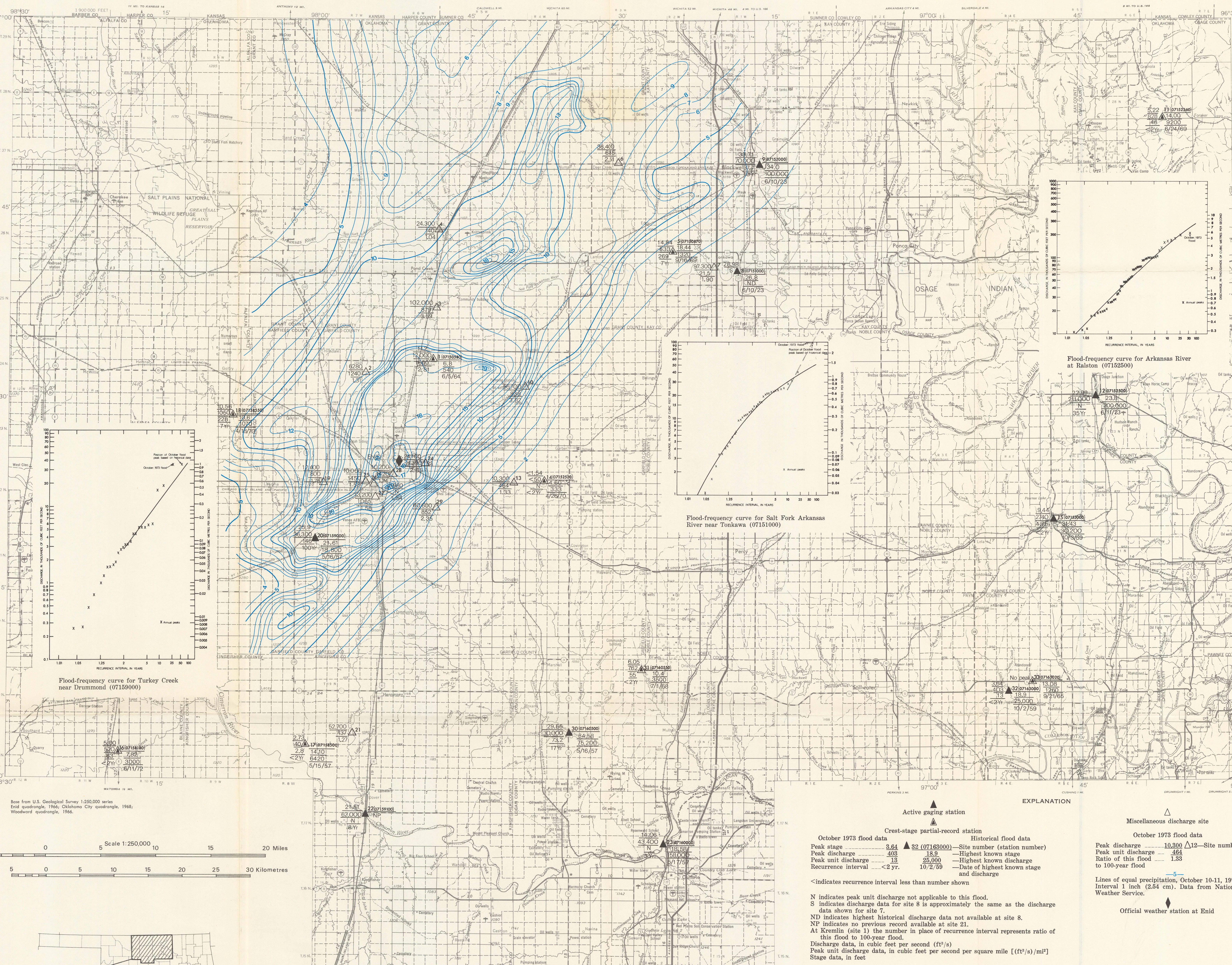


MAP SHOWING DISCHARGE DATA AT GAGING STATIONS AND MISCELLANEOUS SITES, FLOOD-FREQUENCY CURVES FOR SELECTED STREAMS, AND RAINFALL DATA.

Flood-frequency curve for Turkey Creek near Drummond (07159000)

Flood-frequency curve for Salt Fork Arkansas River near Tonkawa (07151000)

Flood-frequency curve for Arkansas River at Ralston (07152500)

Scale 1:250,000

EXPLANATION

Active gaging station

Crest-stage partial-record station

October 1973 flood data		Historical flood data	
Peak stage	3.64	32 (07160000)	Site number (station number)
Peak discharge	405	18.9	Highest known stage
Peak unit discharge	18	25,000	Highest known discharge
Recurrence interval	<2 yr.	10/2/50	Date of highest known stage and discharge

< Indicates recurrence interval less than number shown

N indicates peak unit discharge not applicable to this flood.
S indicates discharge data for site 8 is approximately the same as the discharge data shown for site 7.
ND indicates highest historical discharge data not available at site 8.
NP indicates no previous record available at site 21.
At Kremlin (site 1) the number in place of recurrence interval represents ratio of this flood to 100-year flood.
Discharge data, in cubic feet per second (ft³/s)
Peak unit discharge data, in cubic feet per second per square mile [(ft³/s)/mi²]
Stage data, in feet

Miscellaneous discharge site

October 1973 flood data

Peak discharge	10,300	12 Site number
Peak unit discharge	464	
Ratio of this flood to 100-year flood	1.33	

Lines of equal precipitation, October 10-11, 1973. Interval 1 inch (2.54 cm). Data from National Weather Service.

Official weather station at Enid

Factors for converting English units to International system (SI) units

Multiply English units	By	To obtain SI units
Cubic feet per second (ft³/s)	0.02832	Cubic metres per second (m³/s)
Cubic feet per second per square mile [(ft³/s)/mi²]	.0109	Cubic metres per second per square kilometres [(m³/s)/km²]
Feet (ft)	.3048	Metres (m)
Inches (in)	2.54	Centimetres (cm)
Square miles (mi²)	2.590	Square kilometres (km²)
Miles (mi)	1.609	Kilometres (km)
Acre-feet	1,233	Cubic metres (m³)

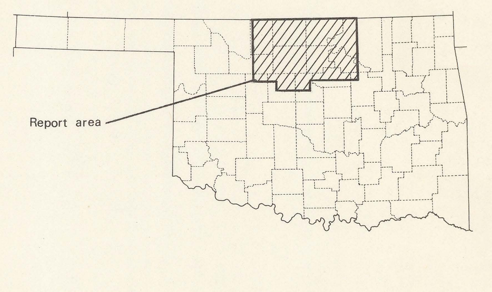


Figure 1.—Map of Oklahoma showing location of the report area.

INTRODUCTION

Heavy and intense rainfall of October 10 and 11, 1973, caused wide-spread flooding along many streams in north-central Oklahoma. This report shows the distribution and amounts of rainfall, and the magnitude and frequency of flood discharges at several sites in the area (sheet 1) and the extent of flooding in the Enid area (sheet 2).

The report area includes approximately 8,100 mi² (21,000 km²) in north-central Oklahoma (fig. 1). Major streams within the area are the Salt Fork Arkansas, Cimarron, Arkansas, and Chikaskia Rivers. The Cimarron and Salt Fork Arkansas Rivers are major tributaries to the Arkansas River, and the Chikaskia River is a major tributary to Salt Fork Arkansas River.

The extent of flooding in the Enid area (sheet 2) was delineated on the topographic map by field inspection and by using flood profiles based on high-water marks obtained by field surveys. The flood boundaries show the limits of flooding from the October 1973 storm.

The data presented in this report provide a basis for formulating effective flood-plain zoning that could minimize existing and future flood problems.

STORM RAINFALL

Rainfall data for the October 1973 storm were collected by the National Weather Service and the U.S. Geological Survey. Amounts and distribution of rainfall are shown by isohyetal lines on the principal map on sheet 1. An area of approximately 500 mi² (1,300 km²) received more than 10 inches (25 cm) of rainfall, and an area of approximately 100 mi² (260 km²) received amounts of 15 to 20 inches (38 to 51 cm).

The National Weather Service station at Enid recorded 15.68 inches (39.83 cm) of rainfall in 13 hours, 12 inches (30 cm) of that amount fell between 6:45 p.m. and 9:45 p.m. on October 10 (fig. 2). The maximum intensity for a 1-hour period was 5.3 inches (13.5 cm) between 8:00 p.m. and 9:00 p.m. Rainfall at the Enid station greatly exceeded the 100-year frequency for all durations reported in U.S. Weather Bureau Technical Paper No. 40 (1961). Table 1 shows rainfall intensities for the 100-year frequency and the maximum October 1973 storm rainfall for various increments of time.

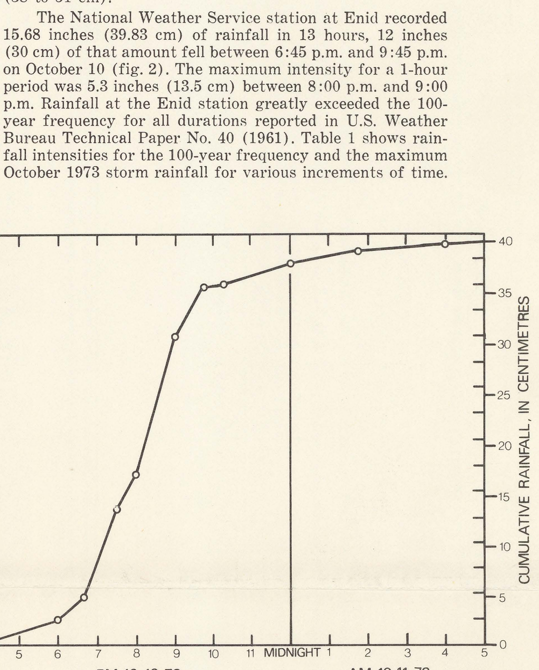


Figure 2.—Duration and intensity of rainfall at the National Weather Service station at Enid.

Table 1.—Summary of rainfall intensities during the October 1973 storm and 100-year rainfall frequency.

Duration, in hours	100-year frequency Technical Paper No. 40	National Weather Service station at Enid October 1973 storm
	Rainfall intensities, in inches, and (centimetres)	
1	4.0 (10.2)	5.31 (13.5)
2	4.7 (11.9)	10.0 (25.4)
3	5.2 (13.2)	12.0 (30.5)
6	6.1 (15.5)	14.0 (35.6)
12	7.2 (18.3)	15.57 (39.6)
24	8.3 (21.1)	15.68 (39.8)

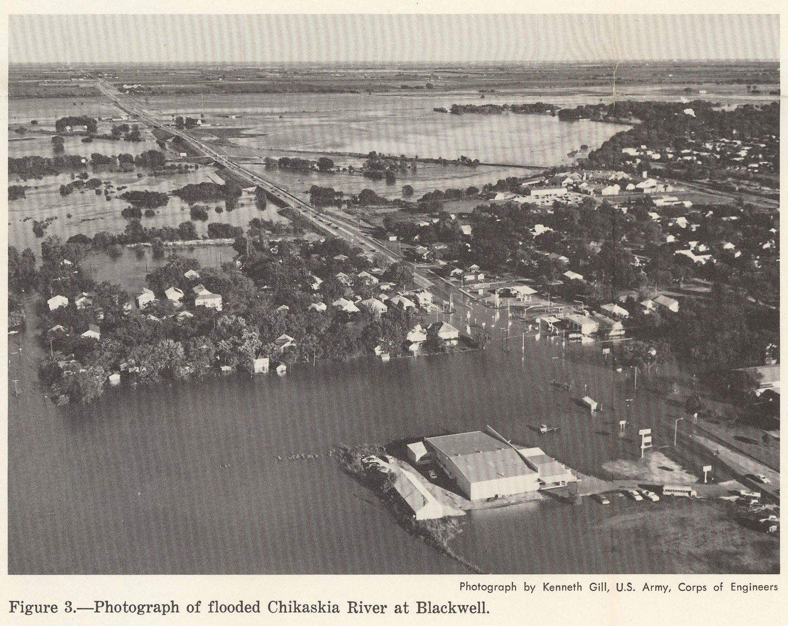
Rainfall during the October 1973 storm was 54 percent of the mean annual precipitation of 29.15 inches (74.0 cm) at the weather station at Enid, and approximately 7 times greater than the normal October rainfall of 2.27 inches (5.77 cm). The total rainfall of 15.68 inches (39.83 cm) exceeded the highest recorded 24-hour total of 12.3 inches (31.2 cm) in the State for any October since records began in 1892.

STORM RUNOFF

Runoff from the storm resulted in record-breaking floods on many streams in north-central Oklahoma (table 2). Several long-time residents in areas where flooding was most severe reported that stream stages during the October 1973 flood were higher than any previous stages since at least 1889. The long-term gaging stations on Turkey Creek near Drummond (site 20), and Salt Fork Arkansas River near Tonkawa (site 8) reached all-time maximum stages and discharges. The 1923 peak stage was higher than the 1973 peak stage for the Arkansas River at Ralston (site 12); however, the peak discharge of the October 1973 flood was greater because of subsequent channel scour. The Chikaskia River reached its highest recorded stage since 1923 and caused extensive flooding in the town of Blackwell. Figure 3 shows the Chikaskia River near the time of its peak stage in the Blackwell area.

The 1957 flood was larger in areal extent and certain isolated storms have caused higher peak unit discharges, but the October 1973 flood is documented as having the highest magnitude of peak unit dicharge over such a large area. The October 1973 flood was also outstanding in terms of devastation because the greatest intensity of rainfall was centered over the large urban area of Enid.

All the flood runoff from the storm drained into Keystone Lake at the confluence of the Arkansas and Cimarron Rivers. The lake is located a few miles east of the report area. The mean daily inflow and change in the lake storage resulting from the storm runoff are shown in figure 4. Although the lake stage and the amount of water stored during this flood was the peak of record, the lake had adequate capacity to store all the storm runoff.



Photograph by Kenneth Gill, U.S. Army, Corps of Engineers

Figure 3.—Photograph of flooded Chikaskia River at Blackwell.

Flood Height and Discharge

The height of a flood at a gaging station is usually stated in terms of gage height, or stage, which is the elevation of the water surface above a selected datum plane. For this report, all peak stages at gaging stations are reported as feet above the gage datum which usually approximates the same level as the streambed.

The rate of discharge of a stream is the volume of water that passes a particular location in a specific period of time. The discharge rates at particular locations for this flood are expressed in cubic feet per second (ft³/s) and represent the peak discharge which generally occurs at the time of maximum stage or height of the flood. The maximum stages and peak discharges for gaging stations and the peak discharges at miscellaneous sites are shown on the principal map on sheet 1 and are listed in table 2.

Peak discharges at miscellaneous sites were determined by indirect methods using hydraulic formulas for flow in open channels, flow over road embankments, and flow through contracted openings at bridges and culverts. Sites for indirect measurements were selected shortly after the flood. A transit-stadia survey of each site was made to determine (1) the water-surface profile as represented by high-water marks, (2) the cross-sectional properties of the stream channel and flood plain, (3) the geometry of the bridge, culvert or roadway embankment, and (4) roughness coefficients.

Peak unit discharge, which is generally expressed in cubic feet per second per square mile, (ft³/s)/mi², or cubic metres per second per square kilometre (m³/s)/km² is an indication of flood intensity. During the October 1973 flood, the peak unit discharge at the indirect discharge measurement sites ranged from 140 (ft³/s)mi² [1.53 (m³/s)km²] for Osage and Pond Creeks at Jefferson (site 4) to 1,660 (ft³/s)mi² [18.09 (m³/s)/km²] for Sand Creek tributary (site 1) near Kremlin. The discharge data shown for Boggy Creek at Lahoma Road in Enid (site 25) is only a field estimate because the high-water marks are unreliable, and the time and effects of the embankment scour at the constriction are uncertain.

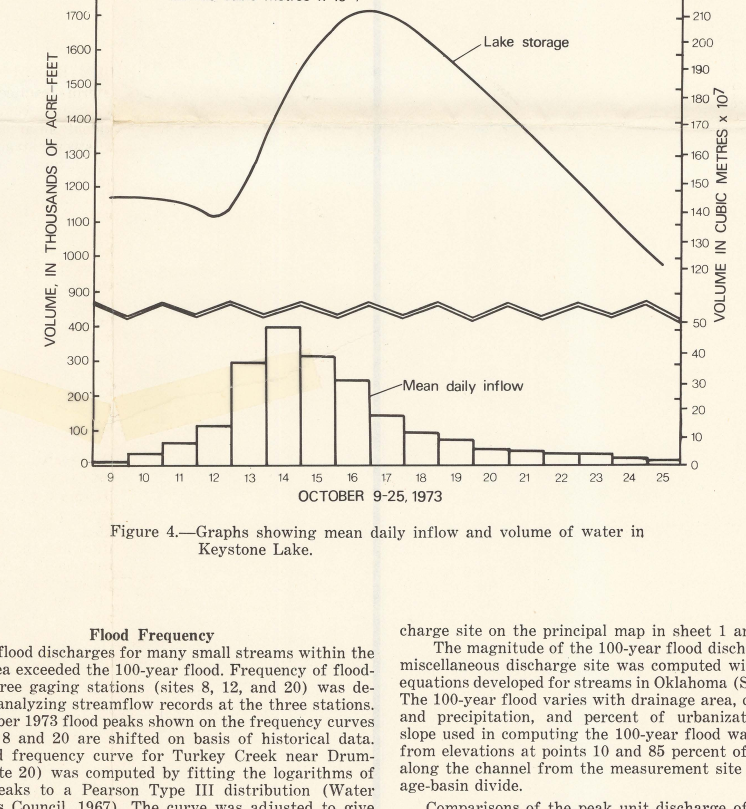


Figure 4.—Graphs showing mean daily inflow and volume of water in Keystone Lake.

Flood Frequency

The flood discharges for many small streams within the storm area exceeded the 100-year flood. Frequency of flooding at three gaging stations (sites 8, 12, and 20) was derived by analyzing streamflow records at the three stations. The October 1973 flood peaks shown on the frequency curves for sites 8 and 20 are shifted on basis of historical data. The flood-frequency curve for Turkey Creek near Drummond (site 20) was computed by fitting the logarithms of annual peaks to a Pearson Type III distribution (Water Resources Council, 1967). The curve was adjusted to give weight to flood frequency values calculated with regression equations developed for streams in Oklahoma (Sauer, 1974a). The flood frequency curves for Salt Fork Arkansas River near Tonkawa (site 8) and Arkansas River at Ralston (site 12) were computed by fitting the logarithms of annual peaks to the Pearson Type III distribution.

As applied to annual floods, recurrence interval is the average interval of time between exceedances of the indicated flood magnitude. For example, a flood of 100-year recurrence interval has a 1 in 100 chance, on the average, of occurring in any given year. The fact that a major flood occurs in one year does not reduce the probability of a flood as great or greater occurring within the same year or during the next year. The recurrence interval of the October 1973 flood discharges or ratio to the 100-year flood discharge is shown at each gaging station and each miscellaneous discharge site on the principal map in sheet 1 and in table 2.

The magnitude of the 100-year flood discharge for each miscellaneous discharge site was computed with regression equations developed for streams in Oklahoma (Sauer, 1974a). The 100-year flood varies with drainage area, channel slope, and precipitation, and percent of urbanization. Channel slope used in computing the 100-year flood was determined from elevations at points 10 and 85 percent of the distance along the channel from the measurement site to the drainage-basin divide.

Comparisons of the peak unit discharge of the October 1973 flood with computed 100-year peak unit discharge for streams in the storm area are shown in figure 5. The computed values were plotted versus drainage area only, thus the shaded area represents the range of 100-year floods for selected streams in the report area. The computed 100-year flood discharges for streams in Enid were adjusted for the effects of existing urbanization (Sauer, 1974b). The effects of urbanization were computed by considering the natural flood frequency curves for the Enid area, rainfall intensity, percentage of drainage area with impervious surface, percentage of drainage area served by storm sewers, and equations developed from urban studies in other parts of the country. Figure 5 shows that the magnitude of the October 1973 flood discharge is greater than the 100-year flood for most streams with drainage areas less than 125 mi² (324 km²).

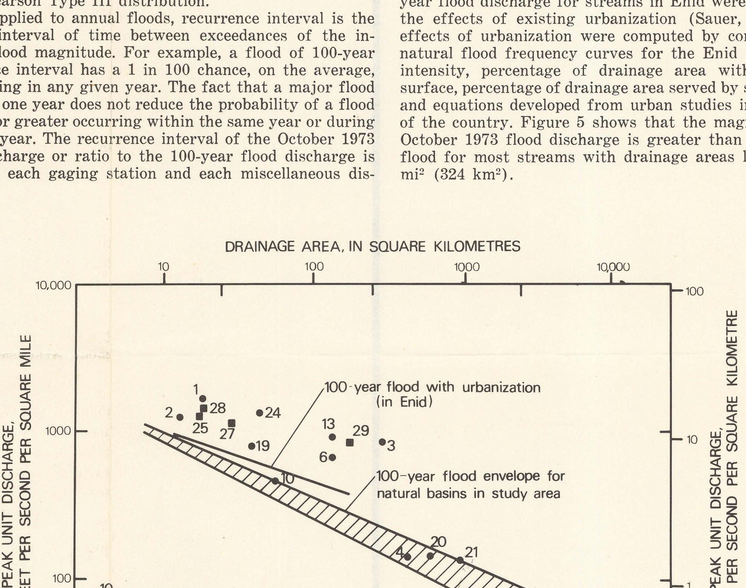


Figure 5.—Graphs showing comparison of peak unit discharge of October 1973 flood with computed 100-year flood.

Flood Damage

The record-breaking floods caused nine persons to lose their lives. Flood damage was most severe in Enid; however, the towns of Blackwell, Dover, Jefferson, and Tonkawa were also severely damaged. In addition, highways, county roads, bridges, city streets, and railroads were damaged considerably.

The President of the United States declared the City of Enid, and Garfield, Grant, Kay, Kingfisher, and Noble Counties disaster areas because of extensive residential and agricultural damage. Parts of Osage and Pawnee Counties were also declared disaster areas by the President because of agricultural damage. Thousands of acres of topsoil and winter wheat crops were lost by erosion.

Damage caused by the flood was estimated at $78 million by the Oklahoma Civil Defense.

Keystone Lake had adequate capacity to store all the storm runoff, thus preventing severe flood damage to the City of Tulsa on the banks of the Arkansas River downstream from Keystone Lake.

Table 2.—Summary of the October 1973 flood, basin characteristics, and historical data.

Site number	Gaging station number	Stream name and location	Drainage area (mi²)	Channel slope (ft/mi)	Annual average precipitation (in)	Computed 100-year flood (ft³/sec)	October 1973 flood: Date of peak	Gage height (ft)	Discharge (ft³/sec)	Ratio to 100-year flood	Previous recorded maximum: Date of peak	Gage height (ft)	Discharge (ft³/sec)	Period of record	Historical information
1	07150580	Sand Creek tributary near Kremlin	7.21	19.3	28.0	4,270	10/10	11.2	12,000	2.81	6/ 5/64	6.8	540	1964-74	Three feet higher than highest stage in at least 43 years
2		Wildhorse Creek near Hillsdale	5.08	36.0	29.0	4,780	10/10	--	6,280	1.31	--	--	--	--	
3		Wildhorse Creek near Pond Creek	116	15.4	29.0	28,400	10/11	--	102,000	3.59	--	--	--	--	Highest stage in at least 62 years as reported by local residents
4		Pond and Osage Creeks near Jefferson	173	6.2	28.0	23,400	10/11	--	24,300	1.04	--	--	--	--	Highest stage in at least 73 years as reported by local residents
5	07150870	Salt Fork Arkansas River tributary near Eddy	2.35	19.8	28.0	2,300	10/11	14.84	633	7 yr[3]	9/16/69	18.44	1,320	1964-74	
6		Deer Creek near Deer Creek	53.1	11.8	29.0	14,500	10/11	--	36,400	2.51	--	--	--	--	Highest stage in at least 52 years as reported by local residents
7		Salt Fork Arkansas River near Tonkawa 4.1 river miles upstream from gage (site 8)	4,520	6.39	25.0	51,200	10/11	28.98	97,300	1.90					
8	07151000	Salt Fork Arkansas River near Tonkawa	4,520	6.39	25.0	51,200	10/11	28.98	97,300	1.90	6/10/23	26.8	Not available	1903-05; 1935-74	Highest stage since at least 1903
9	07152000	Chikaskia River near Blackwell	1,859	7.25	28.1	142,000[1]	10/11	33.71	70,000	13 yr[3]	6/10/23	34.0	100,000	1935-74	Highest recorded stage since at least 1923 flood
10		Red Rock Creek near Hunter	59.4	10.2	29.0	14,600	10/11	--	55,700	3.82	--	--	--	--	Highest stage in at least 84 years as reported by local residents
11	07152360	Elm Creek near Foraker	18.2	17.5	33.0	9,390	10/11	5.22	828	<2 yr[3]	6/24/69	14.0	9,200	1964-74	
12	07152500	Arkansas River at Ralston	54,465	8.26	18.5	285,000	10/13	22.99	211,000	35 yr[3]	6/11/23	23.8	200,000	1925-74	Highest discharge for period of record
13		Black Bear Creek near Garber	22.2	11.1	29.5	7,760	10/10	--	10,300	1.33	--	--	--	--	
14	07152520	Black Bear Creek tributary near Garber	.97	42.3	28.0	1,530	10/10	<1.54	<50	<2 yr[3]	4/26/70	4.60	333	1964-74	
15	07153000	Black Bear Creek at Pawnee	576	4.05	30.2	43,900[1]	10/11	9.44	2,740	<2 yr[3]	10/ 3/59	31.43	30,200	1944-74	
16	07158180	Salt Creek tributary near Okeene	8.23	30.0	26.5	5,500	10/11	5.00	520	<2 yr[3]	6/11/72	7.82	3,000	1964-74	
17	07158500	Preacher Creek near Dover	14.5	14.8	27.5	6,300	10/10	2.73	40	<2 yr[3]	5/15/57	14.10	6,420	1952-57; 1964-74	
18	07158550	Turkey Creek tributary near Goltry	5.08	19.5	27.0	3,250	10/11	10.56	1,050	7 yr[3]	4/18/70	10.6	1,070	1964-74	
19		Sand Creek at Highway 60 near Enid	15.5	16.0	29.0	7,070	10/10	--	12,400	1.75	5/16/57	--	3,890	--	Highest stage in at least 28 years as reported by local residents
20	07159000	Turkey Creek near Drummond	248	5.7	27.2	36,600[1]	10/11	25.9	36,300	100 yr[3]	5/16/57	21.61	18,800	1948-70; 1971-74	Highest stage since at least 1932
21		Turkey Creek near Hennessey	385	6.1	28.5	41,400	10/11	--	52,700	1.27	--	--	--	--	
22	07159100	Cimarron River at Dover	10,787	8.03	20.1	147,000	10/11	21.81	62,000	8 yr[3]				1974	
23	07160000	Cimarron River near Guthrie	11,966	8.03	20.1	161,000	10/11	14.06	43,400	3 yr[3]	5/17/57	18.58	158,000	1937-74	
24		Skeleton Creek at Enid	17.3	19.8	29.0	8,450	10/10	--	24,100	2.85	--	--	--	--	Highest stage in at least 84 years as reported by local residents
25		Boggy Creek at Lahoma Road at Enid	6.91	24.2	29.0	6,340[2]	10/10	--	~~8,730[4]~~ 10,000	~~13.8~~ 1.58 changes from errata sheet	--	--	--	--	
26		Old Channel Boggy Creek at Lahoma Road at Enid	.38	10.7	29.0	900[2]	10/10	--	1,660	NA	--	--	--	--	
27		Boggy Creek Diversion Canal below Rupe Ave. at Enid	12.4	16.3	29.0	8,360[2]	10/10	--	13,200	1.58	7/29/50	--	5,830[5]	--	
28		North Boggy Creek at Enid	7.17	17.6	29.0	5,850[2]	10/10	--	10,200	1.74	--	--	--	--	Highest stage in at least 30 years as reported by local residents
29		Skeleton Creek below Boggy Creek near Enid	71.1	16.3	29.0	25,800[2]	10/10	--	60,600	2.35	--	--	--	--	
30	07160500	Skeleton Creek near Lovell	410	8.4	29.0	75,000[1]	10/11	29.66	30,000	17 yr[3]	5/16/57	34.58	75,200	1949-74	
31	07160550	West Beaver Creek near Orlando	13.9	23.8	30.0	7,800	10/11	6.05	762	<2 yr[3]	7/ 1/68	10.4	3,500	1964-74	
32	07163000	Council Creek near Stillwater	31	17.3	32.5	31,700[1]	10/11	3.64	403	<2 yr[3]	10/ 2/59	18.9	25,000	1934-74	
33	07163020	Corral Creek near Yale	2.89	53.7	33.5	4,500	No peak				9/21/65	13.08	1,260	1964-74	

[1] Weighted with station data
[2] Adjusted for urbanization effects
[3] Recurrence interval in years
[4] Field estimate
[5] Historical measurement made in old channel Boggy Creek; drainage area approximately equal to drainage area for Boggy Creek diversion canal below Rupe Avenue at Enid (site 27).
NA Ratio to 100-year flood not applicable because of runoff from outside the drainage basin.

FLOOD OF OCTOBER 1973 IN ENID AND VICINITY, NORTH-CENTRAL OKLAHOMA

By
Roy H. Bingham, DeRoy L. Bergman,
and Wilbert O. Thomas, Jr.

October 1974
Open file