Alexander, T.W., 1998, Delineation of flooding within the upper Mississippi River Basin—Flood of August 1–3, 1993, in St. Louis and vicinity, Missouri

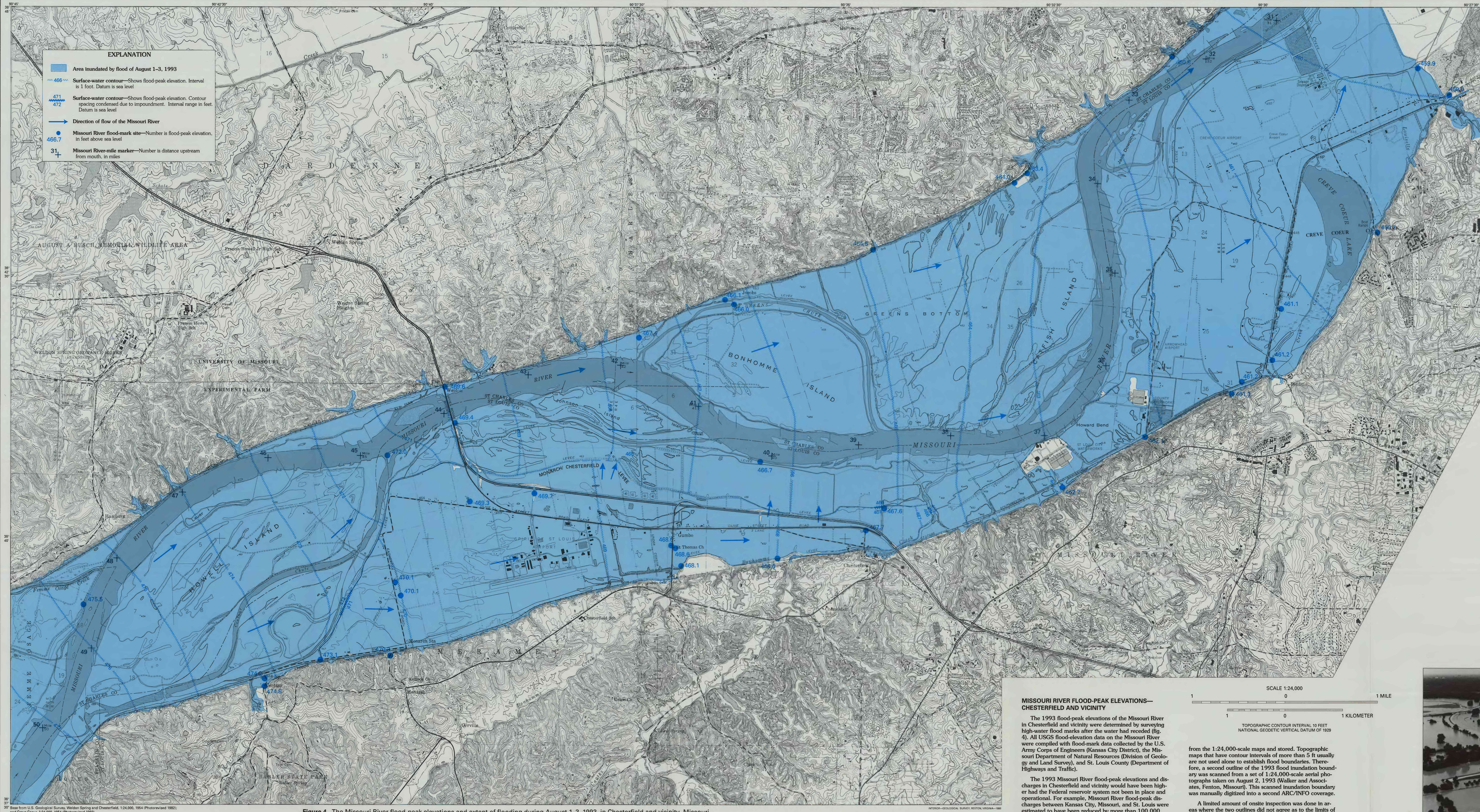
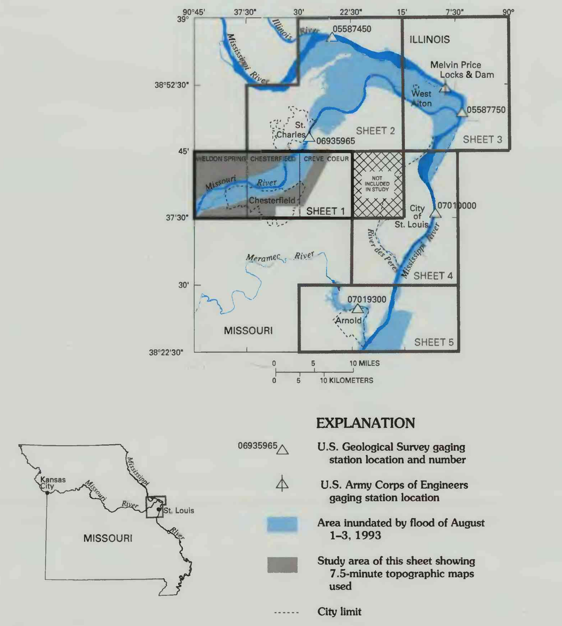


Figure 4. The Missouri River flood-peak elevations and extent of flooding during August 1–3, 1993, in Chesterfield and vicinity, Missouri.



Index to area covered by each sheet of this Atlas, study area on this sheet, and location of selected gaging stations in St. Louis and vicinity, Missouri.

Figure 6. Aerial view of the Missouri River flooding during August 1–3, 1993, at U.S. Highways 40–61 near the Monarch/Chesterfield Levee in Chesterfield, Missouri, looking west (photograph from the Missouri Highway and Transportation Department).

INTRODUCTION

During spring and summer 1993, a number of intense rain storms combined with saturated soils to cause record flooding on many streams and rivers in the Central United States. Flooding on the Missouri and the Mississippi Rivers and many of their tributaries upstream from St. Louis, Missouri, exceeded historical records. The record flood elevations, discharges, and durations resulted in the evacuation of people and livestock, inundation of businesses and more than 15 million acres of farm land, disruption of public utilities, damaging of many roadways and bridges, and breaching of many levee systems.

In July 1993, record-setting flood-peak discharges were recorded in parts of a nine-State area (fig. 1) in the upper Mississippi River Basin. Of the 151 U.S. Geological Survey (USGS) streamflow-gaging stations within the upper Mississippi River Basin, 44 stations had flood peaks that exceeded a discharge having a recurrence interval of 100 year (annual exceedance probability of 0.01). Previous maximum known discharge or regulated discharge was exceeded at 56 of the 151 stations (Parrett and others, 1993, p. 9–14).

Within the flooded area (fig. 1), about 500 counties received some form of Federal assistance. Because the flooding occurred during the prime crop-growing season, agricultural losses were considerable. In some areas, the 1993 crop harvest was a total loss. Flood damages were so great and widespread throughout the nine-State area that only estimates of the economic effects may ever be available. For example, topsoil erosion by the river current and large deposits of gravel, sand, and silt on more than 500 mi of fertile Missouri and Mississippi River flood plains will have long-term, damaging effects on future farm productivity (U.S. Department of Commerce, 1994, p. 25). Initial damage estimates of from $15 billion to $20 billion rank the flood of 1993 as the costliest flood event in United States history and second only to Hurricane Andrew in damages from a weather-related disaster (U.S. Department of Commerce, 1994, p. 24).

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 (Jefferson City Post-Tribune, 1993a). Some 20 of the 48 reported flood-related deaths were in Missouri.

PURPOSE AND SCOPE

A five-sheet hydrologic investigations atlas provides flood-peak elevation data and delineates the areal extent of flooding of the Missouri, the Mississippi, and the Meramec Rivers and the River des Peres in St. Louis and vicinity from August 1 through 3, 1993. The August 1993 flood is compared with the Federal Emergency Management Agency's (FEMA) 100- and 500-year flood profiles.

This atlas is one of a series of USGS reports that document the 1993 flooding in the upper Mississippi River Basin. The information presented here will improve the technical base on which flood-plain management decisions can be made.

CLIMATE CONDITIONS

In early June 1993, a strong low-pressure system developed over the Western United States, and at the same time a strong 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 in the Southeast blocked the eastward movement of storms. A convergence zone developed between the warm, moist air that flows from the Gulf of Mexico and the much cooler and drier air from Canada, which created many 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 Eastern United States from Alabama to Vermont, which were affected by 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 upper Mississippi River Basin; 40-in. totals were recorded in some locations (fig. 2). The larger totals generally were reported in Iowa, Kansas, and Missouri. Areal distribution of total precipitation in the upper Mississippi River Basin as a percentage of the normal (1961–90) precipitation for January through July is shown in figure 3.

By June 1, the spring precipitation which was above average caused discharges of streams and rivers in the upper Mississippi 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 within the lower one-half of the upper Mississippi River Basin. Consequently, flooding on the lower parts of the Missouri River and the upper Mississippi River climaxed with their peak discharges from August 1 through 3, 1993, in St. Louis and vicinity, Missouri.

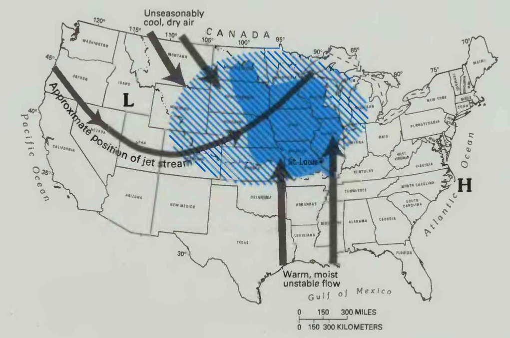


Figure 1. Dominant weather patterns for June through July 1993, upper Mississippi River Basin, and general area of flooding streams, June through August 1993 (modified from Wahl and others, 1993).

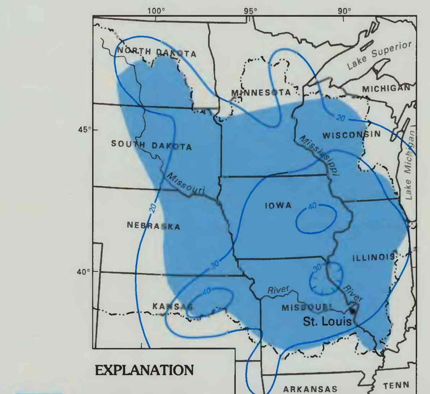


Figure 2. Areal distribution of January through July 1993 total precipitation in the area of flooding within the upper Mississippi River Basin (modified from Wahl and others, 1993).

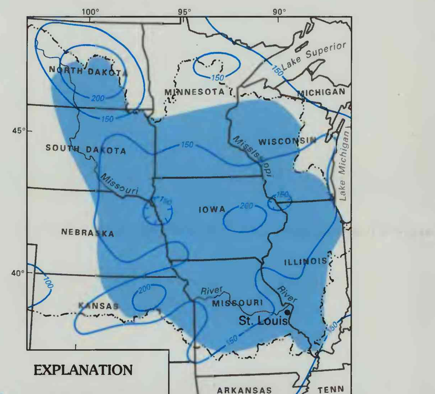


Figure 3. Areal distribution of January through July 1993 total precipitation as a percentage of 30-year (1961–90) normal precipitation in the area of flooding within the upper Mississippi River Basin (modified from Wahl and others, 1993).

MISSOURI RIVER FLOOD-PEAK ELEVATIONS—CHESTERFIELD AND VICINITY

The 1993 flood-peak elevations of the Missouri River in Chesterfield and vicinity were determined by surveying high-water flood marks after the water had receded (fig. 4). All USGS flood-elevation data on the Missouri River were compiled with flood-mark data collected by the U.S. Army Corps of Engineers (Kansas City District), the Missouri Department of Natural Resources (Division of Geology and Land Survey), and St. Louis County (Department of Highways and Traffic).

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

FLOOD PROFILES

The flood-peak elevations determined from surveyed flood marks along the Missouri River flood plain (fig. 4) were used to interpret the 1993 flood profiles and to assist in delineating the area inundated by the August 1 flood peak at Chesterfield and vicinity. These flood marks are subject to errors in maximum-height interpretation, localized increases or decreases in water-surface levels because of water-velocity differences, and accuracy of reference elevations used in the surveying process. The best-fit flood-peak profiles (fig. 5) and surface-water contour lines (fig. 4) were determined from the flood-peak elevation data. Some individual data values are not consistent with the profiles and contour lines; the difference in the data values was based on the quality of the flood mark. Flood-peak elevation locations are plotted and referenced by distance, in river miles, upstream from the mouth of the Missouri River.

The Monarch/Chesterfield Levee system (fig. 4) protecting agricultural and industrial developments was breached on or about July 30, 1993. Flood-peak elevations in the protected area behind the levee differed from those in the Missouri River. In addition, flood-peak elevations on the north bank of the Missouri River differed from those on the south bank. Accordingly, three separate flood profiles, for the north and south banks of the Missouri River and for the Monarch/Chesterfield leveed area are shown in figure 5.

INUNDATED AREA

The extent of Missouri River flooding from August 1 through 3, 1993, in Chesterfield and vicinity was determined by using surface-water contours shown in figure 4. These elevation data were used to hand-draw the outline of the 1993 flood inundation boundary on 1:24,000-scale (contour interval, 10 ft) topographic maps of Chesterfield and vicinity. By using the geographic information system (GIS) software package ARC/INFO[1], the hand-drawn outline of the inundation boundary was manually digitized from the 1:24,000-scale maps and stored. Topographic maps that have contour intervals of more 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 August 2, 1993 (Walker and Associates, Fenton, Missouri). This scanned inundation boundary was manually digitized into a second ARC/INFO coverage.

A limited amount of onsite inspection 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 (including the Monarch /Chesterfield Levee system) may be at or slightly above the August 1 flood-peak elevation; however, some of these small areas may not be delineated. Other discrepancies in the outlines were the result of inaccuracies in the manual delineation of the flood boundary (horizontal/vertical) on topographic maps with a 10-ft contour interval and inconsistencies in visually defining the peak-floodwater/land-surface contact (particularly in local areas of dense vegetation) from the aerial photographs. The August 1 through 3, 1993, Missouri River extent of flooding shown in figure 4 is considered to be the best interpretation on the basis of both inundation outlines.

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 wise flood-plain-management practices. The FEMA has adopted the 100-year flood as the base flood for purposes of defining the flood boundaries of the 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, 1993a, p. 34). To assist in the evaluation of the Missouri River flooding from August 1 through 3, 1993, in Chesterfield and vicinity, the FEMA 100- and 500-year flood profiles (U.S. Department of Housing and Urban Development, 1993b, panels 140, 141) are shown in figure 5.

FLOOD DAMAGES

In Chesterfield and vicinity, a substantial part of the 1993 flood damage was related to the breaching of the Monarch/Chesterfield Levee system (fig. 4). As a result of the breaching of the levee on July 30, about 6 mi of U.S. Highways 40–61 were closed (fig. 6), more than 280 businesses were damaged, water depths behind the levee system were as much as 10 ft, and air traffic was suspended and a number of planes were trapped at the Spirit of St. Louis Airport.

[1]Use of a brand name in this atlas is for identification purposes only and does not constitute endorsement by U.S. Geological Survey.

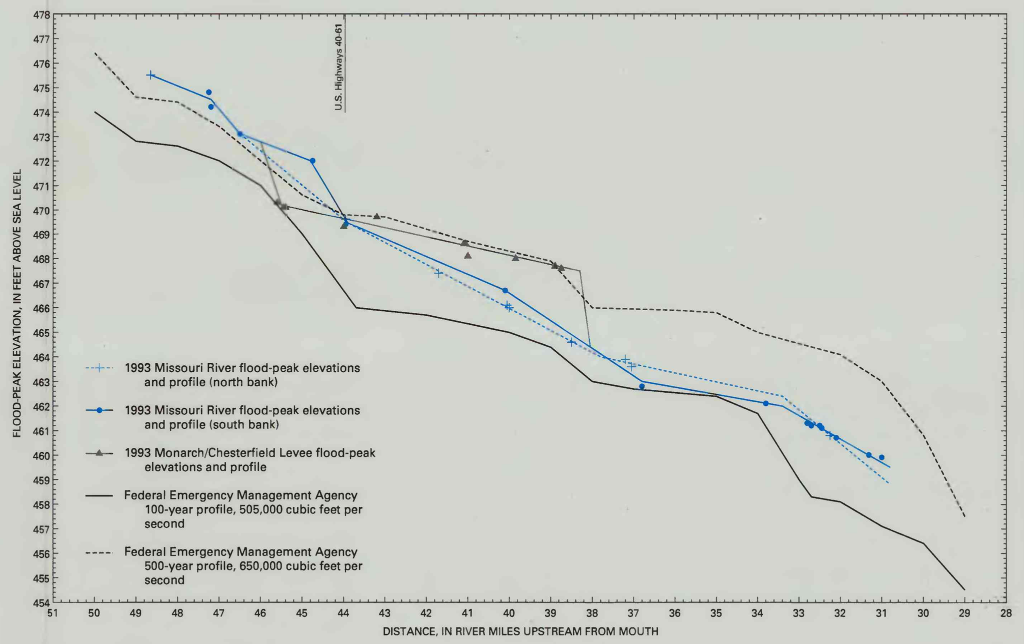


Figure 5. The 1993 flood-peak elevations and profiles and the Federal Emergency Mangement Agency 100- and 500-year flood profiles (U.S. Department of Housing and Urban Development, 1993b, panels 140, 141) along the Missouri River in Chesterfield and vicinity, Missouri.

DELINEATION OF FLOODING WITHIN THE UPPER MISSISSIPPI RIVER BASIN—FLOOD OF AUGUST 1–3, 1993, IN ST. LOUIS AND VICINITY, MISSOURI—CHESTERFIELD AND VICINITY

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