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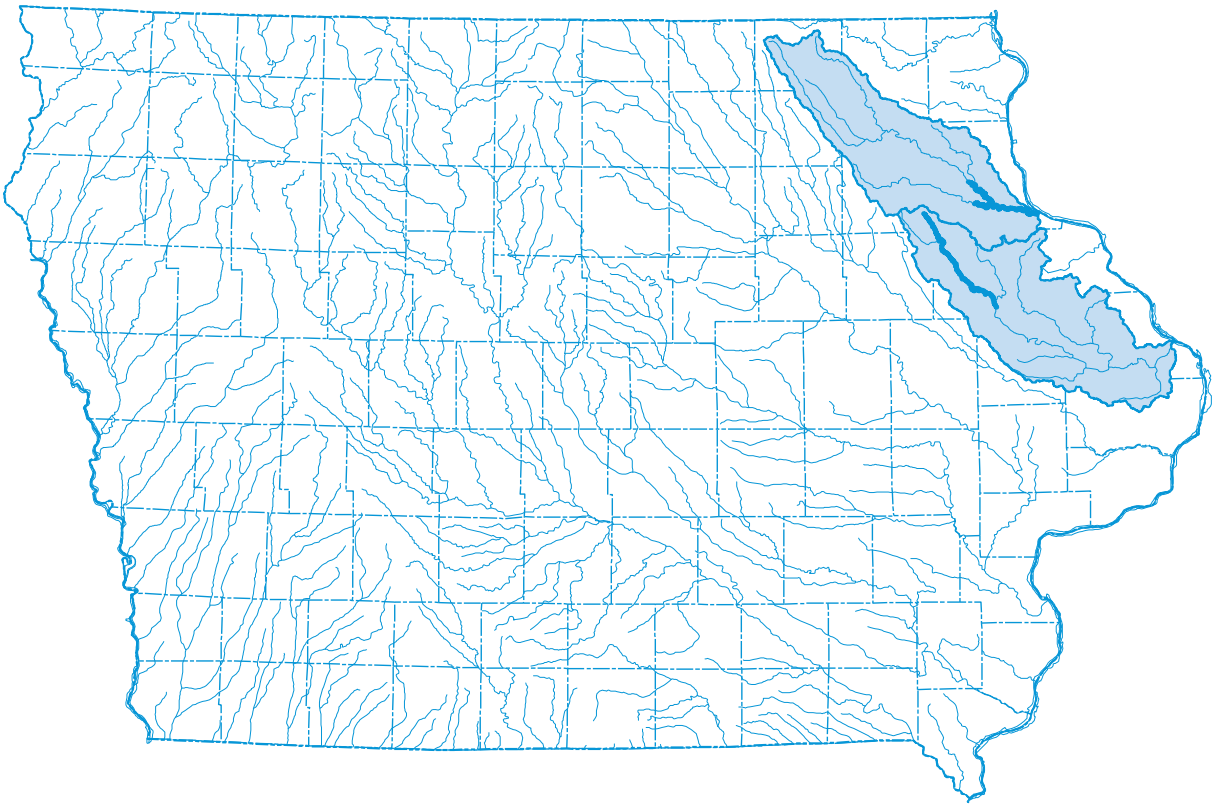
Flood of May 23, 2004, in the Turkey and Maquoketa River Basins, Northeast Iowa



Open-File Report 2006–1067

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

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By David A. Eash

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DIRK KEMPTHORNE, Secretary

U.S. Geological Survey
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Front cover: Map of Iowa showing location of Turkey and Maquoketa River Basins (shaded area) and river reaches profiled in the report (shown with thicker lines).

Contents

Abstract 1
Introduction 1
Basin Descriptions 4
Flood History 6
Flood of May 23, 2004 7
    Storm Description 7
    Flood Description 13
Flood Profile 17
Summary 18
    Acknowledgments 19
Literature Cited 19
Appendix. Temporary Bench Marks and Reference Points 32
    Turkey River 32
    Volga River 33
    Maquoketa River 33

Figures

1–2. Maps showing:
    1. Turkey River Basin and lines of equal rainfall for 72 hours ending at 7:00 a.m., May 23, 2004 2
    2. Maquoketa River Basin and lines of equal rainfall for 72 hours ending at 7:00 a.m., May 23, 2004. 3
3. Graph showing hourly rainfall for May 21–23, 2004, at rain gages in the Turkey and Maquoketa River Basins and vicinity 11
4. Discharge hydrographs at four continuous-record, streamflow-gaging stations in the Turkey River Basin, May 21–27, 2004 14
5. Discharge hydrographs at three continuous-record, streamflow-gaging stations in the Maquoketa River Basin, May 21–27, 2004 15
6–9: Graphs showing profile of the May 2004 flood for the Turkey River, Iowa:
    6 River miles 1.7 to 39.1. 21
    7. River miles 1.7 to 15. 22
    8. River miles 15 to 30. 23
    9. River miles 30 to 39.1. 24
10. Graph showing profile of the May 2004 flood for the Volga River, Iowa; river miles 0.4 to 9.3. 25
11–15: Graphs showing profile of the May 2004 flood for the Maquoketa River, Iowa:
    11. River miles 92.2 to 143.7 26
    12. River miles 92.2 to 105. 27
    13. River miles 105 to 120. 28
    14. River miles 120 to 135. 29
    15. River miles 135 to 143.7. 30

Tables

1. National Flood Insurance Program Bureau and Statistical Agent Iowa loss report for selected counties, May 21–31, 2004, as of July 31, 2005 5
2. Approved Iowa Public Assistance Program project costs for selected counties for disaster number 1518, May–June 2004, as of September 16, 2005 6
3. Maximum stages and discharges for 2004 and selected largest-flood years, and the corresponding recurrence intervals, at streamflow-gaging stations in the Turkey and Maquoketa River Basins, Iowa 8
4. Twenty-four-hour rainfall amounts at selected rain gages in northeast and east-central Iowa during May 21–23, 2004 12
5. Magnitude and frequency of theoretical rainfall amounts for selected storm periods in the Northeast Iowa Climatological Division 12
6. Elevation of high-water marks used in the May 2004 flood profile for the Turkey River, Iowa 17
7. Elevation of high-water marks used in the May 2004 flood profile for the Volga River, Iowa 17
8. Elevation of high-water marks used in the May 2004 flood profile for the Maquoketa River, Iowa 18

Conversion Factors, Vertical Datum, and Abbreviated Units of Measurement

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 29). Elevation refers to distance above or below NGVD 29. NGVD 29 can be converted to the North American Vertical Datum of 1988 (NAVD 88) by using the National Geodetic Survey conversion utility available at *http://www.ngs.noaa.gov/TOOLS/Vertcon/vertcon.html*.

Water year is the 12-month period from October 1 through September 30. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. Thus, the year ending September 30, 2004, is called the "2004 water year."

Flood of May 23, 2004, in the Turkey and Maquoketa River Basins, Northeast Iowa

By David A. Eash

Abstract

Severe flooding occurred on May 23, 2004, in the Turkey River Basin in Clayton County and in the Maquoketa River Basin in Delaware County following intense thunderstorms over northeast Iowa. Rain gages at Postville and Waucoma, Iowa, recorded 72-hour rainfall of 6.32 and 6.55 inches, respectively, on May 23. Unofficial rainfall totals of 8 to 10 inches were reported in the Turkey River Basin. The peak discharge on May 23 at the Turkey River at Garber streamflow-gaging station was 66,700 cubic feet per second (recurrence interval greater than 500 years) and is the largest flood on record in the Turkey River Basin. The timing of flood crests on the Turkey and Volga Rivers, and local tributaries, coincided to produce a record flood on the lower part of the Turkey River. Three large floods have occurred at the Turkey River at Garber gaging station in a 13-year period. Peak discharges of the floods of June 1991 and May 1999 were 49,900 cubic feet per second (recurrence interval about 150 years) and 53,900 cubic feet per second (recurrence interval about 220 years), respectively. The peak discharge on May 23 at the Maquoketa River at Manchester gaging station was 26,000 cubic feet per second (recurrence interval about 100 years) and is the largest known flood in the upper part of the Maquoketa River Basin.

Introduction

Thunderstorms caused severe flooding along the lower Turkey (fig. 1) and upper Maquoketa (fig. 2) Rivers in northeast Iowa in May 2004. New maximum peak discharge records were set during May 22–23, 2004, at 10 U.S. Geological Survey (USGS) streamflow-gaging stations (gaging stations) that included the mainstems of the Turkey River in Clayton County, the Maquoketa River in Delaware County, and Bloody Run Creek in Clayton County, and included tributary streams in the Turkey River Basin in Clayton County, the Winnebago River Basin in Cerro Gordo County, the Cedar River Basin in Black Hawk County, the Boone River Basin in Hancock County, the Mosquito Creek Basin in Pottawattamie County, and the Nishnabotna River Basin in Shelby County (the Nishnabotna River and Mosquito Creek are not shown in figs. 1–2). Significantly high peak stages and discharges were measured during May 22–30, 2004, at gaging stations along the Wapsipinicon River at Independence, Anamosa, and near De Witt; on the Winnebago River at Mason City; on the Shell Rock River at Shell Rock; and along the Cedar River at Cedar Falls, Waterloo, Cedar Rapids, and near Conesville.

The severe storms of May 21–23, 2004, caused flash flooding across north-central and northeast Iowa. Flash flooding of local streams in Cedar Rapids, Fredericksburg in Chickasaw County, Independence, Mason City, and Des Moines flooded homes and businesses, and forced the evacuation of residents. Due to flooding and road closures in Chickasaw County, the Chickasaw County Sheriff's Office and Emergency Management asked motorists to avoid travel through the county (Palmer and Heinselman, *Waterloo Cedar-Falls Courier*, May 23, 2004). On May 26, state officials reported that more than 1,400 homes had been damaged or destroyed since May 21 and that most of the damage had been caused by flooding; and the National Weather Service announced that at least 37 tornadoes had been reported in the State since May 21 (Dorman and Haugen, *Waterloo Cedar-Falls Courier*, May 26, 2004). A woman was killed and the driver was injured when their vehicle struck a washed-out section of a road near Hazleton, in Buchanan County, during the early morning hours of May 23 (Gravelle, *Cedar Rapids Gazette*, May 24, 2004).

A State disaster declaration was issued on May 23, 2004, for 16 counties. On May 25, a Federal disaster declaration was issued to help Iowans recover from losses

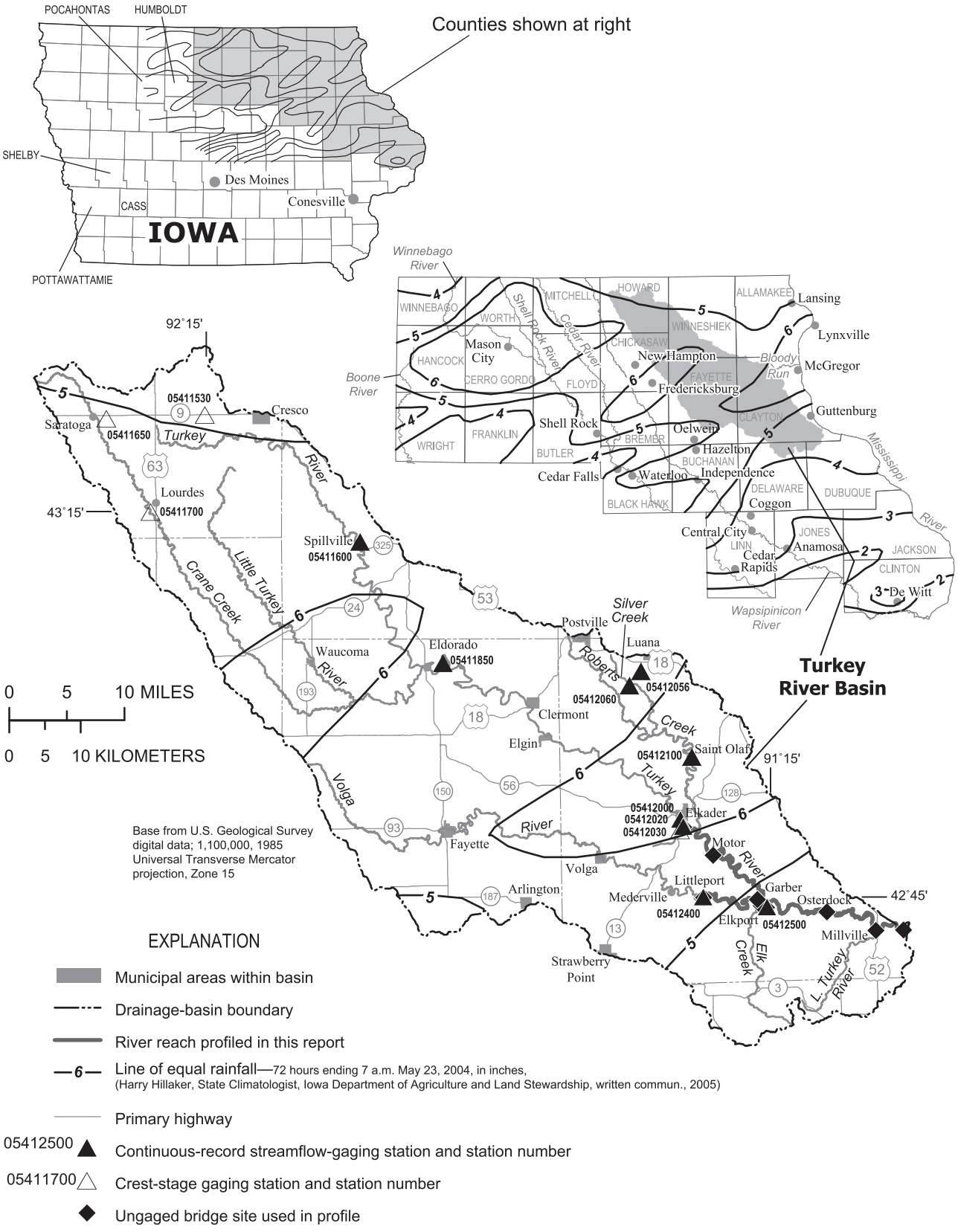

Figure 1. Turkey River Basin and lines of equal rainfall for 72 hours ending at 7:00 a.m., May 23, 2004.

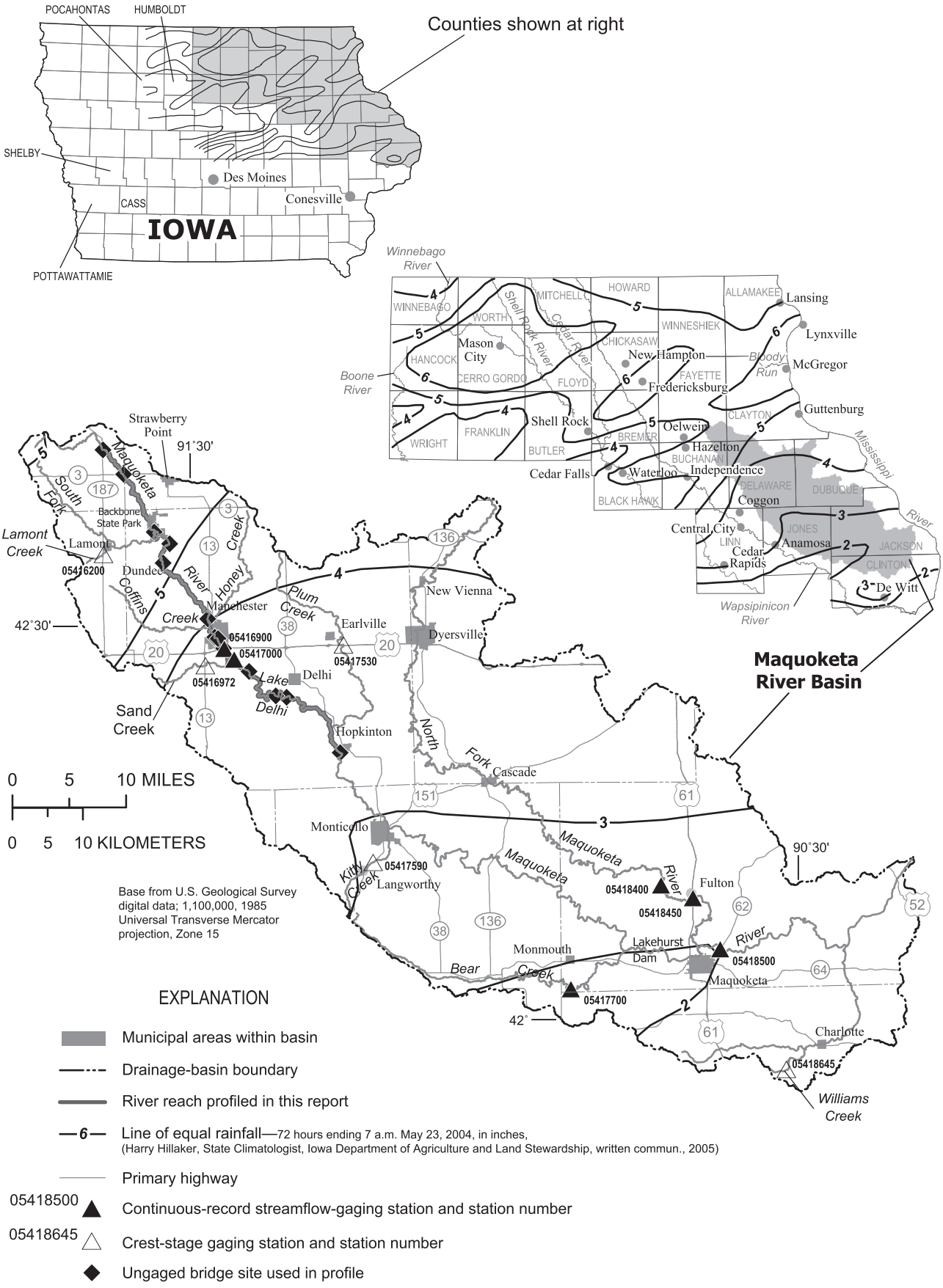

Figure 2. Maquoketa River Basin and lines of equal rainfall for 72 hours ending at 7:00 a.m., May 23, 2004.

caused by the severe storms, tornadoes, and flooding. The Federal disaster declaration (number 1518), which began with 14 counties, and increased to 75 counties, provided aid for losses incurred in Iowa between May 19 and June 24, 2004. The initial 14 counties declared disaster areas were: Bremer, Buchanan, Butler, Cass, Cerro Gordo, Clayton, Delaware, Fayette, Hancock, Humboldt, Jones, Linn, Mitchell, and Pocahontas. On July 27, 2004, Federal Emergency Management Agency (FEMA) officials reported 4,813 individuals had registered for aid, more than $11 million of aid had been approved for individuals, families, and businesses in Iowa, and an additional nearly $2 million had been obligated for improvements to infrastructure (Federal Emergency Management Agency, 2004).

Private property damage claims reported for residential and non-residential buildings in 10 selected counties in northeast Iowa are shown in table 1 (Bonnie Shepard, FEMA, National Flood Insurance Program Bureau and Statistical Agent, written commun., September 2005). Approved public assistance project costs (assistance to local governments for the repair of disaster-damaged public facilities) for the same 10 selected counties in northeast Iowa are shown in table 2 (Dennis Harper, Iowa Homeland Security and Emergency Management Division, State Hazard Mitigation Officer, written commun., September 2005).

This report provides information about the May 2004 thunderstorms and ensuing flood in the Turkey and Maquoketa River Basins. Flood elevations at selected sites along the Turkey, Volga, and Maquoketa Rivers in Clayton and Delaware Counties are presented as flood profiles.

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 problems needing this information. Data for major floods are needed to compute flood-peak discharges and calibrate water-surface-elevation profile models for sites along streams. This report was prepared in cooperation with the Iowa Department of Transportation and the Iowa Highway Research Board. A list of other Iowa flood-profile reports published by the USGS can be obtained from the World Wide Web at *http://ia.water.usgs.gov/projects/profiles/*.

Basin Descriptions

The Turkey and Maquoketa River Basins are adjoining watersheds draining from the northwest to the southeast across northeast Iowa. The two drainage basins, the river reaches profiled, the location USGS gaging stations within these river basins, and the location of bridge sites used in the May 23, 2004, flood profiles are shown in figures 1–2.

The Turkey River Basin originates in Howard County and flows about 148 mi through the cities of Spillville, Clermont, Elgin, and Elkader to its mouth at the Mississippi River in southeastern Clayton County (fig. 1). The Turkey River Basin includes parts of eight counties and drains 1,684 mi^2 (Larimer, 1957). The Little Turkey and Volga Rivers are principal tributaries to the Turkey River. The Little Turkey River, with a drainage area of 355 mi^2 (Larimer, 1957), originates in Howard County and flows about 53 mi through the city of Waucoma to its mouth in Fayette County. The Volga River, with a drainage area of 403 mi^2 (Larimer, 1957), originates in Fayette County and flows about 81 mi through the cities of Fayette and Volga to its mouth in Clayton County.

Most of the Turkey River Basin lies within two landform regions of the State. The northwest or upper part of the basin drains the low-relief plain of the Iowan Surface landform region (Prior, 1991; Horick and Soenksen, 1989; Iowa Natural Resources Council, 1958) (landform regions are not shown in fig. 1). Although streams draining the Iowan Surface are well established, stream gradients are low. In Fayette County, the Turkey River crosses from the Iowan Surface landform region to the Paleozoic Plateau landform region, which drains the southeast or lower part of the basin. The bedrock-dominated, erosional topography of the Paleozoic Plateau is characterized by plateau-like uplands, integrated drainage networks with steep gradients, and deeply entrenched valleys (Prior, 1991; Horick and Soenksen, 1989; Iowa Natural Resources Council, 1958). In parts of the basin, the Turkey River and its tributaries have cut deeply into the bedrock formations. Such entrenched river valleys usually display strong bedrock control in their courses (Prior, 1991). Land use in the basin is predominately agricultural with some livestock and timber operations. Five low-head dams have been constructed across the Turkey River; two low-head dams have been constructed across the Little Turkey River and one has been constructed across the Volga River (Iowa Conservation Commission, 1979). The City of Elkader dam is the largest dam on the Turkey River at a height of 21 ft.

Table 1. National Flood Insurance Program Bureau and Statistical Agent Iowa loss report for selected counties, May 21–31, 2004, as of July 31, 2005.

[Source: Bonnie Shepard, Federal Emergency Management Agency, National Flood Insurance Program Bureau and Statistical Agent, written commun., September 2005. ND, no data]

County	Occupancy	Buildings with damage	Building damage (dollars)	Contents damage (dollars)
Buchanan	Single-family residential	34	289,345	41,090
Buchanan	Multiple occupancy	ND	ND	ND
Buchanan	Non-residential	4	36,566	0
Chickasaw	Single-family residential	1	1,551	0
Chickasaw	Multiple occupancy	ND	ND	ND
Chickasaw	Non-residential	ND	ND	ND
Clayton	Single-family residential	15	322,765	13,185
Clayton	Multiple occupancy[1]	1	7,950	0
Clayton	Non-residential	3	24,594	0
Delaware	Single-family residential	1	7,484	0
Delaware	Multiple occupancy	ND	ND	ND
Delaware	Non-residential	3	343,357	328,421
Dubuque	Single-family residential	ND	ND	ND
Dubuque	Multiple occupancy	ND	ND	ND
Dubuque	Non-residential	ND	ND	ND
Fayette	Single-family residential	ND	ND	ND
Fayette	Multiple occupancy	ND	ND	ND
Fayette	Non-residential	ND	ND	ND
Howard	Single-family residential	ND	ND	ND
Howard	Multiple occupancy	ND	ND	ND
Howard	Non-residential	ND	ND	ND
Jackson	Single-family residential	ND	ND	ND
Jackson	Multiple occupancy	ND	ND	ND
Jackson	Non-residential	ND	ND	ND
Jones	Single-family residential	2	25,622	0
Jones	Multiple occupancy	ND	ND	ND
Jones	Non-residential	ND	ND	ND
Winneshiek	Single-family residential	ND	ND	ND
Winneshiek	Multiple occupancy	ND	ND	ND
Winneshiek	Non-residential	ND	ND	ND
Total		64	1,059,234	382,696

[1]Two to four family residential.

Table 2. Approved Iowa Public Assistance Program project costs for selected counties for disaster number 1518, May–June 2004, as of September 16, 2005.

[Source: Dennis Harper, Iowa Homeland Security and Emergency Management Division, State Hazard Mitigation Officer, written commun., September 2005. 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[1] (dollars)	Utilities (dollars)	Parks and other (dollars)	Total[2] (dollars)
Buchanan	8	74,016	35,517	1,021,495	ND	ND	ND	145,698	1,276,726
Chickasaw	3	2,075	14,011	342,965	ND	500	10,059	10,110	379,720
Clayton	19	114,496	150,208	760,344	4,800	21,866	63,928	124,957	1,240,599
Delaware	6	12,084	30,325	295,185	ND	ND	6,473	53,678	397,745
Dubuque	5	31,413	54,133	242,805	ND	ND	ND	22,361	350,713
Fayette	7	27,028	20,994	560,036	ND	ND	36,741	11,242	656,041
Howard	4	3,000	4,394	204,844	40,690	ND	ND	24,059	276,987
Jackson	0	ND	ND	ND	ND	ND	ND	ND	ND
Jones	7	3,900	48,959	94,485	ND	ND	56,782	13,993	218,119
Winneshiek	4	1,570	3,146	116,987	ND	ND	ND	4,668	126,371
Total	63	269,582	361,687	3,639,146	45,490	22,366	173,983	410,766	4,923,021

[1]Includes some insurance deductibles, and is not the estimated total cost for repair.

[2]Does not include demolition projects because costs have not been estimated as of September 16, 2005.

The Maquoketa River Basin originates in Fayette County and flows about 150 mi through the cities of Manchester, Monticello, and Maquoketa to its mouth at the Mississippi River in eastern Jackson County (fig. 2). The Maquoketa River Basin includes parts of nine counties and drains 1,879 mi^2 (Larimer, 1957). The North Fork Maquoketa River, a major tributary to the Maquoketa River with a drainage area of 592 mi^2 (Larimer, 1957), originates in Dubuque County and flows about 97 mi through the cities of New Vienna, Dyersville, and Cascade to its mouth in Jackson County.

Similar to the Turkey River Basin, most of the Maquoketa River Basin lies within two landform regions of the State. The northwest or upper part of the basin drains the Iowan Surface landform region. In Delaware County, the Maquoketa River crosses from the gently rolling terrain of the Iowan Surface to the steep-to-gently rolling terrain of the Southern Iowa Drift Plain landform region, which drains the southeastern or lower part of the basin (Prior, 1991). In northwest Delaware County, the Maquoketa River valley changes for a few miles from a gently sloped valley to a rugged gorge in Backbone State Park. Farther downstream in central Delaware County, a few miles southeast of Manchester, the Maquoketa River enters a canyon-like valley that persists throughout much of the remaining length of the river (Iowa Natural Resources Council, 1958). Land use in the basin is predominately agricultural and includes some wooded areas. Eight low-head dams have been constructed across the Maquoketa River (Iowa Conservation Commission, 1979); no dams have been constructed across the North Fork Maquoketa River. Six of the dams on the Maquoketa River were originally built for hydroelectric power (Iowa Natural Resources Council, 1958); only the Lakehurst dam upstream from the city of Maquoketa in Jackson County (fig. 2) is currently operating as a hydroelectric dam. The Lake Delhi dam is the largest dam on the Maquoketa River at a height of 38 ft (Iowa Conservation Commission, 1979). Lake Delhi (Federally recognized as Hartwick Lake) is approximately 8 mi in length and 450 acres in area. The local name “Lake Delhi” was adopted by area residents in recognition of the nearby town of Delhi in Delaware County (fig. 2).

Flood History

Continuous records of streamflow have been collected in the Turkey River Basin since October 1932, and intermittent records since August 1913, at the USGS

gaging station Turkey River at Garber (station number 05412500). Continuous records of streamflow have been collected in the Maquoketa River Basin since September 1913, at the USGS gaging station Maquoketa River near Maquoketa (station number 05418500). Peak stages, discharges, and recurrence intervals for the largest known floods, including the May 2004 flood, are listed in table 3 for gaging stations in the Turkey and Maquoketa River Basins. The gaging stations listed in table 3 also are listed in the USGS National Water Information System (NWIS) database, and users may obtain surface-water data for Iowa gaging stations, including information on types of data available and years of data collection, at *http://waterdata.usgs.gov/ia/nwis/sw*. Descriptions of historic floods in the Turkey and Maquoketa River Basins are limited; available information is summarized for floods that occurred in the Turkey River Basin in 1922, 1947, 1972, 1979, 1991, and 1999 in the reports *Turkey/Volga River flood of March 19, 1979* (Iowa Natural Resources Council, 1980), *Floods of July 12, 1972, March 19, 1979, and June 15, 1991, in the Turkey River Basin, Northeast Iowa* (Eash and Koppensteiner, 1996), and *Floods of May 17–20, 1999, in the Volga and Wapsipinicon River Basins, Northeast Iowa* (Ballew and Fischer, 2000); and for floods that occurred in the Maquoketa River Basin in 1925, 1944, 1947, and 2002 in the report *Flood of June 4–5, 2002, in the Maquoketa River Basin, East-Central Iowa* (Eash, 2005).

Flood of May 23, 2004

Table 3 indicates that the flood of May 23, 2004, in the Turkey River Basin is the largest flood on record for the period 1902, 1914–16, 1919–27, 1930, and 1933–2004, and is probably the largest flood since at least 1890. Table 3 also indicates that the flood of May 23, 2004, in the upper Maquoketa River Basin is probably the largest flood for the period 1925, 1928–30, 1933–73, 1976–83, and 2001–2004. A comparison of peak discharges for floods measured at two gaging stations located on the Maquoketa River near Manchester (station numbers 05416900 and 05417000; table 3) indicates that the 2004, 1925, and 1947 floods were the first, second, and third largest floods, respectively, along a 3-mi reach of the Maquoketa River downstream of Manchester. However, photographs taken during the 1925, 1947, and 2004 floods at the same location on West Main Street in Manchester appear to indicate that the 1925, 1947, and 2004 floods were the first, second, and third highest floods, respectively, in the downtown area of Manchester (photographs provided by Larry Schmidt, Street Superintendent, City of Manchester, written commun., October 2005). Schmidt also reported that significant floods occurred in Manchester in 1960, 1969, 1993, and 1999.

Storm Description

The flood was the result of a series of thunderstorms that crossed north-central and northeast Iowa on May 21–23. The following rainfall information was provided by Harry Hillaker, State Climatologist, Iowa Department of Agriculture and Land Stewardship (written commun., September 2005):

> The bulk of the precipitation occurred from late evening of the 21st to about sunrise on the 22nd and again from late evening of the 22nd to the early a.m. of the 23rd. The highest official rainfall total in the State of 7.22 in. was recorded at Mason City in north-central Iowa, while the highest amount in northeast Iowa of 6.38 in. was recorded at the Elkader 1 SE rain gage in Clayton County. However, the rain gage at the Mississippi River Lock and Dam 9 near Lynxville, Wisconsin (located on the border of Allamakee County, Iowa), reported 8.34 in. This amount was confirmed by a second rain gage located at the same site. Frequent, and sometimes heavy, rainfall saturated soils in the two-week period preceding the heavy rains of May 21–23. At the Lansing weather station in Allamakee County, May 2004 was the wettest month (14.87 in.) in 98 years of record (old record was 13.57 in. in July 1999).

The following rainfall information was summarized from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Climatic Data Center (2004a) and the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Weather Service (2004a; 2004b).

> Strong to severe storms developed north of a stationary front across Iowa and northern Illinois during the afternoon and evening hours of May 21. A strong low level jet continuously pumped copious amounts of moisture over the front that resulted in heavy rains of 3 to 6 in., causing widespread flash flooding across northeast Iowa. There were reports from north-central to northeast Iowa of 2 to 4 in. of rainfall in a little more than an hour's time. Some of the storms produced large hail, damaging winds, and tornadoes. A low level jet developed two squall lines in western Iowa during the evening

Table 3. Maximum stages and discharges for 2004 and selected largest-flood years, and the corresponding recurrence intervals, at streamflow-gaging stations in the Turkey and Maquoketa River Basins, Iowa.

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

Site	Period of peak-flow record (water years)	Drainage area (mi^2)	Date	Peak stage[1] (feet)	Peak discharge (ft^3/s)	Recurrence interval[2] (years)
Turkey River Basin						
Crest-stage gaging station 05411530 North Branch Turkey River near Cresco	1966–93	19.5	6/29/1969 8/25/1990 8/15/1993	92.72 93.88 94.61	2,400 3,500 4,500	13 20 35
Continuous-record gaging station 05411600 Turkey River at Spillville	1947, 1956–73, 1978–91	177	6/--/1947 7/12/1972 8/25/1990	[3]18.4 16.73 16.76	[4]10,000 8,600 8,320	25 15 14
Crest-stage gaging station 05411650 Crane Creek tributary near Saratoga	1953–75	4.06	8/31/1962	6.56	1,830	15
Crest-stage gaging station 05411700 Crane Creek near Lourdes	1953–90	75.8	8/31/1962 6/29/1969 6/04/1974	15.70 14.10 13.71	11,900 8,840 7,700	50 20 14
Continuous-record gaging station 05411850 Turkey River near Eldorado	2001–2004	641	6/15/1991 5/23/2004	[3]18.78 19.61	[4]17,600 19,700	[5]11 [5]16
Continuous-record gaging station 05412000 Turkey River at Elkader	1916, 1929, 1933–42	891	6/01/1916 3/16/1929 4/01/1933	[3]34.30 -- --	[4]30,000 [6,7]25,200 [6,7]23,800	45 19 15
Continuous-record gaging station 05412020 Turkey River above French Hollow Creek at Elkader	1991, 2002–2004	903	6/15/1991 5/23/2004	[3]27.32 25.57	38,300 33,300	[5]150 [5]70
Crest-stage gaging station 05412030 French Hollow Creek near Elkader	1990–2004	3.56	5/17/1999 5/23/2004	[4]19.9 [3]20.23	[4]3,100 [4]3,300	19 20
Continuous-record gaging station 05412056 Unnamed Creek near Luana	1987–1992	1.15	6/15/1991	16.82	[8]880	[5]10
Continuous-record gaging station 05412060 Silver Creek near Luana	1988–98	4.39	6/15/1991	14.97	[8]3,300	120
Continuous-record gaging station 05412100 Roberts Creek above Saint Olaf	1987–2001	70.7	6/15/1991	27.88	[8]19,600	200
Continuous-record gaging station 05412400 Volga River at Littleport	2000–2004	348	3/19/1979 6/15/1991 5/17/1999 5/23/2004	[3]18.04 [3]18.51 [3]25.36 21.98	[4]12,600 [4]13,500 [9]30,000 21,000	[5]9 [5]10 [5]320 [5]50
Continuous-record gaging station 05412500 Turkey River at Garber	1902, 1914–16, 1919–27, 1930, 1933–2004	1,545	2/23/1922 3/19/1979 6/15/1991 5/17/1999 5/23/2004	[3,10]28.06 25.59 [3]30.10 30.91 [3]32.80	32,300 26,000 [8]49,900 53,900 66,700	20 9 150 220 >500

Table 3. Maximum stages and discharges for 2004 and selected largest-flood years, and the corresponding recurrence intervals, at streamflow-gaging stations in the Turkey and Maquoketa River Basins, Iowa—Continued.

[mi², square miles; ft³/s, cubic feet per second; <, less than; --, not determined; >, greater than]

Site	Period of peak-flow record (water years)	Drainage area (mi²)	Date	Peak stage[1] (feet)	Peak discharge (ft³/s)	Recurrence interval[2] (years)
Maquoketa River Basin						
Crest-stage gaging station 05416200 Lamont Creek tributary near Lamont	1991–2004	1.78	6/01/2000 5/23/2004	20.13 [11]--	[4]635 >700	9 >11
Continuous-record gaging station 05416900 Maquoketa River at Manchester	2001–2004	275	6/04/2002 5/23/2004	18.35 21.66	10,800 26,000	9 100
Crest-stage gaging station 05416972 Sand Creek near Manchester	1991–2004	11.0	6/04/2002 5/23/2004	19.31 11.80	[4]4,290 860	35 2
Continuous-record gaging station 05417000 Maquoketa River near Manchester	1925, 1928–30, 1933–73, 1976–83	305	6/15/1925 6/13/1947 7/09/1951	-- 21.40 19.65	[12]25,400 20,000 16,800	130 60 30
Crest-stage gaging station 05417530 Plum Creek near Earlville	1966–91	41.1	9/13/1972 6/21/1974 9/26/1981	88.34 88.75 88.22	[4]4,800 [4]6,200 [4]4,500	20 45 18
Crest-stage gaging station 05417590 Kitty Creek near Langworthy	1966–92	14.4	7/19/1969 7/08/1986	90.24 88.68	[8]3,700 2,100	100 17
Continuous-record gaging station 05417700 Bear Creek near Monmouth	1944, 1958–76	61.3	6/--/1944 9/21/1965	[13]21.50 13.76	-- 7,340	-- 80
Continuous-record gaging station 05418400 North Fork Maquoketa River near Fulton	1999–2004	505	5/18/1999 6/05/2002 5/23/2004	16.46 19.87 15.34	10,700 22,600 9,680	6 110 5
Continuous-record gaging station 05418450 North Fork Maquoketa River at Fulton	1974, 1977–91, 2002	516	6/05/2002	21.21	[4]22,600	100
Continuous-record gaging station 05418500 Maquoketa River near Maquoketa	1903, 1914–2004	1,553	--/--/1903 6/27/1944 6/05/2002 5/25/2004	[14]23.50 [14]24.70 34.09 25.61	43,200 48,000 47,900 15,900	40 60 60 2
Crest-stage gaging station 05418645 Williams Creek near Charlotte	1989–2004	1.77	5/29/1996 5/23/2004	13.02 --	[4]990 --	14 --

[1] All values at current datums.

[2] Interpolated using Bulletin 17B flood-frequency analyses (Interagency Advisory Committee on Water Data, 1982) computed through the 2004 water year and rounded to nearest 5 years for 20- to 50-year recurrence intervals, to nearest 10 years for 50- to 200-year recurrence intervals, and to nearest 20 years for 200- to 500-year recurrence intervals.

[3] Gage height determined from floodmark.

[4] Estimated.

[5] Computed using regional regression equations (Eash, 2001).

[6] Discharge is maximum daily average.

[7] From records by Central States Power and Light Corporation (Iowa Geological Survey, 1944).

[8] Discharge computed from indirect measurement.

[9] Based on indirect measurement of discharge at Mederville.

[10] Maximum gage height known since 1890.

[11] Flood peak higher than top of crest-stage gage at 20.6 feet, peak stage not determined.

[12] Discharge computed by Prof. F.A. Nagler, University of Iowa (U.S. Geological Survey, 1964).

[13] Stage affected by backwater.

[14] Prior to Sept. 30, 1972, gaging station at different site and datum.

of May 21. The first squall line traveled north of the stationary front and raced east across Iowa causing storms that brought renewed heavy rain in the early a.m. hours of May 22 over areas in northeast Iowa that had been saturated by storms just hours earlier. The second squall line moved across eastern Iowa during the morning hours of May 22. The second squall line had weakened considerably during the night so severe weather was sporadic, but it produced heavy rain over areas that were already saturated and thus renewed flash flooding.

A second consecutive night of flash flooding affected much of northeast Iowa, when rainfall amounts of 2 to 4 in. occurred in three hours during the early a.m. of May 23. Again, two squall lines developed in the late afternoon of May 22 in western Iowa, one north and one south of the stationary front. These squall lines raced east across eastern Iowa and renewed flash flooding across parts of northeast Iowa that had received three rounds of heavy rains in the past 48 hours. Unofficial rainfall totals of 8 to 10 in. were reported in the Turkey River Basin.

Figure 3 shows hourly rainfall amounts for May 21–23, 2004, at four selected rain gages in northeast Iowa. Hourly data collected at Cascade, McGregor, Spillville, and Strawberry Point (figs. 1–2) may provide a general indication of the timing and intensity of the rainfall in the Turkey River Basin and the upper part of the Maquoketa River Basin. The greatest intensity of rainfall recorded at the four rain gages occurred at Strawberry Point (fig. 3D) between midnight and 1 a.m. on May 23 during which 1.6 in. of rain fell. Data from the four rain gages (fig. 3) indicate that all of the rainfall occurred during a 56-hour period, of which most of the rainfall occurred during about a 46-hour period from 4 a.m. on May 21 to 2 a.m. on May 23. Data from the four rain gages (fig. 3) also indicate that Spillville recorded the greatest 24-hour rainfall of 4.9 in. and McGregor recorded the greatest 48-hour rainfall of 6.0 in. (24- and 48-hour periods are independent of observation times).

Figures 1 and 2 each show an isohyetal map of the areal distribution of rainfall for the 72-hour period ending at 7:00 a.m. on May 23, 2004; data were provided by Harry Hillaker, State Climatologist, Iowa Department of Agriculture and Land Stewardship (written commun., September 2005). A 72-hour time period is shown in figures 1 and 2 to indicate total rainfall for the storms because most of the rainfall occurred during three 24-hour collection periods (7:00 a.m. observation times). Table 4 lists each 24-hour rainfall amount for May 21–23, 2004, for the 17 rain gages nearest to the Turkey and Maquoketa River Basins (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Climatic Data Center, 2004b, 2004c; and Iowa Department of Agriculture and Land Stewardship, State Climatologist Office, 2004). Rainfall recorded during May 19–20 ranged from no rain to 0.05 in. at 15 of the 17 rain gages listed in table 4 (12 of the stations reported no rain; rainfall data for May 19–20 are not listed in table 4); rainfalls of 0.2 in. at Spillville and 1.05 in. at Cresco were reported for this 48-hour time period. A 72-hour rainfall total is listed in table 4 for May 21–23 to include all relevant rainfall that could be considered contributing to the flood of May 23, 2004, with the exception of the additional rainfall recorded at Cresco on May 20th. Seventy-two hour rainfall recorded at Postville and Waucoma on May 23 were 6.32 and 6.55 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 recurrence intervals. Table 5 lists the magnitude and frequency of theoretical rainfall amounts for selected rain periods (durations) from the table in Huff and Angel (1992) for the Northeast Iowa Climatological Division. Fourteen of the 17 rain gages listed in table 4 are in the Northeast Iowa Climatological Division; the Coggon, Central City, and Maquoketa rain gages are located in the East-Central Climatological Division (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Climatic Data Center, 2004b, 2004c; and Iowa Department of Agriculture and Land Stewardship, State Climatologist Office, 2004).

Tables 5 and 3 list recurrence intervals for two different components of a hydrologic event—rainfall and runoff, respectively, and for different locations in the Turkey and Maquoketa River Basins. Recurrence interval is the average interval of time during which a given rainfall or flood will be equaled or exceeded once. For example, a flood with a magnitude that is expected to be exceeded on average once during any 100-year period (recurrence interval) has a 1-percent chance of being exceeded during any particular year. This flood, commonly termed the 100-year flood or 1-percent-annual-chance flood, is one of several selected theoretical peak discharges against which actual flood peaks are compared. Although the recurrence interval represents the long-term average period between rainfalls or floods of a specific magnitude, rare rainfalls or floods could occur at shorter intervals or even within the same year.

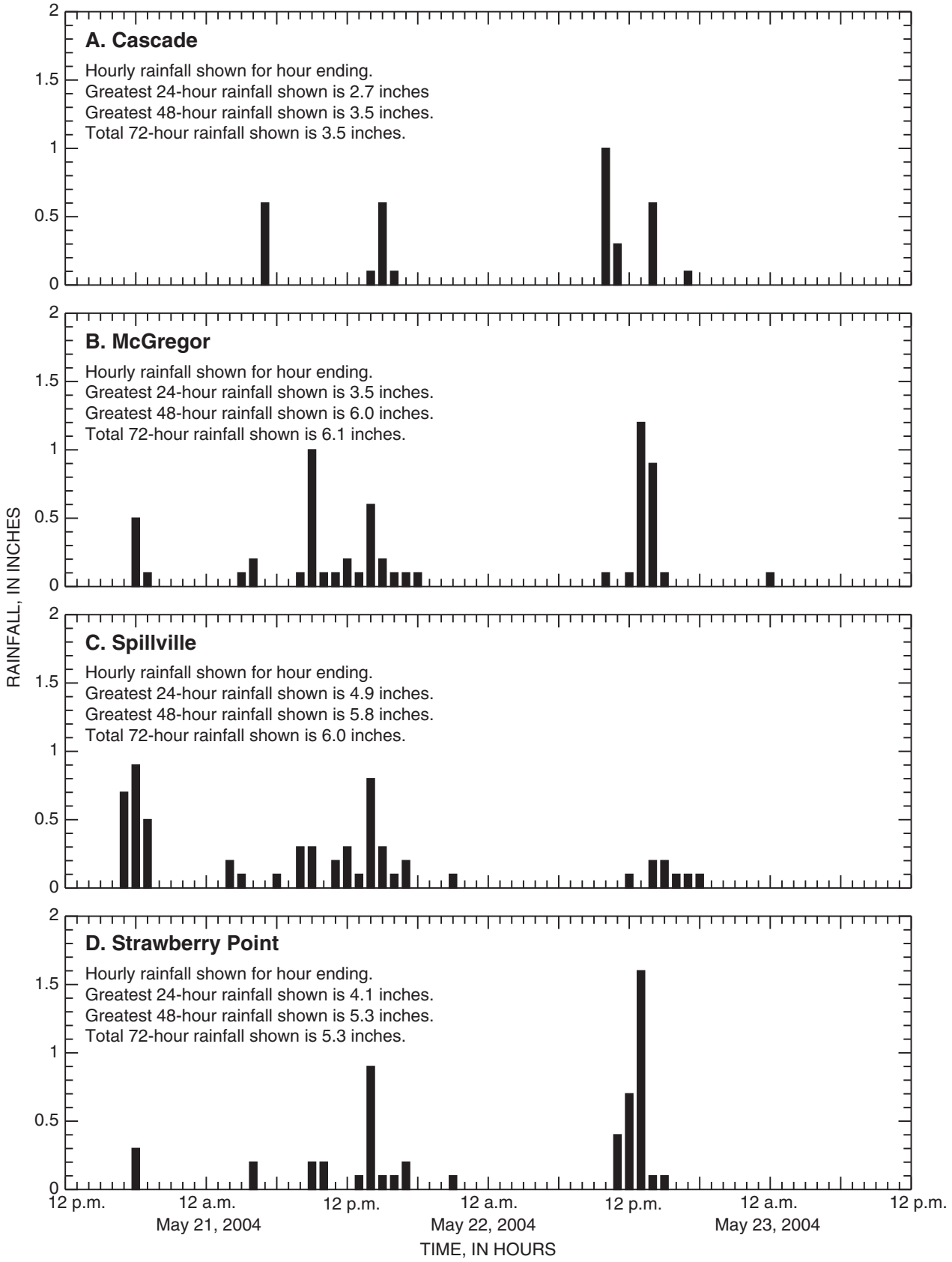

Figure 3. Hourly rainfall for May 21–23, 2004, at four rain gages in the Turkey and Maquoketa River Basins and vicinity (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Climatic Data Center, 2004c). Location of rain gages shown in figures 1–2.

Table 4. Twenty-four-hour rainfall amounts at selected rain gages in northeast and east-central Iowa during May 21–23, 2004.

[ND, no data; T, trace. Location of rain gages shown in figures 1–2.]

Rain gage	Observation time	24-hour rainfall, in inches[1,2,3]			Greatest 48-hour rainfall total (inches)	72-hour rainfall total (inches)
		May 21, 2004	May 22, 2004	May 23, 2004		
Cascade	Midnight[3]	0.6	2.2	0.7	[4]3.5	3.5
Central City	Midnight[3]	0.6	0.7	0.3	[3]1.6	1.6
Coggon	6 a.m.	0.00	1.72	2.24	3.96	3.96
Cresco 1 NE	8 a.m.	1.15	2.88	0.78	4.03	4.81
Elkader 5 SSW	8 a.m.	0.65	2.26	2.50	4.76	5.41
Fayette	7 a.m.	0.89	2.78	2.31	5.09	5.98
Guttenberg L & D 10	6 a.m.	0.00	2.87	1.96	4.83	4.83
Independence	6 a.m.	0.00	1.91	3.66	5.57	5.57
Manchester #2	7 a.m.	0.02	1.93	1.02	2.95	2.97
Maquoketa 4 W	7 a.m.	T	1.21	0.56	1.77	1.77
McGregor	Midnight[3]	2.4	1.4	2.3	[4]6.0	6.1
New Hampton	7 a.m.	0.76	3.96	1.10	5.06	5.82
Oelwein 2 S	7 a.m.	0.18	2.27	2.22	4.49	4.67
Postville	7 a.m.	1.06	4.33	0.93	5.39	6.32
Spillville	Midnight[3]	3.6	1.7	0.7	[4]5.8	6.0
Strawberry Point	Midnight[3]	0.9	2.6	1.8	[4]5.3	5.3
Waucoma	7 a.m.	0.80	4.85	0.90	5.75	6.55

[1] Climatological Data, Iowa (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Climatic Data Center, 2004b).

[2] Iowa Climate Review (Iowa Department of Agriculture and Land Stewardship, State Climatologist Office, 2004).

[3] Hourly Precipitation Data, Iowa (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Climatic Data Center, 2004c).

[4] Calculated from hourly precipitation data shown on figure 3.

Table 5. Magnitude and frequency of theoretical rainfall amounts for selected storm periods in the Northeast Iowa Climatological Division.

[Rainfall amounts from Huff and Angel (1992)]

Duration (hours)	Rainfall (inches) for indicated recurrence interval (years)			
	10	25	50	100
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

Flood Description

As a result of the intense rainfall, severe flooding occurred in the lower part of the Turkey River Basin and the upper part of the Maquoketa River Basin. Peak discharges on the Turkey River for the flood of May 23, 2004, of 33,300 ft^3/s at the Turkey River above French Hollow Creek at Elkader gaging station (station number 05412020, State Highway 13, fig. 1) and 66,700 ft^3/s at the Turkey River at Garber gaging station (station number 05412500, County Road C43), were determined for the flood (table 3). The peak discharge of the 2004 flood at the Garber gaging station is the largest flood on record in the Turkey River Basin. The recurrence interval for the peak discharge of 66,700 ft^3/s at the Turkey River at Garber gaging station is estimated to be greater than 500 years as computed through the 2004 water year using Bulletin 17B flood-frequency analyses (Interagency Advisory Committee on Water Data, 1982). Three large floods have occurred at the Turkey River at Garber gaging station in a 13-year period. Peak discharges of the floods of June 15, 1991, and May 17, 1999, were 49,900 ft^3/s (recurrence interval about 150 years) and 53,900 ft^3/s (recurrence interval about 220 years), respectively.

The peak discharge on the Maquoketa River of 26,000 ft^3/s at the Maquoketa River at Manchester gaging station (station number 05416900, U.S. Highway 20) is the largest flood on record for the upper part of the Maquoketa River Basin. The recurrence interval for the peak discharge of 26,000 ft^3/s at the Maquoketa River at Manchester gaging station is estimated to be approximately 100 years as computed through the 2004 water year using Bulletin 17B flood-frequency analyses.

Discharge hydrographs for continuous-record, gaging stations for May 21–27, 2004, are shown in figure 4 for all four active gaging stations in the Turkey River Basin and are shown in figure 5 for all three active gaging stations in the Maquoketa River Basin. Flooding (recurrence interval of 10 years or greater) that began in the upper part of the Turkey River Basin on May 22 at the Turkey River at Eldorado gaging station (fig. 4A) became major flooding (recurrence interval of 50 years or greater) in the lower part of the basin at the Turkey River above French Hollow Creek at Elkader, the Volga River at Littleport, and the Turkey River at Garber gaging stations on May 23 (figs. 4B, 4C, and 4D). The largest measured discharge in the Turkey River Basin occurred at the Turkey River at Garber gaging station (fig. 4D), which measures the combined flows of the Turkey and Volga Rivers (fig. 1). The discharge hydrographs shown in figure 4 indicate that the floods on the Turkey and Volga Rivers combined to produce a record flood at the Turkey River at Garber gaging station. The peak discharge at the Turkey River above French Hollow Creek at Elkader gaging station, located approximately 17.9 mi upstream of the Garber gaging station, occurred at 7:00 a.m. on May 23. The peak discharge at the Volga River at Littleport gaging station, located approximately 10.5 mi upstream of the Garber gaging station, occurred at 8:30 a.m. on May 23. The travel distance and timing of these two flood crests coincided with other local tributary flow (primarily Roberts and Elk Creeks) to produce the largest peak discharge on record at the Turkey River at Garber gaging station at 12:00 a.m. on May 23. Although the 1991 flood (38,300 ft^3/s) exceeded the 2004 flood (33,300 ft^3/s) at the Turkey River above French Hollow Creek at Elkader gaging station and the 1999 flood (30,000 ft^3/s) exceeded the 2004 flood (21,000 ft^3/s) at the Volga River at Littleport gaging station, the magnitude and timing of the crests of the 2004 flood on the Turkey and Volga Rivers combined to cause the 2004 flood at the Turkey River at Garber gaging station (66,700 ft^3/s) to exceed either of these previous floods at Garber (49,900 ft^3/s in 1991 and 53,900 ft^3/s in 1999).

Major flooding in the upper part of the Maquoketa River Basin began on May 23 and peaked that same day at the Maquoketa River at Manchester gaging station (fig. 5A). The discharge hydrographs in figure 5 indicate the smallest increase in discharge occurred in the lower part of the basin at the North Fork Maquoketa River at Fulton and Maquoketa River near Maquoketa gaging stations (figs. 5B and 5C), which is consistent with rainfall amounts depicted in figure 2. The largest measured discharge in the Maquoketa River Basin occurred at the Maquoketa River at Manchester gaging station (fig. 5A), which measures discharge for the upper part of the basin. The flood attenuated downstream of the Manchester gaging station because of flood-plain and lake-storage effects (Lake Delhi and Lakehurst Dam).

The magnitude of the 2004 flood in comparison to selected theoretical, flood-frequency discharges is shown in figures 4 and 5. Recurrence intervals estimated for the 2004 flood at Eldorado (fig. 4A), Elkader (fig. 4B), and Littleport (fig. 4C) gaging stations are about 16, 70, and 50 years, respectively (table 3), as computed using regional regression equations (Eash, 2001). The recurrence interval for the 2004 flood at the Turkey River at Garber (fig. 4D) gaging station is estimated to be greater than 500 years (table 3), as computed through the 2004 water year using Bulletin 17B flood-frequency analyses (Interagency Advisory Committee on Water Data, 1982). At least 10 years

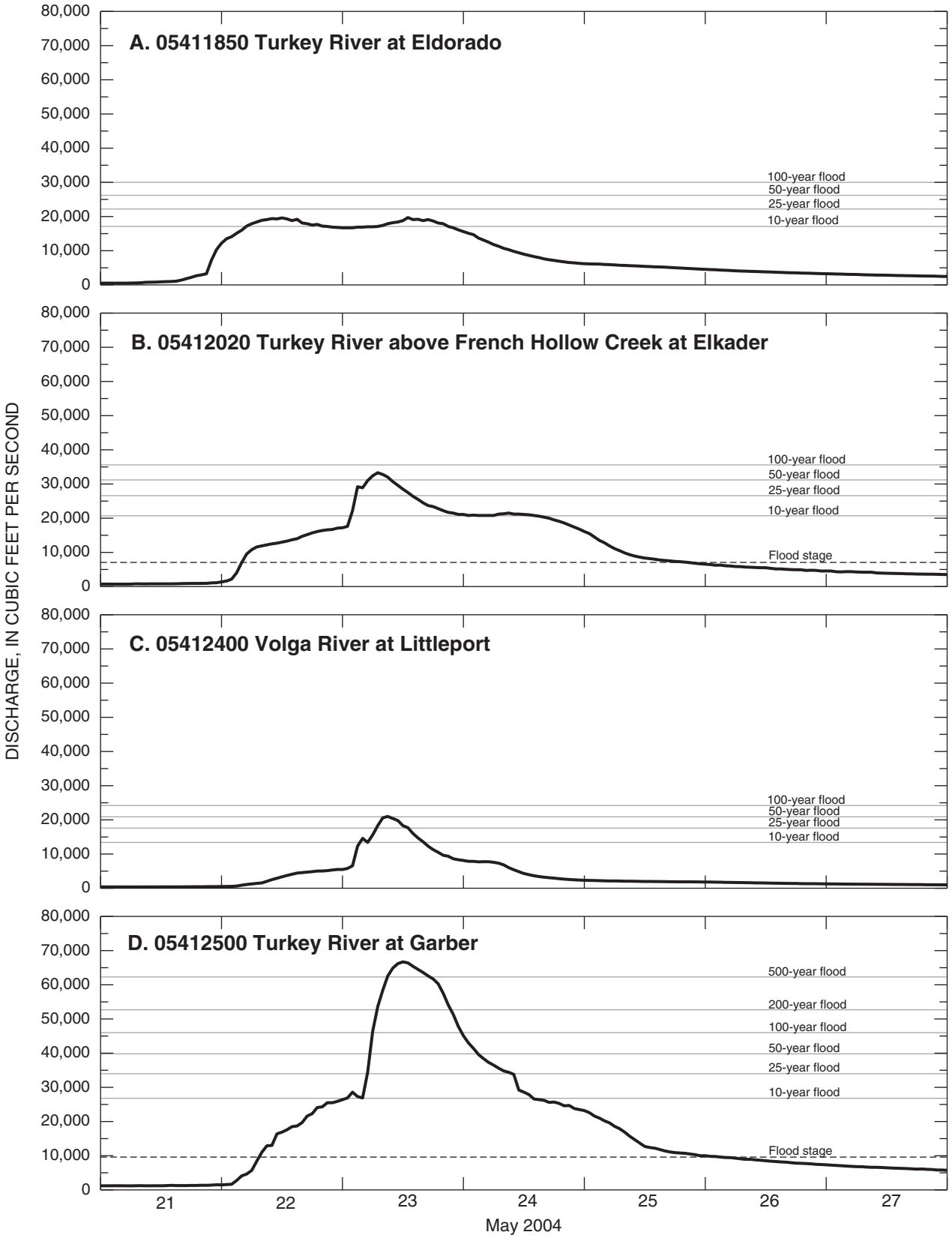

Figure 4. Discharge hydrographs at four continuous-record, streamflow-gaging stations in the Turkey River Basin, May 21–27, 2004. Location of gaging stations shown in figure 1.

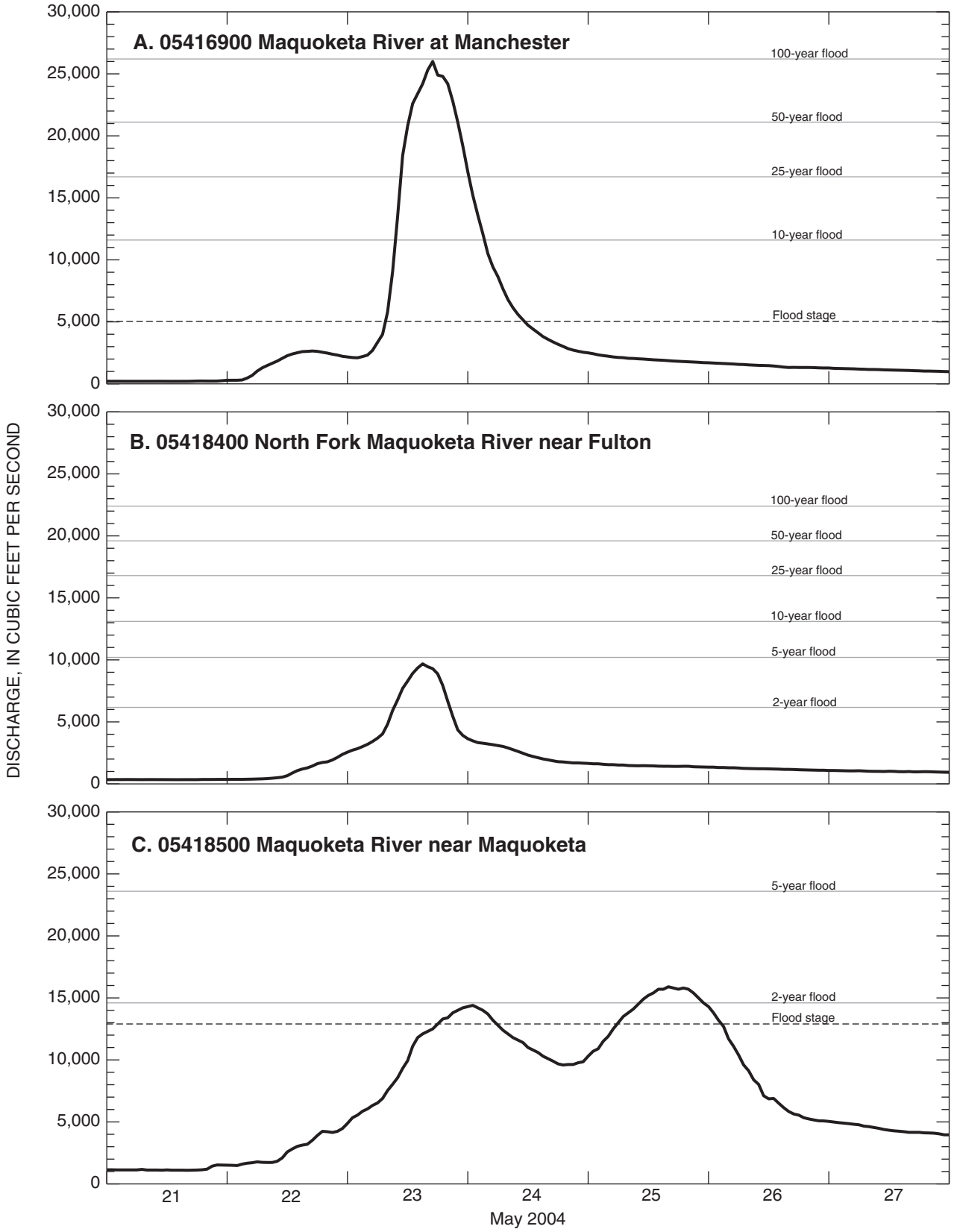

Figure 5. Discharge hydrographs at three continuous-record, streamflow-gaging stations in the Maquoketa River Basin, May 21–27, 2004. Location of gaging stations shown in figure 2.

of gaged annual peak discharges are required to compute flood-frequency analyses using the "Bulletin 17B" method. Regional regression equations were used to compute flood-frequency discharges for the Eldorado, Elkader, and Littleport gaging stations because peak discharge records for these three gages were less than 10 years. Recurrence intervals estimated for the 2004 flood at the Manchester (fig. 5A), Fulton (fig. 5B), and Maquoketa (fig. 5C) gaging stations are about 100, 5, and 2 years, respectively (table 3), as computed through the 2004 water year using the "Bulletin 17B" method.

The flood stage established by the National Weather Service for the Turkey River above French Hollow Creek at Elkader gaging station is 12.0 ft, which is the stage at which minor flooding occurs in areas near the river (at *http://www.crh.noaa.gov/ahps2/hydrograph.php?wfo=arx&gage=ekdi4&view=1,1,1,1,1,1*). The Turkey River above French Hollow Creek at Elkader gaging station was above flood stage from May 22–25 (fig. 4B), and the peak stage of 25.57 ft (table 3) exceeded the flood stage at this site by almost 13.6 ft. The flood stage for the Turkey River at Garber gaging station is 17.0 ft, which is the stage at which minor flooding begins in the communities of Garber, Osterdock, and Millville (at *http://www.crh.noaa.gov/ahps2/hydrograph.php?wfo=arx&gage=grbi4&view=1,1,1,1,1,1*). The Turkey River at Garber gaging station was above flood stage from May 22–26 (fig. 4D), and the peak stage of 32.80 ft (table 3) exceeded the flood stage at this site by 15.8 ft. The flood stage for the Maquoketa River at Manchester gaging station is 14.0 ft, which is the stage at which water is on West Main Street and affects residences on the south side of town (at *http://www.crh.noaa.gov/ahps2/hydrograph.php?wfo=dvn&gage=mchi4&view=1,1,1,1,1,1*). The Maquoketa River at Manchester gaging station was above flood stage from May 23–24 (fig. 5A), and the peak stage of 21.66 ft (table 3) exceeded the flood stage at this site by almost 7.7 ft. The flood stage for the Maquoketa River near Maquoketa gaging station is 24.0 ft, which is the stage at which water begins affecting agricultural fields in the Maquoketa area and several storm sewers in town (at *http://www.crh.noaa.gov/ahps2/hydrograph.php?wfo=dvn&gage=maqi4&type=0&view=1,1,1,1,1,1*). The Maquoketa River near Maquoketa gaging station was above flood stage from May 23–24 and again from May 25–26 (fig. 5C), and the peak stage of 25.61 ft on May 25 (table 3) exceeded the flood stage by about 1.6 ft. Flood stages are not available for the other three gaging stations shown in figures 4 and 5.

The following flood description information presented in this section was obtained from newspaper articles in the *Cedar Rapids Gazette* (Gravelle, May 24, 2004; Hogan, May 25, 2004; Love, May 26, 2004) and the *Des Moines Register* (Jordan, May 24, 2004; Leys, May 24, 2004; Jordan, July 13, 2004; Jordan, February 10, 2005; Harris, September 18, 2005), and from on-line sources obtained from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Climatic Data Center (2004a). Flash flooding was reported in many locations following the storms of May 21–23. In the Turkey and Maquoketa River Basins, flooding damaged several bridges and caused numerous roads to become impassable, closed, or washed-out. The flooding closed State Highway 13 in downtown Manchester and north of Strawberry Point, and closed U.S. Highway 52 at Millville and State Highway 187 at the Fayette County line. On May 23, the Clayton County Sheriff's Office banned travel to and from Volga, Garber, Elkport, and Littleport. In Elkader, flooding along the Turkey River in the early morning hours of May 23, threatened to overtop the dike, and forced emergency crews to evacuate more than 25 homes on the south side of town, shut off gas and electricity, and use a boat to rescue campers from the City Park and nearby Deer Run Resort, reported Paul Olson, Elkader Fire Chief. In Volga, about 24 people were evacuated from rising floodwaters on the Volga River. In Manchester, flooding along the Maquoketa River forced evacuations of some businesses and homes. In Arlington, in southeastern Fayette County, law enforcement officials reported water 3 ft deep inundating roads in town during the early morning hours on May 23.

Flooding on Turkey River devastated the town of Elkport. Residents of Elkport, population 88, and Garber, population 103, went on alert on May 22 because of the rapid rise of the Turkey and Volga Rivers, which converge just upstream of the two communities. In Elkport, the dike protecting the town from the Turkey River and Elk Creek broke at 11:30 a.m. on May 23, for the first time in 50 years, and the entire community was flooded. By the afternoon, most of Elkport's 30 houses were under at least 8 ft of water, causing the town to be a total loss. The combination of floodwaters in Elk Creek and the Turkey River broke the dike and sandbagging became ineffective, reported Roger Bolsinger, Fire Chief of Elkport and Garber. In nearby Garber, 10–12 homes were flooded by the Turkey River. The May 2004 flood resulted in private home buyout assistance totaling more than $2 million from Federal, State, and local governments to remove 42 homes in Iowa from flood plains. Most of the buyout assistance approved by FEMA, about $1.2 million, was for 28 homes in Elkport, and about $425,000 was approved for eight

homes in Garber, with the remaining assistance approved for two homes in Independence, two homes in Mason City, one home in Manchester, and one home in Clayton County.

Flood Profile

To develop a flood profile, the USGS measured the elevation of high-water marks (HWMs) at selected bridge and dam sites along selected reaches of the Turkey and Maquoketa Rivers. River miles were determined for the bridge and dam sites using a geographic information system (GIS) to measure the distance along each river reach from its mouth using USGS 1:24,000-scale topographic-map data. HWMs were measured at all Federal and State Highway bridges and at USGS gaging stations along the selected river reaches. Additional HWMs were measured at county road bridges to keep the maximum distance between points at about 10 river miles. The flood profiles were determined using HWMs generally located immediately downstream and one bridge-length upstream from selected bridges. The HWMs were flagged within 4 days of the flood peak, surveyed to temporary bench marks (see appendix) at bridges and dams within 2 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). The line connecting the marks on the profiles (figs. 6–15 following references) is a linear interpolation and, therefore, only approximates the flood elevation between marks; the line does not depict the effects on the profile caused by intermediate bridges or flood-plain and channel features. Additional HWMs were provided by David Allen, Water Resources Section, Iowa Department of Natural Resources, (written commun., May 2004) for the Maquoketa River profile for the downstream side of the Lake Delhi dam, and the upstream and downstream sides of County Road X21 and Marion Street bridges. The HWMs used to profile the May 23, 2004, flood in the Turkey and Maquoketa River Basins are listed in tables 6–8 and are plotted by river mile in figures 6–15. Primary highways referred to in the report are shown in figures 1–2; secondary roads are not shown.

Table 6. Elevation of high-water marks used in the May 2004 flood profile for the Turkey River, Iowa.

[HWM, high-water mark; NGVD 29, elevation data are referenced to the National Geodetic Vertical Datum of 1929; --, not determined]

Distance upstream from mouth of Turkey River (river miles)	Site description	Downstream HWM (feet above NGVD 29)	Upstream HWM (feet above NGVD 29)
1.71	Iowa, Chicago, and Eastern railroad, east of Millville	616.28	619.44
5.24	U.S. Highway 52, north of Millville	627.90	628.55
12.96	County Roads C43 and X47/Osterdock Road, Osterdock	641.81	643.61
21.16	USGS gaging station 05412500, County Road C43/Jupiter Road, Garber	667.26	--
21.84	County Road C7X, between Elkport and Garber	668.42	668.70
33.79	Galaxy Road (abandoned), Motor	704.79	705.46
39.09	USGS gaging station 05412020, State Highway 13, south of Elkader	720.50	--

Table 7. Elevation of high-water marks used in the May 2004 flood profile for the Volga River, Iowa.

[HWM, high-water mark; NGVD 29, elevation data are referenced to the National Geodetic Vertical Datum of 1929; --, not determined]

Distance upstream from mouth of Volga River (river miles)	Site description	Downstream HWM (feet above NGVD 29)	Upstream HWM (feet above NGVD 29)
0.52	County Road X3C/Grandview Road, north of Elkport	671.13	671.76
9.33	USGS gaging station 05412400, County Road X21/Littleport Road, Littleport	698.98	--

Table 8. Elevation of high-water marks used in the May 2004 flood profile for the Maquoketa River, Iowa.

[HWM, high-water mark; NGVD 29, elevation data are referenced to the National Geodetic Vertical Datum of 1929; --, not determined]

Distance upstream from mouth of Maquoketa River (river miles)	Site description	Downstream HWM (feet above NGVD 29)	Upstream HWM (feet above NGVD 29)
92.17	County Road D47/Marion Street, southwest of Hopkinton	837.05	837.47
101.58	County Road X31/230th Avenue crossing Lake Delhi dam, southwest of Delhi	873.49	897.58
103.58	County Road X29/220th Avenue, southwest of Delhi	[1]898.1	--
109.40	County Road X21/240th Street, southeast of Manchester	904.67	906.03
113.25	USGS gaging station 05416900, U.S. Highway 20, south of Manchester	922.07	922.94
114.42	Marion Street, Manchester	926.29	930.12
114.76	State Highway 13/ West Main Street, Manchester	931.02	932.06
116.98	195th Street, northwest of Manchester	937.22	937.68
117.03	Quaker Mill Pond dam, northwest of Manchester	937.68	949.86
125.52	County Road C64/Richland Street, Dundee	981.66	982.59
127.82	Backbone State Park dam	996.03	1,003.46
131.32	Backbone State Park Road, near road leading to County Road C57/120th Street	1,016.06	[2]1,016.14
139.73	State Highway 3, west of Strawberry Point	1,079.40	1,080.79
143.71	State Highway 187, southeast of Arlington	1,103.84	1,105.07

[1]Estimated flood elevation.

[2]High-water mark on stone shelter building located approximately 320 ft upstream of bridge.

The May 2004 flood along the Turkey River is profiled from the Iowa, Chicago, and Eastern railroad (fig. 7) near the mouth upstream to State Highway 13 near Elkader (fig. 9). The 37-mi river reach that was profiled along the Turkey River is shown in figure 1, and the seven stream sites where HWMs were measured are listed in table 6. A low-water profile measured on September 22, 1992, (Eash and Koppensteiner, 1996) is shown for the river reach. The low-water profile was obtained for the purpose of indicating the range in stage along the stream and to define the low-water slope.

The May 2004 flood along the Volga River is profiled from County Road X3C near Elkport upstream to County Road X21 at Littleport (fig. 10). The 9-mi reach that was profiled along the Volga River is shown in figure 1, and the two stream sites where HWMs were measured are listed in table 7.

The May 2004 flood along the Maquoketa River is profiled from County Road D47 near Hopkinton (fig. 12) upstream to State Highway 187 near Arlington (fig. 15). The 52-mi river reach that was profiled along the Maquoketa River is shown in figure 2, and the 14 stream sites where HWMs were measured are listed in table 8.

Summary

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

Severe flooding occurred on May 23, 2004, in the Turkey River Basin in Clayton County and in the Maquoketa River Basin in Delaware County following intense thunderstorms over northeast Iowa. Seventy-two hour rainfall recorded at Postville and Waucoma on May 23 were 6.32 and 6.55 in., respectively. Unofficial rainfall

totals of 8 to 10 in. were reported in the Turkey River Basin. The peak discharge on May 23 at the Turkey River at Garber gaging station was 66,700 ft^3/s (recurrence interval greater than 500 years) and is the largest flood on record in the Turkey River Basin. The timing of flood crests on the Turkey and Volga Rivers, and local tributaries, coincided to produce a record flood on the lower part of the Turkey River. Three large floods have occurred at the Turkey River at Garber gaging station in a 13-year period. Peak discharges of the floods of June 15, 1991, and May 17, 1999, were 49,900 ft^3/s (recurrence interval about 150 years) and 53,900 ft^3/s (recurrence interval about 220 years), respectively. The peak discharge on May 23 at the Maquoketa River at Manchester gaging station was 26,000 ft^3/s (recurrence interval about 100 years) and is the largest known flood in the upper part of the Maquoketa River Basin.

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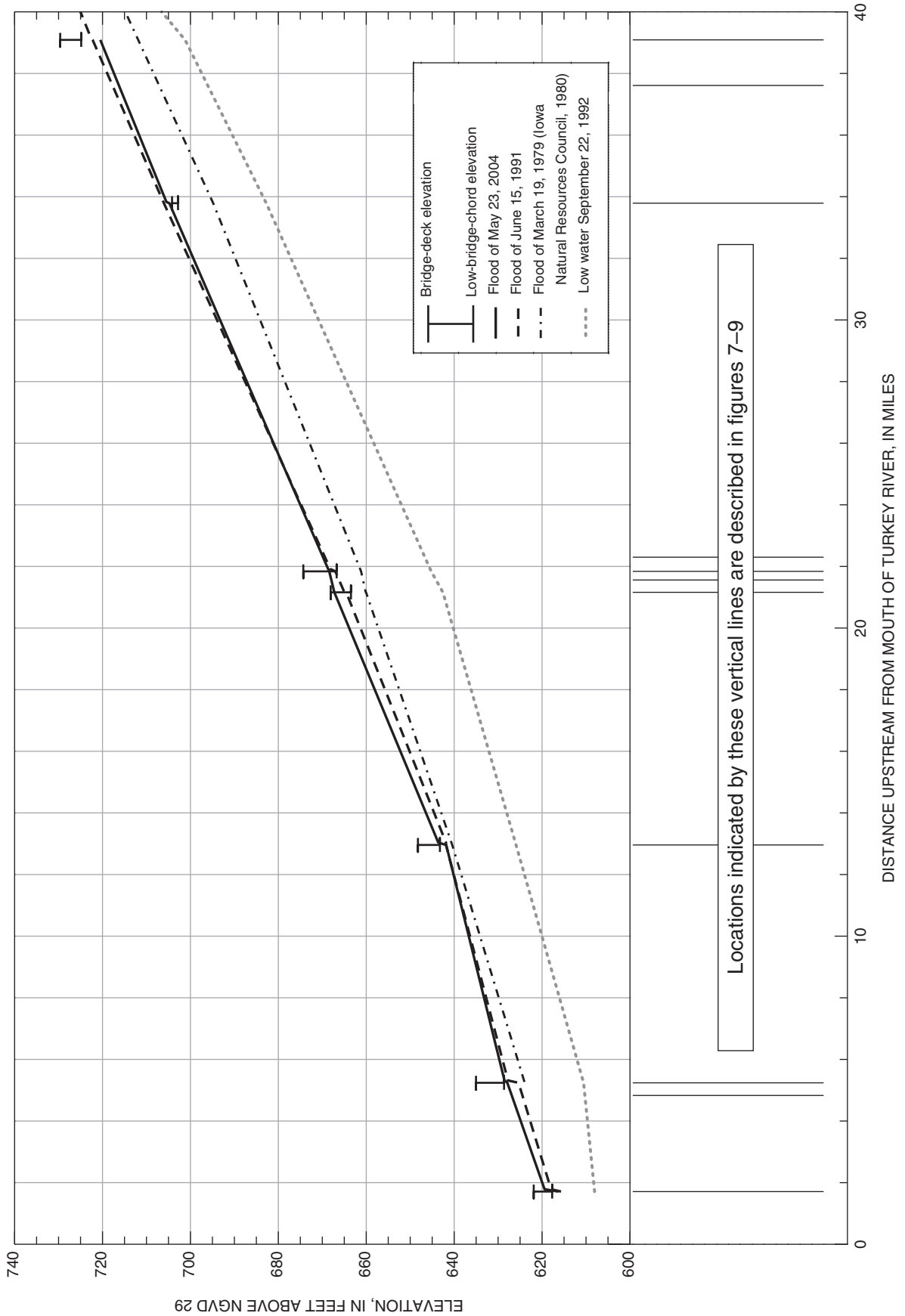

Figure 6. Profile of the May 2004 flood for the Turkey River, Iowa; river miles 1.7 to 39.1.

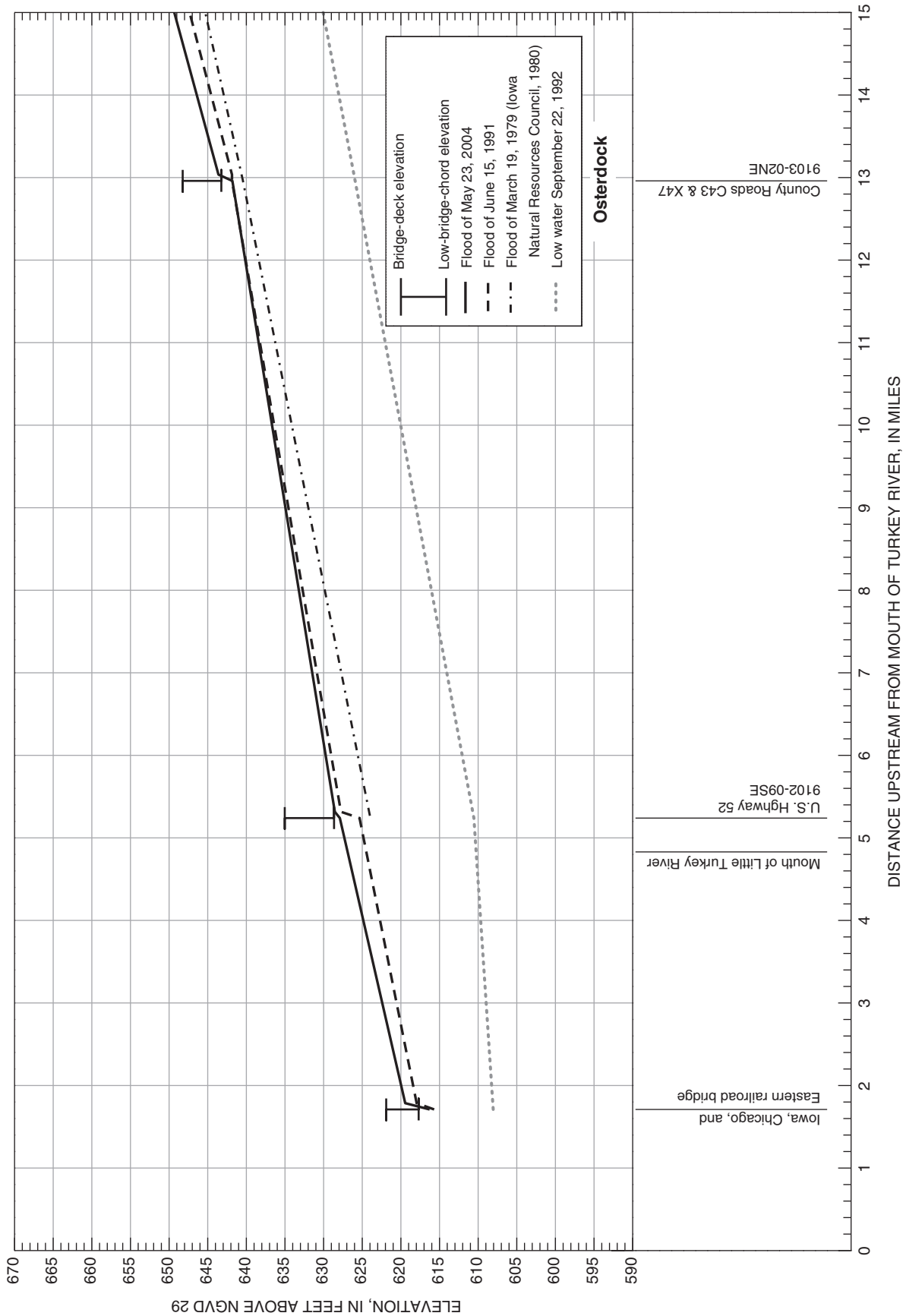

Figure 7. Profile of the May 2004 flood for the Turkey River, Iowa; river miles 1.7 to 15.

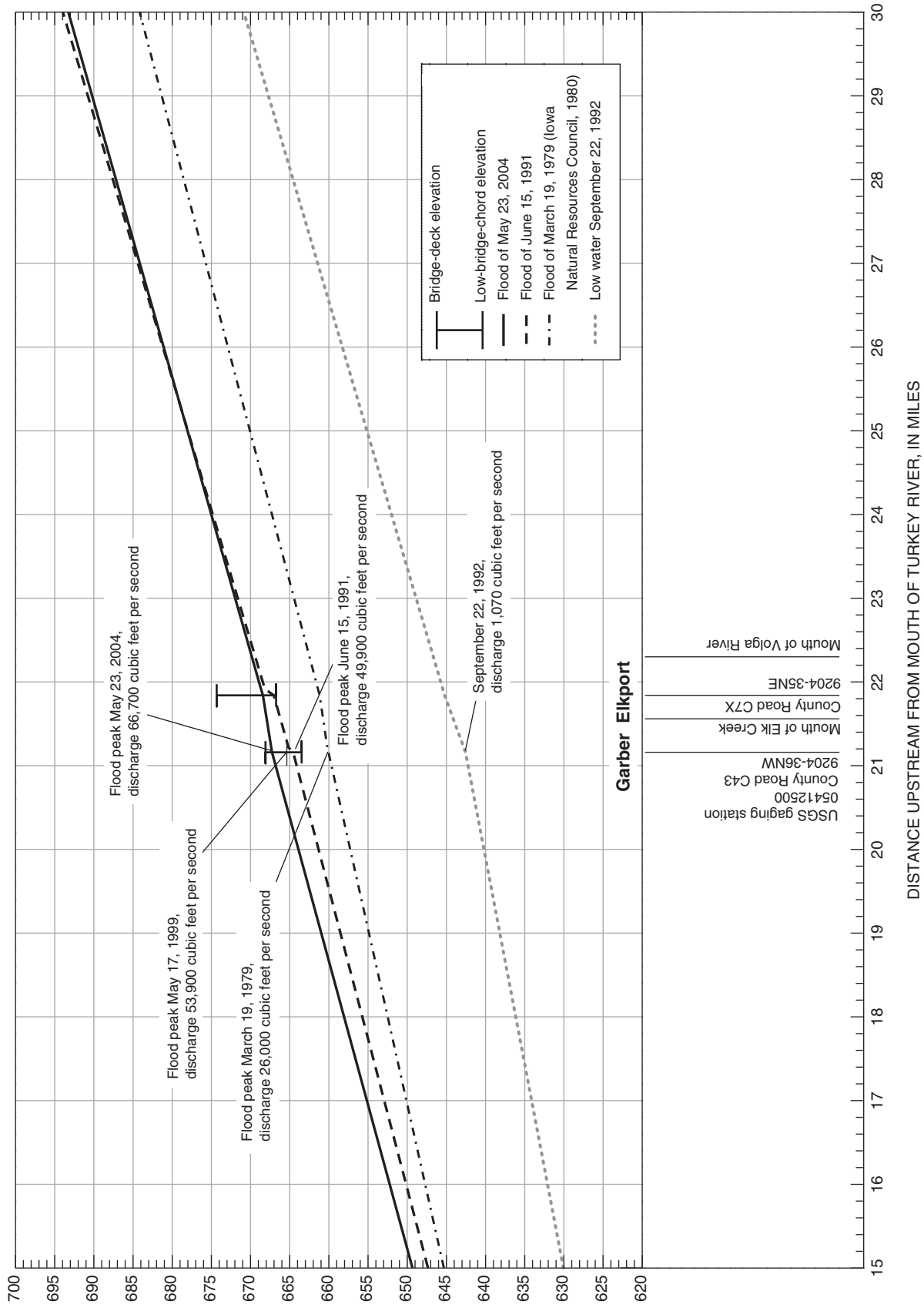

Figure 8. Profile of the May 2004 flood for the Turkey River, Iowa; river miles 15 to 30.

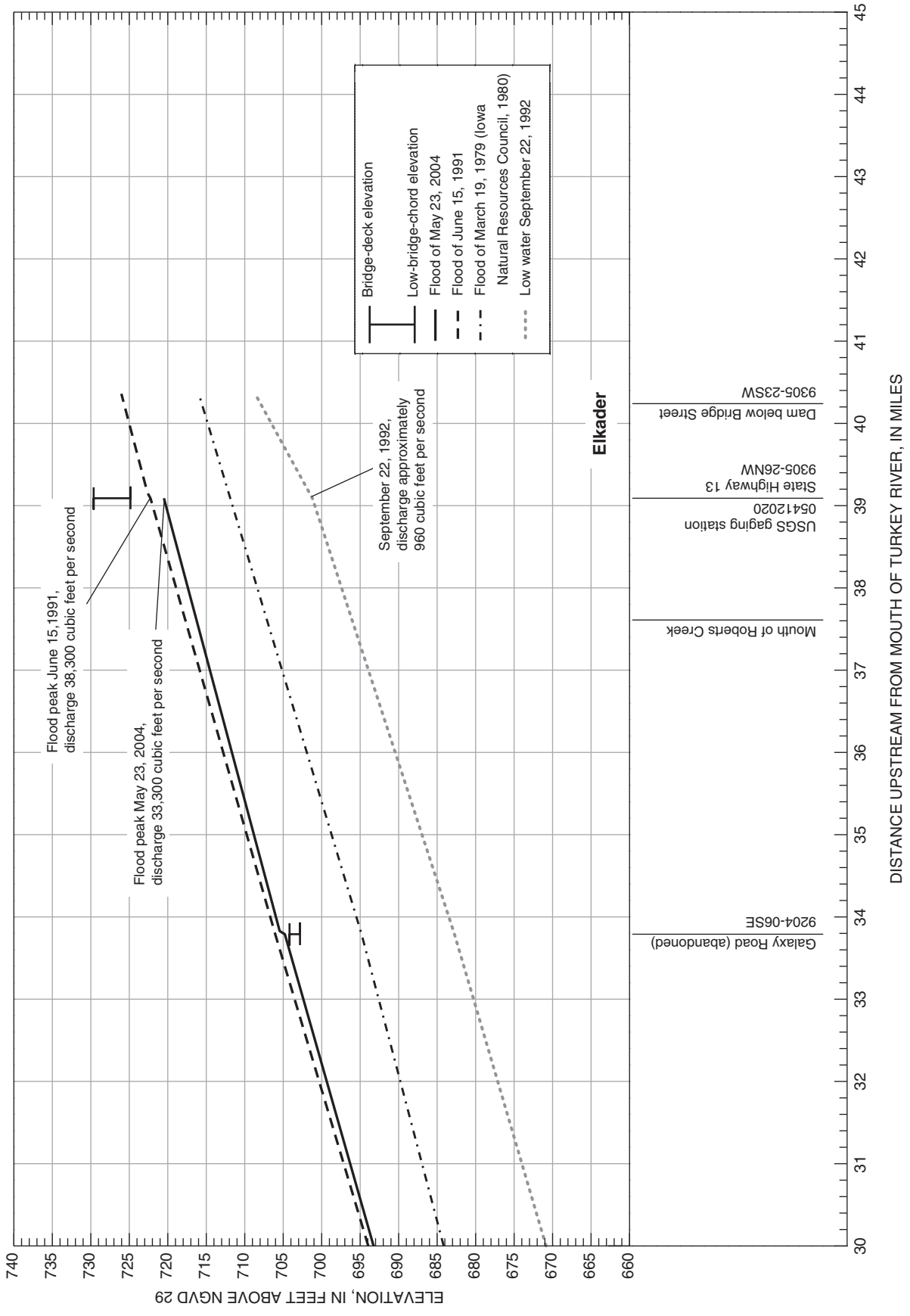

Figure 9. Profile of the May 2004 flood for the Turkey River, Iowa; river miles 30 to 39.1.

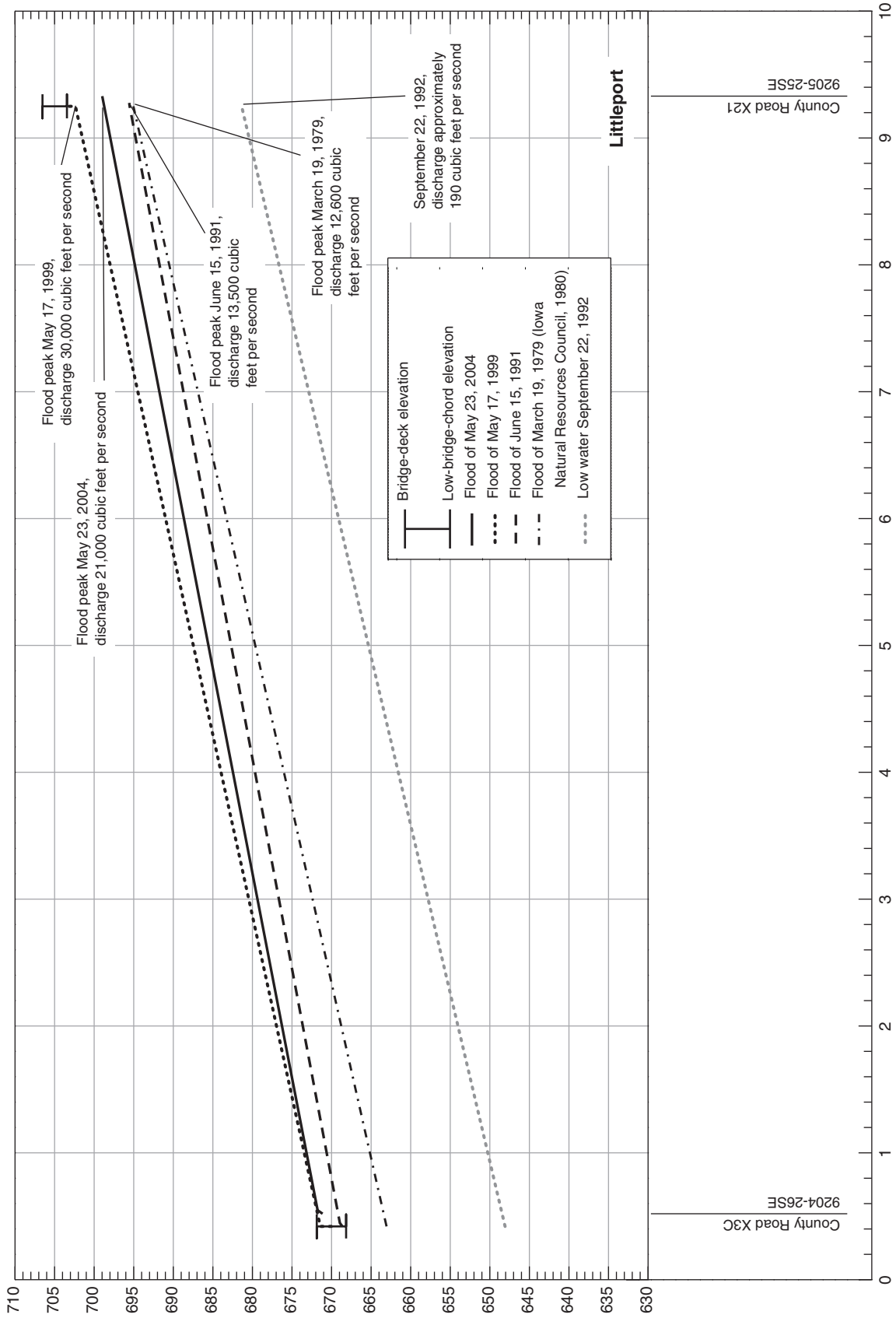

Figure 10. Profile of the May 2004 flood for the Volga River, Iowa; river miles 0.4 to 9.3.

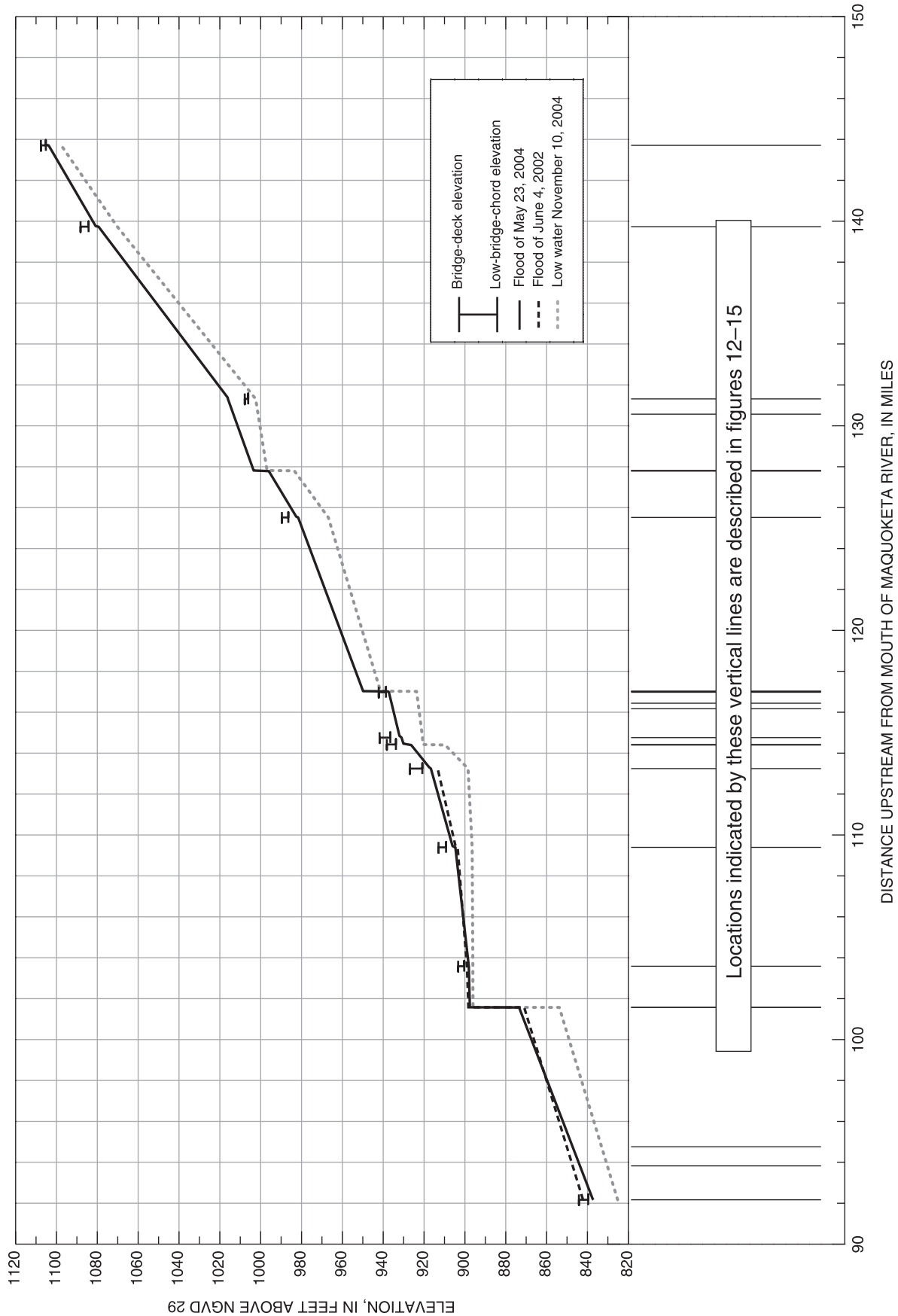

Figure 11. Profile of the May 2004 flood for the Maquoketa River, Iowa; river miles 92.2 to 143.7

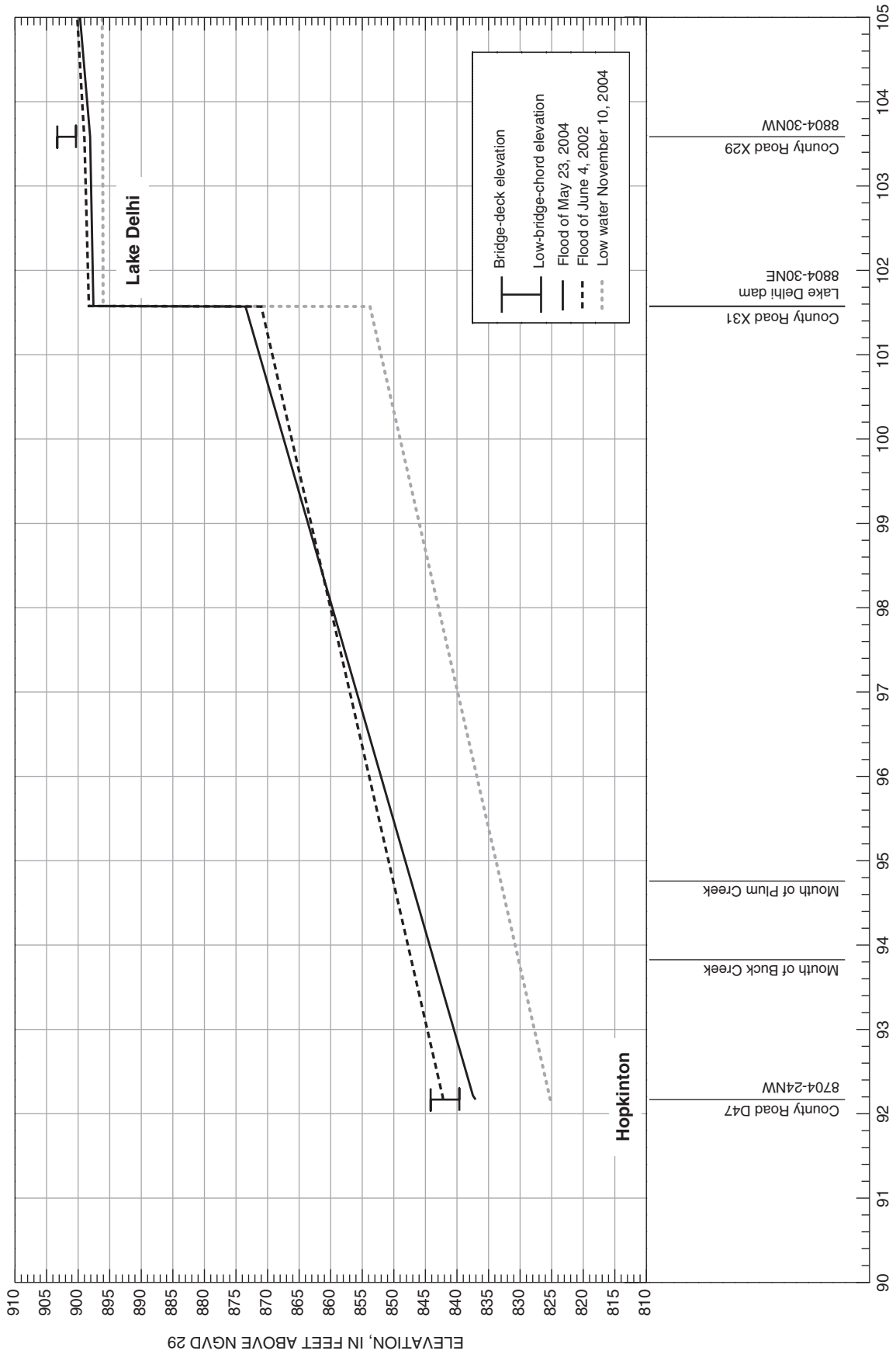

Figure 12. Profile of the May 2004 flood for the Maquoketa River, Iowa; river miles 92.2 to 105.

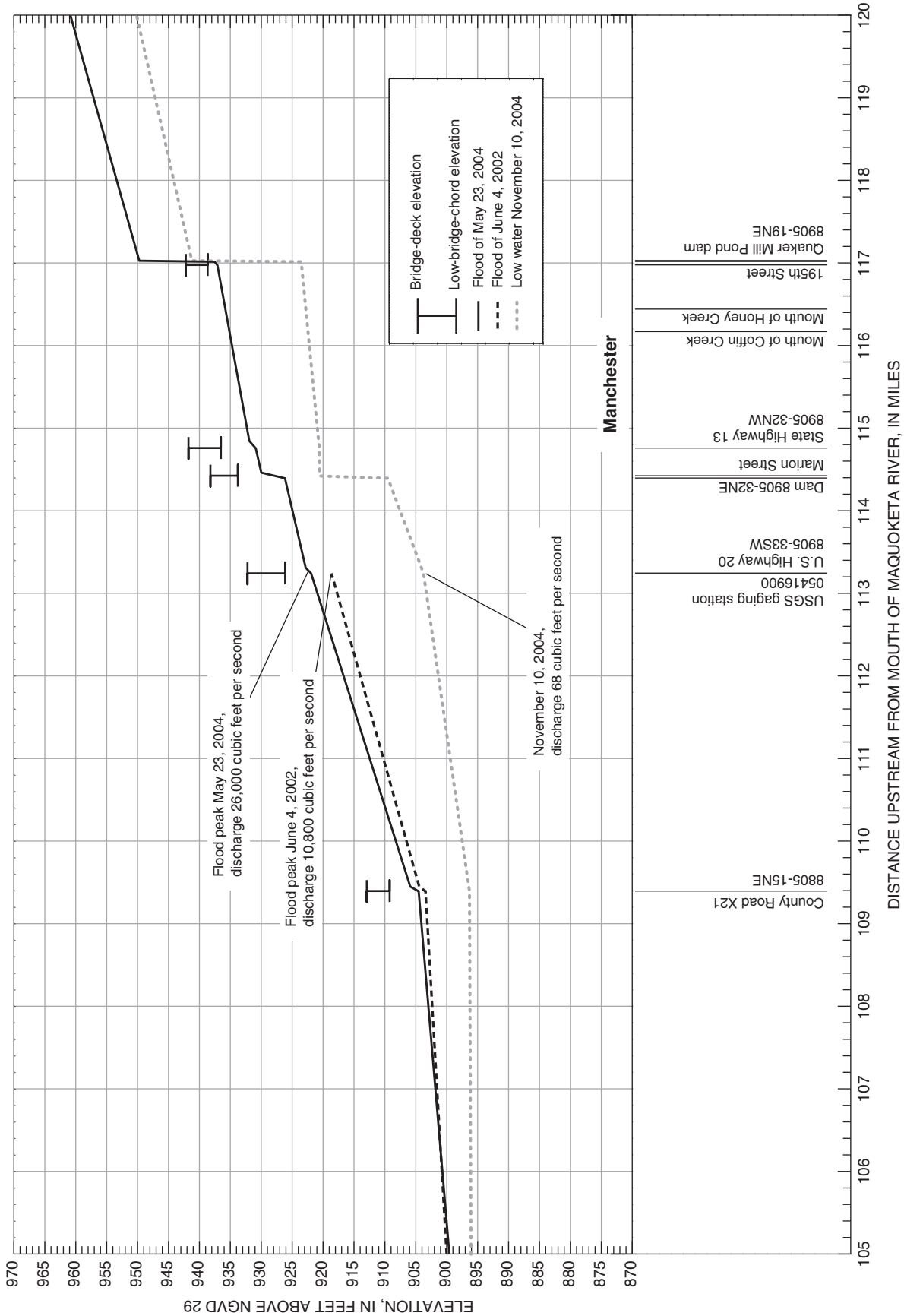

Figure 13. Profile of the May 2004 flood for the Maquoketa River, Iowa; river miles 105 to 120.

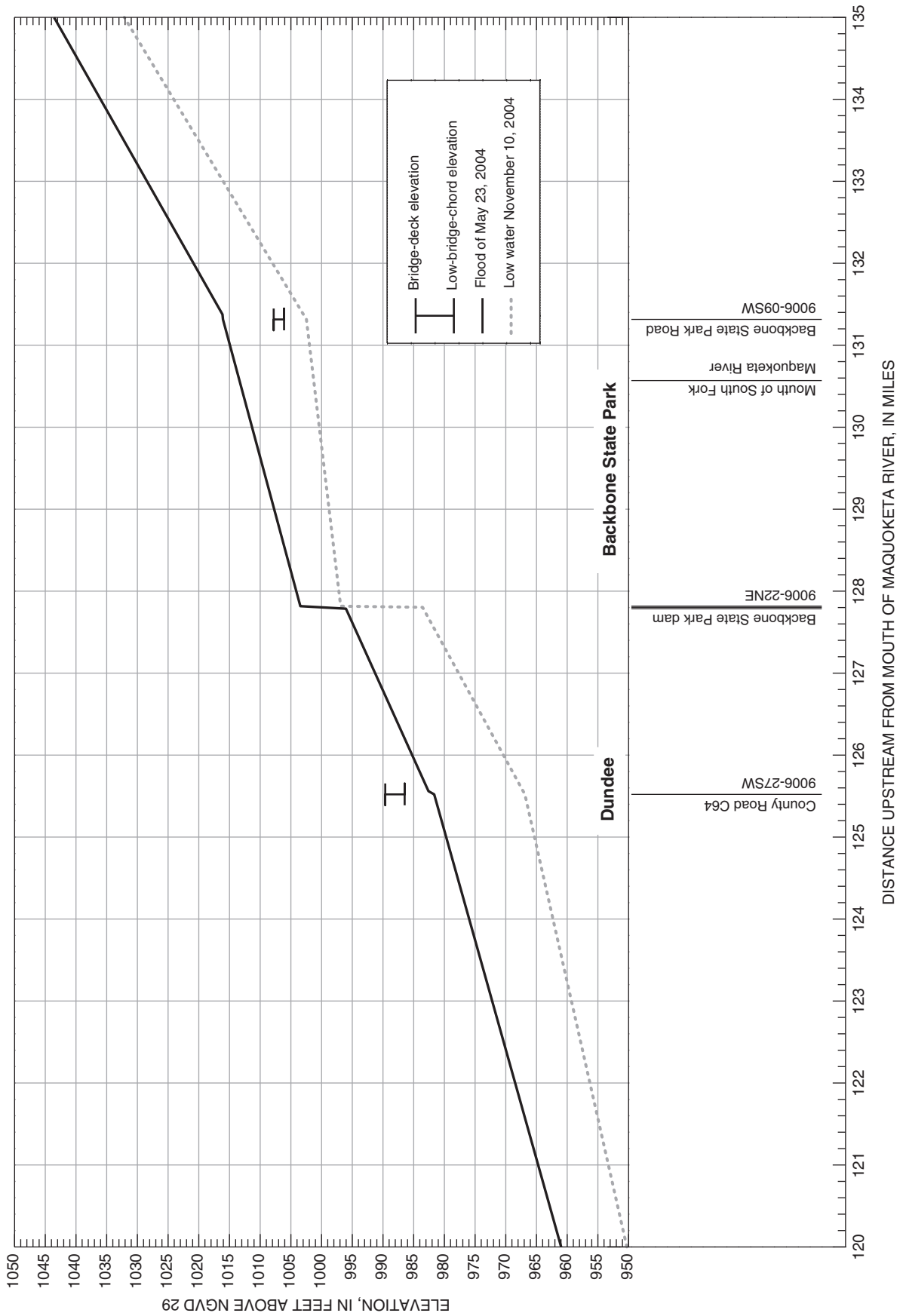

Figure 14. Profile of the May 2004 flood for the Maquoketa River, Iowa; river miles 120 to 135.

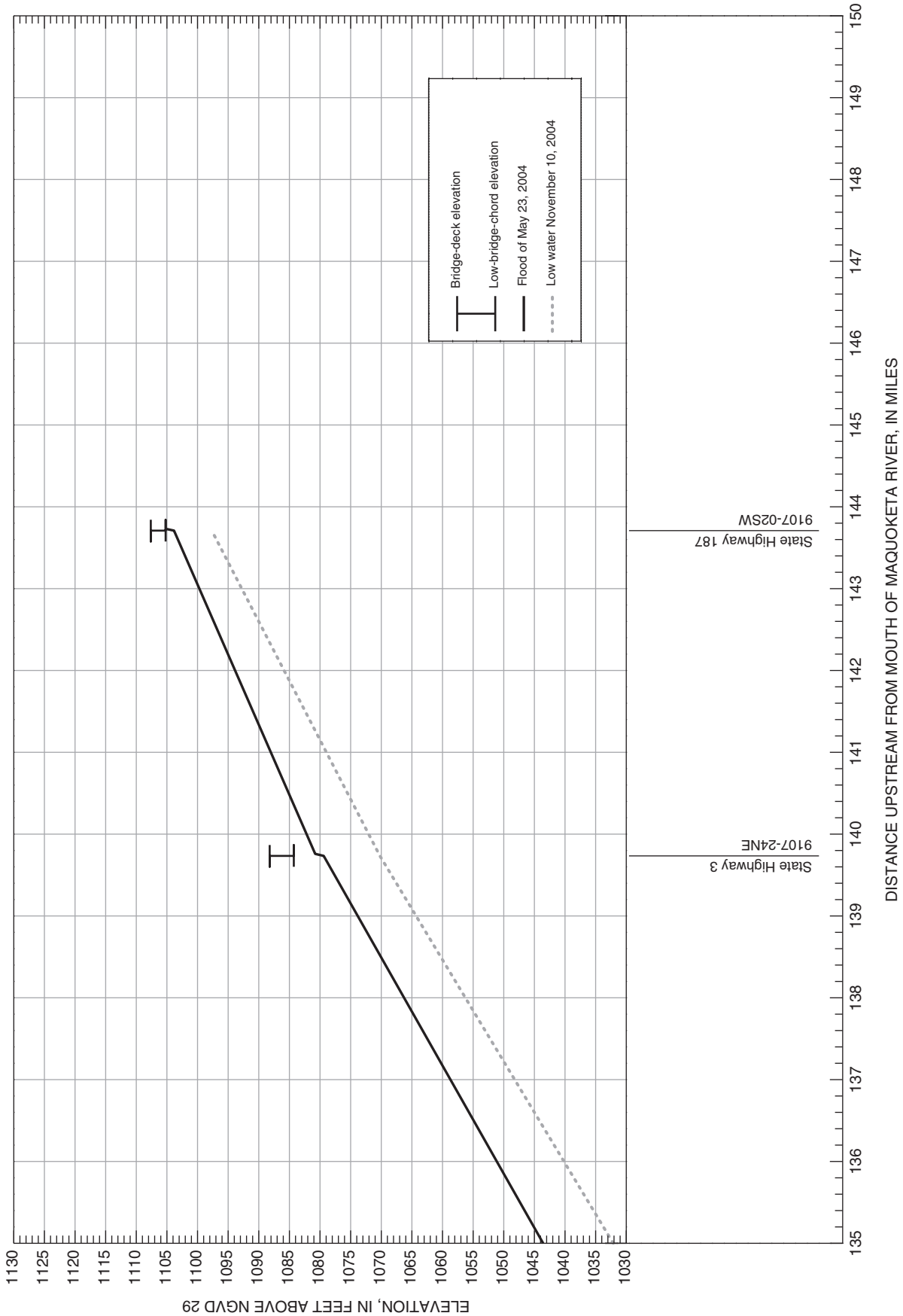

Figure 15. Profile of the May 2004 flood for the Maquoketa River, Iowa; river miles 135 to 143.7.

Appendix

Appendix. Temporary Bench Marks and Reference Points

To facilitate measuring and referencing the high-water marks (HWMs) used in the flood profiles to a common datum, temporary bench marks (TBMs) and reference points (RPs) were found or established by the U.S. Geological Survey (USGS) at bridges and dams along the profiled river reaches. All TBM and RP elevations listed in this tabulation are referenced to the National Geodetic Vertical Datum of 1929. Tables 6–8 list the 23 bridge and dam sites where the USGS measured HWMs for the May 2004 flood profile. Of these 23 sites, TBMs are presented in this appendix for 20 of the sites and RPs are presented for 14 of the sites (note: more than one TBM or RP are listed for some sites). For 5 of the 20 sites listed in this appendix, TBMs and corresponding elevations were established by other agencies and these agencies are noted in the descriptions of the TBMs. The USGS established TBMs at 15 sites and RPs at 14 sites during 2002–04; with the exception of the first four sites listed for the Turkey River for which TBMs and RPs were established by the USGS prior to 1993 and the Volga River at Littleport site for which a bench mark was established in 1964. TBMs or reference marks established at USGS gaging stations are identified in this tabulation with an RM number. TBM and RP elevations established by the USGS were determined from differential leveling, with the exception of TBMs at seven sites, where elevations were determined from post-processed differential positioning using a global positioning system (GPS). Elevations determined using GPS are noted in the TBM and RP descriptions. Level lines or GPS networks, used to establish the third-order accuracy of the 15 TBMs established by the USGS shown herein, were surveyed or configured from bench marks established and adjusted by the Geography Discipline of the USGS and National Geodetic Survey. Errors of closure in the USGS level work were adjusted along level lines to balance TBM and RP elevations. Specific GPS-network and satellite-constellation configurations, equivalent hours of data collection with multiple GPS receivers, and post-processing quality controls were used to control the effects of error in GPS-derived elevations.

The 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 TBM or RP is located is designated by NE, SE, NW, and SW. For example, 9102-12 SW refers to a location in Township 91 North, Range 2 West, southwest quarter of section 12. A number in parentheses following the quarter-section designation indicates the number of the 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 TBM on a bridge dictates the appropriate legal description. An RP, and any additional TBMs, are listed with the related 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.

Standard marks, such as squares, crosses, or marks were chiseled or filed on concrete or metal; or existing bolts on bridges were used as TBMs or RPs. RPs are distinguished from TBMs by the notation "(REFERENCE POINT)" following the legal description. 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 TBMs and RPs are listed in the downstream to upstream order with respect to their correspondence to bridges or dams across the Turkey, Volga, and Maquoketa Rivers. The user of this information is cautioned that 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 TBM or RP.

Turkey River

9102-12 SW (1)—Approximately 2.4 mi east of Millville at Iowa, Chicago, and Eastern railroad bridge over Turkey River, on right upstream bridge footing, 5.1 ft lower than wood plank, most streamward and downstream bolt; top of bolt.

Elevation 616.89 ft.

9102-12 SW (2)—(REFERENCE POINT) Approximately 2.4 mi east of Millville at Iowa, Chicago, and Eastern railroad bridge over Turkey River, on third truss member from right upstream bridge abutment, 6 in. lower than wood deck; chiseled arrow.

Elevation 621.43 ft.

9102-09 SE (1)—At north of Millville, on U.S. Highway 52 bridge over Turkey River, on right upstream wing-

wall; National Geodetic Survey (U.S. Coast & Geodetic Survey) bench mark disk stamped "B179-1970." Elevation obtained from National Geodetic Survey.

Elevation 634.822 ft.

9102-09 SE (2)—(REFERENCE POINT) At north of Millville, on U.S. Highway 52 bridge over Turkey River, on downstream curb between 13th and 14th guardrail posts from right end of bridge; chiseled square.

Elevation 634.78 ft.

9103-02 NE (1)—At Osterdock, on County Roads C43 and X47/Osterdock Road bridge over Turkey River, on right upstream concrete curb; brass tablet stamped "1957." Elevation obtained from Clayton County Engineer (revised elevation).

Elevation 647.94 ft.

9103-02 NE (2)—(REFERENCE POINT) At Osterdock, on County Roads C43 and X47/Osterdock Road bridge over Turkey River, on downstream curb between 31st and 32nd guardrail posts from left end of bridge; chiseled arrow.

Elevation 648.88 ft.

9204-36 NW (1)—At Garber, on County Road C43/Jupiter Road bridge over Turkey River, on center of left upstream guardrail; Iowa Department of Transportation bench mark. (RM 10)

Elevation 672.10 ft.

9204-35 NE (1)—Between Elkport and Garber, on County Road C7X bridge over Turkey River, on right downstream wingwall; Iowa Department of Transportation bench mark. Elevation obtained from Clayton County Engineer.

Elevation 677.27 ft.

9204-35 NE (2)—(REFERENCE POINT) Between Elkport and Garber, on County Road C7X bridge over Turkey River, on downstream concrete barrier guardrail at fourth section from right end of bridge; chiseled square.

Elevation 679.40 ft.

9305-26 NW (1)—Approximately 0.5 mi south of Elkader, on State Highway 13 bridge over Turkey River, on right upstream wingwall; Iowa Department of Transportation bench mark. (RM 1)

Elevation 732.88 ft.

9305-26 NW (2)—Approximately 0.5 mi south of Elkader, on State Highway 13 bridge over Turkey River, on left upstream wingwall; Iowa Department of Transportation bench mark. (RM 2)

Elevation 731.50 ft.

Volga River

9205-25 SE (1)—At Littleport, on County Road X21/ Littleport Road bridge over Volga River, on left upstream wingwall curb; U.S. Geological Survey brass tablet stamped "15 JRE 1964 708."

Elevation 708.254 ft.

Maquoketa River

8704-24 NW (1)—Approximately 0.5 mi southwest of Hopkinton, on County Road D47/Marion Street bridge over southern channel of Maquoketa River, on left downstream end of sidewalk concrete barrier wall; Delaware County bench mark. Elevation of bench mark on bridge surveyed by USGS from elevation southwest of bridge provided by Delaware County Engineer's Office.

Elevation 846.90 ft

8704-24 NW (2)—(REFERENCE POINT) Approximately 0.5 mi southwest of Hopkinton, on County Road D47/ Marion Street bridge over southern channel of Maquoketa River, on downstream side of cyclone fence at 12th fence post from right downstream end of bridge; edge of concrete sidewalk.

Elevation 844.83 ft

8804-30 NE (1)—Approximately 1.5 mi southwest of Delhi, on County Road X31/230th Avenue crossing Lake Delhi dam on Maquoketa River, on end of right downstream wingwall; chiseled cross. Elevation determined using GPS.

Elevation 907.37 ft

8804-30 NW (1)—Approximately 2 mi southwest of Delhi, on County Road X29/220th Avenue bridge over Lake Delhi, on corner of wingwall near guardrail at left downstream end of bridge; chiseled square. Elevation determined using GPS.

Elevation 906.33 ft

8804-30 NW (2)—(REFERENCE POINT) Approximately 2 mi southwest of Delhi, on County Road X29/220th Avenue bridge over Lake Delhi, on metal guardrail between 11th and 12th guardrail posts from right downstream end of bridge; three filed marks. Elevation determined using GPS.

Elevation 911.45 ft

8805-15 NE (1)—Approximately 4 mi southeast of Manchester, on County Road X21/240th Street bridge over Maquoketa River, on corner of wingwall near guardrail at right upstream end of bridge; chiseled square. Elevation determined using GPS.

Elevation 915.58 ft

8805-15 NE (2)—(REFERENCE POINT) Approximately 4 mi southeast of Manchester, on County Road X21/240th Street bridge over Maquoketa River, on metal guardrail behind 3rd drain from right downstream end of bridge; three filed marks. Elevation determined using GPS.

Elevation 917.32 ft

8905-33 SW (1)—Approximately 0.5 mi south of Manchester, on eastbound lane of U.S. Highway 20 bridge over Maquoketa River (downstream bridge), on left upstream abutment; Iowa Department of Transportation bench mark. (RM 1)

Elevation 938.14 ft

8905-33 SW (2)—Approximately 0.5 mi south of Manchester, on eastbound lane of U.S. Highway 20 bridge over Maquoketa River (downstream bridge), on left downstream abutment; chiseled square. (RM 2)

Elevation 938.34 ft

8905-32 NE (1)—At Manchester, on Marion Street bridge over Maquoketa River, at left downstream end of bridge underneath Marion Street bridge sign; chiseled cross.

Elevation 939.00 ft

8905-32 NE (2)—At Manchester, on Marion Street bridge over Maquoketa River, on retaining wall at left upstream abutment; chiseled cross.

Elevation 938.93 ft

8905-32 NE (3)—(REFERENCE POINT) At Manchester, on Marion Street bridge over Maquoketa River, beneath metal box attached to downstream guardrail; edge of concrete sidewalk.

Elevation 940.72 ft

8905-32 NW (1)—At Manchester, on State Highway 13/West Main Street bridge over Maquoketa River, on left downstream end of sidewalk concrete barrier wall at end of metal rail; Iowa Department of Transportation bench mark. Elevation obtained from Iowa Department of Transportation.

Elevation 944.30 ft

8905-32 NW (2)—(REFERENCE POINT) At Manchester, on State Highway 13/West Main Street bridge over Maquoketa River, on downstream side of cyclone fence at 10th fence post from left downstream end of bridge; edge of concrete sidewalk.

Elevation 945.08 ft

8905-19 NE (1)—Approximately 0.5 mi northwest of Manchester, on 195th Street bridge over Maquoketa River, on right upstream end of lower wingwall; chiseled square. Elevation determined using GPS.

Elevation 943.11 ft

9006-27 SW (1)—At west edge of Dundee, on County Road C64/Richland Street bridge over Maquoketa River, on right downstream wingwall; chiseled square. Elevation of bench mark on bridge surveyed by USGS from elevation west of bridge provided by Delaware County Engineer's Office.

Elevation 992.57 ft

9006-27 SW (2)—(REFERENCE POINT) At west edge of Dundee, on County Road C64/Richland Street bridge over Maquoketa River, on guardrail at right of 10th guardrail post from left downstream end of bridge; filed arrow.

Elevation 994.90 ft

9006-22 NE (1)—At Backbone State Park, on southeast dam of two dams across Maquoketa River, below cyclone fence on downstream end of upper horizontal concrete structure on left end of dam; chiseled square. Elevation determined using GPS.

Elevation 1,007.34 ft

9006-22 NE (2)—(REFERENCE POINT) At Backbone State Park, on southeast dam of two dams across Maquoketa River, below cyclone fence on upstream end of upper horizontal concrete structure on left end of dam; most upstream edge of upper horizontal concrete surface. Elevation determined using GPS.

Elevation 1,007.48 ft

9006-22 NE (3)—(REFERENCE POINT) At Backbone State Park, on southeast dam of two dams across Maquoketa River, behind cyclone fence post on upstream end of lower horizontal concrete structure on left end of dam; most upstream edge of lower horizontal concrete surface. Elevation determined using GPS.

Elevation 996.08 ft

9006-09 SW (1)—At Backbone State Park, on Backbone State Park Road bridge across Maquoketa River near road leading to County Road C57/120th Street, on right downstream wingwall; Iowa Department of Transportation bench mark. Elevation determined using GPS.

Elevation 1,010.28 ft

9006-09 SW (2)—(REFERENCE POINT) At Backbone State Park, on Backbone State Park Road bridge across Maquoketa River near road leading to County Road C57/120th Street, on downstream concrete barrier wall about 1 ft right of center of concrete sections; chiseled square. Elevation determined using GPS.

Elevation 1,010.27 ft

9107-24 NE (1)—Approximately 3.5 mi west of Strawberry Point, on State Highway 3 bridge across Maquoketa River, on left downstream lower wingwall; Iowa Department of Transportation bench mark. Elevation obtained from Iowa Department of Transportation.

Elevation 1,088.42 ft

9107-24 NE (2)—(REFERENCE POINT) Approximately 3.5 mi west of Strawberry Point, on State Highway 3 bridge across Maquoketa River, on outer concrete platform behind 8th guardrail post from left downstream end of bridge; chiseled square.

Elevation 1,089.44 ft

9107-02 SW (1)—Approximately 2.25 mi southeast of Arlington, on State Highway 187 bridge across Maquoketa River, on left downstream wingwall; Iowa Department of Transportation bench mark. Elevation determined using GPS.

Elevation 1,109.99 ft

9107-02 SW (2)—(REFERENCE POINT) Approximately 2.25 mi southeast of Arlington, on State Highway 187 bridge across Maquoketa River, on outer concrete platform behind 3rd drain from right downstream end of bridge; chiseled square. Elevation determined using GPS.

Elevation 1,108.37 ft

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