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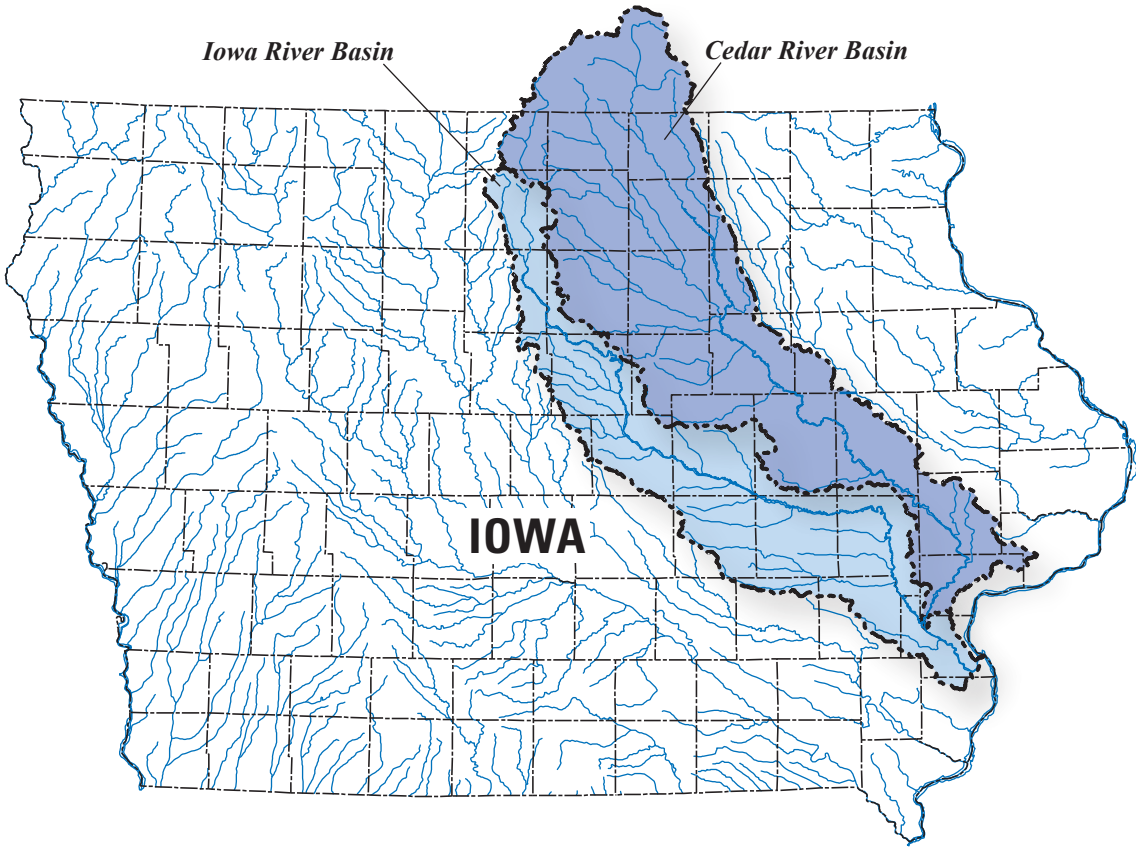


Open-File Report 2010–1190

U.S. Department of the Interior
U.S. Geological Survey

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By S. Mike Linhart and David A. Eash

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KEN SALAZAR, Secretary

**U.S. Geological Survey**
Marcia McNutt, Director

U.S. Geological Survey, Reston, Virginia: 2010

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Suggested citation:
Linhart, S.M., and Eash, D.A., 2010, Floods of May 30 to June 15, 2008, in the Iowa and Cedar River basins, eastern Iowa: U.S. Geological Survey Open-File Report 2010–1190, 99 p. with Appendixes.

ISBN 978-1-4113-2962-1

## Acknowledgments

The authors express their gratitude to the following: Federal Emergency Management Agency (FEMA), U.S. Army Corps of Engineers (USACE), Muscatine County Engineers Office, and the City of Iowa City for providing additional high-water marks for the June 2008 flood along the Iowa and Cedar Rivers; Terry Morse, Iowa Department of Transportation, Dennis Michael with the Louisa County Engineers Office, and the Linn County Engineers Office for providing elevation data for temporary bench marks at bridges; Harry Hillaker, State Climatologist, Iowa Department of Agriculture and Land Stewardship, for providing an isohyetal map of rainfall for the 16-day period ending 7:00 a.m. on June 13, 2008; Bonnie Shepard, National Flood Insurance Program Bureau and Statistical Agent, Federal Emergency Management Agency, for providing private property damage claims for 26 counties in Iowa and 2 counties in Minnesota; and Dennis Harper, State Hazard Mitigation Officer, Iowa Homeland Security and Emergency Management Division, for providing public assistance project costs for 26 counties in Iowa. The authors also express gratitude to the following U.S. Geological Survey employees: Ed Fischer, George Frye, Mike Holt, Kasey Hutchinson, Jon Nania, Phil Soenksen, Seth Studley, Kevin Townsend, and Clint Van Schepen for collecting field data for the determination of water-surface and bench-mark elevations listed in this report; Rochelle Galer for preparing the maps of the Iowa River and Cedar River Basins; and Kaylene Carney for obtaining newspaper articles for the compilation flood description information.

## Contents

## Figures

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## Conversion Factors, Abbreviations, and Datums

Inch/Pound to SI

| Multiply | By | To obtain |
|---|---|---|
| | Length | |
| inch (in.) | 2.54 | centimeter (cm) |
| foot (ft) | 0.3048 | meter (m) |
| mile (mi) | 1.609 | kilometer (km) |
| | Area | |
| square mile ($mi^2$) | 2.590 | square kilometer ($km^2$) |
| | Flow rate | |
| cubic foot per second ($ft^3/s$) | 0.02832 | cubic meter per second ($m^3/s$) |

Elevation or vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 1929).

Elevation refers to distance above or below NGVD 1929.

NGVD 1929 can be converted to the North American Vertical Datum of 1988 by using the National Geodetic Survey conversion utility available at *http://www.ngs.noaa.gov/TOOLS/Vertcon/vertcon.html*.

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Map projections are Universal Transverse Mercator, Zone 15.

Water year is the 12-month period from October 1 through September 30. The water year is designated by the calendar year in which the water year ends and that includes 9 of the 12 months. Thus, the water year ending September 30, 2008, is called the "2008 water year."

# Floods of May 30 to June 15, 2008, in the Iowa River and Cedar River Basins, Eastern Iowa

By S. Mike Linhart and David A. Eash

## Abstract

As a result of prolonged and intense periods of rainfall in late May and early June, 2008, along with heavier than normal snowpack the previous winter, record flooding occurred in Iowa in the Iowa River and Cedar River Basins. The storms were part of an exceptionally wet period from May 29 through June 12, when an Iowa statewide average of 9.03 inches of rain fell; the normal statewide average for the same period is 2.45 inches. From May 29 to June 13, the 16-day rainfall totals recorded at rain gages in Iowa Falls and Clutier were 14.00 and 13.83 inches, respectively. Within the Iowa River Basin, peak discharges of 51,000 cubic feet per second (flood-probability estimate of 0.2 to 1 percent) at the 05453100 Iowa River at Marengo, Iowa streamflow-gaging station (streamgage) on June 12, and of 39,900 cubic feet per second (flood-probability estimate of 0.2 to 1 percent) at the 05453520 Iowa River below Coralville Dam near Coralville, Iowa streamgage on June 15 are the largest floods on record for those sites. A peak discharge of 41,100 cubic feet per second (flood-probability estimate of 0.2 to 1 percent) on June 15 at the 05454500 Iowa River at Iowa City, Iowa streamgage is the fourth highest on record, but is the largest flood since regulation by the Coralville Dam began in 1958.

Within the Cedar River Basin, the May 30 to June 15, 2008, flood is the largest on record at all six streamgages in Iowa located on the mainstem of the Cedar River and at five streamgages located on the major tributaries. Flood-probability estimates for 10 of these 11 streamgages are less than 1 percent. Peak discharges of 112,000 cubic feet per second (flood-probability estimate of 0.2 to 1 percent) at the 05464000 Cedar River at Waterloo, Iowa streamgage on June 11 and of 140,000 cubic feet per second (flood-probability estimate of less than 0.2 percent) at the 05464500 Cedar River at Cedar Rapids, Iowa streamgage on June 13 are the largest floods on record for those sites. Downstream from the confluence of the Iowa and Cedar Rivers, the peak discharge of 188,000 cubic feet per second (flood-probability estimate of less than 0.2 percent) at the 05465500 Iowa River at Wapello, Iowa streamgage on June 14, 2008, is the largest flood on record in the Iowa River and Cedar River Basins since 1903.

High-water marks were measured at 88 locations along the Iowa River between State Highway 99 near Oakville and U.S. Highway 69 in Belmond, a distance of 319 river miles. High-water marks were measured at 127 locations along the Cedar River between Fredonia near the mouth (confluence with the Iowa River) and Riverview Drive north of Charles City, a distance of 236 river miles. The high-water marks were used to develop flood profiles for the Iowa and Cedar River.

## Introduction

In 2008, separate flood events occurred in the Midwest in January, February, March, April, May, June, July, and September (Holmes and others, 2010). At various times during 2008, flooding occurred in parts of Arkansas (Funkhouser and Eng, 2009), Illinois, Indiana (Morlock and others, 2008), Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, Oklahoma, South Dakota, and Wisconsin (Fitzpatrick and others, 2008). The June floods were the most severe and widespread, causing substantial flooding and damage in all of the aforementioned States with the exception of Arkansas. During 2008, new maximum peak discharges were recorded at more than 147 U.S. Geological Survey (USGS) Midwestern streamgages. Flood-probability estimates of peak discharges at 26 of these sites were less than 0.2 percent, and at 67 of the sites, were between 0.2 and 1 percent (Holmes and others, 2010). In the Midwest, the flooding of June 2008 resulted in the loss of 11 lives and damages in excess of $5 billion (National Weather Service, 2009).

Frequent and heavy rainfall events in late May and early June caused record flooding along the Iowa and Cedar Rivers (figs. 1–2) in eastern Iowa in June 2008. New maximum peak discharge records were established from May 30, 2008, to June 15, 2008, at 22 USGS streamgages in the Iowa River and Cedar River Basins, which includes two streamgages along the mainstem of the Iowa River and six streamgages along the mainstem of the Cedar River. Below the confluence of the Iowa and Cedar Rivers, a new maximum peak discharge was recorded at streamgage 05465500 Iowa River at Wapello, Iowa (fig. 1, site 103). From May 30 to June 15, new peak

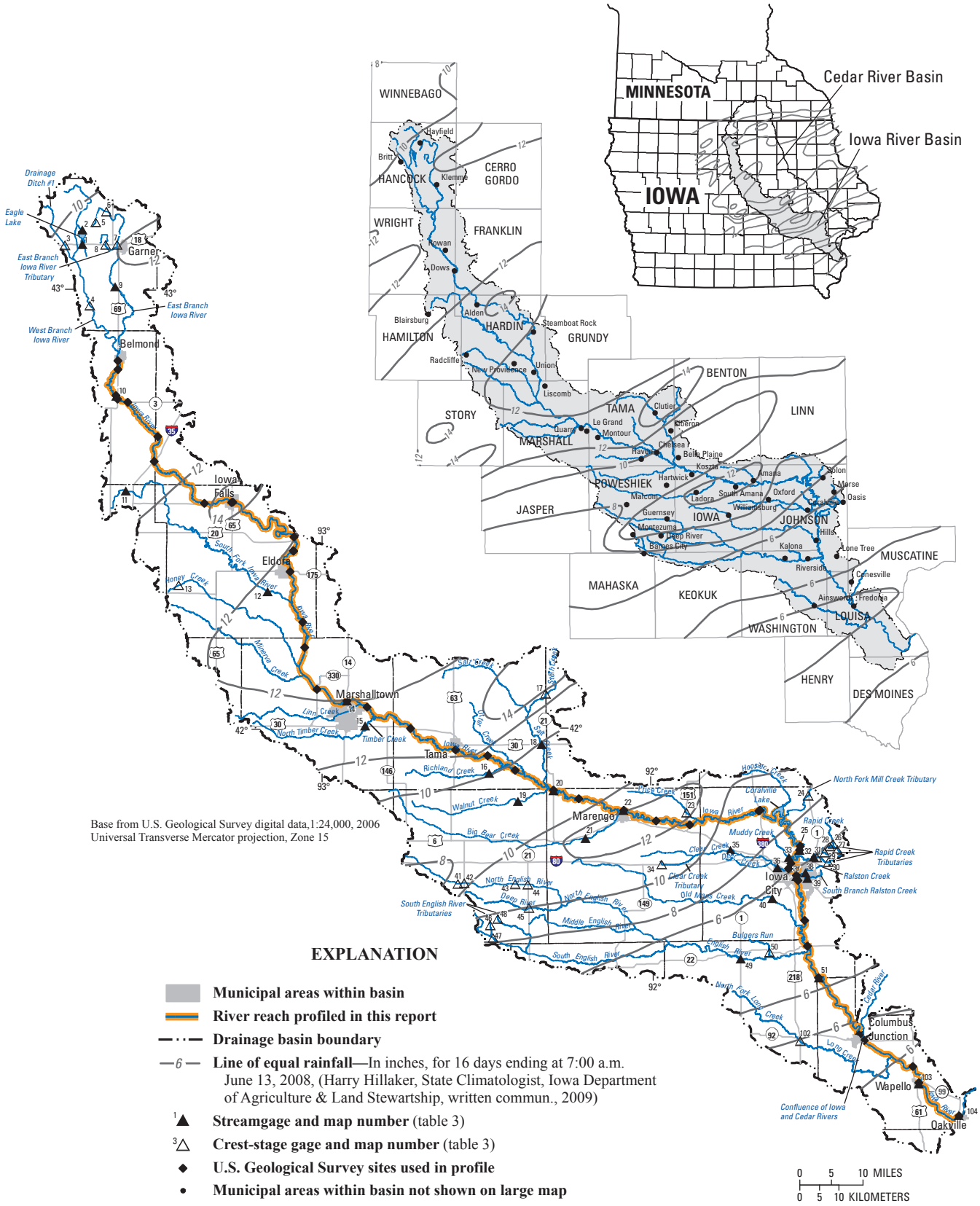


**Figure 1.** Iowa River Basin and lines of equal rainfall for 16 days beginning at 7:00 a.m. on May 29 and ending at 7:00 a.m. on June 13, 2008.

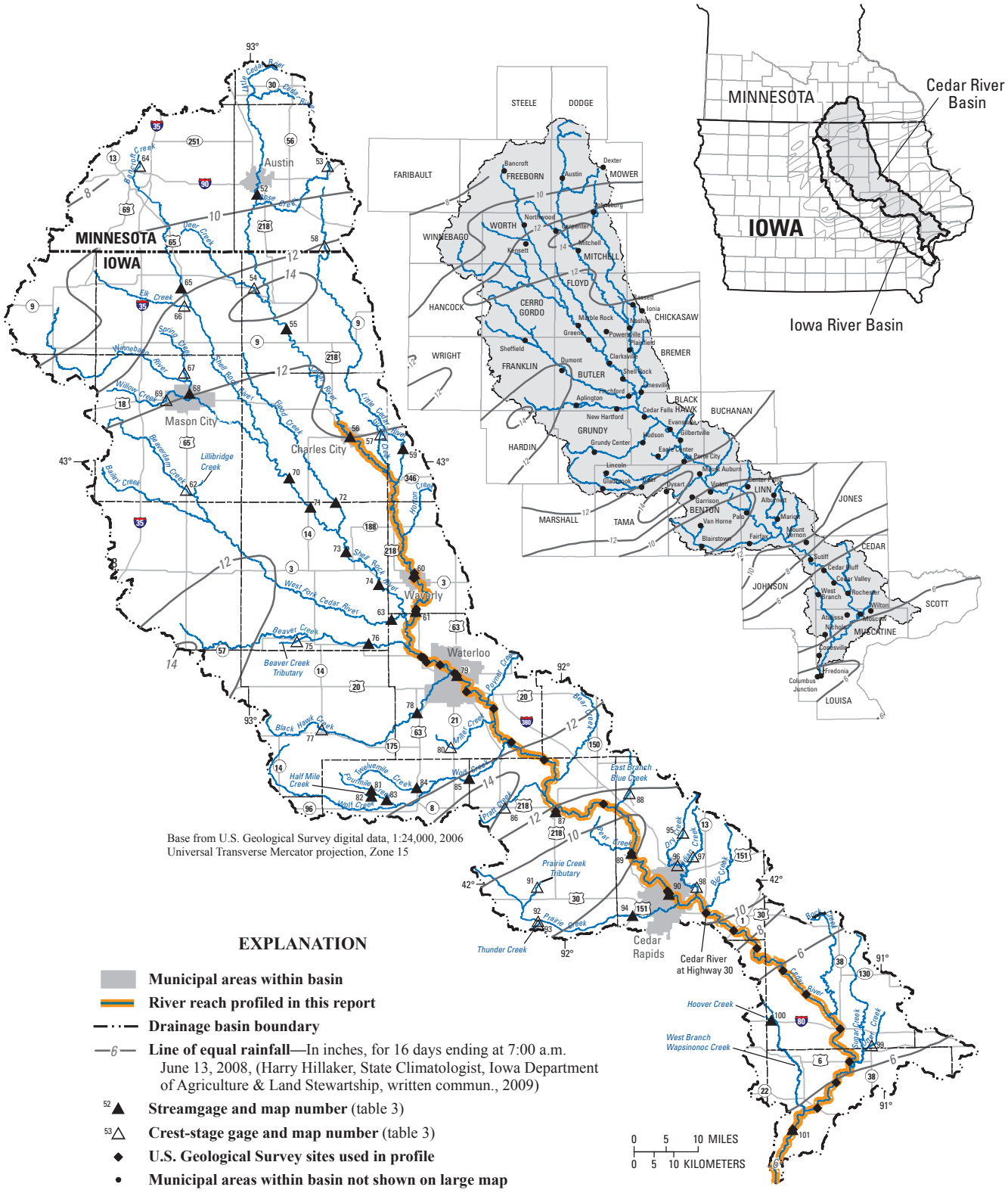


**Figure 2.** Cedar River Basin and lines of equal rainfall for 16 days beginning at 7:00 a.m. on May 29 and ending at 7:00 a.m. on June 13, 2008.

discharge records also were established at two streamgages on one major tributary to the Iowa River and at five streamgages on major tributaries to the Cedar River (figs. 1–2). From May 30 to June 15, four streamgages on minor tributaries to Iowa River and two streamgages on minor tributaries to the Cedar River also recorded new peak discharges. New maximum peak discharges also occurred on April 25 at streamgage 05463500 Black Hawk Creek at Hudson, Iowa (fig. 2, site 78), and on July 21 at streamgage 05453430 North Fork Tributary to Mill Creek near Solon, Iowa (fig. 1, site 24), bringing the total number of streamgages in the Iowa River and Cedar River Basins with record floods in 2008 to 24.

During May and June 2008, record high discharges or flood probabilities of 1 percent or smaller (100-year flooding or greater) occurred at 62 streamgage locations in Iowa, particularly in eastern Iowa (Buchmiller and Eash, 2010). New maximum peak discharges were recorded at 41 of these 62 streamgages, which include the 22 previously noted streamgages within the Iowa River and Cedar River Basins. High water and flooding in the headwater streams in north-central and eastern Iowa, particularly in June, resulted in flooding of historic proportions in the Iowa and Cedar Rivers. Previous flood peak discharges at many locations were exceeded by substantial amounts, in some cases nearly doubling the previous record peak discharge at locations where more than 100 years of streamflow record were available.

The floods of 2008 were severe in many communities in eastern Iowa, forcing the evacuation of thousands of Iowans and threatening critical infrastructures such as drinking-water supplies and wastewater facilities. The greatest urban damage was caused by the Cedar River flood in Cedar Rapids and the Iowa River flood in Iowa City; flood damage in Iowa City included University of Iowa facilities. Many major roads and highways throughout Iowa were closed during the flooding, causing substantial disruptions in transportation. Erosion and sediment deposition from the flooding damaged agricultural lands. As of June 17, 2008, many people (38,043) had been displaced from their homes across 16 counties in Iowa because of the flooding. In addition, 29 counties had received presidential emergency declarations and 83 counties were listed as state disaster areas (Boshart, *Cedar Rapids-Iowa City Gazette*, June 17, 2008).

On May 27, 2008, a Federal disaster declaration (number 1763) was issued to help Iowans recover from losses caused by severe storms, tornados, and flooding (Federal Emergency Management Agency, 2008a). The Federal disaster declaration which began with Butler County, and eventually increased to 85 counties, provided aid for losses incurred in Iowa between May 25 and August 13, 2008. From May 27, 2008, to October 31, 2008, Federal Emergency Management Agency (FEMA) officials reported that 39,928 individuals had registered for aid and as of May 22, 2009, nearly $1.3 billion of aid had been approved for individuals, families, and businesses, in Iowa, and an additional $583 million had been obligated for improvements to infrastructure (Federal Emergency Management Agency, 2009). Private property damage claims reported for residential and nonresidential buildings in 26 selected counties in eastern Iowa, and 2 counties in southern Minnesota, are shown in table 1 (Bonnie Shepard, FEMA, National Flood Insurance Program Bureau and Statistical Agent, written commun., August 2009). Approved public assistance costs (assistance to local governments for the repair of disaster-damaged public facilities) for the same 26 counties in Iowa are shown in table 2 (Dennis Harper, Iowa Homeland Security and Emergency Management Division, State Hazard Mitigation Officer, written commun., November 2009).

## Purpose and Scope

This report is part of an on-going program of preparing water-surface profiles of major floods on streams in Iowa. The program is managed in cooperation with the Iowa Department of Transportation (Iowa DOT) and the Iowa Highway Research Board (Project HR-140). Flood-peak and water-surface-elevation profile information is needed for the economical and safe location and design of bridges and other structures on or over streams and the adjacent flood plains. Defining the limits of flood inundation and establishing encroachment limits on flood plains are related issues dependent on this information. Data for major floods are needed to compute flood-probability discharges and to calibrate water-surface-elevation profile models for sites along streams. A list of other Iowa flood profile reports can be obtained by accessing *http://ia.water.usgs.gov/projects/profiles/*.

This report provides information about the May and June 2008 rainfall and floods from May 30 to June 15, 2008, in the Iowa River and Cedar River Basins, and estimated flood-probability ranges at 52 streamgages and 45 crest-stage gages (CSG) in the basins. High-water marks (HWM) at selected sites along the Iowa River are presented in a flood profile from State Highway 99 near Oakville to U.S. Highway 69 at Belmond, a distance of 319 river miles (mi). HWMs at selected sites along the Cedar River are presented in a flood profile from Fredonia near the mouth (confluence with the Iowa River) to just north of Charles City, a distance of 236 river mi.

## Study Area

The Iowa River and Cedar River Basins are adjacent watersheds draining from the northwest to the southeast across eastern Iowa. The two drainage basins, the river reaches profiled, the location of USGS streamgages within these river basins, and the location of USGS bridge sites used in the June 9–15, 2008, flood profiles are shown in figures 1–2. The Iowa River at its mouth includes the Iowa River and Cedar River Basins with a total drainage area of 12,637 square miles ($mi^2$) (Larimer, 1957). The confluence of the Iowa River and Cedar River is 29.9 mi upstream from the mouth of the Iowa River. The Cedar River Basin at the confluence is the larger basin with a drainage of 7,819 $mi^2$, of which 1,024 $mi^2$ are in Minnesota (Schwob, 1963). Excluding the contributing area

of the Cedar River Basin, the drainage area of the Iowa River Basin is 4,818 mi$^2$. The Iowa River and Cedar River Basins lie within four of Iowa's landform regions (fig. 3), the Des Moines Lobe, the Iowan Surface, the Southern Iowa Drift Plain, and the Iowa-Cedar Lowland. The Iowa-Cedar Lowland was formerly included in the Mississippi Alluvial Plain (Prior, 1991), but is now considered a separate landform because of its uniqueness and the further separation of the alluvial plain landform regions (Prior, Kohrt, and Quade, 2009). The Des Moines Lobe landform region was shaped by the most recent period of glaciation and where much of the land surface is flat to gently sloping with localized areas of depressions, lakes, and ponds. Drainage within the Des Moines Lobe generally is poor and subject to ponding after periods of heavy rain (Iowa Natural Resources Council, 1955). The Iowan Surface landform region is characterized by level to gently rolling landscape features formed by erosion. Streams draining the Iowan Surface are well established but generally have low gradients. The Southern Iowa Drift Plain landform region generally is characterized by steeper and hillier topography formed by deeply dissected drainageways as a result of long-term erosional activity (Prior, 1991). The Iowa-Cedar Lowland is a broad expansive area which includes, the lower reaches of the Iowa and Cedar Rivers to their confluence, and the Iowa River as it flows southeast into the Mississippi River Alluvial Plain landform region (fig. 3). The Iowa-Cedar Lowland landform region was shaped by historic glacial meltwater and windblown processes and is characterized by a broad, flat-floored alluvial floodplain (Prior, Kohrt, and Quade, 2009). More-extensive descriptions of the landform regions are available from Prior (1991) and Prior, Kohrt, and Quade, (2009).

The headwaters of the Iowa River are in Hancock County and small parts of Winnebago and Cerro Gordo Counties. The East Branch Iowa River and West Branch Iowa River join in Wright County to form the mainstem of the Iowa River. Downstream from Belmond, the Iowa River is slow moving and shallow, except, from Alden downstream to below Eldora, where the river flows through a gorge of exposed bedrock outcroppings. Near Le Grand, gorge-like conditions again occur, but in general, the valley floodplain is broad as the river flows through Tama and Iowa Counties. South of Iowa City, the Iowa River flows generally in a southeasterly direction through broad alluvial floodplains to its confluence with the Cedar River. The lower reach of the Iowa River, below its confluence with the Cedar River, consists of islands, sloughs, and oxbow lakes as it continues flowing in a southeasterly direction to its mouth at the Mississippi River in southeast Louisa County. Major tributaries to the Iowa River include the South Fork Iowa and English Rivers. The South Fork Iowa River, with a drainage area of 309 mi$^2$ (Larimer, 1957), originates in Hamilton County and flows southeast to its mouth in Hardin County. The English River, with a drainage area of 638 mi$^2$ (Larimer, 1957), originates in Poweshiek County and flows east to its mouth in Washington County. Other major streams flowing into the Iowa River with drainage areas greater than 200 mi$^2$ include Salt Creek, Big Bear Creek, and Old Mans Creek. Land use in the Iowa River Basin is primarily agricultural. The Iowa River flows through the larger urban areas of Marshalltown in Marshall County and Iowa City in Johnson County. Twelve low-head dams have been constructed across the Iowa River (Iowa Conservation Commission, 1979), but the dams have small pools that probably do not substantially affect the peak discharge of the river, as is the case with the Cedar River (Schwob, 1963), during large flood events. The largest dam on the Iowa River is the Coralville Dam (fig. 1, near site 25) at a height of 100 feet (ft) and was completed in 1958 by the U.S. Army Corps of Engineers for flood protection (U.S. Army Corps of Engineers, accessed October 30, 2009 at *http://www.mvr.usace.army.mil/Coralville/History.htm*). Coralville Lake is approximately 23 mi long and 5,430 acres in area at a normal pool elevation of 683 ft above sea level (U.S. Army Corps of Engineers, accessed October 30, 2009, at *http://www.mvr.usace.army.mil/Coralville/project_facts.htm*). Coralville Lake is located approximately 3 mi north of Iowa City (fig. 1).

The Cedar River originates in Dodge County, Minnesota, and flows generally in a southeasterly direction to its confluence with the Iowa River in Louisa County (fig. 2). The West Fork Cedar River is the largest tributary to the Cedar River with a drainage area of 2,639 mi$^2$ (Larimer, 1957). The West Fork Cedar River originates in Cerro Gordo County and flows southeast to its mouth in Black Hawk County. The Shell Rock River is the largest tributary to the West Fork Cedar River with a drainage area of 1,783 mi$^2$ (Larimer, 1957). The Shell Rock River originates in Freeborn County, Minnesota, and flows southeast to its mouth in Black Hawk County, which is located 1.8 mi upstream from the mouth of the West Fork Cedar River. The Winnebago River is the largest tributary to the Shell Rock River with a drainage area of 700 mi$^2$ (Larimer, 1957). The Winnebago River flows southeast from its headwaters in Freeborn County, Minnesota, to its mouth in Floyd County. Other major streams flowing into the Cedar River with drainage areas greater than 200 mi$^2$ include the Little Cedar River, Beaver Creek, Black Hawk Creek, Wolf Creek, Prairie Creek, and Sugar Creek. The upper part of the Cedar River Basin is wide and fan-shaped and the lower part of the basin is narrow. With tributary inflow from the West Fork Cedar River, Beaver Creek, and Black Hawk Creek, the drainage area of the Cedar River Basin increases from 1,661 mi$^2$ at streamgage 05458500 Cedar River at Janesville, Iowa (fig. 2, site 61) to 5,146 mi$^2$ at streamgage 05464000 Cedar River at Waterloo, Iowa (fig. 2, site 79), an increase of 210 percent (Lara, 1987). The distance between the two streamgages is 20.5 river mi. Land use is primarily agricultural in the Cedar River Basin. The Cedar River flows through the major urban areas of Waterloo in Black Hawk County and Cedar Rapids in Linn County. Twelve low-head dams have been constructed across the Cedar River (Iowa Conservation Commission, 1979), but the dams have small pools that do not substantially affect the peak discharge of the river during large flood events (Schwob, 1963).

**Table 1.** National Flood Insurance Program Bureau and Statistical Agent Iowa and Minnesota loss report for selected counties, June 1-30, 2008, as of June 30, 2009.

[Source: Bonnie Shepard, Federal Emergency Management Agency, National Flood Insurance Program Bureau and Statistical Agent, written commun., August 2009. ND, no data]

| County | Occupancy | Buildings with damage | Building damage (dollars) | Contents damage (dollars) |
|---|---|---|---|---|
| | | Iowa counties | | |
| Benton | Single-family residential | 32 | 1,096,963 | 22,568 |
| Benton | Multiple occupancy[1] | 1 | 11,225 | 0 |
| Benton | Nonresidential | 2 | 125,501 | 0 |
| Black Hawk | Single-family residential | 277 | 12,188,388 | 770,210 |
| Black Hawk | Multiple occupancy[1] | 5 | 311,852 | 0 |
| Black Hawk | Nonresidential | 15 | 1,762,260 | 879,919 |
| Bremer | Single-family residential | 283 | 9,604,336 | 197,571 |
| Bremer | Multiple occupancy[1] | 11 | 344,998 | 3,694 |
| Bremer | Multiple occupancy[2] | 1 | 68,246 | 0 |
| Bremer | Nonresidential | 23 | 1,664,008 | 112,964 |
| Buchanan | Single-family residential | 29 | 242,831 | 16,171 |
| Buchanan | Multiple occupancy[2] | 1 | 0 | 0 |
| Buchanan | Nonresidential | 2 | 15,198 | 0 |
| Butler | Single-family residential | 122 | 4,063,985 | 152,154 |
| Butler | Multiple occupancy[1] | 2 | 54,362 | 0 |
| Butler | Nonresidential | 2 | 55,574 | 5,909 |
| Cedar | Single-family residential | 4 | 333,751 | 113,630 |
| Cedar | Multiple occupancy | ND | ND | ND |
| Cedar | Nonresidential | ND | ND | ND |
| Cerro Gordo | Single-family residential | 77 | 2,258,360 | 249,186 |
| Cerro Gordo | Multiple occupancy | ND | ND | ND |
| Cerro Gordo | Nonresidential | 3 | 114,278 | 12,909 |
| Chickasaw | Single-family residential | 6 | 214,141 | 40,961 |
| Chickasaw | Multiple occupancy | ND | ND | ND |
| Chickasaw | Nonresidential | ND | ND | ND |
| Floyd | Single-family residential | 85 | 2,947,781 | 306,255 |
| Floyd | Multiple occupancy[1] | 1 | 47,492 | 0 |
| Floyd | Nonresidential | 6 | 286,012 | 0 |
| Franklin | Single-family residential | ND | ND | ND |
| Franklin | Multiple occupancy | ND | ND | ND |
| Franklin | Nonresidential | ND | ND | ND |
| Grundy | Single-family residential | 1 | 7,542 | 0 |
| Grundy | Multiple occupancy | ND | ND | ND |
| Grundy | Nonresidential | ND | ND | ND |
| Hancock | Single-family residential | ND | ND | ND |
| Hancock | Multiple occupancy | ND | ND | ND |
| Hancock | Nonresidential | ND | ND | ND |
| Hardin | Single-family residential | ND | ND | ND |
| Hardin | Multiple occupancy | ND | ND | ND |
| Hardin | Nonresidential | ND | ND | ND |
| Iowa | Single-family residential | ND | ND | ND |
| Iowa | Multiple occupancy | ND | ND | ND |
| Iowa | Nonresidential | ND | ND | ND |
| Johnson | Single-family residential | 96 | 7,707,381 | 1,378,202 |
| Johnson | Multiple occupancy[1] | 3 | 202,774 | 0 |
| Johnson | Nonresidential | 63 | 15,380,819 | 2,920,800 |

**Table 1.** National Flood Insurance Program Bureau and Statistical Agent Iowa and Minnesota loss report for selected counties, June 1-30, 2008, as of June 30, 2009.—Continued

[Source: Bonnie Shepard, Federal Emergency Management Agency, National Flood Insurance Program Bureau and Statistical Agent, written commun., August 2009. ND, no data]

| County | Occupancy | Buildings with damage | Building damage (dollars) | Contents damage (dollars) |
|---|---|---|---|---|
| | | Iowa counties—Continued | | |
| Linn | Single-family residential | 457 | 30,542,880 | 1,996,022 |
| Linn | Multiple occupancy[1] | 7 | 395,502 | 1,230 |
| Linn | Multiple occupancy[2] | 5 | 1,853,101 | 66,813 |
| Linn | Nonresidential | 85 | 21,495,220 | 11,498,402 |
| Louisa | Single-family residential | 38 | 2,272,657 | 358,037 |
| Louisa | Multiple occupancy | ND | ND | ND |
| Louisa | Nonresidential | 5 | 198,627 | 13,323 |
| Marshall | Single-family residential | 1 | 12,487 | 0 |
| Marshall | Multiple occupancy | ND | ND | ND |
| Marshall | Nonresidential | ND | ND | ND |
| Mitchell | Single-family residential | 2 | 37,539 | 23,769 |
| Mitchell | Multiple occupancy[2] | 1 | 0 | 9,831 |
| Mitchell | Nonresidential | ND | ND | ND |
| Muscatine | Single-family residential | 55 | 1,723,567 | 232,532 |
| Muscatine | Multiple occupancy | ND | ND | ND |
| Muscatine | Nonresidential | 3 | 328,203 | 0 |
| Poweshiek | Single-family residential | ND | ND | ND |
| Poweshiek | Multiple occupancy | ND | ND | ND |
| Poweshiek | Nonresidential | ND | ND | ND |
| Tama | Single-family residential | 27 | 441,298 | 46,589 |
| Tama | Multiple occupancy | ND | ND | ND |
| Tama | Nonresidential | ND | ND | ND |
| Washington | Single-family residential | ND | ND | ND |
| Washington | Multiple occupancy | ND | ND | ND |
| Washington | Nonresidential | ND | ND | ND |
| Winnebago | Single-family residential | ND | ND | ND |
| Winnebago | Multiple occupancy | ND | ND | ND |
| Winnebago | Nonresidential | ND | ND | ND |
| Worth | Single-family residential | ND | ND | ND |
| Worth | Multiple occupancy | ND | ND | ND |
| Worth | Nonresidential | ND | ND | ND |
| Wright | Single-family residential | ND | ND | ND |
| Wright | Multiple occupancy | ND | ND | ND |
| Wright | Nonresidential | ND | ND | ND |
| | | Minnesota counties | | |
| Freeborn | Single-family residential | 2 | 18,992 | 540 |
| Freeborn | Multiple occupancy | ND | ND | ND |
| Freeborn | Nonresidential | ND | ND | ND |
| Mower | Single-family residential | 24 | 262,070 | 27,656 |
| Mower | Multiple occupancy[2] | 4 | 59,224 | 0 |
| Mower | Nonresidential | 11 | 301,829 | 183,391 |
| Total | | 1,880 | 121,053,254 | 21,641,238 |

[1]Two to four family residential.

[2]Other residential.

**Table 2.** Iowa Public Assistance Program project costs for selected counties for disaster number 1763, May–June 2008, as of August 24, 2009.

[Source: Dennis Harper, Iowa Homeland Security and Emergency Management Division, State Hazard Mitigation Officer, written commun., November 2009. ND, no data]

| County | Number of applicants | Debris removal (dollars) | Emergency protective measures (dollars) | Roads and bridges (dollars) | Water control facilities (dollars) | Buildings and equipment (dollars) | Utilities (dollars) | Parks and other (dollars) | Total (dollars) |
|---|---|---|---|---|---|---|---|---|---|
| Benton | 10 | 134,488.17 | 1,959,096.51 | 563,423.67 | ND | 9,431,519.43 | 3,943,055.46 | 189,034.14 | 16,220,617.38 |
| Black Hawk | 27 | 2,444,525.45 | 2,203,811.08 | 3,513,656.37 | 336,809.42 | 4,018,746.13 | 835,777.83 | 1,660,490.07 | 15,013,816.35 |
| Bremer | 20 | 902,936.89 | 1,700,511.83 | 1,216,117.48 | 8,482.90 | 9,601,645.97 | 191,617.89 | 395,009.85 | 14,016,322.81 |
| Buchanan | 10 | 168,003.77 | 113,377.83 | 382,941.71 | 11,284.00 | 826.00 | 97,698.05 | 34,878.50 | 809,009.86 |
| Butler | 19 | 8,824,072.81 | 971,629.03 | 2,037,416.31 | 655,166.77 | 2,788,475.81 | 454,003.65 | 757,318.77 | 16,488,083.15 |
| Cedar | 3 | 72,687.75 | 47,001.16 | 31,819.51 | ND | 4,723.60 | ND | 111,060.46 | 267,292.48 |
| Cerro Gordo | 19 | 1,083,907.09 | 242,671.21 | 732,181.18 | 74,593.57 | 430,865.43 | 232,937.69 | 248,699.60 | 3,045,855.77 |
| Chickasaw | 8 | 13,264.73 | 67,447.24 | 817,784.43 | 21,430.52 | 16,161.10 | 231,062.21 | 121,718.97 | 1,288,869.20 |
| Floyd | 11 | 230,812.15 | 117,587.64 | 3,898,522.46 | 141,901.54 | 174,986.24 | 14,432.56 | 345,281.56 | 4,923,524.15 |
| Franklin | 11 | 45,950.23 | 106,847.03 | 888,862.03 | 85,481.57 | 13,545.48 | 11,215.61 | 102,187.48 | 1,254,089.43 |
| Grundy | 6 | 15,252.64 | 45,306.07 | 275,156.66 | ND | 6,177.66 | 93,405.74 | 21,480.86 | 456,779.63 |
| Hancock | 8 | 64,260.20 | 72,282.79 | 110,818.63 | 31,798.50 | 8,104.00 | 5,123.05 | ND | 292,387.17 |
| Hardin | 8 | 79,126.07 | 57,206.81 | 139,524.98 | 54,726.13 | 93,628.16 | 64,852.50 | 78,341.65 | 567,406.30 |
| Iowa | 6 | 28,170.14 | 167,731.23 | 1,237,798.42 | ND | 8,892.12 | ND | 12,841.84 | 1,455,433.75 |
| Johnson | 14 | 1,737,065.83 | 9,511,435.87 | 642,285.03 | 1,407,180.42 | 137,044,005.13 | 1,939,362.59 | 731,890.62 | 153,013,225.49 |
| Linn | 29 | 10,844,113.82 | 70,067,385.30 | 8,356,564.99 | 222,305.17 | 127,657,041.62 | 29,374,609.87 | 2,608,574.10 | 249,130,594.87 |
| Louisa | 16 | 670,979.71 | 2,500,408.62 | 1,135,026.88 | 239,271.87 | 827,374.37 | 624,087.74 | 235,123.74 | 6,232,272.93 |
| Marshall | 7 | 22,995.52 | 76,003.73 | 332,305.78 | ND | 104,323.04 | 669,526.16 | 20,407.35 | 1,225,561.58 |
| Mitchell | 7 | 362,216.22 | 36,838.17 | 775,983.26 | ND | 1,530.54 | 18,143.71 | 49,069.88 | 1,243,781.78 |
| Muscatine | 4 | 796,688.64 | 53,169.04 | 1,962,408.49 | ND | 49,411.81 | 396,962.17 | 448,958.04 | 3,707,598.19 |
| Poweshiek | 3 | 34,160.25 | 7,582.50 | 232,326.48 | ND | ND | ND | 2,161.00 | 276,230.23 |
| Tama | 12 | 74,125.76 | 186,933.47 | 598,437.47 | 21,247.96 | 139,377.73 | 18,439.56 | 744,425.88 | 1,782,987.83 |
| Washington | 1 | ND | ND | 128,027.25 | ND | ND | ND | ND | 128,027.25 |
| Winnebago | 5 | 8,900.00 | 48,307.76 | 55,337.28 | ND | 1,585.64 | 4,488.15 | ND | 118,618.83 |
| Worth | 9 | 1,672,427.41 | 55,449.43 | 339,548.06 | 16,950.27 | ND | ND | 13,335.25 | 2,097,710.42 |
| Wright | 8 | 33,763.33 | 74,413.66 | 297,159.82 | ND | 23,915.01 | 30,887.42 | 10,741.34 | 33,763.33 |
| Total | 281 | 30,364,895 | 90,490,435 | 30,701,435 | 3,328,631 | 292,446,862 | 39,251,690 | 8,943,031 | 495,089,860 |

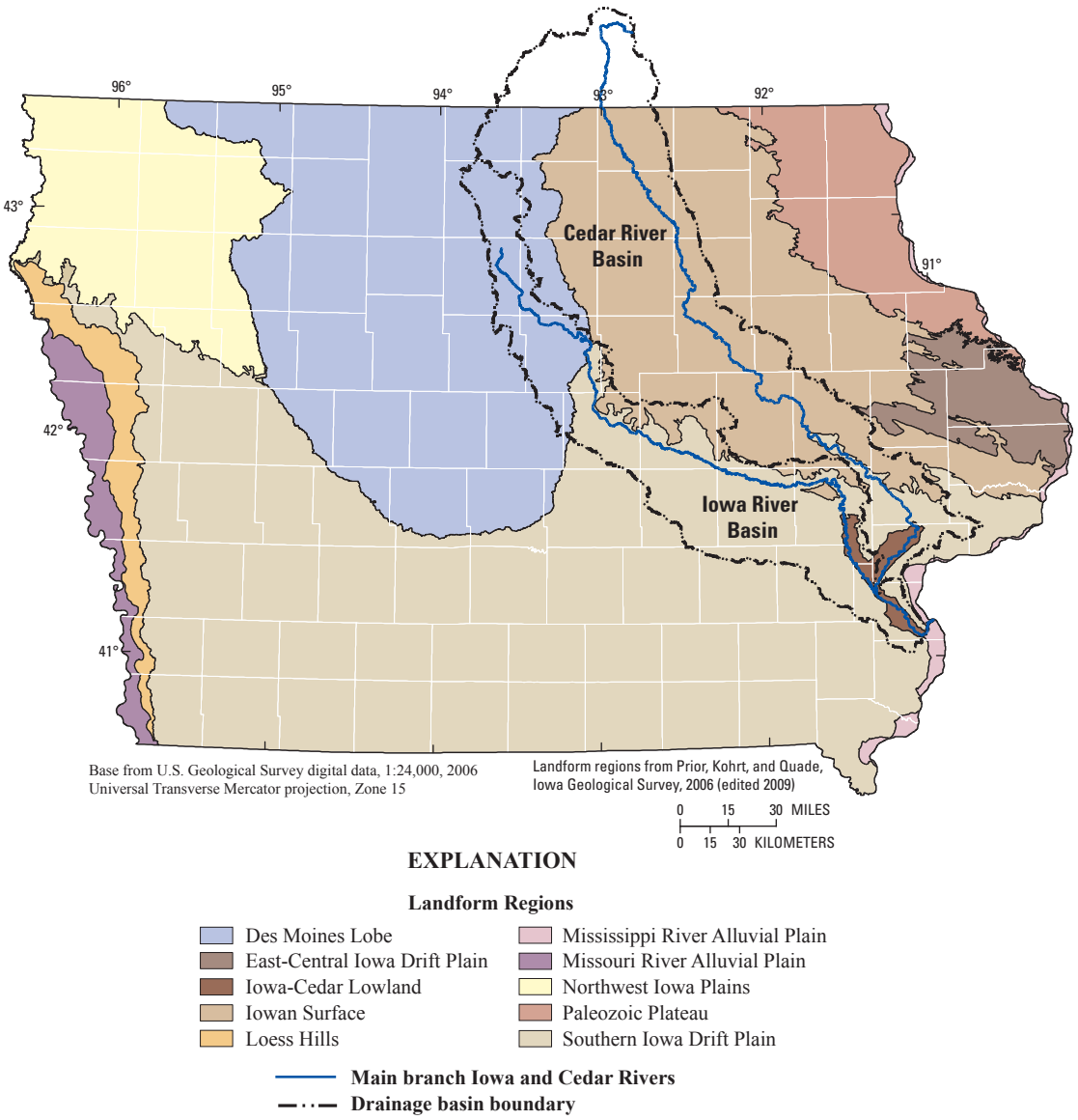


**Figure 3.** Iowa River and Cedar River Basins and landform regions of Iowa.

# Floods of May 30 to June 15, 2008

The floods of May 30 to June 15, 2008, are some of the largest floods on record in the Iowa River Basin and is the largest flood on record in the Cedar River Basin (table 3, at the back of this report). Within the lower part of the Iowa River Basin, the 2008 flood along the mainstem from the streamgage 05453100 Iowa River at Marengo, Iowa (fig. 1, site 22) to the streamgage 05465500 Iowa River at Wapello, Iowa (fig. 1, site 103) is the largest flood on record since regulation of the Iowa River began in 1958 with the operation of the Coralville Dam, with the exception of the streamgage 05455700 Iowa River near Lone Tree, Iowa (fig. 1, site 51) where the 2008 flood is the second largest flood since regulation. Within the Cedar River Basin, the floods of May 30 to June 15, 2008, are the largest on record at all six streamgages located on the mainstem of the Cedar River from the streamgage 05457700 Cedar River at Charles City, Iowa (fig. 2, site 56) to the streamgage 05465000 Cedar River near Conesville, Iowa (fig. 2, site 101) and at five streamgages located on major tributaries. At the streamgage 05464500 Cedar River at Cedar Rapids, Iowa (fig. 2, site 90), the 2008 flood is the largest known since streamgage operation began in 1903. Downstream from the confluence of the Iowa and Cedar Rivers, at the 05465500 Iowa River at Wapello, Iowa streamgage, the 2008 flood also is the largest known since 1903.

## Flood Probability

Flood probability is an estimate of the likelihood of a flood of a specific magnitude occurring in any 1 year, and a flood-probability range expresses the uncertainty of estimating

precise flood probabilities. The reporting ranges are: greater than 10 percent, 4 to 10 percent, 2 to 4 percent, 1 to 2 percent, 0.2 to 1 percent, and less than 0.2 percent. The range is determined by the estimated flood-probability discharges that bracket the observed flood-peak discharge. If the observed peak discharge is the same value as an estimated flood-probability discharge, the lower flood-probability range is used. In the "Flood Description" section and in appendix 1, flood discharges and their respective flood-probability ranges are discussed and are listed in table 3. Unless noted otherwise, flood-probability estimates listed in table 3 were computed using the Weighting of Independent Estimates (WIE) program (Charles Berenbrock and Tim Cohn, U.S. Geological Survey, written commun., 2008) following guidelines in Appendix 8 of Bulletin 17B (Interagency Advisory Committee on Water Data, 1982). The WIE program uses the variance and estimate of the Bulletin 17B streamgage-probability analysis and the variance and estimate of the regional-regression probability calculation (Eash, 2001) to compute a weighted estimate and variance at a streamgage. As noted in table 3, the WIE program was not used to estimate flood probabilities for streamgages with peak-flow records of less than 10 years, in which case only regional-regression probability calculations were used; nor was the WIE program used to estimate flood probabilities for streamgages with basin characteristic values outside of the applicable range of characteristic values used to develop the regional-regression probability calculations, in which case only Bulletin 17B streamgage-probability analyses were used.

For rivers that are noted as regulated in table 3, flood probabilities were computed by the U.S. Army Corps of Engineers (USACE, 2009). Current estimates of flood-probability discharges computed by USACE for regulated streamgages at 05453520 Iowa River below Coralville Dam near Coralville, Iowa (fig.1, site 25), 05454500 Iowa River at Iowa City, Iowa (fig. 1, site 37), 05455700 Iowa River near Lone Tree, Iowa (fig.1, site 51), and at 05465500 Iowa River at Wapello, Iowa (fig. 1, site 103) include the flood-control effect of the Coralville Dam. Current flood-probability estimates for the Iowa City streamgage are lower than those computed for the unregulated streamflow period before the dam was built (Fischer and Eash, 1998), thus the difference in estimated flood-probability ranges listed in table 3 between peak discharges that occurred before and after operation of the dam began in 1958.

Flood probabilities change as streamflow records get longer. Bulletin 17B probability analyses are computed for streamgages using annual peak discharges. Annual peak discharges recorded for the streamgages 05454500 Iowa River at Iowa City, Iowa (fig. 1, site 37) and 05464500 Cedar River at Cedar Rapids, Iowa (fig.2, site 90) are shown in figures 4 and 5. As additional annual peak discharges are measured at streamgages, Bulletin 17B probability estimates are updated and become more statistically reliable. Bulletin 17B, 1-percent probability estimates computed for the Cedar River at Cedar Rapids streamgage for annual peak discharge records ranging from 10 to 106 years is shown in figure 5. A minimum of 10 years of record are required to compute Bulletin 17B probability estimates, thus the 1-percent flood-probability estimates shown in figure 5 range from 10 years (1903–1912) to 106 years (1903–2008) of record (the historic 1851 flood discharge was not included in the probability analyses). The 1-percent flood-probability estimate increases following a large flood event, such as the 1917, 1929, 1933, 1961, 1965, and 2008 floods, and decreases during a period without large flood events, such as the 1918–28 and 1973–89 periods shown on figure 5.

Flood probabilities formerly were reported as flood recurrence intervals expressed in years. For example, a 1-percent flood-probability discharge is the same as the 100-year recurrence-interval flood discharge. But, because of widespread confusion caused in recent years by two or more "100-year floods" occurring in a period of much less than 100 years, the scientific and engineering community has begun expressing the annual likelihood of occurrence of flood discharges as a probability. Percent probability is the inverse of the recurrence interval multiplied by 100. Selected flood probabilities and equivalent flood recurrence intervals are listed in table 4.

**Table 4.** Flood probability and equivalent flood recurrence interval for selected probabilities.

| Flood probability (percent) | Recurrence interval (years) |
|---|---|
| 20 | 5 |
| 10 | 10 |
| 4 | 25 |
| 2 | 50 |
| 1 | 100 |
| .5 | 200 |
| .2 | 500 |

## Storm Description

Heavy rain fell over much of eastern Iowa in late May and the first 2 weeks of June. The storms were part of an exceptionally wet period from May 29 through June 12, when Iowa had a statewide average of 9.03 in. of rainfall; the normal statewide average for the same period is 2.45 in. Leading up to this period of heavy rainfall was a wetter than normal August and October in 2007 followed by an unusually heavy snowpack during the 2007–2008 winter. For a statewide average in February, this snowfall was the third heaviest amount recorded. As a result, the saturated soil and high river levels leading into late May and June 2008 set the stage for severe flooding. Overall, 2008 was the fourth wettest year on record in Iowa, which had an average rainfall of 43.79 in. (Hillaker, 2008a).

The following rainfall and flood information is from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Climatic Data Center (2008a).

*"A very unstable airmass moved into Iowa during the day on May 29 as a warm front lifted north into the state during the afternoon. Thunderstorms erupted quickly during the late afternoon and evening hours over western Iowa and stretching into north central Iowa. The storms became severe with hail and high winds. Most of the hail reported was pea to marble size. Several tornadoes were also reported during the storm. A band of 3 to 5 in. of rain fell between U.S. Highway 30 and U.S. Highway 20 during the event. Extensive flooding occurred along rivers across the central third of the state. On the morning of May 30th heavy rains of 2 to 5 in. resulted in flash flooding in numerous areas across Benton County. U.S. Highway 218 was impassible at several locations due to water flowing over the highway. Other county roads were covered with water as several area streams and creeks overflowed their banks. A bridge on County Road V61 north of Vinton was washed out due to the flash flooding.*

*A warm front draped across northern Missouri and west central Illinois was the focal point for the repeated development of heavy rain-producing showers and thunderstorms during the late evening of June 2 through the early morning of June 4. Scattered showers and thunderstorms initially developed along the boundary over southeast Iowa, northeast Missouri, and west central Illinois during the late evening and overnight hours. Between 6 and 10 a.m. on June 3, a bowing line of thunderstorms raced southeast out of central Iowa into central Illinois producing heavy rains and damaging winds. Heavy rains of 1 to 2 in. fell in a short amount of time resulting in some flash flooding in several parts of Iowa County during the morning and early afternoon hours of June 3. Heavy rains of 1 to 2.5 in. in a short amount of time resulted in flash flooding of some streets near the intersection of Melrose Ave. and Mormon Trek Blvd. (not shown on map) in Iowa City.*

*On June 4, a strong surge of very moist and unstable air moved into Iowa as a warm front stretched east to west along the Iowa/Missouri border. Thunderstorms erupted by the evening and a cyclic supercell developed over southwest Iowa. By the time the night was done, three separate supercells took a similar track across southern Iowa. A cluster of thunderstorms formed over northern Iowa as well. Severe weather was isolated with this area of storms. Copious amounts of rain fell with the storms, both the supercells and the cluster across the north. Flooding became widespread with numerous reports of water over the roads along the track of the supercells, and also over parts of north central into northeast Iowa. The heaviest rainfall occurred over southwest Iowa, where northwest of Creston picked up nearly 8 in. of rain.*

*A very dynamic weather situation unfolded during June 5 and into the day on June 6. A strong upper level low pressure area lifted northeast out of the southern Rockies with a negatively tilted trough of low pressure lifting northeast across the central U.S. An intense low pressure area developed over northern Kansas and lifted north into southeast North Dakota by the morning of June 6. Thunderstorms erupted to the southwest of Iowa in central Kansas, along the dry line there. The storms raced northeast into Iowa by sunset. The most significant feature with this event was the flash flooding. Soil conditions across the state were very saturated. Any significant rainfall resulted in flash flooding. A narrow band of heavier rainfall stretched from south central into central Iowa. Flash flooding occurred in the Des Moines metro area as the airport recorded 4.15 in. of rainfall for the day, with about 3 in. falling in two hours.*

*Low pressure developed over Kansas with a strong southerly flow of very moist air streaming into Iowa ahead of it. A semi-stationary front extended northeast from the low, across northern Iowa during the afternoon into the evening hours. During the initial phase of the severe event, high winds and hail were reported along the line of thunderstorms that formed from northern into west central Iowa. There were four reports of tornadoes in Worth, Winnebago and Cerro Gordo Counties during the afternoon hours of June 7. This was with the initial round of storms. The event transitioned into a major Flood/Flash Flood event during the evening and early morning hours with many locations reporting 1 to 2 in. of rainfall, and spotty amounts of around 5 in. in just a few hours time. The line moved very little for a period of several hours. During the predawn hours, the line became broad and weakened to generally below severe limits. A new round of thunderstorms from Nebraska, which was the southwest part of the extensive line, moved into west central and southwest Iowa. The storm generally remained below severe levels for the most part, but they did produce very heavy rains. Another line of thunderstorms formed and re-intensified along the frontal boundary by the early afternoon hours. Initially, the storms produced strong winds and some small hail. The antecedent soil conditions in Iowa were extremely wet, such that flash flooding was caused by rainfall of an in. or more in an hour, even in rural areas. Heavy rainfall of 3 to 6 in. occurred in a broad swath extending from west-central into north-central, and parts of central and northeast Iowa. This resulted in widespread flash flooding. Eventually, the rain led to major record flooding along many of the rivers in the state.*

*On June 12, an unseasonably strong storm system aloft was located over the northern Rockies. This produced a very strong northward push of moisture into Iowa. An intense line of thunderstorms formed from eastern Nebraska into central Kansas. Many of the storms produced pea to marble size hail, with the stronger storms producing hail around nickel size. After sunset, the storms became more wind producers. The big story became the heavy rain. Many of the storms produced rainfall of 1 to 2 in. per hour, with some areas reporting total rainfall of up to 4 or 5 in. With the very wet soil conditions across the state, it only took between 1/2 and 1 in. of rain to cause flash flooding.*

*A strong cold front moved through eastern Iowa, northeast Missouri, and northern Illinois from June 12 through midday June 13 bringing widespread heavy rains of 1 to 5 in. (with some areas receiving up to around 10 in.), flash flooding, large hail, damaging wind gusts, and two isolated weak tornadoes to the region."*

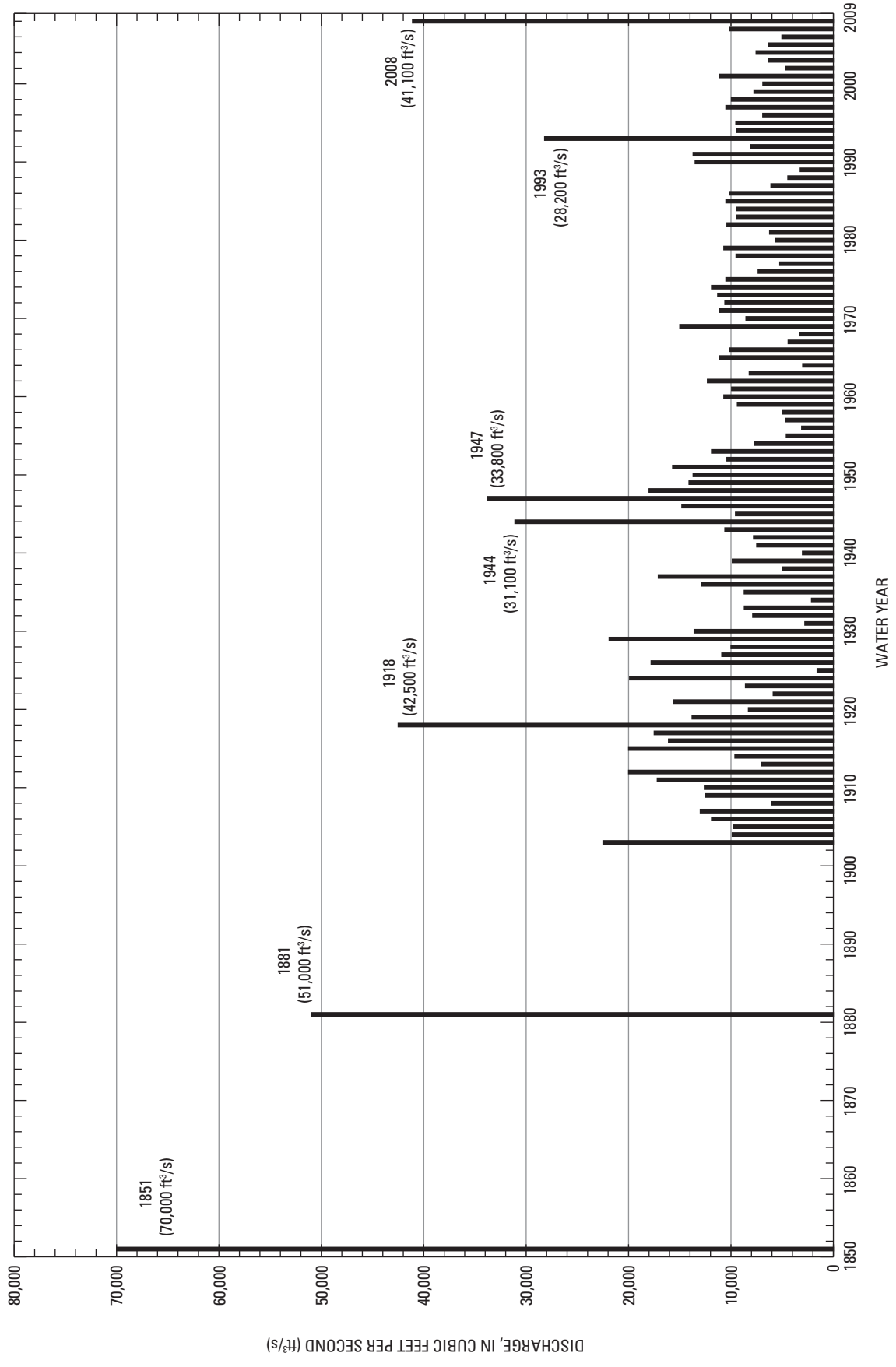


**Figure 4.** Annual peak discharge record for the streamgage 05454500 Iowa River at Iowa City, Iowa. Peak discharges for 1851 and 1881 were estimated from flood elevations collected in 1851 and 1881 by local sources.

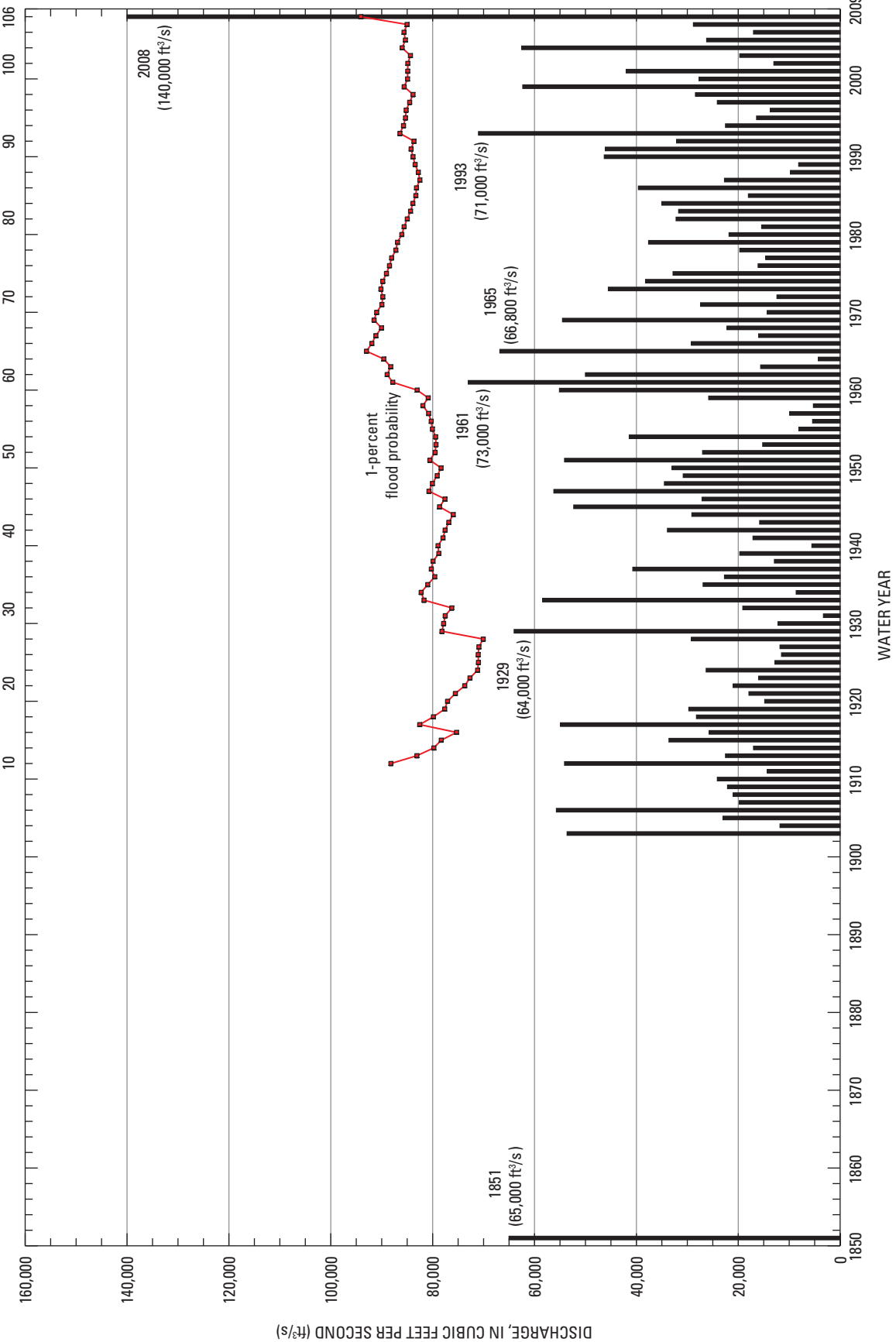


**Figure 5.** Annual peak discharge record and 1-percent flood probability for the streamgage 05464500 Cedar River at Cedar Rapids, Iowa. Peak discharge for 1851 was estimated from flood elevations collected in 1851 by local sources.

Four-hour cumulative rainfall amounts for May 29 to June 13, 2008, for rain gages at Iowa Falls, Iowa City, Mason City, and Waterloo are shown in figure 6. The rainfall data are collected hourly at each site (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Climatic Data Center, 2008d and 2008e). The 4-hour cumulative total begins at midnight. The graphs provide a general indication of the timing and intensity of the rainfall in the Iowa River and Cedar River Basins. The greatest rainfall intensity occurred at Iowa Falls between 8 p.m. and midnight on June 7 during which 2.9 in. of rain fell (fig. 6*A*). Data from the Iowa Falls, Mason City, and Waterloo rain gages indicate that much of the rainfall occurred from May 29–30, and again with even greater amounts, in a 24-hour period from 8 p.m. on June 7 to 8 p.m. on June 8, and also indicate that Mason City recorded the greatest 24-hour and 48-hour rainfall of 6.30 in. and 6.37 in., respectively. The Iowa Falls rain gage recorded the greatest 16-day total of 14.0 in. Little rain fell across eastern Iowa from May 31 to June 2.

Isohyetal maps of the areal distribution of rainfall for the 16-day period beginning at 7:00 a.m. on May 29 and ending at 7:00 a.m. on June 13, 2008, are shown in figures 1 and 2; data were provided by Harry Hillaker, State Climatologist, Iowa Department of Agriculture and Land Stewardship (written commun., October 2009). Each 24-hour rainfall amount from May 29 to June 13, 2008, for 34 selected rain gages in the Iowa River and Cedar River Basins is listed in table 5 (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Climatic Data Center, 2008b, 2008c, 2008d, 2008e; and Hillaker, 2008b, 2008c). The 16-day rainfall total listed in table 5 from May 29 to June 13 is the time period for which the most significant rainfall could be considered directly contributing to the flooding of May 30 to June 15, 2008. Sixteen-day rainfall totals recorded at Iowa Falls and Clutier on June 13 were 14.0 and 13.83 in., respectively.

*The Rainfall Frequency Atlas of the Midwest* (Huff and Angel, 1992) provides a table of the mean distribution of theoretical rainfall amounts for climatological divisions in Iowa for selected rain periods and probabilities (recurrence intervals). The magnitude and probability of theoretical rainfall amounts for selected rain periods (durations) from the table in Huff and Angel (1992) for 5 of the 9 climatological divisions in Iowa are listed in table 6. Twelve of the 34 rain gages listed in table 5 are in the North-Central Iowa Climatological Division, 11 of the rain gages are located in the Central Climatological Division, 8 in the East-Central Climatological Division, 2 in the Northeast Climatological Division, 1 is located in the Southeast Climatological Division (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Climatic Data Center, 2008b, 2008c, 2008d, 2008e; and Hillaker, 2008b, 2008c). A map showing the location of climatological divisions in Iowa is available at *http://www.esrl.noaa.gov/psd/data/usclimdivs/data/map.html*. The greatest 48-hour rainfalls listed in table 5 exceeded 5 in. at seven rain gages located in two climatological divisions (Mason City and Osage rain gages located in the North-Central Climatological Division, and Clutier, Garwin, Iowa Falls, and Toledo rain gages located in the Central Climatological Division). Rainfall probabilities for greatest 48-hour rainfalls for 6 of these 7 rain gages are all estimated to be 4 to 10 percent. The rainfall probability for the largest 48-hour rainfall value listed in table 5 (6.37 in.) for the Mason City Municipal Airport rain gage is estimated to be 2 to 4 percent (table 6).

Probabilities for two different components of a hydrologic event – rainfall and runoff, respectively, and for various locations in the Iowa River and Cedar River Basins are listed in tables 6 and 3. Although the probability is an estimate of the likelihood of a rainfall or flood discharge of a specific magnitude occurring in any one year, more than one rainfall or flood discharge with a specific magnitude and probability could occur in the same year.

## Flood Description

Severe flooding occurred in the Iowa River and Cedar River Basins as a result of the long and intense periods of rain that fell in late May and early June. The 2008 peak discharges for 54 streamgages in the Iowa River and Cedar River Basins are listed in table 3. Also listed in the table are selected historical peak discharges.

Hydrographs of instantaneous discharges measured at selected continuous-record streamgages on the Iowa and Cedar Rivers are presented in figures 7*A*, 7*B*, 8*A*, and 8*B*. The period of record shown is May 29 to July 15, 2008. The streamgages record instantaneous values at 15- or 30-minute time intervals. Gaps in the hydrograph lines indicate missing data that resulted because of equipment malfunction caused by the flooding. Also shown on the hydrographs are lines denoting discharge estimates for selected flood probabilities. The flood-probability range listed in table 3 for the sites is the range between the flood-probability discharges that bracket the flood peak discharge. For example, the 2008 peak discharge at streamgage 05465000 Cedar River near Conesville, Iowa (fig. 2, site 101) falls between the 1-percent and 0.2-percent flood-probability estimates (table 3 and fig. 8*B*). Flood probability estimates for all streamgages downstream of from Coralville Dam were computed by the USACE (U.S. Army Corps of Engineers, 2009).

Discharge hydrographs for the 2008 water year for the streamgages 05454500 Iowa River at Iowa City, Iowa (fig. 1, site 37) and 05464500 Cedar River at Cedar Rapids, Iowa (fig. 2, site 90) are shown on figures 9 and 10. Also shown are long-term median daily discharges calculated for the regulated period of record (1959–2008) for streamgage 05454500 Iowa River at Iowa City, Iowa and calculated for the entire period of record (1903–2008) for streamgage 05464500 Cedar River at Cedar Rapids, Iowa. The discharge for the National Weather Service (NWS) flood stage at each streamgage also is shown. From October to late May, streamflows at both streamgages stayed almost consistently above the long-term median daily

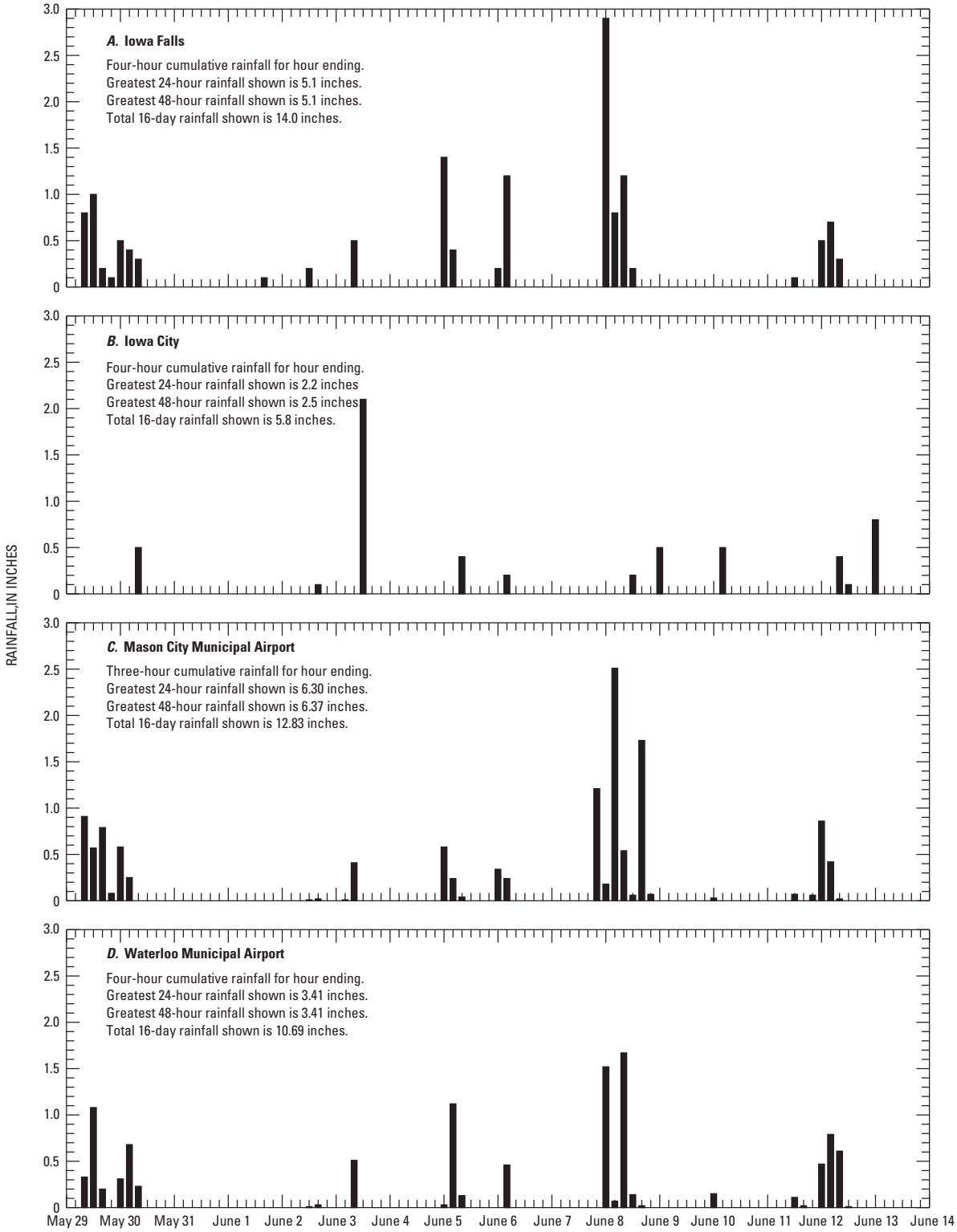


**Figure 6.** Four-hour cumulative rainfall for May 29 to June 13, 2008, at four rain gages in the Iowa River and Cedar River Basins (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Climatic Data Center, 2008d, 2008e).

**Table 5.** Twenty-four-hour rainfall amounts at selected rain gages in eastern Iowa from May 29 to June 13, 2008.

[ND, no data; T, Trace; *, rainfall included in the next day total]

| Rain gage | Observation time | 24-hour rainfall, in inches[1,2,3] | | | | | | | | | | | | | | | | Greatest 48-hour rainfall total, in inches | 16-day rainfall total, in inches |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | May 29, 2008 | May 30, 2008 | May 31, 2008 | June 1, 2008 | June 2, 2008 | June 3, 2008 | June 4, 2008 | June 5, 2008 | June 6, 2008 | June 7, 2008 | June 8, 2008 | June 9, 2008 | June 10, 2008 | June 11, 2008 | June 12, 2008 | June 13, 2008 | | |
| Allison | 7 a.m. | 0.16 | 2.05 | 0 | 0 | 0 | 0.21 | 0.29 | 1.60 | 0.91 | 0 | 2.12 | 0.96 | 0 | 0 | 1.25 | 0 | 3.08 | 9.55 |
| Belle Plaine | 7 a.m. | 1.62 | .02 | 0 | 0 | 0.52 | .71 | 1.69 | .22 | 0 | 0 | 1.10 | 1.05 | 0 | 1.70 | .35 | 0 | 2.40 | 8.98 |
| Brooklyn | 7 a.m. | 0 | 1.23 | 0 | 0 | 0 | .62 | 1.12 | 1.58 | .30 | 0 | .13 | 1.20 | 1.13 | 0 | 2.14 | 0.34 | 2.70 | 9.79 |
| Buckeye | 6 a. m. | .40 | ND | ND | 0 | 0 | .78 | .16 | .89 | 1.30 | 0 | 3.22 | 1.25 | .13 | 0 | 1.57 | 0 | 4.47 | 9.70 |
| Cedar Rapids Ap | Midnight | .35 | 1.06 | 0 | T | .30 | .61 | .21 | 1.38 | .18 | T | 2.41 | .14 | .42 | .06 | 1.73 | 0 | 2.55 | 8.85 |
| Cedar Rapids-1 | 5 p.m. | .38 | 1.35 | 0 | 0 | .22 | .44 | 0 | 1.30 | .16 | 0 | 1.13 | .41 | .36 | .09 | 3.35 | .42 | 3.77 | 9.61 |
| Charles City | 7 a.m. | T | 2.18 | 0 | 0 | 0 | .39 | .17 | 1.66 | .91 | 0 | 3.38 | 1.40 | .05 | 0 | 1.59 | .07 | 4.78 | 11.8 |
| Clutier | 7 a.m. | .13 | * | 5.74 | 0 | 0 | .77 | 0 | 1.24 | .03 | 0 | 0 | 3.28 | .73 | 0 | 1.72 | .19 | 5.74 | 13.83 |
| Dumont | 7 a.m. | .55 | 2.05 | 0 | 0 | 0 | .61 | 0 | 2.59 | 1.20 | 0 | 3.42 | .83 | 0 | 0 | 0 | 1.59 | 4.25 | 12.84 |
| Eldora | 7 a.m. | .43 | 2.84 | 0 | 0 | 0 | .76 | .04 | .71 | 1.59 | 0 | 1.70 | .03 | .06 | 0 | 2.23 | 0 | 3.27 | 10.39 |
| Forest City 2 NNE | Midnight[3] | 1.50 | 0 | .20 | 0 | 0 | .30 | .40 | .30 | .20 | 1.40 | 2.90 | 0 | 0 | 1.50 | .40 | 0 | [4]4.30 | 9.10 |
| Garwin | 7 a.m. | 0 | 5.40 | 0 | 0 | 0 | .30 | .44 | .64 | .54 | T | 2.76 | 0 | .54 | 0 | 2.22 | 0 | 5.40 | 12.84 |
| Gilman | 7 a.m. | 0 | 2.15 | 0 | 0 | 0 | .70 | 1.0 | 1.35 | .45 | 0 | .02 | 2.75 | .82 | 0 | 1.84 | .25 | 3.57 | 11.33 |
| Grundy Center | 7 a.m. | .55 | 2.59 | T | 0 | 0 | .68 | .12 | .53 | .73 | 0 | 1.40 | .71 | .13 | 0 | 2.69 | .02 | 3.14 | 10.15 |
| Hampton | 7 a.m. | .57 | 2.54 | 0 | 0 | 0 | .48 | 0 | 1.62 | .85 | 0 | 3.65 | .73 | .02 | 0 | 1.11 | .06 | 4.38 | 11.63 |
| Ionia 2 W | 8 a.m. | 0 | 2.38 | 0 | 0 | 0 | 0 | 0 | 1.55 | .87 | 0 | 1.93 | 1.68 | .04 | 0 | 1.65 | 0 | 3.61 | 10.1 |
| Iowa City | Midnight[3] | 0 | .50 | 0 | 0 | .10 | 2.10 | 0 | .40 | .20 | 0 | .70 | 0 | .50 | 0 | 1.30 | 0 | [4]2.50 | 5.80 |
| Iowa Falls | Midnight[3] | 2.60 | .70 | 0 | .10 | .20 | .50 | 1.40 | .60 | 1.20 | 2.90 | 2.20 | 0 | 0 | .60 | 1.0 | 0 | [4]5.10 | 14.0 |
| Lake Mills | 7 a.m. | .46 | 2.24 | 0 | 0 | 0 | .22 | .02 | .44 | .39 | 0 | 2.60 | .70 | 0 | .02 | 3.25 | 0 | 3.30 | 10.34 |
| Marshalltown | 7 a.m. | .02 | 3.17 | 0 | 0 | 0 | .79 | .40 | 1.18 | .57 | 0 | .22 | 2.0 | .40 | 0 | 2.62 | T | 3.19 | 11.37 |
| Mason City | 7 a.m. | .31 | 2.63 | .02 | 0 | 0 | .40 | .02 | .94 | .48 | 0 | 3.47 | 1.61 | .01 | T | 1.36 | 0 | 5.08 | 11.25 |
| Mason City Muni AP | Midnight[3] | 2.93 | .25 | 0 | 0 | .03 | .42 | .58 | .62 | .24 | 1.39 | 4.91 | .03 | T | .99 | .44 | 0 | [4]6.37 | 12.83 |
| Northwood | 7 a.m. | .63 | 1.74 | 0 | 0 | 0 | .16 | 0 | .49 | .41 | .19 | 3.63 | .89 | 0 | .13 | 2.49 | 0 | 4.52 | 10.76 |
| Osage | 7 p.m. | .43 | 2.0 | T | 0 | 0 | .36 | .05 | .90 | .60 | 0 | 3.63 | 1.50 | 0 | 1.65 | 1.80 | 0 | 5.13 | 12.92 |
| Parkersburg | 7 a.m. | 0 | 2.64 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.50 | 0 | 0 | 0 | 2.10 | 0 | 3.50 | 8.24 |
| Popejoy 1S | 7 a.m. | 0 | 3.45 | 0 | 0 | 0 | .51 | 0 | 1.70 | .59 | 0 | 4.10 | 0 | 0 | 1.73 | 0 | 0 | 4.10 | 12.08 |
| Swisher | 7 a.m. | 0 | 2.02 | 0 | 0 | 0 | 0 | 1.49 | 1.58 | .21 | 0 | .02 | 2.61 | .30 | 0 | .80 | .84 | 3.07 | 9.87 |
| Tipton | 7 a.m. | T | .58 | .16 | 0 | 0 | .07 | .52 | .76 | .32 | 0 | .08 | .51 | .40 | 0 | .04 | .76 | 1.28 | 4.20 |
| Toledo 3N | 7 a.m. | T | 5.22 | 0 | 0 | 0 | .39 | .33 | .97 | .36 | 0 | T | 3.16 | .57 | 0 | 2.49 | .13 | 5.22 | 13.62 |
| Vinton | 7 a.m. | 0 | 4.25 | 0 | 0 | 0 | .12 | .50 | 1.0 | .25 | 0 | 0 | 2.41 | .40 | 0 | 1.57 | .84 | 4.25 | 11.34 |
| Walford 2 SE | 7 a.m. | 0 | 1.77 | 0 | 0 | 0 | .50 | .60 | 1.48 | .30 | 0 | 0 | 2.54 | .44 | 0 | 1.65 | .95 | 2.98 | 10.23 |
| Wapello | 7 a.m. | 0 | 0 | 1.11 | 0 | 0 | 0 | 1.30 | 0 | .57 | 0 | .39 | .66 | .33 | 0 | 0 | 3.52 | 3.52 | 7.88 |
| Waterloo Muni AP | Midnight[3] | 1.92 | .91 | 0 | 0 | .04 | .51 | .03 | 1.25 | .46 | 1.52 | 1.89 | .15 | T | .60 | 1.41 | 0 | [4]3.41 | 10.69 |
| Zearing | 7 a.m. | .16 | 4.15 | 0 | 0 | 0 | 1.12 | .02 | .49 | 1.81 | 0 | 1.33 | .18 | .15 | T | 2.38 | 0 | 4.31 | 11.79 |

[1]Climatological Data, Iowa (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Climatic Data Center, 2008b, 2008c).

[2]Iowa Climate Review (Iowa Department of Agriculture and Land Stewardship, State Climatologist Office, 2008b, 2008c).

[3]Hourly Precipitation Data, Iowa (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Climatic Data Center, 2008d, 2008e).

[4]Calculated from hourly precipitation data shown on figure 6.

**Table 6.** Magnitude and probability of theoretical rainfall amounts for selected storm periods in the North-Central, Central, East-Central, Northeast, and Southeast Iowa Climatological Divisions.

(Rainfall amounts from Huff and Angel, 1992)

| Duration (hours) | Rainfall (inches) for indicated probabilities | | | |
|---|---|---|---|---|
| | 10 (percent) | 4 (percent) | 2 (percent) | 1 (percent) |
| North-Central | | | | |
| 24 | 4.38 | 5.33 | 6.14 | 7.07 |
| 48 | 4.78 | 5.80 | 6.67 | 7.67 |
| 72 | 5.15 | 6.33 | 7.30 | 8.30 |
| 120 | 5.80 | 7.00 | 8.03 | 9.28 |
| 240 | 7.32 | 8.93 | 10.37 | 11.40 |
| Central | | | | |
| 24 | 4.27 | 5.15 | 5.87 | 6.61 |
| 48 | 4.67 | 5.75 | 6.52 | 7.33 |
| 72 | 5.16 | 6.22 | 7.06 | 8.12 |
| 120 | 5.72 | 6.92 | 7.98 | 9.18 |
| 240 | 7.22 | 8.61 | 9.66 | 10.88 |
| East-Central | | | | |
| 24 | 4.44 | 5.42 | 6.25 | 7.13 |
| 48 | 5.05 | 6.02 | 6.87 | 7.83 |
| 72 | 5.31 | 6.42 | 7.35 | 8.42 |
| 120 | 5.61 | 6.70 | 7.75 | 9.00 |
| 240 | 7.12 | 8.25 | 9.27 | 10.35 |
| Northeast | | | | |
| 24 | 4.31 | 5.11 | 5.73 | 6.36 |
| 48 | 4.69 | 5.62 | 6.34 | 7.09 |
| 72 | 5.14 | 6.19 | 7.00 | 7.84 |
| 120 | 5.64 | 6.84 | 7.75 | 8.77 |
| 240 | 7.07 | 8.29 | 9.20 | 10.19 |
| Southeast | | | | |
| 24 | 4.67 | 5.67 | 6.58 | 7.59 |
| 48 | 5.20 | 6.35 | 7.32 | 8.40 |
| 72 | 5.74 | 6.95 | 7.88 | 8.98 |
| 120 | 6.32 | 7.60 | 8.69 | 9.95 |
| 240 | 7.35 | 8.45 | 9.33 | 10.42 |

discharge (figs. 9 and 10). At Cedar Rapids, snowmelt runoff and rainfall produced flood peaks throughout March and April in 2008 that exceeded the flood stage and are indicative of the high streamflow conditions leading up to the flooding in June (fig. 10). Operation of the Coralville Dam reduced discharges at Iowa City below the flood stage during March and April in 2008 (fig. 9). The hydrograph of the 1993 flood shown in figures 9 and 10 is compared to the 2008 flood in Appendix 1.

## Iowa River Basin

Major flooding (flood probability less than 2 percent) began in the middle part of the Iowa River Basin on May 30, 2008, at the streamgage 05452000 Salt Creek near Elberon, Iowa (fig.1, site 18). The peak discharge at the Elberon streamgage of 22,400 $ft^3/s$ is estimated to have a flood probability of 0.2 to 1 percent. Major flooding occurred in the upper part of the Iowa River Basin on June 9, 2008, at the streamgage 05449500 Iowa River near Rowan, Iowa (fig. 1, site 10, and fig. 7*A*). The peak discharge of 7,890 $ft^3/s$ at the Rowan streamgage occurred at 11:30 p.m. on June 9. The flooding that began in the upper and middle parts of the Iowa River Basin became severe flooding on the mainstem of the Iowa River in the lower part of the basin from the vicinity of Marengo to the mouth of the Iowa River. On June 10, a sharp increase in discharge occurred at the streamgage 05453100 Iowa River at Marengo, Iowa (fig. 1, site 22, and fig. 7*A*), and at 8:20 p.m. on the same day, Coralville Lake overtopped the spillway of the Coralville Dam (*http://www.mvr.usace.army.mil/Coralville/Flood1993Facts.htm*, accessed December 3, 2009). Peak discharges for the streamgages 05451500 Iowa River at Marshalltown, Iowa (fig.1, site 14) and 05453100 Iowa River at Marengo, Iowa (fig. 7*A*) occurred on June 13 and June 12, 2008, respectively. The peak discharge at the Marshalltown streamgage was 22,400 $ft^3/s$. At Marengo, the peak discharge was 51,000 $ft^3/s$ and is the largest peak discharge on record. Between the streamgages at Marshalltown and Marengo the flood probability increased from greater than 2 percent to less than 1 percent as indicated on figure 7*A*. A number of tributaries flow into the Iowa River between the streamgages at Marshalltown and Marengo (fig.1 and table 3) and the tributaries contributed to the timing and magnitude of the record peak discharge at Marengo. Continuous-record streamgages (hydrographs not shown) located on these tributaries include 05451700 Timber Creek near Marshalltown, Iowa (fig. 1, site 15), 05451900 Richland Creek near Haven, Iowa (fig. 1, site 16), 05452000 Salt Creek near Elberon, Iowa (fig 1, site 18), 05452200 Walnut Creek near Hartwick, Iowa (fig. 1, site 19), and 05453000 Big Bear Creek at Ladora, Iowa (fig. 1, site 21). The streamgages at Timber Creek and Richland Creek measured peak-of-the-year discharges on June 8 and the Big Bear Creek streamgage measured peak-of-the-year discharge on June 12 (table 3). The streamgages at Salt Creek and Walnut Creek also measured less significant peak discharges on June 8 and June 12, 2008 (not listed in table 3). The timing of these tributary peak flows to the Iowa River, as well as flood-plain storage effects between Marshalltown and Marengo, probably contributed to the peak discharge at Marengo occurring earlier than the peak discharge at Marshalltown. Coralville Lake reached a record maximum pool elevation of 717.02 ft on June 15, 2008, and downstream from Coralville Lake the streamgage 05453520 Iowa River below Coralville Dam near Coralville, Iowa (fig. 1, site 25, and fig. 7*B*) measured a peak discharge of 39,900 $ft^3/s$ on June 15, 2008, at 4:00 a.m. The 2008 peak discharge for the streamgage

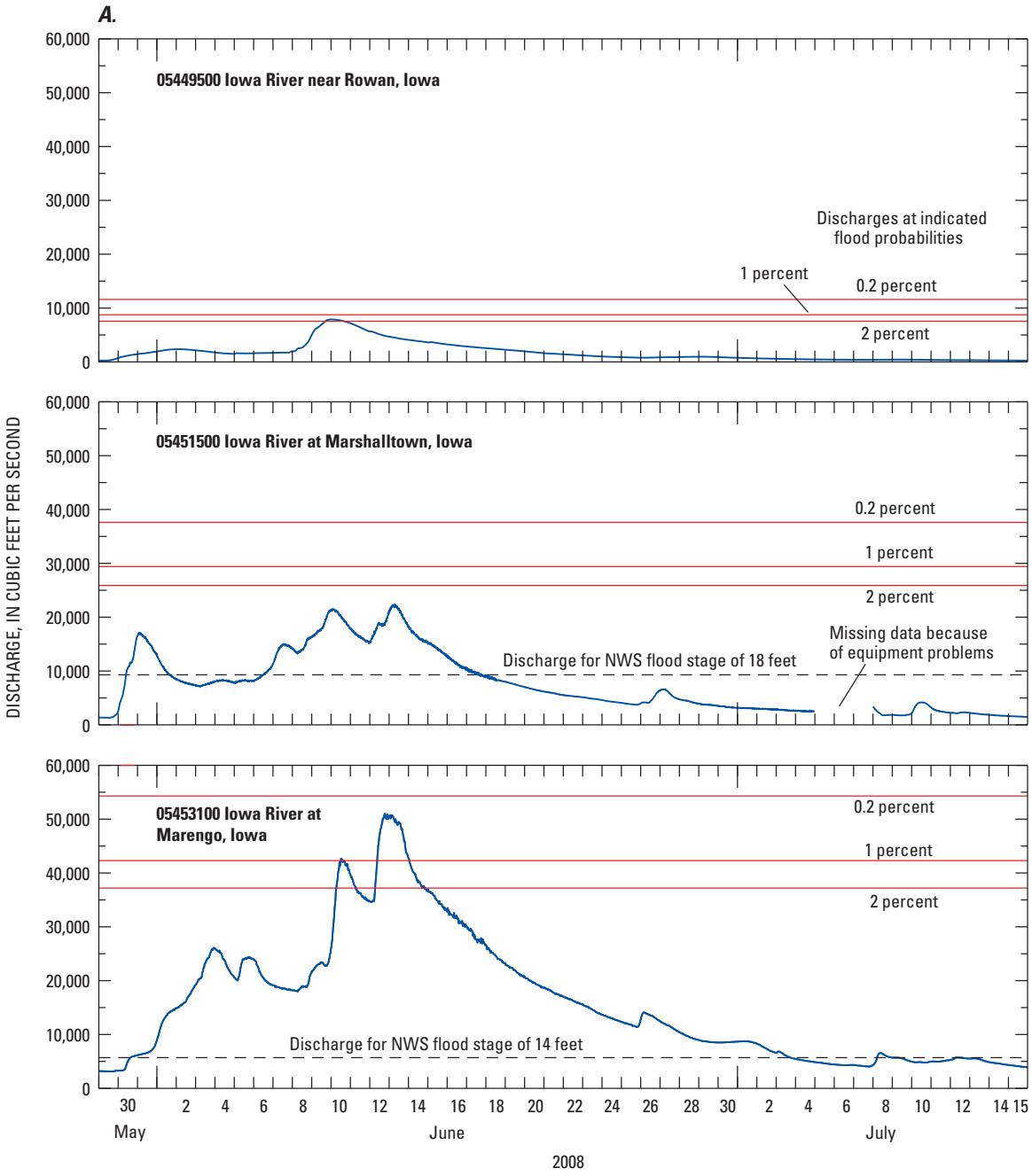


**Figure 7.** Discharge hydrographs for selected streamgages on the Iowa River upstream from the confluence with the Cedar River, May 29 to July 15, 2008. Also shown are flood probabilities in percent at each streamgage and discharges corresponding to the National Weather Service (NWS) flood stage at two streamgages. Location of streamgages shown in figure 1.

05453520 Iowa River below the Coralville Dam, Iowa is the largest discharge measured for the period of record, 1993–2008 (flood-probability estimate of 0.2-1 percent, U.S. Army Corps of Engineers, 2009). At 6:30 a.m. on June 15, 2008, a peak discharge of 41,100 $ft^3/s$ was measured at the streamgage 05454500 Iowa River at Iowa City, Iowa (fig. 1, site 37, and fig. 7*B*) and at 9:30 a.m. on the same day, a peak discharge of 53,700 $ft^3/s$ was measured at the streamgage 05455700 Iowa River at Lone Tree, Iowa (fig. 1, site 51, and fig. 7*B*). The 2008 peak discharge for the streamgage at Iowa City is the fourth highest for the entire peak-flow record (flood-probability estimate of 0.2-1 percent, U.S. Army Corps of Engineers, 2009) and is the highest peak discharge since operation of Coralville Dam began in 1958. The 2008 peak discharge at the Iowa River near Lone Tree streamgage is the second highest for the period of record (flood-probability estimate of 0.2-1 percent, U.S. Army Corps of Engineers, 2009); the largest peak discharge on record occurred in 1993 (table 3). The largest recorded discharge in the Iowa River Basin occurred at the streamgage 05465500 Iowa River at Wapello, Iowa (fig.

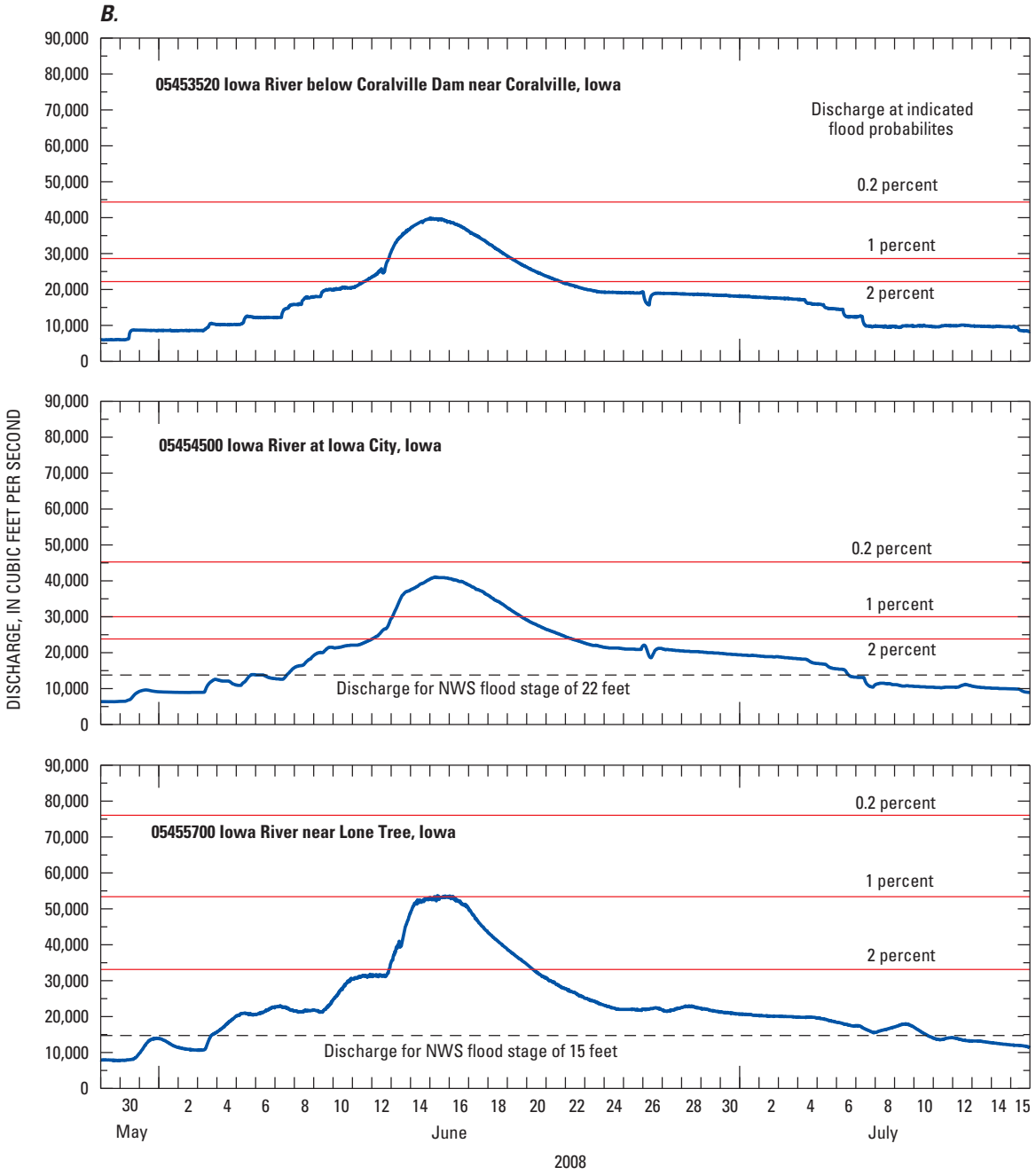


**Figure 7.** Discharge hydrographs for selected streamgages on the Iowa River upstream from the confluence with the Cedar River, May 29 to July 15, 2008. Also shown are flood probabilities in percent at each streamgage and discharges corresponding to the National Weather Service (NWS) flood stage at two streamgages. Flood probabilities for these three regulated streamgages were computed by the U.S. Army Corps of Engineers (2009). Location of streamgages shown in figure 1.—Continued

1, site 103, and fig. 8*B*), which measures the combined flows of the Iowa and Cedar Rivers. The peak discharge at Wapello of 188,000 $ft^3/s$ occurred on June 14, 2008, at 12:30 p.m. (flood-probability estimate of less than 0.2 percent, U.S. Army Corps of Engineers, 2009). The timing and magnitude of the 2008 peak on the Iowa River at Wapello coincides with the high flow on the Iowa River near Lone Tree (fig. 7*B*) and the peak discharge at the streamgage 05465000 Cedar River near Conesville, Iowa (fig. 2, site 101, and fig. 8*B*), which occurred on June 14. Flood probabilities along the mainstem of the Iowa River from Marengo to the mouth were all less than 1 percent as shown on figures 7*A*, 7*B* and 8*B*.

The flood stage established by the National Weather Service for the streamgage 05451500 Iowa River at Marshalltown, Iowa is 18.0 ft, which is the stage at which significant flooding occurs on land along State Highway 330 northwest of Marshalltown as well as nearby agricultural land (at *http://water.weather.gov/ahps2/hydrograph.php?wfo=dmx&gage*

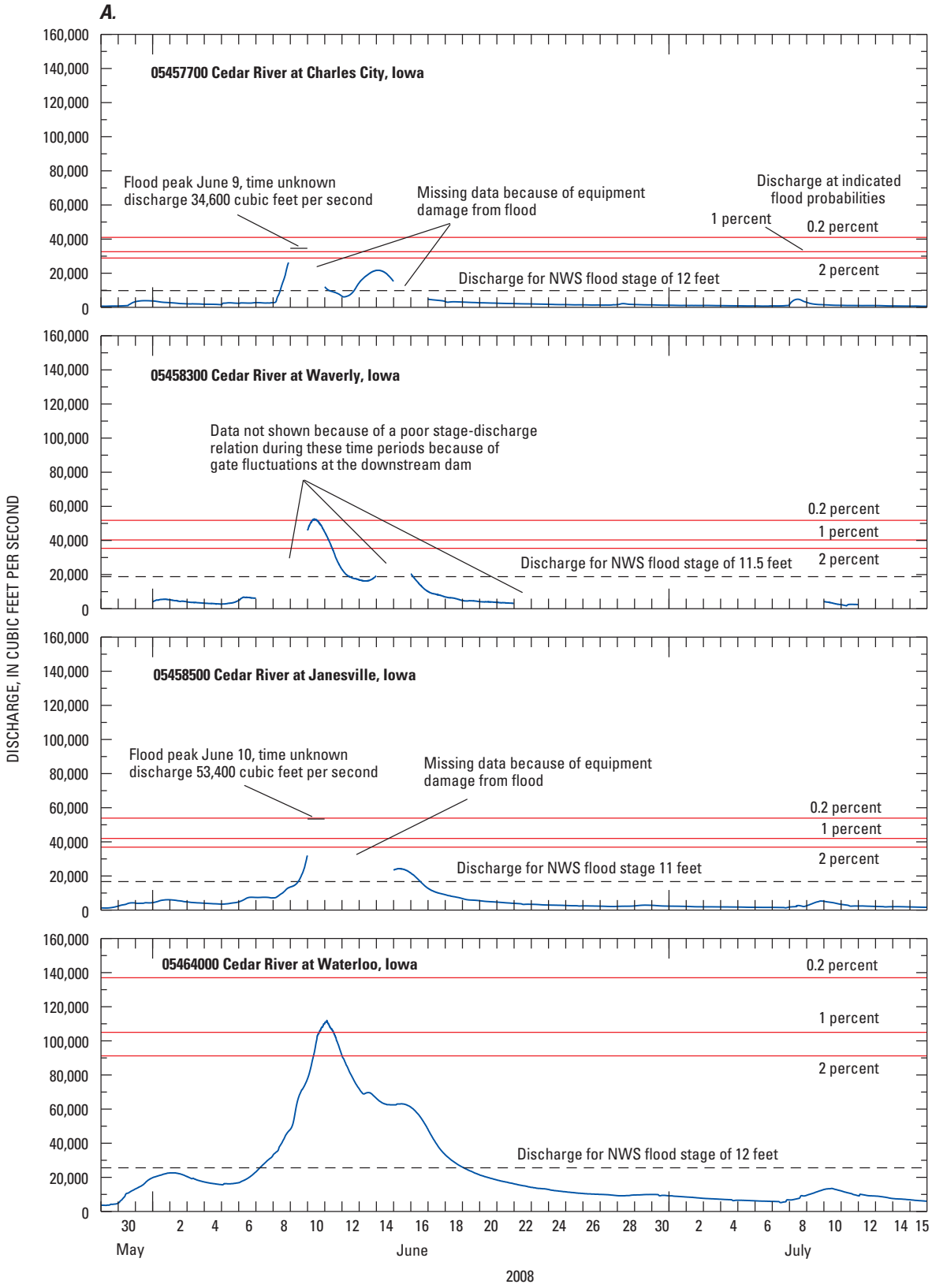


**Figure 8.** Discharge hydrographs for selected streamgages on the Cedar River, May 29 to July 15, 2008. Also shown are flood probabilities in percent at each streamgage and discharges corresponding to the National Weather Service (NWS) flood stage. Locations of streamgages shown in figure 2.

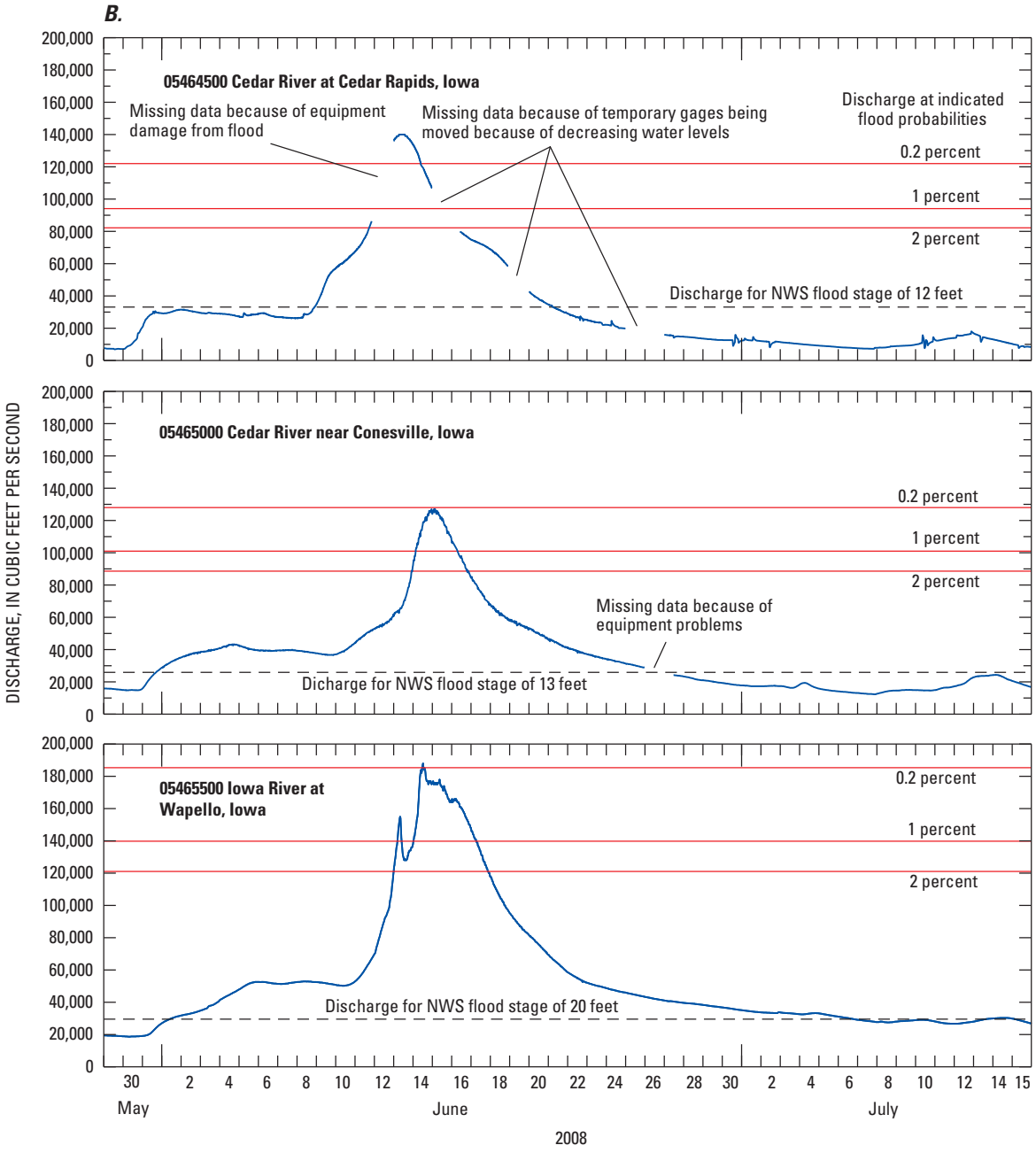


**Figure 8.** Discharge hydrographs for selected streamgages on the Cedar River and for streamgage Iowa River at Wapello, Iowa, May 29 to July 15, 2008. Also shown are flood probabilities in percent at each streamgage and discharges corresponding to the National Weather Service (NWS) flood stage. Flood probability for the Iowa River at Wapello, Iowa, streamgage was computed by the U.S. Army Corps of Engineers (2009). Locations of streamgages shown in figures 1–2.—Continued

*=miwi4&view=1,1,1,1,1,1,1,1,1*). The streamgage Iowa River at Marshalltown was above flood stage from May 30 to June 1, and again June 6–17 (fig. 7*A*), and the peak stage of 21.79 ft (table 3) exceeded the flood stage at this site by 3.79 ft. The flood stage for the streamgage 05453100 Iowa River at Marengo, Iowa is 14.0 ft, which is the stage at which low lying agricultural land along the river is affected (at *http://water.weather.gov/ahps2/hydrograph.php?wfo=dvn&gage=mroi4&view=1,1,1,1,1,1,1,1,1*). The streamgage Iowa River at Marengo was above flood stage from May 30 to July 3, and again on July 8–9 (fig. 7*A*), and the peak stage of 21.38 ft (table 3) exceeded the flood stage at this site by 7.38 ft. The flood stage for the streamgage 05454500 Iowa River at Iowa City, Iowa is 22.0 ft, which is the stage at which urban flooding occurs in Iowa City and water enters homes along Edgewater Drive (not shown on map) (at *http://water.weather.gov/ahps2/hydrograph.php?wfo=dvn&gage=iowi4&view=1,1,1,1,1,1,1,1,1*). The streamgage Iowa River at Iowa

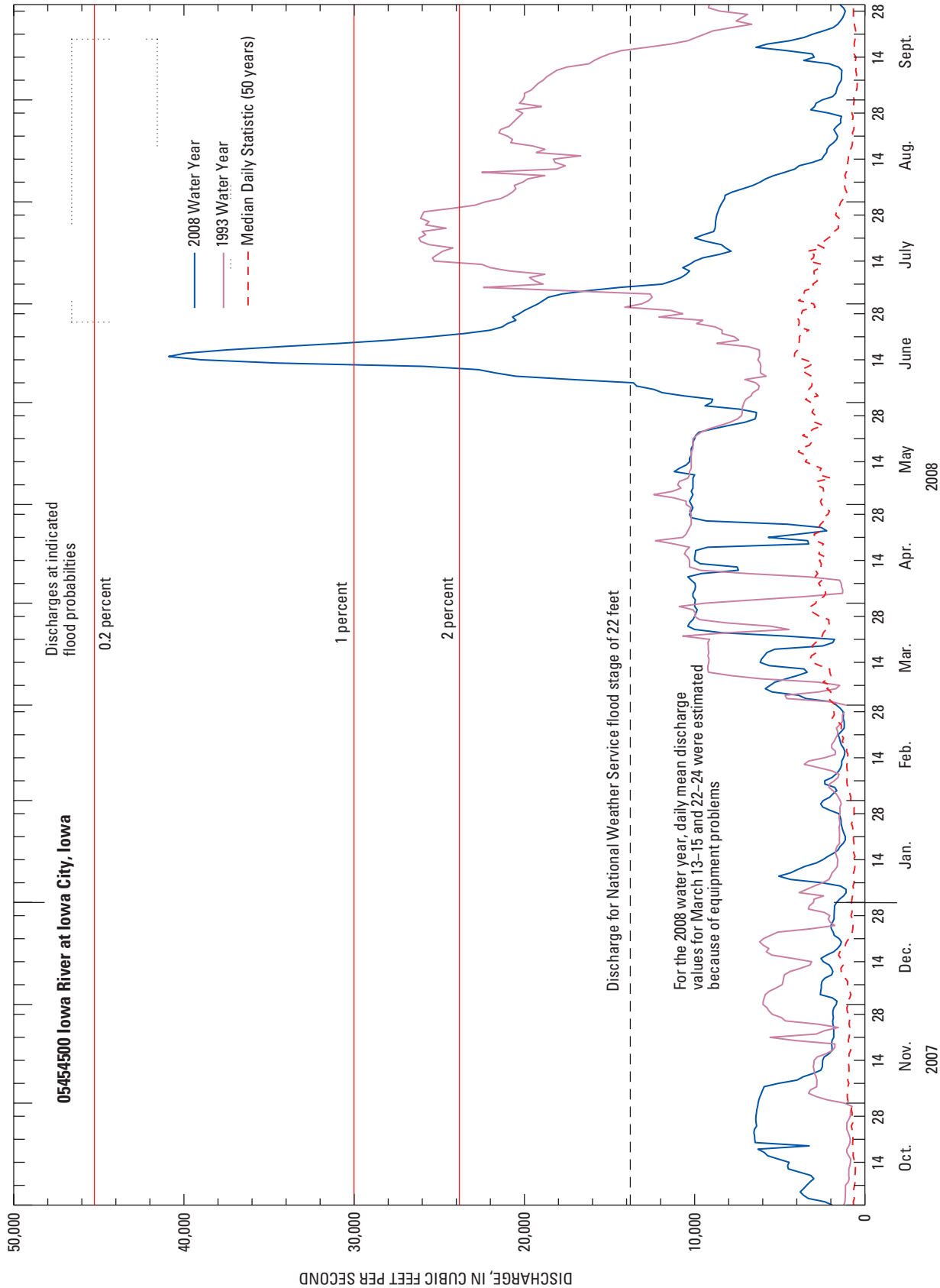


**Figure 9.** Discharge hydrographs of the streamgage 05454500 Iowa River at Iowa City, Iowa, October 1, 2007, to September 30, 2008 (2008 water year), and October 1, 1992, to September 30, 1993 (1993 water year). Discharges are daily mean values. The long-term median daily discharge values were computed for 50 years of record, 1959 to 2008 (post-dam construction). Flood probability computed by the U.S. Army Corps of Engineers (2009). Location of streamgage shown in figure 1.

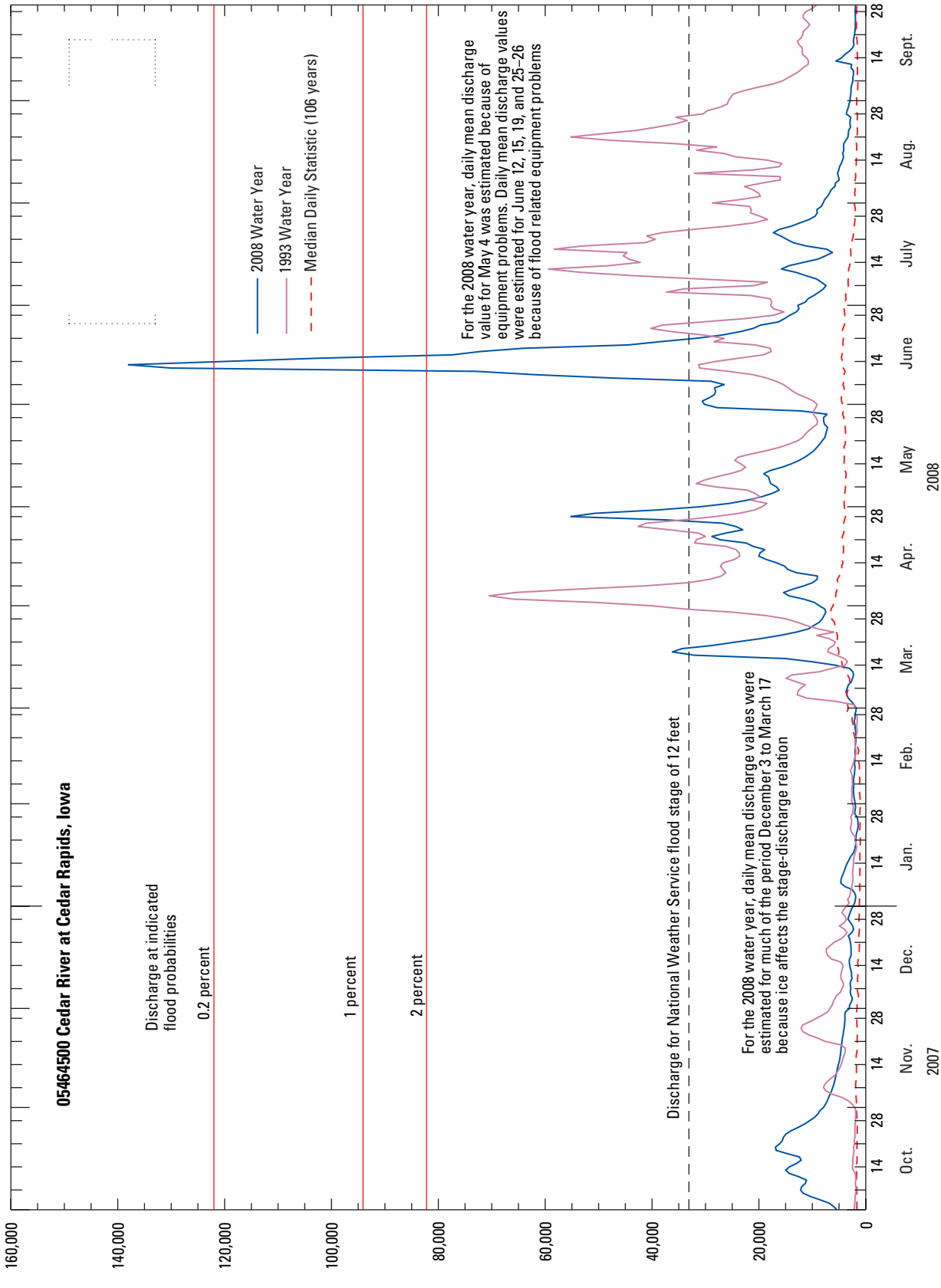


**Figure 10.** Discharge hydrographs of the streamgage 05464500 Cedar River at Cedar Rapids, Iowa, October 1, 2007, to September 30, 2008 (2008 water year), and October 1, 1992, to September 30, 1993 (1993 water year). Discharges are daily mean values. The long-term median daily discharge values were computed for 106 years of record, 1903 to 2008. Location of streamgage shown in figure 2.

City was above flood stage from June 5 to July 7 (figs. 7*B*), and the peak stage of 31.53 ft (table 3) exceeded the flood stage at this site by 9.53 ft. The flood stage for the streamgage 05455700 Iowa River near Lone Tree, Iowa is 15.0 ft, which is the stage at which low lying roads are affected (at *http://water.weather.gov/ahps2/hydrograph.php?wfo=dvn&gage=lnti4&view=1,1,1,1,1,1,1,1*). The streamgage Iowa River near Lone Tree was above flood stage from June 3 to July 10 (fig. 7*B*), and the peak stage of 23.10 ft (table 3) exceeded the flood stage at this site by 8.10 ft. The flood stage for the streamgage 05465500 Iowa River at Wapello, Iowa, is 20.0 ft, and at 22.0 ft homes near the U.S. Highway 61 bridge are affected by water (at *http://water.weather.gov/ahps2/hydrograph.php?wfo=dvn&gage=wapi4&view=1,1,1,1,1,1,1,1*). The streamgage Iowa River at Wapello was above flood stage from June 1 to July 6, and again from July 13–15 (fig. 8*B*), and the peak stage of 32.15 ft (table 3) exceeded the flood stage at this site by 12.15 ft. Flood stages are not available for the streamgage 05449500 Iowa River near Rowan, Iowa, (fig. 7*A*) and the streamgage 05453520 Iowa River below Coralville Dam, Iowa, (fig. 7*B*).

## Cedar River Basin

Flooding in the upper and middle parts of the Cedar River Basin began on May 30, 2008. The peak discharge at streamgage 05464220 Wolf Creek Creek near Dysart, Iowa, (fig. 2, site 85) was 15,700 $ft^3/s$ and is the largest peak discharge for the period of record and has an estimated flood-probability range of 2 to 4 percent. On June 8, the peak discharges at streamgages 05459500 Winnebago River at Mason City, Iowa, (fig. 2, site 68) and 05463000 Beaver Creek at New Hartford, Iowa, (fig. 2, site 76) were 13,100 $ft^3/s$ and 25,900 $ft^3/s$, respectively. Peak discharges were the largest for the respective periods of record and have estimated flood probability ranges of 0.2 to 1 percent. On June 9, the peak discharges at streamgages 05457700 Cedar River at Charles City, Iowa, (fig. 2, site 56, and fig. 8*A*) and 05458000 Little Cedar River near Ionia, Iowa, (fig. 2, site 59) were 34,600 $ft^3/s$ and 24,700 $ft^3/s$, respectively. These peak discharges also were the largest for the respective periods of record and have estimated flood-probability ranges of 0.2 to 1 percent. On June 10, peak discharges at streamgages 05458300 Cedar River at Waverly, Iowa, (fig. 2, site 60, and fig. 8*A*) and 05458500 Cedar River at Janesville, Iowa, (fig. 2, site 61, and fig. 8*A*) were 52,600 $ft^3/s$ and 53,400 $ft^3/s$, respectively. These peak discharges were the largest for the respective periods of record. The estimated flood-probability at Waverly is less than 0.2 percent and at Janesville is 0.2 to 1 percent. Also on June 10, a peak discharge of 60,400 $ft^3/s$ was measured at streamgage 05462000 Shell Rock River at Shell Rock, Iowa, (fig. 2, site 74) and is the largest peak discharge for the period of record with an estimated flood probability of less than 0.2 percent. On June 11 at 3:00 a.m., the Cedar River crested at the streamgage 05464000 Cedar River at Waterloo, Iowa, (fig. 2, site 79, and fig. 8*A*), with a new peak-record discharge of 112,000 $ft^3/s$ (flood-probability estimate of 0.2 to 1 percent). In Cedar Rapids, the maximum discharge at streamgage 05464500 Cedar River at Cedar Rapids, Iowa, (fig. 2, site 90, and fig. 8*B*) was 140,000 $ft^3/s$, which occurred June 13 at 10:15 a.m. The estimated flood-probability of the peak discharge is less than 0.2 percent. The maximum stage was 31.12 ft, which was 11.12 ft higher than the previous maximum stage of 20.00 ft, which occurred March 18, 1929 (table 3). Because the flooded river was approximately 1.6 mi wide and filled with urban obstructions and hazards, it was not possible to measure the peak discharge at the 05464500 Cedar River at Cedar Rapids, Iowa, streamgage. The maximum discharge was prorated from a discharge measurement made 9.9 mi downstream at the Cedar River at Highway 30 (fig. 2; the site was a USGS site used in the profile and also was established to collect water-quality data for the 2008 flood and is otherwise not the location of a streamgage). The discharge measured at the U.S. Highway 30 site was 150,000 $ft^3/s$. On June 14, a record peak discharge at streamgage 05465000 Cedar River near Conesville, Iowa, (fig. 2, site 101, and fig. 8*B*) was 127,000 $ft^3/s$. The flood-probability range of the peak discharge is 0.2 to 1 percent. The peak discharge at Conesville was less than the peak discharge at Cedar Rapids because of flood-plain storage effects. Within the Cedar River Basin, the May 30 to June 15, 2008, flood is the largest on record at all six streamgages located on the mainstem of the Cedar River and at five streamgages located on the major tributaries. Flood-probability estimates for 10 of these 11 streamgages are less than 1 percent. Flood probabilities at all six streamgages along the mainstem of the Cedar River from Charles City to the confluence with the Iowa River were all less than 1 percent as shown in figures 8*A* and 8*B*.

The flood stage established by the National Weather Service for the streamgage 05457700 Cedar River at Charles City, Iowa, is 12.0 ft, which is the stage at which localized street flooding begins and barricades are put in place (at *http://water.weather.gov/ahps2/hydrograph.php?wfo=arx&gage=ccyi4&view=1,1,1,1,1,1,1,1*). The streamgage Cedar River at Charles City was above flood stage from June 8–11, and again from June 12–15 (fig. 8*A*), and the peak stage of 25.33 ft (table 3) exceeded the flood stage by 13.33 ft. The flood stage at the streamgage 05458300 Cedar River at Waverly, Iowa, is 11.5 ft, which is the stage at which lowland flooding of city parks occurs (at *http://water.weather.gov/ahps2/hydrograph.php?wfo=dmx&gage=wvli4&view=1,1,1,1,1,1,1,1*). The streamgage Cedar River at Waverly was above flood stage, based on gage-height data (not shown), from June 9–12, and again from June 13–16 (fig. 8*A*). The flood stage was exceeded by 7.83 ft with a peak stage of 19.33 ft (table 3). At the streamgage 05458500 Cedar River at Janesville, Iowa, the flood stage is 11.0 ft and is the stage at which lowland flooding of the city park occurs (at *http://water.weather.gov/ahps2/hydrograph.php?wfo=dmx&gage=jani4&view=1,1,1,1,1,1,1,1*). The streamgage Cedar River at Janesville was possibly above flood stage from June 9–16, but because of missing data caused by equipment damage from flooding, it is uncertain whether the stage fell below flood stage sometime on June 12

or 13 (fig. 8*A*) as was the case at Charles City and Waverly. The flood stage at the streamgage Cedar River at Janesville was exceeded by 8.45 ft with a peak stage of 19.45 ft (table 3). At the streamgage 05464000 Cedar River at Waterloo, Iowa, the flood stage is 12.0 ft. At 11.5 ft, nearby low-lying agricultural land becomes flooded, and at 13.0 ft, minor street flooding in Evansdale (not shown on map) occurs (at *http://water.weather.gov/ahps2/hydrograph.php?wfo=dmx&gage=aloi4&view=1,1,1,1,1,1,1,1*). The streamgage Cedar River at Waterloo was above flood stage from June 7–19 (fig. 8*A*) and was exceeded by 15.01 ft with a peak stage of 27.01 ft (table 3). At the streamgage 05464500 Cedar River at Cedar Rapids, Iowa, the flood stage is 12.0 ft. At 11.5 ft, water affects Osborn Park (not shown on map) in Cedar Rapids, and at 12.7 ft, water affects the water treatment plant in Palo (at *http://water.weather.gov/ahps2/hydrograph.php?wfo=dvn&gage=cidi4&view=1,1,1,1,1,1,1,1*). The streamgage 05464500 Cedar River at Cedar Rapids, Iowa, was above flood stage from June 8–21 (figs. 8*B*). The flood stage was exceeded by 19.12 ft by a peak stage of 31.12 ft (table 3). Approximately 75 mi downstream at the streamgage 05465000 Cedar River near Conesville, Iowa, the flood stage is 13.0 ft and is the stage at which flooding affects Edgewater Road and 245th Street (not shown on map) near Conesville (at *http://water.weather.gov/ahps2/hydrograph.php?wfo=dvn&gage=cnei4&view=1,1,1,1,1,1,1,1*). The streamgage Cedar River near Conesville was above flood stage from May 31 to June 26 (fig. 8*B*) and the flood stage was exceeded by 10.37 ft by a peak stage of 23.37 ft (table 3).

## Flood Runoff

Flood runoff in 2008 along the mainstem of the Cedar River was greater than along the mainstem of the Iowa River. The relation between unit runoff values (flood runoff) for 2008 peak discharges and drainage area for streamgages on the mainstems of the Iowa and Cedar Rivers is shown in figure 11. Unit runoff values listed in table 3 represent an average discharge per square mile; they are calculated by dividing the peak discharge by the drainage area of the basin upstream from the streamgage. Unit runoff values allow for the comparison of average discharge per square mile between different watersheds with similar sizes of drainage areas. For example, the streamgages 05451500 Iowa River at Marshalltown, Iowa, (fig. 1, site 14) and 05458300 Cedar River at Waverly, Iowa, (fig. 2, site 60) have similar sizes of drainage areas (1,532 $mi^2$ and 1,547 $mi^2$, respectively); but unit runoff values for the 2008 flood peak (table 3, fig. 11) indicate that average discharge per square mile in the Cedar River Basin upstream from the streamgage Cedar River at Waverly, Iowa, was nearly 133 percent greater than average discharge in the Iowa River Basin upstream from the streamgage Iowa River at Marshalltown, Iowa. Along the Iowa River, unit runoff values increased from the streamgage at Marshalltown, Iowa, to the streamgage 05453100 Iowa River at Marengo, Iowa, (fig. 1, site 22) indicating substantial tributary flow to the Iowa River between these two streamgages (fig. 11). A substantial decrease in runoff values between the streamgage at Marengo, located upstream from the Coralville Dam, and streamgages 05453520 Iowa River below Coralville Dam near Coralville, Iowa, (fig. 1, site 25) and 05454500 Iowa River at Iowa City, Iowa, (fig. 1, site 37), located downstream from the Coralville Dam, show the storage effects of Coralville Lake on peak discharge in the Iowa River during the 2008 flood. Overall, flood runoff in 2008 from peak discharges at streamgages along the mainstem of the Cedar River was greater than flood runoff from peak discharges at streamgages along the mainstem of the Iowa River (fig. 11).

## Chronology of Flood Impacts

The following flood description information was obtained from newspaper articles in the *Cedar Rapids-Iowa City Gazette* (Ebaugh, June12, 2008; Belz, June 14, 2008a, and June 15, 2008b; Hennigan and Muller, June 15, 2008; Boshart, June 16, 2008; Dochterman, June 16, 2008; Hennigan, June 17, 2008; Binegar, June 21, 2008; Smith, December 24, 2009), the *Hawk Eye*, Burlington, Iowa, (John Mangalonzo, June 15, 2008), the *Iowa City Press-Citizen* (Sharp, June 16, 2008), the *Mason City Globe-Gazette* (Skipper, June 10, 2008), *Quad City Times* (Associated Press, June 14, 2008), the *Waterloo-Cedar Falls Courier* (Courier Staff, June 9, 2008a; Heinselman, June 11, 2008; Wind, June 11, 2008; Courier Staff, June 14, 2008b; Courier Des Moines Bureau, November 8, 2009, and from online sources (accessed January 11, 2010, at *http://www.rio.iowa.gov/*) obtained from the State of Iowa's Rebuild Iowa Office (RIO). Along the Iowa and Cedar Rivers, the floods of 2008 exceeded the flooding of 1993 and led to the evacuation of many homes and severely disrupted transportation throughout eastern Iowa. Interstates 80 and 380 were closed and bridges in Waterloo, Cedar Rapids, and Iowa City were closed leading to extensive detours. Railroad traffic also was severely disrupted. A bridge between Mason City and Nora Springs (not shown on map) operated by the Iowa, Chicago and Eastern Railroad (IC&E Railroad) was washed out. Amtrak service was rerouted away from Iowa and a number of passengers were put onto buses. On June 8 in Mason City, floodwaters from the Winnebago River inundated the water-treatment plant and city officials reported that the wastewater-treatment plant came within 4 in. of a shut down. Along the Cedar River in Charles City, an estimated 100 residents were evacuated overnight from June 8 to June 9, and more than 500 homes had been damaged by floodwaters. On June 10, 2008, city officials in Waverly estimated 500 homes and businesses were affected by the flooding, about 100 people had been evacuated, and approximately 1,000 homes and businesses were without power. Flooded bridges and roadways blocked east to west traffic through Waverly. On June 10 in Waterloo, the levee system continued to hold back floodwaters from the Cedar River but lift stations could not

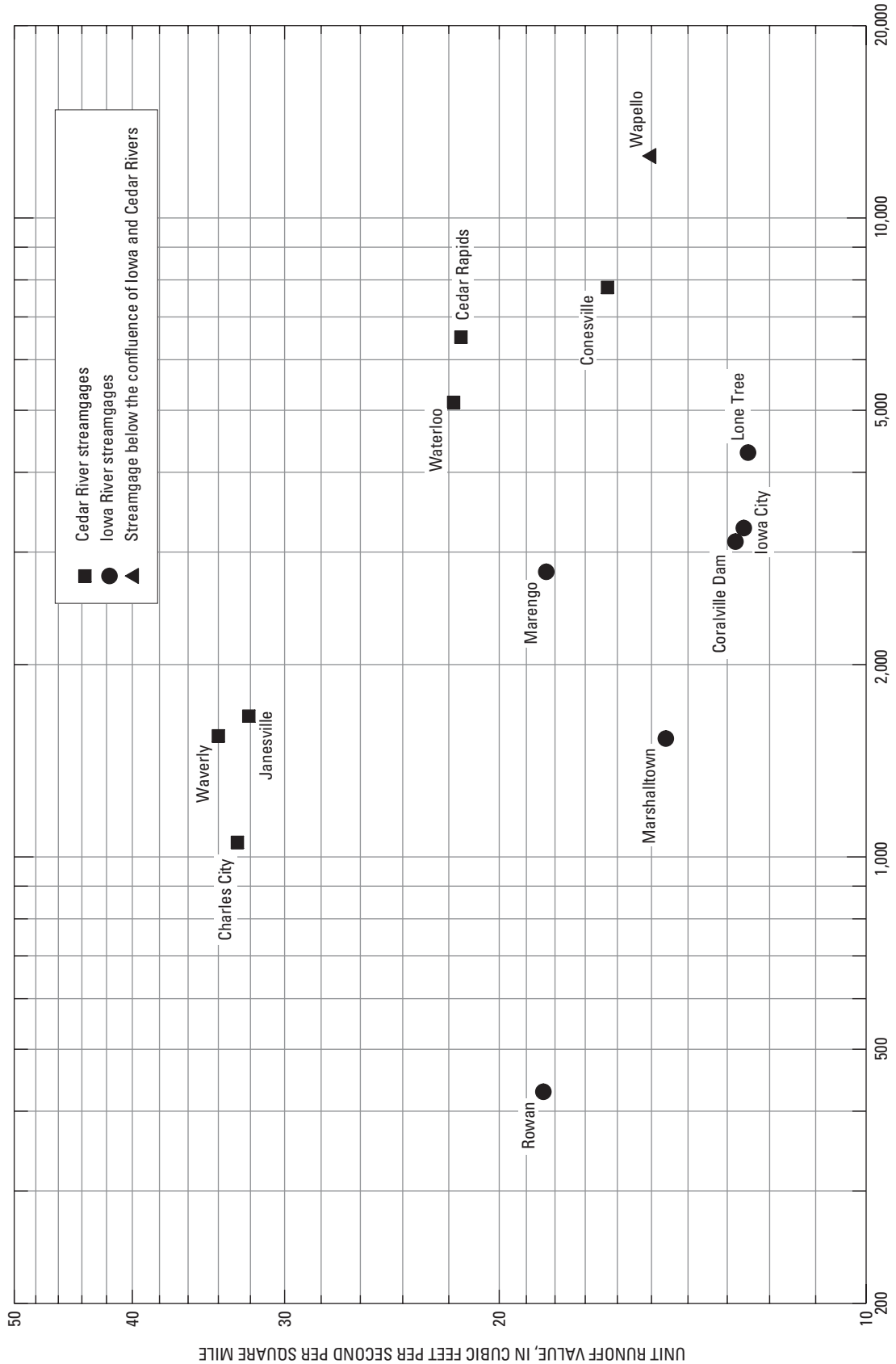


**Figure 11.** Relation between unit runoff values for the 2008 flood and drainage area for streamgages on the Iowa and Cedar Rivers.

keep up with stormwater runoff forcing additional mandatory evacuations as stormwater runoff affected new areas of the city. Around 2:45 p.m. on June 10, at least a third of the Union Pacific Railroad Bridge in downtown Waterloo was washed away by the floodwaters. During the evening of June 10, water from the Coralville Lake began to overtop the emergency spillway of the Coralville Dam; reservoir water continued to flow over the spillway until June 24. The chapter, *The Coralville Dam and Reservoir, Design and Operation* (Castle, 2010), provides information on the operation of Coralville Dam and Reservoir during the 2008 flood. On June 11, the Cedar River flooded a 15-block area in Vinton. The city lost power at 9:50 a.m. when the floors collapsed at the city's auxiliary power plant and distribution center. The State Highway 150 bridge north of town was closed, as were all the bridges across the Cedar River from Vinton to Cedar Rapids. In the town of Palo, all 890 residents were ordered to evacuate their homes. In Cedar Rapids, on June 12 at 9:43 a.m., the Cedar Rapids and Iowa City Railway Co. (CRANDIC/CIC) bridge was destroyed by the flooding. On June 13, as the Cedar River crested in Cedar Rapids, most of the downtown area was inundated by floodwaters and approximately 25,000 residents in Linn County were ordered to evacuate and about 12,000 people were without power. Mercy Hospital was evacuated the morning of June 13. According to Cedar Rapids Fire Department spokesman, Dave Koch, approximately 3,900 homes covering 1,300 blocks and 9.2 $mi^2$ of the city were flooded. City and Federal government buildings on Mays Island (not shown on map) were flooded up to the second floor. With the exception of one well, all of the wells providing the city's domestic water supply were compromised and drinking-water supplies for Cedar Rapids became severely threatened. Firefighters and about 14 U.S. Coast Guard personnel in motor boats were rescuing people and pets in flooded areas of Cedar Rapids. Homes and businesses in Cedar Rapids were flooded to a depth of as much as 12 ft. Initial property damage in Cedar Rapids was estimated at $736 million, with approximately $376 million of that damage to people's homes. The chapter, *Linn County and the Flood* (Langston, 2010), provides additional information on the 2008 flood in Cedar Rapids. Interstate 80 near Tipton (not shown on map), U.S. Highway 30, State Highway 1, and State Highway 13 were closed because of flooding along the Cedar River, and to the south, Interstate 380 and State Highway 965 (not shown on map) were closed because of flooding along the Iowa River, cutting off major routes between Cedar Rapids and Iowa City. According to National Guard spokesman Lt. Col. Greg Hapgood, as of June 13, 220 National Guard members were deployed to Cedar Rapids and another 540 members to Iowa City in response to the flooding. On June 14 in Columbus Junction and Fredonia, just below the confluence of Iowa and Cedar Rivers, authorities ordered evacuations in anticipation of flooding. All of the approximately 250 residents of Fredonia were ordered to evacuate along with those living along the levee and low lying areas of Columbus Junction. On the evening of June 14, the makeshift sand levees along State Highways 92 and 70 gave way to the Iowa River and flooded several businesses in Columbus Junction with several ft of water. Also on June 14, a levee failure along the Iowa River near the town of Oakville flooded the entire town. Earlier in the day, emergency management officials had ordered a mandatory evacuation from Oakville. In Iowa City, the floodwaters of the Iowa River infiltrated the University of Iowa's power plant on the morning of June 14 and the power plant was shut down. An estimated 2,000 volunteers helped lay sandbags around several University of Iowa buildings located on the east side of the Iowa River. In Iowa City, the Iowa River crested on June 15, as the Coralville Reservoir remained almost 5 ft above the spillway; during this time, reservoir storage was 28,300 acres and reservoir length was 45 mi (Castle, 2010). An estimated 400 to 500 homes in Iowa City and approximately 310 homes in Coralville were evacuated. Many businesses in Coralville were flooded along U.S. Highway 6, water depths were as much as 6 to 8 ft according to Assistant Coralville Fire Chief Bill Horning. As the Coast Guard patrolled 1st Avenue (not shown on map) in Coralville and surrounding neighborhoods, Petty Officer Steve Lehmann observed floodwaters that were halfway up the first story of homes and cars almost totally submerged. The Normandy Drive (not shown on map) area of Iowa City was severely flooded. The chapter, *Iowa City and the Flood* (Fosse, 2010), provides additional information of the 2008 flood in Iowa City. On the University of Iowa campus in Iowa City, 22 major buildings were flooded; damage to university facilities and their contents were estimated at $232 million. The total anticipated cost of the flood to the University is $743 million, which includes business interruption, leased replacement space, long-term protection of recovered buildings, and replacement of severely flood-damaged facilities. The chapter, *The University of Iowa and the Flood* (Eckstein and Lehnertz, 2010), provides additional information on the 2008 flooding of the University of Iowa. As of June 15, 2008, there were approximately 36,000 evacuees across 11 counties with 472 displaced Iowans housed in shelters. Statewide, 54 roadways remained closed and more than 4,000 National Guard personnel were expected to be deployed. Eighty-three of Iowa's 99 counties experienced substantial damage from the recent storms and flooding. Three deaths attributed to the flooding were reported, one each in Hamilton, Louisa, and Wright Counties. Soil erosion and sediment deposition related to the flooding damaged farmlands in eastern Iowa. Soil erosion rates following high rainfall intensities on June 12 were estimated to average about 3.6 tons per acre across Linn and Johnson Counties; within some counties in eastern Iowa, soil erosion rates were estimated to approach 50 tons per acre (Cruse and others, 2010).

As a result of the flooding and storms in June 2008, an estimated $316 million in FEMA Hazard Mitigation Funds is being allocated statewide for private home buyout assistance and other forms of mitigation. As of December 4, 2009, about $100 million of this total has so far been approved for local or state use (*http://www.rio.iowa.gov/funds.html*, accessed

January 11, 2010). About another $230 million has been allocated for buyouts under the U.S. Department of Housing and Urban Development's (HUD) Community Development Block Grant funds and approximately $150 million of that has been appropriated for buyouts (*http://www.rio.iowa.gov/funds.html*, accessed January 11, 2010). Overall, about $3.3 billion dollars have been allocated statewide by Federal, State, and local partners to help with various types of recovery efforts as a result of the storms and floods in 2008 and this amount is expected to increase as recovery efforts continue (*http://www.rio.iowa.gov/funds.html*, accessed January 12, 2010). Additional information about the extent of the damage and the financial impacts and estimates of the economic losses associated with the flooding in 2008 in Iowa can be found in the chapters, *Flood Effects on Modern Communities* (Mutel, 2010) and *Economic Losses from the Floods* (Otto, 2010). As of November 8, 2009, Community Development Block Grant funds were approved for buyout assistance for 852 properties in Cedar Rapids, 71 properties in Mason City, 101 properties in Cedar Falls, 28 properties in Waverly, 4 properties in Waterloo, 52 properties in Iowa City, 3 properties in Coralville, 124 properties in Oakville, and numerous other properties in other towns and rural areas, bringing the statewide total to 1,352 properties. In Cedar Rapids, as of December 23, 2009, 45 home owners had accepted FEMA-funded buyout offers, whereas another 72 properties had been approved for FEMA buyout assistance. The city estimated that eventually some 1,300 property buyouts may occur with most of the funding coming from HUD Community Development Block Grant funds. Statewide, another 963 properties had qualified for FEMA buyout assistance as of December 21, 2009 (*http://www.fema.gov/news/newsrelease.fema?id=50119*, accessed January 12, 2010).

## Flood Profile

To develop profiles of the 2008 floods for the Iowa River and Cedar River, the USGS measured high-water marks (HWM) at 60 locations. The USGS also used HWMs measured at 155 locations by FEMA (Federal Emergency Agency, 2008b), USACE, Muscatine County Engineers Office, and the City of Iowa City. The HWMs that were used in the profiles were measured at all Federal and State Highway bridges, at USGS streamgages, at selected county and local bridges, and at selected dams. The HWMs at bridges were located immediately downstream from a bridge and one bridge-length upstream from the bridge. With the exception of Coralville Lake and the river reach between U.S. Highway 20 and Iowa Falls which are in the Iowa River Basin (fig. 1), the maximum distance between profile points was about 10 mi. River mi were determined for the locations using a geographic information system (GIS) to measure the distance along each river reach from its mouth using USGS National Hydrography Dataset (NHD) data.

The HWMs were surveyed to bench marks (see appendix 2) at bridges, dams, and intermediate sites within 4 weeks of the flood peak, and were later referenced to the National Geodetic Vertical datum of 1929 by differential leveling or differential positioning using a global positioning system (GPS). In addition, bridge deck, bridge low-chord, and reference-point elevations were measured with respect to the bench marks. The elevations for the bridge deck and bridge-low chord were generally measured on the lowest end of the bridge. The reference points were established so that low-flow water-surface elevations could be measured by using a weight suspended on a measuring tape. Low-flow water-surface elevations were obtained to indicate the range in stage along the river and to define the low-water slope.

The HWMs are profiled in figures 12–39 and listed in tables 7 and 8. The profile lines connecting the HWMs in the figures approximate the flood elevation between marks. The lines do not account for any intermediate features that could affect flood elevation such as channel morphology or bridges and dams where HWMs were not measured. Primary highways referenced in the report are shown in figures 1 and 2; secondary roads are not shown on the figures.

The May 30 to June 15, 2008, flood along the Iowa River is profiled from State Highway 99 near Oakville (USGS streamgage number 05465700, established April 1, 2009) upstream to U.S. Highway 69 in Belmond (fig. 1). The 319-mi river reach is shown in figure 1, and the 88 stream sites where HWMs were measured are listed in table 7 (at the back of this report). A flood profile measured in July 1969 and a low-water profile measured during October 13–15, 1970 (Heinitz, 1973), are shown (figs. 19–27) for the Iowa River reach upstream from Coralville Lake. For the Iowa River 2008 flood-profile, elevations were estimated for several bridge sites where elevations had not been measured in order to define the 2008 profile line for comparison with the flood profile of 1969. The estimated elevations at these bridge sites are noted in the profile (figs. 24–26) but are not listed in table 7. At the streamgage 05451500 Iowa River at Marshalltown, Iowa, (river mile 214.27; fig. 22) the 2008 flood peak was higher than the 1969 flood peak by 2.69 ft (table 3), however, the peak discharge was less than the 1969 peak discharge. This difference between stage and discharge for the 1969 and 2008 floods is most likely because of continuing channel-aggradation at the Marshalltown location. Of 10 bridge sites on the Iowa River upstream from Coralville Lake, the Iowa River at the State Highway 14 bridge was estimated to have the highest channel-aggradation rate (Eash, 1996).

The May 30 to June 15, 2008, flood along the Cedar River is profiled from Fredonia near the mouth (confluence with the Iowa River) upstream to Riverview Drive north of Charles City (fig. 2). The 236-mi river reach is shown in figure 2, and the 127 stream sites where HWMs were measured are listed in table 8 (at the back of this report). A flood profile

measured in July 1999 and a low-water profile measured in November 1999 (Ballew and Eash, 2001) is shown for the Cedar River reach upstream from the Buchanan-Black Hawk County line. Also shown is a flood profile measured in March, 1961, and low-water profiles measured in August, 1960, and November, 1961 (Schwob, 1963), along the entire Cedar River reach profiled for the 2008 flood.

## Summary

Information on flood-peak and water-surface-elevation profiles is needed for the planning and safe design of bridges and other structures along rivers and streams and also for effective management of flood plains. Data for major floods are needed to compute flood-peak discharges and calibrate water-surface-elevation models. This report was prepared in cooperation with the Iowa Department of Transportation and the Iowa Highway Research Board.

As a result of prolonged and intense periods of rainfall in late May and early June, 2008, along with heavier than normal snowpack the previous winter, severe flooding occurred in the Iowa and Cedar River Basins. Above normal rainfall leading into the fall of 2007 also contributed to the saturated soil conditions leading up to the flood of May 30 to June 15, 2008. The storms were part of an exceptionally wet period from May 29 through June 12, when an Iowa statewide average of 9.03 in. of rain fell; the normal statewide average for the same period is 2.45 in. From May 29 to June 13, the 16-day total rainfall recorded at rain gages in Iowa Falls and Clutier was 14.0 and 13.83 in., respectively. Within the Iowa River Basin, peak discharges of 51,000 $ft^3/s$ (flood-probability estimate of 0.2 to 1 percent) at the streamgage 05453100 Iowa River at Marengo, Iowa on June 12, and 39,900 $ft^3/s$ (flood-probability estimate of 0.2 to 1 percent) at the streamgage 05453520 Iowa River below Coralville Dam near Coralville, Iowa, on June 15 are the largest floods on record for those sites. The peak discharge of 41,100 $ft^3/s$ (flood-probability estimate of 0.2 to 1 percent) on June 15 at the streamgage 05454500 Iowa River at Iowa City, Iowa, is the fourth highest on record, but is the largest flood since regulation by the Coralville Dam began in 1958.

Within the Cedar River Basin, the May 30 to June 15, 2008, flood is the largest on record at all six streamgages located on the mainstem of the Cedar River and at five streamgages located on the major tributaries. Flood-probability estimates for 10 of these 11 streamgages are less than 1 percent. Peak discharges of 112,000 $ft^3/s$ (flood-probability estimate of 0.2 to 1 percent) at the streamgage 05464000 Cedar River at Waterloo, Iowa, on June 11 and of 140,000 $ft^3/s$ (flood-probability estimate of less than 0.2 percent) at the streamgage 05464500 Cedar River at Cedar Rapids, Iowa on June 13 are the largest floods on record for those sites. The peak discharge at streamgage 05464500 Cedar River at Cedar Rapids, Iowa, was prorated from a discharge measurement made 9.9 mi downstream at the Cedar River at U.S. Highway 30. The discharge measured at the U.S. Highway 30 site was 150,000 $ft^3/s$. Downstream from the confluence of the Iowa and Cedar Rivers at the streamgage 05465500 Iowa River at Wapello, Iowa, a peak discharge of 188,000 $ft^3/s$ (flood-probability range estimated to be less than 0.2 percent) on June 14, 2008, is the largest flood on record in the Iowa River and Cedar River Basins since 1903.

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## Figures 12–39

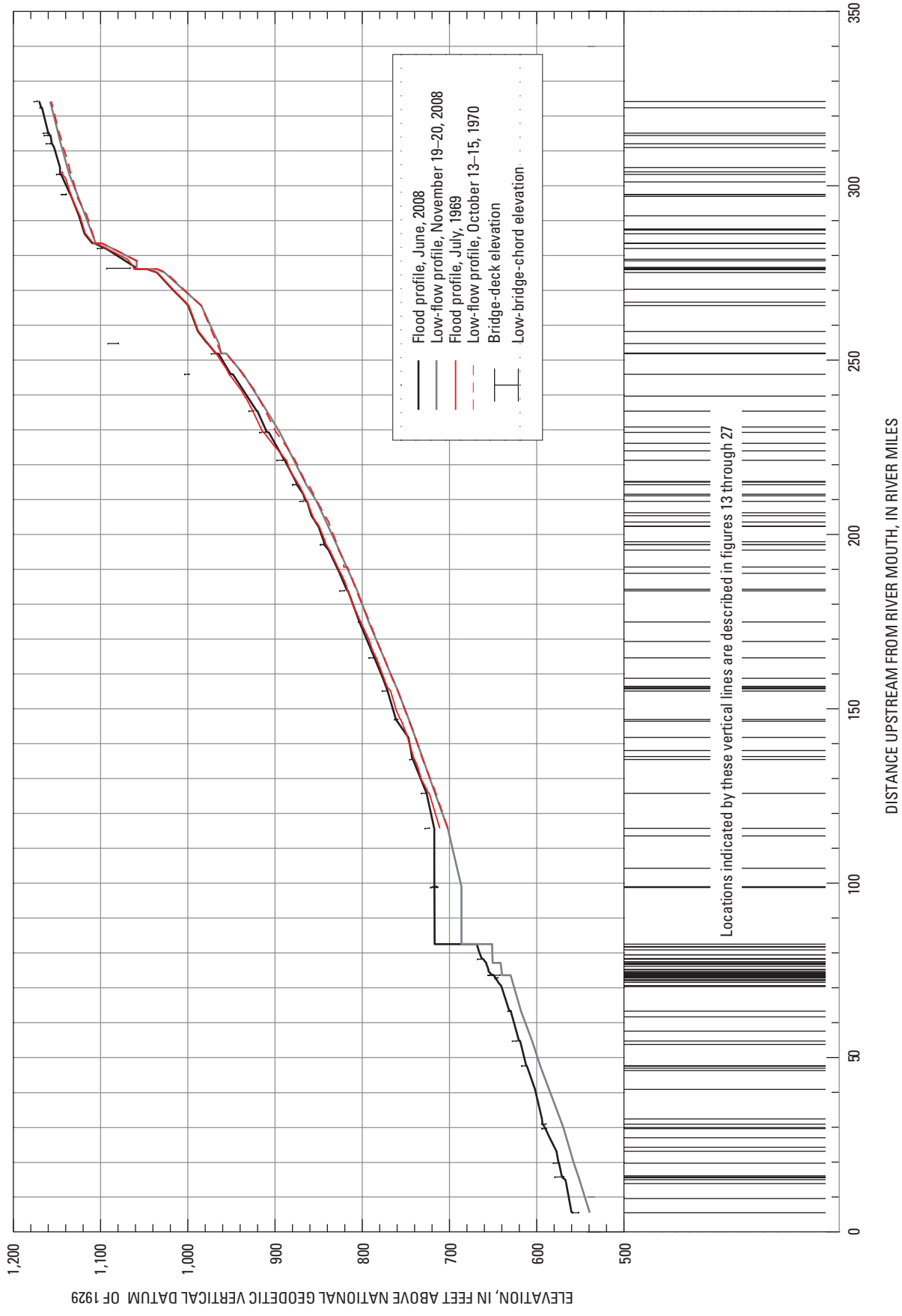


**Figure 12.** Profile of the June 2008 flood for the Iowa River, river miles 5.5 to 324.2.

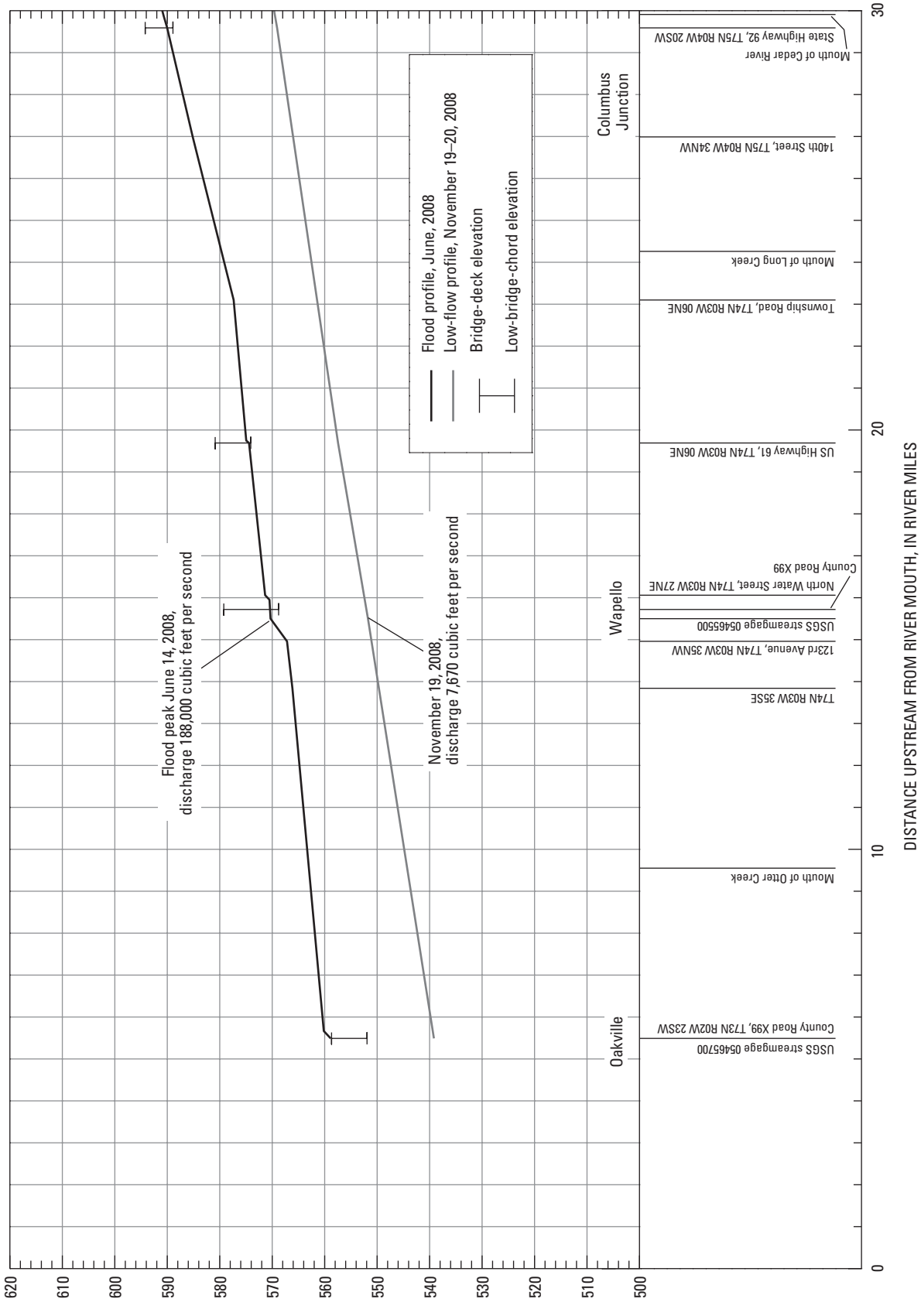


**Figure 13.** Profile of the June 2008 flood for the Iowa River, river miles 5.5 to 30.

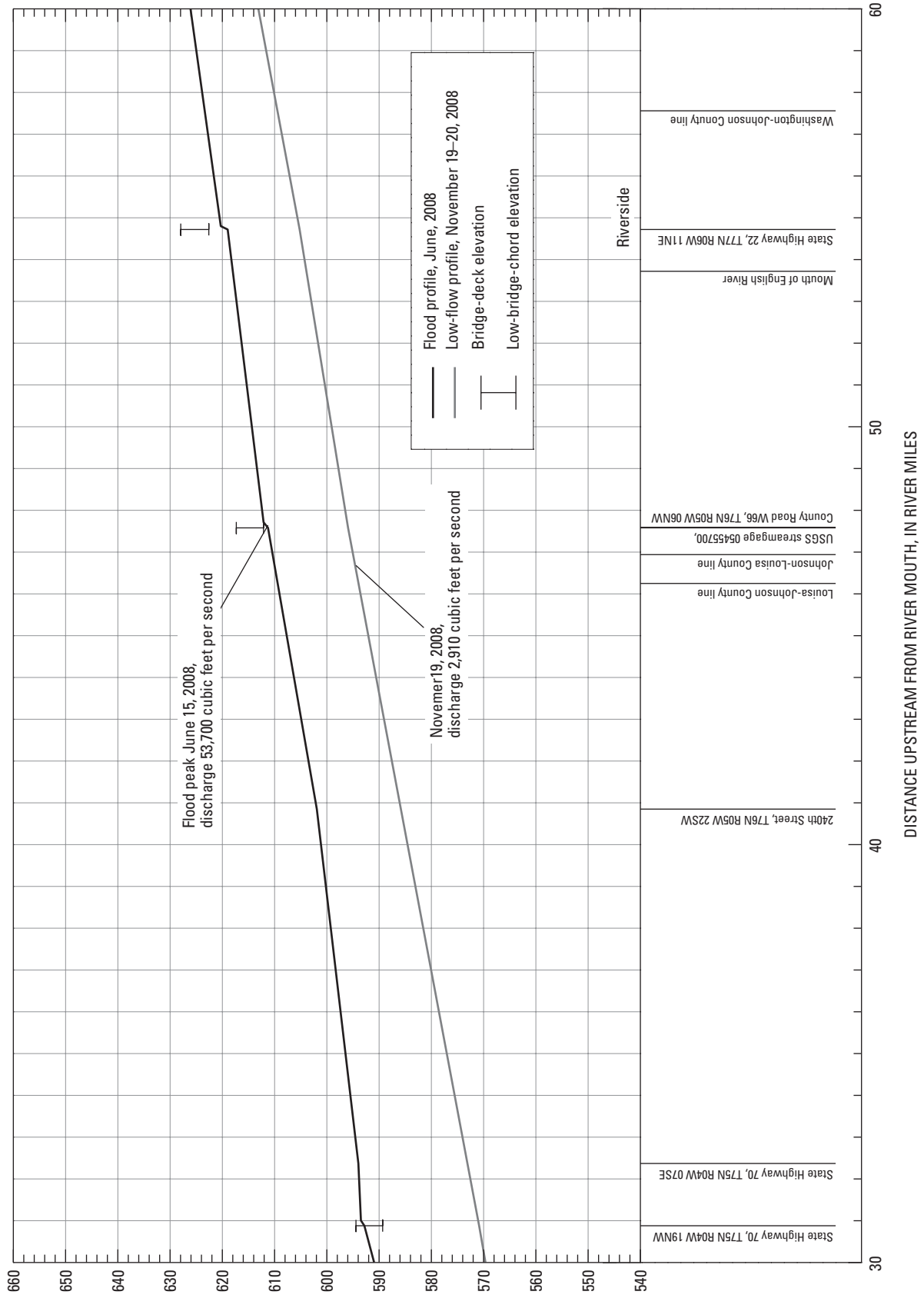


**Figure 14.** Profile of the June 2008 flood for the Iowa River, river miles 30 to 60.

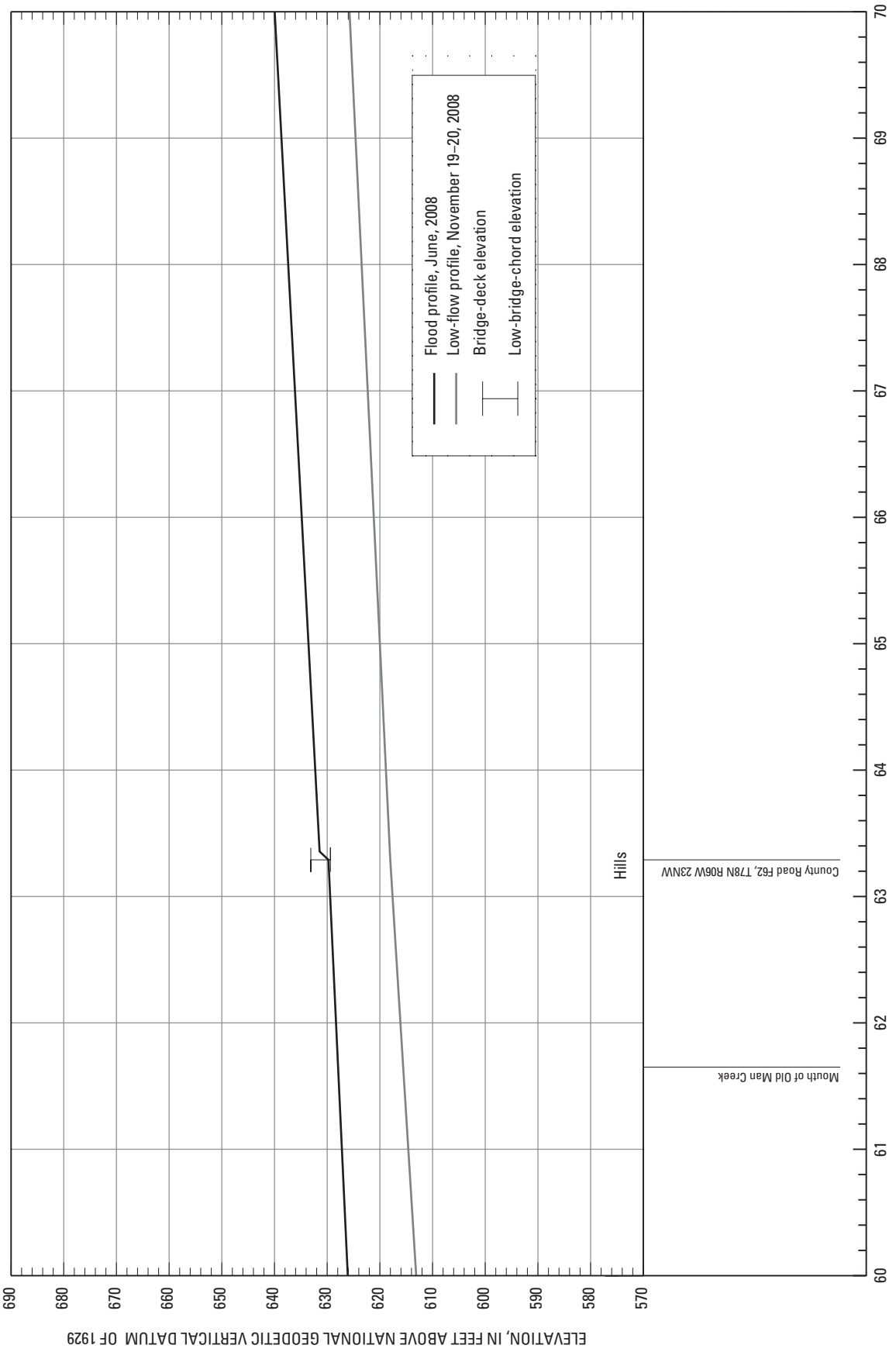


**Figure 15.** Profile of the June 2008 flood for the Iowa River, river miles 60 to 70.

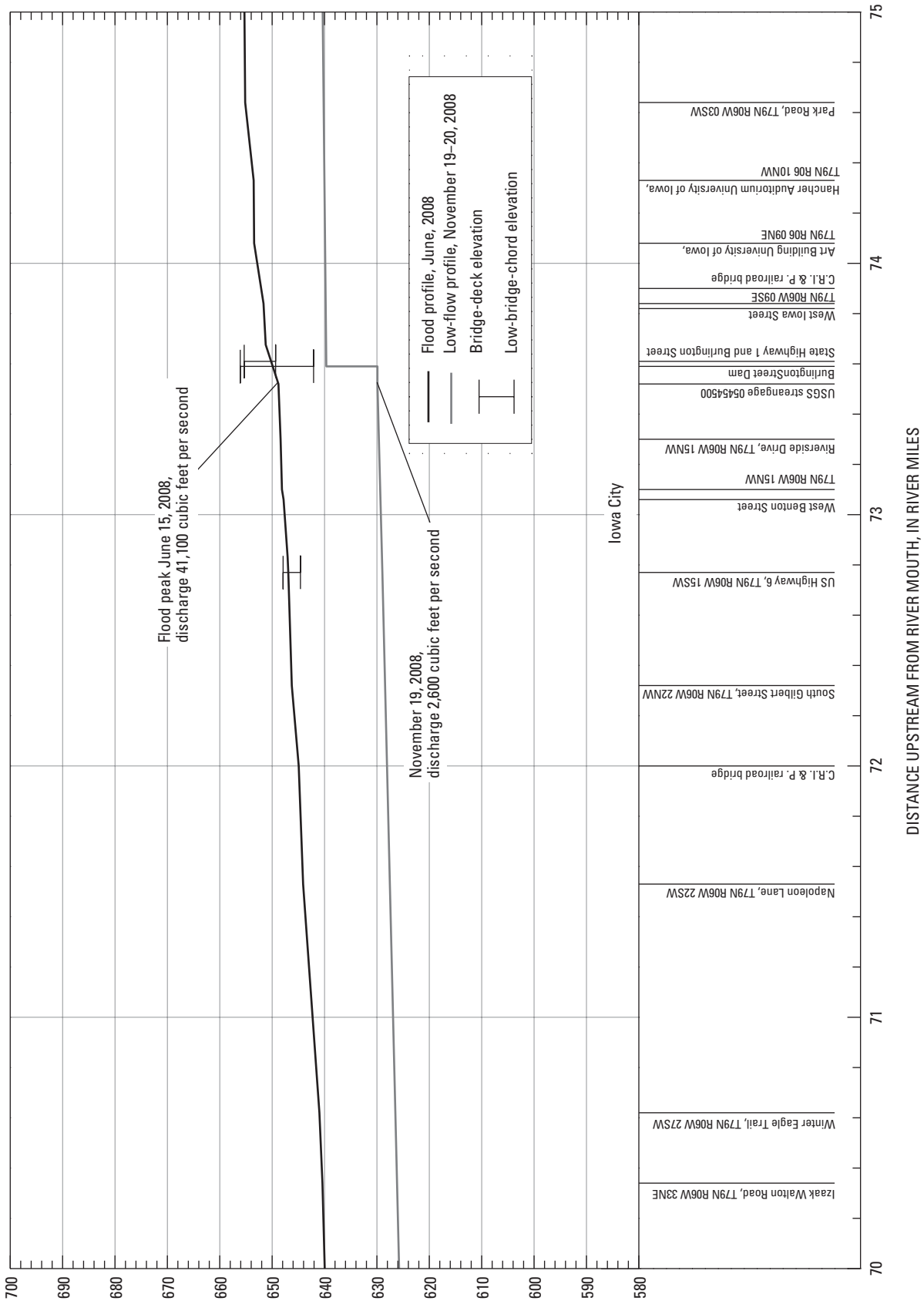


**Figure 16.** Profile of the June 2008 flood for the Iowa River, river miles 70 to 75.

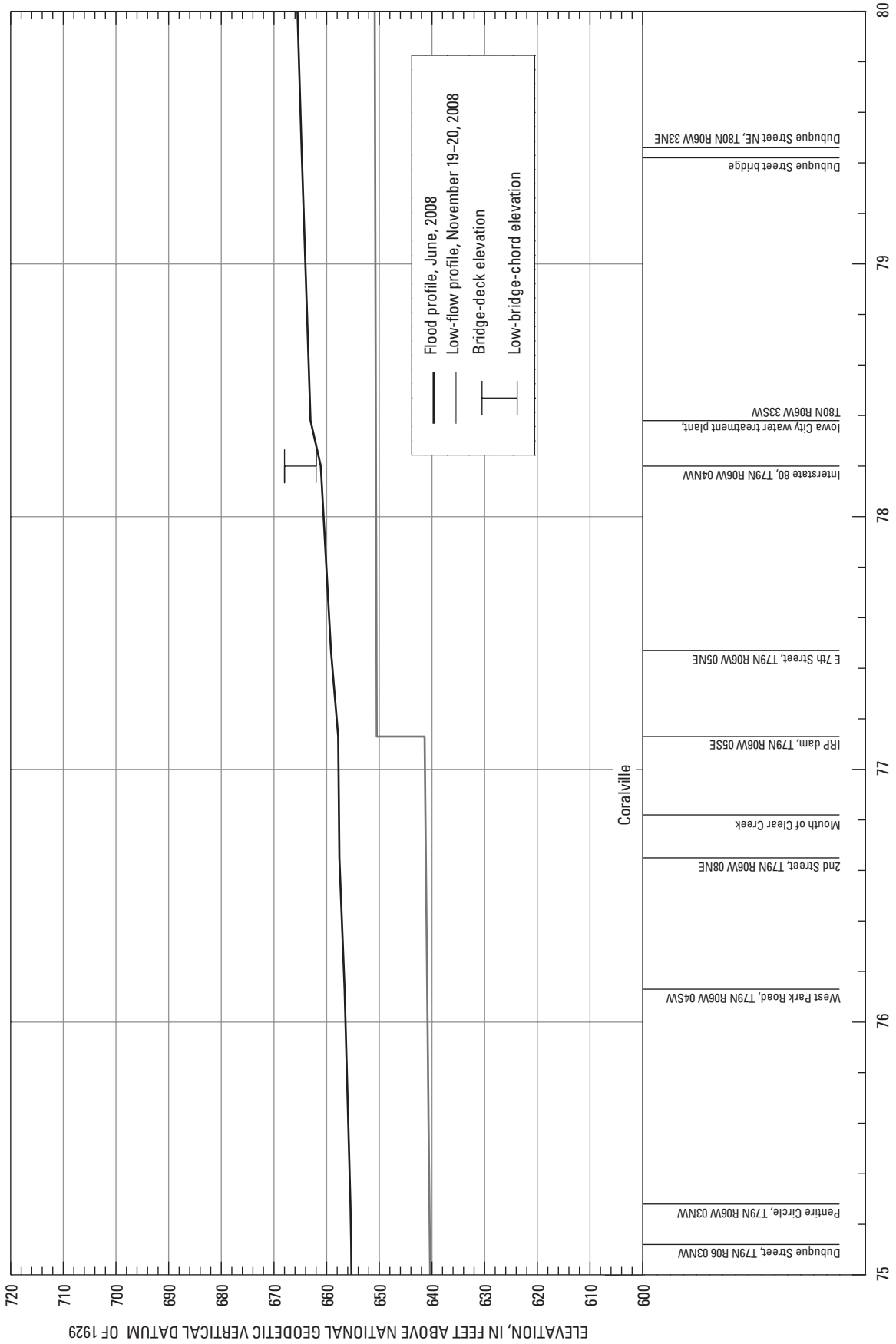


**Figure 17.** Profile of the June 2008 flood for the Iowa River, river miles 75 to 80.

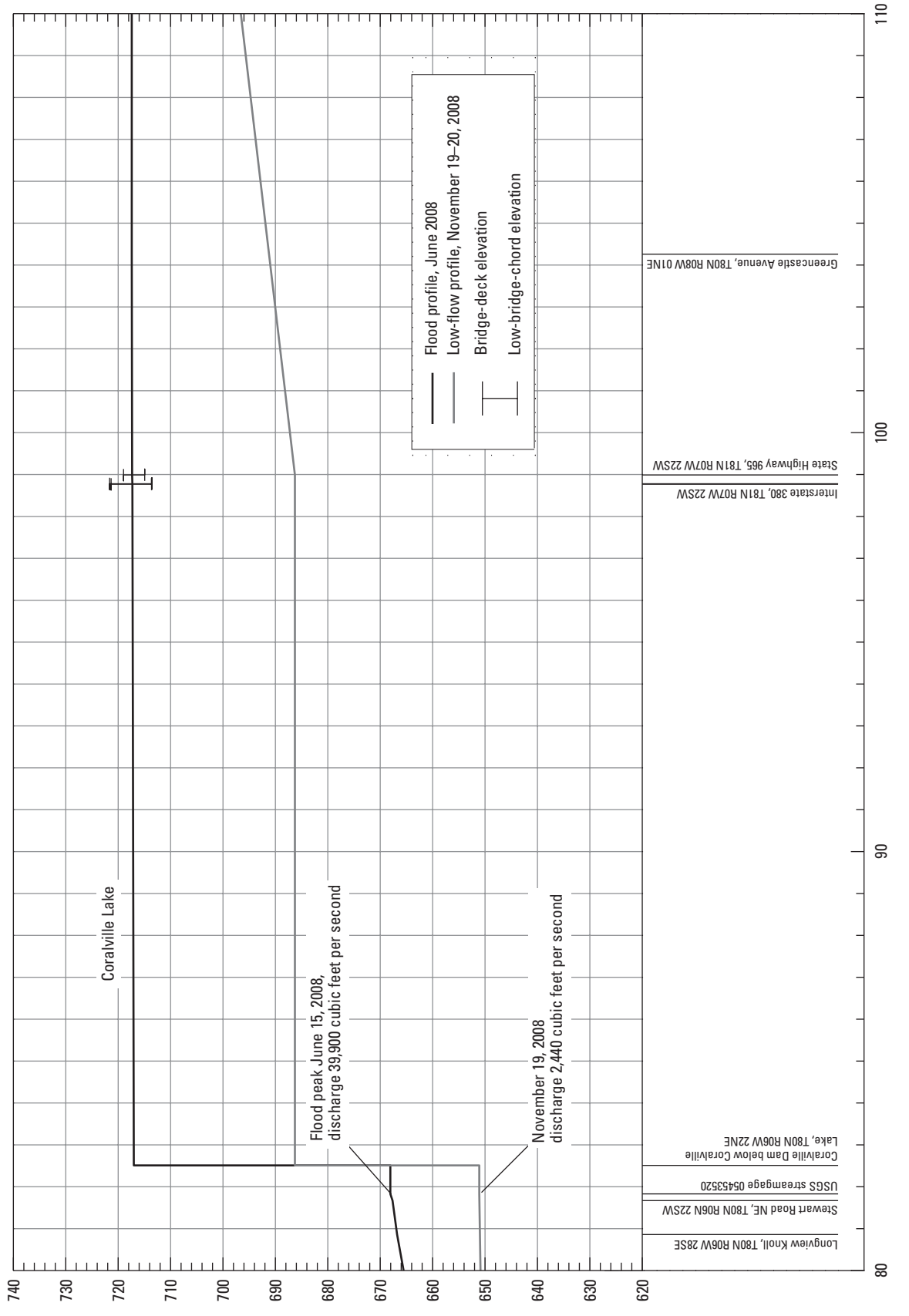


**Figure 18.** Profile of the June 2008 flood for the Iowa River, river miles 80 to 110.

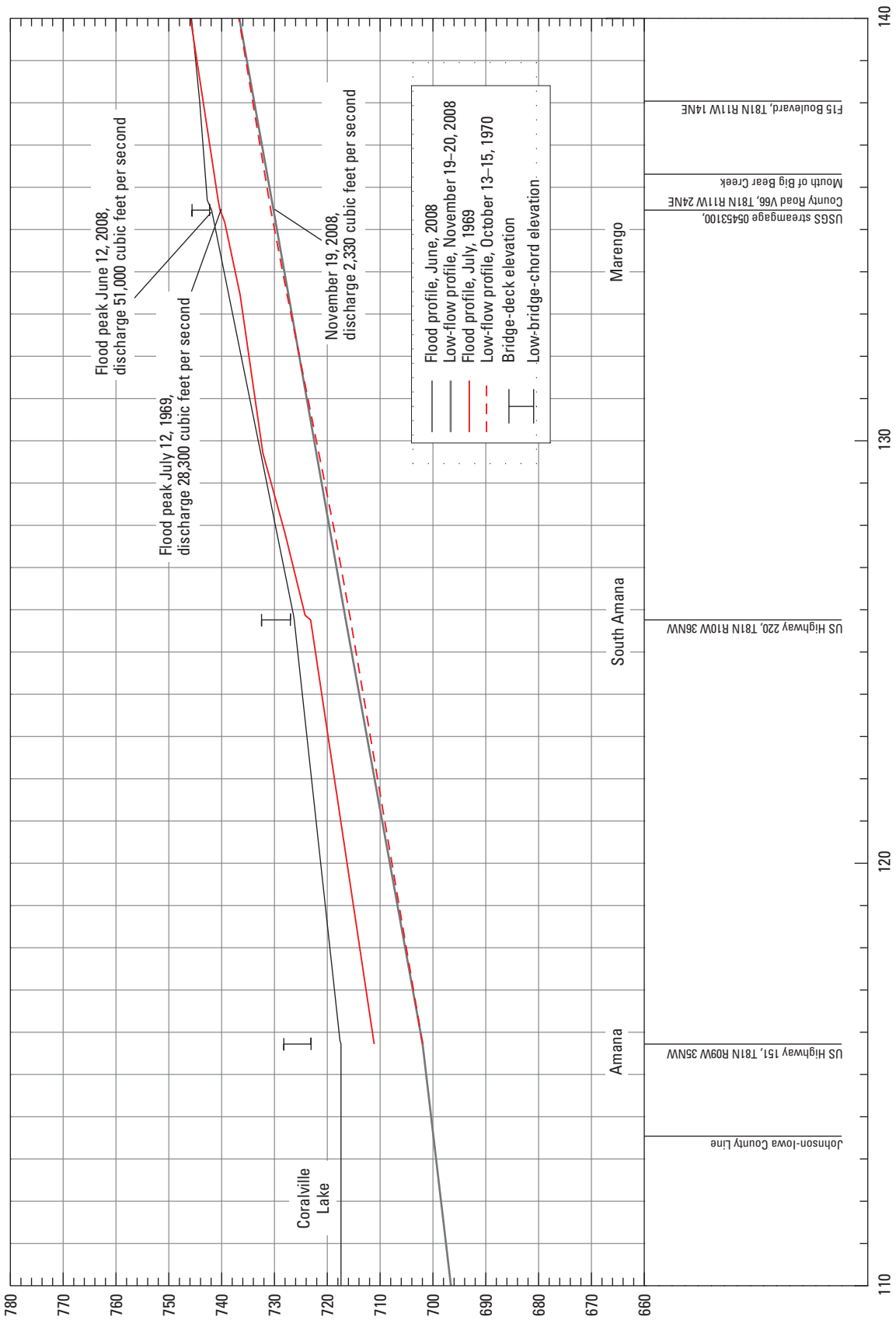


**Figure 19.** Profile of the June 2008 flood for the Iowa River, river miles 110 to 140.

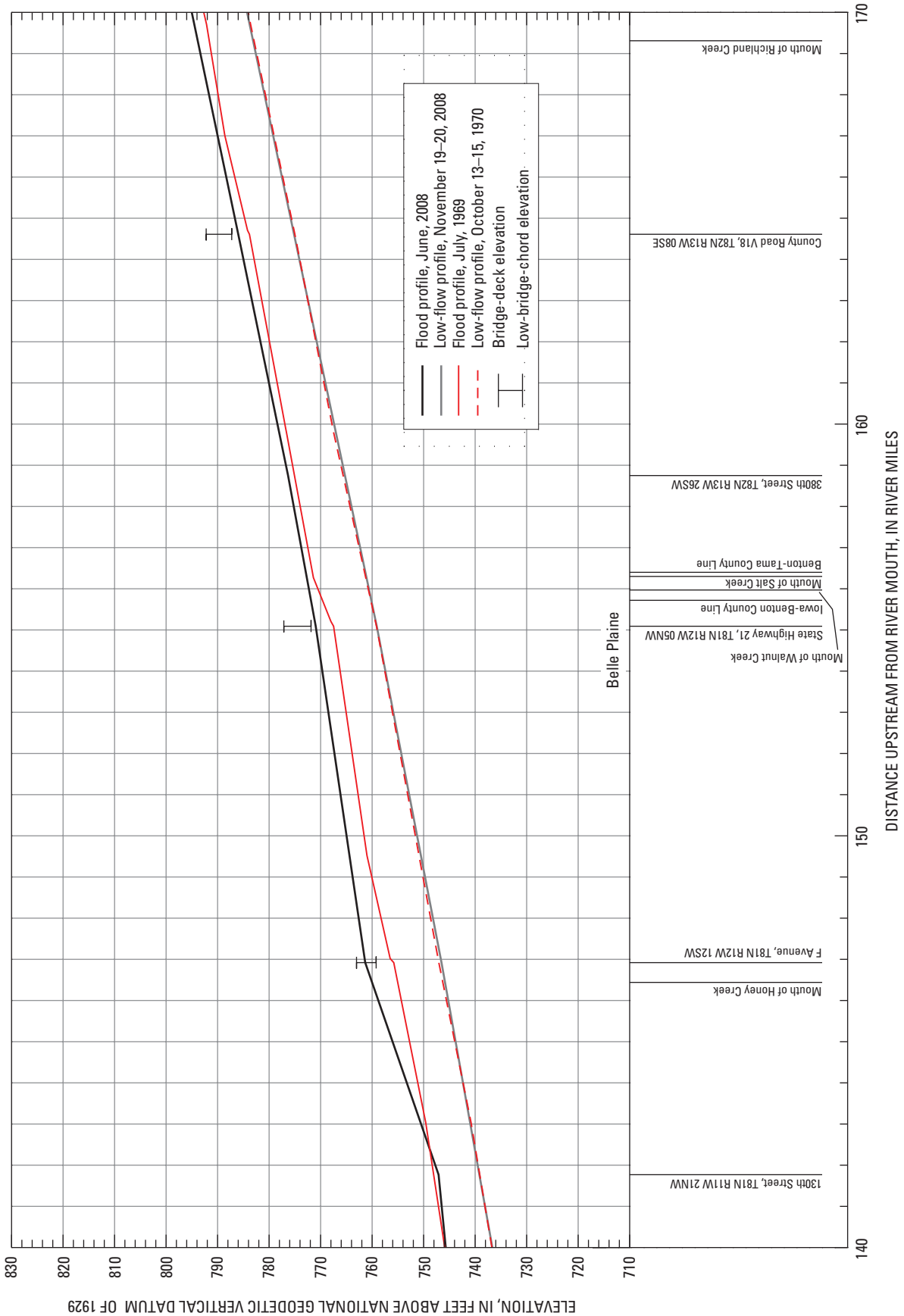


**Figure 20.** Profile of the June 2008 flood for the Iowa River, river miles 140 to 170.

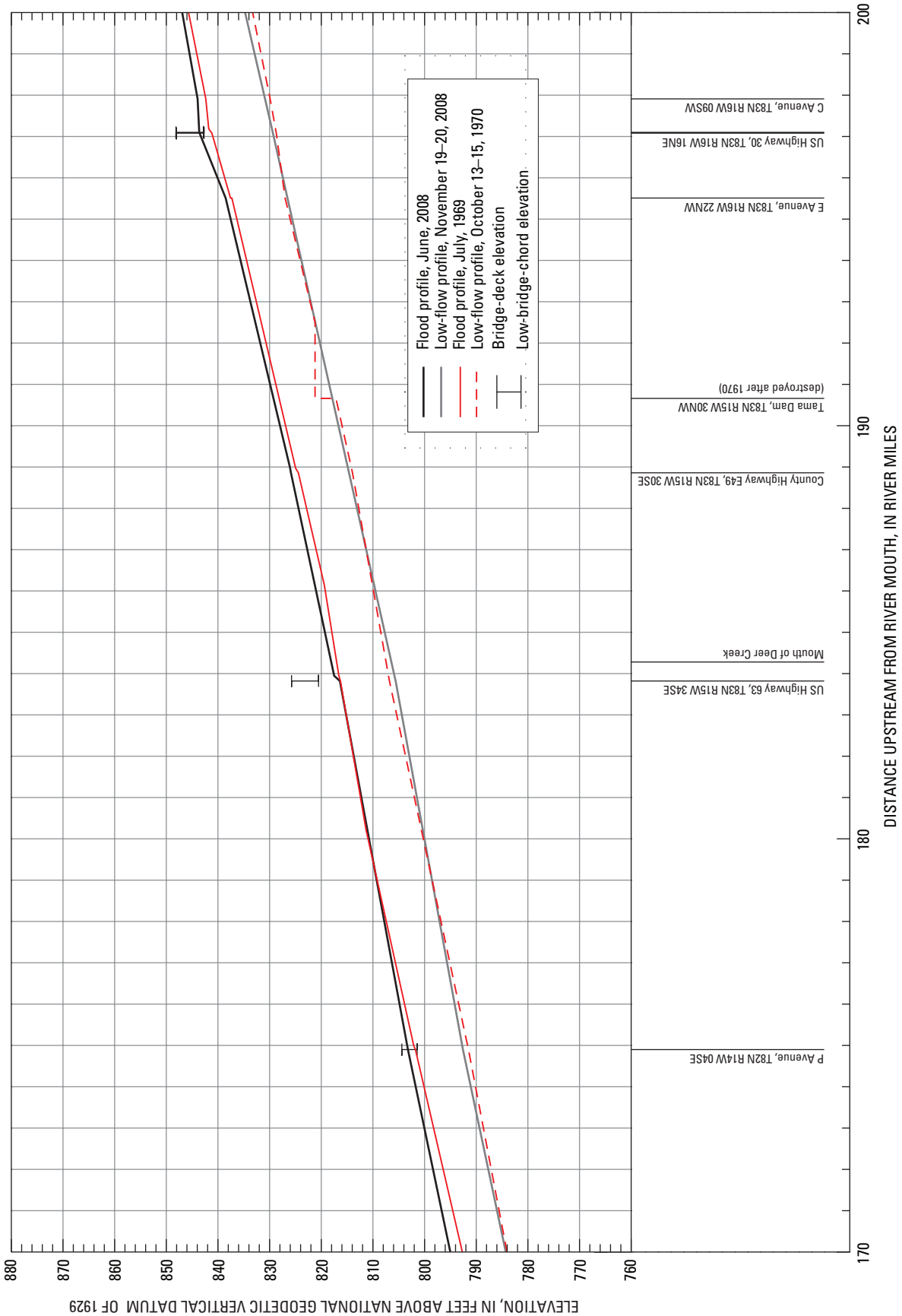


**Figure 21.** Profile of the June 2008 flood for the Iowa River, river miles 170 to 200.

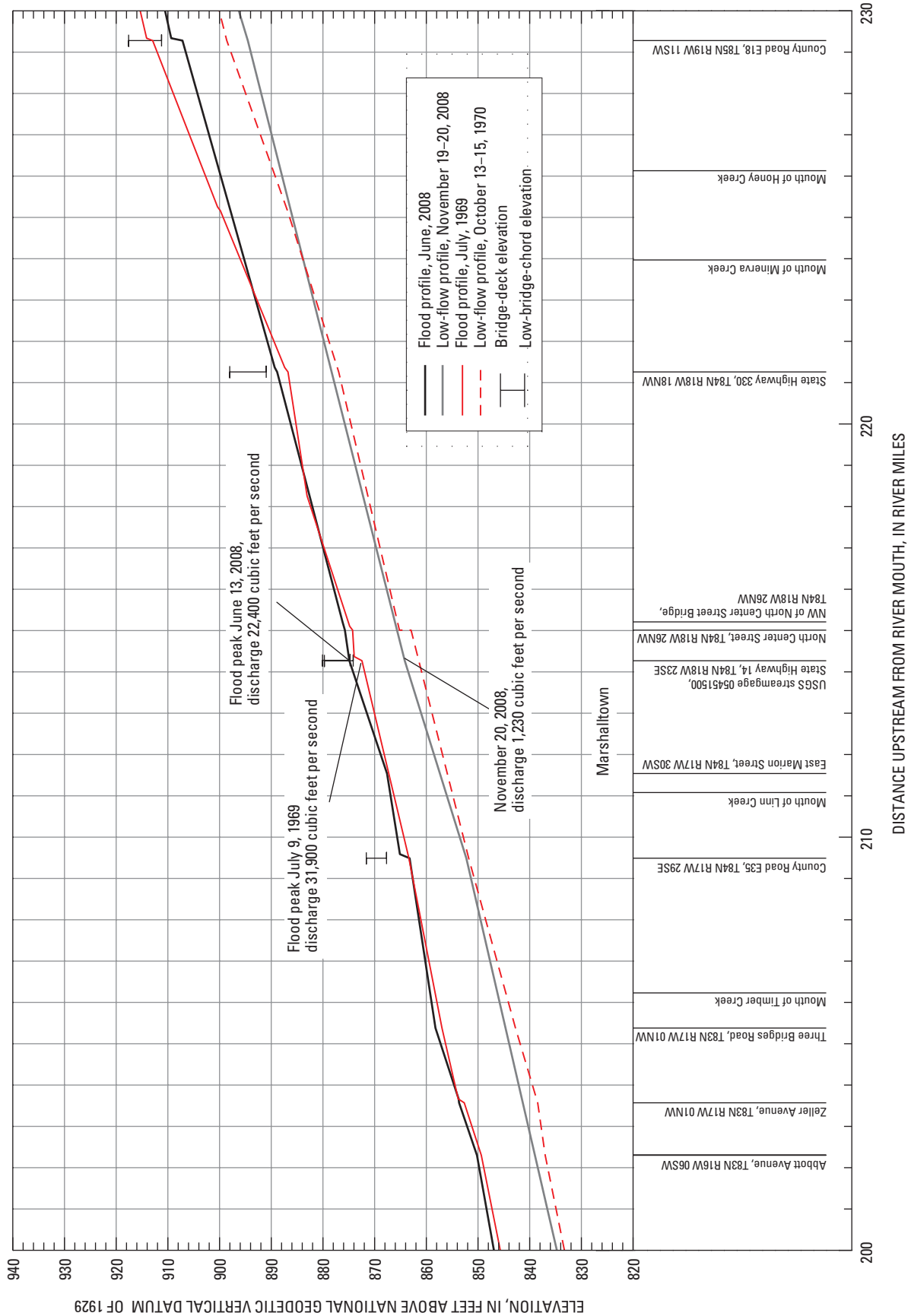


**Figure 22.** Profile of the June 2008 flood for the Iowa River, river miles 200 to 230.

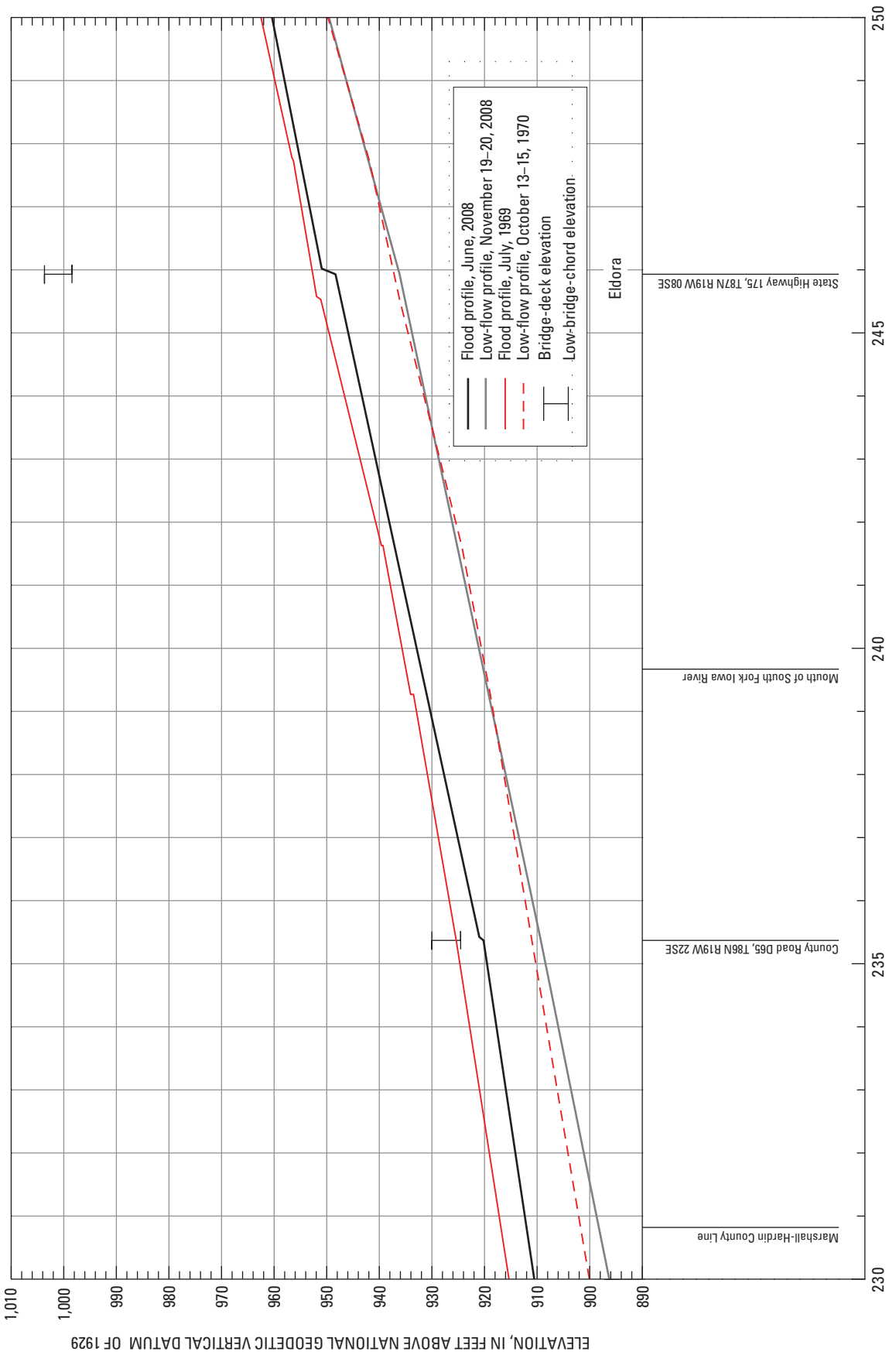


**Figure 23.** Profile of the June 2008 flood for the Iowa River, river miles 230 to 250.

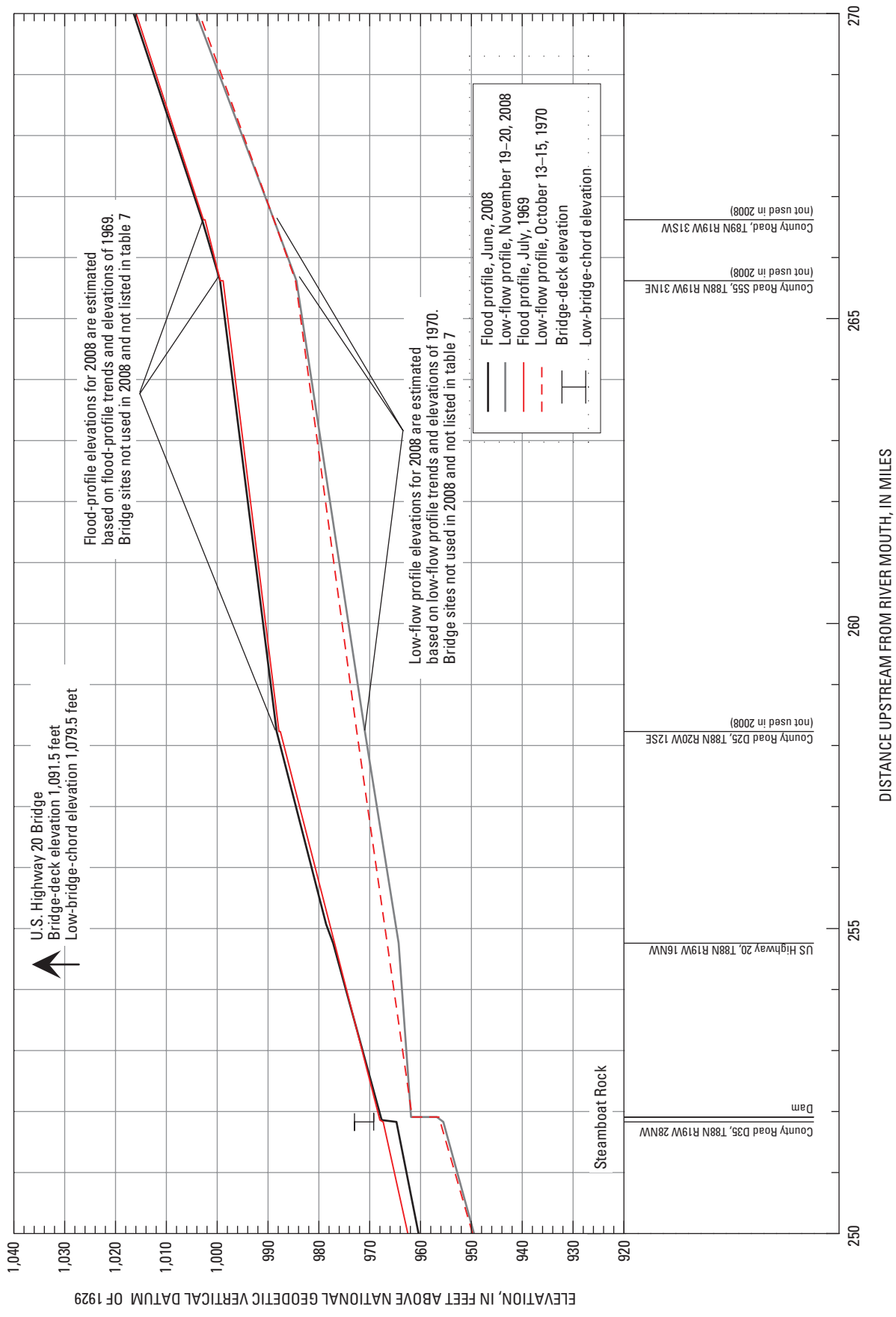


**Figure 24.** Profile of the June 2008 flood for the Iowa River, river miles 250 to 270.

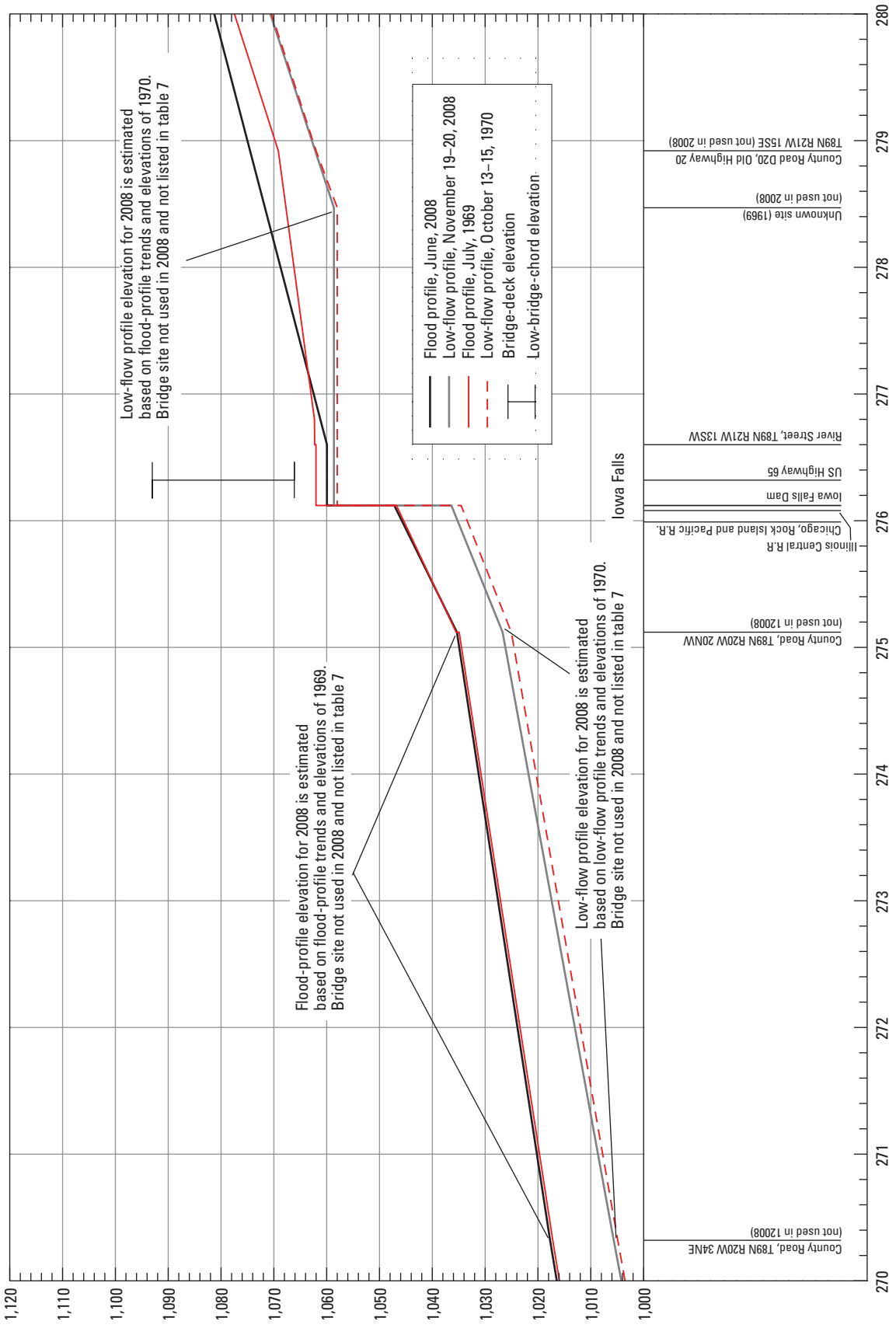


**Figure 25.** Profile of the June 2008 flood for the Iowa River, river miles 270 to 280.

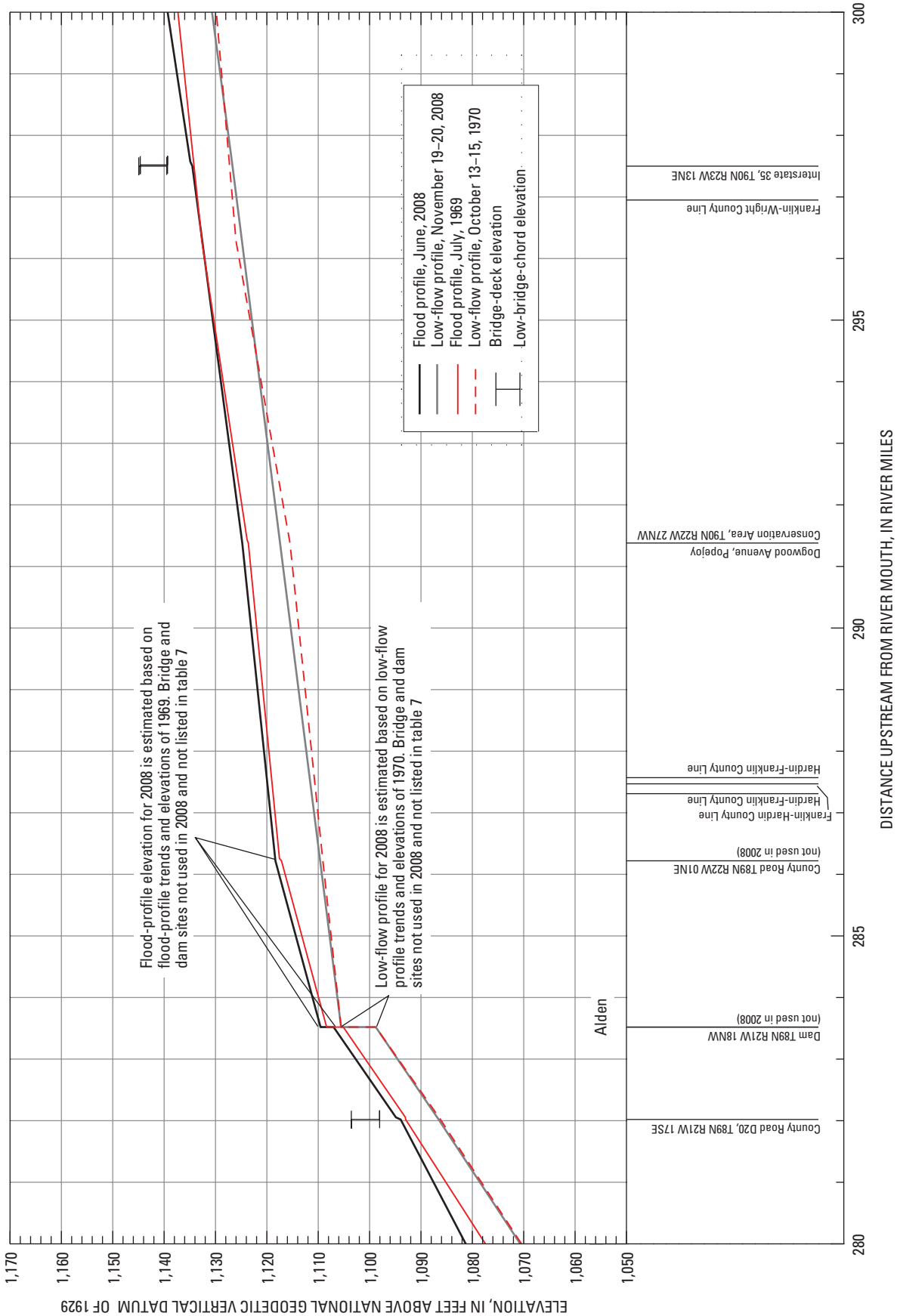


**Figure 26.** Profile of the June 2008 flood for the Iowa River, river miles 280 to 300.

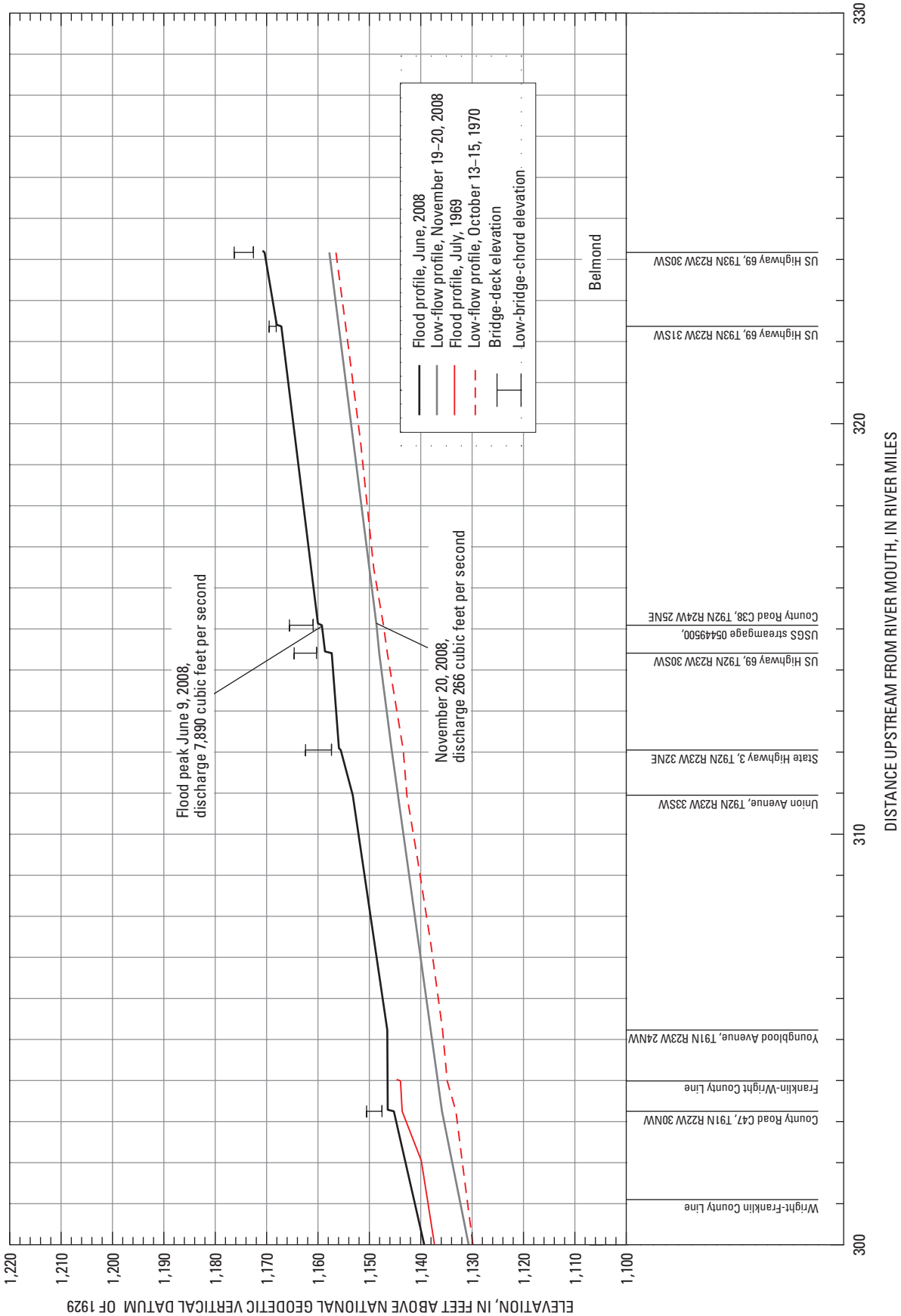


**Figure 27.** Profile of the June 2008 flood for the Iowa River, river miles 300 to 324.2.

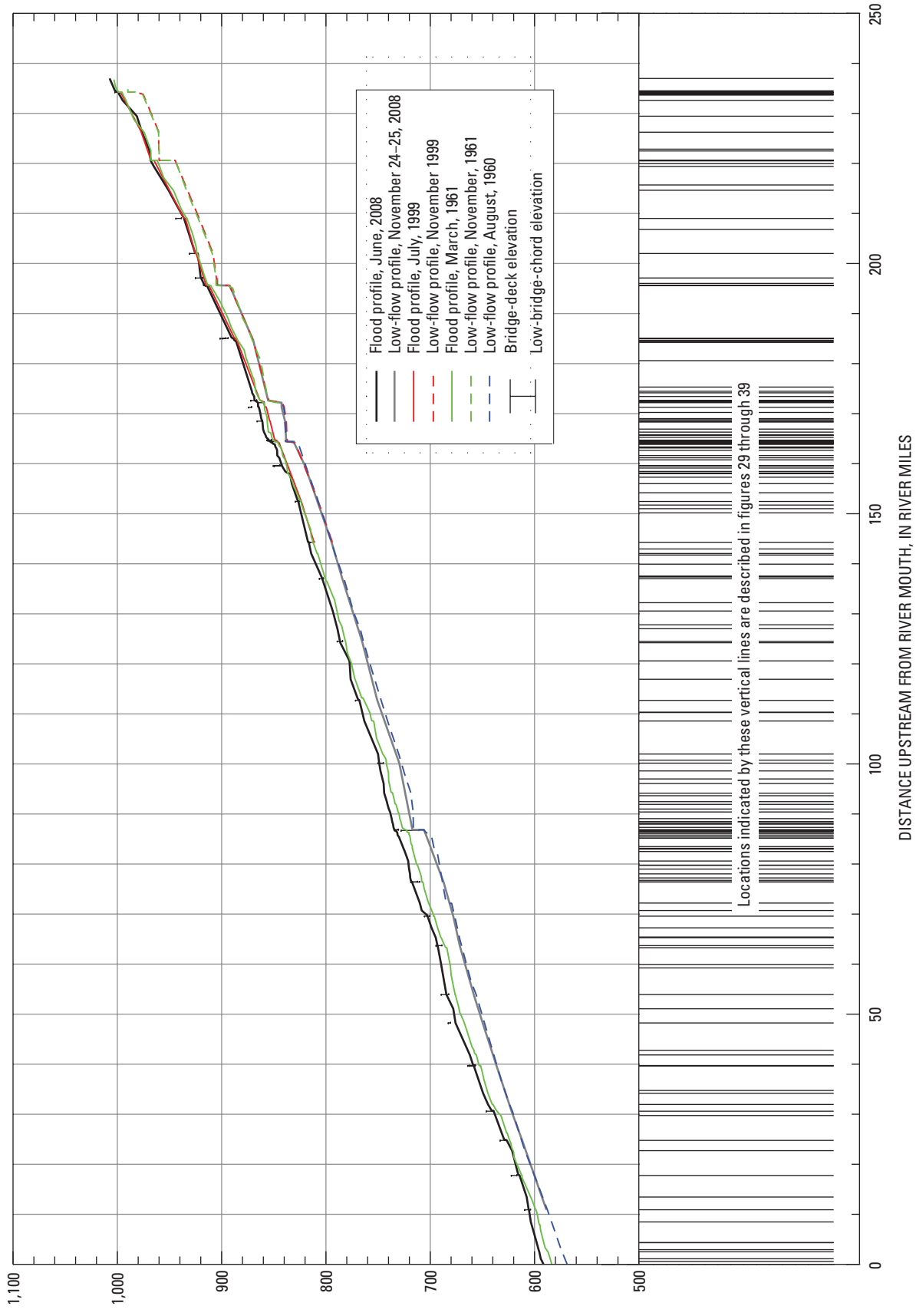


**Figure 28.** Profile of the June 2008 flood for the Cedar River, river miles 0 to 237.

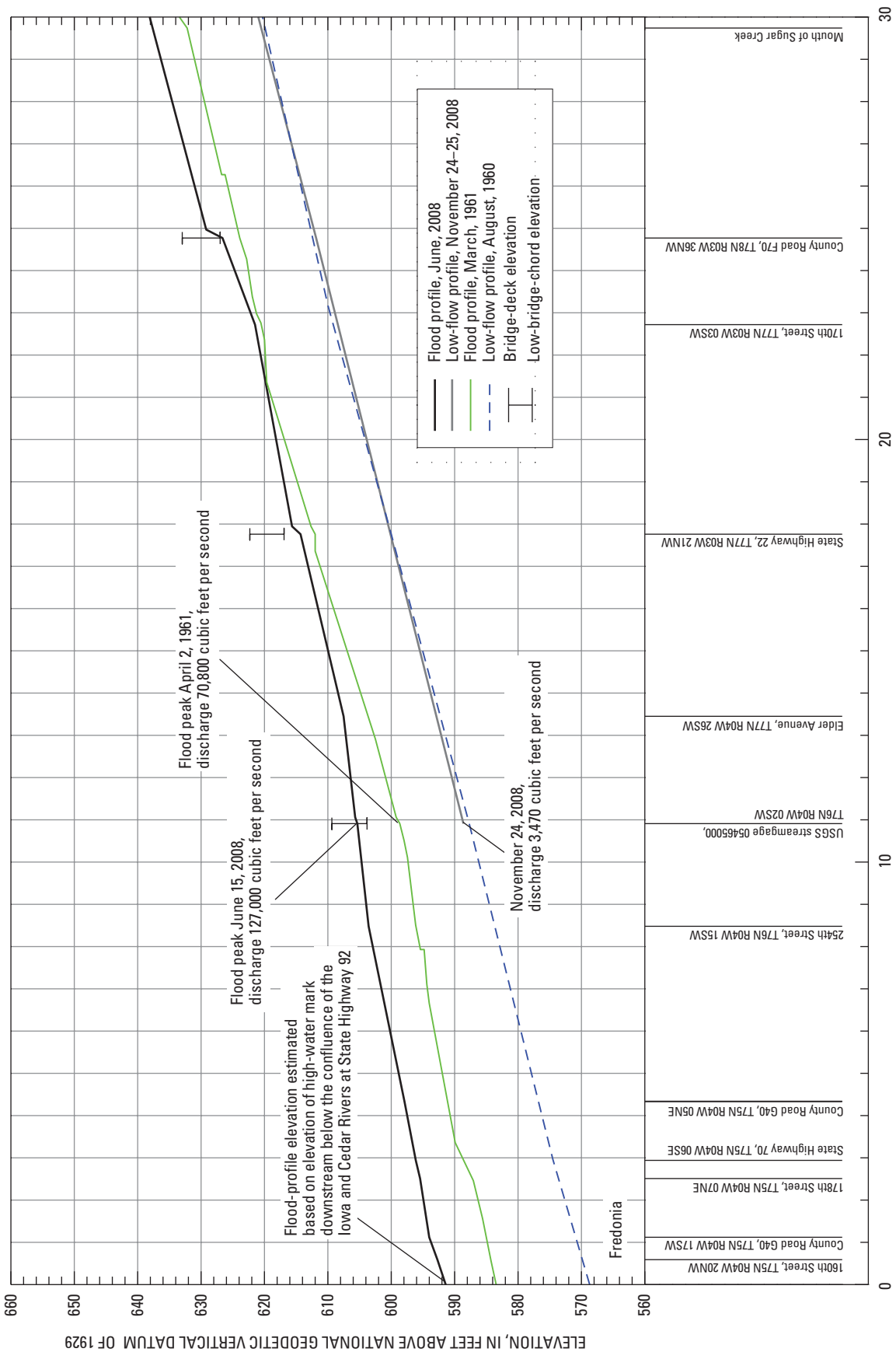


**Figure 29.** Profile of the June 2008 flood for the Cedar River, river miles 0 to 30.

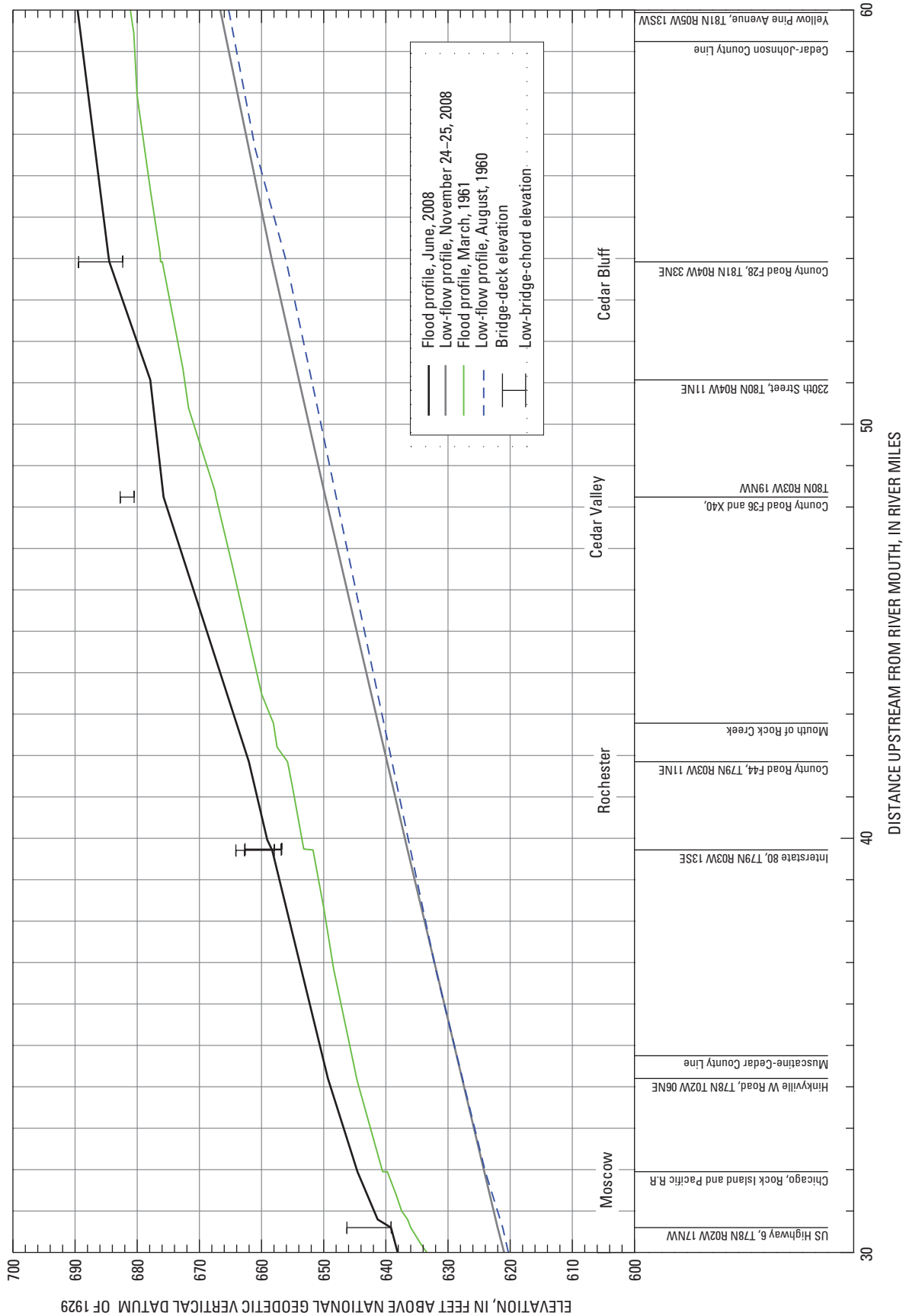


**Figure 30.** Profile of the June 2008 flood for the Cedar River, river miles 30 to 60.

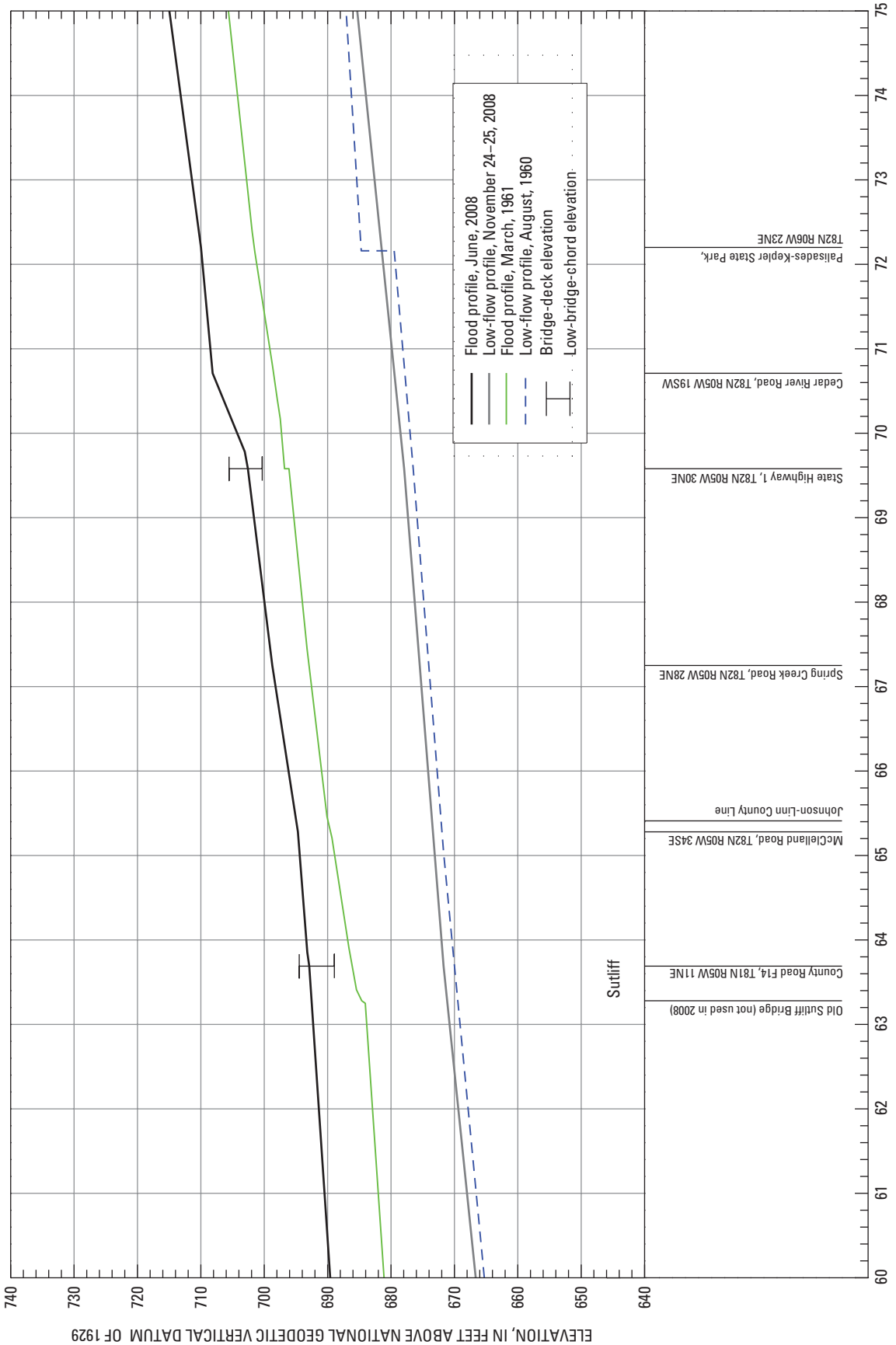


**Figure 31.** Profile of the June 2008 flood for the Cedar River, river miles 60 to 75.

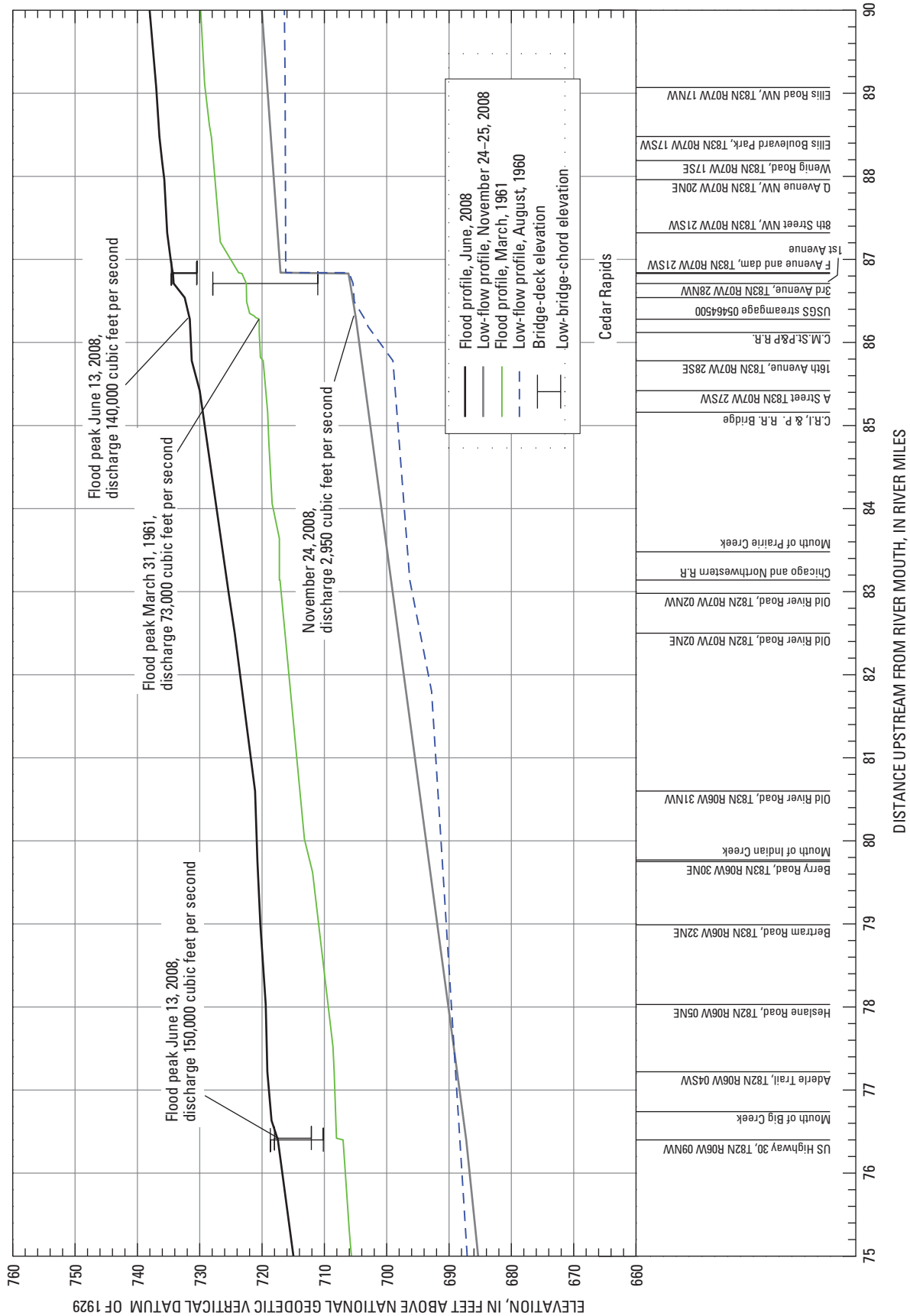


**Figure 32.** Profile of the June 2008 flood for the Cedar River, river miles 75 to 90.

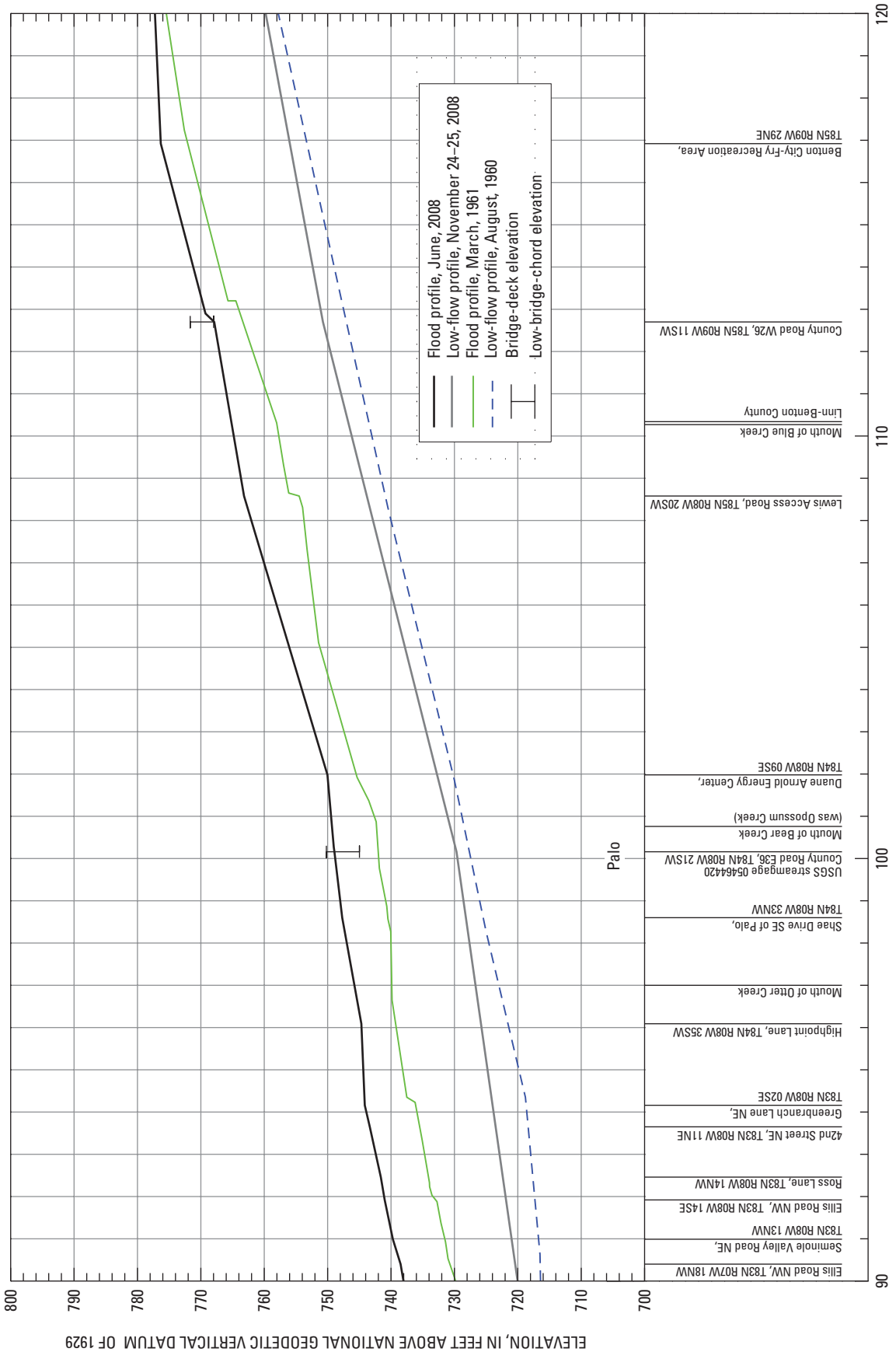


**Figure 33.** Profile of the June 2008 flood for the Cedar River, river miles 90 to 120.

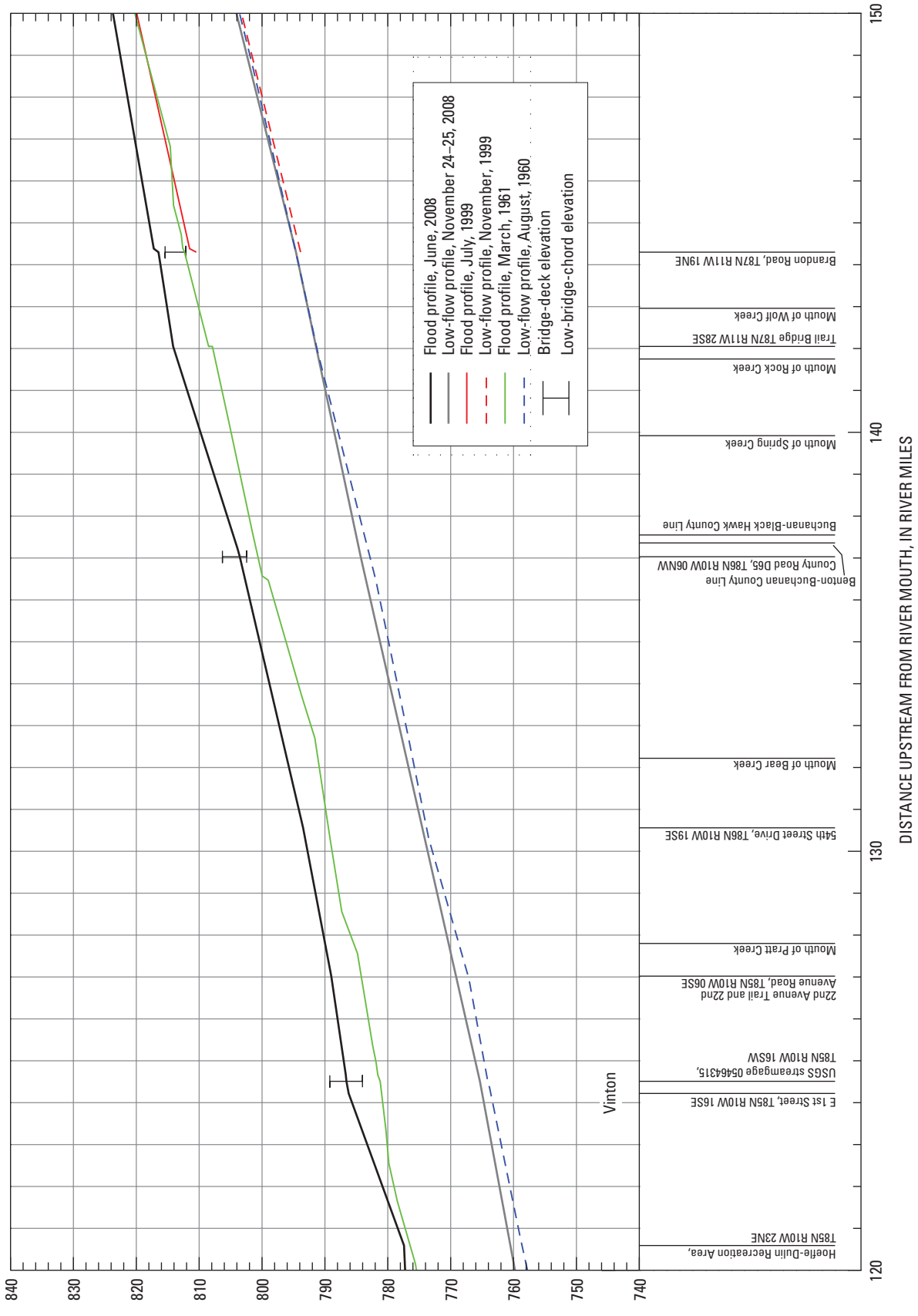


**Figure 34.** Profile of the June 2008 flood for the Cedar River, river miles 120 to 150.

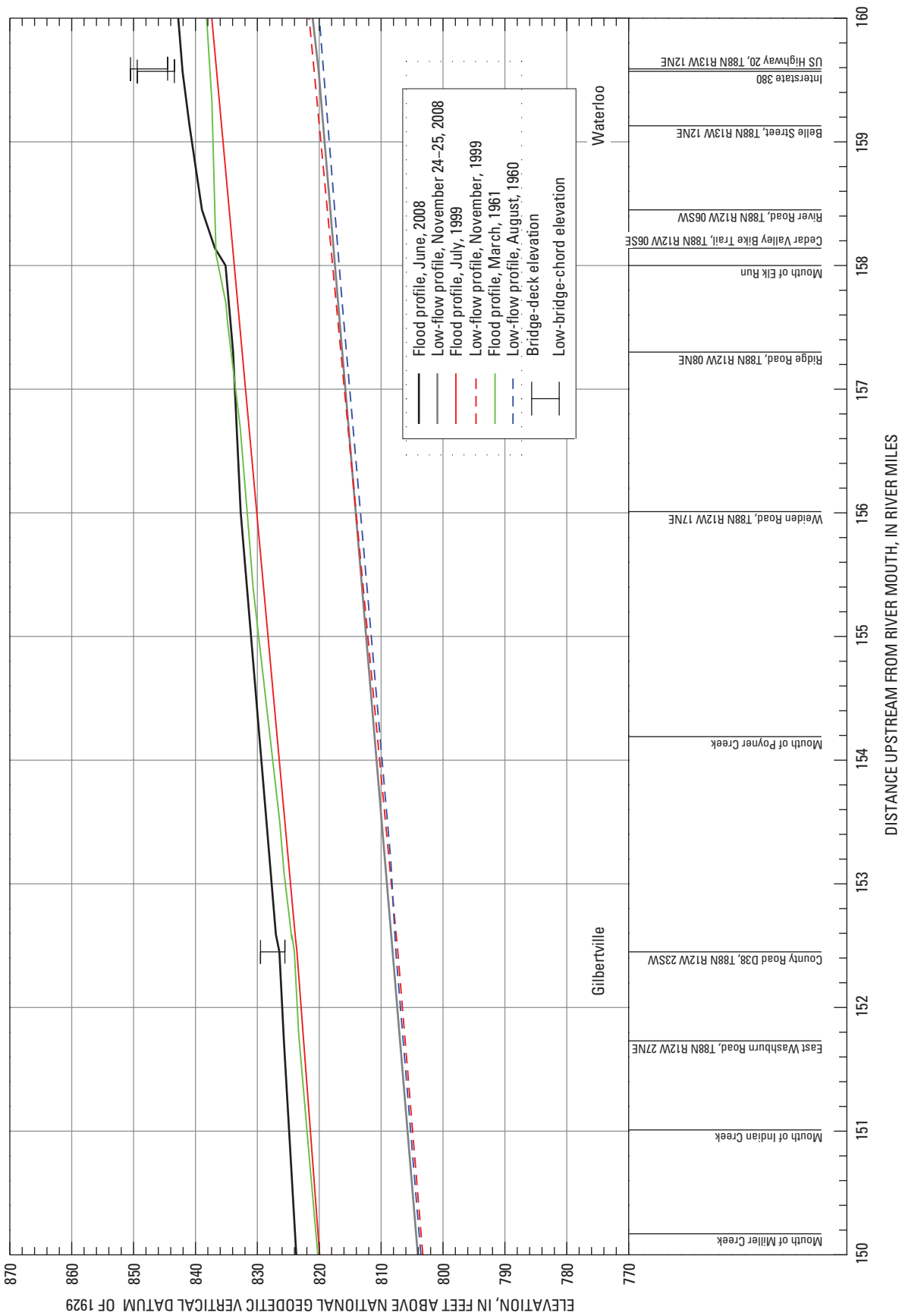


**Figure 35.** Profile of the June 2008 flood for the Cedar River, river miles 150 to 160.

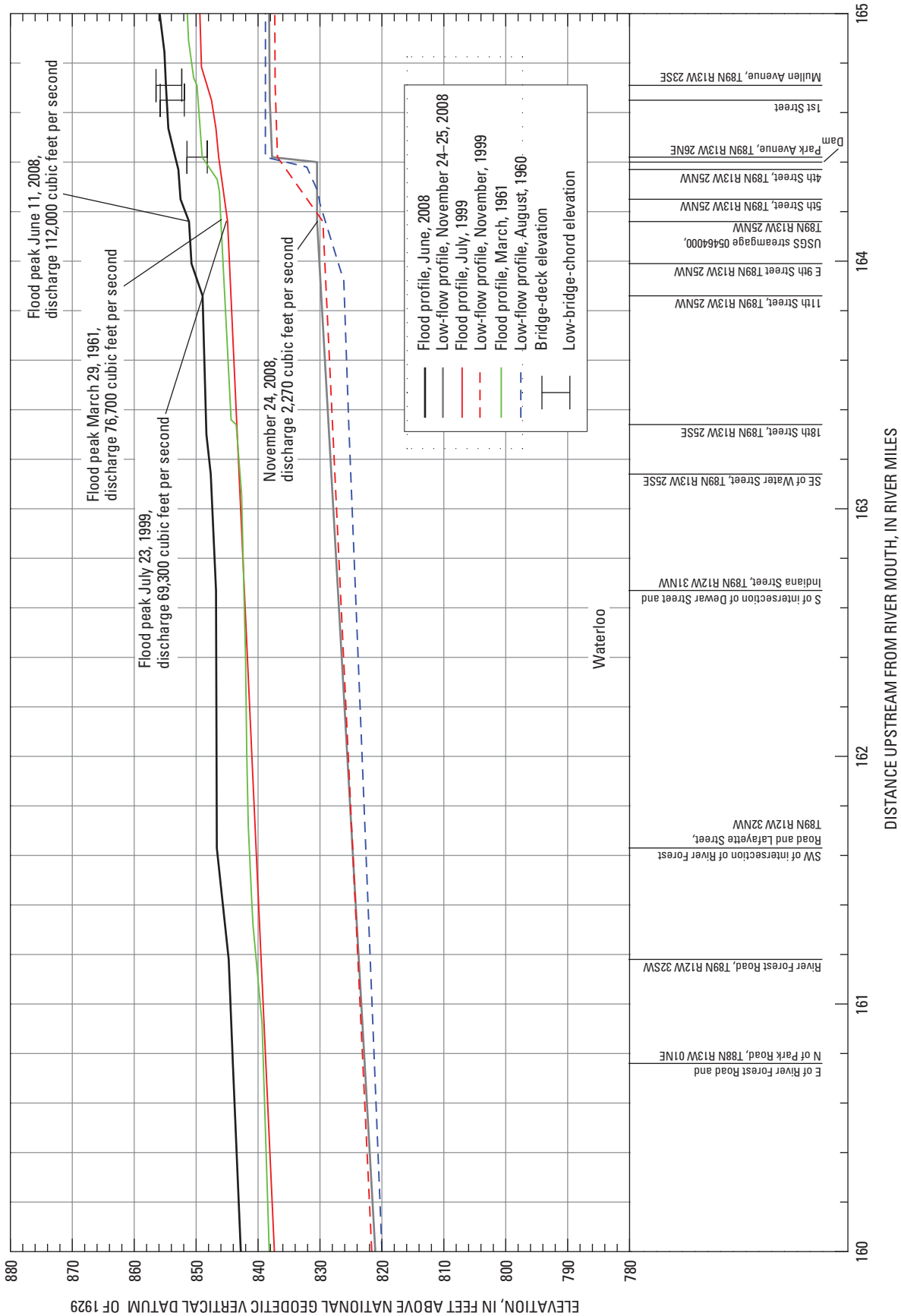


**Figure 36.** Profile of the June 2008 flood for the Cedar River, river miles 160 to 165.

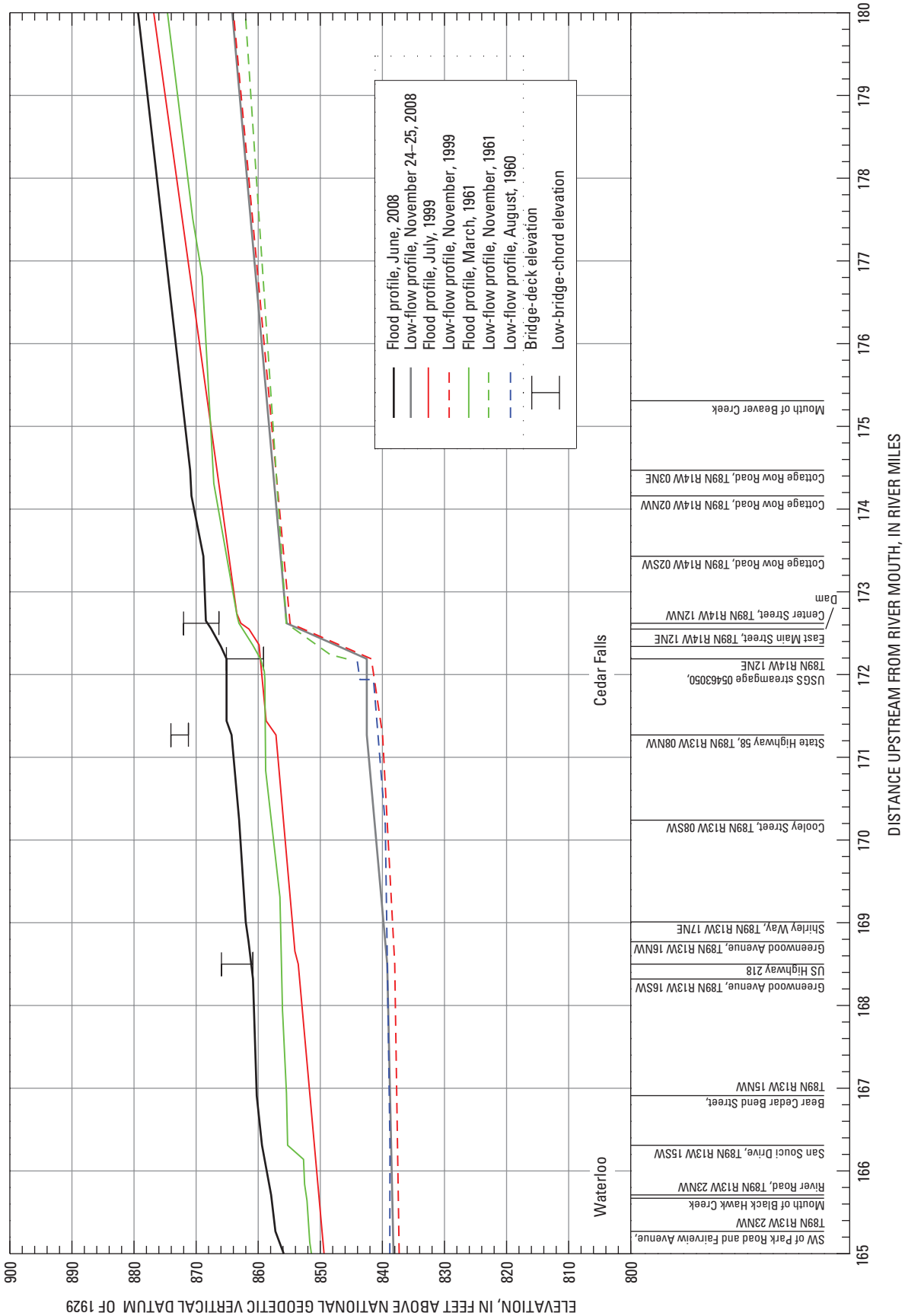


**Figure 37.** Profile of the June 2008 flood for the Cedar River, river miles 165 to 180.

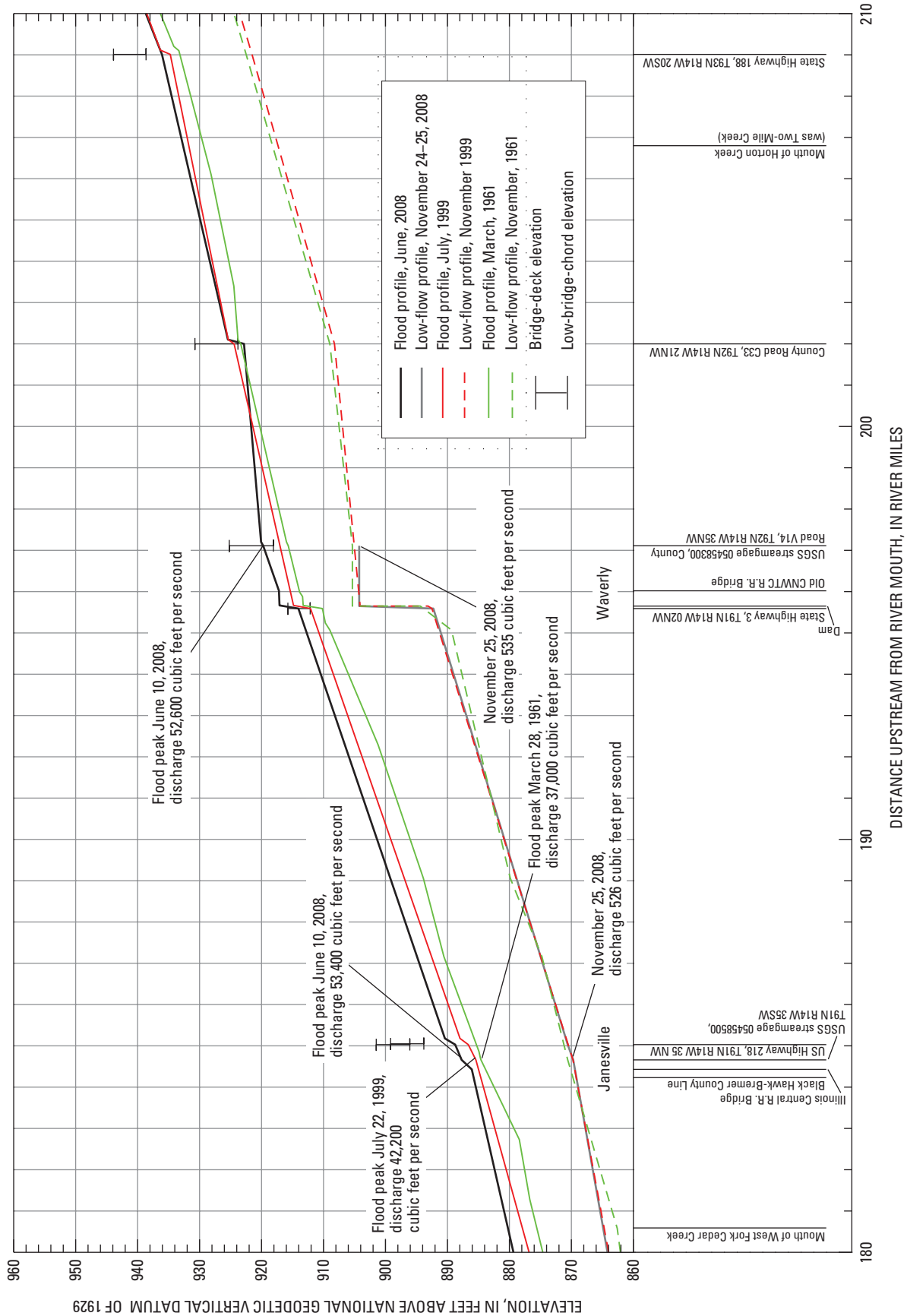


**Figure 38.** Profile of the June 2008 flood for the Cedar River, river miles 180 to 210.

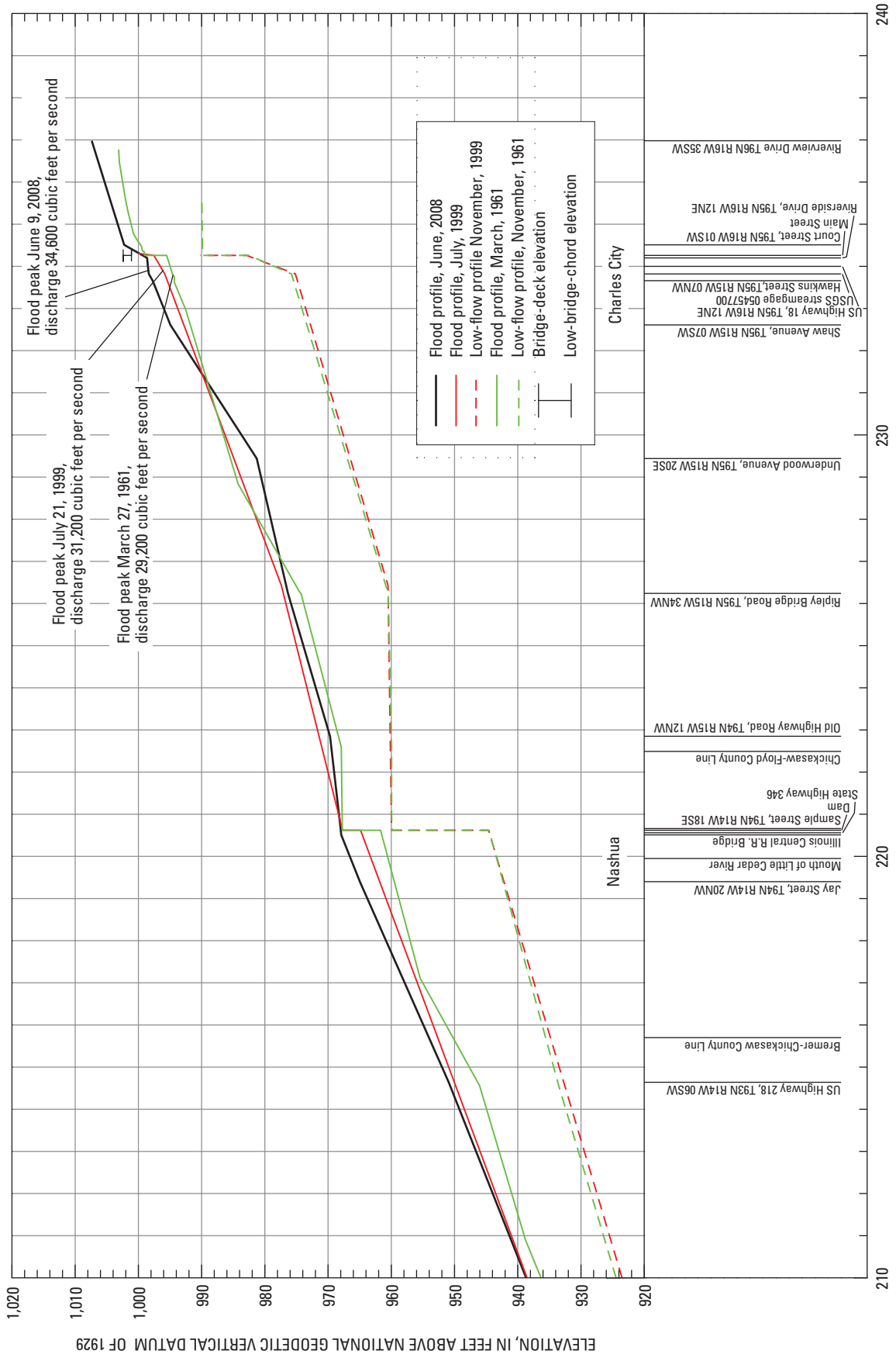


**Figure 39.** Profile of the June 2008 flood for the Cedar River, river miles 210 to 237.

# Tables 3, 7, and 8

**Table 3.** Maximum stages and discharges for 2008 and selected largest-flood years, and the corresponding flood-probability ranges, at streamgages in the Iowa River and Cedar River Basins, Iowa.

[mi², square miles; ft, feet; ft³/s, cubic feet per second; (ft³/s)/mi², cubic feet per second per square mile; ND, not determined; < , less than; >, greater than]

| Map number (fig. 1–2) | Streamgage number and name | Peak–flow record (water years) | Drainage area (mi²) | Date of peak | Peak stage (ft) | Peak discharge (ft³/s) | Flood probability range[1] (percent) | Unit runoff [(ft³/s)/mi²] |
|---|---|---|---|---|---|---|---|---|
| | | | | Iowa River Basin | | | | |
| 1 | 05448285 Eagle Lake Inlet near Britt, Iowa (discontinued) | 1976–80 | 3.83 | 8/21/1979 | 5.60 | 108 | [3]>10 | 28.2 |
| 2 | 05448290 Eagle Lake Outlet near Britt, Iowa (discontinued) | 1976–80 | 11.3 | 8/22/1979 | 4.88 | 101 | [3]>10 | 8.9 |
| 3 | 05448400 West Main Drainage Ditch 1 & 2 near Britt, Iowa | 1966–08 | 21.2 | 4/28/1975<br>6/8/2008 | 83.59<br>83.75 | 372<br>246 | 2–4<br>>10 | 17.5<br>11.6 |
| 4 | 05448500 West Branch Iowa River near Klemme, Iowa (discontinued) | 1949–58 | 112 | 6/21/1954 | 14.97 | 1,920 | 4–10 | 17.1 |
| 5 | 05448600 East Branch Iowa River above Hayfield, Iowa | 1953–08 | 2.23 | 4/11/2001<br>6/8/2008 | 8.12<br>6.02 | [2]439<br>178 | 0.2–1<br>>10 | 196.9<br>79.8 |
| 6 | 05448700 East Branch Iowa River near Hayfield, Iowa (discontinued) | 1952–86, 1990–91 | 7.94 | 6/18/1954 | 13.01 | 457 | 2–4 | 57.6 |
| 7 | 05448800 East Branch Iowa River near Garner, Iowa (discontinued) | 1952–91 | 45.1 | 3/26/1961 | 12.81 | 1,120 | 4–10 | 24.8 |
| 8 | 05448900 East Branch Iowa River tributary near Garner, Iowa (discontinued) | 1952–86 | 5.47 | 6/7/1984 | 10.46 | 660 | 0.2–1 | 120.7 |
| 9 | 05449000 East Branch Iowa River near Klemme, Iowa (discontinued) | 1944, 1949–76, 1978–95 | 133 | 6/19/1954<br>4/8/1965<br>3/31/1993 | [2]11.20<br>9.94<br>10.82 | [2]5,960<br>4,090<br>4,380 | 0.2–1<br>2–4<br>1–2 | 44.8<br>30.8<br>32.9 |
| 10 | 05449500 Iowa River near Rowan, Iowa | 1941–76, 1978–08 | 429 | 6/21/1954<br>6/17/1984<br>6/9/2008 | 14.88<br>15.00<br>15.89 | 8,460<br>8,450<br>7,890 | 1–2<br>1–2<br>1–2 | 19.7<br>19.7<br>18.4 |
| 11 | 05451080 South Fork Iowa River near Blairsburg, Iowa | 2006–08 | 12.0 | 6/8/2008 | 12.50 | 762 | [3]0.2–1 | 63.5 |
| 12 | 05451210 South Fork Iowa River NE of New Providence, Iowa | 1996–08 | 224 | 6/8/2008 | 13.84 | 7,390 | 2–4 | 33.0 |
| 13 | 0545129280 Honey Creek Tributary near Radcliffe, Iowa | 1991–93, 1995–08 | 3.29 | 6/8/2008 | 100.23 | [2]511 | >10 | 155.3 |
| 14 | 05451500 Iowa River at Marshalltown, Iowa | 1903, 1915–27, 1929–30, 1933–08 | 1,532 | 6/4/1918<br>7/9/1969<br>6/13/2008 | 17.74<br>19.10<br>21.79 | 42,000<br>31,900<br>22,400 | <0.2<br>0.2–1<br>2–4 | 27.4<br>20.8<br>14.6 |

**Table 3.** Maximum stages and discharges for 2008 and selected largest-flood years, and the corresponding flood-probability ranges, at streamgages in the Iowa River and Cedar River Basins, Iowa.—Continued

[$mi^2$, square miles; ft, feet; $ft^3/s$, cubic feet per second; $(ft^3/s)/mi^2$, cubic feet per second per square mile; ND, not determined; < , less than; >, greater than]

| Map number (fig. 1–2) | Streamgage number and name | Peak–flow record (water years) | Drainage area ($mi^2$) | Date of peak | Peak stage (ft) | Peak discharge ($ft^3/s$) | Flood probability range[1] (percent) | Unit runoff [$(ft^3/s)/mi^2$] |
|---|---|---|---|---|---|---|---|---|
| | | | | Iowa River Basin—Continued | | | | |
| 15 | 05451700 Timber Creek near Marshalltown, Iowa | 1947, 1950–08 | 118 | 8/16/1977 | 17.69 | 12,000 | 1–2 | 101.7 |
| | | | | 6/15/1982 | 17.30 | 9,940 | 2–4 | 84.2 |
| | | | | 6/8/2008 | 16.19 | 7,010 | 4–10 | 59.4 |
| 16 | 05451900 Richland Creek near Haven, Iowa | 1918, 1950–08 | 56.1 | 4/12/1991 | 26.71 | 12,200 | 0.2–1 | 217.5 |
| | | | | 5/28/1974 | 24.00 | 7,000 | 2–4 | 124.8 |
| | | | | 6/8/2008 | 21.10 | 2,460 | >10 | 43.9 |
| 17 | 05451955 Stein Creek near Clutier, Iowa | 1972–08 | 23.4 | 6/15/1982 | 77.92 | 11,400 | <0.2 | 487.2 |
| | | | | 5/30/2008 | 78.02 | 12,200 | <0.2 | 521.4 |
| 18 | 05452000 Salt Creek near Elberon, Iowa | 1944, 1946–08 | 201 | 6/16/1944 | 19.90 | [2]30,000 | <0.2 | 149.3 |
| | | | | 6/13/1947 | 17.60 | 35,000 | <0.2 | 174.1 |
| | | | | 7/9/1993 | 20.85 | 36,600 | <0.2 | 182.1 |
| | | | | 5/30/2008 | 19.75 | 22,400 | 0.2–1 | 111.4 |
| 19 | 05452200 Walnut Creek near Hartwick, Iowa | 1947, 1950–08 | 70.9 | 4/29/1991 | 16.93 | 7,900 | 4–10 | 111.4 |
| | | | | 8/27/2004 | 15.59 | 7,180 | 4–10 | 101.3 |
| | | | | 7/18/2008 | 15.80 | 4,930 | >10 | 69.5 |
| 20 | 05452500 Iowa River near Belle Plaine, Iowa (discontinued) | 1918, 1940–59 | 2,455 | 6/5/1918 | 17.86 | 43,000 | 0.2–1 | 17.5 |
| | | | | 5/21/1944 | 16.90 | 31,800 | 4–10 | 13.0 |
| | | | | 6/14/1947 | 17.10 | 34,000 | 2–4 | 13.8 |
| 21 | 05453000 Big Bear Creek at Ladora, Iowa | 1946–08 | 189 | 1/5/1946 | [4]13.10 | 9,050 | 2–4 | 47.9 |
| | | | | 3/30/1960 | [4]14.60 | 10,500 | 1–2 | 55.6 |
| | | | | 6/12/2008 | 24.91 | 6,720 | >10 | 35.6 |
| 22 | 05453100 Iowa River at Marengo, Iowa | 1957–08 | 2,794 | 3/31/1960 | 19.21 | 30,800 | 4–10 | 11.0 |
| | | | | 7/12/1969 | 19.79 | 28,300 | 4–10 | 10.1 |
| | | | | 7/19/1993 | 20.31 | 38,000 | 1–2 | 13.6 |
| | | | | 6/12/2008 | 21.38 | 51,000 | 0.2–1 | 18.3 |
| 23 | 05453200 Price Creek near Amana, Iowa | 1966–08 | 29.1 | 6/17/1990 | 88.78 | 5,080 | 2–4 | 174.6 |
| | | | | 6/22/2007 | 88.89 | 5,200 | 2–4 | 178.7 |
| | | | | 6/12/2008 | 91.09 | 3,110 | >10 | 106.9 |
| 24 | 05453430 North Fork Tributary to Mill Creek near Solon, Iowa | 1990–08 | 0.78 | 7/21/2008 | 13.69 | 211 | [5]2–4 | 270.5 |
| 25 | 05453520 Iowa River below Coralville Dam near Coralville, Iowa | 1993–08 | 3,115 | 7/19/1993 | 63.95 | [6]25,800 | [7]1–2 | 8.3 |
| | | | | 6/15/2008 | 68.09 | [6]39,900 | [7] 0.2–1 | 12.8 |
| 26 | 05453600 Rapid Creek below Morse, Iowa (discontinued) | 1951–92 | 8.12 | 6/21/1987 | 25.99 | 3,000 | 2–4 | 369.5 |
| 27 | 05453700 Rapid Creek tributary No. 4 near Oasis, Iowa (discontinued) | 1951–74 | 1.95 | 7/20/1953 | 18.23 | 956 | 4–10 | 490.3 |
| 28 | 05453750 Rapid Creek southwest of Morse, Iowa (discontinued) | 1951–87, 1989–92 | 15.2 | 5/23/1965 | 29.42 | 4,260 | 2–4 | 280.3 |
| | | | | 7/17/1972 | 29.74 | 4,300 | 2–4 | 282.9 |
| 29 | 05453850 Rapid Creek tributary No. 3 near Oasis, Iowa (discontinued) | 1951–86, 1990–92 | 1.62 | 9/21/1965 | 24.16 | 1,200 | 4–10 | 740.7 |
| | | | | 7/17/1972 | 24.11 | 1,200 | 4–10 | 740.7 |

**Table 3.** Maximum stages and discharges for 2008 and selected largest-flood years, and the corresponding flood-probability ranges, at streamgages in the Iowa River and Cedar River Basins, Iowa.—Continued

[mi², square miles; ft, feet; ft³/s, cubic feet per second; (ft³/s)/mi², cubic feet per second per square mile; ND, not determined; < , less than; >, greater than]

| Map number (fig. 1–2) | Streamgage number and name | Peak–flow record (water years) | Drainage area (mi²) | Date of peak | Peak stage (ft) | Peak discharge (ft³/s) | Flood probability range[1] (percent) | Unit runoff [(ft³/s)/mi²] |
|---|---|---|---|---|---|---|---|---|
| | | | Iowa River Basin—Continued | | | | | |
| 30 | 05453900 Rapid Creek tributary near Oasis, Iowa (discontinued) | 1951–90 | 0.97 | 7/18/1956 | 18.32 | 809 | [5]4–10 | 834.0 |
| 31 | 05453950 Rapid Creek tributary near Iowa City, Iowa (discontinued) | 1951–86, 1988, 1990–92 | 3.43 | 7/17/1972 | 26.57 | 2,000 | 2–4 | 583.1 |
| 32 | 05454000 Rapid Creek near Iowa City, Iowa | 1938–08 | 25.3 | 5/23/1965 | 14.10 | 6,100 | 2–4 | 241.1 |
| | | | | 8/10/1993 | 15.61 | 6,700 | 1–2 | 264.8 |
| | | | | 6/13/2008 | 11.56 | 1,690 | >10 | 66.8 |
| 33 | 05454090 Muddy Creek at Coralville, Iowa | 2007–08 | 8.7 | 6/13/2008 | 9.44 | 937 | [3]>10 | 107.7 |
| 34 | 05454180 Clear Creek tributary near Williamsburg, Iowa | 1990–08 | 0.37 | 6/12/2008 | 49.37 | 346 | [5]4–10 | 935.1 |
| 35 | 05454220 Clear Creek near Oxford, Iowa | 1994–08 | 58.4 | 5/10/1996 | 14.89 | 4,230 | 4–10 | 72.4 |
| | | | | 6/3/2008 | 14.29 | 2,390 | >10 | 40.9 |
| 36 | 05454300 Clear Creek near Coralville, Iowa | 1953–08 | 98.1 | 6/17/1990 | 16.36 | 10,200 | 1–2 | 104.0 |
| | | | | 7/6/1993 | 14.74 | 6,760 | 4–10 | 68.9 |
| | | | | 6/13/2008 | 12.35 | 2,840 | >10 | 29.0 |
| 37 | 05454500 Iowa River at Iowa City, Iowa | 1851, 1881, 1903–08 | 3,271 | 6/--/1851 | [4]24.10 | [2]70,000 | [8]<0.2 | 21.4 |
| | | | | 7/17/1881 | [4]21.10 | 51,000 | [8]0.2–1 | 15.6 |
| | | | | 6/8/1918 | [4]19.60 | 42,500 | [8]1–2 | 13.0 |
| | | | | 5/25/1944 | [4]18.00 | 31,100 | [8]4–10 | 9.5 |
| | | | | 6/17/1947 | [4]18.60 | 33,800 | [8]2–4 | 10.3 |
| | | | | 8/10/1993 | 28.52 | [6] 28,200 | [7]1–2 | 8.6 |
| | | | | 6/15/2008 | 31.53 | [6] 41,100 | [7]0.2–1 | 12.6 |
| 38 | 05455000 Ralston Creek at Iowa City, Iowa (discontinued) | 1925–87 | 3.01 | 7/18/1956 | 9.06 | 1,690 | [9]2–4 | 561.5 |
| | | | | 7/17/1972 | 9.01 | 1,760 | [9]2–4 | 584.7 |
| 39 | 05455010 South Branch Ralston Creek at Iowa City, Iowa (discontinued) | 1962, 1964–95, 1999, 2006 | 2.94 | 7/17/1972 | 9.47 | 1,070 | [10]4–10 | 363.9 |
| 40 | 05455100 Old Mans Creek near Iowa City, Iowa | 1951–08 | 201 | 5/15/1982 | [4]15.25 | 13,500 | 1–2 | 67.2 |
| | | | | 7/6/1993 | 17.61 | 13,000 | 1–2 | 64.7 |
| | | | | 6/13/2008 | 15.29 | 3,420 | >10 | 17.0 |
| 41 | 05455140 North English River near Montezuma, Iowa | 1973–08 | 31.0 | 3/18/1978 | 28.18 | [2]4,640 | 2–4 | 149.7 |
| | | | | 6/12/2008 | [2]23.77 | [2]2,060 | >10 | 66.5 |
| 42 | 05455150 North English River near Malcom, Iowa (discontinued) | 1953–61, 1963, 1965–77 | 34.0 | 5/24/1953 | 13.25 | 4,240 | 4–10 | 124.7 |
| 43 | 05455200 North English River near Guernsey, Iowa (discontinued) | 1953–86 | 68.7 | 5/24/1953 | 11.7 | 7,000 | 2–4 | 101.9 |

**Table 3.** Maximum stages and discharges for 2008 and selected largest-flood years, and the corresponding flood-probability ranges, at streamgages in the Iowa River and Cedar River Basins, Iowa.—Continued

[mi², square miles; ft, feet; ft³/s, cubic feet per second; (ft³/s)/mi², cubic feet per second per square mile; ND, not determined; < , less than; >, greater than]

| Map number (fig. 1–2) | Streamgage number and name | Peak–flow record (water years) | Drainage area (mi²) | Date of peak | Peak stage (ft) | Peak discharge (ft³/s) | Flood probability range[1] (percent) | Unit runoff [(ft³/s)/mi²] |
|---|---|---|---|---|---|---|---|---|
| | | | Iowa River Basin—Continued | | | | | |
| 44 | 05455210 North English River at Guernsey, Iowa | 1960, 1966–98, 2000–08 | 81.5 | 6/15/1982<br>6/12/2008 | 87.43<br>86.33 | 7,460<br>5,400 | 4–10<br>>10 | 91.5<br>66.3 |
| 45 | 05455230 Deep River at Deep River, Iowa | 1960, 1966–72, 1974–08 | 30.5 | 5/14/1970<br>4/18/2008 | 83.85<br>81.07 | 6,200<br>1,920 | 0.2–1<br>>10 | 203.3<br>63.0 |
| 46 | 05455280 South English River tributary near Barnes City, Iowa (discontinued) | 1953–76 | 2.51 | 3/2/1970 | 9.04 | 900 | >10 | 358.6 |
| 47 | 05455300 South English River near Barnes City, Iowa (discontinued) | 1953–87 | 11.5 | 7/18/1982 | 13.77 | 2,200 | 2–4 | 191.3 |
| 48 | 05455350 South English River tributary No. 2 near Montezuma, Iowa (discontinued) | 1953–85 | 0.52 | 7/27/1961 | 13.65 | 344 | [5]2–4 | 661.5 |
| 49 | 05455500 English River at Kalona, Iowa | 1930, 1940–08 | 574 | 7/6/1993<br>5/11/1996<br>6/14/2008 | 22.55<br>21.06<br>18.01 | 36,100<br>25,100<br>9,220 | 0.2–1<br>1–2<br>>10 | 62.9<br>43.7<br>16.1 |
| 50 | 05455550 Bulgers Run near Riverside, Iowa | 1965–08 | 6.31 | 9/21/1965<br>6/3/2008 | 89.04<br>86.82 | 3,080<br>785 | 0.2–1<br>>10 | 488.1<br>124.4 |
| 51 | 05455700 Iowa River near Lone Tree, Iowa | 1944, 1957–08 | 4,293 | 7/7/1993<br>6/15/2008 | 22.94<br>23.10 | [6]57,100<br>[6]53,700 | [7]0.2–1<br>[7]0.2–1 | 13.3<br>12.5 |
| | | | Cedar River Basin | | | | | |
| 52 | 05457000 Cedar River near Austin, Minnesota | 1910–14, 1945–08 | 399 | 7/10/2000<br>9/16/2004<br>6/12/2008 | 21.49<br>23.26<br>21.42 | 15,300<br>20,000<br>15,300 | 1–2<br><0.2<br>1–2 | 38.3<br>50.1<br>38.3 |
| 53 | 05457080 Rose Creek tributary near Dexter, Minnesota (discontinued) | 1962–85 | 1.17 | 7/17/1978 | 11.82 | 1,090 | [5]<0.2 | 931.6 |
| 54 | 05457440 Deer Creek near Carpenter, Iowa | 1973–08 | 91.6 | 6/8/2008 | 87.86 | 11,800 | <0.2 | 128.8 |
| 55 | 05457500 Cedar River at Mitchell, Iowa (discontinued) | 1934–42, 1961–62 | 826 | 3/27/1961 | 93.6 | 20,500 | [3]2–4 | 24.8 |
| 56 | 05457700 Cedar River at Charles City, Iowa | 1946–53, 1961–62, 1965–08 | 1,054 | 3/27/1961<br>8/16/1993<br>7/21/1999<br>6/9/2008 | 21.53<br>21.44<br>22.81<br>25.33 | 29,200<br>26,400<br>31,200<br>34,600 | 1–2<br>2–4<br>1–2<br>0.2–1 | 27.7<br>25.0<br>29.6<br>32.8 |
| 57 | 0545776680 Gizzard Creek tributary near Bassett, Iowa | 1990–08 | 3.42 | 7/21/1999<br>6/9/2008 | 102.82<br>102.68 | 1,730<br>1,570 | 4–10<br>4–10 | 505.8<br>459.1 |

**Table 3.** Maximum stages and discharges for 2008 and selected largest-flood years, and the corresponding flood-probability ranges, at streamgages in the Iowa River and Cedar River Basins, Iowa.—Continued

[mi², square miles; ft, feet; ft³/s, cubic feet per second; (ft³/s)/mi², cubic feet per second per square mile; ND, not determined; < , less than; >, greater than]

| Map number (fig. 1–2) | Streamgage number and name | Peak–flow record (water years) | Drainage area (mi²) | Date of peak | Peak stage (ft) | Peak discharge (ft³/s) | Flood probability range[1] (percent) | Unit runoff [(ft³/s)/mi²] |
|---|---|---|---|---|---|---|---|---|
| | | | Cedar River Basin—Continued | | | | | |
| 58 | 05457778 Little Cedar River near Johnsburg, Minnesota | 1986–08 | 45.8 | 9/15/2004<br>6/12/2008 | 18.91<br>16.04 | ND<br>3,710 | ND<br>4–10 | ND<br>81.0 |
| 59 | 05458000 Little Cedar River near Ionia, Iowa | 1954–08 | 306 | 8/16/1993<br>7/21/1999<br>6/9/2008 | 18.99<br>17.52<br>21.32 | 14,000<br>12,200<br>24,700 | 4–10<br>4–10<br>0.2–1 | 45.8<br>39.9<br>80.7 |
| 60 | 05458300 Cedar River at Waverly, Iowa | 2001–08 | 1,547 | 6/10/2008 | 19.33 | 52,600 | [11]<0.2 | 34.0 |
| 61 | 05458500 Cedar River at Janesville, Iowa | 1905–06,<br>1915–21,<br>1923–27,<br>1933–42,<br>1945–08 | 1,661 | 4/1/1933<br>3/17/1945<br>3/28/1961<br>8/18/1993<br>7/22/1999<br>6/10/2008 | 16.00<br>16.20<br>16.33<br>15.74<br>17.15<br>19.45 | 33,300<br>34,300<br>37,000<br>35,000<br>42,200<br>53,400 | 2–4<br>2–4<br>1–2<br>2–4<br>0.2–1<br>0.2–1 | 20.0<br>20.7<br>22.3<br>21.1<br>25.4<br>32.1 |
| 62 | 05458560 Beaverdam Creek near Sheffield, Iowa (discontinued) | 1966–89 | 123 | 6/25/1969 | 59.82 | [2]18,000 | <0.2 | 146.3 |
| 63 | 05458900 West Fork Cedar River at Finchford, Iowa | 1929,<br>1946–08 | 846 | 6/27/1951<br>7/29/1990<br>6/10/2008 | 17.28<br>18.45<br>20.82 | 31,900<br>23,300<br>25,900 | 0.2–1<br>2–4<br>2–4 | 37.7<br>27.5<br>30.6 |
| 64 | 05458960 Bancroft Creek at Bancroft, Minnesota | 1986–08 | 28.7 | 6/14/2001<br>6/12/2008 | 8.81<br>6.48 | 1,070<br>413 | 4–10<br>>10 | 37.3<br>14.4 |
| 65 | 05459000 Shell Rock River near Northwood, Iowa (discontinued) | 1946–86 | 300 | 3/26/1961<br>4/8/1965 | [12]11.68<br>[12]12.07 | [2]3,000<br>[2]3,400 | 2–4<br>1–2 | 10.0<br>11.3 |
| 66 | 05459010 Elk Creek at Kensett, Iowa (discontinued) | 1966–89 | 58.1 | 3/20/1986 | 91.91 | 1,450 | 2–4 | 25.0 |
| 67 | 05459490 Spring Creek near Mason City, Iowa | 1966–08 | 29.3 | 5/22/2004<br>6/6/2008 | 91.15<br>92.91 | 5,340<br>4,680 | 0.2–1<br>1–2 | 182.3<br>159.7 |
| 68 | 05459500 Winnebago River at Mason City, Iowa | 1933–08 | 526 | 3/30/1933<br>3/27/1961<br>6/8/2008 | [4]15.70<br>14.80<br>18.74 | 10,800<br>10,500<br>13,100 | 1–2<br>1–2<br>0.2–1 | 20.5<br>20.0<br>24.9 |
| 69 | 05460100 Willow Creek near Mason City, Iowa | 1966–89,<br>1991–08 | 78.6 | 6/8/2008 | 93.28 | 2,380 | 0.2–1 | 30.3 |
| 70 | 05460500 Shell Rock River at Marble Rock, Iowa (discontinued) | 1933–53,<br>1961–62 | 1,318 | 3/27/1933<br>3/28/1961 | 107.60<br>ND | 36,400<br>[2]32,000 | 0.2–1<br>1–2 | 27.6<br>24.3 |
| 71 | 05461000 Shell Rock River at Greene, Iowa (discontinued) | 1934–42 | 1,357 | 6/25/1938 | 101.70 | 12,000 | [3]>10 | 8.8 |
| 72 | 05461390 Flood Creek near Powersville, Iowa (discontinued) | 1996–99 | 127 | 7/21/1999 | 12.57 | [2]19,000 | [3]<0.2 | 149.6 |
| 73 | 05461500 Shell Rock River near Clarksville, Iowa (discontinued) | 1916–27,<br>1933–34,<br>1961–62 | 1,626 | 3/28/1961 | ND | [2]33,400 | 1–2 | 20.5 |

**Table 3.** Maximum stages and discharges for 2008 and selected largest-flood years, and the corresponding flood-probability ranges, at streamgages in the Iowa River and Cedar River Basins, Iowa.—Continued

[mi², square miles; ft, feet; ft³/s, cubic feet per second; (ft³/s)/mi², cubic feet per second per square mile; ND, not determined; < , less than; >, greater than]

| Map number (fig. 1–2) | Streamgage number and name | Peak–flow record (water years) | Drainage area (mi²) | Date of peak | Peak stage (ft) | Peak discharge (ft³/s) | Flood probability range[1] (percent) | Unit runoff [(ft³/s)/mi²] |
|---|---|---|---|---|---|---|---|---|
| | | | | Cedar River Basin—Continued | | | | |
| 74 | 05462000 Shell Rock River at Shell Rock, Iowa | 1856, 1954–08 | 1,746 | _/_/1856<br>3/28/1961<br>6/10/2008 | [13]17.70<br>16.26<br>20.36 | [2]45,000<br>33,500<br>60,400 | 0.2–1<br>2–4<br><0.2 | 25.8<br>19.2<br>34.6 |
| 75 | 05462750 Beaver Creek tributary near Aplington, Iowa (discontinued) | 1966–91 | 11.6 | 5/19/1983 | 94.27 | [2]3,000 | 4–10 | 258.6 |
| 76 | 05463000 Beaver Creek at New Hartford, Iowa | 1946–08 | 347 | 6/13/1947<br>6/8/2008 | 13.50<br>15.71 | 18,000<br>25,900 | 2–4<br>0.2–1 | 51.9<br>74.6 |
| 77 | 05463090 Black Hawk Creek at Grundy Center, Iowa (discontinued) | 1966–91 | 56.9 | 7/8/1969 | 89.60 | 7,000 | 2–4 | 123.0 |
| 78 | 05463500 Black Hawk Creek at Hudson, Iowa | 1952–95, 2002–08 | 303 | 7/9/1969<br>4/25/2008 | 18.23<br>19.03 | 19,300<br>22,500 | 1–2<br>0.2–1 | 63.7<br>74.3 |
| 79 | 05464000 Cedar River at Waterloo, Iowa | 1929, 1933, 1941–08 | 5,146 | 3/16/1929<br>4/2/1933<br>3/29/1961<br>4/8/1965<br>4/2/1993<br>7/23/1999<br>6/11/2008 | 20.00<br>19.50<br>21.86<br>21.67<br>20.60<br>20.78<br>27.01 | [2]65,000<br>[2]61,000<br>76,700<br>69,500<br>68,100<br>69,300<br>112,000 | [5]4–10<br>[5]4–10<br>[5]4–10<br>[5]4–10<br>[5]4–10<br>[5]4–10<br>[5]0.2–1 | 12.6<br>11.9<br>14.9<br>13.5<br>13.2<br>13.5<br>21.8 |
| 80 | 05464025 Miller Creek near Eagle Center, Iowa | 1990–08 | 9.14 | 6/11/1998<br>4/25/2008 | 47.60<br>44.31 | 3,370<br>1,740 | 2–4<br>>10 | 368.7<br>190.4 |
| 81 | 05464130 Fourmile Creek near Lincoln, Iowa (discontinued) | 1963–67, 1970–74, 1977–80 | 13.78 | 7/3/1979 | 13.51 | 1,100 | >10 | 79.8 |
| 82 | 05464133 Half Mile Creek near Gladbrook, Iowa (discontinued) | 1963–67, 1970–74, 1977–80 | 1.33 | 6/12/1979 | 9.57 | 611 | 4–10 | 459.4 |
| 83 | 05464137 Fourmile Creek near Traer, Iowa (discontinued) | 1963–74, 1976–80 | 19.51 | 3/18/1979 | 11.93 | 1,450 | 4–10 | 74.3 |
| 84 | 05464145 Twelve Mile Creek near Traer, Iowa (discontinued) | 1966–92 | 43.8 | 6/16/1990 | 88.93 | [2]4,070 | 4–10 | 92.9 |
| 85 | 05464220 Wolf Creek near Dysart, Iowa | 1996–98, 2002–08 | 299 | 5/23/2004<br>5/30/2008 | 17.39<br>18.25 | 14,500<br>15,700 | 2–4<br>2–4 | 48.5<br>52.5 |
| 86 | 05464310 Pratt Creek near Garrison, Iowa (discontinued) | 1966–94 | 23.4 | 6/15/1982<br>7/8/1993 | 96.17<br>96.86 | 10,800<br>12,300 | 0.2–1<br>0.2–1 | 461.5<br>525.6 |
| 87 | 05464315 Cedar River at Vinton, Iowa | [14]ND | 6,040 | ND | ND | ND | ND | ND |
| 88 | 05464318 East Blue Creek at Center Point, Iowa (discontinued) | 1966–87, 1990–93 | 17.6 | 7/5/1993 | 84.27 | 4,440 | 4–10 | 252.3 |

**Table 3.** Maximum stages and discharges for 2008 and selected largest-flood years, and the corresponding flood-probability ranges, at streamgages in the Iowa River and Cedar River Basins, Iowa.—Continued

[mi², square miles; ft, feet; ft³/s, cubic feet per second; (ft³/s)/mi², cubic feet per second per square mile; ND, not determined; < , less than; >, greater than]

| Map number (fig. 1–2) | Streamgage number and name | Peak–flow record (water years) | Drainage area (mi²) | Date of peak | Peak stage (ft) | Peak discharge (ft³/s) | Flood probability range[1] (percent) | Unit runoff [(ft³/s)/mi²] |
|---|---|---|---|---|---|---|---|---|
| | | | Cedar River Basin—Continued | | | | | |
| 89 | 05464420 Cedar River at Blairs Ferry Road at Palo, Iowa | [14]ND | 6,342 | ND | ND | ND | ND | ND |
| 90 | 05464500 Cedar River at Cedar Rapids, Iowa | 1851, 1903–08 | 6,510 | 6/_/1851 | 20.00 | [2]65,000 | [5]4–10 | 10.0 |
| | | | | 3/18/1929 | 20.00 | 64,000 | [5]4–10 | 9.8 |
| | | | | 3/31/1961 | 19.66 | 73,000 | [5]2–4 | 11.2 |
| | | | | 4/10/1965 | 18.51 | 66,800 | [5]4–10 | 10.3 |
| | | | | 4/4/1993 | 19.27 | 71,000 | [5]2–4 | 10.9 |
| | | | | 7/25/1999 | 18.31 | 62,300 | [5]4–10 | 9.6 |
| | | | | 5/27/2004 | 18.30 | 62,500 | [5]4–10 | 9.6 |
| | | | | 6/13/2008 | 31.12 | 140,000 | [5]<0.2 | 21.5 |
| 91 | 05464535 Prairie Creek tributary near Van Horne, Iowa | 1990–08 | 0.94 | 5/26/1997 | 18.14 | [2]571 | [5]>10 | 607.4 |
| 92 | 05464560 Prairie Creek at Blairstown, Iowa (discontinued) | 1966–84, 1986–87 | 87.0 | 6/15/1982 | 84.65 | 4,750 | 4–10 | 54.6 |
| 93 | 05464562 Thunder Creek at Blairstown, Iowa | 1977, 1990–98, 2000–08 | 0.96 | 8/16/1977 | 17.02 | 2,610 | [5]0.2–1 | 2,718.8 |
| 94 | 05464640 Prairie Creek at Fairfax, Iowa (discontinued) | 1967–82 | 178 | 3/19/1979 | 14.63 | 8,140 | 4–10 | 45.7 |
| 95 | 05464685 Dry Creek near Alburnett, Iowa (discontinued) | 1961–66, 1970 | 14.0 | 7/3/1962 | [15]864.14 | 1,740 | [3]>10 | 124.3 |
| 96 | 05464690 Dry Creek near Marion, Iowa (discontinued) | 1961–62, 1965, 1970 | 25.9 | 3/2/1970 | [15]799.29 | ND | ND | ND |
| 97 | 05464695 Indian Creek near Marion, Iowa (discontinued) | 1961–66, 1970–71 | 32.0 | 6/4/2002 | [15]801.41 | ND | ND | ND |
| 98 | 05464720 Indian Creek below Cedar Rapids, Iowa (discontinued) | 1961–62, 1964–67, 1970 | 76.2 | 3/2/1970 | [15]714.14 | ND | ND | ND |
| 99 | 05464880 Otter Creek at Wilton, Iowa (discontinued) | 1966–93 | 10.7 | 6/16/1990 | 89.68 | 5,940 | 0.2–1 | 555.1 |
| 100 | 05464942 Hoover Creek at Hoover National Historic Site, West Branch, Iowa | 1967, 1993, 2001–08 | 2.58 | 6/7/1967 | [2]10.50 | [2]1,500 | [3]4–10 | 581.4 |
| | | | | 8/16/1993 | [2]10.30 | [2]1,650 | [3]2–4 | 639.5 |
| | | | | 6/3/2008 | 9.29 | 404 | [3]>10 | 156.6 |
| 101 | 05465000 Cedar River near Conesville, Iowa | 1929, 1940–08 | 7,787 | 4/2/1961 | 16.62 | 70,800 | [5]4–10 | 9.1 |
| | | | | 4/6/1993 | 17.11 | 74,000 | [5]4–10 | 9.5 |
| | | | | 5/29/2004 | 17.00 | 70,200 | [5]4–10 | 9.0 |
| | | | | 6/14/2008 | [16]23.37 | 127,000 | [5]0.2–1 | 16.3 |

**Table 3.** Maximum stages and discharges for 2008 and selected largest-flood years, and the corresponding flood-probability ranges, at streamgages in the Iowa River and Cedar River Basins, Iowa.—Continued

[mi², square miles; ft, feet; ft³/s, cubic feet per second; (ft³/s)/mi², cubic feet per second per square mile; ND, not determined; < , less than; >, greater than]

| Map number (fig. 1–2) | Streamgage number and name | Peak–flow record (water years) | Drainage area (mi²) | Date of peak | Peak stage (ft) | Peak discharge (ft³/s) | Flood probability range[1] (percent) | Unit runoff [(ft³/s)/mi²] |
|---|---|---|---|---|---|---|---|---|
| | | | | Iowa River Basin | | | | |
| 102 | 05465150 North Fork Long Creek at Ainsworth, Iowa | 1951, 1965–08 | 30.2 | 6/20/1990 | 90.66 | [2]5,800 | 1–2 | 192.1 |
| | | | | 6/13/2008 | 91.19 | 4,220 | 4–10 | 139.7 |
| 103 | 05465500 Iowa River at Wapello, Iowa | 1903–08 | 12,500 | 6/3/1903 | ND | 88,700 | 2–4 | 7.1 |
| | | | | 6/18/1947 | [4]16.10 | 94,000 | 1–2 | 7.5 |
| | | | | 4/22/1973 | 28.63 | [6]92,000 | [7]2–4 | 7.4 |
| | | | | 5/19/1974 | 28.12 | [6]82,200 | [7]4–10 | 6.6 |
| | | | | 6/19/1990 | 28.91 | [6]86,600 | [7]2–4 | 6.9 |
| | | | | 7/8/1993 | 28.10 | [2,6]111,000 | [7]2–4 | 8.9 |
| | | | | 6/14/2008 | 32.15 | [6]188,000 | [7]<0.2 | 15.0 |
| 104 | 05465700 Iowa River at Oakville, Iowa | [17]ND | 12,630 | ND | ND | ND | ND | ND |

[1]Flood-probability ranges reflect the uncertainty of estimating flood-probability discharges. The flood probability is calculated using established techniques but then reported in one of the following ranges: greater than 10 percent, 4 to 10 percent, 2 to 4 percent, 1 to 2 percent, 0.2 to 1 percent, and less than 0.2 percent. Unless noted otherwise, flood-probability ranges are based on a weighted average of two independent probability estimates. The WIE (weighting of independent estimates) program was used to estimate flood probabilities following guidelines in Appendix 8 of Bulletin 17B (Interagency Advisory Committee on Water Data, 1982; Charles Berenbrock and Tim Cohn, U.S. Geological Survey, written commun., 2008) ). The WIE program uses the variance and estimate of the Bullet in 17B streamgage-probability analysis and the variance and estimate of the regional-regression probability calculation (Eash, 2001) to compute a weighted probability estimate and variance at a streamgage.

[2]Estimate.

[3]Computed using regional-regression equations (Eash, 2001) because of short peak-flow record.

[4]Streamgage at different datum.

[5]Computed using Bulletin 17B streamgage-probability analysis (Interagency Advisory Committee on Water Data, 1982) because regional-regression equations are not applicable.

[6]Discharge affected by regulation.

[7]Data source: Rock Island District, U.S. Army Corps of Engineers, Iowa River Regulated Flow Frequency Study, Final Report, October 2009.

[8]Computed using Bulletin 17B streamgage-probability analysis for 1851-1958 unregulated period of record.

[9]Computed using 1925-82 unregulated period of record.

[10]Computed using 1964-80 unregulated period of record.

[11]Computed using weighted estimates from nearby downstream streamgage (05458500) and regional regression estimates for this streamgage (05458300) (Eash, 2001).

[12]Stage affected by backwater.

[13]Stage measured at bridge 400 ft downstream, from information provided by U.S. Army Corps of Engineers.

[14]Streamgage operation began March 2009.

[15]Sea-level elevation (NGVD 29).

[16]Peak stage on June 15, 2008, at 23.40 ft at discharge of 127,000 ft³/s.

[17]Streamgage operation began April 2009.

**Table 7.** Locations and elevations of high-water marks used in the Iowa River flood profile from May 30 to June 15, 2008.

[HWM, high-water mark; NGVD 29, National Geodetic Vertical Datum of 1929; --, not determined; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east]

| Distance from mouth (river miles) | Location | Downstream HWM (feet above NGVD 29) | Upstream HWM (feet above NGVD 29) |
|---|---|---|---|
| 5.49 | USGS streamgage 05465700, State Highway 99, near Oakville (T73N R02W 23 SW) | 558.86 | 560.17 |
| 13.84 | SE 1/4 , sec 35, 1.5 miles SE of Wapello (T74N R03W 35 SE) | [2]566.15 | -- |
| 14.96 | 123rd Avenue, Wapello (T74N R03W 35 NW) | [1]567.2 | -- |
| 15.50 | USGS streamgage 05465500, State Highway 99, at Wapello (T74N R03W 27 SE) | 570.32 | -- |
| 15.72 | State Highway 99, Wapello (T74N R03W 27 NE) | -- | 570.52 |
| 16.06 | North Water Street, Wapello (T74N R03W 27 NE) | [1]571.4 | -- |
| 19.69 | U.S. Highway 61, N of Wapello (T74N R03W 16 NE) | 574.42 | 574.95 |
| 23.10 | Township Road, NW of Wapello (T74N R03W 06 NE) | [2]577.35 | -- |
| 26.99 | 140th Street, SE of Fredonia (T75N R04W 34 NW) | [2]585.15 | -- |
| 29.59 | State Highway 92, Columbus Junction (T75N R04W 20 SW) | 590.02 | 590.67 |
| 30.88 | State Highway 70, N of Columbus Junction (T75N R04W 19 NW) | 592.82 | 593.48 |
| 32.37 | State Highway 70, 1.4 miles N of Columbus Junction (T75N R04W 07 SE) | [2]593.97 | -- |
| 40.85 | 240th Street, W of Conesville (T76N R05W 22 SW) | [2]601.92 | -- |
| 47.58 | USGS streamgage 05455700, County Road W66, near Lone Tree (T76N R05W 06 NW) | 611.26 | 612.11 |
| 54.72 | State Highway 22, Riverside (T77N R06W 11 NE) | 618.98 | 620.30 |
| 63.29 | County Road F62, Hills (T78N R06W 23 NW) | 629.76 | 631.44 |
| 70.34 | Izaak Walton Road, S of Iowa City (T79N R06W 33 NE) | [2]640.40 | -- |
| 70.62 | Winter Eagle Trail, Iowa City (T79N R06W 27 SW) | [1]641.0 | -- |
| 71.53 | Napoleon Lane, Iowa City (T79N R06W 22 SW) | [1]644.1 | -- |
| 72.00 | Chicago, Rock Island, and Pacific (C.R.I. & P.) Railroad Bridge, Iowa City (T79N R06W 22 NW) | [2]644.93 | -- |
| 72.32 | South Gilbert Street, Iowa City (T79N R06W 22 NW) | [1]646.3 | -- |
| 72.77 | U.S. Highway 6, Iowa City (T79N R06W 15 SW) | 646.92 | 647.05 |
| 73.06 | West Benton Street, Iowa City (T79N R06W 15 NW) | [1]647.8 | [2]648.13 |
| 73.30 | Riverside Drive, Iowa City (T79N R06W 15 NW) | [1]648.4 | -- |
| 73.52 | USGS streamgage 05454500, at Iowa City (T79N R06W 09 SE) | 648.80 | |
| 73.59 | State Highway 1 and Burlington Street, Iowa City (T79N R06W 09 SE) | -- | 651.23 |
| 73.84 | West Iowa Street, Iowa City (T79N R06W 09 SE) | -- | [3]651.65 |
| 74.08 | Art Building, University of Iowa, Iowa City (T79N R06W 09 NE) | [1]653.4 | -- |
| 74.33 | Hancher Auditorium Building, University of Iowa, Iowa City (T79N R06W 10 NW) | [2]653.53 | -- |
| 74.64 | Park Road, Iowa City (T79N R06W 03 SW) | [3]655.15 | -- |
| 75.12 | Dubuque Street, Iowa City (T79N R06W 03 NW) | [1]655.3 | -- |
| 75.28 | Pentire Circle, Iowa City (T79N R06W 03 NW) | [1]655.5 | -- |
| 76.13 | West Park Road, Iowa City (T79N R06W 04 SW) | [1]656.6 | -- |
| 76.65 | 2nd Street, Coralville (T79N R06W 08 NE) | [1]657.6 | -- |
| 77.13 | IRP dam (T79N R06W 05 SE) | 657.81 | -- |
| 77.47 | E 7th Street, Coralville (T79N R06W 05 NE) | [1]659.2 | -- |
| 78.20 | Interstate 80, Coralville (T79N R06W 04 NW) | 661.11 | -- |
| 78.38 | City of Iowa City Water Treatment Plant (T80N R06W 33 SW) | -- | [3]663.06 |
| 79.46 | Dubuque Street NE, Iowa City (T80N R06W 33 NE) | -- | [1]664.8 |
| 80.86 | Longview Knoll, Iowa City (T80N R06W 28 SE) | [1]666.8 | -- |

**Table 7.** Locations and elevations of high-water marks used in the Iowa River flood profile from May 30 to June 15, 2008.—Continued

[HWM, high-water mark; NGVD 29, National Geodetic Vertical Datum of 1929; --, not determined; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east]

| Distance from mouth (river miles) | Location | Downstream HWM (feet above NGVD 29) | Upstream HWM (feet above NGVD 29) |
|---|---|---|---|
| 81.67 | Stewart Road NE, Iowa City (T80N R06W 22 SW) | [2]667.65 | -- |
| 81.83 | USGS streamgage, 05453520, below Coralville Dam (T80N R06W 22 SE) | 668.07 | -- |
| 82.51 | Coralville Lake Reservoir (T80N R06W 22 NE) | [2]717.02 | -- |
| 98.77 | Interstate 380 (T81N R07W 22 SW) | [2]717.29 | -- |
| 98.99 | State Highway 965 (T81N R07W 22 SW) | -- | [2]717.34 |
| 104.26 | Greencastle Avenue (T80N R08W 01 NE) | [2]717.41 | -- |
| 115.72 | U.S. Highway 151, S of Amana (T81N R09W 35 NW) | [2]717.41 | [2]717.61 |
| 125.76 | State Highway 220, N of S Amana (T81N R10W 36 NW) | [2]726.26 | [2]726.40 |
| 135.46 | USGS streamgage 05453100, County Road V66, at Marengo (T81N R11W 24 NE) | 741.90 | [1]742.7 |
| 138.04 | F15 Boulevard, Marengo (T81N R11W 14 NE) | [1]744.2 | -- |
| 141.77 | 130th Street, Marengo (T81N R11W 21 NW) | [1]747.1 | -- |
| 146.92 | F Avenue, N of Koszta (T81N R12W 12 SW) | [2]761.34 | -- |
| 155.09 | State Highway 21, S of Belle Plaine (T81N R12W 05 NW) | [2]770.95 | -- |
| 158.75 | 380th Street, SE of Chelsea (T82N R13W 26 SW) | [1]776.3 | -- |
| 164.61 | County Road V18, Chelsea (T82N R13W 08 SE) | [1]786.0 | -- |
| 174.90 | P Avenue, E of Tama (T82N R14W 04 SE) | [1]803.2 | -- |
| 183.82 | U.S. Highway 63, Tama (T83N R15W 34 SE) | [2]816.39 | [2]817.50 |
| 188.86 | County Highway E49, W of Tama (T83N R15W 30 SE) | [2]825.87 | [2]826.03 |
| 195.51 | E Avenue, NE of Montour (T83N R16W 22 NW) | [2]838.51 | -- |
| 197.08 | U.S. Highway 30 (T83N R16W 16 NE) | -- | [2]843.62 |
| 197.91 | C Avenue, E of Le Grand (T83N R16W 09 SW) | [1]843.9 | -- |
| 202.30 | Abbott Avenue, N of Le Grand (T83N R16W 06 SW) | [2]850.20 | -- |
| 203.57 | Zeller Avenue, N of Le Grand (T83N R17W 01 NW) | [2]853.66 | [1]853.8 |
| 205.38 | Three bridges Road, N of Quarry (T83N R17W 03 SE) | [2]858.23 | -- |
| 209.49 | County Road E35, E of Marshalltown (T84N R17W 29 SE) | [2]863.23 | [1]865.1 |
| 211.54 | East Marion Street, Marshalltown (T84N R17W 30 SW) | [1]867.6 | -- |
| 214.27 | USGS streamgage 05451500, State Highway 14, at Marshalltown (T84N R18W 23 SE) | 874.89 | -- |
| 215.01 | N Center Street, Marshalltown (T84N R18W 26 NW) | -- | [2]875.75 |
| 215.21 | NW of N Center Street Bridge, Marshalltown (T84N R18W 26 NW) | [1]876.2 | -- |
| 221.26 | State Highway 330, NW of Marshalltown (T84N R18W 18 NW) | [1]888.9 | [2]889.33 |
| 229.28 | County Road E18, W of Liscomb (T85N R19W 11 SW) | 907.17 | 909.35 |
| 235.37 | County Road D65, E of Union (T86N R19W 22 SE) | 920.19 | 921.00 |
| 245.93 | State Highway 175, Eldora (T87N R19W 08 SE) | 948.33 | 950.95 |
| 251.83 | County Road D35, Steamboat Rock (T88N R19W 28 NW) | 964.74 | 967.65 |
| 254.76 | U.S. Highway 20 (T88N R19W 16 NW) | 977.20 | 978.58 |
| 276.12 | Hollis Avenue below Iowa Falls Central States Dam, Iowa Falls (T89N R20W 18 SW) | 1,047.20 | -- |
| 276.6 | River Street, Iowa Falls (T89N R21W 13 SW) | 1,059.95 | -- |
| 282.02 | County Road D20, E of Alden (T89N R21W 17 SE) | 1,093.96 | 1,094.88 |
| 291.38 | Dogwood Avenue, Popejoy Conservation Area (T90N R22W 27 NW) | [1]1,124.8 | -- |
| 297.50 | Interstate 35 (T90N R23W 13 NE) | 1,134.51 | 1,134.91 |
| 303.25 | County Road C47, N of Dows (T91N R22W 30 NW) | 1,145.23 | 1,146.42 |

**Table 7.** Locations and elevations of high-water marks used in the Iowa River flood profile from May 30 to June 15, 2008.—Continued

[HWM, high-water mark; NGVD 29, National Geodetic Vertical Datum of 1929; --, not determined; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east]

| Distance from mouth (river miles) | Location | Downstream HWM (feet above NGVD 29) | Upstream HWM (feet above NGVD 29) |
|---|---|---|---|
| 305.23 | Youngblood Avenue, NW of Dows (T91N R23W 24 NW) | [1]1,146.5 | -- |
| 310.95 | Union Avenue, W of Rowan (T92N R23W 33 SW) | [1]1,153.2 | -- |
| 312.05 | State Highway 3, W of Rowan (T92N R23W 32 NE) | 1,155.57 | 1,155.92 |
| 314.41 | U.S. Highway 69, N of State Highway 3 (T92N R23W 30 SW) | 1,157.32 | 1,158.63 |
| 315.09 | USGS streamgage 05449500, County Road C38, near Rowan (T92N R24W 25 NE) | 1,159.24 | 1,160.01 |
| 322.37 | U.S. Highway 69, S of Belmond (T93N R23W 31 SW) | 1,167.13 | 1,168.03 |
| 324.17 | U.S. Highway 69, Belmond (T93N R23W 30 SW) | 1,170.39 | 1,170.78 |

[1]Federal Emergency Management Agency (FEMA) high-water mark (Federal Emergency Management Agency, 2008b).

[2]U.S. Army Corps of Engineers (USACE) high-water mark.

[3]City of Iowa City high-water mark.

**Table 8.** Locations and elevations of high-water marks used in the Cedar River flood profile from May 30 to June 15, 2008.

[HWM, high-water mark; NGVD 29, National Geodetic Vertical Datum of 1929; --, not determined; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east]

| Distance from mouth (river miles) | Location | Downstream HWM (feet above NGVD 29) | Upstream HWM (feet above NGVD 29) |
|---|---|---|---|
| 0.59 | 160th Street, NW of Fredonia (T75N R04W 20 NW) | [1]592.7 | -- |
| 1.12 | County Road G40, N of Fredonia (T75N R04W 17 SW) | [1]594.0 | -- |
| 2.51 | 178th Street, N of Columbus Junction (T75N R04W 07 NE) | [1]595.5 | -- |
| 2.94 | State Highway 70, N of Columbus Junction (T75N R04W 06 SE) | [1]596.1 | -- |
| 4.33 | County Road G40, N of Columbus Junction (T75N R04W 05 NE) | [1]597.9 | -- |
| 8.48 | 254th Street (Edgewater Road), E of Conesville (T76N R04W 15 SW) | [2]603.57 | -- |
| 10.91 | USGS streamgage 05465000, near Conesville (T76N R04W 02 SW) | 605.35 | 605.69 |
| 13.45 | Elder Avenue, SE of Nichols (T77N R04W 26 SW) | [3]607.52 | -- |
| 17.76 | State Highway 22, E of Nichols (T77N R03W 21 NW) | 614.31 | 615.65 |
| 22.72 | 170th Street, E of Nichols (T77N R03W 03 SW) | [3]621.49 | -- |
| 24.77 | County Road F70, SE of Atalissa (T78N R03W 36 NW) | 626.62 | 629.19 |
| 30.60 | U.S. Highway 6, E of Atalissa (T78N R02W 17 NW) | 639.17 | 641.32 |
| 31.95 | Chicago, Rock Island, and Pacific Railroad, at Moscow (T78N R02W 09 NW) | [2]644.57 | -- |
| 34.20 | Hinkeyville W Road, NW of Moscow (T78N R02W 06 NE) | [2]649.32 | -- |
| 39.71 | Interstate 80, S of Rochester (T79N R03W 13 SE) | 658.28 | 659.08 |
| 41.85 | County Road F44, at Rochester (T79N R03W 11 NE) | [2]662.04 | -- |
| 48.24 | County Roads F36 and X40, at Cedar Valley (T80N R03W 19 NW) | 675.76 | -- |
| 51.07 | 230th Street, N of Nicholson Creek (T80N R04W 11 NE) | [2]677.90 | -- |
| 53.92 | County Road F28 (210th Street), Cedar Bluff (T81N R04W 33 NE) | 684.49 | 684.62 |
| 59.94 | Yellow Pine Avenue, SE of Sutliff (T81N R05W 13 SW) | [2]689.54 | -- |
| 63.69 | County Road F14 (Sutliff Road), Sutliff (T81N R05W 11 NE) | 692.90 | 693.21 |
| 65.28 | McClelland Road, S of Mt. Vernon (T82N R05W 34 SE) | [2]694.69 | -- |
| 67.25 | Spring Creek Road, S of Mt. Vernon (T82N R05W 28 NE) | [2]698.73 | -- |
| 69.58 | State Highway 1, SW of Mt. Vernon (T82N R05W 30 NE) | 702.58 | 703.07 |
| 70.71 | Cedar River Road, SW of Mt. Vernon (T82N R05W 19 SW) | [2]708.14 | -- |
| 72.20 | Palisades-Kepler State Park, W of Mt. Vernon (T82N R06W 23 NE) | [2]709.98 | -- |
| 76.40 | U.S. Highway 30, SE of Cedar Rapids (T82N R06W 09 NW) | 717.46 | 718.48 |
| 77.22 | Anderle Trail, Cedar Rapids (T82N R06W 04 SW) | [1]719.2 | -- |
| 78.03 | Heslane Road, Cedar Rapids (T82N R06W 05 NE) | [1]719.4 | -- |
| 78.99 | Bertram Road, Cedar Rapids (T83N R06W 32 NE) | [1]720.3 | -- |
| 79.75 | Berry Road, Cedar Rapids (T83N R06W 30 NE) | [1]720.7 | -- |
| 80.60 | Old River Road, Cedar Rapids (T83N R06W 31 NW) | [1]721.1 | -- |
| 82.50 | Old River Road, Cedar Rapids (T82N R07W 02 NE) | [1]724.4 | -- |
| 82.98 | Old River Road, Cedar Rapids (T82N R07W 02 NW) | [1]725.4 | -- |
| 85.42 | A Street SW, Cedar Rapids (T83N R07W 27 SW) | [1]730.0 | -- |
| 85.78 | 16th Avenue, Cedar Rapids (T83N R07W 28 SE) | -- | [2]731.28 |
| 86.28 | USGS streamgage 05464500, at Cedar Rapids (T83N R07W 28 NE) | 731.59 | |
| 86.54 | 3rd Avenue, Cedar Rapids (T83N R07W 28 NW) | [2]732.41 | -- |
| 86.71 | U.S. Highway 151 (1st Avenue), Cedar Rapids (T83N R07W 28 NW) | 734.18 | 734.31 |
| 86.83 | E Avenue and F Avenue (under I-380 overpass), Cedar Rapids (T83N R07W 21 SW) | -- | 734.61 |
| 87.32 | 8th Street NW, Cedar Rapids (T83N R07W 20 NE) | [1]735.2 | -- |

**Table 8.** Locations and elevations of high-water marks used in the Cedar River flood profile from May 30 to June 15, 2008.—Continued

[HWM, high-water mark; NGVD 29, National Geodetic Vertical Datum of 1929; --, not determined; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east]

| Distance from mouth (river miles) | Location | Downstream HWM (feet above NGVD 29) | Upstream HWM (feet above NGVD 29) |
|---|---|---|---|
| 87.96 | Q Avenue NW, Cedar Rapids (T83N R07W 20 NE) | [1]735.7 | -- |
| 88.19 | Wenig Road, Cedar Rapids (T83N R07W 17 SE) | [1]736.1 | -- |
| 88.48 | Ellis Boulevard Park, Cedar Rapids (T83N R07W 17 SW) | [1]736.5 | -- |
| 89.07 | Ellis Road NW, Cedar Rapids (T83N R07W 17 NW) | [1]737.0 | -- |
| 90.40 | Ellis Road NW, Cedar Rapids (T83N R07W 18 NW) | [1]738.5 | -- |
| 90.99 | Seminole Valley Road NE, Cedar Rapids (T83N R08W 13 NW) | [1]739.7 | -- |
| 91.92 | Ellis Road NW, Cedar Rapids (T83N R08W 14 SE) | [1]741.0 | -- |
| 92.46 | Ross Lane, Cedar Rapids (T83N R08W 14 NW) | [1]741.6 | -- |
| 93.65 | 42nd Street NE, Cedar Rapids (T83N R08W 11 NE) | [1]743.4 | -- |
| 94.16 | Greenbranch Lane NE, Cedar Rapids (T83N R08W 02 SE) | [1]744.1 | -- |
| 96.09 | High Point Lane, Cedar Rapids (T84N R08W 35 SW) | [1]744.7 | -- |
| 98.60 | Shae Drive, SE of Palo (T84N R08W 33 NW) | [1]747.7 | -- |
| 100.16 | USGS streamgage 05464420, at Palo (T84N R08W 21 SW) | 748.93 | 749.03 |
| 101.98 | Duane Arnold Energy Center, N of Palo (T84N R08W 09 SE) | [2]750.03 | -- |
| 108.58 | Lewis Access Road, SW of Center Point (T85N R08W 20 SW) | [2]763.19 | -- |
| 112.70 | County Road W26 (32nd Avenue) (T85N R09W 11 SW) | 767.89 | 769.27 |
| 116.92 | Benton City-Fry Recreation Area, E of Vinton (T85N R09W 20 NE) | [2]776.32 | -- |
| 120.59 | Hoefle-Dulin Recreation Area, E of Vinton (T85N R10W 23 NE) | [2]777.42 | -- |
| 124.22 | E 1st Street, at Vinton (T85N R10W 16 SE) | [1]786.2 | -- |
| 124.51 | USGS streamgage 05464315, at Vinton (T85N R10W 16 SW) | 786.58 | 786.68 |
| 127.02 | 22nd Avenue Trail and 22nd Avenue Road, NW of Vinton (T85N R10W 06 SE) | [2]788.99 | -- |
| 130.56 | 54th Street Drive, NW of Vinton (T86N R10W 19 SE) | [2]793.47 | -- |
| 137.03 | County Road D65, near Mt. Auburn (T86N R10W 06 NW) | 803.54 | 803.9 |
| 142.05 | Trail Bridge, E of La Porte City (T87N R11W 28 SE) | [2]814.14 | -- |
| 144.30 | Brandon Road, NE of La Porte City (T87N R11W 19 SE) | 816.47 | 817.22 |
| 151.73 | East Washburn Road, Gilbertville (T88N R12W 27 NE) | [1]825.7 | -- |
| 152.45 | County Road D38, Gilbertville (T88N R12W 23 SW) | 826.44 | 827.01 |
| 156.01 | Weiden Road, S of Waterloo (T88N R12W 17 NE) | [1]832.7 | -- |
| 157.30 | Ridge Road, S of Evansdale (T88N R12W 08 NE) | [1]833.9 | -- |
| 158 | Confluence of Elk Run and Cedar River, S of Evansdale (T88N R12W 06 SE) | [1]835.1 | -- |
| 158.14 | Cedar Valley Bike Trail (Old W.C.F & N. R.R. Bridge), S of Evansdale (T88N R12W 06 SW) | -- | [2]836.86 |
| 158.45 | River Road, Evansdale (T88N R12W 06 SW) | [1]839.0 | -- |
| 159.13 | Belle Street, Evansdale (T88N R13W 12 NE) | [1]841.0 | -- |
| 159.57 | Interstate 380/U.S. Highway 20, Waterloo (T88N R13W 12 NE) | 842.09 | 842.58 |
| 160.76 | On berm, E of River Forest Road and N of Park Road, Evansdale (T88N R13W 01 NE) | [1]844.1 | -- |
| 161.18 | River Forest Road, Evansdale (T89N R12W 32 SW) | [1]844.7 | -- |
| 161.63 | SW of intersection of River Forest Road and Lafayette Street, Evansdale (T89N R12W 32 NW) | [1]846.7 | -- |
| 162.67 | S of intersection of Dewar Street and Indiana Street, Waterloo (T89N R12W 31 NW) | [1]846.8 | -- |
| 163.14 | SE of Water Street, Waterloo (T89N R13W 25 SE) | [1]847.6 | -- |

**Table 8.** Locations and elevations of high-water marks used in the Cedar River flood profile from May 30 to June 15, 2008.—Continued

[HWM, high-water mark; NGVD 29, National Geodetic Vertical Datum of 1929; --, not determined; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east]

| Distance from mouth (river miles) | Location | Downstream HWM (feet above NGVD 29) | Upstream HWM (feet above NGVD 29) |
|---|---|---|---|
| 163.30 | 18th Street Bridge, Waterloo (T89N R13W 25 SE) | [2]848.34 | -- |
| 163.36 | 18th Street Bridge, Waterloo (T89N R13W 25 SE) | -- | [1]848.4 |
| 163.86 | 11th Street Bridge, Waterloo (T89N R13W 25 NW) | -- | [2]848.96 |
| 163.99 | East 9th Street, Waterloo (T89N R13W 25 NW) | [1]850.8 | -- |
| 164.16 | USGS streamgage 05464000, at Waterloo (T89N R13W 25 NW) | 851.15 | -- |
| 164.25 | 5th Street Bridge, Waterloo (T89N R13W 25 NW) | [2]852.52 | -- |
| 164.37 | 4th Street Bridge, Waterloo (T89N R13W 25 NW) | -- | [2]852.87 |
| 164.42 | Park Avenue, Waterloo (T89N R13W 26 NE) | 853.37 | 854.49 |
| 164.71 | Mullen Street, Waterloo (T89N R13W 23 SE) | 854.88 | 855.12 |
| 165.27 | SW of Park Road and Fairview Avenue intersection, Waterloo (T89N R13W 23 NW) | [1]857.2 | -- |
| 165.71 | On berm, adjacent to River Road, Waterloo (T89N R13W 22 NE) | [1]857.9 | -- |
| 166.31 | San Souci Drive, Waterloo (T89N R13W 15 SW) | [1]859.4 | -- |
| 166.91 | Bear Cedar Bend Street, Waterloo (T89N R13W 15NW) | [1]860.2 | -- |
| 168.32 | Greenwood Avenue (downstream of U.S. Highway 218 Bridge), Waterloo (T89N R13W 16 SW) | [1]860.8 | -- |
| 168.77 | Greenwood Avenue (upstream of U.S. Highway 218 Bridge), Waterloo (T89N R13W 16 NW) | -- | [1]861.6 |
| 169.01 | Shirley Way, Waterloo (T89N R13W 17 NE) | [1]862.0 | -- |
| 170.24 | Cooley Street, Cedar Falls (T89N R13W 08 SW) | [1]863.1 | -- |
| 171.27 | State Highway 58, Cedar Falls (T89N R13W 08 NW) | [2]864.29 | [4]865.1 |
| 172.19 | USGS streamgage 05463050, at Cedar Falls (T89N R14W 12 NE) | 865.1 | -- |
| 172.34 | East Main Street, Cedar Falls (T89N R14W 12 NE) | [2]866.01 | -- |
| 172.56 | 1st Street and Clay Street, Cedar Falls (T89N R14W 12 NW) | [1]867.6 | -- |
| 172.65 | Center Street, Cedar Falls (T89N R14W 12 NW) | -- | [2]868.43 |
| 173.43 | Cottage Row Road, Waterloo (T89N R14W 02 SW) | [1]868.8 | -- |
| 174.16 | Cottage Row Road, Waterloo (T89N R14W 02 NW) | [1]870.8 | -- |
| 174.47 | Cottage Row Road, Waterloo (T89N R14W 03 NE) | [1]871.0 | -- |
| 184.43 | Illinois Central Railroad Bridge (T91N R14W 35 SW) | -- | [2]886.07 |
| 184.66 | USGS streamgage 05458500, at Janesville (T91N R14W 35 SW) | 887.71 | -- |
| 185.03 | U.S. Highway 218, N of Janesville (T91N R14W 35 NW) | 888.75 | 890.41 |
| 195.59 | State Highway 3, Waverly (T91N R14W 02 NW) | [2]914.05 | [2]917.10 |
| 196.02 | Old CNWTC Railroad Bridge, Waverly (T92N R14W 35 SW) | -- | [2]917.19 |
| 197.11 | USGS streamgage 05458300, County Road V14, at Waverly (T92N R14W 35 NW) | 919.73 | [2]920.08 |
| 202.00 | County Road C33, N of Waverly (T92N R14W 21 NW) | [2]922.83 | [2]925.43 |
| 209.01 | State Highway 188, E of Plainfield (T93N R14W 20 SW) | -- | [2]936.07 |
| 214.64 | U.S. Highway 218 N of 110th Street, S of Nashua (T93N R14W 06 SW) | [1]950.9 | -- |
| 219.40 | Jay Street, Nashua (T94N R14W 20 NW) | [1]965.0 | -- |
| 220.51 | Illinois Central Railroad Bridge, Nashua (T94N R14W 17 SW) | [2]967.92 | -- |
| 220.66 | Sample Street, Nashua (T94N R14W 18 SE) | [1]968.0 | -- |
| 222.85 | Old Highway Road, N of Nashua (T94N R15W 12 NW) | [1]969.7 | -- |
| 226.24 | Ripley Bridge Road, S of Charles City (T95N R15W 34 NW) | [1]976.3 | -- |

**Table 8.** Locations and elevations of high-water marks used in the Cedar River flood profile from May 30 to June 15, 2008.—Continued

[HWM, high-water mark; NGVD 29, National Geodetic Vertical Datum of 1929; --, not determined; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east]

| Distance from mouth (river miles) | Location | Downstream HWM (feet above NGVD 29) | Upstream HWM (feet above NGVD 29) |
|---|---|---|---|
| 229.44 | Underwood Avenue, S of Charles City (T95N R15W 20 SE) | [1]981.3 | -- |
| 232.61 | Shaw Avenue, Charles City (T95N R15W 07 SW) | [1]994.9 | -- |
| 233.66 | Hawkins Street, Charles City (T95N R15W 07 NW) | [1]997.7 | -- |
| 233.82 | USGS streamgage 05457700, at Charles City (T95N R16W 12 NE) | 998.35 | -- |
| 234.00 | U.S. Highway 18, Charles City (T95N R16W 12 NE) | [2]998.50 | -- |
| 234.20 | Riverside Drive, Charles City (T95N R16W 12 NE) | [1]998.6 | -- |
| 234.51 | Court Street, Charles City (T95N R16W 01 SW) | [1]1,002.3 | -- |
| 236.98 | Riverview Drive, N of Charles City (T96N R16W 35 SW) | [1]1,007.4 | -- |

[1]Federal Emergency Management Agency (FEMA) high-water mark (Federal Emergency Management Agency, 2008b).

[2]U.S. Army Corps of Engineers (USACE) high-water mark.

[3]Muscatine County Engineers Office high-water mark.

[4]Estimated flood elevation.

# Appendix 1. Flood History of Iowa River and Cedar River Basins

The earliest large flood in the Iowa River and Cedar River Basins for which any information was recorded occurred in 1851 (Heinitz, 1973). In October 1902 and June 1903 the first U.S. Geological Survey (USGS) streamgages in the State, not located on the Mississippi River, were installed in the basins and streamflow information, including floods, have been collected continuously since then. The streamgages are 05464500 Cedar River at Cedar Rapids, Iowa (fig 2, site 90), and 05454500 Iowa River at Iowa City, Iowa (fig 1, site 37). Streamgages 05451500 Iowa River at Marshalltown, Iowa (fig. 1, site 14), 05458500 Cedar River at Janesville, Iowa (fig 2, site 61), and 05465500 Iowa River at Wapello, Iowa (fig 1, site 103) have complete streamflow record, or almost complete streamflow record, since October 1914.

Maximum stages and discharges, and flood probabilities for the 2008 flood, are listed in table 3 for 54 streamgages in the Iowa River and Cedar River Basins. Also listed in table 3 are selected historical peak discharges. The streamgages listed in table 3 are listed in the USGS National Water Information System (NWIS) database. Users may obtain surface-water data for Iowa streamgages, including information on types of data available and years of data collection, at *http://waterdata.usgs.gov/ia/nwis/sw*. Annual-maximum discharges from the peak-flow records for the Iowa City and Cedar Rapids streamgages and illustrations of the type of record that is collected for each continuous-record streamgage, and crest-stage streamgage listed in table 3, for which a maximum discharge is determined for each water year of streamgage operation are shown in figures 4 and 5. The figures also include the peaks from several floods that occurred before the streamgages were installed. The 1-percent flood probabilities for the streamgage 05464500 Cedar River at Cedar Rapids, Iowa are shown in figure 5. The three largest known floods at Iowa City occurred in 1851, 1881, and 1918. All three of these floods occurred before the Iowa River became a regulated stream downstream from the Coralville Dam in 1958. As indicated in figure 4, one effect of the Coralville Lake is to reduce flood discharges in the Iowa River downstream from the Coralville Dam. Since the beginning of the operation of the Coralville Dam in 1958, two major floods in 1993 and 2008 have occurred that exceeded the storage capacity of Coralville Lake and flowed over the spillway at Coralville Dam.

The Iowa Natural Resources Council (1955) reports that before the operation of streamgages in the Iowa River and Cedar River Basins, historical records indicate that major floods occurred in March 1840, June 1851, June 1858, July 1881, and June 1892. Irving B. Weber, an Iowa City historian and former contributor to the *Iowa City Press-Citizen* newspaper, published a newspaper article on March 19, 1975, titled *Iowa River Floods*. In the article, which was subsequently included in the publication *Historical Stories about Iowa City, Volume 2* (Weber, 1979), Weber included local information and reports from eye-witness accounts of the 1851, 1881, and 1918 floods on the Iowa River in Iowa City. Weber also included an account that described that Native Americans still in the area in 1851 indicated that they knew of one other flood, which their mark west of the Old Capitol (not shown on map) in Iowa City indicated was 1-foot higher than the 1851 flood. Weber reported that the year of this pre-1851 flood was not known, but that settlers in the area apparently placed credence in the Native American information.

## Flood of June 1851

The flood of June 1851 is the largest known flood on the Iowa River at Iowa City and on the Iowa River upstream from the confluence with the Cedar River. Before the 1993 flood (discussed in a following section, Flood of 1993), the 1851 flood was generally recognized as the largest flood on record on some of the upper Mississippi River tributaries, including those in Iowa (Heinitz, 1973). The 1851 flood evidently covered a large area; however, there is little or no accurate information upon which to evaluate conditions for this flood. Before the 1961 flood (also discussed in a following section, Flood of March and April 1961), the 1851 flood was generally believed to have been the largest flood within the Iowa River and Cedar River Basins (Iowa Natural Resources Council, 1955). The flood probability for the peak discharge of the 1851 flood at the 05454500 Iowa River at Iowa City, Iowa streamgage (about 70,000 $ft^3/s$, table 3, fig. 4) is estimated to be less than 0.2 percent (table 3). At the 05464500 Cedar River at Cedar Rapids, Iowa streamgage, the peak discharge of the 1851 flood (about 65,000 $ft^3/s$, fig. 5) is the fifth largest known flood with a flood-probability estimate of 4 to 10 percent (table 3).

## Flood of July 1881

The flood of July 1881 is the second largest known flood on the Iowa River at Iowa City. The second wettest year on record in Iowa was 1881, which had an average rainfall for the State of 44.16 in. (Hillaker, 2008a). The flood probability for the peak discharge of the 1881 flood at the Iowa City streamgage (51,000 $ft^3/s$, table 3, fig. 4) is estimated to be 0.2 to 1 percent (table 3).

## Flood of June 1918

The flood of June 1918 is largest known flood on the Iowa River at Marshalltown and near Belle Plaine. Rainfall in May had saturated the ground and heavy rainfall from May 27 to 28 resulted in minor flooding; continued heavy rainfall from June 3 to 5 caused major flooding (Heinitz, 1973). Flood probabilities for peak discharges of the 1918 flood at streamgages 05451500 Iowa River at Marshalltown, Iowa and 05452500 Iowa River near Belle Plaine, Iowa (fig. 1, site 20) are estimated to be less than 0.2 percent and 0.2 to 1 percent (table 3), respectively. At the 05454500 Iowa River at Iowa City, Iowa streamgage, the peak discharge of the 1918 flood (42,500 $ft^3/s$, table 3, fig. 4) is the third largest known flood with a

flood-probability estimate of 1 to 2 percent (table 3). The 1918 flood was not a significant flood in the Cedar River Basin.

## Flood of March 1929

The flood of March 1929 is the sixth largest known flood on the Cedar River at Waterloo and Cedar Rapids. The flood was the result of rapid melting of heavy snow cover, which had accumulated throughout the previous two months (Schwob, 1963); the frozen ground and snowmelt runoff caused moderate flooding. Flood probabilities for peak discharges of the 1929 flood at streamgages 05464000 Cedar River at Waterloo, Iowa (fig. 2, site 79) and 05464500 Cedar River at Cedar Rapids, Iowa (fig. 5) are estimated to be 4 to 10 percent (table 3). The 1929 flood was not a significant flood in the Iowa River Basin.

## Flood of March 1933

The flood of March 1933 is the second largest known flood on the Winnebago River at Mason City. This flood primarily was the result of heavy rainfall the last 3 days of March culminating a month that was, at that time, the wettest since 1878 (Schwob, 1963). The north-central part of the State received the greatest amount of the monthly rainfall. The upper part of the Winnebago River Basin had a total of 6 or more in. of rainfall; the Black Hawk Creek and Beaver Creek Basins received rainfall totals ranging from 5 to 6.58 in.; the remainder of the Cedar River Basin upstream from Waterloo received 4 to 5 in.; and the Cedar River Basin downstream from Waterloo received 2 to 3 in. (Schwob, 1963). The flood probability for the peak discharge of the 1933 flood at streamgage 05459500 Winnebago River at Mason City, Iowa (fig. 2, site 68) is estimated to be 1 to 2 percent (table 3). At the 05458500 Cedar River at Janesville, Iowa streamgage, the peak discharge of the 1933 flood is the sixth largest known flood with a flood-probability estimate of 2 to 4 percent (table 3). Although the 1933 flood is the largest known flood of the short record available at streamgage 05460500 Shell Rock River at Marble Rock, Iowa (fig. 2, site 70), with a flood-probability estimate of 0.2 to 1 percent, the flood record at streamgage 05462000 Shell Rock River at Shell Rock, Iowa (fig. 2, site 74), located about 33-mi downstream, indicates that the 1933 flood may actually be about the third largest known flood on the Shell Rock River. The floods in 2008 and 1856 at the streamgage 05462000 Shell Rock River at Shell Rock were the largest and second largest floods, respectively, on the Shell Rock River (table 3). The 1933 flood was not a significant flood in the Iowa River Basin.

## Flood of June 1947

The flood of June 1947 is the second largest known flood on Salt Creek near Elberon. Antecedent conditions of saturated soils and swollen rivers contributed to this flood (Heinitz, 1973). Total rainfall from May 25 to June 30 ranged from about 7 in. in the extreme north of the Iowa River and Cedar River Basins, to 20 in. near Traer in the central part of the basins (Iowa Natural Resources Council, 1955). The rainfall occurred during several periods, and intermittent flooding occurred at various locations throughout the basins. The greatest rainfall occurred from June 10 to 13, particularly during the last 2 days of this period. The greatest amount of rainfall was reported at Vinton, where 4.70 in. fell in a 24-hour period, and at Shell Rock, where 4.93 in. fell in a 19-hour period on June 12 to13 (Iowa Natural Resources Council, 1955). The smaller tributaries in the central parts of the Iowa River and Cedar River Basins produced large floods and primarily were responsible for the flood that occurred on the mainstems of the Iowa River and Cedar River (Schwob, 1963). Damage along the Iowa River was particularly severe at Tama and Marshalltown, and along the Cedar River was most severe at Waterloo (Iowa Natural Resources Council, 1955). The flood probability for the peak discharge of the 1947 flood at streamgage 05452000 Salt Creek near Elberon, Iowa (fig. 1, site 18) is estimated to be less than 0.2 percent (table 3).

## Flood of June 1951

The flood of June 1951 is the largest known flood on the West Fork Cedar River at Finchford. The flood was the result of torrential rainfall from June 25 to 26. One storm occurred in the West Fork Cedar River Basin where as much as to 12.00 in. of rainfall was reported at Dumont (Iowa Natural Resources Council, 1955). Smaller amounts of rainfall occurred in the remainder of the upper part of the Cedar River Basin, which was sufficient to cause flooding in all the larger tributaries (Schwob, 1963). The flood probability for the peak discharge of the 1951 flood at streamgage 05458900 West Fork Cedar River at Finchford, Iowa (fig. 2, site 63) is estimated to be 0.2 to 1 percent (table 3). The 1951 flood was not a significant flood in the Iowa River Basin.

## Flood of June 1954

The flood of June 1954 is the largest known flood on the East Branch Iowa River near Klemme and the Iowa River near Rowan. Heavy rainfall in the last few days in May and the first half of June saturated the soil throughout much of the northern half of the State (Heinitz, 1973). The flood resulted from heavy rainfall during June 15 to 22 (Heinitz, 1973); rainfall totals from June 17 to 21 of 11.91 and 10.59 in. were recorded at Britt (fig. 1) and Mason City (fig. 2), respectively (Iowa Natural Resources Council, 1955). Severe flooding occurred along the Iowa River upstream from Iowa Falls which included extensive agricultural damage along the East and West Branches of the Iowa River. Willow Creek caused extensive urban damage in Mason City. The report Floods of June 1954 in Iowa (Yost, 1958) documents this flood.

Flood probabilities for peak discharges of the 1954 flood at streamgages 05449000 East Branch Iowa River near Klemme, Iowa (fig. 1, site 9) and 05449500 Iowa River near Rowan, Iowa (fig. 1, site 10) are estimated to be 0.2 to 1 percent and 1 to 2 percent (table 3), respectively.

## Flood of March and April 1961

The flood of March and April 1961 is the second largest known flood on the Cedar River at Waterloo and Cedar Rapids and is the third largest known flood on the Cedar River at Charles City, Janesville, and near Conesville. The flood resulted from rapid melting of heavy snow cover supplemented by rainfall (Schwob, 1963). Flood probabilities for peak discharges of the 1961 flood at streamgage 05464000 Cedar River at Waterloo (76,700 $ft^3/s$ ) and at streamgage 05464500 Cedar River at Cedar Rapids (73,000 $ft^3/s$, fig. 5) are estimated to be 4 to 10 percent and 2 to 4 percent (table 3), respectively. Flood probabilities for peak discharges of the 1961 flood at streamgages 05457700 Cedar River at Charles City, Iowa (fig. 2, site 56), 05458500 Cedar River at Janesville, Iowa, and 05465000 Cedar River near Conesville, Iowa (fig. 2, site 101) are estimated to be 1 to 2 percent for Charles City and Janesville and 4 to 10 percent for Conesville (table 3). The 1961 flood was not a significant flood in the Iowa River Basin.

## Flood of July 1969

The flood of July 1969 is the second largest known flood on the Iowa River at Marshalltown. Heavy rainfall of 8 in. or more was reported throughout the upper part of the Iowa River Basin in June (Heinitz, 1973). The flood resulted from intense storms from July 6 to 9 with rainfall of 8.61 and 7.33 in. at Eldora and Iowa Falls, respectively. Severe flooding occurred on streams south of Iowa Falls, particularly on the South Fork Iowa River; however, no streamgages were operated on these streams. The flood probability for the peak discharge of the 1969 flood at streamgage 05451500 Iowa River at Marshalltown, Iowa is estimated to be 0.2 to 1 percent (table 3). At streamgage 05453100 Iowa River at Marengo, Iowa (fig.1, site 22), the peak discharge of the 1969 flood is the fourth largest known flood with a flood-probability estimate of 4 to 10 percent (table 3). The 1969 flood was not a significant flood in the Cedar River Basin.

## Flood of 1993

The flood of 1993 is the largest known flood on the Iowa River near Lone Tree, on the English River at Kalona, and on Salt Creek near Elberon. From mid-June through early August, severe flooding in a nine-state area of the upper Mississippi River Basin followed an extended period of persistent precipitation that began in January. Following a wetter than average spring, weather patterns that persisted from early June through July caused the Upper Midwest to be deluged with excessive rainfall (Wahl and others, 1993). The wettest year on record in Iowa was 1993, which had an average rainfall of 48.22 in. (Hillaker, 2008a). The 1993 flood in the upper Midwest is significant with respect to the magnitude and duration of flow. Flood-peak discharges equal or less than a 10-percent flood probability were recorded at 154 streamgages in the flooded region during June through August 1993 (Parrett and others, 1993). Not only were previous maximum peak discharges exceeded at many streamgages, but flood volumes were significantly higher than previous maximums (Southard, 1995). The human and economic costs of the flood were high. Total flood and other related damage in the Upper Mississippi River Basin were estimated in the $10 to $16 billion range, with total Federal expenditures in excess of $5.4 billion (Scientific Assessment and Strategy Team, 1994).

In Iowa, 34 streamgages exceeded previous peak discharges in 1993 with the vast majority of peaks occurring in July (Southard and others, 1994). Eleven streamgages in Iowa with 10 or more years of record on unregulated streams had flood-probability estimates equal to or less than 1 percent and every major reservoir in the State had record pool elevations. As a result of the magnitude of the 1993 flood, computed flood-probability discharges increased at most streamgages in Iowa (Eash, 1997). Two periods of significant flooding occurred in the Cedar Basin in 1993. In early April, flooding caused by snowmelt runoff and rainfall produced maximum discharges for 1993 along the Cedar River from Waterloo to Conesville. In mid-August, additional rainfall on saturated soils produced maximum discharges for 1993 along the Cedar River from Charles City to Janesville and at streamgage 05458000 Little Cedar River at Ionia, Iowa (fig. 2, site 59). Maximum discharges for 1993 along the Iowa River primarily occurred in July. Local streamflow contributions in August produced the peak discharge at the streamgage 05454500 Iowa River at Iowa City (Schaap and Harvey, 1995).

On the Iowa River upstream from the Coralville Dam, the 1993 flood is the second largest known flood at the streamgage 05453100 Iowa River at Marengo with a flood-probability estimate of 1 to 2 percent (table 3). Downstream from the Coralville Dam, at streamgages 05453520 Iowa River below Coralville Dam near Coralville, Iowa (fig. 1, site 25) and at streamgage 05454500 Iowa River at Iowa City (fig. 1, site 37), Iowa, peak discharges of the 1993 flood are the second largest since operation of the dam began in 1958 with flood-probability estimates of 1 to 2 percent (U.S. Army Corps of Engineers, 2009, table 3). Farther downstream from the dam, the flood probability for the peak discharge of the 1993 flood at streamgage 05455700 Iowa River near Lone Tree, Iowa (fig. 1, site 51) is estimated to be 0.2 to 1 percent (U.S. Army Corps of Engineers, 2009, table 3). Considering the entire peak-flow record for the 05454500 Iowa River at Iowa City, Iowa streamgage, the 1993 flood (28,200 $ft^3/s$, fig. 4) is the seventh largest known flood. Downstream from the confluence of the Iowa and Cedar Rivers, the peak discharge of the

1993 flood is the second largest known flood at the streamgage 05465500 Iowa River at Wapello, Iowa with a flood-probability estimate of 2 to 4 percent (U.S. Army Corps of Engineers, 2009, table 3). Flood probabilities for peak discharges of the 1993 flood at streamgages 05455500 English River at Kalona, Iowa (fig. 1, site 49) and 05452000 Salt Creek near Elberon, Iowa are estimated to be 0.2 to 1 percent and less than 0.2 percent and (table 3), respectively. At streamgages 05457700 Cedar River at Charles City, Iowa and 05458500 Cedar River at Janesville, Iowa, peak discharges of the 1993 flood are the fourth largest known floods with flood-probability estimates for the streamgages of 2 to 4 percent (table 3); at the 05464000 Cedar River at Waterloo, Iowa streamgage, the 1993 flood is the fifth largest known flood with a flood-probability estimate of 4 to 10 percent; at the 05464500 Cedar River at Cedar Rapids, Iowa streamgage, the 1993 flood is the third largest known flood (71,000 $ft^3/s$, fig. 5) with a flood-probability estimate of 2 to 4 percent; and at the 05465000 Cedar River at Conesville, Iowa streamgage, the 1993 flood is the second largest known flood with a flood-probability estimate of 4 to 10 percent. At the 05458000 Little Cedar River near Ionia, Iowa streamgage, the peak discharge of the 1993 flood is the second largest known flood with a flood-probability estimate of 4 to 10 percent (table 3).

## Flood of July 1999

The flood of July 1999 is the second largest known flood on the Cedar River at Charles City and Janesville. The flood resulted from the cumulative effect of two thunderstorms in northeast Iowa. From July 18 to 19, as much as 6 in. of rainfall was centered over Cerro Gordo, Floyd, Mitchell, and Worth Counties. From July 20 to 21, a second storm occurred in which an additional rainfall of as much as 8 in. was centered over Chickasaw and Floyd Counties (Ballew and Eash, 2001). Flood probabilities for peak discharges of the 1999 flood at streamgage 05457700 Cedar River at Charles City, Iowa and streamgage 05458500 Cedar River at Janesville, Iowa are estimated to be 1 to 2 percent and 0.2 to 1 percent (table 3), respectively. At streamgage 05461390 Flood Creek near Powersville, Iowa (fig. 2, site 72), the peak discharge of the 1999 flood indicates a major flood with a flood-probability estimate of less than 0.2 percent (table 3). The 1999 flood was not a significant flood in the Iowa River Basin.

## Flood of June 2002

The flood of June 2002 was severe along Indian Creek in Linn County following thunderstorm activity in east-central Iowa. A 24-hour rainfall of 4.76 in. was recorded at Cedar Rapids at 6:00 p.m. on June 4. Radar indications estimated as much as 6 in. of rain fell in the headwaters of the Indian Creek Basin. At two ungaged sites on Indian Creek, one north of Marion and the other near the mouth in Cedar Rapids, peak discharges determined for the 2002 flood were estimated to have flood probabilities of less than 0.2 percent (Eash, 2004). The 2002 flood was not a significant flood on the mainstems of either the Iowa River or the Cedar River.

## Comparison of the 2008 flood with the 1993 flood and other significant historical floods

A comparison of discharge hydrographs for the 1993 and 2008 water years for the streamgages 05454500 Iowa River at Iowa City, Iowa and 05464500 Cedar River at Cedar Rapids, Iowa is shown in figures 9 and 10. Also shown are long-term median daily discharges calculated for the regulated period of record (1959-2008) for the Iowa City streamgage and calculated for the entire period of record (1903-2008) for the Cedar Rapids streamgage, and the discharge for the National Weather Service flood stage at each streamgage. From October to late May, streamflows at both streamgages were relatively similar for both water years because they generally stayed consistently above the long-term median-daily discharge (figs. 9 and 10). At Cedar Rapids, snowmelt runoff and rainfall produced flood peaks during March and April in 1993 and 2008 that exceeded the flood stage, including the maximum peak discharge for 1993 on April 4 (fig. 10). Operation of the Coralville Dam reduced discharges at Iowa City below the flood stage during March and April in 1993 and 2008. Peak discharges in June 2008 spike well above 1993 flood peaks at both streamgages; at Iowa City, the 2008 peak discharge (41,100 $ft^3/s$) was nearly 46 percent larger than the 1993 peak discharge (28,200 $ft^3/s$) and at Cedar Rapids, the 2008 peak discharge (140,000 $ft^3/s$) was 97 percent larger than the 1993 peak discharge (71,000 $ft^3/s$). While peak discharges for 2008 at Iowa City and Cedar Rapids were greater than those for 1993, the duration of 1993 discharges above the flood stage at each streamgage was more than twice as long as that for 2008.

Twenty-five streamgages out of the 104 streamgages listed in table 3 were selected to compare the 2008 flood to significant historical floods. They are sites 10, 12, 14, 18, 22, 25, 37, 40, 49, 51, 52, 56, 59, 60, 61, 63, 68, 74, 76, 78, 79, 85, 90, 101, and 103 in figures 1 and 2 and table 3. The drainage areas of the selected streamgages are all greater than 200 $mi^2$.

The 2008 flood-probability estimates for 23 of the 25 streamgages are less than 4 percent. The two streamgages that have 2008 flood-probability estimates greater than 4 percent are 05455100 Old Mans Creek near Iowa City (fig. 1, site 40) and 05455500 English River at Kalona, Iowa (fig. 1, site 49). The 2008 flood is the largest known flood at 16 sites whereas the 1993 flood is the largest known flood at three sites (the three sites are in the Iowa River Basin); streamgages were operated during the 1993 flood at 22 of the 25 sites. For the remaining six streamgages, the largest known floods occurred in 1851, 1918, 1951, 1954, 1982, and 2004.

Of the 25 streamgages, 10 are located in the Iowa River Basin (above the confluence from the Iowa River and Cedar River), 14 are located in the Cedar River Basin, and one is

located in the Iowa River Basin downstream from the confluence of the Iowa River and Cedar River at Wapello. The 2008 flood is the largest known flood at three of the 10 streamgages in the Iowa River Basin, at 12 of the 14 streamgages in the Cedar River Basin, and at the Wapello streamgage located downstream from the confluence of the Iowa River and Cedar River. Streamgages 05457000 Cedar River near Austin, Minnesota (fig. 2, site 52) and 05458900 West Fork Cedar River at Finchford, Iowa are the only two streamgages in the Cedar River Basin with drainage areas greater than 200 $mi^2$ for which the 2008 flood did not set a new peak discharge record.

At 21 of the 25 streamgages, flood probabilities for a total of 30 peak discharges from the periods of record are estimated to be less than 1 percent (table 3). Of these 30 flood peaks, 17 are for the 2008 flood and 3 are for the 1993 flood (all 3 1993 flood peaks are for streamgages in the Iowa River Basin); of the 10 remaining flood peaks, they occurred in 1851, 1856, 1881, 1918, 1944, 1947, 1951, 1969, 1999, and 2004. Since 1851, the 2008 flood on the Iowa River at streamgage 05454500 Iowa River at Iowa City, Iowa is the fourth largest known flood and the 2008 flood on the Cedar River streamgage 05464500 Cedar River at Cedar Rapids, Iowa is almost twice as large as that of the next largest known flood (the 1961 flood, figs. 4 and 5).

# Appendix 2. List of bench marks and reference points

To facilitate measuring and referencing the high-water marks (HWMs) used in the flood profiles to a common datum, bench marks (BMs), temporary bench marks (TBMs), and reference points (RPs) were found or established by the U.S. Geological Survey (USGS) at selected bridges along the profiled river reaches. All BM, TBM, and RP elevations listed in table 9 are referenced to the National Geodetic Vertical Datum of 1929. The list of 215 sites where the USGS, Federal Emergency Management Agency (FEMA, Federal Emergency Agency, 2008b), U.S. Army Corps of Engineers (USACE), Muscatine County Engineer's Office, and the City of Iowa City, measured HWMs for the June 2008 flood is shown in tables 7 and 8. Of these 215 sites, BMs or TBMs are listed for 79 of the sites and RPs are listed for 61 of the sites in table 9. For 19 of the 79 sites listed in this appendix, BMs and TBMs and corresponding elevations were established by other agencies and these agencies are listed in table 9. BMs or reference marks (RMs) established at USGS streamgages are identified in table 9 with a BM or RM number. BM, TBM, and RP elevations established by the USGS were determined from a combination of global positioning system (GPS) technology and differential leveling. Elevations determined using GPS are noted in the BM, TBM, and RP descriptions. GPS data were collected by the USGS and submitted for processing to the Online Positioning User Service (OPUS), an Internet service provided by the National Geodetic Survey (*http://www.ngs.noaa.gov/OPUS/*). The quality of the GPS data is based on the guidelines of "What to look for in a quality solution" (*http://www.ngs.noaa.gov/OPUS/about.html*, accessed January 22, 2009).

In general, BMs are points that were specifically designed to mark an elevation, such as USGS elevation disks and Iowa DOT bench marks (round-top rods embedded in concrete at one or more corners of a bridge). Marks such as squares and crosses, that were chiseled or filed on concrete or metal; or existing bolts on bridges, were used as TBMs or RPs. RPs were established to permit water-surface elevations to be determined by use of a tape and weight. The terms "right" and "left" in the descriptions are determined as viewed while facing in the downstream direction.

The BM, TBMs, and RPs are designated by an index number or legal description derived from their respective locations using Public Land Survey System coordinates (township, range, section). Within the section, the quarter section in which the BM, TBM, or RP is located is designated by NE, SE, NW, and SW. For Example, T73N R02W 23 SW refers to a location in Township 73 North, Range 2 West, southwest quarter of section 23. A number in parentheses following the quarter-section designation indicates the number of the BM, TBM, or RP in that particular quarter section. The index number serves to describe the legal description of the mark without further reference in the body of the description. The physical location of the BM or TBM on a bridge dictates the appropriate legal description. An RP, and any additional BMs or TBMs, are listed with the related BM or TBM and are identified by the same legal description though, at times, they are in a different section, range, or township as determined by upstream or downstream location.

The BMs, TBMs, and RPs are listed in table 9 in upstream order for the Iowa and Cedar Rivers. The user of this information is cautioned that BMs, TBMs, and RPs listed herein might have been disturbed, destroyed, or moved since elevations were established. It is the responsibility of the user to determine the condition and the suitability of the BM, TBM, or RP.

**Table 9.** Bench marks and reference points used in the May 30 to June 15, 2008, Iowa River and Cedar River flood profiles.

[Bench marks and reference points are listed in upstream order. BM, bench mark; TBM, temporary bench mark; RP, reference point; GPS, Global Positioning System; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east]

| Public Land Survey System (township, range, section, quarter-section) | Mark classification | Location | Mark | Elevation in feet (NGVD 1929) | Elevation determination method |
|---|---|---|---|---|---|
| | | Iowa River | | | |
| T73N R02W 23 SW (1) | TBM | About 0.90 miles northwest of Oakville, site of streamgage 05465700 Iowa River at Oakville, on State Highway 99 bridge over Iowa River, on left downstream end of wingwall girder, on second bolt head from abutment on metal girder under guardrail | Filed cross (BM1) | 560.61 | Elevation supplied by Louisa County Engineer's Office |
| T73N R02W 23 SW (2) | RP | About 0.90 miles northwest of Oakville, site of streamgage 05465700 Iowa River at Oakville, on State Highway 99 bridge over Iowa River, from left downstream end of bridge between 10th and 11th vertical steel posts on downstream girder | Three chisel marks | 561.18 | Surveyed level line from TBM |
| T74N R03W 27 SE (1) | BM | At Wapello, site of streamgage 05465500 Iowa River at Wapello, on State Highway 99 bridge over Iowa River, on right upstream end of bridge on concrete wingwall | USGS bronze bench mark stamped "8 DRL 1964" | 579.77 | Streamgage elevation data |
| T74N R03W 16 NW (1) | BM | About 2 miles north of Wapello, on U.S. Highway 61 bridge over Iowa River, on right downstream end of bridge on concrete rail | Iowa Department of Transportation bench mark. | 583.28 | Elevation supplied by Iowa Department of Transportation |
| T74N R03W 16 NW (2) | RP | About 2 miles north of Wapello, on U.S. Highway 61 bridge over Iowa River, from right downstream end of bridge at 3rd drain on concrete rail | Chiseled square | 584.68 | Surveyed level line from BM |
| T75N R04W 20 SW (1) | BM | About 0.7 miles east of Columbus Junction, on State Highway 92 bridge over Iowa River, on right downstream end of bridge on concrete rail | Iowa Department of Transportation bench mark. | 597.32 | GPS |
| T75N R04W 20 SW (2) | RP | About 0.7 miles east of Columbus Junction, on State Highway 92 bridge over Iowa River, from right downstream end of bridge about 330 ft on concrete rail | Chiseled square. | 598.02 | GPS |
| T75N R04W 19 NW (1) | BM | About 0.7 miles north of Columbus Junction, on State Highway 70 bridge over Iowa River, on right upstream end of bridge on concrete rail | Iowa Department of Transportation bench mark. | 601.75 | GPS |
| T75N R04W 19 NW (2) | RP | About 0.7 miles north of Columbus Junction, on State Highway 70 bridge over Iowa River, from right downstream end of bridge at 5th drain | Chiseled square. | 600.36 | GPS |
| T76N R05W 06 NE (1) | TBM | About 5 miles southeast of Lone Tree, site of streamgage 05455700 Iowa River near Lone Tree, on County Road W66 bridge over Iowa River, on left upstream end of bridge on concrete rail | Chiseled square (RM7) | 620.07 | Streamgage elevation data |
| T76N R05W 06 NE (2) | BM | About 5 miles southeast of Lone Tree, site of streamgage 05455700 Iowa River near Lone Tree, on County Road W66 bridge over Iowa River, on right upstream end of bridge on concrete rail | Iowa Department of Transportation bench mark | 618.72 | Streamgage elevation data |

**Table 9.** Bench marks and reference points used in the May 30 to June 15, 2008, Iowa River and Cedar River flood profiles.—Continued

[Bench marks and reference points are listed in upstream order. BM, bench mark; TBM, temporary bench mark; RP, reference point; GPS, Global Positioning System; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east]

| Public Land Survey System (township, range, section, quarter-section) | Mark classification | Location | Mark | Elevation in feet (NGVD 1929) | Elevation determination method |
|---|---|---|---|---|---|
| | | Iowa River—Continued | | | |
| T77N R06W 02 SE (1) | BM | About 3.5 miles east of Riverside, on State Highway 22 bridge over Iowa River, on right upstream end of bridge on concrete rail | Iowa Department of Transportation bench mark. | 630.53 | GPS |
| T77N R06W 11 NE (1) | RP | About 3.5 miles east of Riverside, on State Highway 22 over Iowa River, from right downstream end of bridge, About 3 ft west of 7th drain on concrete rail | Chiseled square. | 631.08 | GPS |
| T78N R06W 23 NW (1) | TBM | About 0.4 miles east of Hills, on County Road F62 bridge over Iowa River, on right downstream end of bridge on concrete wingwall | Chiseled square. | 635.75 | GPS |
| T78N R06W 23 NW (2) | RP | About 0.4 miles east of Hills, on County Road F62 over Iowa River, from right downstream end of bridge at 4th drain | Chiseled square. | 635.37 | GPS |
| T79N R06W 15 SW (1) | BM | At Iowa City, on U.S. Highway 6 over Iowa River, on left downstream end of bridge on concrete wingwall | Iowa Department of Transportation bench mark. | 648.72 | GPS |
| T79N R06W 15 SW (2) | RP | At Iowa City, on U.S. Highway 6 over Iowa River, from left downstream end of bridge at 20th rail post | Three Chiseled marks. | 651.63 | GPS |
| T79N R06W 09 SE (1) | BM | At Iowa City, at streamgage 05454500 Iowa River at Iowa City, on State Highway 1, About 200 ft downstream of Burlington Street Dam on right bank of Iowa River, about 35 ft upstream of gage house in concrete at sidewalk level | Brass plug (RM9) | 651.21 | Streamgage elevation data |
| T79N R06W 09 SE (2) | RP | At Iowa City, on Burlington Street bridge over Iowa River, from right downstream end of bridge, between 4th and 5th vertical rail posts on concrete lip | Chiseled square | 657.86 | Surveyed from streamgage bench mark |
| T79N R06W 10 SW (1) | BM | At Iowa City, at southeast corner of the intersection of Washington and Madison Streets, near the south end of a step at the west entrance to the Iowa Mechanical Laboratory | State University of Iowa standard disk, stamped 10 | 655.16 | Elevation obtained from the National Geodetic Survey |
| T79N R06W 05 SE (1) | TBM | At Coralville, on 1st Avenue, in parking lot adjacent to pedestrian bridge over Iowa River, on southwest corner of storm intake | Chiseled cross. | 655.16 | GPS |
| T80N R06W 33 SW (1) | RP | About 0.2 miles north of Interstate 80 bridge over Iowa River, on left bank, at Iowa City Water Treatment Plant, on streamward side of intake structure at downstream steel post | Four chisel marks. | 655.17 | GPS |
| T80N R06W 22 SE (1) | BM | About 0.6 miles downstream from Coralville Dam control house, site of streamgage 05453520 Iowa River below Coralville Dam near Coralville, on left bank, on downstream side of gage house near clean out door | Drilled bolt (RM 6) | 655.25 | Streamgage elevation data |

**Table 9.** Bench marks and reference points used in the May 30 to June 15, 2008, Iowa River and Cedar River flood profiles.—Continued

[Bench marks and reference points are listed in upstream order. BM, bench mark; TBM, temporary bench mark; RP, reference point; GPS, Global Positioning System; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east]

| Public Land Survey System (township, range, section, quarter-section) | Mark classification | Location | Mark | Elevation in feet (NGVD 1929) | Elevation determination method |
|---|---|---|---|---|---|
| | | Iowa River—Continued | | | |
| T81N R07W 22 SW (1) | BM | About 4.5 miles northwest of North Liberty, on Interstate 380 bridge over Iowa River, on left downstream end of downstream bridge northbound lanes, on concrete wingwall | Iowa Department of Transportation bench mark | 724.25 | Elevation surveyed from National Geodetic Survey bench mark located on HWY 965 |
| T81N R07W 22 SW (2) | BM | About 4.5 miles northwest of North Liberty, on Interstate 380 bridge over Iowa River, on left upstream end of upstream bridge southbound lanes, on concrete wingwall | Iowa Department of Transportation bench mark | 724.34 | Elevation surveyed from National Geodetic Survey bench mark located on HWY 965 |
| T81N R07W 22 SW (3) | BM | About 4.5 miles northwest of North Liberty, on State Highway 965 bridge over Iowa River, on left upstream end of bridge, on concrete abutment | National Geodetic Survey U.S. Coast & Geodetic Survey bench mark stamped "Z 183 1997." | 719.52 | Elevation obtained from National Geodetic Survey |
| T81N R07W 22 SW (4) | RP | About 4.5 miles northwest of North Liberty, on State Highway 965 bridge over Iowa River, from left end of bridge at 8th drain on downstream side, on concrete lip | Chiseled square | 720.47 | Elevation surveyed from National Geodetic Survey bench mark located on HWY 965 |
| T81N R09W 35 NW (1) | BM | About 1.6 miles south of Amana, on U.S. Highway 151 bridge over Iowa River, on left downstream end of bridge, on concrete abutment | Iowa Department of Transportation bench mark | 729.00 | GPS |
| T81N R09W 35 NW (2) | RP | About 1.6 miles south of Amana, on U.S. Highway 151 bridge over Iowa River, from left downstream end of bridge, About 8 ft to the right of 4th drain, on concrete lip | Chiseled arrow | 735.05 | GPS |
| T81N R10W 36 NW (1) | BM | About 0.6 miles north of South Amana, on State Highway 220 bridge over Iowa River, on right upstream end of bridge, on concrete wingwall | Iowa Department of Transportation bench mark | 735.02 | GPS |
| T81N R10W 36 NW (2) | RP | About 0.6 miles north of South Amana, on State Highway 220 bridge over Iowa River, from right downstream end of bridge, between 13th and 14th drains | Chiseled arrow | 735.26 | GPS |
| T81N R10W 19 SW (1) | BM | About 0.6 miles north of Marengo, site of streamgage 05453100 Iowa River at Marengo, on County Road V66 bridge over Iowa River, on right downstream end of bridge, on concrete abutment | Iowa Department of Transportation bench mark | 746.30 | Streamgage elevation data |
| T81N R12W 12 SW (1) | BM | About 0.9 miles north of Koszta, on County Road V44/F Avenue bridge over Iowa River, on left downstream end of bridge, on concrete abutment | Chiseled square | 763.55 | GPS |

**Table 9.** Bench marks and reference points used in the May 30 to June 15, 2008, Iowa River and Cedar River flood profiles.—Continued

[Bench marks and reference points are listed in upstream order. BM, bench mark; TBM, temporary bench mark; RP, reference point; GPS, Global Positioning System; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east]

| Public Land Survey System (township, range, section, quarter-section) | Mark classification | Location | Mark | Elevation in feet (NGVD 1929) | Elevation determination method |
|---|---|---|---|---|---|
| | | Iowa River—Continued | | | |
| T81N R12W 12 SW (2) | RP | About 0.9 miles north of Koszta, on County Road V44/F Avenue bridge over Iowa River, from left downstream end of bridge, at 43rd vertical rail post | Three chisel marks | 766.80 | GPS |
| T81N R12W 06 NE (1) | BM | About 1.8 miles south of Belle Plaine, on State Highway 21 bridge over Iowa River, on right upstream end of bridge, on concrete bridge rail | Iowa Department of Transportation bench mark. | 779.69 | GPS |
| T81N R12W 05 NW (1) | RP | About 1.8 miles south of Belle Plaine, on State Highway 21 bridge over Iowa River, from right downstream end of bridge, between 7th and 8th drain, on concrete bridge rail | Chiseled square | 780.55 | GPS |
| T82N R13W 19 NE (1) | TBM | About 0.5 miles south of Chelsea, on County Road V18 bridge over Iowa River, on right upstream end of bridge, on curb | Top of bolt | 793.00 | GPS |
| T82N R13W 20 NW (1) | RP | About 0.5 miles south of Chelsea, on County Road V18 bridge over Iowa River, from right downstream end of bridge, between 7th and 8th drains | Three chisel marks | 794.48 | GPS |
| T82N R14W 04 SE (1) | TBM | About 4.7 miles southeast of Tama, on P Avenue bridge over Iowa River, on right downstream end of bridge, on wingwall | Chiseled square | 807.45 | GPS |
| T82N R14W 04 SE (2) | TBM | About 4.7 miles southeast of Tama, on P Avenue bridge over Iowa River, on right upstream end of bridge, on abutment | Chiseled square | 805.26 | GPS |
| T82N R14W 04 SE (3) | RP | About 4.7 miles southeast of Tama, on P Avenue bridge over Iowa River, from right downstream end of bridge, about 10 ft left of 4th drain | Three file marks | 808.44 | GPS |
| T83N R15W 34 SE (1) | BM | About 0.3 miles south of Tama, on U.S. Highway 63 bridge over Iowa River, on left downstream end of bridge, on concrete bridge rail | Iowa Department of Transportation bench mark | 828.44 | GPS |
| T83N R15W 34 SE (2) | RP | About 0.3 miles south of Tama, on U.S. Highway 63 bridge over Iowa River, from left downstream end of bridge near 13th drain, on concrete bridge rail | Chiseled square | 829.69 | GPS |
| T83N R16W 16 NE (1) | BM | About 3 miles east of Le Grand, on U.S. Highway 30 bridge over Iowa River, on right upstream end of upstream bridge westbound lanes, on wingwall | Iowa Department of Transportation bench mark | 850.85 | GPS |
| T83N R16W 16 NE (2) | TBM | About 3 miles east of Le Grand, on U.S. Highway 30 bridge over Iowa River, on right downstream end of upstream bridge westbound lanes, on wingwall | Chiseled cross | 850.86 | GPS |

**Table 9.** Bench marks and reference points used in the May 30 to June 15, 2008, Iowa River and Cedar River flood profiles.—Continued

[Bench marks and reference points are listed in upstream order. BM, bench mark; TBM, temporary bench mark; RP, reference point; GPS, Global Positioning System; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east]

| Public Land Survey System (township, range, section, quarter-section) | Mark classification | Location | Mark | Elevation in feet (NGVD 1929) | Elevation determination method |
|---|---|---|---|---|---|
| | | Iowa River—Continued | | | |
| T83N R16W 16 NE (3) | RP | About 3 miles east of Le Grand, on U.S. Highway 30 bridge over Iowa River, from right downstream end of upstream bridge westbound lanes, near 13th drain, on bridge rail | Chiseled arrow | 850.98 | GPS |
| T84N R17W 29 SE (1) | BM | About 1.9 miles east of Marshalltown, on County Road E35 bridge over Iowa River, on right downstream end of bridge, on wingwall | Iowa Department of Transportation bench mark | 874.25 | GPS |
| T84N R17W 29 SE (2) | RP | About 1.9 miles east of Marshalltown, on County Road E35 bridge over Iowa River, from right downstream end of bridge, between 4th and 5th drains | Chiseled arrow | 874.82 | GPS |
| T84N R18W 23 SE (1) | BM | At Marshalltown, site of streamgage 05451500 Iowa River at Marshalltown, on State Highway 14 bridge over Iowa River, on right downstream end of downstream bridge northbound lanes, on concrete guardrail | USGS bench mark (RM16) | 882.23 | Streamgage elevation data |
| T84N R19W 13 NE (1) | TBM | About 4 miles northwest of Marshalltown, on State Highway 330 bridge over Iowa River, on right upstream end of bridge, on wingwall | Chiseled cross | 900.47 | GPS |
| T84N R18W 18 NW (1) | RP | About 4 miles northwest of Marshalltown, on State Highway 330 bridge over Iowa River, from right downstream end of bridge, About 20 ft to the right of 4th drain, on guardrail | Chiseled arrow | 901.37 | GPS |
| T85N R19W 11 SW (1) | TBM | About 1.4 miles west of Liscomb, on County Road E18 bridge over Iowa River, on right downstream end of bridge, on wingwall | Chiseled square | 920.38 | GPS |
| T85N R19W 11 SW (2) | RP | About 1.4 miles west of Liscomb, on County Road E18 bridge over Iowa River, from right downstream end of bridge, at 13th pillar | Three chiseled marks | 920.89 | GPS |
| T86N R19W 22 SE (1) | BM | About 0.8 miles east of Union, on County Road D65 bridge over Iowa River, on left upstream end of bridge, on wingwall | Iowa Department of Transportation bench mark | 933.18 | GPS |
| T86N R19W 22 SE (2) | RP | About 0.8 miles east of Union, on County Road D65 bridge over Iowa River, from left downstream end of bridge, near 5th drain, on guardrail | Chiseled arrow | 933.15 | GPS |
| T87N R19W 08 SE (1) | BM | At Eldora, on State Highway 175 bridge over Iowa River, on right downstream end of bridge, on wingwall | Iowa Department of Transportation bench mark | 1023.72 | GPS |
| T87N R19W 08 SE (2) | TBM | At Eldora, on State Highway 175 bridge over Iowa River, on left downstream end of bridge, on wingwall | Chiseled cross | 1005.83 | GPS |

**Table 9.** Bench marks and reference points used in the May 30 to June 15, 2008, Iowa River and Cedar River flood profiles.—Continued

[Bench marks and reference points are listed in upstream order. BM, bench mark; TBM, temporary bench mark; RP, reference point; GPS, Global Positioning System; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east]

| Public Land Survey System (township, range, section, quarter-section) | Mark classification | Location | Mark | Elevation in feet (NGVD 1929) | Elevation determination method |
|---|---|---|---|---|---|
| | | Iowa River—Continued | | | |
| T87N R19W 08 SE (3) | RP | At Eldora, on State Highway 175 bridge over Iowa River, from left downstream end of bridge, between 7th and 8th drains, on guardrail | Chiseled arrow | 1014.93 | GPS |
| T88N R19W 28 NW (1) | BM | At Steamboat Rock, on County Road D35 bridge over Iowa River, on left downstream end of bridge, on wingwall | Iowa Department of Transportation bench mark (top of bolt) | 975.81 | GPS |
| T88N R19W 28 NW (2) | RP | At Steamboat Rock, on County Road D35 bridge over Iowa River, from left downstream end of bridge, at 3rd drain, on guardrail | Chiseled arrow | 975.73 | GPS |
| T88N R19W 16 NW (1) | BM | About 2 miles north of Steamboat Rock, on U.S. Highway 20 bridge over Iowa River, on right upstream end of bridge, on wingwall | Iowa Department of Transportation bench mark | 1094.79 | GPS |
| T89N R21W 13 SE (1) | TBM | At Iowa Falls, on U.S. Highway 65 bridge over Iowa River, on left upstream end of bridge, on wingwall | Chiseled square | 1105.88 | GPS |
| T89N R21W 13 SE (2) | RP | At Iowa Falls, on U.S. Highway 65 bridge over Iowa River, from left downstream end of bridge, between 14th and 15th steel posts on guardrail | Three chisel marks | 1102.35 | GPS |
| T89N R21W 13 SE (3) | TBM | At Iowa Falls, on River Street bridge over Iowa River, on right downstream end of bridge, on wingwall | Chiseled cross | 1074.85 | GPS |
| T89N R21W 17 SE (1) | BM | About 1 miles east of Alden, on County Road D20 bridge over Iowa River, on right downstream end of bridge, on wingwall | Iowa Department of Transportation bench mark | 1106.32 | GPS |
| T89N R21W 17 SE (2) | RP | About 1 miles east of Alden, on County Road D20 bridge over Iowa River, from right downstream end of bridge, near 3rd drain, on steel post | Three chiseled marks | 1106.42 | GPS |
| T90N R23W 13 NE (1) | BM | About 2.8 miles south of Dows, on Interstate 35 bridge over Iowa River, on left upstream end of upstream bridge southbound lanes, on concrete guardrail | Iowa Department of Transportation bench mark | 1147.44 | GPS |
| T90N R23W 13 NE (2) | RP | About 2.8 miles south of Dows, on Interstate 35 bridge over Iowa River, from left downstream end of upstream bridge southbound lanes, at 4th drain on concrete lip | Chiseled arrow | 1145.91 | GPS |
| T91N R22W 30 NW (1) | TBM | About 0.7 miles northeast of Dows, on County Road C47 bridge over Iowa River, on left downstream end of bridge, on concrete curb | Chiseled cross | 1150.97 | GPS |
| T91N R22W 30 NW (2) | RP | About 0.7 miles northeast of Dows, on County Road C47 bridge over Iowa River, from left downstream end of bridge, on 9th steel post | Three chisel marks | 1152.99 | GPS |

**Table 9.** Bench marks and reference points used in the May 30 to June 15, 2008, Iowa River and Cedar River flood profiles.—Continued

[Bench marks and reference points are listed in upstream order. BM, bench mark; TBM, temporary bench mark; RP, reference point; GPS, Global Positioning System; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east]

| Public Land Survey System (township, range, section, quarter-section) | Mark classification | Location | Mark | Elevation in feet (NGVD 1929) | Elevation determination method |
|---|---|---|---|---|---|
| | | Iowa River—Continued | | | |
| T92N R23W 29 SE (1) | BM | About 1.6 miles west of Rowan, on State Highway3 bridge over Iowa River, on left upstream end of bridge, on wingwall | Iowa Department of Transportation bench mark | 1167.68 | GPS |
| T92N R23W 32 NE (1) | RP | About 1.6 miles west of Rowan, on State Highway3 bridge over Iowa River, from left downstream end of bridge, at 3rd drain | Chiseled square | 1164.75 | GPS |
| T92N R23W 30 SW (1) | BM | About 0.5 miles north of State Highway 3, on U.S. Highway 69 bridge over Iowa River, on right downstream end of bridge, on abutment guardrail | Iowa Department of Transportation bench mark | 1167.30 | GPS |
| T92N R23W 30 SW (2) | RP | About 0.5 miles north of State Highway 3, on U.S. Highway 69 bridge over Iowa River, from right downstream end of bridge, at second drain on guardrail | Chiseled square | 1167.15 | GPS |
| T92N R24W 25 NE (1) | BM | About 3.8 miles northwest of Rowan, site of streamgage 05449500 Iowa River near Rowan, on County Highway C38 bridge over Iowa River, on left downstream end of bridge, on abutment guardrail | USGS bench mark (RM 9) | 1168.30 | Streamgage elevation data |
| T92N R23W 06 NW (1) | TBM | About 1.3 miles south of Belmond, on U.S. Highway 69 bridge over Iowa River, on left downstream end of bridge, on wingwall | Chiseled square | 1169.63 | GPS |
| T93N R23W 31 SW (1) | RP | About 1.3 miles south of Belmond, on U.S. Highway 69 bridge over Iowa River, from left downstream end of bridge at 3rd drain | Chiseled arrow | 1170.66 | GPS |
| T93N R23W 30 SW (1) | TBM | At Belmond, on U.S. Highway 69 bridge over Iowa River, on right downstream end of bridge, on abutment guardrail | Chiseled cross | 1179.10 | GPS |
| T93N R23W 30 SW (2) | RP | At Belmond, on U.S. Highway 69 bridge over Iowa River, from left downstream end of bridge at 3rd drain, on guardrail | Chiseled arrow | 1179.48 | GPS |
| | | Cedar River | | | |
| T76N R04W 02 SW (1) | BM | About 3.4 miles northeast of Conesville, site of streamgage 05465000 Cedar River near Conesville, on County Road G28 bridge over Cedar River, on right downstream abutment of bridge, on upstream landward rivet in a group of 4 on steel curb | Chiseled cross (RM 9) | 607.00 | Streamgage elevation data |
| T76N R04W 02 SW (2) | RP | About 3.4 miles northeast of Conesville, site of streamgage 05465000 Cedar River near Conesville, on County Road G28 bridge over Cedar River, on downstream lip of bridge, above third drain from right end of bridge | Chiseled square | 610.08 | Streamgage elevation data |
| T77N R03W 21 NW (1) | BM | About 5.5 miles east of Nichols, at State Highway 22 bridge over Cedar River, on right downstream guardrail | Iowa Department of Transportation bench mark | 624.96 | GPS |

**Table 9.** Bench marks and reference points used in the May 30 to June 15, 2008, Iowa River and Cedar River flood profiles.—Continued

[Bench marks and reference points are listed in upstream order. BM, bench mark; TBM, temporary bench mark; RP, reference point; GPS, Global Positioning System; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east]

| Public Land Survey System (township, range, section, quarter-section) | Mark classification | Location | Mark | Elevation in feet (NGVD 1929) | Elevation determination method |
|---|---|---|---|---|---|
| | | Cedar River—Continued | | | |
| T77N R03W 21 NW (2) | RP | About 5.5 miles east of Nichols, at State Highway 22 bridge over Cedar River, near 7th drain from right downstream end of bridge | Chiseled arrow | 626.00 | GPS |
| T78N R03W 36 NW (1) | TBM | About 5.0 miles southeast of Atalissa, at County Road F70/155th Street bridge over Cedar River, on left upstream wingwall guardrail | Chiseled square | 635.74 | Elevation obtained from Muscatine County Engineer's Office |
| T78N R03W 36 NW (2) | RP | About 5.0 miles southeast of Atalissa, at County Road F70/155th Street bridge over Cedar River, at 5th drain from right downstream end of bridge on steel rail | Three chisel marks | 638.00 | Surveyed level line from TBM |
| T78N R02W 08 SW (1) | TBM | About 3.0 miles east of Atalissa, at U.S. Highway 6 bridge over Cedar River, on right upstream bridge rail | Chiseled square | 654.57 | GPS |
| T78N R02W 17 NW (1) | RP | About 3.0 miles east of Atalissa, at U.S. Highway 6 bridge over Cedar River, from right downstream end of bridge, across from 2nd drain on upstream side of bridge | Chiseled square | 654.56 | GPS |
| T79N R03W 13 SE (1) | BM | About 2.3 miles southeast of Rochester, at Interstate 80 bridge over Cedar River, on right downstream guardrail of eastbound lanes | Iowa Department of Transportation bench mark | 665.69 | GPS |
| T79N R03W 13 SE (2) | BM | About 2.3 miles southeast of Rochester, at Interstate 80 bridge over Cedar River, on right upstream guardrail of new bridge, located downstream of existing eastbound lane bridge | Iowa Department of Transportation bench mark | 666.45 | GPS |
| T80N R03W 19 NW (1) | TBM | At Cedar Valley on County Roads F36 and X40/Cedar Valley bridge over Cedar River, on right downstream end of bridge, on streamward corner of old horizontal cement abutment at about curb level | Chiseled cross | 688.09 | GPS |
| T80N R03W 19 NW (2) | RP | At Cedar Valley on County Roads F36 and X40/Cedar Valley bridge over Cedar River, from right downstream end of bridge, near 6th deck drain on guardrail | Two chisel marks | 685.93 | GPS |
| T81N R04W 33 NE (1) | BM | At Cedar Bluff on County Road F28/210th Street bridge over Cedar River, on right upstream bridge rail | Iowa Department of Transportation bench mark | 691.92 | GPS |
| T81N R04W 33 NE (2) | RP | At Cedar Bluff on County Road F28/210th Street bridge over Cedar River, from right downstream end of bridge, near 7th deck drain on rail post | Chiseled arrow | 694.54 | GPS |
| T81N R05W 11 NE (1) | TBM | At Sutliff on County Road F14/Sutliff Road bridge over Cedar River, on left downstream bridge rail | Chiseled square | 696.93 | GPS |
| T81N R05W 11 NE (2) | RP | At Sutliff on County Road F14/Sutliff Road bridge over Cedar River, from left downstream end of bridge, near 7th deck drain | Chiseled square | 698.37 | GPS |

**Table 9.** Bench marks and reference points used in the May 30 to June 15, 2008, Iowa River and Cedar River flood profiles.—Continued

[Bench marks and reference points are listed in upstream order. BM, bench mark; TBM, temporary bench mark; RP, reference point; GPS, Global Positioning System; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east]

| Public Land Survey System (township, range, section, quarter-section) | Mark classification | Location | Mark | Elevation in feet (NGVD 1929) | Elevation determination method |
|---|---|---|---|---|---|
| | | Cedar River—Continued | | | |
| T82N R05W 30 NE (1) | BM | About 3.1 miles south of Mt. Vernon on State Highway 1 bridge over Cedar River, on left downstream wingwall | Iowa Department of Transportation bench mark | 708.22 | GPS |
| T82N R05W 30 NE (2) | RP | About 3.1 miles south of Mt. Vernon on State Highway 1 bridge over Cedar River, from left downstream end of bridge, near 8th deck drain, on bridge rail | Chiseled square | 708.29 | GPS |
| T82N R06W 09 NE (1) | BM | About 3.5 miles east of Cedar Rapids on U.S. Highway 30 bridge over Cedar River, on left downstream wingwall of upstream bridge | Iowa Department of Transportation bench mark | 721.72 | GPS |
| T82N R06W 09 NW (2) | RP | About 3.5 miles east of Cedar Rapids on U.S. Highway 30 bridge over Cedar River, from left downstream end of bridge, near 57th old rail post base on concrete lip | Chiseled square | 721.46 | GPS |
| T83N R07W 28 NE (1) | BM | At Cedar Rapids, site of streamgage 05464500 Cedar River at Cedar Rapids, on right bank of Cedar River About 400 ft north of the 8th Avenue SW bridge over Cedar River and about 5 ft shoreward of the gage house, on top of concrete monument | USGS bronze bench mark (RM2) | 714.17 | Streamgage elevation data |
| T83N R07W 28 NW (1) | BM | At Cedar Rapids, at the intersection of 1st street and 2nd Avenue near the northeast end of a retaining wall for the basement of the Federal Building and about 4.3 ft southeast of the southeast face of the Federal Building | National Geodetic Survey U.S. Coast & Geodetic Survey bench mark disk stamped “C 76 1934” | 726.66 | Elevation obtained from National Geodetic Survey |
| T83N R07W 28 NW (2) | TBM | At Cedar Rapids, on U.S. Highway 151/1st Avenue bridge over Cedar River, on left downstream concrete deck, landward of concrete end post and downstream of bridge rail | Chiseled square | 728.78 | Elevation surveyed from National Geodetic Survey U.S. Coast & Geodetic Survey bench mark |
| T83N R07W 28 NW (3) | RP | At Cedar Rapids, on U.S. Highway 151/1st Avenue bridge over Cedar River, on downstream side on bridge rail near 23rd post from right end of bridge | Three chisel marks | 733.87 | Surveyed level line from TBM |
| T84N R08W 21 SW (1) | BM | About 0.5 miles east of Palo, site of streamgage 05464420 Cedar River at Palo, on County Road E36 bridge over Cedar River, on right downstream wingwall | Linn County bench mark disk No. 812 (BM1) | 753.83 | Elevation obtained from Linn County Engineer’s Office |
| T84N R08W 21 SW (2) | RP | About 0.5 miles east of Palo, site of streamgage 05464420 Cedar River at Palo, on County Road E36 bridge over Cedar River, from right downstream end of bridge, on 11th steel post | Three chiseled marks | 754.01 | Surveyed level line from BM |
| T85N R09W 11 SW (1) | TBM | About 2.4 miles south of Urbana, on County Road W26/32nd Avenue bridge over Cedar River, on right downstream wingwall | Chiseled cross | 777.12 | GPS |

**Table 9.** Bench marks and reference points used in the May 30 to June 15, 2008, Iowa River and Cedar River flood profiles.—Continued

[Bench marks and reference points are listed in upstream order. BM, bench mark; TBM, temporary bench mark; RP, reference point; GPS, Global Positioning System; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east]

| Public Land Survey System (township, range, section, quarter-section) | Mark classification | Location | Mark | Elevation in feet (NGVD 1929) | Elevation determination method |
|---|---|---|---|---|---|
| | | Cedar River—Continued | | | |
| T85N R09W 11 SW (2) | RP | About 2.4 miles south of Urbana, on County Road W26/32nd Avenue bridge over Cedar River, from right downstream end of bridge, on 19th steel post | Three chiseled marks | 778.67 | GPS |
| T85N R10W 16 SW (1) | BM | At Vinton, site of streamgage 05464315 Cedar River at Vinton, on State Highway 150 bridge over Cedar River, on right upstream wingwall | Iowa Department of Transportation bench mark (RM1) | 791.69 | GPS |
| T85N R10W 16 SW (2) | RP | At Vinton, site of streamgage 05464315 Cedar River at Vinton, on State Highway 150 bridge over Cedar River, from right downstream end of bridge, near 12th rail post on concrete lip | Chiseled square | 791.80 | GPS |
| T85N R10W 16 SW (3) | RP | At Vinton, site of streamgage 05464315 Cedar River at Vinton, from right upstream end of bridge, at 3rd deck drain on concrete guardrail | Chiseled square | 795.09 | GPS |
| T86N R10W 06 NW (1) | TBM | About 3 miles northeast of Mt. Auburn, on County Road D65/22nd Avenue bridge over Cedar River, on left downstream abutment corner bridge seat | Chiseled cross | 801.06 | GPS |
| T86N R10W 06 NW (2) | RP | About 3 miles northeast of Mt. Auburn, on County Road D65/22nd Avenue bridge over Cedar River, from left downstream end of bridge, near 62nd steel post | Three chiseled marks | 810.44 | GPS |
| T87N R11W 19 NE (1) | BM | About 1.5 miles northeast of La Porte City, on County Road D48/ Brandon Road bridge over Cedar River, on left downstream curb | National Geodetic Survey U.S. Coast & Geodetic Survey bench mark disk | 816.05 | Elevation obtained from National Geodetic Survey |
| T87N R11W 19 NE (2) | RP | About 1.5 miles northeast of La Porte City, on County Road D48/ Brandon Road bridge over Cedar River, on guardrail and right of 10th guardrail post from left downstream end of bridge | Filed arrow | 818.10 | Surveyed level line from BM |
| T88N R12W 23 SW (1) | BM | At Gilbertville, on County Road D38/East Washburn Road bridge over Cedar River, on left downstream concrete wingwall | USGS brass cap stamped "USGS 8812-23 SW Re-Set" | 843.94 | Elevation obtained from Black Hawk County Engineer's Office |
| T88N R12W 23 SW (2) | RP | At Gilbertville, on County Road D38/East Washburn Road bridge over Cedar River, from left downstream end of bridge, at 21st concrete post | Chiseled square | 841.27 | Surveyed level line from BM |
| T88N R13W 12 NW (1) | BM | At Waterloo, on Interstate 380/U.S. Highway 20 bridge over Cedar River, on right downstream wingwall of downstream bridge main east bound lanes | Iowa Department of Transportation bench mark | 882.09 | Elevation supplied by Iowa Department of Transportation |
| T89N R13W 25 NW (1) | BM | At Waterloo, site of streamgage 05464000 Cedar River at Waterloo, on left bank of Cedar River near East Seventh Street bridge and about 30 ft upstream from gage house, on upstream landward corner of concrete foundation for pumping | USGS bronze bench mark (RM 1) | 846.96 | Streamgage elevation data |

**Table 9.** Bench marks and reference points used in the May 30 to June 15, 2008, Iowa River and Cedar River flood profiles.—Continued

[Bench marks and reference points are listed in upstream order. BM, bench mark; TBM, temporary bench mark; RP, reference point; GPS, Global Positioning System; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east]

| Public Land Survey System (township, range, section, quarter-section) | Mark classification | Location | Mark | Elevation in feet (NGVD 1929) | Elevation determination method |
|---|---|---|---|---|---|
| | | Cedar River—Continued | | | |
| T89N R13W 25 NW (2) | TBM | At Waterloo, on 4th Street bridge over Cedar River, on concrete guardrail at left upstream end of bridge | Chiseled cross | 855.30 | GPS |
| T89N R13W 26 NE (1) | TBM | At Waterloo, on Park Avenue bridge over Cedar River, on curb at left upstream end of bridge, top of most upstream and landward bolt | Chiseled cross | 853.02 | GPS |
| T89N R13W 26 NE (2) | RP | At Waterloo, on Park Avenue bridge over Cedar River, on top of guardrail and right of 5th guardrail post from left downstream end of bridge | Filed arrow | 857.09 | GPS |
| T89N R13W 23 SE (1) | BM | At Waterloo, on 1st Avenue bridge over Cedar River, on right upstream wingwall abutment | Iowa Department of Transportation bench mark | 856.34 | Elevation surveyed from bench mark on Mullen Avenue bridge |
| T89N R13W 23 SE (2) | RP | At Waterloo, on 1st Street bridge over Cedar River, on 15th metal guardrail post from right downstream end of bridge | Chiseled cross | 864.34 | Surveyed level line from BM |
| T89N R13W 23 SE (3) | TBM | At Waterloo, on Mullen Avenue bridge over Cedar River, on right downstream wingwall abutment behind concrete guardrail | Chiseled cross | 856.80 | Elevation surveyed from City of Waterloo bench mark |
| T89N R13W 23 SE (4) | RP | At Waterloo, on Mullen Avenue bridge over Cedar River, on ledge behind concrete guardrail and between 15th and 16th old guardrail bases from right downstream end of bridge | Two chiseled marks | 861.33 | Surveyed level line from TBM |
| T89N R13W 16 SW (1) | BM | At Waterloo, on U.S. Highway 218 bridge over Cedar River, on top of right downstream end of concrete barrier wall | Iowa Department of Transportation bench mark | 868.73 | GPS |
| T89N R13W 16 SW (2) | RP | At Waterloo, on U.S. Highway 218 bridge over Cedar River, on concrete guardrail and above fifth drain from right downstream end of bridge | Two chiseled marks | 869.00 | GPS |
| T89N R13W 18 NW (1) | BM | At Cedar Falls, on State Highway 58 bridge over Cedar River, on left downstream concrete abutment wall | Iowa Department of Transportation bench mark | 879.50 | Elevation supplied by City of Cedar Falls, Land Survey Office |
| T89N R13W 18 NW (2) | BM | At Cedar Falls, on State Highway 58 bridge over Cedar River, on left upstream concrete abutment | Chiseled cross | 873.44 | Elevation supplied by City of Cedar Falls, Land Survey Office |
| T89N R13W 18 NW (3) | RP | At Cedar Falls, on State Highway 58 bridge over Cedar River, on top of concrete guardrail and at center of bridge at 41st drain from right downstream end of bridge | Two chiseled marks | 887.48 | Surveyed level line from BM |
| T89N R14W 12 NE (1) | BM | At Cedar Falls, site of stage only streamgage 05463050 Cedar River at Cedar Falls on State Highway 57 bridge over Cedar River, on right downstream side of bridge, on the concrete base of the gage shelter | Chiseled square (RM1) | 868.09 | Streamgage elevation data |

**Table 9.** Bench marks and reference points used in the May 30 to June 15, 2008, Iowa River and Cedar River flood profiles.—Continued

[Bench marks and reference points are listed in upstream order. BM, bench mark; TBM, temporary bench mark; RP, reference point; GPS, Global Positioning System; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east]

| Public Land Survey System (township, range, section, quarter-section) | Mark classification | Location | Mark | Elevation in feet (NGVD 1929) | Elevation determination method |
|---|---|---|---|---|---|
| | | Cedar River—Continued | | | |
| T89N R14W 12 NE (2) | RP | At Cedar Falls, on State Highway 57 bridge over Cedar River, on concrete guardrail at 10th drain from right downstream end of bridge | Chiseled arrow | 872.95 | Surveyed from streamgage bench mark |
| T89N R14W 12 NW (1) | BM | At Cedar Falls, on Center Street bridge over Cedar River, on right downstream end of sidewalk concrete barrier wall | Iowa Department of Transportation bench mark | 873.69 | Elevation supplied by City of Cedar Falls, Land Survey Office |
| T89N R14W 12 NW (2) | BM | At Cedar Falls, on Center Street bridge over Cedar River, on left downstream end of sidewalk concrete barrier wall | Iowa Department of Transportation bench mark | 874.47 | Elevation supplied by City of Cedar Falls, Land Survey Office |
| T89N R14W 12 NW (3) | RP | At Cedar Falls, on Center Street bridge over Cedar River, on concrete guardrail and below 43rd metal post from left downstream end of bridge | Two chiseled marks | 876.93 | Surveyed level line from BM |
| T91N R14W 35 SW (1) | BM | At Janesville, site of streamgage 05458500 Cedar River at Janesville, on left bank of Cedar River and 300 ft downstream from County Road C50 275th Street, set in concrete just above ground surface and 3 ft northeast of gage house | USGS bench mark (RM 16) | 877.95 | Streamgage elevation data |
| T91N R14W 35 NW (1) | BM | About 0.50 miles north of Janesville, on northbound lane of U.S. Highway 218 bridge over Cedar River upstream bridge, on right downstream end of concrete barrier wall | Iowa Department of Transportation bench mark | 904.70 | Elevation supplied by Iowa Department of Transportation |
| T91N R14W 35 NW (2) | BM | About 0.50 miles north of Janesville, on southbound lane of U.S. Highway 218 bridge over Cedar River downstream bridge, on left upstream end of concrete barrier wall | Iowa Department of Transportation bench mark | 911.14 | Elevation supplied by Iowa Department of Transportation |
| T91N R14W 35 NW (3) | RP | About 0.50 miles north of Janesville, on southbound lane of U.S. Highway 218 bridge over Cedar River downstream bridge, on top of concrete guardrail and about 85 ft from right downstream end of bridge | Two chiseled marks | 907.31 | Surveyed level line from BM |
| T91N R14W 02 NW (1) | TBM | At Waverly, on State Highway 3 bridge over Cedar River, on right downstream handrail and north of lamp post | Chiseled square | 920.27 | GPS |
| T91N R14W 02 NW (2) | TBM | At Waverly, on State Highway 3 bridge over Cedar River, about 30 ft upstream from right upstream end of bridge, on top of streamward corner of concrete retaining wall | Chiseled square | 914.69 | GPS |
| T91N R14W 02 NW (3) | RP | At Waverly, on State Highway 3 bridge over Cedar River, from left downstream end of bridge, on handrail to the left of 15th post | Filed arrow | 921.19 | Surveyed level line from TBM |
| T92N R14W 35 NW (1) | BM | At Waverly, site of streamgage 05458300 Cedar River at Waverly, on County Road V14 bridge over Cedar River, on right downstream concrete guardrail base | Top of 3/8 in anchor bolt (RM 1) | 921.21 | Streamgage elevation data |

**Table 9.** Bench marks and reference points used in the May 30 to June 15, 2008, Iowa River and Cedar River flood profiles.—Continued

[Bench marks and reference points are listed in upstream order. BM, bench mark; TBM, temporary bench mark; RP, reference point; GPS, Global Positioning System; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east]

| Public Land Survey System (township, range, section, quarter-section) | Mark classification | Location | Mark | Elevation in feet (NGVD 1929) | Elevation determination method |
|---|---|---|---|---|---|
| | | Cedar River—Continued | | | |
| T92N R14W 21 NW (1) | BM | About 3.5 miles north of Waverly, on County Road C33 bridge over Cedar River, on right downstream curb near wingwall | Chiseled square enclosing Iowa Department of Transportation bench mark | 931.77 | Elevation obtained from Bremer County Flood Insurance Study Federal Emergency Management Agency, 1990 |
| T92N R14W 21 NW (2) | RP | About 3.5 miles north of Waverly, on County Road C33 bridge over Cedar River, on top of guardrail post at second drain from right downstream end of bridge | Three filed marks | 934.50 | Surveyed level line from BM |
| T93N R14W 29 NE (1) | BM | About 0.5 miles east of Plainfield, on State Highway 188 bridge over Cedar River, on left upstream wingwall | Iowa Department of Transportation bench mark | 946.59 | Elevation supplied by Iowa Department of Transportation |
| T93N R14W 29 NE (2) | BM | About 0.5 miles east of Plainfield, on State Highway 188 bridge over Cedar River, on right upstream wingwall | Iowa Department of Transportation bench mark | 947.22 | Elevation supplied by Iowa Department of Transportation |
| T93N R14W 29 NE (3) | RP | About 0.5 miles east of Plainfield, on State Highway 188 bridge over Cedar River, on concrete curb at third drain from right downstream end of bridge | Two Chiseled marks | 945.63 | Surveyed level line from BM |
| T94N R14W 18 SE (1) | BM | At Nashua, on State Highway 346 bridge over Cedar River, on right upstream wingwall | Iowa Department of Transportation bench mark | 973.28 | Elevation supplied by Iowa Department of Transportation |
| T94N R14W 18 SE (2) | RP | At Nashua, on State Highway 346 bridge over Cedar River, on top of concrete guardrail at third drain from right upstream end of bridge | Two chiseled marks | 975.48 | Surveyed level line fron BM |
| T95N R16W 12 NE (1) | BM | At Charles City, site of streamgage 05457700 Cedar River at Charles City, on right bank of Cedar River and 800 ft downstream from U.S. Highway 18 bridge, 25 ft landward of gage house, and on landward downstream corner of concrete pedestal to walkway | USGS bronze bench mark (RM5) | 993.28 | Streamgage elevation data |
| T95N R16W 12 NE (2) | TBM | At Charles City, near Main Street bridge over Cedar River, on top of bolt head on streamward and upstream side of fire hydrant located on southeast corner of Main and Court Streets | Chiseled cross | 1003.52 | GPS |
| T95N R16W 12 NE (3) | RP | At Charles City, on Main Street bridge over Cedar River, on concrete sidewalk and below seventh handrail post from right downstream end of bridge | Two chiseled marks | 1002.32 | GPS |

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ISBN 978-1-4113-2962-1