Summary of Floods in the United States During 1966

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1870-D

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 1966

By J. O. Rostvedt and others

ABSTRACT

This report describes the outstanding floods in the United States during 1966. The four most destructive floods occurred during March–April in the Red River of the North basin in northwestern Minnesota, during April–May in northeastern Texas, in August, in east-central Nebraska, and in December, in the Southwestern United States.

For the second consecutive year, there was severe flooding in the Red River of the North basin in Minnesota during the spring snowmelt period. Unseasonally warm temperature caused rapid melting of a heavy snow cover, with water equivalent ranging from 5 to 7 inches, which covered the northern two-thirds of the basin. Peak discharges were maximum of record at three gaging sites having periods of record ranging from 20 to 30 years, and peak discharges exceeded 50-year floods at nine sites. Damage from the flood was estimated at $10 million.

In the period April 22–29, from 20 to 26 inches of rain fell in parts of the Sabine River basin in northeastern Texas, and high rates of runoff occurred from the headwaters of the Sulphur River southward to the Trinity River basin. Flood damage was estimated at $12 million, and at least 25 persons lost their lives.

Severe floods occurred along the Loup River and its tributaries in east-central Nebraska on August 12–14. The peak discharge at nearly all gaging stations in the flood area exceeded the previous maximum of record. The floods were caused by heavy rains of from 13 to 17 inches in about 24 hours. The storm was the most widespread in the area since 1896 and may have exceeded the area of the 1896 storm. The floods were unusual because of the consistantly high discharges throughout a large flood area. Flood damage was estimated at $11 million.

In early December a storm moved eastward from the Pacific coast in southern California into Southwestern United States. Intense precipitation occurred around the mountain ranges of south-central California and in a band extending from southeastern Nevada across the southwestern corner of Utah to the Grand Canyon and southward to the moutains of central Arizona. Discharges on many streams exceeded the previous maximums known, and the flood was particularly damaging because of the large area involved.

In addition to these four floods, 19 others of lesser magnitude are considered important enough to be included in this annual summary.

INTRODUCTION

This report summarizes information on outstanding floods in the United States during 1966. 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.

Three water-supply chapters, 1870–A, "Floods of December 1966 in southwestern Utah"; 1870–B, "Floods of April 28, 1966, in the northern part of Dallas, Texas"; and 1870–C, "Floods of December 1966 in the Kern-Kaweah area, Tulare and Kern Counties, California," are special reports that describe floods in detail in their respective areas. The areas for which flood reports have been prepared for 1966 are shown in figure 1. The areas discussed in chapters A–C are indicated by a stippled pattern, and other areas discussed in this summary chapter are shown by a line pattern. The months in which the floods occurred are shown; the map thereby gives both the location and the time distribution of floods during the year.

A flood may be defined as any abnormally high streamflow that overtops natural or artificial banks of a stream; a great number of these events occur that 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 flood flows 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.

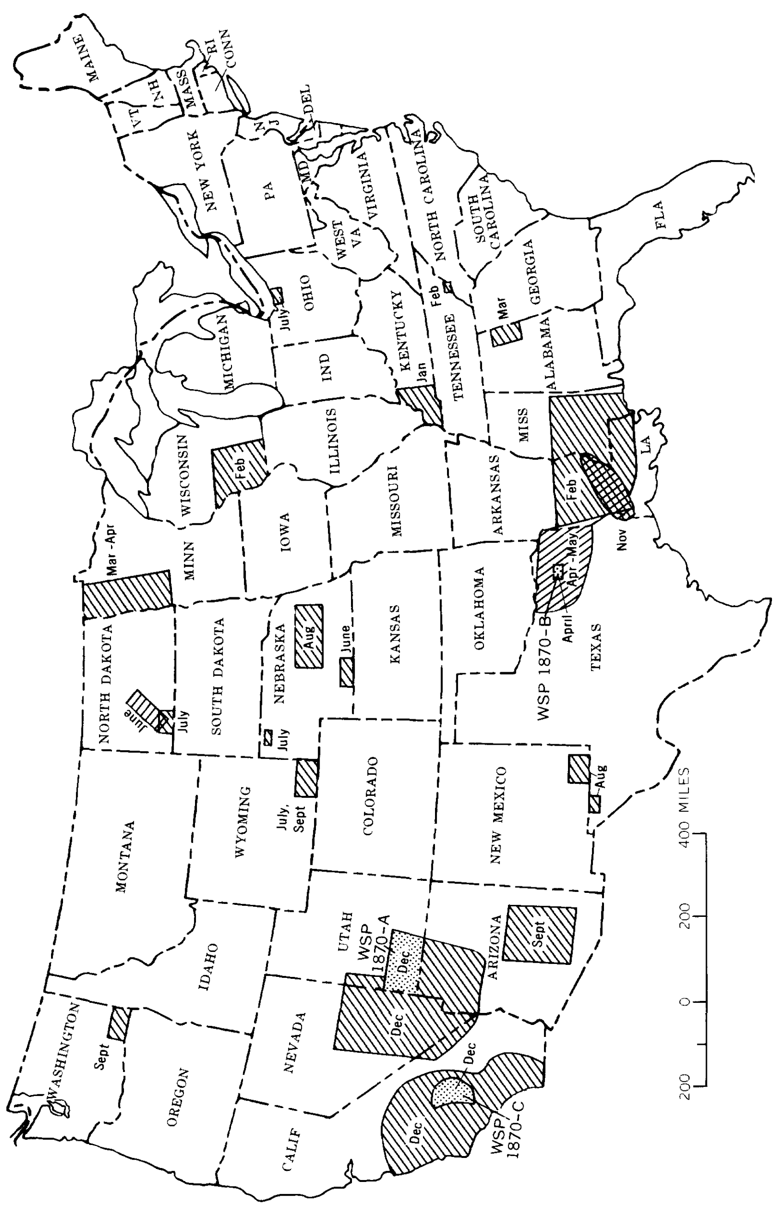

FIGURE 1.—Areas and months of occurrence of outstanding floods in 1966 in the conterminous United States. Stippled pattern indicates the areas for which special reports were prepared.

According to ESSA Weather Bureau data, losses from floods in the United States during 1966 ($150 million) were only 19 percent of those in 1965 ($788 million) and 23 percent of those in 1964 ($652 million); they were about 44 percent of the national annual average of $340 million, based on the 10-year period, 1951–60, adjusted to the 1960 price index.

The number of lives lost owing to floods in 1966 was 50 compared with 119 in 1965 and 100 in 1964, and was considerably less than the national annual average of 80 lives lost during the 41-year period, 1925–65.

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).

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 U.S. Bureau of Reclamation, and other Federal or local agencies. Some data were obtained from U.S. Weather Bureau publications.

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

DETERMINATION OF FLOOD STAGES AND DISCHARGES

Data of peak stages and peak discharges at discharge stations in this report are those which 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 about the range of the computed stage-discharge relation, short extensions may be made to the graph of relation by logarithmetic extrapolation, by velocity-area studies, or by use of other measurable hydraulic factors.

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

EXPLANATION OF DATA

The floods are described in chronological order. Because the type and the amount of information differ for the floods, no consistent form 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 1966 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 is 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 1966 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 1966 flood.

The last column gives the recurrence interval for the 1966 peak discharge. The recurrence interval is the average interval, in years, in which a flood of a given magnitude (the 1966 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 1966

FLOODS OF JANUARY 2-3, IN WESTERN KENTUCKY

By C. H. Hannum

In Kentucky, temperatures in December 1965 were relatively mild, and precipitation was the lowest recorded by many ESSA Weather Bureau stations, some with records going back 50–80 years. Rainfall in the last 10 days of December, ranged from 0.08 inch at Benton to 0.58 inch at Bardwell, in western Kentucky. These were the antecedent conditions prior to the start of heavy rainfall late in the night of December 31 that continued into January 3, 1966. The heaviest rain fell on January 1–2 along a line from Hickman to Benton. Hickman reported 9.80 inches of rain, Mayfield 10.16 inches, and Benton 7.98 inches. Figure 2 shows isohyets for the 2-day period, January 1–2.

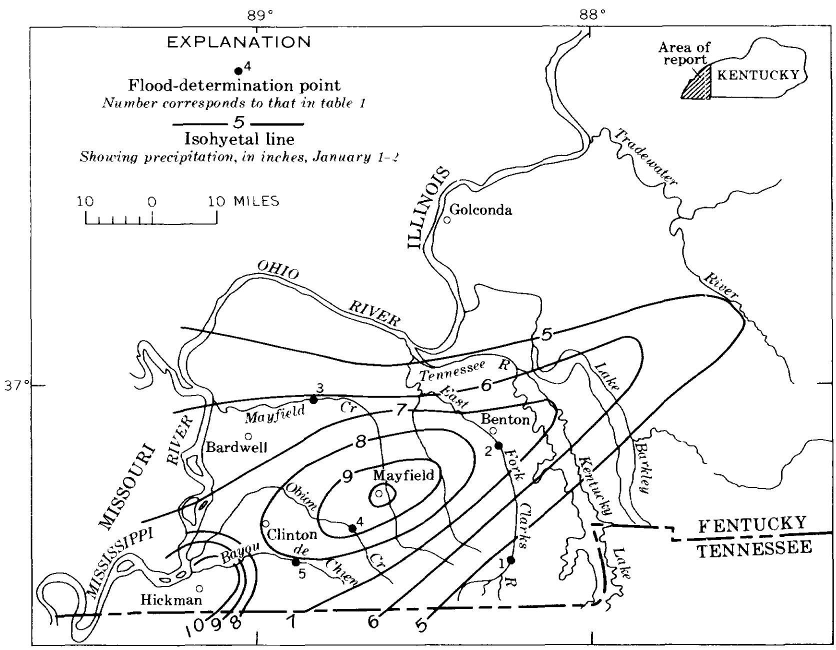

FIGURE 2.—Flood area, location of flood-determination points, and isohyets for January 1–2, floods of January 2–3, in western Kentucky.

Severe flooding occurred in the Obion Creek and Bayou du Chien basins. The peak discharge of 5,250 cfs (cubic feet per second) at the gaging station on Obion Creek at Pryorsburg (table 1, sta. 4) was the second highest for the period of record (1949, 1951–66) and almost equaled the previous maximum; it had a recurrence interval of 50 years. The peak discharge at the gaging station on Bayou du Chien near Clinton (sta. 5) was 9,460 cfs, which was 1.2 times that of the 50-year flood and was the greatest for the period of record (1939–66).

Discharge at gaging stations north and east of these two stations, and outside the area of the heaviest rainfall, were of much less magnitude and frequency (table 1).

TABLE 1.—*Flood stages and discharges, January 2–3, in western Kentucky*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before January 1966: Period	Year	January 1966	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
	Tennessee River basin							
1	East Fork Clarks River at Murray	89.7	1951–66	1952, 1957		15.20	32,300	
					2	10.79	3,680	3
2	East Fork Clarks River near Benton.	227	1937–66	1937		17.8	(1)	
			1938–66	1957		17.10	36,000	
					2	14.26	10,800	8
	Mayfield Creek basin							
3	Mayfield Creek at Lovelaceville	212	1937–66	1937		21.1	19,800	
					3	19.92	13,300	21
	Obion Creek basin							
4	Obion Creek at Pryorsburg	36.8	1949–66	1949		13.0	(1)	
			1951–66	1957		12.60	5,330	
					2	13.08	5,250	50
	Bayou du Chien basin							
5	Bayou du Chien near Clinton	68.7	1939–66	1951		15.0	6,880	
					2	15.99	9,460	[2] 1.2

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

FLOODS OF FEBRUARY 8–13, IN SOUTHWESTERN WISCONSIN

By DONALD C. HURTGEN

Runoff from snowmelt combined with substantial rain on February 8–10 caused high stages on many streams in southwestern Wisconsin. Snow depths in early February in this area ranged from 3 to 8 inches (fig. 3) with a water equivalent of nearly 0.5 inch. Frost depth averaged 12–18 inches.

The Kickapoo River which meanders through high bluffs and narrow valleys was affected the most. The rainfall in the upper reaches of the basin averaged more than 1.5 inches on February 8–10. Maximum temperatures were near 50°F, and overnight minimums were above

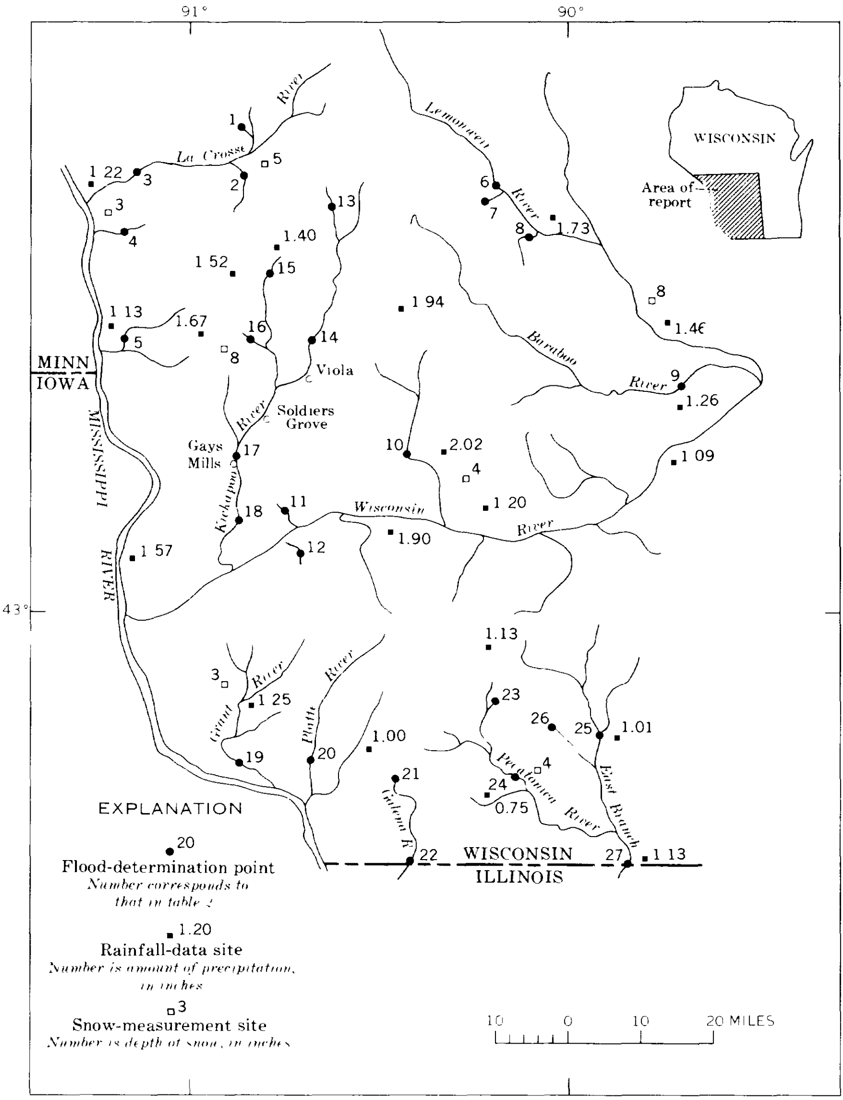

FIGURE 3.—Flood area, location of flood-determination points, rainfall data sites, and depth of snow on the ground, prior to February 8, floods of February 8–13, in southwestern Wisconsin.

freezing. The runoff from the melted snow and the rainfall reached the streams quickly and caused the ice cover on the river to breakup. Ice jams were created at many channel constrictions and threatened low bridges and buildings on the flood plain.

A peak flow of 9,910 cfs with an accompanying gage height of 13.67 feet was registered on Kickapoo River at La Farge (table 2, sta. 14) on February 9. This peak exceeded the previous maximum by nearly 3,000 cfs and had a recurrence interval exceeding 50 years. Peaks at Gays Mills (sta. 17) and Steuben (sta. 18), farther downstream, were near maximum and were of 25- and 20-year recurrence intervals, respectively.

Although most of the Kickapoo valley floor was inundated, damage was confined to flooded basements and ground floors of buildings in the villages of Viola, Soldiers Grove, and Gays Mills. Water flowing over low roads caused some washouts.

Other streams in southwestern Wisconsin had high peaks, but no new records were established. La Crosse River near West Salem (sta. 3) had the second highest peak in the 53 years of record. The discharge in Baraboo River near Baraboo (sta. 9) exceeded the flood of 1935 but was considerably less than that of the record peak of 1917. Peak discharges on the Grant, Platte, and Pecatonica Rivers were well below their record peaks of July 1950. Stages and discharges at crest gages on small basins in the area were also high.

TABLE 2.—*Flood stages and discharges, February 8–10, in southwestern Wisconsin*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before February 1966 — Period	Maximum floods: Known before February 1966 — Year	February 1966	Gage height (feet)	Discharge: C's	Discharge: Recurrence interval (years)
	La Crosse River basin							
1	Beaver Creek near Sparta	1.72	1959–66	1959		13.19	[1]	
					8	12.72	[1]	[1]
2	Little La Crosse River near Leon	77.1	1934–66	1935		14.43	4 620	
					9	9.25	2,150	6
3	La Crosse River near West Salem	398	1914–66	1935		12.2	8 200	
					8	11.29	5,940	5
	Mormon Creek basin							
4	Mormon Creek near La Crosse	25.5	1961–66	1965		11.71	[1]	
					8	11.35	[1]	
	Bad Axe River basin							
5	North Fork Bad Axe River near Genoa.	80.7	1959–66	1959		19.59	3,500	
					9	16.79	2,400	[1]

See footnotes at end of table.

TABLE 2.—*Flood stages and discharges, February 8–10, in southwestern Wisconsin*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before February 1966: Period	Maximum floods: Known before February 1966: Year	Maximum floods: February 1966	Maximum floods: Gage height (feet)	Maximum floods: Discharge: Cfs	Maximum floods: Discharge: Recurrence interval (years)
	Wisconsin River basin							
6	Lemonweir River at New Lisbon	500	1944–66	1960		12.94	6,880	
					12	10.70	1,700	<2
7	Webster Creek at New Lisbon	11.6	1961–66	1965		14.37	425	
					8	14.75	520	(1)
8	One Mile Creek near Mauston	30.4	1958–66	1962		16.36	(1)	
					8	16.37	(1)	
9	Baraboo River near Baraboo	600	1913–22, 1935, 1942–66.	1917		[2] 17.5	7,900	
					13	[3] 22.68	5,900	20
10	Rocky Branch near Richland Center.	1.71	1958–66	1965		15.12	407	
					8	13.4	(1)	
11	Richland Creek near Plugtown	19.1	1958–66	1959		17.02	(1)	
					8	16.44	650	(1)
12	Crooked Creek near Boscobel	13.1	1959–66	1964		18.21	2,460	
					8	12.70	(1)	
13	Morris Creek tributary near Norwalk.	4.67	1960–66	1959		13.10	950	
					8	11.71	460	(1)
14	Kickapoo River at La Farge	266	1939–66	1961		12.70	7,040	
					9	13.67	9,910	[4] 1.30
15	Knapp Creek near Bloomingdale	8.47	1954	1954		10.5	(1)	
			1955–66	1959		8.76	3,710	
					9	4.32	749	2
16	Bishops Branch near Viroqua	7.08	1959–66	1959		13.64	(1)	
					9	12.23	1,250	(1)
17	Kickapoo River at Gays Mills	616	1914–34, 1961, 1964–66.	1961		16.37	12,300	
					10	16.00	10,600	25
18	Kickapoo River at Steuben	690	1933–66	1961		12.33	10,800	
					10	[3] 12.82	10,400	20
	Grant River basin							
19	Grant River at Burton	267	1935–66	1950		24.82	25,000	
					8	[3] 23.03	12,500	4
	Platte River basin							
20	Platte River near Rockville	139	1935–66	1950		17.26	43,500	
					9	10.47	4,510	2
	Galena River basin							
21	Pats Creek near Elk Grove	8.49	1960–66	1960		13.77	(1)	
					8	[3] 12.72	(1)	
22	Galena River at Buncombe	128	1937	1937		17.1	18,000	
			1940–66	1953		15.68	12,400	
					8	12.90	4,000	2
	Rock River basin							
23	Rock Branch near Mineral Point	5.04	1959–66	1960		16.14	1,160	
					8	12.45	315	(1)
24	Pecatonica River at Darlington	274	1940–66	1950		20.71	22,000	
					9	[3] 16.00	5,000	
25	East Branch Pecatonica River near Blanchardville.	221	1940–66	1948		15.74	11,700	
					9	[3] 14.71	4,500	8
26	Yellowstone River near Blanchardville.	29.1	1954–66	1960		10.47	2,240	
					8	9.51	1,750	30
27	Pecatonica River at Martintown	1,040	1940–66	1959		20.23	14,200	
					12	[3] 17.47	5,600	<2

[1] Not determined.
[2] At site 2.3 miles upstream at datum 7.6 ft higher.
[3] Affected by backwater from ice.
[4] Ratio of peak discharge to 50-yr flood.

FLOODS OF FEBRUARY 9-15, IN LOUISIANA

By Braxtel L. Neely, Jr.

Warm, moist air flowing from the Gulf of Mexico brought rains on February 9-17 over Louisiana (fig. 4). During this 9-day period more than 10 inches of rainfall was recorded at each of 28 ESSA Weather Bureau rain gages. The greatest amount of rainfall recorded was 14.57 inches at Amite. The second highest amount was 13.33 inches at Leesville, of which 11 inches fell in 1 day. The 11 inches at Leesville is a record 1-day precipitation for the month of February in Louisiana. The isohyets on figure 4 indicate that heavy rain fell over the entire State.

The heavy rains caused streams at 15 gaging stations to reach a maximum stage or discharge, or both, for the period of record (table

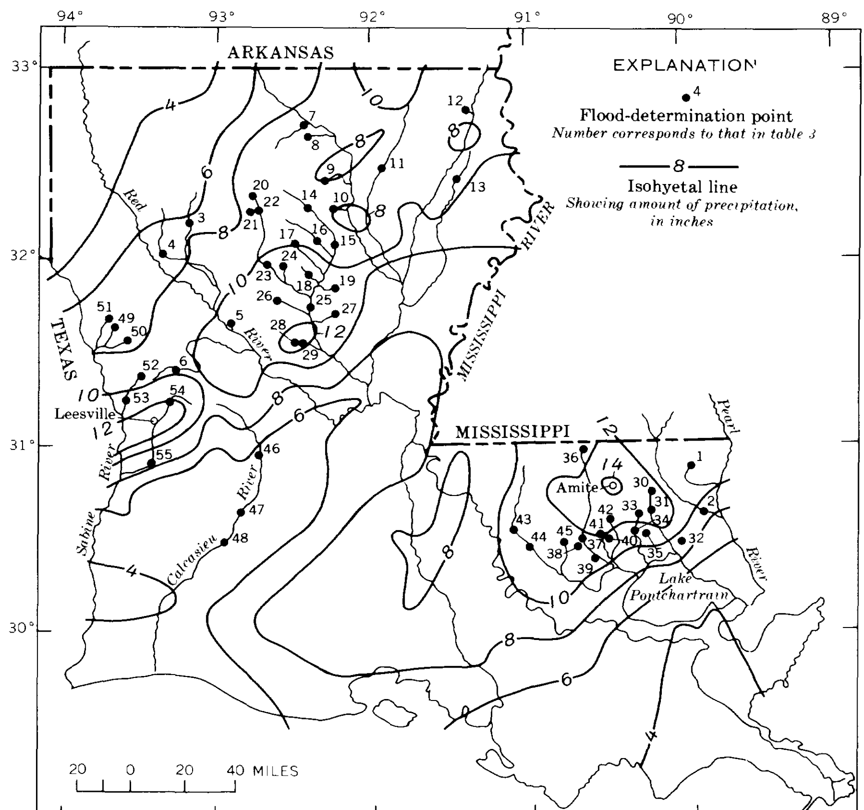

Figure 4.—Flood area, location of flood-determination points, and isohyets for February 9-17, floods of February 9-15, in Louisiana.

3). The recurrence interval of the floods on two streams exceeded 50 years. The discharge of Big Creek at Pollock (sta. 29) was 2.95 times the 50-year flood, and the discharge of Nantachie Creek near Montgomery (sta. 5) was 1.05 times the 50-year flood. The stations listed in table 3 are only those that had floods with recurrence intervals of 4 or more years.

TABLE 3.—*Flood stages and discharges, February 9–15, in the Pearl River basin in Louisiana*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before February 1966 — Period	Known before February 1966 — Year	February 1966	Gage height (feet)	Discharge — Cfs	Discharge — Recurrence interval (years)
1	Boque Lusa Creek near Franklinton	12.1	1948–66	1962		12.63	9,750	
					12	9.70	2,300	9
2	Boque Chitto near Bush	1,210	1937–66	1961		17.04	57,000	
					14	14.15	32,200	4
3	Castor Creek at Castor	27.9	1954–66	1955		48.70	(1)	
					10	48.05	1,600	4
4	Grand Bayou near Coushatta	93.9	1956–66	1958		11.47	7,920	
					11	9.93	3,600	5
5	Nantachie Creek near Montgomery	47	1942–66	1953		14.63	10,500	
					10	12.77	6,940	[2] 1.05
6	Little Sandy Creek at Kisatchie	21.4	1949–66	1953		15.36	5,880	
					9	14.50	5,320	23
7	Stowe Creek near Farmerville	29.0	1954–66	1956		46.38	(1)	
					10	47.61	(1)	
8	Bayou D'Arbonne tributary near Downsville.	.18	1957–66	1958		17.82	92	
					9	19.24	138	(1)
9	North Cheniere Creek at Cheniere	38	1954–66	1955		45.89	(1)	
					10	44.83	(1)	
10	Cypress Creek near Vixen	16	1954–66	1961		47.70	(1)	
					10	48.18	(1)	
11	Bayou Lafourche near Crew Lake	[3] 361	1938–66	1947		28.72	(1)	
				1958			26,800	
					14	27.55	24,800	(1)
12	Lyon Bayou at Forest	9.79	1954–66	1955		47.30	(1)	
					10	47.53	(1)	
13	Bayou Macon near Delhi	[3] 782	1882	1882		37.5		
			1935–66	1958		26.00		
				1965			7,510	
					13	22.88	9,050	(1)
14	Castor Creek at Chatham	60.0	1950–66	1953		46.09	5,150	
					10	46.25	5,420	12
15	Castor Creek near Grayson	271	1940–66	1947		16.25	21,200	
					12	14.17	10,600	5
16	Beaucoup Creek near Cotton Plant.	127	1951–66	1953		13.18	(1)	
					10	12.11	(1)	
17	Flat Creek near Sikes	41.5	1951–66	1953		12.56	(1)	
					10	11.57	(1)	
18	Beech Creek near Olla	58	1954–66	1958		44.46	(1)	
					10	44.18	(1)	
19	Chickasaw Creek near Olla	47.6	1954–66	1954		41.08	(1)	
					10	43.22	(1)	
20	Dugdemona River near Quitman	117	1964–66	1965		40.15	1,080	
					10	44.49	6,300	5
21	Little Dugdemona River near Hodge.	20	1964–66	1965		44.89	(1)	
					10	46.40	(1)	
22	Dugdemona River near Jonesboro	347	1938–66	1945		19.87	30,600	
					11	18.10	19,400	20
23	Dugdemona River near Winnfield	654	1939–66	1953		23.78	27,100	
					13	21.79	19,500	5
24	Brushy Creek near Joyce	24	1964–66	1965		43.07	(1)	
					10	44.91	(1)	
25	Little River near Rochelle	1,880	1957–66	1958		37.32	31,900	
					13	39.22	44,700	7
26	Bear Creek near Packton	11	1954–66	1958		48.29	(1)	
					10	46.79	1,620	8
27	Bayou Funny Louis near Trout	92	1939–66	1953		23.26	32,700	
					10	19.62	9,120	30

See footnotes at end of table.

TABLE 3.—*Flood stages and discharges, February 9–15, in the Pearl River basin in Louisiana*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before February 1966: Period	Known before February 1966: Year	February 1966	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
28	Dyson Creek near Pollock	12	1964–66	1965		42.29	(1)	
					10	45.12	(1)	
29	Big Creek at Pollock	51	1942–66	1953		18.03	23,500	
					10	17.50	20,500	[2] 2.95
30	Tchefuncta River near Franklinton.	53.1	1949–66	1962		47.29	(1)	
					13	46.18	(1)	
31	Tchefuncta River near Folsom	95.5	1943–66	1953		22.26	29,200	
					13	20.48	9,140	9
32	Bogue Faloya at Covington	88.2	1964–66	1964		19.66	8,460	
					13	17.77	6,720	5
33	Chappepeela Creek southeast of Loranger.	91.0	1964–66	1964		12.26	(1)	
					13	11.70	6,500	9
34	Tangipahoa River at Robert	646	1921	1921		27.1	(1)	
			1938–66	1953		23.12	50,500	
					14	20.11	30,800	24
35	Washley Creek near Robert	25.3	1951–66	1953		13.25	(1)	
					13	10.67	2,120	4
36	Tickfaw River at Liverpool	89.7	1956–66	1961		11.58	8,600	
					13	10.36	6,460	9
37	Tickfaw River at Holden	247	1940–66	1962		19.75	14,500	
					14	19.00	12,900	10
38	Hog Branch near Doyle	110	1951–66	1953		22.77	15,100	
					14	18.67	11,200	44
39	Blood River near Springfield	26.6	1964–66	1965		15.32	1,490	
					13	17.41	2,100	4
40	Natalbany River at Baptist	79.5	1943–66	1953		19.73	9,550	
					13	15.36	4,380	4
41	Little Natalbany River at Albany	40.6			13	25.03	3,520	7
42	Ponchatoula Creek at Natalbany	13.8	1951–66	1964		11.95	2,300	
					13	10.14	1,770	7
43	Comite River near Comite	284	1944–66	1953		28.64	(1)	
				1962			20,900	
					12	16.94	13,200	8
44	Amite River near Denham Springs	1,280	1921	1921		35.4	(1)	
			1938–66	1953		32.46	67,000	
					13		39,700	11
					14	28.90		
45	Colyell Creek at Livingston	20.7	1951–66	1953		11.86	4,950	
					14	8.19	1,720	4
46	Calcasieu River near Glenmora	499	1943–66	1953		21.55	59,900	
					12	20.29	47,100	42
47	Calcasieu River near Oberlin	753	1922–25, 1938–66.	1953		26.53	72,800	
					14	23.07	42,400	10
48	Calcasieu River near Kinder	1,700	1922–25, 1938–57, 1961–66.	1953		32.00	182,000	
					15	21.85	49,200	4
49	Bayou Scie at Zwolle	45.9	1950–66	1950		15.82	(1)	
					10	13.48	5,600	11
50	Harpoon Bayou at Many	22.7	1951–66	1961		14.13	(1)	
					9	13.85	(1)	
51	Bayou La Nana near Zwolle	130	1955–66	1961		22.50	9,160	
					10	23.05	9,300	8
52	Bayou Toro near Florien	78.6	1950–66	1953		50.54	18,500	
					10	47.68	8,800	15
53	Bayou Toro near Toro	148	1955–66	1961		24.24	20,500	
					10	23.45	16,800	23
54	Prairie Creek near Leesville	40.0	1949–66	1953		47.68	(1)	
					10	47.24	(1)	
55	Bayou Anacoco near Rosepine	369	1951–66	1953		28.38	64,300	
					11	26.05	43,400	15

NOTE.—Computations of recurrence intervals were based on the report, "Floods in Louisiana, Magnitude and Frequency," 2d ed., by Sauer (1964).

[1] Not determined.
[2] Ratio of peak discharge to 50-yr flood.
[3] Indefinite because of interchange of flows between basins.

FLOODS OF FEBRUARY 10–18, IN SOUTHERN MISSISSIPPI

By Carney P. Humphreys, Jr.

February 1966 was one of the wetter Februarys in the records of Mississippi according to the ESSA Weather Bureau. New maximum records of monthly rainfall and 24-hour rainfall were established at a number of rainfall-recording stations in the State. The heaviest rains of the month fell in a period of less than 24 hours on the 9th and 10th, and rains continued through the 16th. On February 9–10 (fig. 5), rainfall exceeded 9 inches in an area just north of Vicksburg. Such a rain in less than 24 hours is most unusual, as a rainfall of 9.5 inches in 24 hours has a frequency of 100 years, according to the U.S. Weather Bureau (1961).

The heavy rains caused rivers and their tributaries to rise, and flash floods on some small streams damaged bridges and highways.

On February 10, extreme floods occurred on streams draining between 10 and 200 square miles, principally in the Black River basin northeast of Vicksburg. The flood-producing rainfall, 7 inches in 12 hours (of which 6 in. fell in 8 hr) has a recurrence interval exceeding 50 years. Some unusual floods occurred; the most severe were on streams draining about 30 square miles. The peak discharge of Wallsheba Creek at State Highway 433, 5 miles northeast of Bentonia (sta. 17) was 10,500 cfs (table 4). This peak exceeded the 50-year flood from this 36-square-mile drainage area. Cypress Creek at the county highway 7 miles northeast of Bentonia (sta. 16) had a peak discharge of 8,100 cfs from its 32-square-mile drainage area. Big Cypress Creek (drainage area, 89.3 sq mi) at the county highway 1¾ miles north of Vaughn (sta. 15) peaked at 15,800 cfs. All these peak discharges were greater than those expected once in 50 years on an average. Hatcher Bayou at the county highway 2 miles south of Vicksburg (sta. 11) crested at 14,500 cfs (12-yr flood) from its 32.8-square-mile drainage area. Clear Creek near Bovina (sta. 19) (drainage area, 36 sq mi) peaked at 9,110 cfs, a 9-year flood.

In the southern and southeastern parts of the State, moderate flooding was due to periods of rainfall that extended to February 17. On that day, Tallahala Creek near Runnelstown (sta. 3) reached a crest discharge of 16,700 cfs, an 8-year flood. Floods on Bowie Creek near Hattiesburg (sta. 1) and on the Leaf and Chickasawhay Rivers had recurrence intervals of 5 years or less. Pascagoula River at Merrill (sta. 5) reached a crest discharge of 105,000 cfs, which has a frequency of 8 years. Pearl River near Bogalusa (sta. 6) crested at 61,300 cfs, an 8-year flood. In the lower Pearl River basin, floods on Union and McGees Creeks near Tylertown were also of moderate magnitude.

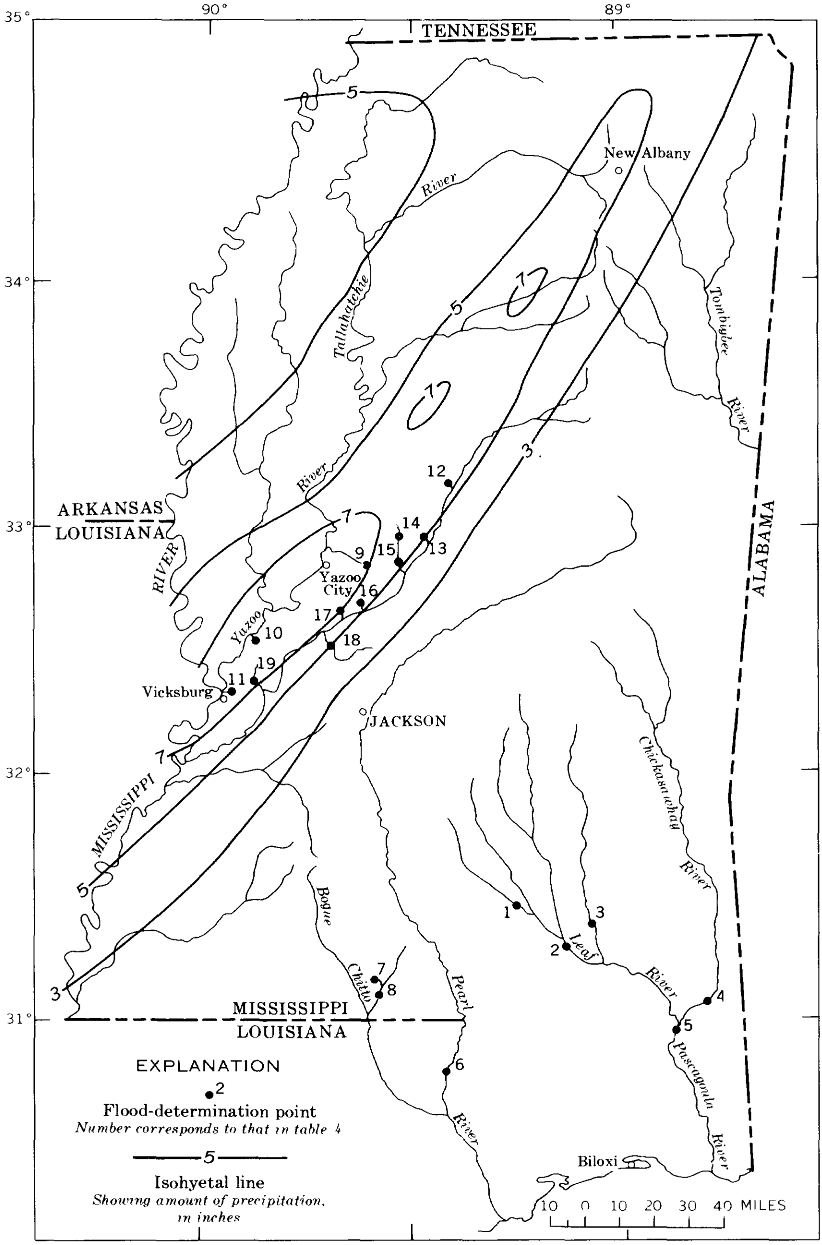

FIGURE 5.—Flood area, location of flood-determination points, and isohyets for February 9–10, floods of February 10–18, in southern Mississippi.

TABLE 4.—*Flood stages and discharges, February 10–18, in southern Mississippi*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before February 1966, Period	Known before February 1966, Year	February (1966)	Gage height (feet)	Discharge, Cfs	Discharge, Recurrence interval (years)
	Pascagoula River basin							
1	Bowie Creek near Hattiesburg	304	1938–66	1961		26.92	34,800	
					13	19.91	9,120	5
2	Leaf River at Hattiesburg	1,760	1900	1900		33.6	(1)	
			1904–66	1919		[2] 25.3	87,900	
					18	25.24	34,300	3
3	Tallahala Creek near Runnelstown.	612	1900	1900		30.5	(1)	
			1939–66	1961		25.07	32,800	
					17	20.20	16,700	8
4	Chickasawhay River at Leakesville.	2,680	1900	1900		38	(1)	
			1939–66	1961		33.52	73,600	
					20	29.02	34,900	5
5	Pascagoula River at Merrill	6,600	1900	1900		32.5	(1)	
			1905–66	1916		31.0	187,000	
					18, 19	26.01	105,000	8
6	Pearl River near Bogalusa	6,630	1938–66	1961		21.70	88,200	
					17	20.58	61,300	8
7	Union Creek near Tylertown	12.6	1952–66	1953		19.2	12,800	
					13	16.12	1,820	6
8	McGees Creek at Tylertown	151	1951–66	1955		26.54	12,400	
					13	23.61	6,930	5
	Yazoo River basin							
9	Short Creek tributary near Yazoo City.	1.49	1964–66	1964		8.50	850	
					10	9.47	1,020	(1)
10	Ballground Creek near Ballground.	18.8			10	108.1	9,500	13
	Hatcher Bayou basin							
11	Hatcher Bayou near Vicksburg	32.8	1962–66	1962		107.4	11,400	
					10	108.0	14,500	12
	Big Black River basin							
12	Jordan Creek near West	15.2	1949–66	1951		300.2	4,100	
					10	299.5	3,000	10
13	Tacketts Creek tributary near Pickens.	.17	1964–66	1964		4.72	86	
					10	5.52	126	(1)
14	Big Cypress Creek near Ebenezer	33.5			10	294.2	8,200	15
15	Big Cypress Creek near Vaughn	89.3	1960–66	1961		213.72	6,750	
					10	215.86	15,800	>50
16	Cypress Creek near Bentonia	32			10	36.04	8,100	>50
17	Wallsheba Creek near Bentonia	36			10	191.9	10,500	>50
18	Bogue Chitto near Flora	127	1952–66	1953		20.88	21,000	
					10	18.45	10,400	4
19	Clear Creek near Bovina	36	1927	1927		32.0	(1)	
			1952–66	1962		29.53	18,000	
					10	27.15	9,110	9

[1] Not determined.
[2] At site 3,000 ft downstream at datum 3.26 ft higher.

A partial estimate of flood damage made by the U.S. Army Corps of Engineers in the Pearl and Pascagoula River basins is as follows:

River	Type of damage				
	Agriculture	Roads and railroads	Hunting, fishing, and logging	Urban	Total
Pearl	$409, 000	$172, 000	----------	[1]$148, 000	$729, 000
Chickasawhay	48, 000	8, 000	----------	[2] 3, 000	59, 000
Leaf	93, 000	28, 000	----------	[3] 31, 000	152, 000
Pascagoula	21, 000	3, 000	$57, 000	----------	81, 000
Total	571, 000	211, 000	57, 000	182, 000	1, 021, 000

[1] At Jackson.
[2] At Shubuta.
[3] At Hattiesburg, $30,000, and at Beaumont, $1,000.

FLOODS OF FEBRUARY 13, IN SEVIER COUNTY, TENN.

By William J. Randolph

Heavy rain fell on ground that was saturated by the melting of about 10 inches of snow in the Great Smoky Mountains and produced moderate to heavy flooding in the Little Pigeon River basin (fig. 6) in Sevier County. Rainfall totaling from 3 to 5 inches, began about noon on February 12 and continued through the night and into the next day.

Stages and discharges in the flood area were obtained at 5 crest-stage stations, 1 regular gaging station, and 1 miscellaneous site. Table 5 is a summary of peak stage and discharge for the floods of February 13 and for previously known maximums at gaging stations in the flood area. An outstanding flood occurred on West Prong Little Pigeon River at Gatlinburg (sta. 5) where the recurrence interval was about 50 years, and where the runoff was 148 cfs per sq mi from a drainage area of 59.9 square miles.

Flooding in Gatlinburg, located along the banks of West Prong Little Pigeon River, was probably the greatest flood since 1896 and was the most damaging in the town's history. Early in the morning of February 13, many guests in tourist accommodations who did not heed earlier warning to move out were caught in about 3 feet of muddy water. Many of the flooded motels were constructed since the previous major flood in 1951. The Tennessee Valley Authority estimated the damage in Gatlinburg at $230,000. Traffic over the mountains upstream from Gatlinburg was interrupted by highway washouts. Downstream in the town of Sevierville the flood was the third in 3 years. The waters

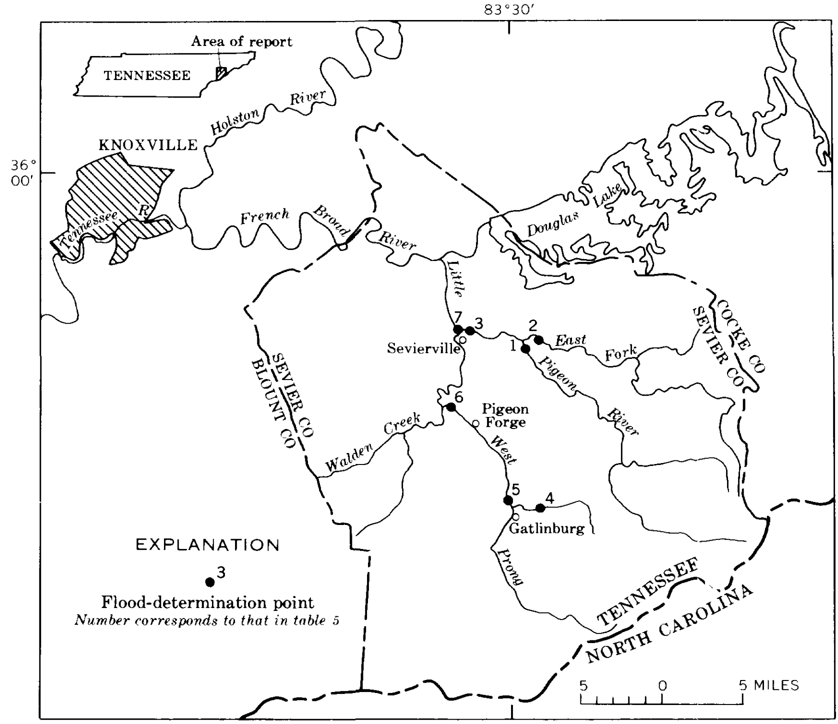

FIGURE 6.—Flood area and location of flood-determination points, floods of February 13, in Sevier County, Tenn.

TABLE 5.—*Flood stages and discharges, February 13, in the Tennessee River basin in Sevier County, Tenn.*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before February 1966 — Period	Year	February 1966	Gage height (feet)	Discharge — Cfs	Recurrence interval (years)
1	Little Pigeon River near Sevierville	110	1954–66	1965		17.42	15,700	
					13	17.48	15,800	[1] 1.09
2	East Fork Little Pigeon River near Sevierville.	64.1	1954–66	1963		19.2	7,950	
					13	16.91	6,000	11
3	Little Pigeon River above West Prong at Sevierville.	201	1954–66	1965		17.09	24,100	
					13	15.54	15,700	13
4	Hog Pen Branch near Gatlinburg	.61	1959–66	1965		3.41	(2)	
					13	2.45	(2)	
5	West Prong Little Pigeon River at Gatlinburg.	59.9			13		8,890	50
6	West Prong Little Pigeon River near Pigeon Forge.	76.2	1946–49, 1954–66.	1965		11.86	8,800	
					13	12.12	9,250	30
7	Little Pigeon River at Sevierville	353	1867, 1875, 1896, 1921–66.	1875		18	55,000	
					13	15.01	33,500	38

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

reached a depth of 2.5 feet in the business section. Damage to highways throughout the flood area and to property in Sevierville may have approached a half million dollars.

FLOODS OF MARCH 3–6, IN NORTHEASTERN ALABAMA

By Jerald F. McCain

Following a wetter than normal February, 2-day rainfalls of 3–6 inches occurred over a small area of northeastern Alabama on March 3–4 (fig. 7). The area of most intense rainfall extended from eastern Marshall County across central DeKalb and northern Cherokee Coun-

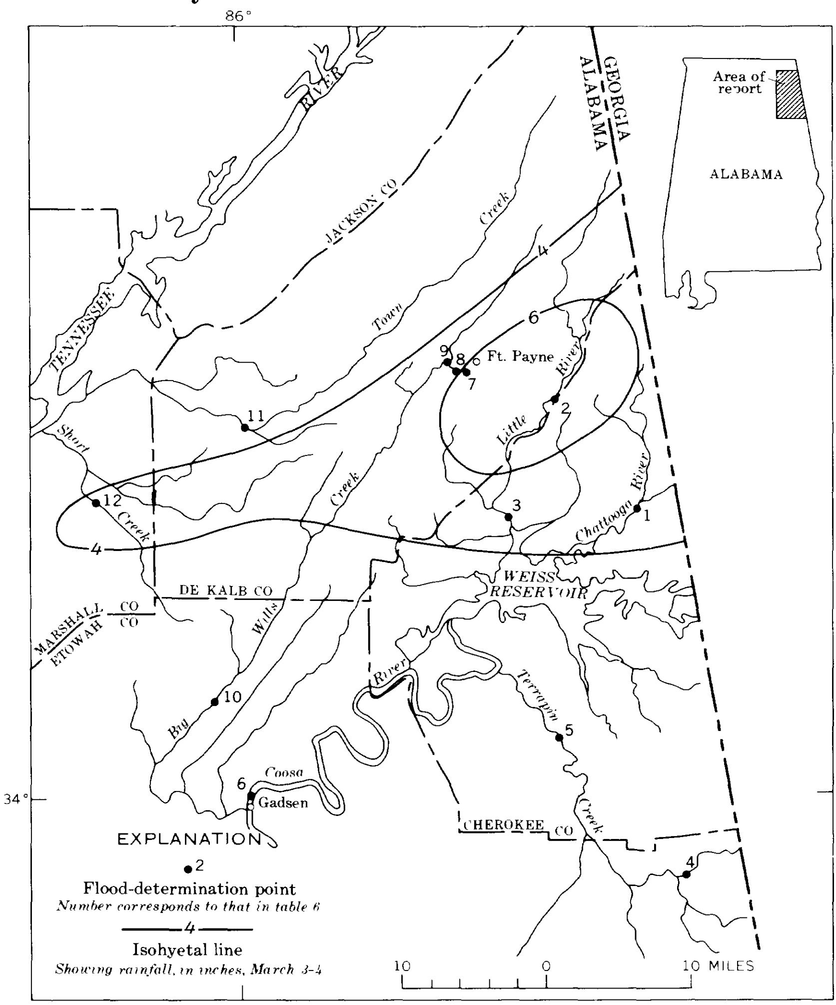

FIGURE 7.—Flood area, location of flood-determination points, and isohyets for March 3–4, floods of March 3–6, in northeastern Alabama.

ties. Most of the rainfall fell on the second day of the storm. At Fort Payne, where the highest total storm rainfall was reported, 0.69 inch of rain fell on March 3, and 5.31 inches fell on March 4. The period of most intense rainfall was during the evening of March 3, according to ESSA Weather Bureau records for Fort Payne. Between 2000 and 2200 hours on March 3, 3.33 inches of rain fell at the Fort Payne weather station. Heaviest rainfall occurred from Fort Payne eastward and was centered over the basin of Little River on Lookout Mountain—largely a wilderness area. Peak discharges of Little River near Jamestown (table 6, sta. 2) and near Blue Pond (sta. 3) had recurrence intervals of 25 years; at Jamestown the peak was the highest in 35 years of record. The peak discharge of Chattooga River above Gaylesville (sta. 1) was the highest since the beginning of record in 1959, but it was not an outstanding flood on that stream.

Moderate floods having recurrence intervals of 2–6 years occurred at several other gaging stations in the storm area. Little Wills Creek in Fort Payne overflowed its banks at several locations. Field estimates of peak discharge at three locations along this stream (stas. 7–9) indicated extremely high rates of runoff from the Little Wills Creek basin. (See table 6.)

Extensive flood damage occurred in Fort Payne along Little Wills Creek. Inadequate drainage structures caused water to overflow the creek banks in the southwestern part of the city. These was considerable damage to buildings and to merchandise in several business establishments. Two major highways in this section of the city were under water for more than an hour during the height of the flood. Much of the storm area consists of mountainous terrain and is sparsely populated. No significant flood damage was reported for areas outside Fort Payne.

TABLE 6.—*Flood stages and discharges, March 3–6, in northeastern Alabama*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before March 1966					
			Period	Year	March 1966	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
	Mobile River basin							
1	Chattooga River above Gaylesville.	368	1959–66	1963		20.95	13,600	
					5	22.03	16,500	8
2	Little River near Jamestown	121	1928–31, 1935–66.	1948		12.9	21,800	
					3	13.83	25,000	25
3	Little River near Bule Pond	194	1959–66	1963		13.55	22,000	
					4	14.45	32,200	25

See footnotes at the end of article.

TABLE 6.—*Flood stages and discharges, March 3–6, in northeastern Alabama*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before March 1966: Period	Year	March 1966	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
	Moble River basin—Continued							
4	Little Terrapin Creek near Borden Springs.	15.9	1960–66	1963		8.86	1,820	
					4	7.11	1,270	5
5	Terrapin Creek at Ellisville	258	1963–66	1963		17.90		
						17.90	13,200	
					4	16.94	10,300	2
6	Coosa River at Gadsden	5,800	1886	1886		37.9	115,000	
			1926–66	1936		31.13	76,900	
					6	23.61	46,800	2
7	Little Wills Creek Alabama Great Southern Rd. at Fort Payne.	3.4			3		[1] 2,200	([2])
8	Little Wills Creek at sewage treatment plant at Fort Payne.	4.2			3		[1] 2,140	([2])
9	Little Wills Creek at Highway I-59 at Fort Payne.	4.9			3		[1] 3,650	([2])
10	Big Wills Creek near Crudup	185	1884	1884		16.3	([2])	
			1944–66	1951		15.5	14,800	
					4	13.66	10,400	6
	Tennessee River basin							
11	Town Creek near Geraldine	141	1957–66	1963		21.70	17,700	
					4	14.85	9,850	2
12	Short Creek near Albertville	91.6	1942	1942		21.2	25,000	
			1946–66	1949		16.37	14,800	
					4	13.54	9,420	2

[1] Estimated.
[2] Not determined.

FLOODS OF MARCH–APRIL, IN NORTHWESTERN MINNESOTA

By D. W. ERICSON

For the second consecutive year, there was severe flooding in the Red River of the North basin in Minnesota (fig. 8) during the spring snowmelt period. There was flooding throughout the basin, except in the extreme southern tributaries where flows were near normal for this time of year.

During the period March 2–5, a major snowstorm in northern Minnesota deposited large amounts of snow over most of the area. Many localities received more than 2 feet of snow from the storm, and this precipitation coupled with the accumulated snow of the winter brought water equivalents of the snowpack up to the 5- to 7-inch range over the northern two-thirds of the basin.

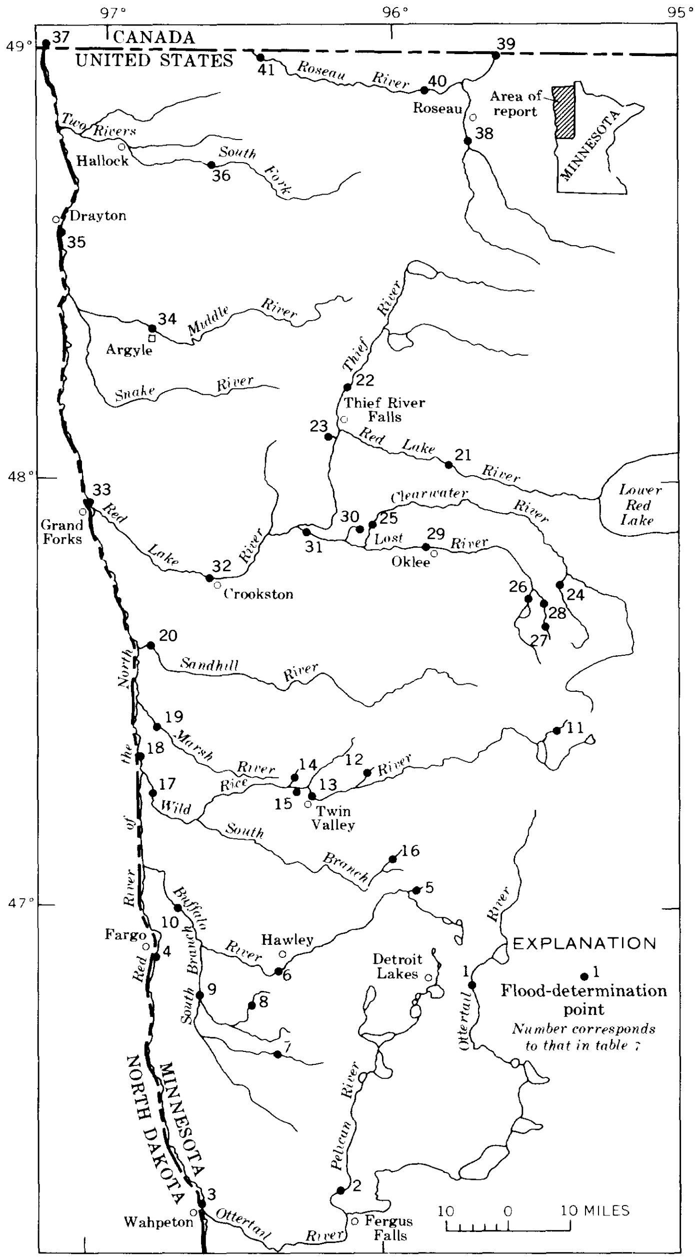

FIGURE 8.—Flood area and location of flood-determination poirts, floods of March-April, in northwestern Minnesota.

These spring floods were 1–2 weeks earlier than average in most of the basin. Unseasonably warm temperatures beginning March 8 caused the breakup on the Red River of the North upstream from Fargo, N. Dak., by the middle of March. From March 14 to 18, daytime temperatures in the fifties and low sixties and nighttime temperatures above freezing caused a continuation of rapid melting of the snowpack in the Buffalo River and Wild Rice River basins to the extent that these streams and their tributaries had peaked by March 18. A cooling trend on March 19 was of such short duration that it had little effect on reducing the peak runoff. Cold weather returned to the area on March 23 when daily maximum temperatures were in the teens and there were some subzero minimum temperatures. The cold weather, which remained through March 28, curtailed the runoff from most tributaries and helped to relieve an extremely critical flood potential.

By March 31, stages on the streams in the central and northern area were rising again as temperatures increased. Peak flows occurred on most of these streams during the April 2–5 period when temperatures were at a maximum. This was the period when flooding was most severe, and were it not followed by cooler temperatures, stages would have been higher than was actually the case, for the snowpack still had a water equivalent of 3 inches in some areas.

The maximum discharge of record, 5.410 cfs, was recorded at the gaging station on South Branch Two Rivers at Lake Bronson (table 7, sta. 36) on April 5. The previous maximum in the 32 years of record at this site was 2,960 cfs. At the time of the peak, more than 50 percent of the farmland upstream from Lake Bronson was inundated.

Peak flows for all the gaged sites in the area are tabulated in table 7. Maximum discharges of record were recorded at three sites, and at nine other sites the floods had recurrence intervals exceeding 50 years.

Ice jams are always a problem during the spring breakup in the Red River of the North basin; but this year, because the spring floods were early, the relatively sound ice formed jams that were larger and more numerous than usual. Cranes were stationed at many bridges to break up the jams as they were being formed, and dynamite was used at many locations to blast the more severe ice jams after they had formed.

The U.S. Army Corps of Engineers estimated the total damages in the Red River basin in Minnesota to be $10.4 million. This included agricultural damages of $7.8 million, urban damages of $1.8 million, and transportation damages of $800,000.

TABLE 7.—*Flood stages and discharges, March–April, in the Red River of the North basin in northwestern Minnesota*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before March 1966: Period	Known before March 1966: Year	March–April 1966	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
1	Ottertail River near Detroit Lakes, Minn.	270	1937–66	1943			371	
				1950		[1] 6.96		
					May 3	4.51	283	3
2	Pelican River near Fergus Falls, Minn.	482	1909–12	1943			756	
			1942–66	1950		[1] 5.60		
					Mar. 21	[1] 8.99		
					Apr. 1	4.73	560	5
3	Red River of the North at Whapeton, N. Dak.	4,010	1897–1966	1897		17.0	(2)	
			1942–66	1952		14.99	7,130	
					Mar. 16	[1] 13.93		
					18	12.91	4,760	6
4	Red River of the North at Fargo, N. Dak.	6,800	1897–1966	1897		[2] 30.1	25,000	
					Mar. 22	30.16	10,700	16
5	Buffalo River near Callaway, Minn.	499.	1960–66	1962		13.35	370	
					Apr. 1	12.35	212	(2)
6	Buffalo River near Hawley, Minn.	322	1921–66	1921		11.3	(2)	
			1945–66	1955		9.31	1,590	22
					Mar. 17	[1] 10.58		
					18	[1] 10.42	1,520	19
7	Whisky Creek at Barnesville, Minn.	62.5	1961–66	1962		6.52	292	
		[5] 25.3			Mar. 14	[1] 8.25	260	(2)
8	Hay Creek above Downer Minn.	5.81	1961–66	1962		13.46	382	
					Mar. 18	5.98	21	(2)
9	South Branch Buffalo River at Sabin, Minn.	522	1945–66	1962		17.04	6,340	
					Mar. 15	[1] 16.78	3,310	[4] 1.05
10	Buffalo River near Dilworth, Minn.	1,040	1931–66	1962		23.56	6,140	
					Mar. 18	[1] 23.31	5,000	50
11	Wild Rice River tributary near Bagley, Minn.	3.34	1961–66	1965		[1] 10.30	67	
					Apr. 1	[1] 11.37	60	(2)
12	Marsh River tributary near Mahnomen, Minn.	6.57	1961–66	1965		[1] 12.90	241	
					Apr. 2	[1] 13.43	205	(2)
13	Wild Rice River at Twin Valley, Minn.	888	1909–17, 1930–66.	1909		[6] 20.0	9,200	
					Mar. 17	[1] 11.51		
					Apr. 2	8.90	2,120	5
14	Wild Rice River tributary near Twin Valley, Minn.	2.25	1961–66	1962		12.39	107	
					Mar. 16	15.70	91	(2)
15	Coon Creek near Twin Valley, Minn.	32.1	1962–66	1962		[1] 12.68	896	
					Mar. 17	13.52	630	(2)
16	South Branch Wild Rice River near Ogema, Minn.	6.50	1963–66	1965		9.87	83	
					Mar. 16	[1] 9.49	57	(2)
17	Wild Rice River at Hendrum, Minn.	1,600	1944–66	1965			6,800	
				1965		[7] 29.52		
					Mar. 26	[7] 29.12		
					31	[7] 28.30	4,120	10
18	Red River of the North at Halstad, Minn.[5]	21,800	1897	1897		38.5	(2)	
		18,000	1936–37, 1942–66.	1965		35.22	25,600	
					Mar. 27	[1] 35.35	26,800	50
19	Marsh River near Shelly, Minn.	151	1944–66	1950		18.96	4,660	
					Mar. 23	[1] 16.09		
					Apr. 2	[7] 13.85	1,460	[4] 1.03
20	Sandhill River at Climax, Minn.	405	1943–66	1965		17.81	4,560	
					Apr. 2	17.33	4,220	[4] 1.60
21	Red Lake River at Highlanding near Goodrich, Minn.	[8] 2,300	1930–66	1950		13.42	3,720	
					Apr. 3	12.68	3,340	32
22	Thief River near Thief River Falls, Minn.	959	1909–17, 1919–26, 1928–66.	1950		17.38	5,610	
					Apr. 3	[1] 15.66	3,320	6
23	Red Lake River tributary near Thief River Falls, Minn.	(2)	1962–66	1965		(2)	150	(2)
					Mar. 20	[1] 10.60	39	(2)
24	Ruffy Brook near Gonvick, Minn.	45.2	1960–66	1965	Apr. 1	[1] 6.10	412	
					2	[1] 5.53	265	5
25	Clearwater River at Plummer, Minn.	512	1939–66	1962		11.90	3,640	
					Apr. 2	[1] 11.12		
					3	[1] 10.73	2,000	10

See footnotes at end of table.

TABLE 7.—*Flood stages and discharges, March–April, in the Red River of the North basin in northwestern Minnesota*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before March 1966: Period	Year	March-April 1966	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
26	Lost River at Gonvick, Minn.	30.9	1960–66	1962		9.06	255	
					Mar. 20	[1] 8.67	35	(2)
27	Lost River tributary near Clearbrook, Minn.	1.79	1960–66	1962		14.35	132	
					Mar. 20	[1] 10.42	30	(2)
28	Lost River tributary at Clearbrook, Minn.	3.05	1960–66	1962		15.83	147	
					Apr. 3	9.37	36	(2)
29	Lost River at Oklee, Minn.	266	1897–1966	1950		18.39	2,700	
					Apr. 2	12.60	2,240	21
30	Clearwater River tributary near Plummer, Minn.	1.17	1961–66	1965		[1] 11.23	177	
					Mar. 20	[1] 11.16	37	(2)
31	Clearwater River at Red Lake Falls, Minn.	1,370	1909–17	1913		[1,9] 17.5		
			1935–66	1950		11.28	9,340	
					Apr. 3	11.02	8,920	34
32	Red Lake River at Crookston, Minn.	[8] 5,280	1901–66	1950		25.70	27,400	
				1965		[1] 25.82		
					Apr. 3	24.41	21,500	[4] 1.35
33	Red River of the North at Grand Forks, N. Dak.	30,100 [5] 26,300	1882–66	1897		[10] 50.2	80,000	
					Apr. 4	45.55	55,000	[4] 1.14
34	Middle River at Argyle, Minn.	265	1945, 1951–66	1950			2,700	
				1965		15.29		
					Apr. 3	[1] 16.00	1,820	11
35	Red River of the North at Drayton, N. Dak.	34,800 [5] 31,000	1860–1966	1950		[11] 41.58	86,500	
					Apr. 8	42.15	67,500	[4] 1.16
36	South Branch Two Rivers at Lake Bronson, Minn.	444	1929–37, 1941–47, 1953–66.	1962		12.82	2,930	
					Apr. 5	18.23	5,410	[4] 1.92
37	Red River of the North at Emerson, Manitoba.	40,200 [5] 36,400	1912–66	1950		90.89	95,500	
					Apr. 11	89.15	66,800	[4] 1.07
38	Roseau River below South Fork near Malung, Minn.	573	1947–66	1965		21.90	4,660	
					Apr. 3	[1] 23.37	4,750	[4] 1.41
39	Sprague Creek near Sprague, Manitoba.	[12] 169	1929–66	1942		15.31	2,070	
					Apr. 3	[1] 12.65		
					18	11.74	932	9
40	Roseau River at Ross, Minn.	1,220	1896–1966	1896		19	(2)	
			1928–66	1950		18.25	6,560	
					Apr. 21	17.17	4,670	28
41	Roseau River below State ditch 51, near Caribou, Minn.	1,570	1916	1916		[13] 15.50	(2)	
			1917, 1920–66.	1950		11.81	4,080	
							3,120	
					Apr. 28	10.34	3,120	5

[1] Affected by backwater from ice.
[2] Not determined.
[3] At site 1-1/2 miles downstream at datum 1 ft lower.
[4] Ratio of peak discharge to 50-yr flood.
[5] Contributing drainage area.
[6] At site 1/4 mile downstream at different datum.
[7] Affected by backwater from Red River of the North.
[8] 1,950 sq mi above Lower Red Lake outlet contributes little to flood peaks.
[9] At site 40 ft upstream at different datum.
[10] At site about 1-1/2 miles upstream at datum 0.5 ft higher.
[11] At site 1-1/2 miles upstream at datum 1.59 ft higher.
[12] Prior to October 1958, 151 sq mi; change due to construction of drainage ditch within basin.
[13] At site at Caribou 0.6 mile upstream at datum 0.95 ft lower.

FLOODS OF APRIL–MAY, IN NORTHEASTERN TEXAS

In the 8-day period, April 22–29, 20–26 inches of rain fell in parts of the Sabine River basin in northeastern Texas. Most of the rain fell within a 72-hour period during April 22–25. The heaviest rains were centered over the Gilmer-Gladewater-Harleton area. At Gladewater, 22.74 inches fell in 60 hours, an amount much greater than the 100-year rainfall in this area.

High rates of runoff occurred in the area of heavy rainfall in northeastern Texas (fig. 9) from the headwater area of the Sulphur River southward to the Trinity River basin. (See table 8.)

The ESSA Weather Bureau estimated $2 million losses to crops and $10 million to other property losses. Floods destroyed bridges and disrupted rail and highway traffic. Damage to roads in Gregg County was estimated at $2 million.

The 40-year old dam forming Lake Devernia failed, as did several other smaller dams in Gregg County. The Texas and Pacific Railway tracks at Hawkins Creek west of Longview were undermined, and two diesel engines and 19 freight cars plunged into the creek. At least 25 persons lost their lives in the flood, of which 21 were due to drowning.

The floods in northern Dallas, which were the worst in the history of the city, are described in the following section of this flood summary.

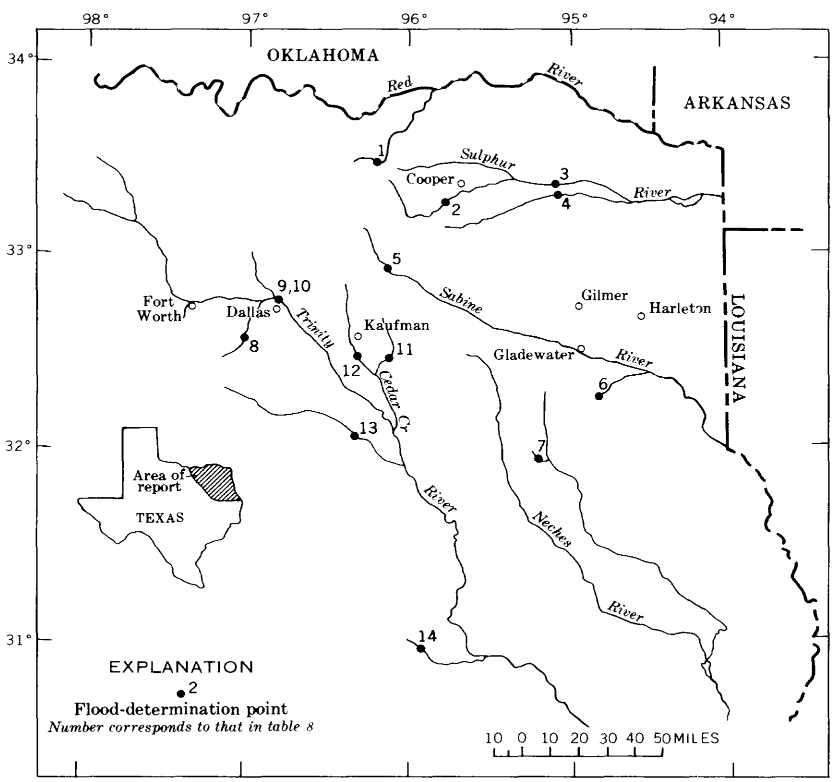

Figure 9.—Flood area and location of flood-determination points, floods of April-May, in northeastern Texas.

TABLE 8.—*Flood stages and discharges, April–May, in northeastern Texas*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before April 1966: Period	Year	April–May 1966	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
			Red River basin					
1	Bois d'Arc Creek near Randolph	72	1922–66	1935		24.6	[2]	
			1963–66	1965		15.69	7,820	
					Apr. 29	19.66	11,600	[3] 1.4
2	South Sulphur River near Cooper	527	1942–66	1953		23.00		
				1965			25,000	
					Apr. 30	23.02	30,500	24
3	Suphur River near Talco	1,365	1908–66	1908, 1914		27.5	[2]	
			1957–66	1958		25.69	50,600	
					Apr. 30	26.40	56,600	16
4	Whiteoak Creek near Talco	494	1870–1966	1945		22.9	[2]	
			1950–66	1958		19.52	26,600	
					May 1	20.28	39,200	[3] 1.1
			Sabine River basin					
5	South Fork Sabine River near Quinlan.	78.7	1890–1966	1902		21	[2]	
			1959–66	1963		16.70	11,500	
					Apr. 25	16.75	11,800	33
6	Rabbit Creek at Kilgore	75.8	1943–66	1945		19.6	[2]	
			1964–66	1965		10.66	1,070	
					Apr. 24	16.40	15,200	[3] 1.1
			Necks River basin					
7	Mud Creek near Jacksonville	376	1885–1966	1908, 1913		20	[2]	
			1939–66	1944		14.09	23,400	
					Apr. 25	15.20	27,500	17
			Trinity River basin					
8	Mountain Creek near Cedar Hill	119	1910–66	1922		30	[2]	
			1961–66	1965		22.48	11,000	
					Apr. 25	25.54	23,100	50
9	Bachman Branch at Dallas	10.0	1900–66	1962		465.6	9,200	
					Apr. 28	467.97	16,000	[2]
10	Turtle Creek at Dallas	7.98	1903–66	1959		8.10	4,650	
					Apr. 28	10.54	12,200	[2]
11	Cedar Creek near Kemp	189	1889–1966	1945		20.5	[2]	
			1963–66	1964		13.83	5,900	
					Apr. 26	16.00	27,000	[3] 1.5
12	Kings Creek near Kaufman	233	1942–66	1949		23.1	[2]	
			1963–66	1963		20.66	12,700	
					Apr. 26	22.73	29,700	[3] 1.5
13	Chambers Creek near Corsicana	963	1870–1966	1887		30	[2]	
			1939–66	1944			48,000	
				1958		28.10		
					Apr. 26	27.81	39,600	13
14	Caney Creek near Madisonville	112	1900–1966	1929		22	[2]	
			1963–66	1965		15.72	2,930	
					Apr. 29	17.37	15,200	34

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

FLOODS OF APRIL 28, IN THE NORTHERN PART OF DALLAS, TEX.

After WILLARD B. MILLS and ELMER E. SCHROEDER (1969)

A rainstorm in the northern part of Dallas (fig. 10) during the early hours of April 28 produced as much as 6.7 inches of rainfall within a 6-hour period; 4.9 inches fell within 1 hour. The intensity of the rainfall exceeded a 100-year return period by a considerable amount for durations of 30 minutes to 2 hours, according to the U.S. Weather

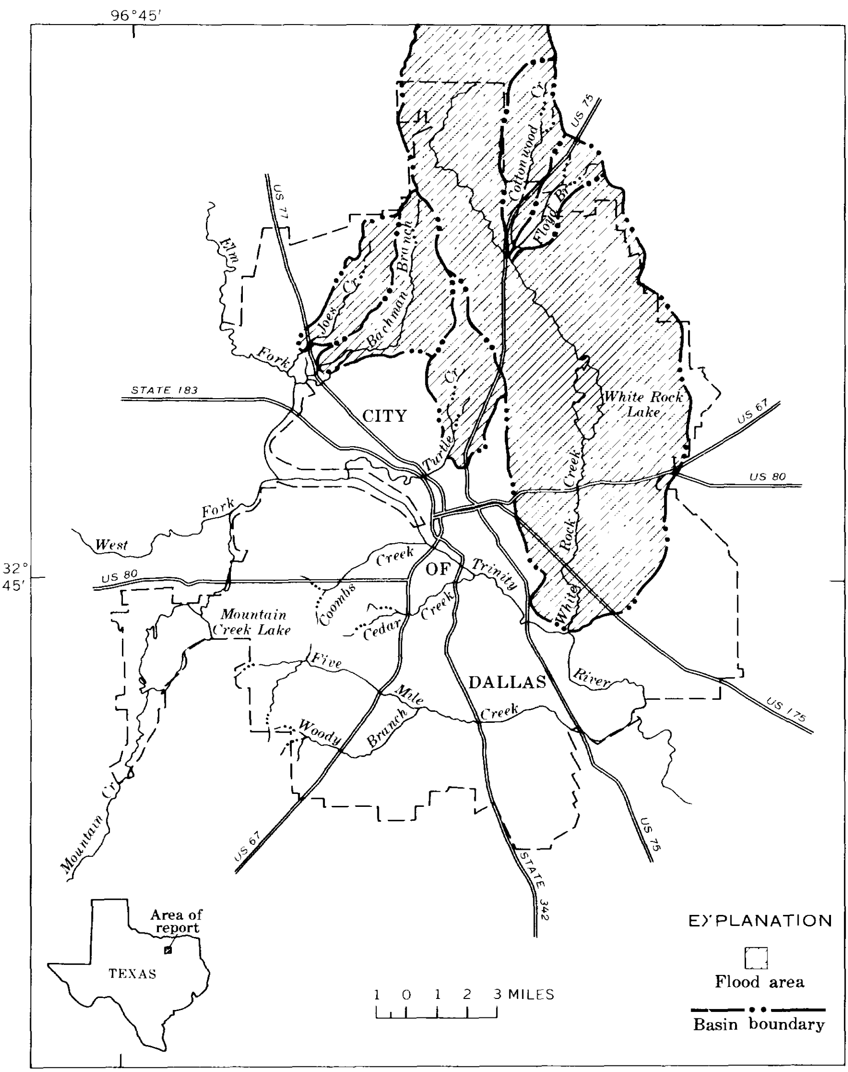

FIGURE 10.—Flood area, flood of April 28, in the northern part of Dallas, Tex.

Bureau (1955). Almost 8 inches of rain had fallen during the preceding 2 weeks. The result was a well-saturated basin in which all storage areas were full. In addition, most of the area is urbanized. This combination of intense rainfall and other hydrologic conditions favorable to high runoff resulted in floodflows at some points exceeding the highest floodflows ever recorded on small streams in Dallas. A peak runoff rate of 3,160 cfs per sq mi occurred on a 1.5-square-mile area. This is the second highest peak rate of runoff per square mile in Texas recorded by the U.S. Geological Survey.

Flood damage in Dallas was estimated at $2.5 million. Bridges were washed away; more than 270 homes and at least 40 businesses were severely damaged; lawns, gardens, and cemeteries were inundated; and seven lives were lost.

These floods are described in detail by Mills and Schroeder (1969). The report described the flood events of April 28, for the following basins in the northern part of Dallas: Joes Creek, Bachman Branch, Turtle Creek, Cottonwood Creek, and Floyd Branch. The floods are described in terms of rainfall (magnitude, intensity, frequency, and distribution); peak discharge at selected points; flood profiles; inundated areas; comparison with previous floods; effects of channel changes on flood profiles; and property damage and loss of life due to the flood. The flood on the main stem of White Rock Creek is also described but in less detail.

FLOODS OF JUNE 23–24, IN SOUTHERN NEBRASKA

By H. D. Brice

Floods of June 23 and 24 were severe along Sappa and Beaver Creeks in southeastern Furnas and southwestern Harlan Counties, Nebr. (fig. 11).

Residents reported that as much as 11 inches of rain fell in 2 days in the Stamford area. The ESSA Weather Bureau recorded 5.74 inches at Orleans (7 miles east of Stamford) and 6.10 inches at Beaver City (13 miles west of Stamford) during this 2-day period. Smaller amounts of rain fell at upstream points in both basins. According to the U.S. Weather Bureau (1961), the recurrence interval of a 6.5-inch point rainfall in 2 days in the Beaver City-Stamford area is about 100 years. The recurrence interval would be much greater for a point rainfall of 11 inches in 2 days.

The maximum discharges on Sappa Creek (table 9), at the gaging stations near Beaver City (sta. 2) and near Stamford (sta. 4), were the greatst in the periods of record (30 yr near Beaver City and 21 yr near Stamford). The recurrence interval for the peak dischage was 32 years near Beaver City. The peak discharge near Stamford was 1.9

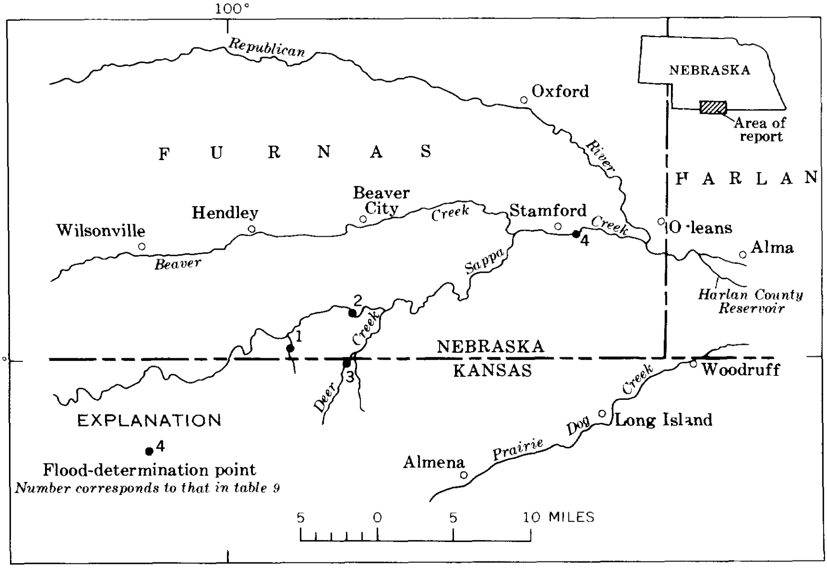

FIGURE 11.—Flood area and location of flood-determination points, floods of June 23–24, in southern Nebraska.

times the 50-year flood, and almost six times as great as the previous maximum discharge in the 21 years of record.

Notable peak discharges also occurred on two tributaries of Sappa Creek (stas. 1, 3).

Inundation of about 8,400 acres along Sappa Creek resulted in crop losses of about $218,000. Other damages were about as follows: Highways and railroads, $160,000; farm buildings, equipment, fences, and so forth, $15,000; and utilities, $5,000. Twenty or more residences

TABLE 9.—*Flood stages and discharges, June 23–24, in southern Nebraska*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before June 1966: Period	Year	June 1966	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
1	Sappa Creek tributary near Hendley.	1.10			23		4,450	([1])
2	Sappa Creek near Beaver City	[2] 1,500	1937–66	1960		20.03	5,690	
					23	20.85	9,500	32
3	Deer Creek near Beaver City	6.47			23		6,980	([1])
4	Sappa Creek near Stamford	[2] 3,840	1946–66	1947		20.10	7,430	
					24	22.13	43,400	[3] 1.9

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

were flooded in Stamford, and four persons were rescued by boat from the roofs of houses there. About 1 mile east of Stamford, two men swam to safety after they were swept off the top of their car during the early hours of June 24. At the crest of the flood, both State Highway 89 and the Chicago Burlington & Quincy Railroad were under water throughout the 7-mile stretch between Stamford and Orleans. At least 2 miles of the railroad track were washed out, and the rails were badly twisted. The railroad was out of service for about 2 weeks. The Sappa Creek bridge on State Highway 89 south of Orleans was closed to traffic for about 3 weeks because of the washout of one of its approaches.

Flooding along Beaver Creek inundated about 1,550 acres between Beaver City and the creek mouth. Damage, consisting mostly of crop losses, was estimated at $55,000. Less severe flooding occurred along Prairie Dog Creek between Almena and Long Island, Kans. (fig. 11), also on June 23–24. About 1,500 acres were inundated, and crop damage was estimated at $11,000.

The foregoing estimates of inundated areas and damages were made by the U.S. Army Corps of Engineers, Kansas City district. Losses from soil erosion are not included in the damage estimates.

FLOODS OF JUNE 24–25, IN SOUTHWEST-CENTRAL NORTH DAKOTA

After ORLO A. CROSBY (1966)

A severe thunderstorm accompanied by much hail swept through southwest-central North Dakota on the afternoon of June 24. Rainfall up to 13 inches caused floods higher than any previously known in the area. The isohyetal map (fig. 12) indicates the extent and magnitude of the storm.

The storm traveled in a northeasterly direction with most of the rain occurring in about 2 hours in any location. The severity and rarity of the storm is indicated by U.S. Weather Bureau Technical Paper 40 (1961) which shows the 100-year 2-hour point rainfall to be about 3 inches in the storm area. Most of the hail occurred in the areas of heaviest rainfall. At the town of Stanton, one third of the windows were reported as having been shattered and buildings were severely damaged. Crops over a large area were destroyed and trees defoliated.

The flood area included parts of the basins of the Knife River, Square Butte Creek, Heart River, and some unnamed small tributaries to the Missouri River. As far as can be ascertained, a flood of this magnitude and areal coverage, caused by a thunderstorm, has not been previously documented in this area. In 1962 a record flood in Bonnes

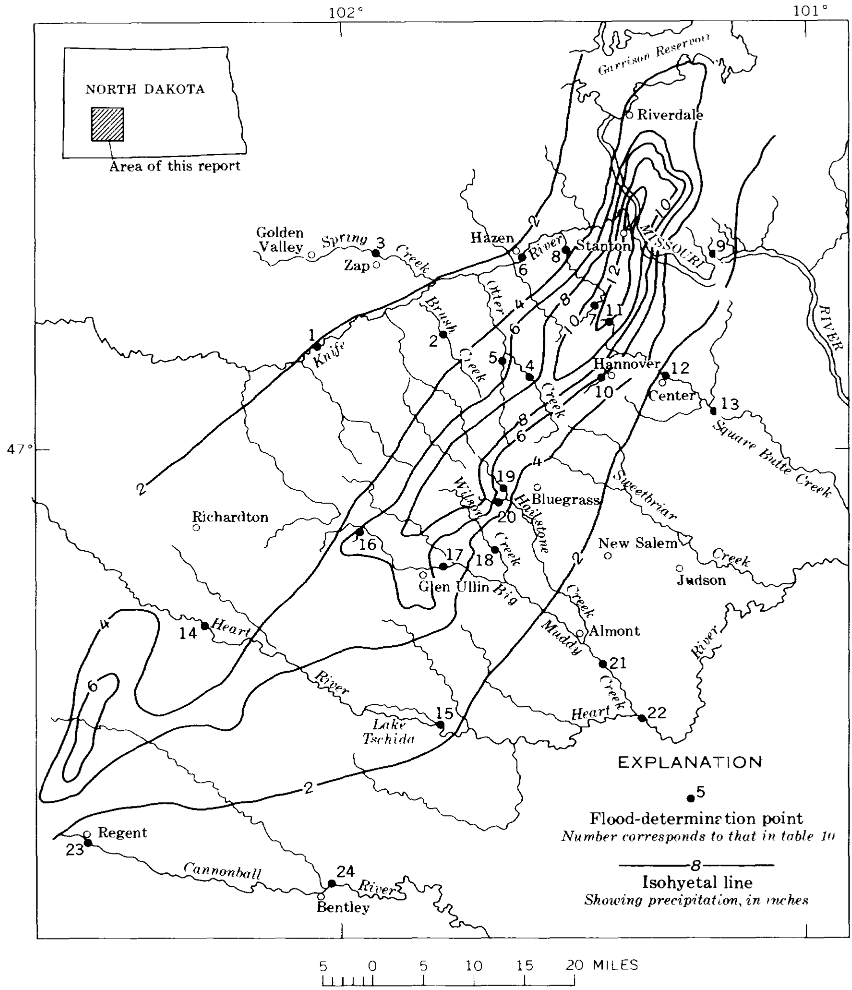

FIGURE 12.—Flood area, location of flood-determination points, and isohyets for June 24–25, floods of June 24–25, in southwest-central North Dakota.

Coulee near Velva resulted in a peak discharge of 26,300 cfs from an area of 52.5 square miles, but the areal coverage of that storm was much less than that of the storm of June 1966. The peak discharge on Knife River at Hazen was the greatest known since 1884, even though less than half of the total drainage area contributed to the flood runoff. A summary of peak stages and discharges at 24 sites is given in table 10. Many of the peak flows substantially exceeded the 50-year flood. The maximum ratio of peak discharge to a 50-year flood was 22 in Otter Creek near Hannover (sta. 4). The maximum discharge rate

TABLE 10.—*Flood stages and discharges, June 24–25, in southwest-central North Dakota*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before June 1966: Period	Maximum floods: Known before June 1966: Year	June 1966	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
	Knife River basin							
1	Knife River near Golden Valley	1,230	1903–66	1943		26.7	11,500	
					26	14.84	2,070	<2
2	Brush Creek near Beulah	23.3			24		6,000	[1] 4.24
3	Spring Creek at Zap	549	1924, 1947–66.	1952		20.03	6,130	
					25	4.78	169	<2
4	Otter Creek near Hannover	42.9			24	12.48	45,300	[1] 22.2
5	West Branch Otter Creek near Beulah.	26.5			24	17.2	23,700	[1] 15.6
6	Knife River at Hazen	2,240	1884–1966	1943		26.3	26,500	
					24	26.99	26,600	[1] 1.17
7	Kineman Creek tributary near Hannover.	2.45			24		7,450	([2])
8	Kineman Creek near Hazen	31.3			24		29,600	[1] 17.4
	Missouri River basin							
9	Missouri River tributary near Hensler.	.65			24		167	([2])
	Square Butte Creek basin							
10	Square Butte Creek tributary near Hannover.	1.45			24		473	([2])
11	Square Butte Creek tributary 2 near Hannover.	.14			24		80.2	([2])
12	Square Butte Creek at Center	56.8	1956–66	1960		7.00	1,000	
					24	10.96	8,000	[1] 2.00
13	Square Butte Creek below Center	146	1965–66	1965		2.55	30	
					24	14.35	9,700	[1] 1.36
	Heart River basin							
14	Heart River near Richardton	1,240	1903–22, 1938, 1943–66.	1950		28.05	23,400	
					24	23.64	10,700	9
15	Heart River below Heart Butte Dam near Glen Ullin.	1,710	1904–66	1947		21.5	[3] 25,000	
					25	6.10	[3] 2,830	
16	Big Muddy Creek tributary near Eagles Nest.	.8			25		1,300	([2])
17	Big Muddy Creek near Glen Ullin.	86.8			24		10,400	[1] 2.00
18	Wilson Creek near Glen Ullin	30.7			24	22.9	20,800	[1] 7.64
19	Hailstone Creek near Bluegrass	34.7			24		12,000	[1] 4.07
20	Hailstone Creek tributary near Bluegrass.	3.26			24		1,860	([2])
21	Big Muddy Creek near Almont	456	1945–66	1950		30.7	20,200	
					25	29.37	8,800	15
22	Heart River near Lark	2,750	1947–66	1950		20.70	[3] 29,200	
					25	16.54	[3] 13 900	
	Cannonball River basin							
23	Cannonball River at Regent	580	1950–66	1950		26.1	20 300	
					25	14.63	4,620	5
24	Cannonball River below Bentley	1,140	1943–66	1950		34.0	51,800	
					26	16.12	5 000	4

[1] Ratio of peak discharge to 50-yr flood.
[2] Not determined.
[3] Flow regulated by Lake Tschida.

determined per square mile was that of Kineman Creek tributary (sta. 7) with 3,040 cfs per sq mi from a drainage area of 2.45 square miles. The ratio to the 50-year flood is not computed for areas smaller than 10 square miles; however, the great magnitude of the peak is apparent because the 50-year flood from 10 square miles in this area is about 850 cfs. Square Butte tributary 2 (sta. 11), in the area of heaviest rainfall, had only moderately high runoff, probably owing to storage at a highway fill upstream.

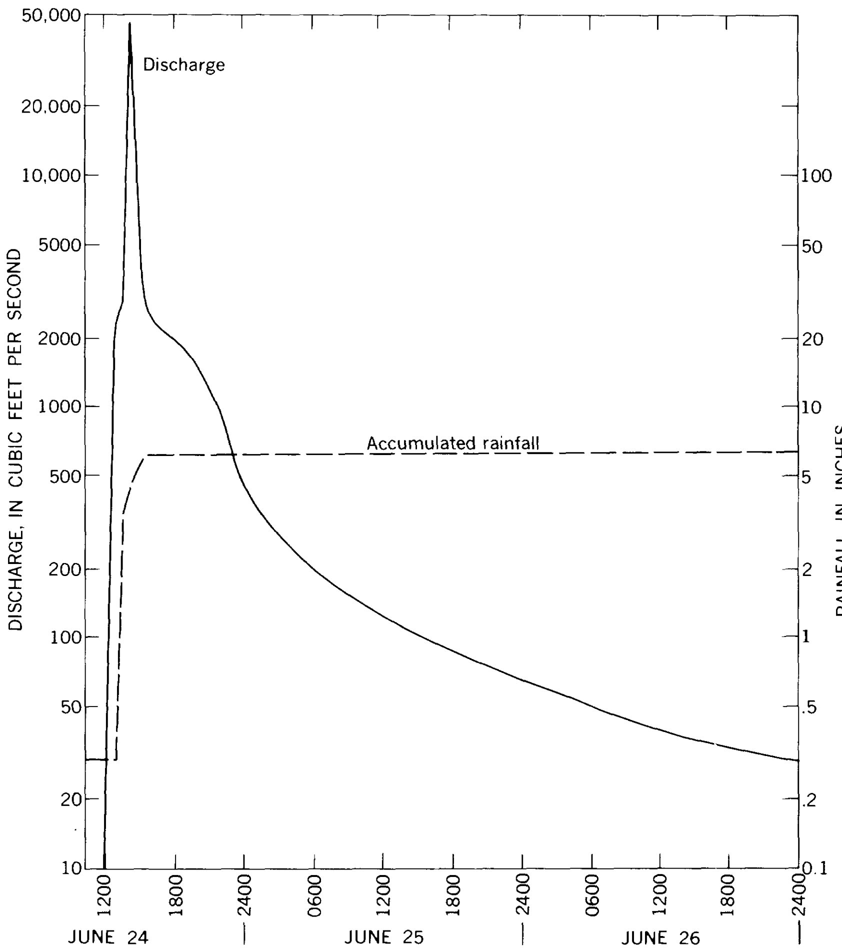

FIGURE 13.—Discharge hydrograph and accumulated rainfall graph for Otter Creek near Hannover, floods of June 24–25, in southwest-central No^th Dakota.

Figure 13 shows the discharge hydrograph and accumulated rainfall graph for Otter Creek near Hannover, which are probably typical for basins of similar size in the flood area. The discharge peaks were very sharp and recessions were rapid.

Damage caused by the flood was extensive. Floodwaters from Big Muddy Creek covered part of Glen Ullin and all of Almont to a depth of 3–4 feet. The residents had been evacuated to higher ground by the time the flood wave arrived. About a third of the residents of Center were evacuated because a large part of the town was inundated by Square Butte Creek. Highway damage was estimated at more than $1 million in a six-county area, of which one-fourth was in Oliver County. Virtually, no bridges or culverts remained in place in the area of severe flooding. Newly opened Interstate 96 was damaged considerably at the bridge over Wilson Creek. The Northern Pacific mainline railroad tracks west of Glen Ullin and the branch line tracks near Stanton were washed out. Power and telephone services were disrupted in much of the area. Municipal and residential water supplies were contaminated. Farm machinery was overturned and ruined, and large numbers of livestock and poultry were washed away or drowned. Many farm buildings on the flood plains were destroyed or washed away.

FLOOD OF JULY 1, IN NORTHWESTERN NEBRASKA

By H. D. Brice

Local ranchers reported that about 3 inches of rain fell in one-half hour on July 1 in the upper reaches of the South Fork of Soldiers Creek in eastern Sioux County, Nebr. No rain fell in the immediate vicinity of the gaging station on Soldiers Creek (fig. 14), and less than 1 inch was observed by the ESSA Weather Bureau at Fort Robinson and at Harrison. Fort Robinson is about 5 miles southeast of the gaging station, and Harrison is about 18 miles west of it.

The peak discharge (6,160 cfs) resulting from this storm was a little more than 1.5 times the previous maximum observed peak (3,970 cfs) during the 12 years of record, and based on a regionalized flood-frequency study, it was 3.78 times the 50-year flood.

The gage height of the July 1966 flood was only 0.1 foot higher than that for the maximum known flood in 1958. Comparison of the gage heights and discharges for the 1958 and 1966 floods indicates a large increase in channel capacity at the gage site during the period between the two floods.

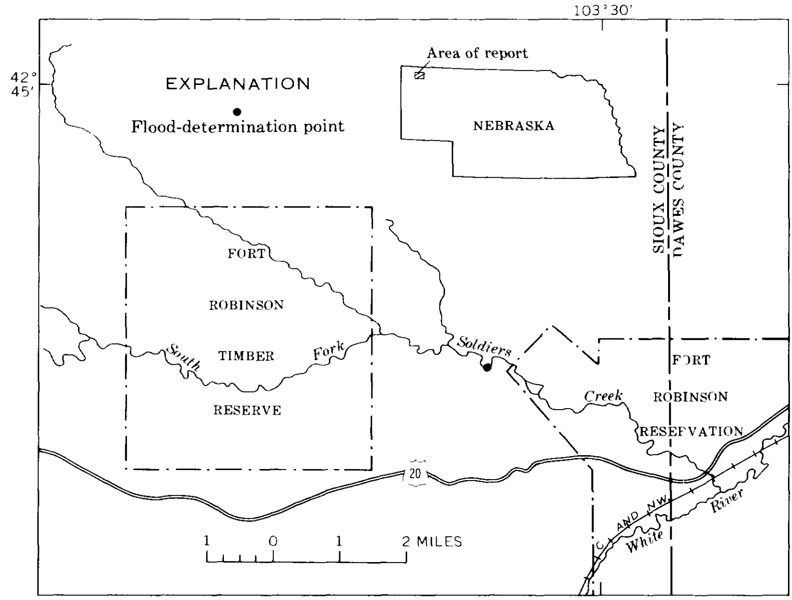

FIGURE 14.—Flood area and location of flood-determination point, flood of July 1, in northwestern Nebraska.

FLOODS OF JULY 12, IN THE VICINITY OF SANDUSKY, OHIO

After WILLIAM P. CROSS (1967)

Flash floods from small drainage areas caused by high-intensity rainstorms can be expected to occur in Ohio in almost any year. Although these floods may be annual events, they would rarely occur at any specific site. Rains from intense rain cells that cause these flash floods are seldom measured by standard rain gages, and chances are small that the floods will occur at an established gaging station.

Rainfall data were collected following a cloudburst storm of July 12, in the vicinity of Sandusky, Ohio (fig. 15), which was notable for unusually high-intensity rainfall and for the large amounts accumulated. Peak discharges were determined at six miscellaneous sites in the area.

Rainfall amounts were obtained by a bucket survey at 162 sites, which provided data for the isohyets of figure 15. Rainfall at a recording rain gage at Sandusky was 9.5 inches in 8 hours and 10.5 inches in 20 hours. Twelve inches of rain fell during the storm in two small cells, and the 6-inch isohyet incloses about 260 square miles. At Sandusky the 100-year frequency 8-hour rainfall is 5 inches and the 100-year frequency 24-hour rainfall is 6 inches (U.S. Weather Bureau, 1955). The 100-year frequency 24-hour rainfall for 260 square miles in the storm area is about 5–1/2 inches (U.S. Weather Bureau, 1960).

The runoff resulting from such a rare storm is usually large. Discharges were extremely great for the Sandusky area, along Lake Erie, where the topography is flat and some soils are sandy. Peak discharges measured from six small drainage basins had recurrence intervals greater than 50 years (table 11).

The flat stream gradients and the large volume of runoff caused ponding in large areas. Total flood damage was estimated by the U.S. Army Corps of Engineers at $5 million. About half the crop damage ($1.6 million) was from standing water. Private property damage ($2.5 million) was from inundation of homes and businesses. About 12,000 homes in Sandusky were damaged to some extent. Damage to streets and sewers in Sandusky was $250,000, and to two hospitals, $75,000. Damage to four railroad underpasses was $150,000. About $250,000 damage was caused in Beachwood Cove, a new subdivision near Huron.

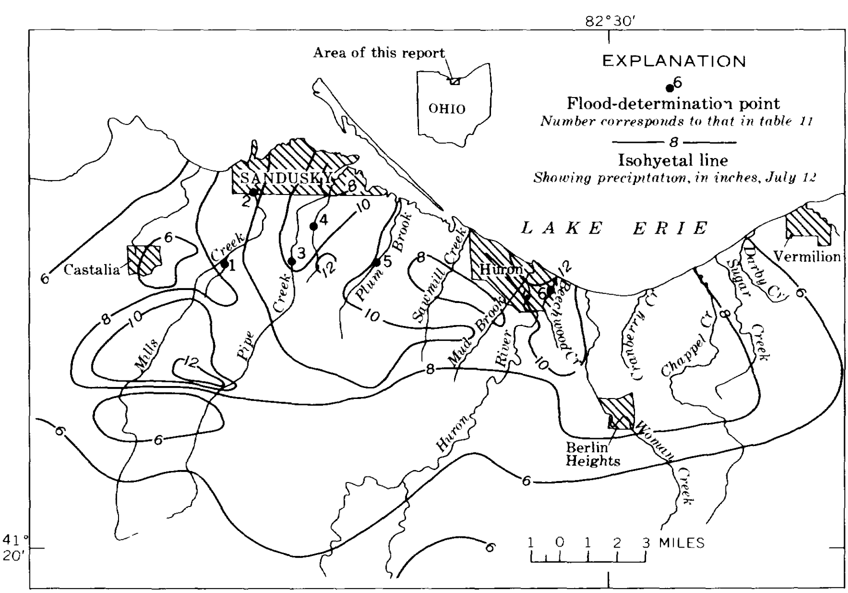

Figure 15.—Flood area, location of flood-determination points, and isohyets for July 12, floods of July 12, in the vicinity of Sandusky, Ohio

TABLE 11.—*Flood discharges, July 12, of streams tributary to Lake Erie in the vicinity of Sandusky, Ohio*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before July 1966: Period	Year	July 1966	Gage height (feet)	Discharge: Cfs	Ratio to 50-year flood
1	Mills Creek tributary near Sandusky.	0.44			12		187	1.67
2	Mills Creek at Sandusky	40.5			12		3,650	1.45
3	Pipe Creek near Sandusky	20.3			12		2,360	1.48
4	Pipe Creek tributary at Sandusky	1.20			12		445	1.96
5	Plum Brook at Bogart	3.46			12		727	1.55
6	Beechwood Creek at Huron	1.68			12		459	1.67

FLOODS OF JULY 12–13, IN SOUTHWESTERN NORTH DAKOTA

Scattered small-area floods occurred in southwestern North Dakota during the evening of July 12 and early morning of July 13. The thunderstorm produced as much as 6 inches of rainfall in some areas. The Bowman and Reeder Weather Bureau stations reported 5.40 and 5.24 inches of rainfall, respectively (fig. 16).

Flood damage was low. Some bridges and culverts were damaged, and some crops were destroyed by hail. A family of four was drowned

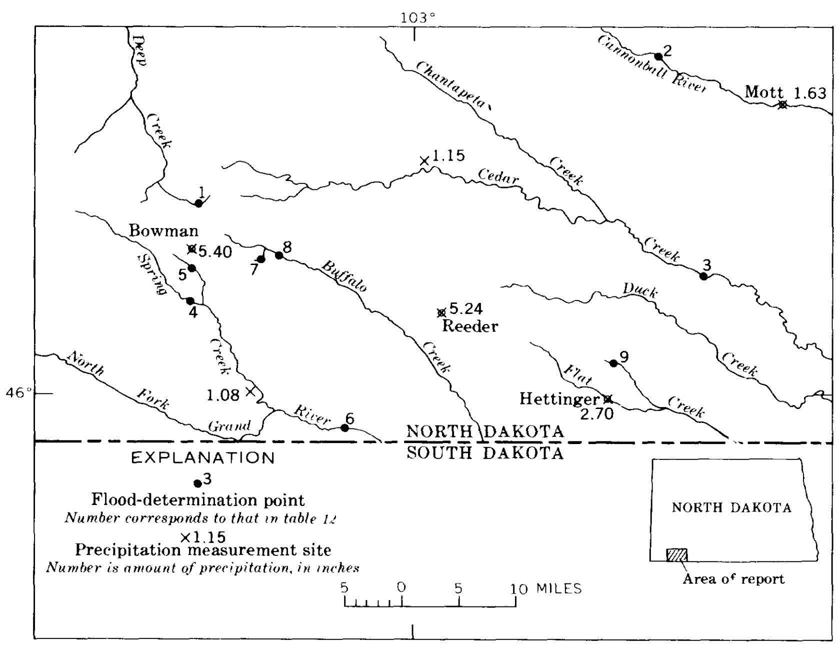

FIGURE 16.—Flood area and location of flood-determination points and precipitation site, floods of July 12–13 in southwestern North Dakota.

near Mott when their car hit a culvert washout and was swept downstream.

Figure 16 shows the points at which flood determinations were made. Station 9 is near the site of heaviest rainfall; it had a unit runoff of 2,470 cfs per sq mi from 1.13 square miles. The storm occurred over a very small area and therefore had little effect on the discharges of the larger streams (table 12). The relative magnitude of the peak discharges of the small streams in the immediate area of the storm is indicated by the fact that the 50-year flood on 10 square miles is about 1,500 cfs.

TABLE 12.—*Flood stages and discharges, July 12–13, in southwestern North Dakota*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before July 1966: Period	Known before July 1966: Year	July 1966	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
	Little Missouri River basin							
1	Deep Creek near Bowman	0.20	1955–66	1955		8.90	57.0	
					12	9.02	58.0	(1)
	Cannonball River basin							
2	Cannonball River at Regent	580	1950–66	1957		17.35	6,040	
					13	5.38	418	<2
3	Cedar Creek at Haynes	553	1950–66	1952		21.25	7,870	
					13	3.46	14	<2
	Grand River basin							
4	Spring Creek near Bowman	51.2	1955–66	1964		5.8	265	
					13	11.80	3,270	30
5	Spring Creek tributary near Bowman.	11.4	1955–66	1958		6.58	80	
					13	7.27	570	7
6	North Fork Grand River at Haley	509	1908–17, 1945–60.	1952		17.03	14,100	
					14	12.40	2,050	4
7	Buffalo Creek tributary near Buffalo Springs.	3.39	1955–66	1958		6.17	389	
					12	7.08	1,320	(1)
8	Buffalo Creek at Buffalo Springs	19.6			12		1,750	30
9	Flat Creek tributary near Hettinger.	1.13			12		2,790	(1)

[1] Not defined.

FLOODS OF JULY 14 AND SEPTEMBER 1, IN SOUTHEASTERN WYOMING

By STANLEY A. DRUSE

General rains accompanied by locally intense thunderstorms produced major floods on several small basins in southeastern Wyoming (fig. 17) on July 14 and September 1. Precipitation was recorded at most ESSA Weather Bureau stations in this area during the periods July 13–14 and August 31 to September 1. In addition, unofficial amounts of precipitation for these storm periods were reported by

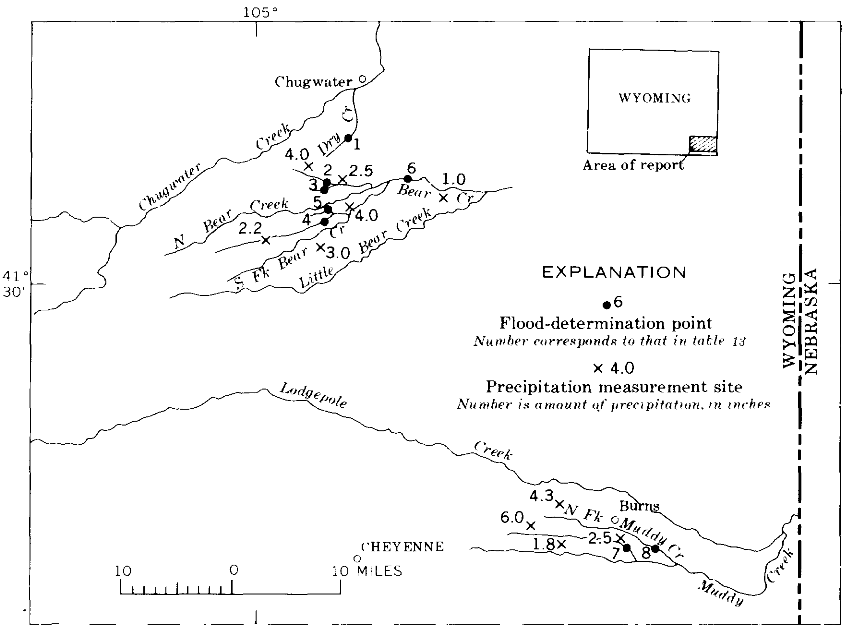

FIGURE 17.—Flood area and location of flood-determination points and precipitation stations, floods of July 14 and September 1, in southeastern Wyoming.

ranchers during a bucket survey of the area. Because of the locally intense nature of the storms, the data provided by the ranchers are indicative of the rainfall that produced the floods; these amounts are shown in figure 17. The amounts of precipitation shown for the Bear Creek basin and Dry Creek are totals for the storm period, July13–14; the amounts shown for the Muddy Creek basir are totals for August 31 to September 1.

Indirect measurements of peak discharge of July 14 were made at five miscellaneous sites in the upper Bear Creek basin (stas. 2–6) and at one miscellaneous site on Dry Creek (sta. 1). Peak discharges and the description of each site are given in downstreams order in table 13. Although the recurrence intervals of these floods are not determined, local ranchers attested to the historical significance of the floods. A rancher living about 4 miles downstream from the measurement site on Bear Creek near Chugwater (sta. 6) described the flood on Bear Creek as the highest for the period 1889 to present. Another rancher who lives near the site on an unnamed tributary to North

Bear Creek near Chugwater (sta. 2) described that flood as the highest during the 50-year period that he has lived there.

Flood damage in the Bear Creek basin was minor; a bunkhouse at one ranch was flooded, and a small amount of damage was done to bridges and pastures.

Floods on September 1 on Muddy Creek and its tributaries (fig. 17) were generated by an intense thunderstorm centered over the upper reaches of North Fork Muddy Creek and adjacent unnamed tributaries. The maximum amount of precipitation recorded for this storm was 6 inches, which was reported to have fallen in about a 4-hour period.

A partial-record station equipped with a crest-stage gage has been maintained on Muddy Creek tributary (sta. 7) since 1960. The previous maximum peak discharge was 210 cfs, whereas the 1966 peak of 1,810 cfs was almost nine times as great. The peak discharges at Muddy Creek tributary and North Fork Muddy Creek (sta. 8) probably exceeded the hypothetical 50-year flood.

Four automobiles, containing a total of nine persons, were swept off Interstate Highway 80 at the North Fork Muddy Creek crossing during the flood; there were no serious injuries. The highway was closed temporarily, and minor damage was sustained by bridges, roads, and farmland on the floodplains.

TABLE 13.—*Flood stages and discharges, July 14 and September 1, in the Platte River basin in southeastern Wyoming*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before July 1966 — Period	Known before July 1966 — Year	July and September 1966	Gage height (ft)	Discharge [1] Cfs
1	Dry Creek near Chugwater (SE¼SW¼ sec. 24, T. 20 N., R. 67 W.).	5.0	1955, 1965–66.	1965			7,550
					July 14		1,400
	Unnamed tributary to:						
2	North Bear Creek near Chugwater (SE¼SW¼ sec. 11, T. 19 N., R. 67 W.).	7.4			July 14		2,840
3	Unnamed tributary to North Bear Creek near Chugwater (SE¼SE¼ sec. 10, T. 19 N., R. 67 W.).	2.4			July 14		1,190
4	South Fork Bear Creek near Chugwater (NE¼NW¼ sec. 34, T. 19 N., R. 67 W.).	16.8			July 14		552
5	Unnamed tributary to South Fork Bear Creek near Chugwater (NE¼SW¼ sec. 27, T. 19 N., R. 67 W.).	1.0			July 14		408
6	Bear Creek near Chugwater (SW¼NW¼ sec. 27, T. 19 N., R. 67 W.).	144			July 14		[2] 7,540
7	Muddy Creek tributary near Burns	41.2	1960–66	1963		5.50	210
					Sept. 1	8.90	1,810
8	North Fork Muddy Creek near Burns (NE¼NE¼ sec. 28, T. 14 N., R. 62 W., about 800 ft downstream from Interstate Highway 80 crossing).	25			Sept. 1		5,460

[1] Recurrence intervals unknown; probably exceed 50 yr for most floods listed.
[2] Maximum since 1889.

FLOODS OF AUGUST 12–14, IN EAST-CENTRAL NEBRASKA

By H. D. Brice

Severe flooding occurred along the Loup River and its tributaries on August 12–14 (fig. 18). The peak discharge at nearly all gaging stations on those streams exceeded the previous maximum of record (table 14).

The flood-causing precipitation began during the midmorning of the 12th and continued into the early hours of the 13th. Unofficial rainfall amounts ranged from 13 to 17 inches in southeastern Greeley County and southwestern Boone County. A resident of Cedar Rapids, in southwestern Boone County, reported a total of 15.9 inches, of which 6 inches fell between 1400 and 1600 hours on the 12th. A bucket survey, made by the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, and the U.S. Geological Survey, showed that much of Greeley County and parts of Valley and Boone Counties received 10 inches or more of rain and that the average rainfall on 12 contiguous counties (including Greeley, Valley, and Boone) ranged from 3.3 to 10.8 inches. (See table 15.) The complete results of the bucket survey, together with ESSA Weather Bureau data for the same storm, are presented in "Climatological Data, Nebraska, August 1966" (ESSA Weather Bureau, 1966).

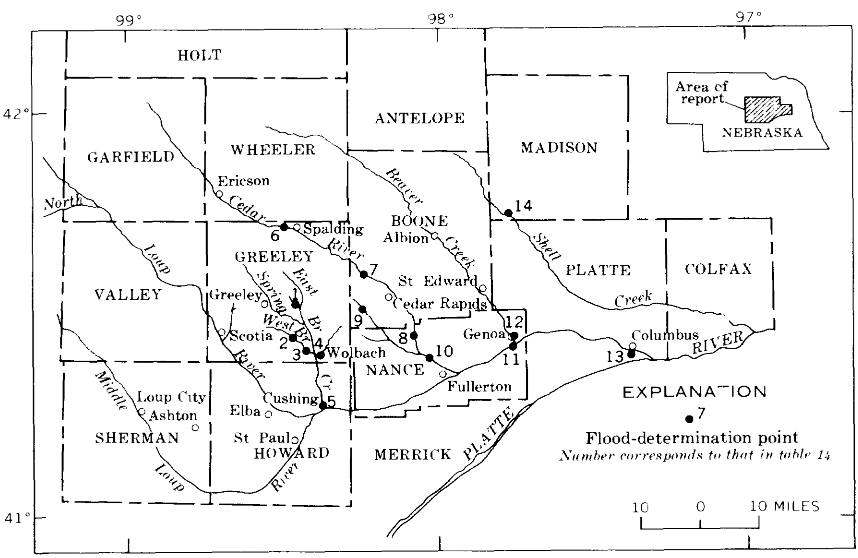

Figure 18.—Flood area and location of flood-determination points, floods of August 12–14, in east-central Nebraska.

TABLE 14.—*Flood stages and discharges, August 12–14, in the Platte River basin in east-central Nebraska*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before August 1966: Period	Year	August 1966	Gage height (feet)	Discharge: Cfs	Ratio to 50-yr flood
1	East Branch Spring Creek tributary near Wolbach.	1.52	1952–66	1956		13.49	370	
					12	13.11	1,340	2.8
2	West Branch Spring Creek at Brayton.	19.5	1945, 1952–66.	1945		18.4	3,700	
					12	23.26	12,800	6.6
3	West Branch Spring Creek near Wolbach.	36.9	1951–66	1953		17.20	4,040	
					12	23.75	12,800	4.7
4	Marys Creek at Wolbach	7.63	1952–66	1964		15.91	1,810	
					12	18.72	4,700	4.1
5	Spring Creek near Cushing	184	1948–1949, 1953–66.	1953		19.44	5,350	
					13	31.21	35,000	5.8
6	Cedar River near Spalding	[1]50 [3]805	1945–53, 1958–66.	1947		[2]7.50	4,000	
					12	6.94	3,080	2.6
7	Cedar River at Primrose	[1]130 [3]870	1960–64	1960		4.53	4,190	
					12	13.55	34,100	6.5
8	Cedar River at Belgrade	[1]320 [3]1,060	1959–65	1965		7.22	3,820	
					13	13.36	55,000	6.1
9	North Branch Timber Creek near Cedar Rapids.	23.5			12		9,930	4.5
10	Cedar River near Fullerton	[1]480 [3]1,220	1941–66	1950		9.64	10,100	
					13	14.90	64,700	5.9
11	Loup River near Genoa	[1]6,000 [3]14,400	1929–32, 1944–66.	1947		10.12	90,000	
					13	13.93	129,000	2.9
12	Beaver Creek at Genoa	[1]410 [3]627	1940–66	1950		[2]18.70	21,200	
					13	19.39	14,200	1.4
13	Loup River at Columbus	[1]6,530 [3]15,200	1895–1915, 1934–66.	1947		12.0	85,000	
					14	13.01	119,000	2.5
14	Shell Creek at Newman Grove	122	1950–66	1950		20.20	12,000	
					12	21.20	14,500	2.6

[1] Contributing.
[2] Site and datum then in use.
[3] Total.

TABLE 15.—*Average precipitation, by county, associated with flooding in the lower Loup River basin, Nebraska, August 12–14, 1966*

[Computed from bucket-survey data collected by U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, and U.S. Geological Survey]

County	Average precipitation (inches)	County	Average precipitation (inches)
Antelope	3.3	Madison	4.7
Boone	8.6	Nance	4.1
Garfield	5.7	Platte	3.3
Greeley	10.8	Sherman	3.6
Holt	4.8	Valley	6.2
Howard	3.7	Wheeler	5.0

With respect to the runoff it generated, the storm was an outstanding hydrologic event on two counts. For one, it resulted in peak discharges far greater than the previously known maximum at several stream-gaging stations. For another, it was one of the few storms known to have produced the annual peak discharge at all gaging stations in the area.

At eight of the gaging stations—all in the Spring Creek and Cedar River drainage basins—the peak discharge during the August 1966 flood was more than 2.5 times the previous maximum. Particularly noteworthy were the peak discharges of the Cedar River at Primrose (sta. 7), at Belgrade (sta. 8), and near Fullerton (sta. 10), as they were 8.1, 14.4, and 6.4 times, respectively, the previously known maxima. The highest recorded rates of runoff of the floods occurred in the upper reaches of the Spring Creek basin and in the area drained by the North Branch of Timber Creek, which is tributary to the Cedar River. The runoff rates for East Branch Spring Creek tributary, West Branch Spring Creek, and Marys Creek, a tributary to Spring Creek (stas. 1–4), ranged from 347 cfs per sq mi from an area of 36.9 square miles to 881 cfs per sq mi from an area of 1.52 square miles; the runoff rate for North Branch Timber Creek (sta. 9) was 414 cfs per sq mi from an area of 23.5 square miles. Even higher runoff rates than those recorded may have occurred elsewhere in the area of heaviest precipitation.

At three stations, the August 1966 peak discharge was 1.2–1.4 times the previously known maximum, and at two it was less than the previously known maximum. A comparison cannot be made for the August 1966 peak on the North Branch of Timber Creek because no previous peak discharge was determined for that site.

Table 16 reveals that the outstanding peak discharges observed in a given year over a significant area ordinarily are the result of two or more storms instead of only one, as in 1966. For example, in 1956 and in 1964, storms on each of four different dates resulted in the annual peak discharge at two or more gaging stations.

Of the known earlier floods in the lower Loup River basin, only the one in June 1896 was comparable in magnitude to that in August 1966. Peak discharges for the 1896 flood were recorded at two sites: the North Loup River near St. Paul and the Loup River at Columbus (sta. 13). Peak discharge near St. Paul was about 2.5 times that of 1966 at the same site, but the peak at Columbus was only 0.6 as great. Apparently the center of the storm that caused the 1896 flood was over the North Loup River basin—probably near Scotia—whereas the center of the storm causing the 1966 flood was several miles east of Scotia and over the drainage basins of tributaries entering the Loup River below the mouth of the North Loup. Rainfall amounts for June 5, 1896, were 12 inches at Greeley, 10.05 inches at Loup City, 5.60 inches at Elba, 4.55 inches at Ashton, and 2.70 inches at Ericson.

TABLE 16.—*Outstanding peak discharges observed at gaging stations in lower Loup River basin*

Permanent station No.	Stream and place of determination	Peak discharge, in cubic feet per second							
		1896	1945	1947	1950	1953	1956	1964	1966
7905	North Loup River near St. Paul.	June 6 [1] 90,000	May 27 15,800	June 22 36,000	July 9 16,800	May 10 9,030	May 29 8,660	Sept. 6 8,160	Aug. 12 36,400
7906	East Branch Spring Creek tributary near Wolbach.					July 3 136	July 4 370	Sept. 5 72	Aug. 12 1,340
7907	West Branch Spring Creek at Brayton.		July 16 3,700			May 10 3,540	July 4 1,690	Sept. 5 1,290	Aug. 12 12,800
7908	West Branch Spring Creek near Wolbach.					May 10 4,040	July 4 880	May 25 640	Aug. 12 12,800
7909	Marys Creek at Wolbach.					July 3 173	July 5 75	May 25 1,810	Aug. 12 4,700
7911	Spring Creek near Cushing.					May 10 5,350	July 5 1,820	May 26 2,730	Aug. 13 35,000
7915	Cedar River near Spalding.		July 16 497	June 23 4,000	July 8 1,320	May 2 749		June 22 710	Aug. 12 3,080
7917.5	Cedar River at Primrose.							June 16 2,320	Aug. 12 34,100
7918	Cedar River at Belgrade.							June 16 [2] 3,780	Aug. 13 55,000
7920	Cedar River near Fullerton.		May 27 1,850	June 23 7,510	July 19 10,100	May 11 6,050	Aug. 18 2,190	May 26 6,500	Aug. 13 64,700
7930	Loup River near Genoa.		June 10 18,800	June 23 90,000	July 9 39,300	May 10 16,000	Nov 22 10,700	May 26 32,800	Aug. 13 129,000
7940	Beaver Creek near Genoa.		June 9 1,120	June 22 2,410	July 19 21,200	May 11 1,400	May 30 865	May 26 18,500	Au.g 13 14,200
7945	Loup River at Columbus.	June 6,7 70,000	June 10 19,600	June 23 85,000	July 10 42,100	May 11 18,200	Nov. 22 7,500	May 26 28,200	Aug. 14 119,000
7950	Shell Creek at Newman Grove.				July 18 12,000	May 10 1,950	Aug. 18 734	June 22 3,460	Aug. 12 14,500
7955	Shell Creek near Columbus.				June 3 5,970	May 12 1,010	May 30 840	June 17 1,900	Aug. 15 1,780

[1] Estimated.
[2] A highly localized storm on May 17, 1965, produced a peak discharge of 3,820 cfs.

In 1945 the maximum discharges were the result of three storms, each over different areas. All these peaks were less than half the August 1966 peaks at the same sites.

A single storm on June 22 and 23, 1947, accounted for all the maximum discharges observed that year. The peak on the Cedar River near Spalding (sta. 6) was the largest recorded at the site, and the peaks of the Loup River near Genoa (sta. 11) and at Columbus (sta. 13) were the second largest recorded at those sites.

Three different summer storms were responsible for the maximum discharges recorded in 1950. The first storm, on June 3, caused the greatest peak ever recorded on Shell Creek near Columbus, but it was so local in extent that the peaks it caused elsewhere were exceeded within the next 2 months. Although the second storm, which occurred on July 8 and 9, caused the annual peak discharge at three of the seven gaging stations then operating in the basin, all these peaks were less than half the maximum observed at those sites. The third storm on July 18 and 19, resulted in the highest peak discharge ever recorded on Beaver Creek near Genoa (sta. 12) and the second highest on Cedar River near Fullerton (sta. 10) and on Shell Creek at Newman Grove (sta. 14).

Peak discharges in 1953 were caused by two storms. The first, which occurred on May 10 and 11, was rather widespread; whereas the second, on July 3, was localized near Wolbach. At none of the 13 gaging stations then in operation was the observed peak the maximum of record.

The four storms that produced the peak discharges in 1956 were centered over different parts of the lower Loup River drainage basin. As in 1953, none of the observed peaks was the maximum of record.

Similarly in 1964, the peak discharges were caused by widely scattered storms on four different dates. The first storm, on May 25 and 26, caused the annual peak discharges for the year at the seven gaging stations in the area extending from Wolbach and Cushing in the Spring Creek drainage basin to the vicinity of Columbus. At the gaging station on Beaver Creek near Genoa (sta. 12), the peak discharge was the second highest recorded. Two widely separated storms on June 16 resulted in the annual peak discharge of the Cedar River at Primrose (sta. 7) and at Belgrade (sta. 8) and of Shell Creek near Columbus. The peak at the Columbus site was the second highest of record. Another June storm, on the 22d, resulted in the annual maximum rate of discharge at two gaging stations, the Cedar River near Spalding (sta. 6) and Shell Creek at Newman Grove (sta. 14). A late-season rain on September 5 and 6 caused the highest observed discharge for the year at the following three locations: North Loup River near St. Paul, tributary to East Branch of Spring Creek near Wolbach (sta. 1), and West Branch of Spring Creek near Wolbach (sta. 3).

The foregoing summary of the outstanding peak discharges of record and the storms that caused them shows that most of the flood-producing storms of record have been of rather local extent and that widespread storms, such as resulted in the extensive flooding of August 1966, are unusual. Moreover, it points out that flood-producing storms of small areal extent have occurred simultaneously in widely separated parts of the lower Loup River basin. Although the available data are not fully representative of the long-term flood history of the area, they provide a basis for concluding that the storm that caused the August 1966 flood was the most widespread in the area since 1896 and possibly extended over a larger area than the storm of that year.

In a report describing the August 1966 flood, Shaffer and Braun (1967) delineated the flooded area along the Loup River between Fullerton and the mouth of the Loup River, along the lower reaches of tributary streams entering the Loup River between those two points, and along the Platte River for a few miles both upstream and downstream from the mouth of the Loup River. Their map shows that the flooded area along the Loup River was 1–3 miles wide and that a large part of the city of Columbus was inundated.

Damages of all types were estimated by the U.S. Army Corps of Engineers and are summarized in table 17.

Flooding and the resulting damage in the basins of Spring Creek, Cedar River, and Beaver Creek, and along the main channel of the Loup River from the vicinity of Fullerton to the mouth of the Loup River were the worst in the memory of most local residents. Flooding along the North Loup River and along the Loup River above Fullerton was less severe. In the Shell Creek basin flooding was confined to low-lying agricultural lands.

Several communities sustained considerable damage. At Scotia, floodwater from Wallace Creek, a tributary of the North Loup, entered 10 homes. Large parts of Greeley and Wolbach in the Spring Creek drainage basin were inundated. At Spalding, on the Cedar River, the municipal powerplant was damaged extensively, but damage to homes and businesses was minor. Downstream at Cedar Rapids many homes and businesses were badly damaged. At Fullerton, located where the Cedar River empties into the Loup River, the railroad depot was destroyed, water and sewer lines were extensively damaged, and many families had to leave their homes; residents there described the flood of 1966 as the worst since the 1923 flood, for which no streamflow data are available. In St. Edward, floodwater from Beaver Creek completely submerged several homes, entered the first floor of 42 others, and filled, or partly filled, the basements of 71 more; 42 businesses were flooded to a depth of 1 foot over the first floor and damage to merchandise was high. Only minor damage occurred in Albion and Genoa, which are in Beaver Creek valley. At the crest of the flood on

TABLE 17.—*Summary of damage, floods of August 1966*

[Data furnished by the U.S. Army Corps of Engineers]

Stream	Area flooded	Damage to urban areas	Damage to agriculture	Damage to utilities and transportation facilities	Cost of repairs to levees and other items	Total
North Loup River	8,800	$10,000	$660,000	$210,000		$880,000
Cedar River	12,300	560,000	1,770,000	420,000		2,750,000
Beaver Creek	9,600	180,000	560,000	510,000		1,250,000
Loup River	38,300	1,450,000	2,010,000	960,000		4,420,000
Shell Creek	8,500	5,000	1,090,000	5,000		1,100,000
Platte River			390,000		$10,000	400,000
Totals	77,500	2,205,000	6,480,000	2,105,000	10,000	10,800,000

August 14, about one-third of Columbus was inundated, and 634 homes and 24 businesses sustained heavy damage. The entire Wagner Lake area of summer homes in Columbus was under water, to a depth of 6 feet above the first floor of some homes.

At the height of the flooding on August 13, the Nebraska State Safety Patrol reported 14 highways closed to traffic. Some stretches of highway were under 4–5 feet of water, several sections of pavement were undermined, and a few bridges and bridge approaches were washed out.

Extensive damage was sustained by the Loup Public Power District. The dike along the power canal broke in several places, and long stretches were weakened by erosion. Bridges, roads, and transmission lines belonging to the Power District also were damaged severely.

About 77,000 acres of agricultural land in the Loup River drainage basin was inundated. Some crops were ruined, and the yield of others reduced. Erosion damage was considerable, particularly in the North Loup River valley.

FLOODS OF AUGUST 22–23, IN WESTERN TEXAS

The following report has been prepared from a flood report of more detail by the U.S. Army Corps of Engineers (1966.)

Rain fell along a frontal system extending from Laredo to El Paso on August 22. More than 12 inches fell in some areas in the mountains west of Dell City (fig. 19). Rainfall amounts and location of the rainfall stations are shown on the map.

Flows from ephemeral streams west of Dell City peaked almost simultaneously and discharged upon irrigated plains 3 or 4 miles west of Dell City. The discharge emerged as sheetflow to flood Dell City and surrounding irrigated developments. About 24,000 acres of irrigated farmland on the plains, from 6 to 10 miles wide, was inundated to a depth of 3 feet. About 500 acres of Dell City was inundated. The combined discharge across the plain was not determined; however, an indirect measurement of 49,900 cfs discharge from a drainage area of 92.3 square miles (table 18) was made on Washburn Draw, 7 miles west of Dell City (sta. 1). Overflow from University Draw and tributaries, all ephemeral streams, flooded an area a quarter of a mile wide at U.S. Highway 62 and 180. Floodwater overtopped a quarter of a mile of highway, undercut the surfacing, and breached the highway. The flow from University Draw contributed to the peak flow of 24,000 cfs on Eight Mile Draw near Salt Flat (sta. 2).

Flood damage in the Dell City area was estimated at about $4.3 million. Most of the business houses, water wells, cesspools, and automobiles in Dell City were damaged by floodwater. Farm roads, county

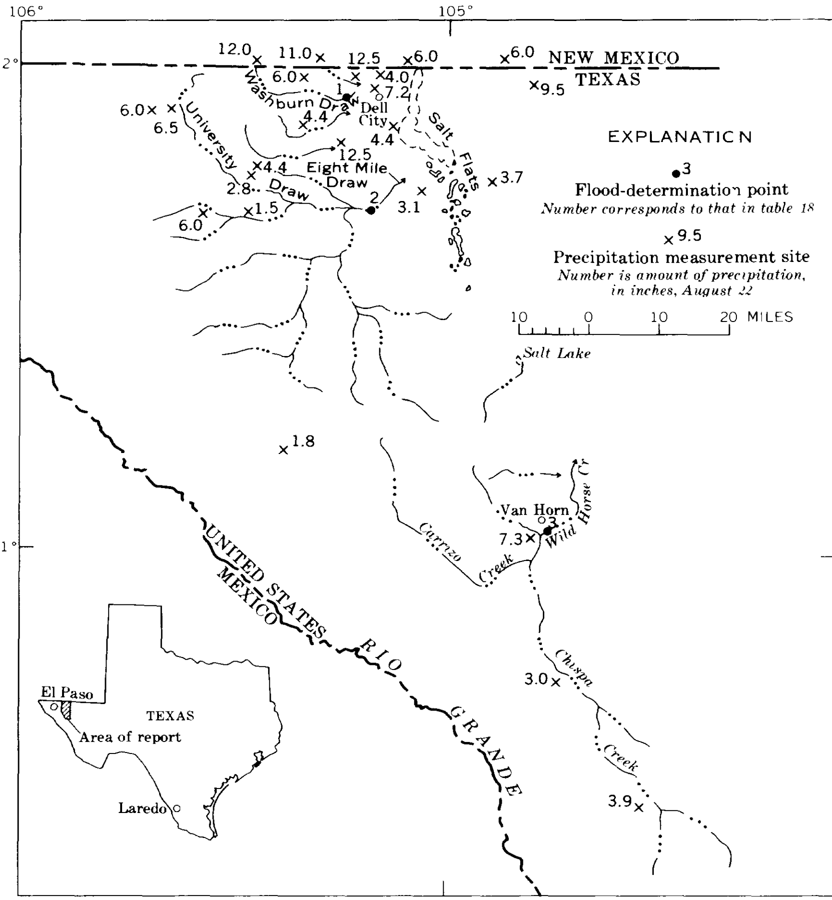

FIGURE 19.—Flood area and location of flood-determination points and precipitation data sites, floods of August 22–23, in western Texas.

roads, and city streets were covered by sediment. Roadbeds were eroded, and surface materials were destroyed. Many acres of land were inundated for longer than a week. Farm laterals and irrigation wells were damaged. Land was damaged by erosion and deposition. Cotton, alfalfa, and grain crops were lost or damaged.

Flooding occurred in Wild Horse Creek and tributaries in the Van Horn vicinity. The peak discharge of Wild Horse Creek east of Van Horn (sta. 3) was 30,500 cfs. According to long-time residents of Van Horn the last flood of similar magnitude was in 1913. Floods from Chispa and Carrizo Creeks south of Van Horn created a flooded area 5 miles wide, which inundated about 500 acres of irrigated land. Below the confluence of the two creeks, on Wild Horse Creek, the flood plains

TABLE 18.—*Flood stages and discharges, August 22–23, in the Rio Grande basin in western Texas*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before August 1966: Period	Known before August 1966: Year	August 1966	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
1	Washburn Draw near Dell City	92.3			23		49,900	
2	Eight Mile Draw near Salt Flat	1,594			23		24,000	
3	Wild Horse Creek near Van Horn	1,609			22		30,500	

were covered up to a width of a quarter of a mile, and a short distance farther downstream the flooded plain was 5 miles wide. Some areas were inundated for a week.

Floods in the irrigated communities near Van Horn damaged irrigation laterals, destroyed fences, eroded and deposited silt on irrigated lands, denuded grasslands, an damage stock tanks, waterways, an erosion control structures. About 58,000 acres of land was inundated, of which 25,000 acres was irrigated land. The Southern Pacific trestle over Carrizo Creek at Collado was badly damaged and about 4 miles east of there, a quarter of a mile of railroad track was severely damaged. Flow from Wild Horse Creek damaged a Texas and Pacific Railway trestle and destroyed 200 feet of embankment and trackage. A bridge on State Highway 54 was destroyed by Sulphur Creek 12 miles north of Van Horn. The level of Salt Lake rose several feet and inundated about 400 feet of the highway which was impassible for a week.

FLOODS OF AUGUST 22–23, IN SOUTHEASTERN NEW MEXICO

By C. CLARE CRANSTON

On August 20, warm, moist air moving inland from the Gulf of Mexico converged with a cold front moving southwestwardly over northwestern Texas and northern New Mexico. Scattered thundershowers occurred along the front, and during the afternoon 1.06 inches of rain was recorded near Elk, N. Mex., about 70 miles northwest of the report area, in the Sacramento Mountains.

As the cold front continued to move slowly southwestward on August 21, the thunderstorm activity increased over eastern and southern New Mexico. Some minor discharge peaks were recorded at several gaging stations on streams in the area. The precipitation reading at 1600 hours at Two River Reservoir, west of Roswell, showed that 2.38 inches of rain had fallen since the previous day. During the afternoon or evening of August 22, the cold front became stationary across western Texas and southern New Mexico.

The Carlsbad weather station recorded continuous rainfall from about 0800 hours on August 22 to 0800 hours on August 23; some periods of intense rainfall were recorded in this period.

An isohyetal map, prepared by the U.S. Army Corps of Engineers, of the 4-day (Aug. 20–23) precipitation total in the area, and the location of flood-determination points, are shown in figure 20.

The Pecos River tributaries throughout southeastern New Mexico began to rise appreciably during the morning of August 22, and some moderate peaks were recorded. During the evening, peaks occurred that were more than 70 percent of the recorded August 23 maximums at gages on Rocky Arroyo at the highway bridge near Carlsbad, and on South Seven Rivers near Lakewood (stas. 9, 7). Other streams in the area had primary peaks of a lesser magnitude.

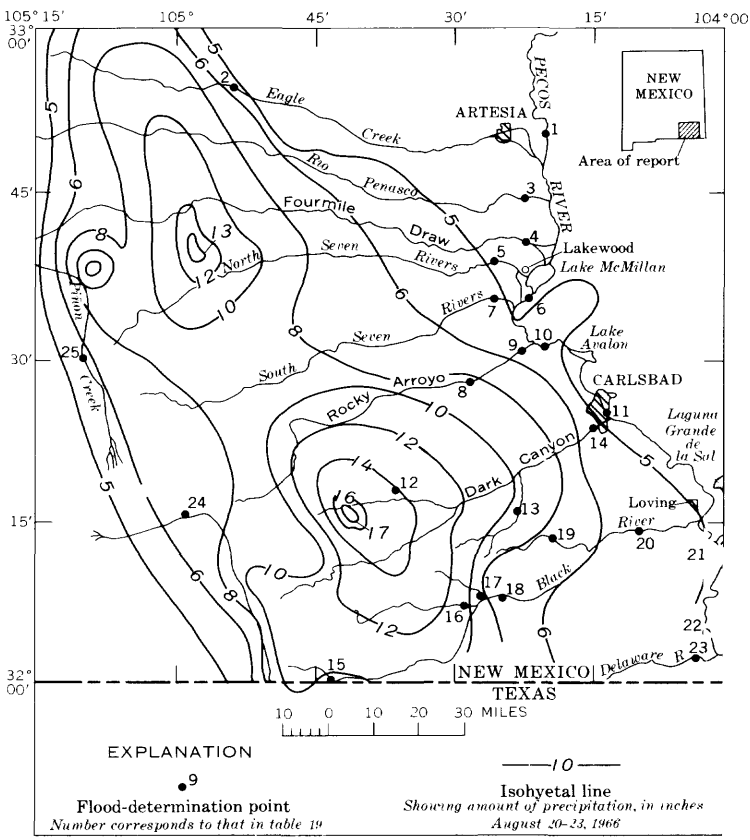

FIGURE 20.—Flood area, location of flood-determination points, and isohyets for August 20–23, floods of August 22–23, in southeastern New Mexico.

Discharges began to increase during the late hours of August 22 and the early hours of August 23 (table 19). During the night of August 22, floodflow from North Seven Rivers (sta. 5) crossed U.S. Highway 285 and the tracks of the Atchison, Topeka, and Santa Fe

TABLE 19.—*Flood stages and discharges, August 22–23, in the Pecos River basin in southeastern New Mexico*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before August 1966: Period	Known before August 1966: Year	August 1966	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
1	Pecos River near Artesia	15,300	1893–1966	1904		(1)	(1)	
			1905–66	1937		(1)	[2] 51,500	
					[3] 24	12.42	7,000	<2
2	Eagle Creek near Hope	95			23		10,300	9
3	Rio Penasco at Dayton	1,070	1941–66	1941		9.0	(1)	
			1951–66	1954		6.82	23,700	
					23	7.90	29,800	[4] 1.3
4	Fourmile Draw near Lakewood	265	1951–66	1954		[5] 13.3	7,650	
					23	19.9	[6] 29,300	[4] 2.2
5	North Seven Rivers near Lakewood.	312			23		37,400	[4] 2.7
6	Pecos River below McMillan Dam	16,990	1843–1966	1893		(1)	(1)	
			1939–40, 1947–66.	1954		(1)	16,100	
					23		[7] 16,500	
7	South Seven Rivers near Lakewood.	220	1893	1893		(8)	(1)	
			1941–66	1954		[5] 22.8	30,000	
					23	18.15	20,100	14
8	Rocky Arroyo near Carlsbad	254	1916–66	1954		56.8	63,300	
					23	50.07	26,000	20
9	Rocky Arroyo at highway bridge near Carlsbad.	285	1941–66	1954		19.2	(1)	
					23	15.35	31,600	24
10	Pecos River at damsite 3 near Carlsbad.	17,980	1939–66	1941			60,000	
					23	20.32	69,000	30
11	Pecos River at Carlsbad	18,000	1843–1966	1904		23.44	90,000	
					23	[9] 21.6	54,400	18
12	Last Chance Canyon tributary near Carlsbad Caverns.	.2	1959–66	1960		5.72	439	
					23	7.77	683	(1)
13	Mosley Canyon near White City	14.6	1959–66	1965		13.7	16,400	
					23	9.93	5,100	12
14	Dark Canyon Draw at Carlsbad	449			23		66,000	[4] 1.3
15	McKittrick Canyon Draw at New Mexico-Texas State line near White City.	71			22		10,900	12
16	Slaughter Canyon near White City	31.9			22		8,610	15
17	Rattlesnake Canyon near White City.	18.8			22		11,900	37
18	Black River at U.S. Highway 285 near White City.	217			23		41,500	[4] 1.1
19	Jurnigan Draw near White City	6.13			23		6,710	42
20	Black River above Malaga	343	1908–66	1908		21	(1)	
			1946–66	1955		14.70	20,500	
					23	21.7	74,600	[4] 1.6
21	Pecos River near Malaga	19,190	1904–66	1941		31.0	63,700	
					23	42.1	120,000	[4] 1.9
22	Pecos River at Red Bluff	19,540	1937–66	1941		28.3	52,600	
					23	33.32	111,000	[4] 2.3
23	Delaware River near Red Bluff	689	1911–66	1955		27.0	81,400	
					22	17.48	33,200	19
24	Box Canyon near El Paso Gap	87			23		5,450	(1)
25	Pinon Creek near Pinon	203			22		7,970	(1)

[1] Not determined.
[2] At site 15 miles upstream.
[3] Result of a flood on Rio Felix, Aug. 23.
[4] Ratio of peak discharge to 50-yr flood.
[5] At site and datum then in use.
[6] Maximum since at least 1929 from information by local residents.
[7] Flow partly regulated.
[8] Exceeded that of 1954 by several feet and believed to be maximum known.
[9] Affected by backwater from Dark Canyon.

Railway and began to inundate the community of Lakewood. Flows in Fourmile Draw near Lakewood (sta. 4) and South Sever Rivers near Lakewood (sta. 7) also began to cross the highway and the railroad. The National Guard, Eddy County Rescue Squad, Eddy County Sheriff's Posse, Civil Defense, and local law enforcement units were mobilized to direct traffic and evacuate people from the Lakewood community.

Storm runoff from the Hackberry Draw basin was impounded against the Carlsbad main canal south and caused minor flooding in the Welshire Addition of west Carlsbad on the evening of August 22.

The flood crest from Dark Canyon Draw (sta. 14) arrived at the confluence of the Pecos River in the early morning of August 23. A siphon for the Carlsbad main canal south, a constriction in Dark Canyon Draw, caused floodwaters to be backed up into the Welshire Addition. Foodwaters overflowed the channel banks upstream from bridges on U.S. Highway 285 and on the Atchinson, Topeka, and Santa Fe Railway, and flooded some of the business district in south Carlsbad.

The Pecos River channel downstream from the mouth of Dark Canyon Draw was not large enough to carry the peak flow from Dark Canyon Draw; consequently, backwater caused flooding upstream along the Pecos River. These floodwaters inundated part of a residential district on the east side of the Pecos River and the gaging station, Pecos River at Carlsbad (sta. 11).

Lake McMillan and Lake Avalon, north of Carlsbad, impounded part of the floodwaters from Rio Penasco, Fourmile Draw, North and South Seven Rivers, Rocky Arroyo (stas. 3–5, 7, 9, respectively), and other smaller Pecos River tributaries. These impoundments reduced the flood crest as it moved down the Pecos River. The spill from Lake Avalon was estimated from a computation of peak flow over Tansil Dam and was about equal to the flow at the Carlsbad gage. The moderated flood crest reached Carlsbad at about 1400 hours August 23, at which time there was still considerable flow in Dark Canyon Draw. The combined Dark Canyon Draw-Pecos River flow prolonged the period of flood-inundation in the confluence area.

The flood crest moving downstream from Carlsbad washed out one end of Six Mile Dam, a small irrigation impoundment, and inundated and damaged an Atchison, Topeka, and Santa Fe Railway bridge near Loving. At the crest, a part of the flow crossed a low divide to the east and entered Laguna Grande de la Sal (fig. 20), a disposal area for the U.S. Borax & Chemical Co., Inc., potash refinery east of Loving.

Receding floodflow from Black River (sta. 20) combined with the flood crest in the Pecos River to produce the maximum known peak discharge, 120,000 cfs at the gaging station, Pecos River near Malaga (Sta. 21). Combined floodflows from all the tributaries above Malaga merged in the Pecos River and resulted in the maximum peak discharge of record of 111,000 cfs (fig. 21) at the gaging station, Pecos River at Red Bluff (sta. 22).

The recurrence intervals of the peak discharges at the flood-determination points indicate the relative magnitude at the sites. At those points where the peak discharge had a recurrence interval greater than 50 years, the ratio of the peak discharge to the 50-year flood is shown.

The U.S. Army Corps of Engineers, the U.S. Soil Conservation Service, and other agencies, estimated damage to residences, farms,

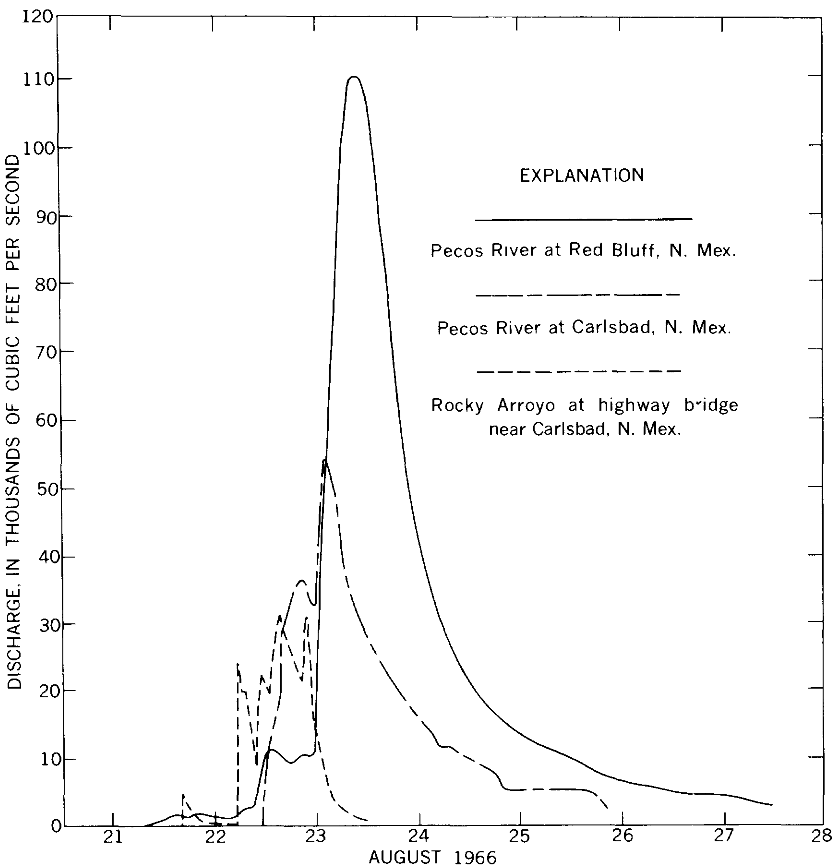

FIGURE 21.—Discharge hydrographs, August 21–27, for Pecos River at Carlsbad and Red Bluff, and for Rocky Arroyo at highway bridge, near Carlsbad, N. Mex.

roads, utilities, railroads, and city property, plus the cost of Red Cross assistance in the area covered by this report at $1,220,000. Of this amount, the Atchinson, Topeka, and Santa Fe Railway sustained damage estimated at $225,000. Two lives were lost, one in North Seven Rivers and one in Fourmile Draw.

FLOODS OF SEPTEMBER 13, IN SOUTH-CENTRAL ARIZONA

By B. N. Aldridge

On September 13, heavy precipitation associated with Hurricane Helga caused flooding in several small drainage basins in south-central Arizona (fig. 22). The most severe floods originated in the Buckeye Hills south of Buckeye between Waterman Wash and the Gila River. Waterman Wash (table 20, sta. 9), had the largest peak since at least

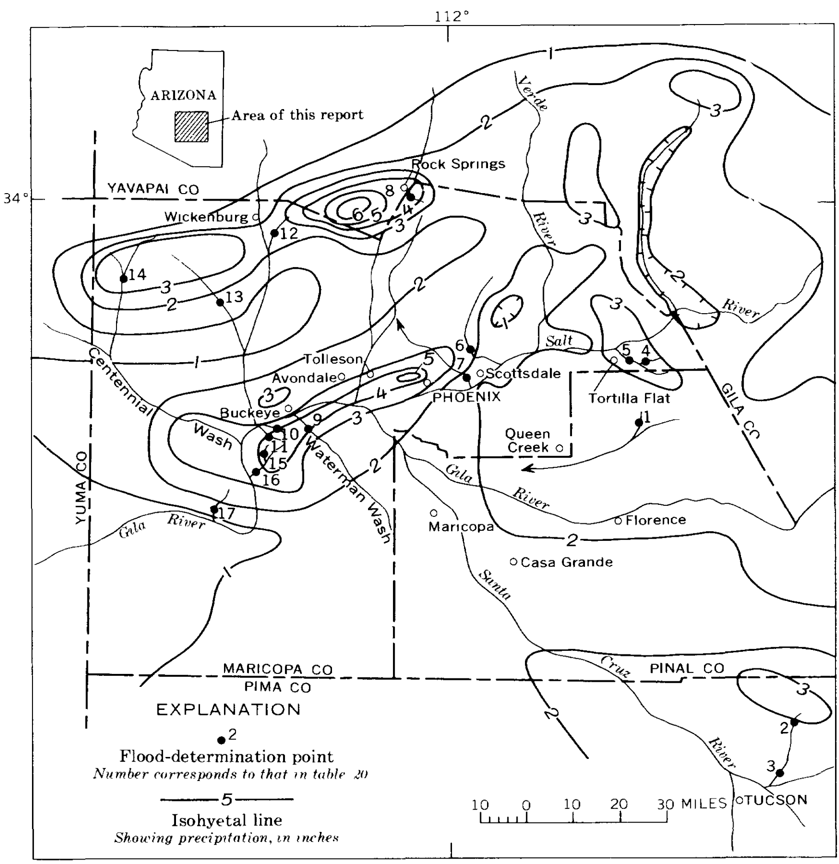

FIGURE 22.—Flood area, location of flood-determination points, and isohyets for September 11–14, floods of September 13, in south-central Arizona.

1959, and Rainbow Wash (sta. 16) had the largest peak since at least 1933. Only a few square miles at the lower end of the Waterman Wash basin contributed to the flood in the stream. The peak discharge at the crest-stage gage 2 miles above the mouth of Waterman Wash (sta. 9) was 5,560 cfs; the peak discharge at the mouth, was estimated to be more than 12,000 cfs (Tinco Van Hylckama, U.S. Geological Survey resident hydrologist, written commun., 1966). The flood deposited 2–3 feet of rock and debris in cottonfields near the mouth of Waterman Wash and damaged dikes and irrigation facilities. Farmers received $120,000 in Federal aid for repair of damages and for realinement of the stream channel.

Small tributaries to the Gila River from the north end of the Buckeye Hills reached extremely high stages. Flow from these tributaries, combined with the flow from Waterman Wash, flooded the grade-level crossing of the Gila River at U.S. Highway 80 south of Buckeye. The flood also washed out sections of an old highway, which generally is used as a bypass when the Gila River crossing is flooded. Small tributaries from the west side of the Buckeye Hills flowed directly into the Gila Bend Canal and caused excessive flow. Overflow from Rainbow Wash also entered the canal just above a siphon that carries the canal under the wash. The hydrostatic pressure in the Gila Bend Canal and the erosional forces of the water in Rainbow Wash destroyed about 50 feet of the canal on each side of the siphon, a gaging station, and an approach to the bridge on the old highway that crosses Rainbow Wash just below the siphon.

About 150 homes in the Phoenix metropolitan area were flooded by a few inches of water when canals broke because of excessive runoff from local sidehill drainages. About 50 families received Red Cross aid. Damage resulted mainly from inundation of carpets, furniture, and personal property. Damage to buildings was relatively small because velocities of flow were fairly low in most of the residential areas. Homes in northeast Scottsdale were flooded when a 25-foot section of the Arizona Canal washed out. In order to lower the water level enough to repair the canal, water was released through the Indian Bend Wash wasteway; considerable flooding occurred along Indian Bend Wash below the canal, but the flow was of much smaller magnitude than some flows that have occurred in the past Some homes north of the Arizona Canal were flooded by streams that flowed into the canal. The Phoenix office of the Small Business Administration estimated that 50–100 Scottsdale homes and about a dozen business establishments received serious flood damage. About 50 families were evacuated in west Phoenix when the Grand Canal overflowed and flooded several home in the Maryvale district. The Roosevelt Canal and some of its laterals broke, and water flooded 30–40 homes in Tolleson and 30 homes in Avondale.

Local flooding occurred in several other areas, and eight homes near Maricopa were flooded. Many schools were closed because of flooded roads and highways, and in a few places the schools were flooded. Heavy flooding in the Queen Creek area (fig. 22) washed out three bridges on the Southern Pacific between Phoenix and Florence. State Highway 88 was closed temporarily at Tortilla Flat because of extremely high water in Tortilla Creek; the flow (sta. 5) was reported by a local resident to be the highest since 1941. The recreational community of Summerhaven on Mount Lemmon near Tucson was severely damaged when Sabino Creek flooded business establishments and cut a new channel down the main street. Farther downstream in Sabino Canyon, roads that were being repaired after an August flood were washed out again, and picnic facilities were damaged. Damages were estimated to be about $10,000. At the Sabino Creek near Tucson (sta. 3) gaging station, the peak discharge was the second highest in 35 years of record. The highest peak (6,400 cfs) occurred on August 12, 1966. Prior to August 12, the maximum discharge of record had been 5,100 cfs in 1954. High flows were recorded in central Yuma County and northern Maricopa County near Wickenburg and Rock Springs, but no flooding occurred.

Peak discharges at selected stations in the flood area are given in table 20. Flood-frequency relations are undefined for the drainages affected by the floods; therefore, the recurrence intervals for the flood peaks were not determined.

Rainfall data for the flood area are meager and may not represent the maximum amounts received during the storm nor the actual rainfall associated directly with the flood. Most of the rain gages are read once a day. The flooding occurred as a result of several hours of rain on the morning of September 13. Rain from the preceding 2 days probably contributed to the floods because the soil was saturated before the rains on September 13. On September 13, 4 inches of rain was recorded at the mouth of Waterman Wash, but more rain may have fallen in parts of the Buckeye Hills; some areas in west Phoenix received as much as 5 inches of rain, but only 1.83 inches was recorded at the official gage at the Phoenix Airport, and 2½ inches of rain was reported at Summerhaven. The isohyets in figure 22 are based on rainfall data collected at ESSA Weather Bureau stations, special precipitation stations operated by the U.S. Geological Survey, and from information from local residents. Although the period shown in figure 22 is September 11–14, in general, the isohyets more nearly represent

TABLE 20.—*Flood stages and discharges, September 13, in south-central Arizona*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before September 1966		September 1966	Gage height (feet)	Discharge: Cfs	Discharge: Cfs per sq mi
1	Queen Creek tributary 3 at Whitlow Dam.	0.26			13	7.55	280	1,080
2	Sabino Creek near Mount Lemmon	3.19	1951–66	1954		11.3	344	
					13	11.9	380	119
3	Sabino Creek near Tucson	35.5	1932–66	1966		9.65	6,400	
					13	9.46	6,020	170
4	Mesquite Creek near Mormon Flat Dam.	4.26	1963–66	1964		12.9	2,200	
					13	23.90	4,360	1,020
5	Tortilla Creek at Tortilla Flat	24.3			13	9.3	6,660	278
6	Indian Bend Wash near Scottsdale	142	1961–66	1961			745	
				1963		1.43		
					13	1.77	596	4.1
7	Indian Bend Wash at Thomas Road in Scottsdale.	([1])			13		1,350	
8	Agua Fria River tributuary 2 near Rock Springs.	1.0	1963–66	1964		19.54	1,200	
					13	12.4	812	812
9	Waterman Wash near Buckeye	[2] 403			13	6.21	5,560	13.8
10	Gila River tributary near Buckeye	.41			13		650	1,580
11	Gila River tributary 2 near Buckeye.	.11			13		160	1,450
12	Ox Wash near Morristown	6.31	1963–66	1964		10.2	2,900	
					13	6.02	1,300	206
13	Jack Rabbit Wash near Tonopah	137	1964–66	1964		9.19	2,070	
					13	8.10	850	6.2
14	Tiger Wash near Aguila	85.2	1963–66	1965		7.5	1,680	
					13	7.96	([3])	
15	Rainbow Wash tributary near Buckeye.	[4] 3.45	1963–66	1964		5.86	763	
					13	6.65	950	275
16	Rainbow Wash near Gila Bend	45			13		5,110	114
17	Windmill Wash near Gila Bend	12.9	1964–66	1965			<10	
					13	8.64	967	75

[1] Water from Arizona Canal. Drainage area indeterminate.
[2] Flood originated in a few square miles at the lower end of the basin.
[3] Discharge not computed.
[4] An area of 1.02 sq mi above stock pond may be partly noncontributing.

the rainfall of September 12–13, because rains on September 11 were very light, and most of the precipitation recorded on September 14 actually fell on September 13.

FLOODS OF SEPTEMBER 13, IN SOUTHEASTERN WASHINGTON

By J. H. BARTELLS

Intense thunderstorm activity occurred on the evening of September 13, over a part of southeastern Washington. In the Pomeroy area (fig. 23), 1.12 inches of rainfall was recorded, most of which fell between 1830 and 1900 hours. Some basins in the area had extremely high rates of runoff, whereas adjoining basins had little or no runoff. The rainfall intensity varied greatly throughout the area, as indicated by the runoff pattern; therefore the rainfall recorded at Pomeroy probably does not indicate the maximum amount that fell in the area.

Two continuous-record stations and four partial-record peak-discharge stations are in the flood area. Indirect measurements of peak discharge were made at six miscellaneous sites. The peak discharges are given in table 21.

Of special interest is the fact that the unit runoff exceeded 1,000 cfs per sq mi at two of the flood determination points. Records have been collected at 21 sites in southeastern Washington which have drainage areas of less than 10 square miles. The average period of record for these stations is 9 years. In addition, measurements of peak flows have been made at 10 miscellaneous sites. In all of these records, a runoff of 1,000 cfs per sq mi has been exceeded only three other times.

The most extensive property damage occurred in the Pomeroy area. Several homes and a few business establishments were damaged by water and mud. Highways were blocked by mud slides and washouts, and severe erosion occurred on some hills and fields.

TABLE 21.—*Flood stages and discharges, September 13, in southeastern Washington*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before September 1966				Discharge	
			Period	Year	September 1966	Gage height (feet)	Cfs	Recurrence interval (years)
	Asotin Creek basin							
1	Bachelor Gulch near Asotin	1.54			13		1,850	1 >10
2	Charley Creek near Asotin	22.1			13		992	1 6.3
3	Asotin Creek below Kearney Gulch near Asotin.	170	1959–66	1965		7.95	2,720	
					13	7.55	2,720	1 2.3
	Alpowa Creek basin							
4	Clayton Gulch near Alpowa	5.60	1961–66	1963		11.38	299	
					13	5.92	57	1
	Deadman Creek basin							
5	South Fork Deadman Creek tributary near Pataha.	0.54	1961–66	1961		8.27	91	
					13	9.90	192	1 2.7
6	Smith Gulch tributary near Pataha	1.85	1955–66	1961		10.86	254	
					13	12.7	656	1 3.6
7	Ben Day Gulch tributary near Pomeroy.	.78	1961–66	1965		7.76	44	
					13	8.70	70	20
8	Meadow Creek near Central Ferry	66.2	1963–66	1963		7.33	2,280	
					13	6.22	2,380	26
	Tucannon River basin							
9	Sweeney Gulch near Pomeroy	4.14			13		950	1 2.8
10	Pataha Creek tributary at Pomeroy	.42			13		2,120	1 >10
11	Pataha Creek at Zumwalt	93.7	1949, 1964	1949			1,620	
					13		2,580	15
12	Linville Gulch near Pomeroy	5.6	1950, 1964	1950			9,750	
					13		689	1 1.6

1 Ratio of peak discharge to 50-yr flood.
> Greater than.

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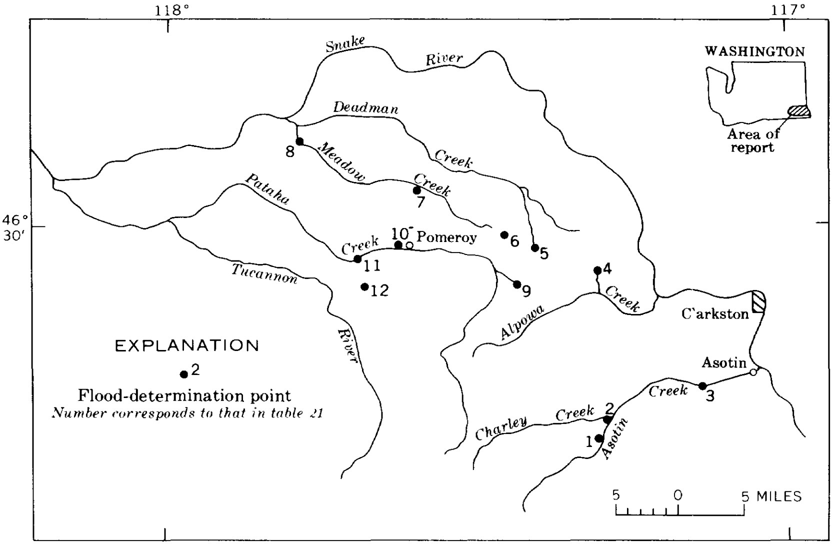


FIGURE 23.—Flood area and location of flood-determination points, floods of September 13, in southeastern Washington.

FLOODS OF NOVEMBER 11–13, IN WEST-CENTRAL LOUISIANA

On November 11 and 12, warm winds from the Gulf of Mexico, overriding colder air, caused thunderstorms in west-central Louisiana. The thunderstorms were accompanied by high winds in an area generally from Beauregard to Pointe Coupee Parishes (fig. 24).

The ESSA Weather Bureau rain gage at DeRidder recorded 8.44 inches. The 4.45 inches measured on the 12th, and the 3.99 inches measured on the 11th were the second and third greatest 1-day precipitation for November recorded at that station. At Forest Hill, 8.04 inches was recorded on the 11th. The 6.10 inches measured on the 12th at Woodworth State Forest was the second greatest 1-day precipitation for November at that station. Isohyetal lines for the period November 11–14 are shown in figure 24.

The flooding was not widespread, and some streams in the area rose to record heights (table 22). The peak discharge of 16,100 cfs in Tenmile Creek near Elizabeth (sta. 6) was 1.41 times that of a 50-year flood. The peak discharge in Sixmile Creek near Sugartown (sta. 5) of 21,600 cfs was equal to a 35-year flood. The peak in Bundick Creek near DeRidder (sta. 9) was maximum during the 11 years of record.

The rain and high wind caused thousands of dollars of damage to fishing camps, businesses, and homes. Some powerlines were knocked down, and a road was washed out.

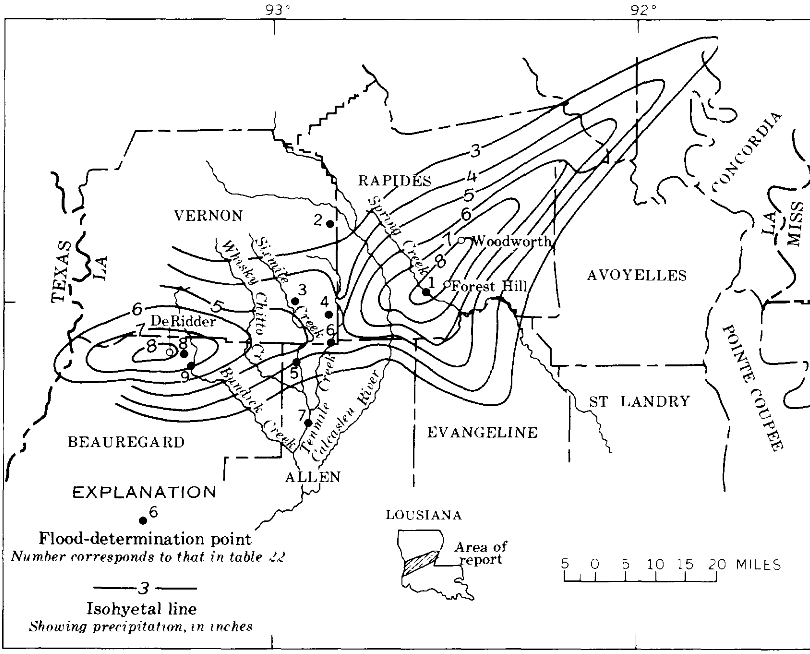


FIGURE 24.—Flood area, location of flood-determination points, and isohyets for November 11–14, floods of November 11–13, in west-central Louisiana.

TABLE 22.—*Flood stages and discharges, November 11–13, in west-central Louisiana*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before November 1966 — Period	Year	November 1966	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
1	Spring Creek near Glenmora	68.3	1886–1966	1953		20.5	(1)	
			1954–66	1957		15.70	2,160	
					12	17.22	(1)	
2	Big Creek near Leander	2 37.1	1951–66	1953		14.94	(1)	
					12	11.95	2,180	3
3	Little Sixmile Creek near Pitkin	10.4	1954–66	1954		15.89	(1)	
					12	15.72	(1)	
4	Big Brushy Creek near Pitkin	34.4	1964–66	1966		16.33	(1)	
					12	20.7	(1)	
5	Sixmile Creek near Sugartown	171	1953	1953		18.3	25,000	
			1956–66	1966		14.17	6,770	
					12	17.66	21,600	35
6	Tenmile Creek near Elizabeth	94.2	1950–66	1953		21.33	31,900	
					12	18.28	16,100	3 1.41
7	Whisky Chitto Creek near Oberlin	510	1939–66	1953		32.8	144,000	
					13	23.87	36,700	14
8	Flat Creek near DeRidder	26.3	1964–66	1966		12.60	(1)	
					11	12.96	(1)	
9	Bundick Creek near DeRidder	120	1956–66	1966		20.36	6,570	
					12	20.79	7,090	3

NOTE.—Computations of recurrence intervals were based on the report, "Floods in Louisiana, Magnitude and Frequency," 2d ed., by Sauer (1964).

1 Not determined.
2 Includes drainage area of Mill Creek.
3 Ratio of peak discharge to 50-yr flood.

FLOODS OF DECEMBER, IN SOUTHWESTERN UNITED STATES

On December 3 a storm moved eastward from the Pacific Ocean into Southwestern United States along a cold front that was moving southward. Intense precipitation occurred around the high mountain ranges in south-central California. A band of intense precipitation extended from southeastern Nevada across the southwestern corner of Utah to the Grand Canyon and southward to the mountains of central Arizona (fig. 25).

Although the storm and floods occurred in adacent parts of four States, the events in each State were reported individually by an

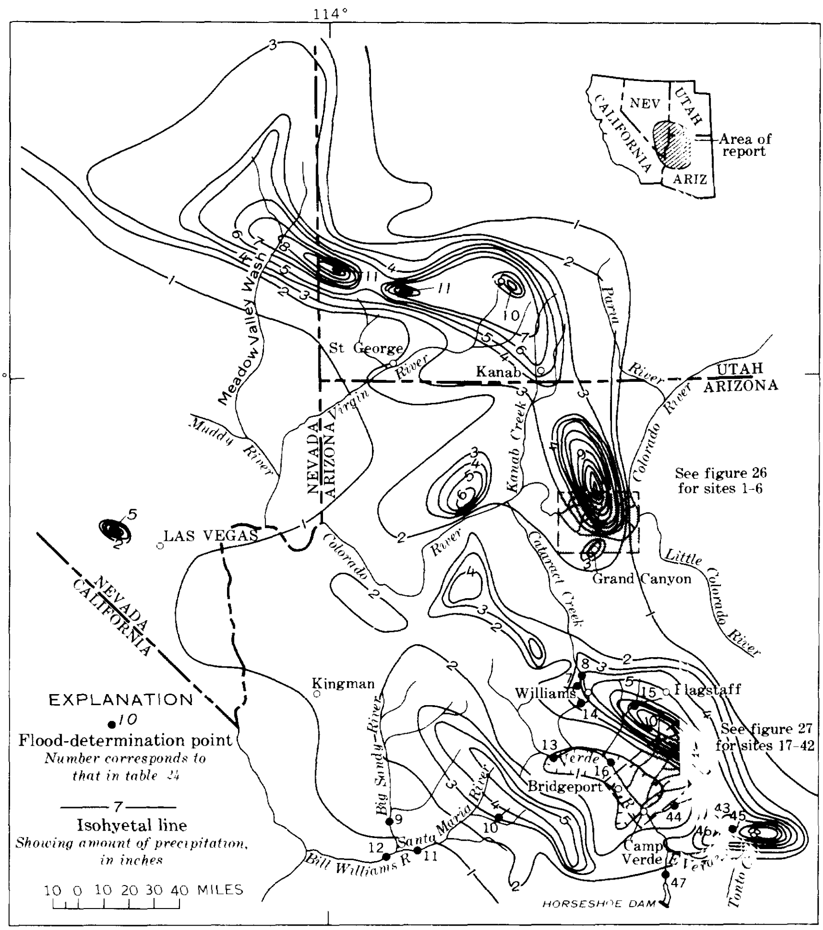


FIGURE 25.—Flood area, location of flood-determination points in northwestern Arizona, and isohyets for December 3–7, in northwestern Arizona and adjacent areas in Utah and Nevada, floods of early December in Southwestern United States.

author in that State. The isohyetal map (fig. 25) depicting the amount of storm rainfall in the flood area in Arizona, Utah, and Nevada was prepared by B. N. Aldridge.

NORTHWESTERN ARIZONA

By B. N. Aldridge

In Arizona, most of the precipitation occurred between the evening of December 4 and the morning of December 7 (table 23). The most severe flooding was along the southeastern tip of the Kaibab Plateau in Grand Canyon National Park and along the west end of the Mogollon Rim south of Flagstaff.

FLOODS IN GRAND CANYON

The floods in Grand Canyon (fig. 26) caused many rockslides and mudflows along tributaries to the Colorado River, and the narrow brushlined channels were eroded into larger channels. Monetary damage caused by the flood was confined to the Bright Angel Creek basin. The flood destroyed the cross-canyon trail (North Rim to Colorado River), a $2-million pipeline, and several bridges, campgrounds, and buildings—some of which were at least 60 years old—and caused more damage than any other known flood in this area. The peak discharge on Bright Angel Creek (sta. 4) had a recurrence interval of more than 50 years (table 24). The pipeline was being built to transport water from Roaring Springs, at the head of Bright Angel Creek on the North Rim, to Phantom Ranch on the canyon floor, and to Grand Canyon Village on the South Rim. At the time of the flood, the pipe-

TABLE 23.—*Daily precipitation, in inches, associated with the floods of December 5–7, in northwestern Arizona*

[From ESSA Weather Bureau records]

Station	Altitude above mean sea level (feet)	Time of observation	December					
			3	4	5	6	7	3–7
Colorado City	5,010	Sunset	0	0.51	1.01	1.66	0.27	3.45
Fredonia	4,675	Sunset	.88	.10	.97	.92	.40	3.27
Tuweep	4,775	2400	.77	.24	1.39	3.57	.08	6.05
Jacob Lake	7,920	1800	(1)	(1)	(1)	6.60	0	6.60
Grand Canyon National Park	6,965	1700	.30	1.15	1.69	1.01	.50	4.65
Grand Canyon Airway	6,971	2400	1.08	.42	1.60	.56	.33	3.99
Camp Wood	5,708	1800	.30	1.00	1.80	2.30	.45	5.85
Groom Creek	6,100	1700	.37	.42	1.70	1.60	1.63	5.72
Crown King	6,000	1300	.25	0	.95	2.07	1.97	5.24
Poland Junction	4,900	2400	.35	0	1.44	1.71	.48	3.98
Natural Bridge	4,607	1700	.28	.09	.42	3.47	1.15	5.41
Payson 12 NNE	5,500	Sunset	.43	.19	1.42	2.87	1.70	6.61
Tonto Creek Fish Hatchery	6,280	0800	0	.55	.71	4.26	3.34	8.86
Junipine	5,124	1800	.51	.40	2.80	4.49	2.25	10.45
Flagstaff WRAP	6,993	2400	.65	.06	.98	2.87	.94	5.50
Williams	5,750	1800	.50	.90	1.15	1.49	1.25	5.20

[1] Amount included in following measurement, time distribution unknown.

line had been completed from Roaring Springs to Phantom Ranch, and it would have been put into service within a few days. The flood cut a new channel past the east end of the recently constructed U.S. Geological Survey residence at Phantom Ranch and destroyed the ranch wrangler's quarters and much of the recreational grounds. The flood demolished the restrooms and a large part of the campground between the ranch and the mouth of Bright Angel Creek. About 10 feet of gravel was deposited in the Colorado River, which changed the control for the Colorado River near Grand Canyon gaging station, which had remained almost constant since the station was installed in 1922.

The large amounts of precipitation and the resultant runoff increased the flow several fold in Roaring Springs in the upper part of the Bright Angel Creek basin. The normal flow of the springs is from

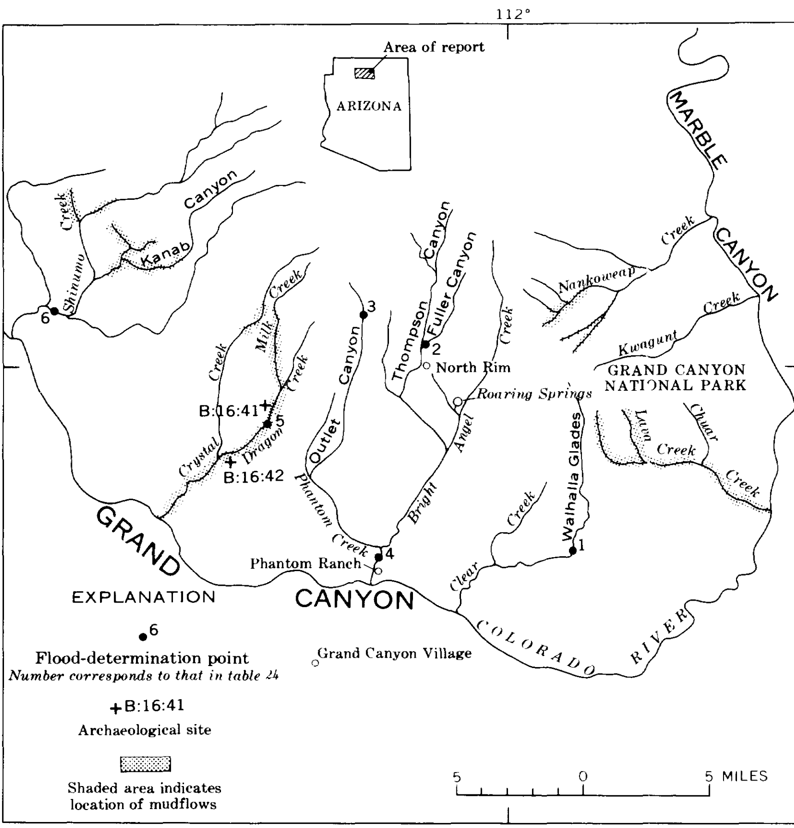


FIGURE 26.—Flood area, location of flood-determination points, and mudflows in Grand Canyon, floods of December 5–7, in northwestern Arizona.

TABLE 24.—*Flood stages and discharges, December 5–7, in northwestern Arizona*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before December 1966: Period	Known before December 1966: Year	December 1966	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence intervals (years)
	Clear Creek basin							
1	Walhalla Glades near North Rim	4.54			6		66	(1)
	Bright Angel Creek							
2	Fuller Canyon near North Rim	3.49			6		187	(1)
3	Outlet Canyon near North Rim	9.42			6		414	(1)
4	Bright Angel Creek near Grand Canyon.	101	1924–66	1936		[2] 15.0	4,400	
					6	11.98	4,000	[3] 1.26
	Crystal Creek basin							
5	Dragon Creek near Grand Canyon	19.2	(4)		6		[4] 29,000	(1)
	Shinumo Creek basin							
6	Shinumo Creek near Grand Canyon,	67.4			6		1,660	17
	Havasu Creek basin							
7	West Cataract Creek near Williams	3.18	1964–66	1965		7.13	122	
					6	7.30	151	(1)
8	Cataract Creek near Williams	46.4	1965–66	1965		4.87	2,270	
					7	3.40	646	(1)
	Bill Williams River basin							
9	Big Sandy River near Wikieup	2,800			7	10.82	28,000	11
10	Kirkland Creek tributary near kirkland.	7.62	1963–66	1964		7.07	1,020	
					7	4.53	190	(1)
11	Santa Maria River near Bagdad	1,210			7	5.66	12,600	8
12	Bill Williams River near Alamo	4,730	1891–1966	1891		(1)	[5] 200,000	
					7	23.19	37,600	9
	Gila River basin							
13	Verde River near Paulden	2,530	1963–66	1965		8.48	6,139	
					7	5.42	1,250	1
14	Hell Canyon near Williams	14.9	1965–66	1965		4.78	1,080	
					6	4.56	955	(1)
15	Volunteer Wash near Bellemont	142	1965–66	1966		4.70	660	
					7	5.73	1,430	(1)
16	Verde River near Clarkdale	3,520	1915–21, 1965–66.	1920		[2] 19.1	50,600	
					6	15.79	22,500	(1)
17	Munds Canyon tributary near Sedona.	1.19	1963–66	1965		6.91	222	
					7	6.40	192	(1)
18	Oak Creek near Cornville	357	1892–1966	1938		23	(1)	
			1939–66	1965		15.18	17,600	
					6	14.68	19,290	25
20	Wet Beaver Creek near Rimrock	95.2	1961–66	1965		11.62	6,150	
					7	9.54	3,200	4
32	Red Tank Draw near Rimrock	49.4	1957–66	1965		7.32	2,010	
					7	4.60	425	1
34	Bar M Canyon near Sedona	25.7	[6] 1962–66	1965		6.23	2,200	
					5	7.94	2,840	12
41	Rattlesnake Canyon near Rimrock.	24.6	1957–66	1965		9.20	1,880	
					7	8.19	1,240	2
42	Dry Beaver Creek near Rimrock	139	1969–66	1965		9.69	9,760	
					7	9.62	9,460	12
43	Dirty Neck Canyon near Clints Well.	3.42	1964–66	1965		5.59	115	
					7	3.73	45	(1)
44	West Clear Creek near Camp Verde.	240	1964–66	1965		8.3	6,510	
					7	6.75	2,670	2

See footnotes at end of table.

TABLE 24.—*Flood stages and discharges, December 5–7, in northwestern Arizona*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before December 1966: Period	Year	December 1966	Gage height (feet)	Discharge: Cfs	Recurrence intervals (years)
	Gila River basin—Continued							
45	East Verde River near Pine	6.65	1961–66	1965		3.67	960	
					7	3.12	318	(1)
46	Webber Creek above West Fork	4.92	1959–66	1961		3.13	399	
	Webber Creek, near Pine.				7	2.39	153	(1)
47	Verde River below Tangle Creek,	5,872	1924–66	1938		19.0	100,000	
	above Horseshoe Dam.)				7	17.96	53,000	10

[1] Not determined.
[2] Site and datum then in use.
[3] Ratio of peak discharge to 50-yr flood.
[4] Mudflow is believed to be highest since A.D. 1100.
[5] Estimated from peak flow of Bill Williams River at Planet, Ariz.
[6] Records for 1962–65 furnished by U.S. Forest Service.

about 5 to 15 cfs; on December 7, however, the springs were discharging as much as 200 cfs of red muddy water, and 2 days later they were still discharging an estimated 150 cfs.

The flood in Dragon Creek, a tributary of Crystal Creek, was of much greater magnitude than the flood in Bright Angel Creek; but there was no economic loss because the basin is completely undeveloped, except for a few archaeological sites. According to Robert Euler (archaeologist, Prescott College, written commun., 1967), these sites date back to about A.D. 1100. Although the Indians left the Grand Canyon before A.D. 1150, the mescal pits—a type of cooking pit built of small rocks placed in a circle—were virtually undisturbed when Euler visited the area in the summer of 1966. A mudflow that originated in Milk Creek, a small tributary of Dragon Creek, destroyed the mescal pit at site B:16:41 (fig. 26) and came within a few inches of overtopping the pit at site B:16:42. At a point between the two sites (sta. 5), the flow was computed by the slope-area method as 29,000 cfs, but a large part of this flow was mud and rock. Much of the debris from the mudflow was deposited in the Colorado River as a large bar at the mouth of Crystal Creek; the bar greatly altered Crystal Rapids, making them much narrower and steeper. A detailed study of Dragon Creek indicated that the mudflow was probably the highest flow—either mud or water—in the creek in the last 900 years; it was definitely the most severe flood along Dragon and Crystal Creeks since the beginning of historic observations in the Grand Canyon dating from Maj. John Wesley Powell's river trips of almost a century ago.

Floods caused rockslides and mudflows in Shinumo, Lava, Kwagunt, and Nankoweap Creeks.

FLOODS IN VERDE RIVER BASIN

The large flows in Hell Canyon and in Sycamore, Oak, and Dry Beaver Creeks (fig. 25) that resulted from the intense precipitation south of Flagstaff caused the Verde River to reach its highest stage since 1937. Several homes and trailers were flooded at Cottonwood, Bridgeport, and Camp Verde (fig. 27). The floodwaters were completely controlled at Horseshoe Dam on the Verde River (fig. 25). At Oak Creek near Cornville (table 24, sta. 18), the peak discharge was the highest since 1938, but the peak stage was less than those during the floods of 1951 and 1965. At Sedona, the December 6 flood stage on

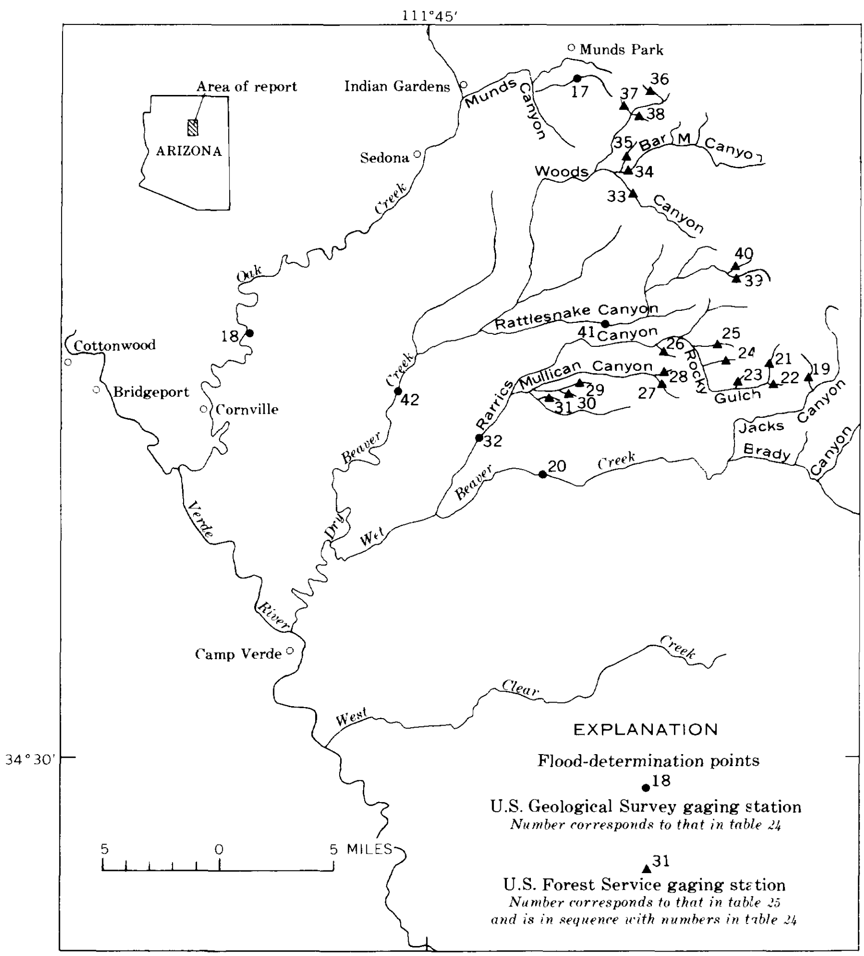


FIGURE 27.—Flood area and location of flood-determination points in Oak Creek and Beaver Creek basins, floods of December 5–7, in northwestern Arizona.

Oak Creek was reported to be higher than in 1965, but at Indian Gardens, it was reportedly about 1-1/2 feet lower than the 1965 peak. A golf clubhouse at Munds Park and campgrounds along Oak Creek were flooded, many homes were isolated, and 13 children were evacuated by cablecar.

In the Beaver Creek basin the floods were less severe in the large streams than they were in 1965, but were much higher in a few small streams near the head of Dry Beaver Creek. The Forest Service operates 20 gaging stations on small watersheds in the Beaver Creek basin (table 25). At stations in Woods and Bar M Canyons and at stations 35 and 38 (fig. 27), the peak discharges on December 7 were the highest in 6 years of record; at stations 36 and 37, the peaks were slightly lower than the peaks in November 1965; at the other 14 sites in the Beaver Creek basin, peaks were very low.

TABLE 25.—*Flood stages and discharges, December 5–7, in Beaver Creek basin, Arizona*

[From U.S. Forest Service records]

Station	Watershed	Drainage area		Location	Peak floods		
					December 1966	Discharge	
		Acres	Sq mi			Cfs	Cfs per sq mi
19	14	1,349	2.11	NW¼ sec. 36, T. 16 N., R. 8 E	7	75.4	35.7
21	13	910	1.42	NW¼ sec. 27, T. 16 N., R. 8 E	7	29.7	20.9
22	12	455	.711	NE¼ sec. 34, T. 16 N., R. 8 E	7	40.0	56.2
23	11	188	.294	NE¼ sec. 32, T. 16 N., R. 8 E	7	7.1	24.1
24	10	571	.892	NE¼ sec. 29, T. 16 N., R. 8 E	7	13.8	15.5
25	7	2,036	3.18	SW¼ sec. 21, T. 16 N., R. 8 E	6	56.9	17.9
26	4	346	.540	NE¼ sec. 26, T. 16 N., R. 7 E	7	32.7	60.6
27	5	66	.089	NW¼ sec. 25, T. 16 N., R. 7 E	7	3.7	41.6
28	6	104	.162	NW¼ sec. 36, T. 16 N., R. 7 E	7	6.7	41.4
29	1	332	.519	SW¼ sec. 31, T. 16 N., R. 7 E	7	.17	.328
30	2	126	.197	SW¼ sec. 31, T. 16 N., R. 7 E		0	0
31	3	362	.566	NW¼ sec. 1, T. 15 N., R. 6 E		0	0
33	Woods Canyon	10,697	16.7	SE¼ sec. 13, T. 17 N., R. 7 E	7	2,300	138
34	Bar M Canyon	16,479	25.7	SE¼SW¼ sec. 12, T. 17 N., R. 7 E	5	[1] 2,840	110
35	18	242	.378	NW¼ sec. 6, T. 17 N., R. 8 E	6	124	328
36	16	252	.409	NW¼ sec. 30, T. 18 N., R. 8 E	7	90.6	222
37	15	163	.255	NE¼ sec. 36, T. 18 N., R. 7 E	7	60.0	235
38	17	299	.467	SE¼ sec. 31, T. 18 N., R. 8 E	6	192	411
39	8	1,802	2.82	SE¼ sec. 5, T. 16 N., R. 8 E	6	95.0	33.7
40	9	1,121	1.75	SE¼ sec. 34, T. 17 N., R. 8 E	7	148	84.6

[1] Slope-area measurement made by U.S. Geological Survey.

FLOODS IN OTHER AREAS

Minor flooding occurred near Williams, when reservoirs in Cataract Creek basin overflowed, and in the Bill Williams River basin (fig. 25). The highest peak since 1951 passed the gage at Bill Williams River at Alamo (sta. 12). Most of the runoff was from the mountains in the headwaters area of the Santa Maria River and Burro Creek. The peaks generally were too small to reach the crest-stage gages in the small low-altitude drainages. Although the precipitation along the headwaters of Tonto Creek was as much as 9 inches, only a moderate amount of runoff resulted.

SOUTHWESTERN UTAH

By Elmer Butler

The storm of December 3–7 in southwestern Utah was of unprecedented intensity and areal coverage for that part of the State (fig. 28), and caused severe floods. Precipitation in the flood area varied from about 1 inch to more than 12 inches.

Record 24-hour amounts of precipitation were measured on December 6, at three stations: At Orderville, 4.44 inches was the greatest 24-hour amount ever recorded at the station and the third largest 24-hour amount recorded anywhere in the State; at Alton, 3.21 inches was the greatest 24-hour amount ever recorded at the station for December; and at Kanab, 2.80 inches was the greatest 24-hour amount ever recorded for all months of record at the station. Precipitation data obtained by the ESSA Weather Bureau during this period are given in table 26.

In addition to precipitation data obtained by the Weather Bureau, data on total precipitation at other sites during the period December 3–7 were obtained from other Federal agencies. The largest amounts

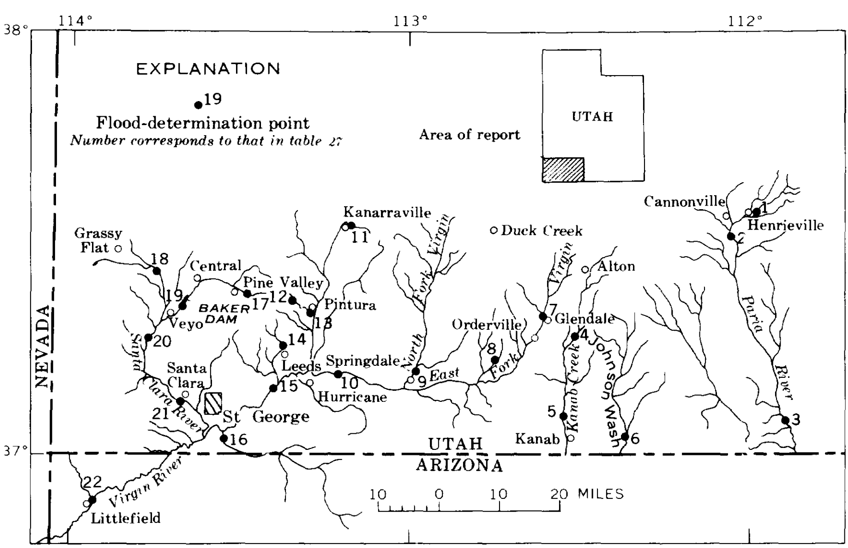


FIGURE 28.—Flood area and location of flood-determination points, floods of December 6–7 in southwestern Utah.

TABLE 26.—*Daily precipitation, in inches, at selected sites in southwestern Utah, December 3–7*

Station	December						
	3	4	5	6	7	3–7	Normal for month (average for 1931–60)
Gunlock	0.42	0.30	0.47	0.80	0	1.99	
LaVerkin	.55	.01	.66	.95	.15	2.32	
St. George	.18	.11	.33	.58	.25	1.45	1.03
Veyo	.45	.47	1.10	1.12	0	3.14	
Zion National Park	.59	.13	.58	2.02	.56	3.88	1.65
Kanab	1.05	.15	1.80	2.80	.15	5.95	1.48
New Harmony	.84	.26	.67	1.24	.66	3.67	
Orderville	1.12	0	1.67	4.44	0	7.23	1.76
Alton	.91	.28	.67	3.21	.51	5.58	1.80

of measured precipitation for the period December 3–7 were 12.60 inches, 11.39 inches, and about 11 inches at Grassy Flats, Duck Creek, and Pine Valley, respectively.

The floods were outstanding in magnitude and were unusual in the coincidence of their occurrence on the tributaries of the Virgin and Santa Clara Rivers. The timing of the runoff from the tributaries was such as to produce a flood on the main stem of the Virgin River below the North Fork (sta. 10) which was the highest known since the first settlers arrived in 1860. However, in 1862, a flood of unknown magnitude on the Santa Clara River at Santa Clara (sta. 21) is believed to have been comparable in size to the 1966 flood.

Most streams in the area are subject to serious flooding from summer thunderstorms caused by heavily moisture-laden air moving in from the Gulf of Mexico. Previous summer storms have caused higher peak flows on some streams, but never such widespread flooding.

The peak discharge of the Virgin River at Virgin (sta. 10) on December 6, was 22,800 cfs, which greatly exceeded the previous maximum discharge at this site of 13,500 cfs on March 3, 1938, and on September 17, 1961, and was the greatest during the period of record, 1909–66. The 1966 flood on the Virgin River at Virgin had a peak discharge 1.8 times as great as the 50-year flood. At seven other gage sites in the flood area, the peak flow in December was the highest of record, and the peak discharge at many of them was greater than the 50-year flood (table 27).

The storm moved into the area on December 3, and floodflows began during the evening of December 5. Most streams reached their peaks late in the evening of December 6, or early in the morning of December 7 (figs. 29 and 30). The flood peaks were generally of short duration, and most streams receded nearly to base flow within 24 hours.

TABLE 27.—*Flood stages and discharges, December 6–7, in southwestern Utah*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before December 1966: Period	Year	December 1966	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
	Paria River basin							
1	Henrieville Creek at Henrieville	34	1959–66	1961		15.6	7,360	
					6	11.81	80	<2
2	Paria River near Cannonville	220	1950–55, 1959–66.	1963		18.0	11,400	
					6	6.33	670	<2
3	Paria River near Kanab	668	1959–66	1963		16.26	15,400	
					7	13.62	1,390	<2
	Kanab Creek basin							
4	Kanab Creek near Glendale	72	1959–66	1963		6.27	1,600	
					6	5.67	1,240	8
5	Kanab Creek near Kanab	198	1959–66	1961		15.70	3,030	
					6	14.40	1,230	2
6	Johnson Wash near Kanab	237	1959–66	1963		[1] 17.11	1,540	
					6	16.00	1,700	4
	Virgin River basin							
7	East Fork Virgin River near Glendale.	74			6	3.40	450	2
8	Mineral Gulch near Mount Carmel	7.6	1959–66	1963		19.69	3,210	
					6	12.03	500	([2])
9	North Fork Virgin River near Springdale.	350	1913–14, 1923, 1925–66.	1938		12.29	7,000	
					6	12.98	9,150	[3] 1.3
10	Virgin River at Virgin	934	1909–66	1938			13,500	
				1961		13.29	13,500	
					6	18.00	22,800	[3] 1.8
11	Kanarra Creek at Kanarraville	10.0	1959–66	1963		3.28	555	
					6	.95	24	([2])
12	South Ash Creek below Mill Creek near Pintura.	11.0			6	5.83	1,910	([2])
13	South Ash Creek near Pintura	14.0	1959–66	1965		13.43	928	
					6	13.54	985	([2])
14	Leeds Creek near Leeds	15.5	1964–66	1964		6.00	2,980	
					6	5.33	2,050	([2])
15	Virgin River near Hurricane	1,535			6	[4] 27.34	20,100	[3] 1.1
16	Fort Pierce Wash near St. George	1,650	1959–66	1964		17.23	8,760	
					6	13.68	1,000	<2
17	Santa Clara River near Pine Valley.	18.7	1959–66	1960		4.86	340	
					6	6.85	776	15
18	Moody Wash near Veyo	33	1954–66	1961		8.60	1,400	
					6	9.75	1,810	[3] 1.1
19	Santa Clara River at Baker Dam near Central.	108			6		2,080	14
20	Santa Clara River above Winsor Dam near St. George.	338	1942–66	1955		11.25	6,190	
					6	10.88	5,930	34
21	Santa Clara River near Santa Clara.	410	1965–66	1965		6.87	1,260	
					7	12.60	6,390	34
22	Virgin River at Littlefield, Ariz	5,090	1930–66	1938			22,000	
				1955		13.60		
					6	15.66	35,200	43

[1] At site 1¼ miles downstream.
[2] Not determined.
[3] Ratio of peak discharge to 50-yr flood.
[4] Maximum stage known since at least 1909.

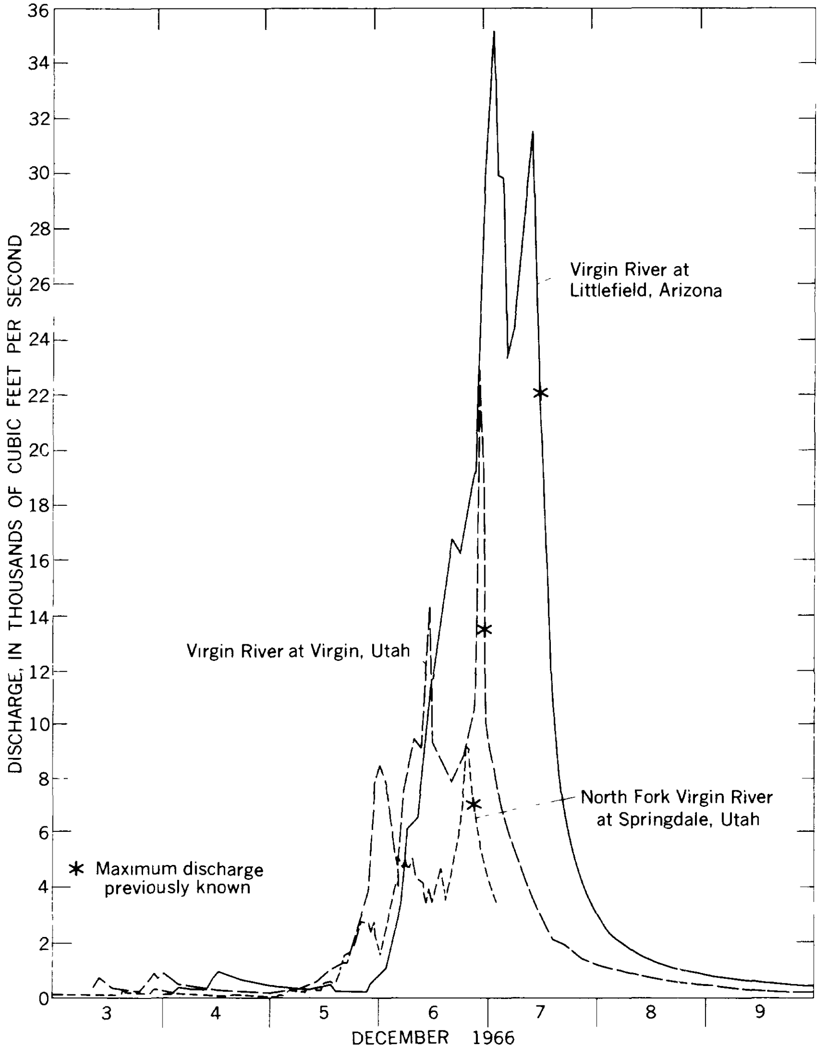


FIGURE 29.—Discharges at selected gaging stations in the Virgin River basin, floods of December 6, 7 in southwestern Utah.

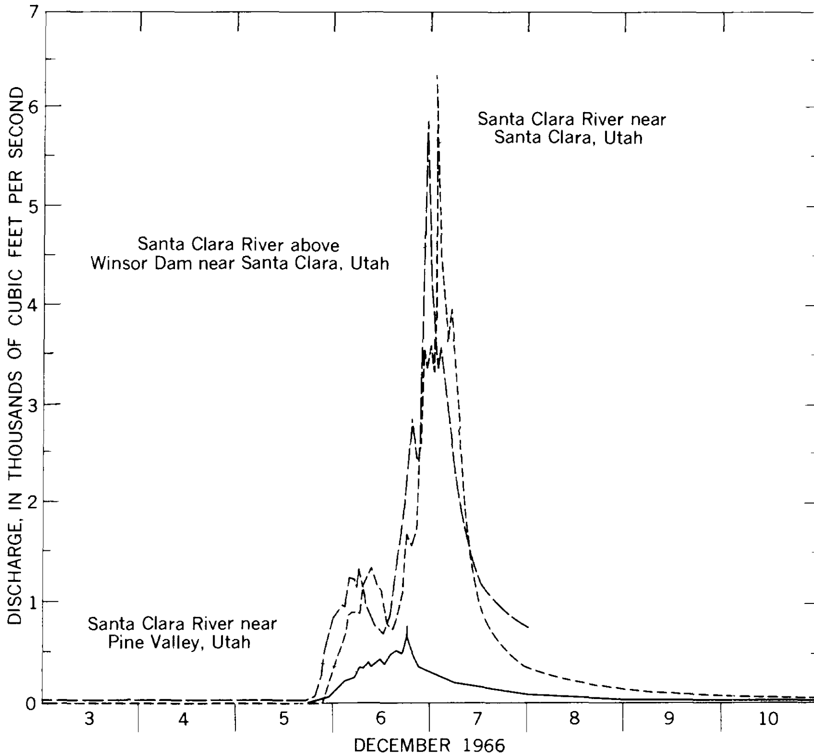


FIGURE 30.—Discharges at selected gaging stations in the Santa Clara River basin, floods of December 6–8 in southwestern Utah.

The U.S. Forest Service reported that floodwater filled, or nearly filled, all reservoirs in the area. The storage behind Baker Dam (drainage area, 108 sq mi) increased an estimated 500 acre-feet in about 5 hours, and the peak flow over the spillway was 2,080 cfs.

Most of the flood damage occurred in the Virgin River basin. The U.S. Soil Conservation Service reported that total damage to crops, fences, roads, bridges, diversion structures, and cropland in Washington County, including damage in Zion National Park, was about $835,000.

According to the U.S. Bureau of Reclamation, damage along the Virgin River between Springdale and Virgin was extensive. More than 90 acres of farmland were washed away by erosion of the river channel, and flooding was extensive on the remaining cropland. Along the Virgin River south of Washington, 43 acres of farmland were washed away. Total damage to State highways was about $75,000. Damage to roads and bridges on National Forest lands was estimated at $46,000.

Total damage to National Forest improvements and lands was estimated at about $70,750.

More detailed information and data for the floods in Utah are available in a report by Butler (1970).

SOUTHERN NEVADA

By R. D. Lamke

Heavy rain fell in southern Nevada during December 3–7.

ESSA Weather Bureau rain gages (fig. 31) recorded storm totals of 7.55 inches at Pioche, 6.47 inches at Ursine just east of Pioche, and 5.07 inches at Little Red Rock west of Las Vegas. The largest daily rainfalls measured were 3.50 inches at Little Red Rock on the 6th, and 3.02 and 2.75 inches on the 5th and 6th at Pioche. Generally, the heaviest rainfalls occurred on December 5 and 6, but the precipitation totals in figure 31 are shown for December 3–7.

A rain gage at the Lee Canyon stream-gaging station (table 28, sta. 13) collected 11.6 inches of rainfall between November 30 and December 8. The resulting flood of 201 cfs at that station was the largest in 7 years of record, even though Lee Canyon was on the northernmost fringe of the storm area over the Spring Mountains, west of Las Vegas. Hydrographs for the flood period for Lee Canyon and selected gaging stations are presented in figure 32. Telephone Canyon (sta. 15) had a peak discharge of 2,500 cfs from a drainage area of 7.20 square miles (table 28). Most of the water in Kyle Canyon came out of Telephone Canyon, although other tributaries also had floodflows. State Highway 39 on the flood plain parallel to the channels of Kyle and Telephone Canyons was washed out in several places. A tributary to Las Vegas Wash (sta. 17), just south of Kyle Canyon, had a discharge of 3,170 cfs from 47 square miles. Flow from this tributary and local inflow caused minor flooding in northwest Las Vegas. Floods occurred in Red Rock Wash (sta. 19) and Cottonwood Wash (sta. 21) west of Las Vegas. Overflow from other smaller tributaries caused road damage in this area. Other washes in Las Vegas with headwaters north, east, and south of town did not have flood peaks because the main part of the storm was centered over the Spring Mountains, west of Las Vegas. Some Las Vegas streets were flooded by local runoff. Lovell Wash (stas. 26, 27), which drains toward the southwest from the Spring Mountains, also had a flood. The buildings at Spring Mountain Youth Camp were damaged by sediment from a small tributary of Lovell Wash.

Virgin River at Littlefield, Ariz. (sta. 1), just upstream from the Nevada border, had a peak discharge of 35,200 cfs, which was the maximum discharge in 37 years of record and 1.6 times the previous known maximum. Considerable damage was done to irrigation facilities within Nevada along the Virgin River. Floods also occurred near Caliente and Pioche on Meadow Valley Wash (sta. 10) and its larger tributaries, but they were not outstanding.

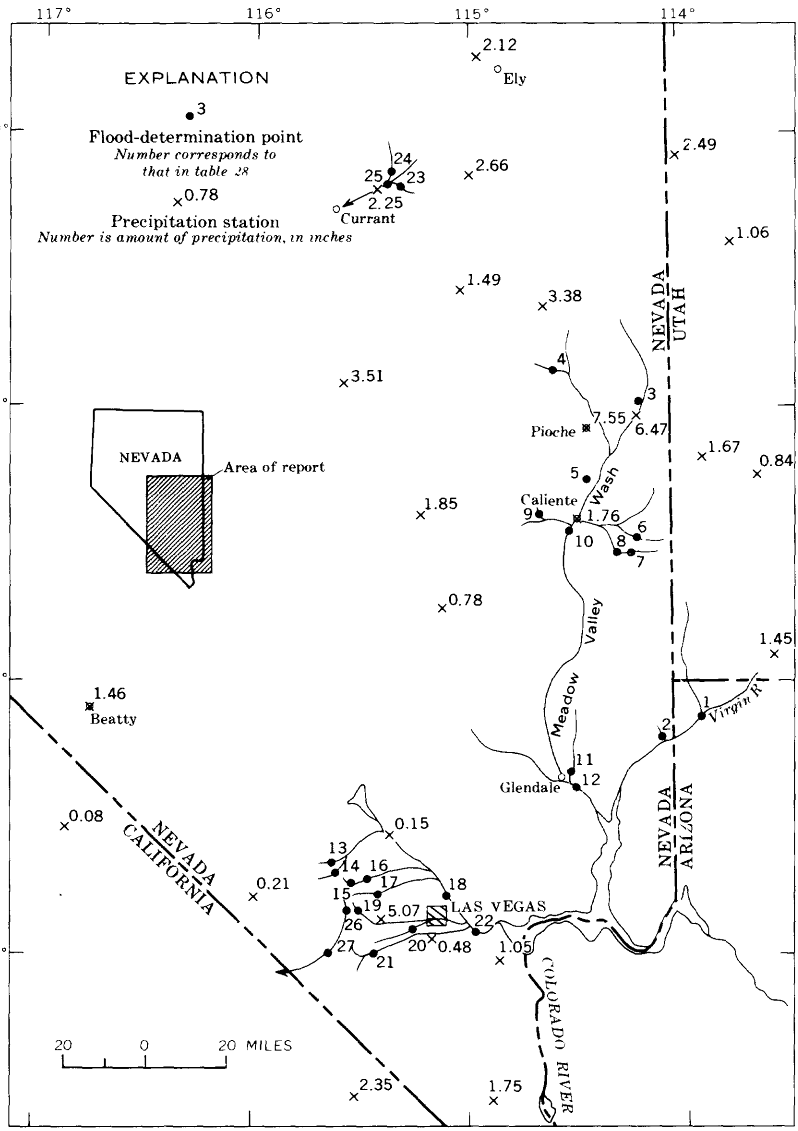


FIGURE 31.—Flood area and location of flood-determination points and precipitation stations, floods of December 6–8 in southern Nevada.

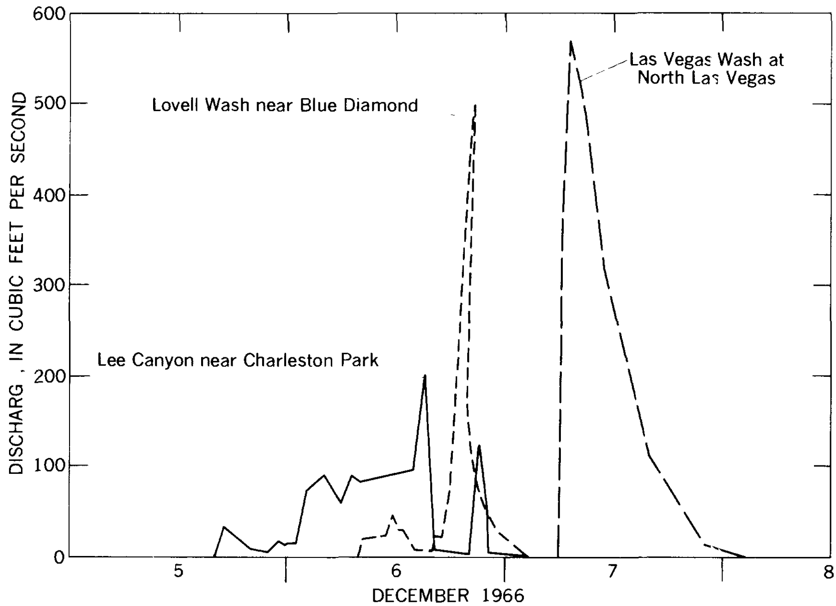


FIGURE 32.—Discharge at selected gaging stations, December 5–8, in southern Nevada.

TABLE 28.—*Flood stages and discharges, December 6–8 in southern Nevada*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before December 1966 — Period	Known before December 1966 — Year	December 1966	Gage height (feet)	Discharge — Cfs	Discharge — Recurrence interval (years)
	Virgin River basin							
1	Virgin River at Littlefield, Ariz.	5,090	1930–66	1938			22,000	
				1955		13.60		
					6	15.66	35,200	
2	Pulsipher Wash near Mesquite	4.58	1963–66	1963		(1)	[2] 280	
					6	6.38	523	
3	Spring Valley Creek near Ursine	293	1963–66	1966		1.76	[3] 52	
					6	3.02	[3] 362	
4	Patterson Wash tributary near Pioche.	5	1964–66	1966		5.05	16	
					6	4.00	[2] 2	
5	Caselton Wash near Panaca	75	1963–66	1963		(1)	1,100	
					6	6.72	600	
6	Matthews Canyon Wash near Caliente.	34	1959–66	1965		11.85	[3] 206	
					6	9.81	[3] 77	
7	Pine Canyon Wash above dam near Caliente.	40			6		940	
8	Pine Canyon Wash near Caliente	45	1959–66	1966		3.63	[3] 156	
					7	3.92	[3] 238	
9	Meadow Valley Wash tributary near Caliente.	.5	1964–66	1966		3.2	[2] .5	
					6	3.24	[2] 1.5	
10	Meadow Valley Wash near Caliente	1,670	1951–60, 1965–66.	1956		7.10	1,500	
					7	5.30	680	

See footnotes at end of table.

TABLE 28.—*Flood stages and discharges, December 6–8, in southern Nevada*—Con.

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before December 1966, Period	Year	December 1966	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
	Virgin River basin—Continued							
11	Weiser Wash near Glendale	43	1966	1966		(1)	[2] 300	
					6	(1)	[2] 100	
12	Muddy River near Glendale	[4] 6,780	1950–66	1960		20.36	7,380	
					8	6.61	602	
	Las Vegas Wash basin							
13	Lee Canyon near Charleston Park	9.20	1961–66	1961		(1)	119	
					6	2.73	201	
14	Deer Creek near Charleston Park	1.27			6	(1)	[2] 50	
15	Telephone Canyon near Charleston Park.	7.20	1962–66	1965		(1)	[2] 5	
					6	7.78	2,500	
16	Kyle Canyon near Charleston Park.	35.9	1961–66	1964		(1)	[2] 10	
					6	6.00	1,660	
17	Las Vegas Wash tributary near Charleston Park.	47			6		3,170	
18	Las Vegas Wash at North Las Vegas	(1)	1962–66	1963		2.40	414	
					7	2.72	578	
19	Red Rock Wash near Blue Diamond.	7.60	1962–66	1965		2.47	221	
					6	4.6	2,500	
20	Flamingo Wash at Las Vegas	(1)	1965–66	1965		(1)	306	
					6	(1)	814	
21	Cottonwood Wash near Blue Diamond.	18.3	1961–66	1965		3.29	33.4	
					6	7.24	946	
22	Las Vegas Wash near Henderson	[5] 2,125	1957–66	1957		[6] 4.70	1,400	
					8	7.11	180	
	Railroad Valley							
23	Currant Creek tributary near Currant.	3.13	1962–66	1963		5.21	99	
					6	2.70	[2] 5	
24	Little Currant Creek near Currant	12.9	1965–66	1965		(2)	<10	
					6	4.1	366	
25	Currant Creek below Little Currant Creek near Currant.	30.0	1964–66	1965		2.92	9.5	
					6	6.20	404	
	Pahrump and Mesquite Valleys							
26	Lovell Wash near Charleston Park	14			6		421	
27	Lovell Wash near Blue Diamond	52.7	1965–66	1965		(1)	15	
					6	6.45	499	

[1] Unknown.
[2] Estimated.
[3] Regulated.
[4] Contributing area, about 3,000 sq mi.
[5] Contributing area, 1,518 sq mi.
[6] At site 2.5 miles downstream, contributing area, 1,571 sq mi.

An isolated area of flooding occurred near Currant. Little Currant Creek (sta. 24) had a peak discharge of 366 cfs from 12.9 square miles.

Flood magnitude and frequency relations are not defined for this part of Nevada. Therefore, the frequency of these floods is not known, but floods of these magnitudes around Las Vegas and Current are rare.

Total flood damage in Nevada was estimated at $1 million, and one person was drowned in Red Rock Canyon.

FLOODS OF DECEMBER, IN CENTRAL AND SOUTHERN CALIFORNIA

By A. O. Waananen

Storms during the first week of December deposited heavy precipitation over the entire State of California. They culminated in a warm, intense storm during the period December 4–6 that caused record-breaking floods on December 5–6 in the Buena Vista and Tulare Lake basins in the San Joaquin Valley and in the Salinas River basin in the central coastal area, and severe floods over much of the State. The area in central and southern California most severely affected and the location of flood-determination sites for which peak stage and discharge data are furnished in this report are shown in figure 33. Total flood damage was estimated to be more than $38.6 million.

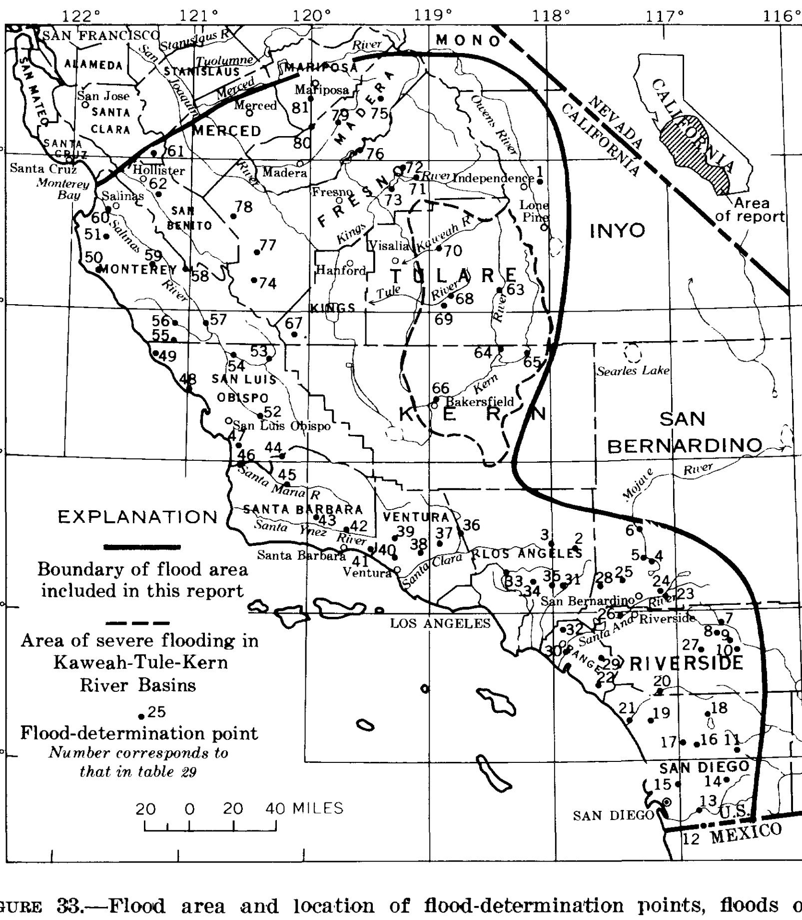


FIGURE 33.—Flood area and location of flood-determination points, floods of December in central and southern California.

The floods were highest of record in many basins in the southern Sierra Nevada and the central coastal area, and the peak discharges on many streams had recurrence intervals of more than 50 years. In many other streams, the floods approached the magnitudes of those in 1955, 1963, and 1965. A summary of flood stages and discharges for selected streams in the flood area is given in table 29. The recurrence interval, or return period, is given for the many streams that are not substantially affected by regulation or storage.

TABLE 29.—*Flood stages and discharges, December 5–7, in central and southern California*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before December 1966: Period	Known before December 1966: Year	December 1966	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
	Owens Lake basin							
1	Mazourka Creek near Independence.	15.6	1960–66	1964		1.37	1	
					6	2.46	1,300	(1)
	Antelope Valley							
2	Big Rock Creek near Valyermo	22.9	1923–66	1938		(1)	8,300	
					6	4.54	1,290	13
3	Little Rock Creek near Little Rock.	49.0	1931–33, 1935–66.	1938		(1)	[2] 17,000	
	Mojave River basin							
					6	7.97	1,970	10
4	Deep Creek near Hesperia	136	1859–1966	1938		(1)	46,600	
					6	9.92	15,400	44
5	West Fork Mojave River near Hesperia.	74.6	1859–1966	1938		(1)	26,100	
					6	9.85	6,320	28
6	Mojave River at lower narrows near Victorville.	514	1856–1966	1938		20.7	70,600	
					6	10.0	17,900	15
	Salton Sea basin							
7	Whitewater River at White Water	57.4	1938	1938		(1)	[3] 42,000	
			1948–66	1965		13.60	24,000	
					6	3.30	[2] 5,500	30
8	Snow Creek near White Water	10.8	1921–31, 1959–66.	1965		12.1	4,200	
					6	7.12	1,680	38
9	Tahquitz Creek near Palm Springs	16.8	1948–66	1965		10.34	2,900	
					6	8.25	1,350	18
10	Palm Canyon Creek near Palm Springs.	93.3	1931–41, 1948–66.	1937		5.80	3,850	
					6	4.60	975	3
11	Chariot Creek near Julian.	7.94	1961–66	1965		8.20	220	
					6	8.86	340	(1)
	Tia Juana River basin							
12	Tia Juana River near Dulzura	481	1937–66	1937		8.50	4,700	
					7	5.56	1,770	(1)

See footnotes at end of table.

TABLE 29.—*Flood stages and discharges, December 5–7, in central and southern California*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before December 1966: Period	Known before December 1966: Year	December 1966	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
	Otay River basin							
13	Jamul Creek near Jamul	70.3	1940–66	1947		6.42	4,000	
					6	5.56	2,720	9
	Sweetwater River basin							
14	Sweetwater River near Descanso	45.5	1906–27, 1957–66.	1927		[3] 13.2	11,200	
					6	8.93	3,890	12
	San Diego River basin							
15	San Diego River near Santee	377	1915–66	1916		[3] 25.1	70,200	
					6	9.30	[4] 3,400	
	San Dieguito River basin							
16	Santa Ysabel Creek near Ramona	112	1913–22, 1944–66.	1916		[3] 14.0	28,400	
					6	11.44	[4] 6,050	
17	Guejito Creek near San Pasqual	22.5	1947–66	1965		7.45	2,550	
					6	6.78	2,920	20
	San Luis Rey River basin							
18	West Fork San Luis Rey River near Warner Springs.	25.5	1913–15, 1956–66.	1958		10.77	2,060	
					6	11.87	4,200	21
19	San Luis Rey River near Bonsall	512	1891	1891		(1)	128,000	
			1915–18, 1930–66.	1938		[3] 12.60	[4] 18,100	
					7	10.84	[4] 6,080	
	Santa Margarita River basin							
20	Murrieta Creek at Temecula	222	1931–66	1943		13.82	17,500	
					6	4.86	1,510	3
21	Santa Margarita River at Ysidora	739	1924–27, 1931–66.	1927		[3] 18.00	33,600	
					7	12.83	[5] 6,720	5
	San Juan Creek basin							
22	San Juan Creek near San Juan Capistrano.	106	1929–66	1938		(1)	13,000	
					6	5.38	9,000	25

See footnotes at end of table.

TABLE 29.—*Flood stages and discharges, December 5–7, in central and southern California*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before December 1966: Period	Known before December 1966: Year	December 1966	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
	Santa Ana River basin							
23	Santa Ana River near Mentone	209	1891	1891		(1)	53,700	
			1916–66	1938		14.3	52,300	
					6	13.25	15,300	(1)
24	Plunge Creek near East Highlands	16.9	1920–66	1938		(1)	5,340	
					6	5.20	4,770	30
25	Lytle Creek near Fontana	46.3	1920–21, 1926–27, 1931–38, 1943, 1947–66.	1938		(1)	25,200	
					6	9.76	7,200	21
26	Santa Ana River at Riverside Narrows, near Arlington.	850	1862	1862		(1)	320 000	
			1928–66	1938		(1)	100 000	
					6	11.94	15 300	8
27	San Jacinto River near San Jacinto.	141	1921–27, 1930–66.	1927		(1)	45,000	
					6	9.80	5,720	10
28	Cucamonga Creek near Upland	10.1	1928–66	1938		(1)	10,300	
					6	5.50	1,320	8
29	Santiago Creek at Modjeska	12.5	1962–66	1965		6.60	1,500	
					6	7.47	1,420	(1)
30	Santa Ana River at Santa Ana	1,685	1923–66	1938		10.20	46,300	
					5	[3] 5.90	[4] 5,700	
	San Gabriel River basin							
31	Fish Creek near Duarte.	6.36	1918–66	1965		6.80	2,250	
					6	6.22	1,670	(1)
32	Brea Creek below dam, near Fullerton.	21.6	1942–66	1944		6.13	[4] 655	
					3	4.78	[4] 406	
	Los Angeles River basin							
33	Little Tujunga Creek near San Fernando.	21.1	1914, 1929–66.	1938		(1)	[2] 8,500	
					6	3.40	901	3
34	Arroyo Seco near Pasadena	16.0	1914–66	1938		9.42	8,620	
					6	4.80	1,530	7
35	Santa Anita Creek near Sierra Madre.	9.71	1917–66	1938		(1)	5,200	
					6	7.60	1,360	(1)
	Santa Clara River basin							
36	Piru Creek above Lake Piru	372	1956–66	1962		12.20	12,200	
					6	8.26	4,640	6
37	Sespe Creek near Fillmore	251	1916–66	1938		(1)	53,000	
					6	13.40	21,600	25
38	Santa Paula Creek near Santa Paula.	40.0	1933–66	1938		10.56	13,500	
					6	6.43	4,500	14
	Ventura River basin							
39	North Fork Matilija Creek at Matilija Hot Springs.	15.6	1934–66	1938		(1)	5,580	
					6	4.47	2,000	8
40	Ventura River near Ventura	188	1933–66	1938		19.2	39,200	
					6	17.30	[4] 9,900	10

See footnotes at end of table.

TABLE 29.—*Flood stages and discharges, December 5–7, in central and southern California*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before December 1966: Period	Known before December 1966: Year	December 1966	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
	Carpinteria Creek basin							
41	Carpinteria Creek near Carpinteria.	13.1	1941–66	1952		9.75	2,440	
					6	8.60	2,720	18
	Santa Ynez River basin							
42	Santa Ynez River below Gibraltar Dam near Santa Barbara.	216	1920–66	1938		(1)	[4] 35,500	
					6	17.50	[4] 17,500	
43	Santa Cruz Creek near Santa Ynez	73.9	1942–66	1962		9.75	4,520	
					6	10.30	5,800	12
	Santa Maria River basin							
44	Cuyama River below Buckhorn Canyon, near Santa Maria.	884	1904–05, 1960–66.	1905		[3] 10.0	10,000	
					6	11.26	9,680	(1)
45	Sisquoc River near Sisquoc	281	1930–33, 1938, 1944–66.	1938		[3] 8.1	11,000	
					6	15.75	23,200	32
46	Santa Maria River at Guadalupe	1,742	1941–69	1952		8.18	32,800	
					6	8.20	[4] 16,000	
	Arroyo Grande basin							
47	Arroyo Grande at Arroyo Grande	102	1940–66	1952		11.97	5,370	
					6	12.88	5,400	9
	Santa Rosa Creek basin							
48	Santa Rosa Creek near Cambria	12.5	1955	1955		15.2	(1)	
			1958–66	1960		10.36	2,520	
					6	10.00	2,050	5
	Arroyo de la Cruz basin							
49	Arroyo de la Cruz near San Simeon	41.2	1951–66	1955		12.40	17,700	
					6	15.27	35,200	[7] 2.8
	Big Sur River basin							
50	Big Sur River near Big Sur	46.5	1951–66	1958		11.56	5,680	
					6	10.30	4,510	2
	Carmel River basin							
51	Carmel River at Robles del Rio	193	1955	1955		11.7	6,930	
			1958–66	1958		10.50	7,100	
					6	9.50	4,750	5

See footnotes at end of table.

TABLE 29.—*Flood stages and discharges, December 5–7, in central and southern California*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before December 1966: Period	Known before December 1966: Year	December 1966	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
	Salinas River basin							
52	Salinas River near Pozo	74.1	1943–66	1943		13.55	7,210	
					6	14.23	14,100	[7] 1.2
53	Cholame Creek near Shandon	227	1959–66	1962		6.90	1,100	
					6	10.45	6,100	(1)
54	Estrella River near Estrella	924	1955–66	1958		7.20	8,850	
					6	9.20	17,600	16
55	Nacimiento River near Bryson	140	1955–66	1955		24.63	30,300	
					6	23.78	28,400	1.2
56	San Antonio River near Lockwood	223			6	9.2	11,000	(1)
57	Salinas River near Bradley	2,536	1949–66	1958		12.53	[4] 28,400	
					7	16.2	[4] 34,000	
58	San Lorenzo Creek below Bitterwater Creek near King City.	233	1959–66	1963		8.13	2,130	
					6	9.74	3,630	5
59	Arroyo Seco near Soledad	244	1906–66	1958		16.40	28,300	
					6	16.30	27,700	25
60	Salinas River near Spreckles	4,157	1862, 1911, 1914.			25.0	75,000	
			1930–66	1938, 1952		26.85		
					9	22.70	[4] 19,500	
	Pajaro River basin							
61	Cedar Creek near Bell Station	12.8	1962–66	1963		6.85	3,490	
					6	4.37	859	6
62	Tres Pinos Creek near Tres Pinos	206	1938	1938		9.0	(1)	
			1940–66	1941		7.75	8,060	
					6	4.99	879	2
	Buena Vista Lake basin							
63	Little Kern River near Quaking Aspen Camp.	132	1955, 1958–66.	1955		12.4	12,200	
					6	12.60	13,100	[7] 1.4
64	Kern River at Kernville	1,009	1905–12, 1950, 1954–66.	1950		18.4	38,000	
					6	22.2	74,000	[7] 1.6
65	South Fork Kern River near Onyx	530	1914, 1930–42, 1947–66.	1962		6.79	3,460	
					6	16.9	28,700	[7] 2.0
66	Kern River near Bakersfield	2,407	1895–1906, 1909–66.	1950		[8] 461.37	36,000	
					7	[8] 454.94	[4] 9,290	

See footnotes at end of table.

TABLE 29.—*Flood stages and discharges, December 5–7, in central and southern California*—Continued

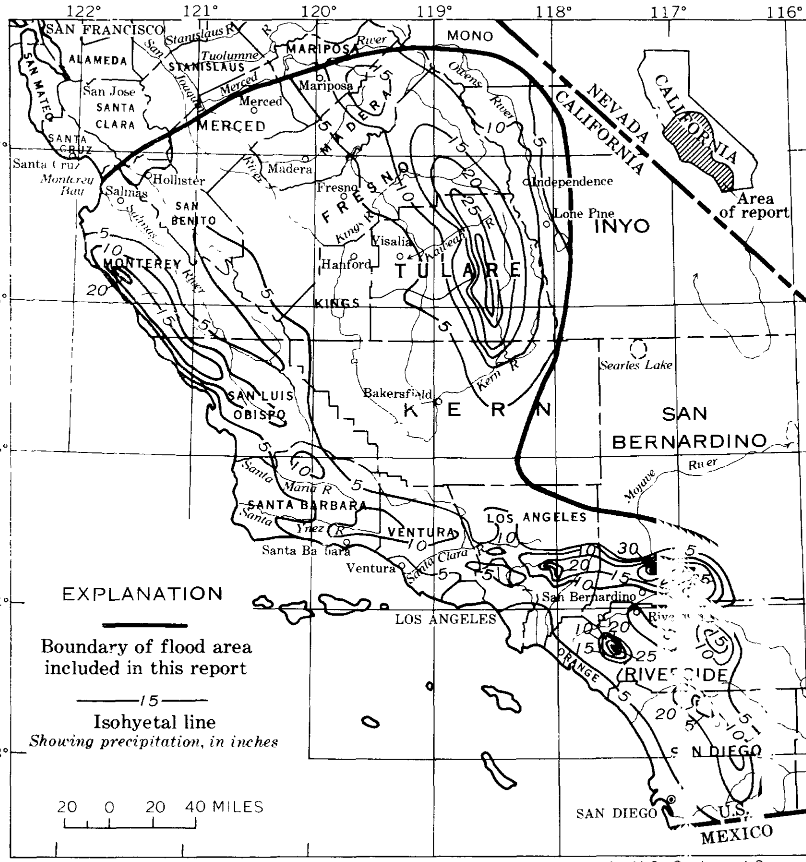
No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before December 1966 — Period	Known before December 1966 — Year	December 1966	Gage height (feet)	Discharge — Cfs	Discharge — Recurrence interval (years)
	Tulare Lake basin							
67	Avenal Creek near Avenal	57.1	1962–66	1962		4.10	400	
					6	5.72	1,540	(1)
68	Tule River near Springville	225	1955, 1958–66.	1955		13.7	21,000	
					6	17.18	49,600	7 2.8
69	South Fork Tule River near Success.	109	1931–54, 1956–66.	1950		11.36	7,100	
					6	12.50	14,300	7 1.7
70	Kaweah River at Three Rivers	418	1955	1955		17.9	(1)	
			1959–66	1963		13.68	30,900	
					5	9 16.69	73,000	7 2.0
71	Kings River below North Fork, near Trimmer.	1,342	1952–66	1955		23.08	85,200	
					6	(1)	4 63,300	27
72	Big Creek above Pine Flat Reservoir, near Trimmer.	69.9	1951, 1953–66.	1955		9.21	10,400	
					6	8.43	7,540	7 1.1
73	Mill Creek near Piedra	120	1958–66	1958		7.29	5,000	
					6	9.53	11,000	7 1.4
74	Los Gatos Creek above Nunez Canyon, near Coalinga.	95.8	1946–66	1958, 1962		(1)	2,560	
					6	7.61	1,980	6
	San Joaquin River basin							
75	Chiquito Creek near Bass Lake	60.1	1922–28, 1952–66.	1955		16.38	8,630	
					6	11.25	3,000	11
76	San Joaquin River below Kerchkhoff Powerhouse, near Prather.	1,481	1911–14, 1937, 1943–66.	1955		51.0	4 92,200	
					6	31.60	4 28,800	
77	Cantua Creek near Cantua Creek	46.4	1958–66	1958		5.34	751	
					6	4.57	651	(1)
78	Panoche Creek below Silver Creek, near Panoche.	293	1951–53,	1952		7.05		
			1958–66.	1958			5,090	
					6	4.15	250	
79	Fresno River near Knowles	133	1912, 1916–66.	1955		11.52	13,300	
					6	6.62	3,800	5
80	Chowchilla River at Buchanan damsite, near Raymond.	235	1931–66	1955		16.50	30,000	
					6	10.52	6,880	8
81	Mariposa Creek near Catheys Valley.	65.7	1958–66	1958		11.62	7,180	
					6	9.72	3,820	(1)

1 Not determined.
2 Estimated.
3 At site and datum then in use.
4 Affected by regulation, storage or diversion.
5 Result of failure of detention dam.
6 Maximum observed.
7 Ratio of peak discharge to 50-yr flood.
8 Elevation, in feet.
9 Stage from flood mark, 19.0 ft.

The flood-producing rains were preceded by a series of small Pacific storms in November which brought seasonal precipitation to most of the State. The precipitation occurred as rain at altitudes below 6,000 feet and as rain and snow at altitudes higher than 6,000 feet in the Sierra Nevada. A cold front that moved into the State on December 1 was followed by a series of storms that brought moist air from the southwest and caused general precipitation of December 1–3. A strong flow of warm, moist Pacific air on December 4–6 caused heavy precipitation in the Coast Ranges and coastal basins from Monterey Bay to the Mexican border and in the southern Sierra Nevada. Torrential rain occurred in headwater areas of the Kaweah, Tule, and Kern River basins. Total precipitation observed during the storm period December 1–6 was more than 30 inches at Johnsondale, in the upper Kern River basin about 50 miles northeast of Bakersfield, and at Hockett Meadows, in the upper Kaweah River basin about 60 miles southeast of Fresno; a maximum of 34.27 inches was observed at Lake Arrowhead Ranger Station, in the San Bernardino Mountains about 12 miles northeast of San Bernardino in southern California. One-day rain totals were as high as 17.00 inches at Hockett Meadows and 12.90 inches at Giant Forest, both in the upper Kaweah River basin, and 13.30 inches at Lake Arrowhead Ranger Station. A maximum 3-day precipitation of 27.50 inches was observed at Hockett Meadows. Total storm precipitation of more than 20 inches occurred also in other mountain areas in central and southern California, as shown in the isohyetal map for the period December 1–6 given in figure 34.

Floods in Great Basin streams (stas. 1–11) draining the interior slopes of the Coastal Ranges were moderately severe, but generally they did not exceed previous record flows. (See table 29.) The peak discharge of 15,400 cfs on December 6 in Deep Creek near Hesperia (sta. 4) in the Mojave River basin was only 33 percent of the record flow in March 1938, and 71 percent of that in November 1965. In the Whitewater River basin, peak flows were less than one-half of those in 1965. In Inyo County, the Los Angeles Aqueduct was severely damaged by floodflows and debris, and by washouts near Lone Pine, upstream from the main reservoirs. Highway overflows and damage were extensive along the eastern slopes of the Sierra Nevada and in the Whitewater River basin.

In coastal basins south of the Santa Ana River to the Mexican border, the December floods were greater than the 1965 floods in many streams, particularly in San Diego County. The peak discharge of 3,890 cfs on December 6, in Sweetwater River near Descanso (sta. 14) was three times that in 1965, but only one-third of the record flow in 1927. Flooding in Santee, 12 miles east of San Diego, forced evacuation



Isohyets by U.S. Geological Survey; data from U.S Weather Bureau

FIGURE 34.—Isohyets of total precipitation December 1–6, floods of December in central and southern California.

of about 30 residents. Street and highway damage in San Diego County was severe. In Orange County, although the 1965 and 1966 floodflows were generally equivalent, the peak discharge of 9,000 cfs on December 6 in San Juan Creek near San Juan Capistrano (sta. 22) was more than twice that in 1965 and was the highest recorded since 1938.

Coastal basins from the Santa Ana River to the Los Angeles River (stas. 33–35) experienced floods comparable to those in 1965. Heavy precipitation in headwater areas in the San Bernardino and San Gabriel Mountains, northeast of Los Angeles, produced intense runoff that caused landslides, road washouts, and heavy flood damage. Overflow of a small reservoir forced evacuation of about 200 persons at

La Verne, about 28 miles east of Los Angeles. The peak discharge of 4,770 cfs December 6 in Plunge Creek near East Highlands (sta. 24) exceeded that in 1965 and was 90 percent of the record flow in 1938. Through operation of the extensive system of flood-control reservoirs and other facilities available in this region, the peak flows and associated potential damage in downstream areas were reduced very substantially. However, some flood damage resulted from local flooding.

Flooding was less severe in coastal basins west of the Los Angeles River basin and south of the Santa Ynez River. Peak discharges were generally lower than those in 1965 and only about one-third of the record flows in 1938. In Carpinteria Creek near Carpinteria (sta. 41), however, the peak flow of 2,720 cfs on December 6 was the maximum in the 26-year record. Floodflows in the Santa Ynez River basin were as much as 3 times those in 1965. New record flows occurred in several streams in the Santa Maria River basin; the flow of 23,200 cfs on December 6 in Sisquoc River near Sisquoc (sta. 45) was more than twice the maximum of record in 1938. Extensive overflows occurred in the sparsely settled upstream areas in the Sisquoc River basin and caused damage to roads, stream channels, and flood-plain lands. Storage of all Cuyama River flow in Twitchell Reservoir reduced floodflows downstream in the Santa Maria River.

Peak discharges in several coastal basins north of the Santa Maria River approached the magnitudes of the floods in 1955 and 1958. Arroyo de la Cruz near San Simeon (sta. 49), however, had a peak discharge of 35,200 cfs on December 6 that was twice the record flow in 1955, and the flood-discharge rate was 854 cfs per sq mi from 41.2 square miles.

Flood peaks in the Salinas River and tributaries exceeded previous peaks of record. The peak discharge of 14,100 cfs on December 6 in Salinas River near Pozo (sta. 52) and in Estrella River near Estrella (sta. 54) were twice the record flows in 1943 and 1958, respectively. However, Nacimiento Reservoir on Nacimiento River and San Antonio Reservoir on San Antonio River (completed in 1965) contained the floodflows in these tributaries and substantially reduced flooding downstream on the Salinas River. Nevertheless, about 32,900 acres of pasture and agricultural lands was flooded in the Salinas River valley, and losses to crops and some new plantings were heavy. Many roads in the basin were closed by slides, inundation, or damage to bridges. Many ranchhouses and other buildings sustained high-water damage.

The Kaweah-Tule-Kern River basins, northeast of Bakersfield, were particularly hard hit by the heavy rains and resulting floods. The flood peaks in the upper parts of these basins were substantially above those for maximum floods during the previous 60 years of record. The maximum discharge of 74,000 cfs on December 6 in Kern River at Kernville (sta. 64) was nearly twice the previous maximum flow in 1950, was 1.6 times the magnitude of the 50-year flood, and may have exceeded the legendary floods of 1867. The peak discharge of 49,000 cfs on the same day in Tule River near Springville (sta. 68) was 2.4 times that in 1955 and 2.8 times the 50-year flood, and the 73,000 cfs in Kaweah River at Three Rivers (sta. 70) was 2.4 times the record flow in 1963. Flood damage to highways, bridges, residences, and other buildings, and recreational facilities, was tremendous in these basins. At Kernville (sta. 64), in the Kern River basin upstream from Isabella Reservoir, a key bridge was lost and flood waters isolated the area. Hundreds of residents were stranded in the upper Kern River basin. Several hundred families were evacuated from their homes in the Porterville area about 50 miles north of Bakersfield. The floods in these basins are described more fully in a report by Dean (1971). The area of this detailed report is shown in figure 33.

Floodflows in the Kings River basin, north of the Kaweah River, were substantial, but were less than record flows. The flow in Mill Creek near Piedra (sta. 73) of 11,000 cfs on December 6 was equivalent to about 1.4 times the 50-year flood. Pine Flat Reservoir contained all inflow, but floodflows in downstream tributaries contributed to flooding in the lower part of the basin.

Some west-side tributaries in the San Joaquin Valley experienced severe flooding, principally in the vicinity of Coalinga, about 55 miles southwest of Fresno. The peak discharge of 1,980 cfs on December 6 in Los Gatos Creek above Nunez Canyon, near Coalinga (sta. 74), was 77 percent of the record flows in 1958 and 1962.

Despite extensive reservoir storage of floodflows in the Kings, Kaweah, Tule, and Kern River basins, about 141,800 acres of agricultural land was flooded in the Tulare Lake-bed area and on the valley floor in the Tulare and Buena Vista Lake basins, causing substantial agricultural flood damage.

In the San Joaquin River basin, floodflows although heavy, were about one-third of previous record flows. The peak discharge of 3,800 cfs on December 6 in Fresno River near Knowles (sta. 79)—for example, was only 29 percent of the maximum flow in 1955. Extensive flood damage occurred to powerplant facilities along the San Joaquin River above Millerton Lake, and about 35,000 acres of land was flooded downstream on the valley floor.

Four deaths were attributed directly to the floods; two occurred in Tulare County and one each in Kern and Monterey Counties. The U.S. Army Corps of Engineers estimated total flood damage in the Salinas

River basin and in basins tributary to the San Joaquin Valley to be as follows:

Basin	Damage
Salinas River basin	
Salinas River	$6,138,000
San Joaquin Valley	
Kern River	4,640,000
Other Buena Vista Lake basin streams	1,129,000
Tule River	6,186,000
Kaweah River	4,750,000
Kings River	2,047,000
Tulare Lake bed and other Tulare Lake basin streams	2,688,000
San Joaquin River	984,000
Total	28,562,000

These estimates include about $4.5 million in damage to U.S. Forest Service and National Park Service facilities. Also, $14.5 million of the total damage of $18.2 million in the Kern, Tule, Kaweah, Kings, and San Joaquin River basins occurred upstream from major reservoirs on these streams. The reservoirs—Isabella, Lake Success, Lake Kaweah, Pine Flat, and Millerton Lake—contained nearly all the floodflows and thus reduced the potential damage downstream. Additional flood damage of more than $10 million occurred in Inyo, San Bernardino, Riverside, Orange, and San Diego Counties. Damage from stream overflow, streambed erosion, and deposition of sediment and other debris constituted the major part of the flood losses. However, damage to dwellings, commercial and industrial facilities, and other improvements was tremendous in many areas, and damage to public facilities was very heavy.

FLOODS OF DECEMBER, IN SOUTH-CENTRAL CALIFORNIA

In the large area of general flooding in Southwestern United States in early December, the floods in a part of the area, the Kern, Tule, and Kaweah River basins in south-central California (fig. 35) were outstanding enough to be described in a special report by Dean (1971).

The report covers the area of most intense precipitation and runoff. The report describes the storm and precipitation, the floods in each basin, storage regulation, flood damage, comparison to previous floods, sedimentation and channel changes, and flood frequency. It includes a summary of flood stages and discharges and detailed information on stage, discharge, and reservoir contents at 46 sites in the area.

The floods were caused by a strong inflow of warm, moist Pacific air across central California on December 4–6 which dropped as much as 15 inches of rain in 24 hours. The resulting floodflows exceeded pre-

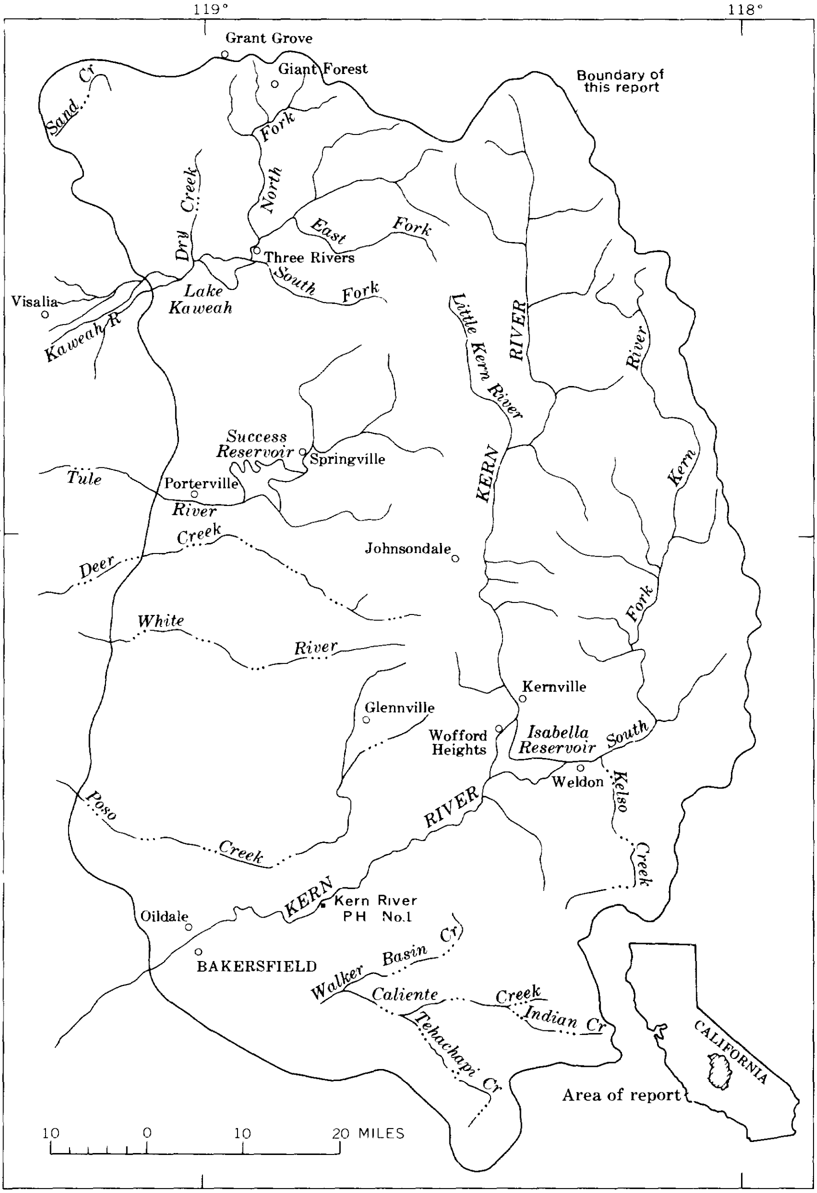


Figure 35.—Flood area, December, in south-central California.

vious maximums at all gaging stations in the Kern and Tule River basins and at most stations in the Kaweah basin. Areas of central California to the north and west had severe flooding but in general the floods were not maximum of record.

Peak flows generally were $1\frac{1}{2}$ to 2 times the magnitude of the probable 50-year flood. The December peak of 60,000 cfs on the Kern River near Kernville was more than twice the previous maximum of 27,400 cfs during the floods of November 1950 and December 1955. The period of record at the Kernville station began in 1912. Floodmarks for the historic flood of 1867 were 3 feet higher than for 1966 near Kernville.

Flood damage estimated at $15 million in mountain and foothills areas includes $4.5 million damage to U.S. Forest Service and U.S. National Park Service facilities. Three reservoirs operated by the U.S. Army Corps of Engineers on the Kern, Tule, and Kaweah Rivers controlled the floods and prevented catastrophic damage to Bakersfield, Porterville, Visalia, and smaller cities. The reservoirs are estimated to have prevented a total of $81 million in potential downstream damage. Three lives were lost, one by drowning and two from exposure after isolation in mountain areas during the storm.

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UNITED STATES DEPARTMENT OF THE INTERIOR

ROGERS C. B. MORTON, *Secretary*

GEOLOGICAL SURVEY

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