HYDROLOGIC ATLAS HA 735–A
Alexander, T.W., 1995, Delineation of flooding within the upper Mississippi River Basin—flood of July 30, 1993, in Jefferson City and vicinity, Missouri

INTRODUCTION

During spring and summer 1993, numerous intense rain storms combined with saturated soils to cause record flooding on many streams and rivers in the Central United States. Within the nine-State flooded area (fig. 1), the record flood elevations, discharges, and durations resulted in the evacuation of people and livestock, inundation of businesses, disruption of public utilities, damaging of numerous roadways and bridges, and the breaching of many levee systems. In Missouri alone, more than 19,000 people were evacuated, and more than 500 mi of Missouri River and Mississippi River flood plains were inundated as a result of the 1993 flood.

In July 1993, record-setting flood-peak discharges were recorded over parts of a seven-State area in the Missouri River Basin (fig. 1). Of the 65 U.S. Geological Survey streamflow-gaging stations within the Missouri River Basin, 16 stations had flood-peak discharges exceeding the discharge associated with the 100-year recurrence interval. Previous maximum known discharge or maximum known regulated discharge was exceeded at 28 of the 65 stations (Parrett and others, 1993, p. 12–14).

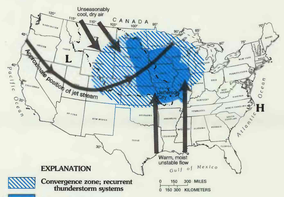

Figure 1. Dominant weather patterns for June through July 1993, Missouri River Basin and surrounding region, and general area of flooding streams, June through August 1993. (Modified from Wahl and others, 1993.)

PURPOSE AND SCOPE

This report provides Missouri River flood-peak elevation data and delineates the areal extent of flooding in Jefferson City and vicinity, Missouri, for July 30, 1993. The July 1993 flood is compared with the Federal Emergency Management Agency's (FEMA) 100- and 500-year flood profiles. This report is one of a series of U.S. Geological Survey reports to document the flooding within the upper Mississippi River Basin in 1993 and to improve the technical base on which flood-plain management decisions can be made by other agencies.

CLIMATE CONDITIONS

In early June 1993, a weather pattern characterized by a strong low-pressure system developed over the Western United States, and a corresponding large high-pressure system developed over the Southeastern United States (fig. 1). The jet stream dipped south over the Western United States and flowed northeasterly across the upper Midwest. The high-pressure system to the southeast blocked the eastward movement of storms, thus creating a convergence zone between the warm, moist flow from the Gulf of Mexico and the much cooler and drier air from Canada that resulted in thunderstorms. This pattern persisted through most of June and July (National Weather Service, 1993). As a result, the upper Midwest within this convergence zone was deluged with rain, while the Southeastern and the Eastern United States from Alabama to Vermont, which were under the effect of the high-pressure system, were extremely hot and dry. Slight movements in the atmospheric pattern determined the timing and location of the excessive rainfall throughout the upper Midwest (Wahl and others, 1993, p. 2–3).

Many of the National Weather Service precipitation stations in the upper Midwest had the wettest or nearly wettest January to July on record (Kunkel and others, 1994). Total precipitation amounts recorded for the first 7 months of 1993 generally exceeded 20 in. throughout the lower Missouri River Basin with 40 in. totals recorded in some locations (fig. 2). The larger totals generally were reported in Iowa, Kansas, and Missouri. Areal distribution of total precipitation in the lower Missouri River Basin as a percentage of the normal (1961–90) precipitation for January through July is shown in figure 3.

By June 1, the much larger-than-average spring precipitation caused discharges of streams and rivers in the lower Missouri River Basin to be well above average seasonal discharges. The excessive rainfall during June and July continued to increase the discharges of already swollen streams and rivers throughout the Missouri River Basin. For example, flooding on the lower Missouri River climaxed during the last week of July with the discharge of the Missouri River near Jefferson City peaking on July 30.

MISSOURI RIVER FLOOD-PEAK ELEVATIONS AND DISCHARGES, 1993

The 37 flood-peak elevations on the Missouri River near Jefferson City were determined from a U.S. Geological Survey (USGS) stage-gaging station at Jefferson City and by surveying high-water flood marks after the water had receded (fig. 4). All USGS flood-elevation data were compiled with other flood-mark data collected by the U.S. Army Corps of Engineers (Kansas City District) and the Missouri Department of Natural Resources (Division of Geology and Land Survey).

The elevations and duration of the 1993 flood at Jefferson City are shown by the hydrograph in figure 5. It shows the June through August elevations for the Missouri River at the USGS stage-gaging station (06910450) on the downstream side of the bridge on west-bound U.S. Highway 54. At this station, the Missouri River flood-peak elevation of 559.30 ft above sea level on July 30, 1993, was greater than the previous maximum elevation of July 1951 by more than 4 ft. Although only stage (elevation) data are collected at the gaging station on the Missouri River at Jefferson City, flood-peak elevations and discharges are available for the other USGS streamflow-gaging stations along the lower Missouri River from St. Joseph to Hermann, Missouri (table 1).

The 1993 Missouri River flood-peak elevations and discharge in the Jefferson City vicinity could have been even higher had the Federal reservoir system not been in place and operational. For example, Missouri River flood-peak discharges were estimated to have been reduced by more than 100,000 ft³/s between Kansas City and St. Louis, Missouri, as a result of storage of flood flows in reservoirs upstream (Perry, 1994, p. 11).

FLOOD PROFILES

The flood-peak elevations determined from the USGS stage-gaging station at Jefferson City (06910450) and from surveyed flood marks along the Missouri River flood plain can be used to interpret the 1993 flood profile and to assist in delineating the inundated area of the July 30 peak discharge in the Jefferson City vicinity. These flood marks are subject to errors in maximum-height interpretation, localized increases or decreases in water-surface levels due to water-velocity differences, and accuracy of reference mark elevations used in the surveying process. Therefore, the best fit flood-peak profiles (fig. 6) and surface-water contour lines (fig. 4) have been hand drawn from these elevation data. Flood-peak elevation locations are plotted and referenced by distance in river miles upstream from the mouth of the Missouri River.

The Missouri River flood plain through the reach, upstream and downstream of Jefferson City, is fairly uniform at about 1.5 mi wide. In places, levees around agricultural fields have resulted in minor flood-profile differences of less than 0.5 ft on opposite sides (upstream/downstream) of these levees. However, the ponding of floodwater along the upstream side of the U.S. Highway 54 embankment in the Cedar City/North Jefferson City area caused lateral differences in flood-peak elevations of more than 2 ft between opposite banks (north/south) of the Missouri River main channel (fig. 4). As a result, the north- and south-bank flood profiles were developed separately (fig. 6).

INUNDATED AREA

The extent of Missouri River flooding on July 30, 1993, near Jefferson City was determined by using flood-peak elevations interpreted from the north- and south-bank profiles shown in figure 6. These elevation data were used to hand draw the outline of the 1993 flood inundation boundary on 1:24,000-scale (contour interval = 20 ft) topographic maps of the Jefferson City vicinity. By using geographic information system technology, the hand-drawn outlined inundation boundary was manually digitized from the 1:24,000-scale maps and stored by using the software package ARC/INFO[1]. Topographic maps having contour intervals greater than 5 ft usually are not used alone to establish flood boundaries. Therefore, a second outline of the 1993 flood inundation boundary was scanned from a set of 1:24,000-scale aerial photographs taken on July 30. This scanned inundation boundary was manually digitized into a second ARC/INFO coverage.

A limited amount of onsite checking was done in areas where the two outlines did not agree as to the limits of flood inundation. For example, some small areas of land within the inundation boundary may be at or slightly above the July 30 peak elevation; however, some of these small areas may not be delineated. Other discrepancies in the outlines were the result of inaccuracies in manually delineating the flood boundary (horizontal/vertical) on topographic maps with a 20 ft contour interval, and inconsistencies in visually defining from the aerial photographs the flood-water/ground-surface contact within local areas of dense vegetation. The flood boundary shown in figure 4 is considered the best possible interpretation based on both inundation outlines.

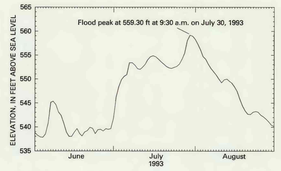

Figure 5. Elevation hydrograph for the Missouri River at Jefferson City, Missouri (06910450), June through August 1993.

FEDERAL EMERGENCY MANAGEMENT AGENCY 100- AND 500-YEAR FLOOD PROFILES

The National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973 were established to encourage State and local governments to adopt sound flood plain management practices. The FEMA has adopted the 100-year flood as the base flood for purposes of defining the flood boundaries of flood-insurance-rate maps. The 500-year flood can be used to identify additional areas of flood risk in a community (U.S. Department of Housing and Urban Development, 1979, p. 12). To assist in the evaluation of the Missouri River flooding on July 30, 1993, in the Jefferson City vicinity, the FEMA 100- and 500-year flood profiles (U.S. Department of Housing and Urban Development, 1979, panel 2) are provided in figure 6.

FLOOD DAMAGES

Damages from the 1993 flooding were so large and widespread throughout the flooded areas of the Missouri and Mississippi River flood plains that only estimates of the total economic effects may ever be available. Property damages were estimated to be greater than $10 billion (Parrett and others, 1993). Because the flood occurred during the prime crop-growing season, agricultural losses were considerable along the fertile Missouri and Mississippi River flood plains.

More than one-half of the 114 Missouri counties were declared Federal disaster areas. Damages in the flood-stricken areas of Missouri have been estimated to be $3 billion, with about one-half of that in agricultural losses (Associated Press, 1993). About 20 of the 48 reported flood-related deaths within the nine-State flooded area (fig. 1) were in Missouri.

In the Jefferson City vicinity, a substantial part of the flood damage was to homes and businesses within the Cedar City corporate limits (fig. 4). The east- and west-bound lanes of U.S. Highway 54 were inundated (fig. 7) and badly damaged just north of Jefferson City, and only small sections of U.S. Highways 54 and 63 and State Highway 94 roadways and ramps in the Cedar City area remained above the flood waters (fig. 8). Highways 63 and 94 were under water and closed for several days, as was the Jefferson City Memorial Airport, where air traffic was suspended. Some Jefferson City streets, including streets in subdivision areas within the corporate limits, were flooded by Missouri River backwater (fig. 4).

ADDITIONAL DATA

Additional flood-peak elevations for the flood of 1993 may be obtained by writing to Robert E. Myers, State Land Surveyor, Missouri Department of Natural Resources, Division of Geology and Land Survey, Rolla, Missouri; the Glasgow Project Office, U.S. Army Corps of Engineers, Kansas City District, Glasgow, Missouri; and the Missouri Highway and Transportation Department, Division of Bridges, Jefferson City, Missouri.

[1] Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

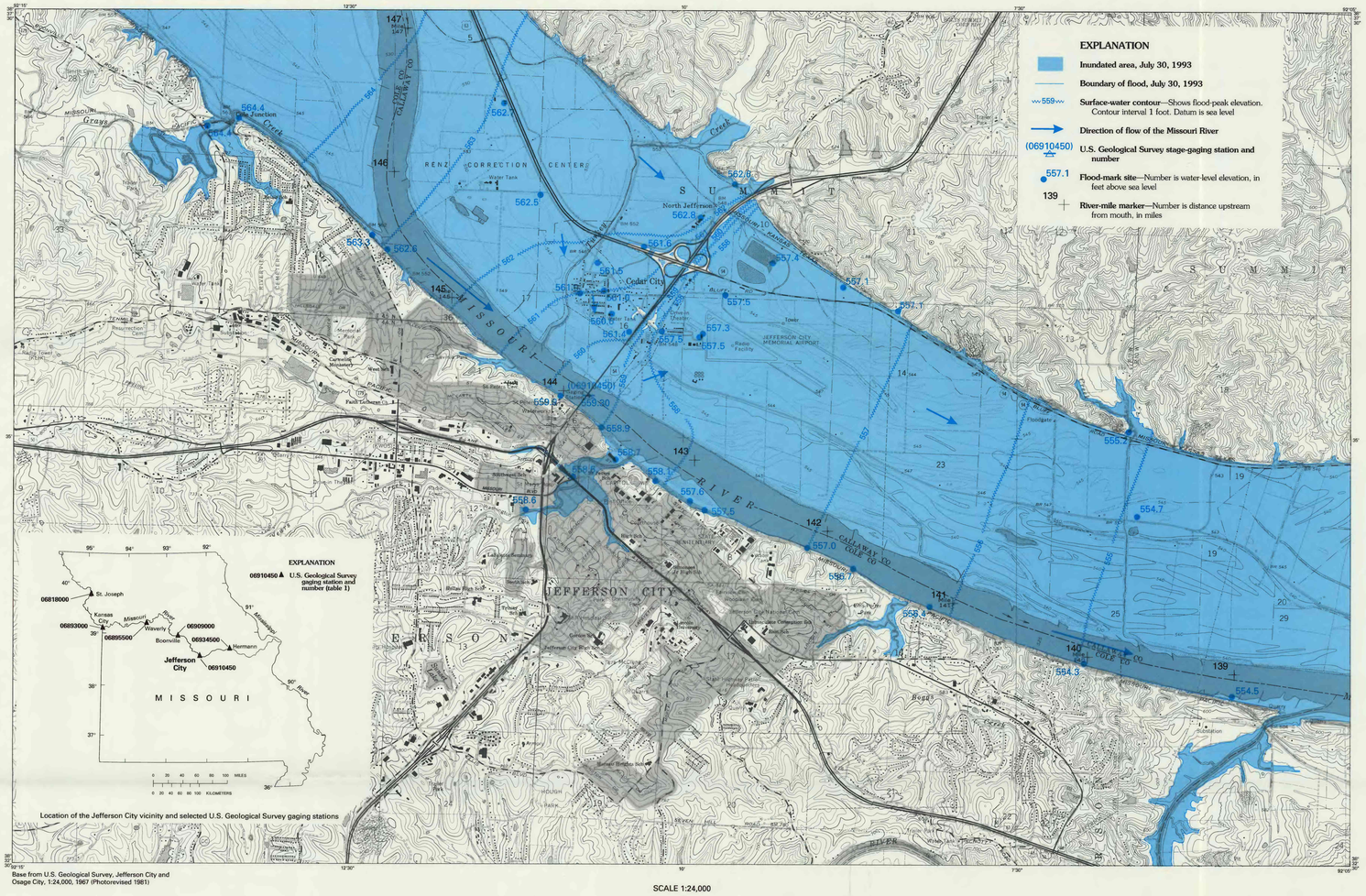

Figure 4. Missouri River flood-peak elevations and extent of flooding on July 30, 1993, in Jefferson City and vicinity, Missouri.

Table 1. Summary of 1993 flood-peak elevations and discharges for streamflow- and stage-gaging stations on the lower Missouri River

[USGS, U.S. Geological Survey; >, greater than; —, not available]

USGS station number (fig. 4)	Station name	River mile	Date of flood peak	Flood-peak elevation, in feet above sea level	Flood-peak discharge, in cubic feet per second	Recurrence interval, in years
06818000	Missouri River at St. Joseph, Mo.	448.2	7–26	820.26	335,000	>100
06893000	Missouri River at Kansas City, Mo.	366.1	7–27	755.27	541,000	>100
06895500	Missouri River at Waverly, Mo.	293.5	7–27	677.15	633,000	>100
06909000	Missouri River at Boonville, Mo.	196.6	7–29	602.52	755,000	>100
06910450	Missouri River at Jefferson City, Mo.[1]	143.8	7–30	559.30	—	—
06934500	Missouri River at Hermann, Mo.	97.9	7–31	518.53	750,000	>100

[1] Stage-gaging station.

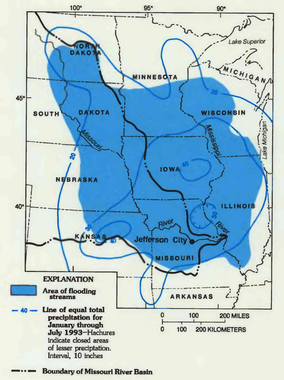

Figure 2. Areal distribution of January through July 1993 total precipitation in the area of flooding within the lower Missouri River Basin and surrounding region. (Modified from Wahl and others, 1993.)

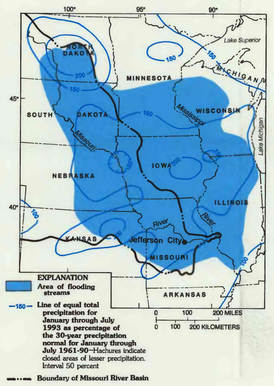

Figure 3. Areal distribution of January through July 1993 total precipitation as percentage of 30-year (1961–90) normal precipitation in the area of flooding within the lower Missouri River Basin and surrounding region. (Modified from Wahl and others, 1993.)

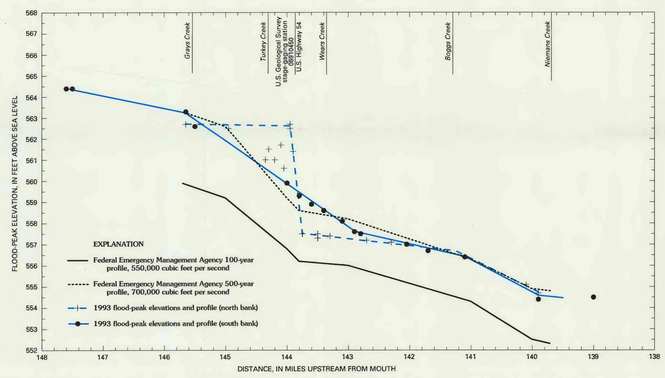

Figure 6. The 1993 flood-peak elevations and profiles and the Federal Emergency Management Agency 100- and 500-year profiles (U.S.Department of Housing and Urban Development, 1979, panel 2) along the Missouri River in Jefferson City and vicinity, Missouri.

Figure 7. Aerial view of the Missouri River flooding on July 30, 1993, at U.S. Highway 54 just north of Jefferson City, Missouri, looking south (photograph from the Missouri Highway and Transportation Department).

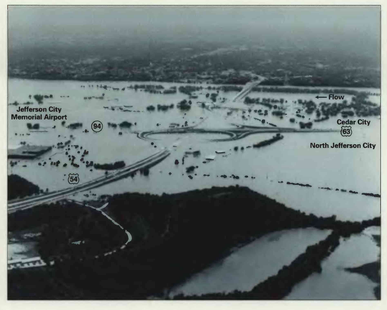

Figure 8. Aerial view of the Missouri River flooding on July 30, 1993, in the vicinity of Cedar City and Jefferson City Memorial Airport immediately north of Jefferson City, Missouri, looking south (photograph from the Missouri Highway and Transportation Department).

REFERENCES CITED

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Wahl, K.L., Vining, K.C., and Wiche, G.J., 1993, Precipitation in the Upper Mississippi River Basin, January 1 through July 31, 1993: U.S. Geological Survey Circular 1120–B, 13 p.

CONVERSION FACTORS AND VERTICAL DATUM

Multiply inch-pound unit	by	To obtain metric unit
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
cubic foot per second (ft^3/s)	0.2832	cubic meter per second

Sea Level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

DELINEATION OF FLOODING WITHIN THE UPPER MISSISSIPPI RIVER BASIN—FLOOD OF JULY 30, 1993, IN JEFFERSON CITY AND VICINITY, MISSOURI

By Terry W. Alexander

1995