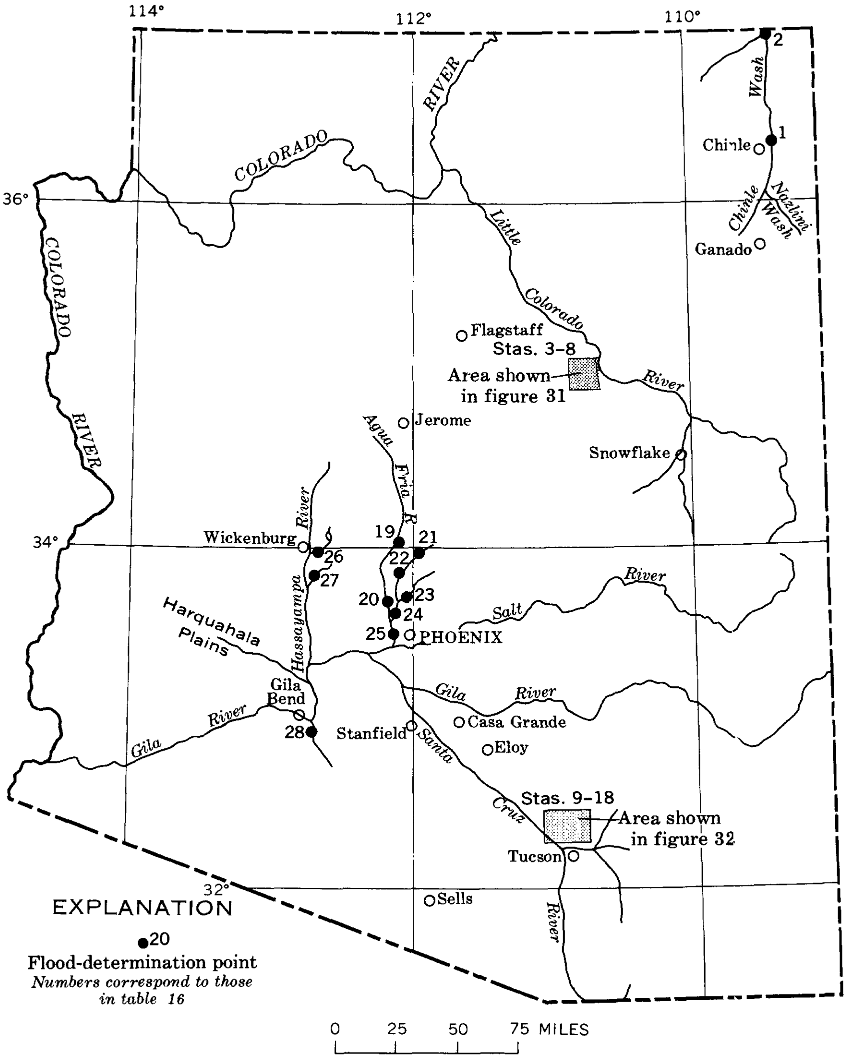

Figure 30.—Flood area; location of flood-determination points, flood from thunderstorms of July–September in Arizona.

In Flagstaff 2½ to 3 inches of rain fell in a period of half an hour during the afternoon of July 30. Many homes and business places in the low-lying areas of the city were inundated by overflow from the River de Flag and by direct runoff from the surrounding hills. Damage amounted to about $100,000.

About midnight on July 30, a flash flood of about 20,000 cfs originated in Nazlini Wash, a tributary to Chinle Wash in northeastern Arizona. The flood claimed eight lives when the bridge that spanned

TABLE 16.—*Flood stages and discharges, July–September in Arizona*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to July 1964: Period	Maximum floods: Prior to July 1964: Year	Maximum floods: July–Sept. 1964 (date)	Maximum floods: Gage height (ft)	Maximum floods: Discharge: Cubic feet per second	Maximum floods: Discharge: Cubic feet per second per square mile
1	Chinle Wash at Chinle	[1] 750			July 31		[2] 20,000	
2	Chinle Wash near Mexican Water.	3,660			Aug. 1	7.2	3,280	0.9
3	Ruby Wash above airport levee at Winslow.	[3] 5			Aug. 12		[4] 2,100	420
4	Ruby Wash at city limits of Winslow.	[3] 11			Aug. 12		[4] 2,400	220
5	Ruby Wash at railroad bridge at Winslow.	[3] 12.8			Aug. 12		[4] 2,200	170
6	Ice House Wash at city limits of Winslow.	[3] 2.2			Aug. 12		[4] 1,600	730
7	Ice House Wash ½-mile downstream from railroad bridge at Winslow.				Aug. 12		[4] 390	
8	Toltec Wash at U.S. Highway 66, 1 mile west of Winslow.	[3] 3.2			Aug. 12		1,130	350
9	Rillito Creek tributary No. 3 at Orange Grove Road near Tucson.	.12			Sept. 6		43	360
10	Pima Wash at Ina Road near Tucson.	4.93			Sept. 6	11.12	195	40
11	Pima Wash tributary at First Avenue near Tucson.	.15			Sept. 6		[5] 104	690
12	Pima Wash tributary No. 2 at First Avenue near Tucson.	.06			Sept. 6		[5] 49	820
13	Pima Wash tributary No. 3 at Ina Road near Tucson.	.06			Sept. 6		[5] 63	1,000
14	Pima Wash tributary No. 3 at First Avenue near Tucson.	.24			Sept. 6		[5] 134	560
15	Geronimo Wash at Skyline Drive near Tucson.	2.08			Sept. 6	11.9	445	214
16	Rillito Creek tributary at U.S. Highway 89 near Tucson.	.07			Sept. 6		154	2,200
17	Nanini Wash at Ina Road near Tucson.	.37			Sept. 6		[5] 455	1,230
18	Rillito Creek tributary No. 2 near Tucson.	1.68			Sept. 6		2,670	1,590
19	Agua Fria River tributary No. 2 near Rock Springs.	1.0	1963–64	1963		6.28	411	
					Aug. 2	19.54	1,200	1,200
20	Agua Fria River at Grand Avenue near El Mirage.	[6] 114	1963–64	1963		2.54	700	
					July 30	3.73	2,500	22
21	New River near Rock Springs.	67.3	1962–64	1962		3.1	1,050	
					Aug. 2	6.3	4,900	73
22	New River near Black Canyon.	85.7	1960–64	1963		7.33	4,620	
					Aug. 2	7.18	4,380	51
23	Skunk Creek at State Highway 69 near Phoenix.	77.6	1952–64	1959		4.0	9,000	
					Aug. 1	4.49	11,500	148
24	New River at Glendale Avenue near Glendale.	323	1952–64	1959			5,500	
					Aug. 1	6.72	7,000	22
25	Agua Fria River at Buckeye Road at Avondale.	[6] 486	1959–64	1959		11.0	4,700	
					Aug. 1	10.17	3,000	6
26	Powder House Wash about ½ mile above mouth near Wickenburg.	1.83			July 14		1,980	1,080
27	Ox Wash near Morristown	7.44	1938–64				1,770	
					Aug. 26	10.2	2,900	390
28	Sand Tanks Wash at U.S. Highway 80 at Gila Bend.	265			Aug. 14		5,910	22

[1] Less than ½ of the drainage area contributed to the flood.
[2] Estimated on basis of channel geometry.
[3] Drainage area is approximate.
[4] Estimates by the U.S. Army Corps of Engineers.
[5] Approximate.
[6] Drainage area does not include the 1,459 sq mi above Lake Pleasant that was noncontributing to this flood.

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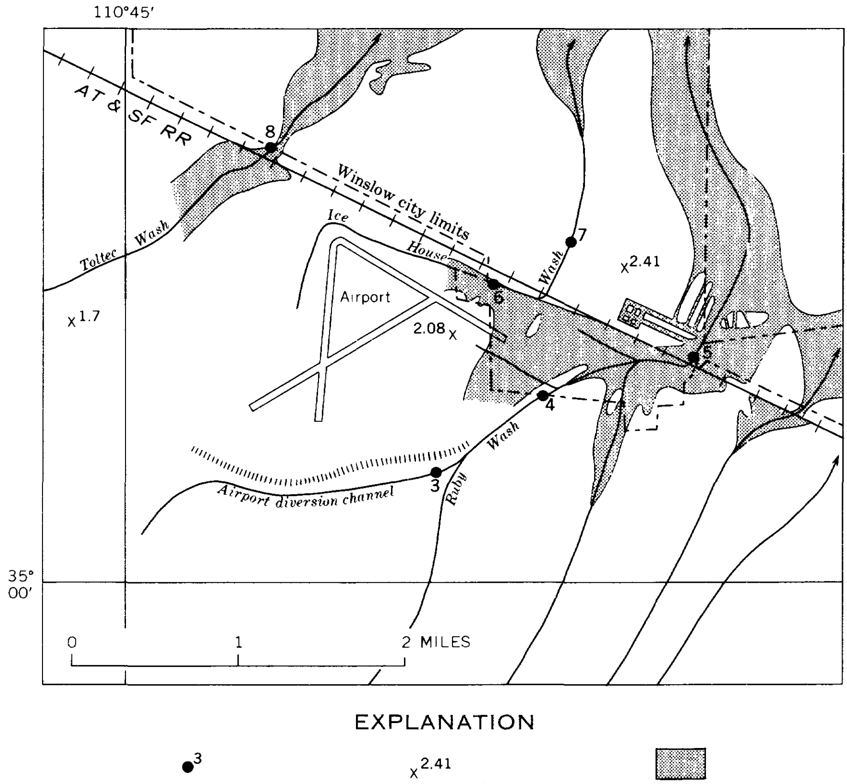
Chinle Wash, which provided access to the Canyon de Chelly National Monument, at Chinle (sta. 1) was washed away (fig. 30). The victims were passengers in a car that was either driven into the washout or carried away when the bridge collapsed. Information from local residents indicates that most of the runoff originated from the eastern slopes of the drainage basin, which includes about one-third of the 750 square miles of drainage area above the bridge. No precipitation data are available from the Nazlini Wash drainage basin. The U.S. Weather Bureau reported 0.34 inch of rainfall on July 30 and 0.33 inch on August 1 at Chinle; the Ganado station about 30 miles south of Chinle, recorded 0.64 inch on July 30 and 0.70 inch on August 1. A continuous-recording gaging station—Chinle Wash near Mexican Water (sta. 2)—is about 60 miles downstream from station 1. Between Chinle and the gaging station, there is considerable channel and reservoir storage; therefore, the streamflow records are not indicative of flow at station 1. At the gaging station (sta. 2), peaks occurred on July 31 and August 1; the highest (3,280 cfs) was on August 1. A local resident stated that this peak discharge was the highest since at least 1950.

Several sections of State Highway 177 and of the Apache Railway near Snowflake were washed out by floods on July 31 after a rainfall of 3 to 4 inches in 1 hour. Streets and some business establishments in Snowflake were flooded by Little Cottonwood Wash. Additional rain on August 1 and 2 kept the wash at a high stage for 3 days.

Floods on August 1 and 2 in the Phoenix area damaged streets and roads throughout the metropolitan district; the most damage occurred at grade-level crossings along the Agua Fria and New Rivers. The flood of August 1 originated mainly in Skunk Creek (sta. 23), which had a peak discharge of 11,500 cfs. Stages on Skunk Creek and on the New River below Skunk Creek were the highest since at least 1951. By the time the peak had reached the mouth of the Agua Fria River, the discharge had been reduced considerably, but it was still the largest peak since December 1959. The flood of August 2 originated in the New River upstream from Skunk Creek. In the valley around Phoenix, cottongrowers sustained heavy losses from the floods of August 1 and 2, and large acreages of cotton were damaged by rain. Irrigation works and roads in the Eloy, Casa Grande, and Stanfield areas were damaged by overflow from the Santa Cruz River.

The floods of August 1 and 2 marooned about 300 persons in a dozen small villages west of Sells in central Pima County. Food was flown into the area, where about 40 families had been without food for a week. Two persons died, and epidemics of fever and diarrhea broke out in three villages where the drinking water had been contaminated by the floodwaters.

Runoff from intense rainfall on August 12 caused severe flood damage in Winslow, a city of 10,000 persons. Newspapers referred to this flood as the worst in the history of Winslow. Most of the runoff originated in a 20-square-mile area southwest of town. The U.S. Weather Bureau reported 2.04 inches of rainfall received at the Winslow airport between 4 p.m. and 5 p.m. The U.S. Army Corps of Engineers (1964b) reported rainfall totals of 1.7 inches west of town and 2.41 inches within the city limits (fig. 31). The maximum 30-minute rainfall-intensity rate at the airport was 3.12 inches per hour. Five small washes flow through Winslow (fig. 31). These washes have moderate channel gradients of about 30–40 feet per mile southwest of town and very mild



Flood-determination point
Numbers correspond to those in table 16

Site of rainfall determination and amount, in inches

Flooded area (U.S. Army Corps of Engineers, 1964b)

FIGURE 31.—Flood area; location of flood-determination points and rainfall measurement sites, flood of August 12 in Winslow, Ariz.

gradients of about 10–15 feet per mile in town. The main streams in the developed part of town are Ruby and Ice House Washes. The storm moved over the drainage basins of these two washes from the northeast and then returned to the northeast. The combined flows from the airport diversion channel and Ruby Wash inundated the south-side housing areas. Floodwater in some of the houses was 2½ to 3 feet deep. Bridge openings under the railroad tracks on the south side of Winslow were not large enough to accommodate the flow, and water spread along the railroad embankment and was ponded along the south side of the tracks. This ponding reduced the peak flow into the business district on the north side of the tracks. The bridge opening at Ice House Wash became plugged with debris, and water flowed east along the tracks to Ruby Wash. At the railroad bridge, Ruby Wash (sta. 5) peaked at about 5:50 p.m. on August 12. Water poured over the tracks near the center of town and flooded a low-lying area just north of the tracks and east of the bridge. Dikes along Ruby Wash broke and allowed considerable flooding of low areas along the north side of town. About 300 to 500 persons were evacuated from their homes. The U.S. Army Corps of Engineers (1964b) estimated total damage to be $307,000, of which $205,000 was residential damage (table 17). Most of the damage resulted from inundation, rather than from the velocity of the floodwater. Many low-cost residences were damaged when their adobe walls dissolved and collapsed. Large amounts of silt were deposited in the flooded areas. Trains were delayed for 3 hours, and the airport was closed during the night of August 12 because of debris on the runway. A health problem arose because floodwater had washed through cesspools and spread contaminated water through town. A large number of mosquitoes hatched in ponds that remained after the flood. The U.S. Army Corps of Engineers estimated the flow at several places (stas. 3–7), and the U.S. Geological Survey computed the flow of Toltec Wash by use of the contracted-opening method (table 16).

In Casa Grande, which is in the bottom of a large bowllike depression, 3.08 inches of rain fell in 2 hours from another storm on August 12. Sheetflow and ponding in areas that had little or no drainage facilities inundated roads and highways. Several homes in Casa Grande and on the surrounding farms were damaged by floodwater.

A bridge at U.S. Highway 80 at Gila Bend (sta. 28) was washed out, on August 14, by floodwater from Sand Tank Wash. The flood resulted from a combination of natural runoff and spillage from an irrigation canal that broke because of a large amount of intercepted inflow.

A flood on August 26 damaged crops in the Harquahala Plains (unofficial estimates of damage were about $500,000) and washed out a section of highway at Ox Wash near Morristown, south of Wicken-

TABLE 17.—*Summary of damage from flood of August 12 in Winslow, Ariz.*

[Data from U.S. Army Corps of Engineers (1964b)]

Type of property	Damage		
	Physical damage [1]	Emergency costs and business losses	Total
Residential	$186, 000	$19, 000	$205, 000
Commercial	13, 000	6, 000	19, 000
Public	9, 000	1, 000	10, 000
Railroad	36, 000	4, 000	40, 000
Industrial	7, 000	7, 000	14, 000
Streets and highways [2]	17, 000	2, 000	19, 000
Total	268, 000	39, 000	307, 000

[1] Includes cost of cleanup.
[2] Includes cost of repairs to levees.

burg (sta. 27), which temporarily halted traffic on U.S. Highways 60, 70, 89, and 93. The peak flow of Ox Wash was 2,900 cfs from a drainage area of 7.44 square miles—the highest flow at that location since at least 1938.

An intense rainstorm, covering about 10 square miles, occurred over a subdivision north of Tucson on September 6 (fig. 32). The storm started shortly after 2 p.m. and lasted for 2 to 3 hours. One resident measured 4.9 inches of precipitation in a 2-hour period, and several others reported between 3 and 5 inches of rain in 2 to 3 hours. The U.S. Weather Bureau (1961) indicates that a storm of this duration and intensity in this area has a recurrence interval of more than 100 years. Several persons nearly lost their lives when floodwater engulfed their vehicles or collapsed pavements at stream crossings. The Riverside housing development on the northwest corner of La Canada Drive and Roller Coaster Road was badly damaged by water and debris. A few other homes near the mouths of small washes sustained wind, water, and debris damage. Damage to county roads was estimated at $10,000 (oral commun., Pima County Engineer, 1964). Peak discharges were measured at four places in or near the area of intense precipitation (table 16), and estimates of peak flow were obtained at several other places. Several of the estimates indicate unit rates of runoff of 1,000 to 1,300 cfs per sq mi.

On September 13, flash floods closed highways and stranded about 200 persons in Sabino Canyon near Tucson. On September 14, the U.S. Weather Bureau reported 1.25 inches of rain in a 30-minute period at the Sky Harbor Airport in Phoenix—the highest 30-minute intensity ever reached there. Large amounts of rainfall were recorded in some parts of the city; one observer measured 2.48 inches in 45 minutes. Business establishments were flooded throughout the city.

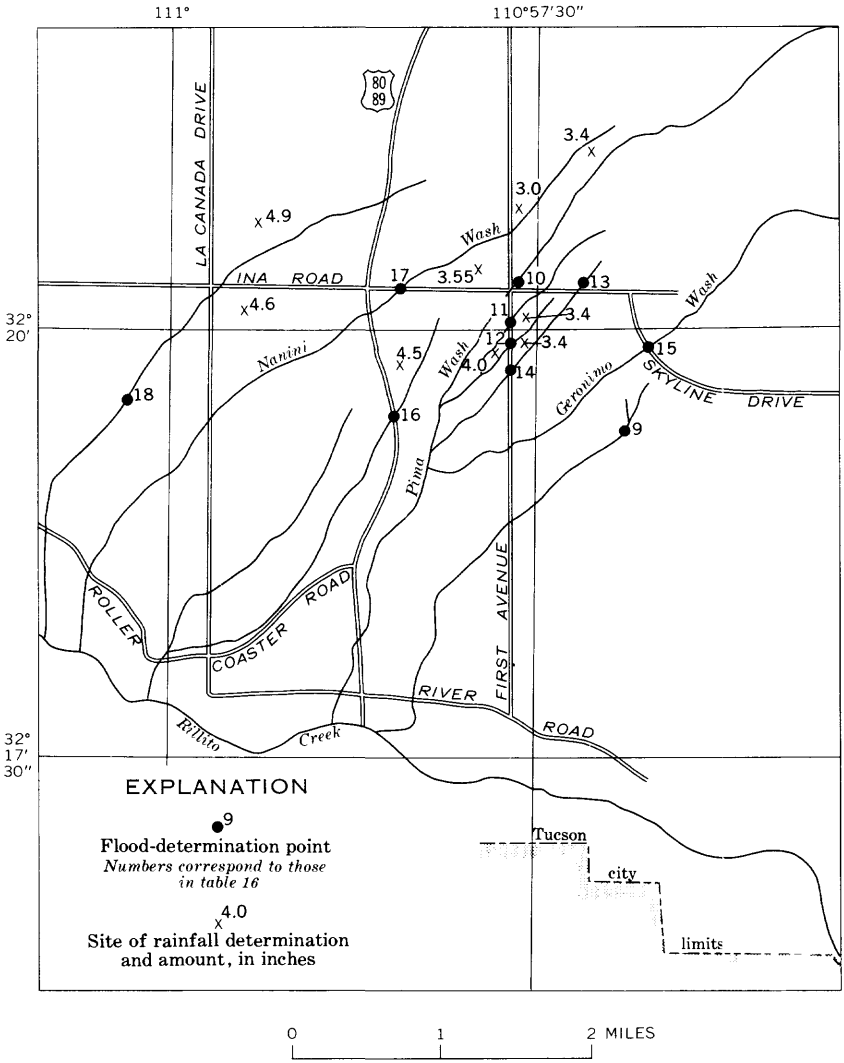


FIGURE 32.—Flood area; location of flood-determination points and rainfall-measurement sites, flood of September 6 near Tucson, Ariz.

Streets became rivers, and sections of pavement collapsed. Cotton crops in the valley surrounding Phoenix were badly damaged by rain, hail, and floodwater. Damage from this storm, most of which was from direct rainfall, ponding, and failure of local drainage structures, was unofficially estimated to be about $1 million.

FLOODS OF JULY 30 AND AUGUST 2 IN SOUTHWESTERN COLORADO

A flood on Disappointment Creek in southwestern Colorado (fig. 33) was due to an intense rainstorm of short duration, which is the usual cause of floods on this stream. The abrupt peak discharge at the gaging station near Dove Creek lasted only 5 to 10 minutes and was

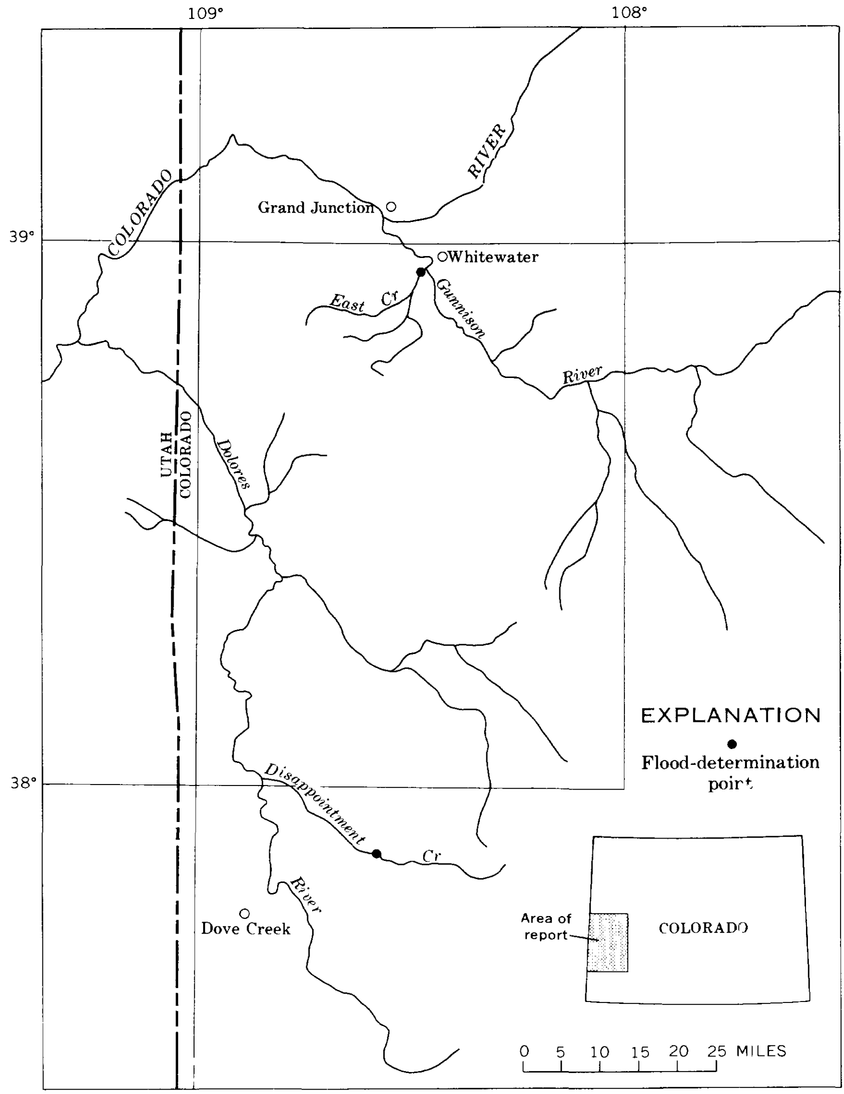


FIGURE 33.—Flood area; location of flood-determination points, floods of July 30 and August 2 in southwestern Colorado.

2,240 cfs, which was about 500 cfs higher than the previous maximum in 7 years of record. The peak discharge was about 1½ times the magnitude of a 50-year flood.

Mud flows covered sections of 20 miles of the only road in the valley, which was impassable until the mud was removed. The bridge over Disappointment Creek 6 miles below the gaging station was destroyed, which caused considerable inconvenience and many miles of extra travel on highway detours.

Only 3 days after the flood on Disappointment Creek, another flood occurred about 70 miles farther north, on East Creek near Whitewater, Colo. (fig. 33). This flood was also due to rainfall of short duration. The peak discharge on East Creek of 3,630 cfs, the highest in the memory of nearby residents, came from a drainage area of 112 square miles. The runoff of 32 cfs per sq mi is very high for this area and is greater than that for a 50-year flood. A much greater flood than this occurred on West Creek, in an adjacent basin, in 1940, when a peak discharge of 11,700 cfs resulted from rain on a drainage basin of similar size.

The flood of August 2 caused minor damage to a hayfield near the canyon at the mouth of East Creek at the Gunnison River.

FLOODS OF AUGUST IN UTAH

By Elmer Butler

In August, several floods were caused by intense thunderstorms and cloudbursts in southwestern and central Utah, where the annual floods usually come from thunderstorms during late summer and early fall. Small-area high-intensity storms often cover a small part of a drainage basin. These storms cause abrupt peak discharges which are high for the immediate area affected but which attenuate very rapidly with distance downstream.

Because of the sparsity of rain gages in Utah and the small areas covered by the thunderstorms, reported rainfall figures very often have no true relation to the intensity of a storm that may have produced a significant flood.

Damage from the widely scattered floods is usually light or nonexistant because of the absence of destructibile property on the flood plains.

The August floods in Utah are described, in chronological order, and their peak discharges are listed, in downstream order, in table 18.

Scattered rains occurred over southern Utah (fig. 34) on August 1, and near Orangeville, they were intense enough to cause unusual floods on Cottonwood Creek. The peak discharge of 7,220 cfs on Cottonwood Creek near Orangeville (sta. 2) on August 1 was the greatest in 52

TABLE 18.—*Flood stages and discharges, August in Utah*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Aug. 1964: Period	Maximum floods: Prior to Aug. 1964: Year	Aug. 1967 (date)	Gage height (ft)	Discharge: Cubic feet per second	Discharge: Ratio to a 50-year flood
	Green River basin							
1	Huntington Creek near Huntington.	188	1909–64	1930		7.5	2,500	
					1	3.34	169	(1)
2	Cottonwood Creek near Orangeville.	205	1909–27, 1932–64	1941		6.38	2,870	
					1	9.05	7,220	1.7
3	Cottonwood Creek below Grimes Wash, near Orangeville.	220			1		4,930	1.1
4	Ferron Creek (upper station) near Ferron.	157	1911–23, 1948–64	1952		9.71	4,190	
					1	3.00	75	(1)
5	San Rafael River near Castle Dale.	927	1948–64	1952		[2] 7.56	4,510	
					2	3.70	1,460	(1)
	Kanab Creek basin							
6	Hog Canyon ¾ mile upstream from mouth near Kanab.	18.5		1961			[3] 6,580	
					12		10,850	4.7
	Virgin River basin							
7	Tributary to East Fork Virgin River near Orderville.	0.51			12		1,420	(1)
8	Leeds Creek near Leeds	15.5			12	6.0	2,980	1.5
9	Cottonwood Canyon near Harrisburg	43			12		6,440	1.4
10	Twist Hollow near St. George	4.9			12		1,340	(4)
11	Twist Hollow at St. George	14.1			12		4,280	2.0
	See footnotes at end of table.							
12	The Gap near St. George.	3.15			12		5,630	(4)
	Sevier Lake basin							
13	Dry Wash at Antimony	22			4		2,310	4.0
14	Anderson Wash near Sigurd.	1.4			15		840	(4)
	Cedar City Valley							
15	Coal Creek above Right Hand Creek near Cedar City.	54.2	1959–64	1959		12.40	1,210	
					4	14.00	1,350	1.4
16	Shurtz Creek near Cedar City.	12.8	1959–64	1961		15.20	416	
					4	20.3	1,230	3.2
	Escalante Valley							
17	Tributary to Little Pinto Creek near Newcastle	0.30			11		2,630	(4)
18	Joel Wash (upper site) near Newcastle.	5.86			11		1,390	(4)
19	Joel Wash near Newcastle.	12.3			11		2,470	(4)

[1] Less than mean annual flood.
[2] At different site and datum.
[3] At mouth near Kanab.
[4] Undefined by flood-frequency data, but probably greater than a 50-year flood.

years of record. When the peak arrived at a point 2½ miles downstream, below Grimes Wash (sta. 3), it had decreased to 4,390 cfs. Most of the runoff for the greatest flood known to local residents on Cottonwood Creek came from about 14 square miles of the 220 square miles draining the basin. The local pattern of the flood-causing storm is apparent from the low peak discharges at three nearby stream-gaging stations (stas. 1, 4, and 5). No precipitation was recorded for the U.S. Weather Bureau precipitation station at Castle Dale on August 1.

Scattered rains over southern Utah with some local precipitation of very high intensity on August 4 caused floods at Antimony and Cedar City (fig. 34). The peak discharges on Dry Wash at Antimony (sta. 13) and on Coal Creek (sta. 15) and Shurtz Creek (sta. 16) near Cedar City each exceeded that of a 50-year flood. No damage was caused by these floods.

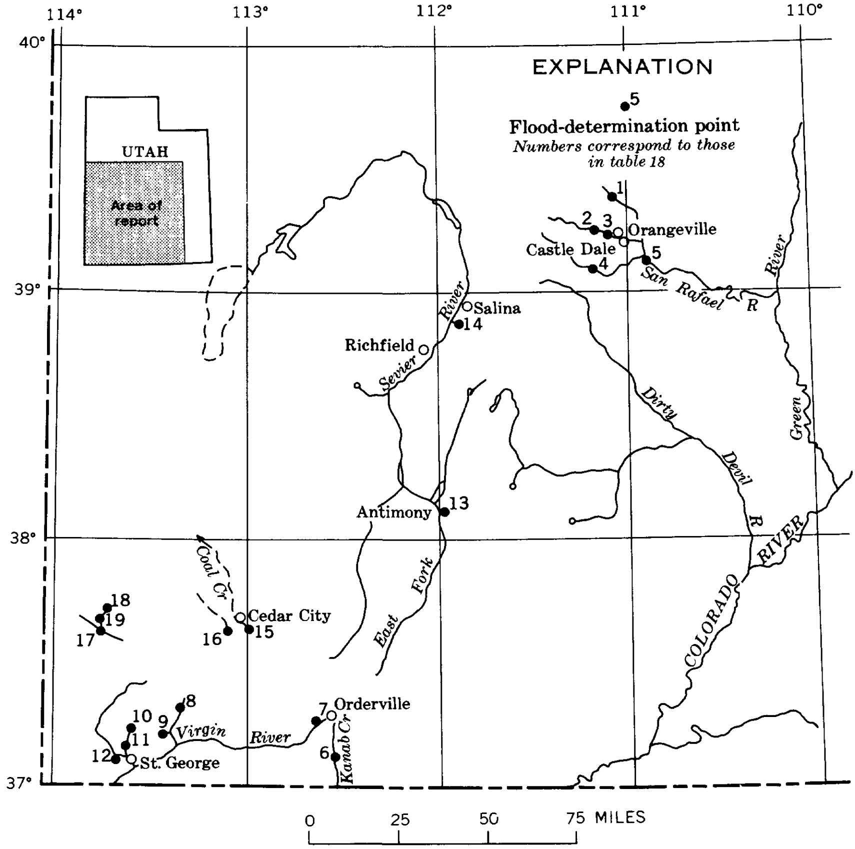


FIGURE 34.—Flood area, location of flood-determination points, floods of August in Utah.

Scattered rains on August 11 and 12 and locally heavy storms caused floods on several small streams in southwestern Utah (fig. 34). Flood-frequency relations are undefined for drainage areas of less than about 15 square miles in the region of flooding, but it is believed that all peak discharges had recurrence intervals that are more than 50 years (table 18). The peak discharge of 2,630 cfs on a tributary to Little Pinto Creek near Newcastle (sta. 17) from a drainage area of 0.30 square mile was the maximum known unit-rate of runoff (8,770 cfs per sq mi) for Utah.

Rainfall recorded by the U.S. Weather Bureau in the area ranged from zero at St. George on August 11 to 0.54 inch at Orderville on August 12.

The floods were in sparsely inhabited areas, and little damage resulted. The flood on the tributary to the East Fork Virgin River (sta. 7) caused several thousand dollars' worth of damage to a farm home and to farm equipment, and some farm animals were lost. About $3,000 damage to farmlands and machinery resulted from floods in The Gap near St. George (sta. 12). Floodwaters overflowed State Highway 10 and caused about $500 damage.

A flood on Anderson Wash near Sigurd (sta. 14) on August 15 was due to a cloudburst.

The peak discharge of 840 cfs from a drainage area of 1.4 square miles was probably greater than that of a 50-year flood. The rain over Anderson Wash was intense, but the U.S. Weather Bureau precipitation station at Richfield recorded only 0.04 inch rainfall, and the station at Salina recorded no rainfall.

Damage to farm crops, fences, and irrigation systems was estimated by the U.S. Soil Conservation Service to be $1,600.

FLOODS OF SEPTEMBER 9–11 IN THE SANTA CRUZ RIVER BASIN, ARIZONA

By B. N. ALDRIDGE and OTTO MOOSBURNER

Moist tropical air associated with Hurricane Tillie off the west coast of Baja California, moved into southern Arizona on September 9. The moist air met a cold front and produced intense rainfall over a fairly large part of southeastern Arizona late on September 9 and early on September 10. The storm centered in the upper Santa Cruz River basin (fig. 35). A maximum 2-day (September 9–10) precipitation of 6.75 inches was reported in two places—one, in the foothills of the Santa Catalina Mountains, and the other, north of Sahuarita. The isohyetal lines in figure 35 are based on precipitation data from 35 U.S. Weather Bureau stations and 27 U.S. Army Corps of Engineers field-survey stations (U.S. Army Corps of Engineers, 1964c).

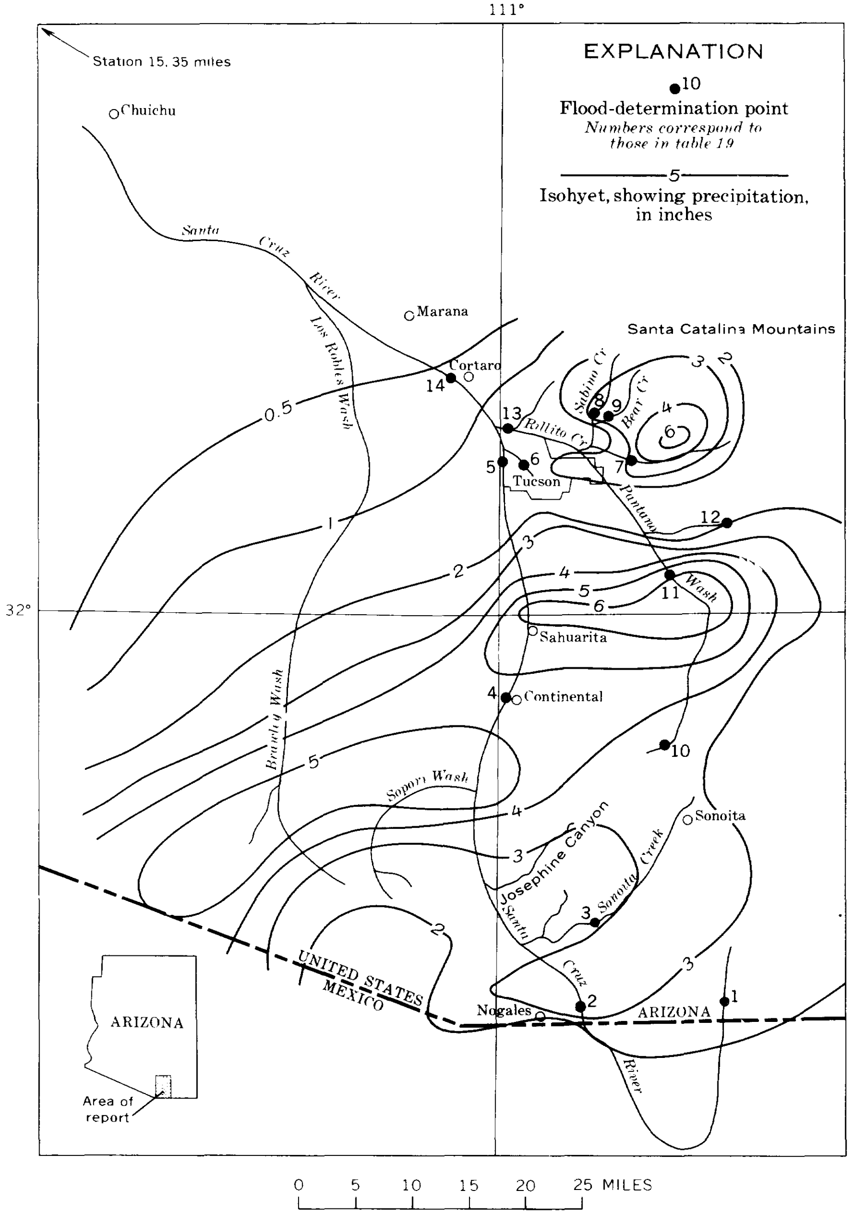


FIGURE 35.—Flood area; location of flood-determination points and isohyets for September 9–10, floods of September 9–11 in the Santa Cruz River basin, Arizona. Isohyets from U.S. Army Corps of Engineers (1964c).

The Santa Cruz River and its major tributaries had high peak discharges and large volumes of flow during the flood period. Large flows entered the Santa Cruz River from minor tributaries about 2 miles downstream from the Santa Cruz River near the Nogales gaging station (sta. 2). The tributaries crested about 1 hour before the Santa Cruz River crested, and local residents reported that the combined flow in the Santa Cruz River at this point was the highest in 55 years (U.S. Army Corps of Engineers, 1964c). The flood in Josephine Canyon was one of the largest known to local residents, and the flow was estimated to be almost as great as that in the Santa Cruz River above Josephine Canyon (U.S. Army Corps of Engineers, 1964c). The volume of runoff in the Santa Cruz River from this one storm exceeded the mean annual runoff at the Continental (sta. 4) and Tucson (sta. 5) gaging stations. At four other gaging stations in the basin—Santa Cruz River near Lochiel (sta. 1), Sonoita Creek near Patagonia (sta. 3), Pantano Wash near Vail (sta. 11), and Santa Cruz River at Cortaro (sta. 14)—the runoff was more than 50 percent of the mean annual runoff. The peak flow of 13,000 cfs of Santa Cruz River at Tucson (sta. 5) was the third highest in 59 years of record (table 19). The peak flows at

TABLE 19.—*Flood stages and discharges, September 9–11 in the Santa Cruz River basin, Arizona*

No.	Stream and place of determination	Drainage area (sq mil)	Maximum floods: Prior to Sept. 1964: Period	Year	Sept. 1964 (date)	Gage height (ft)	Discharge: Cubic feet per second	Recurrence interval (years)
1	Santa Cruz River near Lochiel	82.2	1949–64	1950		6.75	4,520	
					9	6.44	2,330	4
2	Santa Cruz River near Nogales.	533	1930–64	1935		12.3	12,000	
					11	7.47	2,260	2
3	Sonoita Creek near Patagonia	209	1930–64	1946		13.0	14,000	
					10	8.79	2,640	2
4	Santa Cruz River at Continental.	1,662	1940–64	1955		11.34	17,500	
					10	10.13	14,000	13
5	Santa Cruz River at Tucson	2,222	1905–64	1961		21.30	16,600	
					10	18.05	13,000	9
6	Tucson Arroyo at Vine Avenue, Tucson.	8.2	1956–64	1961		10.35	5,000	
					10	4.39	137	(1)
7	Tanque Verde Creek near Tucson.	43.0	1959–64	1963		3.50	1,520	
					10	4.86	2,630	10
8	Sabino Creek near Tucson	35.5	1932–64	1954		8.43	5,100	
					13	5.82	1,310	3
9	Bear Creek near Tucson	16.3	1959–64	1960		2.30	575	
					13	2.38	433	(1)
10	Barrel Canyon near Sonoita	14.1	1962–64	1963		2.57	145	
					10	4.78	879	(1)
11	Pantano Wash near Vail	457	1958–64	1958		24	38,000	
					10	11.06	9,960	7
12	Rincon Creek near Tucson	44.8	1952–64	1955		9.90	8,250	
					23	5.30	948	1
13	Rillito Creek near Tucson	918	1908–64	1929		[2] 24	24,000	
					10	8.58	9,420	10
14	Santa Cruz River at Cortaro	3,503	1936–64	1940		[2] 9.9	17,000	
					10	9.29	15,900	9
15	Santa Cruz River near Laveen	8,581	1940–64	1962		17.50	9,200	
					14	13.67	1,280	(1)

[1] Not determined.
[2] Site and datum then in use.

the Continental and Cortaro gaging stations were the third highest in 25 and 29 years of record, respectively.

At Pantano Wash near Vail, the peak flow of 9,960 cfs was the highest since 1959, when the gage was installed; the discharge, however, is low in comparison to the peak flow of 38,000 cfs on August 11, 1958. Because of the long duration of flow on September 10, much of the flow reached the Rillito Creek near Tucson gaging station (sta. 13). The peak discharge of 9,420 cfs was the highest since 1950 at this station. The large flow (peak discharge 2,630 cfs) from Tanque Verde Creek near Tucson (sta. 7) also contributed to the flooding on Rillito Creek. Sabino, Bear, and Rincon Creeks had peaks of 1,310, 433, and 948 cfs, respectively, and contributed very little water to the flood. The flood crests on Rillito Creek and on the Santa Cruz River reached the confluence almost simultaneously, causing a high peak flow of 15,900 cfs at Santa Cruz River at Cortaro (sta. 14). (See fig. 36.)

Many places were inundated in the 140-mile reach of the Santa Cruz River between the Mexican border and Chuichu. The two major reaches of flooding were from Continental to Sahuarita and from Marana to Chuichu. The first reach was flooded from about 3 miles upstream (south) from Continental to about 5 miles downstream (north) from Sahuarita—a length of 15 miles. Considerable damage

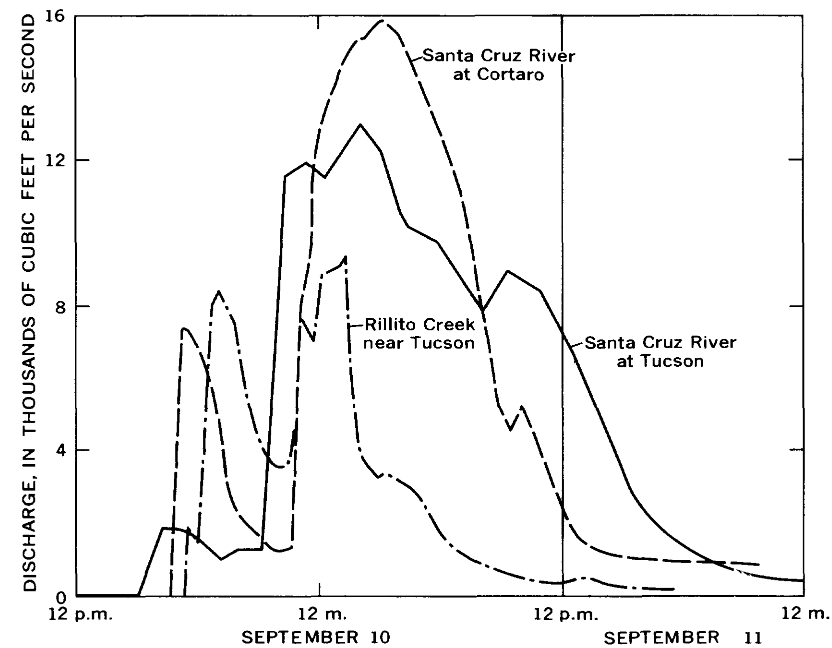


FIGURE 36.—Discharges, September 10–11, at selected stations in the Santa Cruz River basin, Arizona.

resulted where water left the river at horseshoe bends. The flood inundated many acres of cotton that was almost ready for harvesting. In about half of the reach, the inundated area was more than 1 mile wide. Water reentering the river channel from the overflow area caused considerable bank cutting and gullying. East-west roads and railroad embankments formed dikes that backed water up as much as 2 miles over flat fields. Between Tucson and Marana, most of the water was confined by dikes. In the Marana area, however, dikes were overtopped, and large tracts of farmland were flooded. Farther downstream dikes failed completely, and large areas along 35 miles of flood plain were inundated. As a precautionary measure, 42 families were evacuated from Chuichu. Downstream from Chuichu the flood water spread out onto a broad flat desert area and did little damage. In this area the flood dissipated rapidly, and by the time the flow reached the mouth of the Santa Cruz River, the discharge had been reduced and neither the peak discharge nor the volume was unusual.

Large amounts of precipitation fell in the headwaters of Los Robles Wash (fig. 35). Rangeland absorbed most of the runoff, and the flow in Los Robles Wash was contained in the small channel. The peak discharge to the Santa Cruz River from Los Robles Wash probably had little effect on the flow of the river.

The U.S. Army Corps of Engineers (1964c) estimated flood damage at about $2,485,000 in the Santa Cruz River basin (table 20); agricultural damage accounted for about 80 percent of the total. Agricultural losses include damage to land, crops, livestock, irrigation ditches, dikes, and equipment. Damage to transportation facilities accounted

TABLE 20.—*Summary of damage resulting from floods of September 9–11 in the Santa Cruz River basin, Arizona*

[Data from U.S. Army Corps of Engineers (1964c)]

County	Damage		
	Agricultural	Nonagricultural	Total
Main stem of the Santa Cruz River:			
Santa Cruz County	$75,000	$20,000	$95,000
Pima County	1,395,000	280,000	1,675,000
Pinal County	475,000	45,000	520,000
Total, main-stem damage	1,945,000	345,000	2,290,000
Principal tributaries to the Santa Cruz River:			
Santa Cruz County	15,000	5,000	20,000
Pima County	20,000	155,000	175,000
Total, principal-tributary damage	35,000	160,000	195,000
Grand total	1,980,000	505,000	2,485,000

for most of the nonagricultural losses. Commercial losses were minor, because the Santa Cruz River is well entrenched in most of the urban areas, and the channel is degrading. After this flood, the channel bed at Ajo Road in Tucson was about 2–3 feet lower than it was after the flood of August 22–23, 1961, and 8 feet lower than it was when the bridge was built in 1958. (U.S. Army Corps of Engineers, 1964c).

FLOODS OF SEPTEMBER 9–13 IN CENTRAL AND NORTHERN FLORIDA AND SOUTHERN GEORGIA CAUSED BY HURRICANE DORA

By James W. Rabon

Hurricane Dora was the first storm of full-hurricane intensity to cross into northeastern Florida from the Atlantic Ocean since U.S. Weather Bureau records have been kept. The storm center moved inland over St. Augustine on September 10 and continued its path by moving along an almost due west track across northern Florida and reached the southeast corner of Alabama on the afternoon of September 11 (fig. 37). The storm center then took a sharp turn to the north and the east, and crossed southern Georgia on September 12. Heavy rains accompanying the storm across the interior of northern Florida produced significant rises on many streams and lakes north of Ocala and in some areas along the gulf coast. Additional rains, some of which were extremely heavy, fell over much of the northern interior of Florida on September 12 as the storm center moved eastward through southern Georgia. Strong winds of long duration produced abnormally high tides along the Atlantic and gulf coasts. Northeastern Florida was declared a major disaster area on September 10.

High antecedent moisture conditions contributed to considerable flooding over the entire area. Streamflow for the 11 months October 1963–August 1964 ranged from about 35 to 75 percent above normal in the southern part of the area. In the northern part, streamflow for the same 11 months ranged from about three to almost five times as great as normal. Runoff ranged from about 3.5 inches in excess of normal in the southern part to 17 inches in excess in the northern part.

Highest sustained winds, estimated near 125 miles per hour, were observed at St. Augustine. Sustained winds of 82 miles per hour were recorded at the Jacksonville airport, and this was the first time in the U.S. Weather Bureau history that winds of full-hurricane force had been observed in Jacksonville. Measured rainfall totals during the 4-day period September 9–12 were near, or in excess of, the estimated 50-year 4-day storm at almost all weather stations in the area between Madison County and the St. Johns River, and from about Alachua

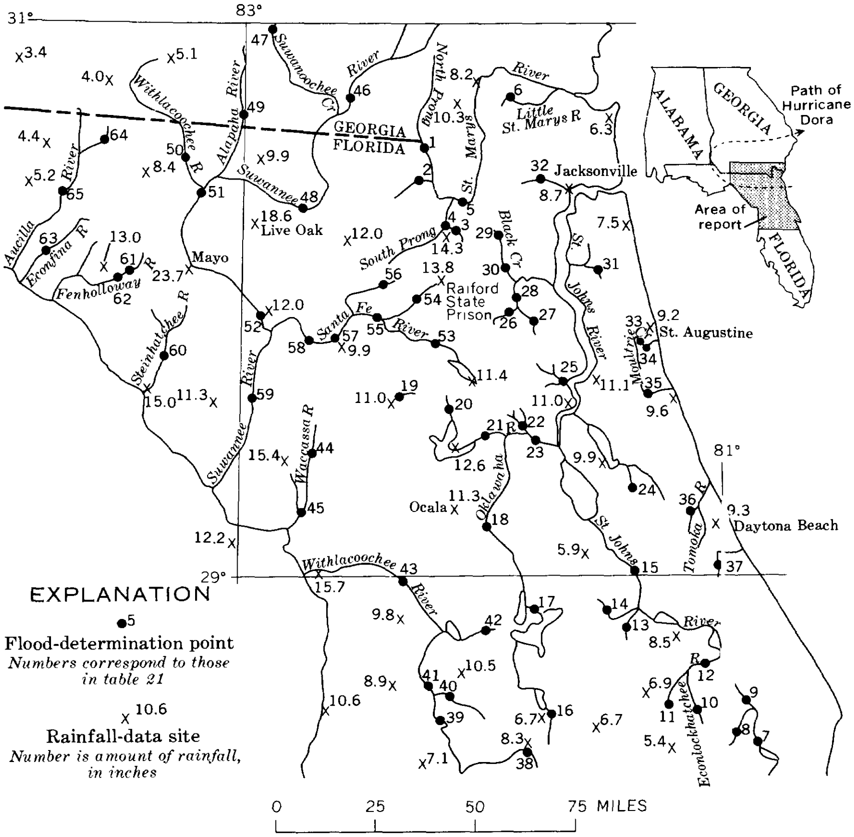


FIGURE 37.—Flood area; location of flood-determination points and total rainfall September 9–13, floods of September 9–13 in central and northern Florida and southern Georgia.

County northward. Some stations in this area measured 4-day totals in excess of the estimated 100-year storm. The heaviest rains fell in the Suwannee and Lafayette County areas. The greatest storm total reported was 23.73 inches at Mayo (Lafayette County); 14.62 inches of this total fell during the 24-hour period ending at 6 p.m. on September 12. Live Oak (Suwannee County) reported a storm total of 18.62 inches of which 12.95 inches fell during the 24-hour period ending at 6 p.m. on September 12. Storm rainfall in excess of 10 inches fell over an estimated 10,000-square-mile area. Figure 38 shows the rainfall depth-duration curve for the recording-gage weather station at Raiford State Prison.

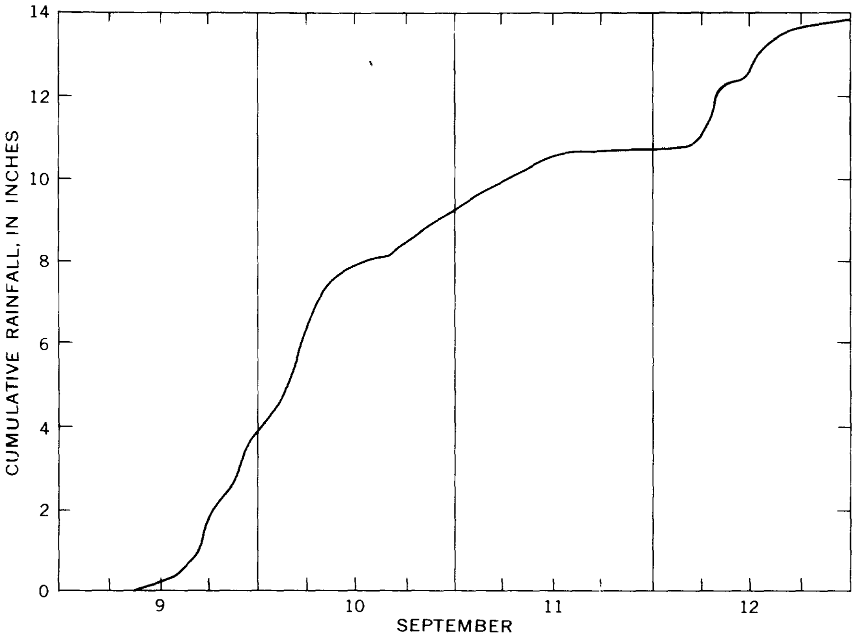


FIGURE 38.—Cumulative rainfall, September 9–12, at Raiford State Prison weather station, Florida.

Maximum stages and discharges of record occurred at 23 of 65 gaging stations in the area (table 21). At least 16 stations had peak discharges that were nearly equal to or greater than those for 50-year floods. The peak discharge of New River near Lake Butler (sta. 54) was 44 percent greater than the 50-year flood discharge. The discharge hydrograph at this station is shown in figure 39. Rainfall-runoff comparisons can be made from figures 38 and 39.

The highest tides from the hurricane were observed in the St. Augustine area, where observers reported tides estimated at 12 feet high, or about 4 feet higher than any others known. Tides north of Daytona Beach ranged from 5 to 10 feet above normal, and tides along the gulf coast between Tampa Bay and St. Marks ranged from 2 to 6 feet above normal. There was considerable flooding along the St. Johns River in Jacksonville on September 10. Strong southerly winds caused the river to overtop its north bank in the area where the river turns east to the Atlantic Ocean. Peak stages recorded September 10 at three gaging stations at Jacksonville were maximum stages since at least 1944.

The one fatality in Florida directly attributed to the storm was a drowning at Live Oak. High tides along the Atlantic coast caused extensive beach erosion, inundated most beach communities, and washed out, or undermined, beach roads and beach residences. Wind and tide

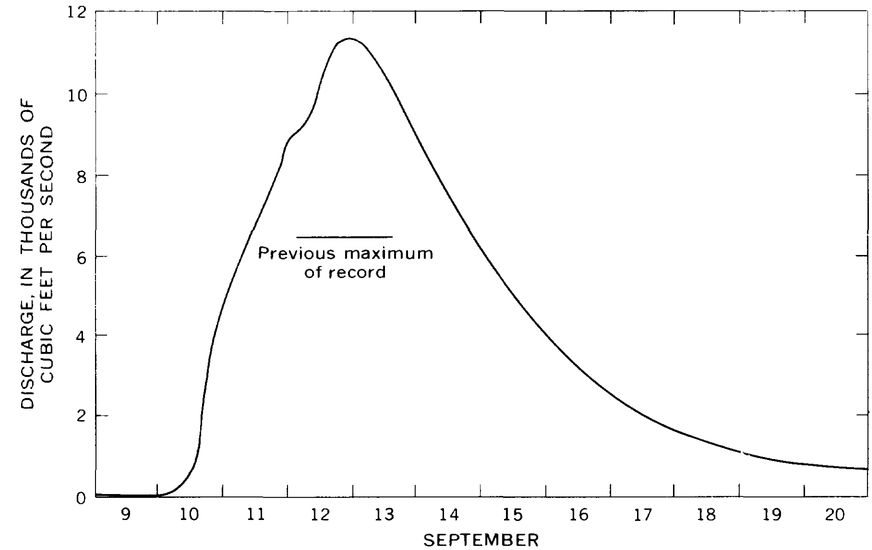


FIGURE 39.—Discharge of New River near Lake Butler, Fla., September 9–20. Drainage area, 212 square miles.

damages were extensive north of St. Augustine, where several beach residences were washed into the sea. South of Daytona Beach, wind and tide damages were relatively small. High winds in Duval County, including metropolitan Jacksonville, caused a massive utilities failure. Numerous trees were uprooted throughout the coastal counties and added to the overall destruction when they fell on buildings or across utility lines. The wind-induced flooding along the St. Johns River at Jacksonville forced the evacuation of a number of riverfront residences. Tidal flooding on the gulf coast was aggravated by heavy rains which produced widespread flooding on many streams emptying into the gulf. Numerous residents in the gulf coast area were forced to evacuate their homes because of rising waters. Many roads in this area were temporarily closed by floodwaters.

The very heavy rains that fell in Lafayette and Suwannee Counties caused flooding on many small streams and lakes, and many poorly drained areas were inundated when water collected in low places. Scattered residential areas throughout the heavy-rain areas became small lakes, and many residents had to flee when the rising waters entered their homes. The town of Live Oak was especially hard hit by floods; a large part of the business district and some residential areas were inundated for several days. Floodwaters from streams, lakes and poorly drained collecting basins closed many roads throughout the area for several days. Consequently, road damage was widespread, and some communities were almost completely isolated by the floodwaters.

TABLE 21.—*Flood stages and discharges, September in central and northern Florida and southern Georgia, from Hurricane Dora*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Sept. 1964: Period	Maximum floods: Prior to Sept. 1964: Year	Maximum floods: Sept. 1964 (date)	Maximum floods: Gage height (ft)	Maximum floods: Discharge: Cubic feet per second	Maximum floods: Discharge: Recurrence interval (years)
	St. Marys River basin							
1	North Prong St. Marys River at Moniac, Ga.	106	1921–23, 1927–34, 1951–64.	1928		[1] 16.7	[1] 6,060	
					13, 14	18.41	4,590	16
2	Middle Prong St. Marys River at Taylor, Fla.	127	1955–64	1958		12.0	1,790	
					12	14.38	3,920	18
3	Turkey Creek at Macclenny, Fla.	20.9	1955–64	1963		7.10	1,270	
					12	7.62	1,730	11
4	South Prong St. Marys River at Glen St. Marys, Fla.	150	1947	1947		13.0		
			1950–64	1950			6,200	
					12	14.23	7,510	[2] 1.30
5	St. Marys River near Macclenny, Fla.	720	1926–64	1947		22.29	28,100	
					13	23.25	26,000	[3] 1.14
6	Little St. Marys River near Hilliard, Fla.	18.1	1961–64	1962		6.03	768	
					13	7.40	2,150	[2] 2.47
	St. Johns River basin							
7	St. Johns River near Cocoa, Fla.	1,237	1953–64	1953		16.96	10,700	
					12	15.89	7,160	6
8	Jim Creek near Christmas, Fla.	22.7	1960–64	1960		9.18	3,750	
					10	7.75	2,220	[2] 2.07
9	St. Johns River near Christmas, Fla.	1,418	1933–64	1953			11,700	
				1960		10.81		
					15	9.48	8,930	7
10	Econlockhatchee River near Bithlo, Fla.	119	1960–64	1960		20.51	7,840	
					12	17.88	4,050	29
11	Little Econlockhatchee River near Union Park, Fla.	27.1	1959–64	1960		11.64	1,640	
					11	10.01	824	10
12	Econlockhatchee River near Chuluota, Fla.	260	1935–64	1960		18.69	11,000	
					12	15.30	5,450	7
13	Wekiva River near Sanford, Fla.	(3)	1935–64	1945			2,060	
				1960		6.09		
					13	5.27	1,650	(3)
14	Black Water Creek near Cassia, Fla.	110	1962–64	1962		8.19	263	
					13	9.06	506	(3)
15	St. Johns River near De Land, Fla.	2,960	1933–64	1953			17,100	
				1953		7.17		
					18, 19		13,400	5
					23	6.14		
16	Big Creek near Clermont, Fla.	68	1958–64	1960		6.23	69[illegible]	
					15	5.79	414	1
17	Haines Creek at Lisbon, Fla.	640	1942–64	1958			1,330	
				1960		64.50		
					11, 12		964	6
18	Oklawaha River near Ocala, Fla.	1,070	1930–64	1960		5.68	2,270	
					11	4.48	1,360	3
19	Hogtown Creek near Gainesville, Fla.	15.6	1959–64	1961		9.89	500	
					12	12.23	1,210	[2] 1.59
20	Lochloosa Creek at Grove Park, Fla.	34.7	1958–64	1960		7.90	920	
					12	9.45	1,520	(3)
21	Orange Creek at Orange Springs, Fla.	1,210	1942–52, 1955–64	1941		10.6	2,400	
					13	9.86	2,170	(3)
22	Deep Creek near Rodman, Fla.	54.3	1959–64	1960		14.16	1,670	
					11	14.07	1,590	11
23	Oklawaha River at Riverside Landing near Orange Springs, Fla.	2,940	1943–64	1960		9.80	7,830	
					15	9.73	8,760	11
24	Little Haw Creek near Seville, Fla.	120	1951–64	1960			1,600	
				1953		8.72		
					14	8.54	1,020	2
25	Rice Creek near Palatka, Fla.	353	1959–64	1960			[4] 5,240	
					11		[4] 6,480	(3)

See footnotes at end of table.

TABLE 21.—*Flood stages and discharges, September in central and northern Florida and southern Georgia, from Hurricane Dora*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Sept. 1964: Period	Prior to Sept. 1964: Year	Sept. 1964 (date)	Gage height (ft)	Discharge: Cubic feet per second	Discharge: Recurrence interval (years)
	St. Johns River basin—Continued							
26	South Fork Black Creek near Camp Blanding, Fla.	34.8	1958–64	1959		11.24	3 240	
					10	7.85	780	1
27	Greens Creek near Penney Farms, Fla.	14.9	1958–64	1960		6.00	1,360	
					10	5.85	1,270	11
28	South Fork Black Creek near Penney Farms, Fla.	134	1939–64	1944		26.33	13,900	
					11	20.04	6,440	5
29	Yellow Water Creek near Maxville, Fla.	25.7	1958–64	1963		8.64	1,000	
					([3])	9.71	1,890	10
30	North Fork Black Creek near Middleburg, Fla.	174	1919	1919		25.3	15,000	
			1931–64	1944		23.76	10,400	
					11	22.92	11,200	11
31	Durbin Creek near Durbin, Fla.	36.7	1961–64	1963		5.45	332	
					11	11.98	4,140	[2] 2.55
32	Trout River at Dinsmore, Fla.	20	1961–64	1963		7.18	522	
					11	7.82	646	11
	Coastal basins between St. Johns River and Lake Okeechobee and the Everglades							
33	Moultrie Creek at State Highway 207 near St. Augustine, Fla.	22.1	1961–64	1964		8.47	682	
					10	9.02	836	([3])
34	Moultrie Creek near St. Augustine, Fla.	23.3	1919	1919		13	([3])	
			1939–64	1941		9.31	1,370	
					10	9.06	1,450	[2] 1.32
35	Fish Swamp Outlet near Summer Haven, Fla.	4.86	1962–64	1963		[5] 5.66	([3])	
					10	[5] 5.38	357	([3])
36	Little Tomoka River near Ormand Beach, Fla.	10	1962–64	1963		3.56	100	
					10	5.09	392	16
37	Spruce Creek near Samsula, Fla.	32	1951–64	1953		15.49	798	
					10	14.05	1,610	[2] 1.07
	Withlacoochee River basin							
38	Withlacoochee River near Eva, Fla.	130	1958–64	1960		6.90	2,160	
					13	6.40	1,310	10
39	Withlacoochee River at Trilby, Fla.	580	1928–29, 1930–64	1934		[1] 20.5	[1] 8,840	
					21	14.71	3,030	5
40	Little Withlacoochee River at Rerdell, Fla.	160	1958–64	1960		12.32	3,400	
					17	8.13	748	2
41	Withlacoochee River at Croom, Fla.	880	1934	1934		[1] 15.2	([3])	
			1939–64	1960		13.78	8,650	
					22	10.20	3,640	6
42	Chitty Chatty Creek near Wildwood, Fla.	25			13	5.22	112	1
43	Withlacoochee River near Holder, Fla.	1,710	1928–29, 1931–64	1960		13.28	8,660	
					([6])	9.22	3,980	3
	Waccassa River basin							
44	Waccassa River near Bronson, Fla.	150	1961–64	([3])		([3])	([3])	
					12	5.49	1,090	5
45	Waccassa River near Gulf Hammock, Fla.	[7] 400			12	6.96	[7] 12,200	[2] 2.28

See footnotes at end of table.

TABLE 21.—*Flood stages and discharges, September in central and northern Florida and southern Georgia, from Hurricane Dora*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Sept. 1964: Period	Prior to Sept. 1964: Year	Sept. 1964 (date)	Gage height (ft)	Discharge: Cubic feet per second	Discharge: Recurrence interval (years)
	Suwannee River basin							
46	Suwannee River at Fargo, Ga.	1,260	1921–23, 1927–31, 1937–64.	1928			[1] 13,800	
				1929		[1] 19.6		
					17	18.6	9,940	10
47	Suwanoochee Creek at Dupont, Ga.	143	1930–64	1929		11.2	(3)	
			1948–64	1959		8.2	1,480	
					15	7.42	1,100	5
48	Suwannee River at White Springs, Fla.	1,990	1906–08, 1927–64	1948		36.65	28,500	
					17	35.82	23,300	30
49	Alapaha River at Statenville, Ga.	1,400	1862–1964	1948		29.8	27,300	
					18		[4] 4,660	2
50	Withlacoochee River near Pinetta, Fla.	2,220	1928–64	1948		38.64	79,400	
					20	14.17	4,740	1
51	Suwannee River at Ellaville, Fla.	6,580	1927–64	1948		40.88	95,300	
					22	26.17	27,600	5
52	Suwannee River at Branford, Fla.	7,090	1931–64	1948		34.07	83,900	
					24	25.32	26,400	6
53	Santa Fe River near Graham, Fla.	135	1957–64	1959		13.39	1,120	
					12	14.97	2,360	(3)
54	New River near Lake Butler, Fla.	212	1950–64	1950		12.02	6,470	
					12	15.33	11,400	[2] 1.44
55	Santa Fe River at Worthington, Fla.	630	1931–64	1934			17,500	
				1944		24.94		
					13	28.40	20,000	46
56	Swift Creek near Lake Butler, Fla.	27	1957–64	1960		8.61	913	
					13	10.62	1,880	(3)
57	Santa Fe River near High Springs, Fla.	950	1931–64	1948		15.71	12,700	
					15		20,000	[2] 1.75
					16	[5] 18.96		
58	Santa Fe River near Fort White, Fla.	1,080	1927–30, 1932–64	1948			12,300	
				1948		[5] 13.70		
					16	15.34	17,000	[2] 1.30
59	Suwannee River near Wilcox, Fla.	9,500	1930–31, 1941–64	1948		22.32	84,700	
					22, 23	14.96	36,700	7
	Steinhatchee River Basin							
60	Steinhatchee River near Cross City, Fla.	350	1950–64	1957		15.84	4,320	
					13, 14	18.90	17,600	[2] 1.44
	Coastal basins between Steinhatchee River and Aucilla River							
61	Fenholloway River near Foley, Fla.	70	1955–64	1957		14.08	1,620	
					12	15.21	3,210	[2] 1.08
62	Fenholloway River at Foley, Fla.	80	1946–64	1948		16.03	2,640	
					12	18.52	4,810	[2] 1.43
63	Econfina River near Perry, Fla.	192	1950–61	1957		12.78	2,540	
					17	11.59	1,250	3
	Aucilla River basin							
64	Little Aucilla River near Greenville, Fla.	20	1963					
					14	4.35	187	(3)
65	Aucilla River at Lamont, Fla.	680	1950–64	1957		[1] 14.93	[1] 6,580	
					15	10.95	2,280	(3)

[1] At different site or datum.
[2] Ratio of peak discharge to 50-yr flood.
[3] Not determined.
[4] Maximum daily discharge.
[5] Affected by backwater.
[6] Peak occurred on October 4, 1964.
[7] Includes that of Otter Creek.

Agriculture on the northern peninsula sustained considerable water damage. Many crops, such as corn, cotton, peanuts, and especially those crops grown in poorly drained areas, were under water for several days, and crop losses were severe. A considerable amount of pastureland was flooded throughout the area, which caused supplemental feeding of livestock to be necessary for some time after the storm passed.

Flood damage listed in table 22 (which gives a partial summary of property damage in Florida) was almost $150 million. In the Brunswick, Ga., area alone, damage was estimated at more than $3,250,000.

TABLE 22.—*Summary of estimated property damage (excluding agriculture) resulting from Hurricane Dora, September 9–13 in central and northern Florida*

[Data furnished by the Florida State Civil Defense Agency]

County	Public	Private	Erosion of beaches	Total
Northern Florida area:				
Alachua	$737, 800	$380, 000		$1, 117, 800
Baker	55, 000			55, 000
Bradford	71, 500	60, 000		131, 500
Clay	2, 090, 200	6, 000, 000		8, 090, 200
Columbia	298, 000	250, 000		548, 000
Dixie	1, 043, 900	150, 000		1, 193, 900
Duval	10, 061, 000	60, 000, 000	$3, 250, 000	73, 311, 000
Flagler	69, 250	86, 500	3, 530, 000	3, 685, 750
Gilchrist	(1)			
Hamilton	15, 000			15, 000
Lafayette	108, 000	135, 000		243, 000
Madison	(1)			
Nassau	639, 000	2, 950, 000	4, 362, 000	7, 951, 000
Putnam	43, 500	1, 000, 000		1, 043, 500
St. Johns	1, 373, 000	20, 000, 000	15, 840, 000	37, 213, 000
Suwannee	1, 605, 500	4, 000, 000		5, 605, 500
Taylor	331, 000	1, 500, 000		1, 831, 000
Union	206, 000	200, 000		406, 000
Total	18, 747, 650	96, 711, 500	26, 982, 000	142, 441, 150
Central Florida area:				
Citrus	207, 000	729, 000		936, 000
Levy	186, 000	375, 000		561, 000
Marion	81, 000	26, 500		107, 500
Orange	179, 000	225, 000		404, 000
Seminole	122, 800	118, 000		240, 800
Volusia	590, 000	1, 551, 000	100, 000	2, 241, 000
Total	1, 365, 800	3, 024, 500	100, 000	4, 490, 300
Grand total	20, 113, 450	99, 736, 000	27, 082, 000	146, 931, 450

[1] Unknown.

FLOODS OF SEPTEMBER 15-30 IN SOUTH-CENTRAL AND NORTHEASTERN TEXAS

Rains which covered large sections of Texas during the last half of September caused flash floods on small creeks and much damage in local areas. The damaging storms began September 15 and continued intermittently through September 27. The areas of high runoff are shown in figures 40, 41, and 42.

MIDDLE NUECES RIVER BASIN

Torrential rains, unofficially reported up to 12.5 inches, fell during the night of September 15 on Dimmit County in the area between Carrizo Springs and Encinal (fig. 40). The resulting flood caused the largest rise (20,800 cfs at a stage of 30.25 ft) since 1959 on the Nueces River near Asherton (sta. 22, table 23). The significance of this flood, which has a modest 8-year recurrence, lies in the fact that the entire runoff originated in Dimmit County downstream from the Nueces River below the Uvalde station (sta. 21). As shown in figure 43, no storm runoff occurred at gaging stations above the Asherton station (sta. 22) prior to September 20. The rains caused flash flooding on El Morro Creek at Asherton, and on San Roque and Apourcean Creeks at Catarina. Downstream from Asherton almost all the residences were flooded by 6 to 8 inches of water. A resident who had lived in Asherton for 42 years said that this was, by far, the most floodwater he had ever seen. The flood caused damage estimated at $1 million in Dimmit County—the greatest damage in that county's history.

MIDDLE RIO GRANDE AND UPPER NUECES RIVER BASINS

Heavy rains on September 19 and 20 in the Devils River and upper Nueces River basins caused flash floods on almost all small streams and flooding of border towns and cities along the Rio Grande. Within 24 hours, beginning on the night of September 19, up to 15 inches of rain fell on the Devils River basin, and up to 17 inches was reported on the upper Nueces River basin. Near-record floods ended a 3-year period of no flow at West Nueces River near Brackettville (sta. 20). Figure 40 shows the flood-determination points, and the hydrographs in figure 43 demonstrate the flash-flood characteristic of the upper Nueces River. They also show the reduction in peak flows as the flood traveled downstream. From a combined flow of 246,000 cfs at West Nueces River near Brackettville (sta. 20) and 108,000 cfs at Nueces River at Laguna (sta. 19), only 188,000 cfs occurred at Nueces River below Uvalde (sta. 21). The peak discharge at West Nueces near Brackettville has a recurrence interval of 46 years, and was the third highest since at least 1879.

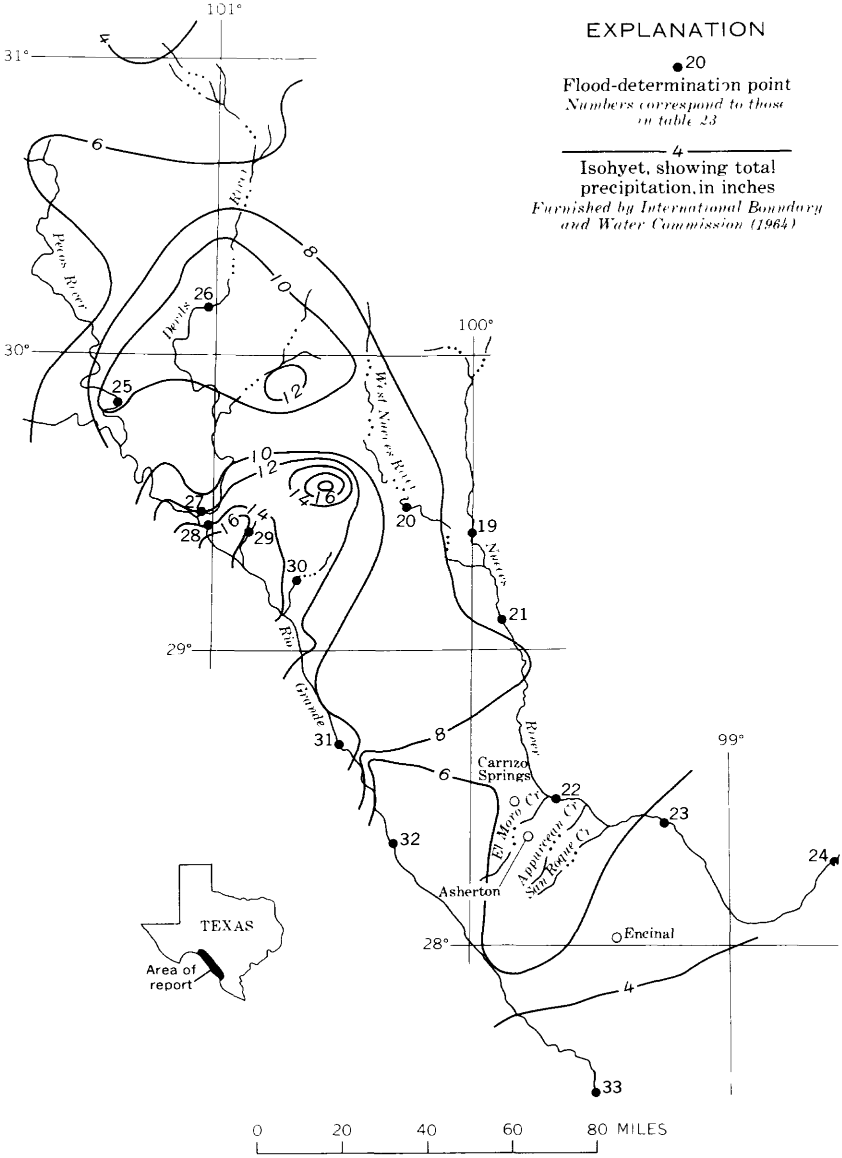


FIGURE 40.—Flood area; location of flood-determination points and isohyets for September 15–30 for the middle Rio Grande and upper and middle Nueces River basins in south-central Texas, floods of September 15–30 in south-central and northeastern Texas.

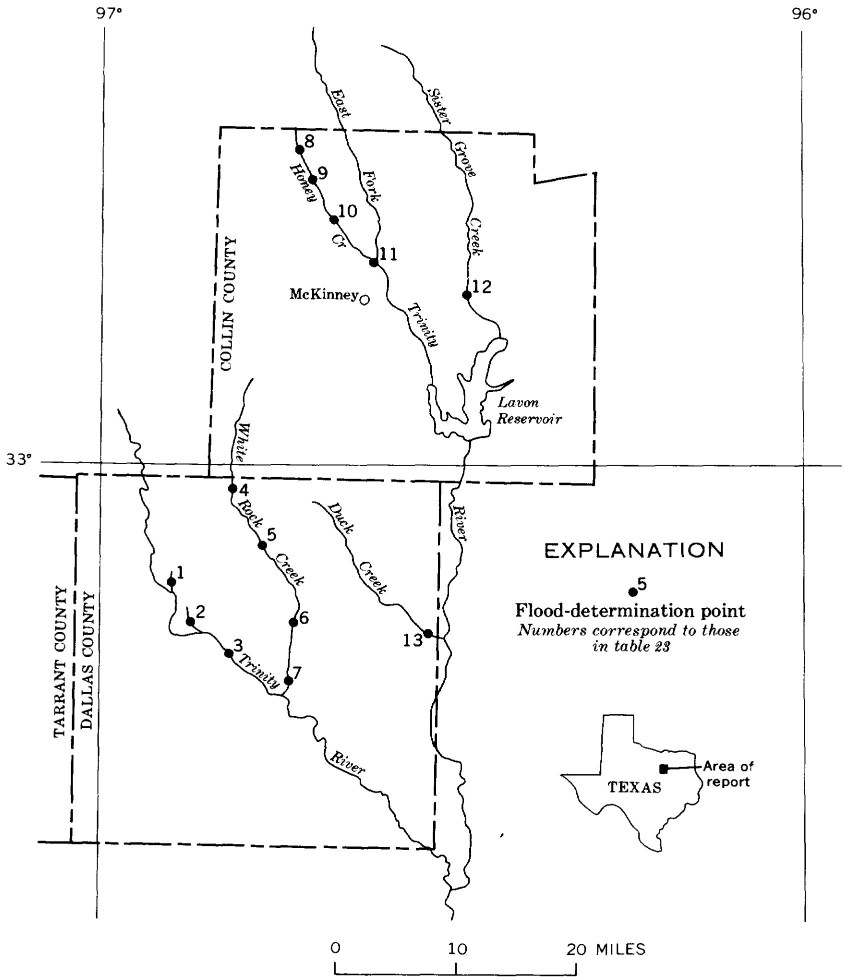


FIGURE 41.—Flood area; location of flood-determination points for the upper Trinity River basin in northeastern Texas, floods of September 15–30 in south-central and northeastern Texas.

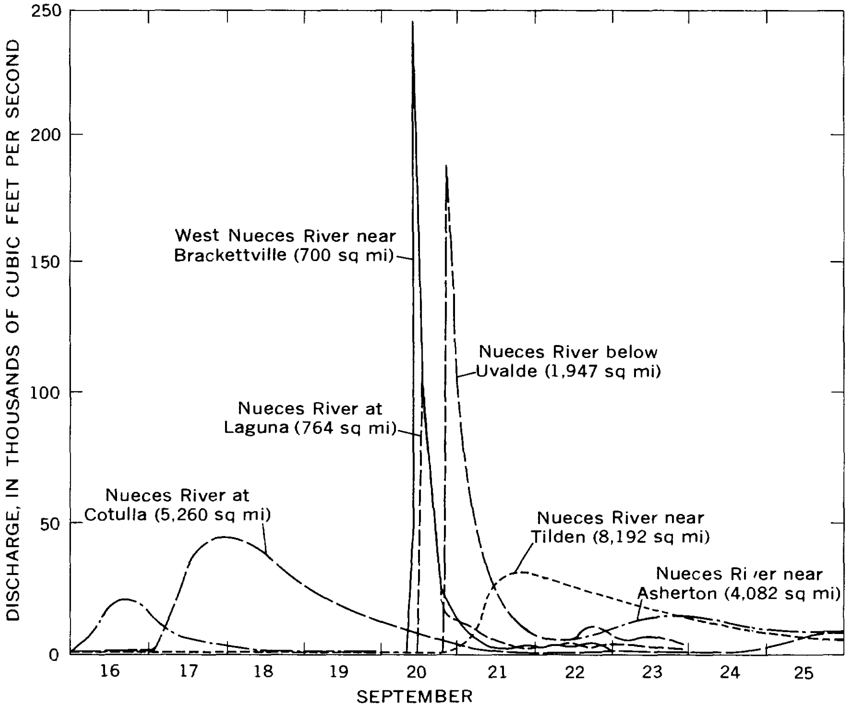


FIGURE 43.—Discharge hydrographs for six gaging stations, September 15–30, floods of September 15–30 in south-central and northeastern Texas.

UPPER TRINITY RIVER BASIN

During the first 8 hours of September 21, torrential rains of more than 12 inches fell in a band extending from northeastern Tarrant County eastward over Dallas and Collin Counties (fig. 41). Flash flooding from tributaries of the Trinity River resulted in two deaths by drowning and in property damage estimated at $5 million. The heaviest rain fell on an area north of Dallas. McKinney received 12.10 inches of rain between 1:15 a.m. and 7a.m. Flooding of homes occurred in all sections of McKinney. Several homes in north Dallas were damaged. The flood-determination points are shown in figure 41, and peak flows are listed in table 23. Figures 44 and 45 illustrate the intensity and accumulation of rainfall, the resulting discharges, and the total storm runoff for stations near the north and south ends of the intense rainfall area.

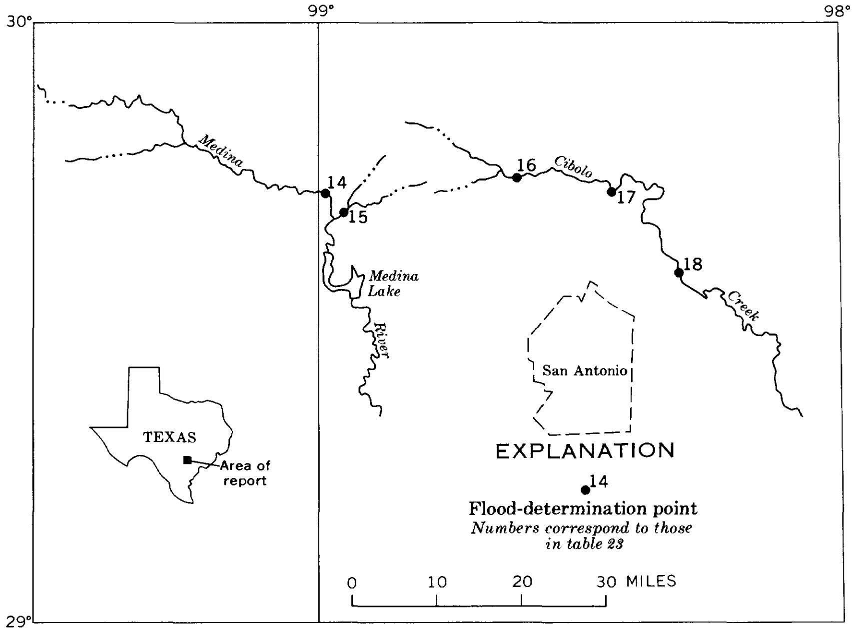


FIGURE 42.—Flood area; location of flood-determination points in the upper San Antonio River basin in south-central Texas, floods of September 15–30 in south-central and northeastern Texas.

The following paragraph concerning the Rio Grande flood is based on a description by The International Boundary and Water Commission of the U.S. and Mexico (1964).

Rainfall amounts up to 20.33 inches were measured September 15–30. Figure 40 shows isohyets for this period, during which all the tributaries of the Rio Grande in the area had significant floods. San Felipe and Pinto Creeks had 24- and 26-year floods, respectively. (See stas. 29 and 30, table 23.) The floodflows from these tributaries combined with ungaged storm runoff to cause large floods on the Rio Grande below Amistad Dam (sta. 28, table 23). On September 24 the Rio Grande at Eagle Pass (sta. 31) peaked at 285,000 cfs. This discharge was equal to that for the fifth largest peak known to have occurred within the past 99 years. The 180,000 cfs peak at Laredo (sta. 33) was the seventh largest peak within the past 99 years. The volume of water passing the Laredo station during the period from September 21 to October 1 was 1,572,000 acre-feet.

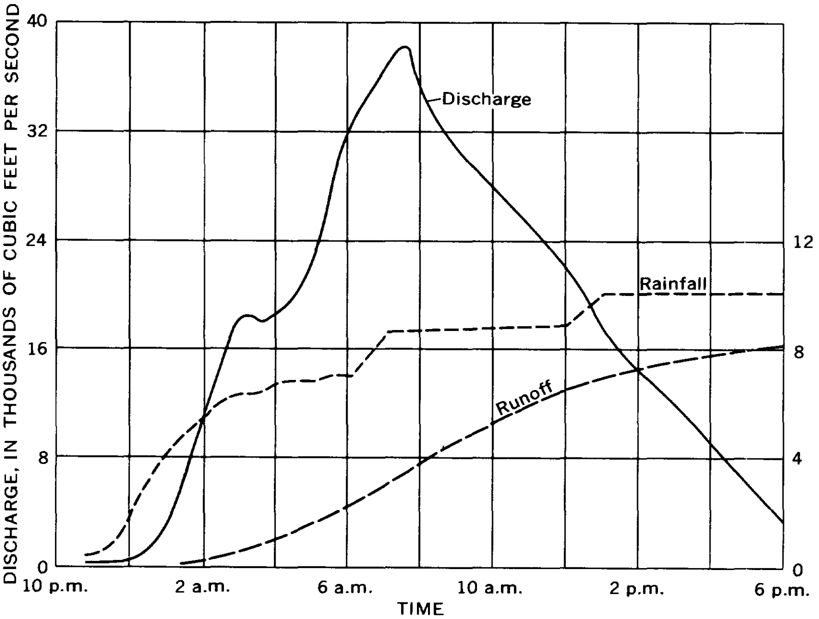


FIGURE 45.—Hydrograph and mass rainfall-runoff curves for gaging station at White Rock Creek at Greenville Avenue, Dallas, Tex., for flood of September 20–21.

TABLE 23.—*Flood stages and discharges, September 15–30 in south-central and northeastern Texas*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Sept. 1964: Period	Year	Sept. 1964 (date)	Gage height (ft)	Discharge: Cubic feet per second	Recurrence interval (years)
1	Bachman Branch at Dallas.	10.0	1900–64	1962		465.6	9,200	
					21	459.30	3,620	(1)
2	Turtle Creek at Dallas	7.98	1903–64	1959		8.10	4,650	
					21	6.79	3,240	3
3	Trinity River at Dallas	6,106	1840–1964	1866, 1908		52.6	184,000	
					22	38.06	32,600	3
4	White Rock Creek at Keller Springs Road, Dallas.	29.4	1886–1964	1942		569.6	(1)	
					21	574.51	37,900	(1)
5	White Rock Creek at Greenville Ave., Dallas.	66.4	1886–1964	1942		490.1	(1)	
					21	490.43	38,100	(1)
6	White Rock Creek at White Rock Lake, Dallas.	100	1910–64	1942		465.2	(1)	
					21	465.60	28,300	(1)
7	White Rock Creek at Scyene Road, Dallas.	125	1886–1964	1942		[2] 409.2	28,000	
					21	404.30	30,200	(1)
8	Honey Creek subwatershed 11 near McKinney.	2.14	1952–64	1958			[3] 1,880	
					21		[4] 1,380	(1)
9	Honey Creek subwatershed 12 near McKinney.	1.26	1952–64	1957			[3] 1,490	
					21		[3] 850	(1)
10	Honey Creek near McKinney.	39.0	1930–64	1950		23.0	(1)	
			1951–64	1957		20.29	7,920	
					21	17.66	3,370	(1)

See footnotes at end of table.

TABLE 23.—*Flood stages and discharges, September 15–30 in south-central and northeastern Texas*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Sept. 1964 — Period	Year	Sept. 1964 (date)	Gage height (ft)	Discharge: Cubic feet per second	Recurrence interval (years)
11	East Fork Trinity River near McKinney.	190	1913–64	1942		21	(1)	
			1949–64	1950		17.23	(1)	
					21	16.86	19,000	15
12	Sister Grove Creek near Princeton.	113	1865–1964	1913		22	(1)	
			1949–64	1957		16.28	9,080	
					21	16.38	7,080	4
13	Duck Creek near Garland.	31.6	1895–1964	1949		21.5	(1)	
			1958–64	1962		20.80	16,000	
					21	17.80	6,200	(1)
14	Medina River near Pipe Creek.	474	1880–1964	1919		43	(1)	
			1922–34, 1953–64	1932		35.2	64,000	
					27	28.2	39,800	11
15	Red Bluff Creek near Pipe Creek.	56.3	1905–64	1937		17	(1)	
					27	22.64	46,900	[5] 3.0
16	Cibolo Creek near Boerne.	68.4	1892–1964	1952		16.3	25,600	
					27	19.15	36,400	[5] 2.1
17	Cibolo Creek near Bulverde.	198	1868–1964	1943		25	(1)	
			1946–64	1958		22.5	21,100	
					27	20.93	19,000	13
18	Cibolo Creek at Selma.	274	1869–1964	1889		26	(1)	
			1946–64	1958		21.7	49,200	
					27	17.12	26,500	15
19	Nueces River at Laguna.	764	1866–1964	1955		32.70	307,000	
					20	23.4	108,000	12
20	West Nueces River near Brackettville.	700	1879–1964	1935		40	550,000	
					20	31.3	246,000	46
21	Nueces River below Uvalde.	1,947	1836–1964	1935		40.4	616,000	
					20	24.4	188,000	24
22	Nueces River near Asherton.	4,082	1900–64	1913, 1935		33	(1)	
			1939–64	1959		30.88	28,500	
					16	30.25	20,800	8
					23	29.65	14,500	5
23	Nueces River at Cotulla.	5,260	1879–1964	1935		32.4	82,600	
					17	27.75	46,000	23
					26	19.15	12,500	3
24	Nueces River near Tilden.	8,192	1902–64	1946		26.46	70,000	
					21	23.26	31,800	8
25	Pecos River near Shumla.	[6] 35,162	1900–64	1954		[7] 96.24	948,000	
					24		51,800	6
26	Devils River near Juno.	2,730	1882–1964	1954		35.0	393,000	
					21	21.4	104,000	7
27	Devils River at mouth near Del Rio.	4,305	1900–64	1932		[8] 36.60	597,000	
					21		122,000	6
28	Rio Grande below Amistad Dam.	[6] 126,423	1954–64	1954		55.72	1,158,000	
					24	29.90	172,000	4
29	San Felipe Creek near Del Rio.	46	1932–64	1935		23.20	45,000	
					24	18.91	28,600	24
30	Pinto Creek near Del Rio.	249	1929–64	1948		32.0	186,000	
					20	26.56	91,800	26
31	Rio Grande at Eagle Pass.	[6] 130,575	1746–1964	1865		56.00	1,236,000	
				1954		53.51	964,100	
					24	37.07	285,000	9
32	Rio Grande at San Antonio Crossing near El Indio.	[6] 132,347	1953–64	1954		42.70	912,000	
					25	26.03	250,000	9
33	Rio Grande at Laredo	[6] 135,976	1745–1964	1865		62.5	950,000	
					26	39.50	180,000	9

[1] Not determined.
[2] Caused by backwater from Trinity River in 1908.
[3] Inflow computed on basis of change in contents plus outflow for 15-minute interval—adjusted for rainfall on pool surface.
[4] Inflow computed on basis of change in contents plus outflow for 5-minute interval—adjusted for rainfall on pool surface.
[5] Ratio of peak discharge to 50-yr flood.
[6] Excludes noncontributing area.
[7] Site and datum then in use.
[8] At a point 3.7 miles upstream.

UPPER SAN ANTONIO RIVER BASIN

Record floods occurred on September 27 in the area northwest of San Antonio as a result of rain which fell on the basins of Cibolo and Red Bluff Creeks during the night of September 26–27 (fig. 42). Even though the maximum official rainfall was only about 5 inches, the highest flood in history occurred at Red Bluff Creek near Pipe Creek (sta. 15) and Cibolo Creek near Boerne (sta. 16). (See table 23.)

FLOODS OF SEPTEMBER 27–28 NEAR HAMMOND, LA.

By Braxtel L. Neely, Jr.

A severe electrical storm accompanied by heavy rains occurred during the evening of September 27 and early morning of September 28 near Hammond, La. (fig. 46). Just north of Hammond, 12.77 inches of rain was recorded by the U.S. Weather Bureau. The storm, according to local gages, produced 4.78 inches of rain on the city. The most intense part of the storm and most of the rain occurred between 6 p.m. and 10 p.m. Although most of the storm was confined to the Hammond area, the U.S. Weather Bureau recorded 2.69 inches of rain about 15 miles north of Hammond at Amite. Other gages in the area recorded lesser amounts of rain.

Natalbany River at Baptist (drainage area, 79.5 sq mi), about 4 miles west of Hammond, had a peak discharge of 8,410 cfs, which has a recurrence interval of about 32 years and was the second highest peak of record since the gage was installed in 1943. The maximum peak during the flood of May 3, 1953, had a peak discharge of 9,550 cfs, which was slightly greater than that of a 50-year flood. Ponchatoula Creek at Natalbany, which is about 3 miles north of Hammond and has a drainage area of 13.8 square miles, had a peak discharge of 2,300 cfs, which was the maximum of record since the gage was installed in 1951 and had a recurrence interval of about 17 years.

Several homes in the Hammond area were inundated by the flash flood, which caused extensive damage to carpets and other household contents. Several people living in the lower areas were evacuated by the fire department and other volunteer units. Many streets in Hammond became impassable because of the depths of water in the streets.

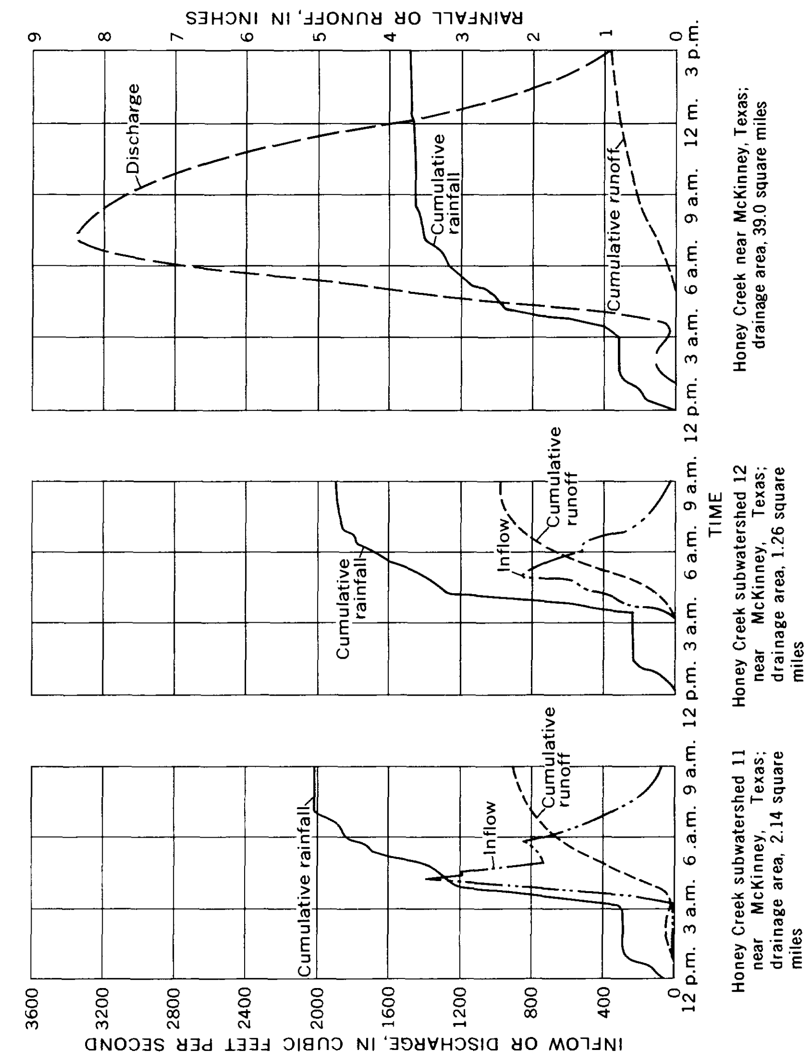


FIGURE 44.—Hydrograph and mass rainfall-runoff curves at three gaging stations in Honey Creek watershed, Texas, for flood of September 21.

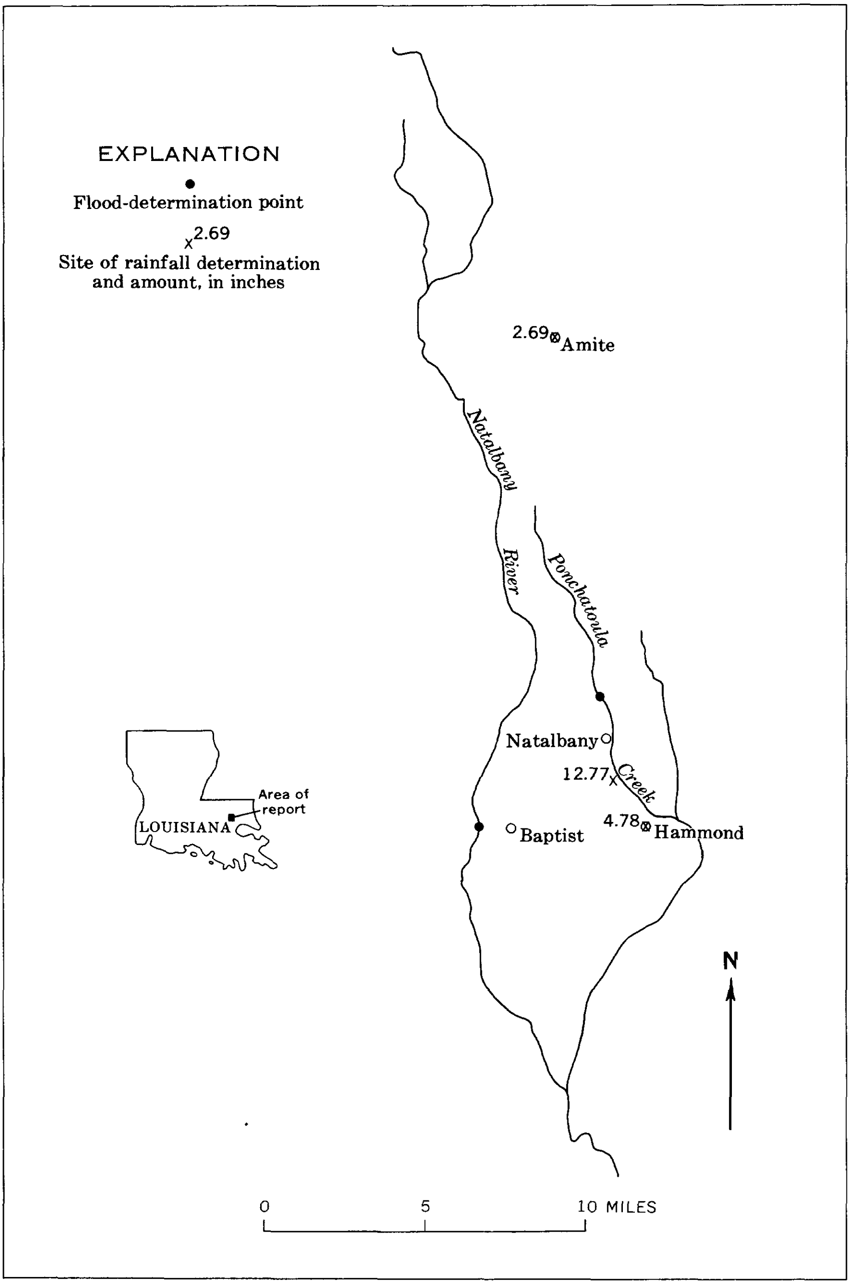


FIGURE 46.—Flood area; location of flood-determination points, floods of September 27–28 near Hammond, La.

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FLOODS OF SEPTEMBER-OCTOBER IN THE EASTERN TENNESSEE RIVER BASIN IN NORTH CAROLINA

By H. G. Hinson

Severe floods in the eastern Tennessee River basin (fig. 47) resulted from two storms in an 8-day period, September 28–October 5. The maximum rainfall measured for the first storm was at Rosman, in the upper French Broad River basin, where 15.94 inches in 48 hours (or less) was observed September 28–30. The total rainfall for the 3-day period was 16.35 inches. The second storm, October 3–5, was associated with Hurricane Hilda, a tropical storm moving northward from the Gulf of Mexico. The measured rainfall was again a maximum for the storm at Rosman, where 13.10 inches in a 24-hour period was observed October 4–5. The total rainfall for the 3-day period was 17.53 inches.

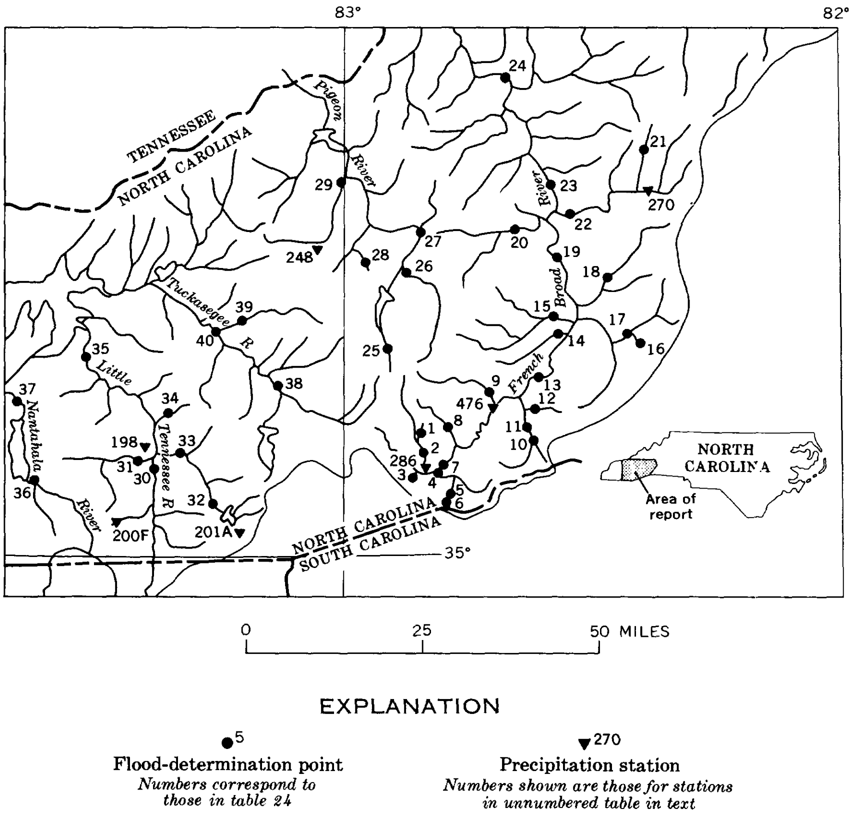

Figure 47.—Flood area; location of flood-determination points and rainfall stations, floods of September–October in eastern Tennessee River basin in North Carolina.

Maximum total rainfall during the 8-day period, September 28–October 5 was 35.38 inches at Rosman. This was also a maximum of record for an 8-day period in the Tennessee Valley.

Total rainfall for selected periods at representative stations (fig. 47) reported by the Tennessee Valley Authority is shown below:

TVA station No.	Station	Total rainfall (in.)			
		Sept. 28–30	Oct. 2–3	Oct. 4–5	Sept. 28–Oct. 5
198	Franklin	7. 53	0	7. 08	14. 61
200F	Coweeta	12. 76	. 30	9. 39	22. 45
201A	Highlands	14. 37	. 41	10. 79	25. 57
248	Eaglenest Mountain	3. 96	. 56	3. 82	8. 34
270	Swannanoa (near)	5. 12	. 10	4. 29	9. 51
286	Rosman, No. 2	17. 24	. 61	17. 53	35. 38
476	Pisgah Forest	9. 18	. 22	8. 53	17. 93

The dates shown above relate to dates of occurrence of rainfall rather than to dates of observation. To give a complete picture of the combined storm periods, rainfall totals for the interim period October 2–3 and for the overall period September 28–October 5 are shown.

The first storm, September 28–30, produced floods in the extreme headwaters of the French Broad River that almost equaled the record flood of July 1916, although only moderate floods occurred elsewhere in the Tennessee River basin. Because of dry antecedent conditions, flooding throughout the area was not as severe as it might otherwise have been. The September storm, however, set the stage for floods resulting from the second storm, October 4–5, which were the greatest known at many locations in the eastern Tennessee River basin.

The amount of damages in the upper French Broad River basin as estimated by the Tennessee Valley Authority follows:

Class	*Damage*
Industrial	$208, 600
Commercial	342, 300
Residential	41, 700
Utility	2, 600
Municipal	3, 400
Railroad	10, 000
Highway	105, 000
Agricultural	12, 800
Other rural property	15, 000
Intangibles (not included above)	74, 600
Total	816, 000

Peak stages and discharges for floods in October at stations shown in figure 47 are summarized in table 24.

TABLE 24.—*Flood stages and discharges, September–October in the eastern Tennessee River basin in North Carolina*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Oct. 1964: Period	Year	Oct. 1964 (date)	Gage height (ft)	Discharge: Cubic feet per second	Recurrence interval (years)
1	Jason Branch near Rosman.	0.45			4		94	2
2	North Fork French Broad River near Calvert.	37.0			4		6,170	29
3	Morton Creek near Reid.	1.18			4		410	9
4	French Broad River at Rosman.	67.9	1908–64	1916		13.9	([1])	
			1935–64	1940		11.86	9,410	
					4	14.95	13,500	[2] 1.15
5	Middle Fork French Broad River near Middle Fork.	1.66			4		416	5
6	Middle Fork French Broad River at Middle Fork.	2.18			4		600	7
7	French Broad River at Calvert.	103	1916–64	1916		13.5		
				1928			16,100	
					4	11.75	13,000	17
8	Catheys Creek near Brevard.	11.7	1945–64	1949		4.35	1,250	
					4	5.4	2,350	43
9	Davidson River near Brevard.	40.4	1869–1964	1876		11.9	([1])	
			1921–64	1928		11.8	8,400	
					4	10.64	6,470	17
10	Little River above High Falls near Cedar Mountain.	26.8	1962–64	1963		3.59	1,140	
					4	7.30	4,430	26
11	Little River near Penrose.	41.4	1916–64	1916		[3] 14	([1])	
			1940, 1942–64	1940		11	3,400	
					4	12.88	4,200	14
12	Crab Creek near Penrose.	10.9	1916–64	1916		[3] 10.5	([1])	
			1943–64	1952		7.57	1,500	
					4	8.92	3,000	[2] 1.65
13	French Broad River at Blantyre.	296	1791–1964	1916		27.1	([1])	
			1921–64	1928		22.9	26,500	
					5	25.5	30,000	[2] 1.31
14	Boylston Creek near Horseshoe.	14.8	1943–55	1950		5.67	805	
					4	7.28	2,500	[2] 1.33
15	Mills River near Mills River.	66.7	1876–1964	1940		13.62	13,400	
					4	12.27	6,910	[2] 1.12
16	Laurel Branch near Edneyville.	.57	1955–64	1957		21.04	132	
					4	21.12	134	4
17	Clear Creek near Hendersonville.	42.2	1863–1964	1916		[3] 16	([1])	
			1946–55	1949		10.50	4,020	
					4	12.2	8,000	[2] 1.45
18	Cane Creek at Fletcher.	63.1	1876–1964	1916		[3] 14.8	23,000	
					4	9.73	3,400	6
19	French Broad River at Bent Creek.	676	1916–64	1916		27.3	([1])	
			1933–64	1940		12.60	23,600	
					5	15.80	30,600	32
20	Hominy Creek at Candler.	79.8	1859–1964	1940		18.0	13,100	
					4	7.89	3,470	4
21	Beetree Creek near Swannanoa.	5.46	1926–64	1940		6.20	1,370	
					4	3.81	278	2
22	Swannanoa River at Biltmore.	130	1791–1964	1791		26	40,000	
					4	11.16	5,210	7
23	French Broad River at Asheville.	945	1791–1964	1916		23.1	110,000	
					5	12.75	36,200	23
24	French Broad River at Marshall.	1,332	1791–1964	1916		[3] 22	115,000	
					6	10.49	34,100	8
25	West Fork Pigeon River above Lake Logan near Hazelwood.	27.6	1954–64	1959		6.95	5,050	
					4	6.88	4,940	6
26	East Fork Pigeon River near Canton.	51.5	1954–64	1957		7.78	6,640	
					4	7.91	6,920	10
27	Pigeon River at Canton.	133	1810, 1876, 1907–09, 1928–65.	1940		20.75	31,600	
					4	11.83	11,400	6
28	Allen Creek near Hazelwood.	14.4	1940	1940		7.0	([1])	
			1949–64	1959		4.07	1,470	
					4	3.49	953	2.5

See footnotes at end of table.

TABLE 24.—*Flood stages and discharges, September–October in the eastern Tennessee River basin in North Carolina*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Oct. 1964: Period	Year	Oct. 1964 (date)	Gage height (ft)	Discharge: Cubic feet per second	Recurrence interval (years)
29	Jonathan Creek near Cove Creek.	65.3	1929–64	1961		7.95	3,560	
					4	4.60	1,220	1.1
30	Little Tennessee River near Prentiss.	140	1898	1898		[3] 15	(1)	
			1943–64	1949		12.85	5,900	
					4	17.30	12,200	40
31	Cartoogechaye Creek near Franklin.	57.1	1961–64	1961		10.40	2,560	
					4	12.96	4,720	12
32	Cullasaja River at Highlands.	14.9	1927–64	1940		9.35	5,100	
					4	7.34	3,750	[2] 1.15
33	Cullasaja River at Cullasaja.	86.5	1907–09, 1920–64	1940		20.83	16,500	
					4	21.45	16,900	[2] 1.62
34	Coon Creek near Franklin.	1.60			4	5.75	256	4
35	Little Tennessee River at Needmore.	436	1898, 1940	1898		[3] 13	(1)	
			1945–64	1949		11.10	20,200	
					5	12.87	22,100	14
36	Nantahala River near Rainbow Springs.	51.9	1940–64	1949		9.70	6,300	
					4	8.46	5,130	12
37	Nantahala River at Nantahala.	144	1942–64	1946		8.15	[4] 7,510	
					4	4.75	[4] 2,020	
38	Tuckasegee River at Tuckasegee.	143	1840, 1876, 1928, 1935–64.	1940		21.1	40,800	
					4	14.36	[4] 13,800	
39	Scott Creek above Sylva.	50.7	1940–64	1940		8.6	3,200	
					4	7.54	2,030	5
40	Tuckasegee River at Dillsboro.	347	1928–64	1940		21.96	52,600	
					4	15.61	[4] 25,300	

[1] Unknown.
[2] Ratio of peak discharge to 50-yr flood.
[3] Gage height determined by Tennessee Valley Authority.
[4] Affected by regulation.

FLOODS OF OCTOBER 4–8 FROM HURRICANE HILDA IN SOUTHEASTERN LOUISIANA AND SOUTHERN MISSISSIPPI

On the morning of September 28, a weak cyclonic circulation formed just off the southern coast of western Cuba. The circulation advanced west-northwestward into the Gulf of Mexico and continued to strengthen, becoming Hurricane Hilda during the early morning of September 30. Hurricane Hilda attained its greatest intensity on October 1, about 350 miles south of New Orleans, with estimated maximum winds of 150 miles per hour and a low central pressure of 27.79 inches. The hurricane center turned northward and crossed the Louisiana coast of St. Mary Parish, between Point au Fer and Marsh Island, about 6 p.m. on October 3 (fig. 48). Sustained winds of 100 to 120 miles per hour occurred along the immediate coast in the Morgan City–New Iberia–Abbeville area. Hurricane Hilda gradually diminished in force as the eye of the storm moved from the Franklin–Baldwin area, where a low pressure of 28.40 inches was reported. The storm advanced north-northeastward, passing over Plaquemine into East Baton Rouge Parish on October 4, where cold air from the northwest moved into the circulation. The associated strong pressure rises forced

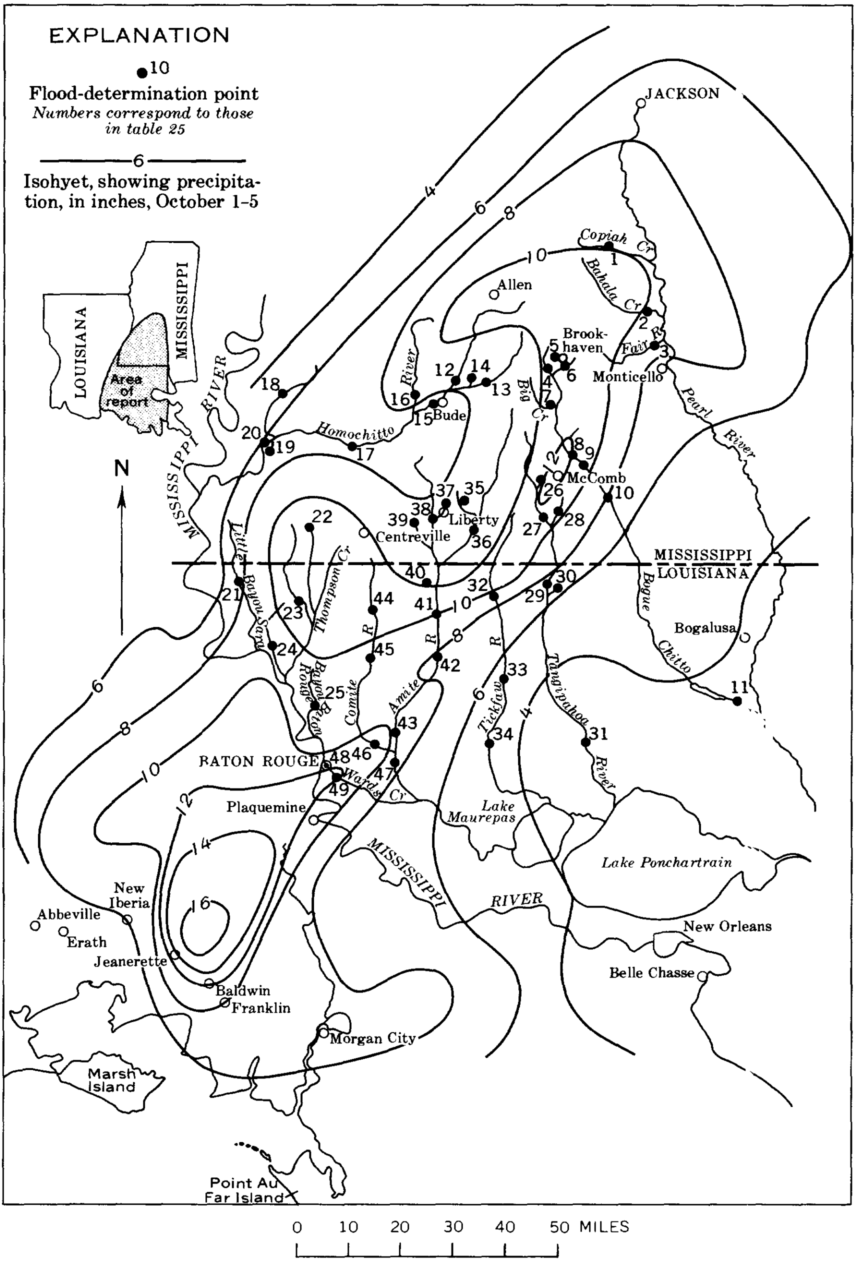

FIGURE 48.—Flood area; location of flood-determination points and isohyets for October 1–5, floods of October 4–8 from Hurricane Hilda in southeastern Louisiana and southern Mississippi.

the storm to make a turn to the east-northeast. The winds decreased to less than hurricane force as it moved through the Florida Parishes and passed over Bogalusa about 10 a.m. The storm moved eastward through coastal Mississippi, where it continued to weaken, and passed north of Mobile, Ala., to northern Florida and southern Georgia on October 5.

LOUISIANA

By Braxtel L. Neeley, Jr.

On October 3 and 4 heavy rains fell to the west and north of the path of the hurricane center. The greatest amount of accumulated rainfall measured in Louisiana during Hilda's passage was 17.71 inches, at the Jeanerette Experiment Farm between noon on October 2 and 9 a.m. on October 4. The greatest part of this (16.01 in.) fell between 7:30 a.m. on October 3 and 9 a.m. on October 4, an average rate of 15.07 inches in 24 hours. The greatest recorded 24-hour precipitation for any October in Louisiana was 15.40 inches, at Belle Chasse on October 2, 1937. Hurricane Hilda's rainfall was recordbreaking for some stations for October.

The heavy rains produced flooding that was the highest of record on three streams in the State (table 25). The magnitude of the floods on Comite River near Clinton (sta. 44) was great. The rainfall was heavy on the upper end of the Amite and Comite Rivers and on the tributary basins of the lower end of the Comite River. The magnitude of the discharges on the Comite River attenuated, and by the time the crest reached Olive Branch (sta. 45) and Comite (sta. 46), it was a fairly small flood. The peak discharge on the Amite River near Darlington (sta. 41; 44,500 cfs) and at Grangeville (sta. 42; 49,000 cfs) was sharply reduced by the time it reached Magnolia (sta. 43; 29,900 cfs), but was suddenly increased near Denham Springs (sta. 47; 49,000 cfs) downstream from its confluence with Comite River. The discharge on Tangipahoa River near Kentwood (sta. 29) is unknown, but the peak stage was the highest of record since the gage was installed in 1951.

In the course of Hilda's travels through Louisiana, more than 19,000 homes were affected; almost 2,600 of them were demolished or severely damaged. There was damage and service interruption to more than 100,000 telephones, while more than 180,000 electric-power customers were affected. In many areas the winds and rains did considerable damage to agricultural products.

TABLE 25.—*Flood stages and discharges, October 4–8 in southeastern Louisiana and southern Mississippi*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Oct. 1964: Period	Maximum floods: Prior to Oct. 1964: Year	Maximum floods: Oct. 1964 (date)	Maximum floods: Gage height (ft)	Maximum floods: Discharge (cfs)
	Pearl River basin						
1	Copiah Creek near Hazlehurst, Miss.	47.5	1948–64	1950		20.14	8,000
					4	24.40	22,000
2	Bahala Creek near Oma, Miss.	154	1961–64	1961		20.5	15,000
					5	20.21	14,000
3	Fair River near Wanilla, Miss.	85	1955	1955		196.14	5,920
					4	201.45	[1]
4	Bogue Chitto near Brookhaven, Miss.	30	1952–64	1961		18.6	9,000
					4	19.33	8,600
5	Guy Lee Branch at Brookhaven, Miss.	1.0	1955–64	1955		444.5	1,100
					4	441.73	740
6	East Bogue Chitto at Brookhaven, Miss.	18.0	1952–64	1961		410.8	7,200
					4	411.4	6,900
7	Big Creek near Bogue Chitto, Miss.	55.2	1952–64	1955		27.03	10,600
					4	27.40	13,900
8	Bogue Chitto near Summitt, Miss.	255	1950–64	1950		315.6	[1]
					4	314.1	28,300
9	Bogue Chitto near Pricedale, Miss.	265	1919–64	1919		303.4	[1]
					4	298.6	27,000
10	Bogue Chitto near Tylerton, Miss.	502	1936	1936		34.5	[1]
			1944–64	1950		33.50	45,700
					5	28.91	27,700
11	Bogue Chitto near Bush, La.	1,210	1938–64	1961		17.04	57,000
					8	12.53	20,600
	Homochitto River basin						
12	Homochitto River at Eddiceton, Miss.	180	1938–64	1939		[1]	30,900
					4	16.82	29,400
13	McCalls Creek near Lucien, Miss.	60	1951–64	1961		91.83	21,000
					4	90.93	18,300
14	Beaver Run near McCalls Creek, Miss.	2.61	1955–64	1955		8.15	874
					4	5.60	447
15	Homochitto River near Bude, Miss.	399	1942–64	1961		201.2	[1]
					4	202.61	[1]
16	Middle Fork Homochitto River near Meadville, Miss.	95			4	202.33	[1]
							[1]
17	Homochitto River at Rosetta, Miss.	750	1949–64	1949		37.80	[1]
			1951–64	1961		31.20	97,000
					4	29.3	141,000
18	Second Creek near Kingston, Miss.	31.8	1945	1945		18	[1]
			1955–64	1955		14.5	[1]
					4	11.05	[1]
19	Observers Draw near Doloroso, Miss.	.22	1955–64	1955		8.93	387
					4	[1]	80
20	Homochitto River near Doloroso, Miss.	1,120	1938–46	1938		38.4	[1]
			1948–64	1953		33.00	79,000
					4	29.57	[1]
	Little Bayou Sara basin						
21	Little Bayou Sara near Turnbull, La.	22.3	1950–61, 1963–64	1960		22.10	[1]
					4	17.06	[1]
	Thompson Creek basin						
22	Moores Branch near Woodville, Miss.	0.21	1955–64	1955		10.32	416
					4	5.45	177
23	West Fork Thompson Creek near Wakefield, La.	35.3	1950–64	1953		22.65	18,100
					4	20.12	13,600
24	Alexander Creek near St. Francisville, La.	23.9	1953–64	1953		14.18	[1]
					4	13.25	[1]

See footnotes at end of table.

TABLE 25.—*Flood stages and discharges, October 4–8 in southeastern Louisiana and southern Mississippi*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Oct. 1964, Period	Year	Oct. 1964 (date)	Gage height (ft)	Discharge (cfs)
	Bayou Baton Rouge basin						
25	Bayou Baton Rouge above Baker, La.	13.7	1953–64	1953		22.64	4,300
					5	21.77	3,300
	Mississippi River Delta						
26	Tangipahoa River tributary near McComb, Miss.	2.71			4	7.84	703
27	Tangipahoa River near McComb, Miss.	79.2			4	281.7	6,260
28	Little Tangipahoa River at Magnolia, Miss.	39.7	1952–64	1953		21.12	2,900
					4	22.22	7,600
29	Tangipahoa River near Kentwood, La.	[2] 296	1951–64	1951		14.06	(1)
					4	14.33	(1)
30	Ashleys Branch tributary near Kentwood, La.	.04	1958–64	1962		15.40	49.0
					4	15.62	55.4
31	Tangipahoa River at Robert, La.	646	1921	1921		27.1	(1)
			1938–64	1953		23.13	50,500
					7	17.36	14,800
32	Tickfaw River at Liverpool, La.	89.7	1956–64	1961		11.58	8,600
					4	11.48	7,900
33	Tickfaw River at Montpelier, La.	220	1951–64	1962		104.4	(1)
					4	102.15	(1)
34	Tickfaw River at Holden, La.	24.7	1940–64	1943		19.75	
				1962			14,500
					7	16.47	6,160
35	Stock Pond Draw near Liberty, Miss.	.43	1955–64	1955		6.10	358
					4	4.16	175
36	East Fork Amite River near Liberty, Miss.	183	1892–1964	1955		267.0	27,400
					4	266.2	21,700
37	Tanyard Creek at Liberty, Miss.	8.7	1951–64	1955		94.3	8,000
					4	93.73	5,600
38	West Fork Amite River near Liberty, Miss.	152	1931–64	1950		265.4	(1)
					4	264.8	21,300
39	CRS's Draw near Liberty, Miss.	.84	1955–64	1955		8.67	720
					4	6.87	487
40	Woodland Creek Tributary No. 2 near Felps, La.	.13	1958–64	1962		15.72	68.0
					4	15.65	65.0
41	Amite River near Darlington, La.	580	1949–64	1955		21.17	55,700
					5	19.37	44,500
42	Amite River at Grangeville, La.	741	(3)	(3)		17.4	(1)
			1951–64	1955		16.7	63,800
					6	15.35	49,000
43	Amite River at Magnolia, La.	884	1949–64	1955		48.26	36,800
					6	45.89	29,900
44	Comite River near Clinton, La.	88	1949–64	1961		15.35	22,500
					5	15.36	22,600
45	Comite River near Olive Branch, La.	145	1942–64	1961		[4] 21.37	19,900
					5	19.52	15,500
46	Comite River near Comite, La.	284	1944–61	1953		[5] 28.6	20,500
			1962–64	1962		19.03	20,900
					6	18.82	20,100
47	Amite River near Denham Springs, La.	1,280	1921	1921		35.4	(1)
			1938–64	1953		32.46	67,000
					7	30.15	49,900
48	Ward Creek at Government Street, at Baton Rouge, La.	4.04	1954–64	1954		13.62	
				1962			2,030
					4	11.43	1,690
49	Ward Creek at Siegen Lane, near Baton Rouge, La.	40.0	1947–64	1959		20.20	6,400
					4	19.61	5,500

[1] Not determined.
[2] Includes Terrys Creek.
[3] Occurred before 1951; date unknown.
[4] At site 1,400 ft. upstream.
[5] Prior to channel dredging in August 1961.

MISSISSIPPI

After WILSON and ELLISON (1968)

In Mississippi most of the rainfall on October 3 and 4 fell in the central and southern parts. There were many flash floods, and heavy and excessive rainfalls occurred in parts of Mississippi north of the path of the hurricane center. The greatest amount of rainfall measured in Mississippi during Hilda's passage was 12.48 inches at the McComb Federal Aviation Agency airport, of which 10.89 inches fell on October 4, an all-time Mississippi record 24-hour rainfall for October. At Allen (Copiah County), 10.88 inches was recorded, of which 10.75 inches fell in 24 hours.

Isohyetal lines of the rainfall (fig. 48) indicate the general path of Hurricane Hilda as it came up the east side of the Mississippi River into Wilkinson County, was buffeted back into Louisiana and then to the east by the cold wave, moved into Mississippi again south of McComb, and proceeded north almost to Jackson, where it again was pushed south and rapidly east by the cold front. The time distribution of rainfall at Brookhaven, Bude (fire tower), and Jackson (Thompson Field) is shown in figure 49. The storm lasted for about 24 hours. The unusual intensity of this rain may best be understood by comparing station data with frequency curves (fig. 50), which indicate that the McComb, Brookhaven, and Allen rainfalls of 10½ to 12½ inches in approximately 24 hours exceeded that which may be expected to recur in this area on the long-term average of once in 100 years. The frequency of short-duration rainfall (4 hr. or less) was not unusual, ranging from 1 to 10 years (fig. 50). Rainfalls of longer duration (12 to 24 hr) have higher indicated frequencies, ranging from 10 to more than 100 years. Consideration of these data verifies observations that the resulting floods were more severe on larger streams where the time of concentration was 12 to 24 hours than they were on small streams where the time of concentration was less than 4 hours. A 10-inch rainfall in 24 hours has an indicated frequency of once in about 100 years and an 8-inch rainfall once in about 25 years (fig. 50). These extreme rains fell on large areas. At least 10 inches of rain fell over an area of 1,300 square miles, and at least 8 inches fell over an area of 4,000 square miles (fig. 48).

Floods resulting from this rainfall were extremely high on streams draining areas between 10 and 750 square miles. Streams that had the greatest floods (table 25) are the small western tributaries of the Pearl River between Jackson and Monticello, Bogue Chitto, Tangipahoa River, Amite River, and Homochitto River. Several peak discharges exceeding those which might be expected to be equaled or exceeded on the average of once in 50 years.

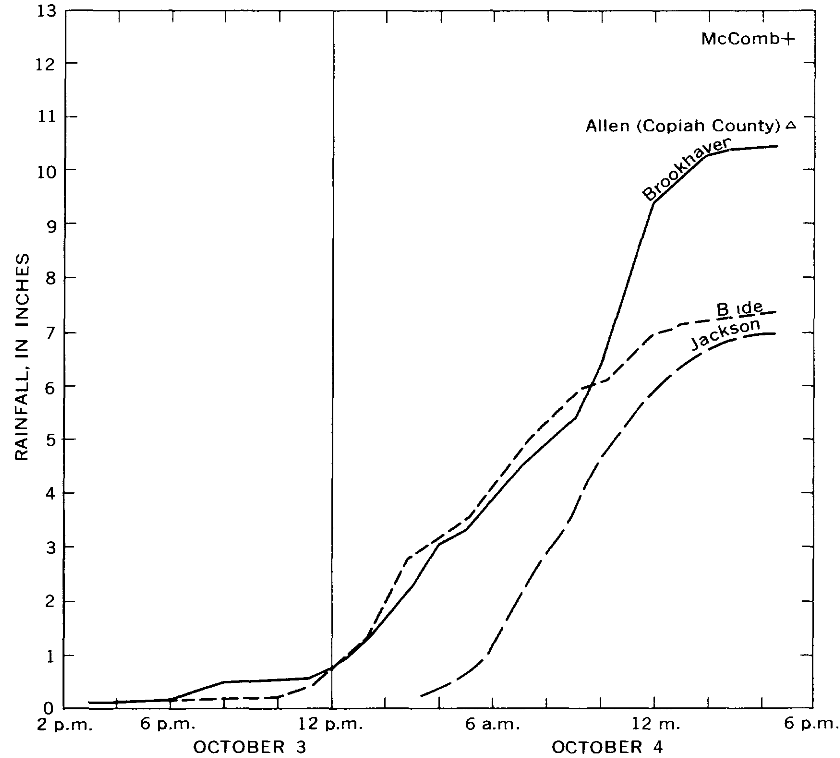

Figure 49.—Cumulative rainfall at selected stations in Mississippi, October 3–4.

Floods on the small western tributaries of the Pearl River south of Jackson were extreme on Copiah Creek, Bahala Creek, and the Fair River, but discharge was equivalent only to about the annual flood on Purple, Town, and Lynch Creeks at Jackson. Floods on the Pearl River, its eastern tributaries, and the greatest affected streams of the Pascagoula River basin to the east did not exceed annual floods.

The peak discharge on Little Tangipahoa River at Magnolia (sta. 28, State Highway 48) was 2.6 times as great as the previous maximum in 13 years of record. Near-record floods occurred on both the East and West Forks Amite River and on their tributaries.

Along the upper reaches of the Homochitto River, flood peaks at Eddiceton (sta. 12) and on McCalls Creek near Lucien (sta. 13) were moderate, but at Rosetta (sta 17), the Homochitto River flood exceeded the 50-year flood, peaking at a record 141,000 cfs from the 750-square-mile drainage area—45 percent greater than the previous maximum in 14 years of record.

Nine of the sites for which peak stages and discharges are shown in table 25 have drainage areas of less than 3 square miles. Peak discharges from these culvert-sized streams throughout the storm area were not large. Comparison with previously recorded peaks indicates that the floods were not severe, many of the peaks being less than 50 percent of the maximum peaks of record.

Floodmarks were observed at several highway crossings of streams that had extreme floods but whose stages and discharges were not gaged. The floodmarks, referenced to the elevation of the lowest bridge stringers (steel or concrete) are given in the table on the next page for five bridges at four highway crossings.

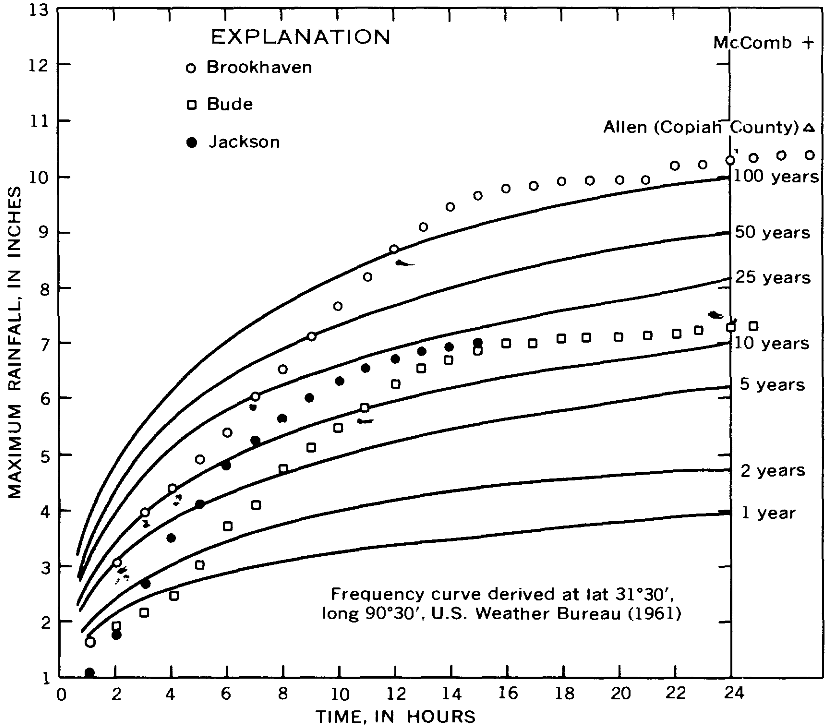

FIGURE 50.—Comparison of October 3–4 rainfall at selected sites in Mississippi with frequency curves.

Flood damage caused by Hurricane Hilda was surprisingly small, although some bridge and road washouts occurred, and some crops were damaged. Perhaps the single most descriptive example of flood damage was the observation, in a 1-hour period, of about 20 head of cattle—some dead, and some still alive—floating beneath the Copiah Creek bridge at State Highway 28 east of Hazlehurst.

Stream and location	Bridge	Distance of floodmark below low stringer (ft)
Tangipahoa River at State Highway 24, 4.4 miles west of McComb.	Main channel	1.19
East Fork Amite River at State Highway 24, 7.3 miles east of Liberty.	do	.75
West Fork Amite River at State Highway 24, 2.2 miles west of Liberty.	do	4.7
Beaver Creek at State Highway 24, 5.7 miles east of Centreville.	do	3.7
Do	Relief Opening No. 1 left	3.4

FLOODS OF OCTOBER IN EASTERN NORTH CAROLINA

By H. G. Hinson

Severe floods occurred in early October in the Atlantic Coastal Plain in eastern North Carolina (fig. 51) following heavy rains during late September and early October. Floods on some streams in the area had recurrence intervals of more than 50 years (table 26).

In eastern North Carolina, there was significant rainfall during each day from September 28 to October 5, with the greatest intensity occurring on October 5. For example, the maximum rainfall, recorded at Smithfield, for the 8-day period was 13.16 inches, 5.77 inches of which fell on October 5. Amounts were less than that elsewhere in the flood area, although the pattern was complex. The antecedent conditions were conducive to high runoff because there had been substantial rainfall in mid-September.

On Neuse River near Goldsboro (sta. 23), the peak discharge was the greatest since 1929, and the peak stage was the highest since 1919 (discharge unknown). Figure 52 shows the water-surface profiles in the vicinity of Goldsboro for the highest floods of record. The profiles provide data of interest in an area of urbanization and rapid development on the flood plain of the Neuse River. In addition to water-surface elevations for the various floods, figure 52 shows the peak discharges associated with these floods. A change in the relationships between discharge and stage (higher stage with respect to discharge) during the period of record is indicated.

The flood on the Neuse River caused considerable hardship because the river remained at high flood stages for a long time. At Goldsboro and Kinston, the Neuse River remained above bankfull stage for 12 and 14 days, respectively. More than 2,000 persons were evacuated from their homes. Because of extensive development on the flood plain, the flood damage was high. Total damage in eastern North Carolina was estimated by the U.S. Weather Bureau (Environmental Science Service Administration) at more than $13 million.

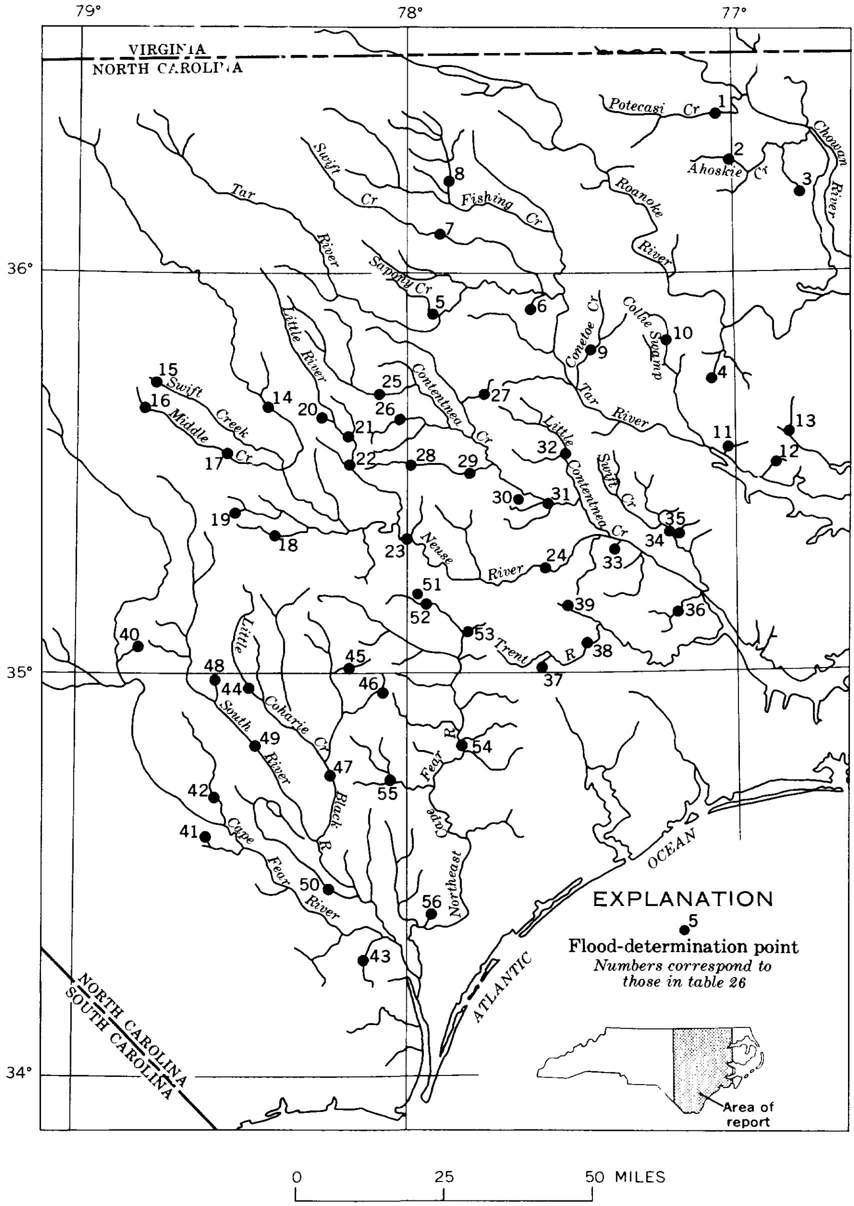

FIGURE 51.—Flood area; location of flood-determination points, floods of October in eastern North Carolina.

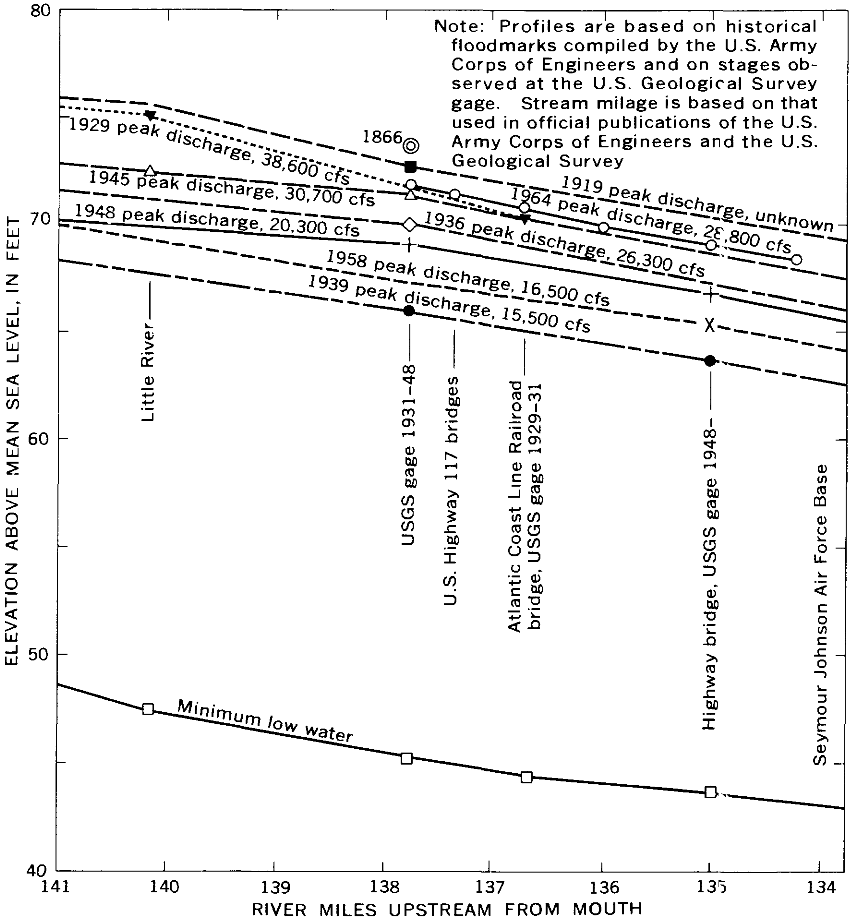

FIGURE 52.—Flood profiles of the Neuse River near Goldsboro, N.C.

Peak stages and discharges for floods at selected stations in eastern North Carolina are summarized in table 26.

Notable flooding other than on Neuse River occurred on tributary streams such as Stone Creek (sta. 18), Hannah Creek (sta. 19), Contentnea Creek (sta. 31), and other small streams. Locally severe floods occurred on tributaries in the Chowan, Roanoke, Pamlico, and Cape Fear River basins; low-lying roads and dwellings were submerged, and damage was moderate.

TABLE 26.—*Flood stages and discharges, October in eastern North Carolina*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Oct. 1964: Period	Maximum floods: Prior to Oct. 1964: Year	Oct. 1964 (date)	Gage height (ft)	Discharge: Cubic feet per second	Discharge: Recurrence interval (years)
	Chowan River basin							
1	Potecasi Creek near Union.	191	1940	1940		24.1	7,000	
			1958–64	1958		19.12	4,050	
					7	17.66	3,190	21
2	Ahoskie Creek at Ahoskie.[1]	64.3	1940	1940		15.1	(2)	
			1950–65	1960		14.11	2,530	
					5	10.72	2,580	
3	Chinkapin Creek near Colerain.	8.9	1953–64	1961		23.71	960	
					6	21.36	282	2
	Roanoke River basin							
4	Smithwick Creek tributary near Williamston.	0.9	1953–64	1955		23.86	250	
					5	23.90	252	19
	Pamlico River basin							
5	Sapony Creek near Nashville.	64.8	1950–64	1959		14.94	2,420	
					6	15.6	2,840	7
6	Harts Mill Run near Tarboro.	8.6	1953–64	1960		21.81	630	
					5	21.46	530	5
7	Swift Creek at Hilliardston.	163	1924	1924		14.5	(2)	
			1963–64	1964		10.64	1,450	
					6	11.89	2,030	2
8	Little Fishing Creek near White Oak.	175	1959	1959		19.3	(2)	
			1960–64	1962		16.75	3,500	
					6	13.07	2,200	2
9	Conetoe Creek near Bethel.	78.1	1955	1955		16.7	(2)	
			1957–64	1960		15.00	2,130	
					7	15.50	1,500	3
10	Collie Swamp near Everetts.	29	1953–64	1955		23.02	1,900	
					5	22.54	1,450	8
11	Herring Run near Washington.	15	1946	1946		17.0	(2)	
			1950–64	1964		14.85	[3] 620	
					5	13.69	482	2
12	Upper Goose Creek near Yeatsville.	1.49	1953–64	1955		24.00	300	
					5	22.17	152	4
13	Acre Swamp near Pinetown.	39	1953–64	1955		24.46	2,950	
					5	22.12	1,220	6
	Neuse River basin							
14	Neuse River near Clayton.	1,140	1919	1919		21.15	21,200	
			1927–64	1945		22.12	22,900	
					6	13.95	10,800	2
15	Swift Creek near Apex	20	1954–64	1954		24.02	3,150	
					5	21.30	920	<2
16	Middle Creek near Holly Spring.	8.2	1954–64	1955, 1956		24.81	1,070	
					5	23.47	500	<2
17	Middle Creek near Clayton.	80.7	1940–64	1955		13.14	5,400	
					6	11.56	3,540	3
18	Stone Creek near Newton Grove.	28	1953–64	1962		24.58	3,110	
					5	24.4	3,000	[4] 1.21
19	Hannah Creek near Benson.	2.6	1953–64	1959		23.17	808	
					5	23.19	820	[4] 1.15
20	Long Creek near Selma	6.9	1953–64	1959		24.96	2,050	
					6	22.96	1,370	3
21	Little River near Kenly	190			6	16.30	5,030	10

See footnotes at end of table.

TABLE 26.—*Flood stages and discharges, October in eastern North Carolina*—Con.

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Oct. 1964: Period	Year	Oct. 1964 (date)	Gage height (ft)	Discharge: Cubic feet per second	Recurrence interval (years)
	Neuse River basin—Continued							
22	Little River near Princeton.	229	1919, 1924, 1928–64.	1924		14.90	(2)	
			1930–64	1959		13.53	6,260	
					6	13.94	7,150	18
23	Neuse River near Goldsboro.	2,390	1929–64	1929		[5] 27.3	38 600	
					9	26.07	28 800	12
24	Neuse River at Kinston.	2,690	1919, 1924, 1928, 1930–64.	1919		25.0	39 000	
					13	22.86	26,000	7
25	Contentnea Creek near Lucama.	156			6	16.28	5 860	25
26	Lee Swamp tributary near Lucama.	2.8	1953–64	1960		25.96	508	
					5	27.0	476	10
27	Whiteoak Swamp tributary near Wilson.	2.6	1953–64	1960		22.65	375	
					5	23.37	505	24
28	Nahunta Swamp near Pikeville.	19	1953–64	1960		20.38	1,070	
					5	21.89	1,900	33
29	Nahunta Swamp near Shine.	77.6	1955–64	1960		12.21	2,910	
					6	14.14	5 470	[4] 1.04
30	Shepherd Run near Snow Hill.	1.5	1953–64	1960		21.69	250	
					5	20.6	118	4
31	Contentnea Creek at Hookerton.	729	1924, 1928–64	1928		23.3	(2)	
			1929–64	1929		18.90	11,100	
					7	22.11	17,200	[4] 1.20
32	Little Contentnea Creek near Farmville.	93.3	1955	1955		18.9	(2)	
			1957–64	1960		17.39	2,490	
					6	19.65	5 170	27
33	Halfmoon Creek near Fort Barnwell.	4.9	1953–64	1955		21.67	1,600	
					5	19.34	317	2
34	Swift Creek near Vanceboro.	182	1909, 1928	1909		22	(2)	
			1950–64	1955		19.67	6 060	
					8	16.10	4 090	42
35	Palmetto Swamp near Vanceboro.	24	1953–64	1955		26.14	3 700	
					5	21.38	453	<2
36	Bachelor Creek near New Bern.	34	1953–64	1955		23.58	7,000	
					5	14.88	520	<2
37	Rattlesnake Branch near Comfort.	2.5	1953–64	1962		26.17	1,280	
					6	22.37	173	2
38	Trent River near Trenton.	168	1928	1928		17.3	7,600	
			1951–64	1955		17.84	9,100	
					8	14.32	2,380	12
39	Vine Swamp near Kinston.	6.30	1953–64	1955		23.71	840	
					5	22.17	330	2
	Cape Fear River basin							
40	Reese Creek near Fayetteville.	7.89	1953–64	1955		22.56	690	
					5	22.04	596	38
41	Brown Creek near Elizabethtown.	14	1953–64	1955		20.93	2,000	
					6	19.95	760	42
42	Turnbull Creek near Elizabethtown.	71.6	1949	1949		27.59	3 500	
			1953–64	1955		25.38	1,760	
					7	24.89	1,650	[4] 1.02
43	Hood Creek near Leland.	21.6	1953–64	1955		10.39	2,050	
					6	7.37	621	2
44	Little Coharie Creek Roseboro.	96.4	1924	1924		11.6	(2)	
			1950–64	1955		9.00	1,860	
					7	9.97	3,400	38
45	Turkey Creek near Turkey.	16	1953–64	1955		22.60	1,190	
					5	22.05	830	5
46	Stewarts Creek tributary near Warsaw.	.6	1953–64	1959		24.20	142	
					5	21.9	49	2
47	Black River near Tomahawk.	680	1928, 1945, 1948, 1951–64.	1928		22.0	14,500	
					9	21.14	11,200	29
48	Big Swamp near Roseboro.	32	1953–64	1960		21.32	1,220	
					7	22.82	3,500	[4] 1.82

See footnotes at end of table.

TABLE 26.—*Flood stages and discharges, October in eastern North Carolina*—Con.

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Oct. 1964: Period	Maximum floods: Prior to Oct. 1964: Year	Maximum floods: Oct. 1964 (date)	Maximum floods: Gage height (ft)	Maximum floods: Discharge: Cubic feet per second	Maximum floods: Discharge: Recurrence interval (years)
	Cape Fear River basin—Continued							
49	South River near Parkersburg.	382	1918 or 1928	1918 or 1928		15.88	(2)	
			1952–64	1955		14.20	5,000	
					10	14.32	5,900	21
50	Colly Creek near Kelly.	103	1908, 1928, 1945.	1908		11.1	(2)	
			1950–64	1955		7.20	910	
					10	7.10	1,000	11
51	Northeast Cape Fear River tributary near Mount Olive.	.63	1953–64	1955		21.63	118	
					5	20.57	79	13
52	Northeast Cape Fear River tributary near Seven Springs.	47.5	1958–64	1962		9.51	2,250	
					6	9.59	2,740	[4] 1.01
53	Matthews Creek near Pink Hill.	8.61	1953–64	1955		21.96	809	
					5	19.38	55	<2
54	Northeast Cape Fear River near Chinquapin.	600	1908, 1928	1908		[6] 22.6	(2)	
			1941–64	1962		20.16	20,400	
					9	14.94	7,310	13
55	Rockfish Creek near Wallace.	63.8	1948	1948		[7] 15.5	2,800	
			1955–64	1962		12.82	4,450	
					6	10.68	1,710	2
56	Turkey Creek near Castle Hayne.	10	1953–64	1955		26.00	4,000	
					5	22.34	230	<2

[1] Entire basin above station canalized since July 1964.
[2] Unknown.
[3] Runoff affected by ditches and canals above station.
[4] Ratio of peak discharge to 50-yr flood.
[5] At railroad bridge 1½ miles upstream, present datum.
[6] At site 1,000 ft upstream, present datum.
[7] At former site and datum.

FLOODS OF DECEMBER IN HAWAII

After STUART H. HOFFARD (1965)

After the wettest November of record for much of Kauai and Maui, the State of Hawaii had several damaging high-intensity rainstorms in December. In many places, especially on Kauai, Oahu, and Maui, rain in substantial quantities, interrupted by periods of partial clearing, fell each day from December 9 to 24.

On Kauai, high stages were recorded on December 14 (table 27) at several stream-gaging stations in the northern half of the island (fig. 53). The Haena water-supply line was broken by floodwaters at the Manoa Stream crossing. The Hanalei River overflowed onto the Belt Road and halted traffic on the one road into Hanalei. On December 16, rainfall and flooding were islandwide. Flooding occurred at Kekaha, and high water again isolated Hanalei. Scenic boat trips on the Wailua River were canceled for the first time in 18 years because of the large amount of debris in the swollen river.

On Oahu, on December 9–10 heavy rains hit the entire windward side of the island and part of the Honolulu area (fig. 54). Slides

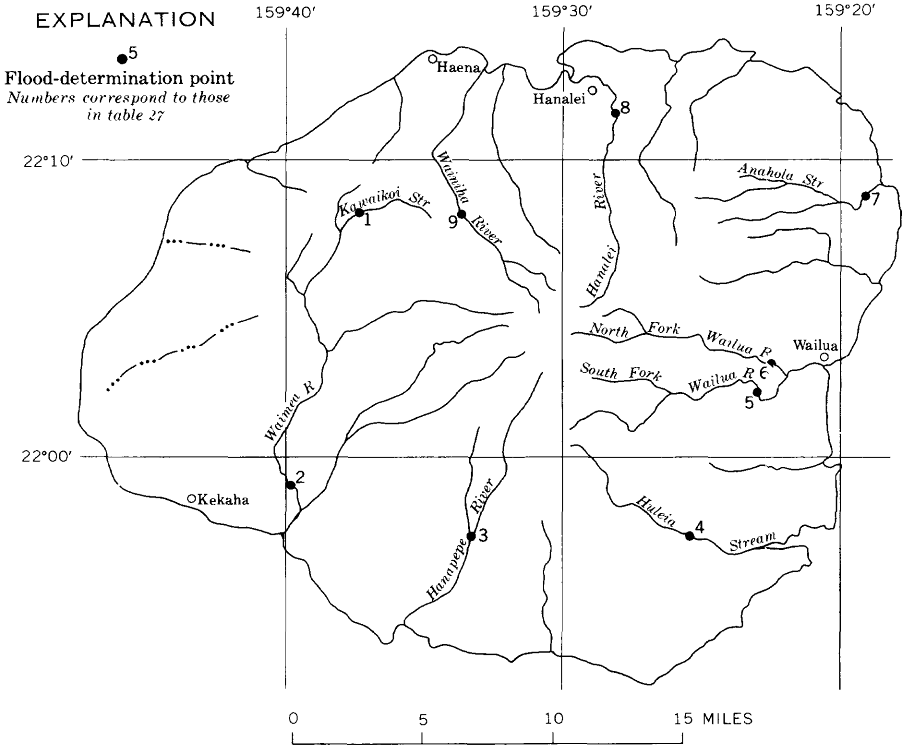

FIGURE 53.—Flood area; location of flood-determination points, floods of December on the island of Kauai, Hawaii.

occurred along highways from Manoa Valley to Makapuu Point and to Waimea Bay. Four families were evacuated from Kahaluu Valley when the Ahuimanu Stream flooded. A prolonged storm on December 16–23 caused heavy runoff from Kahuku to Kaena Point and southward along the Waianae coast. The hydrograph of Makaha Stream (fig. 55) shows typical streamflow in the area for the flood period. Noteworthy peaks occurred somewhere in the flood area nearly every day during the storm (table 28). New record peaks occurred on December 23 at every crest-stage gage and gaging station in the Waianae area. There were no long-term gaging stations in the area on which to base estimates of recurrence intervals. About 50 houses were inundated in the Makaha and Waianae Valleys, and one young girl was drowned.

TABLE 27.—*Flood stages and discharges, December on the island of Kauai, Hawaii*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods prior to Dec. 1964: Period	Maximum floods prior to Dec. 1964: Year	Peaks of Dec. 1964 (date)	Gage height (ft)	Discharge (cfs)
1	Kawaikoi Stream near Waimea.	4.1	1909–16, 1919–64	1916		15.2	10,700
					16	9.33	3,200
2	Waimea River near Waimea	57.8	1910–19, 1943–64	1949		19.3	37,100
					16	12.45	13,500
3	Hanapepe River below Manuahi Stream near Eleele.	18.8	1917–21, 1926–64	1963		14.87	39,000
					16	8.62	8,940
4	Huleia Stream near Lihue	17.6	1912–16, 1962–64	1963		19.82	13,200
					14	13.03	3,560
					16	16.35	7,500
5	South Fork Wailua River near Lihue.	22.4	1911–64	1963		22.9	87,300
					16	17.63	18,900
6	North Fork Wailua River near Kapaa.	18.7	1952–64	1955		19.88	53,200
					14	8.28	6,280
					16	9.02	7,780
7	Anahola Stream at Anahola	9.89	1962–64	1964		11.53	2,910
					14	10.43	2,200
					16	11.08	2,690
8	Hanalei River near Hanalei	19.1	1912–19, 1962–64	1963		13.13	34,700
					16	12.49	29,400
9	Wainiha River near Hanalei	10.2	1952–64	1956		14.1	(1)
				1959			20,100
					16	5.43	4,210

[1] Not determined.

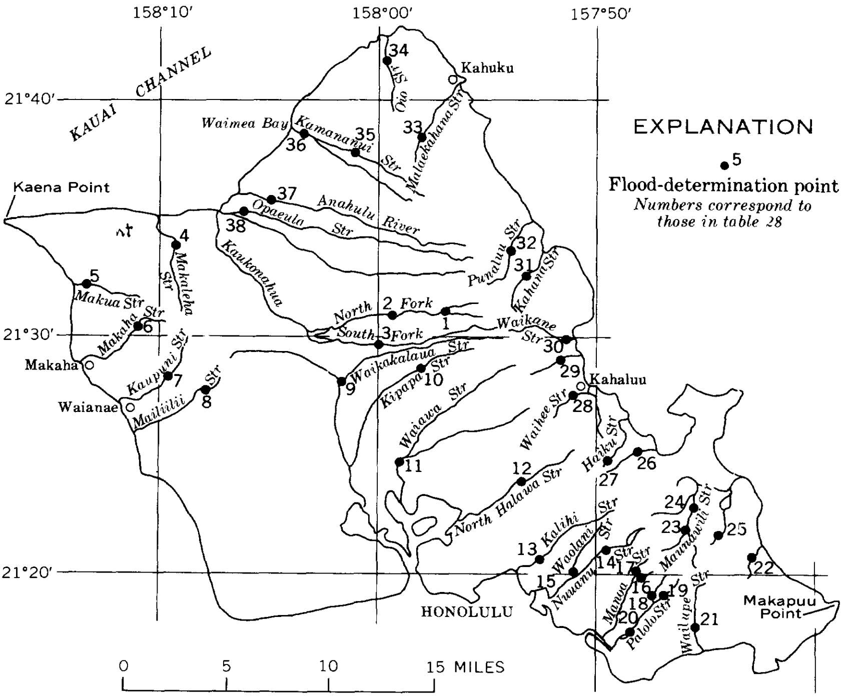

FIGURE 54.—Flood area; location of flood-determination points, floods of December on the island of Oahu, Hawaii.

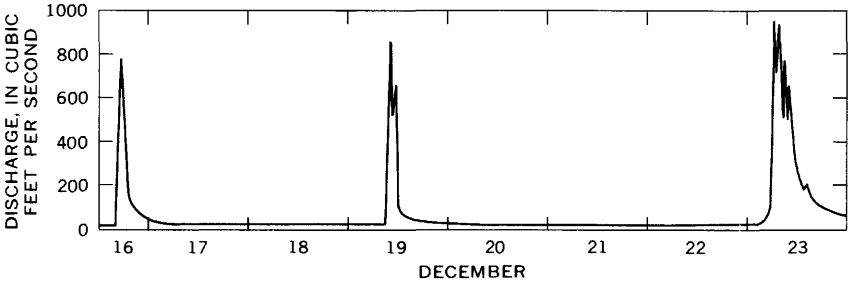

FIGURE 55.—Discharge of Makaha Stream near Makaha, on the island of Oahu, Hawaii, December 16–23.

TABLE 28.—*Flood stages and discharges, December on the island of Oahu, Hawaii*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods prior to Dec. 1964: Period	Maximum floods prior to Dec. 1964: Year	Peaks of Dec. 1964 (date)	Gage height (ft)	Discharge (cfs)
1	North Fork Kaukonahua Stream above Right Branch near Wahiawa.	1.38	1913–53, 1960–64	1933		11.7	5,490
					15	8.48	2,580
2	North Fork Kaukonahua Stream near Wahiawa.	4.86	1946–64	1963		20.95	4,660
					15	10.98	2,350
					19	8.48	1,750
3	South Fork Kaukonahua Stream at East Pump Reservoir near Wahiawa.	4.04	1958–64	1963		11.33	5,460
					15	5.78	1,490
					19	4.46	769
4	Makaleha Stream near Waialua.	4.15	1958–64	1963			2,040
					23	7.01	2,580
5	Makua Stream at Makua	4.07	1957–64	1962		6.81	942
					23	7.90	1,520
6	Makaha Stream near Makaha	2.13	1959–64	1962		6.50	1,170
					23	5.91	965
7	Kaupuni Stream, at an altitude of 374 ft, near Waianae.	3.27	1960–64	1962		4.06	690
					23	4.75	1,340
8	Mailiilii Stream near Waianae	1.51	1957–64	1958		2.58	820
					23	2.78	975
9	Waikakalaua Stream near Wahiawa.	7.14	1958–64	1963		16.50	4,830
					23	6.40	279
10	Kipapa Stream near Wahiawa	4.29	1957–64	1963		12.29	5,680
					10	6.28	696
					15	7.74	1,310
					19	6.72	866
11	Waiawa Stream near Pearl City.	26.4	1953–64	1954		19.27	16,900
					10	9.20	3,020
					19	12.03	5,710
12	North Halawa Stream near Aiea.	3.45	1929–33, 1953–64	1932		13.36	6,650
					9	8.88	577
					19	8.38	444
13	Kalihi Stream at Kalihi	5.18	1960–64	1960		8.0	6,350
					9	4.30	1,160
					19	6.84	3,900
14	Nuuanu Stream below reservoir 2 wasteway, near Honolulu.	3.35	1913–64	1921		8.74	6,990
					19	4.53	509
15	Waolani Stream at Honolulu	1.28	1957–64	1963		6.14	2,500
					19	2.03	387
16	East Branch Manoa stream near Honolulu.	1.06	1913–21, 1925–64	1921		10.4	3,090
					10	4.25	730
17	West Branch Manoa Stream near Honolulu.	1.14	1913–21, 1925–64	1921		10.4	3,250
					10	3.87	563
18	Pukele Stream near Honolulu	1.18	1926–64	1930		7.75	2,600
					10	5.78	905
19	Waiamao Stream near Honolulu.	1.04	1926–64	1930		6.27	1,550
					10	4.76	484
20	Palolo Stream near Honolulu	3.63	1952–64	1958		5.33	3,250
					10	3.82	1,350
21	Wailupe Stream at Aina Haina.	2.35	1957–64	1958		7.20	2,170
					10	4.24	1,230

TABLE 28.—*Flood stages and discharges, December on the island of Oahu, Hawaii*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods prior to Dec. 1964		Peaks of Dec. 1964 (date)	Gage height (ft)	Discharge (cfs)
			Period	Year			
22	Unnamed stream at Waimanalo.	1.21	1958–64	1958		6.00	665
					10	3.17	147
23	Makawao Stream near Kailua	2.04	1912–16, 1958–64	1958		9.08	2,140
					19	6.68	944
24	Maunawili Stream at State Highway 61, near Kailua.	5.34	1958–64	1958		11.08	2,550
					10	5.72	610
					19	8.36	1,390
25	Kaelepulu Stream tributary at Kailua.	.16	1963–64	1963		6.40	370
					10	1.66	32
					23	3.70	139
26	Keaahala Stream at Kamehameha Highway at Kaneohe.	.62	1958–64	1958		8.18	1,780
					9	4.17	441
27	Haiku Stream near Heeia	.97	1914–19, 1939–64	1951		5.39	3,160
					10	3.16	495
28	Waihee Stream near Heeia	.93	1935–64	1963		6.06	1,560
					9	5.04	557
29	Waiahole Stream, at an altitude of 250 ft, near Waiahole.	.99	1955–64	1963		4.80	2,230
					10	3.06	320
30	Waikane Stream at an altitude of 75 ft, at Waikane.	2.22	1960–64	1963		9.46	4,560
					10	4.92	741
31	Kahana Stream at an altitude of 30 ft, near Kahana.	3.74	1914–17, 1958–64	1963		8.10	5,430
					15	5.83	2,570
32	Punaluu Stream near Punaluu	2.78	1953–64	1961		6.06	2,970
					15	5.52	2,550
33	Malaekahana Stream near Laie.	.64	1963–64	1964		5.54	500
					9	4.89	323
					16	4.79	299
					23	4.72	282
34	Oio Stream near Kahuku	2.13	1957–64	1963		6.54	1,070
					23	6.79	1,110
35	Kamananui Stream at Pupukea Military Road, near Maunawai.	3.13	1964	1964		7.50	1,020
					9	8.12	1,260
					16	7.58	1,050
					23	7.33	969
36	Kamananui Stream at Maunawai.	9.79	1958–64	1963		7.92	3,450
					9	6.62	1,690
					16	6.70	1,780
					23	7.40	2,650
37	Anahulu River near Haleiwa	13.5	1957–64	1958		9.77	3,870
					15	6.30	2,090
38	Opaelua Stream near Haleiwa	5.96	1955–64	1956		8.74	4,120
					15	7.02	2,480

On Maui, the storm of December 16–23 caused flooding on the western part of the island (fig. 56). The highest peaks from this storm occurred on December 16 (table 29), but serious flood damage did not occur until the peaks on December 19. Heavy runoff on the night of December 19 washed thousands of tons of soil from recently cultivated pineapple fields into normally small dry gulches. The floodwaters from one of the gulches flowed through the Napili Kai Hotel and grounds and deposited an estimated 2,000 cubic yards of mud to a depth of 30 inches. Twenty-four hours later, another flood occurred in the same gulch, adding to the damage caused the previous night. Damage to the hotel, furnishings, and grounds was estimated at $150,000. A hydrograph for Honokohau Stream (sta. 3) is shown in figure 57.

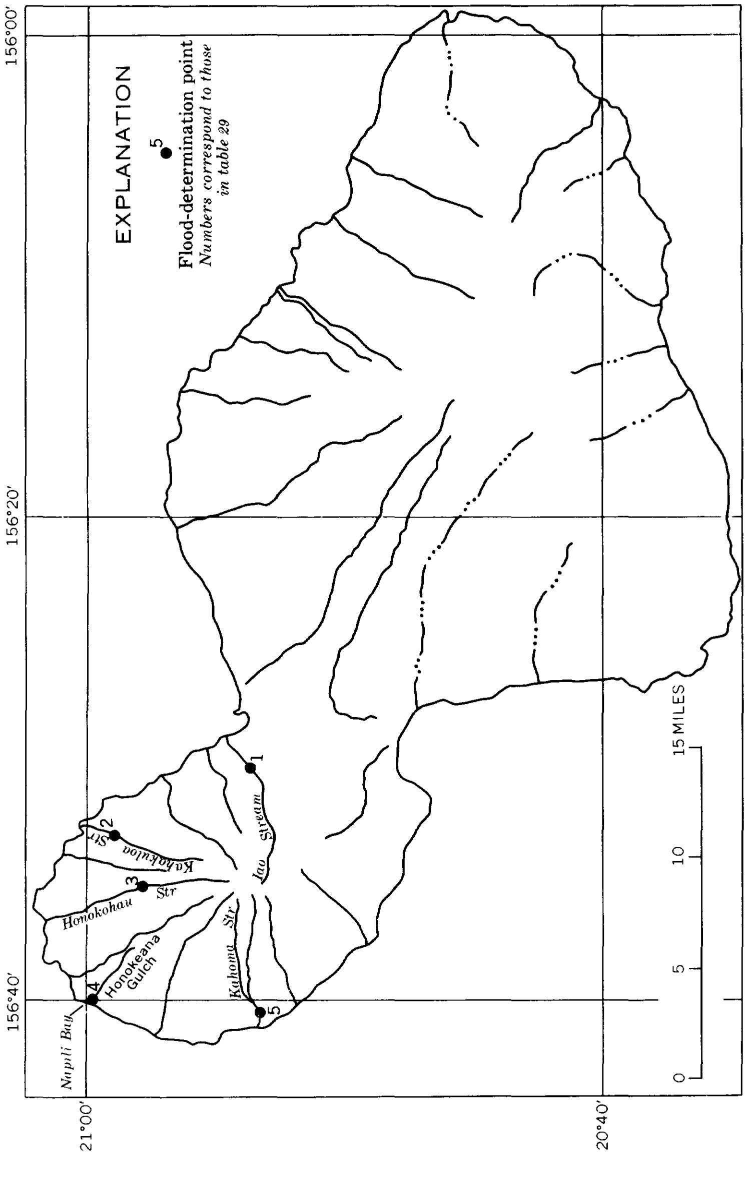

Figure 56.—Flood area; location of flood-determination points, floods of December on the island of Maui, Hawaii.

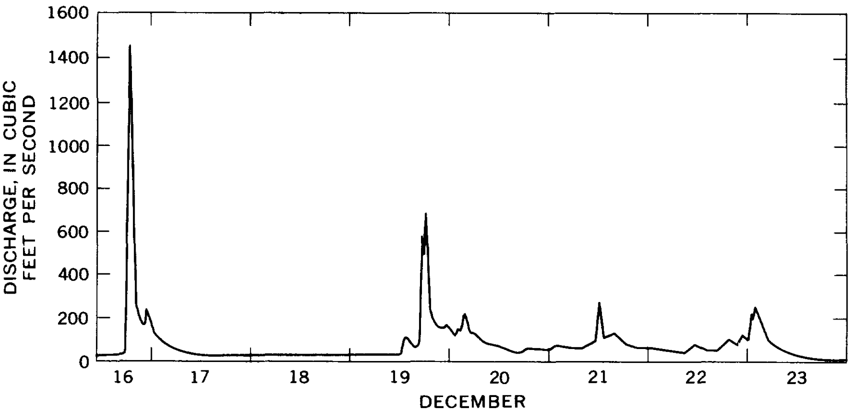

FIGURE 57.—Discharge of Honokohau Stream near Honokohau, on the island of Maui, Hawaii, December 16–23.

TABLE 29.—*Flood stages and discharges, December on the island of Maui, Hawaii*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods prior to Dec. 1964: Period	Maximum floods prior to Dec. 1964: Year	Peaks of Dec. 1964 (date)	Gage height (ft)	Discharge (cfs)
1	Iao Stream at Wailuku	8.24	1950–64	1950		6.21	7,540
					19	4.06	2,270
2	Kahakuloa Stream near Honokohau.	3.47	1939–43, 1947–64	1942		7.02	3,080
					16	6.02	673
					19	5.07	345
3	Honokohau Stream near Honokohau.	4.09	1913–20, 1922–64	1942		8.40	3,740
					16	5.91	1,450
					19	4.64	687
4	Honokeana Gulch near Honokohau.	.59			19	10.57	750
5	Kahoma Stream at Lahaina	5.22	1960–64	1960			7,750
					16	6.60	627
					19	4.85	263

FLOODS OF DECEMBER 1964–JANUARY 1965 IN THE FAR WESTERN STATES

The floods of December in the Far Western States were the most damaging in the history of the area. They were outstanding because of the recordbreaking discharges and the unusually large areas involved—Oregon, northern California, western Nevada and Idaho, and southern Washington (fig. 58). Forty-seven lives were lost, and damage amounted to about $430 million.

The floods resulted from a series of storms in late December—primarily from the warm torrential rains of December 21–23, which reflected the combined effect of moist unstable airmasses, strong west-southwest winds, and mountain ranges oriented at nearly right angles to the flow of air. In Idaho, Washington, and parts of Oregon, melted snow augmented the rain that fell on frozen ground and quickly reached the streams with little loss.

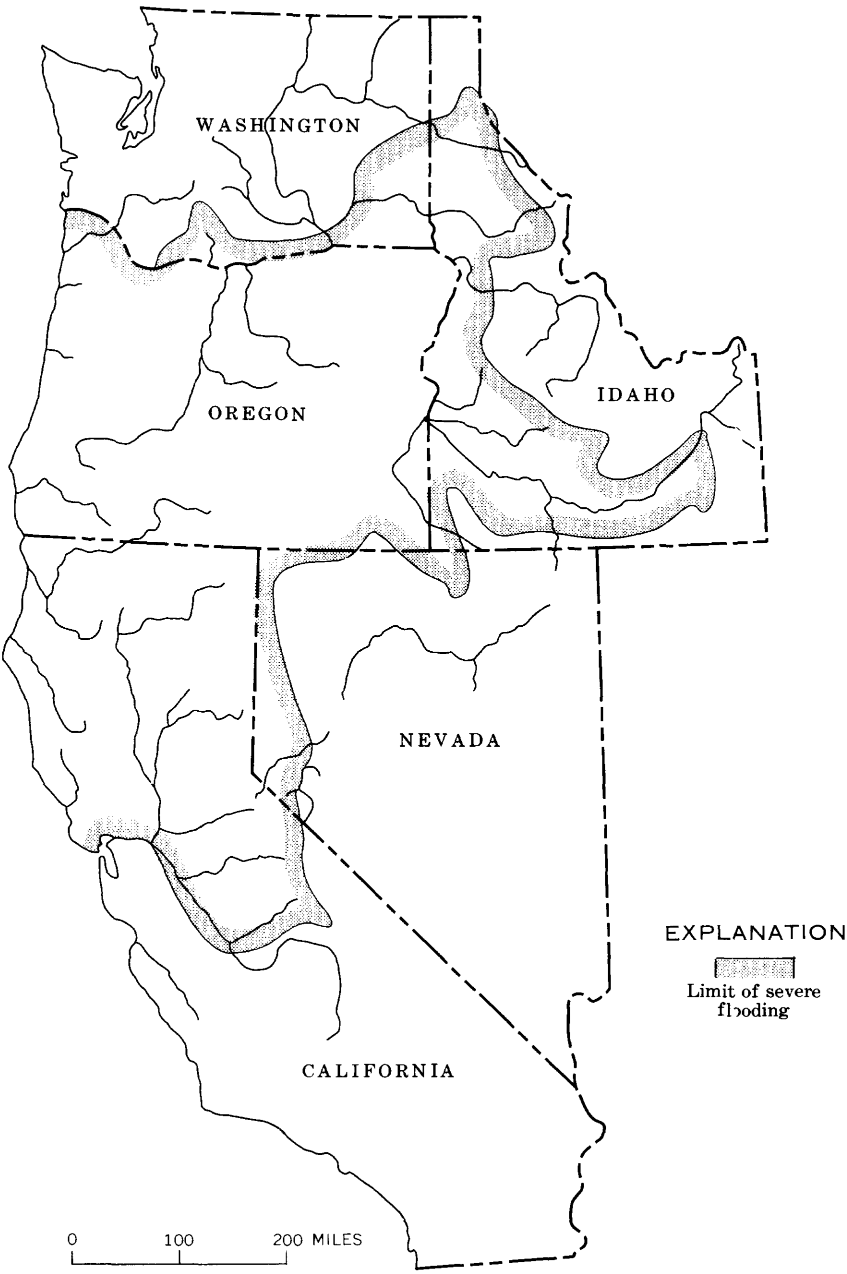

FIGURE 58.—Flood area; December 1964–January 1965 in the Far Western States.

On many streams, uncontrolled by reservoir storage, the peak discharge exceeded any previously recorded. Almost every town along the Eel River in California was under water. The Willamette River in Oregon was barely retained in its channel at Portland, as emergency workers added 3 feet of flashboards to the existing concrete seawall, but other cities in the Willamette River basin were damaged considerably. The extensive damage to roads and bridges was unprecedented. The operation of storage reservoirs on many of the rivers prevented much greater damage.

The suspended-sediment concentration and load of most streams greatly exceeded any that had been measured previously in the flood-affected area. In Idaho, Washington, and parts of Oregon, the ground thaw that occurred during the period of high runoff resulted in conditions conducive to severe erosion of the uplands and subsequent silt deposition on flooded stream terraces. The greatest concentration of suspended sediment was in streams that drain areas bordering the lower Snake and lower Columbia Rivers.

These floods are fully described in Water-Supply Paper 1866 (Waananen and others, 1970).

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INDEX

Floods of 1964 in the United States

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1840

This volume was published as separate chapters A–C

UNITED STATES DEPARTMENT OF THE INTERIOR

WALTER J. HICKEL, *Secretary*

GEOLOGICAL SURVEY

William T. Pecora, *Director*

CONTENTS

[Letters designate the separately published chapters]

U. S. GOVERNMENT PRINTING OFFICE : 1970 O - 372-048