U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

INTRODUCTION

During spring, summer, and fall 1993, record flooding disrupted business and transportation and caused widespread property damage and personal hardship in parts of Iowa, Illinois, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, and Wisconsin. In an effort to document the 1993 flooding, the U.S. Geological Survey (USGS) is publishing a series of reports collectively known as Circular 1120, *Floods in the upper Mississippi River Basin, 1993*. Also, hydrologic atlases, such as this one, are being published for Davenport, Iowa City, and Des Moines, Iowa, Jefferson City and St. Louis, Missouri, Kansas City, Kansas, and Kansas City, Missouri.

This hydrologic atlas describes the flooding from June 18 through August 4, 1993, along the Des Moines and the Raccoon Rivers, and Beaver, Fourmile, and Walnut Creeks in Des Moines and vicinity. Water service in Des Moines was disrupted when the Raccoon River flooded the Des Moines Water Works treatment plant, which is southwest of downtown Des Moines. Many areas were without electricity because several electrical substations were inundated. Flooding also closed many roads, including Interstates 35 and 80, and caused extensive damage to public and private property. The 1993 inundated areas are presented and compared with those estimated by the Federal Emergency Management Agency (FEMA) for the 100-year flood (Federal Emergency Management Agency 1979, 1981, 1982a–b, 1984a–b, 1987, 1992a–d). The 1993 flood elevations are presented and compared with those estimated for the FEMA 100- and 500-year floods (Federal Emergency Management Agency, 1988, 1992e).

DESCRIPTION OF THE AREA

Des Moines is in south-central Iowa. The drainage basin for the USGS streamflow-gaging station on the Des Moines River below the Raccoon River at Des Moines is located mostly in Iowa and in a small part of Minnesota (fig. 1). Most of the basin has low relief, contains many ponds and marshes that have no drainage outlets, and is used primarily for agriculture.

Saylorville Dam, which is about 9 miles north-northwest of downtown Des Moines (fig. 2), has regulated the flow of the Des Moines River since April 12, 1977. Beaver Creek joins the Des Moines River downstream from Saylorville Dam and just upstream from the crossing of Interstate 35 and 80. About one-third of the basin is drained by the unregulated Raccoon River, which joins the Des Moines River in downtown Des Moines. Walnut Creek joins the Raccoon River in southwestern Des Moines and Fourmile Creek joins the Des Moines River southeast of the Des Moines city boundary.

CLIMATIC 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. The jet stream dipped south over the Western United States and flowed in a northeasterly direction across the upper Midwest. The high-pressure system to the southeast blocked the eastward movement of storms, thus creating a convergence zone between the flow of warm, moist air from the Gulf of Mexico and the much cooler, drier air from Canada, which resulted in thunderstorms. 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 influence of the high-pressure system, were very 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).

In Iowa, the wettest November through June period in 121 years of recordkeeping was followed by the wettest month ever recorded, July 1993 (National Oceanic and Atmospheric Administration, 1993a). The locations of selected precipitation stations within the drainage basin for the streamflow-gaging station on the Des Moines River below the Raccoon River at Des Moines streamflow-gaging station are shown in figure 1. During May, June, and July 1993, these stations recorded more than 100 percent of normal rainfall (table 1). Rainfall at Boone was 424 percent of normal for the month of July (National Oceanic and Atmospheric Administration, 1993a–b). Of the many different storms that contributed to the flooding in the Des Moines area, two are of special importance. Extreme rains from June 16 through 20 raised the water level of Saylorville Lake above that of the emergency spillway. The Des Moines River below the Raccoon River at Des Moines rose above flood stage when the excessive rains from July 8 through 11 contributed to the worst of the 1993 flooding. During these 4 days, much of the basin received some rainfall. Recorded totals of more than 4 inches (in.) were common and more than 9 in. of rainfall was recorded at Carroll and Boone (National Oceanic and Atmospheric Administration, 1993a).

FLOOD DISCHARGE

Maximum discharges and stages at selected streamflow-gaging stations are listed in table 2. The rate of discharge of a stream is the volume of flow that passes a specific location in a given period of time. Floods are described in terms of discharge and elevation because changes in the river channel can affect the relation between water-surface elevation and discharge. During flooding, the river may widen or deepen its channel so that a subsequently greater discharge might be associated with a lower water-surface elevation.

Discharges at three Des Moines River streamflow-gaging stations are shown in figure 3. The station near Stratford (05481300) is upstream from Saylorville Lake, the station near Saylorville (05481650) is downstream from the lake, and the station at Des Moines (05485500) is downstream from the confluence with the Raccoon River. In figure 4, the cumulative discharge of the three main flood-discharge contributors is compared with the discharge of the Des Moines River below the Raccoon River at Des Moines. No travel-time adjustments were made before adding the discharges together to produce the shaded areas. Discharge at streamflow-gaging station 05485500 is the sum of the flows from the Des Moines River near Saylorville (05481650), Beaver Creek near Grimes (05481950), and the Raccoon River near Van Meter streamflow-gaging stations and local inflows with various time-of-travel lags from a few hours or a day.

Table 1. Precipitation recorded during May through July 1993 within the drainage basin of the Des Moines River below the Raccoon River at Des Moines streamflow-gaging station

[in., inches; —, not available. Data from National Oceanic and Atmospheric Administration (1993a–b). Percentage of normal is percentage of normal precipitation from 1961–1990]

Period of rainfall	Algona 3W		Boone		Carroll		Estherville 2N		Perry		Pocahontas		Webster City		Windom	
	Rain (in.)	Percent of normal	Rain (in.)	Percent of normal	Rain (in.)	Percent of normal	Rain (in.)	Percent of normal	Rain (in.)	Percent of normal	Rain (in.)	Percent of normal	Rain (in.)	Percent of normal	Rain (in.)	Percent of normal
Month of May	6.94	**197**	6.16	**138**	4.71	**109**	7.36	**222**	5.59	**132**	4.09	**110**	5.41	**145**	7.87	**247**
June 16–20	1.80	—	1.69	—	.69	—	2.64	—	2.13	—	1.42	—	2.46	—	4.16	—
Month of June	9.06	**217**	7.95	**152**	6.08	**124**	13.51	**333**	5.53	**115**	7.67	**183**	10.10	**223**	10.16	**257**
July 4–6	.06	—	.96	—	.56	—	.29	—	.87	—	.12	—	.65	—	.36	—
July 8–11	3.87	—	9.06	—	9.59	—	3.44	—	3.77	—	2.63	—	4.26	—	1.66	—
July 17–19	1.16	—	2.79	—	.62	—	.84	—	.24	—	1.25	—	4.26	—	1.24	—
Month of July	8.21	**206**	16.28	**424**	12.36	**283**	7.62	**218**	8.45	**224**	7.49	**176**	12.49	**285**	5.57	**137**

Table 2. Summary of maximum stages and discharges at selected streamflow-gaging stations in Des Moines and vicinity, Iowa

[mi², square miles; ft, feet above gage datum; ft³/s, cubic feet per second; >, greater than; —, not available. Data from Federal Emergency Management Agency (1988, 1992e), O'Connell and others (1991), and Southard and others (1994)]

Station number (fig. 2)	Station name	Drainage area (mi²)	Gage datum above sea level (ft)	Flood of June 18–August 4, 1993: Date (month/day)	Maximum stage (ft)	Maximum discharge (ft³/s)	Recurrence interval (years)	Previous maximum discharge: Date (month/year)	Maximum stage (ft)	Maximum discharge (ft³/s)	FEMA study flood information: 100-year discharge (ft³/s)	500-year discharge (ft³/s)
05481300	Des Moines River near Stratford	5,452	894.00	7/11	25.64	42,100	[1]25	6/54	[2]29.7	57,400	—	—
05481650	Des Moines River near Saylorville	5,841	787.42	7/11	[3]24.22	38,400	>100[4,5](1.2)	6/54	[6]24.50	[6]60,000	32,000	—
				7/21	[3]22.90	[7]45,700	>100[4,5](1.4)	6/84	[8]20.72	[8]30,100		
05481950	Beaver Creek near Grimes	358	806.98	7/10	16.58	[9]14,300	>100[1,4](1.2)	6/86	14.73	7,980	8,770	10,580
05484500	Raccoon River at Van Meter	3,441	841.16	7/10	26.34	[9]70,100	>100[1,4](1.3)	6/47	21.37	41,200	—	—
05484800	Walnut Creek at Des Moines	78.4	801.04	7/09	15.74	4,110	[1]4	5/86	18.32	12,500	17,000	27,000
05485500	Des Moines River below Raccoon River at Des Moines	9,879	762.52	7/11	34.29	[9]116,000	>100[4,5](1.8)	6/47	[6,10]20.8	[6,10]77,000	63,900	—
								6/84	[8]28.46	[8]58,400		
05485640	Fourmile Creek at Des Moines	92.7	795.87	7/09	14.02	4,210	[1]6	8/77	14.64	5,380	6,140	8,720

[1] Based on information from Eash (in press).
[2] Converted to current gage datum.
[3] Maximum stage did not occur on same date as maximum discharge.
[4] Ratio of maximum discharge to that of the 100-year flood.
[5] Based on information from the U.S. Army Corps of Engineers (Hydraulics Branch, oral commun., 1994)
[6] Before Saylorville Dam began to affect flow (April 12, 1977).
[7] Maximum discharge for 1993 exceeds the previous maximum recorded regulated discharge.
[8] After Saylorville Dam began to affect flow (April 12, 1977).
[9] Maximum discharge for 1993 exceeds the previous maximum recorded discharge.
[10] Gaging station was at site 0.8 mi upstream at datum 773.68 ft.

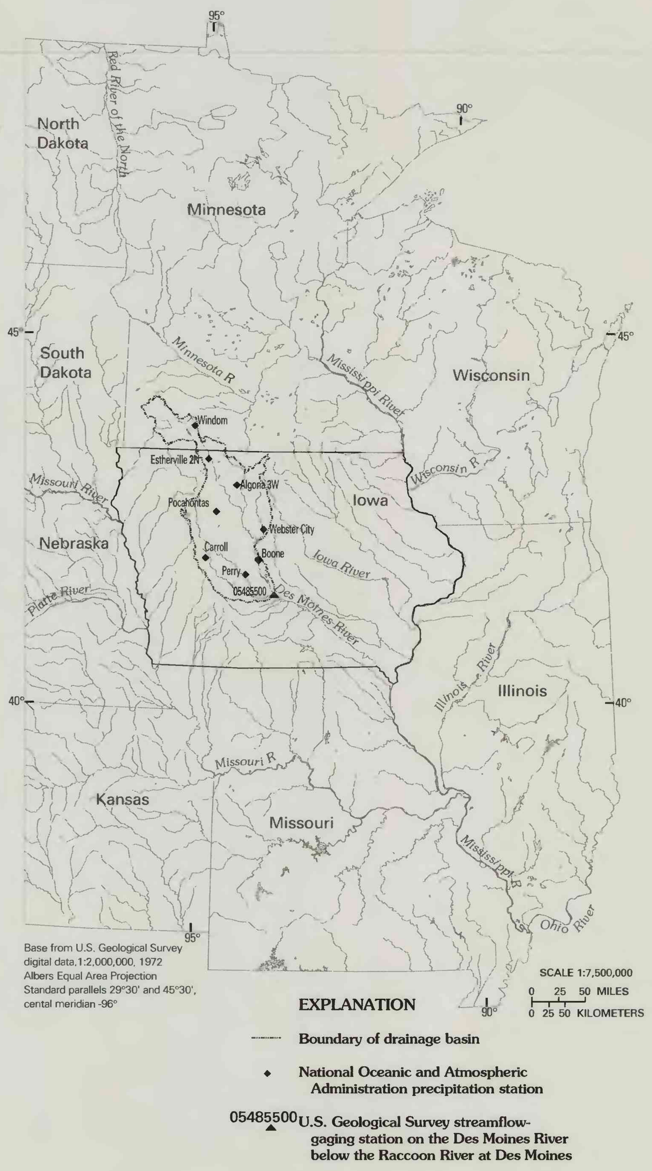

Figure 1. Location of the drainage basin for the streamflow-gaging station on the Des Moines River below the Raccoon River at Des Moines and selected National Oceanic and Atmospheric Administration precipitation stations.

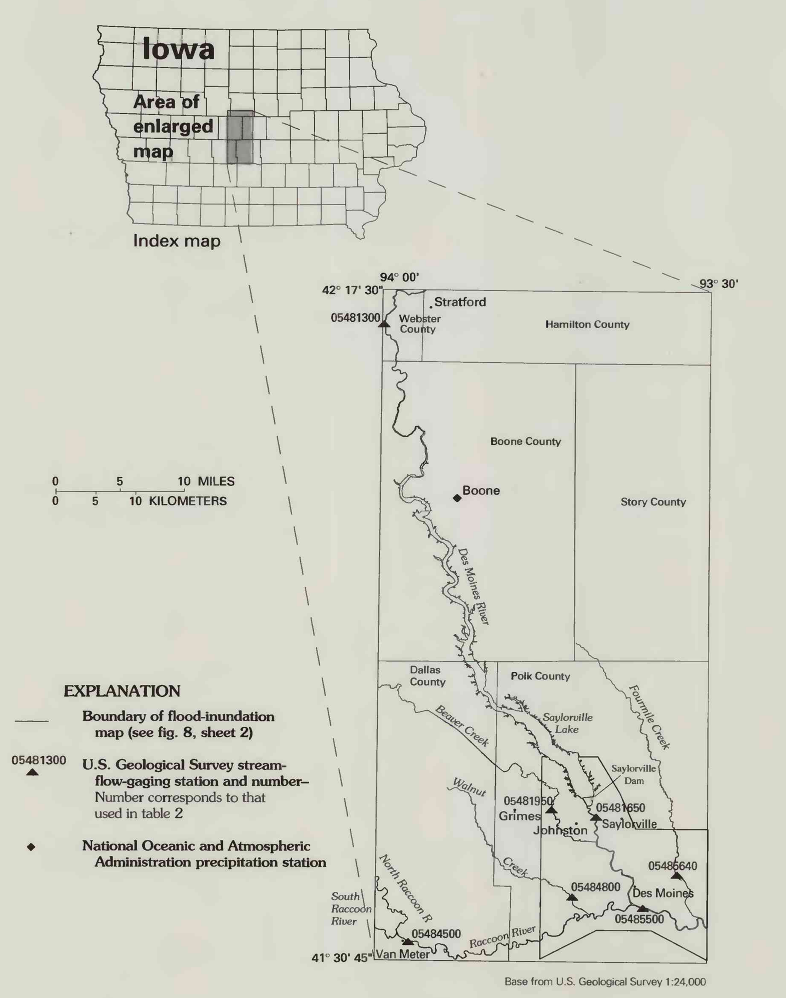

Figure 2. Location of U.S. Geological Survey streamflow-gaging stations and boundary of flood-inundation (fig. 8 on sheet 2).

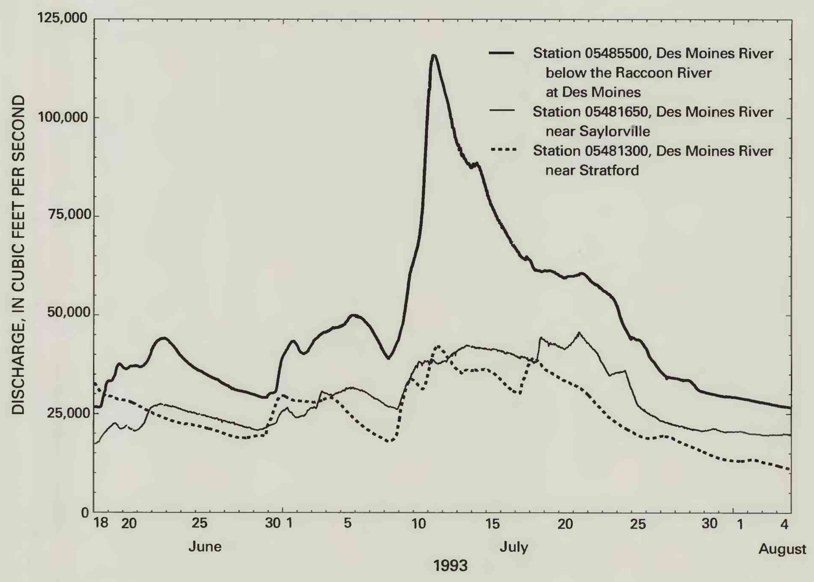

Figure 3. Discharge at U.S. Geological Survey streamflow-gaging stations on the Des Moines River in Des Moines and vicinity, June 18 through August 4, 1993 .

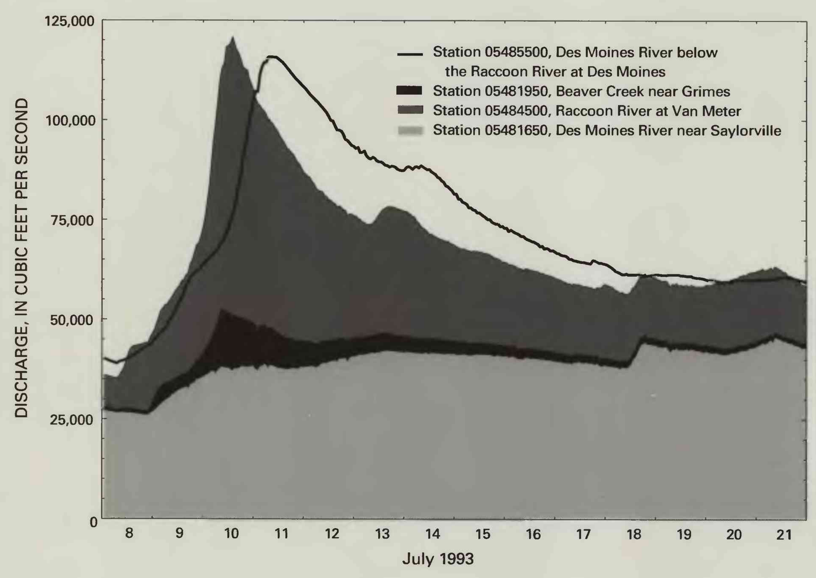

Figure 4. Cumulative discharge for U.S. Geological Survey inflow-gaging stations in the Des Moines vicinity and discharge for the Des Moines River below the Raccoon River at Des Moines, July 8 through 21, 1993.

FLOOD ELEVATIONS

The elevation of a flood at a streamflow-gaging station usually is stated in terms of gage height or stage, and is the elevation of the water surface above a selected datum. From June 18 through August 4, 1993, the stage of the Des Moines River at the stream-flow-gaging station below the Raccoon River at Des Moines equaled or exceeded 23 feet (ft), which is defined by the National Weather Service (Michael Longnecker, written commun., 1995) as the flood stage at that station.

The maximum Saylorville Lake water-surface elevation of 892.03 ft occurred on July 13 (U.S. Army Corps of Engineers, 1994). The level of Saylorville Lake was above the elevation of the emergency spillway for more than 1 month (fig. 5). The maximum water-surface elevations that occurred on July 11 along the Des Moines River between the streamflow-gaging station near Saylorville (05481650) and State Highway 46 are shown in figure 6. The maximum water-surface elevations at the Des Moines River near Saylorville and the Des Moines River below the Raccoon River at Des Moines also were recorded on July 11 (table 2). Figure 7 shows selected July 11 maximum water-surface elevations closest to the Raccoon River within the study area.

Maximum stages recorded at USGS and U.S. Army Corps of Engineers (USACE) streamflow-gaging stations have been converted to elevations and are reported to the nearest hundredth of a foot on the flood-inundation map (fig. 8 on sheet 2). The maximum water-surface elevation recorded at Fourmile Creek at Interstate 80 is reported to the nearest tenth of a foot (Larry Ellis, National Weather Service, written commun., 1993). At ungaged locations, maximum water-surface elevations were determined by using standard surveying techniques by the USACE and the cities of Johnston, Des Moines, and West Des Moines. On the flood-inundation map, maximum elevations for these locations are reported to the nearest tenth of a foot (see fig. 8 on sheet 2).

INUNDATED AREA

Several sources of information were used to determine the areas inundated in 1993 (fig. 8 on sheet 2). The cities of Des Moines (Roger Schletzbaum, Des Moines Engineering Department, written commun., 1993) and West Des Moines (James D. Hoefler, West Des Moines Engineering Department, written commun., 1993) provided inundation maps of selected areas flooded in 1993 (fig. 9 on sheet 2).

Flood-extent boundaries not mapped by Des Moines and West Des Moines were determined by the USGS by using several different methods. Aerial photographs taken on July 12 and 20, 1993, for the USACE and a videotape from the West Des Moines Police Department were used to draw flood-extent boundaries. These boundaries were adjusted where the known 1993 maximum water-surface elevations appeared to be significantly different from those in the photographs or the videotape and in areas where the edge of the floodwaters was obscured on the photographs or the videotape by buildings or vegetation. These adjustments were based on comparisons of the 1993 water-surface elevations with the topographic elevations on the 1:24,000 base maps and more detailed elevation maps from the USACE. In some places, the flood-inundation boundary crosses back and forth across topographic contour lines of different elevations because the topography has changed since the base maps were published (fig. 9 on sheet 2).

FLOOD-RECURRENCE INTERVAL

The recurrence interval is the long-term average number of years between occurrences of annual-maximum flood peaks that exceed a given magnitude. The magnitude may be expressed in terms of peak discharge or peak stage (water-surface elevation). The recurrence interval also is the reciprocal of the annual probability or chance of occurrence of a flood that exceeds the given magnitude. For example, a flood magnitude that has a recurrence interval of 100 years (the 100-year flood) has a 1-percent chance (0.01 probability) of being exceeded in any given year. Recurrence intervals do not imply regularity of occurrence—the 100-year flood might be exceeded in consecutive years or might not occur at all for more than 100 years.

Recurrence intervals for selected maximum elevations and discharges are statistics that can change and that tend to become more reliable as more data are collected and used in the computations. Long-term climatic changes and physical changes in the basin can alter the recurrence for a specified discharge. Examples of such basin changes include extensive urbanization, implementation of agricultural conservation practices, installation of drainage systems, and construction of reservoirs.

During the 1993 flood, the maximum discharge at several streamflow-gaging stations had recurrence intervals of more than 100 years (table 2). A comparison of the flood-inundation boundaries with the FEMA 100-year flood boundaries (fig. 8, sheet 2) indicates that the 1993 flood was greater than a 100-year flood for the Des Moines and the Raccoon Rivers and Beaver Creek within the study area. A comparison of the Des Moines and Raccoon River flood profiles of maximum water-surface elevations with the FEMA 100- and 500-year flood profiles (figs. 6, 7) indicates that the 1993 flood was greater than the 100-year flood and possibly the 500-year flood.

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

The FEMA 100-year flood boundary (Federal Emergency Management Agency, 1979, 1981, 1982a–b, 1984a–b, 1987, 1992a–d) is presented in figure 8 (sheet 2). The 100-year flood boundary outlines those areas expected to be inundated during a 100-year flood. The outlined areas do not include those areas protected by flood-prevention measures, such as dikes, levees, or other structures, which may fail or be overtopped during larger floods. The FEMA 100-year flood boundary is of interest to many people because it is the basis for flood-insurance rates and it may affect local zoning ordinances and qualification for home and business loans.

The FEMA flood-boundary information is published in map form for individual cities and Polk County within the study area. The FEMA maps were prepared by different contractors at different times on a variety of base maps and were published at different scales. For this Hydrologic Investigations Atlas, the 100-year flood boundary was created by combining information from the appropriate city and county maps. The FEMA maps may be revised as changes in the area of interest and the drainage basins warrant. These changes can affect the flow of floodwaters and can be reflected in future FEMA maps. For official FEMA information, one should examine individual FEMA maps, including any that may have been published since this Hydrologic Investigtions Atlas was published.

The 100- and 500-year flood profiles (Federal Emergency Management Agency, 1988, 1992e) are shown in figures 6 and 7. The 500-year flood profile is not available for the Des Moines River upstream or downstream of the Des Moines city limits. The FEMA 100- and 500-year flood discharges, as available, are included in table 2.

ADDITIONAL INFORMATION

Additional information that pertains to the 1993 floods in the Midwest can be found in USGS Circular 1120, *Floods in the upper Mississippi River Basin, 1993*. That report, which is being published as individual chapters (1120–A, 1120–B, 1120–C, and so forth), provides data and findings on the magnitude and frequency of maximum discharges, precipitation, water-quality characteristics, effects of reservoir storage on flood maximums, effects of inundation on ground-water quality, flood-discharge volumes, transport of sediment, assessment of sediment deposited on flood plains, stream-channel scour at selected bridges, and documentation of geomorphologic changes.

Additional information also is available from the USACE, Rock Island District; the engineering departments of the cities of West Des Moines, Des Moines, and Johnston; and the Iowa Department of Transportation. Also, the areas in Des Moines and vicinity inundated in 1993 may be compared with areas inundated in 1947, 1954, and 1960, which are shown in Myers (1963).

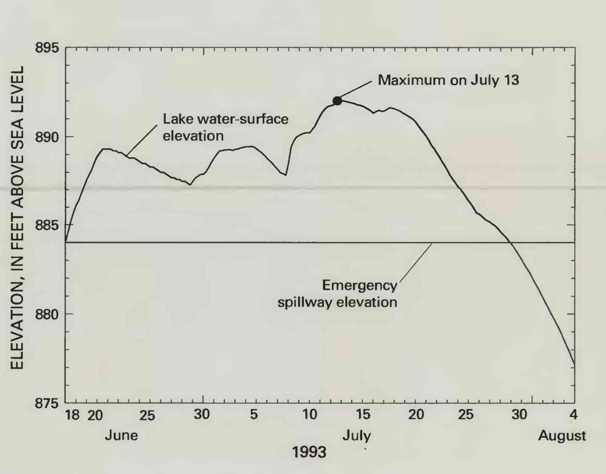

Figure 5. Water-surface elevation for Saylorville Lake, June 18 through August 4, 1993.

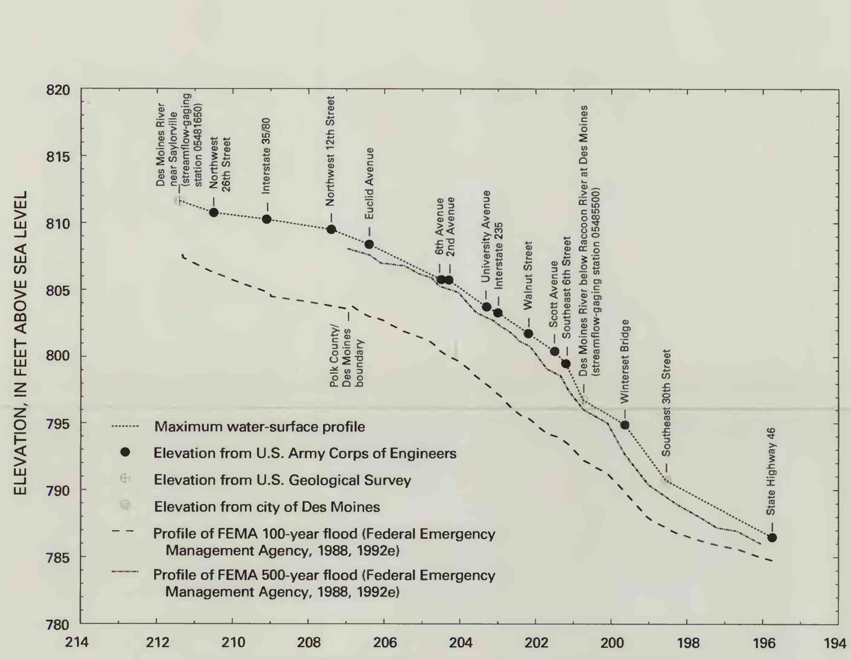

Figure 6. Profiles of maximum water-surface elevations along the Des Moines River, July 11, 1993, and of Federal Emergency Management Agency (FEMA) 100- and 500-year floods.

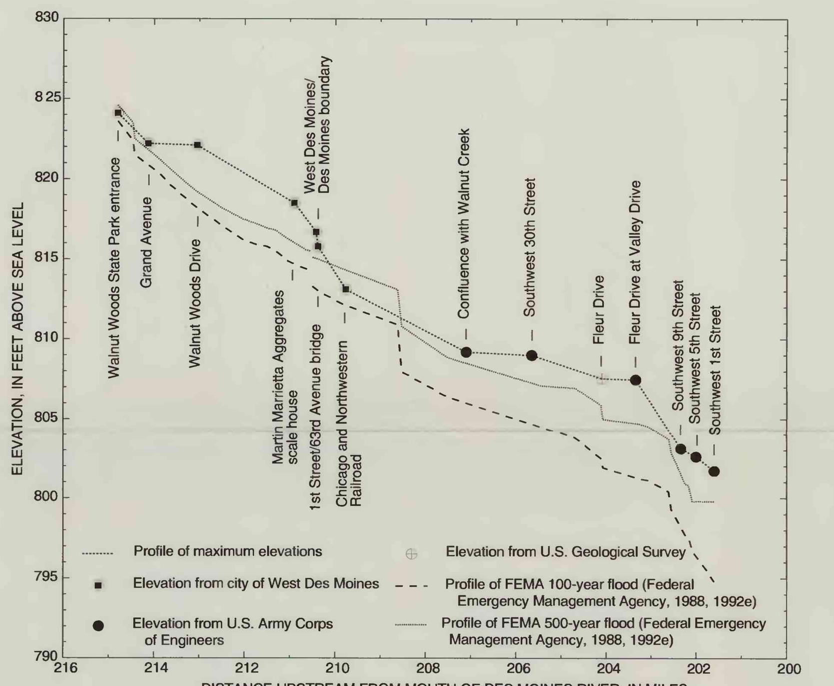

Figure 7. Profiles of maximum water-surface elevations along the Raccoon River, July 11, 1993, and of Federal Emergency Management Agency (FEMA) 100- and 500-year floods.

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_____1992c, Flood insurance rate map for Polk County, Iowa: Baltimore, Md, community 190901, panels 0175 C and 0200C, scale 1:24,000.

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi²)	2.590	square kilometer
cubic foot per second (ft³/s)	0.02832	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 both the United States and Canada, formerly called Sea Level Datum of 1929.

Water year: In U.S. Geological Survey reports, the water year is the 12-month period, October 1 through September 30. The water year is designated by the calendar year in which it ends. Thus, the year ending September 30, 1993, is called the "1993 water year."

DELINEATION OF FLOODING WITHIN THE UPPER MISSISSIPPI RIVER BASIN—FLOOD OF JUNE 18 THROUGH AUGUST 4, 1993, IN DES MOINES AND VICINITY, IOWA

By
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1996