Summary of Floods in the United States During 1967

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1880-C

Prepared in cooperation with Federal, State, and local agencies

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By J. O. ROSTVEDT *and others*

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SUMMARY OF FLOODS IN THE UNITED STATES DURING 1967

By J. O. Rostvedt and others

ABSTRACT

This report describes the most outstanding floods in the United States during 1967. The two most destructive floods occurred in August in east-central Alaska and in September and October in southern Texas.

In east-central Alaska, heavy rain on August 8–17 produced record-breaking floods near Fairbanks. Peak discharges on some streams in the area were from two to four times the 50-year flood. Flood damage was estimated to have been $85 million, and six lives were lost.

Torrential rains produced by Hurricane Beulah caused record-breaking floods on many streams in a 50,000-square-mile area in southern Texas and northeastern Mexico in September and October. As much as 25.5 inches of rain was measured at ESSA Weather Bureau stations in the period September 19–25. Major flooding occurred in the basins of the Guadalupe, San Antonio, Mission, Aransas, and Nueces Rivers and in many small coastal basins in Texas; on the Rio Grande and its floodways; and in the Rio Alamo and Rio San Juan basins in Mexico. Peak discharges at several sites in Texas were more than three times the magnitude of a 50-year flood. Total damage in Texas due to wind, rain, stream flooding, sheet flow, ponding, and tidal flooding was $167 million.

In addition to the two floods mentioned above, 27 others of lesser magnitude are considered important enough to be included in this annual flood summary.

INTRODUCTION

This report summarizes information on outstanding floods in the United States during 1967. The floods reported were unusual hydrologic events in which large areas were affected, or great damage resulted, or record-high discharges or stages occurred, and sufficient data were available for the preparation of a report.

Water-Supply Paper 1880–A, "Floods of August 1967 in East-Central Alaska," and Texas Water Development Board Report 83, "Floods from Hurricane Beulah in South Texas and Northeastern Mexico, September–October 1967," are examples of special reports that describe floods in detail in their respective areas. The areas for which flood reports have been prepared for 1967 are shown in figure 1. The areas in the two above-mentioned illustrations as well as five other areas covered by separate reports are indicated by a stippled pattern and are listed in the references cited. All 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 distribution of floods during the year.

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

Each flood in this report was selected as an outstanding or relatively 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 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 determine floodflows are: Drainage area, altitude, geology, shape, slope, aspect, and vegetative cover. Except for vegetative cover, which varies seasonally, the physiographic features are fixed for any given area. The combination of the magnitude and intensity of meteorological phenomena, antecedent moisture conditions, and the effect of inherent physiographic features on runoff determines what the magnitude of a flood will be.

According to ESSA Weather Bureau data, losses from floods in the United States during 1967 ($375 million) were about 94 percent of the national annual average of $400 million, based on the 15-year period, 1951–65, adjusted to the 1965 price index.

The number of lives lost owing to floods in 1967 was 34 compared with 50 in 1966 and 119 in 1965, and was much less than the national annual average of 79 lives lost during the 42-year period, 1925–66.

Many of the flood reports give the amount of rainfall and the duration of the storm producing 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).

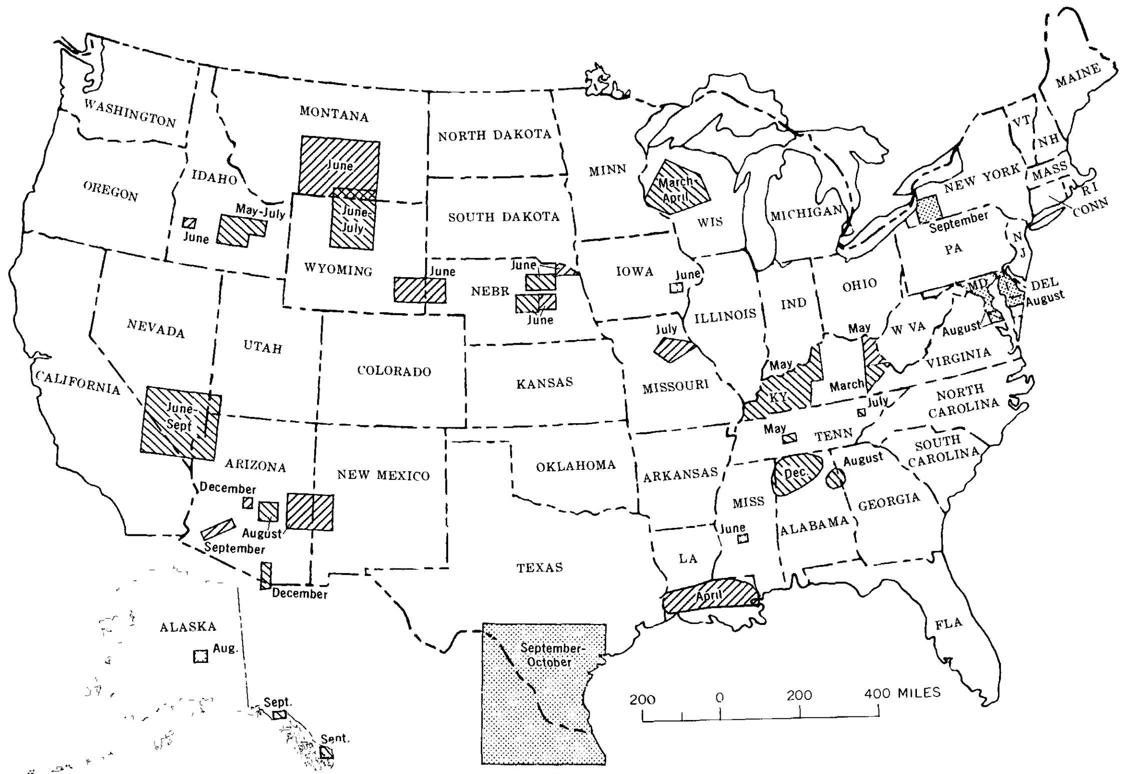

FIGURE 1.—Areas and months of occurrence of outstanding floods in 1967 in the conterminous United States and Alaska. Stippled pattern indicates the area for which a special report was prepared.

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

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

DETERMINATION OF FLOOD STAGES AND DISCHARGES

Data of peak stages and peak discharges at discharge stations in this report are those that are obtained and compiled in regular procedure 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 extensions 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 Benson and Dalrymple (1967). More detailed information concerning the latest techniques is available in recent reports by Dalrymple and Benson (1967), Bodhaine (1968), Matthai (1967) and Hulsing (1967).

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 can be 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.

When considerable rainfall data are available, they are presented in tabular form and show daily or storm totals. When sufficient data are available to determine the pattern and distribution of rainfall, an isohyetal map may be shown.

A summary table of peak stages and discharges is given for each flood unless the number of stations in the report is small, and then 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 1967 floods. This period does not necessarily correspond to that of gaging-station operation, but 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, prior to the 1967 flood being reported, in which the maximum stage or discharge occurred. The third column gives the date of the peak stage or discharge of the 1967 flood.

The last column gives the recurrence interval for the 1967 peak discharge. The recurrence interval is the average interval, in years, in which a flood of a given magnitude (the 1967 peak) 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, or it is one that has a 5-percent chance of occurring in any year. The recurrence intervals in the tables were obtained from U.S. Geological Survey reports on flood magnitude and frequency. In nearly all flood-frequency reports used, the data limit the determination of recurrence intervals to 50 years. In a few reports the limit is less than 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.

SUMMARY OF FLOODS OF 1967

FLOODS OF MARCH 7, IN SOUTHEASTERN KENTUCKY

BY C. H. HANNUM

The heaviest general precipitation in about 3 months in Kentucky fell from March 4 through 7: total amounts during the period were as much as 5 inches in some areas. Much of the precipitation on the 6th and 7th was snow in the northwestern two-thirds of Kentucky.

Heavy precipitation, mostly rain, in southeastern Kentucky caused considerable flooding in the headwaters of North Fork and Middle Fork Kentucky River and their tributaries. Rainfall reports for March 4–7 in the area were: 3.70 inches at Baxter, 3.31 inches at Hazard, 3.81 inches at Hyden, 3.45 inches at London, and 5.16 inches at Jeremiah, in the headwaters of North Fork Kentucky River. Locatior of ESSA Weather Bureau precipitation stations and amounts recorded are shown in figure 2.

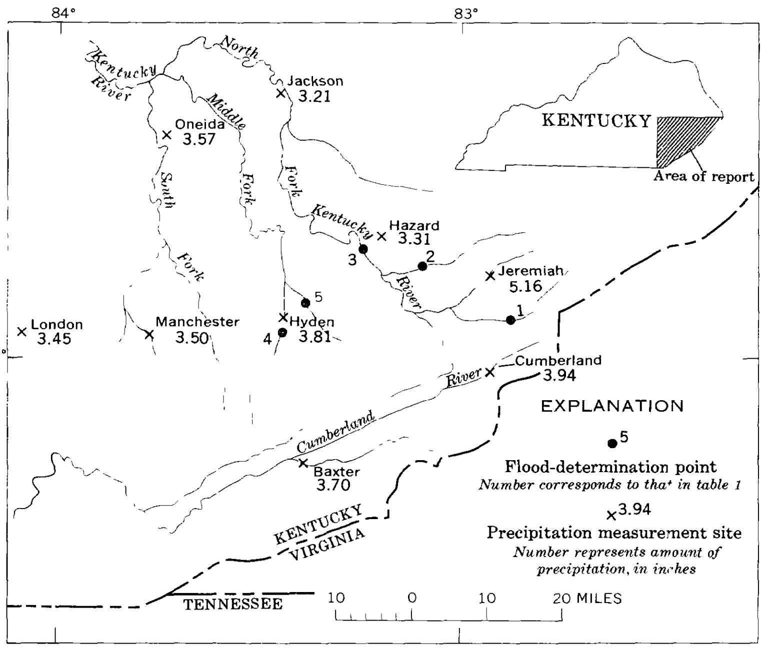

FIGURE 2.—Flood area and location of flood-determination points and precipitation sites. Floods of March 7, in southeastern Kentucky.

The peak discharge for Middle Fork Kentucky River near Hyden (sta. 4) was 23,600 cfs (cubic feet per second), which is the third highest discharge for the period of record (1957–67). Cutshin Creek at Wooten (sta. 5) had a peak discharge of 9,560 cfs, the second highest discharge for the 10-year record. Location of these and other stream-gaging stations reported on are shown in figure 2. The recurrence interval of the flood on Middle Fork Kentucky River at Hyden and Leatherwood Creek at Daisy (sta. 2) is 47 years compared to 34 years for Cutshin Creek at Wooten and 17 years for North Fork Kentucky River at Hazard (sta. 3). The discharge for North Fork Kentucky River at Whitesburg (sta. 1) in the upper part of the basin was 3,890 cfs, which is less than a 2-year flood.

Comparison of recurrence intervals indicates the concentration of the storm of March 4–7. Other data for these stations are given in table 1.

TABLE 1.—*Flood stages and discharges, March 7, in the Kentucky River basin in southeastern Kentucky*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before March 1967: Period	Known before March 1967: Year	March 1967	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
1	North Fork Kentucky River at Whitesburg.	66.4	1957–67	1957		14.7	7,730	
					6	9.98	3,890	<2
2	Leatherwood Creek at Daisy, Ky.	40.9	1965–67	1966		9.27	3,150	
					7	12.26	7,370	47
3	North Fork Kentucky River at Hazard.	466	1940–67	1957		37.54	47,800	
					7	29.85	35,500	17
4	Middle Fork Kentucky River near Hyden.	202	1957–67	1957		33.3	60,000	
					7	20.36	23,600	47
5	Cutshin Creek at Wooten	61.3	1957–67	1957		19.43	(1)	
			1958–67	1963		16.23	14,200	
					7	13.41	9,560	34

1 Not determined.

FLOODS OF MARCH 27–APRIL 4, IN NORTHWESTERN AND WEST-CENTRAL WISCONSIN

By DONALD C. HURTGEN

The sudden spring breakup in Wisconsin during March and April caused damaging floods, especially in the Chippewa River basin (fig. 3).

Heavy snows that had been deposited from December 1966 to February 1967 in northern Wisconsin, had a water equivalent of as much as 6 inches in early March. Precipitation was light during the first half of March, and below zero temperatures were experienced through March 18. On March 26 and 27 a light rain fell in northern Wisconsin, but in the west-central area, amounts exceeding 1 inch were received. Daytime temperatures of more than 40°F with cold nights, which began on March 22 throughout the flood area, primed the area in the north for possible flooding. In west-central Wisconsin, streams reached peak flows as early as March 27 and 28.

On March 30 and 31, near-record high temperatures of 70°F and above, and night temperatures above freezing started rapid snowmelt in the north, and high runoff reached rivers and streams quickly. Rivers rose sharply, causing the ice cover to break up, and high stages resulted. On April 2, rain of about 1 inch or more prolonged the flood or produced secondary peaks on some streams. Additional rain fell on April 6, 7, and 9, but by this time peaks had passed and no further flooding resulted.

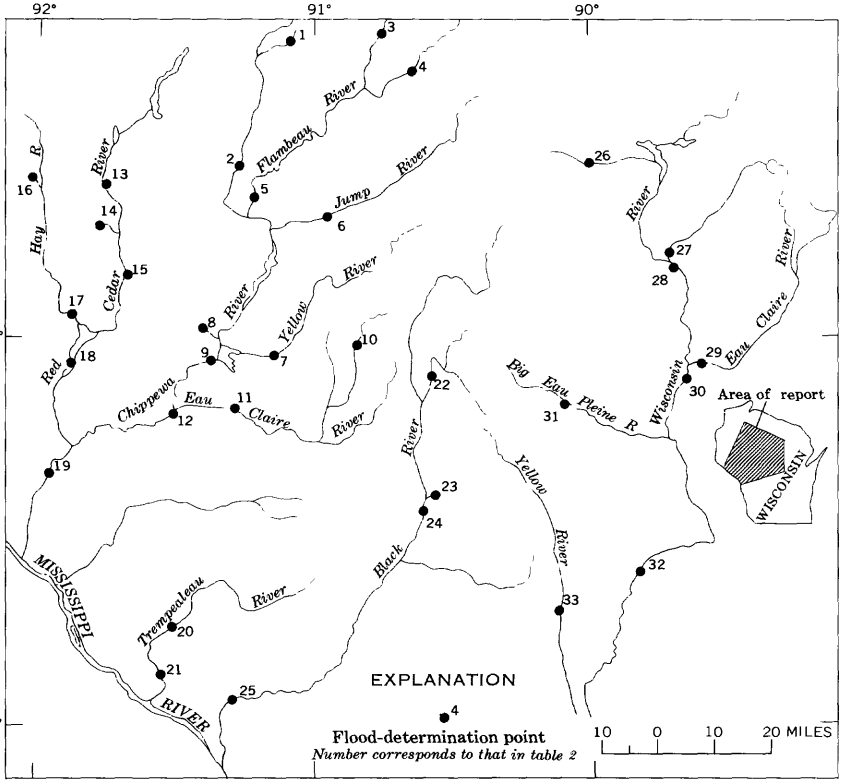

FIGURE 3.—Flood area and location of flood-determination points, floods of March 27–April 4, in northwestern and west-central Wisconsin.

Maximum peaks of record occurred on the Chippewa River at Eau Claire (sta. 12) and at Durand (sta. 19), Hay River at Wheeler (sta. 17), Black River near Galesville (sta. 25), Poplar River near Owen (sta. 22), and Red Cedar River near Colfax (sta. 15). Second highest peaks of record were recorded on Chippewa River at Chippewa Falls (sta. 9), Red Cedar River at Menomonie (sta. 18), Jump River at Sheldon (sta. 6), Yellow River at Cadott (sta. 7), and Yellow River at Babcock (sta. 33). Many other streams registered peaks with recurrence intervals of more than 20 years. (See table 2.)

Two gaging-station recorders were damaged by high water. Submergence covers protected recorders at several other overtopped gages.

The lower Chippewa River basin sustained property damage estimated at $1 million. A large part of the business section and the State University area in Eau Claire were inundated. Many highways were blocked by high water or washouts. Businesses located on flood plains in Chippewa Falls and Durand were damaged.

TABLE 2.—*Flood stages and discharges: March 27–April 4, in northwestern and west-central Wisconsin*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before March 1967: Period	Year	March–April 1967	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
	Chippewa River basin							
1	Kenyon Creek near	7.5	1960–67	1965		12.42	280	
	Radisson.				Mar. 31	12.85	330	(1)
2	Chippewa River near	1,630	1914–67	1941		20.46	25,800	
	Bruce.				Apr. 1	[2] 17.48	19,000	16
3	Flambeau River at Babbs	1,000	1930–67	1946		9.45	[3] 9,440	
	Island near Winter.				Apr. 2	8.58	[3] 8,540	
4	South Fork Flambeau	615	1930–67	1943		14.32	10,200	
	River near Phillips.				Apr. 2	12.45	6,900	7
5	Flambeau River near	1,897	1952–67	1954		10.90	[3] 17,400	
	Bruce.				Apr. 2	10.67	[3] 17,000	
6	Jump River at Sheldon	574	1916–67	1941		18.8	46,000	
					Apr. 1	14.14	20,900	[4] 1.21
7	Yellow River at Cadott	351	1943–67	1943		12.2	15,900	
					Mar. 31	[5] 14.18	12,000	23
8	Duncan Creek at Bloomer	49.2	1945–51, 1958–67	1959		10.83	2,300	
					Mar. 31	9.56	1,780	(1)
9	Chippewa River at Chippewa Falls.	5,600	1888–1967	1941		24.8	102,000	
					Apr. 1 or 2	22.49	83,300	20
10	Goggle-eye Creek near	7.04	1958–67	1958		20.99	2,610	
	Thorp.				Mar. 30	15.83	1,150	(1)
11	Eau Claire River near Fall Creek.	758	1943–55, 1958–67	1955		16.11	17,200	
					Mar. 31	17.59	20,500	37
12	Chippewa River at Eau Claire.	6,630	1903-8, 1944–54	1954			80,000	
13	Red Cedar River near	450			Apr. 2		94,000	26
	Cameron.				Mar. 30	10.00	4,650	(1)
14	East Branch Pine Creek	3.85						
	tributary near Dallas.		1960–67	1960		18.75	730	
15	Red Cedar River near	1,100			Mar. 30	15.59	430	(1)
	Colfax.		1914–67	1934		11.4	21,900	
16	Lightning Creek near	19.8			Mar. 31	[5] 9.08	22,800	[4] 1.40
	Owen.		1958–67	1965		12.18	1,200	
17	Hay River at Wheeler	426			Mar. 30	12.39	1,550	(1)
			1915–67	1934		16.6	(1)	
			1951–67	1965		14.65	10,900	
18	Red Cedar River at	1,760			Mar. 31	15.04	13,600	[4] 1.04
	Menomonie.		1907–8, 1913–67	1934		16.0	40,000	
19	Chippewa River at Durand	9,010			Mar. 31	12.80	33,200	[4] 1.41
			1884–1967	1884		18.4	160,000	
			1928–67	1954		15.40	101,000	
					Apr. 2	16.93	123,000	[4] 1.07
	Trempealeau River basin							
20	Trempealeau River at	552	1961–67	1965		7.15	9,740	
	Arcadia.				Mar. 27	6.88	8,340	3
21	Trempealeau River at Dodge.	643	1914–19, 1934–67	1956		10.35	17,400	
					Mar. 28	[5] 10.42	7,350	<2

See footnotes at end of table.

TABLE 2.—*Flood stages and discharges: March 27–April 4, in northwestesn and west-central Wisconsin*—Continned

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before March 1967 — Period	Known before March 1967 — Year	March–April 1967	Gage height (feet)	Discharge — Cfs	Discharge — Recurrence interval (years)
	Black River basin							
22	Poplar River near Owen	159	1958–67	1958		19.46	8,250	
					Mar. 31	19.12	10,000	(1)
23	Cawley Creek near Neillsville.	38.6	1961–67	1961		[2] 16.00	1,500	
					Mar. 30	17.11	3,400	(1)
24	Black River at Neillsville	756	1905–9, 1914–67	1938		23.8	43,800	
					Mar. 31	18.00	25,700	7
25	Black River near Galesville	2,120	1932–67	1938		14.31	58,000	
					Apr. 1	14.63	65,500	30
	Wisconsin River basin							
26	Spirit River at Spirit Falls	82	1942–67	1942		10.00	4,180	
					Apr. 2	7.91	2,960	5
27	Prairie River near Merrill	181	1914–31, 1940–67	1941		9.45	5,800	
					Mar. 31	6.76	2,670	7
28	Wisconsin River at Merrill	2,780	1903–67	1941		18.26	[3] 49,400	
					Apr. 2	13.04	[3] 23,800	8
29	Eau Claire River at Kelly	326	1914–26, 1940–67	1926		8.4	8 300	
					Apr. 1	[5] 9.38	6,260	38
30	Wisconsin River at Rothschild.	4,000	1941–67	1941		22.3	75 000	
					Mar. 31	18.46	49,200	5
31	Big Eau Pleine River near Stratford.	224	1914–25, 1937–67	1938		24.5	41.000	
					Mar. 30	20.36	18 100	21
32	Wisconsin River at Wisconsin Rapids.	5,400	1914–50, 1958–67	1938		19.10	70 400	
					Apr. 3 or 4	(1)	61.000	8
33	Yellow River at Babcock	223	1944–67	1952		17.38	11,600	
					Mar. 31	17.05	10,800	32

[1] Not determined.
[2] Affected by backwater from ice.
[3] Regulated by reservoirs.
[4] Ratio of peak discharge to 50-yr flood.
[5] At different site or datum.

FLOODS OF APRIL 13–15, IN SOUTHWESTERN MISSISSIPPI

By B. E. WASSON

Rainfall on April 13–15 ranged from 7 to 12 inches in Wilkinson, Amite, Pike, and Walthall Counties in southwestern Mississippi (fig. 4). Similar heavy rainfall was recorded to the south in Louisiana. Southeastward toward the Mississippi gulf coast, about 4 inches of rain fell.

The rain in Mississippi was caused by a frontal system that moved into the western part of the State in the late afternoon of April 13 and cleared the southeast corner of the State during the morning of

April 15. The rainfall at most ESSA Weather Bureau stations in southwestern Mississippi generally was intense just after the front moved in (2.09 in. in 1 hr was reported at Tylertown). The rain continued for about 30 hours.

Flooding was severe in the Woodville area, where 12 inches of rain fell during the storm period. The peak discharge of Buffalo River at U.S. Highway 61 north of Woodville (sta. 1) was 43,300 cfs (table 3), which was almost as great as the maximum discharge during the 26 years of record. The peak discharge of Little Tangipahoa River at Magnolia (sta. 2), was 5,000 cfs, which was the second highest flood during 17 years of record. The peak discharge of Tanyard Creek at Liberty (sta. 3) was 3,200 cfs, which has been exceeded five times during the past 16 years. The Amite River near Darlington, La., (sta. 4), has had three higher floods during the 17 years of record.

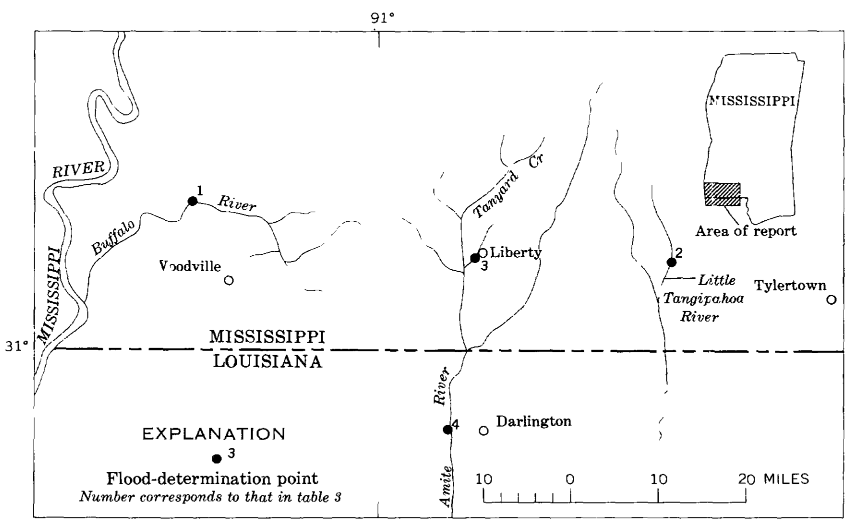

FIGURE 4.—Flood area and location of flood-determination points, floods of April 13–15, in southwestern Mississippi.

TABLE 3.—*Flood stages and discharges, April 13–15, in southwestern Mississippi*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before April 1967: Period	Known before April 1967: Year	April 1967	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
				Buffalo River basin				
1	Buffalo River near Woodville.	182	1942–67	1964	----------	20.19	44,800	----------
			----------	----------	15	19.88	43,300	----------

TABLE 3.—*Flood stages and discharges, April 13–15, in southwestern Mississippi*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before April 1967 — Period	Year	April 1967	Gage height (feet)	Discharge — Cfs	Recurrence interval (years)
	Mississippi River Delta							
2	Little Tangipahoa River at Magnolia.	40	1951–67	1964		22.22	7,600	
					14	21.47	5,000	
3	Tanyard Creek at Liberty	8.7	1951–67	1955		94.31	8,000	
					15	92.38	3,200	
4	Amite River near Darlington, La.	580	1949–67	1955		[1] 18.18	5[illegible],700	
					15	18.97	39,300	

[1] At different channel 700 ft to the left, at datum 2.99 ft higher.

FLOODS OF APRIL 13–17, IN SOUTHERN LOUISIANA

By FRED N. LEE

Intense rainfalls, associated with prefrontal squall lines, drenched the southern part of Louisiana on April 13–15, causing severe flooding and great damage in some areas. More than 10 inches of rain fell over a 20- to 30-mile-wide area, extending from the northeast corner of Cameron Parish in the southwestern part of the State to central Tangipahoa Parish in the southeastern part of the State (fig. 5).

Two cells of intense rainfall occurred, one over the Jennings area and the other over an area northeast of Baton Rouge. Rainfall stations within these cells reported extremely large rainfalls, and all-time rainfall records were exceeded at Jennings and Batcn Rouge. Some of the larger rainfall amounts were: 15.30 inches at Jennings, 15.55 inches at Mermentau (5 miles southeast of Jennings), 12.64 inches at Baton Rouge, 15.79 inches at Stoneypoint (20 miles northeast of Baton Rouge) and 12.75 inches at Amite. At Jennings, 12.20 inches of rain fell between 8 p.m. on the 13th and 3 a.m. on the 14th; this amount in 24 hours would be a record amount for April in the Southwest Division. At Baton Rouge, 11.01 inches of rain fell in 9 hours, beginning at 2 a.m. on the 14th, an all-time record for the station.

Most of the flooding occurred in the southeastern part of the State, known locally as the Florida Parishes. Hog Branch near Doyl (drainage area, 110 sq mi) had a peak discharge 1.34 times the 50-year flood

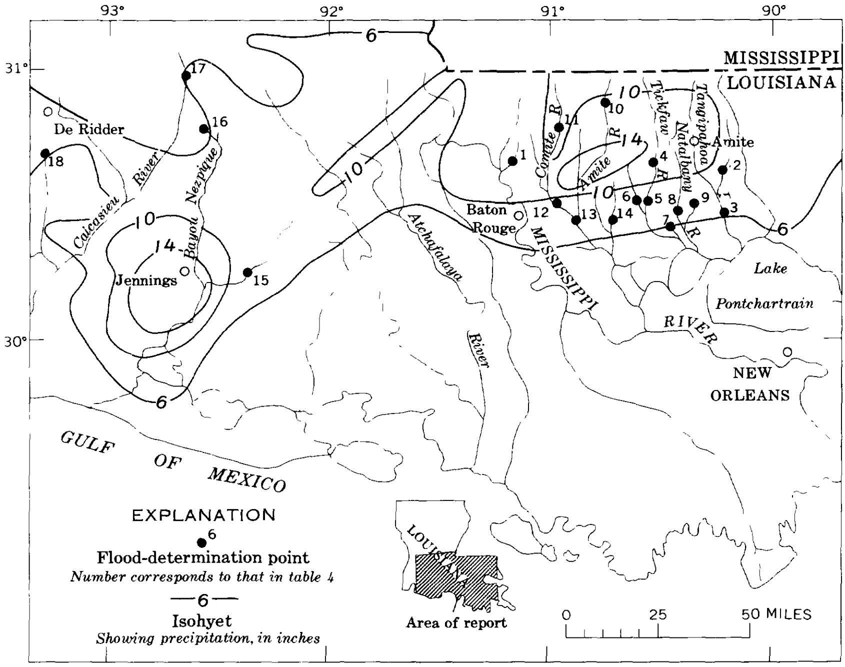

FIGURE 5.—Flood area, location of flood-determination points, and isohyets for April 13–15, floods of April 13–17, in southern Louisiana.

(table 4, sta. 6), which slightly exceeded the previous maximum discharge of record in 1953.

Damage was caused to private and public property when the discharge capacities of several streams and local drainage ditches were exceeded. Houses and streets were flooded, and many persons moved from their homes because of the rising water. Much seed rice was washed away in the southwestern part of the State, and in the southeastern part, the strawberry crop, which was at its harvest peak, was severely damaged. In Livingston Parish, more than 75,000 chickens were drowned by the rising water. Because of the extensive damage, seven parishes were declared disaster areas by the U.S. Small Business Administration. The seven parishes were Livingston and East Baton Rouge, east of the Mississippi River, and West Baton Rouge, Pointe Coupee, St. Landry, Acadia, and Jefferson Davis, west of the Mississippi River.

TABLE 4.—*Flood stages and discharges, April 13–17, in southern Louisiana*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before April 1967: Period	Year	April 1967	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
	Bayou Baton Rouge basin							
1	Bayou Baton Rouge above	13.7	1953–67	1953		22.64	4,300	
	Baker.				14	20.96	2,650	28
	Mississippi River Delta							
2	Chappepeela Creek south-	91.0	1964–67	1964		12.26	(1)	
	east cf Loranger.				14	15.26	(1)	
3	Tangipahoa River at	646	1921	1921		27.1	(1)	
	Robert.		1939–67	1953		23.13	50 500	
					15	19.68	28 100	17
4	Tickfaw River at Mont-	220	1951–67	1962		104.41	(1)	
	pelier.				15	102.91	(1)	
5	Tickfaw River at Holden	247	1940–67	1943		19.75		
				1962			14 500	
					15	18.78	12,000	8
6	Hog Branch near Doyle	110	1951–67	1953		22.77	15,100	
					15	21.72	15,300	[2]1.34
7	Blood River near Spring-	26.6	1964–67	1966		17.41	2,100	
	field.				17	19.58	2,740	8
8	Natalbany River at Baptist	79.5	1944–67	1953		19.73	9,550	
					15	18.20	6,390	12
9	Ponchatoula Creek at Na-	13.8	1951–67	1964		11.95	2,300	
	talbany.				15	11.85	2,270	15
10	Amite River near Darling-	580	1949–67	1955		[3]18.18	55,700	
	ton.				15	18.97	39,300	8
11	Comite River near Olive	145	1943–67	1961		21.37	19,900	
	Branch.				15	18.43	13,400	5
12	Comite River near Comite	[4]284	1944–67	1953		28.64		
13	Amite River near Denham			1962			20,900	
	Springs.				14	21.20	17,600	22
		1,280	1921	1921		35.4		
			1939–67	1953		32.46	67,000	
14	Colyell Creek at Livingston				17	31.39	47,800	22
		20.7	1951–67	1953		11.86	4,950	
					15	10.66	2,940	15
	Mermentau River basin							
15	Bayou Wikoff near Rayne	51.3	1953–67	1955		20.21	3,750	
					15	18.14	4,100	5
16	Beaver Creek at Beaver	14.4	1953–67	1953		19.18	(1)	
					15	16.43	1,720	5
	Calcasieu River basin							
17	Calcasieu River near	499	1944–67	1953		21.55	59,900	
	Glenmora.				16	17.29	22,800	4
18	Cowpen Creek near	28.3	1954–67	1955		20.25	(1)	
	De Ridder.				14	17.41	(1)	

[1] Not determined.
[2] Ratio of peak discharge to 50-yr flood.
[3] At different site and datum.
[4] Since 1957, flow from 46 sq mi diverted from basin.

FLOODS OF APRIL 30–MAY 15, IN KENTUCKY

By C. H. HANNUM

Precipitation was below average for April throughout Kentucky. April was the fourth consecutive month with below-average precipitation in western Kentucky. Rainfall during the first 2 weeks of May over much of the State exceeded average amounts for the entire month and came in three storm periods that caused flooding throughout the State.

General rains started to fall throughout the State on April 30 and continued to May 2. Heavy rainfall on April 30 and May 1 caused moderate rises on many streams. The heaviest rain fell between the Green and the Ohio Rivers in west-central Kentucky (fig. 6). This storm caused extremely high floods on two tributaries of the Green River. The peak discharge in Bear Creek near Leitchfield (sta. 6) was 7,880 cfs (1.48 times the 50-yr flood). North Fork Rough River near Westview (sta. 7) had the third highest flood for the period of record (1954–67), and Rock Lick Creek near Glen Dean (sta. 8) had the sixth highest flood for the period of record (1956–67). Peak discharges on other small streams in the area had recurrence intervals less than 2 years. Other data for these stations are given in table 5.

TABLE 5.—*Flood stages and discharges, April 30–May 1, in the Green River basin in west-central Kentucky*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before April 1967				Discharge	
			Period	Year	April–May 1967	Gage height (feet)	Cfs	Recurrence interval (years)
5	Bacon Creek near Priceville.	85.4	1957–67	1957		21.8	[1]	
		[2] 54.4	1959–67	1964		14.01	2,400	
					May 1	10.85	1,140	<2
6	Bear Creek near Leitchfield.	30.8	1937	1937		21	[1]	
			1949–67	1957		21.33	8,070	
					May 1	21.12	7,880	[3] 1.48
7	North Fork Rough River near Westview.	42.0	1954–67	1964		20.12	3,890	
		[2] 23.0			Apr. 30	18.17	3,010	[1]
8	Rock Lick Creek near Glen Dean.	20.1	1956–67	1959		18.36	8,720	
					May 1	16.27	3,990	[1]
9	Caney Creek near Horse Branch.	124	1956–67	1957		[4] 14.43	10,000	
					May 1	11.81	3,030	<2

[1] Unknown.
[2] Area contributing to direct runoff.
[3] Ratio of peak discharge to 50-yr flood.
[4] Did not occur simultaneously with peak discharge.

The second storm period on May 5–7 caused severe flooding on Tygarts Creek at Olive Hill. Figure 6 shows the amount of the general rainfall for May 5–7 and the location of gaging stations. The peak discharge for Tygarts Creek at Olive Hill (sta. 1) was 8,460 cfs. This discharge was 1.55 times the 50-year flood compared to recurrence intervals of 18 years for the peak discharge for Triplett Creek at Morehead (sta. 3). Peak discharges of other streams in the area had recurrence interval of 5 years or less (table 6).

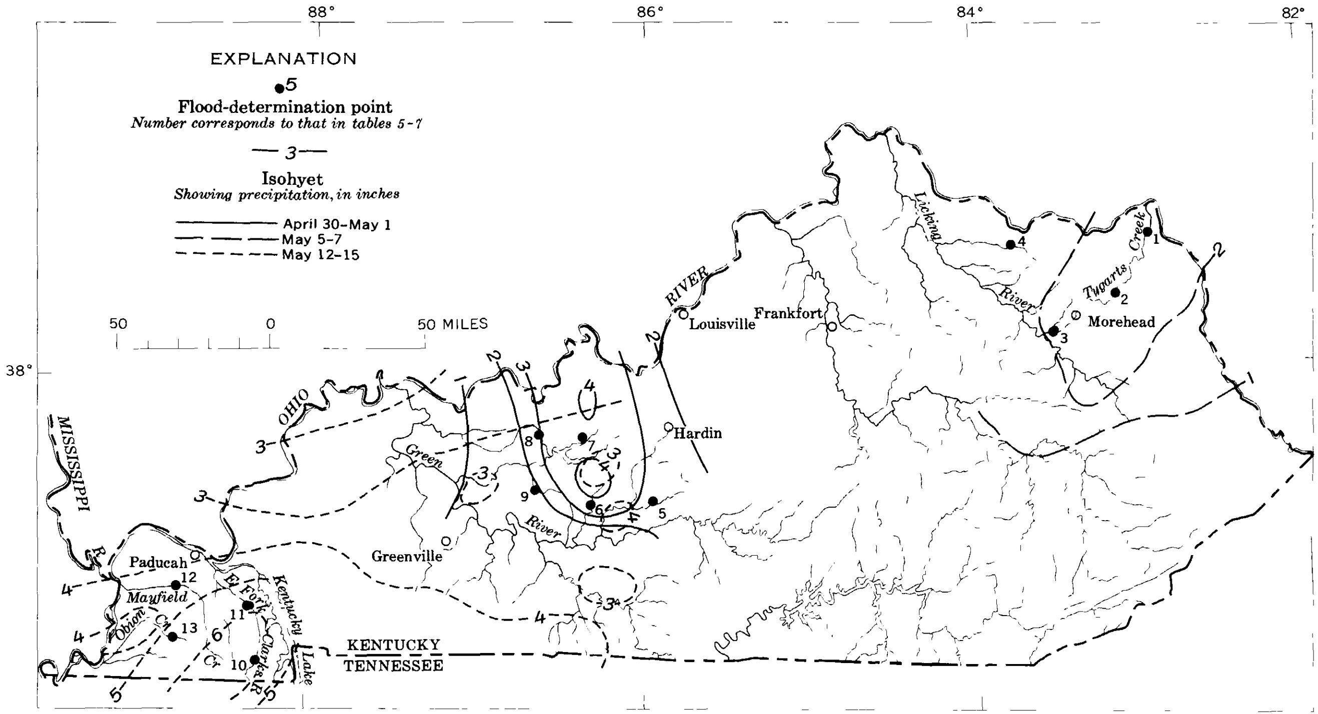

Figure 6.—Flood area, location of flood-determination points, and isohyets for three storms, flood of April 30–May 15, in Kentucky.

TABLE 6.—*Flood stages and discharges, May 7, in northeastern Kentucky*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before May 1967: Period	Known before May 1967: Year	May 1967	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
	Tygarts Creek basin							
1	Tygarts Creek at Olive Hill	59.6	1957–67	1963		15.01	8 970	
					7	15.65	8 460	[1]1.55
2	Tygarts Creek near Greenup	242	1940–67	1962		21.38	14 800	
					7	18.79	9,580	5
	Licking River basin							
3	Triplett Creek at Morehead	47.9	1939–67	1939		18.9	44,000	
					7	12.50	9,850	18
4	North Fork Licking River near Lewisburg	119	1938	1938		22.7	(2)	
			1946–67	1948		20.7	11,300	
					7	11.41	4,090	<2

[1] Ratio of peak discharge to 50-yr flood.
[2] Unknown.

The third storm period between May 12 and 15 caused general flooding in central and western Kentucky. The heaviest rainfall occurred in southwestern Kentucky, west of Kentucky Lake, causing severe flooding in the upper reach of East Fork Clarks River. The peak discharge on East Fork Clarks River at Murray (sta. 10) was 9,900 cfs, which is 1.11 times the peak discharge of a 50-year flood compared to recurrence interval of 38 years for the same flood on East Fork Clarks River at Benton (sta. 11). Peak discharges of other streams in western Kentucky had recurrence intervals of 3 years or less. Rainfall during the third storm period was less in central Kentucky with two small areas getting a little more than 4 inches of rain (see fig. 6). Rock Lick Creek near Glen Dean (sta. 8) had the fifth highest flood for the period of record (1956–67); peak discharge was 5,690 cfs. Other small streams in the area had peak discharges with recurrence intervals of 6 years or less (see table 7).

TABLE 7.—*Flood stages and discharges, May 14–15, in central and western Kentucky*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before May 1967 — Period	Known before May 1967 — Year	May 1967	Gage height (feet)	Discharge — Cfs	Discharge — Recurrence interval (years)
	Green River basin							
5	Bacon Creek near Priceville	85.4	1957–67	1957		21.8	([1])	
		[2] 54.4	1959–67	1964		14.01	2,400	
					15	8.95	712	<2
6	Bear Creek near Leitchfield	30.8	1937	1937		21	([2])	
			1949–67	1957		21.33	8,070	
					14	15.94	3,790	6
8	Rock Lick Creek near Glen Dean.	20.1	1956–67	1959		18.36	8,720	
					14	17.12	5,690	([1])
	Tennessee River basin							
10	East Fork Clarks River at Murray.	89.7	1951–67	1952, 1957		15.20	32,300	
					14	13.15	9,900	[3] 1.11
11	East Fork Clarks River near Benton.	227	1937–67	1937		17.8	([1])	
			1938–67	1957		17.10	33,000	
					15	15.51	17,300	38
	Mayfield Creek basin							
12	Mayfield Creek at Lovelaceville.	212	1937–67	1937		21.1	19,800	
					15	18.57	6,340	<2
	Obion Creek basin							
13	Obion Creek at Pryorsburg	36.8	1949	1949		13.0	([1])	
			1951–67	1957		13.08	5,330	
					14	10.95	3,200	3

[1] Unknown.
[2] Area contributing to direct runoff.
[3] Ratio of peak discharge to 50-yr flood.

FLOODS OF MAY 13, IN MAURY COUNTY, TENN.

By WILLIAM J. RANDOLPH

The month of May was unusually wet in Tennessee, and over most of the State the total rainfall for the month was the greatest of record. The weather during the month was characterized by heavy rainfall, hailstorms, several tornadoes and numerous severe thunderstorms. The most severe storm occurred during May 12 and 13 in the central Tennessee area, particularly in Maury County (fig. 7). Storm rainfall of 8.75 inches, and amounts of more than 7.5 inches in an 18-hour period and of 3.3 inches in a 1-hour period, were recorded at Culleoka in the

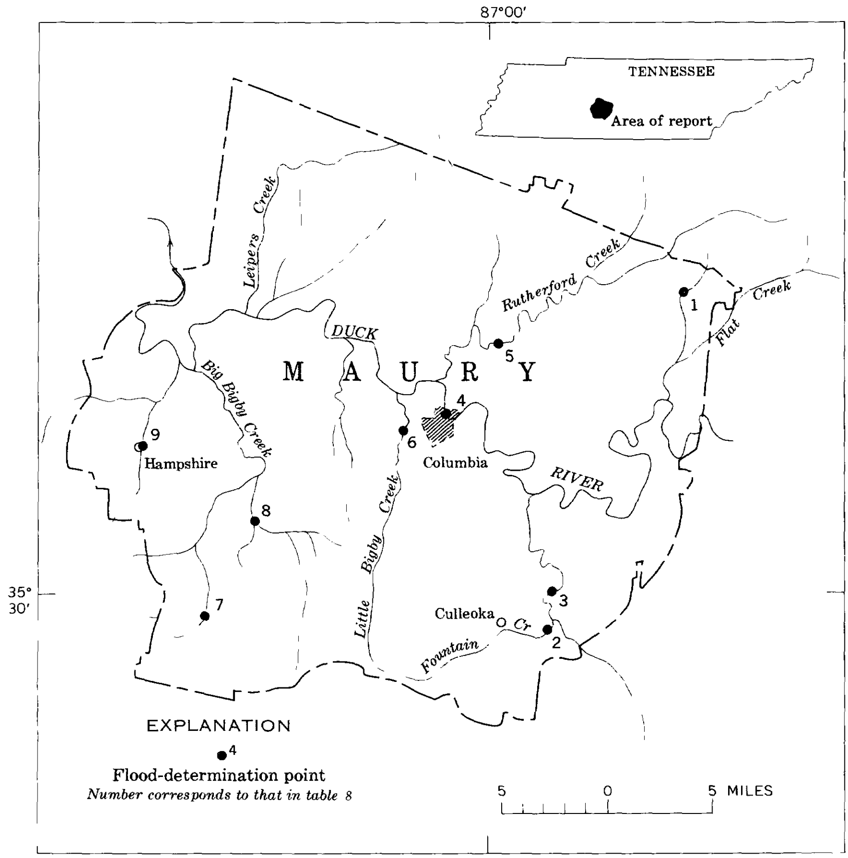

FIGURE 7.—Flood area and location of flood-determination poirts, floods of May 13, in Maury County, Tenn.

southeastern corner of the county. Storm rainfall of 5.69 inches was recorded at Columbia on May 13.

Most of the streams in the county, which are relatively small tributaries to the Duck River, had record or near-record floods. Information from long-time residents indicates that this flood was probably the greatest in the past 100 years at Columbia and Hampshire. The flood on the Duck River at Columbia was the eighth highest since 1874.

Indirect measurements of peak discharge were made at two gaging stations and three miscellaneous sites. A summary of peal- stages and discharges and frequency data for the flood area is given in table 8.

TABLE 8.—*Flood stages and discharges, May 13, in Tennessee River basin, Maury County, Tenn.*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before May 1967: Period	Year	May 1967	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
1	Little Flat Creek tributary near Rally Hill.	0.63	1955–67	1955		5.98	372	
					13	3.92	179	(1)
2	Fountain Creek near Culleoka.	26.9			13	14.16	9,260	[2] 1.95
3	Fountain Creek near Fountain Heights.	74.0			13	24.54	20,000	[2] 1.91
4	Duck River at Columbia	1,208	1905–8, 1920–67	1948		51.75	61,100	
					14	39.75	32,900	2
5	Rutherford Creek near Carters Creek.	68.8	1954–67	1955		24.38	11,800	
					13	17.84	6,160	10
6	Little Bigby Creek at Columbia.	43.2			13		16,000	[2] 2.34
7	Big Bigby Creek at Sandy Hook.	17.5	1954–67	1955		11.22	2,550	
					13	9.81	2,680	23
8	Sugar Fork at Mount Pleasant.	36.7			13		10,500	[2] 1.75
9	Baptist Branch at Hampshire.	6.46			13		4,830	(1)

[1] Unknown.
[2] Ratio of peak discharge to 50-yr flood.

Damage from the flood to railroads, highways, cropland, and more than 70 homes was extensive. The greatest damage was caused by Little Bigby Creek which flows through the western edge of Columbia. Floodwaters entered 64 homes in the Valewood and West Haven subdivisions, with depths of flooding as much as 8 feet above the floors. The floodwater rose nearly 8 feet in 1 hour, trapping people in their homes. The timing of the flood during the daylight hours could possibly be credited with preventing the loss of many lives. In the town of Hampshire about 11 homes were flooded, and the Hampshire School had nearly 5 feet of water over the lower floor.

FLOODS OF MAY–JULY, IN THE BIG LOST RIVER AND BIG WOOD RIVER BASINS, IDAHO

By C. A. THOMAS

Peak discharges during the period May 23–25 in the upper Big Lost River and Big Wood River basins (fig. 8) were maximum or near maximum of record at gaging stations in the upper Big Lost and Big Wood River basins (table 9). Volumes of discharge for the 30 days from May 24 to June 22 were also record or near-record highs in the Big Lost River basin (table 10).

Snow in the mountains was reported to be about 147 percent of normal on May 1. Cool weather delayed snowmelt until May 15. A week of above-average temperatures produced record peak flows during the

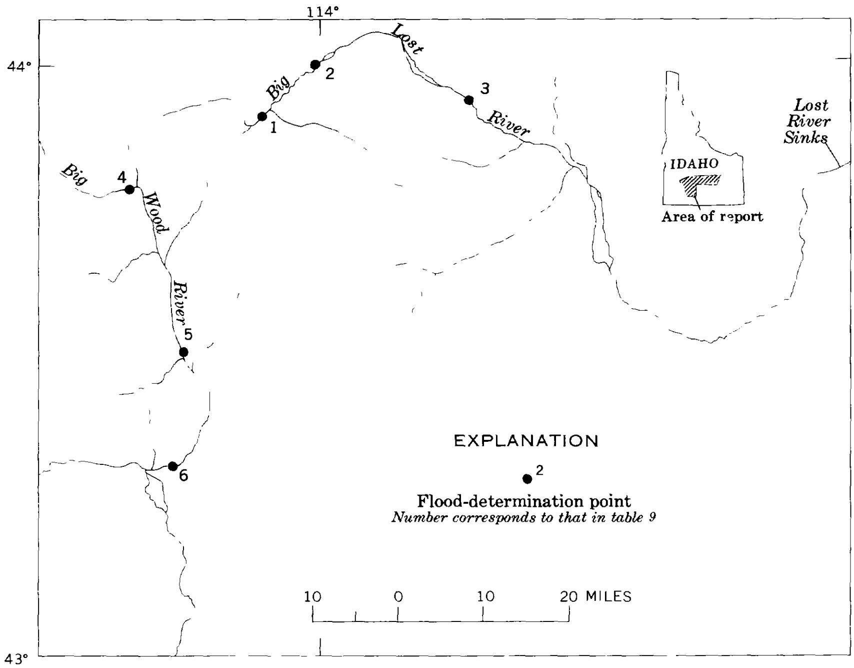

FIGURE 8.—Flood area and location of flood-determination points, floods of May–July, in the Big Lost River and Big Wood River basins, Idaho.

period May 23–25. Below-average temperatures again delayed snowmelt the first half of June, but rain and some snowmelt maintained streamflows at relatively high levels. During the period June 15–22, streamflow increased to flood levels owing to snowmelt from near-average temperatures and to runoff from several heavy showers.

In the Big Wood River basin considerable damage occurred from erosion and flooding of crops.

Along the Big Lost River, damage from the flood of May 23–25 was relatively light. The peak discharge of 4,420 cfs at Howell Ranch (sta. 2) was reduced by diversions into sinks near Chilly and by storage in Mackay Reservoir. The peak outflow from Mackay Reservoir was about 55 percent of the peak flow at Howell Ranch. Damage to the more highly developed section of the valley below Mackay Reservoir was minimal. However, the extended period of extremely high flows from May 18 to July 20 filled the reservoir and increased the groundwater storage. The peak discharge of the secondary peak on June 22 at Howell Ranch was 3,860 cfs. The peak discharge from Mackay Reservoir on June 24 was 2,400 cfs, 62 percent of that at Howell Ranch.

TABLE 9.—*Flood stages and discharges, May–July, in Big Lost and Big Wood River basins, Idaho*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before May 1967 — Period	Known before May 1967 — Year	May–June 1967	Gage height (feet)	Discharge — Cfs	Discharge — Recurrence intervals (years)
	Big Lost River basin							
	Big Lost River:							
1	At Wild Horse, near Chilly.	114	1944–67	1965		6.39	1,420	
					May 25	6.23	1,380	25
2	At Howell Ranch, near Chilly.	450	1921–67	1954		6.00	3,960	
					May 25	6.02	4,420	50
3	Below Mackay Reservoir, near Mackay.	813	1904–6, 1912–14, 1919–67	1921			2,990	
					June 23		2,430	12
	Big Wood River basin							
	Big Wood River:							
4	Near Ketchum	137	1948–67	1956			1,620	
					May 24	5.92	1,690	32
5	At Hailey	640	1921–67	1958			4,680	
					May 25	5.72	4,830	35
6	Near Bellevue	824	1912–67	1956			4,180	
					June 21		3,280	10

TABLE 10.—*Comparison of the average discharge of highest 30-day period during 1967 with the prior highest 30-day period of record for the Big Lost River basin*

Stream and place of determination	Drainage area (sq mi)	Average of highest 30-day period: Prior to 1967 — Period	Prior to 1967 — Year	1967	Cfs	Recurrence interval (years)
Big Lost River:						
At Howell Ranch near Chilly	450	1921–67	1956		2,390	
				May 24–June 22	2,443	60
Below Mackay Reservoir, near Mackay	813	1904–6, 1912–14, 1919–67	1965		2,063	
				June 17–July 16	1,909	28

Flow below Mackay Reservoir exceeded the channel capacity, about 1,500 cfs for more than 1 month. Valley subsoils were saturated. According to reports of the U.S. Army Corps of Engineers, overland flows inundated about 7,000 acres, and high ground-water flooded about 7,000 acres, damaging crops, contaminating wells, flooding basements, and damaging roads and other improvements. The Corps of Engineers estimated that damages from the flood totaled $675,000 in addition to flood-fighting expenses, estimated at $54,000. The Corps of

Engineers operations prevented damages estimated at more than $100,000.

FLOODS OF JUNE 1, IN SOUTHWESTERN JACKSON, MISS.

After KENNETH V. WILSON (1968)

Intense rain in Jackson, Miss., on the morning of June 1 fell on ground already soaked by more than 1 inch of rain on the afternoon of May 31. Figure 9 shows that the storm rainfall on June 1 ranged from 2 to 4 inches in the southwestern part of Jackson. An average of about 3 inches fell on the Cany Creek basin, 2¾ inches on the Hardy Creek basin, 2½ inches on the Three-Mile and the Lynch Creek basins, and less than 2 inches on the Town Creek basin. The rain started about 9:20 a.m., was very intense from 9:50 a.m. to 10:50 a.m., and ceased at 2:45 p.m.; most of the rain fell in a 1-hour period.

Flash floods occurred in southwestern Jackson. Some homes were flooded as a result of ditches and culverts being overtaxed during the intense downpour; other homes and business places were flooded by overflow from the creeks in the area. Floods from the West Branch of Lynch Creek had never been closer than 6 inches from the floors of stores in the vicinity of U.S. Highway 80 since they were built in 1949. These floors were flooded to a depth of 6 or 7 inches during the flood of June 1, 1967, whereas the flood on Lynch Creek at Valley Street (sta. 2) was about equal to the mean annual flood.

On Three-Mile Creek the peak discharge at Terry Road (sta. 4) was about equal to the mean annual flood, but on the tributary at Alta Woods Boulevard (sta. 3), drainage area, 0.12 sq mi, the peak discharge (183 cfs) was the highest flood since at least 1950.

The peak discharge of 1,450 cfs from 1.07 sq mi on Hardy Creek at McDowell Road (sta. 5) exceeded the 50-year flood, but at Terry Road (sta. 6) the peak discharge of 1,880 cfs from the 2.13 sq mi drainage area was only a 10-year flood. At least eight houses were flooded from Hardy Creek.

This was the greatest flood on Cany Creek since canalization of the creek and since residential occupation of the flood plain began several years ago. At Raymond Road (sta. 7) the peak discharge of 2,320 cfs from the 1.80-sq mi drainage area was greater than a 50-year flood. The 1,000-foot-wide flood plain just upstream from Raymond Road was inundated by as much as 3 feet of water. At Cooper Road (sta. 9) the peak was a 10-year flood. Fifteen homes were flooded by Cany Creek.

The peak discharges on several small Cany Creek tributaries were extremely great. (See table 11.)

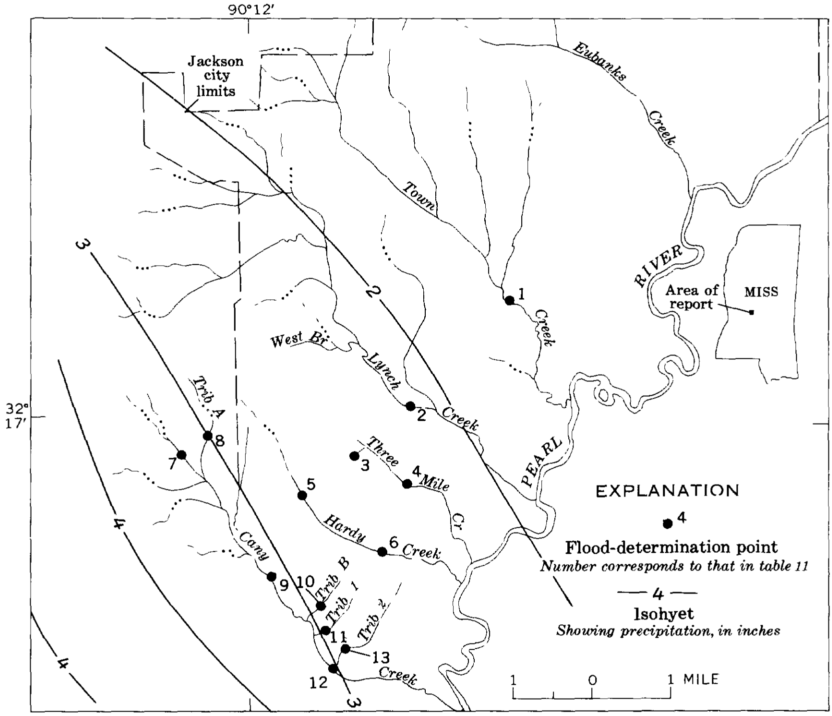

FIGURE 9.—Flood area, location of flood-determination points, and isohyets for June 1, floods of June 1, in southwestern Jackson, Miss.

More details of these floods are available in the open-file report by Wilson (1968). The report describes the runoff characteristics of the several drainage basins. It has a map of the flooded area along Cany and Hardy Creeks, and it describes the areas flooded by other streams. Water-surface profiles of Cany and Hardy Creeks show profiles of the flood of June 1967, the flood of May 1966, the 50-year flood under conditions existing in 1967, and the hypothetical 50-year flood with improved channels and 50-percent storm sewer drainage. The report contains discharge data from four rural sites south and west of Jackson.

TABLE 11.—*Flood stages and discharges, June 1, in the Pearl River basin in southwestern Jackson, Miss.*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before June 1967: Period	Year	June 1967	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
1	Town Creek at Gallatin Street.	11.3	1953–67	1953			4 210	
					1		800	<2
2	Lynch Creek at Valley Street.	11.3	1953–67	1953			5 320	
					1		2,950	2
3	Three-Mile Creek tributary at Alta Woods Boulevard.	.12	1966–67	1966			131	
					1		183	
4	Three-Mile Creek at Terry Road.	1.12	1959–67	1966			1 470	
					1		1,140	3
5	Hardy Creek at McDowell Road.	1.07			1		1,450	>50
6	Hardy Creek at Terry Road.	2.13	1961–66	1964			1,450	
					1		1,880	10
7	Cany Creek at Raymond Road.	1.80			1		2,320	>50
8	Cany Creek tributary A at Raymond Road.	.72			1		1,170	
9	Cany Creek at Cooper Road.	5.76			1		3,410	10
10	Cany Creek tributary B at Sykes Park at Sykes Road.	.31			1		377	
11	Cany Creek tributary No. 1 at Meadowlane.	.34	1965–67	1965			200	
					1		207	<2
12	Cany Creek at Terry Road.	8.31	1961–67	1964			2,900	
					1		3,500	10
13	Cany Creek tributary No. 2 at Mason Boulevard.	.15			1		187	

FLOODS OF JUNE 7, IN THE WAPSINONOC CREEK BASIN, IOWA

After HARLAN H. SCHWOB (1968)

An outstanding storm on the night of June 6–7 dropped from 4 to 13 inches of rain in 14 hours over the Wapsinonoc Creek basin in east-central Iowa. An isohyetal map (fig. 10) was prepared from data of a bucket survey provided by the Iowa Natural Resources Council. The maximum reported storm rainfall was 13 inches at a site 3½ miles north and 2 miles east of West Liberty. Because the storm of high rainfall concentration was nearly centered over the 180-sq mi basin of Wapsinonoc Creek, the resulting floods were outstanding.

Peak discharges at six indirect measurement sites in the area of extreme flooding greatly exceeded a 50-year flood (table 12). An open-file report (Schwob, 1968) gives much additional hydrologic data on the flood. It gives estimated peak discharges at many points (other than those at which indirect measurements were made) along Wapsinonoc Creek and tributaries, flood elevations at upstream and downstream sides of bridges, and streambed elevations.

Several business places in the town of West Branch were damaged by floodwaters, but property loss was minor. One small county bridge was washed out. Agricultural damage was also minor, as crops were generally in the early stage of growth and were not seriously damaged by the brief period of inundation.

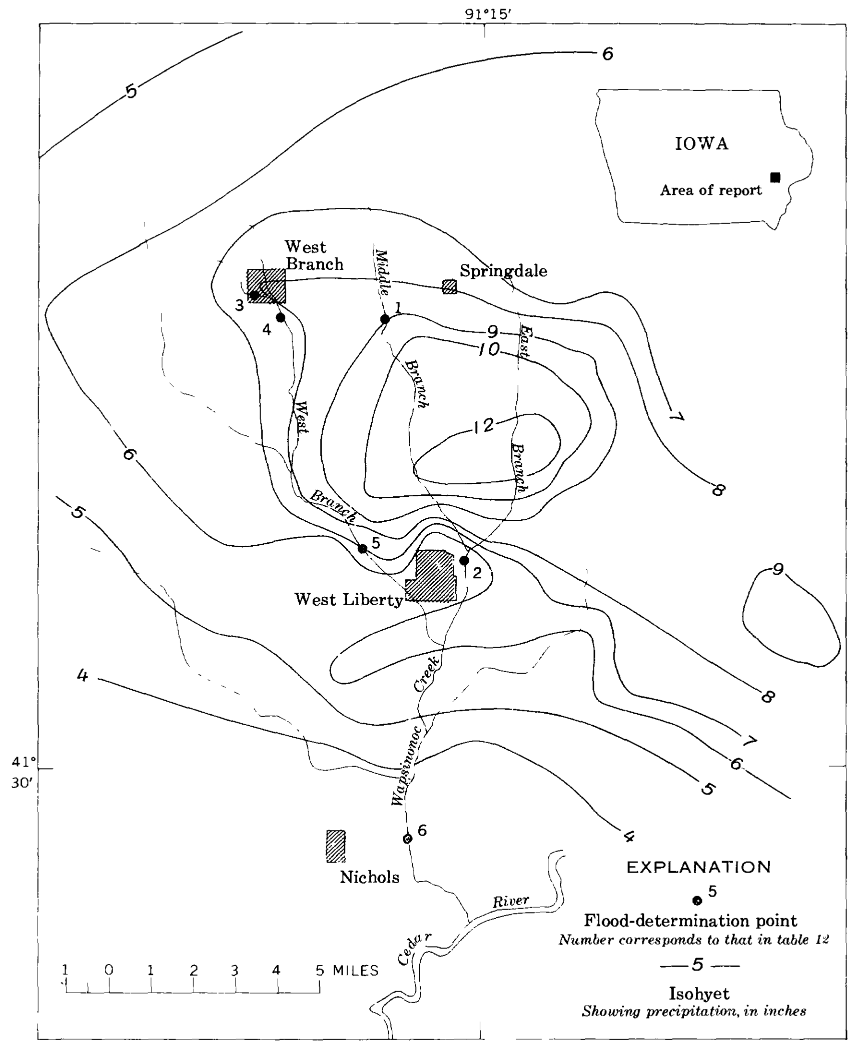

FIGURE 10.—Flood area, location of flood-determination points, and isohyets for June 6–7, floods of June 7, in the Wapsinonoc Creek basin, Iowa.

TABLE 12.—*Flood stages and discharges, June 7, in Wapsinonoc Creek basin, Iowa*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before June 1967				Discharge	
			Period	Year	June 1967	Gage height (feet)	Cfs	Ratio of peak discharge to 50-year flood
1	Middle Branch Wapsinonoc Creek at Interstate 80 near Springdale.	10.5			7		4,330	2.43
2	Wapsinonoc Creek at County bridge east of West Liberty.	45.6			7		18,600	4.09
3	West Branch Wapsinonoc Creek tributary at West Branch.	2.73			7		1,500	1.88
4	West Branch Wapsinonoc Creek at Interstate 80 near West Branch.	7.94			7		3,370	2.11
5	West Branch Wapsinonoc Creek at U.S. Highway 6 near West Liberty.	46.6			7		18,000	3.84
6	Wapsinonoc Creek at State Highway 22 near Nichols.	161			7		27,400	2.76

FLOODS OF JUNE, IN SOUTH-CENTRAL MONTANA

By MELVIN V. JOHNSON and R. J. OMANG

Two major rainstorms occurred in south-central Montana (fig. 11) during the period June 6–15. ESSA Weather Bureau made a bucket survey of precipitation to help define the storm boundaries The first storm on June 6–7 (fig. 12) caused flooding of different intensities in the Musselshell River basin. A second major storm on June 13–15 struck the Musselshell River basin again and also produced heavy precipitation on large areas of the upper Yellowstone River basin. In figure 13 the isohyets show total precipitation for the period June 13–15. Although the isohyets show two major storm areas, the pattern of runoff varied greatly (table 13). Some small basins showed little or no runoff, whereas adjacent basins had record-breaking flows.

The greatest amount of rainfall occurred northeast of Roundup and west of Lavina. The rains of June 6–7 caused many maximum peak discharges of record in the tributary streams and high flood stages on the mainstem Musselshell River. Subsequent precipitation on June 13–15 on the already-saturated ground caused record-breaking flows on much of the mainstem stream and extended the flood duration to about 2 weeks. Several instances of very intense short-duration rains over small areas were noted. An example is Pike Creek (table 13, sta. 17) with a drainage area of 90 sq mi of which only about 20 sq mi contributed to the peak flow of 23,000 cfs.

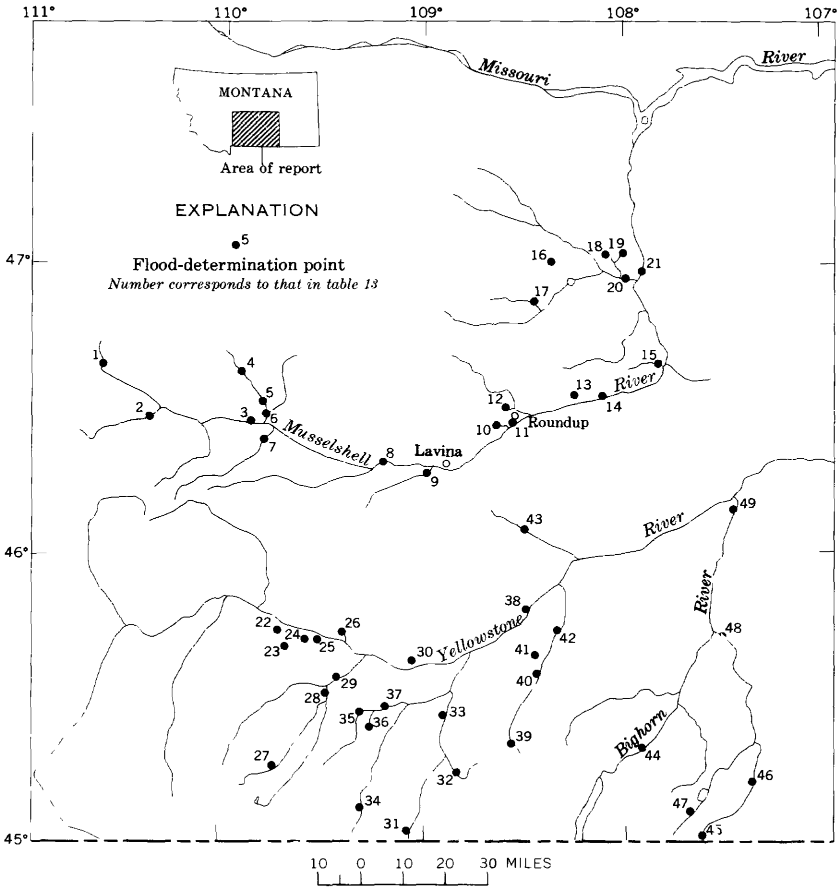

FIGURE 11.—Flood area and location of flood-determination points, floods of June, in south-central Montana.

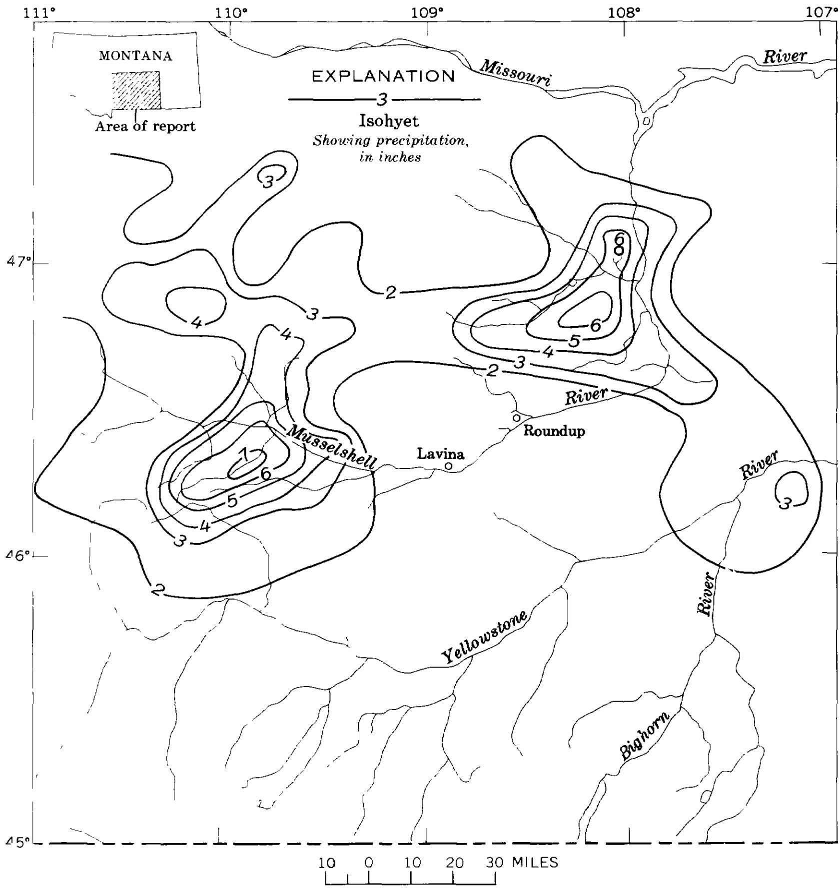

FIGURE 12.—Rainfall, in inches, June 6–7, south-central Montana.

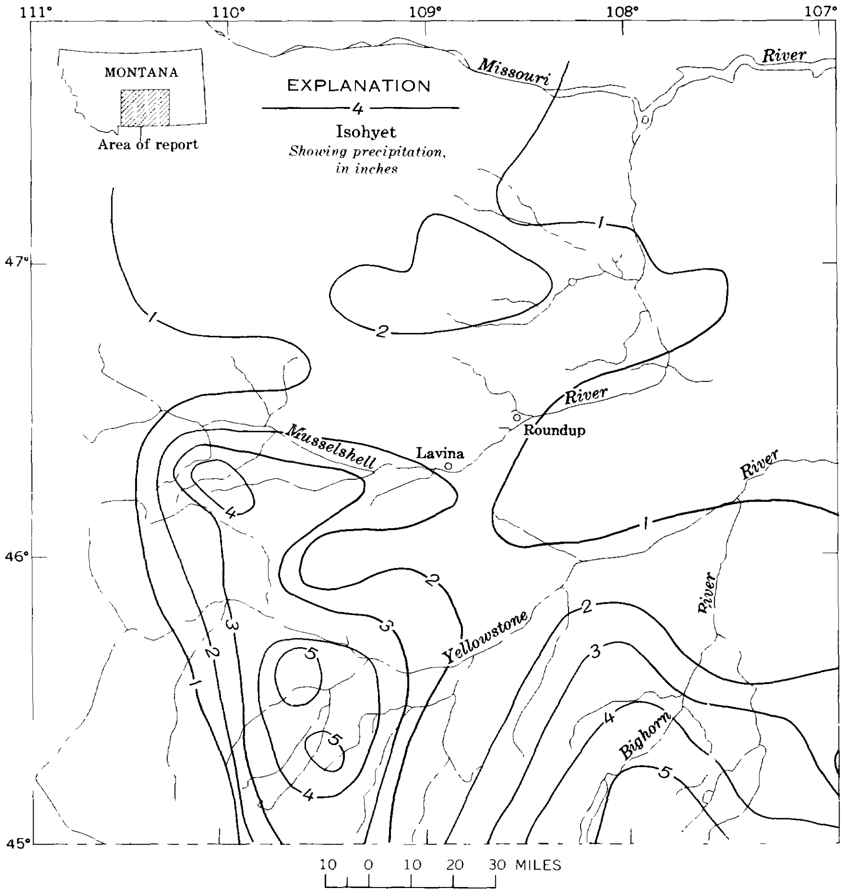

FIGURE 13.—Rainfall, in inches, June 13–15, in south-central Montana.

TABLE 13.—*Flood stages and discharges, June, in south-central Montana.*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before June 1967: Period	Known before June 1967: Year	June 1967	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
	Musselshell River basin							
1	North Fork Musselshell River near Delpine.	31.4	1940–67	1950		4.63	423	
					12	2.26	105	2
2	South Fork Musselshell River above Martinsdale.	287	1942–66	1948		6.56	1,240	
			1942–67	1967		6.19	1,330	
					8	6.12	1,180	5
3	Musselshell River at Harlowton.	1,125	1908–67	1938		[1]8.72	4,530	
					15	7.52	2,880	6
4	Antelope Creek tributary near mouth near Harlowton.	1.92	1956–67	1956		1.60	207	
					June		0	
5	Antelope Creek tributary No. 2 near Harlowton.	21.2	1956–67	1962		5.56	3,230	
					13	1.32	125	2
6	Antelope Creek at Harlowton.	88.7	1950–67	1950		16.73	24,400	
					7	.60	70	<2
7	American Fork below Lebo Creek near Harlowton.	166	1947–67	1948		5.67	956	
					14	5.97	1,570	25
8	Musselshell River near Ryegate.	1,982	1947–67	1948		10.92	6,260	
					16	10.7	9,500	21
9	Big Coulee near Lavina	232	1958–67	1966		4.97	582	
					18	6.88	2,400	17
10	Currant Creek near Roundup.	220	1958–67	1959		6.65	780	
					7	9.75	1,620	8
11	Musselshell River near Roundup.	4,023	1946–67	1948		11.0	7,460	
					18	12.45	9 610	8
12	South Willow Creek tributary near Roundup.	1.38	1962–67	1965		9.90	510	
					7	1.75	45	2
13	Musselshell River tributary near Musselshell.	10.8	1963–67	1965		1.73	150	
					June		0	
14	Musselshell River at Musselshell.	4,568	1929–32, 1946–67	1948		8.5	4 790	
					19	11.57	9 850	8
15	Butts Coulee near Melstone.	5.96	1963–67	1965		3.9	114	
					18	2.60	62	2
16	McDonald Creek at Winnett.	421	1931–45, 1953–67	1964		10.0	1.440	
					16	6.83	890	2
17	Pike Creek near Winnett	90			6		23 000	[2]10.6
18	Gorman Coulee near Cat Creek.	2.32	1955–67	1955		5.59	385	
					7	5.00	328	16
19	Gorman Coulee tributary near Cat Creek.	.81	1955–67	1955		3.02	159	
					7	4.14	230	17
20	Flatwillow Creek near Mosby.	1,855	1964–67	1964		9.82	3 580	
					8	7.08	[3]960	<2
21	Musselshell River at Mosby.	7,846	1929–67	1944		14.43	18 000	
					18	13.57	11.900	7
	Yellowstone River basin							
22	Yellowstone River tributary near Greycliff.	2.72	1960–67	1965		2.31	48	
					14	1.52	32	([4])
23	Bridger Creek near Greycliff.	61.5	1960–67	1964			80	
					14		2,680	[2]2.58
24	Work Creek near Reed Point.	32.5	1959–67	1962		4.08	406	
					14	4.65	720	[2]1.18
25	Hump Creek near Reed Point.	7.61	1960–67	1962		2.96	307	
					27	1.93	130	8
26	Berry Creek near Columbus.	23.5	1958–67	1962		6.62	(4)	
					27	.71	.8	
27	West Rosebud Creek near Roscoe.	52.1	1966–67	1966		1.99	398	
					21	3.50	922	2
28	Rosebud Creek near Absarokee.	394	1935–67	1937		6.36	4,850	
					15	5.28	5,790	50
29	Stillwater River near Abasarokee.	975	1911–14, 1935–67	1948		6.63	10,600	
					15	7.17	12,000	[2]1.05

See footnotes at end of table.

TABLE 13.—*Flood stages and discharges, June, in south-central Montana*—Con.

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before June 1967 — Period	Year	June 1967	Gage height (feet)	Discharge — Cfs	Recurrence interval (years)
	Yellowstone River basin—Continued							
30	Allen Creek near Park City.	7.17	1961–67	1961		5.68	1,580	
					17	2.00	196	45
31	Clarks Fork Yellowstone River at Chance.	1,154	1921–67	1928		[1] 6.5	10,900	
					15	7.90	9,730	4
32	Bluewater Creek near Bridger.	28.1	1960–67	1964		9.92	2,650	
					30	1.42	29	<2
33	Clarks Fork Yellowstone River at Edgar.	2,032	1922–67	1936		8.62	10,900	
					23	8.61	10,600	[2] 1.31
34	Rock Creek near Red Lodge.	124	1932–67	1957		4.78	3,110	
					21	3.96	1,320	25
35	Red Lodge Creek above Cooney Reservoir near Boyd.	143	1937–67	1957		6.56	1,360	
					15	7.00	2,260	[2] 1.33
36	Willow Creek near Boyd	53.3	1937–67	1957		6.66	848	
					15	7.08	1,720	[2] 1.79
37	Red Lodge Creek below Cooney Reservoir near Boyd.	210	1938–67	1957		9.39	[3] 2,900	
					15	10.17	[3] 3,470	[2] 1.60
38	Yellowstone River at Billings.	11,783	1904–05, 1929–67	1944		[1] 12.5	64,800	
					16	10.47	64,000	20
39	Pryor Creek above Pryor	42.6	1921–24, 1967	1924		[1] 2.65	112	
					15	2.88	342	3
40	Wets Creek near Billings	8.14	1955–67	1964		6.9	565	
					6	2.46	149	2
41	West Buckeye Creek near Billings.	1.54	1955–67	1966		3.8	225	
					6	2.69	149	10
42	Pryor Creek near Billings	435	1912–24, 1938–67	1964		15.04	3,720	
					14	4.72	520	<2
43	Crooked Creek near Shepherd.	7.21	1962–67	1962		13.68	5,120	
					11	7.85	1,980	[2] 3.54
44	Bighorn River near St. Xavier.	19,667	1935–67	1935			37,400	
					30		[3] 19,600	([4])
45	Little Bighorn River at State line, near Wyola.	193	1939–67	1944		4.87	2,730	
					6	4.07	1,360	2
46	Little Bighorn River below Pass Creek, near Wyola.	428	1939–67	1963		7.43	3,630	
					15	7.00	2,950	13
47	Lodgegrass Creek above Willow Creek diversion, near Wyola.	80.7	1939–67	1964		6.14	1,130	
					15	5.17	703	6
48	Little Bighorn River near Hardin.	1,294	1953–67	1965			4,520	
					18		4,040	7
49	Bighorn River at Bighorn	22,885	1945–67	1947		[1] 8.79	26,200	
					30	9.15	[3] 19,700	4

[1] At different site or datum.
[2] Ratio of peak discharge to 50-yr flood.
[3] Discharge regulated.
[4] Not determined.

The heaviest precipitation in the upper Yellowstone River area occurred during the period June 13–15. Runoff from rainfall augmented by snowmelt from higher altitudes caused devastating floods on tributary streams. Many bridges were destroyed, and some areas were isolated for nearly 1 week. ESSA Weather Bureau estimated that damage of from $1 to $2 million occurred on streams tributary to the Yellowstone River.

Damage to roads, buildings, and cropland was extensive, partly because of the unusually long duration of flooding. Much of the wide flood plain was inundated for many days, and in some areas the prolonged flooding caused total crop loss. ESSA Weather Bureau estimated that flood losses in the Musselshell River basin would probably be several million dollars. Part of the town of Roundup (population, about 3,000) was covered with flood waters for nearly 2 weeks. The mayor of Roundup estimated that the flood losses amounted to more than $2.5 million in the town and surrounding areas.

FLOODS OF JUNE, IN NEBRASKA

By H. D. Brice

June 1967 was one of the wettest months of record in Nebraska. Every ESSA Weather Bureau station in the State reported above-normal rainfall; at half the stations the total for the month was more than twice normal, and at a few others it was more than three times normal. Runoff from the rains caused many streams to overflow, and in several places extensive flooding occurred.

The first of the flood events for which stage and discharge data were obtained was in the extreme western part of the State. Apparently the storm that caused the flooding was small in area and was centered over the lower part of the Horse Creek drainage basin (fig. 14). According

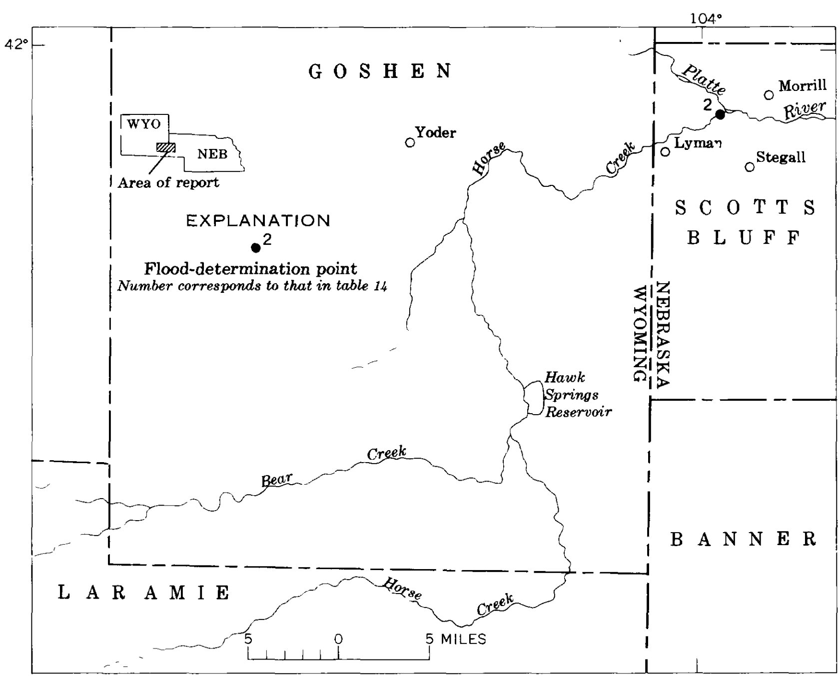

FIGURE 14.—Flood area and location of flood-determination point, flood of June 6, in Horse Creek basin, Nebraska.

to the "Lyman Leader" of June 8, 3½ inches of rain fell on the afternoon of June 6 a few miles west of Stegall, in west-central Scotts Bluff County; during the same storm, 1.34 inches was measured at Lyman. At the gaging station on Horse Creek near Lyman (sta. 2), the peak discharge on June 6 was about 2½ times the previous maximum in a 37-year record at that site (table 14); the recurrence interval is about 50 years. The storm did not extend very far westward into Wyoming, and at Horse Creek near Yoder, Wyo. (about 13 miles upstream from Lyman), the daily discharge on June 6 was 0.7 cfs, and on June 7, only 82 cfs.

Ranchers in the vicinity of Stegall reported that flooding east, south, and west of the town was the most damaging in more than 30 years. Overflow from canals, drains, and natural channels resulted in erosion of, and silt deposition on, cultivated fields and pastures. Deposition of silt in the canals and drains also was destructive.

The other floods in June for which stage and discharge data were obtained occurred in the eastern half of the State during the third week of the month. Each resulted from heavy precipitation on areas

TABLE 14.—*Flood stages and discharges, June, in Nebraska*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before June 1967: Period	Known before June 1967: Year	June 1967	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
	Bow Valley Creek basin							
1	Bow Valley Creek near Fordyce.	52.3			19		3,150	
	Platte River basin							
2	Horse Creek near Lyman	1,570	1931–67	1957		7.28	2,040	
		[1]1,530			6	10.82	5,110	50
3	Wood River near Gibbon	572	1949–67	1960		16.14	2,100	
					15	16.79	4,050	[2]1.24
4	Wood River near Alda	628	1954–67	1960		11.06	1,370	
					16	12.22	1,630	7
5	Elkhorn River near Norfolk.	2,790	1897–1903, 1940–67	1944		[3]11.8	14,300	
		[1]1,790			14	8.52	15,900	15
6	Middle Logan Creek at Laurel.	110			19		6,610	[2]1.06
	Logan Creek:							
7	Near Laurel	25.3			19	14.61	1,280	9
8	At Pender	731	1966–67	1966		21.06	19,000	
					19	22.08	22,100	[2]1.22
9	Near Bancroft	855			19		18,200	42
10	Near Uehling	1,030	1940–67	1940		20.6	22,200	
					15	17.28	12,600	12
	Kansas River basin							
11	Big Blue River at Seward	1,099	1954–67	1957		22.34	15,300	
					16	22.83	14,500	25
12	Big Blue River near Crete	2,716	1945–67	1950		28.74	27,600	
					16	29.80	24,300	25

[1] Area contributing directly to surface runoff.
[2] Ratio of peak discharge to 50-yr flood.
[3] At different site and datum.

where antecedent precipitation had reduced markedly the absorptive capacity of the soil. At several widely separated points, either the peak stage or the peak discharge exceeded the previously observed maximum (table 14).

Precipitation amounts during the period June 3–15 in the Atkinson-Norfolk area, in northeastern Nebraska, ranged from 2.54 to 10.91 inches (fig. 15). Some rain fell each day during the period at the Nor-

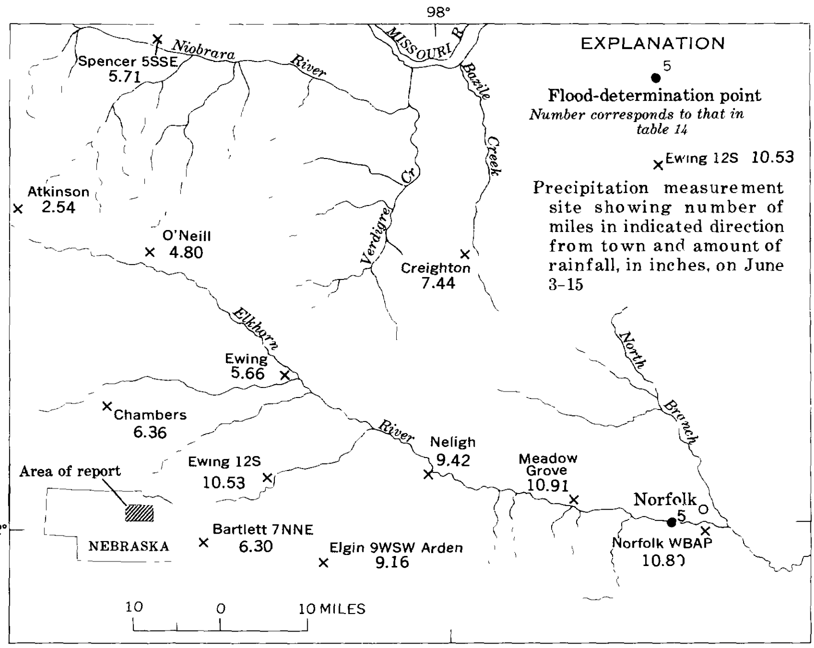

FIGURE 15.—Flood area and location of flood-determination points and precipitation sites, flood of June 14, near Norfolk, Nebr.

folk airport, and the amount falling on June 12–15 was more than one-third the cumulative total.

The peak discharge of Elkhorn River near Norfolk (sta. 5) on June 14 was the largest in the 35-year period of record.

Precipitation, which caused widespread flooding in and around the city of Grand Island, ranged from 8.08 to 13.69 inches in the area during the period May 26 to June 15 (fig. 16). As 16.96 inches fell at Ravenna, a short distance outside the area draining toward Grand Island, it is likely that as much as 15 or 15½ inches fell on part of the area that produced the floodwaters. Graphs of accumulated rainfall at Elm Creek, Gibbon, and Grand Island are shown in figure 17. Virtually all the precipitation prior to June 13 either evaporated or was absorbed by the soil, and the flood-producing rain was that which fell on June 13–15 on the already water-soaked soil.

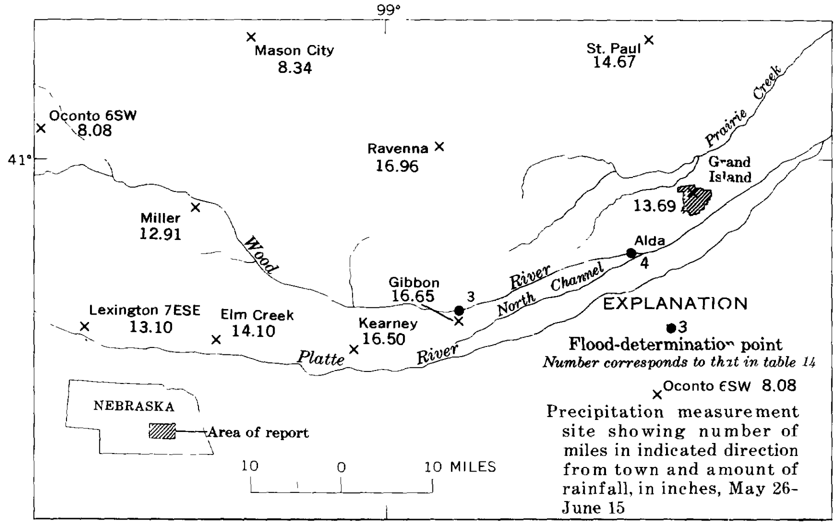

FIGURE 16.—Flood area and location of flood-determination points and precipitation sites, floods of June 15–16, in central Nebraska.

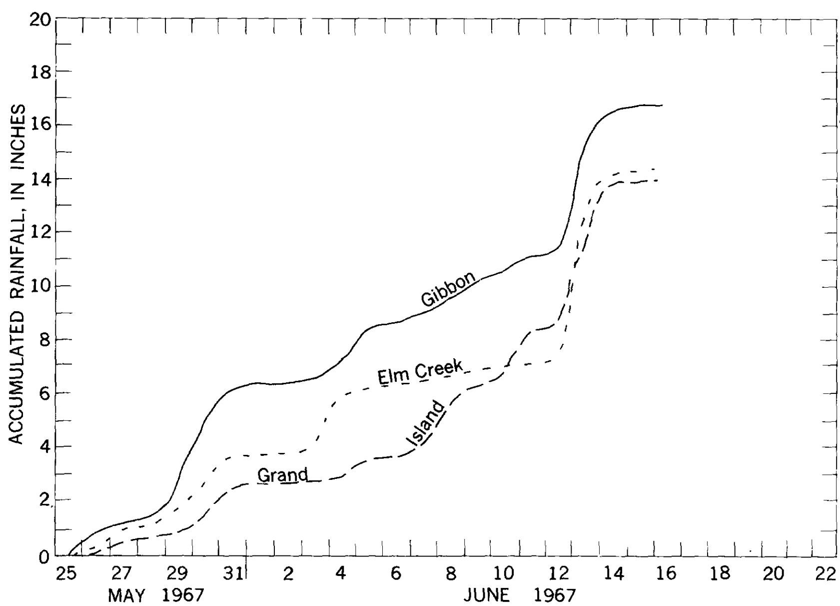

FIGURE 17.—Accumulated rainfall, May 25–June 15, at three precipitation stations in central Nebraska.

Although the greater discharge on Wood River occurred at the upstream station near Gibbon (sta. 3), no flooding occurred at that site. Instead, all the flooding of significance was downstream from the Alda gaging station (sta. 4), and was due largely to inflow from North Channel, which is tributary to Wood River about 2 miles below the gaging station near Alda. Because both North Channel and Wood River below its confluence with North Channel are only shallowly incised into a surface of almost negligible relief, their overflow resulted in widespread flooding of adjacent farmland. South of the city of Grand Island, the floodwaters spilled northward through breaches in the divide between it and Warm Slough, a drainageway whose flow in the Grand Island vicinity is impeded by cross-drainage embankments of roads and railroads and by housing and industrial developments. Local runoff was already causing ponding along Warm Slough before spillage from the overflowing Wood River added to the volume. As a result, widespread flooding occurred in the urbanized area adjacent to, and including, the southernmost part of Grand Island.

At the same time, runoff from the precipitation of June 13–15 on the upper part of the drainage basin of Prairie Creek was swelling the flow of Prairie Creek and its tributaries in that area. Overflow from one of these tributaries inundated part of the Government reservation on which the Cornhusker Ordnance Plant is situated. Because culverts through the embankments for the highway and railroad extending northwestward from northern Grand Island could not transmit all the flow of Prairie Creek and its tributaries, widespread ponding occurred on the south side of the embankments. Before the ponded water topped the highway and railroad, the inundated area increased to include the northernmost part of Grand Island, a section of the city previously free from flooding.

Despite so much water being impounded by the highway and railroad embankments, many square miles of farmland on the downstream side of the embankments also were inundated. The floodwaters there were derived partly from flow through the culverts in the embankments, partly from flow over the embankments, and partly from the rain that fell on the Prairie Creek drainage basin north of the highway and railroad.

The great extent of the flooded areas was due largely to the flatness of the terrain. In most places, the floodwater was less than 3 feet deep, and drained away slowly. Where the soils and subsoils are highly porous, much water infiltrated to the zone of saturation and raised the water table higher than basement floors in many places.

At the height of the flooding in Grand Island, an estimated 5,000 of the 30,000 residents of the city were forced to leave their homes.

Total damage to residential property within the city was estimated at $2,280,000, to commercial property at $560,000, and at $410,000, to municipal property and utilities. Much of the damage to residential property resulted from collapse of basement walls. Crop damage was high because water drained from some fields so slowly. In many places, drainage was slowed because culverts through embankments of section-line roads were clogged with debris.

The previous most serious flood in the Grand Island vicinity was in 1960 and was due to rapid melting of snow. As shown in figure 18, both the peak discharge and the maximum daily mean discharge of the Wood River near Alda (sta. 4) during the 1967 flood were greater than those during the 1960 flood, and the accumulated runoff during the rainfall flood of 1967 was more than four times the runoff during the snowmelt flood of 1960.

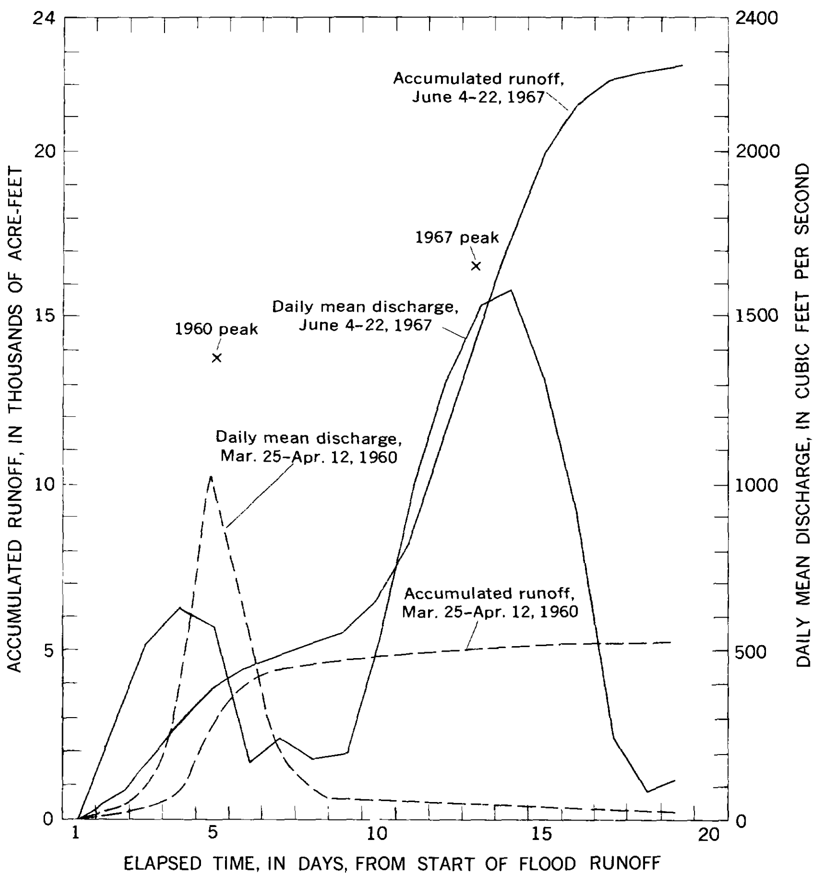

FIGURE 18.—Comparison of daily mean discharge and accumulated runoff, snowmelt flood of March–April 1960 and rainfall flood of June 1967, Wood River near Alda, Nebr.

On June 4–16, widespread heavy precipitation on the Blue River drainage basin caused flooding at several places. Total recorded rainfall ranged from 3.87 inches at Clay Center to 14.15 inches at a station 9 miles west of Osceola (fig. 19).

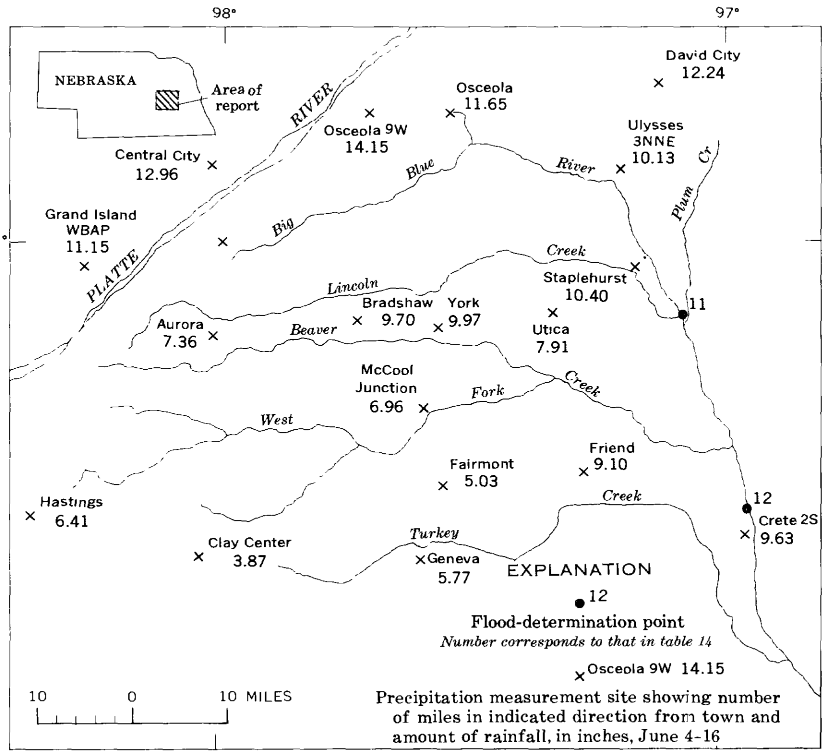

FIGURE 19.—Flood area and location of flood-determination points and precipitation sites, floods of June, in the Blue River basin, Nebraska.

Osceola was especially hard hit on June 14. A tornado, which did considerable damage to the central part of town at 12:30 a.m. was followed by torrential rain that caused Davis Creek, which flows through town, to overflow. No measurements of stage or discharge were made on Davis Creek, but local residents described the flooding as the worst in their memory.

The peak stage of the Big Blue River at both Seward (sta. 11) and Crete (sta. 12) on June 16 was higher than any previously recorded. However, the peak discharge at each site was slightly less than the previous maximum. Several farm families living in threatened areas along the Big Blue River north of Seward had to be evacuated. On June 14, flooding was so widespread and bridge washouts so numerous that 13 sections of Federal and State highways were closed to traffic, and an equal number were under water but open to limited traffic. By June 17, the number of closed sections was reduced to 10.

Rainfall ranged from 5.16 to 10.43 inches on the upper Logan Creek and Bow Creek basins in northeastern Nebraska (fig. 20) during the

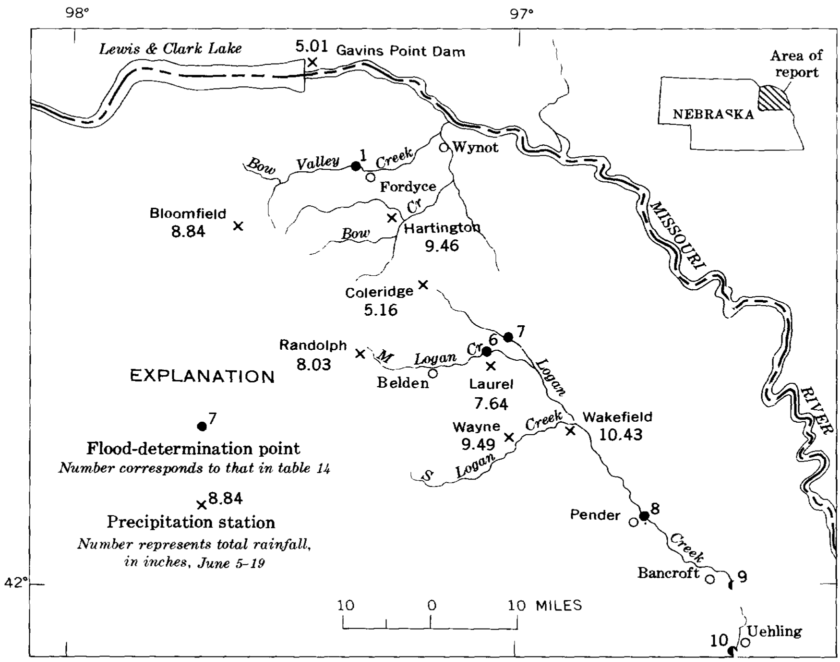

FIGURE 20.—Flood area and location of flood-determination points and precipitation sites, floods of June 19, in northeastern Nebraska.

period June 5–19. Although some rain fell almost every day during that period, the largest amounts fell during the storms of June 5–6, 13–15, and 18–19. The last storm was a torrential downpour on soil that had little capacity remaining to absorb or store moisture.

Some peak discharges in the Logan Creek drainage basin on June 19 were exceptionally great. The peak at Pender (sta. 8) exceeded the maximum discharge measured near Uehling in a 28-year period of record and had a recurrence interval greater than 50 years. The recurrence intervals of the peak discharges near Bancroft (sta. 9) and near Uehling (sta. 10) were 42 and 12 years, respectively. As is obvious from the downstream decrease of the flood crest, the worst flooding was in the upper part of the basin. Farmers living in the vicinities of Randolph, Belden, and Laurel reported that Middle Logan Creek reached its highest stage in 30 years. U.S. Highway 20, which follows Middle Logan Creek, was under 6 inches of water both east and west of Belden.

Farmers living near Fordyce reported that flooding on Bow Valley Creek (sta. 1) was the worst in several years. As a result of bank erosion, the channel width of Bow Creek near Hartington was increased as much as 40 feet at some points, and the approach to the State Highway 12 bridge east of Wynot was washed out. Several other bridges in that vicinity also were damaged.

According to State Civil Defense officials, 61 of the 93 counties in Nebraska sustained flood damages during June 1967. Damage to public property was estimated at $8.5 million, and to private property, at $40.8 million, of which rural losses accounted for $23 million. Federal Government aid for repair or reconstruction of damages to public property amounted to $1.2 million.

FLOOD OF JUNE 21, IN NORTHERN BOISE, IDAHO

By C. A. Thomas

An intense thunderstorm of rain and hail which began near Lake Lowell and traveled in an east-northeast direction to the north end of Boise, Idaho, caused flooding along a segment of the Boise Front, the foothills northeast of Boise (fig. 21), on the afternoon of June 21. Measurements of peak discharges at eight sites are given in table 15.

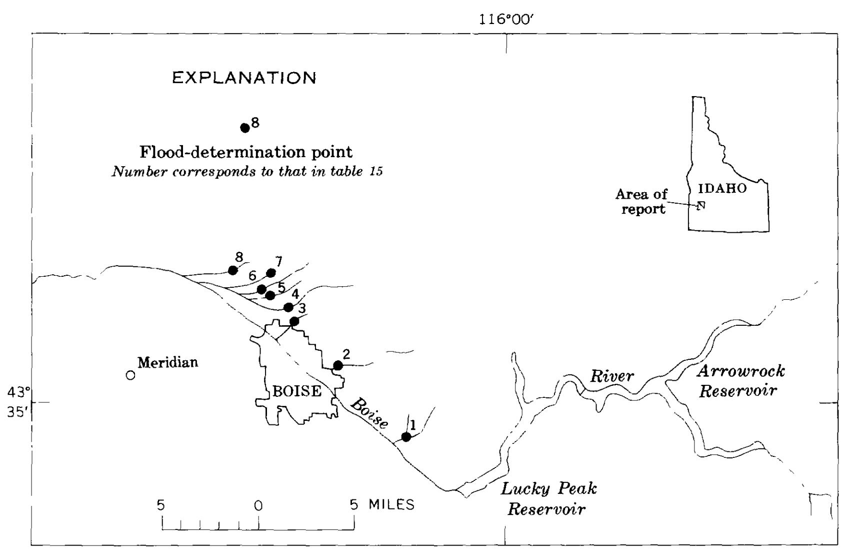

FIGURE 21.—Flood area and location of flood-determination points, flood of June 21, in northern Boise, Idaho.

According to ESSA Weather Bureau, a rain gage on a farm 1 mile west of Meridian caught 2.75 inches of precipitation during the storm. The duration of the storm was reported by observers to be about 12 minutes.

High rates of runoff were confined to the segment of the front between Ussery Street (sta. 3) and Pierce Gulch (sta. 7). Discharge rates were much lower than those during the flood of August 1959 when the flooding occurred in the hills farther southeast. The 1959 storm centered about Maynard Gulch (sta. 1).

Water and sediment from the flood damaged highways and homes. Estimates of total damages from the storm were from $2 to $4 million.

Thunderstorm events in the Boise area are of considerable hydrologic interest. A large section of Boise is vulnerable to flooding from the Boise Front. Local and Federal agencies have planned and recommended dams on the foothill channels to store floodwaters to alleviate flood damage; these flood data assist in evaluating magnitude and frequencies of the thunderstorm floods along the front.

TABLE 15.—*Flood stages and discharges, June 21, in Boise River basin, northern Boise, Idaho*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before June 1967: Period	Known before June 1967: Year	June 1967	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
1	Maynard Gulch at State Highway 21 crossing.	2.25	1959	1959		---	9,540	---
			---	---	21	---	0	---
2	Cottonwood Creek at Boise.	16.0	1939–41, 1959	1959		---	(1)	---
			---	---	21	---	5	---
3	Ussery Street Gulch above Hill Road at Boise.	.06	---	---	21	---	90	---
4	Stuart Gulch above Hill Road at Boise.	9.04	1965	1965		---	412	---
			---	---	21	---	37	---
5	Polecat Gulch at mouth of canyon near Boise.	1.01	---	---	21	---	210	---
6	Unnamed tributary at 5600 Hill Road near Boise.	.25	---	---	21	---	9.8	---
7	Pierce Gulch 1.5 miles upstream from Hill Road near Boise.	1.18	---	---	21	---	34	---
8	Seaman Gulch above Hill Road near Eagle.	1.76	---	---	21	---	12	---

[1] Measured upstream in 2 channels in 1959 as follows: 2,300 cfs in Curlew Gulch and 1,580 cfs in Cottonwood Creek above Curlew Gulch; peak flow at gage unknown.

FLOODS OF JUNE AND JULY, IN NORTH-CENTRAL WYOMING

BY STANLEY A. DRUSE

Floods occurred on many streams in the Wind River and the Bighorn River basins in north-central Wyoming during June and July (fig. 22). A combination of snowmelt runoff, rainfall runoff, and necessary large releases of water from reservoirs produced significant

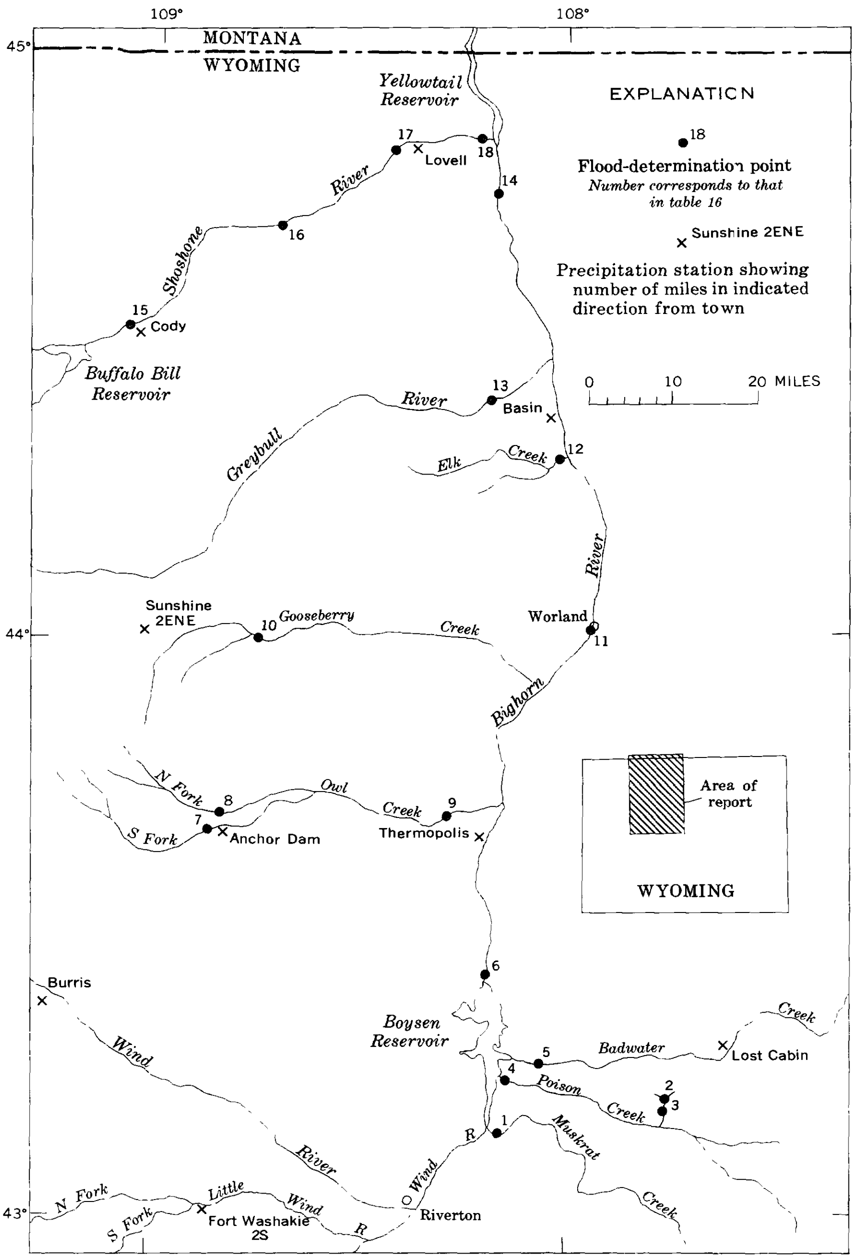

FIGURE 22.—Flood area and location of flood-determination points and precipitation stations, floods of June and July, in north-central Wyoming.

floods on the Wind, Bighorn, and Shoshone Rivers. General rains with locally intense thunderstorms, in two storm periods in June, produced record or near-record floods on many streams tributary to the Wind and Bighorn Rivers. Although only the most noteworthy floods are described and listed in table 16, the great runoff from nearly all streams in the basins resulted in the filling of reservoirs to record or near-record elevations.

Precipitation was reported by most ESSA Weather Bureau stations in north-central Wyoming during the periods June 5–16 and 20–24. Precipitation amounts at selected ESSA Weather Bureau stations during these periods are given in table 17. Although maximum daily amounts were not high, precipitation that fell prior to the higher intensity storms wetted the soil to alloy high rates of runoff throughout the area.

TABLE 16.—*Flood stages and discharges, June and July, in the Bighorn River basin in north-central Wyoming*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before June 1967: Period	Year	June-July 1967	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
1	Muskrat Creek near Shoshoni.	733	1950–58, 1960–67	1962		6.44	13,300	
					June 5	3.50	4,000	6
2	Deadman Gulch near Lysite.	4.11	1965–67	1965		2.48	301	
					June 14	4.34	1,180	([1])
3	Deadman Gulch near Moneta.	4.46	1958–67	1962		22.69	1,330	
					June 14	17.45	975	([1])
4	Poison Creek near Shoshoni.	500	1949–53, 1955–56, 1959–67	1965		5.22	2,650	
					June 5	5.83	2,950	5
5	Badwater Creek at Bonneville.	808	1923, 1947–67	1923		([1])	13,600	
					June 15	5.43	5,460	8
6	Wind River below Boysen Reservoir.	7,701	1951–67.	1951		11.90	11,100	
					July 7	13.35	[2] 13,500	([1])
7	South Fork Owl Creek near Anchor.	87	1940–43, 1959–67	1941		[3] 7.59	1,940	
					June 22	4.62	1,740	20
8	North Fork Owl Creek below Cup Creek near Anchor.	60	1962–67	1963		([1])	1,370	
					June 22	2.55	1,250	12
9	Owl Creek near Thermopolis.	478	1911, 12, 1915–17, 1932, 1938–67	1963		8.73	[2] 7,030	
					June 23	6.50	[2] 1,850	3
10	Gooseberry Creek at Dickie.	95	1958–67	1963		5.66	1,130	
					June 15	4.54	747	4

See footnotes at end of table.

TABLE 16.—*Flood stages and discharges, June and July, in the Bighorn River basin in north-central Wyoming*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before June 1967 — Period	Known before June 1967 — Year	June-July 1967	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
11	Bighorn River at Worland	10,810	1965–67	1965		10.53	[2] 8,750	
					June 23	13.69	[2] 15,900	(1)
12	Elk Creek near Basin	96.9	1959–67	1959		10.45	3,850	
					June 6	10.91	4,260	[4] 2.4
13	Greybull River near Basin [3]	1,115	1930–67	1963		8.83	19,400	
					June 15	7.11	8,700	30
14	Bighorn River at Kane	15,765	1929–67	1935		[5] 11.10	25,200	
					June 24	10.83	[2] 25,000	(1)
15	Shoshone River below Buffalo Bill Reservoir.	1,538	1918, 1921–67	1918		(1)	[2] 18,700	
					July 1	10.02	[2] 11,000	(1)
16	Shoshone River near Garland.	2,036	1958–67	1965		[6] 9.53	[2] 9,850	
					July 1	8.76	[2] 13,300	(1)
17	Shoshone River near Lovell.	2,350			July 1	6.49	[2] 13,400	(1)
18	Shoshone River at Kane	2,989	1958–67	1961		10.34	[2] 13,200	
					July 1	(1)	[7] 12,400	(1)

1 Not determined.
2 Regulated by reservoirs.
3 At site ½ mile upstream at different datum.
4 Ratio of peak discharge to 50-yr flood.
5 At site 12½ miles downstream at different datum.
6 At site 100 ft downstream at different datum.
7 Maximum daily discharge.

TABLE 17.—*Rainfall, in inches, June 5–16 and 20–24, at selected ESSA Weather Bureau stations in north-central Wyoming*

Station	June 5–16: Total	June 5–16: Maximum daily — Day	June 5–16: Maximum daily — Amount	June 20–24: Total	June 20–24: Maximum daily — Day	June 20–24: Maximum daily — Amount	June total
Burris	2.72	14	1.24	1.63	23	0.88	7.15
Fort Washakie 2S	2.81	14	1.32	.92	21	.53	5.15
Lost Cabin	3.02	15	1.02	1.29	23	.80	4.60
Thermopolis	2.99	14	1.45	1.74	23	1.20	5.65
Anchor Dam	3.94	14	1.53	2.00	23	.98	6.58
Sunshine 2ENE	3.70	14	.93	1.15	23	1.15	5.08
Basin	2.96	6	.95	1.17	23	.80	4.56
Cody	2.44	13	.51	.76	23	.51	3.52
Lovell	1.30	7	.40	.94	23	.58	3.29

Rainfall and snowmelt runoff filled Boysen Reservoir to the highest water-surface elevation since the dam was completed in 1951. The combined snowmelt and rainfall runoff peak discharge on the Wind River upstream from Boysen Reservoir was not exceptionally high, but the volume of runoff was above average. High peak discharges, produced by locally intense thunderstorms, occurred on drainage basins of three streams that flow directly into Boysen Reservoir—Muskrat Creek (sta. 1), Poison Creek (stas. 2–4), and Badwater

Creek (sta. 5). The maximum discharge for the period of record occurred at two of the stations; the other sites had peaks that rank near the peak of record. None of these floods caused any serious damage.

The hydrographs of daily mean discharges (fig. 23) for Wind River below Boysen Reservoir (sta. 6) and two downstream stations on the Bighorn River (stas. 11, 14) show that flood peaks on the Wind and Bighorn Rivers below Boysen Reservoir were caused by a combination of large releases of water from the reservoir and by rainfall runoff from tributaries entering below the reservoir. Flood peaks on the

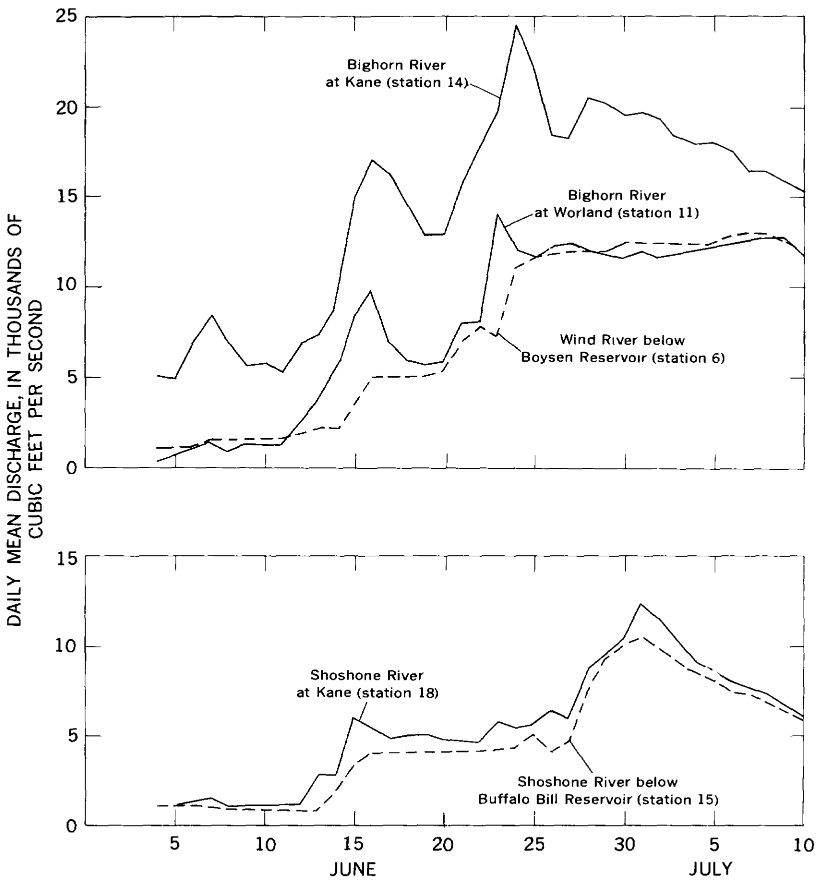

FIGURE 23.—Daily discharge hydrographs for selected stations in the Bighorn River basin, Wyoming.

Shoshone River were caused mainly by the large releases of water from Buffalo Bill Reservoir; this fact is indicated by the hydrograph of daily mean discharges (fig. 23) for Shoshone River below Buffalo Bill Reservoir (sta. 15) and Shoshone River at Kane (sta. 18). The releases from both reservoirs were large in order to maintain space for flood storage from additional rainfall and snowmelt runoff.

The peak discharge of 25,000 cfs at Bighorn River at Kane (sta. 14) nearly equaled the maximum of record (1929–67)—25,200 cfs in 1935. Several streams that flow from the west into the Bighorn River had peak discharges that either approached or exceeded the maximum of record. The flood on Elk Creek (sta. 12) was 2.4 times the theoretical 50-year flood. The contribution of the tributaries to the flood peaks on the Bighorn River is indicated by figure 23.

The large volume of runoff during this storm period in June and July from the Bighorn and Shoshone Rivers is indicated by the recurrence interval of the highest mean discharge for a consecutive period of 30 days during the 1967 water year. The highest mean discharge for a consecutive 30-day period at Bighorn River at Kane (sta. 14), during the 1967 water year, was 17,320 cfs (June 15–July 14). Based on a frequency curve computed from the station record for the period 1952–67, since Boysen Reservoir was constructed, the 1967 high 30-day mean discharge has a recurrence interval of more than 50 years. The 1967 high 30-day mean discharge for Shoshone River at Lovell (sta. 17, period of record, 1966–67) was 6,557 cfs during the period June 15–July 14. Based on a frequency curve for Shoshone River at Byron (period of record, 1929–66, discontinued), the high 30-day mean discharge for Shoshone River at Lovell has a recurrence interval of about 12 years. High-flow records for these two Shoshone River stations should be nearly equivalent.

The floods on the Bighorn and Shoshone Rivers resulted in the filling of Yellowtail Reservoir to an elevation that inundated the U.S. Highway 14 Alternate causeway across the upstream end of the reservoir during the period June 29 to July 19, and it was closed to traffic during the period June 29 to July 22. The water level of the reservoir was allowed to inundate the causeway because downstream tributaries were already at flood stage, and large releases from Yellowtail Reservoir would have increased the flooding and perhaps caused extensive damage. There was little damage to the causeway, but towns in the area suffered financially because all traffic on U.S. Highway 14 Alternate had to be rerouted. The floodflows in the Bighorn Basin also caused considerable damage to railway bridges and irrigation canals.

FLOODS OF JUNE TO SEPTEMBER, IN SOUTHERN NEVADA

By R. D. Lamke

Many small-area high-intensity summer thunderstorms occurred throughout southern Nevada. Widely scattered local flooding occurred on many days from the middle of June through September (table 18). Some flood measurement sites had floods on more than one occasion during the summer. Precipitation data generally were not available within the storm areas, and precipitation data obtained at nearby ESSA Weather Bureau rain gages were not representative of the rainfall from these local storms. The most noteworthy floods during the summer of 1967 are briefly described. Peak discharges were measured at 14 selected sites (fig. 24).

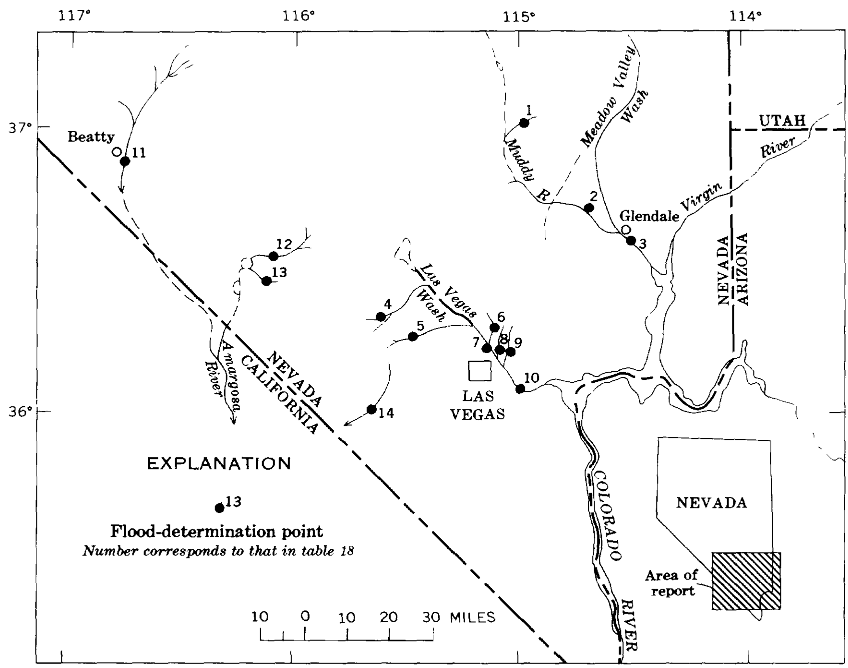

Figure 24.—Flood area and location of flood-determination points, floods of June to September, in southern Nevada.

TABLE 18.—*Flood stages and discharges, June to September, in southern Nevada*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to June 1967 — Period	Prior to June 1967 — Year	June–September 1967	Gage height (feet)	Discharge (cfs)
	Virgin River basin						
1	Muddy River tributary near Alamo	2	1964–67	1966		3.95	10
					Sept. 7	4.76	77
2	Muddy River near Moapa	[1] 3,820	1913–17	1914		9.9	([2])
			1945–67	1960		6.55	1,100
					Sept. 7	12.35	5,100
3	Muddy River near Glendale	[3] 6,780	1950–67	1960		20.36	7,380
					Sept. 8	12.06	1,200
	Las Vegas Wash basin						
4	Lee Canyon near Charleston Park	9.20	1961–67	1966		2.73	201
					July 15	[4] 2.30	560
5	Kyle Canyon near Charleston Park	35.9	1961–67	1966		6.00	1,660
					July 15	2.83	712
					Sept. 4	4.47	1,580
6	Las Vegas Wash tributary near North Las Vegas.	62	1963–67	1963		([2])	160
					June 19	4.70	459
7	Las Vegas Wash at North Las Vegas	([2])	1962–67	1966		2.72	578
					June 19	2.94	720
					Aug. 8	1.02	66
					Sept. 25	3.58	1,170
8	Las Vegas Wash tributary near Nellis Air Force Base.	18.1	1961–67	1965		3.17	100
					June 19	4.42	362
					Aug. 8	4.37	339
					Sept. 25	4.54	351
9	Las Vegas Wash tributary No. 2 near Nellis Air Force base.	50			June 19		355
					Aug. 8		250
					Sept. 25		350
10	Las Vegas Wash near Henderson	[5] 2,125	1957–67	1957		[6] 4.70	1,400
					June 21	5.94	74
					Aug. 10	5.63	64
					Sept. 8	6.82	112
					Sept. 25	5.92	86
	Death Valley						
11	Amargosa River near Beatty	470	1963–67	1964		0.69	25
					Aug. 30	5.86	4,220
12	Amargosa River tributary near Mercury.	110	1963–67	1964		([2])	40
					August	4.07	600
13	Amargosa River tributary near Johnnie.	2.2			July 15	5.68	68
					Sept. 4	7.04	93
	Pahrump and Mesquite Valleys						
14	Lovell Wash near Blue Diamond	52.7	1965–67	1966		6.45	499
					Sept. 4	5.98	559

[1] Contributing area, about 40 sq mi.
[2] Unknown.
[3] Contributing area, about 3,000 sq mi.
[4] Channel excavated prior to flood.
[5] Contributing area, 1,518 sq mi.
[6] At site 2.5 miles downstream; contributing area, 1,571 sq mi.

A flood occurred on June 19 on part of Las Vegas Wash and its tributaries in and near Las Vegas. Many downtown streets were flooded, and a boy was drowned. The ESSA Weather Bureau station at the airport southwest of town recorded 0.75 inch of rain, of which 0.49 inch fell between 10 a.m. and noon. Desert National Wildlife Refuge, about 20 miles northwest of town, had 0.95 inch of rain. Las Vegas Wash at North Las Vegas (sta. 7), a tributary near North Las Vegas (sta. 6), and another tributary near Nellis Air Force Base (sta. 8) had the maximum discharges of their 5–7 years of record. Another storm occurred in the Las Vegas area on August 8, slightly south of the area of the June storm. The August peak discharge was almost as high as the June peaks at two Las Vegas Wash tributaries near Nellis Air Force Base (stas. 8, 9). The same general area was flooded on September 25. The Weather Bureau station at the airport recorded 0.66 inch, of which 0.45 inch fell between 6 and 7 p.m. Peaks comparable to the June floods occurred on the two Las Vegas Wash tributaries near Nellis Air Force Base (stas. 8, 9) and the peak discharge of 1,170 cfs at the gaging station on Las Vegas Wash at North Las Vegas (sta. 7) exceeded the June peak of 720 cfs. The 11-mile channel between the gaging stations on Las Vegas Wash at North Las Vegas (sta. 7) and near Henderson (sta. 10) is wide, flat, and brushy. Flood peaks occurring at the gaging station at North Las Vegas are severely attenuated downstream by channel storage and channel losses. By the time the June, August, and September peaks reached the gaging station near Henderson, about 2 days later, they were only minor rises.

On July 15, a storm occurred on Charleston Peak, about 30 miles northwest of Las Vegas. Lee Canyon (sta. 4) had a peak discharge of 560 cfs from 9.20 square miles, the maximum discharge in 7 years of record. No precipitation stations are within the drainage basin, but 1.6 inches was recorded at the gaging station. Greater amounts probably fell higher in the basin. Peaks occurred also on Kyle Canyon (sta. 5) and a small tributary to Amargosa River (sta. 13). On September 4 another local thunderstorm occurred on Charleston Peak. The peak discharge on Kyle Canyon was almost as great as that on December 6, 1966, and the peak discharge on Lovell Wash (sta. 14) was greater. Lee Canyon had only a minor peak on September 4.

On August 30 a flash flood on Amargosa River near Beatty (sta. 11) had a peak discharge of 4,220 cfs, which was by far the highest during the 5 years of record at the gaging station. Local residents stated that it had been more than 30 years since a comparable flood had occurred. A discharge hydrograph for August 30 and 31 is shown in figure 25. The ESSA Weather Bureau station at Beatty had 0.70 inch of rain, of which 0.64 inch occurred from 2 to 3 p.m. Rainfall north of Beatty probably was greater.

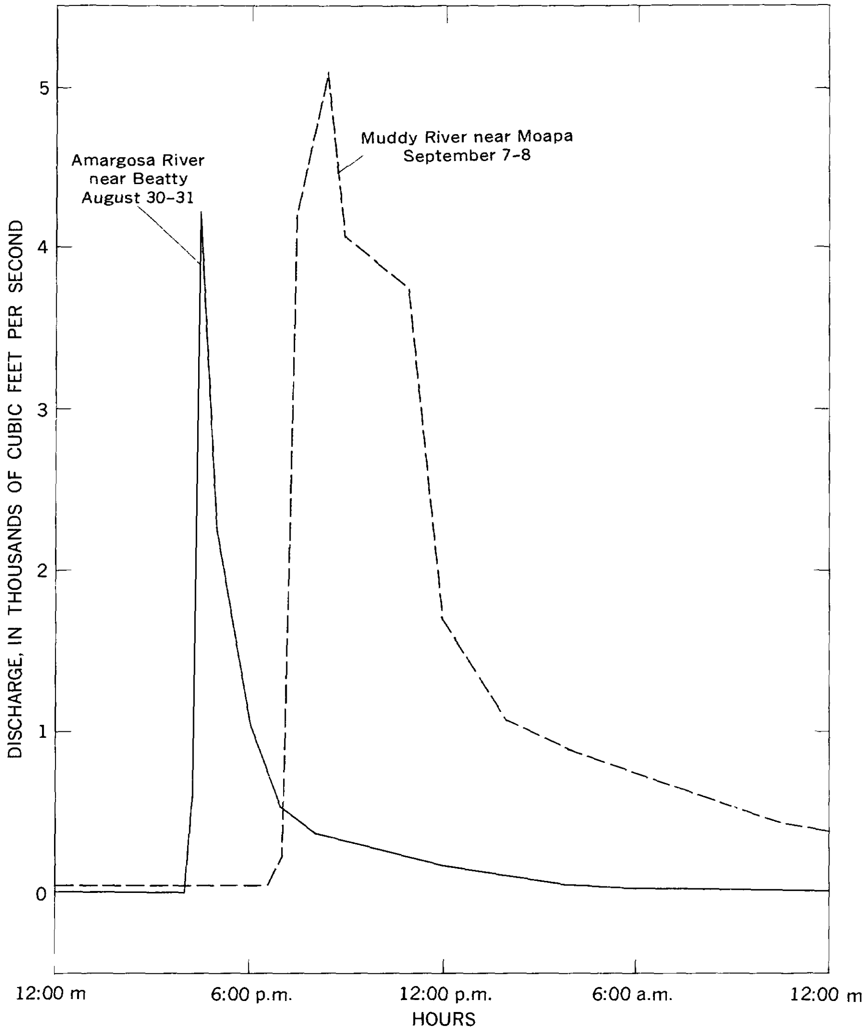

FIGURE 25.—Discharge of Amargosa River near Beatty, Nev., August 30–31, and Muddy River near Moapa, Nev., September 7–8.

A flash flood occurred in the Muddy River basin on September 7. The peak discharge of 5,100 cfs from a drainage area of about 40 square miles was the highest in almost 30 years of record at the gaging station near Moapa (sta. 2). Discharge hydrograph for September 7 and 8 is shown in figure 25. At the gaging station downstream at Glendale (sta. 3), the peak was much smaller because of attenuation and also because Meadow Valley Wash did not flood.

Flood magnitude and frequency relations are not defined for this part of Nevada, and the frequency of these floods is not known. However, the discharges measured near the storm centers probably occur once in 30 years or more.

FLOODS OF JULY, IN THE VICINITY OF OLIVER SPRINGS, TENN.

By Charles R. Gamble

Two intense storms on July 5–7 and 10–11 caused major flooding in the town of Oliver Springs, Tenn. (fig. 26). The town experienced flood conditions from the morning of July 6 to July 12, and was affected for at least 1 week thereafter during emergency repair and cleanup operations.

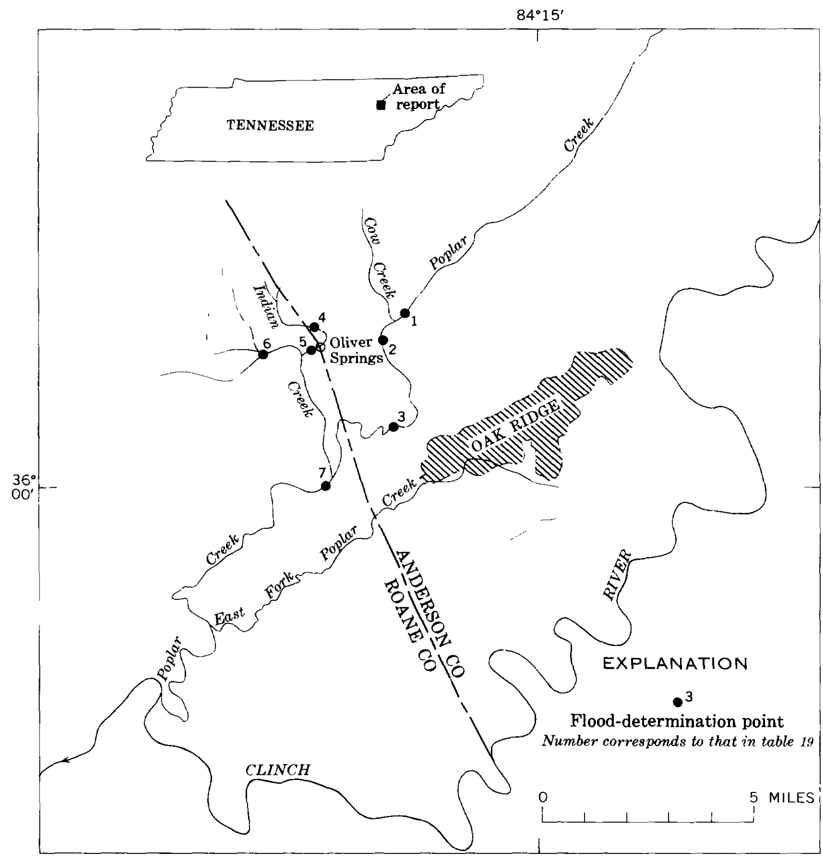

FIGURE 26.—Flood area and location of flood-determination points, floods of July, in the vicinity of Oliver Springs, Tenn.

The storm of July 5–7 produced rainfall ranging from 9.5 to 11 inches in Oliver Springs and at higher altitudes in the headwaters of Indian Creek. The storm of July 10–11 produced additional rainfall ranging from 5.5 inches in Oliver Springs to 9.0 inches in the headwaters of nearby streams.

Most of the streams in the storm area are relatively small headwater streams with steep slopes. Hardest hit was Indian Creek, which flows through the middle of Oliver Springs. The flood of July 11 was the greatest flood on Indian Creek known in this century; it exceeded the record flood of June 1928 by about 1.5 feet. The flood of July 6 was only about 0.8 foot lower than the 1928 flood.

Indirect measurements of peak discharge were made at two crest-stage partial-record stations (stas. 3, 5) and at four miscellaneous sites (stas. 1, 2, 4, 6) (table 19). Station 7 is a complete record station. The most outstanding flood (1,050 cfs per sq mi from an area of 5.82 sq mi) occurred on Indian Creek about half a mile north of Oliver Springs.

Almost the entire town of Oliver Springs was flooded, and more than 80 families were evacuated. Three frame houses and a church were washed off their foundations and destroyed. Numerous other structures were destroyed or heavily damaged by the high water. Damage was estimated at $560,000.

TABLE 19.—*Flood stages and discharges, July, in the Clinch River basin in the vicinity of Oliver Springs, Tenn.*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before July 1967: Period	Known before July 1967: Year	July 1967	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
1	Poplar Creek above Cow Creek near Oliver Springs.	21.8			11		4,400	
2	Poplar Creek below Cow Creek near Oliver Springs.	26.6			11		6,000	
3	Poplar Creek near Oliver Spring.	55.9	1900–67	1928		([1])	[2] 4,000	
					6	18.14	6,430	
4	Indian Creek near Reed School at Oliver Springs.	5.82			11		6,100	
5	Indian Creek at Oliver Springs.	18.4	1962–67	1965		14.35	3,380	
					11	18.85	10,200	
6	Big Mountain Creek near Oliver Springs.	9.35			11		4,510	
7	Poplar Creek near Oak Ridge.	82.5	1960–67	1963		22.38	6,350	
					6	24.24	7,830	

[1] Unknown.
[2] About; from reports by Tennessee Valley Authority.

FLOODS OF JULY 9–12, IN NORTHEASTERN MISSOURI

By L. D. Hauth

Rainfall amounts as much as 9 inches in 5 hours were recorded on July 8–9 in the Salt River basin and the Chariton River basin in northeastern Missouri (fig. 27). The storm moved eastward on the night of

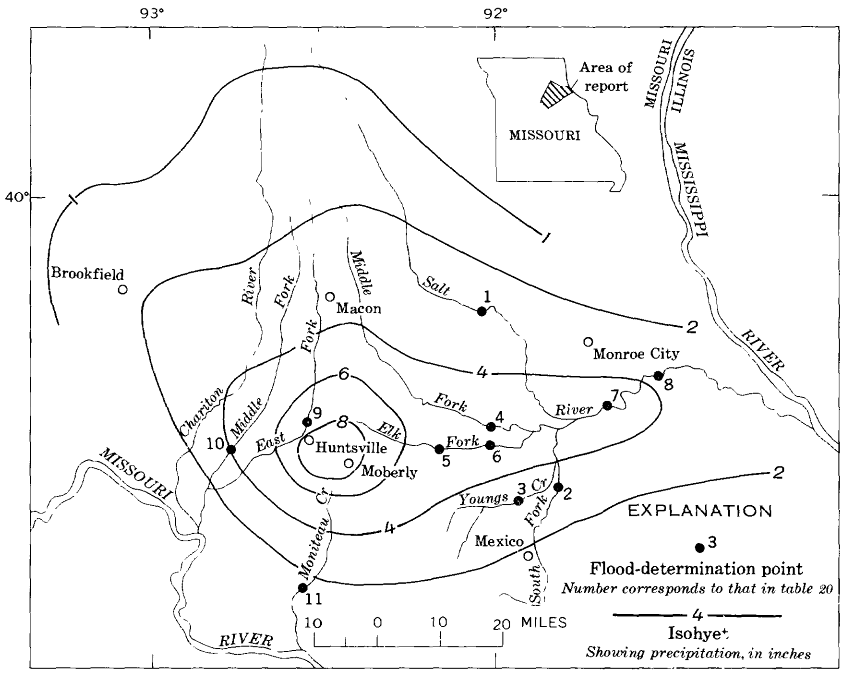

Figure 27.—Flood area, location of flood determination points and isohyets for July 8–9, floods of July 9–12, in northeastern Missouri.

July 8 and early morning of July 9. By about 6 a.m. on July 9, the showers had moved out of the area. The heaviest rainfall amounts were over the city of Moberly, and just south of the small town of Huntsville. The rain was a result of severe thunderstorm activity associated with the passage of a cold front through the Midwest. The soil moisture content in this area was high from showers prior to the flood-producing storm.

The basins most affected by the storm were the East Fork of the Chariton River and the Elk Fork Salt River. A flood profile was made of Elk Fork Salt River in the vicinity of the discontinued gaging station at State Highway 15 near Paris (sta. 6). The flood profile indicated a maximum stage of about 24 feet at the discontinued gage, and the previously determined stage-discharge relationship for this station indicates a discharge of about 29,000 cfs. At a stage of 24 feet, the bridge on State Highway 15 was inundated to a depth of nearly 4 feet. The flood of July 31, 1958, reached a stage of 21.03 feet and a discharge of 22,300 cfs at this station (table 20).

TABLE 20.—*Flood stages and discharges, July 9–12, in northeastern Missouri*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before August 1967 — Period	Known before August 1967 — Year	August 1967	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
	Salt River basin							
1	Salt River near Shelbina	481	1930–67	1947		27.4	23,000	
					10	8.45	1,690	
2	South Fork Salt River at Santa Fe.	298	1940–67	1944		21.10	13,100	
					9	13.90	5,750	<2
3	Youngs Creek near Mexico	67.4	1930–67	1958		16.52	6,530	
					9	14.85	4,780	10
4	Middle Fork Salt River at Paris.	356	1940–67	1958		29.94	23,100	
					10	19.29	8,050	8
5	Elk Fork Salt River near Madison.	200			9		33,300	>50
6	Elk Fork Salt River near Paris.	262	1928–67	1958		21.03	22,300	
					9	23.97	29,000	>50
7	Salt River near Monroe City.	2,230	1928	1928		36	(1)	
			1940–67	1958		34.81	71,100	
					11	29.02	41,800	6
8	Salt River near New London.	2,480	1922–67	1958		29.92	64,700	
					12	25.28	3[illegible] 100	4
	Chariton River basin							
9	East Fork Chariton River near Huntsville.	220	1963–67	1966		17.09	3,980	
					10	19.8	19,200	50
10	Middle Fork Chariton River below Salisbury.	201	1965–67	1966		17.20	4,550	
					10	16.05	2,440	<2
	Moniteau Creek basin							
11	Moniteau Creek near Fayette.	81	1944–67	1944		22.9	(1)	
			1948–67	1961		19.6	4,330	
					9	16.74	1,900	2

[1] Unknown.

An indirect measurement of flow (contracted-opening) was made about 18 miles upstream on Elk Fork Salt River near Madison (sta. 5). The discharge at this site was 33,300 cfs. The peak stage of 19.8 feet on East Fork Chariton River near Huntsville (sta. 9) was the maximum stage for the period of record (1963–67). A discharge of 19,200 cfs was determined by slope-area method at this site. The peak discharge at each of the two sites was greater than a 50-year flood. Local residents indicated that the Elk Fork Salt River had not been this high since 1871. The unit discharges for Elk Fork Salt River near Madison and East Fork Chariton River near Huntsville were 166 and 87 cfs per sq mi, respectively, which are comparable to other outstanding floods in Missouri.

Business establishments, homes, and utilities in Moberly were flooded, according to the "St. Louis Post Dispatch." An engineering firm from Kansas City estimated the total damage in Moberly to be as much as $1 million. The firm's report showed damages to streets and bridges to be $66,000; to drainage facilities, dikes, and levees, $22,000; and to public utilities, $27,000. Damage to residences and business firms were not released. Damage to one bridge leading to the city reservoir was estimated at $33,000. Extensive crop damage occurred in both basins.

FLOODS OF AUGUST, IN EAST-CENTRAL ALASKA

From J. M. CHILDERS, J. P. MECKEL, and G. S. ANDERSON (1971)

East-central Alaska had record floods near Fairbanks (fig. 28) following extensive rains of August 8–17. Precipitation during this period totaled as much as 10 inches, which is close to the average annual precipitation for this area.

The most extensive flooding occurred in the White Mountains northeast of Fairbanks and along the major streams draining those mountains. Some of the major streams flooded were the Salcha, Chena, Chatanika, Tolovana, and lower Tanana Rivers, and Birch Creek west of Circle.

Peak discharges on some streams in the flood area were from two to four times the probable 50-year flood. The peak discharge of 74,400 cfs on the Chena River at Fairbanks was from 1,980 square miles of drainage area and was 2.6 times the 50-year flood.

Ground-water levels in the Tanana River flood plain rose to the land surface during the flood causing foundation failures and contamination of shallow wells and prevented drainage of subsurface structures. Ground-water levels remained above normal until the middle of September.

Total flood damage was estimated to have been more than $85 million. Six lives were reported lost, and more than 7,000 persons were evacuated during the flood.

A report by Childers, Meckel, and Anderson (1971) furnishes hydrologic data for development planning. It discusses antecedent streamflow, meteorology of the storm, and flood frequency; describes floods, inundated areas, flood profiles, flood damage, ground-water conditions, and stages and discharges of major streams for August 1967. The report gives data for 53 sites some of which are gaging

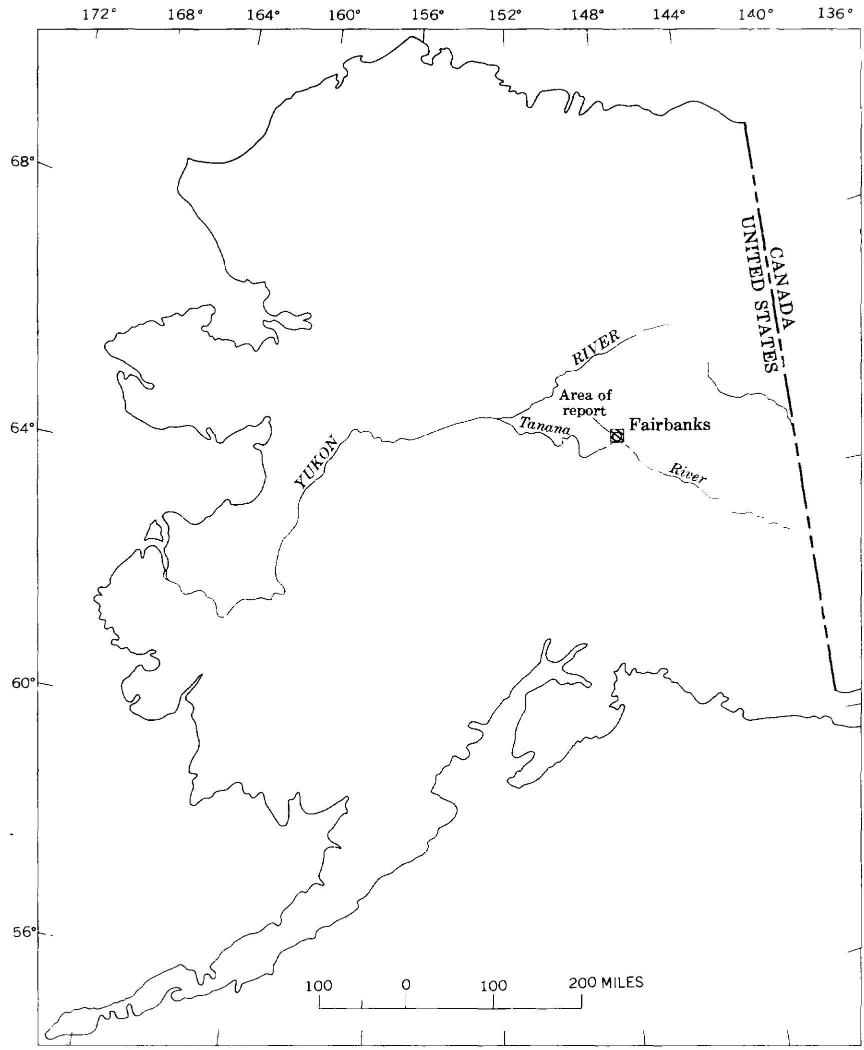

FIGURE 28.—Location of flood area, floods of August, in east-central Alaska.

stations and some are miscellaneous measuring sites. A table of precipitation data from the ESSA Weather Bureau records, groundwater observation well recession data for 41 wells at Fairbanks and Nenana, and selected well description data and water-quality data are in the report.

A Hydrologic Investigations Atlas (Childers and Meckel, 1967) has been published which delineates the boundary of the flooded area in Fairbanks.

FLOODS OF AUGUST 11–13, IN EASTERN ARIZONA AND WESTERN NEW MEXICO

By Alberto Condes de la Torre

Intense rainfall on August 11–12 caused flooding in the upstream part of Gila River basin (fig. 29). On August 11, a stationary front

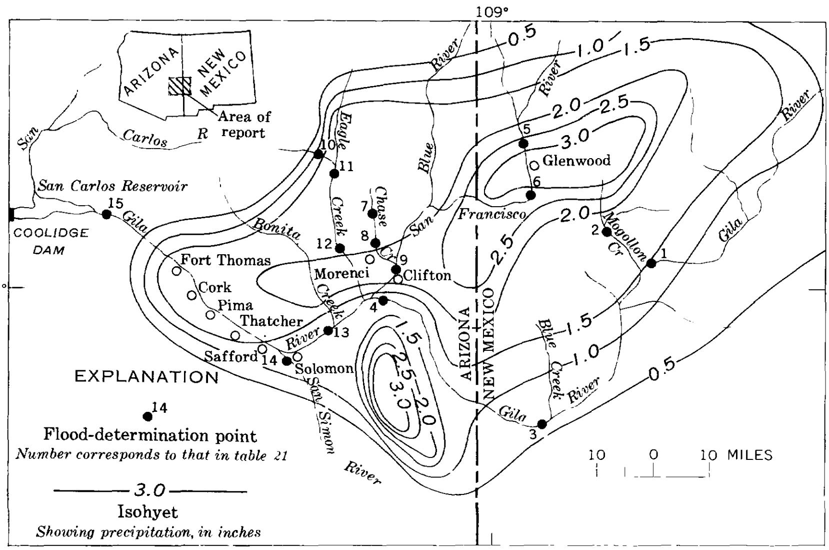

Figure 29.—Flood area, location of flood-determination points, and isohyets for August 11–12, floods of August 11–13, in eastern Arizona and western New Mexico.

that curved southeastward from western New Mexico to the Gulf of Mexico began to move eastward, which allowed additional moist air to move in from the gulf. Large amounts of rain fell as the front moved over the mountains along the Arizona-New Mexico State line. The maximum storm rainfall officially recorded was 3.34 inches at Glenwood, N. Mex. More rain may have fallen in mountainous areas where data were not available.

In the Gila River valley, extensive damage was done to personal property, crops, roads, and bridges. The flood inundated 3,050 acres of land, killed livestock, and damaged crops and farm machinery. Most of the inundated land was under cultivation for the first time since the flood of December 1965. All the Gila River roadcrossings between the San Francisco River and U.S. Highway 70 were closed because of the flood. Bridges at Pima and Safford suffered only minor damage and were reopened on August 13. New bridge approaches at Solomon, Thatcher, and Cork and grade-level crossings at Sanchez and Fort Thomas were washed out and remained closed for some time. Four families were evacuated from the riverside community of Little Hollywood, 1 mile east of Safford, six families in Pima left their homes, and others on farms north and east of Safford were forced to move because of the rising water.

The U.S. Geological Survey's Gila River Phreatophyte Project is in the Gila River flood plain between U.S. Highway 70 and the San Carlos Reservoir. The flood caused considerable erosion and deposition in this reach. A ground-water observation well equipped with a water-level recorder was lost, and the streamflow gaging station at Calva (sta. 15) was damaged beyond repair. The U.S. Bureau of Indian Affairs was constructing a new channel for the Gila River at the upper end of San Carlos Reservoir. The flood filled the channel with debris, and the cost of cleaning the channel was estimated to be $15,000.

The storm caused moderate to extreme amounts of runoff in Mogollon Creek, in tributaries to the Gila River between the Arizona-New Mexico State line and the San Francisco River, and in the lower reaches of the San Francisco River, Eagle and Bonita Creeks, and the San Simon River. Gila River near Clifton, Ariz. (sta. 4) had a peak discharge of 11,100 cfs at 2 a.m. on August 12. This peak was caused by tributary inflow near the gage. As flow from farther upstream on the Gila River passed the gage, a secondary peak was recorded. Because of the storm pattern, peaks at stations upstream on the Gila River occurred progressively later than those at the gage near Clifton. The peak discharge below Blue Creek near Virden, N. Mex. (sta. 3), occurred at 5:30 a.m. on August 12, and the peak near Gila, N. Mex. (sta. 1), occurred at 5 a.m. on August 13.

San Francisco River at Clifton (sta. 9) had a peak discharge of 34,700 cfs at 5:30 a.m. on August 12. This peak was caused by the large inflows from the Blue River and other tributaries which empty into San Francisco River just above the station at Clifton. The peak of San Francisco River near Alma, N. Mex. (sta. 5), occurred at 1 p.m. on August 12 (discharge, 6,230 cfs), when the storm was moving upstream.

North of Morenci, Chase Creek (sta. 8) had the highest peak discharge measured in recent years—2,930 cfs from a 11.9-sq-mi drainage area (table 21). Chase Creek did not contribute appreciably to the flooding at Clifton, because the water ponded behind large mine dumps about 2 miles north of Morenci; however, even without the ponding, the flow through Clifton probably would not have equaled that of December 1906, when a dam broke at Morenci and a discharge of 17,660 cfs occurred from a drainage area of 28 sq mi (Olmstead, 1919).

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TABLE 21.—*Flood stages and discharges, August 11–13, in the Gila River basin in eastern Arizona and western New Mexico*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before August 1967: Period	Known before August 1967: Year	August 1967	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
1	Gila River near Gila, N. Mex.	1,864	1928–67	1941		17.2	25,400	
					13	8.14	5,210	4
2	Mogollon Creek near Cliff, N. Mex.	69			12	14.5	10,800	[1] 3.53
3	Gila River below Blue Creek, near Virden, N. Mex.	3,203	1927–67	1941		25.78	41,700	
					12	17.7	11,500	6
4	Gila River near Clifton, Ariz.	4,010	1881–1967	1941		[2] 20.12	28,200	
					12	15.1	11,100	6
5	San Francisco River near Alma, N. Mex.	1,546	1904–14, 1964–6	1905		[2] 14	25,000	
					12	7.24	6,230	10
6	San Francisco River near Glenwood, N. Mex.	1,653	1928–67	1965		11.00	8,200	
					12	([3])	[4] 8,000	15
7	Chase Creek near Clifton, Ariz.	1.37	1963–67	1964		13.9	600	
					12	12.5	400	([3])
8	Chase Creek 2½ miles north of Morenci, Ariz.	11.9			12		2,930	2.9
9	San Francisco River at Clifton, Ariz.	2,766	[5] 1880–1967	1906		([3])	143,450	
			1927–67	1965		11.00	30,500	
					12	11.8	34,700	18
10	Willow Creek near Double Circle Ranch, near Morenci, Ariz.	149	1944–67	1965		9.00	7,500	
					12	2.64	76.2	<2
11	Eagle Creek near Double Circle Ranch, near Morenci, Ariz.	377	1944–67	1965		9.20	13,600	
					11	7.50	6,000	9
12	Eagle Creek above pumping plant, near Morenci, Ariz.	613	1917–67	1965		12.8	21,000	
					12	9.10	7,650	7
13	Gila River at head of Safford Valley, near Solomon, Ariz.	7,896	1914–67	1916		[2] 14.0	100 000	
					12	13.3	34 800	10
14	San Simon River near Solomon, Ariz.	2,192	[6] 1885–1967	1931		19.0	27,500	
					12	18.1	5 570	3
15	Gila River at Calva, Ariz.	11,470	1906–67	1916			[4] 100 000	
			1930–67	1965		15.5	39 000	
					13	16.0	40 000	17

[1] Ratio of peak discharge to 50-yr flood.
[2] Datum then in use.
[3] Not determined.
[4] Estimated.
[5] From Olmstead (1919).
[6] Approximate period from studies by Olmstead (1919) and Moosburner (written commun., 1967).

By 9:30 a.m. on August 12, the Gila River flood crest (34,800 cfs) had reached the head of Safford Valley near Solomon, Ariz. (sta. 13). The flood exceeded the capacity of the main channel of the Gila River, and water spread onto the flood plain. The flood crest reached U.S. Highway 70 above San Carlos Reservoir at 7:15 a.m. on August 13; the peak discharge at this point was 40,400 cfs. Storage in San Carlos Reservoir increased 65,900 acre-feet between midnight on August 12 and midnight on August 17; during this period, 4,534 acre-feet of water was released below Coolidge Dam. The momentary maximum discharges of the Gila and San Francisco Rivers for the floods of

August 11–13 are relatively close to the maximum peak discharges for the floods of December 1965, when some of the highest peaks of record were measured (table 21).

The San Francisco River flooded about three blocks in Clifton, and the residents were evacuated. Some business establishments were flooded by water that backed up through a storm drain; however, damage was slight. Several small farms and ranches along the San Francisco River north of Clifton received a small amount of damage. Much of a new highway being built along the river was washed out.

The flood on Chase Creek washed out sections of U.S. Highway 666, which remained closed for about 1 week. About 30 persons were marooned for 2 days at picnic areas along Chase Creek.

In the Gila River valley, extensive damage was done to personal property, crops, roads, and bridges. The flood inundated 3,050 acres of land, killed livestock, and damaged crops and farm machinery. Most of the inundated land was under cultivation for the first time since the flood of December 1965. All the Gila River roadcrossings between the San Francisco River and U.S. Highway 70 were closed because of the flood. Bridges at Pima and Safford suffered only minor damage and were reopened on August 13. New bridge approaches at Solomon, Thatcher, and Cork and grade-level crossings at Sanchez and Fort Thomas were washed out and remained closed for some time. Four families were evacuated from the riverside community of Little Hollywod, 1 mile east of Safford, six families in Pima left their homes, and others on farms north and east of Safford were forced to move because of the rising water.

The U.S. Geological Survey's Gila River Phreatophyte Project is in the Gila River flood plain between U.S. Highway 70 and the San Carlos Reservoir. The flood caused considerable erosion and deposition in this reach. A ground-water observation well equipped with a water-level recorder was lost, and the streamflow gaging station at Calva (sta. 15) was damaged beyond repair. The U.S. Bureau of Indian Affairs was constructing a new channel for the Gila River at the upper end of San Carlos Reservoir. The flood filled the channel with debris, and the cost of cleaning the channel was estimated to be $15,000.

The total damage to public, commercial, residential, and rural property was estimated to be $889,000 in Graham County, and $40,200 in Greenlee County (table 22). In New Mexico, a gaging station that was established on Mogollon Creek in May 1967 was destroyed by the flood. The flood did little damage elsewhere in New Mexico.

TABLE 22.—*Damage from floods of August 11–13, in eastern Arizona*

Type of property		Damage
Graham County:		
County roads		$55,000
Private commercial property		4,000
Residential property		26,000
Agricultural loss:		
Inundated land and crops	$628,750	
Crops in storage	5,000	
Livestock	750	
Buildings, fences and other farm property	18,000	
Farm machinery	42,000	
Total agricultural loss		694,500
Public utilities		1,000
U.S. Geological Survey Phreatophyte Project		15,000
Loss of income		90,000
Emergency protection		3,500
Total damage in Graham County		889,000
Greenlee County:		
U.S. Highway 666		40,000
Public utilities		200
Total damage in Greenlee County		40,200
Total flood damage in Arizona		929,200

FLOODS OF AUGUST 18, NEAR APACHE LAKE, ARIZ.

By H. W. HJALMARSON

On the evening of August 18, a high-intensity thunderstorm caused flash flooding in Crabtree and Davis Washes, other small tributaries to Apache Lake, and tributaries to Canyon Lake (fig. 30). The flood in Crabtree Wash reportedly occurred in two waves, the second of which was about 6 feet high. Several persons who were camping and picnicking at the mouth of the wash prior to the flood were swept into Apache Lake—3 were drowned, and 16 were injured. Three cars were washed into the lake, eight other vehicles were inundated, and a large amount of camping gear was destroyed.

The storm centered on the divide between Lewis and Pranty Creek and Crabtree Wash. According to a local newspaper, precipitation in the upper part of the Crabtree Wash basin was from 4 to 5 inches in a 1-hour period, which is greatly in excess of the 2¾ inches given by the U.S. Weather Bureau (1961) for a 1-hour storm of a 100-year recurrence interval. Hail was ankle deep in places.

In the area of maximum runoff and along the main stem of Crabtree Wash, no suitable sites were found for making indirect measure-

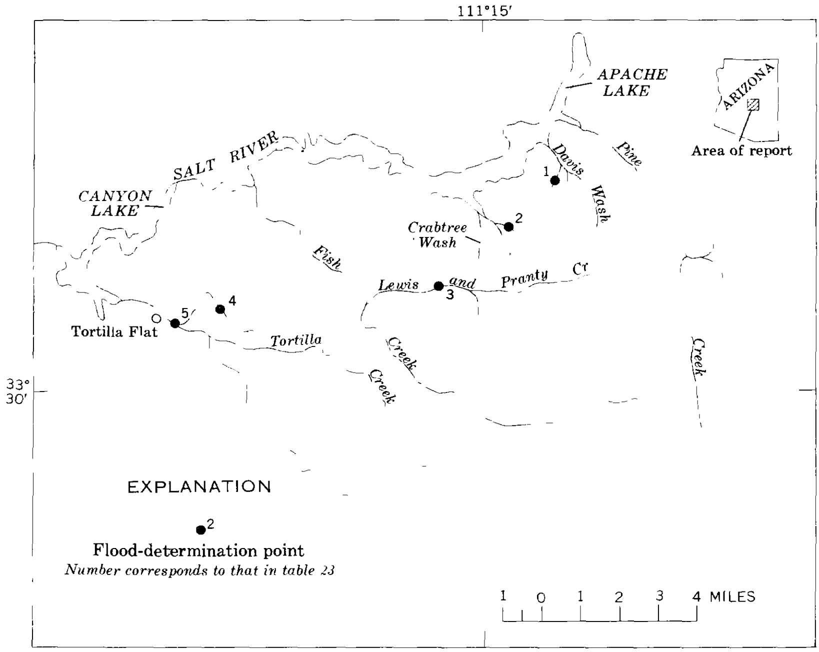

FIGURE 30.—Flood area and location of flood-determination points, flood of August 18, near Apache Lake, Ariz.

ments; therefore, an estimate of the peak discharge at the mouth of Crabtree Wash was based on the channel geometry. The discharge from the 2.46-square-mile drainage areas was estimated as 4,000–5,000 cfs, and the unit discharge was about 1,800 cfs per sq mi. In about a third of the basin, peak discharges were less than 900 cfs per sq mi; therefore the unit runoff from the western two-thirds of the basin was probably 2,000–2,500 cfs per sq mi, which may be the highest runoff reported in Arizona for a drainage area of this size. The magnitude and frequency relations for floods in this area have been defined only for drainage areas of more than 30 square miles (Patterson and Somers, 1966); but, by relating the discharge of the small area to the curves for the defined areas, a recurrence interval of considerably more than 50 years is indicated.

As determined by a slope-area measurement, the peak discharge from the upper 13.4 square miles of the Lewis and Pranty Creek basin (sta. 3) was 3,310 cfs (table 23). According to personnel of the local highway maintenance shop, the flow originated in an area estimated to be only 4 square miles. The unit discharge from the storm area was about 800 cfs per sq mi.

TABLE 23.—*Flood stages and discharges, August 18, near Apache Lake, Ariz.*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before August 1967 — Period	Known before August 1967 — Year	August 1967	Gage height (feet)	Discharge — Cfs	Discharge — Cfs per sq mi
1	Davis Wash tributary at State Highway 88 near Roosevelt.	0.09	------	------	18	------	55	610
2	Crabtree Wash tributary at State Highway 88 near Roosevelt.	.26	------	------	18	------	221	850
3	Lewis and Pranty Creek below Mud Spring Canyon near Tortilla Flat.	13.4 [1]4	------	------	18	------	3,310	247
4	Mesquite Creek near Mormon Flat Dam.	4.26	1963–66	1966	------	23.90	4,360	------
					18	9.4	1,250	292
5	Tortilla Creek at Tortilla Flat	24.3	1941–66	1966	------	9.3	6,660	------
					18	6.8	975	40

[1] Estimated area from which flood originated.

The water-surface elevation of Apache Lake rose 0.45 foot between 7 and 9 p.m. on August 19, which represents an increase of 1,200 acre-feet. Most of the increase was the result of discharge from Crabtree Wash and Davis Wash and of direct rainfall on the lake. The peak discharge from Davis Wash was not so great as that from Crabtree Wash; the peak in Davis Wash was estimated to be 2,000–3,000 cfs from a 4.3-sq-mi drainage area. Pine Creek, which is east of Davis Wash, had a very low peak discharge.

Some flooding occurred in other places between Apache Lake and Tortilla Flat. The highway was closed at Tortilla Flat, and a heavy-duty tire-service truck valued at $17,000 was demolished when it was washed off the highway near Canyon Lake.

FLOODS OF AUGUST, IN MARYLAND AND DELAWARE

From D. H. CARPENTER and R. H. SIMMONS (1969)

Precipitation was unusually heavy throughout the month of August in Maryland and Delaware (fig. 31). It was the wettest month for much of the two-State area since August 1955, which was, in turn, the wettest month on record for Maryland and the second wettest for Delaware. The August 1967 total precipitation of 19.08 inches at Denton, Md., was only slightly less than the greatest monthly total ever recorded at an official ESSA Weather Bureau station in Maryland, 20.35 inches at Leonardtown in August 1945. The August 1967 total of 17.69 inches at Bridgeville, Del., set a new record for total monthly precipitation at any official station in Delaware. The previous maximum was 16.08 inches at Dover in August 1939.

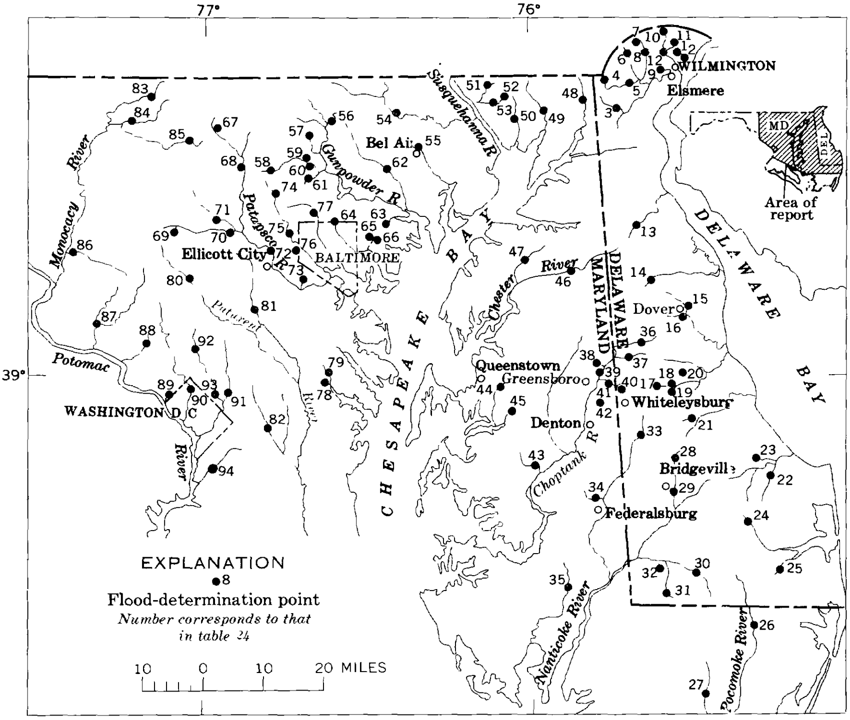

FIGURE 31.—Flood area and location of flood-determination points, floods of August, in Maryland and Delaware.

Four storms in August produced significant flooding. All four storms were characterized by intense squalls and thunderstorms. The soil infiltration capacity seldom had a chance to recover fully between events. As a result, a net effect of cumulative runoff sensitivity became apparent as smaller amounts of rainfall produced proportionally greater peaks toward the end of the month.

The first storm occurred between August 3 and 5 and caused the most widespread damage. It hit hardest on the central eastern shore (fig. 32). At most localities the major part of the rain fell on the night of August 3, in what was described by one area resident as four or five distinct thunderstorms. This was followed by generally less intense storms in the afternoon and evening of August 4. The storms throughout the period were convective thunderstorms fed by unstable maritime tropical air. Only the rain on the night of August 3 contributed to most of the peaks on the small drainage basins. However, all the

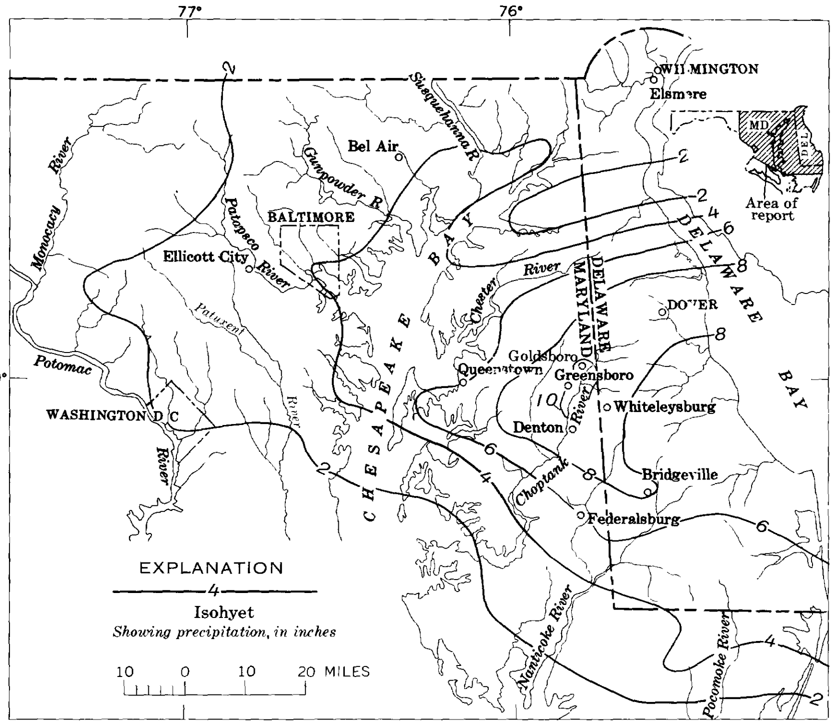

Figure 32.—Isohyetal map of total precipitation, August 3–5, floods of August in Maryland and Delaware.

rain in the period probably affected the peaks on the larger, slower moving streams. Three rain gages in the storm area collected more than 6 inches of rain each in less than 12 hours during the storm. The greatest amount of rain recorded, and believed reliable, during the August 3–5 storm was 9.15 inches in 6 hours at Goldsboro, Md. Two and a half inches was registered in 1 hour at this site, and a total of 10.85 inches was recorded over the 3-day period. In addition, somewhat less reliable data from other gages in the area indicated that even greater point rainfall totals may have occurred. A small nonrecording gage in Whiteleysburg, Del., was reported to have accumulated 11.6 inches between 5 p.m. on the 3d and 4:30 a.m. on the 4th.

Between 6 and 7 inches of rain in 12 hours is described in U.S. Weather Bureau Technical Paper 40 as a 100-year storm for this region of the United States. Much more severe flooding could no doubt result from a similar storm if it occurred on terrain having less permeable soil and more topographic relief.

The second major storm occurred on the night of August 9. Its effects were significant only in the northern counties of the two-State area east of Frederick County, Md. (fig. 33). The resultant flooding

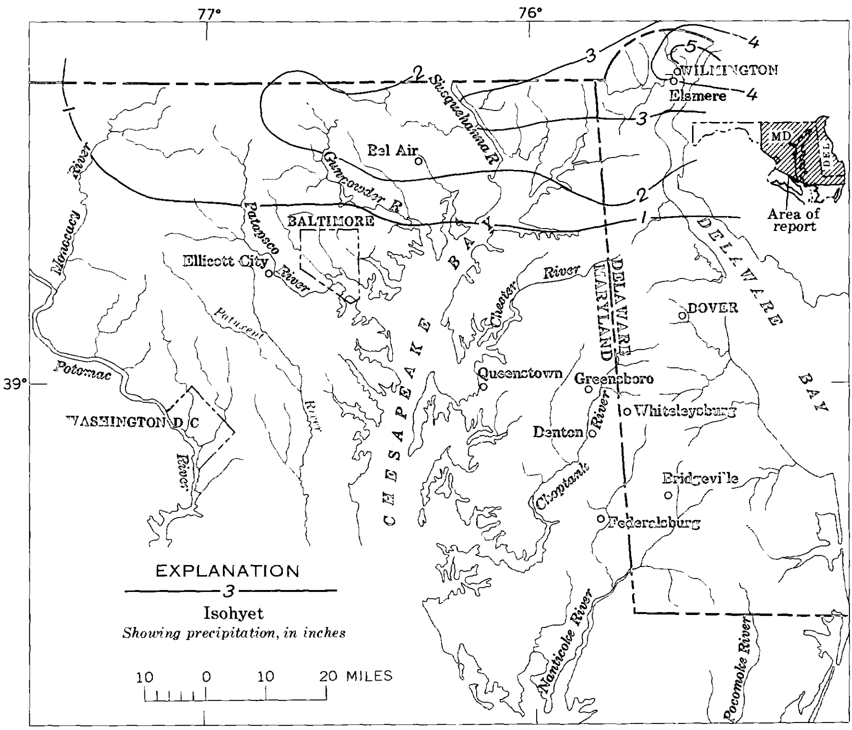

FIGURE 33.—Isohyetal map of total precipitation, August 9–10, floods of August, in Maryland and Delaware.

was extremely destructive in the area of Elsmere, a suburb southwest of Wilmington, Del. The storm was composed of thunderstorms and squalls associated with passage of a cold front.

Extremely heavy rains fell again late on the night of August 24, and early on the morning of the 25th. Frontal-type thunderstorms associated with an almost stationary cold front were responsible for this precipitation. A fairly narrow band extending from the Washington metropolitan area through Baltimore to Bel Air, Md., was hardest hit along with a large part of Dorchester County and much of the Nanticoke River basin on the Eastern Shore (fig. 34). This storm occurred immediately after the last of several periods of rather steady moderate rainfall. Analysis of the rainfall-runoff relationship should take the antecedent conditions into account.

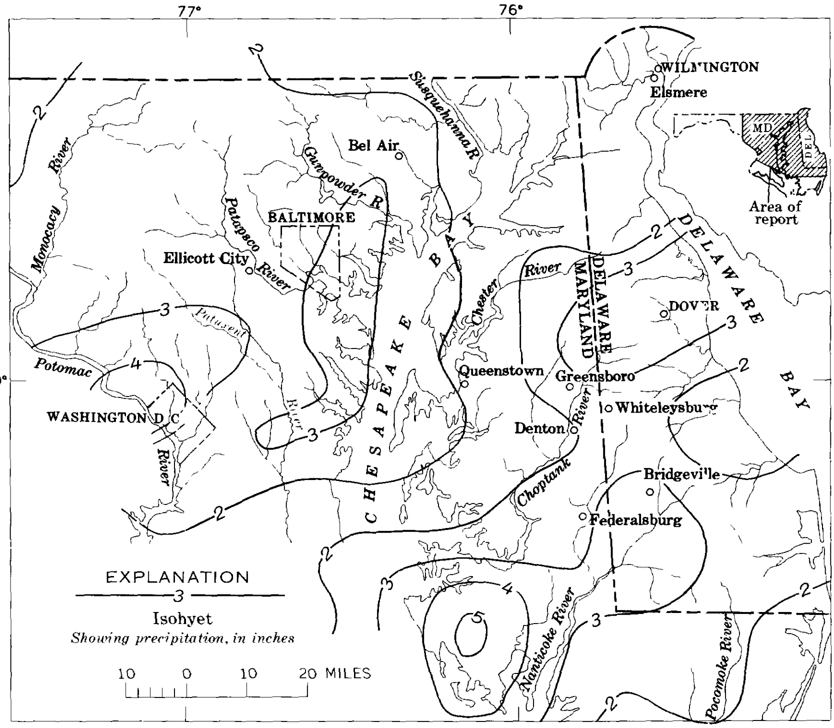

FIGURE 34.—Isohyetal map of total precipitation, August 23–25, floods of August in Maryland and Delaware.

On August 26 and 27, some scattered convective thunderstorm activity culminated in the passage of very intense thunderstorms associated with a well-defined cold front. The heaviest rain fell in a band about 20 miles wide running from Ellicott City, Md., to Wilmington, Del. (fig. 35). Most of the damage resulting from this storm occurred in Wilmington and vicinity.

The maximum rainfall recorded for each of the storm periods of August 9–10, 24–25, and 26–27 was between 5 and 6 inches.

Study of the point rainfall totals from each of the storms indicates that the areal distribution of rainfall was rather uneven, as is characteristic of thundershower precipitation, and the network of rain gages was not sufficient to define completely the distribution. For example, rain gages Wilmington 1 and 2 are only 1.8 miles apart, and yet their catch differed by more than 50 percent for the critical rainfall on August 27. Therefore, considerably larger totals and higher intensity rainfall than can be inferred from the isohyetal maps may

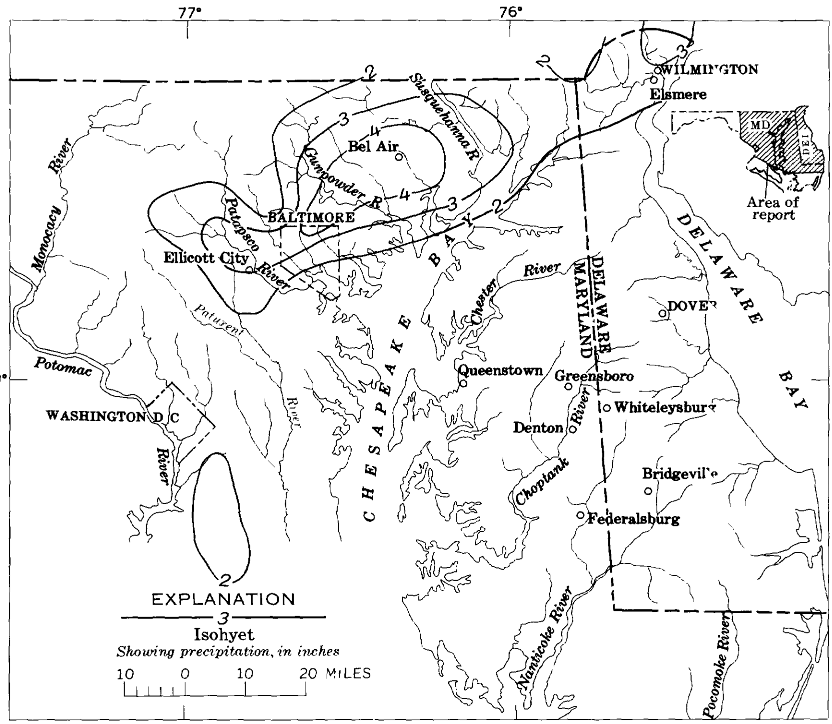

Figure 35.—Isohyetal map of total precipitation, August 25–28, floods of August in Maryland and Delaware.

have been associated with the runoff at some sites. Conversely, some gaged sites with small drainage areas within regions shown as having heavy rainfall did not have significant peaks.

The four heavy independent rainstorms during August caused unusual flooding over wide areas of Maryland and Delaware. As a result of the storms, maximum peak discharges for periods of record occurred at 14 of the 30 regular streamflow gaging stations on streams on the Eastern Shore of Maryland and Delaware and at six regular gaging stations on the Western Shore of Maryland. (See table 24.)

On the evening of August 3, violent thunderstorms began dropping torrential rains over the two-State area. Hardest hit were the central parts of Delaware and the Maryland eastern shore. By the morning of August 4, many areas in Caroline County, Md., and Kent County, Del., south of Dover, were covered with water. Most secondary roads and some major highways were inundated.

TABLE 24.—*Flood stages and discharges, August, in Maryland and Delaware*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before August 1967: Period	Known before August 1967: Year	August 1967	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
	Delaware River basin							
1	Matson Run at Lea Blvd., Wilmington, Del.	0.94			27		1,120	
2	Shellpot Creek at Wilmington, Del.	7.46	1946–67	1952		7.97	4,080	
					10	8.29	3,630	
					27	9.10	4,650	[1]1.7
3	Christina River at Coochs Bridge, Del.	20.5	1944–67	1947		12.41	2,620	
					4	10.04	1,340	
					10	10.83	1,700	3
					28	9.93	1,290	
4	White Clay Creek above Newark, Del.	66.7	1953–59, 1963–67.	1955		9.21	4,050	
					4	3.86	864	
					10	9.97	4,540	5
					27	4.01	924	
5	White Clay Creek near Newark, Del.	87.8	1933–37, 1944–57.	1937		23.0	(2)	
			1960–67	1960		16.11	6,340	
					3	11.63	2,640	
					10	16.41	6,640	10
					27	9.56	1,520	
6	Mill Creek at Hockessin, Del.	4.0	1966–67	1966		5.22	504	
					10	7.07	727	3
7	Red Clay Creek tributary near Yorklyn, Del.	.5	1966–67	1966		4.12	22	
					9	5.78	49	
8	Red Clay Creek at Woodale, Del.	47.0	1944–67	1960		9.93	6,000	
					10	6.40	2,460	2
9	Little Mill Creek at Elsmere, Del.	6.70	1964–67	1964		5.75	735	
					3	4.51	372	
					10	8.58	3,960	[1]1.5
					27	6.71	1,210	
		.9	1966–67	1966		3.99	43	
10	Brandywine Creek tributary near Centerville, Del.				27	3.99	43	
		.5	1966–67	1966		6.08	144	
11	Willow Run at Rockland, Del.				9	7.91	245	
					27	10.49	372	
		314	1948–67	1955		13.89	17,800	
12	Brandywine Creek at Wilmington, Del.				5	6.40	3 200	
					10	7.64	4 880	
					27	7.20	4 200	
		3.85	1952–53. 1955–67	1960		4.10	510	
13	Blackbird Creek at Blackbird, Del.				4	1.82	82	
	Leipsic River basin							
14	Leipsic River near Cheswold, Del.	9.35	1944–67	1960		6.45	1,340	
					4	3.84	233	
	St. Jones River basin							
15	St. Jones River at Dover, Del.	31.9	1958–67	1960		9.45	1,900	
					26	5.91	652	
16	Puncheon Branch at Dover, Del.	2.4	1966–67	1966		3.94	129	
					4	5.04	284	
	Murderkill River Basin							
17	Black Swamp Creek near Felton, Del.	4.56			4		1,430	[1]1.4
18	Murderkill River near Felton, Del.	13.6	1932–33, 1960–67	1960		6.87	805	
					4	8.83	2,090	35
					25	5.52	325	

See footnotes at end of table.

TABLE 24.—*Flood stages and discharges, August, in Maryland and Delaware*—Con.

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before August 1967: Period	Year	August 1967	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
	Murderkill River basin—Continued							
19	Murderkill River tributary near Felton, Del.	1.2	1966–67	1966		5.10	37	
					4	8.10	360	
20	Pratt Branch near Felton, Del.	3.29	1966–67	1966		6.8	(2)	
					4	10.50	459	
	Mispillion River basin							
21	Beaverdam Branch at Houston, Del.	2.83	1959–67	1960		5.55	176	
					4	4.17	76	
	Broadkill River basin							
22	Beaverdam Creek near Milton, Del.	6.10	1966–67	1966		4.29	21	
					25	4.02	20	
23	Sowbridge Branch near Milton, Del.	7.08	1957–67	1958		5.86	80	
					5	6.33	134	
					25	5.81	76	
	Indian River basin							
24	Stockley Branch at Stockley, Del.	5.24	1944–67	1948		[3] 5.0	132	
					4	3.67	107	2
					25	3.47	89	
25	Pepper Creek at Dagsboro, Del.	8.78	1960–67	1962		5.25	292	
					4	4.30	180	
					25	5.67	346	6
	Pocomoke River basin							
26	Pocomoke River near Willards, Md.	60.5	1951–67	1962		12.03	848	
					26	10.38	586	2
27	Nassawango Creek near Snow Hill, Md.	44.9	1950–67	1953		7.82	988	
					25	6.64	452	2
	Nanticoke River basin							
28	Toms Dam Branch near Greenwood, Del.	6.2	1966–67	1966		5.40	54	
					4	7.94	88	2
29	Nanticoke River near Bridgeville, Del.	75.4	1935	1935		11.0	(2)	
			1944–67	1958		8.84	2,300	
					5	8.86	2,360	13
					26	7.49	1,130	
30	Trap Pond Outlet near Laurel, Del.	16.7	1952–67	1962		3.55	462	
					5	3.24	349	
					25	4.09	608	7
31	Meadow Branch near Delmar, Del.	3.4	1967	1967		5.00	66	
					25	6.53	99	
32	Holly Ditch near Laurel, Del.	2.19	1951–56,	1961		3.30	62	
			1960–63			3.70		
					25	3.70	26	
33	Marshyhope Creek near Adamsville, Del.	44.8	1935	1935		14.5	(2)	
			1944–67	1958		11.55	2,270	
					5	11.98	3,060	12
					26	8.37	598	
34	Faulkner Branch at Federalsburg, Md.	7.10	1951–67	1960		4.73	672	
					4	4.00	398	
					25	5.03	792	12

See footnotes at end of table.

TABLE 24.—*Flood stages and discharges, August, in Maryland and Delaware*—Con.

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before August 1967 — Period	Maximum floods: Known before August 1967 — Year	Maximum floods: August 1967	Maximum floods: Gage height (feet)	Maximum floods: Discharge — Cfs	Maximum floods: Discharge — Recurrence interval (years)
	Transquaking River basin							
35	Chicamacomico River near Salem, Md.	15.0	1952–67	1961		4.40	470	
					5	3.83	294	
					25	4.42	518	7
	Choptank River basin							
36	Beachy Neidig Ditch near Willow Grove, Del.	2.4	1966–67	1966		4.18	13	
					4	8.46	67	
37	Meredith Branch near Sandtown, Del.	8.8	1966–67	1966		[4] 0.87	16	
					4	6.39	2,140	[1] 1.3
38	Oldtown Branch at Goldsboro, Md.	3.9	1967	1967		5.36	(5)	
					4	9.79	760	
39	Choptank River near Goldsboro, Md.	113	1949–67	1960		12.45	5,040	
					4	14.47	6,970	15
					26	8.80	2,120	
40	Sangston Prong near Whiteleysburg, Del.	2.0	1966–67	1966		3.84	35	
					4	9.16	765	
					25	6.11	121	
41	Gravelly Branch tributary near Greensboro, Md.	1.1			4		664	
42	Spring Branch near Greensboro, Md.	3.8	1967	1967		4.77	(5)	
					4	10.85	965	
43	Beaverdam Branch at Matthews, Md.	5.85	1951–67	1960		10.24	2,200	
					4	6.06	693	12
	Wye River basin							
44	Sallie Harris Creek near Carmichael, Md.	8.09	1952–67	1960		7.43	1,240	
					4	7.33	1,180	22
45	Mill Creek near Skipton, Md.	4.6	1966–67	1966		4.53	(5)	
					4	[6] 11.2	1,520	[1] 1.4
	Chester River basin							
46	Unicorn Branch near Millington, Md.	22.3	1949–67	1960		7.17	1,060	
					4	5.34	582	2
47	Morgan Creek near Kennedyville, Md.	10.5	1952–67	1960		8.88	1,530	
					4	7.08	823	7
	Elk River basin							
48	Big Elk Creek at Elk Mills, Md.	52.6	1884	1884		[7] 19	(2)	
			1933–67	19[illegible]7		14.5	1[illegible],600	
					10	10.35	6,120	10
	Northeast River basin							
49	Northeast Creek at Leslie, Md.	24.3	1949–67	1958		6.92	3,220	
					10	7.74	4,060	12
					27	4.56	1,210	
	Principio Creek basin							
50	Principio Creek near Principio Furnace, Md.	9.03	1967	1967		[6] 7.5	1,400	
					4	6.18	730	
					9	8.89	4,260	38
					27	5.98	642	

See footnotes at end of table.

TABLE 24.—*Flood stages and discharges, August, in Maryland and Delaware*—Con.

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before August 1967: Period	Known before August 1967: Year	August 1967	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
	Susquehanna River basin							
51	Octoraro Creek near Rising Sun, Md.	193	1884	1884	---	24.3	[2]	---
			1933–58, 1963, 1965–67	1942	---	17.57	35,000	---
			---		10	9.58	[8] 6,870	3
52	Basin Run at West Nottingham, Md.	1.3	1967	1967	---	7.96	[5]	---
			---		4	9.65	[5]	---
			---		9	13.48	825	---
53	Basin Run at Liberty Grove, Md.	5.31	1949–58, 1965–67	1958	---	6.33	1,560	---
			---		4	4.93	910	13
			---		9	7.66	2,400	[1] 1.5
54	Deer Creek at Rocks, Md.	94.4	1927–67	1933	---	[9] 17.7	13,600	---
			---		4	9.82	3,920	3
			---		27	9.49	3,720	---
	Bush River basin							
55	Bynum Run at Bel Air, Md.	8.52	1945–50, 1956–67	1945	---	6.25	3,620	---
			---		25	6.56	1,280	3
			---		27	6.44	1,220	---
	Gunpowder River Basin							
56	Little Falls at Blue Mount, Md.	52.9	1933	1933	---	14	[2]	---
			1945–67	1950	---	11.93	5,730	---
			---		3	7.34	2,750	3
			---		9	6.36	2,170	2
57	Piney Creek near Hereford, Md.	1.5	1966–67	1967	---	10.41	[5]	---
			---		9	11.65	534	---
58	Slade Run near Glyndon, Md.	2.09	1948–67	1956	---	4.68	485	---
			---		27	3.96	222	---
59	Western Run tributary at Western Run, Md.	.26	1966–67	1967	---	3.85	[5]	---
			---		27	8.11	236	---
60	Western Run at Western Run, Md.	59.8	1945–67	1956	---	10.84	5,590	---
			---		27	7.53	2,610	3
61	Baisman Run at Broadmoor, Md.	1.47	1965–67	1965	---	2.70	80	---
			---		3	3.04	131	---
			---		9	3.28	167	---
			---		27	3.50	200	---
62	Little Gunpowder Falls at Laurel Brook, Md.	36.1	1927–67	1933	---	10.3	9,200	---
			---		4	5.56	1,860	2
			---		27	7.72	5,130	10
63	Whitemarsh Run at White Marsh, Md.	7.61	1960–67	1960	---	6.60	1,780	---
			---		4	4.30	830	---
			---		25	6.00	1,510	5
			---		27	5.60	1,350	---
	Back River basin							
64	West Branch Herring Run at Idlewylde, Md.	2.13	1958–64, 1966–67	1958	---	5.78	602	---
			---		25	4.03	449	---
			---		27	6.46	1,540	---
65	Stemmers Run at Rossville, Md.	4.94	1959–67	1965	---	7.86	1,720	---
			---		4	6.19	953	3
			---		25	6.94	1,200	5
			---		27	5.50	770	---
66	Brien Run at Stemmers Run, Md.	1.97	1959–67	1960	---	5.03	506	---
			---		3	4.27	376	---
			---		25	4.29	379	---
			---		27	3.12	206	---

See footnote at end of table.

TABLE 24.—*Flood stages and discharges, August, in Maryland and Delaware*—Con.

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before August 1967: Period	Known before August 1967: Year	August 1967	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
	Patapsco River basin							
67	Cranberry Branch near Westminster, Md.	3.29	1949–67	1949		5.2	750	
					9	3.86	[10] 170	
68	North Branch Patapsco River at Cedarhurst, Md.	56.6	1946–67	1955		10.38	4,130	
					9	5.63	1,645	2
69	Hay Meadow Branch tributary at Poplar Springs, Md.	0.54	1966–67	1966		3.85	([6])	
					27	5.92	188	
70	South Branch Patapsco River at Henryton, Md.	64.4	1949–67	1956		19.40	12,100	
					10	6.25	1,960	2
					27	10.38	4,080	5
71	Piney Run near Sykesville, Md.	11.4	1932–67	1956		12.0	7,380	
					27	[6] 7.17	2,100	25
72	Patapsco River at Hollofield, Md.	285	1933	1933		19.5	([2])	
			1945–67	1956		15.88	19,000	
					27	6.32	[11] 5,240	
73	East Branch Herbert Run at Arbutus, Md.	2.47	1956, 1958–67	1956		5.7	1,090	
					3	3.90	545	
					25	3.79	512	
74	Gwynns Falls near Owings Mills, Md.	4.90	1959–67	1964		2.60	240	
					10	3.28	478	
					27	5.06	1,330	35
75	Gwynns Falls at Villa Nova, Md.	32.5	1956, 1958–67	1956		12.6	5,270	
					10	6.70	1,200	
					25	7.15	1,340	
					27	8.92	2,010	2
76	Dead Run at Franklintown, Md.	5.52	1960–67	1961		6.16	1,180	
					3	6.86	1,430	6
					25	6.84	1,420	8
					27	6.03	1,140	4
77	Jones Falls at Sorrento, Md.	25.2	1958–67	1960		6.06	685	
					4	6.03	678	
					25	6.98	915	
					27	7.89	1,140	
	South River basin							
78	North River near Annapolis, Md.	8.5	1932–67	1944		6.22	5,000	
					4	2.10	85	
79	Bacon Ridge Branch at Chesterfield, Md.	6.92	1944–52, 1965–67	1944		5.49	2,100	
					4	3.88	390	4
	Patuxent River basin							
80	Patuxent River near Unity, Md.	34.8	1945–67	1956		14.35	10,700	
					27	7.52	1,800	3
81	Little Patuxent River at Guilford, Md.	38.0	1933–67	1952		13.26	5,300	
					25	7.18	783	
82	Western Branch near Largo, Md.	30.2	1950–67	1955		8.51	1,580	
					25	5.62	640	
					27	6.06	750	2

See footnotes at end of table.

TABLE 24.—*Flood stages and discharges, August, in Maryland and Delaware*—Con.

No.	Stream and place of determination	Drainage area (sq. mi)	Maximum floods: Known before August 1967: Period	Year	August 1967	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
			Potomac River basin					
83	Piney Creek tributary at Taneytown, Md.	0.62	1967	1967		9.71	([5])	
					9	9.85	200	
84	Big Pipe Creek at Bruceville, Md.	102	1948–67	1949		11.92	9,500	
					10	8.38	3,760	2
85	Little Pipe Creek at Avondale, Md.	8.10	1948–56, 1959–63, 1967	1956		8.47	1,880	
					9	4.93	513	2
86	Bennett Creek at Park Mills, Md.	62.8	1949–58, 1960–67	1952		10.34	3,230	
					27	6.79	2,110	2
87	Seneca Creek at Dawsonville, Md.	101	1931–67	1956		12.17	15,000	
					27	7.64	2,660	2
88	Watts Branch at Rockville, Md.	3.70	1958–67	1965		5.32	932	
					4	5.58	1,230	
					25	5.50	1,130	
89	Little Falls Branch near Bethesda, Md.	4.1	1945–67	1966		6.82	2,680	
					24	5.70	1,900	
90	Rock Creek at Sherrill Drive, Washington, D.C.	62.2	1930–67	1956		13.19	7,220	
					4	5.93	[12] 1,280	
					25	10.30	[12] 3,440	3
91	Northeast Branch Anacostia River at Riverdale, Md.	72.8	1933, 1939–67	1933		15.5	10,500	
					25	6.44	4,080	3
92	Northwest Branch Anacostia River near Colesville, Md.	21.1	1924–67	1953		10.99	4,910	
					25	9.15	1,740	2
93	Northwest Branch Anacostia River near Hyattsville, Md.	49.4	1933	1933		13.5	([2])	
			1939–67	1966		13.50	7,000	
					4	8.57	1,980	
					19	8.84	2,100	2
					25	12.67	5,030	8
94	Henson Creek at Oxon Hill, Md.	16.7	1949–67	1955		7.33	3,000	
					27	3.68	636	

[1] Ratio of peak discharge to 50-yr flood.
[2] Discharge unknown.
[3] From graph based on gage readings.
[4] Maximum observed.
[5] Not determined.
[6] Stage from high-water profile.
[7] About.
[8] Discharge regulated since 1951 by reservoir 2,800,000,000 gal. capacity.
[9] Maximum stage known since at least 1888.
[10] Discharge regulated since 1957 by reservoir, 113,700,000 gal. capacity.
[11] Discharge regulated since 1954 by reservoir, 42,100,000,000 gal. capacity.
[12] Discharge regulated since 1964.

In Delaware, about 36 bridges and culverts were washed out or badly damaged. Four pond dams were washed out. At Killen Pond Dam, three persons lost their lives when the vehicle in which they were riding plunged into a 75-foot-wide break in the road-topped earthen dam.

Highway and public property damage was estimated at $125,000 in Caroline County, Md., and at $200,000 in the State of Delaware.

The damage to highway structures appears to have resulted from high velocities of flow through the bridges and culverts, causing excessive turbulence and scouring at the downstream sides. The scouring

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progressed upstream from the outlets and eroded the soil from around the culverts, also eating the roadway embankments out from under the pavement. The soil throughout most of the affected area is sandy and has little cohesive strength.

Water covered many roads in low areas for a period of more than 24 hours. Erosion of highway embankments was extensive. Crop damage also ran high; some fields were replanted as many as three times in August because of flooding and unusual weather conditions Corn and soybean crops sustained the most damage.

The worst flooding in 32 years occurred at Greensboro and Federalsburg, Md. Damage to homes and business establishments was especially heavy. Many persons were driven from their homes by water that reached depths of about 4 feet on streets in downtown Federalsburg, and damage to private property was estimated at $150,000. Although Federalsburg is often flooded, this was the worst since 1935. The flooding resulted from excessively high flow in the Marshyhope Creek basin. Peak flow exceeded the maximum previously recorded at the gaging station on Marshyhope Creek near Adamsville (sta. 33).

At Greensboro the volunteer firemen's carnival sustained a loss estimated at $10,000.

Garland Lake, the largest lake in Caroline County (70 acres), was emptied through a break in the dam.

The second storm, on August 9 and 10, was the worst for the northern regions of the two States. Major roads and highways were closed to traffic in many areas in New Castle County, Del. The city of Elsmere was hardest hit when water from Little Mill Creek spilled over its banks on the night of August 9. Many persons were driven from their homes and lost all their personal belongings, except the clothes they were wearing.

Elsmere has previously had flooding problems, but this flood was the worst since July 1952. Many homes and apartment buildings in the basin are built on low-lying land that is occasionally inundated.

Many streamflow gaging stations in Cecil County, Md., and in the Wilmington, Del., area recorded new maximums for the periods of record.

The storm of August 24–25 hit hardest in the Washington, D.C., metropolitan area, but many streamflow gaging stations in the two-State area of Maryland and Delaware recorded new maximums. Flood damage was generally light. Damage to the residential and commercial area in Queenstown, Md., was reported by the U.S. Army Corps of Engineers to have been $200,000.

On August 26 and 27, torrential rains accompanied by violent electric storms struck the northern part of the two-State area. Some streets in Wilmington, Del., and its suburbs appeared to be rivers rather than roadways. Elsmere again was one of the hardest hit areas. Some sections of the city were still vacant as a result of the storm of August 9 and 10; therefore evacuation was not necessary, and additional property damage sustained was less.

Shellpot Creek at Wilmington (sta. 2) recorded a new maximum of record during this flood. Matson Run (sta. 1), a tributary to Shellpot Creek, had a runoff of 1,190 cfs per sq mi.

The open-file report by Carpenter and Simmons (1969) gives additional details. Data in addition to peak stages and discharges are: Station descriptions, daily discharges, stages and discharges at given intervals of time so that hydrographs of the flood period can be produced, and rainfall amounts.

FLOODS OF AUGUST 24–25, IN THE WASHINGTON, D.C., METROPOLITAN AREA IN VIRGINIA

From E. M. Miller and F. P. Kapinos (1968)

Precipitation was substantially above normal throughout Virginia in August, which was the wettest month since August 1955 in most of the State. Much of the rain fell during the period August 19–25, which was associated with a series of cold fronts that became quasistationary within or near the State. ESSA Weather Bureau reported that as much as 9.36 inches of rain fell at Falls Church in the 6-day period, August 19–25.

After 6 days of nearly steady rain, torrential downpours on the night of August 24 dumped more than 6 inches on parts of northern Virginia. Rainfall was the most intense between 6 p.m. and midnight, during which the ESSA Weather Bureau station at National Airport in Washington recorded as much as 2 inches in 2½ hours. Vienna had the heaviest rainfall with 7.21 inches in 25 hours. Undoubtedly, the precipitation prior to August 24 was an important factor contributing to the unusually high runoff. An isohyetal map (fig. 36) for the August 19–25 storm was prepared by the ESSA Weather Bureau Forecast Center, Suitland, Md.

The floods resulting from the intense rain caused great inconvenience and much damage in urban areas. No lives were lost, nor were homes or other buildings destroyed. However, hundreds of stores and homes were flooded. This flood, unlike that which struck Arlandria, a northern section of Alexandria, in 1963 (Anderson, 1968), built up more slowly and allowed the merchants and residents in the area to move automobiles and remove stock from endangered sites.

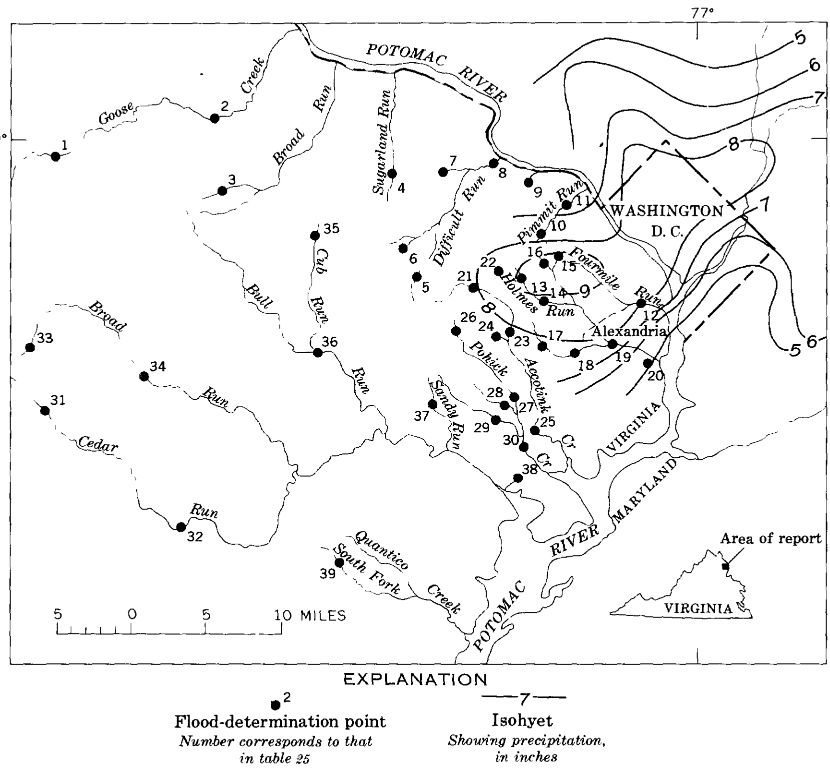

FIGURE 36.—Flood area, location of flood-determination points, and isohyets for August 19–25, floods of August 24–25 in the Washington, D.C., metropolitan area in Virginia.

Police, Fire Department, and Rescue Squad personnel were busy throughout the night evacuating persons from apartments and houses and rescuing stranded motorists.

An official of the Virginia Department of Highways estimated that damage to the roads in Fairfax County was about $100,000. Major damage included the washout of a bridge and a culvert and the undermining and settling of several abutments.

Although this flood was not especially destructive, it caused major inconveniences. Unusually high discharges occurred in the Accotink Creek, Pohick Creek, Sandy Run, and upper Cameron Run basins; lesser flooding occurred at scattered points throughout the area (table 25). County roads that were built for rural traffic are now suburban streets, carrying commuter traffic to and from the Washington metropolitan area. At some time during the night of August 24 and the morning of August 25, all major roads in northern Virginia were closed to traffic. Fairfax County Police described the flooding as the worst in at least 12 years, noting that, for the first time in some decades, about 35 roads, at least four of them major arteries, were closed. Those closed highways created major traffic snarls during the morning rush hours.

The open-file report by Miller and Kapinos (1968) gives additional details. Data are given for more streams than are listed in table 25 of this report. Data in addition to peak stages and discharges are: Station descriptions, daily discharges, stages and discharges at given intervals of time so that hydrographs of the flood period may be produced, and rainfall amounts. Flood profiles are shown along Accotink Creek, Bull Run, and Difficult Run.

TABLE 25.—*Flood stages and discharges, August 24–27, in the Potomac River basin in the Washington, D.C., metropolitan area in Virginia.*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before August 1967 — Period	Known before August 1967 — Year	August 1967	Gage height (feet)	Discharge — Cfs	Discharge — Recurrence interval (years)
1	Goose Creek near Middleburg.	116	1966–67	1966		8.96	2,350	
					25	14.44	6,920	(1)
2	Goose Creek near Leesburg.	338	1889–1967	1889		[2] 29	(1)	
			1909–12,	1937		[2] 26.86	45,000	
			1930–67	1942		22.9	45,000	
					25	14.00	10,300	4
3	Broad Run at Lenah	1.09	1962–67	1965		3.18		
					24	4.20		
4	Sugarland Run at Herndon.	3.36	1965–67	1965		6.56	480	
					24	6.98	565	7
5	Difficult Run near Fairfax.	4.29	1950–67	1952		7.40	783	
					24	7.8	1,180	(1)
6	South Fork Little Difficult Run near Fairfax.	1.59	1966–67	1966		6.37	80	
					24	8.31	200	2
7	Colvin Run at Reston	5.09	1961–67	1963		5.13	790	
					24	6.37	600	3
8	Difficult Run near Great Falls.	58	1935–67	1956		10.96	3,190	
					25	13.18	6,610	20
9	Scott Run near McLean	4.69	1961–67	1966		23.30	3,560	
					24	22.75	2,900	40
10	Pimmit Run near Falls Church.	2.87	1961–67	1966		6.56		
					24	6.34		
11	Pimmit Run at Arlington	8.12	1961–67	1966		8.79	2,700	
					24	8.8	2,700	15
12	Fourmile Run at Alexandria.	14.4	1951–67	1963		9.89	11,700	
					24	7.93	6,290	20
13	Holmes Run at Merrifield	2.70	1960–67	1966		5.11	1,220	
					24	5.40	2,330	>100
14	Holmes Run near Annandale.	7.10	1960–67	1966		7.93	1,400	
					24	8.7	2,700	35
15	Tripps Run at Falls Church.	1.78	1960–67	1966		8.64	1,500	
					24	8.50	1,150	4
16	Tripps Run tributary near Falls Church.	.50	1962–67	1966		6.52	318	
					24	6.48	315	2
17	Backlick Run at Springfield.	2.02	1960–67	1966		6.10	1,050	
					24	5.50	810	7
18	Backlick Run at Alexandria.	13.4	1960–67	1966		9.18	4,960	
					24	6.76	2,970	8
19	Cameron Run at Alexandria.	33.7	1955–67	1966		14.14	9,300	
					25	12.72	6,950	10
20	Penn Daw outfall at Alexandria.	.82	1961–67	1961		6.02	406	
					24	4.34	159	<2
21	Accotink Creek at Fairfax.	6.80	1961–67	1966		7.69	1,720	
					24	8.98	3,900	50
22	Long Branch at Vienna	1.18	1964–67	1966		33.28	1,160	
					24	35.34	1,640	(1)

See footnotes at end of table.

TABLE 25.—*Flood stages and discharges, August 24–27, in the Potomac River basin in the Washington, D.C., metropolitan area in Virginia*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before August 1967 — Period	Year	August 1967	Gage height (feet)	Discharge — Cfs	Recurrence interval (years)
23	Accotink Creek near Annandale.	23.6	1947–67	1947		9.9	3,950	
					24	11.84	7,870	>100
24	Long Branch near Annandale.	3.71	1947–57, 1959–67	1966		5.10	2,330	
					24	6.30	3,300	>100
25	Accotink Creek near Lorton.	39.8			25		8,620	75
26	Rabbit Branch near Burke.	3.81	1961–62, 1964–67	1961		6.07	586	
					24	7.70	2,500	>100
27	Pohick Creek near Springfield.	15.0	1961–67	1961		7.52	1,320	
					25	10.36	3,510	35
28	Middle Run near Lorton	3.56	1961–67	1966		5.22	1,100	
					24	5.70	1,430	45
29	South Run near Lorton	6.54	1961–67	1966		6.03	1,300	
					24	5.92	1,240	10
30	Pohick Creek at Lorton	31.0	1961–67	1966		6.15	2,340	
					25	9.1	5,500	30
31	Cedar Run near Warrenton.	13.0	1942	1942		13	(1)	
			1951–67	1955		9.59	3,100	
					24	9.30	2,760	10
32	Cedar Run near Catlett	93.5	1942–67	1942		22	( )	
			1951–67	1955		17.25	7,300	
					25	12.55	4,010	4
33	Broad Run near Warrenton.	2.94	1950–67	1961		6.61	175	
					24	6.99	200	(1)
34	Broad Run at Buckland	50.3	1951–67	1956		13.08	11,600	
					25	8.44	3,090	4
35	Cub Run near Chantilly	7.13	1963–67	1967		5.92	428	
					24	6.22	443	2
36	Bull Run near Manassas	147	1951–67	1952			11,200	
				1956		16.45	11,200	
					25	19.27	13,000	25
37	Sandy Run near Fairfax Station.	2.35	1966–67	1966		19.42	250	
					24	21.37	1,700	>100
38	Giles Run near Woodbridge.	4.54	1965–67	1966		6.70	960	
					27	6.40	870	(1)
39	South Fork Quantico Creek near Independent Hill.	7.50	1951–67	1958		8.31	1,000	
					25	7.18	510	2

[1] Not determined.
[2] At site 400 ft downstream and at datum 4.2 ft lower.

FLOODS OF AUGUST 25–26, IN NORTHEASTERN ALABAMA

By G. H. NELSON, JR. and J. F. MCCAIN

During the period August 24–25, intense rainfall caused severe flooding in a small area of northeastern Alabama. The area of heaviest rainfall and flood damage was in the Tallapoosa River and Choccolocco Creek basins (fig. 37). During the 7-day period preceding August 24, general rains occurred in the area, and ESSA Weather Bureau reported a total of 3.83 inches at Anniston and 3.50 inches at Heflin. During the morning of August 24, heavy rainfall occurred throughout the area. At Jacksonville, 5.24 inches of rainfall was recorded for the 6-hour period beginning at 6 a.m. on August 24, of which 2.95 inches occurred in a 2-hour period. The 6-hour rainfall

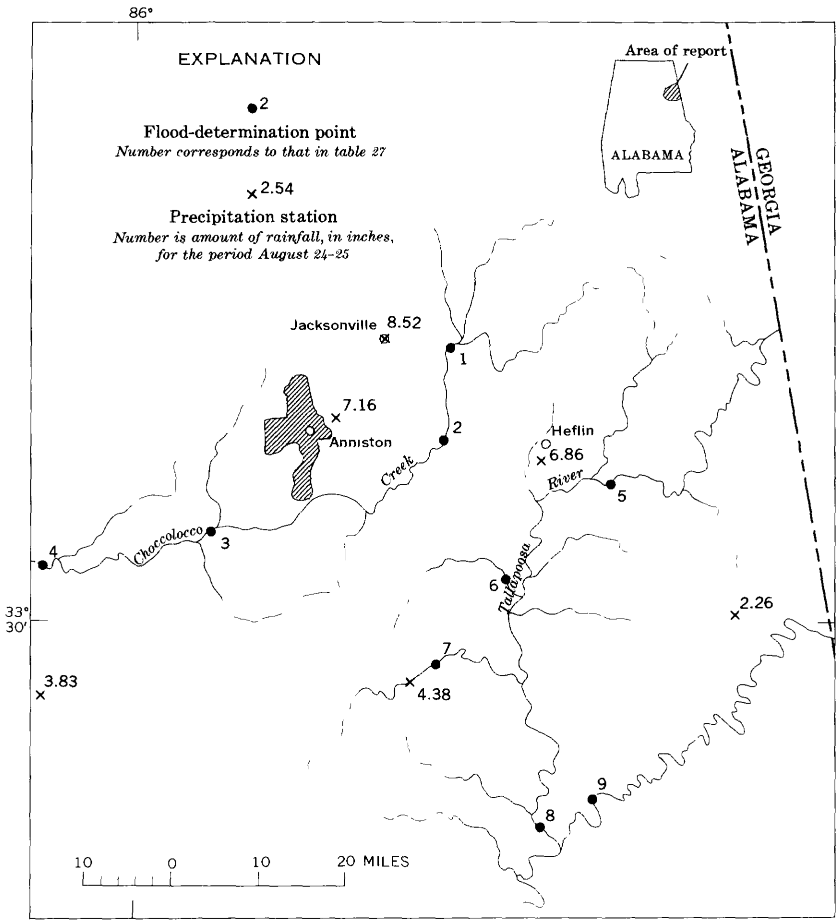

FIGURE 37.—Flood area and location of flood-determination points and rainfall data sites, floods of August 25–26, in northeastern Alabama.

recorded at Jacksonville will occur on an average of only one time in 50 years. Rainfall amounts for the storm period and total rainfall amounts for the preceding 7 days are given in table 28.

In response to the intense rains falling on extremely wet surface soils, streams in the area quickly overflowed their banks inundating much valuable farmland covered with almost mature crops. On many of the streams, flooding conditions were further aggravated by small dam failures in upstream areas. Severe flooding occurred mainly on tributaries of the Tallapoosa River and along Choccolocco Creek (table 27). A near-record discharge occurred at the gaging station on Choccolocco Creek near Jenifer (sta. 3).

TABLE 26.—*Daily precipitation, in inches, associated with the flood of August 25–26, in northeastern Alabama*

[From ESSA Weather Bureau records]

Station	Hour of observation	August 17–23	August 24	August 25	August 24–25
Anniston	12 p.m.	3.83	5.57	1.59	7.16
Delta	7 a.m.	1.51	3.64	.74	4.38
Heflin	8 a.m.	3.50	6.50	.36	6.86
Hightower	8 a.m.	.30	1.88	.38	2.26
Jacksonville	[1]12 p.m.	2.73	5.77	2.75	8.52
Talladega	6 p.m.	.70	2.46	1.37	3.83

[1] Data listed from hourly precipitation records.

TABLE 27.—*Flood stages and discharges, August 25-26, in northeastern Alabama*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before August 1967: Period	Year	August 1967	Gage height (feet)	Discharge: Cfs	Recurrence internal (years)
	Choccolocco Creek:							
1	Near White Plains	104			25		27,900	[1]1.4
2	At Choccolocco	129	1956–61	1957		11.95	6,860	
					25	16.67	[2]32,000	[1]1.6
3	Near Jenifer	281	1903–08, 1929–32, 1935–67	1936 1963		17.68	22,500	
					25	17.47	21,600	12
4	At Jackson Shoals, near Lincoln.	484	1960–67	1963		39.98	36,900	
					26	34.65	21,600	7
5	Tallapoosa River near Heflin.	444	1953–67	1961		26.39	19,300	
					26	22.02	10,000	2
6	Chulafinnee Creek at Hollis.	28.5			25		13,900	[1]2.4
7	Unnamed tributary to Ketchepedrakee Creek near Delta.	5.45			25		4,170	([3])
8	Tallapoosa River near Ofelia.	787	1939–58, 1960–67	1963		20.40	38,000	
					26	13.60	17,900	4
9	Little Tallapoosa River near Wedowee.	592	1940–67	1961		22.58	25,500	
					25	8.32	2,840	<2

[1] Ratio of peak discharge to 50-yr flood.
[2] Estimated by rating extension.
[3] Unknown.

At a discontinued gaging station on Choccolocco Creek at Choccolocco (sta. 2), a peak stage 4.72 feet higher than the previously recorded maximum stage occurred. Further upstream on Choccolocco Creek at State Highway 9 near White Plains (sta. 1), a peak discharge of 27,900 cfs was computed by indirect methods. The peak discharge at this site was 1.4 times as great as the 50-year flood. Outstanding flood events also occurred on tributaries of the Tallapoosa River in the vicinity of Heflin. A peak discharge of 13,900 cfs was computed by indirect methods for Chulafinnee Creek at Hollis (sta. 6). This peak discharge was 2.4 times as great as the 50-year flood at the site. An indirect measurement of peak discharge made on a tributary to Ketchepedrakee Creek (sta. 7) yielded an extremely high rate of peak runoff from the small watershed. The flood was much less severe on the main stem of the Tallapoosa River. At the gaging station at Heflin (sta. 5), the peak discharge was about equal to the mean annual flood. Because of the extremely high runoff near Heflin, the peak discharge at the crest-stage station on the Tallapoosa River near Ofelia (sta. 8) represented a slightly higher flood event with a recurrence interval of 4 years.

Extensive damage to residences, farmlands, and crops and to bridges and highways occurred throughout the area. In Calhoun County alone, an estimate of $2 million damage was made by the county commission. Officials of Cleburne County stated that 21 bridges had washed out during the flood, and at least 10 more were damaged. The Cleburne County Commission estimated highway and bridge damage in excess of $100,000. Damage to farmlands and crops were exceptionally high, and more than 2,000 acres of prime farmland in Cleburne County was ruined by erosion and sediment deposition. An estimated 200 farm ponds were destroyed by the flood waters. Along Choccolocco Creek near Oxford, high water forced many families from their homes and water damage was high.

All major highways in the area were closed during the height of the flood. The major highway, U.S. Highway 78, between Birmingham and Atlanta, Ga., was closed for several hours on August 24. A Greyhound bus was swept from U.S. Highway 78 just west of Heflin by a surge of water caused by a dam failure on a lake upstream. Rescue squads from Heflin rushed to the scene, secured the bus, and moved the passengers to high ground. An automobile accident east of Heflin resulting in one death was caused by the rain-slickened highway, and cannot be directly attributed to the flood.

FLOODS OF SEPTEMBER 2–5, IN SOUTHWESTERN ARIZONA

By L. L. Werho

On September 1, a tropical storm moved into southwestern Arizona from the Pacific Ocean. Warm, moist air remained in the area through September 5, and as a result, sporadically heavy rains caused extremely high runoff in places. The area affected by the storm was the desert lowlands in eastern Yuma County and southwestern Maricopa County (fig. 38). The area is a series of desert valleys separated by low narrow mountain ridges, which rise as much as 2,000 feet above the valleys. In general, the valley floors have mean altitudes of about 1,000 feet, and the mountains have altitudes of 1,500–3,000 feet.

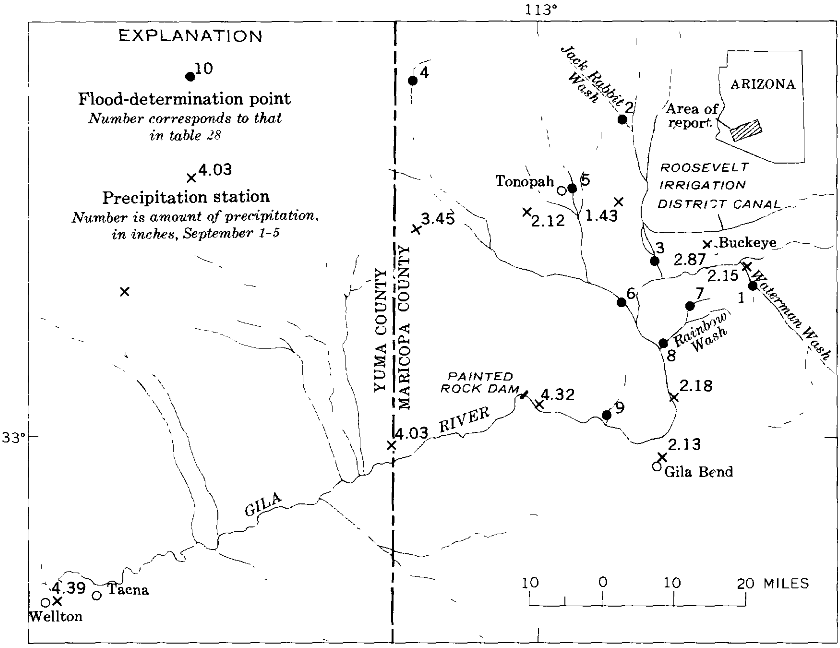

Figure 38.—Flood area and location of flood-determination points and precipitation stations, floods of September 2–5, in southwestern Arizona.

The amount of precipitation produced by the storm was extremely large for this part of the State, although intensities were generally low. Most of the precipitation fell between the evening of September 1 and the morning of September 3. The maximum amount of precipitation recorded during the storm was 4.39 inches at Wellton; many precipitation stations, all of which are in the valleys, recorded 2–4 inches of precipitation, and precipitation in the mountains was probably greater.

The maximum precipitation recorded in a 24-hour period was 3.25 inches at Wellton, on September 2. On September 5, 1.85 inches of rain fell in Buckeye between 5:15 and 6:55 a.m. Local residents reported this rain to be the heaviest in at least 17 years. The station at Painted Rock Dam recorded 1.04 inches of rain between 4 and 5 a.m. on September 5.

The storm produced some runoff in most of the streams in eastern Yuma County and southwestern Maricopa County. On September 3, maximum peak discharges occurred at five streamflow stations in the Buckeye area (table 28). On September 5, excessive runoff in the form of sheetflow broke the banks of the Roosevelt Irrigation District Canal and flooded Buckeye.

Streamflow records in southwestern Arizona are too short in duration to give a true indication of the magnitude of the flood in relation to past floods. The peak discharge (6,040 cfs) at Jack Rabbit Wash near Tonopah (sta. 2) was nearly three times the previously recorded maximum. The peak discharge (11,900 cfs) on Rainbow Wash near Gila Bend (sta. 8) was more than twice the 1966 peak—the previously recorded maximum. According to a local resident who had lived in the area since 1933, the peaks of 1966 and 1967 on Rainbow Wash were the highest known.

TABLE 28.—*Flood stages and discharges, September 2–5, in Gila River basin in southwestern Arizona*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before September 1967, Period	Known before September 1967, Year	September 1967	Gage height (feet)	Discharge, Cfs	Discharge, Cfs per sq mi
1	Waterman Wash near Buckeye.	403	1959–67	1966		6.21	5,560	
					3	6.56	6,300	15.6
2	Jack Rabbit Wash near Tonopah.	137	1964–67	1964		9.19	2,070	
					3	10.2	6,040	44.1
3	Hassayampa River near Arlington.	1,470	1961–67	1964		6.05	6,500	
					5	5.78	5,270	3.58
4	Tiger Wash near Aguila	85.2	1963–67	1966		7.96	(1)	
					3 or 5	6.17	(1)	(1)
5	Winters Wash near Tonopah	47.8	1962–67	1962		6.16	776	
					3	6.11	[2] 750	15.7
6	Centennial Wash near Arlington.	1,810	1961–67	1961		4.70	14,500	
					5	3.27	1,040	.57
7	Rainbow Wash tributary near Buckeye.	[3] 3.45	1963–67	1966		6.65	950	
					3	7.42	1,430	415
8	Rainbow Wash near Gila Bend.	[2] 45	1933–67	1966			5,110	
					2 or 3	(1)	11,900	264
9	Windmill Wash near Gila Bend.	12.9	1964–67	1966		8.64	967	
					3	10.55	2,510	195

[1] Not determined.
[2] About.
[3] 1.02 sq mi above stock pond, may be partly noncontributing.

Flood data are insufficient to determine recurrence intervals for the flood peaks in the area; however, curves developed by Patterson and Somers (1966) for adjacent areas can be used to estimate the recurrence intervals. The curve for the hydrologic area in the Colorado River basin with the highest mean annual flood was used with the steepest composite regional frequency curve to estimate the minimum probable recurrence intervals for the flood peaks—10 years for the flood on Jack Rabbit Wash and 30 years for the flood on Rainbow Wash. The relations defined are for mountain areas that receive much more precipitation than the flood area; therefore, recurrence intervals must be greater than these estimates. More reasonable estimates of the recurrence intervals would be more than 30 years for Jack Rabbit Wash and more than 50 years for Rainbow Wash.

The maximum unit discharges for the floods of September 1967 (fig. 39) are similar in magnitude to those for the floods of 1939, which

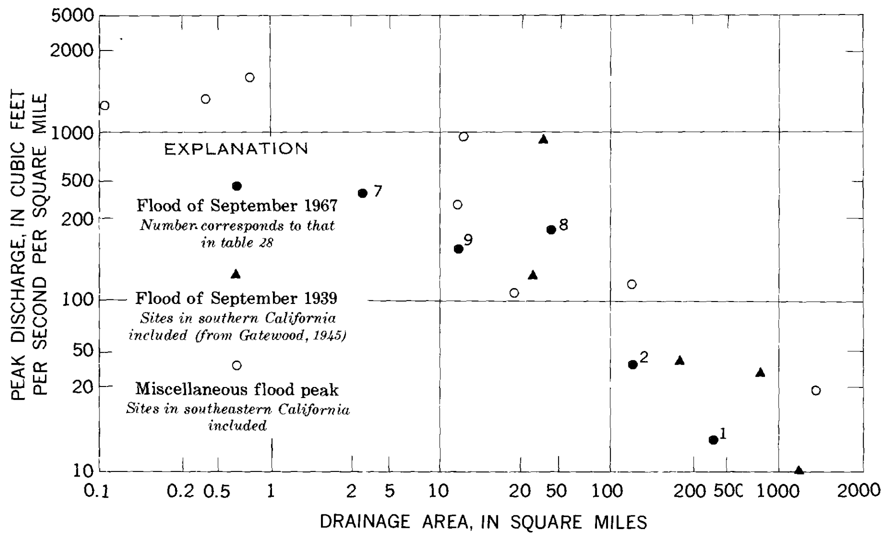

FIGURE 39.—Comparison of maximum unit discharges for floods of September 1967, in southwestern Arizona with those for previous floods in southwestern Arizona and southeastern California.

Gatewood (1945, p. 2) described as follows: "In many of the small drainage basins the peak discharges probably exceeded any that occurred in the previous 50 to 100 years."

The floods of September 3 on Waterman Wash and Rainbow Wash did considerable damage to roads, farmland, and irrigation facilities. The September 5 flood damaged farmland and facilities near the outskirts of Buckeye and several homes and business establishments in Buckeye. After the flood in the Buckeye area, the U.S. Department of Agriculture allocated $100,000 for clearing debris from stream channels, restoring dikes and concrete ditches, and releveling irrigated land. In other places, most of the flooding occurred in sparsely settled undeveloped areas, and damage generally was light. Some irrigation ditches near Tacna were damaged; however, the damage was offset by a $6,000 savings in cost of irrigation water. In Yuma County, many stream crossings on gravel roads were damaged, and about half the Gila River road crossings were closed. The Yuma County engineer estimated damages to roads in Yuma County to be about $70,000.

FLOODS OF SEPTEMBER, IN SALMON RIVER IN SOUTHEASTERN ALASKA

By C. W. Boning

The third flood since 1961 on the Salmon River near Hyder in southeastern Alaska occurred in mid-September. All these floods were caused by the self-dumping of Summit Lake, a body of water formed by the damming of the Salmon River by Salmon Glacier in British Columbia (fig. 40). Previous recorded breakouts of Summit Lake occurred in December 1961 and November-December 1965.

Breakout began slowly, about 2 weeks before the flood, as evidenced by cessation of flow from the full lake northward into the Bowser River drainage. As the subglacial tunnel enlarged the flow increased to the peak on September 17 at 6 p.m. The magnitude of the flood was comparable to that of the previous breakouts, and the peak discharge was estimated to be 104,000 cfs at a gage height of 28.97 feet.

During the floodflow a definite change from very violent standing waves to a smooth, but faster, flowing water surface occurred. This change is believed to have been caused by a shift from extreme antidunes to a plane bed. A discharge measurement made on the rising stage at 47,000 cfs had a mean velocity of 16.2 feet per second; maximum measured surface velocity was 28.4 feet per second. Average velocity at the cable measurement site was estimated as 25.4 feet per second during the peak flow.

The breakout of Summit Lake is similar to that of many other glacial-dammed lakes. No definite frequency of breakout has developed for Summit Lake as it has for other lakes in Alaska. Under certain conditions, biennial occurrence of floods of this magnitude could be attained because complete filling of the lake after previous breakouts has required 2 years.

Flood damage in 1967 was relatively small and equivalent to that from the 1965 flood. A road from Hyder paralleling the river was inundated in numerous places; the little-used highway bridge at the gaging station, 9 miles upstream from the mouth, collapsed when it was submerged by standing waves. A protection dike built near Hyder after the 1961 flood was partly cut away by the swift currents, and emergency repair was necessary to prevent the stream from breaking through or overtopping the dike.

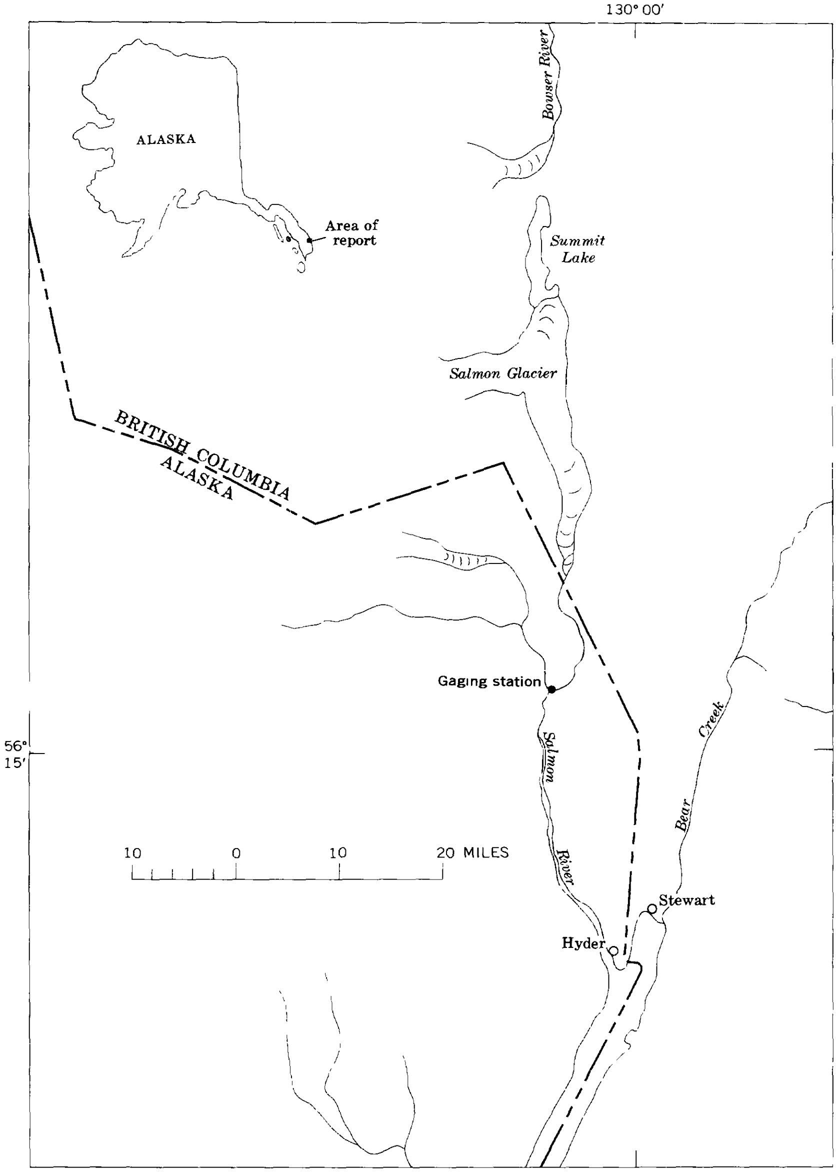

FIGURE 40.—Flood area, flood of September, in Salmon River in southeastern Alaska.

FLOODS OF SEPTEMBER 15, IN THE LYNN CANAL AREA OF SOUTHEASTERN ALASKA

By C. W. Boning

Heavy rains that fell over most of southeastern Alaska in mid-September, caused high runoff in most areas and flooding on streams near Skagway and Haines (fig. 41) on September 15.

The rainstorm that caused the flood moved inland from the Pacific Ocean and resulted in heavy precipitation on the islands of southeast Alaska. However, normal precipitation on those islands is very high, and the rain-forest vegetation generally prevents major flooding. In upper Lynn Canal near Haines and Skagway, however, the terrain is steep and rugged, and rapid runoff occurs. Daily precipitation for the storm area is shown in table 29.

Floodwaters of the Skagway River seriously threatened Skagway when a dike between the river and the city was cut by the swollen stream. The city was evacuated, and emergency repair work to the dike prevented major damage. Roads northwest of Skagway were inundated by the Taiya River, and extensive work was required to repair the damage.

Periods of gaging-station records are relatively short in this area, and flood-frequency analyses are not available. Stages were higher than those for previous floods that were reported by local residents. Peak discharges of streams in the flood area are given in table 30.

Table 29.—*Precipitation, in inches, September 12–16, at representative points in the Lynn Canal area of southeastern Alaska*

Station	September					
	12	13	14	15	16	12–16
Skagway	0.74	0.27	1.46	3.04	0.17	5.68
Haines	1.17	.84	1.52	2.98	------	6.51
Linger Longer	.85	1.21	1.47	2.20	.28	6.01
Eldred Rock	.56	1.63	.85	3.08	.49	6.61
Point Retreat	1.51	.28	2.05	1.04	------	4.88
Auke Bay	.65	.11	1.28	.11	------	2.15
Gustavus	.54	.37	.90	1.50	.05	3.36

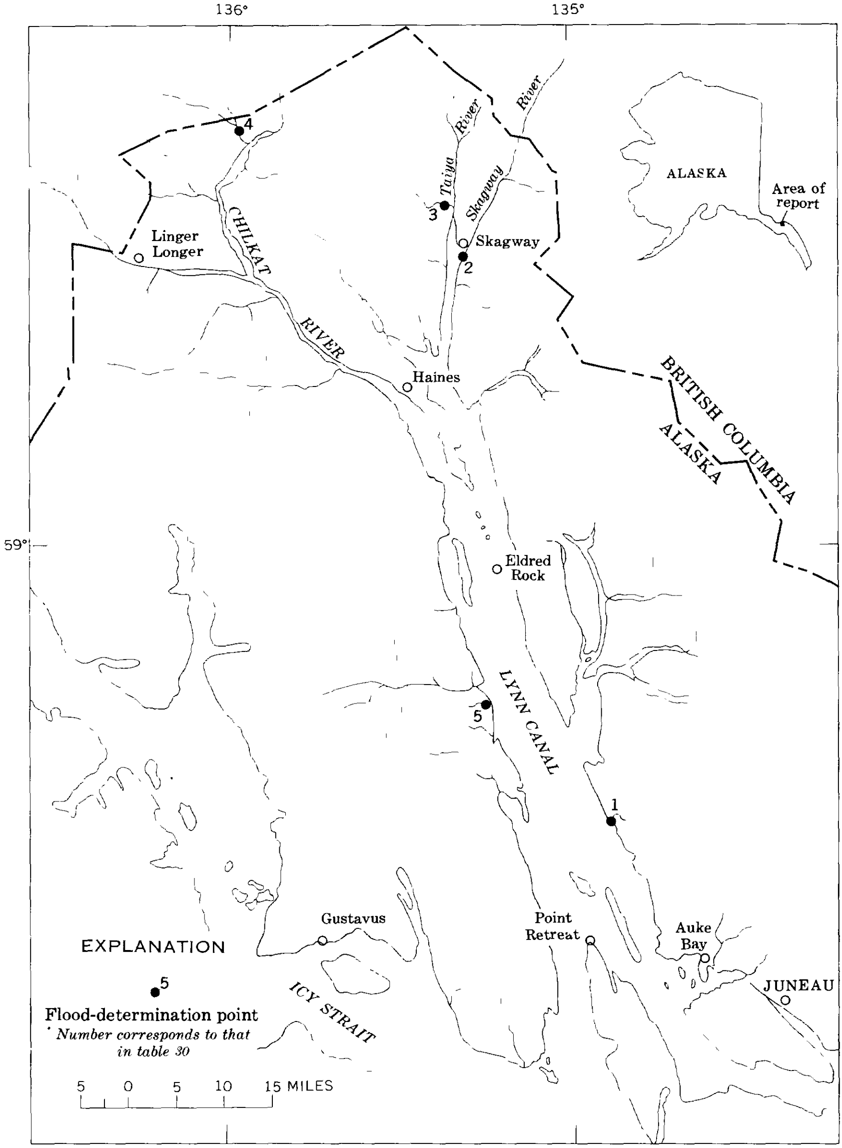

FIGURE 41.—Flood area and location of flood-determination points and precipitation data sites, floods of September 15, in the Lynn Canal area of southeastern Alaska.

TABLE 30.—*Flood stages and discharges, September 15, in the Lynn Canal area of southeastern Alaska*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before September 1967 — Period	Known before September 1967 — Year	September 1967	Gage height (feet)	Discharge — Cfs	Discharge — Recurrence interval (years)
	Bessie Creek basin							
1	Bessie Creek at mouth, 16.5 miles northwest of Auke Bay.	1.35			15	6.88	249	
	Skagway River basin							
2	Skagway River at mouth, at Skagway.	145	1964–67	1966		6.01	3,010	
					15	8.50	13,600	
	Taiya River basin							
3	West Creek at mouth, 5 miles northwest of Skagway.	43.2	1962–67	1962		5.68	3,800	
					15	7.75	9,800	
	Chilkat River basin							
4	Chilkat River, 36 miles above mouth, 16 miles north of Klukwan.	190	1962–67	1962		13.06	12,700	
					15	14.59	22,000	
	William Henry Creek basin							
5	William Henry Creek at mouth, 20.5 miles northwest of Auke Bay.	1.58			15	13.70	663	

FLOODS OF SEPTEMBER–OCTOBER, FROM HURRICANE BEULAH IN SOUTHERN TEXAS AND NORTHEASTERN MEXICO

From R. U. GROZIER and others (1967)

Torrential rainfall produced by Hurricane Beulah caused floods of record-breaking magnitude on many streams in a 50,000-square-mile area of southern Texas and northeastern Mexico (fig. 42) in September and October. The hurricane crossed the Texas coastline near Brownsville about daybreak on September 20 and was dissipated in the mountains of northern Mexico on September 22. In the period September 19–25, as much as 25.5 inches of rain was measured at ESSA Weather Bureau stations. Unofficial measurements were as much as 34 inches in the Nueces River basin in Texas and as much as 35 inches in the Rio Alamo basin in Mexico.

Major flooding occurred in the basins of the Guadalupe, San Antonio, Mission, Aransas, and Nueces Rivers and in many small coastal basins in Texas; on the Rio Grande and its floodways; and in the Rio Alamo and Rio San Juan basins in Mexico. Peak discharges at several

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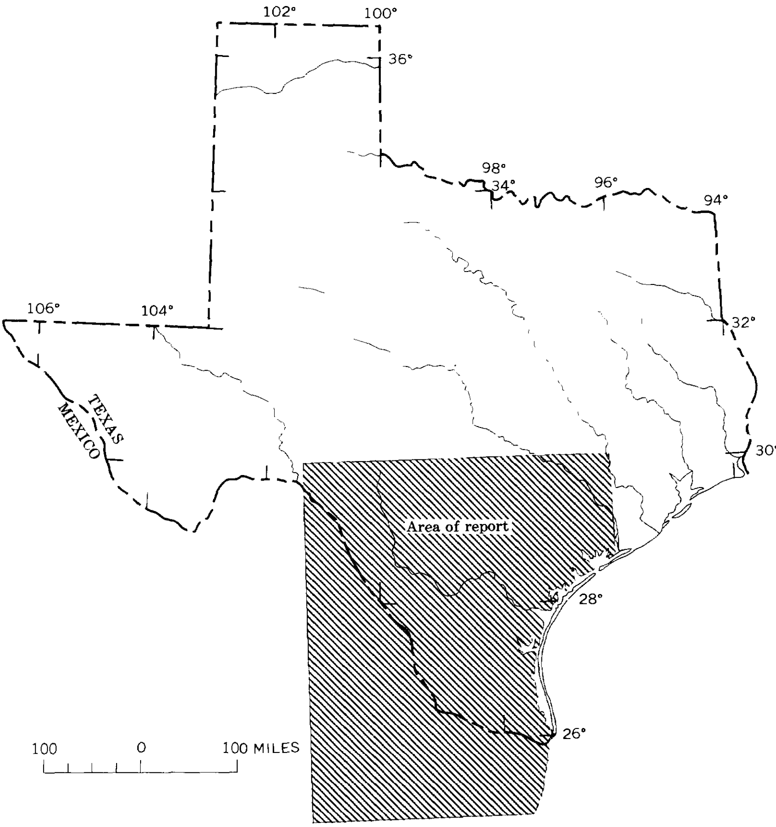

FIGURE 42.—Flood area, September–October, from Hurricane Beulah in southern Texas and northeastern Mexico.

sites in Texas were more than three times the magnitude of a 50-year flood. The floods in Mexico were so great that most of the recording gages were either submerged, destroyed, or unable to record peak discharges because water overflowed the natural divides and bypassed the gaging stations.

Total damage in Texas due to wind, rain, stream flooding, sheet flow, ponding and tidal flooding was $167 million.

These floods are described in detail in a special report by Grozier (1968). The report includes a discussion of the storm, tabulation of rainfall data, an isohyetal map, a description of the floods by basins, a summary of flood damage, a section on the effect of fresh-water inflow on the quality of water in three coastal bays, discussions of the effect of rainfall on ground-water recharge, and of ponded water on the Coastal Plains, and detailed information on stage and discharge for September–October.

FLOODS OF SEPTEMBER 27–29, IN WESTERN NEW YORK

By F. Luman Robison

On September 27–29, a record-breaking rainfall in the western third of New York State caused flooding of many streams and widespread damage to public and private property. Rain began on the afternoon of September 27 and continued until the early morning of September 29. The maximum official rainfall measurement for the storm was 6.54 inches near Friendship (fig. 43), and an unofficial measurement of 8.0 inches was made nearby. A rainfall of 5 inches in 24 hours in this

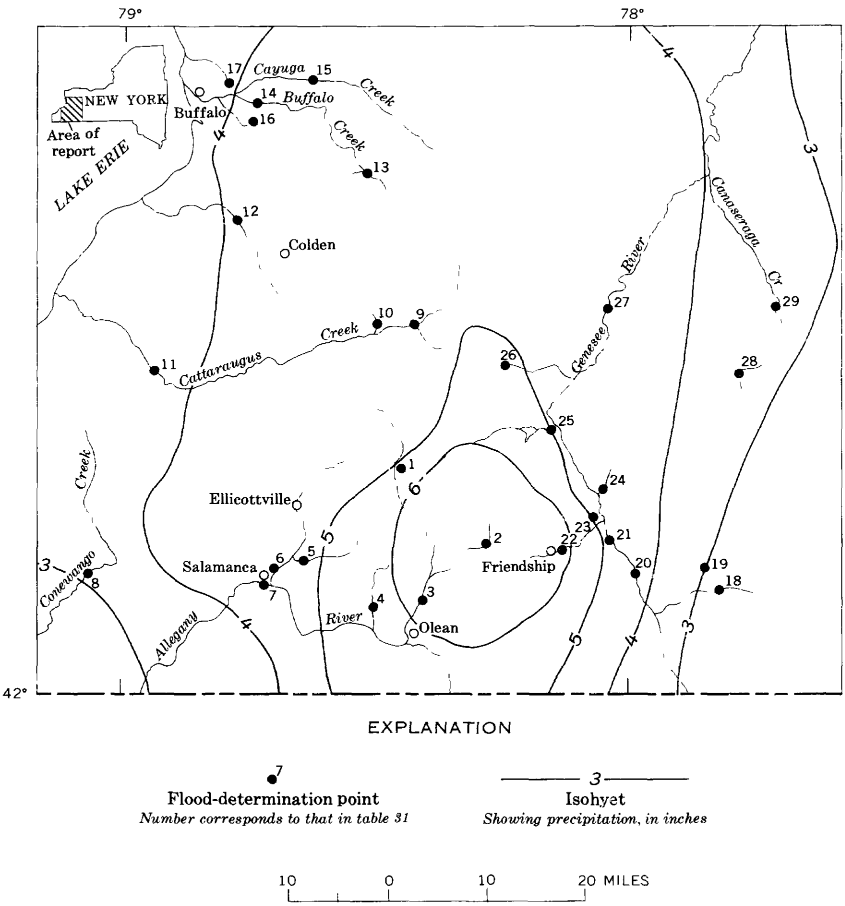

Figure 43.—Flood area, location of flood-determination points, and isohyets for September 27–29, floods of September 27–29, in western New York.

area can be expected on the average of once in 100 years (U.S. Weather Bureau, 1961). The total rainfall at Friendship in 28 hours was therefore greater than that of a 100-year storm. A September 24-hour record was established at Buffalo where 3.63 inches of rain fell. The extent and distribution of the storm rainfall is shown in figure 43.

Streams in the area of heavy precipitation rose rapidly. Stages on the Allegheny River and its tributaries approached or exceeded record heights (table 31) and flooded buildings, fields, and highways. The stage on the Allegheny River at Salamanca (sta. 7) was slightly below the maximum stage during the flood of 1956, whereas those on many smaller streams were new maximums of record. Great Valley Creek near Salamanca (sta. 6) reached a stage more than 7 feet higher than the previous maximum stage of 10.7 feet in 1956, and the discharge was nearly three times that of the greatest flood previously known on this stream.

The peak discharge of Van Campen Creek at Friendship (sta. 22)

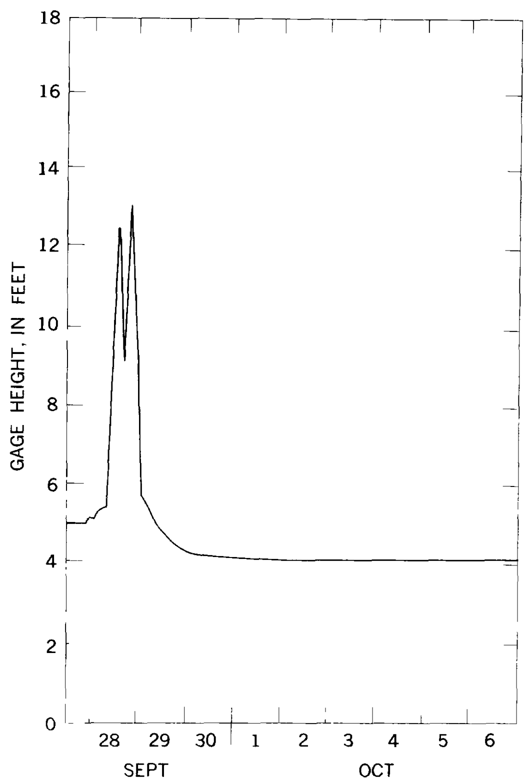

FIGURE 44.—Stage hydrograph for Van Campen Creek at Friendship, N.Y., floods of September 27–29, in western New York.

was extremely high, 3.3 times the 50-year flood (table 31). Figure 44, a stage hydrograph for Van Campen Creek, illustrates the effect of timing on flood magnitude. The water at this station is contributed mainly by three tributaries—the North, the West, and the South Branches of Van Campen Creek. When the first surge of water reached the station, the stage rose about 7½ feet and then receded sharply about 3½ feet. When the second surge arrived, the stage rose about half a foot higher than that of the first surge peak. There are no water-stage recorders on the separate branches of Van Campen Creek; therefore the timing of the peak discharge of the three branches is unknown. However, it can be assumed that the recorded maximum stage at the station would have been higher and the flood damage would have been more severe if the peaks of the three branches had arrived simultaneously at the station.

The peak stages and discharges at 29 stream-gaging stations in the flood area are given in table 31.

Two lives were lost; one when overflowing Great Valley Creek washed an automobile from U.S. Highway 219, and one when a highway was washed out.

Cattaraugus County was declared a disaster area by the U.S. Small Business Administration, thus allowing victims of flood damage to borrow money for rehabilitation at low interest rates. Cattaraugus and Allegany Counties were declared major disaster areas by President Johnson and were allocated $525,000 for emergency repairs to public facilities.

The greatest loss occurred to highways, bridges, and other public facilities. In Cattaraugus County, nine county bridges were destroyed and 19 were damaged; a State bridge and a railroad bridge were damaged. Six bridges were damaged in Allegany County. Damage to public facilities in Cattaraugus County was more than $1,250,000, and damage in Allegany County was nearly $600,000. These losses when added to those of crop losses and damage to farmland and private buildings will total several million dollars. Damage in the city of Salamanca was $293,000.

Many families were evacuated from their homes in Salamanca, Friendship, and Ellicottville. Flooding in Olean and other communities, which are protected by floodwalls and dikes, was due mostly to overloaded sewers and ditches and damage was light.

A report by Robison (1969) contains more details on the rainfall of September 27–29, shows stage hydrographs for several additional stations listed in table 31, contains some photographs of the flooded area and some newspaper reports describing local conditions in the flood area.

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TABLE 31.—*Flood stages and discharges, September 27–29, in western New York*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before September 1967: Period	Known before September 1967: Year	September 1967	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
	Allegheny River basin							
1	Gates Creek at Franklinville.	19.3			28		4,880	[1] 1.2
2	Johnsons Creek at Cuba	2.10			28		632	33
3	Olean Creek near Olean	198	1950	1950		(2)	16,100	
			1958–67	1961		12.76	7,540	
					29	16.06	18,200	23
4	Fivemile Creek at Allegheny.	34.1			28		3,840	7
5	Wrights Creek at Willoughby.	30.2			28		9,370	[1] 1.7
6	Great Valley Creek near Salamanca.	142	1951–67	1956		10.66	9,680	
					28	17.90	28,600	[1] 1.8
7	Allegheny River at Salamanca.	1,608	1904–67	1956		[3] 15.11	49,100	
					29	16.24	41,700	12
8	Conewango Creek at Waterboro.	290	1939–67	1947			8,600	
				1956		11.58		
					30	8.38	2,590	<2
	Streams tributary to Lake Erie							
9	Cattaraugus Creek near Arcade.	78.4	1963–67	1964		7.46	4,380	
					28	9.84	9,730	28
10	Elton Creek at The Forks	71.6	1963–67	1963		6.43	3,230	
			1963–67	1964		7.28	3,170	
					28	10.73	5,830	4
11	Cattaraugus Creek at Gowanda.	432	1940–67	1942			35,900	
				1956		14.14		
					28	12.96	28,800	12
12	Eighteenmile Creek at North Boston.	37.2	1963–67	1964		8.83	3,010	
					29	12.5	5,790	22
13	Buffalo Creek near Wales Hollow.	80.1	1963–67	1964			4,430	
				1964		[4] 8.75		
					28	11.61	9,260	18
14	Buffalo Creek at Gardenville.	144	1939–67	1942		[4] 11.90		
				1955			13,000	
				1956		7.07	13,000	
					29	8.50	10,500	2
15	Cayuga Creek near Lancaster.	94.9	1939–67	1959			8,750	
				1960		[4] 12.58		
					28	8.16	5,350	2
16	Cazenovia Creek at Ebenezer.	134	1941–67	1955		15.82	13,500	
					29	11.45	8,020	2
	Niagara River basin							
17	Scajaquada Creek at Buffalo.	15.9	1957–67	1963		14.38	2,620	
					28	8.73	1,360	(2)

See footnotes at end of table.

TABLE 31.—*Flood stages and discharges, September 27–29, in western New York*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before September 1967, Period	Known before September 1967, Year	September 1967	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
	Genesee River basin							
18	Dyke Creek near Andover	37.8	1964–67	1964		6.58	3,510	
					28	6.71	3,780	[1]1.1
19	Elm Valley Creek near Alfred.	1.15			28		288	(2)
20	Genesee River at Scio	308	1917–67	1950		11.22	23,300	
					29	9.01	7,180	2
21	Genesee River tributary at Belmont.	2.51			28		784	(2)
22	Van Campen Creek at Friendship.	45.8	1964–67	1964		10.56	5,720	
					28	13.10	13,400	[1]3.3
23	Baker Creek at Belvidere.	2.33			28		956	[1]1.2
24	Angelica Creek at Transit Bridge.	86.5	1964–67	1964		7.79	5,210	
					28	10.28	9,560	[1]1.4
25	Caneadea Creek at Caneadea.	62.0	1950–67	1960		10.74	[5]9,600	
					28	13.09	[5]13,800	(2)
26	Sixtown Creek tributary near Centerville.	1.67			28		201	(2)
27	Genesee River at Portageville.	981	1909–67	1916		[6]12.81	44,400	
					29	22.94	38,900	40
28	Canaseraga Creek near Canaseraga.	58.2	1964–67	1964		7.69	2,980	
					28	11.10	5,480	[1]1.1
29	Canaseraga Creek near Dansville.	153	1911–12, 1916–67	1940		13.1	8,830	
					28	10.74	4,020	<2

[1] Ratio of peak discharge to 50-yr flood.
[2] Not determined.
[3] At site 715 miles downstream at different datum.
[4] Affected by ice jam.
[5] Regulated by Rushford Reservoir.
[6] At site 8 miles downstream at different datum.

FLOODS OF DECEMBER 18–19, IN NORTHERN ALABAMA

By J. F. McCAIN

Widespread flooding occurred in many areas of northern Alabama on December 18–19. General rains of 2–8 inches fell during the first half of December; the largest amounts fell in the western part of the State. A series of violent thunderstorms late on the 17th and early on the 18th dumped as much as 7 inches of rain on some areas. At 3:45 a.m. on the 18th, a tornado touched down in several places in southern Huntsville causing great damage. Large volumes of storm runoff blocked highways and streets, disrupting the usual heavy flow of morning traffic to the Redstone Arsenal. The heaviest rainfall in the storm area was along a line from Haleyville in the western part of the State to Huntsville in the northeastern part. (See fig. 45). A

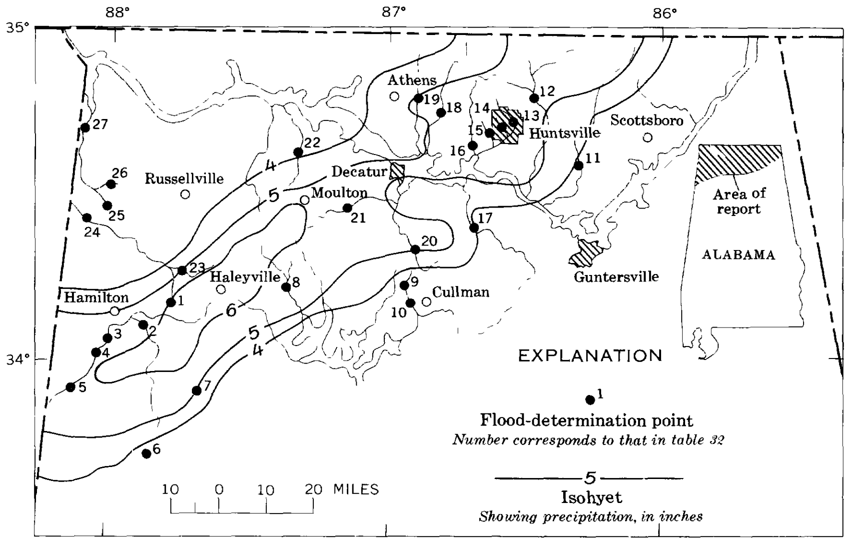

FIGURE 45.—Flood area and location of flood-determination points and isohyets for December 18–19, northern Alabama.

total storm rainfall of 6.99 inches at Haleyville was reported by ESSA Weather Bureau. The time distribution of rainfall at three widely separated Weather Bureau stations at Hamilton, Moulton, and Huntsville (fig. 46) shows a remarkable similarity of amounts of rainfall (about 5½ inches) and of the time pattern. The areal distribution of the rainfall for the period December 17–19 is shown in figure 45.

Maximum floods of record occurred at several gaging stations in the flood area (table 32). At Buttahatchee River below Hamilton (sta. 3), the flood crest on December 18 was 1.58 feet higher than the previous maximum stage in 17 years of record. Maximum peak stages and discharges of record occurred at Woods Creek near Hamil-

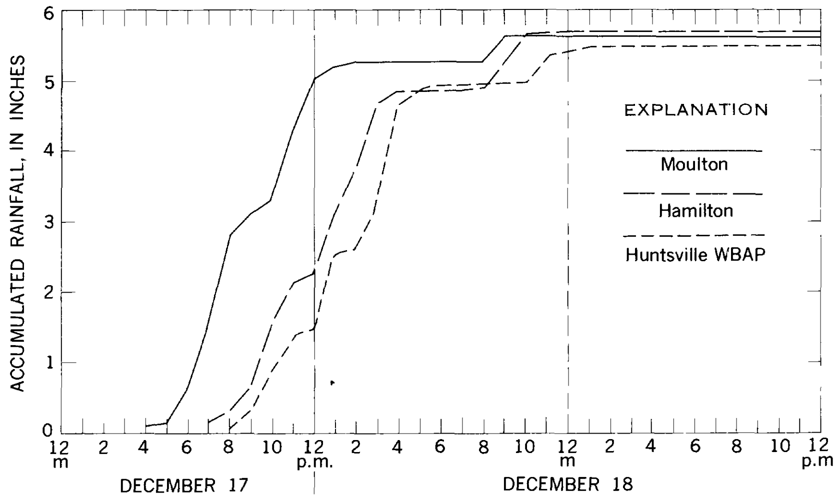

FIGURE 46.—Accumulated rainfall at selected ESSA Weather Bureau stations in northern Alabama, December 17–18.

ton (sta. 2), West Flint Creek near Oakville (sta. 21), Indian Creek near Madison (sta. 16), and Bear Creek near Red Bay (sta. 24). The maximum stage of record occurred at New River near Winfield (sta. 7). The peak discharge of Bear Creek near Hackleburg (sta. 23) has a recurrence interval of 50 years, although it was not so large as that of the flood of April 1962.

Four persons were killed as a result of the storm, two by the tornado and two by drowning: property damage occurred throughout the storm area, but the major part of the damage was in Huntsville. Parts of three counties were declared disaster areas by the U.S. Small Business Administration. Total damage in the Huntsville area was estimated at $5.3 million of which $1.8 million was at Redstone Arsenal. Several houses were flooded in Athens, as were streets in Athens and Decatur. Three county bridges were destroyed, and several others were damaged in the Haleyville area.

TABLE 32.—*Flood stages and discharges, December 18–19, in northern Alabama*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before December 1967: Period	Maximum floods: Known before December 1967: Year	Maximum floods: December 1967	Maximum floods: Gage height (feet)	Maximum floods: Discharge: Cfs	Maximum floods: Discharge: Recurrence interval (years)
	Mobile River basin							
1	Barn Creek near Hackleburg.	12.9	1960–67	1962		13.39	3,960	
					18	13.23	3,100	2
2	Woods Creek near Hamilton.	14.1	1959–67	1962		11.00	1,140	
					18	14.22	2,500	2
3	Buttahatchee River below Hamilton.	284	1951–67	1951		26.75	24,200	
					18	28.33	27,900	5
4	Buttahatchee River near Henson Springs.	330			19		22,000	2
5	Buttahatchee River near Sulligent.	472	1939–67	1946		15.5	33,000	
				1950		16.4	32,800	
					19	16.10	27,500	7
6	Luxapallila Creek near Fayette.	127	1945–67	1949		13.8	9,910	
					18	13.48	12,300	33
7	New River near Winfield	55.6	1951–67	1961		23.88	(1)	
					18	24.11	(1)	
8	Sipsey Fork near Grayson	91.3			18	38.29	14,200	5
9	Jaybird Creek near West Point.	1.42	1965–67	1967		4.35	180	
					18	4.50	200	(1)
10	Vest Creek near Bladwin	1.64	1963–67	1964		8.08	1,320	
					18	4.24	129	(1)
	Tennessee River basin							
11	Paint Rock River near Woodville.	320	1936–67	1963		22.60	46,700	
					18	20.32	32,300	18
12	Flint River near Chase	342	1930–67	1963		27.55	55,900	
					18	20.97	29,900	12
13	Pinhook Creek at Traylor Island at Huntsville.	21.4			18		5,070	48
14	Broglan Branch at SW Seminole Drive at Huntsville.	9.62			18		1,870	(1)
15	McDonalds Creek at Redstone Arsenal (Gate Eight) at Huntsville.	8.47			18		3,300	(1)
16	Indian Creek near Madison.	49.0	1960–67	1963		10.70	8,170	
					18	10.90	8,650	33
17	Cotaco Creek at Florette.	136	1966–67	1966		12.66	3,170	
					19	12.15	2,600	<2
18	Limestone Creek near Athens.	119	1940–67	1963		15.50	29,000	
					18	12.17	12,000	12
19	Piney Creek near Athens	55.8	1959–67	1963		13.38	12,900	
					18	9.81	5,930	7
20	Flint Creek near Falkville	86.3	1953–67	1961		15.77	12,200	
					18	13.29	4,800	2
21	West Flint Creek near Oakville.	87.6	1953–67	1957		21.3	4,210	
					18	23.32	5,120	2
22	Big Nance Creek at Courtland.	166	1936–40, 1946–67.	1950		22.60	12,300	
					19	21.09	8,560	3
23	Bear Creek near Hackleburg.	143	1957–67	1962		28.88	15,500	
					18	27.90	13,800	50
24	Bear Creek near Red Bay	263	1914–20, 1959–67	1961		16.66	15,300	
					19	17.61	17,200	28
25	Cedar Creek near Pleasant Site.	189	1948, 1951, 1955, 1957–67	1955		[2] 24.4	13,000	
					19	16.68	5,990	2
26	Little Bear Creek near Halltown.	78.2	1951, 1955, 1957–67	1955		[2] 13.7	6,800	
					18	12.05	4,340	5
27	Bear Creek at Bishop	667	1926–27, 1929–31, 1934–67	1926		22.0	32,000	
				1955		21.98	37,000	
					19	15.91	11,400	2

[1] Unknown.
[2] Based on flood profile furnished by the Tennessee Valley Authority.

FLOODS OF DECEMBER 19–23, IN CENTRAL AND SOUTHERN ARIZONA

By B. N. Aldridge

On December 19 and 20, warm rain fell on moist snow in central and southern Arizona and caused floods in several small areas (fig. 47). Peak discharges in parts of the Santa Cruz River basin were the greatest since the early 1900's. Less severe flooding occurred in the Cave Creek and Agua Fria River basins near Phoenix. Flooding occurred south of Nogales, Sonora, in Mexico, but little is known about these floods, except that several highways and railroads were washed out, and many persons were marooned.

Storms moved into Arizona on December 12–16 and 18–20. The storms brought a substantial amount of snow into much of Arizona. Late on December 18, warm air moved in from the south ahead of a cold front that was advancing eastward from California; the precipitation changed from snow to rain at the lower altitudes. The rain reduced snow depths in some areas, and a shallow snow cover remained in the Santa Cruz River basin at altitudes of more than 4,000 feet and in the Cave Creek and Agua Fria River basins at altitudes of more than 3,000 feet. Residents reported 8–12 inches of snow on the mountains northwest of Nogales, on December 19. Rainfall intensity increased on December 19, and rain fell at altitudes to about 5,500 feet in the Santa Cruz River basin; the amount of precipitation on December 19 ranged from 1 to 3 inches, most of it fell in a 5- to 6-hour period.

The Santa Cruz River heads in the United States, flows southward into Mexico, thence westward and northwestward, and returns to the United States 5 miles east of Nogales, Ariz. (fig. 47). Although the peak discharge at the gaging station near Lochiel, Ariz. (sta. 1), was large for December, it was much less than those that have occurred during summer floods (table 33). The magnitude of the peak increased gradually until it reached San Lazero, Sonora (near sta. 2), and increased rapidly downstream from there. Large amounts of inflow were contributed by three ungaged tributaries that enter the Santa Cruz River from the south about 4½ miles downstream from San Lazero. One of these tributaries, which has a drainage area of about 25 square miles, carried more water than the Santa Cruz River above the tributaries with 337 square miles of drainage area. Other tributaries in Mexico that have drainage areas extending above an altitude of about 4,500 feet contributed to the flood, but to a much smaller degree.

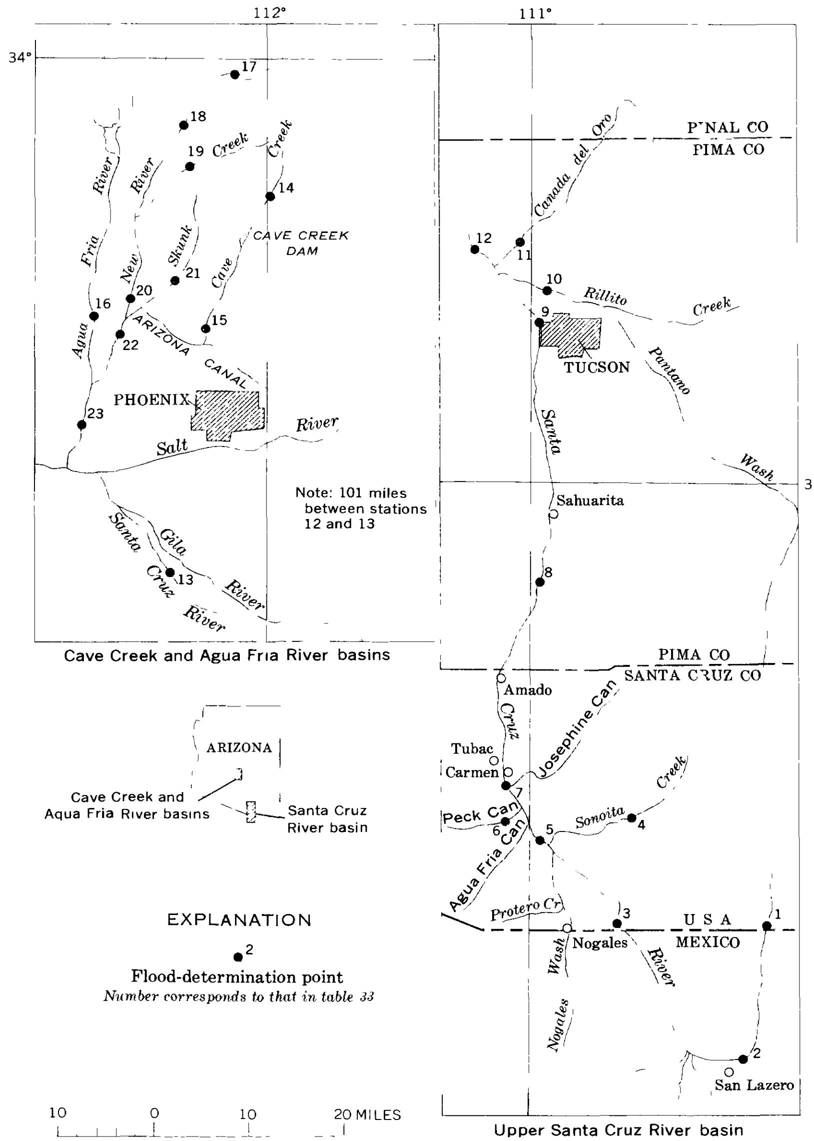

FIGURE 47.—Flood area and location of flood-determination points, floods of December 19–23, in central and southern Arizona

TABLE 33.—*Flood stages and discharges, December 19–23, in the Gila River basin in central and southern Arizona*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before December 1967 Period	Known before December 1967 Year	December 1967	Gage height (feet)	Discharge Cfs	Discharge Recurrence interval (years)
1	Santa Cruz River near Lochiel, Ariz.	82.2	1949–67	1965		8.90	4,810	
					20	4.53	986	1
2	Santa Cruz River at El Cajon, Sonora, Mexico.	303	1954–67	1955		6.00	4,590	
					20	4.0	1,500	2
3	Santa Cruz River near Nogales, Ariz.	533	[1] 1930–67	1935			12,000	
				1955		13.71		
					20	13.5	15,200	50
4	Sonoita Creek near Patagonia, Ariz.	209	1930–67	1946		13.0	14,000	
					20	10.38	5,410	3
5	Santa Cruz River 1½ miles below Sonoita Creek, near Nogales, Ariz.	1,004			20		17,500	40
6	Peck Canyon at mouth, near Nogales, Ariz.	47.8			20		7,000	[2] 1.3
7	Santa Cruz River at Tumacacori, Ariz.	1,178			20		28,500	[2] 1.4
8	Santa Cruz River at Continental, Ariz.	1,662	1940–46, 1952–67	1955		15.3	17,500	
					20	15.3	18,000	18
9	Santa Cruz River at Tucson, Ariz.	2,222	1905–67	1961		21.30	16,600	
					20	17.24	16,100	15
10	Rillito Creek near Tucson, Ariz.	892	1909–67	1929		[3] 24.	24,000	
					20	6.72	7,100	6
11	Canada del Oro near Tucson, Ariz.	250	1965–67	1965		4.53	2,290	
					19	7.65	13,900	38
12	Santa Cruz River at Cortaro, Ariz.	3,503	1940–47, 1950–67	1940		[3] 9.9	17,000	
					21	12.17	15,800	8
13	Santa Cruz River near Laveen, Ariz.	8,581	1940–46, 1948–67.	1962		17.50	9,200	
					23	15.98	3,820	8
14	Cave Creek near Cave Creek, Ariz.	121	1958–67	1959		8.47	8,570	
					19	8.62	12,400	88
15	Cave Creek at Phoenix, Ariz.	[4] 252	1921–67	1921			25,000	
					19	4.30	4,080	[5] 30
16	Agua Fria River at El Mirage, Ariz.	[6] 1,637	1963–67	1966		4.09	2,900	
					19	4.05	3,200	[6] 10
17	New River near Rock Springs, Ariz.	67.3	1962–67	1964		6.3	4,900	
					19	8.3	10,600	23
18	New River at New River, Ariz.	85.7	1961–67	1963		7.33	4 620	
					19	9.12	12,600	20
19	Deadman Wash near New River, Ariz.	11.1	1959–67	1959		7.0	1,850	
					19	5.52	950	5
20	New River at Bell Road near Peoria, Ariz.	187	1963–67	1965		10.5	4 060	
					19	13.5	14 600	15
21	Skunk Creek near Phoenix, Ariz.	64.6	1952–67	1964		[3] 4.0	11,500	
					19	5.7	5 900	5
22	New River near Glendale Ariz.	323	[7] 1896–1967	1943			[7] 38 000	
					19	6.7	19 800	15
23	Agua Fria River at Avondale, Ariz.	2,013	1959–67	1959		11.0	4 700	
					20	12.7	20,000	([8])

[1] Flood of December 1914 probably exceeded that of December 1967.
[2] Ratio of peak discharge to 50-yr flood.
[3] Site and datum then in use.
[4] Includes 161 sq mi above Cave Creek Dam, which has been virtually noncontributing since 1923; maximum discharge from Cave Creek Dam in December 1967 was 455 cfs on December 20.
[5] Based on size of contributing area.
[6] Includes 1,459 sq mi above Waddell Dam, which has been virtually noncontributing since 1927; does not include 247 sq mi above McMiken Dam, from which flow has been diverted into the Agua Fria River since 1956; maximum release from Waddell Dam in December 1967 was 1,840 cfs on December 20.
[7] From U.S. Army Corps of Engineers.
[8] Not determined.

At Santa Cruz River near Nogales (sta. 3), the peak discharge was the largest during the period of gaging-station record, which started in 1930; however, the flood was less severe than the floods of December 1914 and September 1926. There was virtually no inflow from tributaries between this point and Protero Creek. Moderately large flows were contributed by Nogales Wash and Sonoita Creek; a large flow came from Agua Fria Canyon, and the peak in Peck Canyon was reported by residents to have been the largest known since about 1900. The flood caused considerable erosion in Peck Canyon. According to a resident, there was no evidence of severe erosion prior to the flood; therefore, the December flood may be the largest since much earlier than 1900. Downstream from Peck Canyon to Amado, the peak was the highest known. Although the floods of December 1914 and December 1967 reached about equal stages at Carmen, the channel was larger in 1967 than it was in 1914. The peak discharge at Tucson was the second largest since 1905 and was the largest winter peak since that date. Peak flows at Tucson generally result from summer convective storms, and large winter peaks are rare.

A single flood crest was recorded at gaging stations along the Santa Cruz River upstream from Rillito Creek (fig. 48), but residents stated that there were two distinct crests in the reach immediately downstream from Peck Canyon. The first crest occurred about 3 a.m. on December 20, when peaks from Protero Creek, Peck Canyon, and Agua Fria Canyon reached the river; the second crest occurred about 9 a.m., when flow from Sonoita Creek and the Santa Cruz River reached the mouth of Peck Canyon. A single line of floodmarks remained after the peaks; therefore, the second peak must have been higher than the first.

The Southern Pacific and U.S. Highway 89 run parallel to the Santa Cruz River from Tucson to the mouth of Sonoita Creek. The flood washed out several short sections of railroad, a quarter of a mile of spur track at Sahuarita, 800 feet of U.S. Highway 89 at the mouth of Josephine Canyon, and several footbridges and many grade-level river crossings on farm and county roads. Several homes near Amado were flooded to the eaves, and 32 persons were evacuated by helicopter. The flood eroded large sections of farmland next to the river channel and inundated cropland. The most severe damage was in Santa Cruz County, especially near Tubac. Overbank flooding extended downstream to a point about 4 miles south of Tucson; from there to about the Pima-Pinal County line, the flow was fairly well confined in the main channel. In Pinal County, the river flowed out onto an alluvial plain in a multichannel-distributary system. Many acres of farmland were flooded, and the magnitude of the peak was reduced considerably.

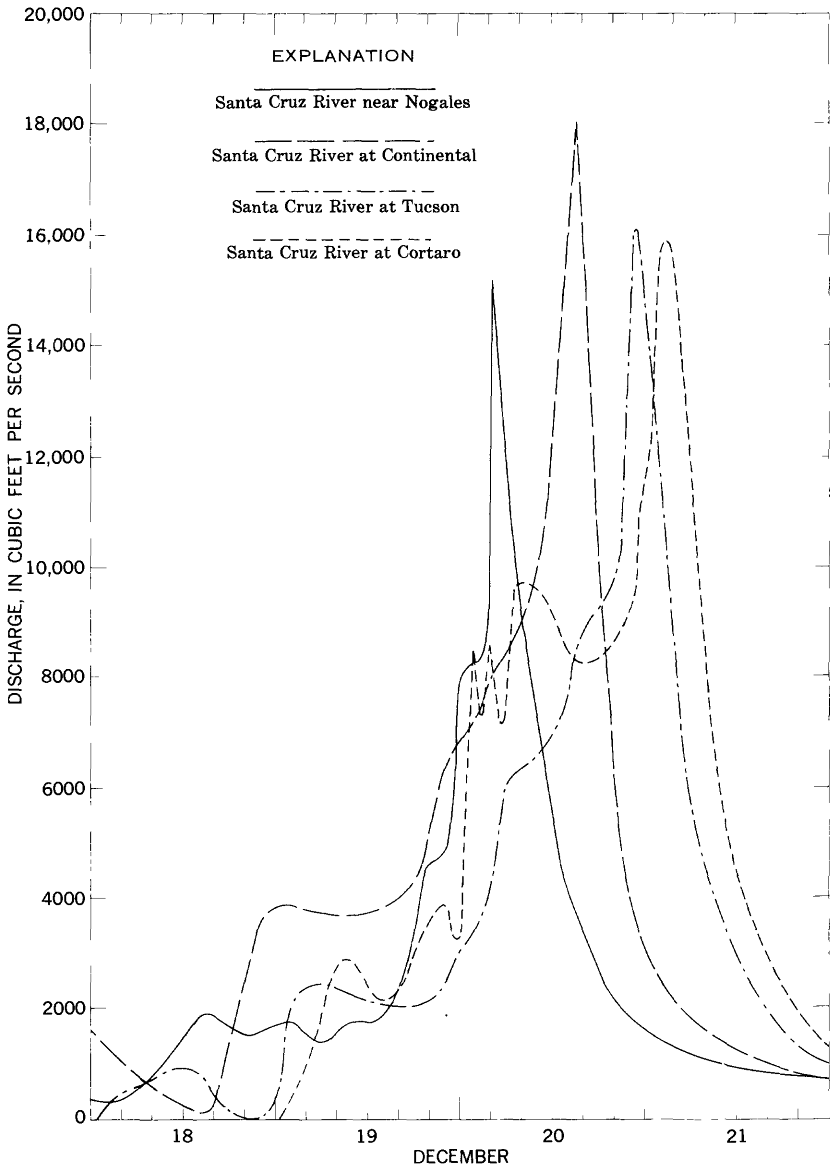

FIGURE 48.—Discharge hydrographs, December 18–21, for selected gaging stations on the Santa Cruz River, floods of December 19–23, in central and southern Arizona.

Unofficial estimates of flood damages along the Santa Cruz River were about $1 million. One person drowned while trying to ford Canada del Oro at Tucson.

The floods along Cave Creek and New River were probably the most severe since 1943. Floodwater from the Cave Creek basin above Cave Creek Dam was stored in the detention reservoir and released at a maximum rate of 455 cfs. The water that reached Phoenix was mostly from the tributaries to Cave Creek below the dam. Water from Cave Creek is usually intercepted by the Arizona Canal, but the flood of December 19 exceeded the capacity of the canal; small amounts of water flowed over the canal into residential areas. Almost all streets crossing the New River or the Agua Fria River in the western suburbs of Phoenix were closed because of floodwater; the two main highways out of Phoenix remained open, but one of these was closed at the Gila River crossing a few miles farther west. Between 200 and 300 persons were evacuated from homes along the New and Agua Fria Rivers. Water was as much as 2 feet deep in some homes, apartment buildings, and schools. Road and highway damage was estimated to be more than $250,000, and damage to private property probably was many thousands of dollars.

REFERENCES CITED

Anderson, D. G., 1968, Floods of August 20 in Fourmile Run, Fairfax County, Va., *in* Rostvedt, J. O., and others, Summary of floods in the United States during 1963: U.S. Geol. Survey Water-Supply Paper 1830–B, p B106–B109.

Benson, M. A., and Dalrymple, Tate, 1967, General field and office procedures for indirect discharge measurements: U.S. Geol. Survey Tech. Water-Resources Inv., book 3, chap. A1, 30 p.

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

Carpenter, D. H., and Simmons, R. H., 1969, Floods of August 1967 in Maryland and Delaware: U.S. Geol. Survey open-file report, 98 p.

Childers, Joseph M., and Meckel, James P., 1967, Flood of August 1967 at Fairbanks, Alaska: U.S. Geol. Survey Hydrol. Inv. Atlas HA–294.

Childers, J. M., Meckel, J. P., and Anderson, G. S., 1971, Floods of August 1967 in east-central Alaska: U.S. Geol. Survey Water-Supply Paper 1880–A (in press).

Corbett, D. M., and others 1943, Stream-gaging procedure, a manual describing methods and practices of the Geological Survey: U.S. Geol. Survey Water-Supply Paper 888, 245 p.

Dalrymple, Tate, and Benson, M. A., 1967, Measurement of peak discharge by the slope-area method: U.S. Geol. Survey Tech. Water-Resources Inv., book 3, chap. A2, 12 p.

Dalrymple, Tate, and others, 1937, Major Texas floods of 1936: U.S. Geol. Survey Water-Supply Paper 816, 146 p.

Gatewood, J. S., 1945, Notable local floods of 1939, part 1, Floods of September 1939 in Colorado River basin below Boulder Dam: U.S. Geol. Survey Water-Supply Paper 967-A, 39 p.

Grozier, R. U., and others, 1968, Floods from Hurricane Beulah in south Texas and northeastern Mexico, September-October 1967: Texas Water Development Board Rept. 83, 197 p.

Hulsing, Harry, 1967, Measurement of peak discharge at dams by indirect methods: U.S. Geol. Survey Tech. Water-Resources Inv., book 3 Chap. A5, 29 p.

Johnson, Hollister, 1936, The New York State flood of July 1935: U.S. Geol. Survey Water-Supply Paper 773-E, p. 233-268.

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

Miller, E. M., and Kapinos, F. P., 1968, Floods of August 24-25, 1967, in the Washington metropolitan area: U.S. Geol. Survey open-file report, 83 p.

Olmstead, F. H., 1919, Gila River flood control—a report on flood control of the Gila River in Graham County, Arizona: U.S. 65th Cong., 3d Sess., S. Doc. 436, 94 p.

Patterson, J. L., and Somers, W. P., 1966, Magnitude and frequency of floods in the United States, part 9, Colorado River basin: U.S. Geol. Survey Water-Supply Paper 1683, 475 p.

Robison, F. L., 1969, Floods in New York—1967: New York Conservation Dept., Water Resources Comm., RI-3, 32 p.

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

Schwob, Harlan H., 1968, Flood of June 7, 1967 in the Wapsinonoc Creek basin, Iowa: U.S. Geol. Survey open-file report, 21 p.

Tracy, H. J., 1957, Discharge characteristics of broad-crested weirs: U.S. Geol. Survey Circ. 397, 15 p.

U.S. Weather Bureau, 1961, Rainfall frequency atlas of the United States: U.S. Weather Bur. Tech. Paper 40, 115 p.

——— 1967, Climatological data (by States): various months, 1967.

Wilson, Kenneth V., 1968, Floods of June 1, 1967, in southwestern Jackson, Mississippi: U.S. Geol. Survey open-file rept., 22 p., 7 figs.

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U.S. GOVERNMENT PRINTING OFFICE: 1972 O—427-151