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# Hydrologic, Hydraulic, and Flood Analyses of the Blackberry Creek Watershed, Kendall County, Illinois

Scientific Investigations Report 2007–5141

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

**Cover.** Photograph taken south of Galena Road and north of Plan Corp Railroad tracks in Kendall County, Illinois in April 2004.

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By Elizabeth A. Murphy, Timothy D. Straub, David T. Soong, and
Christopher S. Hamblen

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**U.S. Department of the Interior**
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## Conversion Factors and Datums

| Multiply | By | To obtain |
|---|---|---|
| | Length | |
| inch (in.) | 25.4 | millimeter (mm) |
| foot (ft) | 0.3048 | meter (m) |
| mile (mi) | 1.609 | kilometer (km) |
| | Area | |
| square foot ($ft^2$) | 0.09290 | square meter ($m^2$) |
| square mile ($mi^2$) | 2.590 | square kilometer ($km^2$) |
| acre | 0.4047 | square hectometer |
| | Flow rate | |
| cubic foot per second ($ft^3/s$) | 0.02832 | cubic meter per second ($m^3/s$) |
| inch per hour (in/h) | 0.0254 | meter per hour (m/h) |
| | Hydraulic gradient | |
| foot per mile (ft/mi) | 0.1894 | meter per kilometer (m/km) |

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C=(°F-32)/1.8$$

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88). Historical data collected and stored as National Geodetic Vertical Datum of 1929 (NGVD 29) have been converted to NAVD 88 for use in this publication.

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83). Historical data collected and stored as North American Datum of 1927 (NAD 27) have been converted to NAD 83 for use in this publication.

# Hydrologic, Hydraulic, and Flood Analyses of the Blackberry Creek Watershed, Kendall County, Illinois

By Elizabeth A. Murphy, Timothy D. Straub, David T. Soong, and Christopher S. Hamblen

## Abstract

Results of the hydrologic model, flood-frequency, hydraulic model, and flood-hazard analysis of the Blackberry Creek watershed in Kendall County, Illinois, indicate that the 100-year and 500-year flood plains cover approximately 3,699 and 3,762 acres of land, respectively. On the basis of land-cover data for 2003, most of the land in the flood plains was cropland and residential land. Although many acres of residential land were included in the flood plain, this land was mostly lawns, with 25 homes within the 100-year flood plain, and 41 homes within the 500-year flood plain in the 2003 aerial photograph.

This report describes the data collection activities to refine the hydrologic and hydraulic models used in an earlier study of the Kane County part of the Blackberry Creek watershed and to extend the flood-frequency analysis through water year 2003. The results of the flood-hazard analysis are presented in graphical and tabular form.

The hydrologic model, Hydrological Simulation Program—FORTRAN (HSPF), was used to simulate continuous water movement through various land-use patterns in the watershed. Flood-frequency analysis was applied to an annual maximum series to determine flood quantiles in subbasins for flood-hazard analysis. The Hydrologic Engineering Center-River Analysis System (HEC-RAS) hydraulic model was used to determine the 100-year and 500-year flood elevations, and the 100-year floodway. The hydraulic model was calibrated and verified using observations during three storms at two crest-stage gages and the U.S. Geological Survey streamflow-gaging station near Yorkville. Digital maps of the 100-year and 500-year flood plains and the 100-year floodway for each tributary and the main stem of Blackberry Creek were compiled.

## Introduction

The Blackberry Creek watershed is a 68.1 mi$^2$ primarily agricultural watershed, approximately 40 mi west of metropolitan Chicago. The Kendall County part of the Blackberry Creek (approximately 10.6 mi$^2$) starts near the county boundary with Kane County at US Route 30 and extends to the confluence with the Fox River (fig. 1). The Kendall County part of the watershed extends approximately 12.0 river miles.

Urban development has increased in the watershed during the past few decades, with appreciable residential and commercial lands spreading out within the jurisdiction of United City of Yorkville, Village of Montgomery, Kendall County, and in the eastern part near Aurora and various other sections of the creek. The Blackberry Creek Watershed Resources Planning Committee projected that population and urbanized land are expected to double by 2020 (Blackberry Creek Watershed Resources Planning Committee, 1999).

Urbanization could cause adverse effects such as increasing flood peak volume and magnitude, as well as pollutants carried by urban runoff. For the Blackberry Creek watershed, flooding and associated damages have increased during the last three decades. Significant flood damage occurred during the storms of July 1983, July 1996, and February 1997. The storm of July 17–18, 1996, in particular, caused disastrous flood damage to many watershed locations, with more than 1,000 homes affected and more than $13 million in damage (Blackberry Creek Watershed Resource Planning Committee, 1999). The Blackberry Creek Watershed Resource Planning Committee was formed in 1996 to address the effects of urban development on flooding, in-stream biota, and pollutant loadings, and the need for information and scientific tools for resource protection in watershed planning and management. This committee drafted the Blackberry Creek Watershed Management Plan (Blackberry Creek Watershed Resources Planning Committee, 1999). One of the key recommendations in the plan was to update the available hydrologic and hydraulic models and the flood-hazard maps for the Blackberry Creek watershed.

In response to the information needs expressed in the management plan—hydrologic, hydraulic, and flood-hazard analyses—in 2004 the U.S. Geological Survey (USGS), in cooperation with the United City of Yorkville, Kendall County, Village of Montgomery, Illinois Department of Natural Resources-Office of Water Resources (IDNR-OWR), and Federal Emergency Management Agency (FEMA), began a study of the watershed. The USGS is using a continuous

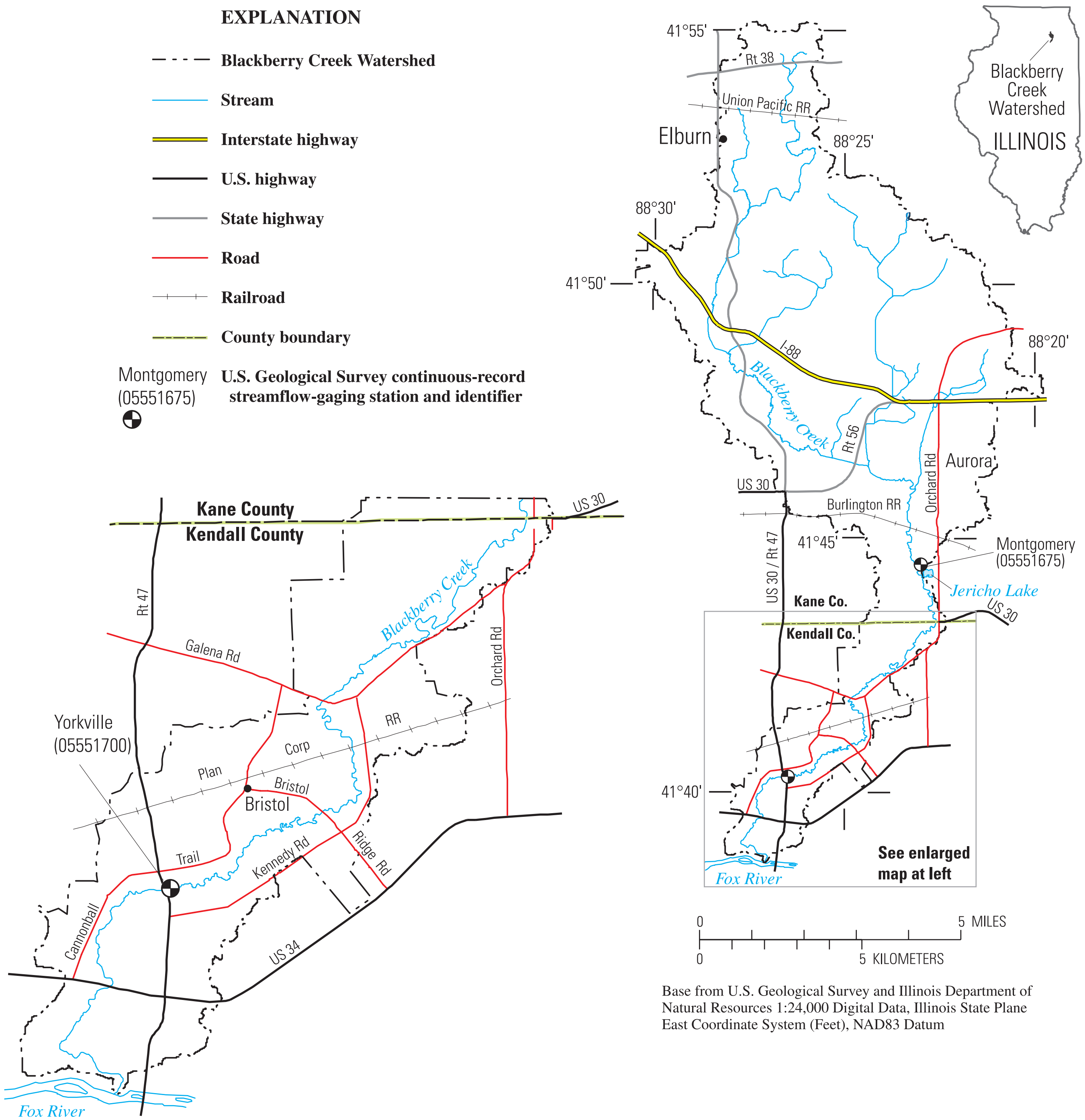



**Figure 1.** Location of Blackberry Creek watershed in Kane and Kendall Counties in northeastern Illinois. The study area includes only that part of the watershed in Kendall County.

hydrologic simulation/flood-frequency approach to generate the flood-peak streamflows used in the hydraulic model. This study demonstrates the successful application of this approach with the goal of promoting the use of this advanced technique for flood-hazard studies in other watersheds.

## Purpose and Scope

This report describes the procedures used in developing hydrologic and hydraulic models, and estimating flood-peak magnitudes and recurrence intervals used for flood-hazard analysis. The report includes detailed flood-hazard maps on digital orthophoto quadrangles (DOQs) of the watershed, as well as flood-frequency estimates for the watershed and subwatersheds.

To address the flood-hazard analysis on the watershed scale, the entire watershed (the main stem as well as seven tributaries of Blackberry Creek in Kane and Kendall Counties) was included in the hydrologic analyses. The flood-frequency, hydraulic, and flood-hazard analysis for the Kane County part of the watershed was documented in Soong and others (2005) and is not included in this report.

## Previous Studies

Effective peak-flood discharges for Blackberry Creek (Federal Emergency Management Agency, 2002) for two locations in Kendall County were determined in 1976 using a U.S. Department of Agriculture (USDA) Technical Report 20 hydrologic model (TR-20, USDA, 1992). These numbers were determined to be outdated by comparing them to the flood frequencies (Soong and others, 2004) estimated using data from the U.S. Geological Survey's streamflow-gaging station near Yorkville (station 05551700, fig. 1).

A flood-hazard study of the Blackberry Creek watershed in Kane County, Illinois, has been completed by the USGS and Kane County Division of Environmental and Building Management (KCDEM) (Soong and others, 2005). The 100- and 500-year flood plain and 100-year floodway maps were generated for the determination of flood hazard areas in Blackberry Creek watershed in Kane County; however, a refined digital elevation model (DEM) was not available for the Kendall County part of the watershed during the study period from 2000 to 2004. Without detailed elevation data, refined watershed boundaries and flood-hazard mapping could not be completed. Also, some cross-section intervals were too large in Kendall County for accurate flood-hazard analysis; therefore, flood-hazard analysis was performed only for the Kane County part of the Blackberry Creek watershed in the study. To gain confidence in the accuracy of estimated flood quantiles from various land uses in the watershed, the USGS used a continuous hydrologic simulation/flood frequency approach. Flood quantiles were estimated along the main stem and six major tributaries (excluding the Aurora Chain-of-Lakes tributary) of Blackberry Creek. The estimated flood quantiles were used in the hydraulic model to determine flood stages and floodway encroachment. In 2005, the USGS and KCDEM completed an addendum to the report by Soong and others (2005) that added the Aurora Chain-of-Lakes tributary to the analyses.

Before the Soong and others (2005) study, the U.S. Department of Agriculture, Soil Conservation Service (now the Natural Resources Conservation Service (NRCS)) conducted a watershed-wide flood-hazard analysis to estimate flood quantiles and flood stages along Blackberry Creek (U.S. Department of Agriculture, Soil Conservation Service, 1989). The 1989 USDA study used the TR-20 hydrologic model with U.S Weather Bureau Technical Paper 40 rainstorms (Hershfield, 1961) for estimating peak discharges, and the Soil Conservation Service Water Surface Profile hydraulic model (WSP2, USDA, 1976) for estimating peak stages. Besides identifying the 100- and 500-year flood plains and the floodway, the study also identified developed areas prone to flooding, evaluated the importance of natural storage in the watershed, and suggested alternatives for flood-plain management.

Regional regression equations for Illinois were developed by Soong and others (2004). The regional regression equation estimates the mean (logarithmic) value of flood quantiles obtained at different watersheds in a region with the same set of explanatory variables. These equations can be applied to the rural streams in the watershed, but could not be applied to the streams in urban areas because the equations were developed based on rural streams. Also, the FEMA guidelines suggest that regional regression equations be used only for preliminary studies.

## Approach

The overall approach of this study is similar to that of Soong and others (2005) and is depicted in a flowchart shown in figure 2. The steps followed are listed below.

1. Observed precipitation and other meteorological time series were input to a hydrologic model to supply a continuous streamflow time series at the outlet of each subbasin in the watershed. The Hydrological Simulation Program–FORTRAN (HSPF, Bicknell and others, 2000) was used to perform the hydrologic modeling.
2. Utilizing the flood-peak data—specifically, the annual maximum series (AMS), determined from the streamflow time series—flood quantiles for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year floods were estimated at selected locations using flood-frequency analysis procedures. Procedures for the flood-frequency analysis followed the recommendations described in Bulletin 17B (U.S. Interagency Advisory Committee on Water Data, 1982). The frequency analysis was completed with the PEAKFQ program (Version 4.1, Thomas and others, 1998).

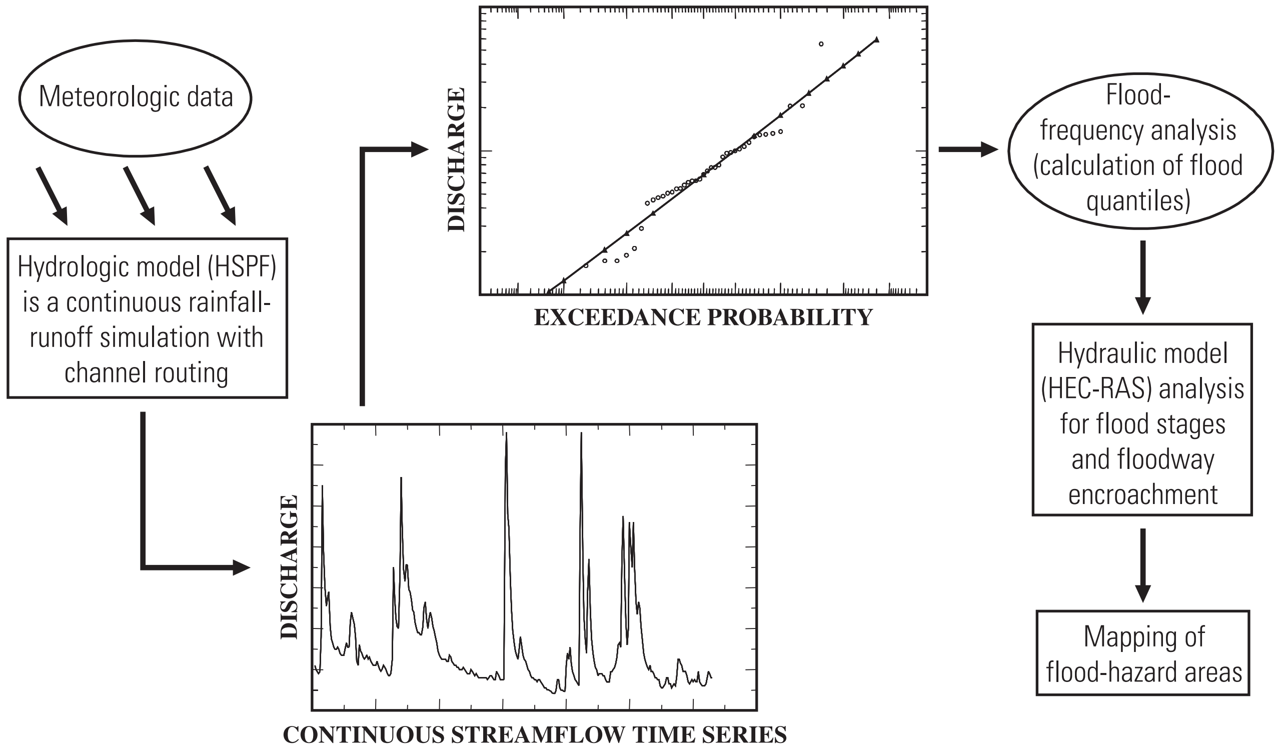



**Figure 2.** General approach used for the Blackberry Creek watershed study, Kendall County, Illinois. [HSPF, Hydrological Simulation Program–FORTRAN; HEC-RAS, Hydrologic Engineering Center-River Analysis System].

3. The HEC-RAS (Hydrological Engineering Center-River Analysis System) hydraulic model (U.S. Army Corps of Engineers, 2002) was used in this study to route the flood-peak discharge and determine the flood elevations throughout Blackberry Creek watershed. The 100- and 500-year flood elevations subsequently were used to delineate flood plains for the main stem. Encroachment analysis also was performed in HEC-RAS to determine the floodway widths.
4. Using geographic information system (GIS) techniques and digital datasets, the resulting flood elevations from the hydraulic model were mapped for the 100- and 500-year flood plains and for the floodway. These maps were overlaid on DOQs to determine flood-hazard areas. The FEMA designation for the areas within the 100-year flood plain boundary, areas between the 100-year and 500-year flood plain boundaries, and areas within the 500-year flood plain boundaries are Special Flood Hazard Areas, Areas of Moderate Flood Hazard, and Areas of Minimal Flood Hazard, respectively. These maps are not FEMA-approved flood insurance rate maps (FIRMs) and are subject to revision.

The approach used in this flood-hazard study was unique because flood quantiles were estimated using flood-frequency analysis on simulated flood data and not design storms. This flood-hazard study details the continuous-simulation/flood-frequency approach and explains how the approach is applied in the Blackberry Creek watershed. The success of the continuous-simulation/flood-frequency approach in this study indicates that this approach could be applied in flood-hazard studies in other watersheds in similar hydrogeologic settings.

## Study Area Description

The Blackberry Creek watershed extends approximately 33 river miles from northeast of the intersection of Illinois Routes 47 and 38 (fig. 1) to the confluence with the Fox River in Kendall County. The climate, topography, physiography, and streamflow are important characteristics in understanding the hydrology and hydraulics of the watershed.

### Climate

The climate of northeastern Illinois is humid continental with warm to hot summers and moderate to fairly cold winters. The proximity of the watershed to Lake Michigan (approximately 45 mi) has a moderating effect on climate at the watershed (Federal Emergency Management Agency, 1996). The long-term average annual precipitation is 37 in. and the long-term average temperature is approximately 49 °F at Aurora (U.S. Department of Commerce, 2001) for

132 and 122 years of data, respectively. Cyclonic and convective storms have caused excessive surface runoff in northern Illinois. The largest streamflow values often are observed from mid-winter to late spring, when ground conditions (soil moisture and vegetation growth) are conducive to minimal infiltration rates and large runoff amounts. Intense, short-duration storms during the summer season have produced major floods in the Blackberry Creek watershed.

### Topography and Physiography

The Blackberry Creek watershed is within the Bloomington Ridged Plain (Leighton and others, 1948). The area is characterized by low, broad morainic ridges with intervening wide stretches of flat or gently undulating ground moraine. The physiographic contrasts between various parts of Illinois result because of the topography of the bedrock surface, extent of the multiple glaciations, differences in glacial morphology, the age of uppermost drift, and other factors (Leighton and others, 1948, p. 18). Parent soil materials in the Blackberry Creek watershed are loess, glacial till, lacustrine, outwash alluvium, and organic deposits. Illinois Episode and older drift are below the Wisconsin Episode in most places. The glacial deposits range from thin (less than 1 ft thick) near the Fox River to thick (exceeding 100 ft) in the uplands (Leighton and others, 1948, fig. 3). Older drift sheets fill and cover irregularities of the bedrock surface. Watershed topography developed from the succession of two or three drift sheets resulting from subsequent glaciations. The topography varies from level and nearly level to rolling with numerous small depressions and steeper slopes at headwater sections of the main stem and tributaries. The change in relief from the headwaters to the mouth of Blackberry Creek is about 300 ft.

### Streamflow Characteristics

Discharge at the USGS streamflow-gaging station at Blackberry Creek near Yorkville (USGS station 05551700, fig. 1) was compared to the discharge simulated in the hydrologic model. This gaging station has a drainage area of 65.41 $mi^2$, so it drains most of the watershed. The average and range of surface-water flows from the watershed are discussed in terms of the daily mean discharges measured at the Blackberry Creek near Yorkville gaging station. Annual mean of the daily mean discharge is a characteristic of the yearly flow budget from the watershed. Overall, the annual mean of daily mean discharge of the Blackberry Creek watershed ranged from 16.7 $ft^3/s$ to 97.8 $ft^3/s$, with an average of 53.5 $ft^3/s$ based on streamflow records from water year (WY) 1961 to WY 2004. During the same time period, the daily mean streamflow at this station ranged from 1.3 $ft^3/s$ recorded on September 20, 2003, to 3,460 $ft^3/s$, recorded on July 18, 1996 (in which the maximum peak discharge was 5,510 $ft^3/s$) (LaTour and others, 2006). A flow-duration curve for the same time period showed that the daily mean streamflow would equal or exceed 110 $ft^3/s$ 10 percent of the time, 31 $ft^3/s$ 50 percent of the time, and 9.9 $ft^3/s$ 90 percent of the time.

# Input Data

Data needed for input and use in model development and verification and flood-hazard mapping included stream and flood-plain cross sections, streamflow, soil, land use, meteorologic, and topographic. The coordinate system used in this report is the Illinois State Plane Coordinate System—East Zone HARN (High Accuracy Reference Network), NAD83, and NAVD88 altitude.

## Cross Section

The WSP2 hydraulic routing model developed during the U.S. Department of Agriculture, Soil Conservation Service study (1989) included natural and structural cross sections surveyed by the Illinois Department of Transportation, Division of Water Resources (IDOT-DWR) in 1985 and by the Illinois State Water Survey in 1975. The WSP2 program (U.S. Department of Agriculture, Soil Conservation Service, 1976; U.S. Department of Agriculture, Soil Conservation Service, 1993) simulates hydraulic structures using fewer cross sections (no approach or departure cross sections) than the HEC-RAS program. Review and field verification of the data from 1985 also indicated that bridges had been modified since 1985 and that additional bridges needed to be added in model simulation. Also, the approach and departure cross sections of hydraulic structures were needed in the HEC-RAS models.

Limited surveys were conducted by the USGS and the IDNR-OWR to acquire data for new bridges and culverts, to survey approach and departure cross sections for the hydraulic structures, and to document natural cross sections in the watershed. New natural cross-sectional surveys were conducted to fill in the gaps between available surveyed data in the main stem of Blackberry Creek. The cross sections surveyed in 1985 were kept in the model with the coordinates converted from NAD27/NGVD29 to NAD83/NAVD88 using the CORPSCON program (U.S. Army Corps of Engineers, 1997); the cross sections surveyed in 1975 were discarded because of uncertainties in georeferencing and because the cross sections were completed using a simplified approach (8-point surveys). The rest of the survey coordinates are referenced to the Illinois State Plane Coordinate System—East Zone HARN, NAD83, and NAVD88 altitude. During the model evaluation stage, additional cross sections were added by interpretation from the DEM.

## Streamflow

Streamflow data are available at two locations in the watershed: the USGS streamflow-gaging station Blackberry

Creek near Yorkville (station 05551700) located close to the downstream end of the watershed, and the USGS streamflow-gaging station Blackberry Creek near Montgomery (station 05551675) located at the Jericho Road bridge crossing in Kane County (fig. 1). The unit-value discharges have been developed for the Yorkville station after September 1989 and for the Montgomery station for the period of record (water years 1998 to 2005). The unit-value discharges were aggregated to form the hourly streamflow time-series data so they could be compared to simulated hourly streamflow with the HSPF model simulation. The peak, daily mean, and unit-value discharge data for the two stations are published in the USGS annual water data report for Illinois (LaTour and others, 2006). The streamflow data at both stations were used in the calibration and verification of the model parameters in the Soong and others (2005) study, but only data from the Yorkville station are used in this study.

## Soil

The NRCS maintains three soil geographic databases: Soil Survey Geographic (SSURGO), the State Soil Geographic (STATSGO), and National Soil Geographic (NATSGO) databases. Among the databases, the SSURGO database provides the most detailed soil information, whereas the NATSGO database provides the least detailed soil information. The SSURGO database for Illinois (U.S. Department of Agriculture, Natural Resources Conservation Service, 1995) was used for assessing soil information for the Kane County part of the Blackberry Creek watershed; the STATSGO database for Illinois (U.S. Department of Agriculture, Natural Resources Conservation Service, 1994) was used for the Kendall County part of the watershed because the SSURGO database was not available for Kendall County at the time of this study.

The hydrologic soil groups A, B, C, and D (Donigian and Davis, 1978, p. 61) were used to classify soils in the watershed. Soil group A has the highest infiltration capacity (0.4-1.0 in/h). Soil group B has the second highest infiltration capacity (0.1-0.4 in/h), and soil groups C and D have smaller infiltration capacities of 0.05-0.1 and 0.01-0.05 in/h, respectively (U.S. Environmental Protection Agency, 2000). Soil group A has the lowest runoff potential because of high infiltration capacity and good drainage, with the amount of runoff increasing for B, C, and D. Soil group B is the dominant soil type for the Blackberry Creek watershed (fig. 3). In the hydrologic model, soil groups A and B were simulated as one soil type and soil groups C and D as another soil type.

## Land-Use

The land-use categories used in the hydrologic model were interpreted from the Illinois land-cover database (Luman and others, 1996). The USGS digitized low-, medium-, and high-density urban areas using the 2004 Kane (Thomas Nicoski, Kane County GIS-Technologies, written commun., 2005) and 2003 Kendall aerial maps (Arron Lee, The Sidwell Company, written commun., November 2005) and incorporated the new data in the HSPF model. These land-cover data are presented in figure 4. Future conditions data are available for Kane representing 2020 conditions (Kevin Beutell, Conservation Design Forum, written commun., 2004) and complete build-out for Kendall (Todd Vanadilok, Teska Associates, Inc., written commun., 2005).

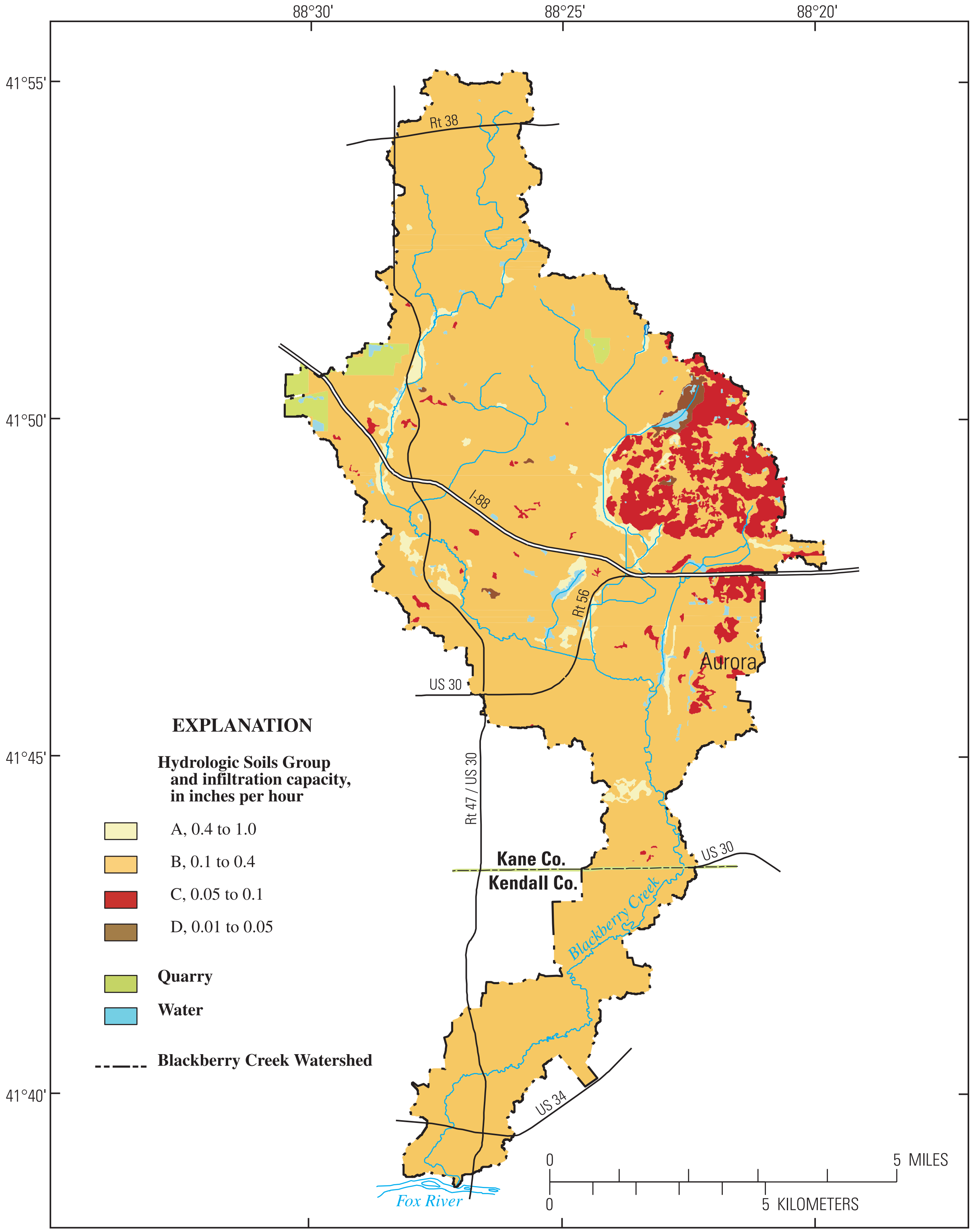
## Meteorology

Meteorological data, including potential evapotranspiration, precipitation, air temperature, net solar radiation, wind movement, and dewpoint temperature, were input to HSPF for deriving the runoffs. A meteorological database for water years 1949–99 was established during the Soong and others (2005) study. This study extended meteorological data to water year 2003 with data available from the Argonne National Laboratory, including measured air temperature, dewpoint temperature, wind movement, and net solar radiation (LaTour and others, 2006). The potential evapotranspiration was computed externally using the Lamoreux Potential Evapotranspiration (LXPET) program (Lamoreux, 1962; Murphy, 2005); snowmelt and snowmelt accumulation were computed with the energy balance approach specified in the HSPF program (Bicknell and others, 2000).

Precipitation data collected from precipitation gages in the vicinity of the watershed used in the Soong and others (2005) study also were extended to water year 2003. These precipitation gaging stations are shown in table 1 and figure 5. All these stations have a reading accuracy of 0.01 in. and record at hourly or daily intervals. Because flow computations are performed at 1-hour intervals (treated as instantaneous flows), stations with time steps greater than 1 hour were disaggregated to a 1-hour time step by referring to information from nearby stations as outlined in Soong and others (2005). Precipitation data from Aurora and St. Charles were used in the calibration and verification of the HSPF model (Soong and others, 2005) and for further verification in this study because of their proximity to the Blackberry Creek watershed. The Thiessen method (Chow and others, 1988) was used to assign station values to parts of the watershed (fig. 5). Argonne National Laboratory precipitation data were shown to be representative of the region (Soong and others, 2005) and are used for long-term hydrologic simulation in HSPF.

## Topography

Topographic features of the watershed were determined with a DEM. The DEM also was used to analyze subbasin delineation and surface slopes and in flood-hazard mapping. Topographic points were provided to Kendall County in 2005 (Gary Lobdell, The Sidwell Company, written commun., 2005) and were determined from aerial photography com-




Kane County part of watershed from SSURGO database, U.S. Department of Agriculture, Natural Resources Conservation Service, 1995. Kendall County part of watershed from STATSGO database, U.S. Department of Agriculture, Natural Resources Conservation Service, 1994.

Base from U.S. Geological Survey and Illinois Department of Natural Resources 1:24,000 Digital Data, Illinois State Plane East Coordinate System (Feet), NAD83 Datum.

**Figure 3.** Hydrologic soil groups in the Blackberry Creek watershed, Illinois.

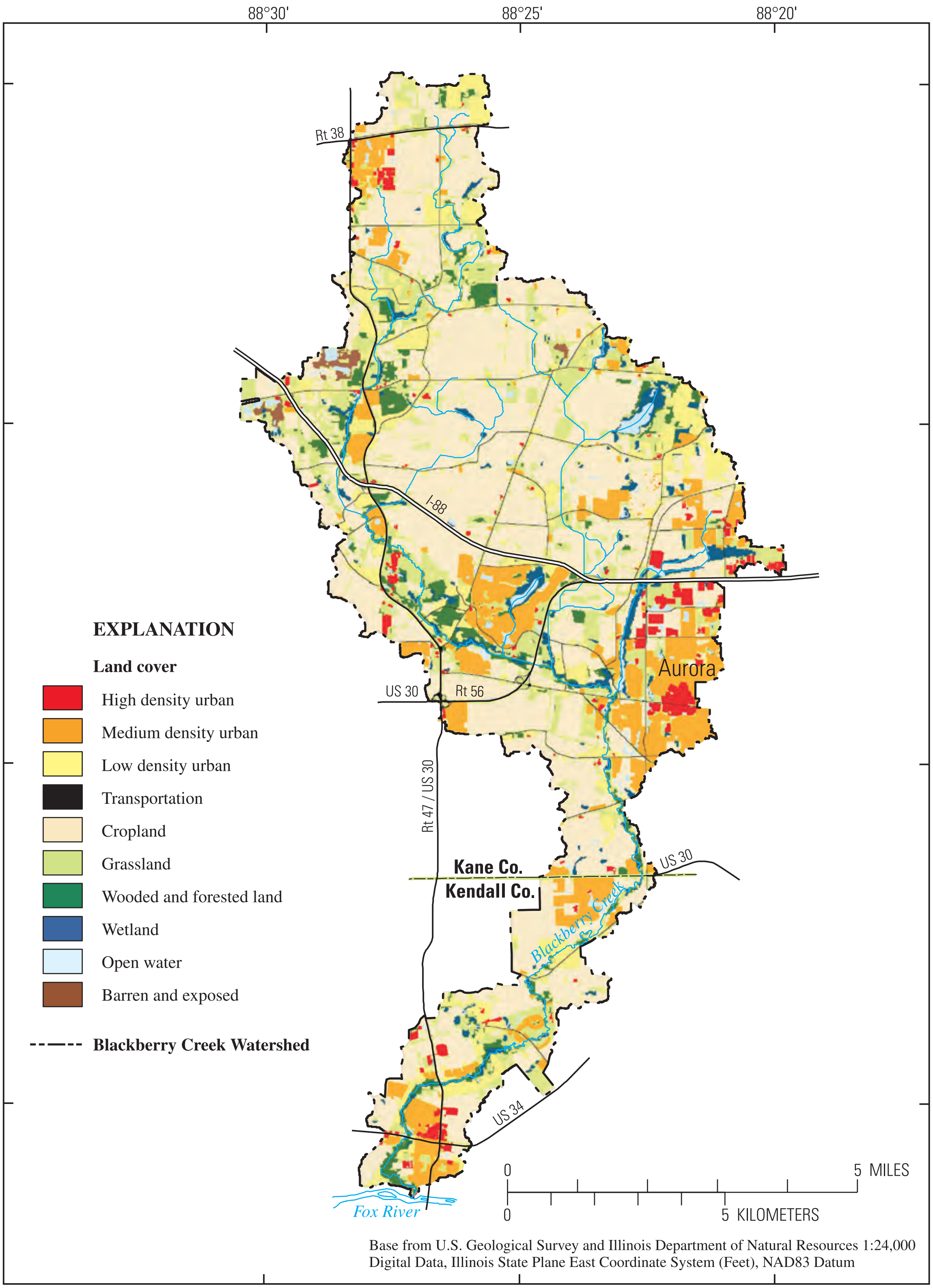


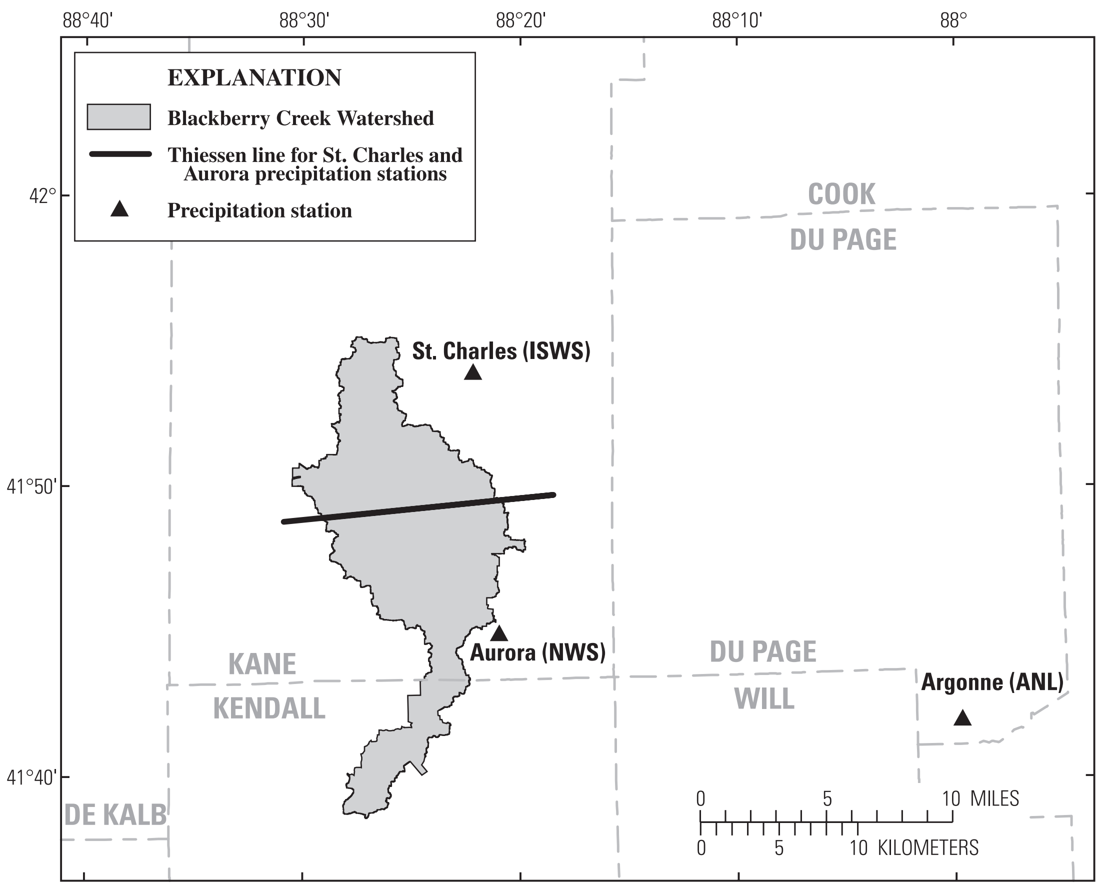

**Figure 4.** Land cover in the Blackberry Creek watershed, Illinois.

pleted in 2003. The USGS produced a 10-ft by 10-ft DEM using these topographic points (an accuracy statement can be found in appendix A). The refined DEM was used with Arc-Hydro (Maidment, 2002) to delineate subbasins of the Blackberry Creek watershed and in mapping the flood-hazard areas. The subbasin numbering system used in the study is shown in table 2 and figure 6. Considering the refined Kendall County elevation data, there are differences in the subbasin delineation as compared to Soong and others (2005). Manual adjustments to the watershed boundary were made to account for present and future developments that alter the natural drainage. Along the western part of the watershed in Kendall County, an existing boundary for the Rob Roy watershed (Jeffrey Freeman, Engineering Enterprises, Inc., written commun., 2005) was matched where discrepancies existed.

**Table 1.** Selected precipitation stations in the vicinity of the Blackberry Creek watershed, Kendall County, Illinois.

| Station name | Station type | Time step | Installed[1] |
|---|---|---|---|
| | National Weather Service | | |
| Aurora | Standard nonrecording | Daily | 1948 |
| | Illinois State Water Survey | | |
| St. Charles | Universal weighing | Hourly | 1989 |
| | Argonne National Laboratory | | |
| Argonne National Laboratory | Universal weighing | Daily | 1948 |

[1]All stations currently (2007) are in operation.




Base from U.S.Geological Survey 1:100,000-scale digital data,
Albers Equal-Area Conic Projection
Standard parallels 45° and 33°, central meridian -89°.

**Figure 5.** Location of precipitation stations in the vicinity of the Blackberry Creek watershed, Illinois. [NWS, National Weather Service; ISWS, Illinois State Water Survey; ANL, Argonne National Laboratory].

**Table 2.** Delineated subbasin numbering system used in this study of the Blackberry Creek watershed, Illinois.

| Stream reach | Subbasins (upstream to downstream) (fig. 6) |
|---|---|
| Tributary F | 10 |
| Tributary D | 22, 21, 20 |
| Tributary C | 33, 32, 31, 30 |
| Prestbury Tributary | 41, 40 |
| Lake Run Tributary | 57, 56, 55, 54, 53, 52, 51, 50 |
| East Run Tributary | 64, 63, 62, 61, 60 |
| Chain-of-Lakes Tributary | 79, 78, 77, 76, 75, 74, 73, 72, 71, 70 |
| Main stem of Blackberry Creek | 208, 210, 213, 216, 218, 223, 226, 230, 233, 236, 240, 250, 260, 265, 270, 276, 278, 279, 280, 286, 290 |

# Hydrologic, Hydraulic, and Flood Analyses

Hydrologic analysis was completed using the continuous hydrologic model, HSPF. The simulated streamflow from the hydrologic model was used in a flood frequency analysis to estimate flood quantiles at the outlet of each subbasin in the watershed. The estimated flood quantiles were used as input for the hydraulic model, HEC-RAS. The flood elevations simulated by the hydraulic model were used to map the 100- and 500-year flood plain boundaries. These analyses are described in more detail in the following sections.

## Continuous Hydrologic Model

Observed precipitation and other meteorological time series were input to a hydrologic model, HSPF, to provide a continuous-streamflow time series at various locations in the Blackberry Creek watershed. From each streamflow time series, a flood-peak series was determined and used to calculate flood quantiles at that location with the flood-frequency analysis.

HSPF (Bicknell and others, 2000) is public-domain software supported by the USGS and U.S Environmental Protection Agency (USEPA). It is among the most comprehensive continuous- simulation hydrologic models available (Singh, 1995); it can be used for evaluating the effects of various land uses on runoff and stormwater-management practices. HSPF contains sediment and water-quality modules that could be used in later studies to perform water-quality analyses. HSPF also is an accepted hydrologic model by FEMA for use in the National Flood Insurance Program (NFIP) (Federal Emergency Management Agency, 2007). HSPF was used in this study to simulate continuous water movement through various patterns of land uses in the watershed. In the simulation, various water movements in the hydrologic cycle, including interception, depression and storage, infiltration, interflow, ground water, soil moisture, surface runoff, and evapotranspiration (fig. 7) were described. Snow accumulation and melt also were simulated.

Simulating the physical processes of the hydrologic cycle in the Blackberry Creek watershed with HSPF involves preparing a user control input (UCI) file. The UCI file describes the conceptualized physical process of water (or other constituents) movement over the land, through the soil (fig. 7), and in the channels of the actual watershed so HSPF can simulate the movement.

In an HSPF simulation, computations are performed on land surfaces with spatially averaged land use and/or on channel reach segments. Land with a pervious surface is called a pervious-land segment (symbol PERLND) and land with impervious surface is called an impervious-land segment (symbol IMPLND). Further division of PERLND or IMPLND to more descriptive land-use segments can be done based on the model simulation objectives. The PERLNDs and IMPLNDs used in describing the land uses of the Blackberry Creek watershed are given in table 3. As described previously, the land-use categories generally follow the land-cover database categories (Luman and others, 1996). The USGS digitized low-, medium-, and high-density urban areas using the 2004 Kane and 2003 Kendall aerial maps. A summary of percentages of PERLND and IMPLND for Kendall County subbasins is presented in table 4.

Hydrologic model parameters that are used to simulate the continuous water movement and storage among various physical components in the hydrologic cycle significant to different land-use segments were calibrated and verified in Soong and others (2005) and are used in this study (table 5); however, the streamflow simulations have been increased from 49 water years (WY 1950–99) to 54 WY (WY 1950–2003) based on observed meteorological data from Argonne National Laboratory (LaTour and others, 2006). For event verifications, the precipitation data from St. Charles and Aurora also have been included for water year 2003.

Aside from the streamflow volumes estimated by the hydrologic analysis, channel storage and roughness characteristics can modify the shape and peaks of outflow hydrographs. To determine a streamflow time series at each subbasin outlet, a routing function (stage, storage volume, and discharge rating) was developed for each subbasin. The rating for the subbasin is developed in the HEC-RAS model by modeling the reach that is within the subbasin. A range of discharges expected in the subbasin are modeled, and the resulting stage and storage volume for each discharge are used in the HSPF routing function.

Kendall County, the City of Montgomery, and the United City of Yorkville all have regulations that include stormwater detention release rates. These regulations were put in place to control large storm run offs as the watershed has become more urbanized. Kendall County and the City of Montgomery have a release rate of 0.10 $ft^3$/s-acre of impervious land, whereas the release rate in the United City of Yorkville is 0.15 $ft^3$/s-acre of

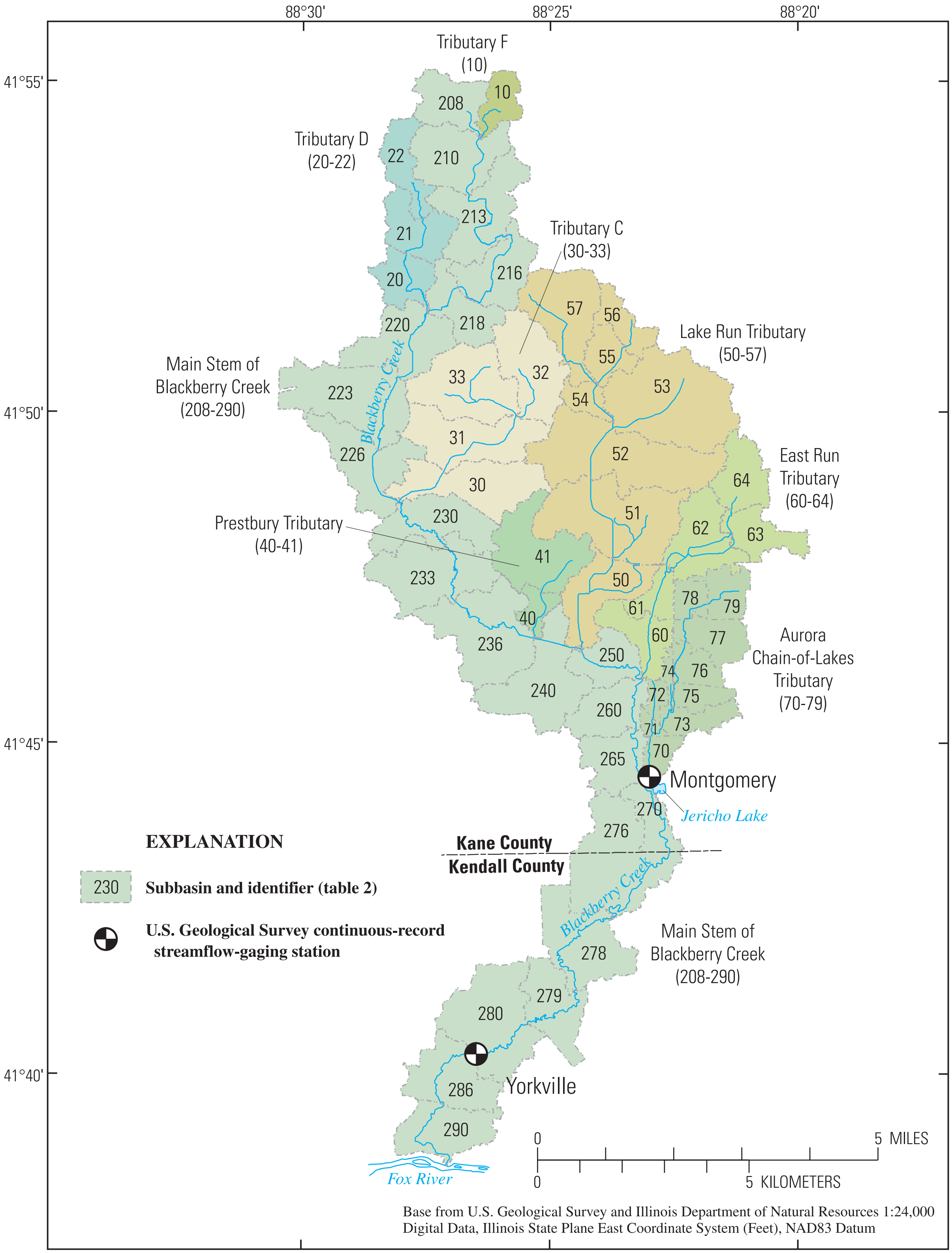
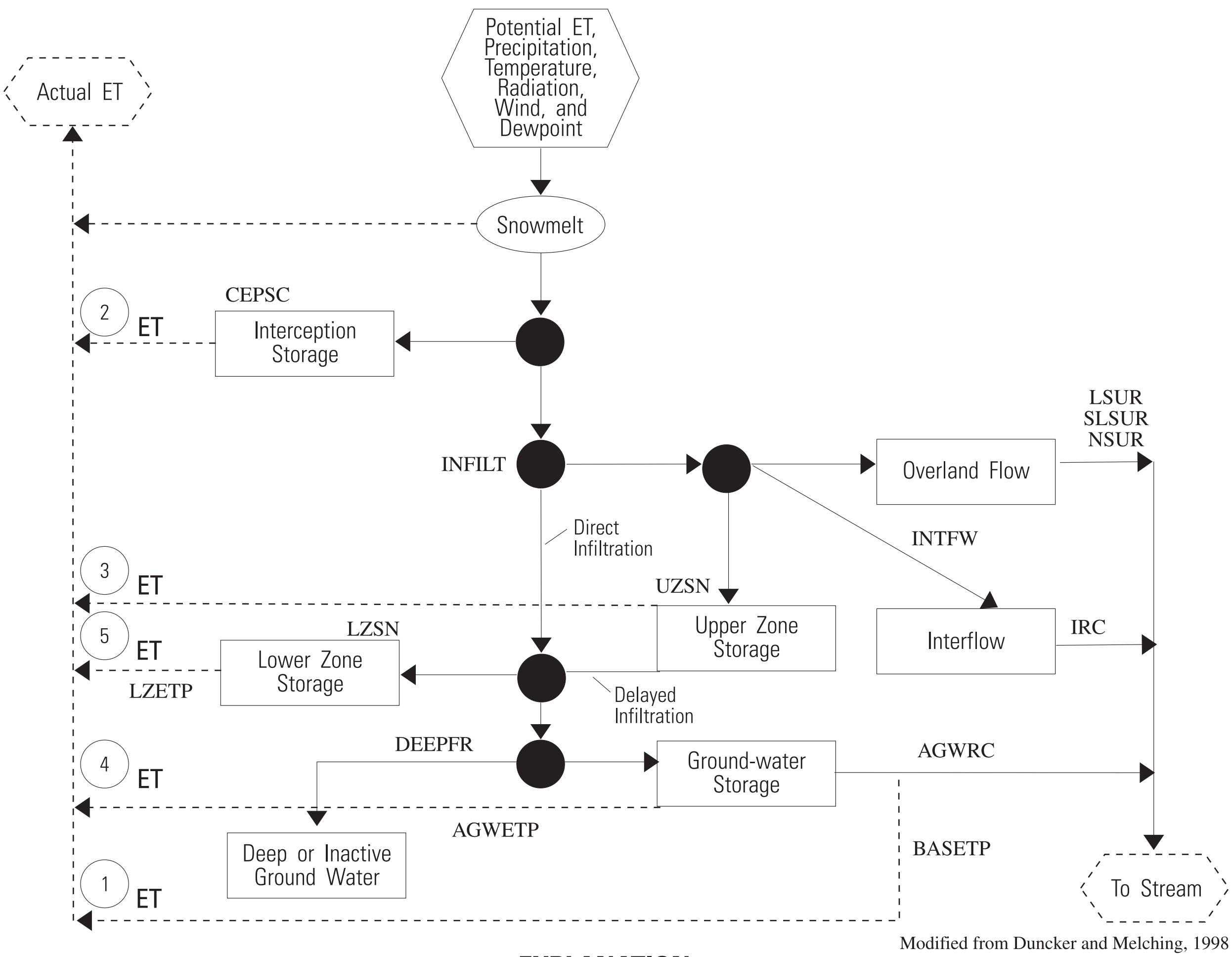
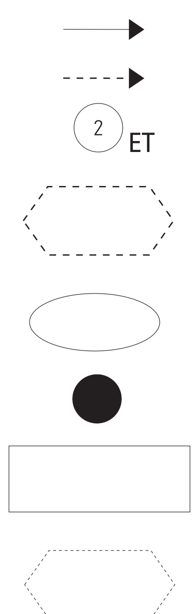



**Figure 6.** Subbasins and their associated numbering system used in the Blackberry Creek watershed in Kane and Kendall Counties, Illinois.




**EXPLANATION**




SYMBOLS

- Flow direction
- Water lost to evapotranspiration (ET)
- Number denotes the order water is taken to meet evapotranspiration (ET) demand
- Input
- Process
- Model decision point
- Storage
- Output

| PARAMETER | |
|---|---|
| CEPSC | Interception storage |
| INFILT | Infiltration |
| LSUR | Length of overland flow plane |
| NSUR | Manning's n for the overland flow plane |
| SLSUR | Slope of overland flow plane |
| INTFW | Interflow |
| UZSN | Upper zone storage |
| IRC | Interflow recession constant |
| LZSN | Lower zone nominal storage |
| LZETP | Lower zone evapotranspiration |
| DEEPFR | Fraction of ground-water inflow that goes to inactive ground water |
| BASETP | Base-flow evapotranspiration |
| AGWETP | Active ground-water evapotranspiration |
| AGWRC | Active ground-water recession constant |

**Figure 7.** Hydrological Simulation Program–FORTRAN process model.

**Table 3.** Land cover represented by PERLNDs (pervious lands) and IMPLNDs (impervious lands) in the Hydrological Simulation Program–FORTRAN.

| HSPF | Land cover |
|---|---|
| | PERLND |
| Cropland | Row crops, small grains, orchards/nurseries |
| Grassland | Urban grassland, rural grassland |
| Forested and wooded land | Deciduous woods, open woods, coniferous woods |
| Pervious residential | 90 percent of low density urban; 50 percent of medium density urban |
| Wetland | Shallow marsh/wet meadow, deep marsh, bottomland forest, swamp, shallow water wetland |
| Barren and exposed land | Quarries, bare soil surfaces, beaches |
| | IMPLND |
| High density urban | All or nearly all of the land surface covered with manmade structures, open water (Open water is a separate category in the land-cover database but is simulated in the hydrologic model as impervious land.) |
| Impervious residential | 10 percent of low density urban; 50 percent of medium density urban |
| Transportation | Interstates, highways, primary roads |

**Table 4.** Percent values of PERLNDs (pervious lands) and IMPLNDs (impervious lands) in the Kendall County part of the Blackberry Creek watershed, Illinois.

| | Percent in watershed[1] | |
|---|---|---|
| PERLND or IMPLND | Kendall County | Kane and Kendall County |
| Cropland | 46.1 | 47.0 |
| Grassland | 15.0 | 19.6 |
| Forested and wooded land | 5.1 | 3.9 |
| Wetland | 2.6 | 2.9 |
| Pervious residential | 11.1 | 8.7 |
| High density urban | 2.9 | 2.6 |
| Impervious residential | 15.4 | 11.9 |
| Transportation | .6 | 1.2 |
| Barren and exposed land | .0 | .4 |

[1]Percent values are rounded to the tenth.

**Table 5.** Hydrologic Simulation Program–FORTRAN (HSPF) model parameters for the Blackberry Creek watershed, Illinois.

[ft/ft, foot per foot; Parameters: FOREST, fraction of pervious land covered by forest; LZSN, lower zone nominal storage; INFILT, infiltration; NSUR, Manning's n for overland flow plane; AGWRC, active ground-water recession constant; DEEPFR, fraction of ground-water inflow; AGWETP, active ground-water evapotranspiration; INTFW, interflow; IRC, interflow recession constant; Surface slopes: Flat to moderate is defined by a slope of less than or equal to 0.03 ft/ft; Steep is defined by a slope greater than 0.03 ft/ft; Soil groups: Soil 1 includes hydrologic soil groups A and B; Soil 2 includes hydrologic soil groups C and D (see figure 3 for of soil groups data)]

| Pervious land segment (PERLND) | HSPF model parameters | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | FOREST | LZSN | INFILT | NSUR | AGWRC | DEEPFR | AGWETP | INTFW | IRC |
| Cropland (flat to moderate) (soil 1) | 0.00 | 4.0 | 0.080 | 0.10 | 0.980 | 0.05 | 0.05 | 4.5 | 0.70 |
| Cropland (flat to moderate) (soil 2) | .00 | 3.5 | .030 | .10 | .980 | .05 | .05 | 4.5 | .70 |
| Cropland (steep) (soil 1) | .00 | 3.5 | .075 | .10 | .980 | .05 | .05 | 4.0 | .65 |
| Cropland (steep) (soil 2) | .00 | 3.0 | .025 | .10 | .980 | .05 | .05 | 4.0 | .65 |
| Grassland (flat to moderate) (soil 1) | .05 | 4.5 | .085 | .40 | .980 | .05 | .05 | 5.0 | .70 |
| Grassland (flat to moderate) (soil 2) | .05 | 4.0 | .035 | .40 | .980 | .05 | .05 | 5.0 | .70 |
| Grassland (steep) (soil 1) | .05 | 4.0 | .080 | .40 | .980 | .05 | .05 | 4.5 | .65 |
| Grassland (steep) (soil 2) | .05 | 3.5 | .030 | .40 | .980 | .05 | .05 | 4.5 | .65 |
| Forested and wooded land (flat to moderate) (soil 1) | .40 | 5.0 | .105 | .45 | .980 | .05 | .10 | 4.7 | .70 |
| Forested and wooded land (flat to moderate) (soil 2) | .40 | 4.5 | .055 | .45 | .980 | .05 | .10 | 4.7 | .70 |
| Forested and wooded land (steep) (soil 1) | .40 | 4.5 | .100 | .45 | .980 | .05 | .10 | 4.2 | .65 |
| Forested and wooded land (steep) (soil 2) | .40 | 4.0 | .050 | .45 | .980 | .05 | .10 | 4.2 | .65 |
| Pervious residential (flat to moderate) (soil 1) | .20 | 4.7 | .090 | .25 | .980 | .05 | .05 | 4.6 | .70 |
| Pervious residential (flat to moderate) (soil 2) | .20 | 4.2 | .040 | .25 | .980 | .05 | .05 | 4.6 | .70 |
| Pervious residential (steep) (soil 1) | .20 | 4.2 | .085 | .25 | .980 | .05 | .05 | 4.1 | .65 |
| Pervious residential (steep) (soil 2) | .20 | 3.7 | .035 | .25 | .980 | .05 | .05 | 4.1 | .65 |
| Wetland (soil 1) | .10 | 4.5 | .150 | .20 | .985 | .05 | .60 | 3.5 | .70 |
| Wetland (soil 2) | .10 | 4.0 | .100 | .20 | .985 | .05 | .60 | 3.5 | .70 |
| Barren and exposed (soil 1) | .00 | 7.5 | .250 | .05 | .980 | .05 | .15 | 3.5 | .70 |
| Barren and exposed (soil 2) | .00 | 7.5 | .200 | .05 | .980 | .05 | .15 | 3.5 | .70 |

impervious land. To incorporate these release rates, detention routing was added to the hydrologic model. The amount of detention required in each subbasin was determined by the increase in impervious land surface from the 1996 conditions to the 2003 and 2004 conditions.

To verify the model for the extended simulation [compared to the simulation in Soong and others (2005)], and other updated data, storm hydrographs were compared to evaluate the magnitude, timing, and flow duration during different storm events. Flows produced by three selected storms were compared at the Yorkville streamflow-gaging station (fig. 8).

In addition to the three storms during the extended simulation period, the performance of the model was verified for the July 1996 storm. This storm was larger than a 500-year return period event and tests the ability of the model to simulate extreme events. The simulated peak discharge (5,280 $ft^3/s$ on July 18 at 18:00) is within 5 percent of the observed peak discharge (5,510 $ft^3/s$ on July 18 at 22:00) (fig. 9). Results, as shown in figures 8 and 9, indicate that simulated flow volumes, peak discharges, and the magnitude, timing, and duration of flow hydrographs were generally in good agreement with the observed data at the Yorkville streamflow-gaging station.

## Flood-Frequency Analysis

Utilizing the AMS determined from simulated streamflow records at various locations in the watershed from the hydrologic model, flood-frequency analysis was used to estimate flood quantiles. The 100- and 500-year floods determined in this analysis were then used in the hydraulic model analysis. Precipitation data from Argonne National Laboratory (LaTour and others, 2006) was determined to be representative for the long-term simulation with the HSPF Blackberry Creek hydrologic model in Soong and others (2005). Precipitation data from Argonne National Laboratory is also used in this study for long-term hydrologic simulation. The flood quantiles for the subbasins of Blackberry Creek watershed in Kendall County were calculated from the flood-frequency analysis for simulated AMS for the period of water years 1950 to 2003. The estimated 1.25-, 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year flood quantiles for these subbasins are presented in table 6. A comparison of the 10-, 100-, and 500-year flood quantiles at the county border, the USGS Yorkville streamflow-gaging station, and the outlet of the watershed is presented in table 7.

The USDA (1989) and FEMA (2002) studies were based on different land uses and drainage areas, and are included for general reference. The quantiles from the present study and those derived from the annual maximum series at the USGS Yorkville streamflow-gaging station differed by 11 percent for the $Q_{10}$, 4 percent for the $Q_{100}$, and 3 percent for the $Q_{500}$.

## Hydraulic Model

The HEC-RAS hydraulic model (U.S. Army Corps of Engineers, 2002) was used in this study to compute the corresponding 100- and 500-year flood elevations with respect to flood quantiles estimated from hydrologic analysis, so that the flood elevations can be used for delineating flood plain boundaries on maps; to compute the reach-wise, depth-surface, and area-volume relations for channel and reservoir routing in HSPF model simulation; and to perform encroachment

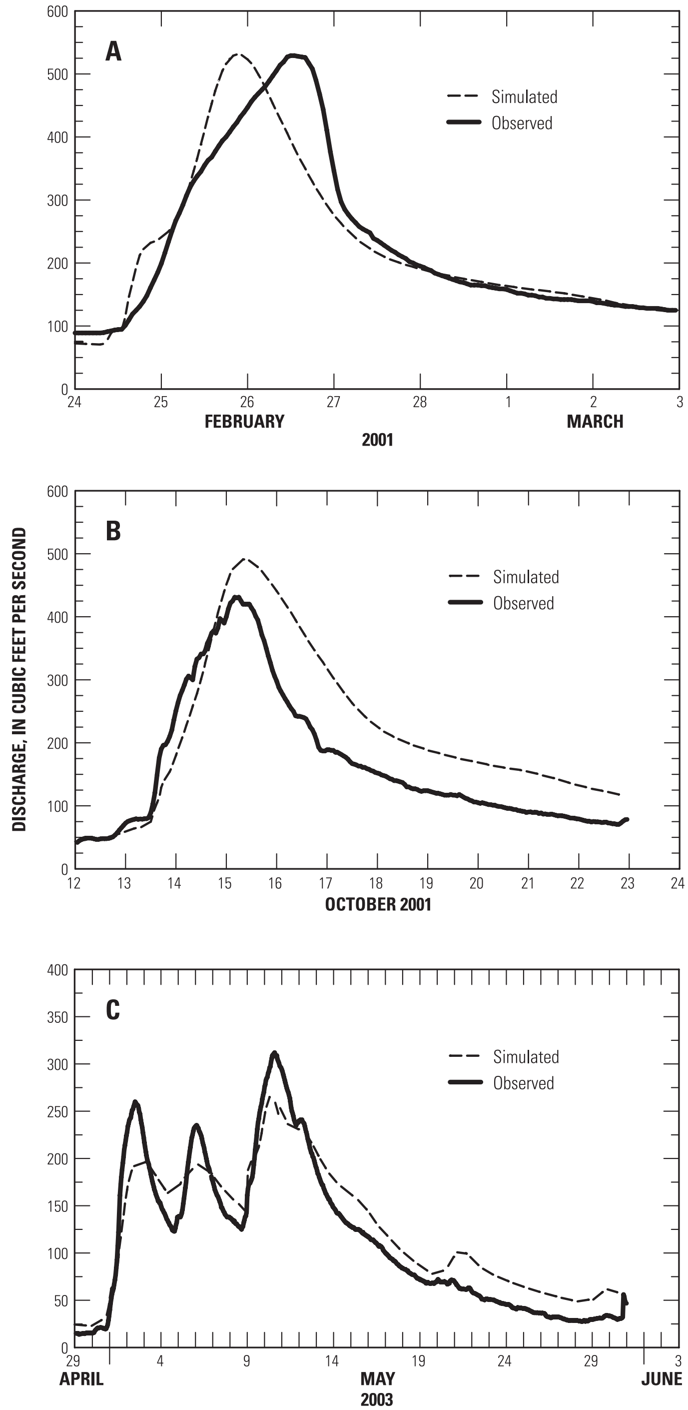



**Figure 8.** Simulated and observed hourly streamflow at the U.S. Geological Survey Yorkville streamflow-gaging station, Blackberry Creek watershed, Illinois, for selected storm events from water years 2000–03.

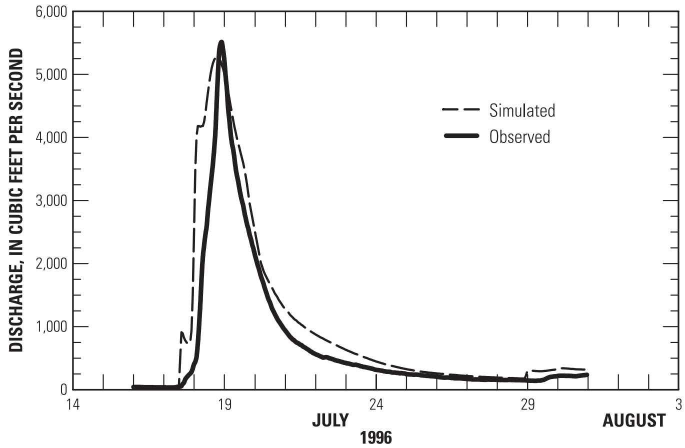



**Figure 9.** Simulated and observed hourly streamflow at the U.S. Geological Survey Yorkville streamflow-gaging station, Blackberry Creek watershed, Illinois, for the July 1996 storm event.

**Table 6.** Estimated flood quantiles at 1.25-, 2-, 10-, 25-, 50-, 100-, 200-, and 500-year recurrence intervals for subbasins (upstream to downstream) of the Kendall County part of Blackberry Creek watershed, Illinois.

[$Q_T$, flood quantile at T-year recurrence interval, in $ft^3/s$ cubic feet per second]

| Subbasin number | Flood quantile, $Q_T$ | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | $Q_{1.25}$ | $Q_2$ | $Q_5$ | $Q_{10}$ | $Q_{25}$ | $Q_{50}$ | $Q_{100}$ | $Q_{200}$ | $Q_{500}$ |
| 270 | 331 | 565 | 981 | 1,316 | 1,810 | 2,229 | 2,692 | 3,206 | 3,968 |
| 276 | 335 | 569 | 985 | 1,321 | 1,816 | 2,237 | 2,704 | 3,222 | 3,993 |
| 278 | 340 | 572 | 982 | 1,313 | 1,798 | 2,211 | 2,668 | 3,173 | 3,925 |
| 279 | 345 | 580 | 993 | 1,326 | 1,814 | 2,228 | 2,687 | 3,196 | 3,951 |
| 280 | 356 | 595 | 1,013 | 1,349 | 1,842 | 2,260 | 2,721 | 3,232 | 3,991 |
| 286 | 363 | 605 | 1,028 | 1,366 | 1,863 | 2,284 | 2,749 | 3,263 | 4,026 |
| 290 | 370 | 614 | 1,040 | 1,381 | 1,881 | 2,303 | 2,771 | 3,287 | 4,053 |

**Table 7.** Comparison of flood quantiles for three locations in the Kendall County part of Blackberry Creek watershed, Illinois. The three scenarios include the present study, two previous studies of the watershed, and the flood-frequency analysis of the annual maximum series from the U.S. Geological Survey Yorkville streamflow-gaging station for the water years 1961–2003.

[$Q_T$, flood quantile at T-year recurrence interval, in $ft^3/s$ cubic feet per second; --, not applicable]

| Scenario | Subbasin 270 (county boundary) | | | Subbasin 280 (Yorkville streamflow gage) | | | Subbasin 290 (outlet of watershed) | | |
|---|---|---|---|---|---|---|---|---|---|
| | $Q_{10}$ | $Q_{100}$ | $Q_{500}$ | $Q_{10}$ | $Q_{100}$ | $Q_{500}$ | $Q_{10}$ | $Q_{100}$ | $Q_{500}$ |
| Present study | 1,316 | 2,692 | 3,968 | 1,349 | 2,721 | 3,991 | 1,381 | 2,771 | 4,053 |
| Based on Annual Maximum Series calculated at Yorkville gage | -- | -- | -- | 1,502 | 2,818 | 3,857 | -- | -- | -- |
| Federal Emergency Management Agency Study (2002)[1] | 870 | 1,750 | -- | -- | -- | -- | 890 | 1,800 | -- |
| U.S. Department of Agriculture Study (1989) | 2,140 | 3,340 | 3,940 | 2,180 | 3,400 | 4,010 | 2,190 | 3,420 | 4,030 |

[1] Drainage areas differ from the present study (59.6 $mi^2$ at the county boundary and 73.5 $mi^2$ at the mouth).

analysis to determine proper floodway boundaries. HEC-RAS is an accepted computer hydraulic model by FEMA for NFIP usage (Federal Emergency Management Agency, 2003). Procedures for developing a HEC-RAS model can be found in the HEC-RAS users' manual (U.S. Army Corps of Engineers, 2002).

Steady-state analysis was used in this study to determine the water-surface elevations for flood-hazard analysis. Data needed for a steady-state flow simulation with HEC-RAS include boundary conditions, peak discharges, and flow regimes. Boundary conditions, as known stages or flood discharges, must be specified to start a water-surface computation in a river reach. Stage boundary conditions were specified at the upstream and downstream ends of the Blackberry Creek HEC-RAS model for mixed flow analysis. Normal depth boundary conditions were specified at the uppermost stream cross section. A normal depth boundary condition also was specified at the most downstream cross section with the junction of the Fox River. In HEC-RAS simulation, discharges are specified at cross sections within a subbasin utilizing the generated flood quantiles specified at the outlet of the subbasin.

The ineffective flow areas option of HEC-RAS was used to define areas of cross sections that contained water not actively being conveyed (ineffective flow). Ineffective flow areas are specified at natural cross sections where the floodplain is very wide and where contraction/expansion exists, and at hydraulic structures such as bridges and culverts. At very wide natural cross sections, the locations of ineffective flow area are first identified by inspection of an aerial photograph. Later, the locations are adjusted after inspecting the energy gradient line of HEC-RAS output, and inundation drawn on contour maps. For hydraulic structure sites, an initial estimate for locating ineffective areas at expansion and contraction cross sections was obtained using 1:4 and 1:1 ratios (streamwise distance to lateral cross-section distance), respectively. Similarly, the locations of ineffective flow areas at approaching and departure cross sections are adjusted by inspecting energy gradient lines, channel velocity, and hydraulic output at structures.

To verify the model for the extended simulation [compared to the simulation in Soong and others (2005)], and other updated data, the Yorkville streamflow-gaging data and data from two crest-stage (CSG) gages were used from WY 2001–03. The results at Galena Road and Bristol Ridge Road bridges and Yorkville station (fig. 1) are presented in table 8. The average difference in observed and simulated flood elevations for the eight readings was 0.38 ft with a standard deviation of 0.24 ft. Possible reasons for discrepancies could be attributed to changes in channel geometry or seasonal vegetation differences that caused different flow resistances. Although adjusting the Manning's roughness coefficients could modify the flood water-surface elevations and improve the comparison, adjustments were not done because the Manning's coefficients were determined based on field reconnaissance and will be used for other flood discharges.

## Flood-Hazard Analysis

The estimated flood quantiles were used to establish the flow data for the HEC-RAS hydraulic model for estimating flood stages and for flood plain and floodway analysis. An encroachment analysis was conducted to determine the floodway width using guidelines established by the State of Illinois (Illinois Department of Natural Resources, 2002), which stated that "The regulatory floodway boundaries are determined by hydraulic and hydrologic analyses, which calculate that portion of the flood plain that must be preserved to store and discharge floodwaters without causing damaging or potentially damaging increases in flood stage and flood velocities or loss of flood storage which would result singularly or cumulatively in more than a 0.1 ft increase in flood stage or a 10 percent increase in velocity." For floodway analysis, "In general, the final encroachments should have a consistent and smooth transition from one cross section to the next" (U.S. Army Corps of Engineers, 2002). A plan view of the floodway encroachments was used to determine if the encroachments transitioned smoothly or if they were erratic. Ineffective flow

**Table 8.** Comparision of peak-flood stages simulated with the hydraulic model and observed values at Galena Road bridge and Bristol Ridge Road bridge and at U.S. Geological Survey Yorkville streamflow gaging station (station number 05551700).

[All elevations presented are in NAVD88]

| Location (fig. 1) | October 14–15, 2001 | | May 12–13, 2002 | | May 10–12, 2003 | |
|---|---|---|---|---|---|---|
| | Simulated | Observed | Simulated | Observed | Simulated | Observed |
| Galena Road bridge | 643.93 | 643.32 | 644.24 | 644.18 | 643.17 | --[1] |
| Bristol Ridge Road bridge | 634.43 | 633.89 | 634.71 | 634.5 | 633.64 | 633.68 |
| USGS Yorkville streamflow-gaging station | 619.05 | 618.45 | 619.46 | 618.95 | 618.09 | 618.56 |

[1]Note: Vandalism of crest-stage gages at Galena Road caused no data to be collected for this event.

areas (defined in the Hydraulic Model section) can be a cause of erratic encroachment transitions. The erratic encroachments were further refined and the model was re-run to make sure encroachment guidelines were met. At bridge locations, natural cross sections upstream and downstream were used to make sure to make sure that the floodway at the contraction and expansion of the bridge was reasonable.

The resulting flood elevations from the hydraulic model were mapped for the 100- and 500-year flood plains and for the 100-year floodway. Boundaries of the flood plains and floodway are presented in figure 10. These maps are not FEMA-approved Flood Insurance Rate Maps, and are subject to revision.

The 100- and 500-year flood plains covered 3,699 and 3,762 acres of land, respectively (table 9). More than 40 percent of the land in the flood plains was used for cropland. Approximately 33 percent of the 100-year flood plain and 34 percent of the 500-year flood plain were classified as residential. Although many acres of residential land were included in the flood plain, this land mostly was residential lawns with 25 homes within the 100-year flood plain and 41 homes within the 500-year flood plain in the 2003 aerial photograph.

The 100-year flood magnitude, selected hydraulic characteristics, and encroachment analysis at each cross section has been compiled from the hydraulic model analysis. The results are presented in table 10.

# Summary

The Blackberry Creek watershed in Kane and Kendall Counties, Illinois, has undergone rapid urbanization in recent decades. The population and urbanized lands in the watershed are projected to double from the 1990 condition by the year 2020. Flood-induced damage has occurred more frequently in recent years in urban areas of the watershed, and there are concerns about the effect of urbanization on flood peaks and volumes and potential effects on the water quality and stream habitats.

To address some of the issues listed above, the U.S. Geological Survey (USGS), in cooperation with the United City of Yorkville, Kendall County, the Village of Montgomery, Illinois Department of Natural Resources, Office of Water Resources, and Federal Emergency Management Agency, conducted a flood-hazard study of the Blackberry Creek watershed during 2004–05. This report describes the data collected to refine the hydrologic and hydraulic models from those used in the Soong and others (2005) study of the Kane County part of the Blackberry Creek watershed and extension of the flood-frequency analysis through water year 2003, and presents a map of the 100- and 500-year flood plains and 100-year floodway. The USGS is using a continuous hydrologic simulation/flood frequency approach to generate the flood quantiles used in the hydraulic model. This study demonstrates the successful application of this approach with the goal of promoting the use of this advanced technique for flood-hazard studies in other watersheds.

The hydrologic model, Hydrologic Simulation Program–FORTRAN (HSPF), was used in this study to simulate continuous water movement through various land uses in the watershed. The hydrologic model was developed from a 2003 digital elevation model, and from soil and land-use data. Observed precipitation and other meteorologic time series were input to the hydrologic model to supply a continuous streamflow time series at various locations in the watershed.

**Table 9.** The 2003 land cover (by area and percent) and areas included in the 100- and 500-year flood plains in the Blackberry Creek watershed, Kendall County, Illinois.

| Land-cover category | 100-Year flood plain area (acres) | Percent of total 100-year flood plain area | 500-year flood plain area (acres) | Percent of total 500-year flood plain area |
|---|---|---|---|---|
| Cropland | 1,551.92 | 41.95 | 1,559.60 | 41.45 |
| Forested and wooded land | 297.66 | 8.05 | 299.71 | 7.97 |
| Grassland | 468.39 | 12.66 | 469.45 | 12.48 |
| High density residential | 4.72 | .13 | 6.60 | .18 |
| Low density residential | 434.78 | 11.75 | 484.96 | 12.89 |
| Medium density residential | 803.04 | 21.71 | 803.04 | 21.35 |
| Transportation | 40.07 | 1.08 | 40.07 | 1.07 |
| Wetland | 98.74 | 2.67 | 98.74 | 2.62 |
| Total | 3,699.32 | 100.00 | 3,762.18 | 100.00 |

**Table 10.** Hydraulic characteristics corresponding to 100-year flood elevation and floodway encroachment for the Blackberry Creek watershed, Kendall County, Illinois.

[All elevations given are in NAVD88. ft, feet; $ft^2$, square foot; ft/s, feet per second]

| Cross section label (appendix B) | Cross section number | Distance (ft) | Top width (ft) | | Cross section area ($ft^2$) | | | Mean velocity (ft/s) | | | Base flood water-surface elevation (ft) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Without floodway | With floodway | Without floodway | With floodway | Percent change | Without floodway | With floodway | Percent change | Regulatory | Without floodway | With floodway | Change |
| | 1 | 0 | 92.68 | 67.75 | 370.03 | 353.25 | -5 | 7.49 | 7.84 | 5 | 572.45 | 572.45 | 572.55 | 0.10 |
| A | 388 | 388 | 150.38 | 103.00 | 641.83 | 608.03 | -5 | 4.32 | 4.56 | 6 | 574.79 | 574.79 | 574.84 | .05 |
| | 658 | 658 | 288.56 | 267.00 | 1,134.76 | 1,128.88 | -1 | 2.44 | 2.45 | 0 | 575.57 | 575.57 | 575.62 | .05 |
| | 780 | 780 | 126.96 | 101.00 | 522.68 | 512.02 | -2 | 5.30 | 5.41 | 2 | 575.76 | 575.76 | 575.80 | .04 |
| | 802 | 800 | 120.00 | 119.31 | 696.62 | 697.33 | 0 | 3.98 | 3.97 | 0 | 575.96 | 575.96 | 576.00 | .04 |
| | 833 | 830 | 119.00 | 118.61 | 1,278.04 | 1,279.23 | 0 | 2.17 | 2.17 | 0 | 576.27 | 576.27 | 576.30 | .03 |
| | 841 | 840 | 67.24 | 58.80 | 594.72 | 548.23 | -8 | 4.66 | 5.05 | 8 | 576.17 | 576.17 | 576.18 | .01 |
| B | 861 | 850 | 104.00 | 88.00 | 1,372.53 | 1,364.19 | -1 | 2.02 | 2.03 | 0 | 586.32 | 586.32 | 586.35 | .03 |
| | 934 | 944 | 201.35 | 135.00 | 804.36 | 777.63 | -3 | 3.44 | 3.56 | 3 | 586.24 | 586.24 | 586.28 | .04 |
| | 1015 | 1,044 | 233.93 | 180.00 | 1,062.87 | 1,001.82 | -6 | 2.61 | 2.77 | 6 | 586.54 | 586.54 | 586.55 | .01 |
| C | 2543 | 1,649 | 364.49 | 271.00 | 1,329.98 | 1,220.92 | -8 | 2.08 | 2.27 | 9 | 587.50 | 587.50 | 587.50 | .00 |
| | 3020 | 2,046 | 471.09 | 379.00 | 1,675.26 | 1,562.02 | -7 | 1.65 | 1.77 | 7 | 588.05 | 588.05 | 588.05 | .00 |
| | 3880 | 2,934 | 168.72 | 129.00 | 948.52 | 878.20 | -7 | 2.92 | 3.16 | 8 | 589.15 | 589.15 | 589.16 | .01 |
| | 4405 | 3,459 | 354.21 | 291.00 | 1,420.46 | 1,309.42 | -8 | 1.95 | 2.12 | 9 | 589.95 | 589.95 | 589.98 | .03 |
| | 4520 | 4,133 | 380.31 | 352.00 | 1,167.10 | 1,126.19 | -4 | 2.37 | 2.46 | 4 | 591.41 | 591.41 | 591.47 | .06 |
| | 4874 | 4,487 | 310.93 | 244.00 | 1,109.95 | 1,029.31 | -7 | 2.50 | 2.69 | 8 | 592.71 | 592.71 | 592.77 | .06 |
| D | 5487 | 5,100 | 346.97 | 282.55 | 1,047.01 | 979.25 | -6 | 2.65 | 2.83 | 7 | 594.87 | 594.87 | 594.91 | .04 |
| | 5633 | 5,732 | 381.43 | 335.91 | 1,289.73 | 1,228.22 | -5 | 2.15 | 2.26 | 5 | 596.73 | 596.73 | 596.78 | .05 |
| | 6425 | 6,085 | 458.69 | 366.00 | 1,308.66 | 1,206.17 | -8 | 2.12 | 2.30 | 8 | 597.66 | 597.66 | 597.71 | .05 |
| E | 7081 | 6,741 | 522.77 | 406.54 | 1,556.90 | 1,442.05 | -7 | 1.78 | 1.92 | 8 | 599.36 | 599.36 | 599.40 | .04 |
| | 7275 | 7,354 | 250.49 | 205.20 | 942.57 | 862.97 | -8 | 2.94 | 3.21 | 9 | 600.94 | 600.94 | 600.99 | .05 |
| | 7765 | 7,844 | 604.32 | 446.12 | 1,753.26 | 1,598.80 | -9 | 1.58 | 1.73 | 9 | 602.35 | 602.35 | 602.43 | .08 |
| | 8400 | 8,572 | 531.56 | 342.20 | 1,668.86 | 1,515.17 | -9 | 1.66 | 1.83 | 10 | 603.44 | 603.44 | 603.51 | .07 |
| F | 8850 | 9,022 | 661.27 | 540.95 | 1,766.54 | 1,609.20 | -9 | 1.57 | 1.72 | 10 | 604.24 | 604.24 | 604.31 | .07 |
| | 9532 | 9,669 | 463.68 | 329.81 | 915.07 | 833.87 | -9 | 3.03 | 3.32 | 10 | 605.90 | 605.90 | 605.97 | .07 |

**Table 10.** Hydraulic characteristics corresponding to 100-year flood elevation and floodway encroachment for the Blackberry Creek watershed, Kendall County, Illinois.—Continued

[All elevations given are in NAVD88. ft, feet; ft$^2$, square foot; ft/s, feet per second]

| Cross section label (appendix B) | Cross section number | Distance (ft) | Top width (ft) | | Cross section area (ft$^2$) | | | Mean velocity (ft/s) | | | Base flood water-surface elevation (ft) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Without floodway | With floodway | Without floodway | With floodway | Percent change | Without floodway | With floodway | Percent change | Regulatory | Without floodway | With floodway | Change |
| | 9712 | 9,811 | 84.96 | 84.00 | 494.10 | 500.54 | 1 | 5.61 | 5.54 | -1 | 606.44 | 606.44 | 606.52 | 0.08 |
| | 9772 | 9,866 | 86.13 | 84.00 | 559.52 | 559.36 | 0 | 4.91 | 4.91 | 0 | 607.22 | 607.22 | 607.22 | .00 |
| G | 10267 | 10,405 | 323.61 | 240.00 | 1,217.05 | 1,143.90 | -6 | 2.26 | 2.40 | 6 | 608.35 | 608.35 | 608.36 | .01 |
| | 10680 | 11,005 | 367.87 | 311.00 | 1,149.79 | 1,060.85 | -8 | 2.39 | 2.59 | 8 | 609.26 | 609.26 | 609.27 | .01 |
| | 11546 | 11,816 | 322.14 | 253.00 | 1,773.25 | 1,638.85 | -8 | 1.55 | 1.68 | 8 | 610.44 | 610.44 | 610.47 | .03 |
| H | 12150 | 12,916 | 232.35 | 168.00 | 755.04 | 699.33 | -7 | 3.64 | 3.93 | 8 | 613.11 | 613.11 | 613.13 | .02 |
| | 13400 | 13,680 | 458.12 | 409.00 | 1,537.24 | 1,465.18 | -5 | 1.79 | 1.88 | 5 | 615.55 | 615.55 | 615.57 | .02 |
| | 14198 | 14,478 | 418.33 | 381.00 | 1,843.90 | 1,784.86 | -3 | 1.49 | 1.54 | 3 | 616.69 | 616.69 | 616.76 | .07 |
| | 14845 | 15,091 | 362.91 | 289.00 | 1,319.71 | 1,237.22 | -6 | 2.08 | 2.22 | 7 | 617.52 | 617.52 | 617.60 | .08 |
| I | 15428 | 15,674 | 425.83 | 345.00 | 1,678.90 | 1,561.46 | -7 | 1.64 | 1.76 | 7 | 618.54 | 618.54 | 618.60 | .06 |
| | 16470 | 16,788 | 704.65 | 560.03 | 2,532.03 | 2,308.85 | -9 | 1.09 | 1.19 | 9 | 619.69 | 619.69 | 619.76 | .07 |
| | 17222 | 17,653 | 410.79 | 352.29 | 1,221.40 | 1,149.99 | -6 | 2.25 | 2.39 | 6 | 621.21 | 621.21 | 621.29 | .08 |
| | 17299 | 17,734 | 384.52 | 299.47 | 1,250.25 | 1,142.83 | -9 | 2.20 | 2.41 | 10 | 621.43 | 621.43 | 621.52 | .09 |
| J | 17468 | 17,898 | 513.87 | 394.00 | 1,647.11 | 1,516.48 | -8 | 1.67 | 1.81 | 8 | 621.79 | 621.79 | 621.89 | .10 |
| | 17533 | 17,966 | 96.63 | 97.00 | 527.15 | 536.44 | 2 | 5.16 | 5.07 | -2 | 621.85 | 621.85 | 621.95 | .10 |
| | 17584 | 18,046 | 94.55 | 95.00 | 537.52 | 545.25 | 1 | 5.06 | 4.99 | -1 | 622.10 | 622.10 | 622.18 | .08 |
| | 17632 | 18,064 | 439.29 | 358.95 | 1,441.82 | 1,312.87 | -9 | 1.89 | 2.07 | 10 | 622.39 | 622.39 | 622.45 | .06 |
| | 17773 | 18,201 | 385.86 | 300.61 | 1,378.52 | 1,260.84 | -9 | 1.97 | 2.16 | 10 | 622.66 | 622.66 | 622.73 | .07 |
| | 17905 | 18,332 | 76.34 | 75.00 | 489.55 | 492.09 | 1 | 5.56 | 5.53 | -1 | 622.95 | 622.95 | 623.02 | .07 |
| K | 18780 | 19,303 | 593.02 | 466.10 | 2,801.59 | 2,555.48 | -9 | 0.97 | 1.06 | 9 | 624.42 | 624.42 | 624.49 | .07 |
| | 19706 | 20,229 | 601.08 | 466.71 | 2,489.03 | 2,267.28 | -9 | 1.09 | 1.20 | 10 | 624.91 | 624.91 | 624.99 | .08 |
| | 21000 | 21,237 | 561.42 | 477.49 | 2,352.38 | 2,218.63 | -6 | 1.16 | 1.23 | 6 | 625.53 | 625.53 | 625.61 | .08 |
| L | 22067 | 22,560 | 1,199.92 | 1,001.37 | 3,058.63 | 2,844.06 | -7 | 0.89 | 0.96 | 8 | 626.61 | 626.61 | 626.71 | .10 |
| | 22979 | 23,449 | 649.45 | 519.54 | 2,216.55 | 2,046.40 | -8 | 1.23 | 1.33 | 8 | 627.76 | 627.76 | 627.86 | .10 |
| | 24120 | 24,744 | 689.01 | 596.37 | 2,860.13 | 2,718.34 | -5 | 0.95 | 1.00 | 5 | 629.03 | 629.03 | 629.12 | .09 |
| | 24718 | 25,113 | 509.22 | 429.62 | 2,295.63 | 2,172.85 | -5 | 1.19 | 1.25 | 5 | 629.28 | 629.28 | 629.38 | .10 |

**Table 10.** Hydraulic characteristics corresponding to 100-year flood elevation and floodway encroachment for the Blackberry Creek watershed, Kendall County, Illinois.—Continued

[All elevations given are in NAVD88. ft, feet; $ft^2$, square foot; ft/s, feet per second]

| Cross section label (appendix B) | Cross section number | Distance (ft) | Top width (ft) | | Cross section area ($ft^2$) | | | Mean velocity (ft/s) | | | Base flood water-surface elevation (ft) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Without floodway | With floodway | Without floodway | With floodway | Percent change | Without floodway | With floodway | Percent change | Regulatory | Without floodway | With floodway | Change |
| M | 25448 | 25,988 | 1,639.09 | 793.75 | 960.18 | 948.12 | -1 | 2.80 | 2.83 | 1 | 630.98 | 630.98 | 631.03 | 0.05 |
| | 26448 | 26,947 | 876.97 | 666.33 | 3,351.94 | 3,090.36 | -8 | 0.80 | 0.87 | 9 | 632.19 | 632.19 | 632.19 | .00 |
| | 27267 | 27,766 | 997.33 | 754.32 | 2,628.31 | 2,394.53 | -9 | 1.02 | 1.12 | 10 | 632.66 | 632.66 | 632.64 | -.02 |
| | 28364 | 28,945 | 857.44 | 656.02 | 2,107.01 | 1,904.80 | -10 | 1.28 | 1.41 | 10 | 633.82 | 633.82 | 633.81 | -.01 |
| | 29083 | 29,664 | 969.83 | 795.04 | 2,546.24 | 2,301.28 | -10 | 1.06 | 1.17 | 10 | 634.63 | 634.63 | 634.67 | .04 |
| N | 30180 | 31,001 | 726.00 | 620.74 | 2,331.62 | 2,201.60 | -6 | 1.15 | 1.22 | 6 | 635.73 | 635.73 | 635.83 | .10 |
| | 31650 | 32,327 | 1,102.24 | 881.57 | 2,861.68 | 2,643.15 | -8 | 0.94 | 1.02 | 9 | 636.88 | 636.88 | 636.97 | .09 |
| | 31770 | 32,401 | 962.61 | 736.82 | 2,570.49 | 2,353.31 | -8 | 1.05 | 1.14 | 9 | 636.94 | 636.94 | 637.03 | .09 |
| | 31829 | 32,452 | 304.23 | 153.77 | 774.76 | 789.41 | 2 | 3.47 | 3.40 | -2 | 636.92 | 636.92 | 637.01 | .09 |
| | 31858 | 32,507 | 334.28 | 153.77 | 795.35 | 808.39 | 2 | 3.38 | 3.32 | -2 | 637.05 | 637.05 | 637.13 | .08 |
| | 31927 | 32,614 | 252.91 | 245.12 | 1,327.25 | 1,307.54 | -1 | 2.02 | 2.06 | 2 | 637.28 | 637.28 | 637.35 | .07 |
| O | 32253 | 32,969 | 831.60 | 687.27 | 2,458.82 | 2,256.38 | -8 | 1.09 | 1.19 | 9 | 637.76 | 637.76 | 637.84 | .08 |
| | 33143 | 33,907 | 1,210.34 | 1,090.56 | 3,320.73 | 3,181.69 | -4 | 0.81 | 0.84 | 4 | 638.35 | 638.35 | 638.44 | .09 |
| | 34379 | 35,075 | 661.93 | 507.39 | 1,631.46 | 1,494.59 | -8 | 1.65 | 1.80 | 9 | 639.66 | 639.66 | 639.74 | .08 |
| P | 34650 | 36,378 | 654.25 | 514.25 | 1,995.64 | 1,807.78 | -9 | 1.35 | 1.50 | 10 | 641.54 | 641.54 | 641.62 | .08 |
| | 35603 | 37,425 | 710.59 | 561.56 | 2,198.26 | 2,016.61 | -8 | 1.23 | 1.34 | 9 | 642.60 | 642.60 | 642.70 | .10 |
| | 37484 | 38,285 | 641.33 | 453.96 | 2,114.65 | 1,920.93 | -9 | 1.28 | 1.41 | 10 | 643.10 | 643.10 | 643.20 | .10 |
| | 37602 | 38,404 | 93.32 | 93.00 | 591.46 | 600.47 | 2 | 4.57 | 4.50 | -2 | 643.15 | 643.15 | 643.25 | .10 |
| | 37646 | 38,454 | 90.71 | 90.50 | 597.89 | 605.94 | 1 | 4.52 | 4.46 | -1 | 643.63 | 643.63 | 643.72 | .09 |
| | 37793 | 38,610 | 598.75 | 460.04 | 2,482.89 | 2,259.83 | -9 | 1.09 | 1.20 | 10 | 644.07 | 644.07 | 644.15 | .08 |
| Q | 37896 | 38,699 | 504.74 | 360.75 | 1,630.89 | 1,485.41 | -9 | 1.66 | 1.82 | 10 | 644.10 | 644.10 | 644.18 | .08 |
| | 38700 | 39,613 | 683.68 | 555.12 | 2,589.19 | 2,363.36 | -9 | 1.04 | 1.14 | 10 | 644.95 | 644.95 | 645.02 | .07 |
| | 39493 | 40,406 | 1,130.73 | 953.94 | 3,601.24 | 3,315.51 | -8 | 0.75 | 0.82 | 9 | 645.30 | 645.30 | 645.39 | .09 |
| R | 40145 | 41,118 | 1,571.81 | 1,192.79 | 4,231.25 | 3,840.04 | -9 | 0.64 | 0.70 | 9 | 645.54 | 645.54 | 645.64 | .10 |
| | 40922 | 41,895 | 994.06 | 787.47 | 2,909.72 | 2,727.99 | -6 | 0.93 | 0.99 | 6 | 645.83 | 645.83 | 645.93 | .10 |

**Table 10.** Hydraulic characteristics corresponding to 100-year flood elevation and floodway encroachment for the Blackberry Creek watershed, Kendall County, Illinois.—Continued

[All elevations given are in NAVD88. ft, feet; $ft^2$, square foot; ft/s, feet per second]

| Cross section label (appendix B) | Cross section number | Distance (ft) | Top width (ft) | | Cross section area ($ft^2$) | | | Mean velocity (ft/s) | | | Base flood water-surface elevation (ft) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Without floodway | With floodway | Without floodway | With floodway | Percent change | Without floodway | With floodway | Percent change | Regulatory | Without floodway | With floodway | Change |
| | 42160 | 42,652 | 731.44 | 551.25 | 2,221.49 | 2,042.22 | -8 | 1.22 | 1.32 | 8 | 646.29 | 646.29 | 646.38 | 0.09 |
| | 42330 | 42,934 | 68.62 | 68.62 | 441.34 | 445.88 | 1 | 6.13 | 6.06 | -1 | 646.93 | 646.93 | 647.00 | .07 |
| | 42393 | 42,997 | 68.64 | 68.62 | 483.56 | 486.69 | 1 | 5.59 | 5.56 | -1 | 647.55 | 647.55 | 647.60 | .05 |
| S | 42604 | 43,237 | 1,001.39 | 830.19 | 4,205.14 | 3,912.81 | -7 | 0.64 | 0.69 | 8 | 648.17 | 648.17 | 648.22 | .05 |
| | 43056 | 43,689 | 1,175.02 | 937.70 | 4,500.99 | 4,103.52 | -9 | 0.60 | 0.66 | 10 | 648.28 | 648.28 | 648.32 | .04 |
| | 44035 | 44,668 | 860.50 | 622.88 | 2,711.00 | 2,482.75 | -8 | 1.00 | 1.09 | 9 | 648.60 | 648.60 | 648.64 | .04 |
| | 44642 | 45,302 | 772.90 | 613.24 | 2,309.18 | 2,088.00 | -10 | 1.17 | 1.30 | 10 | 648.95 | 648.95 | 648.98 | .03 |
| T | 45561 | 46,221 | 1,035.93 | 848.34 | 3,022.75 | 2,782.50 | -8 | 0.89 | 0.97 | 9 | 649.47 | 649.47 | 649.53 | .06 |
| | 45873 | 46,725 | 1,336.30 | 819.50 | 2,373.07 | 2,157.97 | -9 | 1.14 | 1.25 | 10 | 649.75 | 649.75 | 649.80 | .05 |
| | 46058 | 46,907 | 1,150.76 | 486.48 | 1,413.47 | 1,301.52 | -8 | 1.91 | 2.08 | 9 | 649.95 | 649.95 | 649.98 | .03 |
| | 46097 | 46,947 | 1,314.45 | 589.14 | 687.06 | 690.20 | 0 | 3.94 | 3.92 | -1 | 650.03 | 650.03 | 650.06 | .03 |
| | 46154 | 47,012 | 948.53 | 525.81 | 1,993.17 | 1,798.00 | -10 | 1.36 | 1.50 | 10 | 650.33 | 650.33 | 650.36 | .03 |
| | 46377 | 47,228 | 1,026.77 | 609.61 | 2,189.61 | 2,039.04 | -7 | 1.23 | 1.33 | 8 | 650.49 | 650.49 | 650.52 | .03 |
| | 47422 | 48,091 | 872.29 | 621.09 | 2,375.58 | 2,166.74 | -9 | 1.14 | 1.25 | 10 | 651.14 | 651.14 | 651.15 | .01 |
| | 47959 | 48,843 | 900.90 | 582.44 | 2,543.80 | 2,321.88 | -9 | 1.06 | 1.16 | 9 | 651.79 | 651.79 | 651.79 | .00 |
| U | 48534 | 49,372 | 975.74 | 872.00 | 3,407.72 | 3,123.15 | -8 | 0.79 | 0.87 | 10 | 652.07 | 652.07 | 652.10 | .03 |
| | 49230 | 50,068 | 1,177.28 | 925.74 | 3,818.36 | 3,449.83 | -10 | 0.71 | 0.78 | 10 | 652.29 | 652.29 | 652.34 | .05 |
| | 51006 | 50,602 | 1,366.49 | 1,152.85 | 4,007.97 | 3,677.21 | -8 | 0.67 | 0.74 | 10 | 652.49 | 652.49 | 652.54 | .05 |
| | 52181 | 53,093 | 990.40 | 776.97 | 2,897.42 | 2,681.58 | -7 | 0.93 | 1.01 | 9 | 654.01 | 654.01 | 654.09 | .08 |
| V | 54165 | 55,023 | 1,026.63 | 953.01 | 4,183.34 | 4,019.51 | -4 | 0.65 | 0.67 | 3 | 654.87 | 654.87 | 654.97 | .10 |
| | 55241 | 56,077 | 770.49 | 535.24 | 2,566.59 | 2,339.28 | -9 | 1.05 | 1.16 | 10 | 655.44 | 655.44 | 655.51 | .07 |
| | 55700 | 56,534 | 622.37 | 503.30 | 2,300.27 | 2,088.36 | -9 | 1.18 | 1.29 | 9 | 655.79 | 655.79 | 655.84 | .05 |
| | 55800 | 56,629 | 154.60 | 129.46 | 848.93 | 803.87 | -5 | 3.19 | 3.36 | 5 | 655.82 | 655.82 | 655.87 | .05 |
| | 55860 | 56,689 | 159.70 | 139.59 | 917.51 | 882.01 | -4 | 2.95 | 3.07 | 4 | 656.00 | 656.00 | 656.06 | .06 |
| | 55880 | 56,721 | 907.28 | 756.41 | 3,074.42 | 2,780.84 | -10 | 0.88 | 0.97 | 10 | 656.16 | 656.16 | 656.22 | .06 |

**Table 10.** Hydraulic characteristics corresponding to 100-year flood elevation and floodway encroachment for the Blackberry Creek watershed, Kendall County, Illinois.—Continued

[All elevations given are in NAVD88. ft, feet; $ft^2$, square foot; ft/s, feet per second]

| Cross section label (appendix B) | Cross section number | Distance (ft) | Top width (ft) | | Cross section area ($ft^2$) | | | Mean velocity (ft/s) | | | Base flood water-surface elevation (ft) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Without floodway | With floodway | Without floodway | With floodway | Percent change | Without floodway | With floodway | Percent change | Regulatory | Without floodway | With floodway | Change |
| W | 55980 | 56,824 | 1,034.82 | 887.83 | 4,054.93 | 3,705.49 | -9 | 0.67 | 0.73 | 9 | 656.21 | 656.21 | 656.27 | 0.06 |
| | 56760 | 57,604 | 602.86 | 450.40 | 2,270.21 | 2,067.11 | -9 | 1.19 | 1.31 | 10 | 656.49 | 656.49 | 656.57 | .08 |
| | 57625 | 58,428 | 1,228.11 | 1,247.00 | 3,626.21 | 3,735.84 | 3 | 0.75 | 0.72 | -4 | 656.82 | 656.82 | 656.90 | .08 |
| X | 58600 | 59,629 | 638.86 | 522.27 | 2,462.74 | 2,352.15 | -4 | 1.10 | 1.15 | 5 | 657.35 | 657.35 | 657.44 | .09 |
| | 59575 | 60,405 | 896.64 | 719.48 | 3,911.05 | 3,626.31 | -7 | 0.69 | 0.75 | 9 | 657.69 | 657.69 | 657.78 | .09 |
| | 60998 | 61,760 | 707.88 | 518.33 | 2,715.08 | 2,468.87 | -9 | 1.00 | 1.10 | 10 | 658.20 | 658.20 | 658.27 | .07 |
| Y | 62421 | 63,247 | 568.55 | 416.54 | 2,237.72 | 2,056.21 | -8 | 1.21 | 1.32 | 9 | 659.23 | 659.23 | 659.25 | .02 |
| | 62563 | 63,392 | 630.25 | 460.58 | 2,624.21 | 2,419.91 | -8 | 1.03 | 1.12 | 9 | 659.34 | 659.34 | 659.36 | .02 |
| Z | 62638 | 63,467 | 640.42 | 461.17 | 2,461.73 | 2,271.41 | -8 | 1.09 | 1.19 | 9 | 659.37 | 659.37 | 659.39 | .02 |

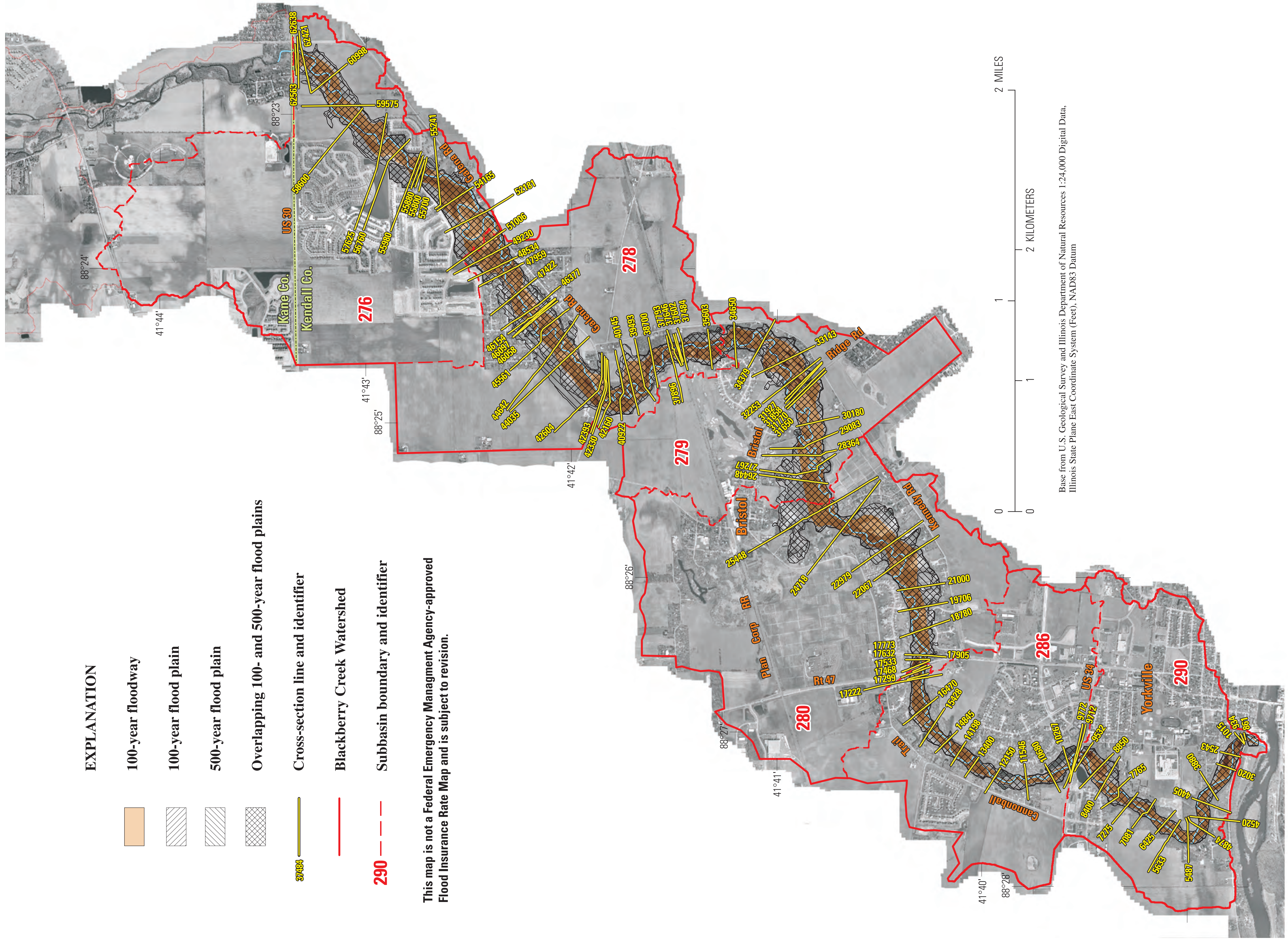



**Figure 10.** 100- and 500-year flood plains and 100-year floodway for Blackberry Creek watershed in Kendall County, Illinois.

Results indicate that simulated flow volumes, peak discharges, and flow hydrographs are generally in good agreement with the observed data. The capability of the hydrologic model to simulate an extreme flood was verified with the July 17–18, 1996, flood event.

Flood-frequency analysis was applied to an annual maximum series to determine flood quantiles in subbasins for flood-hazard analysis. The simulated annual maximum series was determined from the long-term streamflow series (water years 1950–2003) continuously simulated with the HSPF model. Simulated flood quantiles were compared to observed flood quantiles at the USGS streamflow-gaging station near Yorkville. The simulated flood quantiles at locations inside the watershed other than the Yorkville streamflow-gaging station were compared to those determined in a US Department of Agriculture (1989) study and using the USGS regional flood-frequency equations. These comparisons confirmed that the flood quantiles estimated as part of the present study are reasonable. The 100- and 500-year flood discharges were then used in the hydraulic model.

The HEC-RAS hydraulic model was used to determine the 100- and 500-year flood elevations throughout Blackberry Creek watershed. Encroachment analysis also was performed using HEC-RAS to determine the floodway. The model was calibrated and verified using two crest-stage gages and the U.S. Geological Survey Yorkville streamflow-gaging station. The average difference in observed and simulated flood elevations for the eight readings was 0.38 ft with a standard deviation of 0.24 ft. Using geographic information system techniques, the flood elevations from the hydraulic model were digitally mapped for the 100- and 500-year flood plains and the 100-year floodway.

Results indicate that the 100-year and 500-year flood plains cover approximately 3,699 and 3,762 acres of land, respectively. Based on the 2003 land-cover data, most of the land in the flood plains was cropland and residential land. Although many acres of residential land were included in the flood plain, this land mostly was residential lawns with 25 homes within the 100-year flood plain, and 41 homes within the 500-year flood plain in the 2003 aerial photograph.

## Acknowledgments

Joe Wyrot, City Engineer, and Anton Graf, former City Administrator, of the United City of Yorkville, Jeff Wilkins, Kendall County Administrator, and Anne Marie Gaura, Montgomery Village Manager, supported the format of this watershed study and use of advanced methodologies. They also assisted in data acquisition and facilitated communications with municipalities and interested groups. Illinois Department of Natural Resources-Office of Water Resources provided surveying assistance including establishing control points and surveying channel cross sections. Stephen Westenbrook, USGS-Wisconsin Water Science Center and Chad Menke, USGS-Indiana Water Science Center completed technical reviews of the report.

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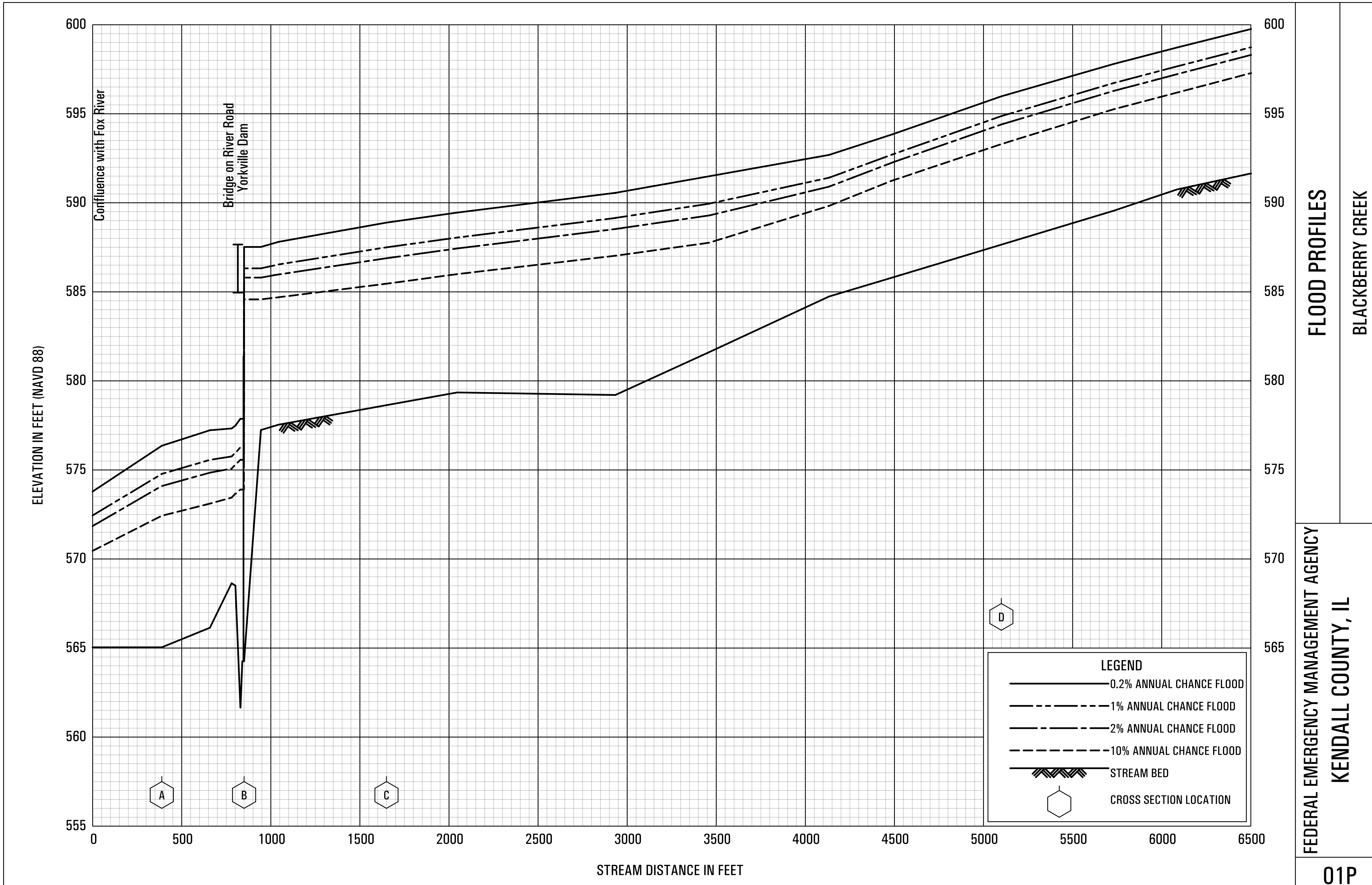
# Appendix A. Digital Elevation Model Accuracy Statement

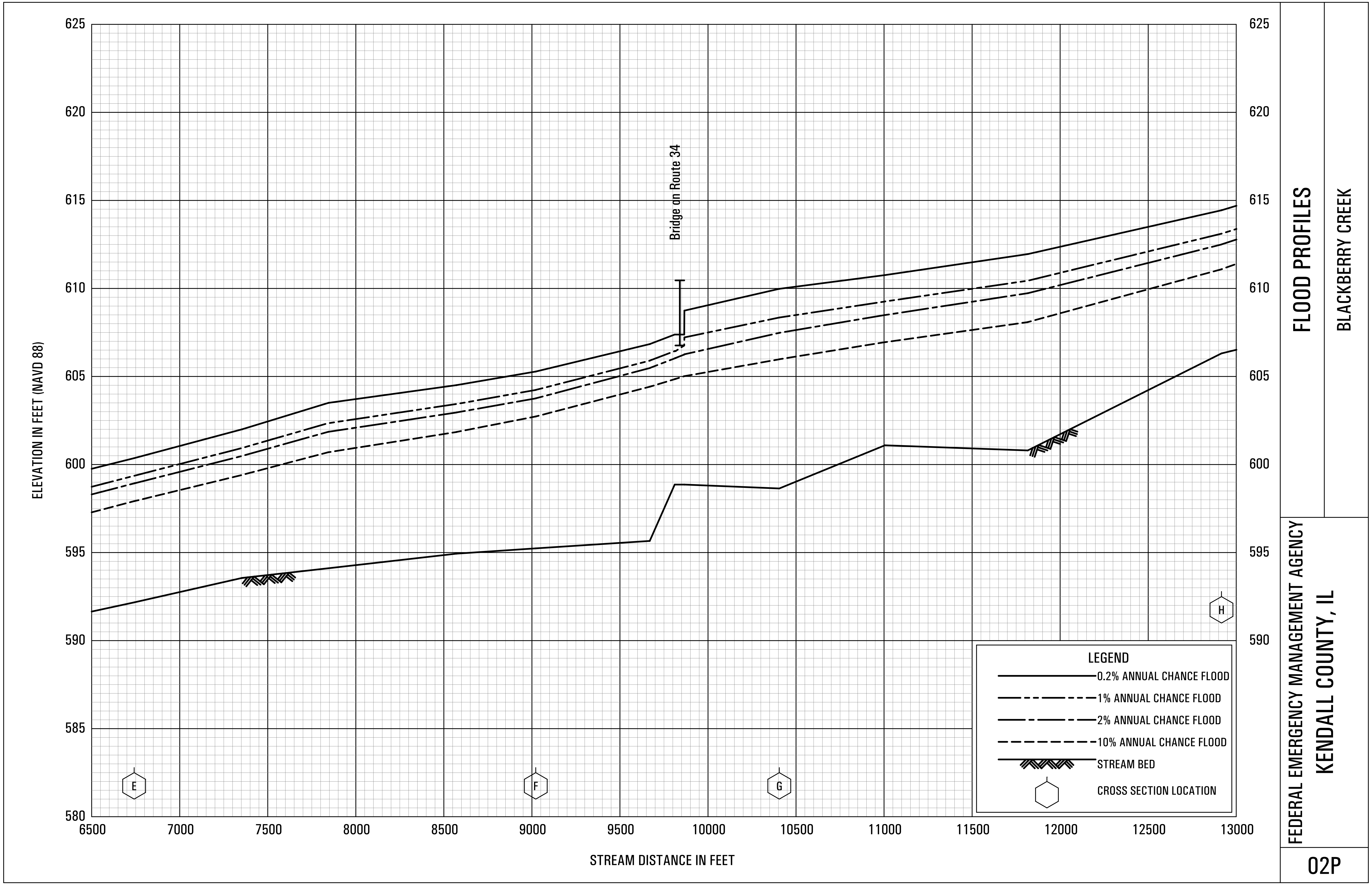
The 2003 DEM, with a 10-ft by 10-ft grid covering the Kendall County part of the Blackberry Creek watershed, was checked for elevation accuracy using a set of benchmarks. The check resulted in a vertical root-mean-square error ($RMSE_z$) of 0.6 ft, with a mean of 0.0 ft and skew of -0.04 ft (error is defined as benchmark elevation minus DEM elevation) for 37 points selected by The Sidwell Company (Gary Lobdell, The Sidwell Company, written commun., 2006). According to the Guidelines and Specifications for Flood Hazard Mapping Partners (Federal Emergency Management Agency, 2003), a DEM used for a 2-ft contour interval map should have an $RMSE_z$ of 0.6 ft, which is equivalent to a vertical accuracy of 1.2 ft at the 95-percent confidence level when errors follow a normal distribution. Vertical accuracy is defined as “the linear uncertainty value, such that the true or theoretical location of the point falls within ± of that linear uncertainty value 95-percent of the time.” (Federal Emergency Management Agency, 2003). The $RMSE_z$ of the 2003 DEM met these criteria, so the DEM was used for model analysis.

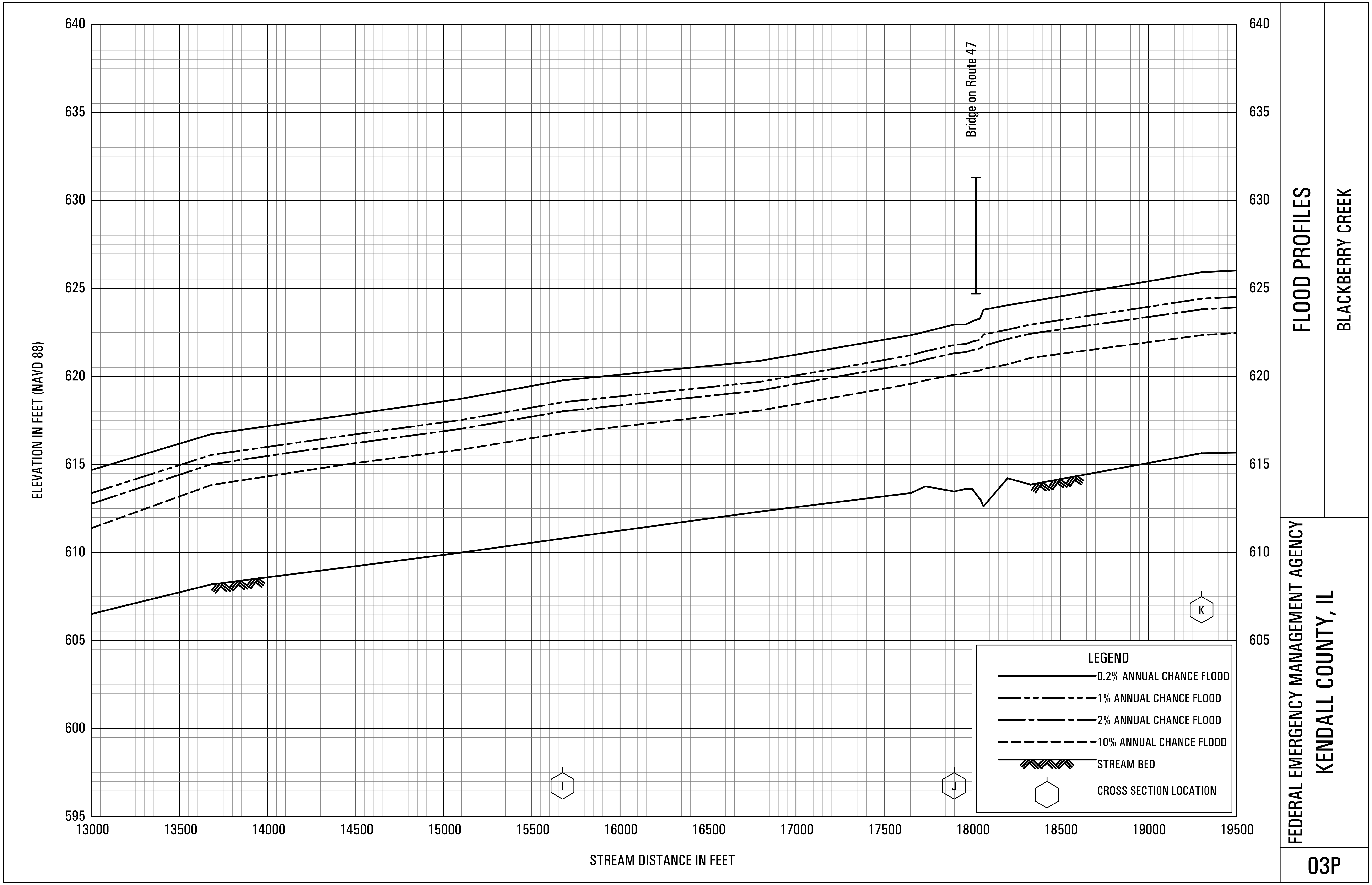
# Appendix B. Flood Profiles

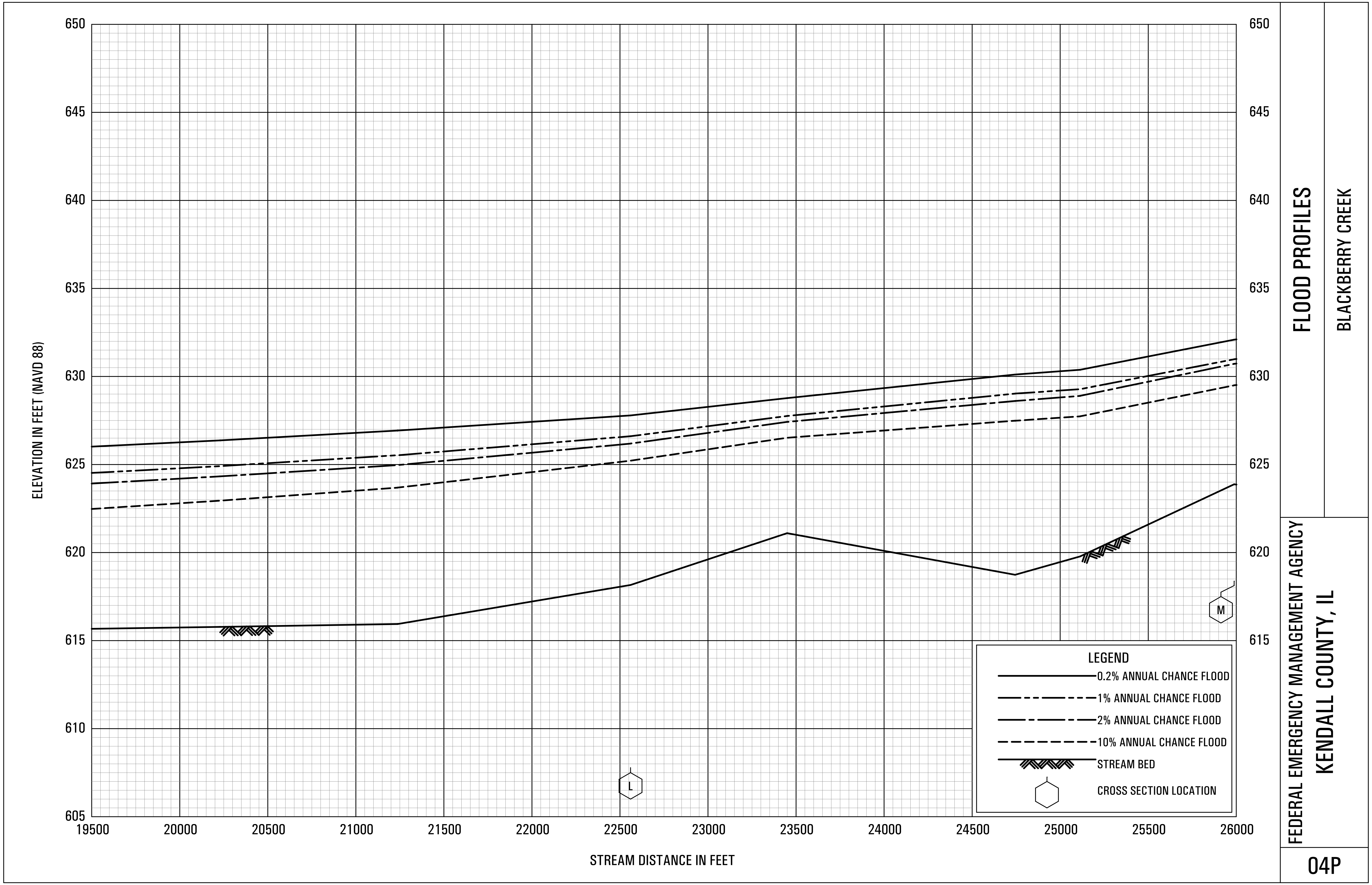
Note: To convert from recurrence interval to annual chance, the percent exceedance probability percentage is divided by 100 to obtain a fraction and then the inverse of that fraction is calculated. For example, an annual chance of 50 percent corresponds to a recurrence interval of 2 years (50/100 = 0.5; 1/0.5 = 2).

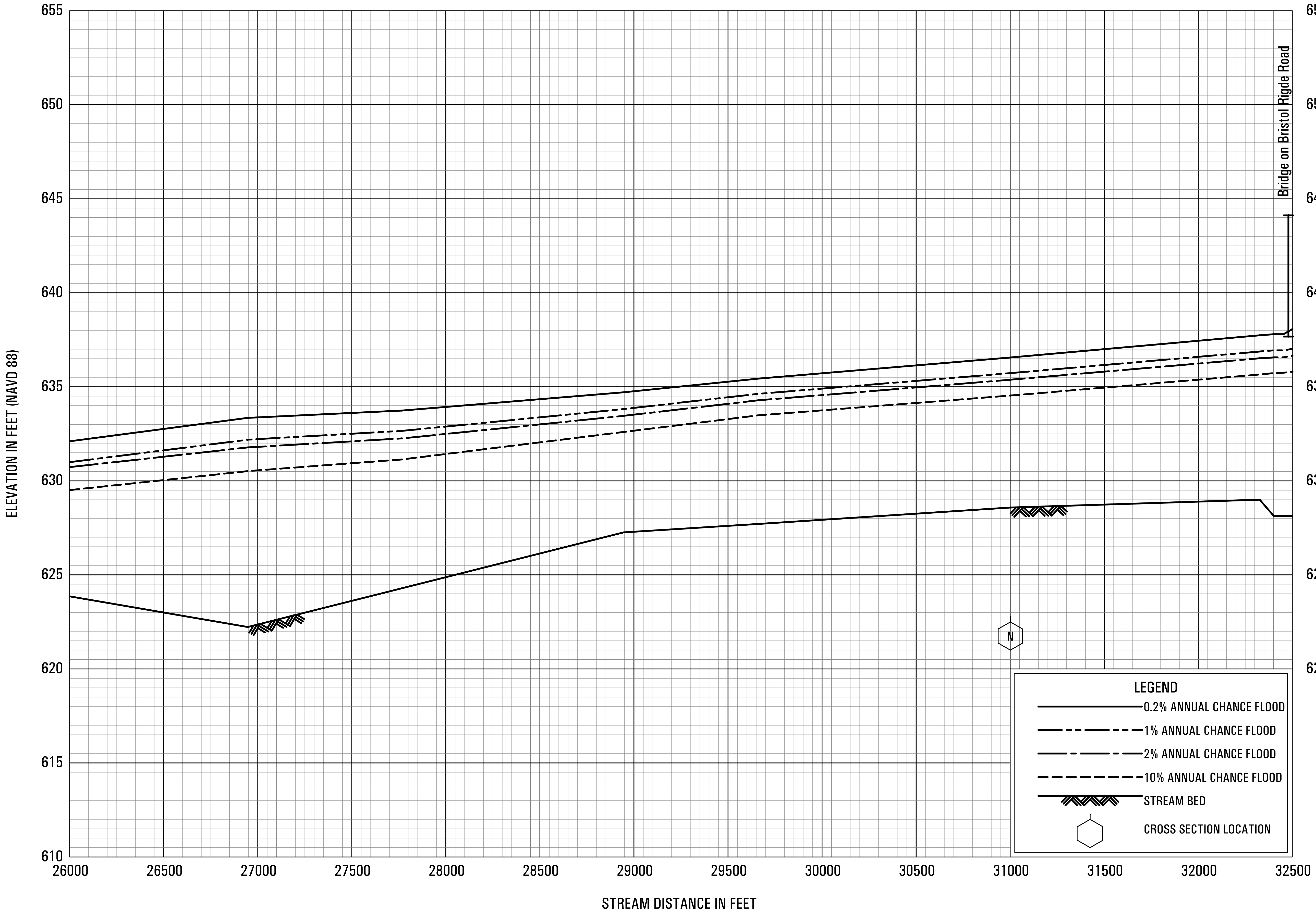


ELEVATION IN FEET (NAVD 88)
STREAM DISTANCE IN FEET
Confluence with Fox River
Bridge on River Road
Yorkville Dam
600
595
590
585
580
575
570
565
560
555
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
A
B
C
D
LEGEND
0.2% ANNUAL CHANCE FLOOD
1% ANNUAL CHANCE FLOOD
2% ANNUAL CHANCE FLOOD
10% ANNUAL CHANCE FLOOD
STREAM BED
CROSS SECTION LOCATION
FLOOD PROFILES
BLACKBERRY CREEK
FEDERAL EMERGENCY MANAGEMENT AGENCY
KENDALL COUNTY, IL
01P


ELEVATION IN FEET (NAVD 88)
625
620
615
610
605
600
595
590
585
580
6500
7000
7500
8000
8500
9000
9500
10000
10500
11000
11500
12000
12500
13000
STREAM DISTANCE IN FEET
Bridge on Route 34
E
F
G
H
LEGEND
0.2% ANNUAL CHANCE FLOOD
1% ANNUAL CHANCE FLOOD
2% ANNUAL CHANCE FLOOD
10% ANNUAL CHANCE FLOOD
STREAM BED
CROSS SECTION LOCATION
FLOOD PROFILES
BLACKBERRY CREEK
FEDERAL EMERGENCY MANAGEMENT AGENCY
KENDALL COUNTY, IL
02P


ELEVATION IN FEET (NAVD 88)
640
635
630
625
620
615
610
605
600
595
13000
13500
14000
14500
15000
15500
16000
16500
17000
17500
18000
18500
19000
19500
STREAM DISTANCE IN FEET
Bridge on Route 47
I
J
K
LEGEND
0.2% ANNUAL CHANCE FLOOD
1% ANNUAL CHANCE FLOOD
2% ANNUAL CHANCE FLOOD
10% ANNUAL CHANCE FLOOD
STREAM BED
CROSS SECTION LOCATION
FLOOD PROFILES
BLACKBERRY CREEK
FEDERAL EMERGENCY MANAGEMENT AGENCY
KENDALL COUNTY, IL
03P


650
645
640
635
630
625
620
615
610
605
ELEVATION IN FEET (NAVD 88)
19500
20000
20500
21000
21500
22000
22500
23000
23500
24000
24500
25000
25500
26000
STREAM DISTANCE IN FEET
L
M
LEGEND
0.2% ANNUAL CHANCE FLOOD
1% ANNUAL CHANCE FLOOD
2% ANNUAL CHANCE FLOOD
10% ANNUAL CHANCE FLOOD
STREAM BED
CROSS SECTION LOCATION
FLOOD PROFILES
BLACKBERRY CREEK
FEDERAL EMERGENCY MANAGEMENT AGENCY
KENDALL COUNTY, IL
04P



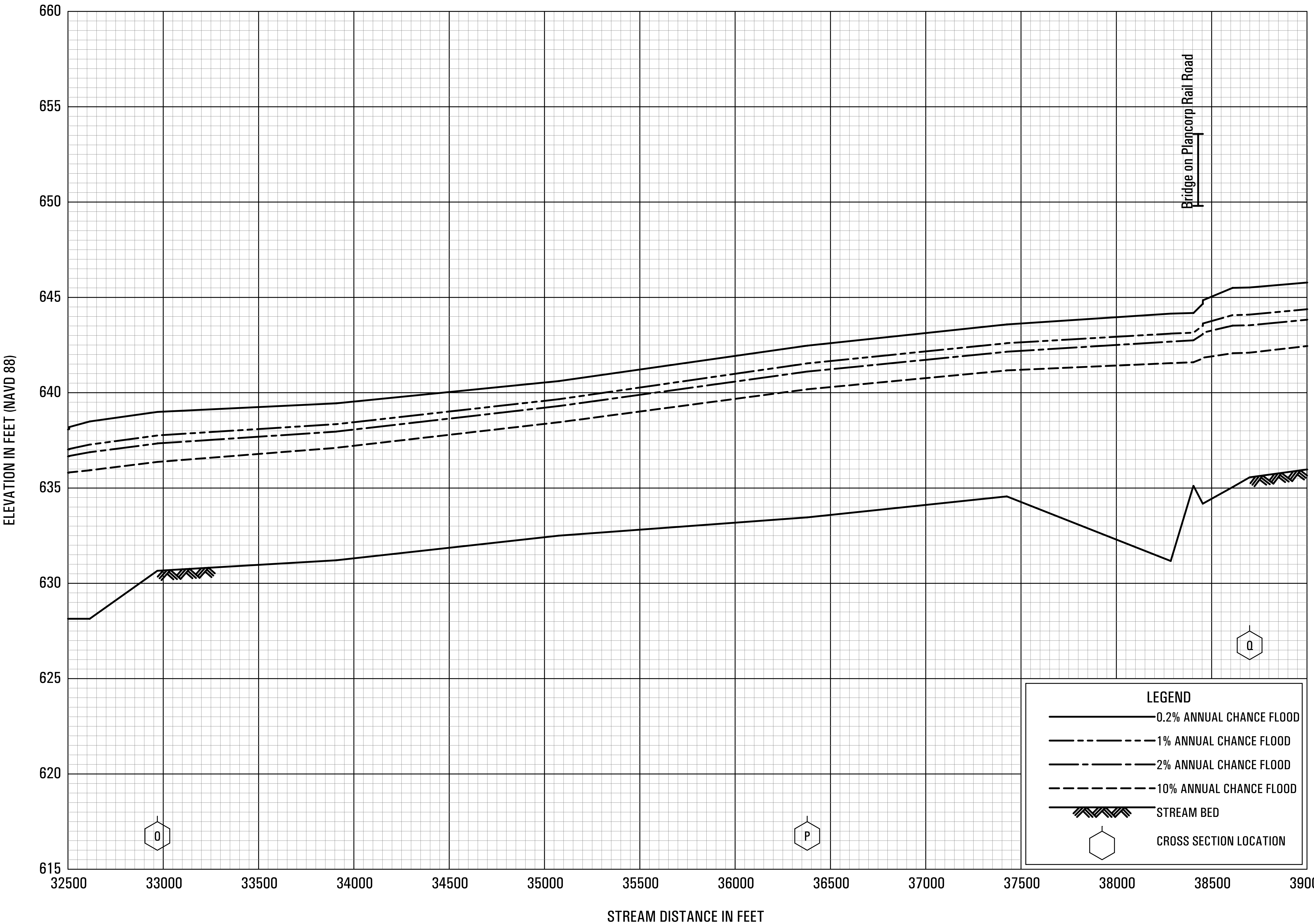

FLOOD PROFILES

BLACKBERRY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

KENDALL COUNTY, IL

05P



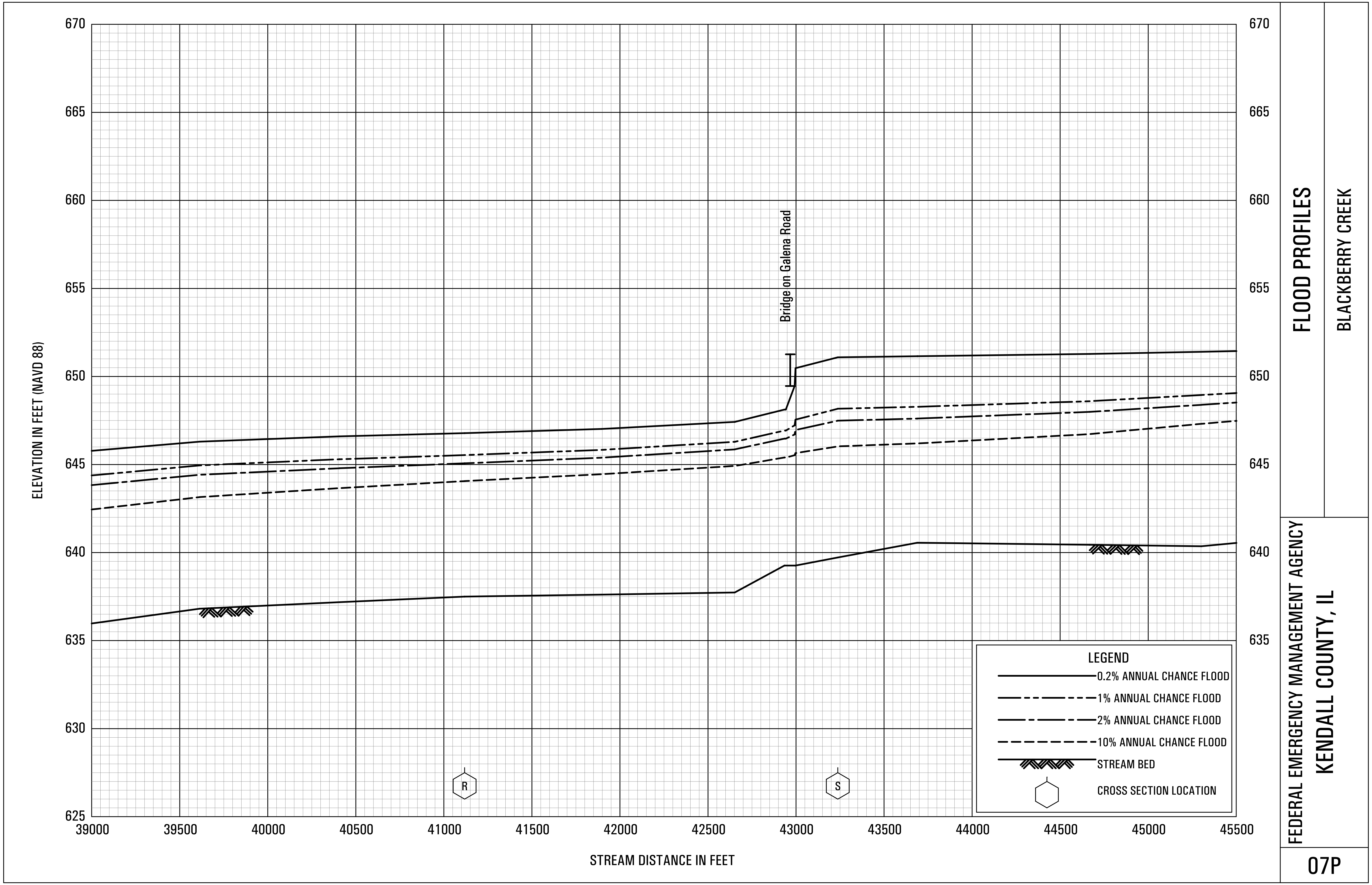

FLOOD PROFILES

BLACKBERRY CREEK

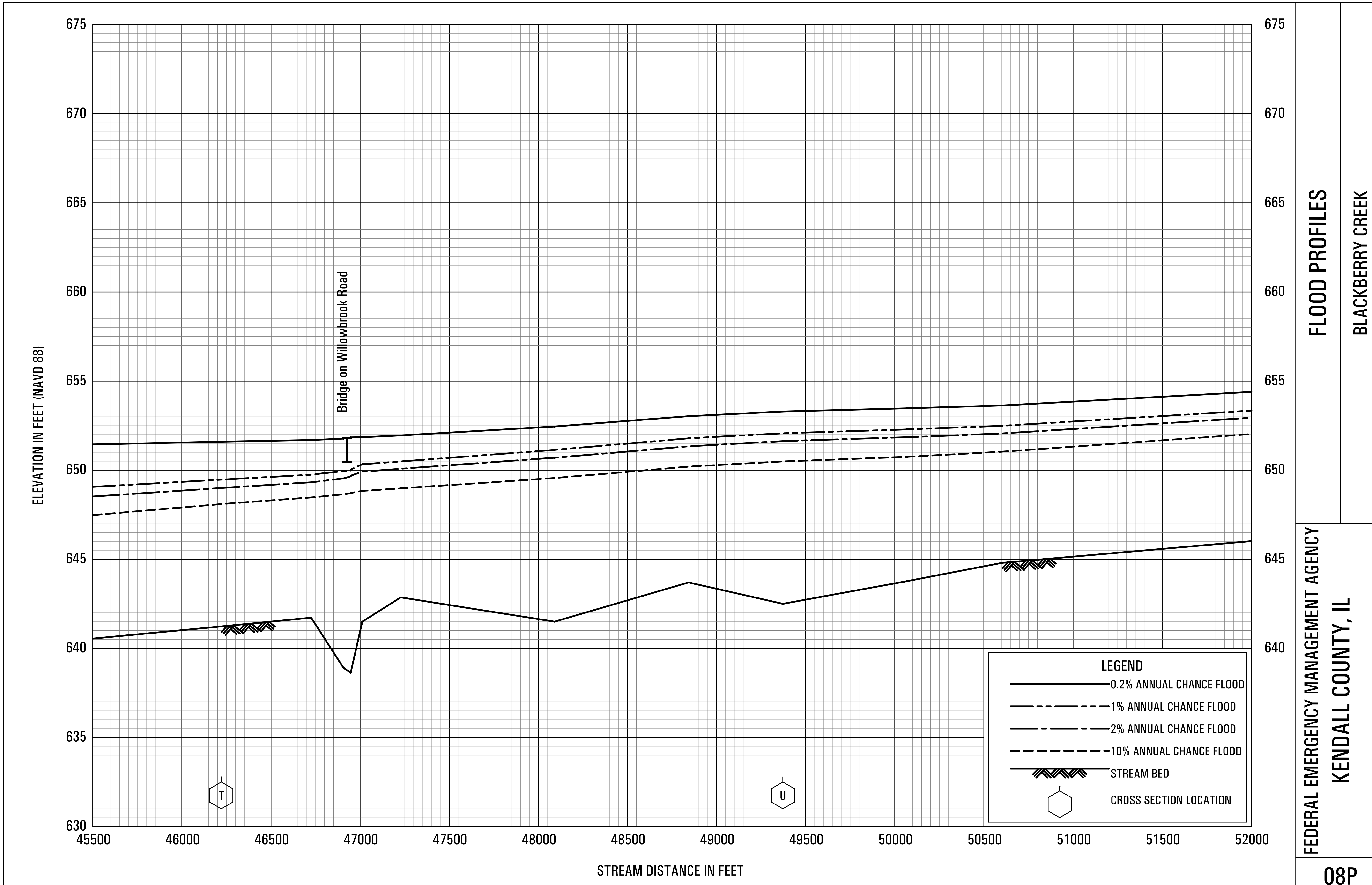
FEDERAL EMERGENCY MANAGEMENT AGENCY

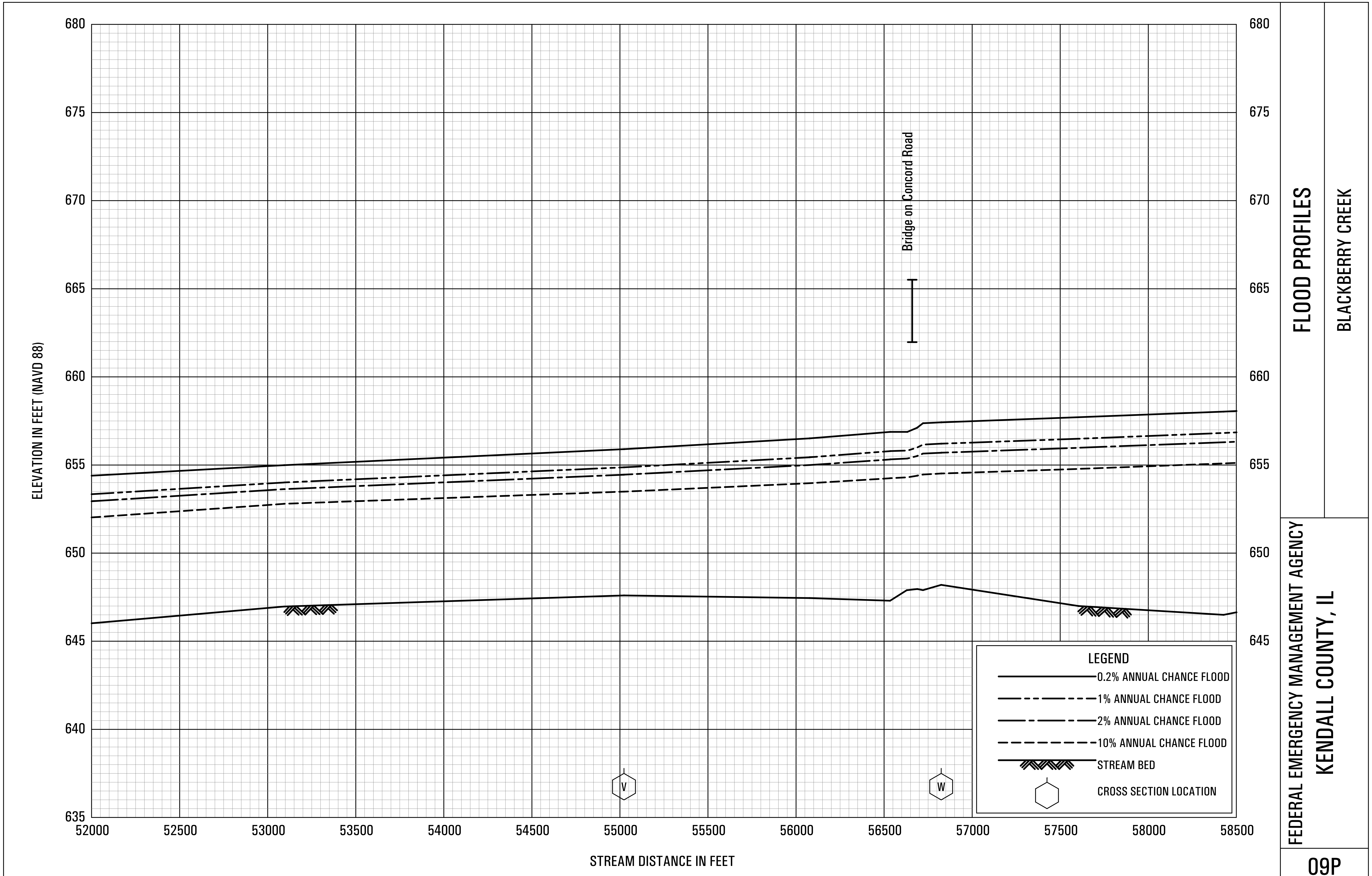
KENDALL COUNTY, IL

06P



ELEVATION IN FEET (NAVD 88)
670
665
660
655
650
645
640
635
630
625
39000
39500
40000
40500
41000
41500
42000
42500
43000
43500
44000
44500
45000
45500
STREAM DISTANCE IN FEET
Bridge on Galena Road
R
S
LEGEND
0.2% ANNUAL CHANCE FLOOD
1% ANNUAL CHANCE FLOOD
2% ANNUAL CHANCE FLOOD
10% ANNUAL CHANCE FLOOD
STREAM BED
CROSS SECTION LOCATION
FLOOD PROFILES
BLACKBERRY CREEK
FEDERAL EMERGENCY MANAGEMENT AGENCY
KENDALL COUNTY, IL
07P


675
670
665
660
655
650
645
640
635
630
ELEVATION IN FEET (NAVD 88)
Bridge on Willowbrook Road
45500
46000
46500
47000
47500
48000
48500
49000
49500
50000
50500
51000
51500
52000
STREAM DISTANCE IN FEET
T
U
LEGEND
0.2% ANNUAL CHANCE FLOOD
1% ANNUAL CHANCE FLOOD
2% ANNUAL CHANCE FLOOD
10% ANNUAL CHANCE FLOOD
STREAM BED
CROSS SECTION LOCATION
FLOOD PROFILES
BLACKBERRY CREEK
FEDERAL EMERGENCY MANAGEMENT AGENCY
KENDALL COUNTY, IL
08P


680
675
670
665
660
655
650
645
640
635
ELEVATION IN FEET (NAVD 88)
52000
52500
53000
53500
54000
54500
55000
55500
56000
56500
57000
57500
58000
58500
STREAM DISTANCE IN FEET
Bridge on Concord Road
V
W
LEGEND
0.2% ANNUAL CHANCE FLOOD
1% ANNUAL CHANCE FLOOD
2% ANNUAL CHANCE FLOOD
10% ANNUAL CHANCE FLOOD
STREAM BED
CROSS SECTION LOCATION
FLOOD PROFILES
BLACKBERRY CREEK
FEDERAL EMERGENCY MANAGEMENT AGENCY
KENDALL COUNTY, IL
09P

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