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Prepared in cooperation with the Iowa Department of Transportation and the Iowa Highway Research Board (Project HR-140)

Summary of U.S. Geological Survey Reports Documenting Flood Profiles of Streams in Iowa, 1963–2012

Scientific Investigations Report 2014–5085

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

Cover photograph. View looking south at Colfax, Iowa, August 14, 2010, from the State Highway 117 bridge over the South Skunk River. Photograph by U.S. Geological Survey.

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U.S. Geological Survey
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The information contained herein also is based on data collected by the U.S. Army Corps of Engineers, the National Weather Service, and several State and local agencies who were involved with the collection of flood data.

Contents

Figures

Tables

Conversion Factors and Datums

Inch/Pound to SI

Multiply	By	To obtain
	Length	
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. The NGVD 29 can be converted to the North American Vertical Datum of 1988 by using the National Geodetic Survey conversion utility (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Climatic Data Center, 2013).

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, 2012, is the “2012 water year.”

Summary of U.S. Geological Survey Reports Documenting Flood Profiles of Streams in Iowa, 1963–2012

By David A. Eash

Abstract

This report is part of an ongoing program that is publishing flood profiles of streams in Iowa. The program is managed by the U.S. Geological Survey in cooperation with the Iowa Department of Transportation and the Iowa Highway Research Board (Project HR-140). Information from flood profiles is used by engineers to analyze and design bridges, culverts, and roadways. This report summarizes 47 U.S. Geological Survey flood-profile reports that were published for streams in Iowa during a 50-year period from 1963 to 2012. Flood events profiled in the reports range from 1903 to 2010. Streams in Iowa that have been selected for the preparation of flood-profile reports typically have drainage areas of 100 square miles or greater, and the documented flood events have annual exceedance probabilities of less than 2 to 4 percent. This report summarizes flood-profile measurements, changes in flood-profile report content throughout the years, streams that were profiled in the reports, the occurrence of flood events profiled, and annual exceedance-probability estimates of observed flood events. To develop flood profiles for selected flood events for selected stream reaches, the U.S. Geological Survey measured high-water marks and river miles at selected locations.

A total of 94 stream reaches have been profiled in U.S. Geological Survey flood-profile reports. Three rivers in Iowa have been profiled along the same stream reach for five different flood events and six rivers in Iowa have been profiled along the same stream reach for four different flood events. Floods were profiled for June flood events for 18 different years, followed by July flood events for 13 years, May flood events for 11 years, and April flood events for 9 years.

Most of the flood-profile reports include estimates of annual exceedance probabilities of observed flood events at streamgages located along profiled stream reaches. Comparisons of 179 historic and updated annual exceedance-probability estimates indicate few differences that are considered substantial between the historic and updated estimates for the observed flood events. Overall, precise comparisons for 114 observed flood events indicate that updated annual exceedance probabilities have increased for most of the observed flood events compared to the historic annual exceedance probabilities. Multiple large flood events exceeding the 2-percent annual exceedance-probability discharge estimate occurred at 37 of 98 selected streamgages during 1960–2012. Five large flood events were recorded at two streamgages in Ames during 1990–2010 and four large flood events were recorded at four other streamgages during 1973–2010. Results of Kendall's tau trend-analysis tests for 35 of 37 selected streamgages indicate that a statistically significant trend is not evident for the 1963–2012 period of record; nor is an overall clear positive or negative trend evident for the 37 streamgages.

Introduction

This report is part of an ongoing program that is publishing flood profiles of streams in Iowa. The program is managed by the U.S. Geological Survey (USGS) in cooperation with the Iowa Department of Transportation (Iowa DOT) and the Iowa Highway Research Board (Project HR-140). The flood-profile part of Project HR-140 is the preparation of longitudinal, water-surface elevation profiles of major flood events or of selected or theoretical discharges, or both, on principal streams in Iowa. The HR-140 flood-profile project began in 1958 and flood events in 1960 were the first floods profiled as part of this project. A total of 36 flood-profile reports have been prepared as part of Project HR-140 since the first flood-profile report was published in 1963 (Schwob, 1963), and the most recent flood-profile report was published in 2012 (Barnes and Eash, 2012). During this 50-year period from 1963–2012, a total of 47 flood-profile reports have been prepared either solely by the USGS or in cooperation with Iowa DOT or other state and local agencies (fig. 1). Flood events profiled in the reports range from a flood on the Des Moines River in 1903 to floods in the Maquoketa, Little Maquoketa (not shown on fig. 1), and South Skunk River Basins in 2010.

In most instances, flood records are limited to measurements of peak stage at a few locations along streams in Iowa. Major streams in Iowa are crossed at numerous locations by state and county roads and by municipal streets. Because of the size, cost, and overall importance of major stream crossings, it is beneficial to have more than just the minimum information about the magnitude and effects of floods on major streams. The efficient and safe design of bridges and culverts

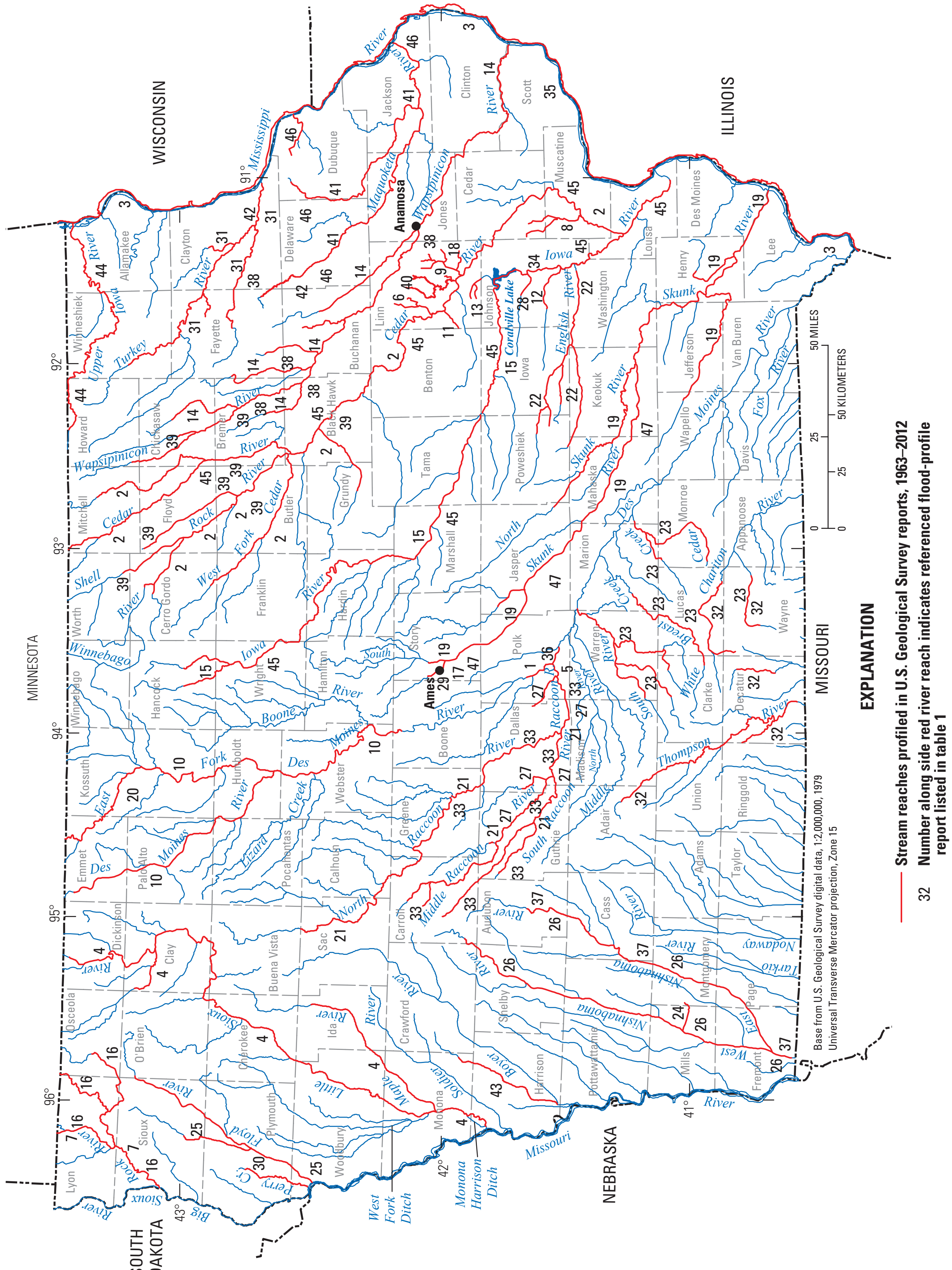

Figure 1. Stream reaches in Iowa where major flood events or selected or theoretical discharges, or both, have been profiled in reports prepared by the U.S. Geological Survey, 1963–2012.

depends, to a considerable extent, on accurate hydrologic information. In the design of a bridge or culvert, the engineer must provide adequate capacity for flow under or through the structure, as well as providing for vehicular traffic across it. In addition, attention must be given to what affect the structure, including its approach embankments, will have on the existing natural and manmade drainage facilities in the area. To resolve these matters satisfactorily, the designer needs reliable information about the amount of water flowing in the stream and, most importantly, about the magnitude and frequency of floods. Information from flood profiles is used by engineers to analyze and design bridges, culverts, and roadways. Water-surface elevations, collected upstream and downstream from bridges, enable engineers to model the hydraulics of actual flood events. Flood-profile reports provide engineers with information on the magnitude and frequency of flood events.

Flood-peak discharge and flood-profile information is needed for the economical and safe location of bridges and other structures on or over streams in Iowa and the adjacent flood plains. Defining the limits of flood inundation and establishing encroachment limits on flood plains are related issues dependent on information about flood-peak elevation and discharge. Data for major flood events are needed to compute annual exceedance-probability discharges and to calibrate water-surface elevation profile models for sites along streams. A list of USGS flood-profile reports for Iowa is available at *http://ia.water.usgs.gov/projects/profiles/ and http://ia.water.usgs.gov/flood/reports.html*.

Purpose and Scope

This report summarizes 47 USGS flood-profile reports that were published for streams in Iowa during a 50-year period from 1963 to 2012. Streams in Iowa selected for the preparation of flood-profile reports typically have drainage areas of 100 square miles (mi^2) or greater, and the documented floods have annual exceedance probabilities (AEPs) of less than 2–4 percent, or recurrence intervals (RIs) greater than 25–50 years. For example, a flood magnitude that has a 1-percent chance (AEP=0.01) of being exceeded during any particular year is expected to be exceeded on average once during any 100-year period (RI=100 years) (Holmes and Dinicola, 2010). Percent probability is the inverse of the RI multiplied by 100. This report summarizes flood-profile measurements, changes in flood-profile report content throughout the years, streams that were profiled in the reports, the occurrence of flood events profiled, and AEP estimates of observed flood events.

Flood-Profile Measurements

To develop flood profiles for selected flood events on selected stream reaches, the USGS measured high-water marks and river miles, typically at selected bridge sites. Flood profiles are longitudinal profiles of a river depicted graphically with river miles defining the abscissa (horizontal axis) and water-surface elevations defining the ordinate (vertical axis). Since the early 1990s, river miles for flood profiles were determined 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. Before the early 1990s, manual methods were used to measure river miles along stream reaches using the best available maps and aerial photography (Barnes and Eash, 1994; Einhellig and Eash, 1996; Eash, 1996b; Eash and Koppensteiner, 1996).

High-Water Marks

Since the mid-1990s, high-water marks (HWMs) used in the profiles were typically measured within a few days after the flood events at all Federal and State highway bridges, at USGS streamgages, at selected county and local bridges, and at selected dams. County and local bridges were selected along the profiled reaches to obtain HWMs at intervals of about every 10 miles (mi) or less apart. Before the mid-1990s, HWMs were collected at almost every bridge crossing along the profiled reaches.

The HWMs at bridges were located immediately downstream from the bridge and one bridge-length width distance upstream from the bridge. The one bridge-length width distance used for measuring HWM elevations on the upstream side of bridges, in addition to the HWM elevation measured on the downstream side of bridges, provides an indication of the amount of fall or backwater caused by the contraction in the channel width from the bridge-structure openings. The drawdown zone on the upstream side of a bridge is assumed to be approximately one bridge-length width in distance upstream from the bridge opening and the use of one bridge-length width distance on the upstream side of a bridge attempts to avoid the collection of HWMs in the drawdown zone (Matthai, 1967).

Average HWM elevations determined for the upstream and downstream sides of bridges define the water-surface elevations for plotting flood profiles. Average HWM elevations generally were calculated on the basis of about 2 to 5 HWMs surveyed on each side of the bridge. A brief description noting the type of HWM surveyed, the general location of the HWM, and the quality of the HWM were noted at the time the HWM was surveyed. Typical HWM descriptions include comments such as mud line, seed line, stain line, or debris on an object such as a tree, an embankment, or a structure such as a bridge, a building, or a fence post. Each HWM surveyed was rated as excellent, good, fair, or poor (Benson and Dalrymple, 1967). Average HWM elevations were calculated for each side of the bridge on the basis of all of the surveyed HWM elevations or on selected HWM elevations with higher-quality ratings.

The HWMs were surveyed to bench marks (BMs) and temporary bench marks (TBMs) at bridges, dams, and intermediate sites typically within a few days of the flood peak, and were later referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29) by differential leveling or differential positioning using a global positioning system (GPS). The NGVD 29, spheroidal in shape, is a level surface that approximates mean sea level (Kennedy, 1990). Occasionally, HWMs were flagged, described, and rated to preserve the marks until they could be surveyed to BMs and TBMs at a later time. The profile lines connecting the HWMs in flood-profile graphs in flood-profile reports approximate the flood elevation between HWMs. The lines do not account for any intermediate features that could affect flood elevation such as channel and floodplain morphology or bridges and dams where HWMs were not measured.

Bench Marks

To facilitate measuring and referencing the HWMs used in the flood profiles to a common datum, BMs, TBMs, and reference points (RPs) were found or established by the USGS at selected bridges and dams along the profiled stream reaches. All BM, TBM, and RP elevations are referenced to the NGVD 29. Before the mid-1990s, BM, TBM, and RP elevations established by the USGS were determined from differential leveling (Kennedy, 1990; Kenney, 2010), and since the mid-1990s, they have been determined from a combination of GPS technology and differential leveling (Eash and Koppensteiner, 1997a; Eash and Koppensteiner, 1997b; Ballew and Fischer, 2000; Ballew and Eash, 2001).

Level lines to establish third-order accuracy for differential leveling of BMs and TBMs were surveyed from first- or second-order BMs established and adjusted by the National Geodetic Survey (NGS; 2012) or the USGS (U.S. Geological Survey, 2005). Errors in closure in the USGS level work were adjusted along the level line to the elevations published by the NGS and the USGS.

The USGS has been using survey-grade GPS equipment in Iowa for referencing BMs and TBMs to NGVD 29 since the mid-1990s. Elevations surveyed using GPS equipment were collected in North American Vertical Datum of 1988 and were then converted to NGVD 29 using the National Geodetic Survey conversion utility (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Climatic Data Center, 2013). Global Navigation Satellite System (GNSS) data were surveyed by the USGS using static and Real Time Kinematic (RTK) survey methods to establish vertical datum for BMs and TBMs (Rydlund and Densmore, 2012). From the mid-1990s until 2004, static surveys of GNSS data were measured using specific GPS-network and satellite-constellation configurations, equivalent hours of data collection with multiple GPS receivers, and post-processing quality controls to control the effects of errors in the elevation-solution results. Since 2004, static surveys of GNSS data collected from a single GPS receiver were submitted for processing to the Online Positioning User Service (OPUS), an Internet service provided by the NGS (2014). The quality of the OPUS solution results is based on the guidelines of "What to look for in a quality solution" (National Geodetic Survey, 2014). Since 2010, most of the GNSS data were surveyed and processed using RTK equipment and the Iowa Real-Time Network (Iowa Department of Transportation, 2014), also referred to as the IaRTN SmartNet, a GNSS reference station network service provided by Iowa DOT and Leica Geosystems (Leica Geosystems, 2011). The quality of the RTK solution results is based on an average of multiple sets of GNSS data collected using satellite configurations spaced at least 30 minutes apart, and on comparisons of elevations between RTK GNSS surveys of GPS BMs and published elevations.

In general, BMs are points that were designed specifically to mark an elevation (Rydlund and Densmore, 2012), such as USGS elevation disks and Iowa DOT BMs (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, were used as TBMs or RPs. The BMs, TBMs, and RPs are designated in flood-profile reports by an index number or legal description derived from their respective locations using Public Land Survey System coordinates (township, range, section, and quarter section).

In addition, bridge-deck, low-bridge chord, and reference-point elevations were measured with respect to the BMs and TBMs. The elevations for the bridge deck and low-bridge chord generally were measured on the lowest end of the bridge. The inclusion of bridge-deck and low-bridge chord elevations in flood-profile reports began in the mid-1980s (Heinitz, 1986a). The RPs 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 stream and to define the low-water slope.

Peak Discharges

Peak-discharge measurements are needed to estimate the AEP, or RI, of observed flood events, which are then used to provide information on the magnitude and frequency of floods at locations along profiled stream reaches. Direct measurements of peak discharges usually were determined using current meters or hydroacoustic equipment (Turnipseed and Sauer, 2010; Mueller and Wagner, 2009) to measure streamflow at streamgage locations or at selected sites along profiled reaches. Continuous-record and crest-stage streamgages located along profiled reaches also provide direct measurements of peak discharge by the automatic recording of peak stages at continuous-record streamgages or by the recording of HWMs at crest-stage streamgages. Stage-discharge relations, or rating curves, maintained for streamgages, are then used to determine the peak discharges of flood events at these locations (Kennedy, 1984).

For floods that are profiled or documented along stream reaches where streamgage information is not available, indirect measurements are made to determine peak discharges of flood events at selected locations. Dependent on the type of indirect measurement applicable for a selected stream site, additional field surveys of HWMs, channel and flood-plain cross sections, and bridge or culvert geometry are required before computations of peak discharges can be made. Peak discharges listed in flood-profile reports that were determined using indirect-measurement methods typically are noted as computed from an indirect measurement.

The most common indirect-measurement method used for determining peak discharges at profiled stream sites in Iowa is the contracted-opening measurement. The contraction of a stream channel by a road crossing creates an abrupt drop in water-surface elevation between an approach section and the contracted section under the bridge (Matthai, 1967). The contracted section framed by the bridge abutments and the channel bed can be utilized as a discharge meter to compute a peak discharge. If at least 0.5 foot (ft) of fall is measured at a bridge site between upstream and downstream HWMs, a contracted-opening indirect measurement can be made to determine the peak discharge of the flood at this location.

The slope-area method is the second most common indirect-measurement method used for determining peak discharges at profiled stream sites in Iowa. In the slope-area method, discharge is computed on the basis of a uniform-flow equation involving channel characteristics, water-surface profiles, and a roughness coefficient (Dalrymple and Benson, 1967). The drop in a water-surface elevation profile for a uniform reach of channel represents losses caused by bed roughness, which allows for the application of the Manning equation (Dalrymple and Benson, 1967) to compute a peak discharge. Other methods of indirect measurements that have been used for determining peak discharges at stream sites in Iowa for flood-profile reports include the culvert method (Bodhaine, 1968), the flow-over-road-embankment method (Hulsing, 1967), and the step-backwater method (Davidian, 1984).

Flood-Profile Reports

Streams in Iowa where major flood events or selected or theoretical discharges, or both, have been profiled in reports published by the USGS during 1963–2012 are shown in figure 1. Flood events profiled in the reports range from a flood on the Des Moines River in 1903 to floods in the Maquoketa, Little Maquoketa, and South Skunk River Basins in 2010. Numbers next to profiled stream reaches shown in red in figure 1 correspond to the 47 flood-profile reports listed in table 1 in chronological order. Of these reports, 36 were prepared in cooperation with Iowa DOT as part of the HR-140 project. Prior to 1975, flood-profile reports were funded cooperatively by the Iowa State Highway Commission before the reorganization into Iowa DOT. Three of the reports listed in table 1 were prepared in cooperation with Linn County, two of the reports were prepared in cooperation with the City of Cedar Rapids, one report was prepared in cooperation with the Iowa Institute of Hydraulic Research and the City of Des Moines, and one report was prepared in cooperation with Iowa Geological Survey. Four of the reports listed in table 1 are Hydrologic Investigations Atlases prepared solely by the USGS. The first Atlas listed in table 1 by Myers (1963) also was included in the report by Carpenter and Appel (1966).

Changes in Report Content Throughout the Years

The 47 flood-profile reports from table 1, organized by river basin and with stream names and dates of the floods profiled included, are listed in table 2. Profiles of selected discharges were included in 16 of the first 19 flood-profile reports that were published before 1979. Flood profiles of selected discharges typically are profiles of AEP or RI discharge estimates computed at the time the report was prepared. Because profiles of AEP discharges are estimates of the magnitude and frequency of floods, they are theoretical and do not represent measured water-surface elevations of observed flood events. Annual AEP discharge estimates used for developing theoretical profiles were calculated using USGS regression equations (Schwob, 1953; Schwob, 1966a; Lara, 1973) that were current at the time the report was prepared. Flood profiles of selected discharges were determined from stage-discharge relations (rating curves) at streamgages (Kennedy, 1984) and supplemental discharge measurements, or by standard methods of step-backwater computation (Davidian, 1984). At some locations, estimates of selected-discharge elevations were based on extensions of rating curves.

Flood-profile reports include a map of the stream reaches profiled and the drainage-basin boundary for the profiled streams, which includes county lines, highways, and municipal areas within the basin for locational reference. The reports usually include sections describing the river basin study area, the flood history of the river basin, and the observed flood events and profiles. Information on rainfall amounts, antecedent conditions, and storm descriptions leading to the flood event typically are included in the reports. Since 1996, most reports have included isohyetal maps illustrating the areal distribution of the rainfalls that caused the flood events. Most of the isohyetal maps were provided by Harry Hillaker, State Climatologist, Iowa Department of Agriculture and Land Stewardship. A list of BMs and RPs at bridge sites along the profiled stream reaches is included in 31 of the reports (table 2). Eight of the reports include a flood-inundation map of the flood event and one report includes aerial photography of the flood (table 2).

Flood-profile reports include flood-peak discharge, stage, and date information for selected largest flood events at streamgages located in the basin of the profiled stream reaches. Before 1993, many of the reports included graphs depicting annual peak discharges for the period of record for these streamgages; and before 1999, most reports included the publication of annual peak-discharge records for these streamgages. Annual peak-discharge records are available for

Table 1. Chronology of U.S. Geological Survey reports documenting flood profiles of streams in Iowa, 1963–2012.

Report number	Report citation
1	Myers, R.E., 1963, Floods at Des Moines, Iowa: U.S. Geological Survey Hydrologic Investigations Atlas HA-53, 1 sheet, scale 1:24,000, *in* Carpenter, P.J., and Appel, D.H., 1966, Water-surface profiles of Raccoon River at Des Moines, Iowa: U.S. Geological Survey Open-File Report 67–37, 12 p. Prepared solely by U.S. Geological Survey.
2	Schwob, H.H., 1963, Cedar River Basin floods: Ames, Iowa Department of Transportation, Iowa Highway Research Board Bulletin No. 27, 59 p.
3	Schwob, H.H., and Meyers, R.E., 1965, The 1965 Mississippi River flood in Iowa: U.S. Geological Survey Open-File Report 65–145, 46 p. Sponsored cooperatively by the Iowa Geological Survey.
4	Schwob, H.H., 1966b, Little Sioux River Basin floods: U.S. Geological Survey Open-File Report 67–196, 60 p.
5	Carpenter, P.J., and Appel, D.H., 1966, Water-surface profiles of Raccoon River at Des Moines, Iowa: U.S. Geological Survey Open-File Report 67–37, 12 p., includes Hydrologic Investigations Atlas HA-53 (listed above). Sponsored cooperatively by the Iowa Institute of Hydraulic Research and City of Des Moines.
6	Schwob, H.H., 1967, Floods on Otter Creek in Linn County, Iowa: U.S. Geological Survey Open-File Report 67–195, 22 p. Sponsored cooperatively by Linn County, Iowa.
7	Carpenter, P.J., 1967, Floods in Rock River Basin: U.S. Geological Survey Open-File Report 67–36, 28 p.
8	Schwob, H.H., 1968, Flood of June 7, 1967, in the Wapsinonoc Creek Basin, Iowa: U.S. Geological Survey Open-File Report 68-b, 21 p.
9	U.S. Geological Survey, 1968, Flood profile study, Squaw Creek, Linn County, Iowa: U.S. Geological Survey Open-File Report 68–302, 13 p. Sponsored cooperatively by the City of Cedar Rapids, Iowa.
10	Schwob, H.H., 1970d, Floods in the upper Des Moines River Basin, Iowa: U.S. Geological Survey Open-File Report 70–296, 49 p.
11	Schwob, H.H., 1970c, Flood profile study, Morgan Creek, Linn County, Iowa: U.S. Geological Survey Open-File Report 70–295, 16 p. Sponsored cooperatively by the City of Cedar Rapids, Iowa.
12	Schwob, H.H., 1970a, Flood of March 3, 1970, on Old Mans Creek, Johnson County, Iowa: U.S. Geological Survey Open-File Report 70–293, 9 p.
13	Schwob, H.H., 1970b, Flood profile study, Hoosier Creek, Linn County, Iowa: U.S. Geological Survey Open-File Report 70–294, 18 p. Sponsored cooperatively by Linn County, Iowa.
14	Schwob, H.H., 1971, Floods in the Wapsipinicon River Basin, Iowa: U.S. Geological Survey Open-File Report (unnumbered), 52 p.
15	Heinitz, A.J., 1973a, Floods in the Iowa River Basin upstream from Coralville Lake, Iowa: U.S. Geological Survey Open-File Report 73–106, 75 p.
16	Heinitz, A.J., 1973b, Floods in the Rock River Basin, Iowa: U.S. Geological Survey Open-File Report 74–1047, 74 p.
17	Lara, O.G., and Heinitz, A.J., 1976, Flood of June 27, 1975, in city of Ames, Iowa: U.S. Geological Survey Open-File Report 76–728, 56 p.
18	Heinitz, A.J., 1977, Floods in the Big Creek Basin, Linn County, Iowa, U.S. Geological Survey Open-File Report 77–209, 35 p. Sponsored cooperatively by Linn County, Iowa.
19	Heinitz, A.J., and Wiitala, S.W., 1978, Floods in the Skunk River Basin, Iowa: U.S. Geological Survey Open-File Report 79–272, 80 p.
20	Heinitz, A.J., 1979, Supplement to floods in the upper Des Moines River Basin, Iowa: U.S. Geological Survey Open-File Report 79–1486, 6 p.
21	Heinitz, A.J., 1980, Floods in the Raccoon River Basin, Iowa: U.S. Geological Survey Open-File Report 80–162, 110 p.
22	Heinitz, A.J., and Riddle, D.E., 1981, Floods in the English River Basin, Iowa: U.S. Geological Survey Open-File Report 81–67, 61 p.
23	Heinitz, A.J., 1986a, Floods in south-central Iowa: U.S. Geological Survey Open-File Report 85–100, 95 p.
24	Heinitiz, A.J., 1986b, Floods of June–July, 1982, in Iowa: U.S. Geological Survey Open-File Report 85–151, 18 p. (Also available at *http://pubs.usgs.gov/of/1985/0151/report.pdf*.)
25	Heinitz, A.J., 1986c, Floods in the Floyd River Basin, Iowa: U.S. Geological Survey Open-File Report 86–476, 61 p. (Also available at *http://pubs.usgs.gov/of/1986/0476/report.pdf*.)
26	Eash, D.A., and Heinitz, A.J., 1991, Floods in the Nishnabotna River Basin, Iowa: U.S. Geological Survey Open-File Report 91–171, 118 p. (Also available at *http://pubs.usgs.gov/of/1991/0171/report.pdf*.)
27	Baebenroth, R.W., and Schaap, B.D., 1992, Floods of 1986 and 1990 in the Raccoon River Basin, west-central Iowa: U.S. Geological Survey Open-File Report 92–94, 144 p. (Also available at *http://pubs.usgs.gov/of/1992/0094/report.pdf*.)

Table 1. Chronology of U.S. Geological Survey reports documenting flood profiles of streams in Iowa, 1963–2012.—Continued

Report number	Report citation
28	Barnes, K.K., and Eash, D.A., 1994, Flood of June 17, 1990, in the Clear Creek Basin, east-central Iowa: U.S. Geological Survey Open-File Report 94–78, 21 p. (Also available at *http://pubs.usgs.gov/of/1994/0078/report.pdf*.)
29	Einhellig, R.F., and Eash, D.A., 1996, Floods of June 17, 1990, and July 9, 1993, along Squaw Creek and the South Skunk River in Ames, Iowa, and vicinity: U.S. Geological Survey Open-File Report 96–249, 34 p. (Also available at *http://pubs.usgs.gov/of/1996/0249/report.pdf*.)
30	Eash, D.A., 1996b, Flood of May 19, 1990, along Perry Creek in Plymouth and Woodbury Counties, Iowa: U.S. Geological Survey Open-File Report 96–476, 39 p.
31	Eash, D.A., and Koppensteiner, B.A., 1996, Floods of July 12, 1972, March 19, 1979, and June 15, 1991, in the Turkey River Basin, northeast Iowa: U.S. Geological Survey Open-File Report 96–560, 55 p. (Also available at *http://pubs.usgs.gov/of/1996/0560/report.pdf*.)
32	Eash, D.A., and Koppensteiner, B.A., 1997a, Floods of September 15–16, 1992, in the Thompson, Weldon, and Chariton River Basins, south-central Iowa: U.S. Geological Survey Open-File Report 97–122, 68 p. (Also available at *http://pubs.usgs.gov/of/1997/0122/report.pdf*.)
33	Eash, D.A., and Koppensteiner, B.A., 1997b, Flood of July 9–11, 1993, in the Raccoon River Basin, west-central Iowa: U.S. Geological Survey Open-File Report 97–557, 117 p. (Also available at *http://pubs.usgs.gov/of/1997/0557/report.pdf*.)
34	Schaap, B.D., and Harvey, C.A., 1995, Delineation of flooding within the upper Mississippi River Basin, 1993—Flood of June 29–September 18, 1993, in Iowa City and vicinity, Iowa: U.S. Geological Survey Hydrologic Investigations Atlas HA735-B, 1 sheet, scale 1:24,000. Prepared solely by U.S. Geological Survey.
35	Schaap, B.D., 1996a, Delineation of flooding within the upper Mississippi River Basin—Flood of June 19–July 31, 1993, in Davenport, Iowa, and vicinity: U.S. Geological Survey Hydrologic Investigations Atlas HA735-C, 1 sheet, scale 1:24,000. Prepared solely by U.S. Geological Survey.
36	Schaap, B.D., 1996b, Delineation of flooding within the upper Mississippi River Basin—Flood of June 18 through August 4, 1993, in Des Moines and vicinity, Iowa: U.S. Geological Survey Hydrologic Investigations Atlas HA735-D, 2 sheets, scale 1:24,000. Prepared solely by U.S. Geological Survey.
37	Fischer, E.E., 1999, Flood of June 15–17, 1998, Nishnabotna and East Nishnabotna Rivers, southwest Iowa: U.S. Geological Survey Open-File Report 99–70, 15 p. (Also available at *http://pubs.usgs.gov/of/1999/0070/report.pdf*.)
38	Ballew, J.L., and Fischer, E.E., 2000, Floods of May 17–20, 1999, in the Volga and Wapsipinicon River Basins, northeast Iowa: U.S. Geological Survey Open-File Report 00–237, 36 p. (Also available at *http://pubs.usgs.gov/of/2000/0237/report.pdf*.)
39	Ballew, J.L., and Eash D.A., 2001, Floods of July 19–25, 1999, in the Wapsipinicon and Cedar River Basins, northeast Iowa: U.S. Geological Survey Open-File Report 01–13, 45 p. (Also available at *http://pubs.usgs.gov/of/2001/0013/report.pdf*.)
40	Eash, D.A., 2004a, Flood of June 4, 2002, in the Indian Creek Basin, Linn County, Iowa: U.S. Geological Survey Open-File Report 2004–1074, 31 p. (Also available at *http://pubs.usgs.gov/of/2004/1074/ofr20041074.pdf*.)
41	Eash, D.A., 2004b, Flood of June 4–5, 2002, in the Maquoketa River Basin, east-central Iowa: U.S. Geological Survey Open-File Report 2004–1250, 29 p. (Also available at *http://pubs.usgs.gov/of/2004/1250/pdf/ofr20041250.pdf*.)
42	Eash, D.A., 2006, Flood of May 23, 2004, in the Turkey and Maquoketa River Basins, Northeast Iowa: U.S. Geological Survey Open-File Report 2006–1067, 35 p. (Also available at *http://pubs.usgs.gov/of/2006/1067/pdf/OFR_2006-1067.pdf*.)
43	Fischer, E.E., and Eash, D.A., 2008, Flood of May 6, 2007, Willow Creek, West-Central Iowa: U.S. Geological Survey Open-File Report 2008–1229, 11 p. with appendix. (Also available at *http://pubs.usgs.gov/of/2008/1229/pdf/OFR2008-1229.pdf*.)
44	Fischer, E.E., and Eash, D.A., 2010, Flood of June 8–9, 2008, Upper Iowa River, northeast Iowa: U.S. Geological Survey Open-File Report 2010–1087, 17 p. with appendix. (Also available at *http://pubs.usgs.gov/of/2010/1087/pdf/OF2010-1087.pdf*.)
45	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. (Also available at *http://pubs.usgs.gov/of/2010/1190/pdf/of2010-1190.pdf*.)
46	Eash, D.A., 2012, Floods of July 23–26, 2010, in the Little Maquoketa River and Maquoketa River Basins, northeast Iowa: U.S. Geological Survey Open-File Report 2011–1301, 45 p. with appendix. (Also available at *http://pubs.usgs.gov/of/2011/1301/pdf/of2011-1301.pdf*.)
47	Barnes, K.K., and Eash, D.A., 2012, Flood of August 11–16, 2010, in the South Skunk River Basin, central and southeast Iowa: U.S. Geological Survey Open-File Report 2012–1202, 27 p. with appendix. (Also available at *http://pubs.usgs.gov/of/2012/1202/of2012-1202.pdf*.)

Table 2. Streams in Iowa for which profiles of major floods are documented in U.S. Geological Survey reports, 1963–2012.

Report number[a]	Stream name and dates of floods profiled[b]	Profiles of selected discharges[c]	List of bench marks and reference points
	Mississippi River		
3	Mississippi River floods of April 1952, April 1960, April 24–May 1, 1965; from Minnesota to Missouri for 1952 and 1965 floods.	no	no
35	Mississippi River flood of July 9, 1993, in vicinity of Davenport and Bettendorf; includes flood-inundation map.	no	no
	Northeast Iowa River Basins		
31	Turkey River floods of July 12, 1972; March 19, 1979; and June 15, 1991. Volga River flood of March 19, 1979, and June 15, 1991; Roberts Creek flood June 15, 1991. Otter Creek flood of June 15, 1991.	no	yes
38	Volga River floods of March 19, 1979; June 15, 1991; and May 17, 1999.	no	yes
42	Turkey River floods of March 19, 1979; June 15, 1991; and May 23, 2004. Volga River floods of March 19, 1979; June 15, 1991; May 17, 1999; and May 23, 2004.	no	yes
44	Upper Iowa River flood of June 8–9, 2008.	no	yes
46	Little Maquoketa River and North Fork Little Maquoketa River flood of July 23, 2010.	no	yes
	Maquoketa River Basin		
41	Maquoketa River and North Fork Maquoketa River flood of June 4–5, 2002.	no	yes
42	Maquoketa River floods of June 4, 2002, and May 23, 2004.	no	yes
46	Maquoketa River floods of June 4–5, 2002; May 23, 2004; and July 24–26, 2010. North Fork Maquoketa River floods of June 4–5, 2002, and July 23–24, 2010.	no	yes
	Wapsipinicon River Basin		
14	Wapsipincon River floods of April 1962; July 1962; July 14–18, 1966; July 18–25, 1968; and June 29–July 9, 1969. Buffalo Creek flood of June 1964; July 17, 1968; and July 18, 1969. Pine Creek flood of July 17, 1968. Little Wapsipinicon River (Buchanan/Fayette Counties) floods of July 14, 1966, and July 17, 1968. Crane Creek flood of July 1968. East Branch Wapsipinicon River floods of July 14, 1966, and June 26,1969.	yes	no
38	Wapsipinicon River floods of July 1968 and May 1999. Crane Creek floods of July 1968; and May 1999. Litte Wapsipinicon River floods of July 14, 1966; July 17, 1968; and May 17, 1999. Otter Creek flood of May 1999.	no	yes
39	Wapsipinicon River floods of June 29–July 1, 1969; May 1999; and July 21, 1999.	no	yes
	Iowa River Basin		
12	Old Mans Creek flood of March 3, 1970.	yes	yes
13	Hoosier Creek, only selected discharge profiles.	yes	yes
15	Iowa River floods of June 1944; June 1947; June 21–28, 1954; July 1–12, 1969; and June 1972. West Branch Iowa River floods of June 1944; June 21, 1954; and July 1969. East Branch Iowa River floods of June 1944; June 17–19, 1954; and July 29, 1969.	yes	no
22	English River floods of September 21, 1965; June 14, 1966; April 30, 1974. North English River flood of April 28, 1974. South English River flood of April 29, 1974. Middle English River flood of April 1974. Deep River flood of April 29, 1974.	no	yes
28	Clear Creek flood of June 17, 1990.	no	yes
34	Iowa River floods, maximum elevations during July 19–August 10, 1993, in vicinity of Iowa City; includes flood-inundation map	no	no
45	Iowa River floods of July 1–12, 1969, and June 9–15, 2008.	no	yes

Table 2. Streams in Iowa for which profiles of major floods are documented in U.S. Geological Survey reports, 1963–2012.—Continued

Report number[a]	Stream name and dates of floods profiled[b]	Profiles of selected discharges[c]	List of bench marks and reference points
	Cedar River Basin		
2	Cedar River floods of March 29–April 4, 1960; March 27–April 2, 1961; and March 30–April 5, 1962. Black Hawk Creek floods of May 1957, August 1957, March 1960; and April 1960. West Fork Cedar River floods of March 1961 and March 1962. Shell Rock River floods of March 1961 and March–April 1962. Winnebago River floods of March 1961 and March 1962. Willow Creek floods of March 1961 and March 1962. Little Cedar River floods of March 1961 and March 1962. Flood Creek flood of May 10, 1963.	yes	no
6	Otter Creek, West Otter Creek, and East Otter Creek floods of September 21, 1965, and June 28, 1966.	yes	yes
8	Wapsinonoc Creek, West Wapsinonoc Creek, and Hoover Creek flood of June 7, 1967.	no	yes
9	Squaw Creek, only selected discharge profiles and flood-inundation map.	yes	no
11	Morgan Creek, only selected discharge profiles.	yes	yes
18	Big Creek floods of July 1971, December 1971, and May 16, 1974. East Big Creek flood of May 16, 1974. Crapabble Creek flood of May 16, 1974. Elbow Creek flood of May 16, 1974. Abbe Creek flood of May 16, 1974.	yes	yes
39	Cedar River floods of March 27–29, 1961, and July 21–23, 1999. Shell Rock River floods of March 1961 and July 1999. Flood Creek floods of May 10, 1963, and July 1999.	no	yes
40	Indian Creek and Dry Creek floods of September 13–14, 1961; July 3, 1962; and June 4, 2002; includes flood-inundation map.	no	yes
45	Cedar River floods of March 27–April 2, 1961; July 21–23, 1999; and June 9–15, 2008.	no	yes
	Skunk River Basin		
17	South Skunk River flood of June 27–28, 1975; and Squaw Creek flood of June 27, 1975; includes flood-inundation map and aerial photography of flood event.	no	yes
19	Skunk River floods of September 1965 and April 1973. South Skunk River floods of May 19–20, 1944; June 16, 1972; May 18–22, 1974; and June 27–28, 1975. Big Creek flood of April 22, 1973. Cedar Creek flood April 22, 1973, and April 24, 1976. North Skunk River flood of May 1974. Indian Creek flood of June 14, 1972. Squaw Creek flood of June 27, 1975.	yes	no
29	South Skunk River floods of June 27–28, 1975; June 17, 1990; and July 9, 1993. Squaw Creek floods of June 27, 1975; June 17, 1990; and July 9, 1993.	no	yes
47	South Skunk River floods of May 19–20, 1944; June 27–28, 1975; June 17, 1990; July 9–15, 1993; and August 11–16, 2010.	no	yes
	Des Moines River Basin		
1	Des Moines River floods of May 31, 1903; June 26, 1947; June 24, 1954; and April 2, 1960; includes flood-inundation map.	yes	no
10	Des Moines River floods of June 23–24, 1947; June 13, 1953; June 21–22, 1954; July 1964; September 1964; April 8–10, 1965; and April 11–14, 1969. East Fork Des Moines River floods of April 1965 and October 1968.	yes	no
20	East Fork Des Moines River floods of April 1965, October 1968, April 1969, and August 1979.	no	no
23	South River flood of July 1981; Squaw Creek flood of July 1981; Otter Creek flood of July 5, 1981; White Breast Creek floods of July 5, 1981, and July 16, 1982; Cedar Creek floods of July 4, 1981, and July 3, 1982; and North Cedar Creek floods of July 4, 1981, and July 16, 1982.	no	yes
36	Des Moines River flood of July 11, 1993; profile in vicinity of Des Moines, includes flood-inundation map.	no	no

Table 2. Streams in Iowa for which profiles of major floods are documented in U.S. Geological Survey reports, 1963–2012.—Continued

Report number[a]	Stream name and dates of floods profiled[b]	Profiles of selected discharges[c]	List of bench marks and reference points
	Raccoon River Basin		
1, 5	Raccoon River floods of June 13 and 26, 1947, and April 2, 1960; includes flood-inundation map.	yes	no
21	Raccoon River floods of June 13, 1947, and March 19, 1979. North Raccoon River floods of March 1979. South Raccoon River flood of March 1979. Middle Raccoon River flood of March 1979.	no	yes
27	Raccoon River floods of March 19, 1979, and July 1, 1986. South Raccoon River floods of March 1979 and June 29–July 1, 1986. Middle Raccoon River floods of March 1979 and June 29–July 1, 1986. Walnut Creek floods of July 1, 1973, and May 10, 1986. Mosquito Creek flood of June 29–July 1, 1986. Willow Creek flood of June 29–July 1, 1986.	no	yes
33	Raccoon River floods of June 13, 1947; March 19, 1979; July 1, 1986; and July 9–11, 1993. North Raccoon River floods of March 1979; June 29–July 1, 1986; and July 9–11, 1993. South Raccoon River floods of March 1979; June 29–July 1, 1986; and July 9–11, 1993. Brushy Creek flood of July 9–11, 1993. Middle Raccoon River flood of March 1979; June 29–July 1, 1986; and July 9–11, 1993. Storm Creek flood of July 9–11, 1993.	no	yes
36	Raccoon River flood of July 11, 1993; profile in vicinity of Des Moines, includes flood-inundation map.	no	no
	Western Iowa River Basins		
4	Little Sioux River floods of June 1953, June 1954, March 1962, July 1962, September 1964, and April 1965; Maple River flood of March 1962; and Ocheyedan River flood of September 8–9, 1964.	yes	no
7	Rock River floods of March 29–30, 1962; September 7–8, 1964; and April 2, 1965.	yes	no
16	Rock River floods of March 29–30, 1962; September 7–8, 1964; April 2, 1965; and April 7–8, 1969. Little Rock River flood of April 1969. Otter Creek flood of April 6, 1969.	yes	yes
25	Floyd River floods of June 7–8, 1953; March 1962; March 3–4, 1973; and June 20–21, 1983. West Branch Floyd River floods of March 3, 1973, and June 20, 1983.	no	yes
30	Perry Creek flood of May 19, 1990.	no	yes
43	Willow Creek flood of May 6, 2007.	no	yes
	Nishnabotna River Basin		
24	Indian Creek flood of June 15, 1982.	no	no
26	Nishnabotna River floods of September 15, 1972, and May 27, 1987. West Nishnabotna River floods of September 1972 and May 1987. East Nishnabotna River floods of September 12–15, 1972, and May 27, 1987. Indian Creek flood of June 15, 1982.	no	yes
37	Nishnabotna River flood of September 15, 1972, and June 17, 1998. East Nishnabotna River floods of September 12–15, 1972, and June 15–17, 1998.	no	yes
	Southern Iowa River Basins		
23	Chariton River and South Fork Chariton River flood of July 4, 1981.	no	yes
32	Thompson River flood of September 15–16, 1992. Elk Creek flood of September 15, 1992. Weldon River flood of September 15, 1992. Chariton River flood of July 4, 1981, and September 15, 1992. South Fork Chariton River flood of July 4, 1981, and September 15, 1992.	no	yes

[a]See table 1 for report citation for report number.

[b]Days of some floods are approximate for downstream or upstream ends of profiles.

[c]Selected discharges typically are annual exceedance-probability discharge (flood-frequency discharge) estimates computed at time of report preparation.

streamgages at *http://nwis.waterdata.usgs.gov/ia/nwis/peak*. Additional surface-water data for Iowa streamgages, including information on types of data available and years of data collection, are available from the USGS National Water Information System (NWIS) database (U.S. Geological Survey, 2011). Before 1991, many of the reports included stage-discharge relations (rating curves) for streamgages along the profiled stream reaches; rating curves are available for streamgages at *http://waterwatch.usgs.gov/index.php*, by first selecting "Toolkit," then selecting "Rating Curve," and then by typing the streamgage site number in the "Customized Rating Curve Builder."

Most of the flood-profile reports include estimates of the magnitude and frequency of observed flood events at streamgages along profiled stream reaches (see the "Annual Exceedance-Probability Estimates" section for more information). Before 2009, estimates of the magnitude and frequency of observed flood events at streamgages were reported as RIs, in years, and estimated to a precise number of years, such as 75 years. Since 2009, estimates of the magnitude and frequency of observed flood events at streamgages have been reported as AEPs, in percent, and estimated as a percent range, such as 1–2 percent. Before 1997, most reports included graphs or tables of annual exceedance-probability relations or estimates calculated from regional regression equations (Schwob, 1953; Schwob, 1966a; Lara, 1973; Lara, 1987; Eash, 1993), indicating the magnitude and frequency of observed flood events at streamgages located along profiled stream reaches. Since 1997, most of the reports have included discharge hydrographs of observed flood events at streamgages along the profiled reaches. Most of the hydrographs depict discharges for selected AEPs that graphically indicate the magnitude and frequency of flood events at streamgage locations. Most hydrographs also depict discharges corresponding to the National Weather Service designated flood stages (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Climatic Data Center, 2009), if available, that were effective at the time of the floods.

Since about the mid-1990s, most flood-profile reports have included more detailed descriptions of flood events and information on flood damages. Since the mid-2000s, most of the reports have included flood damage amounts for federally declared disasters, including private property damage-claim payments for residential and nonresidential buildings, obtained from Bonnie Shepard, Federal Emergency Management Agency, National Flood Insurance Program Bureau and Statistical Agent; and public assistance costs approved by the Iowa Public Assistance Program (assistance to local governments for the repair of disaster-damaged public facilities), obtained from Dennis Harper, Iowa Homeland Security and Emergency Management Division, State Hazard Mitigation Officer.

Streams Profiled and Not Profiled in Reports

A total of 94 stream reaches with unique stream names have been profiled in USGS flood-profile reports (table 2, fig. 1). Approximately 94 stream reaches in Iowa with drainage areas of 100 mi^2 or greater have not been profiled in USGS flood-profile reports (table 3). Streams with the largest drainage areas, greater than or equal to 400 mi^2, at their mouths that have not been profiled include the Boone, Boyer, Middle, Nodaway, North, and Soldier Rivers; Lizard Creek; and the Monona Harrison and West Fork Ditches (table 3, fig. 1).

It is worth noting that the total number of 94 stream reaches profiled from table 2 and the total number of 94 stream reaches not profiled from table 3 are overcounted because of stream reach naming conventions. Although the main-stem channels of some streams maintain the same stream name upstream and downstream from major tributary inflows such as the Little Sioux and Turkey Rivers, other main-stem channels have different stream names for reaches upstream and downstream from major tributary inflows such as the Skunk and Raccoon Rivers. Thus, a flood profile for a specific distance along some main-stem channels may count as a single stream reach name, whereas a profile of a similar distance along other main-stem channels may count as two or more stream reach names. Because of this, the total numbers of stream reaches profiled from table 2, or not profiled from table 3, are approximate numbers.

Streams Profiled for Multiple Flood Events

Fifty-one streams in Iowa from table 2 that have been profiled in USGS reports (1963–2012) for multiple flood events and the flood years profiled are listed in table 4. The Des Moines River has been profiled for 11 different flood events, 3 rivers in Iowa (the Iowa, South Skunk, and Wapsipinicon Rivers) have been profiled for 7 different flood events, 2 rivers in Iowa (the Little Sioux and Raccoon Rivers) have been profiled for 6 flood events, and the Cedar River has been profiled for 5 flood events (table 4). Because the floods profiled for these rivers were not always along the same stream reaches, the greatest number of flood events profiled along the same stream reach is listed in the last column of table 4. The reports displaying the greatest number of flood events profiled along the same stream reach are highlighted as a bold number in the preceding column of report numbers. Three rivers in Iowa (the Des Moines, Little Sioux, and South Skunk Rivers) have been profiled along the same stream reach for five different flood events, and six rivers in Iowa (the East Fork Des Moines, Floyd, Iowa, Raccoon, Rock, and Volga (not shown on fig. 1) Rivers) have been profiled along the same stream reach for four different flood events (table 4). Although streams profiled for additional flood events in later reports generally reproduced the profiles of flood events from earlier reports, earlier flood profiles were not always reproduced alongside later flood profiles to provide graphs for the

Table 3. Streams in Iowa with drainage areas greater than 100 square miles that have not been profiled in U.S. Geological Survey flood-profile reports.

[mi^2, square miles]

Stream name	Tributary to or State line	Drainage area at mouth or State line (mi^2)[a]	County location of mouth of stream or at State line
Bear Creek	Iowa River	222	Iowa
Bear Creek	Maquoketa River	111	Jackson
Beaver Creek	Cedar River	391	Black Hawk
Beaver Creek	Des Moines River	372	Polk
Big Cedar Creek	North Raccoon River	342	Sac
Big Devil Creek	Mississippi River	152	Lee
Black Cat Creek	East Fork Des Moines River	119	Kossuth
Boone River	Des Moines River	906	Webster
Boyer River	Missouri River	1,188	Pottawattamie
Brushy Creek	Des Moines River	108	Webster
Buffalo Creek	East Fork Des Moines River	168	Kossuth
Buttrick Creek	North Raccoon River	218	Greene
Camp Creek	North Raccoon River	148	Calhoun
Cedar Creek	North Raccoon River	162	Greene
Chequest Creek	Des Moines River	125	Van Buren
Clanton Creek	Middle River	160	Warren
Crane Creek	Little Turkey River	214	Fayette
Crooked Creek	Skunk River	286	Jefferson
Cylinder Creek	Des Moines River	112	Palo Alto
Deep Creek	Maquoketa River	143	Jackson
Deep Creek	Floyd River	156	Plymouth
Eagle Creek	Boone River	108	Hamilton
East Boyer River	Boyer	131	Crawford
East Branch Indian Creek	Indian Creek	134	Story
East Branch West Nishnabotna River	West Nishnabotna River	227	Pottawattamie
East Fork Hundred and Two River	Missouri State line	111	Taylor
East Nodaway River	Nodaway	334	Page
English Creek	Des Moines River	112	Marion
Farm Creek	West Nishnabotna River	122	Mills
Flint River	Mississippi River	148	Des Moines
Fourmile Creek	Des Moines River	121	Polk
Fox River	Missouri State line	188	Van Buren
Grand River	Missouri State line	206	Ringgold
Haitz Ditch	Monona Harrison Ditch	153[b]	Monona
Hardin Creek	North Raccoon River	168	Greene
Hartgrave Creek	West Fork Cedar River	185	Butler
Honey Creek	Iowa River	110	Marshall
Indian Creek	East Nishnabotna River	184	Cass
Keg Creek	Missouri River	217[b]	Mills
Lake Creek	North Raccoon River	129	Calhoun
Little River	Missouri State line	102	Decatur

Table 3. Streams in Iowa with drainage areas greater than 100 square miles that have not been profiled in U.S. Geological Survey flood-profile reports.—Continued

[mi^2, square miles]

Stream name	Tributary to or State line	Drainage area at mouth or State line (mi^2)[a]	County location of mouth of stream or at State line
Little Turkey River	Turkey River	355	Fayette
Lizard Creek	Des Moines River	437	Webster
Long Creek	Thompson River	124	Decatur
Long Creek	Iowa River	154	Louisa
Lost Island Outlet	Little Sioux River	156	Clay
Lotts Creek	East Fork Des Moines River	166	Humboldt
Lytle Creek	North Fork Maquoketa River	116	Jackson
Middle Nodaway River	Nodaway River	341	Montgomery
Middle River	Des Moines River	558	Warren
Mill Creek	Little Sioux River	294	Cherokee
Minerva Creek	Iowa River	164	Marshall
Monona Harrison Ditch	Missouri River	967[b]	Harrison
Mosquito Creek	Missouri River	267	Pottawattamie
Mud Creek	Rock River	138	Lyon
Mud Creek	Wapsipinicon River	128	Scott
Muddy Creek	Little Sioux River	103	Clay
Nodaway River	Missouri State line	1,182	Page
North Blackhawk Creek	Blackhawk Creek	119	Grundy
North Branch Lizard Creek	Lizard Creek	149	Pocahontas
North River	Des Moines River	400	Polk
Okoboji Lake Outlet	Little Sioux River	151	Dickinson
Pidgeon Creek	Missouri River	165	Pottawattamie
Platte River	Missouri State line	282	Taylor
Prairie Creek	Cedar River	216	Linn
Prairie Creek	Boone River	142	Wright
Salt Creek	Iowa River	223	Tama
Sevenmile Creek	West Nodaway River	124	Montgomery
Silver Creek	West Nishnabotna River	282	Mills
Sixmile Creek	Big Sioux River	108	Sioux
Soap Creek	Des Moines River	253	Wapello
Soldier River	Missouri River	445	Harrison
South Beaver Creek	Beaver Creek	116	Butler
South Branch Lizard Creek	Lizard Creek	157	Webster
South Fork Iowa River	Iowa River	309	Hardin
Sugar Creek	Des Moines River	111	Lee
Sugar Creek	Cedar River	222	Muscatine
Tarkio River	Missouri State line	206	Page
Timber Creek	Iowa River	124	Marshall
Troublesome Creek	East Nishnabotna River	131	Cass
Turkey Creek	East Nishnabotna River	134	Cass
Walnut Creek	West Nishnabotna River	223	Fremont

Table 3. Streams in Iowa with drainage areas greater than 100 square miles that have not been profiled in U.S. Geological Survey flood-profile reports.—Continued

[mi^2, square miles]

Stream name	Tributary to or State line	Drainage area at mouth or State line (mi^2)[a]	County location of mouth of stream or at State line
Walnut Creek	Skunk River	102	Jefferson
Waterman Creek	Little Sioux River	140	O'Brien
West Branch Hundred and Two River	West Fork Hundred and Two River	125	Taylor
West Buttrick Creek	Buttrick Creek	116	Greene
West Fork Ditch	Monona Harrison Ditch	701[b]	Monona
West Fork Hundred and Two River	Missouri State line	212	Taylor
West Fork Middle Nodaway River	Middle Nodaway River	129	Adair
West Fork West Nishnabotna River	West Nishnabotna River	151	Shelby
West Nodaway River	Nodaway River	347	Montgomery
White Fox Creek	Boone	112	Hamilton
Wolf Creek	Cedar River	328	Black Hawk
Yellow River	Mississippi River	241	Allamakee

[a]Drainage area from Larimer (1957).

[b]Drainage area from Iowa StreamStats (*http://water.usgs.gov/osw/streamstats/iowa.html*).

comparison of multiple flood events. The greatest number of multiple flood events profiled for a stream reach usually will be present in the reports listed with the higher report numbers in table 4.

The five floods profiled for a reach of the South Skunk River (Barnes and Eash, 2012) are illustrated in figure 2. An inspection of the discharges listed in figure 10 in Barnes and Eash (2012) for the water-surface elevations of the five flood profiles and the three low-water profiles for two streamgages located along this reach (05470000 and 05471000, fig. 3, map numbers 49 and 51), indicate that the stage-discharge relations seem reasonably ordered with lower to higher water-surface elevations corresponding with lower to higher peak and low-flow discharges. Note that in figure 10 in Barnes and Eash (2012) the date of June 17, 1975, should be June 17, 1990, for streamgage 05470000 for the discharge of 6,600 cubic feet per second (ft^3/s). Thus the multiple flood and low-water profiles (fig. 2; Barnes and Eash, 2012, fig. 10) do not seem to indicate substantial changes to the stage-discharge relation because of scour of the channel bed or aggradation of the channel bed or flood plain along this river reach for the period 1944 to 2010.

Yet, farther downstream, along the South Skunk River, a substantial change in the stage-discharge relation with time is apparent. At streamgage 05471500 South Skunk River near Oskaloosa (fig. 3, map number 53), the August 2010 flood peak was higher than the May 1944 flood peak by about 0.6–1.4 ft (depending on whether the 1944 HWM was obtained on the upstream or downstream side of the bridge); however, the peak discharge for the 2010 flood of 25,200 ft^3/s was less than the 1944 peak discharge of 37,000 ft^3/s (fig. 7 in Barnes and Eash, 2012). This difference between the stage and discharge for the 1944 and 2010 floods most likely is because of continuing flood-plain and channel aggradation at the Oskaloosa streamgage location (Eash, 1996a), but also could be due to more vegetal growth on the flood plain during the August 2010 flood than during the May 1944 flood.

An inspection of water-surface elevations and peak discharges of flood events measured at streamgage locations along profiled stream reaches for the 50 other streams listed in table 4 documented several substantial changes to stage-discharge relations, as discussed below. At streamgage 05451500 Iowa River at Marshalltown (fig. 3, map number 27), the June 2008 flood peak was higher than the July 1969 flood peak by 2.69 ft; however, the 2008 peak discharge of 22,400 ft^3/s was less than the 1969 peak discharge of 31,900 ft^3/s (fig. 22 in Linhart and Eash, 2010). This difference between stage and discharge for the 1969 and 2008 floods most likely is because of continuing channel and flood-plain aggradation at the Marshalltown streamgage location. Of 10 bridge sites investigated for channel and flood-plain aggradation on the Iowa River upstream from Coralville Lake (fig. 1), the Iowa River at the Marshalltown streamgage location was estimated to have the highest channel and flood-plain aggradation rates (Eash, 1996a).

Along the Iowa River further downstream from the Marshalltown streamgage location, the July 1969 flood was higher than the June 1947 flood by 0.56 ft at discontinued streamgage 05452500 Iowa River near Belle Plaine (fig. 3, map number 28) and by 1.59 ft at streamgage 05453100 Iowa River at Marengo (fig. 3, map number 29); however, the 1969 peak discharge of 30,000 ft^3/s was less than the 1947 peak discharge of 34,000 ft^3/s at the Belle Plaine streamgage

Table 4. Streams in Iowa that have been profiled for multiple flood events and the flood years profiled in U.S. Geological Survey reports, 1963–2012.

Stream name	Flood years profiled (table 2)	Report numbers[a] (table 1)	Greatest number of flood events profiled along the same stream reach
Big Creek (Linn County)	July 1971, December 1971	**18**	2
Black Hawk Creek (Black Hawk/Grundy Counties)	May 1957, March 1960, April 1960	**2**	2
Buffalo Creek (Jones/Linn/Delaware/Buchanan Counties)	1964, 1968, 1969	**14**	3
Cedar Creek (Henry/Van Buren/Jefferson/Wapello Counties)	1973, 1976	**19**	2
Cedar Creek (Mahaska/Marion/Monroe Counties)	1981, 1982	**23**	2
Cedar River	1960, 1961,1962, 1999, 2008	**2**, 39, **45**	3
Chariton River	1981, 1992	23, **32**	2
Crane Creek (Black Hawk/Bremer Counties)	1968, 1999	14, **38**	2
Des Moines River	1903; 1947; 1953; 1954; 1960; July 1964; September 1964; April 8, 1965; April 13, 1965; 1969; 1993	1, 5, **10**, 36	5
Dry Creek (Linn County)	1961, 1962, 2002	**40**	3
East Branch Iowa River	1944, 1954, 1969	**15**	3
East Branch Wapsipinicon River	1966, 1969	**14**	2
East Fork Des Moines River	1965, 1968, 1969, 1979	10, **20**	4
East Nishnabotna River	1972, 1987, 1998	26, **37**	2
East Otter Creek (Linn County)	1965, 1966	**6**	2
English River	1965, 1966, 1974	**22**	3
Flood Creek (Butler/Floyd Counties)	1963, 1999	2, **39**	2
Floyd River	1953, 1962, 1973, 1983	**25**	4
Indian Creek (Linn County)	1961, 1962, 2002	**40**	3
Iowa River	1944, 1947, 1954, 1969, 1972, 1993, 2008	**15**, 34, 45	4
Little Cedar River	1961, 1962	**2**	2
Little Sioux River	1953, 1954, March 1962, July 1962, 1964, 1965	**4**	5
Little Wapsipinicon River (Buchanan/Fayette Counties)	1966, 1968, 1999	14, **38**	3
Maquoketa River	2002, 2004, 2010	41, 42, **46**	3
Middle Raccoon River	1979, 1986, 1993	21, 27, **33**	3
Mississippi River	1952, 1960, 1965, 1993	**3**, 35	2
Nishnabotna River	1972, 1987, 1998	26, **37**	2
North Cedar Creek (Marion/Monroe Counties)	1981, 1982	**23**	2
North Fork Maquoketa River	2002, 2010	41, **46**	2
North Raccoon River	1979, 1986, 1993	21, **33**	3
Otter Creek (Linn County)	1965, 1966	**6**	2
Raccoon River	June 13, 1947; June 26, 1947; 1960; 1979; 1986; 1993	5, 21, 27, **33**, 36	4
Rock River	1962, 1964, 1965, 1969	7, **16**	4
Shell Rock River	1961, 1962, 1999	2, **39**	2
South Fork Chariton River	1981, 1992	23, **32**	2
South Raccoon River	1979, 1986, 1993	21, 27, **33**	3

Table 4. Streams in Iowa that have been profiled for multiple flood events and the flood years profiled in U.S. Geological Survey reports, 1963–2012.—Continued

Stream name	Flood years profiled (table 2)	Report numbers[a] (table 1)	Greatest number of flood events profiled along the same stream reach
Skunk River	1965, 1973	**19**	2
South Skunk River	1944, 1972, 1974, 1975, 1990, 1993, 2010	17, 19, 29, **47**	5
Squaw Creek (Story County)	1975, 1990, 1993	17, **29**	3
Turkey River	1972, 1979, 1991, 2004	31, **42**	3
Volga River	1979, 1991, 1999, 2004	31, 38, **42**	4
Walnut Creek (Polk/Dallas Counties)	1973, 1986	**27**	2
Wapsipinicon River	April 1962, July 1962, 1966, 1968, 1969, May 1999, July 1999	**14**, 38, **39**	3
West Branch Iowa River	1944, 1954, 1969	**15**	3
West Branch Floyd River	1973, 1983	**25**	2
West Fork Cedar River	1961, 1962	**2**	2
West Nishnabotna River	1972, 1987	**26**	2
West Otter Creek (Linn County)	1965, 1966	**6**	2
White Breast Creek (Marion/Warren/Lucas/Clarke Counties)	1981, 1982	**23**	2
Willow Creek (Cerro Gordo County)	1961, 1962	**2**	2
Winnebago River	1961, 1962	**2**	2

[a]Bold report numbers indicate which reports have the greatest number of flood events profiled along the same stream reach.

and the 1969 peak discharge of 28,300 ft^3/s was less than the 1947 peak discharge of 34,000 ft^3/s at the Marengo streamgage (figs. 5-6 in Heinitz, 1973a). These differences between stage and discharge for the 1947 and 1969 floods at the Belle Plaine and Marengo streamgages on the Iowa River could have been caused by several factors, or a combination of factors, such as the development of the flood plain during 1947–69, more vegetal growth on the flood plain during the July 1969 flood than during the June 1947 flood, and channel and flood-plain aggradation that likely was occurring during this time period at both streamgages (Eash, 1996a).

At streamgage 05422000 Wapsipinicon River near DeWitt (fig. 3, map number 23), the July 1968 flood peak was higher than the April 1962 flood peak by 0.24 ft; however, the 1968 peak discharge of 13,800 ft^3/s was less than the 1962 peak discharge of 17,600 ft^3/s (plate 2 in Schwob, 1971). Schwob (1971) noted that a “vegetation shift” apparently occurs in the wide heavily wooded flood plain at places downstream of Anamosa (fig. 1); for the same discharge, summer flood elevations will be higher than winter-spring flood elevations.

At streamgage 05462000 Shell Rock River at Shell Rock (fig. 3 map, number 42), the July 1999 flood peak was higher than the March 1961 flood peak by 0.47 ft; however, the 1999 peak discharge of 27,500 ft^3/s was less than the 1961 peak discharge of 33,500 ft^3/s (fig. 17 in Ballew and Eash, 2001). This difference between stage and discharge for the 1961 and 1999 floods most likely is due to a seasonal “vegetation shift” during which there is more vegetation in the channel and on the flood plain in July than in March. This vegetation shift causes the July flood elevation to be higher than the March flood elevation. Seasonal variability in the density of vegetation in channels and on flood plains can affect the roughness, or resistance to flood flows, in channels and on flood plains and can cause shifts in stage-discharge relations (Arcement and Schneider, 1989; Soong and others, 2012).

At streamgage 05416900 Maquoketa River at Manchester (fig. 3, map number 10), the July 2010 flood peak was higher than the May 2004 flood peak by 2.82 ft; however, the 2010 peak discharge of 26,600 ft^3/s was only slightly larger than the 2004 peak discharge of 26,000 ft^3/s (fig. 12 in Eash, 2012). The difference in stage between the 2004 and 2010 floods could have been caused by several factors, or a combination of factors, such as more vegetal growth on the flood plain during the July 2010 flood than during the May 2004 flood, channel and flood-plain aggradation, or other changes in the geometry of the channel and flood plain downstream from the streamgage that could affect the stage-discharge relation at the streamgage.

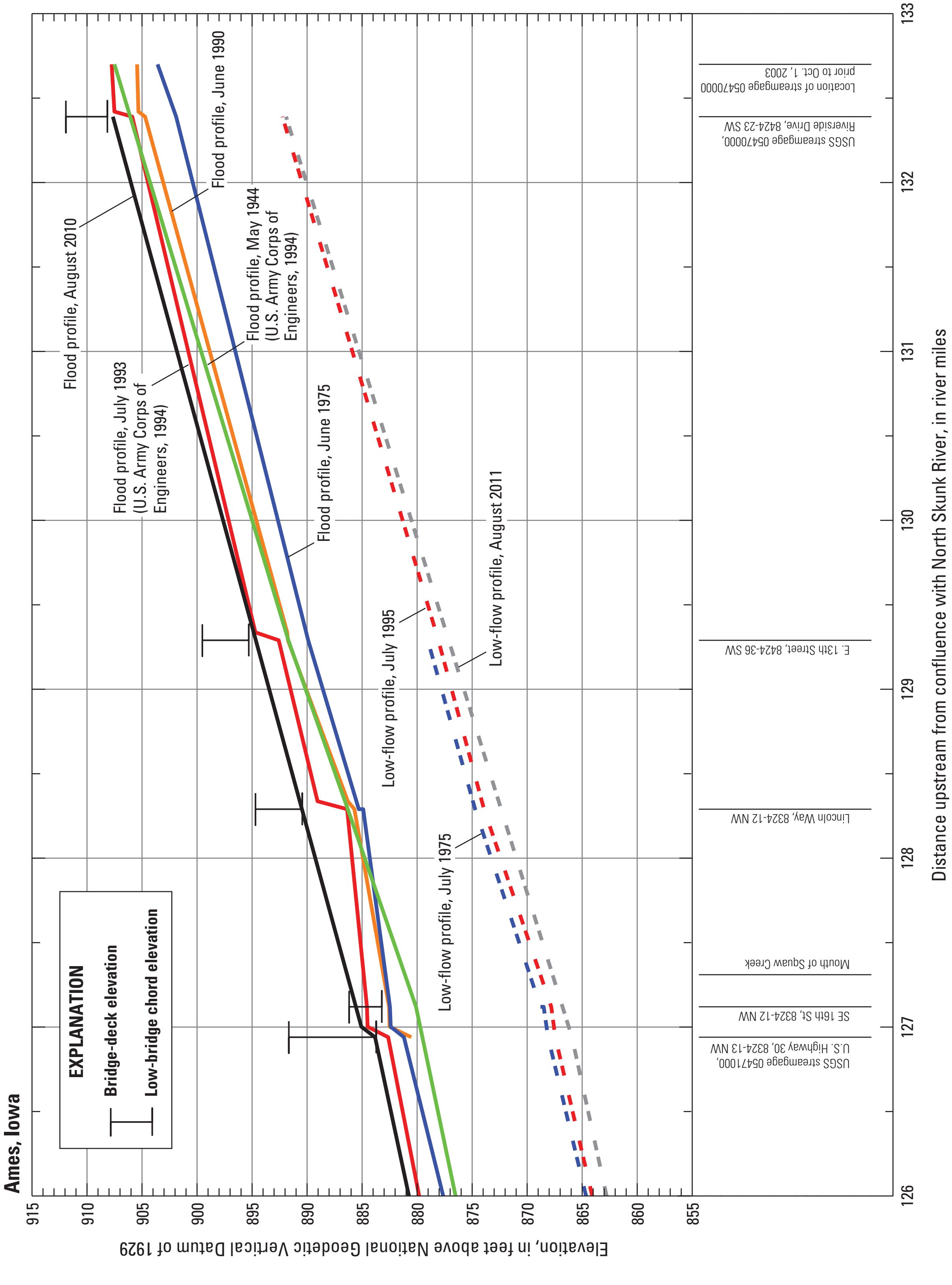

Figure 2. Profiles of the 1944, 1975, 1990, 1993, and 2010 floods on the South Skunk River, river miles 126 to 133. [USGS, U.S. Geological Survey]

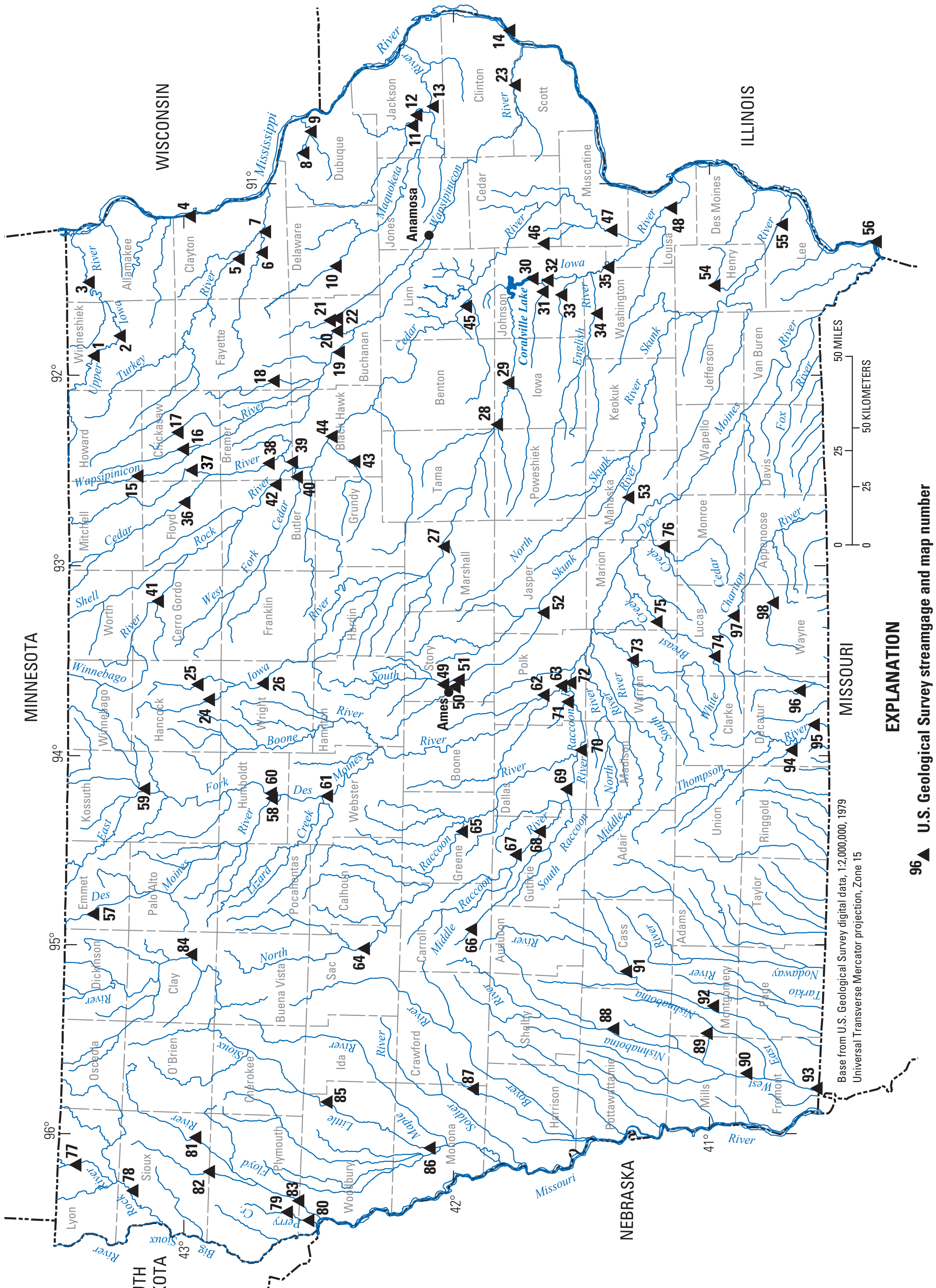

Figure 3. Location of U.S. Geological Survey streamgages listed in this report.

Occurrence of Flood Events Profiled

The years and months of occurrence of flood events profiled in USGS reports (1963–2012) and the number of stream reaches profiled in each month are depicted in table 5. As the "Total" column on table 5 indicates, June is the month for which flood events have been profiled for the greatest number of years. Floods were profiled for June flood events for 18 different years, followed by July flood events for 13 years, May flood events for 11 years, and April flood events for 9 years. These monthly totals coincide with annual maximum streamflows in Iowa that typically occur during April through July (Eash and others, 2013).The greatest number of stream reaches profiled for flood events in a single month was 11 stream reaches profiled for the July 1993 floods, followed by 8 stream reaches profiled for the July 1981 and March 1962 floods, and 7 stream reaches profiled for May 1974 floods. Although almost all of the numbers in the grey cells are a count of the number of stream reaches profiled for a single flood event (some of which occurred over a large geographic area in multiple river basins, such as the 1993 flood on the Des Moines, Iowa, Mississippi, Raccoon, and South Skunk Rivers), some of the numbers in the grey cells are a count of different flood events that occurred in a single month such as the June 13 and 26, 1947, floods on the Raccoon River (table 2). It is noted that although the number of stream reaches profiled in any month in table 5 is a reflection of the flooding, it is also an indication of Iowa DOT's and other agencies' interests in having the profiles collected; not all major floods that occurred in Iowa during 1960–2010 were profiled by the USGS.

The year with the greatest number of stream reaches profiled was 1962 with 15 stream reaches profiled during March, April, and July; followed by 1974 with 12 stream reaches profiled during April and May; and then followed by1969 with 11 stream reaches profiled during April, June, and July; and 1993 also with 11 stream reaches profiled during July (table 5). The month with the greatest number of stream reaches profiled was July with 51 stream reaches profiled during 13 different flood years, followed by June with 50 stream reaches profiled during 18 different flood years (table 5). As indicated in table 5, the greatest number of flood events and stream reaches profiled occurred from about 1961 to 1974 when the flood-profile program first began and there likely was a strong interest in collecting many flood profiles. Before about 1975, there was a greater tendency to collect flood profiles for AEPs of greater than 2–4 percent, or for RIs less than 25–50 years, whereas after about 1975, there was a greater tendency to collect flood profiles for AEPs of less than 2–4 percent and to not collect profiles for similar flood events along reaches where a new profile would only provide little additional information.

Annual Exceedance-Probability Estimates

As previously mentioned, before 2009, estimates of AEPs were reported in flood-profile reports as flood RIs expressed in years. For example, a flood magnitude that has a 1-percent chance (AEP=0.01) of being exceeded during any particular year is expected to be exceeded on average once during any 100-year period (RI=100 years) (Holmes and Dinicola, 2010). Percent probability is the inverse of the RI multiplied by 100. Because of widespread confusion caused in recent years by two or more "100-year floods" happening 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. Selected AEPs and equivalent flood RIs are listed in table 6. Although the annual probability is an estimate of the likelihood of a flood discharge of a specific magnitude happening in any 1 year, more than one flood discharge with a specific magnitude and AEP or RI could happen in the same year.

For example, two large flood events happened during 1993 at streamgage 05470000 South Skunk River near Ames (fig. 3, map number 49), of which a flood-peak discharge of 11,100 ft^3/s occurred on July 9, and another flood-peak discharge of 11,200 ft^3/s occurred on August 16 (Einhellig and Eash, 1996; table 7, available at *http://pubs.usgs.gov/sir/2014/5085/downloads/*). A 1-percent AEP, or 100-year RI, discharge of 9,090 ft^3/s was computed at this streamgage following the 1993 flood (Eash, 1997). Thus, two flood events that theoretically each had less than a 1-percent probability of occurring during any 1 year occurred at this site during the same year. The AEP estimates updated through the 2012 water year at this streamgage estimate the 1-percent AEP, or 100-year RI, discharge to be 12,400 ft^3/s, and estimate the AEPs of these two 1993 flood events to be 1.7 and 1.6 percent, respectively, or RIs to be 59 and 62 years, respectively, based on a longer period of peak-flow record (table 7). 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, 2012, is the "2012 water year." This change in the AEP and RI estimates for the 1993 floods at this streamgage demonstrates the uncertainty in the estimates and how the estimates may change with time as the annual peak-discharge record becomes longer.

Historic and Updated Estimates of Observed Flood Events

The AEPs, in percent, or RIs, in years, are estimated for observed flood-peak discharges at streamgages and are published in USGS flood-profile reports to indicate the probability or frequency of the flood events. The AEP and RI estimates of 179 observed flood peaks published in USGS flood-profile reports during 1963–2012, of which 178 are profiled flood events at 98 streamgages in Iowa, are listed in table 7; the August 16, 1993, flood at streamgage 05470000 (fig. 3, map number 49) was not a profiled flood event. The AEPs or RIs estimated for observed flood peaks at streamgages are interpolated from theoretical AEP estimates computed at

Table 5. Years and months of occurrence of flood events profiled in U.S. Geological Survey reports during 1963–2012 and number of stream reaches profiled in each month.

[Cells highlighted in grey are individual months for which flood events were profiled, and numbers in grey cells are the number of stream reaches profiled in each month from table 2]

Month	1903	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
January																																	
February																																	
March																		2	5	8								1			2		
April										1								3	1	3			5				5				3	5	
May	1	1													1						1											7	
June		3			4						3	5										1		2	3		1			3			2
July																				4		1		3		5	5		1	1	1		
August															1							1											
September																			2			4	5							3			
October																										1							
November																																	
December																													1				

Month	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total[a]
January																																				0
February																																				0
March				6																																6
April	1																																			9
May											1	3			1									5					3			1				11
June							1	2			4				3	4							2				4						3			18
July						8	3											11						4											4	13
August				1																															1	4
September																	5																			5
October																																				1
November																																				0
December																																				1

[a]Total number of years for which flood events were profiled in U.S. Geological Survey flood-profile reports for each specific month.

Table 6. Annual exceedance probability and equivalent flood recurrence interval for selected probabilities.

Annual exceedance probability (percent)	Recurrence interval (years)
50	2
20	5
10	10
4	25
2	50
1	100
0.5	200
0.2	500

streamgages; see the following "Estimates at Streamgages" section for information on the computation of AEPs at streamgages. Two sets of AEP and RI estimates are listed in table 7 for each of the 179 observed flood peaks. First, historic AEP and RI estimates are listed in table 7, which are the estimates that were published in the flood-profile reports for the observed flood peaks. Second, updated AEP and RI estimates are listed in table 7, which were computed for the observed flood peaks using peak-flow data through the 2012 water year, unless noted otherwise.

Comparisons of historic and updated AEP and RI estimates listed in table 7 indicate few differences that are considered substantial between the two sets of estimates for the 179 observed flood-peak discharges, although estimation limitations for some historic AEPs and RIs prevent precise comparisons. In this report, differences between historic and updated AEPs that are considered substantial are those differences greater than the following selected ranges: from 0.2 to 0.5 percent, 0.5 to 1 percent, 1 to 2 percent, 2 to 4 percent, or 4 to 10 percent. These comparisons signify that AEP estimates for most of these observed events have not changed considerably since they were computed for the preparation of the flood-profile reports. The more recent flood-profile reports, which were published after about 2004, are less likely to have differences between historic and updated (2012) AEP and RI estimates that are considered substantial because the peak-flow records used to estimate AEPs at these streamgages differ by only a few years. The early flood-profile reports, which were published before about 1986, are more likely to have differences between historic and updated (2012) AEP and RI estimates that are considered substantial because the peak-flow records used to estimate AEPs at these streamgages differ by a greater number of years.

Differences between historic and updated AEP and RI estimates that are considered substantial are highlighted in grey in table 7 for 25 of the 179 (14 percent) observed flood events at streamgages. For example, for a recent flood event in 2002 at active streamgage 05418400 North Fork Maquoketa River near Fulton and at discontinued streamgage 05418450 North Fork Maquoketa River at Fulton (fig. 3, map numbers 11 and 12, respectively), the historic AEP and RI estimates were both published as 0.91 percent and 110 years, respectively. The updated AEP and RI estimates for the 2002 flood at these two streamgages are both 3.1 percent and 32 years, respectively (table 7). These differences between historic and updated AEP and RI estimates are considered substantial, and they are due to the occurrence of three additional large flood events in the years 2008, 2010, and 2011 since the preparation of the flood-profile report documenting the 2002 flood event (Eash, 2004b). The 1-percent AEP, or 100-year RI flood, estimates increased by 30 and 26 percent between 2003 and 2012 at streamgages 05418400 and 05418450, respectively. These increases in AEP estimates at these two streamgages during a short period of record caused differences between historic (2003) and updated (2012) AEP estimates of the 2002 flood that are considered substantial.

Of the 23 additional observed flood events highlighted in table 7 that are considered to have substantial differences between historic and updated AEP and RI estimates, all but 1 of them indicate that updated AEP estimates are greater, or updated RI estimates are lower, compared to historic AEP and RI estimates. To investigate these differences, peak-flow records were inspected for the streamgages for these 23 observed flood events. For the 22 observed flood events for which updated AEPs increased compared to historic AEPs, it seems that large flood events much greater than, or near the magnitude of, the observed flood events occurred at the streamgages for 19 of these observed flood events since the occurrence of the observed flood events. Differences between the flood-estimation methods used to compute historic and updated AEP estimates also could be a factor in the differences between historic and updated AEPs of observed flood events. At streamgages 05420850, 05473500, and 05487800 (fig. 3, map numbers 18, 54, and 74), no floods occurred since the observed flood event listed in table 7 that exceeded the observed flood event, and the differences between the historic and updated AEP estimates at these three streamgages likely are due to differences between the flood-estimation methods used to compute the AEP estimates. For the one observed flood event at streamgage 05482300 (fig. 3, map number 64) for which the updated AEP decreased, or the RI increased, compared to the historic AEP and RI, the peak-flow record indicates that no floods occurred during 1980–2012 that exceeded the 1979 flood, and the difference between historic and updated AEP and RI estimates also likely is due to differences between the flood-estimation methods used to compute the AEP estimates.

Historic AEP and RI estimates published in the early flood-profile reports were limited in terms of the extent of the probability or frequency that could be estimated for large flood events. For instance, before about 1973, AEP or RI estimates computed at streamgages from annual streamgage-probability analyses were limited to AEP estimates as small as 2 percent or RI estimates as large as 50 years. Observed floods with peak discharges that were less than this 2-percent AEP limitation, or greater than this 50-year RI limitation, were estimated to be “less than 2 percent” or “greater than 50 years.” From about 1973 to the late 1990s, AEP or RI estimates were limited to AEP estimates as small as 1 percent or RI estimates as large as 100 years; therefore, large observed flood events that exceeded this limitation were estimated to be “less than 1 percent” or “greater than 100 years” or were expressed as a ratio of the observed flood discharge to the 1-percent or 100-year flood discharge. Since about 1999 to present (2014), AEP and RI estimates in flood-profile reports have been limited to AEP estimates as small as 0.2 percent and RI estimates as large as 500 years, and large observed flood events that exceed this limitation are estimated to be “less than 0.2 percent” or “greater than 500 years.” Also, since 2009, historic AEP estimates were reported as a percent range, such as 1-2 percent. Thus, comparisons of some historic and updated AEP and RI estimates of observed flood events from flood-profile reports are not precise. For example, the 1968 flood peak of 24,200 ft^3/s at streamgage 05421200 (fig. 3, map number 20) listed in table 7 has a historic AEP and RI estimate of less than 2 percent and greater than 50 years, respectively, and has a updated AEP and RI estimate of less than 0.2 percent and greater than 500 years, respectively. It is noted that 20 of the 179 (11 percent) updated AEP estimates listed in table 7 for observed flood events are less than 0.2 percent, or RIs are greater than 500 years.

Of the 179 observed flood events at streamgages listed in table 7, precise comparisons of differences between historic and updated estimates of AEPs can be made for 114 of the observed flood events including the 25 that are highlighted. Of these 114 precise comparisons, the differences for 80 of the comparisons indicate that updated AEP estimates are greater, or updated RI estimates are lower, compared to historic AEP and RI estimates; the differences for 26 of the comparisons indicate that updated AEP estimates are lower, or RI estimates are greater, compared to historic AEP and RI estimates; and there were no differences between historic and updated AEPs for 8 of the comparisons. Although several of the differences between historic and updated AEPs are negligible, overall, the precise comparisons indicate that updated AEPs have increased, or RIs have decreased, for most of the observed flood events compared to the historic AEPs and RIs. These increases in updated AEPs likely are due to the occurrence of additional large flood events at the streamgages since the occurrence of the observed flood events, and to differences between the flood-estimation methods used to compute historic and updated AEP estimates.

Estimates at Streamgages

As previously mentioned, AEPs estimated for observed flood peaks at streamgages are interpolated from theoretical AEP estimates computed at streamgages. The historic AEP and RI estimates were interpolated from AEP estimates computed at streamgages using the flood-estimation methods that were deemed to be most appropriate at the time the reports were prepared. The 179 historic AEP and RI estimates of observed flood events at streamgages were interpolated from theoretical AEP estimates that were computed at the streamgages using one of the following four streamgage flood-estimation methods noted in table 7: (1) Bulletin 17B (B17B) annual streamgage-probability analyses computed from annual peak-flow records collected at streamgages (Interagency Advisory Committee on Water Data, 1982; Flynn and others, 2006); (2) regional regression equations (RREs) developed from regional regression analyses of basin-characteristic measurements and streamgage AEP estimates (Schwob, 1963; Schwob, 1966a; Lara, 1973; Eash, 2001); (3) weighted independent estimates (WIE) analyses (Cohn and others, 2012), which compute weighted AEP estimates at streamgages from the variance and AEP estimates of B17B annual streamgage-probability analyses, and the variance and AEP estimates of RRE probability calculations at streamgages; or (4) other flood-estimation methods computed by the USGS (Dalrymple, 1960; Myers, 1963; Schwob, 1970a; Heinitz, 1973a; Eash, 2001) or by the U.S. Army Corps of Engineers (Hydraulics Branch, oral commun.,1994; 2004; 2009; 2010). The AEP estimates listed in table 7 for regulated streamgages located on the Mississippi River and on the Iowa and Des Moines Rivers downstream from U.S. Army Corps of Engineers reservoirs were computed by the U.S. Army Corps of Engineers for regulated periods of record.

Unless noted otherwise, the 179 updated (2012) AEP and RI estimates of observed flood events at streamgages were interpolated from AEP estimates computed at streamgages in Iowa using the WIE flood-estimation method (Cohn and others, 2012) and peak-flow data collected through the 2012 water year. Updated (2012) AEP estimates and associated 95-percent confidence intervals computed at streamgages are presented in table 7 for 10-, 4-, 2-, 1-, and 0.2-percent AEPs, which are equivalent to 10-, 25-, 50-, 100-, and 500-year RIs.

The 2012 WIE analyses were computed using new flood-estimation methodologies that are described in Eash and others (2013). A new annual streamgage-probability analysis named the expected moment algorithm (EMA), along with a new test within the EMA program for detecting low outliers named the multiple Grubbs-Beck (MGB) test, collectively referred to as the EMA/MGB analysis method (Cohn, 2013; Cohn and others, 1997, 2001, 2013; Eash and others, 2013), was used to compute 2012 AEP estimates at unregulated streamgages listed in table 7. The AEP estimates from the EMA/MGB analyses at streamgages used in the 2012 WIE analyses were computed using peak-flow data through the 2012 water year and the results of a new statewide regional skew study (Eash and others, 2013). The AEP estimates from RRE calculations at streamgages used in the 2012 WIE analyses were computed using new RREs developed for three new flood regions defined for Iowa (Eash and others, 2013). The development of new RREs for Iowa included the use of basin characteristics measured from high-resolution (1:24,000-scale) elevation, stream, and watershed-boundary data, and the use of a new optimization test for determining the best transformation for drainage area for each flood region.

The AEPs change as streamflow records become longer. The EMA/MGB analyses are computed for streamgages using annual peak-discharge data. As additional annual peak discharges are measured at streamgages, EMA/MGB and WIE estimates of AEPs are updated and become more statistically reliable. A minimum of 10 years of record is recommended by the Interagency Advisory Committee on Water Data (1982) to compute EMA/MGB estimates of AEPs.

Multiple Large Flood Events at Streamgages during 1960–2012 and Trend Analyses

To identify streamgages from table 7 with multiple large flood events, a 2-percent AEP, or a 50-year RI, flood value was selected to represent a large flood event. An inspection of annual peak discharges in the USGS NWIS database (U.S. Geological Survey, 2014) was conducted for the 98 selected streamgages shown in figure 3 and listed in table 7 to determine which streamgages recorded two, or more, observed peak discharges during 1960–2012 that represent large flood events because they exceed the discharge estimate listed in table 7 for a 2-percent AEP, or a 50-year RI flood. The 1960–2012 period of record was selected because 1960 was the first year flood events were profiled as part of Iowa DOT Project HR-140 and 2012 was the most recent water year available in the USGS NWIS database at the time this report was prepared. A total of 37 streamgages with multiple large flood events during 1960–2012 are listed in table 8; also listed are the number of multiple large flood events that occurred at each streamgage during 1960-2012 and the years of occurrence. Five large flood events, the greatest number of large flood events during 1960–2012, were recorded at two streamgages in Ames at the South Skunk River near Ames and at Squaw Creek at Ames (streamgages 05470000 and 05470500, fig. 3, map numbers 49 and 50, respectively). The five large flood events at each of these two Ames streamgages occurred during a 21-year period from 1990 to 2010 (table 8). Four large flood events were recorded at four sites during 1973–2010 that include streamgage 05412500 Turkey River at Garber (fig. 3, map number 7), streamgage 05471000 South Skunk River below Squaw Creek near Ames (fig. 3 map number 51), streamgage 05474500 Mississippi River at Keokuk (fig. 3, map number 56), and streamgage 06807470 Indian Creek near Emerson (fig. 3, map number 89). Of the 16 large flood events recorded at these four streamgages, 13 occurred during 1991–2010 (table 8). Although table 7 does not include every streamgage in Iowa operated by the USGS during 1960–2012, and therefore table 8 may not include every streamgage in Iowa where multiple large flood events were recorded during 1960–2012, table 8 does provide a good indication of locations in the State where multiple large flood events occurred during 1960–2012 because most of the large flood events that occurred in Iowa during this time period were documented in flood-profile reports.

To investigate if there may be any statistically significant trends in the annual peak-discharge records of the 37 selected streamgages listed in table 8, the Kendall's tau hypothesis test in the USGS Surface Water time series STATistics (SWSTAT) program (Lumb and others, 1990) was used to analyze for trends for a 50-year period of record from 1963 to 2012. The Kendall's tau test computes the monotonic relation between peaks (discharge) and time (water years) (Helsel and Hirsch, 2002), and is a nonparametric test that can be used to indicate the likelihood of a positive or negative trend with time (Rasmussen and Perry, 2001). Using the Kendall's tau test, the rank of each annual peak-discharge value is compared to the rank of the values following it in the series. If the second value is consistently greater than the first, the Kentau coefficient is positive. If the second value is consistently lower, the Kentau coefficient is negative. An equal number of positive and negative values would indicate that a trend does not exist. Thus, the Kentau value is a measure of the correlation between the series and time. A Ken p-value threshold of 5 percent (α=0.05) was used in this investigation for the Kendall's tau test, and Ken p-values less than or equal to 5 percent indicate statistically significant trends (positive or negative).

The results of the Kendall's tau test (table 8) indicate a statistically significant negative trend at streamgage 05420690 East Fork Wapsipinicon River near New Hampton (fig. 3, map number 17) and a statistically significant positive trend at streamgage 05487980 White Breast Creek near Dallas (fig. 3, map number 75). Wahl (1998) describes how Kendall's tau test results may be sensitive to multiyear sequences of larger or smaller discharges if the sequences happen near the beginning or end of the period of record used in the test. Although trend results are relatively insensitive to individual outliers, multiyear sequences of extremes near either end of the record can have a significant effect on the test results, but may imply no systematic change.

Annual peak-discharge records for the two streamgages initially indicated to have significant trends were retested using the Kendall's tau test after two annual peak discharges were removed, consecutively, from either the beginning or the end of the record, or one each was removed from the beginning and the end of the record. A record-length threshold of 95 percent was used for the retesting of the trend analysis. A statistically significant negative trend resulted for the retesting of the East Fork Wapsipinicon River near New Hampton streamgage (05420690) peak-flow record at the 95-percent record threshold. Because the East Fork Wapsipinicon River near New Hampton streamgage peak-flow record length is only 27 years and the indication of a significant trend at this streamgage is isolated and not supported by trends at nearby streamgages, there is uncertainty about whether the peak-flow record for this streamgage represents an actual trend or is an anomaly. The removal of the 1963–64 peak discharges for the retesting of the White Breast Creek near Dallas streamgage (05487980) resulted in a Ken p-value of 0.069 indicating there is not a statistically significant trend in the 1965–2012 period of record. The Kendall's tau test results are sensitive to the smaller discharges at the beginning, and the larger discharges

Table 8. Multiple large flood events at selected U.S. Geological Survey streamgages during 1960–2012 and trend analyses.

[AEP, annual exceedance probability; Kentau, Kendall's tau; Ken *P*-value, probability level of Kendall's tau. Ken *P*-values indicating a statistically significant trend are highlighted in grey]

Streamgage number	Map number (fig. 3)	Streamgage name	Number of flood events during 1960–2012 with AEPs less than 2 percent and years of occurrence[a]	Kentau	Ken *P*-value	Trend analysis period of record (water years)	Number of years included in trend analysis
05389500	4	Mississippi River at McGregor	(2) 1965, 2001	-0.015	0.887	1963–2005, 2008–12	48
05412020	5	Turkey River above French Hollow Creek at Elkader	(3) 1991, 2004, 2008	0.164	0.533	2002–12	11
05412500	7	Turkey River at Garber	(4) 1991, 1999, 2004, 2008	-0.138	0.160	1963–2012	50
05414450	8	North Fork Little Maquoketa River near Rickardsville	(2) 1972, 2008	0.116	0.260	1963–79, 1981–88, 1991–95, 1997–2012	46
05414500	9	Little Maquoketa River near Durango	(2) 1972, 2011	0.002	1.000	1963–83, 1986–88, 1990–92, 1998–99	29
05416900	10	Maquoketa River at Manchester	(3) 2004, 2008, 2010	-0.030	0.945	2001–2012	12
05418500	13	Maquoketa River near Maquoketa	(2) 2002, 2010[b]	-0.130	0.190	1963–2009, 2011–12	49
05420500	14	Mississippi River at Clinton	(2) 1965, 2001	0.041	0.682	1963–2012	50
05420650	16	Little Wapsipinicon River near New Hampton	(2) 1990, 1993	-0.098	0.476	1966–93	28
05420690	17	East Fork Wapsipinicon River near New Hampton	(2) 1969, 1990	-0.350	0.011	1966–81, 1983–93	27
05421550	21	Buffalo Creek above Winthrop	(2) 1968, 1979	-0.182	0.200	1963–88	26
05421600	22	Buffalo Creek near Winthrop	(2) 1968, 1979	-0.012	0.958	1966–87, 1990	23
05453100	29	Iowa River at Marengo	(2) 1993, 2008	-0.091	0.357	1963–2012	50
05453520	30	Iowa River below Coralville Dam near Coralville	(2) 1993, 2008	-0.079	0.649	1993–2012	20
05454500	32	Iowa River at Iowa City	(2) 1993, 2008	-0.027	0.789	1963–2012	50
05455500	34	English River at Kalona	(2) 1993, 1996	-0.002	0.987	1963–2012	50
05455700	35	Iowa River near Lone Tree	(3) 1974, 1993, 2008	0.005	0.967	1963–2012	50
05457700	36	Cedar River at Charles City	(2) 1999, 2008	0.059	0.563	1963–2012	48
05458500	39	Cedar River at Janesville	(2) 1999, 2008	0.030	0.763	1963–2012	50
05464942	46	Hoover Creek at Hoover National Historic Site, West Branch	(2) 1967, 1993	0.055	0.876	2001–2011	11
05470000	49	South Skunk River near Ames	(5) July 1993, August 1993, 1996, 2008, 2010	-0.043	0.664	1963–2012	50
05470500	50	Squaw Creek at Ames	(5) 1990, 1993, 1996, 2008, 2010	-0.059	0.557	1965–2012	48

Table 8. Multiple large flood events at selected U.S. Geological Survey streamgages during 1960–2012 and trend analyses.—Continued

[AEP, annual exceedance probability; Kentau, Kendall's tau; Ken *P*-value, probability level of Kendall's tau. Ken *P*-values indicating a statistically significant trend are highlighted in grey]

Streamgage number	Map number (fig. 3)	Streamgage name	Number of flood events during 1960–2012 with AEPs less than 2 percent and years of occurrence[a]	Kentau	Ken *P*-value	Trend analysis period of record (water years)	Number of years included in trend analysis
05471000	51	South Skunk River below Squaw Creek near Ames	(4) 1993, 1996, 2008, 2010	-0.090	0.425	1963–79, 1990, 1992–2012	39
05474500	56	Mississippi River at Keokuk	(4) 1973, 1993, 2001, 2008	0.126	0.201	1963–2012	50
05476750	58	Des Moines River at Humboldt	(2) 1969, 1993	0.166	0.091	1963–2012	50
05481650	62	Des Moines River near Saylorville	(3) 1965, 1993, 2008	0.038	0.700	1963–2012	50
05483318	66	Brushy Creek near Templeton	(2) 1993, 1996	0.061	0.563	1966–70, 1972–93, 1996–2012	44
05484000	69	South Raccoon River at Redfield	(3) 1993, 1998, 2008	0.080	0.417	1963–2012	50
05484800	71	Walnut Creek at Des Moines	(2) 1986, 2010	0.150	0.171	1972–2012	41
05485500	72	Des Moines River below Raccoon River at Des Moines	(2) 1993, 2008	0.069	0.487	1963–2012	50
05487470	73	South River near Ackworth	(2) 1990, 2008	0.074	0.452	1963–2012	50
05487980	75	White Breast Creek near Dallas	(3) 1982, 1992, 1993	0.225	0.023	1963–94, 1996–2012	49
06807470	89	Indian Creek near Emerson	(4) 1982, 1987, 1998, 1999	0.180	0.074	1966–2012	47
06809500	92	East Nishnabotna River at Red Oak	(3) 1972, 1998, 2007	-0.018	0.861	1963–2012	50
06810000	93	Nishnabotna River above Hamburg	(2) 1998, 2007	0.036	0.719	1963–2012	50
06897950	94	Elk Creek near Decatur City	(2) 1993, 2007	-0.035	0.740	1967–2012	46
06898000	95	Thompson River at Davis City	(2) 1992, 1993	0.100	0.307	1963–2012	50

[a]See table 7 for 2-percent AEP estimate.

[b]Peak discharge affected by Lake Delhi Dam failure 74 miles upstream.

at the end, of the 1963–2012 peak-discharge record for the White Breast Creek near Dallas streamgage.

The results of the Kendall's tau test for 35 of the 37 streamgages listed in table 8 indicate that statistically significant trends are not evident in the 1963–2012 peak-flow records of these streamgages. A Kendall's tau retest using 95 percent of the 1963–2012 peak-flow record for the two streamgages, which are identified as having statistically significant trends in table 8, indicates there is not a statistically significant trend at one of the streamgages. Kentau values for 20 of the tests were positive, indicating a trend of increasing annual peak discharge, and were negative for 17 of the tests, indicating a trend of decreasing annual peak discharge; therefore, there is no overall clear indication of a positive or negative trend for all 37 streamgages. Only 17 of the 37 streamgages have complete annual peak-discharge records for all 50 years for the 1963–2012 period of record. Of the 17 streamgages with complete records for 1963–2012, Kentau values are positive for 11 of the streamgages. Because most of the Kentau values are near zero and most of the Ken *p*-values are much greater than 5 percent for the 17 streamgages, the results suggest there is no overall clear indication of a positive or negative trend for the 17 streamgages for the 1963–2012 period of record.

Computation and Reporting of Updated Estimates of Observed Flood Events

The computation and reporting of updated (2012) AEP estimates of observed flood events at streamgages listed in table 7 followed recommendations provided by the USGS Office of Surface Water Technical Memorandum 2013.01 (*http://water.usgs.gov/admin/memo/SW/sw13.01.pdf*). Updated AEPs of observed flood events at streamgages were calculated using a log-linear interpolation of WIE estimates computed at streamgages, unless noted otherwise. Although flood-frequency concepts, such as the B17B flood-estimation method (Interagency Advisory Committee on Water Data, 1982), were developed to provide reasonably precise estimates of AEPs at streamgages, there is more uncertainty in the estimation of AEPs for observed flood events. To indicate the uncertainty, updated AEP estimates (table 7) are accompanied with a 66.7-percent confidence interval that is likely to include the true AEP. Although the log-linear interpolation is reasonable for the estimation of AEPs for observed flood events, for the estimation of AEP confidence intervals for observed flood events, the log-linear interpolation fails to account for the uncertainty of the assumptions associated with the computed mean, standard deviation, and skew of the log-Pearson Type III (LP3) distribution of the logarithms (base 10) of the annual peak discharges, and the greater uncertainty because of the lack of reference data for the observed flood event being assessed. Because a nonparametric method can be used to compute AEP confidence intervals that are less susceptible to the assumptions associated with an LP3 distribution, confidence intervals of updated AEPs (table 7) were computed using a procedure based on the Beta distribution.

The Beta distribution procedure requires the number of years in the period of record and the rank of the observed flood event. The uncensored peak-discharge record length and the historic record length used in the EMA/MGB, or AEP, analysis at each streamgage are listed in table 7. The uncensored record length represents the number of actual peak discharges included in the EMA/MGB analysis and does not include any minimum-recording-threshold discharge values from crest-stage streamgages and missing years of record, whereas the historic record length includes censored data such as minimum-recording-threshold discharge values from crest-stage streamgages and missing years of record. The rank of each observed flood event listed in table 7 is determined on the basis of (1) the historic record length if the observed flood discharge is known to be greater than the lower perception threshold discharge used for the missing years of record in the EMA/MGB analysis, (2) the uncensored record length if the observed flood discharge is not known to be greater than the lower perception threshold discharge used for the missing years of record in the EMA/MGB analysis, or (3) a hybrid record length for a crest-stage streamgage if the observed flood discharge is not known to be greater than the lower perception threshold discharge used for the missing years of record, but is known to be greater than the lower perception threshold discharge used for minimum-recording-threshold discharge values in the EMA/MGB analysis.

The use of the 66.7-percent confidence level was selected by the USGS because confidence intervals based on 90- or 95-percent levels result in ranges that are extremely large and tend to be misunderstood by readers. It is important to note that the use of the nonparametric confidence intervals computed using the Beta distribution procedure provide the AEP range that is expected for a flood of a given rank within a specified period of record, and that these confidence intervals are not centered around the interpolated AEP estimate. As a result, the AEP estimate occasionally will be outside of the range of the confidence intervals because of the large uncertainty in the statistics. To provide additional information on the uncertainty of AEP estimates of observed flood events at streamgages, AEP estimates and associated 95-percent confidence intervals computed at streamgages using the WIE estimation method, unless noted otherwise, also are presented in table 7.

Summary

Flood-peak discharge and flood-profile information is needed for the economical and safe-location design of bridges and other structures on or over streams in Iowa and the adjacent flood plains. This report is part of an ongoing program of publishing flood profiles of streams in Iowa. The program is managed by the U.S. Geological Survey (USGS) in cooperation with the Iowa Department of Transportation (Iowa DOT) and the Iowa Highway Research Board (Project HR-140). This report summarizes 47 USGS flood-profile reports that were published for streams in Iowa during a 50-year period from 1963 to 2012. Thirty-six of these reports were prepared as part of Project HR-140. Flood events profiled in the reports range from a flood on the Des Moines River in 1903 to floods in the Maquoketa, Little Maquoketa, and South Skunk River Basins in 2010.

Streams in Iowa that have been selected for the preparation of flood-profile reports typically have drainage areas of 100 square miles (mi^2) or greater, and the documented flood events have annual exceedance probabilities (AEPs) of less than 2–4 percent, or recurrence intervals (RIs) greater than 25–50 years. This report summarizes flood-profile measurements, changes in flood-profile report content throughout the years, streams that were profiled in the reports, the occurrence of flood events profiled, and AEP estimates of observed flood events. To develop flood profiles for selected flood events on selected stream reaches, the USGS measured high-water marks (HWMs) and river miles at selected locations, typically at bridge sites. Flood profiles are longitudinal profiles of a river depicted graphically with river miles defining the abscissa and water-surface elevations defining the ordinate.

Average HWM elevations determined for the upstream and downstream sides of bridges define the water-surface elevations for plotting flood profiles. Average HWM elevations were calculated on the basis of several HWMs surveyed on each side of the bridge. The HWMs at bridges were located immediately downstream from a bridge and one bridge-length width distance upstream from the bridge. To facilitate measuring and referencing the HWMs used in the flood profiles to a common datum, bench marks (BMs), temporary bench marks (TBMs), and reference points were found or established by the USGS at selected bridges along the profiled stream reaches. The HWMs were surveyed to BMs and TBMs at bridges typically within a few days 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. Peak-discharge measurements are needed to estimate the AEP, or RI, of observed flood events to provide information on the magnitude and frequency of the floods at locations along profiled stream reaches. Direct, or indirect, measurement methods are used by the USGS to determine the peak discharge of flood events along profiled stream reaches.

Flood-profile reports include a map of the stream reaches profiled and the drainage-basin boundary for the profiled streams. Flood-peak discharge, stage, and date information for selected largest flood events at streamgages located in the basin of the profiled stream reaches also are included in flood-profile reports. A total of 94 stream reaches with unique stream names have been profiled in USGS flood-profile reports and approximately 94 stream reaches in Iowa with drainage areas of 100 mi^2 or greater have not been profiled in USGS flood-profile reports. Three rivers in Iowa (the Des Moines, Little Sioux, and South Skunk Rivers) have been profiled along the same stream reach for five different flood events, and six rivers in Iowa (the East Fork Des Moines, Floyd, Iowa, Raccoon, Rock, and Volga Rivers) have been profiled along the same stream reach for four different flood events. Floods were profiled for June flood events for 18 different years, followed by July flood events for 13 years, May flood events for 11 years, and April flood events for 9 years.

Most flood-profile reports include estimates of AEPs, or RIs, of observed flood events at streamgages along profiled stream reaches. Comparisons of 179 historic and updated AEP and RI estimates indicate few differences that are considered substantial between the two sets of estimates for the observed flood events, although estimation limitations for some historic AEPs and RIs prevent precise comparisons. Overall, precise comparisons for 114 observed flood events indicate that updated AEPs have increased, or RIs have decreased, for most of the observed flood events compared to the historic AEPs and RIs. Of the 25 observed flood events that are considered to have substantial differences between historic and updated AEP and RI estimates, all but one of them indicate that updated AEP estimates are greater, or updated RI estimates are lower, compared to historic AEP and RI estimates. Increases in updated AEP estimates for most of the observed flood events were due to the occurrence of additional large flood events at the streamgages since the occurrence of the observed flood events. Differences between the flood-estimation methods used to compute historic and updated AEP estimates could also be a factor in the differences between historic and updated AEPs of observed flood events.

An inspection of the 1960–2012 annual peak-discharge records of 98 selected streamgages determined that multiple large flood events exceeding the 2-percent AEP, or 50-year RI, flood discharge estimate occurred at 37 of the streamgages. Five large flood events were recorded at two streamgages in Ames during 1990–2010 and four large flood events were recorded at four other streamgages during 1973–2010. Results of Kendall's tau trend-analysis tests for 35 of the 37 selected streamgages indicate that a statistically significant trend is not evident for the 1963–2012 period of record; nor is an overall clear positive or negative trend evident for the 37 streamgages.

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