THE FLOOD OF DECEMBER 1982 AND THE 100- AND 500-YEAR FLOOD ON THE BUFFALO RIVER, ARKANSAS

By Braxtel L. Neely, Jr.

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CONTENTS

Page

ILLUSTRATIONS

Page

TABLES

CONVERSION FACTORS

For use of readers who prefer to use metric units, conversion factors for terms used in this report are listed below:

Multiply	By	To obtain
foot (ft)	0.3048	meter (m)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
inch (in.)	25.4	millimeter (mm)
square mile (mi^2)	2.590	square kilometer (km^2)

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ABSTRACT

Flood profiles, peak discharges, and stages for the December 1982, the 100-year, and the 500-year floods at 17 sites along the Buffalo River were determined. These sites are (1) near the mouth, (2) Rush, (3) Buffalo Point, (4) Highway 14, (5) Maumee, (6) Gilbert, (7) St. Joe, (8) Woolum, (9) Mt. Hersey, (10) Carver, (11) Hasty, (12) Pruitt, (13) Ozark, (14) Kyles Landing, (15) Steel Creek, (16) Highway 74, and (17) Highway 21. Typical synthetic stage hydrographs for the 100- and 500-year floods were determined for each site. Flow-duration data for gaging stations at St. Joe and Rush are shown. The average velocity of the water for the 100- and 500-year floods is shown for each site. Approximate flood boundaries delineating the 100- and 500-year floods are shown for Ponca, Steel Creek, Pruitt, St. Joe, and Buffalo Point.

INTRODUCTION

The Buffalo River is a scenic river in the Ozark Mountains in north-central Arkansas. The river meanders through the rugged mountains and empties into the White River (fig. 1). The act establishing Buffalo National River as a part of the National Park Service system was approved in 1972. The National Park Service is developing several recreational park sites along this scenic river. The magnitude, frequency, duration and velocities of floods are primary factors needed for establishing guidelines for developing facilities and managing park sites.

This report provides information on the December 1982, the 100-year and 500-year floods along the Buffalo River at 17 park sites. This report was prepared by the U.S. Geological Survey in cooperation with the National Park Service. It is based on data collected during the December 1982 flood and long term data for the gaging stations at St. Joe and Rush.

FLOOD DISCHARGES

December 1982 Flood

Rainfall on December 2 and 3, 1982 caused widespread flooding along the Buffalo River. The peak discharge at the gaging station near St. Joe was 158,000 ft^3/s on December 3, 1982. This discharge has a recurrence interval of about 65 years. The peak discharge at the discontinued gaging station near Rush was 215,000 ft^3/s, which is slightly greater than a 100-year flood. The drainage areas at St. Joe and Rush are 829 and 1,091 mi^2, respectively. The total rainfall measured at each of seven rain gages by the National Weather Service was between 8 and 9 in. throughout the Buffalo River basin. Hourly rainfall measured at four rain gages showed that the intensities were fairly uniform throughout the basin. Examination of total and hourly rainfall suggests that changes in discharges along the Buffalo River upstream from St. Joe were relatively uniform. Therefore, discharges for the December 1982 flood along the Buffalo River upstream from St. Joe were computed by the equation:

$$Q = 6{,}277\ A^{0.48}$$

Where Q equals discharge in ft^3/s, and A equals drainage area in mi^2. The exponent, 0.48, is used by Patterson (1971) for computing the 25-year flood. The constant, 6,277, is required to allow the computed discharge to match the actual discharge gaged at St. Joe. Discharges between St. Joe and Rush were computed by interpolating logarithmically between the stations. Discharges downstream from Rush were computed by the equation:

$$Q = 7{,}486\ A^{0.48}$$

The constant, 7,486, is required to allow the computed discharge to match the actual discharge gaged at Rush.

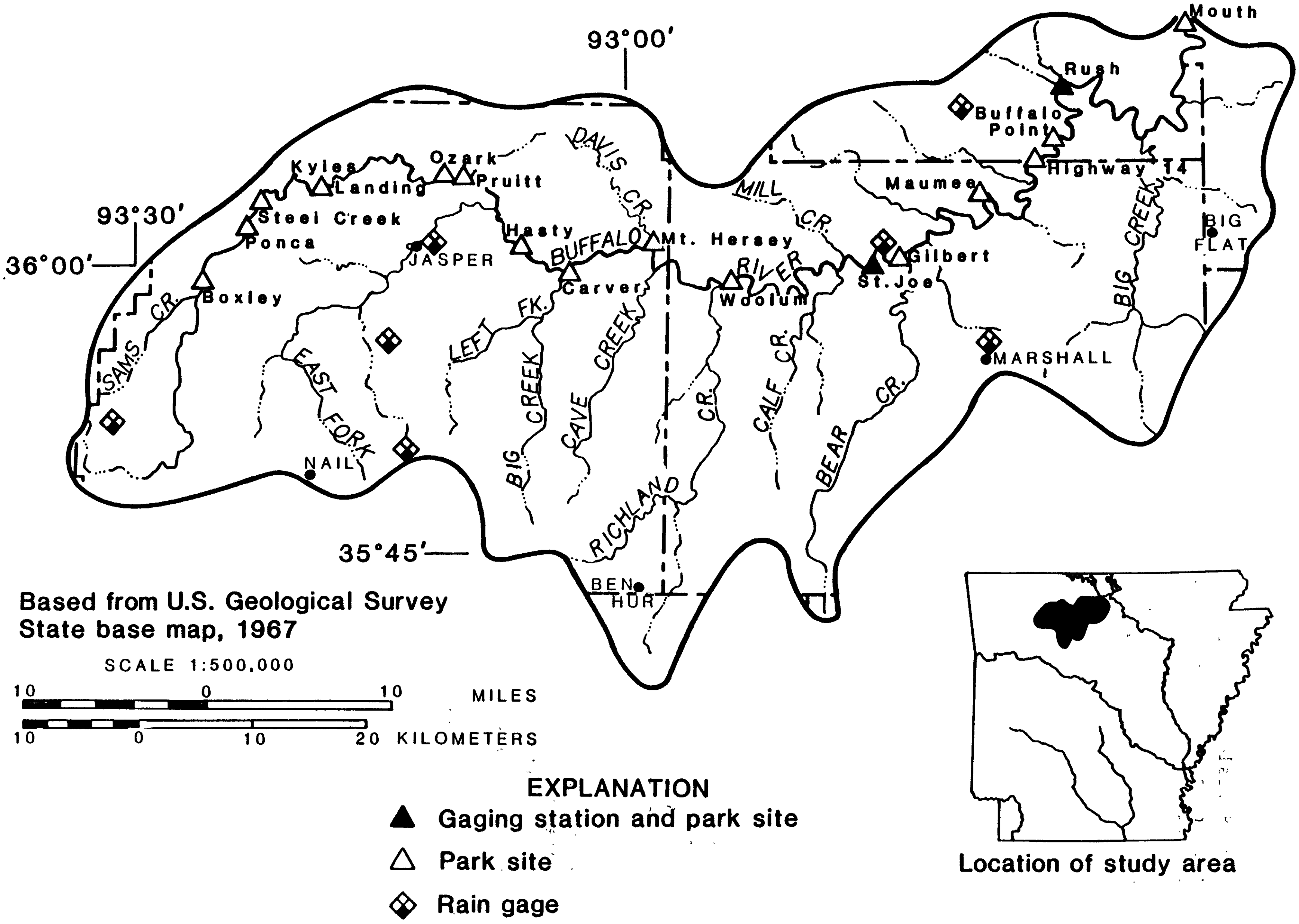


Figure 1.--Location of Buffalo River and 17 park sites.

100-Year and 500-Year Floods

Peak discharges are expressed as floods of selected recurrence interval. A 100-year flood for example may be expected to be equaled or exceeded on the average of once in 100 years. This does not mean floods occur at uniformly spaced intervals. In fact, a flood of this magnitude can be equaled or exceeded more than once in the same year, or can occur in consecutive years. Another way of expressing recurrence interval is in terms of probability. A 100-year and 500-year flood has a 1 percent and 0.2 percent chance, respectively, of being equaled or exceeded in any year.

The U.S. Geological Survey operated a gaging station near Rush from 1927 through 1974 and has operated a gaging station near St. Joe since 1940. The annual peak discharges at St. Joe for the period of record and the historical peak in 1915 were used to develop a discharge frequency curve by the log-Pearson type III method. The annual peak discharges at Rush for the period of record and the historical peaks of water years 1915 and 1983 (December 1982) were used to develop a discharge frequency curve by the same method. A regional skew value was used in both computations following methods outlined by the U.S. Water Resources Council (1981).The 100-year and the 500-year discharges were determined at both gaging stations (Rush and St. Joe) using this analysis. Discharges for all other stations for the 100-year and 500-year floods along the Buffalo River were computed by the equations:

$$Q_{100} = 7{,}100\ A^{0.48}$$
$$Q_{500} = 10{,}000\ A^{0.48}$$

where, Q_{100} equals discharge in ft^3/s for the 100-year flood, Q_{500} equals discharge in ft^3/s for the 500-year flood, and A equals drainage area in mi^2. The exponent, 0.48 is used by Patterson (1971) and the constants, 7,100 and 10,000, (as determined in the 1982 flood analysis) were used for the respective stations. Discharge for the stations between Rush and St. Joe was determined using the equations rather than by interpolation as done for the December 1982 flood because of the slight difference between the discharge determined from the frequency curve and by equations at the Rush and St. Joe stations.

FLOOD PROFILES

December 1982 Flood Profile

Highwater marks for the flood of December 1982 were recovered at each of the 17 park sites. These highwater marks and cross sections were tied in by level survey. A water-surface profile for the December 1982 flood was developed by plotting the elevation of the highwater marks against river miles (fig. 2). A water-surface profile was also computed using the step-backwater method (Sherman, 1976). Discharges along the Buffalo River for the December 1982 flood that were used in this method were computed as described in the section "December 1982 Flood". Cross sections used in this method were determined at each park site by level survey. On running the step-backwater program, it was discovered that additional intermediate cross sections were needed. These intermediate cross sections were picked from topographic maps

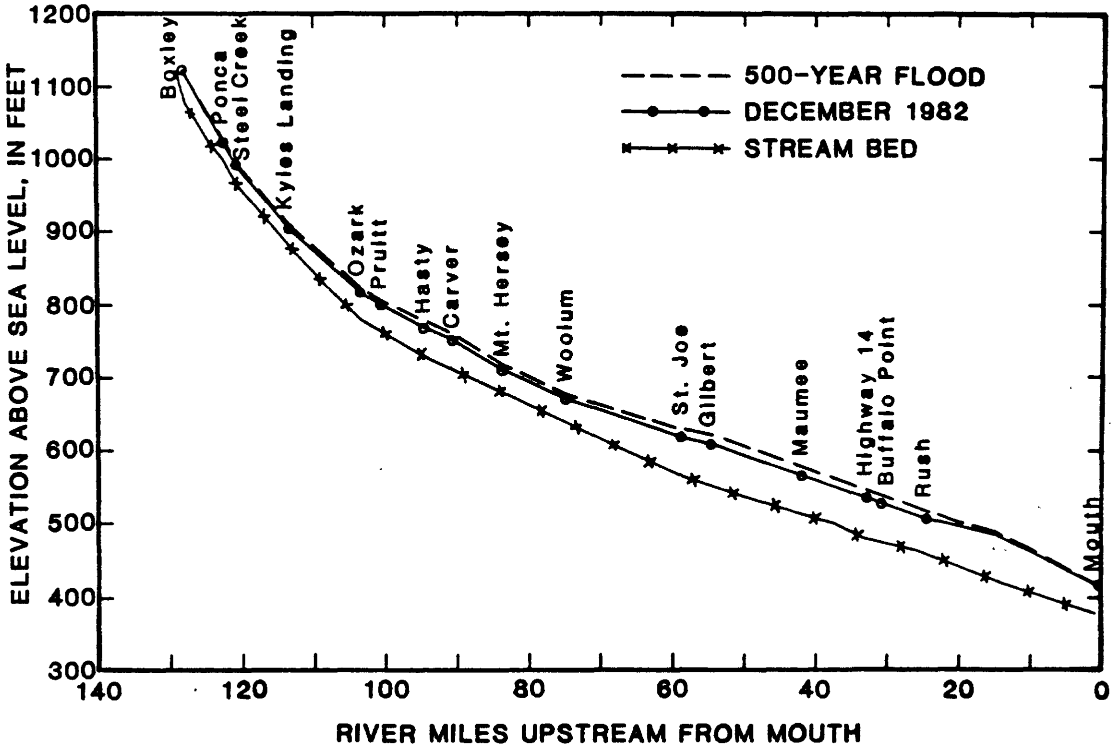


Figure 2.--Water-surface profiles of Buffalo River of the December 1982 and 500-year floods.

at sites where contour lines crossed the stream. The depth of water below the contour lines at these sites was estimated to be 4 feet to conform with depths determined by level surveys. Manning's roughness coefficients (Barnes, 1967) were assigned in the field at each of the 17 park sites. Roughness coefficients for cross sections picked from topographic maps were estimated based on field selections at nearby cross sections. In running the step-backwater program, roughness coefficients had to be adjusted along each reach between park sites to compute water surface elevations that agreed with highwater marks. These adjustments were minor and the final roughness coefficients used were reasonable. Roughness coefficients that were used were fairly uniform throughout the length of the Buffalo River.

The discharges that were used and the highwater elevations at each park site are shown in table 1.

100-Year and 500-Year Flood Profiles

The water-surface profiles along the Buffalo River for the 100-year and the 500-year floods were also computed by the step-backwater method. The cross sections and roughness coefficients used were the same as described in the previous section. The discharges that were used are described in the section, "100-Year and 500-Year Floods". The discharges used and the water-surface elevations computed are shown in table 1. The 500-year profile is shown on figure 2. The 100-year profile is not shown on figure 2 because of its close proximity to the December 1982 profile.

FLOOD VELOCITIES

The average velocities computed at each park site during the 100-year and the 500-year floods are shown in table 1. Maximum point velocities could not be determined, but are usually between one and one-half and two times the average velocities.

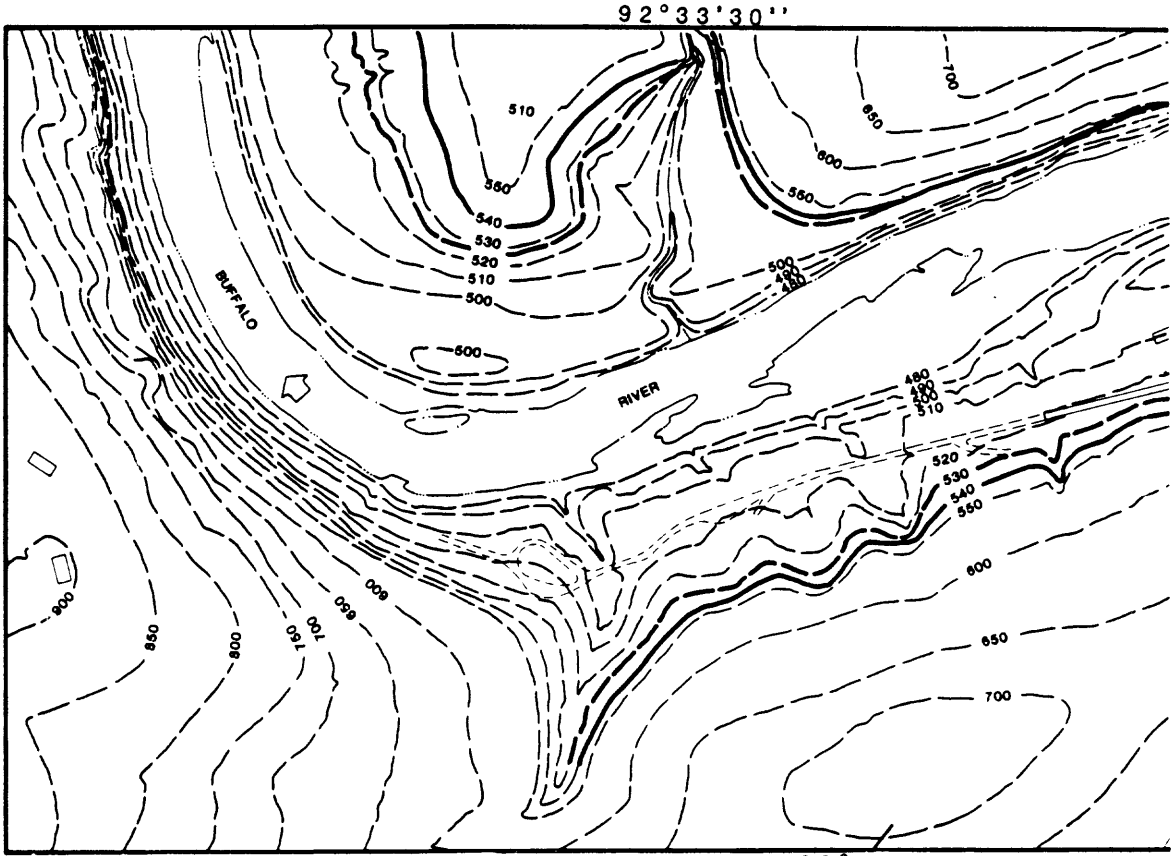
FLOOD BOUNDARIES

Flood boundaries for the 100- and 500-year floods are delineated for five sites on topographic maps furnished by the National Park Service. Detailed topographic maps were not available for the other sites. The sites where flood boundaries are delineated are Ponca, Steel Creek, Pruitt, St. Joe, and Buffalo Point (figs. 3-7). The water surfaces used in preparing the boundaries were determined by using the elevations computed for each park site and making adjustments both upstream and downstream based on the slope of the water surface.

Table 1.--Summary of stages and discharges along the Buffalo River at 17 park sites

Site	River mile	Drainage area (square miles)	December 1982 flood		100-year flood			500-year flood		
			Elevation (feet)	Discharge (cubic feet per second)	Elevation (feet)	Discharge (cubic feet per second)	Velocity (feet per second)	Elevation (feet)	Discharge (cubic feet per second)	Velocity (feet per second)
Mouth	0	1,340	417.0	237,000	417.0	225,000	8.6	425.2	317,000	9.2
Rush	24.4	1,091	507.8	215,000	506.8	209,000	8.1	514.7	299,000	9.2
Buffalo Point	30.9	1,079	529.4	212,000	528.4	203,000	10.2	537.5	286,000	11.4
Highway 14	32.5	1,072	537.4	211,000	536.3	202,000	8.3	545.7	285,000	9.0
Maumee	41.8	1,008	562.4	197,000	562.4	196,000	8.4	571.0	276,000	9.2
Gilbert	53.7	843	604.3	161,000	605.3	180,000	5.8	615.3	254,000	6.1
St. Joe	58.2	829	614.1	158,000	616.3	176,000	5.7	625.0	243,000	6.3
Woolum	75.2	732	669.0	149,000	670.9	168,000	5.6	676.2	237,000	6.0
Mt. Hersey	83.8	529	706.6	127,000	709.0	144,000	14.2	716.1	203,000	14.2
Carver	91.0	394	751.7	111,000	754.1	125,000	6.4	760.2	176,000	7.2
Hasty	94.7	382	767.8	109,000	770.1	123,000	9.6	776.5	174,000	11.0
Pruitt	01.6	190	800.4	77,900	802.2	88,100	7.3	807.8	125,000	8.0
Ozark	03.3	188	812.1	77,500	813.4	88,700	7.7	817.5	123,000	8.2
Kyles Landing	13.4	150	900.4	69,500	901.7	78,700	12.2	905.5	111,000	13.1
Steel Creek	120.8	123	989.6	63,200	990.7	71,500	14.8	994.2	101,000	15.1
Ponca	122.8	116	1022.3	61,500	1023.6	69,500	7.7	1028.0	97,900	8.3
Boxley	128.4	67.8	1120.0	47,500	1120.6	53,700	14.2	1122.3	75,700	16.5

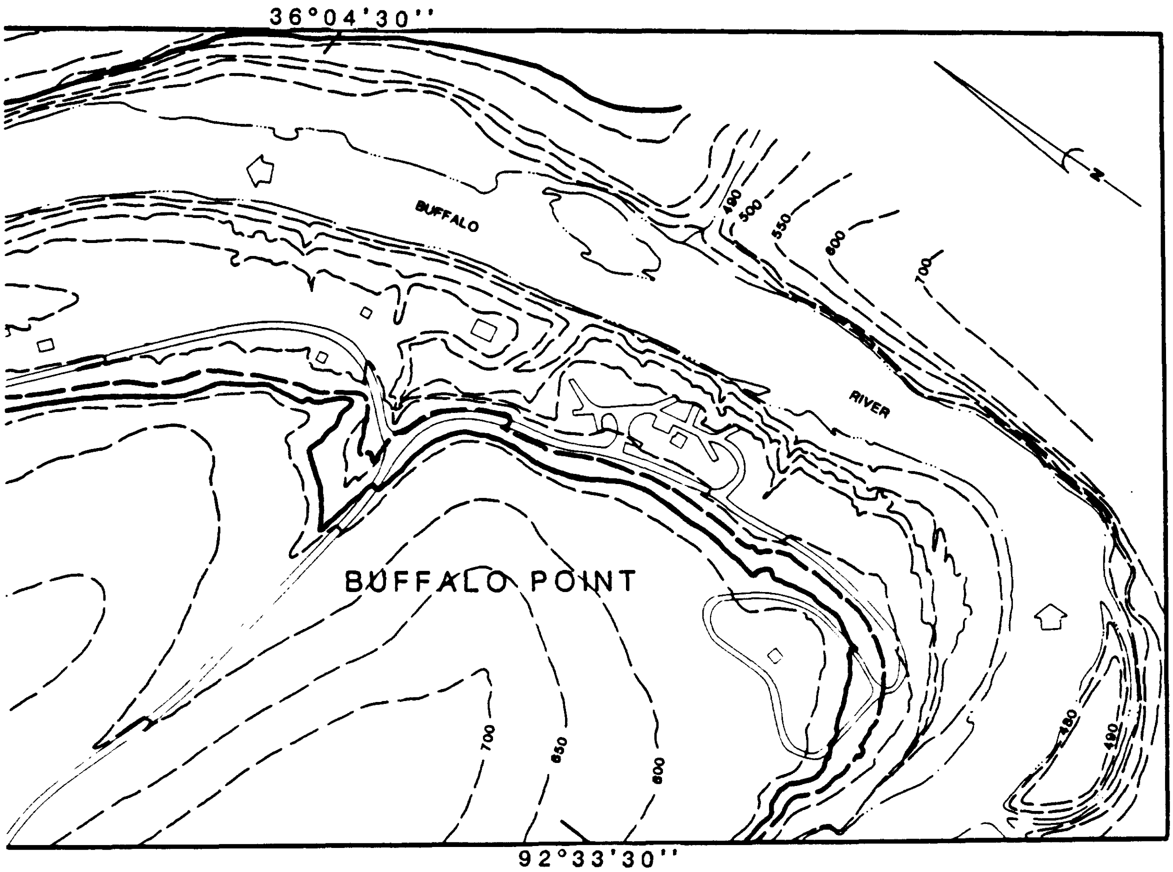
92°33'30''



36°04'30''

Base from National Park Service
1:2400
0 0.1 0.2 MILES
0 0.1 0.2 0.3 KILOMETERS
Contour interval variable
Datum is sea level

Figure 3.—Flood boundaries of the 100-year and 500-year floods

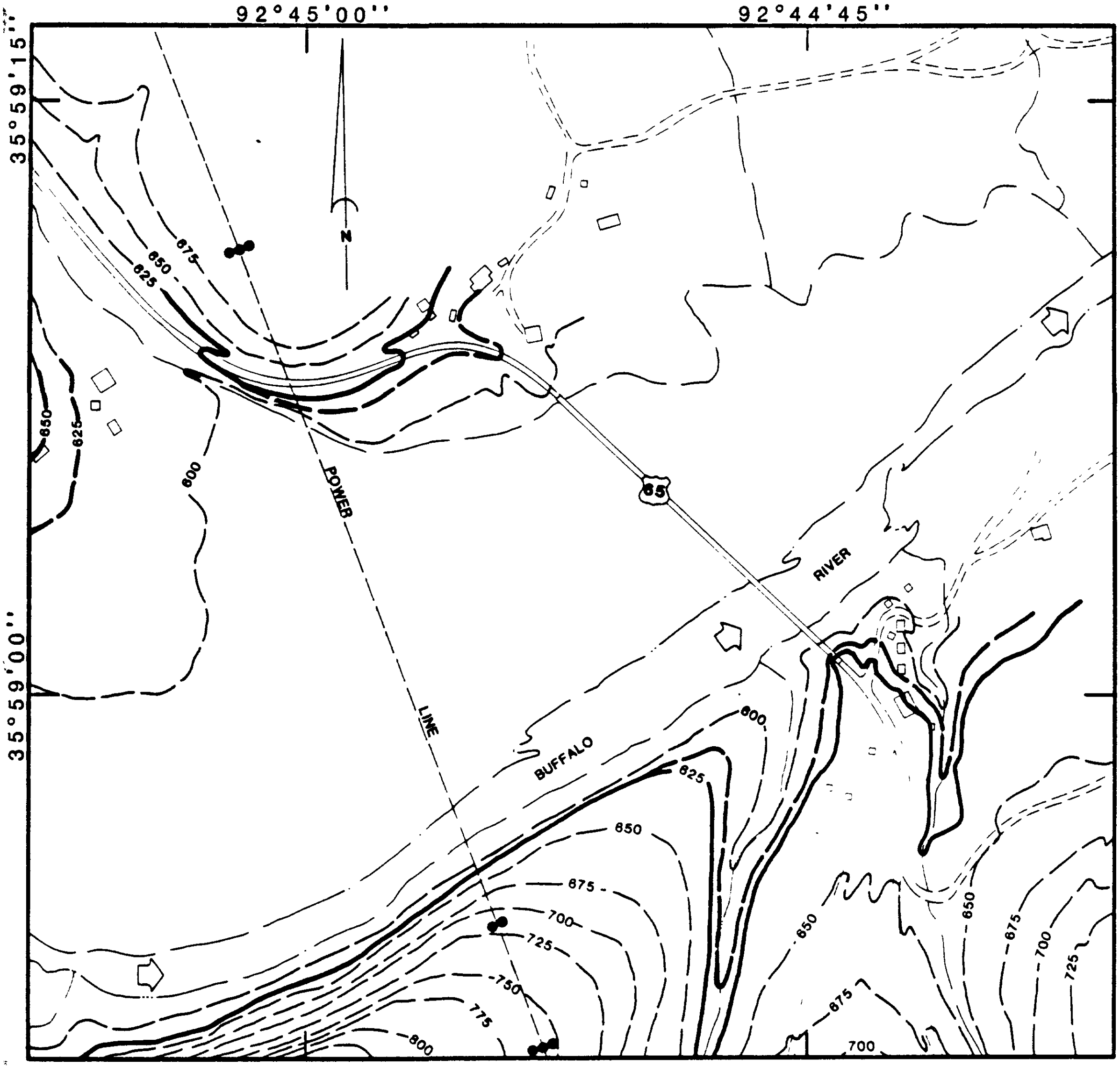


EXPLANATION

APPROXIMATE BOUNDARY OF 500-YEAR FLOOD

APPROXIMATE BOUNDARY OF 100-YEAR FLOOD

on Buffalo River at Buffalo Point, Ark.



Base from National Park Service
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0 0.1 0.2 0.3 KILOMETERS

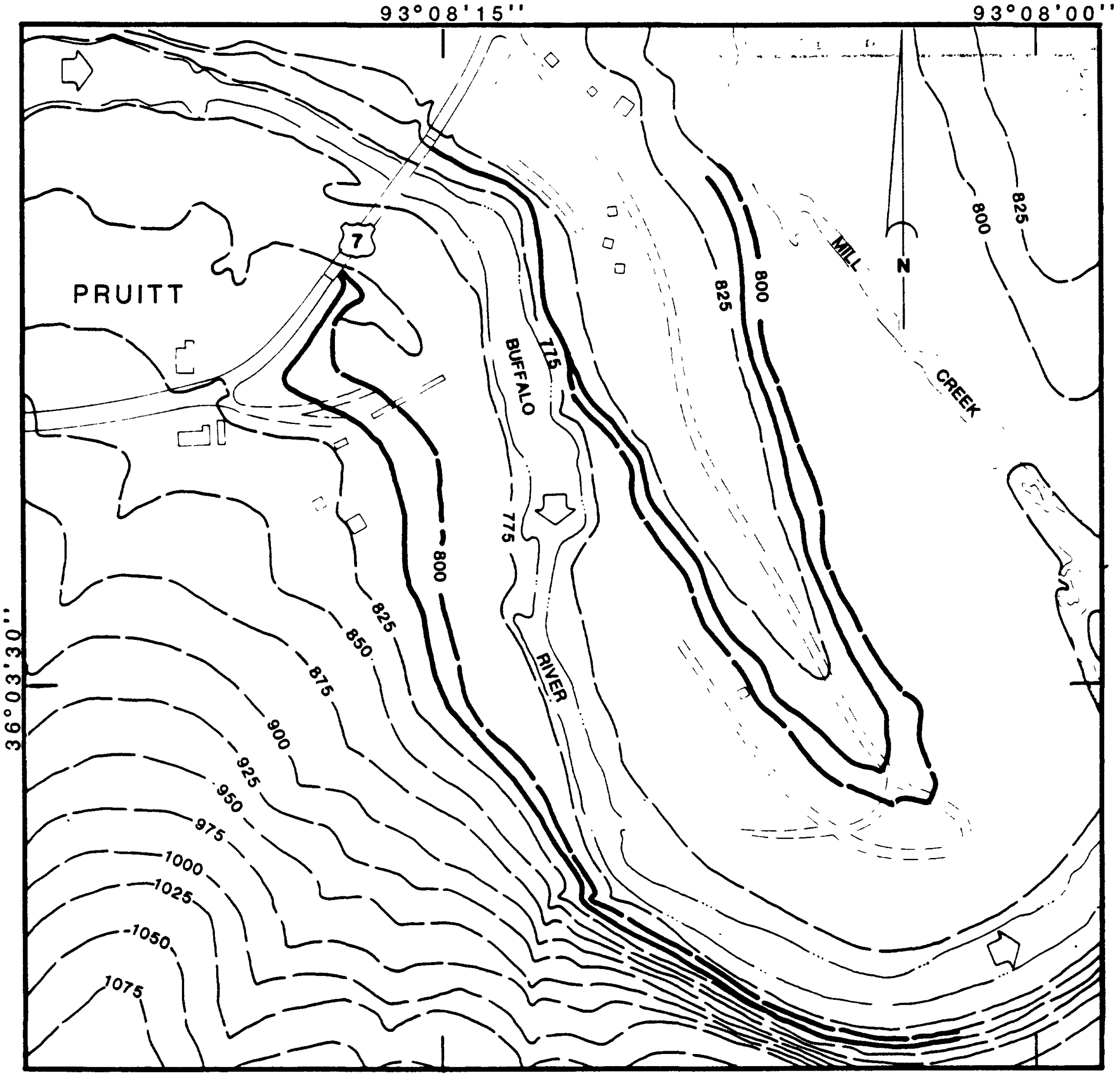
Contour interval variable
Datum is sea level

EXPLANATION

APPROXIMATE BOUNDARY OF 500-YEAR FLOOD

APPROXIMATE BOUNDARY OF 100-YEAR FLOOD

Figure 4.--Flood boundaries of the 100-year and 500-year floods on Buffalo River near St. Joe, Ark.



Base from National Park Service
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0 0.1 0.2 MILES

0 0.1 0.2 0.3 KILOMETERS

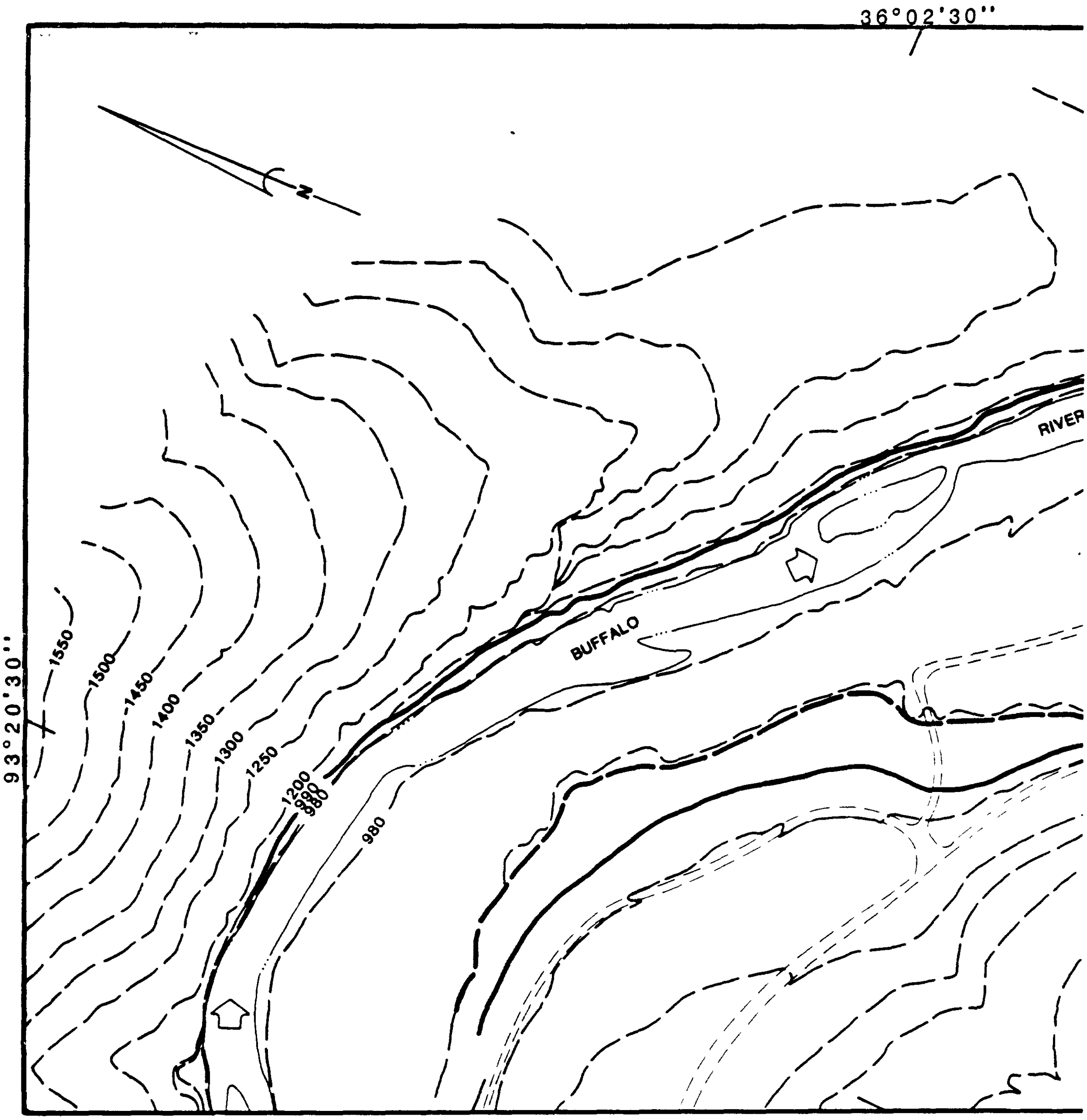
Contour interval variable
Datum is sea level

EXPLANATION

APPROXIMATE BOUNDARY OF 500-YEAR FLOOD

APPROXIMATE BOUNDARY OF 100-YEAR FLOOD

Figure 5.--Flood boundaries of the 100-year and 500-year floods on Buffalo River at Pruitt, Ark.



Base from National Park Service
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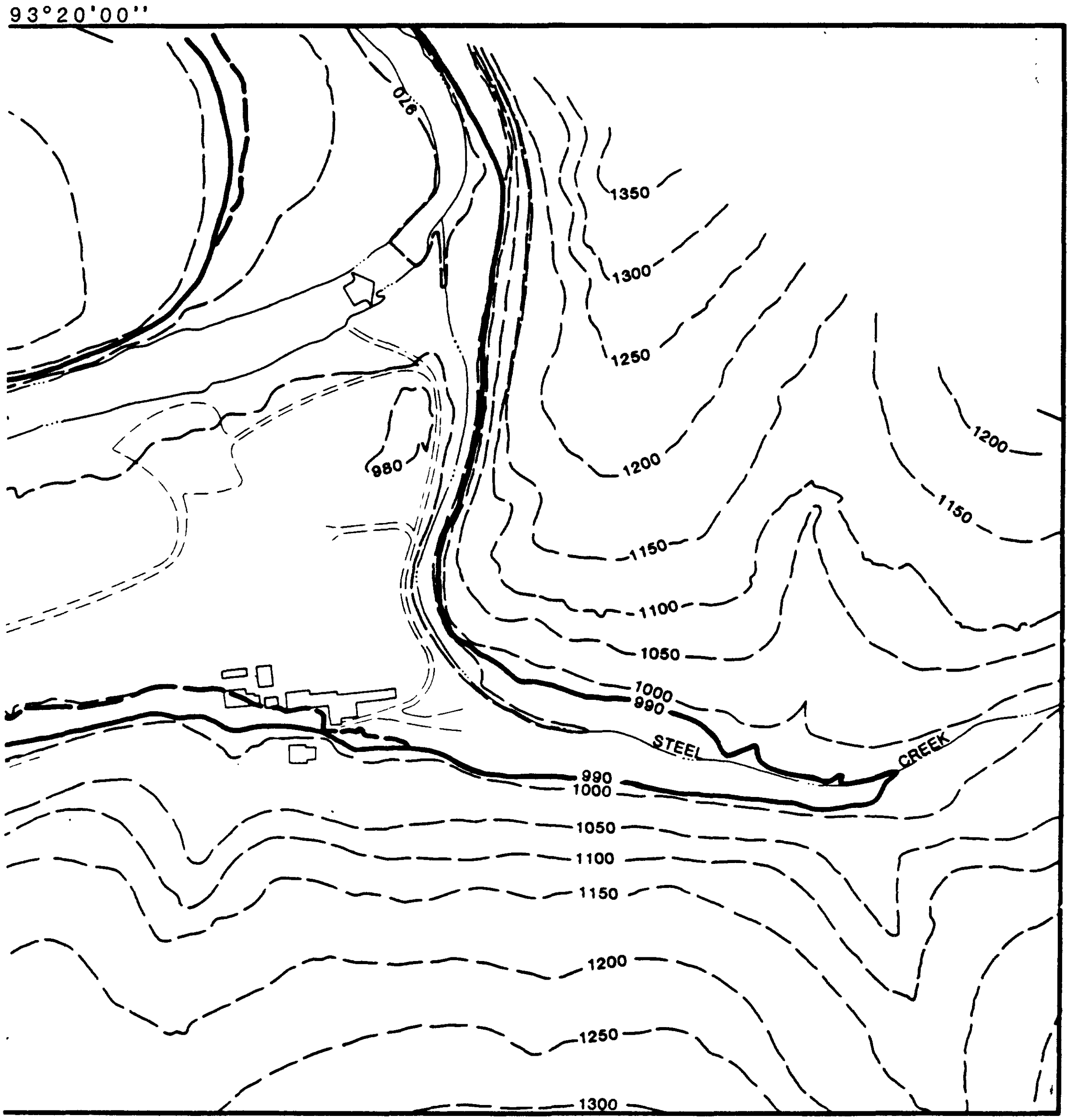
0 0.1 0.2 MILES

0 0.1 0.2 0.3 KILOMETERS

Contour interval variable
Datum is sea level

Figure 6.—Flood boundaries of the 100-year and 500-year floods

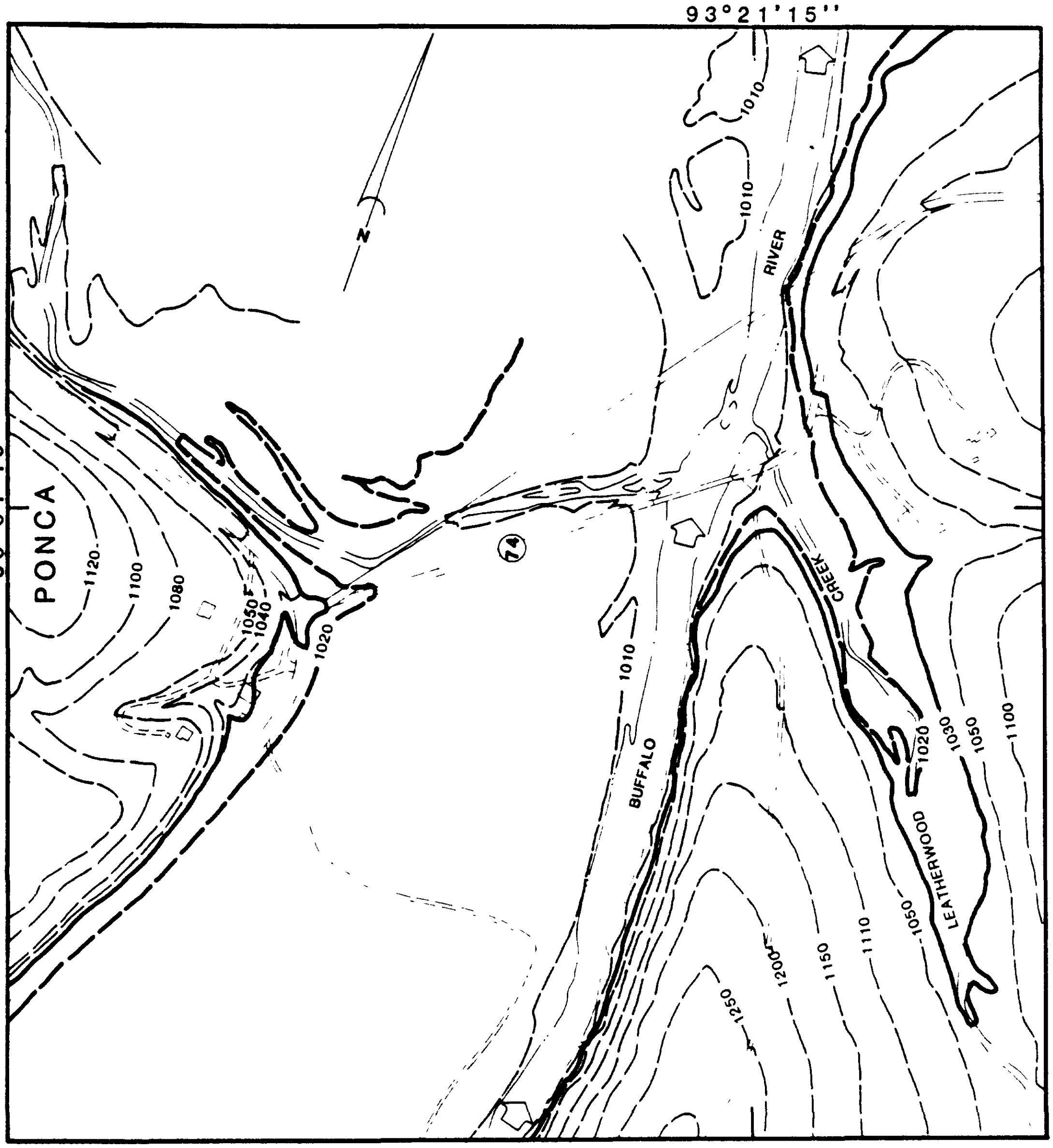


EXPLANATION

APPROXIMATE BOUNDARY OF 500-YEAR FLOOD

APPROXIMATE BOUNDARY OF 100-YEAR FLOOD

on Buffalo River at Steel Creek, Ark.



Base from National Park Service
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0 0.1 0.2 MILES

0 0.1 0.2 0.3 KILOMETERS

Contour interval variable
Datum is sea level

EXPLANATION

——— APPROXIMATE BOUNDARY OF 500-YEAR FLOOD

— — — APPROXIMATE BOUNDARY OF 100-YEAR FLOOD

Figure 7.--Flood boundaries of the 100-year and 500-year floods on Buffalo River at Ponca, Ark.

HYDROGRAPHS FOR THE 100-YEAR AND 500-YEAR FLOODS

Hydrographs for the five highest floods on the Buffalo River at St. Joe were originally selected to estimate a typical hydrograph. One was not used because of a double crest, and one was not used because of missing record. The three hydrographs that were used are shown in figure 8. The time scale was shifted so that the peaks would line up.

Adjustments were then made to each discharge coordinate so that the peak discharge for each hydrograph would equal 176,000 ft^3/s which is equal to the 100-year discharge for St. Joe. The adjustments were made by first subtracting a base flow, multiplying by a constant, and then adding the base flow back. The constant was different for each hydrograph. These adjusted hydrographs are shown in figure 9. The arithmetic average of these three hydrographs was used as the typical hydrograph for the 100-year flood at St. Joe (fig. 9). A typical hydrograph for the 500-year flood was computed in the same manner.

Three of the highest floods at the gaging station at Rush were selected to compute typical hydrographs. Typical hydrographs for the 100-year and the 500-year floods at Rush were computed using the same procedure as described for St. Joe.

Typical hydrographs for the 100-year flood at all other park sites were computed by making adjustments to the typical hydrograph for St. Joe. Adjustments were made to the discharge ordinate by multiplying each discharge by a constant. Adjustments were made to the time scale by multiplying each time by a constant. The constants for adjusting discharge and time are not the same. The assumption was made that unit runoff is the same throughout the basin. Therefore, if the drainage area at some site is one-fourth the drainage area at St. Joe, then the volume of water under the hydrograph would equal one-fourth the volume at St. Joe. The constant for adjusting discharge was made by first determining the peak discharge for the 100-year flood at each site using the equation discussed in a previous section, "100-Year and 500-Year Floods". The ratio of this discharge to the discharge at St. Joe is the constant needed for adjusting discharges. By assuming the unit runoff principle, the constant for adjusting discharge times the constant for adjusting time should equal the drainage area divided by the drainage area at St. Joe. The adjustment for time was made by using this principle.

Typical hydrographs for the 500-year flood at all park sites were computed by making adjustments to the 500-year hydrograph for St. Joe following the procedures described in the previous paragraph.

The typical 100-year and 500-year hydrographs computed for Rush were almost identical to those computed by using the data for the three highest floods.

Stage hydrographs are needed at each park site for planning and managing the sites. All of the hydrographs that have been discussed thus far are discharge hydrographs. A stage-discharge relation (rating curve) was developed for each site using the cross-sectional properties computed in the step-backwater analysis. The rating curves were used with the discharge hydrographs to compute stage hydrographs. The stage hydrographs for the 100-year and 500-year floods at each park site are shown on figures 10-25. The hydrographs presented for the mouth of Buffalo River (fig. 26) were prepared to reflect simultaneous flooding of both Buffalo River and the White River. The hydrograph of the December 1982 flood on the White River at Calico Rock was assumed to have a typical shape of the hydrographs on the White River at the mouth of Buffalo River. This hydrograph was adjusted to agree with the peak stages of the 100- and 500-year stages on the White River at the mouth of the Buffalo River and assumed to be typical.

FLOW DURATION

Flow-duration data were developed for the gaging stations at St. Joe and Rush. The data for St. Joe are based on 44 years of record (1940-83). The data for the discontinued gage at Rush are based on 46 years of record (1929-74). These data are shown in table 2.

FLASH-FLOOD POTENTIAL

The steep slopes and relatively narrow widths of the Buffalo River make it susceptible to flash flooding. The typical hydrographs at Steel Creek (fig. 12) show that the peak occurs about 12 hours after the stage begins to rise. The drainage area at Steel Creek is 123 mi^2. At St. Joe where the drainage area is 829 mi^2, the peak occurs about 36 hours after the initial rise (fig. 20). Data are not available to relate the time of rainfall to time of peak.

DEBRIS LOADS

During floods, large amounts of debris are carried by the river. This usually does not present a threat to destroying bridges because most of the bridges are either low-water bridges or highwater bridges that span the channel with very little contraction. However, debris buildup on houses, barns, and other buildings on the flood plain does increase the probability of structure failure.

Table 2.--Flow-duration data on Buffalo River near St. Joe and Rush

Station name	Records used (water year)	Flow, in cubic feet per second, which was equaled or exceeded for percentage of time indicated in column subheads																	
		99.9	99.5	99	98	95	90	80	70	60	50	40	30	20	10	5	2	1	0.5
Buffalo River near St. Joe	1940-83	9.6	13	16	21	32	47	76	116	193	309	489	774	1,240	2,290	3,610	7,200	11,800	19,200
Buffalo River near Rush	1929-74	15	21	27	36	52	72	109	163	249	387	611	956	1,540	2,810	4,660	9,300	15,300	23,000

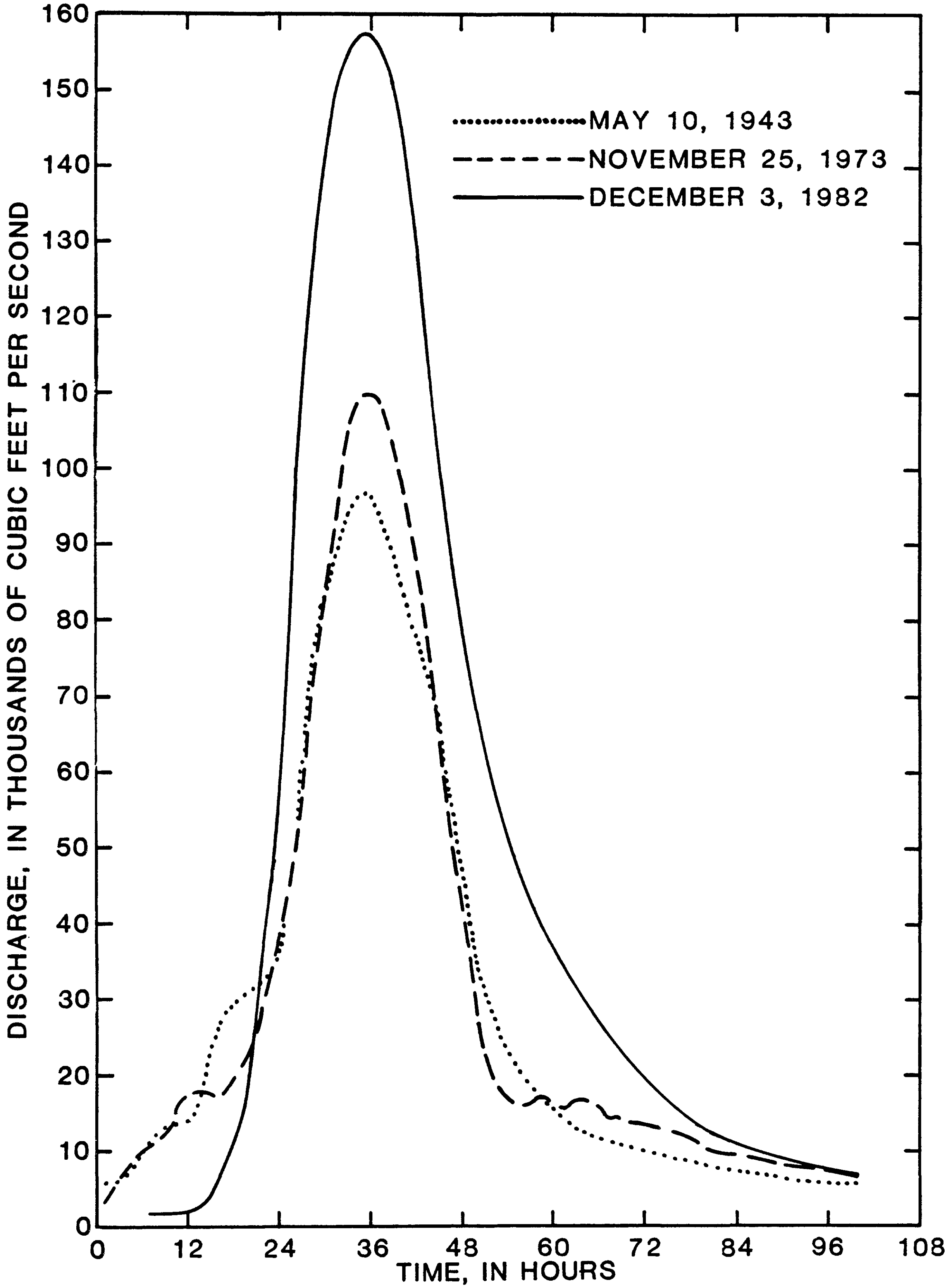

Figure 8.--Hydrographs of discharge of the Buffalo River near St. Joe for the floods of May 10, 1943, November 25, 1973 and December 3, 1982.

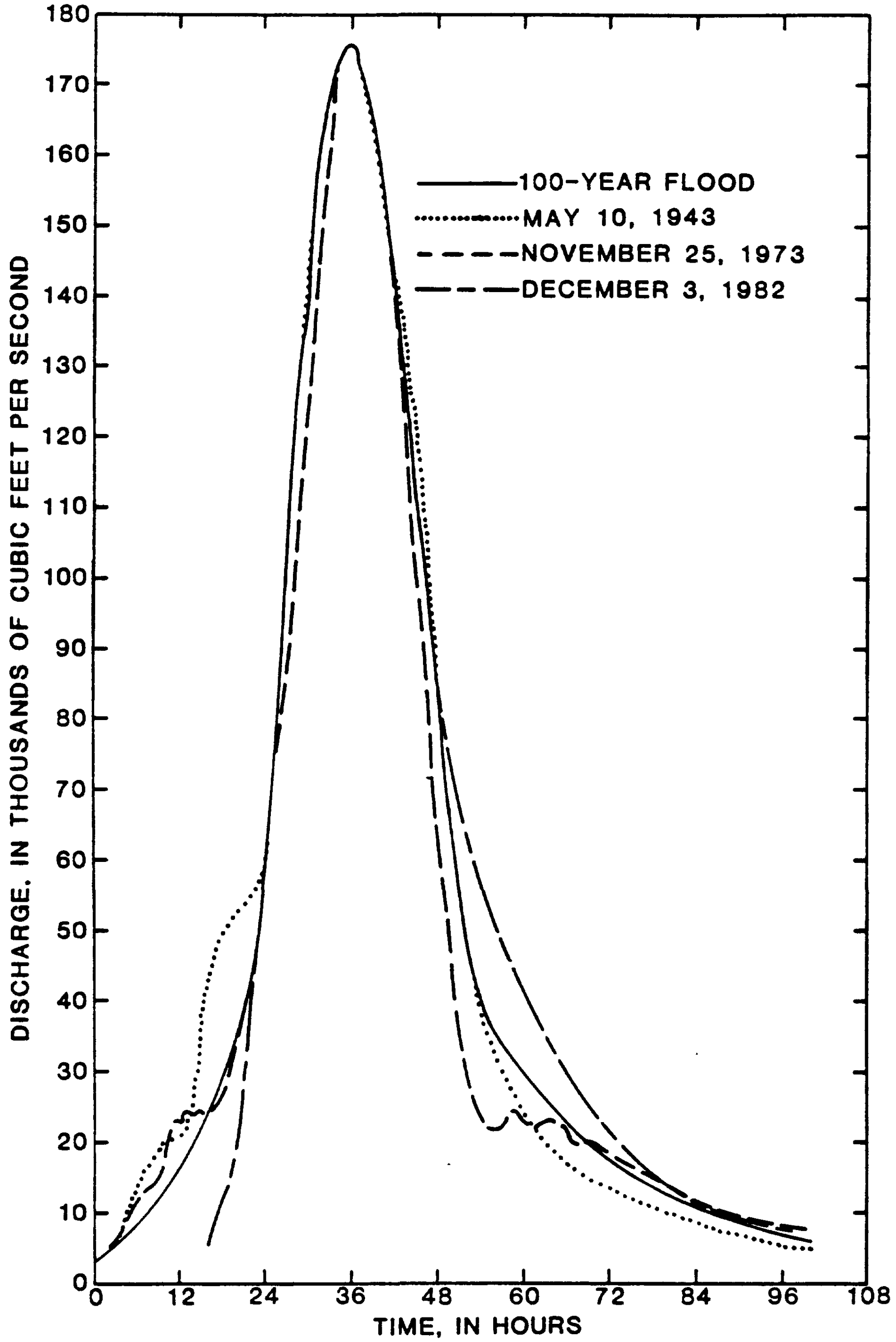

Figure 9.--Typical hydrograph of the 100-year flood discharge on Buffalo River near St. Joe and adjusted hydrographs for the floods of May 10, 1943, November 25, 1973 and December 3, 1982.

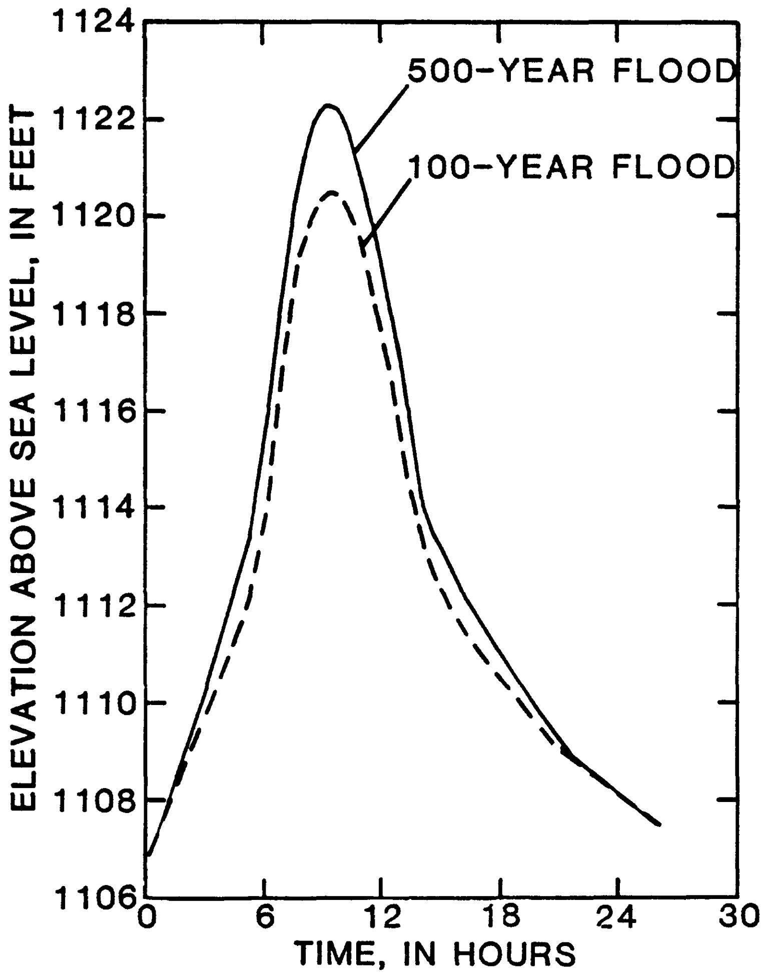

Figure 10.--Typical stage hydrographs of 100-year and 500-year floods on Buffalo River near Boxley, Ark.

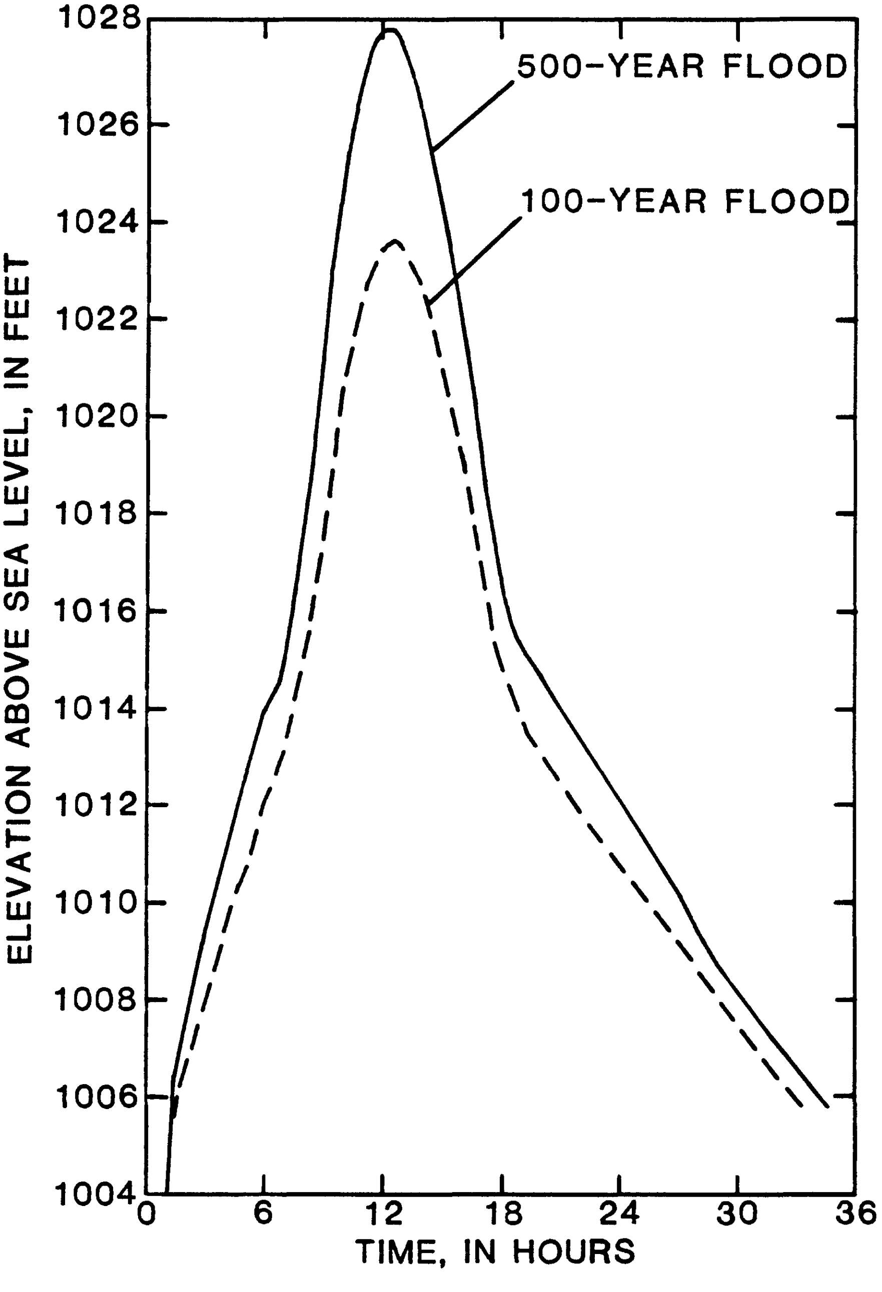

Figure 11.--Typical stage hydrographs of 100-year and 500-year flood floods stage on Buffalo River at Ponca, Ark.

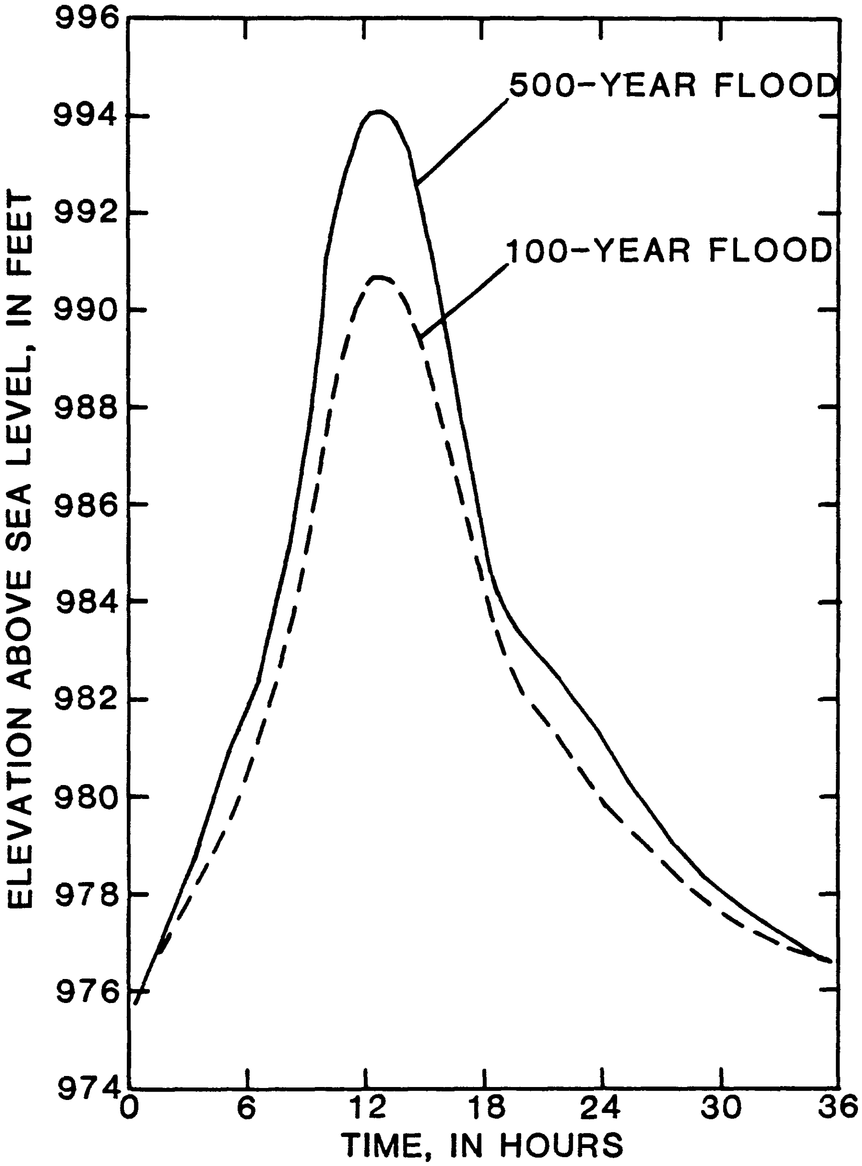

Figure 12.--Typical stage hydrographs of 100-year and 500-year floods on Buffalo River at Steel Creek, Ark.

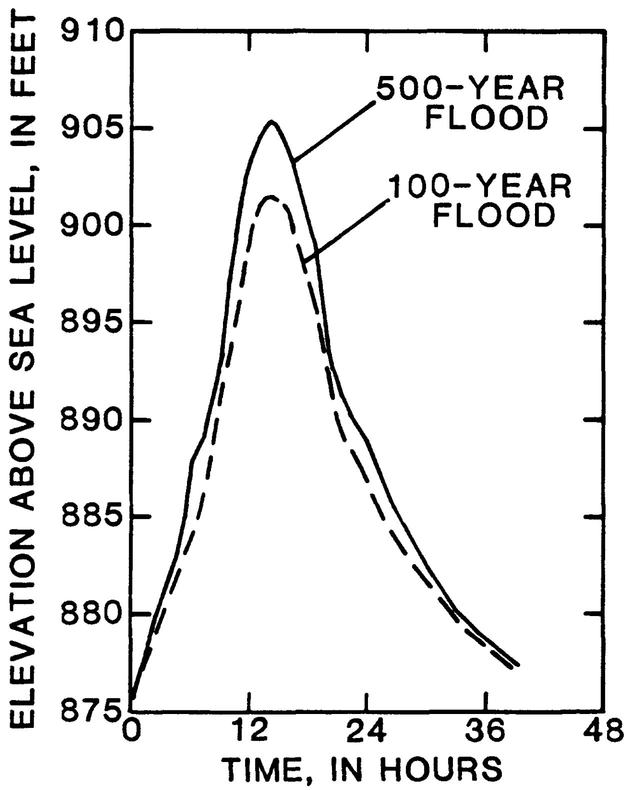

Figure 13.--Typical stage hydrographs of 100-year and 500-year floods on Buffalo River at Kyles Landing, Ark.

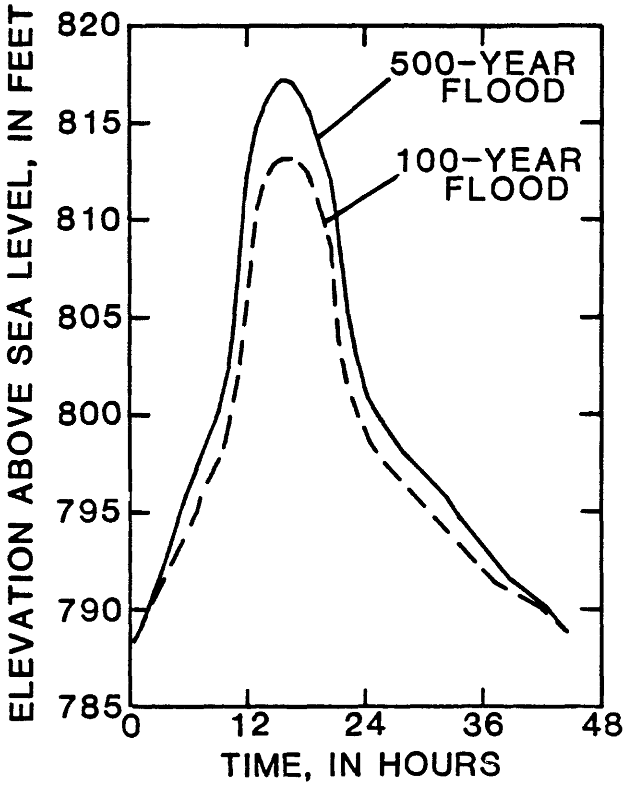

Figure 14.--Typical stage hydrographs of 100-year and 500-year floods on Buffalo River at Ozark, Ark.

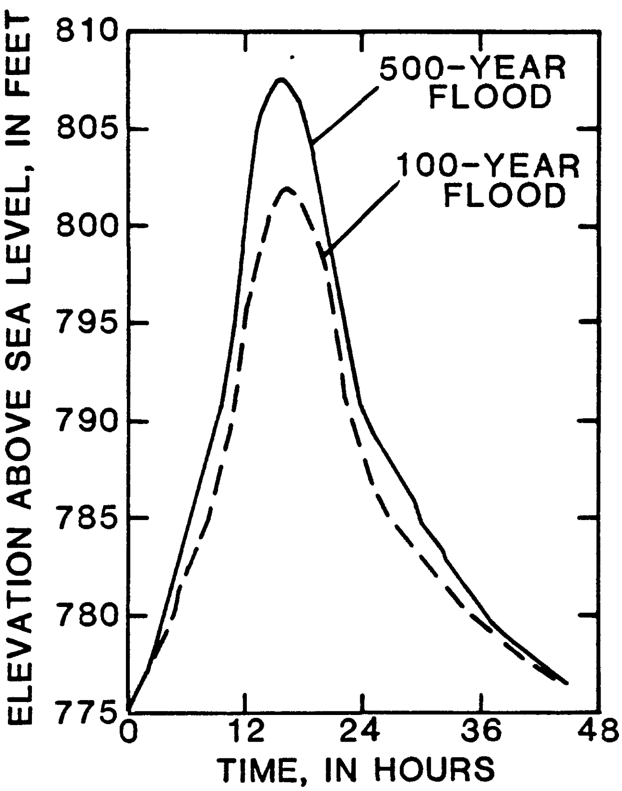

Figure 15.--Typical stage hydrographs of 100-year and 500-year floods on Buffalo River at Pruitt, Ark.

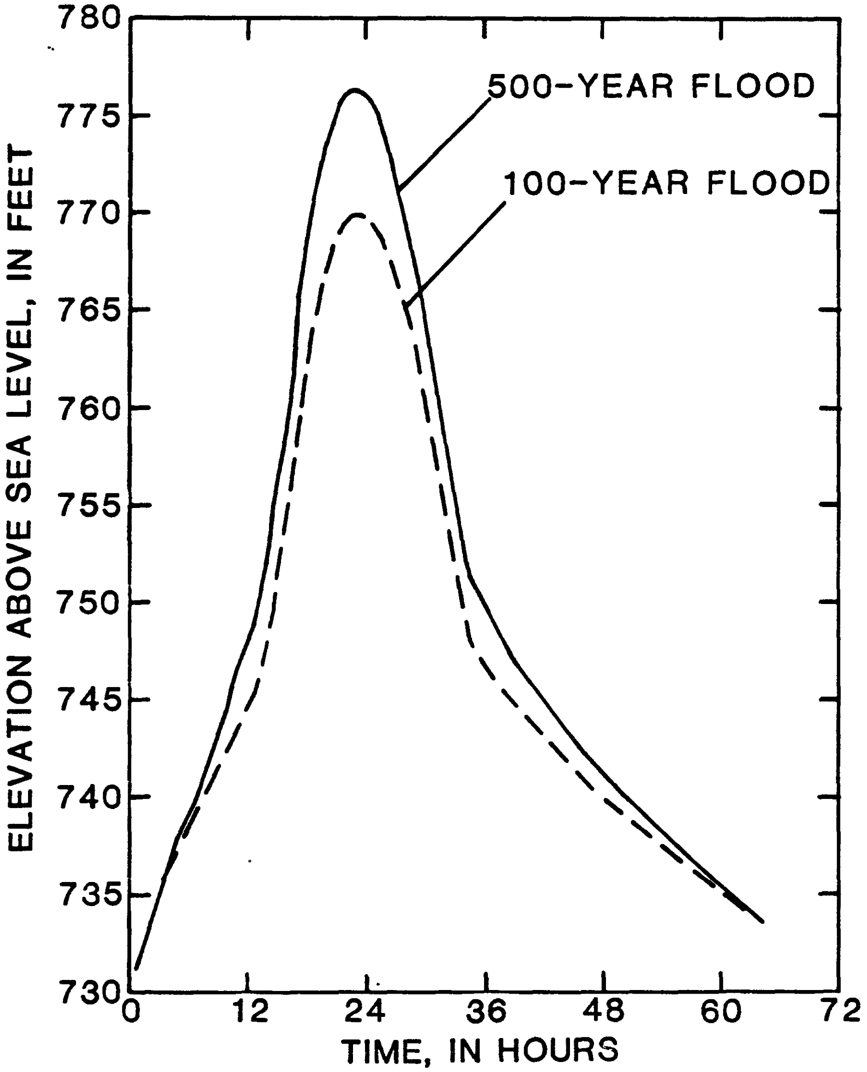

Figure 16.--Typical stage hydrographs of 100-year and 500-year floods on Buffalo River near Hasty, Ark.

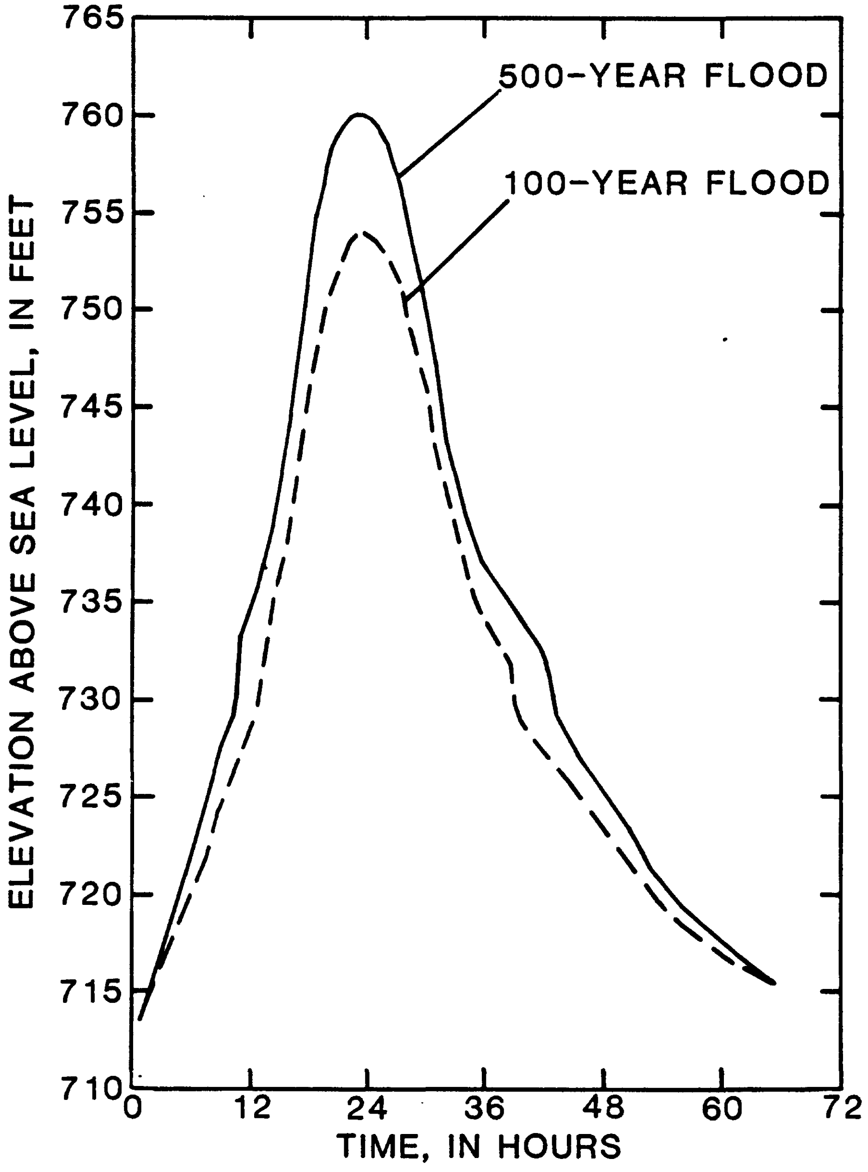

Figure 17.--Typical stage hydrographs of 100-year and 500-year floods on Buffalo River near Carver, Ark.

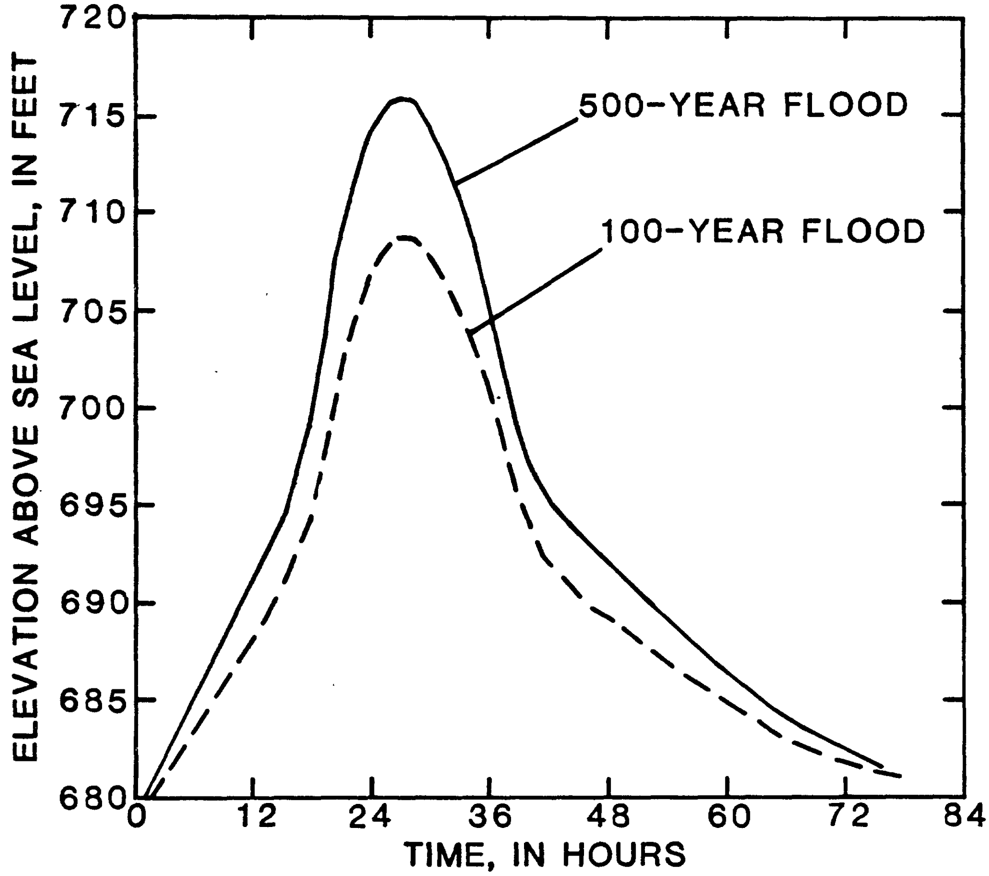

Figure 18.--Typical stage hydrographs of 100-year and 500-year floods on Buffalo River near Mt. Hersey, Ark.

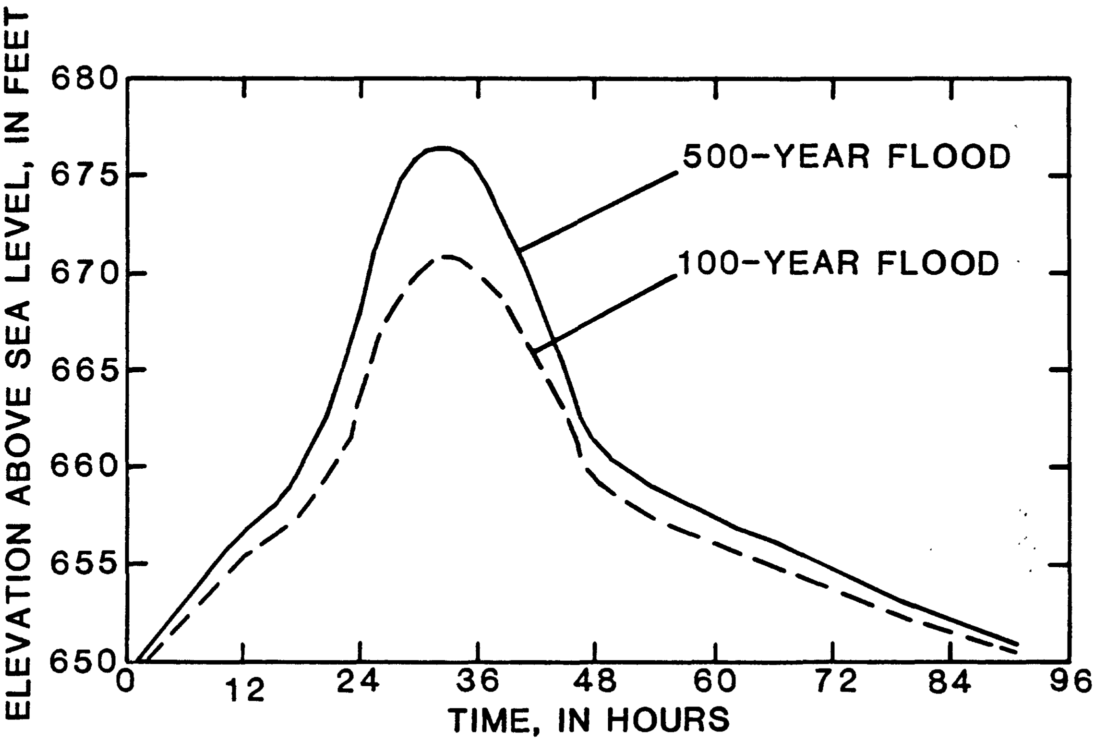

Figure 19.--Typical stage hydrographs of 100-year and 500-year floods on Buffalo River at Woolum, Ark.

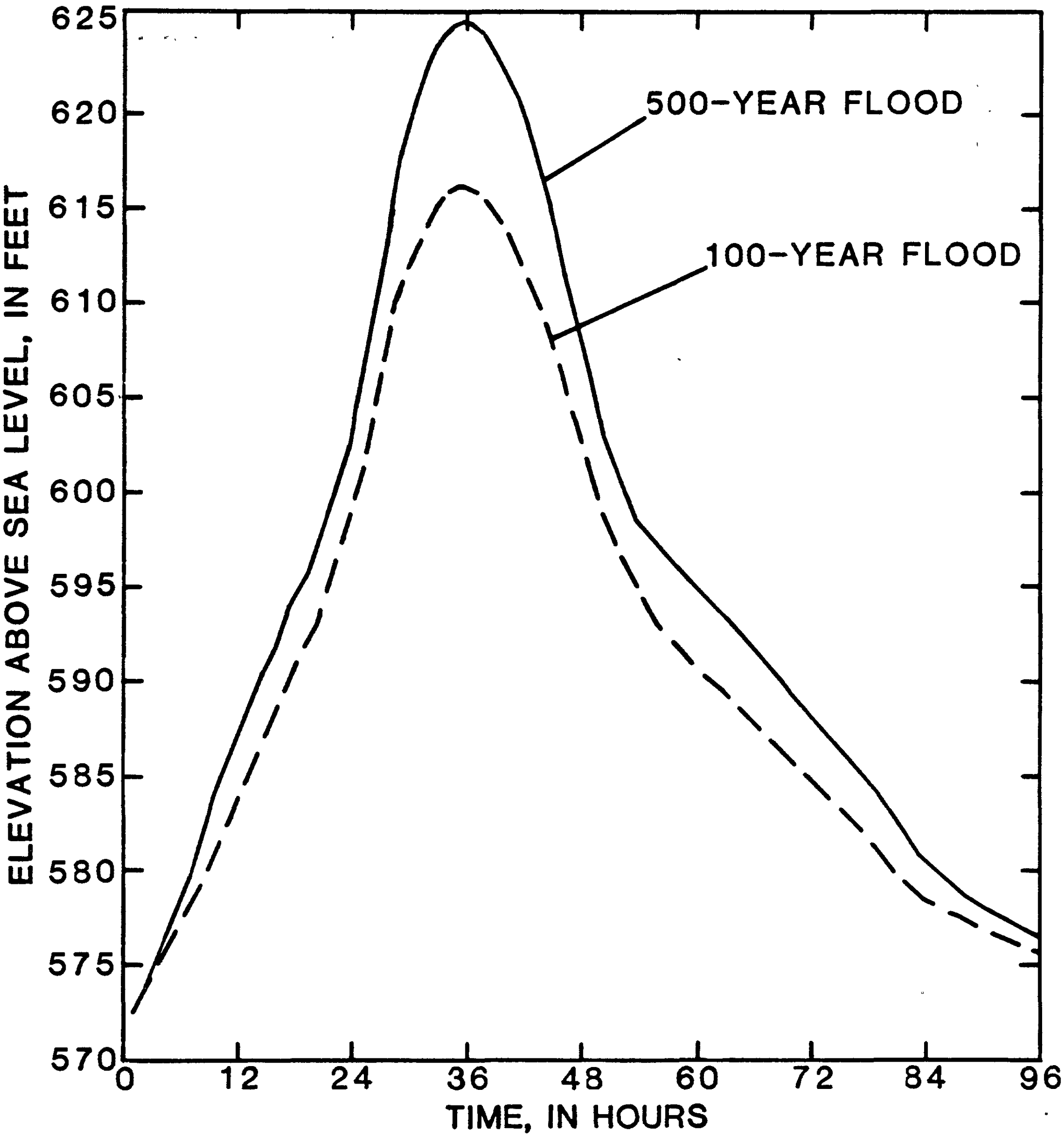

Figure 20.--Typical stage hydrographs of 100-year and 500-year floods on Buffalo River near St. Joe, Ark.

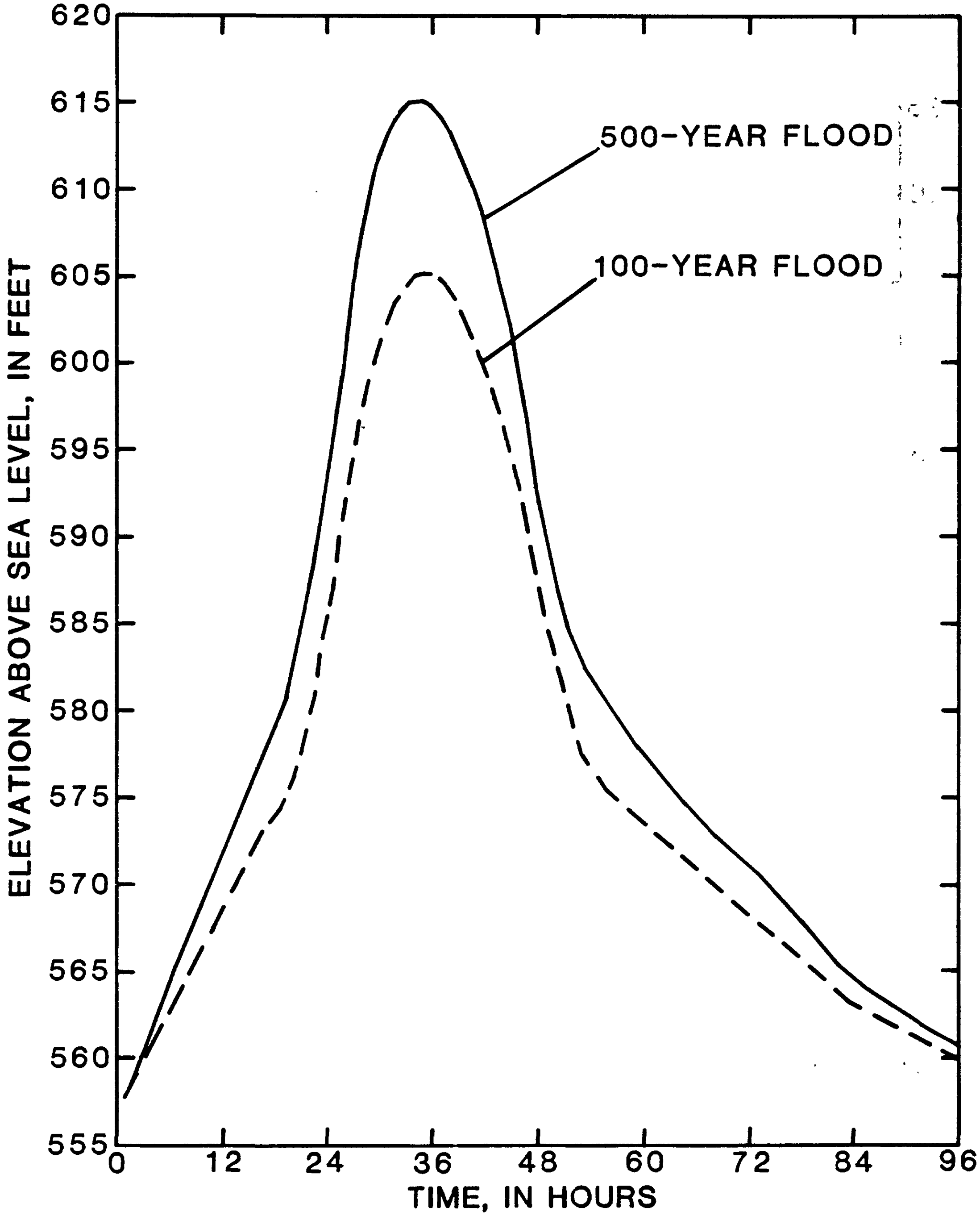

Figure 21.--Typical stage hydrographs of 100-year and 500-year floods on Buffalo River near Gilbert, Ark.

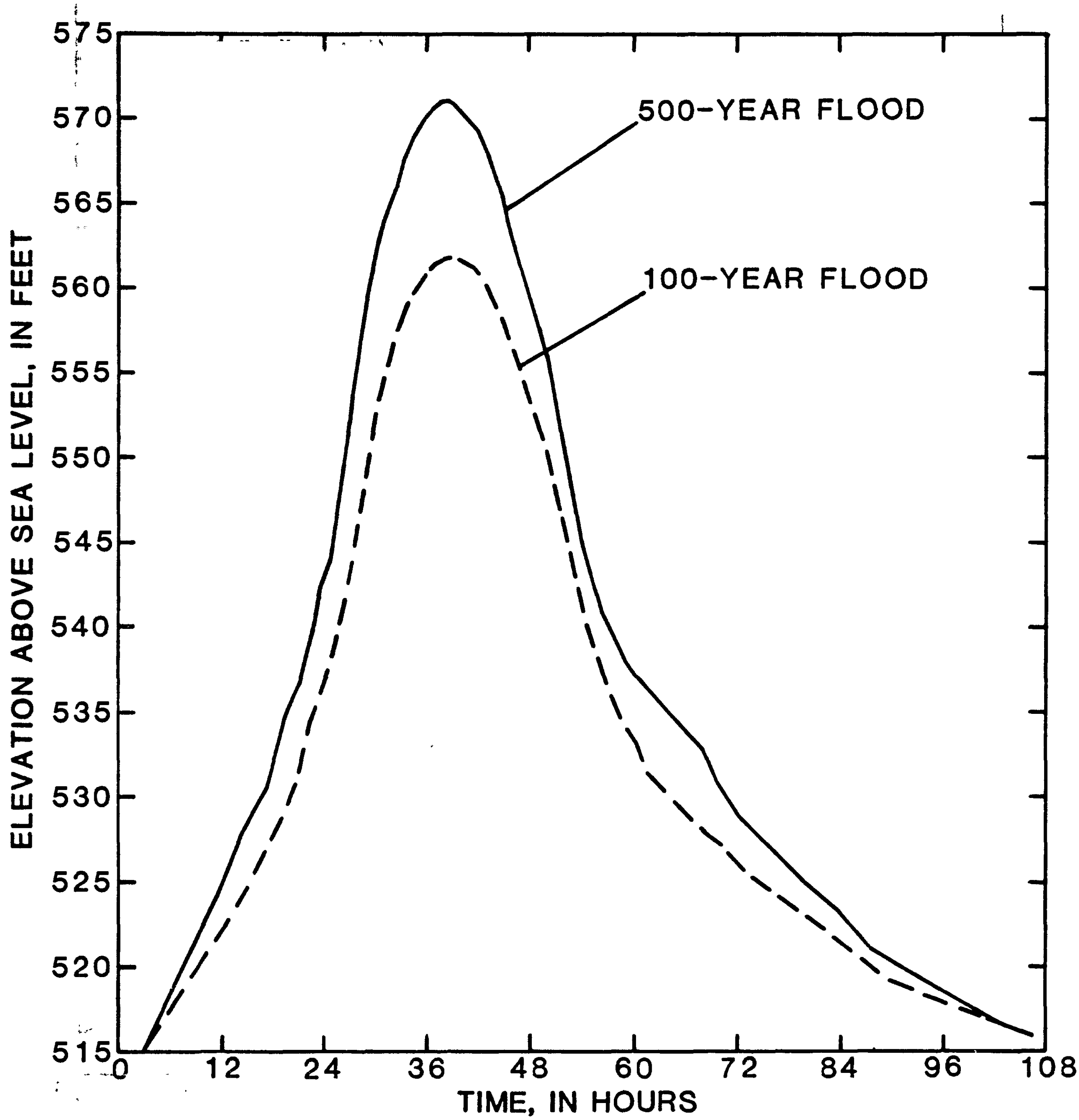

Figure 22.--Typical stage hydrographs of 100-year and 500-year floods on Buffalo River near Maumee, Ark.

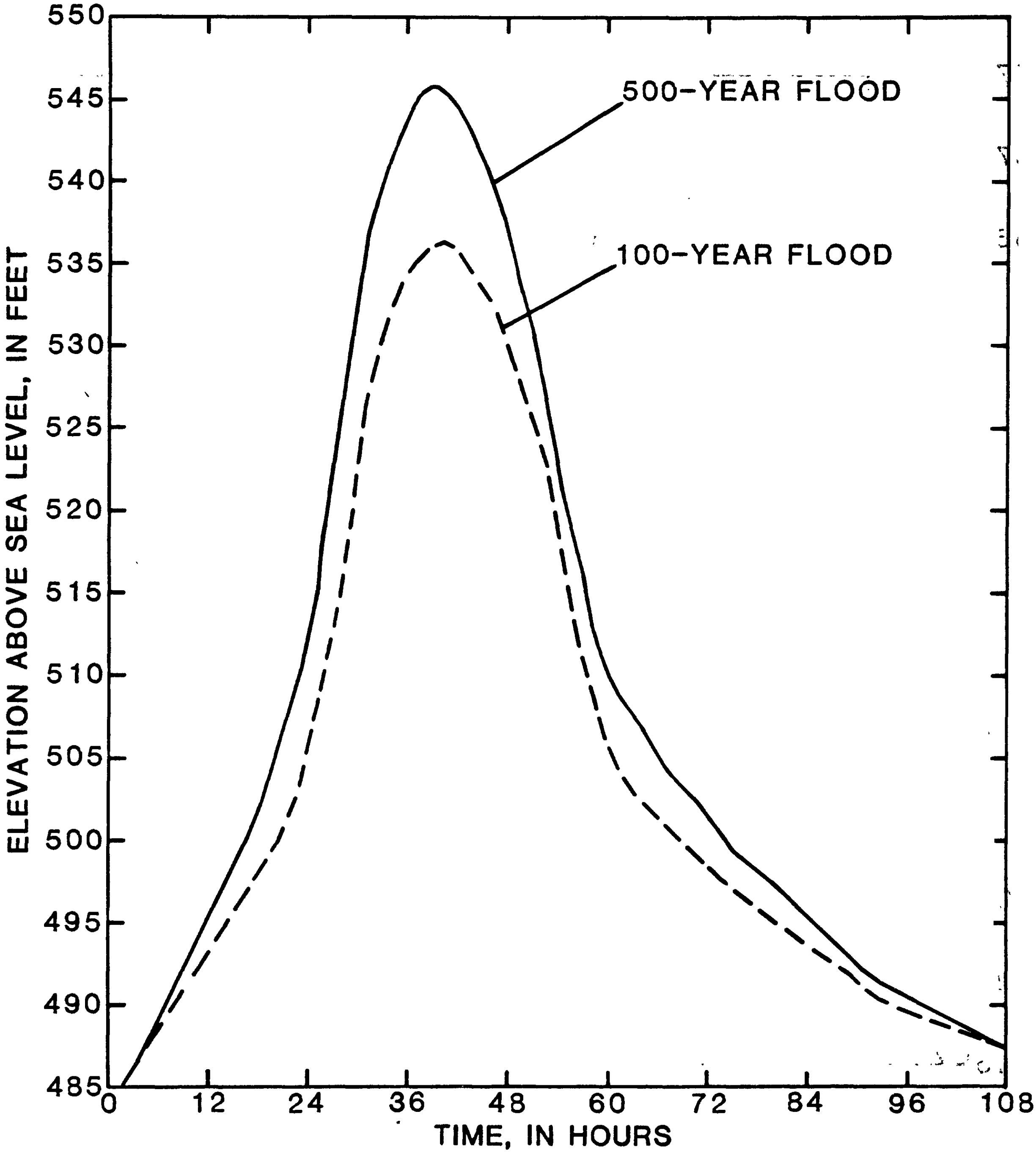

Figure 23.--Typical stage hydrographs of 100-year and 500-year floods on Buffalo River at State Highway 14.

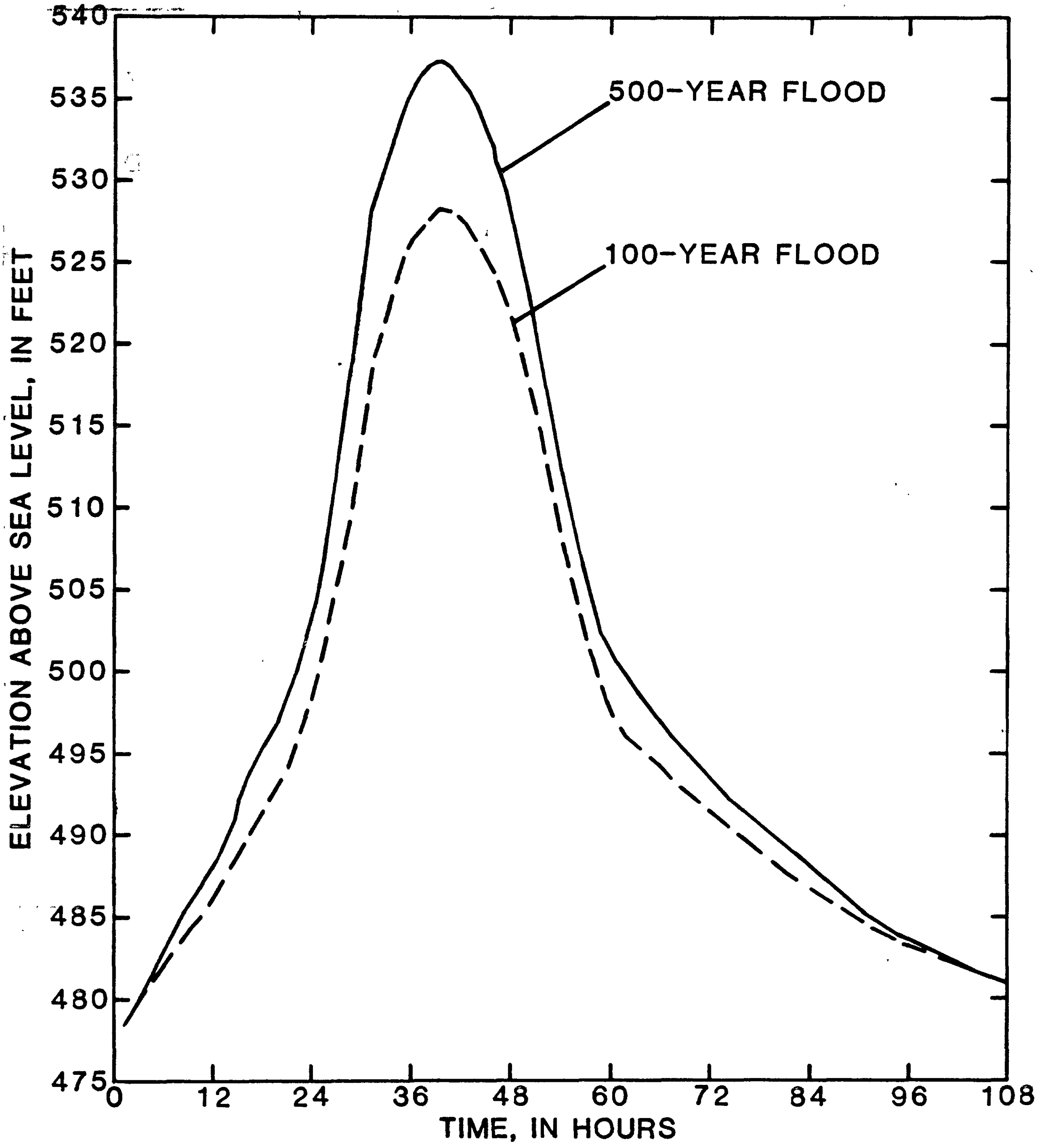

Figure 24.--Typical stage hydrographs of 100-year and 500-year floods on Buffalo River at Buffalo Point, Ark.

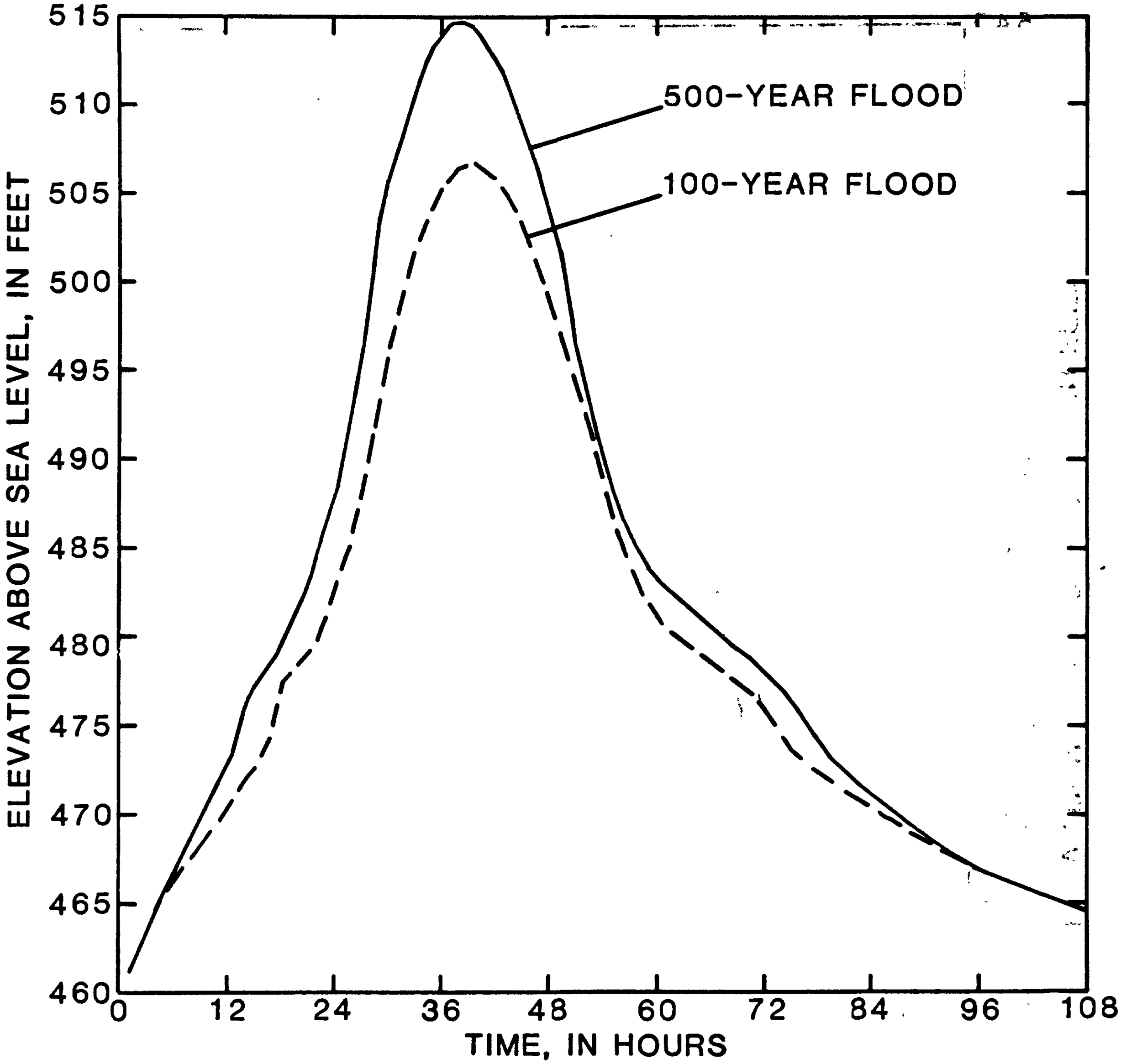

Figure 25.--Typical stage hydrographs of 100-year and 500-year floods on Buffalo River near Rush, Ark.

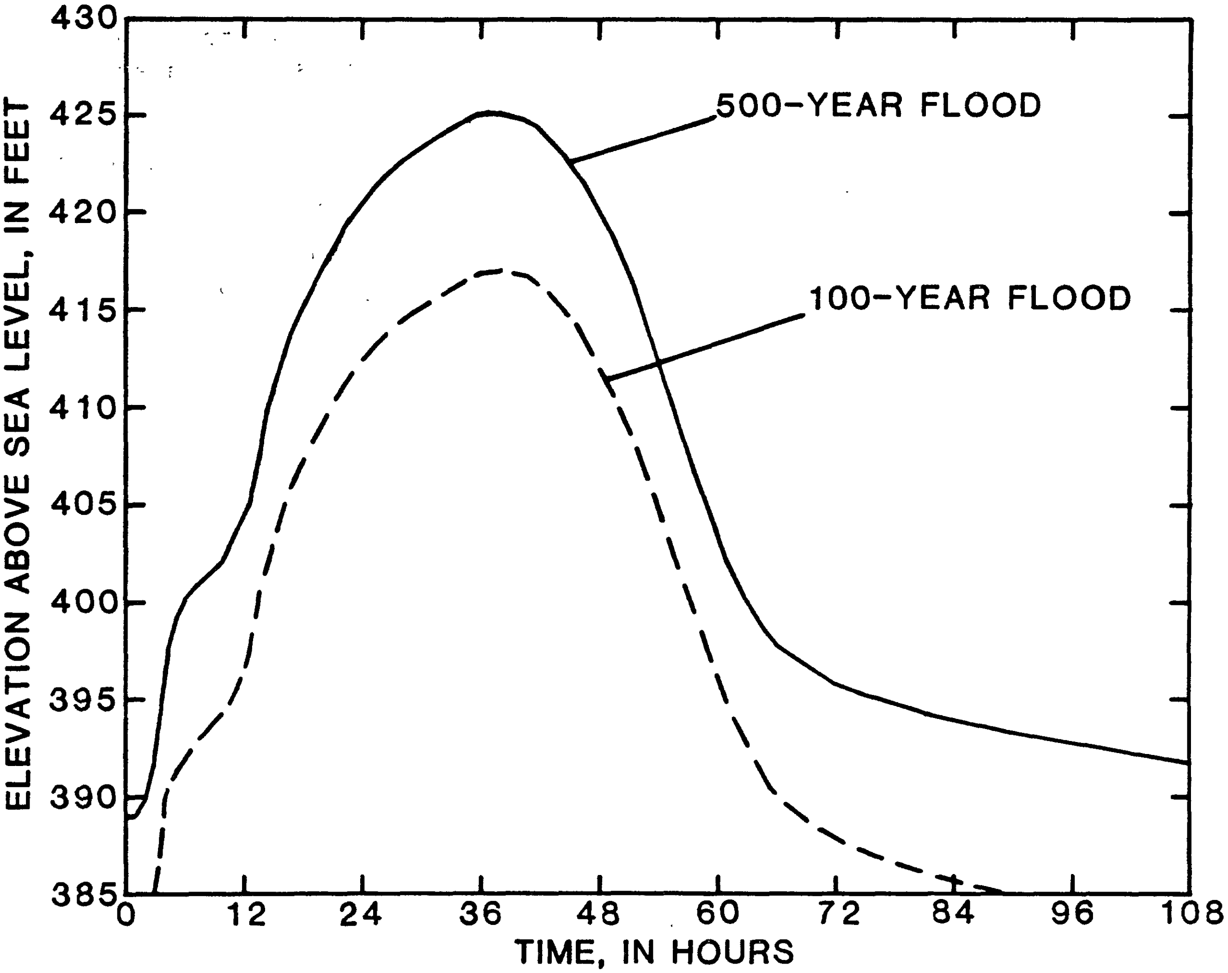

Figure 26.--Typical stage hydrographs of 100-year and 500-year floods on Buffalo River at mouth.

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