CIVIL ENGINEERING STUDIES
Illinois Center for Transportation Series No. 10-063
UILU-ENG-2010-2003
ISSN: 0197-9191

IMPLEMENTATION AND EVALUATION OF THE STREAMFLOW STATISTICS (STREAMSTATS) WEB APPLICATION FOR COMPUTING BASIN CHARACTERISTICS AND FLOOD PEAKS IN ILLINOIS

Prepared By
Audrey L. Ishii
David T. Soong
Jennifer B. Sharpe
U.S. Geological Survey

Research Report ICT-10-063

A report of the findings of
ICT-R27-6
Internet-Based Flood-Peak Discharges Determination for Rural Streams—
Illinois StreamStats

Illinois Center for Transportation

January 2010

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-ICT-10-063		

4. Title and Subtitle
Implementation and evaluation of the Streamflow Statistics (StreamStats) web application for computing basin characteristics and flood peaks in Illinois

5. Report Date
January 2010

6. Performing Organization Code

7. Author(s)
Audrey L. Ishii, David T. Soong, Jennifer B. Sharpe

8. Performing Organization Report No.
ICT-10-063
UILU-ENG-2010-2003

9. Performing Organization Name and Address
U.S. Geological Survey
Illinois Water Science Center
1201 W. University Avenue
Urbana, IL 61801

10. Work Unit (TRAIS)

11. Contract or Grant No.

12. Sponsoring Agency Name and Address
Illinois Department of Transportation
Bureau of Materials and Physical Research
126 East Ash Street
Springfield, IL 62704

13. Type of Report and Period Covered
Final Report

14. Sponsoring Agency Code

15. Supplementary Notes
Prepared in cooperation with the Illinois Department of Natural Resources, Office of Water Resources, and the Illinois Department of Transportation

16. Abstract
Illinois StreamStats (ILSS) is a Web-based application for computing selected basin characteristics and flood-peak quantiles based on the most recently (2010) published (Soong et al., 2004) regional flood-frequency equations at any rural stream location in Illinois. Limited streamflow statistics including general statistics, flow durations, and base flows also are available for U.S. Geological Survey (USGS) streamflow-gaging stations. ILSS can be accessed on the Web at *http://streamstats.usgs.gov/* by selecting the *State Applications* hyperlink and choosing *Illinois* from the pull-down menu.

ILSS was implemented for Illinois by obtaining and projecting ancillary geographic information system (GIS) coverages; populating the StreamStats database (StreamStatsDB) with streamflow-gaging station data; processing the 30-meter digital elevation model (DEM) for Illinois to conform to streams represented in the National Hydrography Dataset 1:100,000 stream coverage; and customizing the Web-based Extensible Markup Language (XML) programs for computing basin characteristics for Illinois. The basin characteristics computed by ILSS then were compared to the basin characteristics used in the published study, and adjustments were applied to the XML algorithms for slope and basin length. Testing of ILSS was accomplished by comparing flood quantiles computed by ILSS at an approximately random sample of 170 streamflow-gaging stations computed by ILSS with the published flood-quantile estimates. Differences between the log-transformed flood quantiles were not statistically significant at the 95-percent confidence level for the State as a whole, nor by the regions determined by each equation, except for region 1, in the northwest corner of the State. In region 1, the average difference in flood-quantile estimates ranged from 3.76 percent for the 2-year flood quantile to 4.27 percent for the 500-year flood quantile. The total number of stations tested in region 1 was small (21) and the mean difference is not large (less than one-tenth of the average prediction error for the regression-equation estimates). The sensitivity of the flood-quantile estimates to differences in the computed basin characteristics are determined and presented in tables. A test of usage consistency was conducted by having at least 7 new users compute flood-quantile estimates at 27 locations. The average maximum deviation of the estimate from the mode value at each site was 1.31 percent for the 100-year flood quantile after four mislocated sites were removed. A comparison of manual 100-year flood-quantile computations with ILSS computations at 34 sites indicated no statistically significant difference. ILSS appears to be an accurate, reliable, and effective tool for flood-quantile estimates.

17. Key Words	18. Distribution Statement
Flood frequency,flood-peak estimation, flood-peak discharge, streamflow statistics, automated watershed delineation, basin characteristics, Web application, StreamStats	No restrictions.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CONVERSION FACTORS

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
meter (m)	3.281	foot (ft)
	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
	Slope	
foot per mile (ft/mi)	0.1894	meter per kilometer

ABBREVIATIONS, ACRONYMS, AND SYMBOLS

BCF	basin characteristic file
BL	basin length
BS	BasinSoft
DA	drainage area
DEM	digital elevation model
DRGs	digital raster graphics
ESRI	Environmental Systems Research Institute, Inc.
GIS	geographic information system
ICT	Illinois Center for Transportation
IDNR–OWR	Illinois Department of Natural Resources–Office of Water Resources
IDOT	Illinois Department of Transportation–Bureau of Bridges and Structures
ILSS	Illinois StreamStats
LFP	longest flow path
MCL	main channel length
NED	National Elevation Dataset
NHD	National Hydrography Dataset
NLCD	National Land Cover Data
NRCS	Natural Resources Conservation Service
PermAvg	average soil permeability
σ	standard deviation
SL	slope
StreamStatsDB	StreamStats database
USGS	U.S. Geological Survey
USGS–ILWSC	USGS–Illinois Water Science Center
%Water	percentage of open water and herbaceous wetland
WATSTORE	Water Storage Retrieval system
WBD	Watershed Boundary Dataset
WDNR	Wisconsin Department of Natural Resources
WSRT	Wilcoxon Signed Rank Test
XML	extensible markup language

ACKNOWLEDGMENTS

This report describes the results of research project ICT-R27-6, *Internet-Based Flood-Peak Discharges Determination for Rural Streams—Illinois StreamStats.* This project was conducted in cooperation with the Illinois Center for Transportation; the Illinois Department of Transportation (IDOT), and the Illinois Department of Natural Resources, Office of Water Resources (IDNR-OWR). The research team thanks the Technical Review Panel for the guidance and oversight. The members of the TRP were Matthew O'Connor (chair, IDOT), Arlan Juhl (IDNR-OWR), Mark Gawedzinski (IDOT), and Neil Vanbebber (IDOT).

The authors thank the many IDOT and IDNR–OWR hydraulic engineers who helped with the testing and evaluation of the functionality of Illinois StreamStats, and Ann Holtrop, formerly of the Watershed Protection Section, Illinois Natural History Survey, Illinois Department of Natural Resources, who processed the majority of the dendritic network by June 2006 and graciously provided the data for use in this study.

The authors thank the U.S. Geological Survey (USGS) StreamStats team, especially Alan Rea, Kernell Ries, and David Stewart who assisted with technical implementation and testing issues. The authors thank Christine Dartiguenave and Sreeresh Sreedhar of ESRI, Inc., who completed the XML programming for the basin-length characteristics. Finally, the authors thank Thomas Over and Timothy Straub of the USGS Illinois Water Science Center, and David Eash of the USGS Iowa Water Science Center who offered suggestions on the statistical analyses and watershed-geomorphology issues.

DISCLAIMER

The contents of this report reflect the view of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Illinois Center for Transportation, the Illinois Department of Transportation, or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

Trademark or manufacturers' names appear in this report only because they are considered essential to the object of this document and do not constitute an endorsement of the product by the U.S. Geological Survey, the Federal Highway Administration, the Illinois Department of Transportation, or the Illinois Center for Transportation.

EXECUTIVE SUMMARY

The rural flood-frequency equations for Illinois were implemented in a U.S. Geological Survey (USGS) StreamStats Web-based application, the Illinois StreamStats (ILSS), in cooperation with the Illinois Center for Transportation, the Illinois Department of Transportation, and the Illinois Department of Natural Resources–Office of Water Resources. ILSS computes selected basin characteristics and flood-peak quantiles based on the most recently (2010) published (Soong et al., 2004) regional flood-frequency equations at any rural stream location in Illinois. Limited streamflow statistics including general statistics, flow durations, and base flows also are available for USGS streamflow-gaging stations. ILSS can be accessed *on* the Web at *http://streamstats.usgs.gov/* by selecting the *State Applications* hyperlink and choosing *Illinois* from the pull-down menu.

The basin characteristics produced by ILSS were compared to the basin characteristics published in Soong et al. (2004) and used in the rural flood-frequency equations at 283 rural streamflow-gaging station locations by testing for significant differences at the 95-percent confidence level using the paired t-test. There were no significant differences in drainage area and percentage of open water and herbaceous wetland, although relative differences were larger for smaller drainage areas, where local hydraulic-control features are relatively important. StreamStats enables the user to manually edit the drainage basin. Average permeability had a small significant difference (less than 0.25 percent), and no correction was considered necessary because of the very low sensitivity of the flood quantile to this characteristic. Significant differences were found in basin length and slope. Basin length was adjusted using a linear best-fit regression line. The adjusted basin length did not differ significantly from the published values. The slope was adjusted by a linear best-fit regression line on log-transformed slope values. The adjusted values were not significantly different from the published values according the paired t-test, but did have a significant difference according to the Wilcoxon signed-rank test, with a mean difference of 4.22 percent.

A sensitivity analysis was used to determine the sensitivity of a large sample (271) of the estimated flood-peak quantiles to basin-characteristic differences. For the common range of 60 to 120 percent of published (Soong et al., 2004) basin characteristics that were tested, the greatest average range of sensitivity of the resulting flood-peak quantiles was (in order from greatest to least) drainage area, %Water, slope, average permeability, and basin length. The relative range in sensitivity does not indicate the likelihood of computing any particular basin characteristic difference, but rather the influence of the basin characteristics in the regional regression equations.

The flood-peak quantiles produced by ILSS were compared to the published values at an approximately random sample of 170 streamflow-gaging stations. There were no significant differences between the log-transformed flood-peak quantile estimates published in Soong et al. (2004) and those computed by ILSS, either taken as a whole or sorted by the hydrographic regions identified in Soong et al. (2004), except for region 1. Region 1 had a small statistically significant difference ranging from 3.76 percent for the 2-year flood-quantile estimate to 4.27 percent for the 500-year flood-quantile estimate at the 95-percent confidence level. All 21 stations were considered in the analysis, because of the few stations available in region 1. The total number of stations in region 1 was small and the mean difference is less than one-tenth of the average prediction errors for the 2- to 500-year regression-equation estimates, which range from 39.5 to 54.9 percent, respectively.

A test of the ILSS usage reliability was conducted by having at least 7 new users compute flood-quantile estimates at 27 locations. The average maximum deviation of the 100-year flood quantile estimate from the mode value at each site was 1.31 percent after

four mislocated sites were removed. A comparison of manual 100-year flood-quantile computations with ILSS at 34 sites indicated no statistically significant difference.

ILSS appears to be an accurate, reliable, and effective tool for flood-quantile estimates and the determination of a consistent set of basin characteristics.

INTRODUCTION

Streamflow statistics such as peak-discharge estimates for floods of various frequencies (flood quantiles) are used widely in engineering and scientific applications such as determining flood plains, designing hydraulic structures such as bridges and culverts, and the planning and management of the State’s water resources to protect water quality and supply. While representative streamflow records are essential for deriving reliable flow statistics, streamflow records are site-specific information, whereas the need for such information is region-wide. The U.S. Geological Survey (USGS) has developed regional regression equations for estimating statistical streamflow characteristics at ungaged sites, which are used to transfer site-based information, such as streamflow statistics, to those sites. The equations were developed by use of regression-analysis techniques to relate streamflow characteristics to basin characteristics, which can be determined through a variety of methods (Jennings et al., 1994). To apply the regional regression equations, the user must determine the same basin characteristics for ungaged sites that were determined for gaged sites and used in the regional regression equations. These characteristics are determined by a variety of methods such as the manual or digital measurement of maps; from field surveys; from paper records; or by other methods, such as geographic information system (GIS) software. Such steps are time-consuming or require considerable user expertise, and the results can be inconsistent. A single, integrated application that provides an automated determination of the needed basin characteristics and solves the regional regression equations to provide the estimated flood quantiles can reduce the time required and the potential inconsistencies in the results. To meet this need, the USGS, in cooperation with the Environmental Systems Research Institute (ESRI), Inc., has developed StreamStats, a national Web-based GIS application that serves streamflow statistics and determines basin characteristics and flood quantiles based on consistently processed data sets and methods in utilizing the flood-frequency regional regression equations (Ries et al., 2008).

The USGS–Illinois Water Science Center (USGS–ILWSC) used basin characteristics that were derived from GIS data layers and from the application of an Arc INFO-based program, BasinSoft (version 1.1, Harvey and Eash, 1996), to determine the current (2010) regional regression equations for estimates of flood quantiles for rural streams in Illinois. The regional analysis included the investigation of functional relations with more numerous, consistently determined basin characteristics than was possible in earlier investigations (Soong et al., 2004). However, the use of GIS-based data and methods also created difficulties for users who do not have the resources to access the GIS databases and (or) software for determining these selected basin characteristics. The availability of StreamStats provided the opportunity to satisfy the public need for the utilization of GIS techniques without extensive software or user expertise; consequently, the USGS–ILWSC, in cooperation with the Illinois Center for Transportation (ICT), the Illinois Department of Transportation–Bureau of Bridges and Structures (IDOT); and the Illinois Department of Natural Resources–Office of Water Resources (IDNR–OWR), conducted this study to implement and evaluate the StreamStats application for determining basin characteristics and flood-peak quantiles for rural streams in Illinois.

The purpose of this report is to describe the procedures used to develop Illinois StreamStats (ILSS) and the analyses performed to evaluate ILSS and present the results. This includes the preparation of the GIS-data layers and Web-based Extensible Markup Language (XML) programming, the development of the streamflow-statistics database, the evaluation and adjustment of the basin characteristics determined from ILSS, and the evaluation of the flood-peak quantiles from ILSS. The limitations of the application and the sensitivity to basin characteristics differences also are described.

IMPLEMENTING ILLINOIS STREAMSTATS (ILSS)

StreamStats is a USGS Web-based application that makes the process of computing streamflow statistics faster and more consistent than previously used manual methods. StreamStats can be accessed on the Web at *http://streamstats.usgs.gov/*. StreamStats includes five major components: (1) the user interface, which displays the maps and enables users to select the stream locations for which information is desired; (2) the database, which contains previously published streamflow statistics and other descriptive information for streamflow-gaging stations; (3) the automated GIS processes, which determine the drainage boundaries and other drainage-basin characteristics by utilizing the underlying preprocessed GIS database; (4) the GIS database, which stores the base-map data; and (5) the implementation of the National Streamflow Statistics program (Ries, 2006), which uses the regional regression equations along with the basin-characteristics input to compute and output the various streamflow statistics to the user display.

The implementation of ILSS required the collection and processing of base GIS-data layers for consistency in projection, hydroprocessing of the digital elevation model (DEM), development of ancillary data layers, programming algorithms for computing selected basin characteristics, comparing ILSS results—both basin characteristics and flood-peak quantiles—with those obtained in the 2004 analysis, and providing adjustments where required.

DATA PREPARATION

Processing of three primary GIS-data layers was needed to produce the ILSS data layers. In the present study, the 1:100,000-scale USGS National Hydrography Dataset (NHD) (*http://nhd.usgs.gov/*) was used to develop a dendritic stream network. This processing involved the removal of braided streams and reconnecting or removing disconnected stream segments. All elevation information used in ILSS, including flow direction and flow accumulation, was derived from the USGS 1-arc second National Elevation Dataset (NED). The 1-arc second NED is a national seamless DEM with a resolution of 30 m (*http://seamless.usgs.gov/viewer.htm*). The downloaded NED blocks were merged and reprojected to the Albers Equal-Area Conic projection. After tile edges were examined to make sure elevation values were consistent, the NED was resampled to a 10-m resolution grid for the ILSS project. A hydro-corrected DEM was developed from the NED. This was done by first filling depressions or sinks in the NED (areas surrounded by areas of higher elevation values). Next, the NHD streams were "burned" into the NED to create well-defined flow paths through the elevation data. The “burning” process involves artificially reducing the elevation of DEM cells that are co-located with the NHD stream lines. The processing was done by the 8-digit Hydrologic Unit Code watershed. These data layers, along with the Natural Resources Conservation Service (NRCS) Watershed Boundary Dataset (WBD) (*http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/*), were processed through the ESRI ArcHydro Tools (ESRI, Inc., 2005) interface to produce all the data layers used in ILSS.

Using ArcHydro Tools, Version 1.1—a set of utilities developed to operate in the ArcGIS environment (*http://www.crwr.utexas.edu/gis/gishydro06/ArcHydro/ArcHydroTools/Doc/Arc%20Hydro%20Tools%20-%20Overview.pdf*)—49 processing units, based on the WBD 8-digit hydrologic units, were created and additional data layers were generated for each processing unit. These layers were developed to calculate basin characteristics used in the Illinois flood-peak regional equations. Primary base-grid data layers that were created include catchments, flow accumulation, flow direction, and an artificial flow-path grid used to delineate drainage basins in the ILSS application. These layers then were used to create layers that control the StreamStats delineation, including AdjointCatchment, Catchment, DrainageLine, DrainagePoint, LongestFlowPathCat, and LongestFlowPathAdjCat. After all 49 processing units were processed, the global geodatabase was created. This database directs StreamStats as to how all the units interact. In addition, the NED was resampled to 100 m for use in the basin-length calculations (see programming for basin length (BL) in the Computer Code Development section).

GIS-data layers for average soil permeability (PermAvg), open water and herbaceous wetland (from which %Water is calculated), and hydrologic regions also are used for computing basin characteristics. The PermAvg grid was obtained by taking the arithmetic average of the high and low soil-permeability values from the STATSGO soil database (Natural Resources Conservation Service, 1993, *http://www.ncgc.nrcs.usda.gov/products/datasets/statsgo/*). The open-water and herbaceous-wetland grid was derived from the 1992 National Land Cover Data (NLCD) (*http://www.epa.gov/mrlc/nlcd.html*). The regions grid defines which regression equations to use after a user has delineated a drainage basin in ILSS; the regions used in ILSS are shown in figure 1.

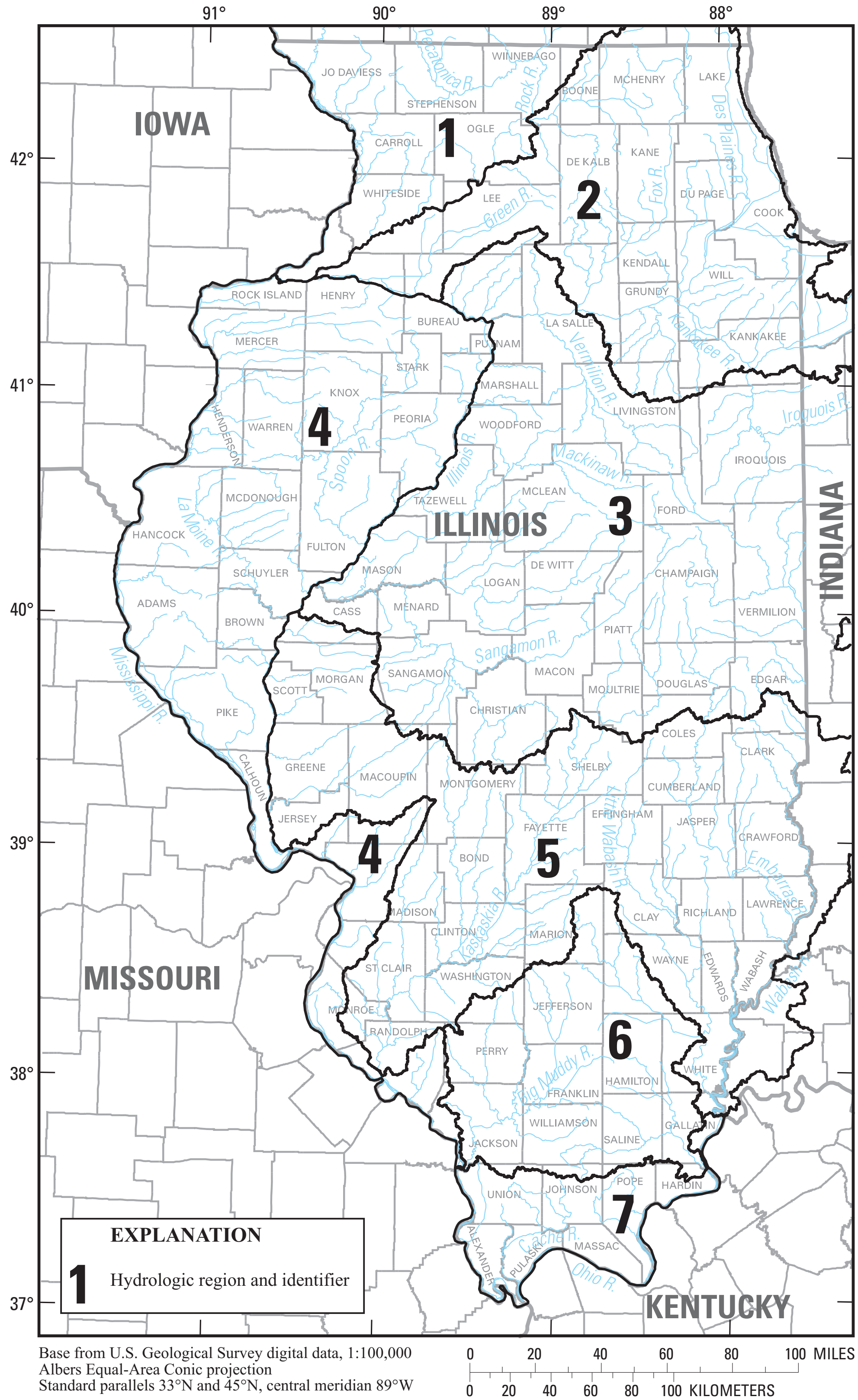

Figure 1. Hydrologic regions for flood-frequency regression equations of rural streams in Illinois (Soong et al., 2004).

The majority of Illinois Digital Raster Graphics (DRGs) used as base map for the evaluation of the ILSS were purchased in 1998 from the EROS Data Center. Other DRGs not included in this purchase were obtained from several different Web sites, including the ISGS (*http://www.isgs.uiuc.edu/nsdihome/webdocs/drg/*), the Indiana Spatial Data Portal at Indiana University (*http://www.indiana.edu/~gisdata/*), and the Wisconsin Department of Natural Resources (WDNR) (*ftp://gomapout.dnr.state.wi.us/*). DRGs at scales of 1:24,000, 1:100,000, and 1:250,000 are displayed in ILSS to assist users with locating their sites.

COMPUTER CODE DEVELOPMENT

XML algorithms are the computer codes implemented in the ArcHydro Tools parameter-configuration software to direct the computation of a basin characteristic when it is selected by a user. XML is understood by all modern Web browsers. The Web software used in StreamStats—ArcIMS—has many predefined XML algorithms for computing common parameters. For those basin characteristics for which XML algorithms were already defined, such as drainage area and stream slope, all that was needed was to make the fields specific to Illinois. XML algorithms also were customized for computing PermAvg, %Water, and the placeholder variable for the portion of the regression equation indicating the hydrologic region factor. For both PermAvg and %Water, the XML calculates an area-weighted value based on the delineated drainage basin.

A new XML algorithm was coded by ESRI to replicate the BL parameter derived by the BasinSoft program (Harvey and Eash, 1996) and used in the Illinois regional regression equations. The algorithm is discussed below.

Several definitions of BL exist in the literature. The BasinSoft definition of BL states that it is measured, in miles, along a line areally centered through the basin polygon from the basin outlet to where the main-channel extension meets the basin divide (Harvey and Eash, 1996). These two end points, the basin-outlet and the basin-divide point, are located on the perimeter of the basin polygon and BasinSoft calculates the least-cost path through the polygon connecting the points to measure BL. BasinSoft prompts the user to manually digitize the main-channel extension to the divide, based on contours displayed on screen. This manual method of extending the main channel may result in different extensions by different users. For example, one user may identify the main channel as the major named stream for a given basin, whereas another user may identify the main channel as the longest flow path (LFP) for the basin. Similarly the basin divide (the point where the main channel, if extended, would cross the drainage basin boundary) could be interpreted as the nearest saddle point (a local low point on the basin boundary) or as the highest point on the upper basin boundary. For consistency, the endpoint used in the ILSS is based on the LFP extended to the intersection with the highest adjacent point on the basin boundary.

The least-cost path in the ILSS is determined by first creating a cost-surface wherein each grid cell is assigned a cost based on the inverse of the Euclidean distance from the basin boundary. The XML algorithm then computes the path resulting in the least-cost path from the basin divide LFP endpoint to the outlet using this cost surface. The grid-cell size used in BasinSoft was 100.12 ft, whereas in StreamStats, computer processing limitations required that the cell-size be increased to 100 m.

The final step in the XML programming was to incorporate adjustments to the StreamStats-computed basin characteristics to make them more comparable with the original basin characteristics determined from BasinSoft. These adjustments consisted of a power equation for the slope and a linear equation for the basin length. The determination of the coefficients for these equations is discussed in the Evaluation and Adjustment of Basin Characteristics section.

ILLINOIS STREAMSTATS DATABASE

Information from the Illinois StreamStats database (StreamStatsDB) is available through the StreamStats GageInfo tool. The database was designed to be populated with site-specific information for streamflow-gaging stations and other data-collection stations, such as basin and climatic characteristics (Physical Characteristics) and streamflow statistics. The current (2010) StreamStatsDB implementation in ILSS was developed by the USGS StreamStats team by importing station descriptions and streamflow statistics from an obsolete database known as the Basin Characteristic File (BCF) of the USGS Water Storage Retrieval (WATSTORE) System, the contemporaneous water-information database. The BCF has not been updated since the 1990's, and no time tags were associated with any of the data entered into the BCF. As a result, the information from the BCF is likely to be at least 10 years old. Consequently, the values do not necessarily agree with more recently published values, or with the values computed by ILSS. The flow-duration and general flow statistics by StreamStatsDB were obtained from Wolock (2003a), and base-flow statistics were obtained from Wolock (2003b). The flood quantiles are from a variety of sources, including Soong et al. (2004). The sources are documented on the StreamStats Web pages.

EVALUATION AND ADJUSTMENT OF BASIN CHARACTERISTICS

The sets of BasinSoft- and GIS-map-derived basin characteristics used in the regression equations for determining flood quantiles published in Soong et al. (2004) were compared with the approximately equivalent basin characteristics available from ILSS. To determine whether adjustments to ILSS computations of basin characteristics were required, basin characteristics were obtained from ILSS before the quantile regression-equation computations were implemented in ILSS. The ILSS values were obtained by identifying streamflow-gaging stations on the digital/base maps and selecting the nearest road crossing as the starting point for the ILSS watershed delineation. The percent and absolute differences between the two data sets for each basin characteristic were statistically analyzed by use of parametric and non-parametric significance tests. The distribution of the differences data set generally was not perfectly normal; therefore, non-parametric tests may be preferred to detect significant differences in the two data sets. Both parametric and non-parametric significance tests were computed, because the paired t-test is often considered sufficiently robust to detect differences even where normality in the data sets is moderately violated (Berk and Carey, 2004). The distributions of the differences are shown in the Sensitivity of Flood-Peak Quantiles section. The distributions generally were mildly skewed and (or) too leptokurtic (most values near the mean with few extreme values) to be considered normal.

All basin characteristics were tested with both the parametric paired t-test and the non-parametric Wilcoxon signed-rank test (WSRT). Because of the large range in values, the differences of the log-tranformed basin characteristics were also tested for drainage area, slope, %Water , and PermAvg. Of the original 288 streamflow-gaging stations used in the flood-frequency regression analysis, two drainage basins were in the Lake Michigan watershed, which is not implemented in ILSS, and three additional drainage basins were found to have errors in the original data set, so the tests utilized 283 streamflow-gaging stations. Basin length, which is applied only in the region 4 part of the State, was tested at 47 streamflow-gaging stations. The differences of the log-transformed values are not reported because the transformation was not suitable for the relatively small range and linear relation between the ILSS and published values for basin length. The results of the tests are shown in table 1.

Table 1. Differences between the published basin characteristics (Soong et al., 2004) and the Illinois StreamStats (ILSS) basin characteristics (published value minus ILSS value).

Statistic	**DA**	**SL**	**SLadj**	**BL**	**BLadj**	**%Water**	**PermAvg**
	Statistics for drainage-basin characteristic						
n	283	283	283	47	47	283	283
Mean of diffs	-.12357	-1.56415	.782558	.4897	.00037	-.02103	.006958
Mean of percent diffs	.042	-8.569	-4.225	4.036	-6.783	-.486	.253
Median of diffs	-.008	.047	.121	.130	-.235	.000	.000
Median of percent diffs	-.019	.783	2.542	1.716	-2.547	.000	.000
t-test p-value[a]	.2022	.0222	.2436	.0464	.9988	.4708	.0436
WSRT p-value[b]	.0897	.2882	.0057	.0089	.1109	.9030	.8578
	Test statistics for log-transformed drainage-basin characteristic						
t-test p-value[a]	0.3415	0.0240	0.9982	-	-	0.3816	0.0724
WSRT p-value[b]	0.8978	0.5861	0.0328	-	-	0.9737	0.7965

[*n*, number of paired observations; diffs, differences; percent diffs, 100 times differences divided by published value; WSRT, Wilcoxon signed-rank test; DA, drainage area; SL, slope; SLadj, the adjusted StreamStats SL; BL, basin length; BLadj, adjusted BL; %Water, percent open water and herbaceous wetland; PermAvg, areally weighted average of permeability; - ,not applicable]

[a] p-values greater than 0.05 indicate that there is not a statistically significant mean difference between the published (Soong et al., 2004) values and the ILSS values.
[b] p-values greater than 0.05 indicate that there is not a statistically significant median difference between the published (Soong et al., 2004) value and the ILSS values.

Paired t-test p-values greater than 0.05 indicate that the mean difference between the data sets is not statistically significant at the 0.05 significance level (referred hereafter as the “95-percent confidence level”) (Schlotzhauer and Littel, 1987). Wilcoxon signed-rank test p-values greater than 0.05 indicate that the median difference between the data sets is not statistically significant at the 95-percent confidence level (Helsel and Hirsch, 2002). Results of the tests and subsequent adjustments (where performed) are described below.

DRAINAGE BASIN AREA, PERCENT WATER, AVERAGE SOIL PERMEABILITY

Mean differences between the mean values published in Soong et al. (2004) and those obtained from ILSS for drainage area (DA) and percentage of open water and herbaceous wetland (%Water) were not statistically significant. The scatter plot in figure 2 demonstrates the relation between the DA values published in Soong et al. (2004) and those available from ILSS on logarithmically scaled axes. The same relation is shown on arithmetically scaled axes in figure 3. The scatter plots for PermAvg and %Water are not shown, because these basin characteristics are derived directly from the watershed drainage area.

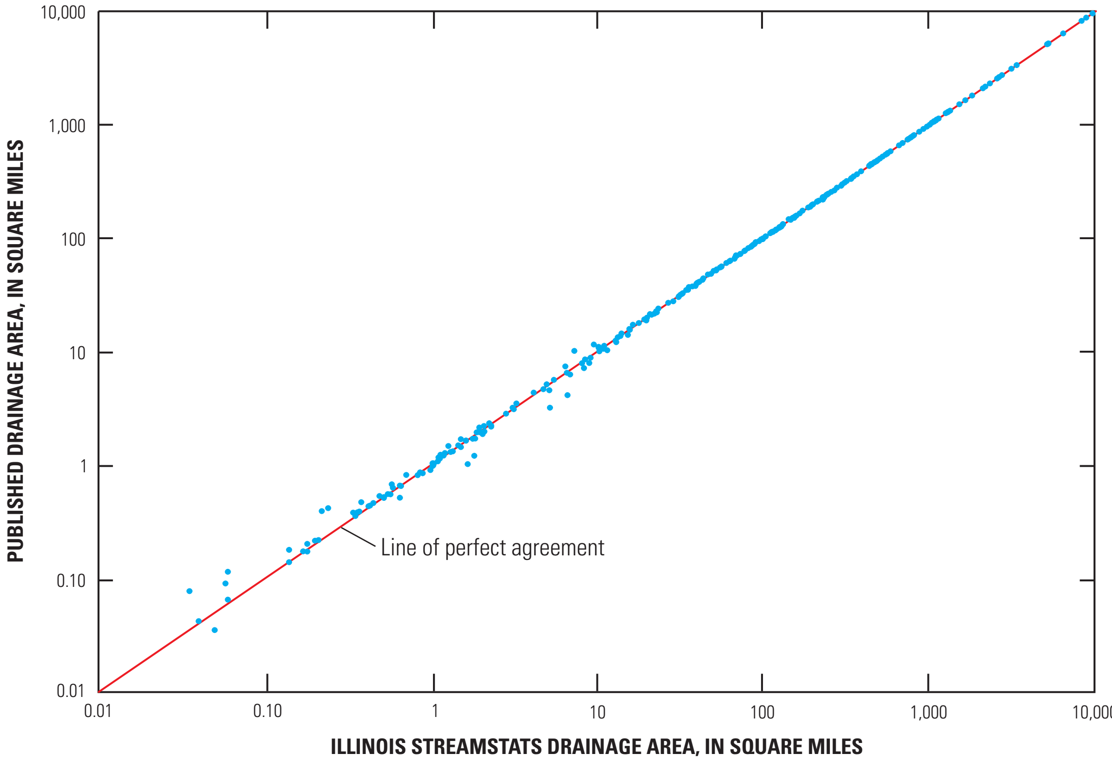

Figure 2. Relation between Illinois StreamStats and published drainage areas (Soong et al., 2004)—logarithmically scaled axes.

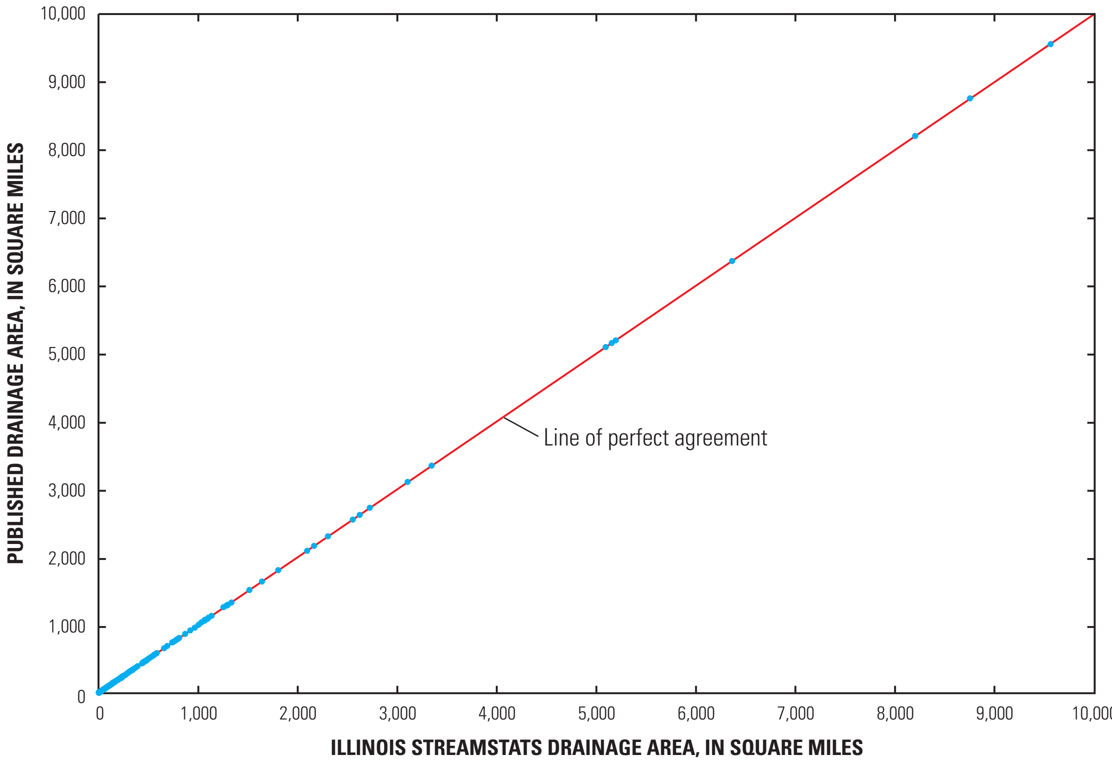

Figure 3. Relation between Illinois StreamStats and published drainage areas (Soong et al., 2004)—arithmetically scaled axes.

Differences between the Soong et al. (2004) published values and the values computed by ILSS as percent differences are shown in figure 4. Percent difference is computed as 100*(2004_DA - ILSS_DA)/2004_DA, where 2004_DA is the published value in Soong et al. (2004) and ILSS_DA is the ILSS value. The same data are plotted on truncated scales in figures 5 and 6 to better illustrate the relative size of the difference for smaller watersheds. The percent differences are larger for smaller watersheds, especially those under 0.5 mi^2. A major reason for this occurrence is that, for a given difference between the values, the percent difference increases as the magnitude of the initial value decreases. For example, a difference of 0.1 mi^2 is 1 percent where the initial drainage area is 10 mi^2, but the difference is 10 percent where the drainage area is 1 mi^2.

It should be noted that the correctness of the drainage areas was not determined. In some cases, ILSS may compute a more correct drainage area than was determined by manual methods. These values were obtained from ILSS without any user intervention. In practice, the user can use the EditBasin tool to ensure that the watershed is properly represented with consideration of local hydraulic flow controls such as roads and culverts. The computed basin characteristics and flood quantiles then will be produced for the edited watershed.

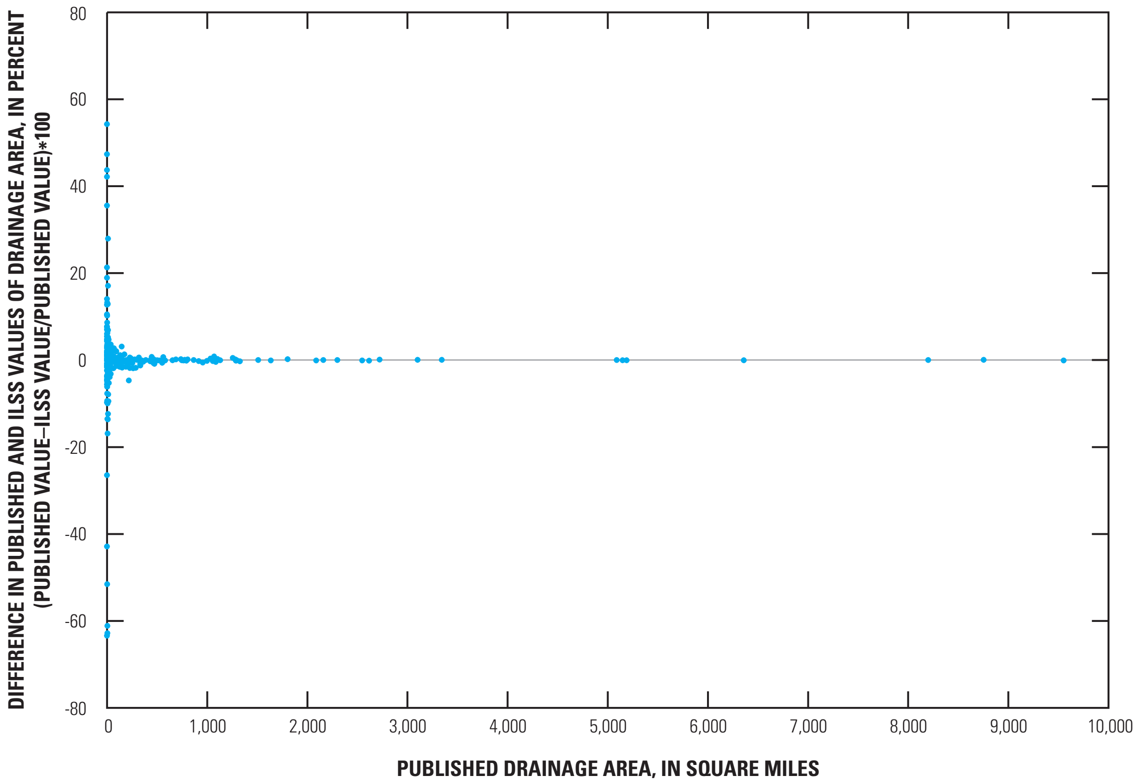

Figure 4. Relation between percent differences in published and Illinois StreamStats (ILSS) values of drainage areas and published drainage areas (Soong et al., 2004)—full scale.

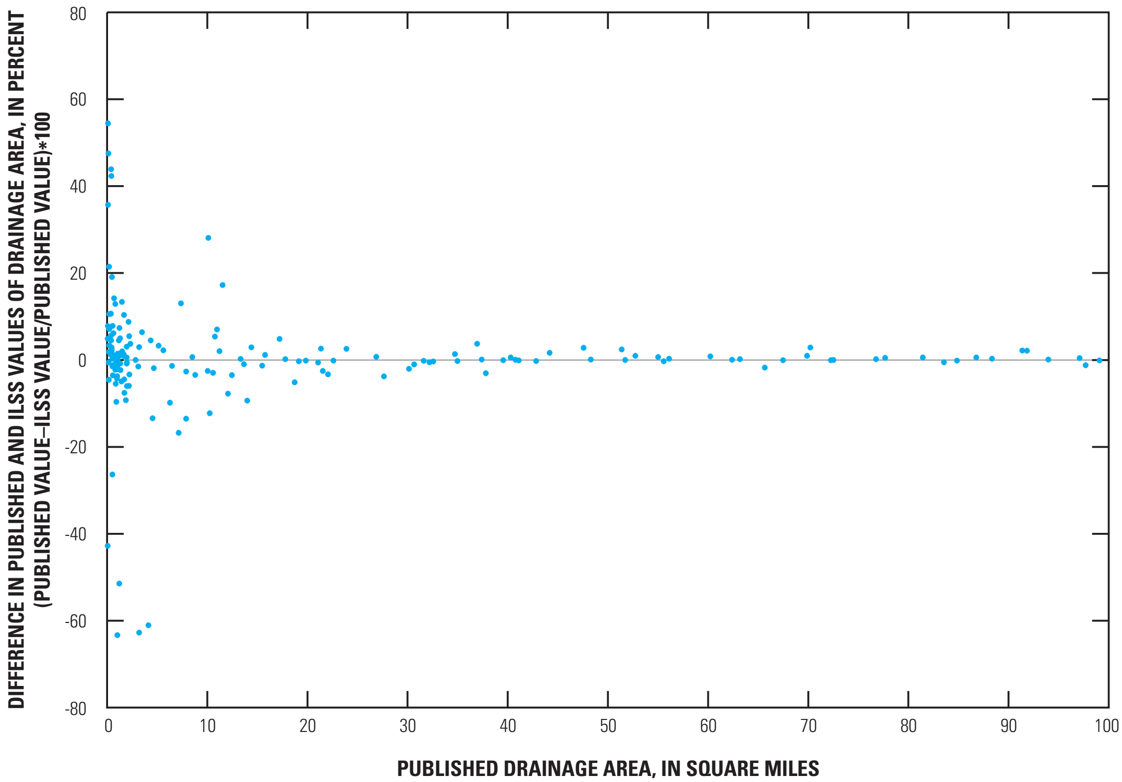

Figure 5. Relation between percent differences in published and Illinois StreamStats (ILSS) values of drainage areas and published drainage areas (Soong et al., 2004)—scale truncated to 100 square miles.

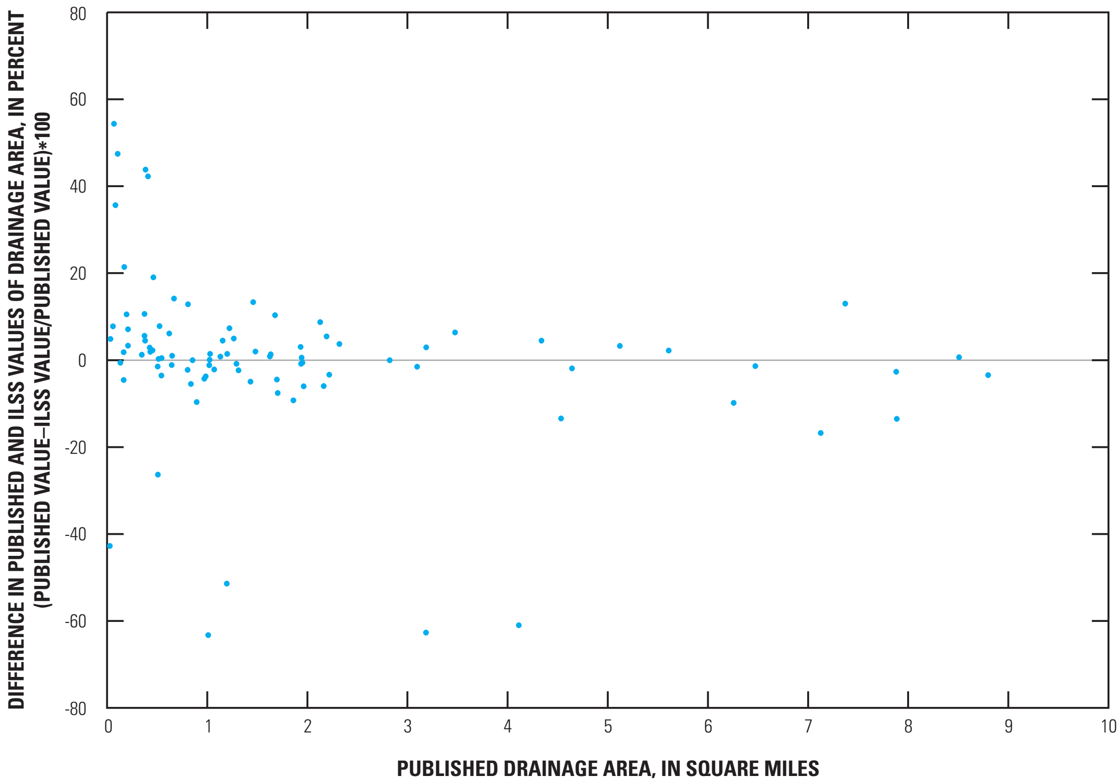

Figure 6. Relation between percent difference in published and Illinois StreamStats (ILSS) values of drainage areas and published drainage areas (Soong et al., 2004)—scale truncated to 10 square miles.

The paired t-test p-value (0.0436) indicated that the difference between the 2004 PermAvg and the ILSS-computed PermAvg was statistically significant, but the Wilcoxon signed-rank test p-value (0.8578) indicated that the difference was not statistically significant. The average mean difference between PermAvg determined using BasinSoft (BS) and ILSS was very small (0.25 percent), resulting in a potential adjustment-equation slope for PermAvg that was very close to 1.0 (1.016) and the intercept that was close to zero (-0.0156). The mean difference of the log-tranformed values was not statistically significant. Furthermore, the sensitivity of the computed flood quantiles to differences in PermAvg also was very small, as discussed in the Sensitivity of Flood-Peak Quantiles section; therefore, no adjustment equation was applied to the PermAvg basin characteristics.

The paired t-test p-values indicated that differences in the mean values of basin length (BL) (0.0464) and slope (SL) (0.0222) were significant. The Wilcoxon signed-rank test p-values indicated that the differences between the median values of BL (p-value = 0.0089) were significant, but differences for SL (p-value = 0.2882) were not significant. These characteristics were further analyzed to see whether an adjustment factor could be determined using simple linear regression as described in the next two sections.

BASIN LENGTH

BasinSoft (version 1.1, Harvey and Eash, 1996) was used to determine the BL values that were used in the current (2010) update of techniques for estimating flood quantiles for rural streams in Illinois (Soong et al., 2004). The definitions of BL differ in two regards between ILSS and BasinSoft: (1) the intersection of the LFP with the watershed divide is used as the second endpoint of the least-cost path from the watershed outlet in ILSS, rather than the intersection of the user-determined main channel with the watershed divide that is used in BasinSoft; and (2) the computational-grid spacing was changed in the ILSS to from 10 to 100 m because of computer-processing limitations.

The BL differences computed using the original 10-m computation grid in ILSS were not statistically significant from those computed by BasinSoft, but the computational time was prohibitive; therefore, the 100-m grid values with an applied-adjustment equation is used in ILSS.

A linear equation was found to adjust the set of ILSS values of BL computed with the 100-m computational grid so that the differences between the adjusted BL values (BLadj) and the BasinSoft computed BL values (BS_BL) were not statistically significant. The equation was

$$BLadj=1.0164*ILSS\_BL+0.2364$$
$$\text{R-squared} = 0.9915.$$

where ILSS_BL is the value of BL computed by ILSS using the 100-m grid as discussed in the section on BL (see fig. 7).

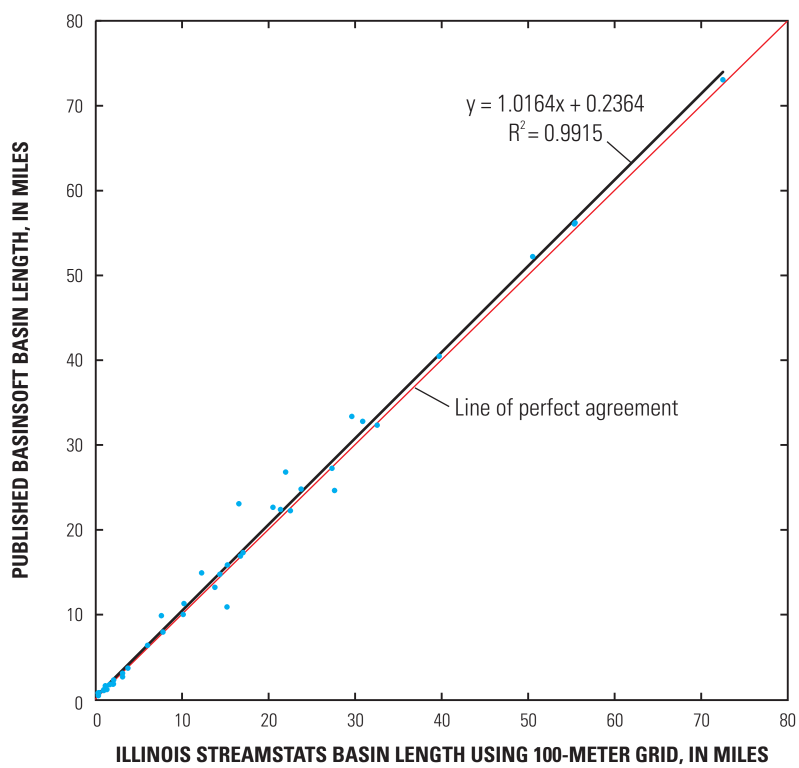

Figure 7. Relation between Illinois StreamStats basin length using 100-meter grid and the published BasinSoft basin length (Soong et al., 2004).

STREAM SLOPE

BasinSoft (version 1.1, Harvey and Eash, 1996) was used to determine the slope basin characteristic that was used in the current (2010) update of techniques for estimating flood quantiles for rural streams in Illinois (Soong et al., 2004). The main channel was determined by using the 1:100,000-scale NHD and manually extending the apparent main channel to an intersection with the watershed divide, an adjacent saddle point between peaks. The slope was determined by determining the elevation, in feet, at points of 10 and 85 percent along the main channel from the outlet, and dividing the difference in elevation by 75 percent of the total main-channel length (which is the distance between the 10 and 85 percent points), in miles. The StreamStats method is based on an ArcIMS XML algorithm, the $SL_{10\text{-}85}$, which determines the longest flow path from the outlet to the divide by using the DEM to determine the flow path from the watershed outlet, extending up the longest continuous flow path to the adjacent peak point on the watershed divide. The slope is determined by dividing the difference in elevation, in feet, at 10 and 85 percent of the distance from the outlet to the intersection of the LFP with the watershed divide, by 75 percent of the total LFP length (the distance between the 10 and 85 percent points), in miles.

The distribution of the differences in SL displayed a skew, with larger values of SL determined by ILSS than those determined using BasinSoft. The t-test for differences in SL (table 1) indicated that differences in the means for both the values and the log-transformed values were statistically significant (p-value of 0.0222, and 0.0240 respectively); thus, a correction was tried. The best-fit linear-regression equation (determined by linear regression on log-transformed variables—see fig. 8) was determined to be

SLadj=1.0767*(ILSS_SL)**0.9486
R-squared = 0.9529.

where

SLadj is ILSS slope adjusted to be closer to the BasinSoft slope, and
ILSS_SL is the ILSS slope.

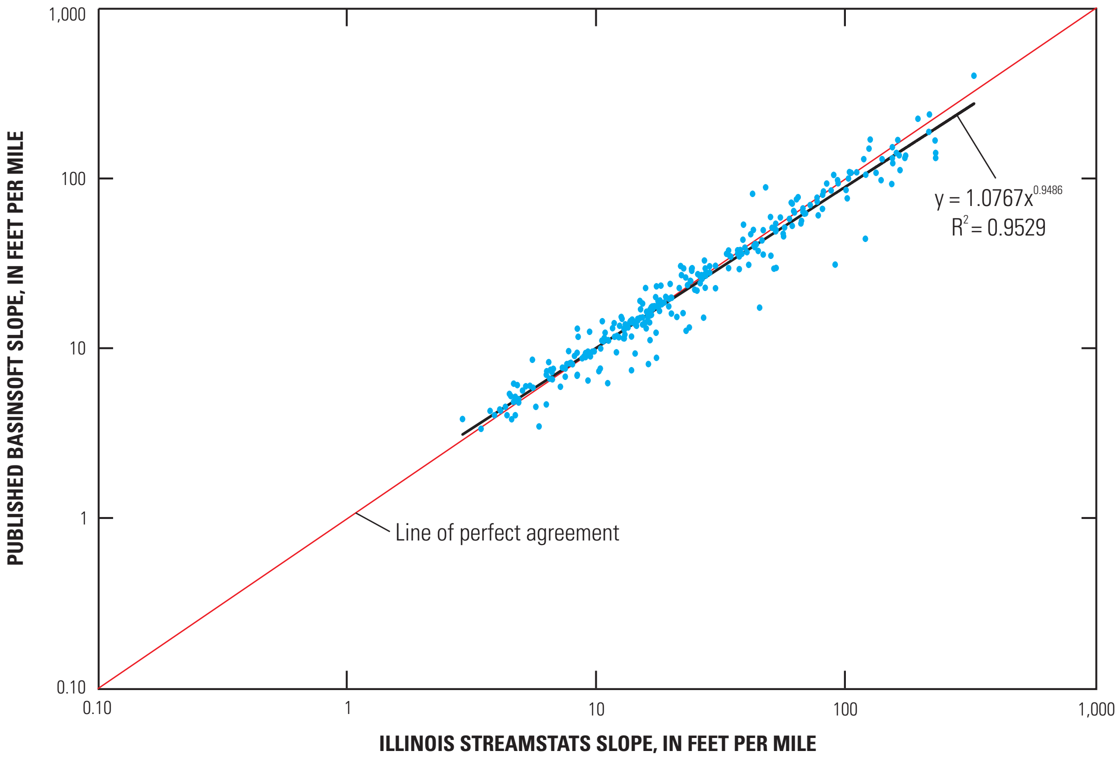

Figure 8. Relation between Illinois StreamStats and published BasinSoft slope (Soong et al., 2004).

The residuals from the adjusted values as percent differences were plotted in relation to the 2004 values for drainage area (2004_DA) and BasinSoft slope (BS_SL) and no pattern was apparent (figs. 9 and 10); therefore, no regression relation utilizing these basin characteristics was considered. The adjustment equation removed the statistical significance of the differences determined by the paired t-test, but the adjusted values were significantly different from the published values under the Wilcoxon signed-rank test. Similar results were found for the log-transformed values. The mean percent difference between the published values and the adjusted values was -4.22, compared to -8.57 for the mean difference for the unadjusted values; however, the median percent difference decreased from -0.783 to -2.54, indicating a slightly more skewed distribution after adjustment. The adjusted distribution was found to be preferable according to the t-test assumption of a normal distribution. Figure 8 demonstrates that there is a skew in the distribution of the ILSS slopes compared to the BasinSoft slopes, but the effect of this on the overall distribution and relevance of the test was considered nominal.

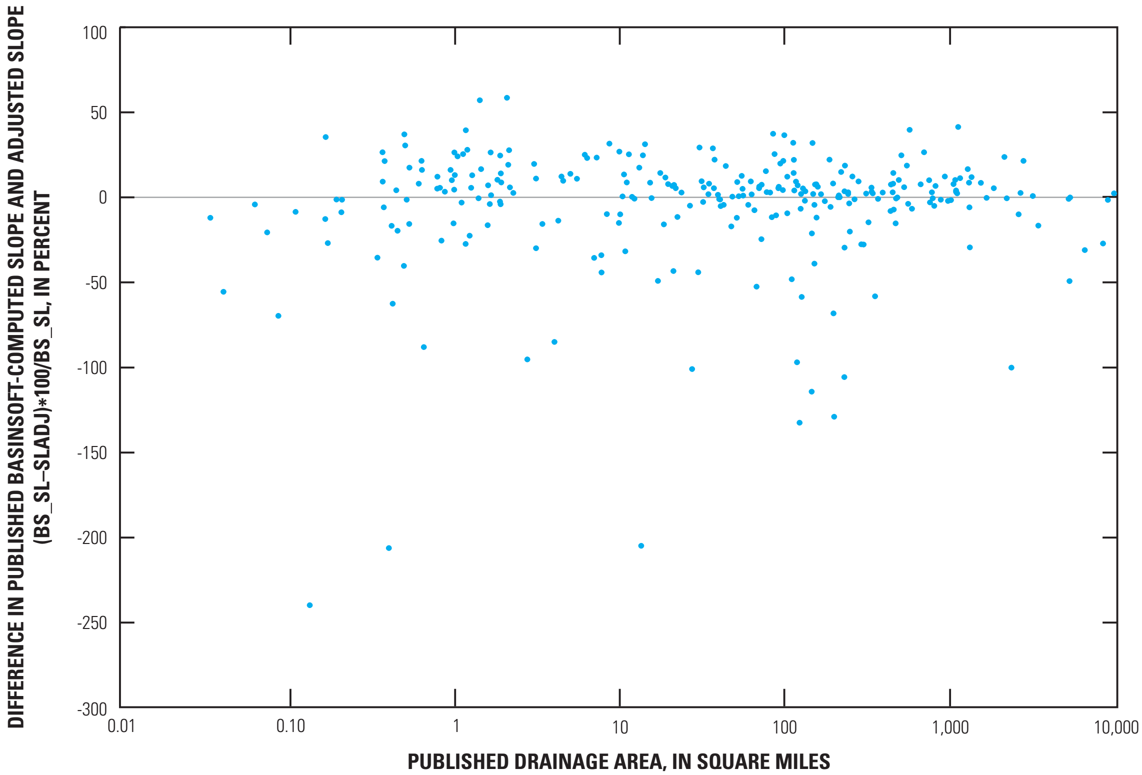

Figure 9. Relation between adjusted slope residual (published BasinSoft-computed stream slope (BS_SL) minus adjusted slope (SLadj), expressed as a percent [(BS_SL-SLadj)*100/BS_SL]), and published drainage area (Soong et al., 2004).

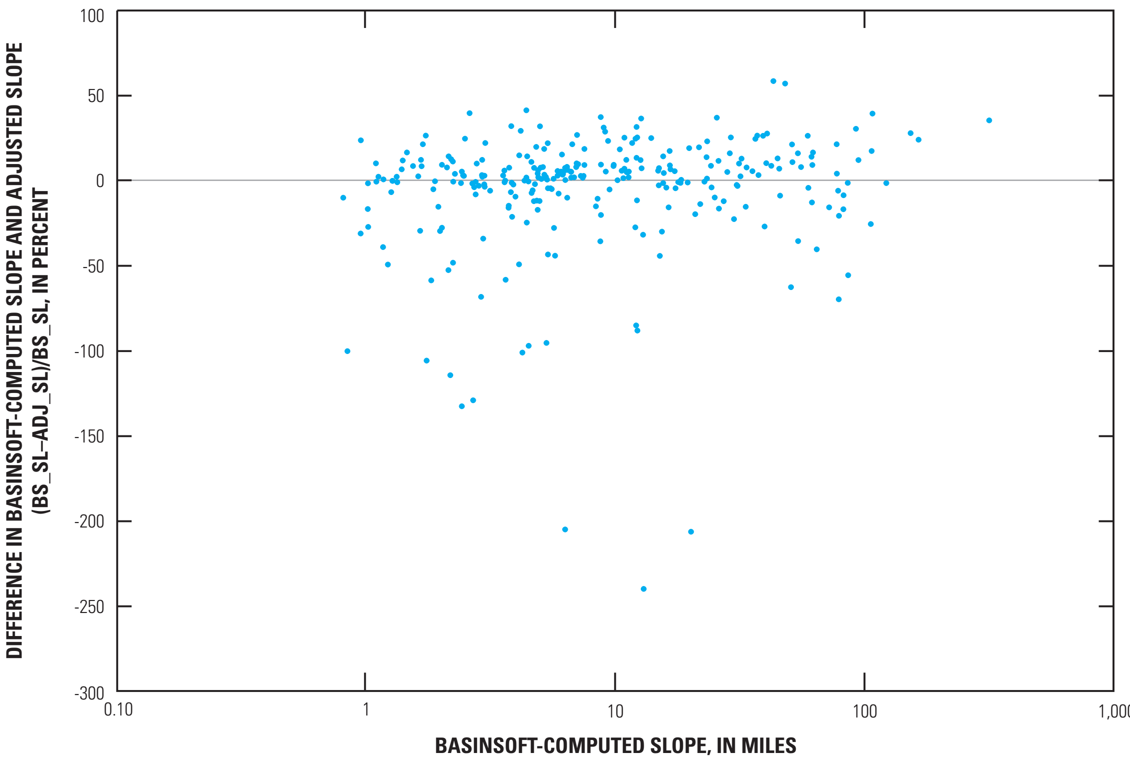

Figure 10. Relation between adjusted slope residual (published BasinSoft-computed stream slope (BS_SL) minus adjusted slope (SLadj), expressed as a percent [(BS_SL-SLadj)*100/BS_SL]), and BasinSoft slope.

The channel lengths of the BasinSoft main channel (MCL) and the ILSS LFP were available for 47 drainage basins in region 4. Their magnitudes did not differ significantly, although the LFP generally was longer than the MCL, indicating that the larger slopes in ILSS may not be a direct result of the length difference, but rather the elevation differences as computed at points 10 and 85 percent along the LFP from the outlet. The automated method of selecting the intersection of the LFP with the basin divide may tend to seek the high point on the divide, whereas the manual determination of the main-channel extension to the basin divide for Illinois tended to select the saddle; therefore, the ILSS may result in a higher 85-percent elevation and a larger value of SL.

The regression equation did not completely remove the statistically significant difference in the two data sets according to the Wilcoxon signed rank test; however, the sample of 170 adjusted slopes obtained from ILSS for the quantile test reported in the next section was not significantly different according to the Wilcoxon signed-rank test nor the paired t-test and also was not significantly different when sorted by region and tested.

EVALUATION OF FLOOD-PEAK QUANTILES

In general, the user cannot assume that the flood-peak quantiles computed by ILSS and those published in Soong et al. (2004) are identical; however, a reasonable sample of the flood-peak quantiles computed by ILSS should be unbiased compared with the published regression equation flood-peak quantiles, and the mean of the differences should not be significantly different from zero at the 95-percent confidence level.

An approximately random sample of 170 streamflow-gaging stations was tested for all quantiles to verify the ILSS application. The sample was selected by numbering the observations and using a random number set to select the sample. The sample was increased by adding all locations in regions 1 and 7, because of the small sample size in those regions. All regions also had at least one station crossing the 8-digit Hydrologic Unit Code processing units. All stations that had drainage basins crossing more than one hydrologic region were removed from this comparison, because the quantiles published in Soong et al. (2004) used only the regional regression equation applicable at the streamflow station and did not weight by percent area in separate hydrologic regions. ILSS computes the quantiles in each region separately and provides a weighted-quantile estimate as well as each regional quantile estimate in the output. For the test of quantile estimates, the selection of starting points was determined by obtaining a list of the latitude and longitude to the nearest second of the intersection of the NHD stream network with the digitized drainage divide. The nearest road crossing to this intersection was selected in ILSS to determine the basin characteristics and compute the flood quantiles.

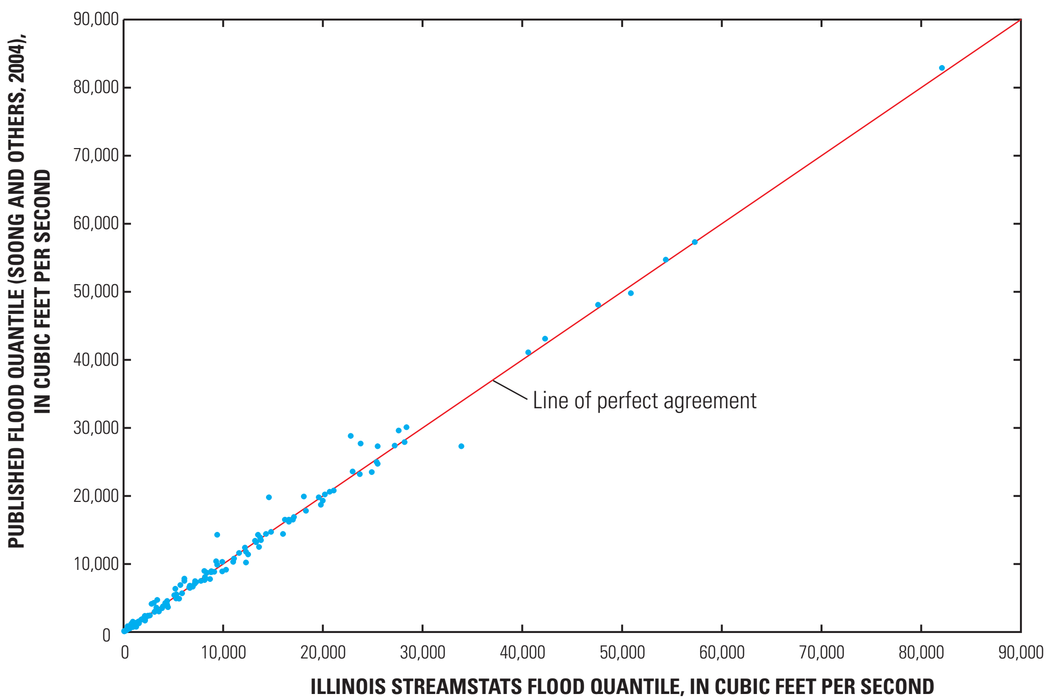

Figure 11. Relation between StreamStats and Soong et al. (2004) 100-year flood quantiles.

Because of the very large range in quantile estimates, the significance testing was done on three datasets: the differences between the published quantile and the ILSS quantile (published quantile - ILSS quantile) referred to hereafter as the simple differences; the proportional differences resulting from dividing the simple differences by the published quantiles ([published quantile - ILSS quantile]/published quantile); and the differences of the log-transformed quantiles (log [published quantile] – log [ILSS] quantile). The results of the significance testing using the proportional differences and the differences of the log-transformed quantiles are presented in tables 2 – 9, along with the mean and median statistics for the proportional differences. The significance testing utilized both the t-test and the Wilcoxon Signed Rank Test. For the data set consisting of simple differences, neither test indicated any significant difference between the means in either in the overall sample or the individual regions. However, this test was not considered strictly valid because of the large range in quantiles values; therefore, the simple differences results are not included in the following tables. The logarithmic transformations address the problem of the large range of values observed in the simple differences, whereas the statistics for the proportional differences provide a practical measure of the differences. The proportional differences are related to the differences of the log-transformed quantiles (A) by the following equation:

$$\frac{(Q_T^{\;2004} - Q_T^{\;ILSS})}{Q_T^{\;2004}} = 1 - e^{-A}$$

where

$$A = log\left(\frac{Q_T^{\;2004}}{Q_T^{\;ILSS}}\right) = log(Q_T^{\;2004}) - log(Q_T^{\;ILSS}) \text{ and}$$

Q is the flood quantile,
T is the t-year recurrence interval
ILSS is the ILSS-computed value, and
2004 is the value published in Soong et al. (2004).

Table 2 displays the results of the tests on the proportional and log-transformed quantiles for the entire sample. It was found that there was no statistically significant difference for any quantile when all the regions were grouped together. A scatter plot of the published 100-year flood quantiles with those obtained from ILSS is illustrated in figure 11. Analyzing the regions separately resulted in a small but significant difference in the flood quantiles for region 1 only (table 3); the tests for the other regions did not indicate a statistically significant difference (tables 4-9).

Region 1 had a small statistically significant difference ranging from 3.8 percent for the 2-year flood-quantile estimate to 4.3 percent for the 500-year flood-quantile estimate at the 95-percent confidence level. All 21 streamflow-gaging stations were considered in the analysis, because of the few streamflow-gaging stations available in region 1. The statistical significance of the difference could be by chance, in light of the small size of the sample. In any case, the difference is small (less than one-tenth) compared to the average prediction errors of the 20 to 500-year regression equation estimates in this region, which range from 39.5 to 54.9 percent, respectively.

Table 2. Comparison of published (Soong et al., 2004), Q_T^{2004}, and Illinois StreamStats (ILSS), Q_T^{ILSS}, flood quantiles as proportional differences—($[Q_T^{2004} - Q_T^{ILSS}]/ Q_T^{2004}$) and differences of the log-transformed quantiles (log $[Q_T^{2004}]$ - log $[Q_T^{ILSS}]$)—for selected streamflow-gaging stations, all regions.

Statistic	Recurrence interval						
	2-year	**5-year**	**10-year**	**25-year**	**50-year**	**100-year**	**500-year**
	Statistics for proportional differences						
n	170	170	170	170	170	170	170
Mean	-.01260	-.01455	-.01666	-.01707	-.01923	-.01742	-.01962
Median	.00632	.00863	.00835	.00803	.00819	.00942	.00908
t-test p-value[a]	.2563	.2272	.1829	.1909	.1536	.2035	.1739
WSRT p-value[b]	.2053	.2195	.3244	.2825	.3678	.2518	.2619
	Test statistics for differences of the log-transformed quantiles						
t-test p-value[a]	.6732	.6574	.5804	.6263	.5474	.6930	.6482
WSRT p-value[b]	.1531	.1759	.2459	.2044	.2739	.1835	.1919

[*n*, number of paired observations; WSRT, Wilcoxon signed-rank test]

[a] p-values greater than 0.05 indicate that there is not a statistically significant mean difference between the published (Soong et al., 2004) values and the ILSS values.

[b] p-values greater than 0.05 indicate that there is not a statistically significant median difference between the published (Soong et al., 2004) values and the ILSS values.

Table 3. Comparison of published (Soong et al., 2004), Q_T^{2004}, and Illinois StreamStats (ILSS), Q_T^{ILSS}, flood quantiles as proportional differences—($[Q_T^{2004} - Q_T^{ILSS}]/ Q_T^{2004}$) and differences of the log-transformed quantiles (log $[Q_T^{2004}]$ - log $[Q_T^{ILSS}]$)—for streamflow-gaging stations, sorted by region: Region 1.

Statistic	Recurrence interval						
	2-year	**5-year**	**10-year**	**25-year**	**50-year**	**100-year**	**500-year**
	Statistics for proportional differences						
n	21	21	21	21	21	21	21
Mean	.037587	.039758	.038617	.037923	.038068	.040158	.042711
Median	.02905	.02723	.02716	.02899	.0299	.03137	.03636
t-test p-value[a]	.0228	.025	.0381	.0487	.0525	.0473	.0422
WSRT p-value[b]	.0149	.0187	.0209	.035	.0425	.0317	.0286
	Test statistics for differences of the log-transformed quantiles						
t-test p-value[a]	0.0182	0.02	0.029	0.0366	0.0393	0.035	0.0308
WSRT p-value[b]	0.0149	0.0187	0.0187	0.0167	0.0258	0.0187	0.0209

[*n*, number of paired observations; WSRT, Wilcoxon signed-rank test]

[a] p-values greater than 0.05 indicate that there is not a statistically significant mean difference between the published (Soong et al., 2004) values and the ILSS values.

[b] p-values greater than 0.05 indicate that there is not a statistically significant median difference between the published (Soong et al., 2004) values and the ILSS values.

Table 4. Comparison of published (Soong et al., 2004), Q_T^{2004}, and Illinois StreamStats (ILSS), Q_T^{ILSS}, flood quantiles as proportional differences—($[Q_T^{2004} - Q_T^{ILSS}]/ Q_T^{2004}$) and differences of the log-transformed quantiles (log $[Q_T^{2004}]$ - log $[Q_T^{ILSS}]$)—for selected streamflow-gaging stations, sorted by region: Region 2.

Statistic	Recurrence intervals						
	2-year	**5-year**	**10-year**	**25-year**	**50-year**	**100-year**	**500-year**
	Statistics for proportional differences						
n	40	40	40	40	40	40	40
Mean	-.06117	-.06990	-.07504	-.07625	-.08452	-.08074	-.09006
Median	.01508	.01743	.01511	.02321	.01903	.02566	.02334
t-test p-value[a]	.108	.0938	.0817	.0912	.0708	.0887	.0733
WSRT p-value[b]	.9055	.9579	.8373	.979	.9369	.9673	.9474
	Test statistics for differences of the log-transformed quantiles						
t-test p-value[a]	0.1948	0.1788	0.1601	0.1891	0.1471	0.1948	0.1662
WSRT p-value[b]	0.9579	0.9895	0.902	0.9055	0.979	0.902	0.9055

[*n*, number of paired observations; WSRT, Wilcoxon signed-rank test]

[a] p-values greater than 0.05 indicate that there is not a statistically significant mean difference between the published (Soong et al., 2004) values and the ILSS values.

[b] p-values greater than 0.05 indicate that there is not a statistically significant median difference between the published (Soong et al., 2004) values and the ILSS values.

Table 5. Comparison of published (Soong et al., 2004), Q_T^{2004}, and Illinois StreamStats (ILSS), Q_T^{ILSS}, flood quantiles as proportional differences—($[Q_T^{2004} - Q_T^{ILSS}]/ Q_T^{2004}$) and differences of the log-transformed quantiles ($\log [Q_T^{2004}] - \log [Q_T^{ILSS}]$)—for selected streamflow-gaging stations, sorted by region: Region 3.

Statistic	**Recurrence interval**						
	2-year	**5-year**	**10-year**	**25-year**	**50-year**	**100-year**	**500-year**
	Statistics for proportional differences						
n	34	34	34	34	34	34	34
Mean	-.00761	-.01171	-.01259	-.01438	-.01595	-.01472	-.01481
Median	.00314	-.00052	.00212	.00102	-.00199	.00289	.00162
t-test p-value[a]	.6672	.5491	.5304	.4927	.4606	.5052	.5168
WSRT p-value[b]	.8123	.7065	.6684	.6094	.5997	.6557	.7442
	Test statistics for differences of the log-transformed quantiles						
t-test p-value[a]	0.9094	0.8042	0.7915	0.7593	0.7296	0.7874	0.8089
WSRT p-value[b]	0.8336	0.7442	0.6684	0.6153	0.6181	0.6684	0.757

[*n*, number of paired observations; WSRT, Wilcoxon signed-rank test]

[a] p-values greater than 0.05 indicate that there is not a statistically significant mean difference between the published (Soong et al., 2004) values and the ILSS values.

[b] p-values greater than 0.05 indicate that there is not a statistically significant median difference between the published (Soong et al., 2004) values and the ILSS values.

Table 6. Comparison of published (Soong et al., 2004), Q_T^{2004}, and Illinois StreamStats (ILSS), Q_T^{ILSS}, flood quantiles as proportional differences—($[Q_T^{2004} - Q_T^{ILSS}]/ Q_T^{2004}$) and differences of the log-transformed quantiles (log $[Q_T^{2004}]$ - log $[Q_T^{ILSS}]$)—for selected streamflow-gaging stations, sorted by region: Region 4.

Statistic	Recurrence Interval						
	2-year	**5-year**	**10-year**	**25-year**	**50-year**	**100-year**	**500-year**
	Statistics for proportional differences						
n	32	32	32	32	32	32	32
Mean	.014143	.01712	.018984	.01889	.022862	.021554	.022185
Median	.006028	.008519	.008731	.007102	.00985	.007138	.006338
t-test p-value[a]	.2553	.2365	.2255	.2634	.1937	.2405	.2619
WSRT p-value[a]	.1892	.2605	.2851	.3452	.246	.3067	.3388
	Test statistics for differences of the log-transformed quantiles						
t-test p-value[a]	0.1914	0.1675	0.1552	0.1768	0.1256	0.1548	0.1639
WSRT p-value[b]	0.1755	0.2373	0.2685	0.3067	0.2079	0.2709	0.3203

[*n*, number of paired observations; WSRT, Wilcoxon signed-rank test]

[a] p-values greater than 0.05 indicate that there is not a statistically significant mean difference between the published (Soong et al., 2004) values and the ILSS values.

[b] p-values greater than 0.05 indicate that there is not a statistically significant median difference between the published (Soong et al., 2004) values and the ILSS values.

Table 7. Comparison of published (Soong et al., 2004), Q_T^{2004}, and Illinois StreamStats (ILSS), Q_T^{ILSS}, flood quantiles as proportional differences—($[Q_T^{2004} - Q_T^{ILSS}]/ Q_T^{2004}$) and differences of the log-transformed quantiles (log $[Q_T^{2004}]$ - log $[Q_T^{ILSS}]$)—for selected streamflow-gaging stations, sorted by region: Region 5.

Statistic	Recurrence interval						
	2-year	**5-year**	**10-year**	**25-year**	**50-year**	**100-year**	**500-year**
	Statistics for proportional differences						
n	20	20	20	20	20	20	20
Mean	-.05530	-.05519	-.06051	-.06277	-.06303	-.06281	-.06382
Median	-.00446	-.00677	-.00852	-.00895	-.00985	-.00923	-.00997
t-test p-value[a]	.0983	.0966	.0832	.0752	.0748	.079	.0788
WSRT p-value[b]	.2069	.2837	.2121	.1925	.1564	.165	.1819
	Test statistics for differences of the log-transformed quantiles						
t-test p-value[a]	0.1	0.098	0.0832	0.0745	0.0741	0.08	0.0811
WSRT p-value[b]	0.2247	0.2837	0.2121	0.1992	0.1819	0.165	0.1819

[*n*, number of paired observations; WSRT, Wilcoxon signed-rank test]

[a] p-values greater than 0.05 indicate that there is not a statistically significant mean difference between the published (Soong et al., 2004) values and the ILSS values.

[b] p-values greater than 0.05 indicate that there is not a statistically significant median difference between the published (Soong et al., 2004) values and the ILSS values.

Table 8. Comparison of published (Soong et al., 2004), Q_T^{2004}, and Illinois StreamStats (ILSS), Q_T^{ILSS}, flood quantiles as proportional differences—($[Q_T^{2004} - Q_T^{ILSS}]/ Q_T^{2004}$) and differences of the log-transformed quantiles ($\log [Q_T^{2004}] - \log [Q_T^{ILSS}]$)—for selected streamflow-gaging stations, sorted by region: Region 6.

Statistic	**Recurrence interval**						
	2-year	**5-year**	**10-year**	**25-year**	**50-year**	**100-year**	**500-year**
	Statistics for proportional differences						
n	15	15	15	15	15	15	15
Mean	.014886	.016165	.014695	.019418	.015057	.019857	.017840
Median	.022989	.026059	.02451	.030965	.027231	.033419	.028037
t-test p-value[a]	.5268	.5245	.5811	.4846	.6006	.5022	.5634
WSRT p-value[b]	.3591	.3591	.391	.3258	.3303	.3258	.3591
	Test statistics for differences of the log-transformed quantiles						
t-test p-value[a]	0.4279	0.4192	0.4633	0.375	0.4709	0.3832	0.4301
WSRT p-value[b]	0.2769	0.3028	0.2958	0.2676	0.2769	0.2676	0.2769

[*n*, number of paired observations; WSRT, Wilcoxon signed-rank test]

[a] p-values greater than 0.05 indicate that there is not a statistically significant mean difference between the published (Soong et al., 2004) values and the ILSS values.

[b] p-values greater than 0.05 indicate that there is not a statistically significant median difference between the published (Soong et al., 2004) values and the ILSS values.

Table 9. Comparison of published (Soong et al., 2004), Q_T^{2004}, and Illinois StreamStats (ILSS), Q_T^{ILSS}, flood quantiles as proportional differences—($[Q_T^{2004} - Q_T^{ILSS}]/ Q_T^{2004}$) and differences of the log-transformed quantiles (log $[Q_T^{2004}]$ - log $[Q_T^{ILSS}]$)—for streamflow-gaging stations, sorted by region: Region 7.

Statistic	**Recurrence interval**						
	2-year	**5-year**	**10-year**	**25-year**	**50-year**	**100-year**	**500-year**
	Statistics for proportional differences						
n	8	8	8	8	8	8	8
Mean	.02548	.02479	.02104	.02506	.01963	.024224	.021489
Median	-.01248	-.01393	-.01675	-.01317	-.01878	-.01443	-.01801
t-test p-value[a]	.3994	.4024	.4656	.3804	.4877	.3966	.4435
WSRT p-value[b]	.8438	.8438	.8438	.7422	.7422	.7422	.7422
	Test statistics for differences of the log-transformed quantiles						
t-test p-value[a]	0.3778	0.3782	0.4332	0.356	0.4515	0.3685	0.4108
WSRT p-value[b]	0.7422	0.7422	0.7422	0.7422	0.7422	0.7422	0.7422

[*n*, number of paired observations; WSRT, Wilcoxon signed-rank test]

[a] p-values greater than 0.05 indicate that there is not a statistically significant mean difference between the published (Soong et al., 2004) values and the ILSS values.

[b] p-values greater than 0.05 indicate that there is not a statistically significant median difference between the published (Soong et al., 2004) values and the ILSS values.

TEST OF ILLINOIS STREAMSTATS USAGE CONSISTENCY

Typical road-crossing design-site locations were collected from the IDOT district offices and compiled into a test data set to test the consistency of ILSS usage. A list of 28 structures was compiled with latitude and longitude, description, and structure-identification number. Additional structures were distributed (not repeated) among the districts included for optional extra testing; the list was distributed to the IDOT district offices. At least seven users returned completed tests, and the results were compiled. One structure-site description was found to be ambiguous and was removed from the results. Additionally, at least two users had some difficulty finding the correct site and selected locations that obviously were incorrect. These results also were removed from the final results. The final results included 6 or 7 results at 27 locations. The average maximum deviation from the mode value of the 100-year flood quantiles result at each site was 1.31 percent. As a result of the rare difficulty in identifying the correct location, the IDOT Structure Identification Management System shapefile was added to the ILSS implementation. This enables the user to select the coverage for display and use the ILSS Identify tool to determine whether the structure site has been correctly identified.

Some of the sites tested had completed manually computed quantile estimates available. Figure 12 shows the comparison of the 34 sites with manual analyses that were tested with ILSS. The accuracy of the manually computed quantile estimates cannot be evaluated because they were not repeated tests; however, a paired t-test between the manual computations and ILSS 100-year flood quantile estimates indicated no statistically significant difference at the 95-percent confidence level.

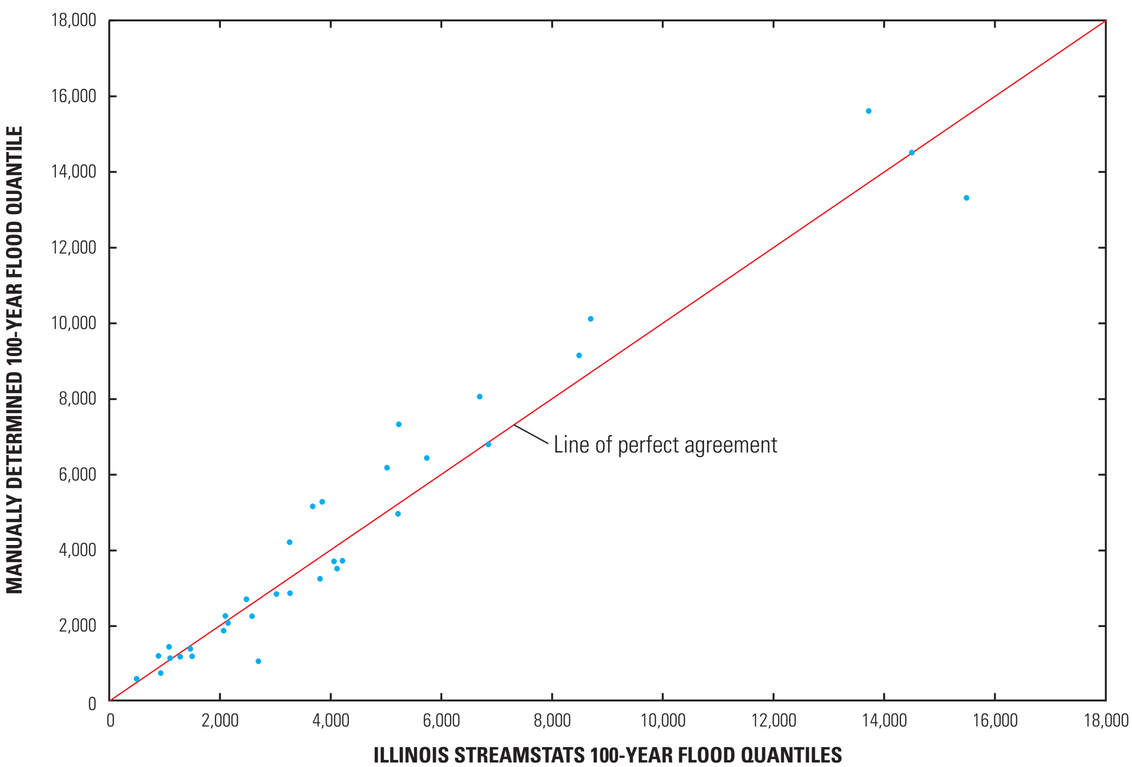

Figure 12. Relation between Illinois StreamStats (ILSS) and manually determined 100-year flood quantiles.

SENSITIVITY OF FLOOD-PEAK QUANTILES

A sensitivity analysis was performed to demonstrate the deviation from the 2004 flood quantiles that may be expected for a range of differences in basin characteristics. To illustrate a range of potential differences, the proportional differences between the basin characteristics determined from ILSS and those from Soong et al. (2004) for a sample of the rural streamflow-gaging stations used in the flood-frequency regression equations were determined. The sample size was 271 stations, except for basin length, which used 47 stations.

The proportional difference in basin characteristic is expressed as

$$\Delta(BC) = \frac{(BC_{2004} - BC_{ILSS})}{BC_{2004}}, \quad (1)$$

where

BC is a basin characteristic parameter,
Δ is the difference,
ILSS represents the ILSS-computed value, and
2004 is the value published in Soong et al. (2004).

Figures 13*A* through 13*E* are histograms of the proportional differences in DA, SL, PermAvg, %Water, and BL. Interval of the histogram is set to 0.05, and three lines in each plot indicate the mean (center) and the range of ±1 standard deviation, σ. The range of ± σ includes more than 67 percent of the differences, because the differences are not distributed normally. The percent of values included in the ± σ are shown on each histogram.

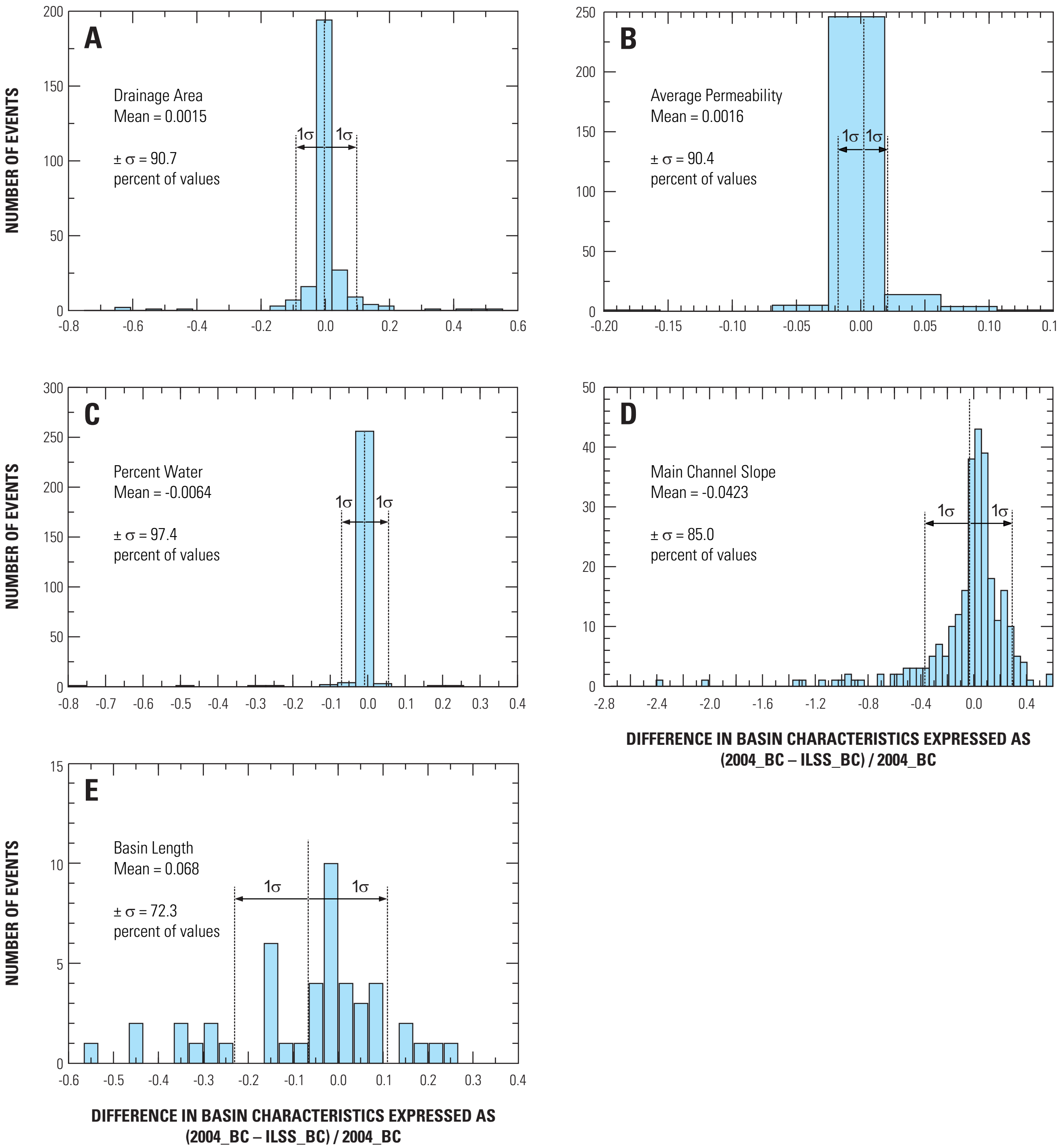

Figure 13. Distribution of differences in basin characteristics between the published (Soong et al., 2004) basin characteristics (2004_BC) and the Illinois StreamStats basin characteristics (ILSS_BC) for (a) drainage area, (b) average permeability, (c) percentage of open water and herbaceous wetland, (d) slope, and (e) basin length.

The sensitivity of the estimated flood quantiles, Q_T, to the total drainage area is shown in table 10. The range of drainage areas tested was from 40 to 160 percent of the published (*BC_{2004}*) values, with a corresponding range in the flood quantiles change, expressed as the ratio of the tested Q_T to the published Q_T (Q_T^{TEST}/Q_T^{2004}) from 0.46 to 1.49 for Q_{100} and Q_{500} in region 4 to as little as 0.52 to 1.40 for Q_5 through Q_{500} in regions 2, 6, and 7. Drainage area is used in all regional regression equations.

Table 10. Sensitivity of flood quantiles based on the published (Soong et al., 2004) regression equations for specified return-intervals, Q_T, to differences in drainage area for (a) regions 1, 3, and 5; (b) regions 2, 6, and 7; and (c) region 4, expressed as the ratio of the tested Q_T to the published Q_T, corresponding to percent of published drainage area.

	Ratio of tested Q_T to published Q_T									
Q_T	40%	60%	80%	90%	95%	105%	110%	120%	140%	160%
(a) Regions 1, 3, and 5										
Q_2	0.50	0.68	0.85	0.92	0.96	1.04	1.07	1.15	1.29	1.42
Q_5	0.51	0.68	0.85	0.92	0.96	1.04	1.07	1.15	1.28	1.42
Q_{10}	0.51	0.69	0.85	0.92	0.96	1.04	1.07	1.14	1.28	1.42
Q_{25}	0.51	0.69	0.85	0.93	0.96	1.04	1.07	1.14	1.28	1.41
Q_{50}	0.51	0.69	0.85	0.93	0.96	1.04	1.07	1.14	1.28	1.41
Q_{100}	0.51	0.69	0.85	0.93	0.96	1.04	1.07	1.14	1.28	1.41
Q_{500}	0.51	0.69	0.85	0.93	0.96	1.04	1.07	1.14	1.28	1.41
(b) Regions 2, 6, and 7										
Q_2	0.51	0.69	0.85	0.93	0.96	1.04	1.07	1.14	1.28	1.41
Q_5	0.52	0.69	0.85	0.93	0.96	1.04	1.07	1.14	1.27	1.40
Q_{10}	0.52	0.69	0.85	0.93	0.96	1.04	1.07	1.14	1.27	1.40
Q_{25}	0.52	0.69	0.85	0.93	0.96	1.04	1.07	1.14	1.27	1.40
Q_{50}	0.52	0.69	0.85	0.93	0.96	1.04	1.07	1.14	1.27	1.40
Q_{100}	0.52	0.69	0.85	0.93	0.96	1.04	1.07	1.14	1.27	1.40
Q_{500}	0.52	0.69	0.85	0.93	0.96	1.04	1.07	1.14	1.27	1.40
(c) Region 4										
Q_2	0.51	0.69	0.85	0.93	0.96	1.04	1.07	1.14	1.28	1.41
Q_5	0.49	0.67	0.84	0.92	0.96	1.04	1.08	1.15	1.30	1.44
Q_{10}	0.48	0.67	0.84	0.92	0.96	1.04	1.08	1.16	1.31	1.45
Q_{25}	0.48	0.66	0.83	0.92	0.96	1.04	1.08	1.16	1.31	1.46
Q_{50}	0.47	0.66	0.83	0.92	0.96	1.04	1.08	1.16	1.32	1.47
Q_{100}	0.47	0.65	0.83	0.92	0.96	1.04	1.08	1.16	1.32	1.48
Q_{500}	0.46	0.65	0.83	0.91	0.96	1.04	1.08	1.17	1.33	1.49

[DA, drainage area; Q_T, flood quantile; Q_2, two-year flood quantile; Q_5, five-year flood quantile; Q_{10}, 10-year flood quantile; Q_{25}, 25-year flood quantile; Q_{50}, 50-year flood quantile; Q_{100}, 100-year flood quantile; Q_{500}, 500-year flood quantile; %, percent]

The sensitivity of the estimated flood quantiles, Q_T, to the value of stream or main-channel slope is shown in table 11. The range of slopes tested was from 60 to 140 percent of the published (*BC_{2004}*) values, with a corresponding range in the flood quantile changes, expressed as the ratio Q_T^{TEST}/Q_T^{2004} from 0.76 to 1.19 for Q_{500} in region 1 to as little as 0.84 to 1.12 for Q_2 in regions 2, 6, and 7. The stream slope characteristic used in all regional regression equations was the main-channel slope, determined by dividing the elevation difference, in feet, by the distance, in miles, at points 10 and 85 percent from the outlet to the intersection of the main channel and the basin divide. The main-channel slope was determined using BasinSoft, which is used as the published (Soong et al., 2004) slope value for the sensitivity analysis.

Table 11. Sensitivity of flood quantiles based on the published (Soong et al., 2004) regression equations for specified return-intervals, Q_T, to differences in stream slope for (a) regions 1, 3, and 5; (b) regions 2, 6, and 7; and (c) region 4, expressed as the ratio of the tested Q_T to the published Q_T, corresponding to percent of published stream slope.

Q_T	Ratio of tested Q_T to published Q_T							
	60%	**80%**	**90%**	**95%**	**105%**	**110%**	**120%**	**140%**
(a) Regions 1, 3, and 5								
Q_2	0.81	0.91	0.96	0.98	1.02	1.04	1.08	1.14
Q_5	0.80	0.91	0.96	0.98	1.02	1.04	1.08	1.16
Q_{10}	0.79	0.90	0.95	0.98	1.02	1.04	1.09	1.17
Q_{25}	0.78	0.90	0.95	0.98	1.02	1.05	1.09	1.17
Q_{50}	0.78	0.90	0.95	0.98	1.02	1.05	1.09	1.18
Q_{100}	0.77	0.89	0.95	0.97	1.02	1.05	1.10	1.18
Q_{500}	0.76	0.89	0.95	0.97	1.03	1.05	1.10	1.19
(b) Regions 2, 6, and 7								
Q_2	0.84	0.93	0.96	0.98	1.02	1.03	1.06	1.12
Q_5	0.83	0.92	0.96	0.98	1.02	1.04	1.07	1.13
Q_{10}	0.82	0.92	0.96	0.98	1.02	1.04	1.07	1.14
Q_{25}	0.81	0.91	0.96	0.98	1.02	1.04	1.08	1.15
Q_{50}	0.80	0.91	0.96	0.98	1.02	1.04	1.08	1.15
Q_{100}	0.80	0.91	0.96	0.98	1.02	1.04	1.08	1.16
Q_{500}	0.79	0.90	0.95	0.98	1.02	1.04	1.09	1.17
(c) Region 4								
Q_2	0.83	0.92	0.96	0.98	1.02	1.04	1.07	1.13
Q_5	0.81	0.91	0.96	0.98	1.02	1.04	1.08	1.15
Q_{10}	0.80	0.91	0.96	0.98	1.02	1.04	1.08	1.15
Q_{25}	0.80	0.91	0.95	0.98	1.02	1.04	1.08	1.16
Q_{50}	0.79	0.90	0.95	0.98	1.02	1.04	1.09	1.17
Q_{100}	0.79	0.90	0.95	0.98	1.02	1.05	1.09	1.17
Q_{500}	0.78	0.90	0.95	0.97	1.02	1.05	1.09	1.18

[Q_T, flood quantile; Q_2, two-year flood quantile; Q_5, five-year flood quantile; Q_{10}, 10-year flood quantile; Q_{25}, 25-year flood quantile; Q_{50}, 50-year flood quantile; Q_{100}, 100-year flood quantile; Q_{500}, 500-year flood quantile; %, percent]

The sensitivity of the estimated flood quantiles, Q_T, to the computation of average permeability is shown in table 12. The range of average permeability differences tested was from 60 to 140 percent of the published (BC_{2004}) values, with a corresponding range in the flood quantile changes, expressed as the ratio Q_T^{TEST}/Q_T^{2004}, of 1.12 to 0.93 for Q_2 through Q_{500}. The average permeability is used in the regional regression equations for only regions 1, 3, and 5. The sensitivity of the flood quantiles to average permeability is relatively low, with very large percent changes in the basin characteristic resulting in only small changes in the computed flood quantile. Differences in average permeability are expected to be the effect of differences in the watershed delineation only, as the permeability layer that was implemented in ILSS is identical to the one used in Soong et al. (2004).

Table 12. Sensitivity of flood quantiles based on the published (Soong et al., 2004) regression equations for specified return-intervals, Q_T, to differences in average permeability for regions 1, 3, and 5, expressed as the ratio of the tested Q_T to the published Q_T, corresponding to percent of published average permeability.

Q_T	Ratio of tested Q_T to published Q_T							
	60%	**80%**	**90%**	**95%**	**105%**	**110%**	**120%**	**140%**
	Regions 1, 3, and 5							
Q_2	1.12	1.05	1.02	1.01	0.99	0.98	0.96	0.93
Q_5	1.12	1.05	1.02	1.01	0.99	0.98	0.96	0.93
Q_{10}	1.12	1.05	1.02	1.01	0.99	0.98	0.96	0.93
Q_{25}	1.12	1.05	1.02	1.01	0.99	0.98	0.96	0.93
Q_{50}	1.12	1.05	1.02	1.01	0.99	0.98	0.96	0.93
Q_{100}	1.12	1.05	1.02	1.01	0.99	0.98	0.96	0.93
Q_{500}	1.12	1.05	1.02	1.01	0.99	0.98	0.96	0.93

[Q_T, flood quantile; Q_2, two-year flood quantile; Q_5, five-year flood quantile; Q_{10}, 10-year flood quantile; Q_{25}, 25-year flood quantile; Q_{50}, 50-year flood quantile; Q_{100}, 100-year flood quantile; Q_{500}, 500-year flood quantile; %, percent]

The sensitivity of the estimated flood quantiles, Q_T, to the computation of %Water area is shown in table 13. The range of %Water differences tested was from 60 to 140 percent of the average base values for all 100 stations, including individual stations that may have a value of zero percent, making a base-value increase or decrease impossible. The corresponding range in the flood quantile changes, expressed as the ratio Q_T^{TEST}/Q_T^{2004}, ranged from 1.37 to 0.75 to as little as 1.27 to 0.80 for Q_2 through Q_{500}. The %Water basin characteristic is used in the regional regression equations for only regions 2, 6, and 7. The sensitivity of the flood quantiles to %Water area is relatively low, with very large percent change in the basin characteristic, resulting in only small changes in the computed flood quantile. Differences in %Water are expected to be the effect of differences in the watershed delineation only, as the water bodies and herbaceous wetland layer that was implemented in ILSS is identical to the one used in Soong et al. (2004).

Table 13. Sensitivity of flood quantiles based on the published (Soong et al., 2004) regression equations for specified return-intervals, Q_T, to differences in selected percentage water bodies and herbaceous wetland area (%Water) for regions 2, 6, and 7, expressed as the ratio of the tested Q_T to the published Q_T, corresponding to percent of published %Water.

Q_T	Ratio of tested Q_T to published Q_T								
	60%	**80%**	**90%**	**95%**	**105%**	**110%**	**120%**	**140%**	**160%**
	Regions 2, 6, and 7								
Q_2	1.27	1.11	1.05	1.02	0.98	0.96	0.92	0.85	0.80
Q_5	1.31	1.12	1.06	1.03	0.97	0.95	0.91	0.84	0.78
Q_{10}	1.32	1.13	1.06	1.03	0.97	0.95	0.90	0.83	0.77
Q_{25}	1.34	1.14	1.06	1.03	0.97	0.95	0.90	0.82	0.76
Q_{50}	1.35	1.14	1.06	1.03	0.97	0.95	0.90	0.82	0.76
Q_{100}	1.36	1.14	1.07	1.03	0.97	0.94	0.90	0.82	0.75
Q_{500}	1.37	1.15	1.07	1.03	0.97	0.94	0.89	0.81	0.75

[Q_T, flood quantile; Q_2, two-year flood quantile; Q_5, five-year flood quantile; Q_{10}, 10-year flood quantile; Q_{25}, 25-year flood quantile; Q_{50}, 50-year flood quantile; Q_{100}, 100-year flood quantile; Q_{500}, 500-year flood quantile; %, percent]

The sensitivity of the estimated flood quantiles, Q_T, to the basin length is shown in table 14. The range of basin length differences tested was from 40 to 130 percent of the published (BC_{2004}) values, with a corresponding range in the flood quantile changes, expressed as the ratio Q_T^{TEST}/Q_T^{2004}, from 1.28 to 0.93 for Q_{500} to as little as 1.01 to 1.00 for Q_2. Basin length is used in the regional regression equation only for region 4.

Table 14. Sensitivity of flood quantiles based on the published (Soong et al., 2004) regression equations for specified return-intervals, Q_T, to differences in basin length for region 4, expressed as the ratio of the tested Q_T to the published Q_T, corresponding to percent of published basin length.

Q_T	Ratio of tested Q_T to published Q_T								
	40%	**60%**	**80%**	**90%**	**95%**	**105%**	**110%**	**120%**	**130%**
	Region 4								
Q_2	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Q_5	1.09	1.05	1.02	1.01	1.00	1.00	0.99	0.98	0.98
Q_{10}	1.14	1.07	1.03	1.01	1.01	0.99	0.99	0.97	0.96
Q_{25}	1.18	1.10	1.04	1.02	1.01	0.99	0.98	0.97	0.95
Q_{50}	1.21	1.11	1.05	1.02	1.01	0.99	0.98	0.96	0.95
Q_{100}	1.23	1.12	1.05	1.02	1.01	0.99	0.98	0.96	0.94
Q_{500}	1.28	1.15	1.06	1.03	1.01	0.99	0.97	0.95	0.93

[Q_T, flood quantile; Q_2, two-year flood quantile; Q_5, five-year flood quantile; Q_{10}, 10-year flood quantile; Q_{25}, 25-year flood quantile; Q_{50}, 50-year flood quantile; Q_{100}, 100-year flood quantile; Q_{500}, 500-year flood quantile; %, percent]

The sensitivity analysis indicates that for the common range of 60 to 120 percent of the published basin characteristics that was tested, the estimated flood quantiles were most sensitive to drainage-area differences, with the range in quantile changes, expressed as the ratios Q_T^{TEST}/Q_T^{2004}, varying from 0.45 (1.14-0.69) to 0.52 (1.17-0.65). The flood quantiles were less sensitive to %Water, with the range of quantile changes expressed as the ratios Q_T^{TEST}/Q_T^{2004}, varying from 0.35 (1.27-0.92) to 0.48 (1.37-0.89). The range of quantile changes, expressed as the ratios Q_T^{TEST}/Q_T^{2004}, for stream slope was 0.22 (1.06-0.84) to 0.34 (1.10-0.76), and for basin length the range of quantile changes expressed as the ratios Q_T^{TEST}/Q_T^{2004}, was from 0 (1.0-1.0) to 0.20 (1.15-0.95). For average permeability the minimum and maximum range of quantile changes expressed as the ratios Q_T^{TEST}/Q_T^{2004}, was 0.16 (1.12-0.96). The relative sensitivity does not indicate the likelihood of computing any particular basin characteristic difference, but rather the influence of the basin characteristics in the equation.

CONCLUSIONS AND LIMITATIONS

The ILSS implementation of the regional regression equations for estimated flood quantiles at ungaged, unregulated rural sites for Illinois was found to be an adequate method for applying the most current (2010) published equations (Soong et al., 2004). The basin characteristics computed by ILSS were compared to the basin characteristics published in Soong et al. (2004) and used in the rural flood-frequency equations at the applicable regional subsets of 283 rural streamflow-gaging station locations. There were no significant differences in drainage area and percentage of open water and herbaceous wetland, although relative differences were larger for smaller drainage areas. StreamStats enables the user to manually edit the drainage basin if errors in the drainage-area delineation are found. Average permeability had a small significant difference (less than 0.25 percent). Significant differences were found in BL and slope; BL was adjusted using a linear best-fit regression line. The adjusted BL did not differ significantly from the published values at the 95-percent confidence level. The slope was adjusted by a linear best-fit regression line on log-transformed slope values. This removed the statistical significance of the differences determined by the t-test, but the adjusted values were significantly different from the published values under the Wilcoxon signed-rank test, with a mean difference of -4.76 percent. The adjusted distribution was selected as preferable.

A sensitivity analysis was done to determine the sensitivity of the estimated flood-peak quantiles to the basin-characteristic differences. For the common range of 60 to 120 percent of published (Soong et al., 2004) basin characteristics that were tested, the greatest average range of sensitivity of the resulting flood-peak quantiles was (in order from greatest to least) drainage area, %Water, slope, average permeability, and basin length. The relative sensitivity does not indicate the likelihood of computing any particular basin characteristic difference, but rather the influence of the basin characteristics in the equation.

The flood-peak quantiles produced by ILSS were compared to the published values at an approximately random sample of 170 streamflow-gaging stations. There were no significant difference at the 95-percent confidence level between the log-transformed flood-peak quantile estimates published in Soong et al. (2004) and those computed by ILSS, either taken as a whole or sorted by the hydrographic region identified in Soong et al. (2004), except for region 1. Region 1 had a small statistically significant difference ranging from 3.8 percent for the 2-year flood-quantile estimate to 4.3 percent for the 500-year flood-quantile estimate at the 95-percent confidence level. All 21 stations were considered in the analysis, because of the few stations available in region 1. The total number of stations in region 1 was small (21) and the mean difference is less than one-tenth of the average prediction errors for the 2- to 500-year regression-equation estimates, which range from 39.5 to 54.9 percent, respectively.

A test of usage reliability was conducted by having at least 7 new users compute ILSS estimates at 27 locations. The average maximum deviation from the mode value of the 100-year flood quantile estimate at each site was 1.31 percent after four mislocated sites were removed. A comparison of manual 100-year flood-quantile computations with ILSS estimates at 34 sites indicated no statistically significant difference. The estimates of flood quantiles computed by ILSS are based on the assumption that streamflow at the site is not appreciably regulated. ILSS does not return a warning of the presence of regulation or urbanization in a delineated drainage basin; consequently, the user should consider this possibility when using the tool. All other limitations described in Soong et al. (2004) apply to ILSS.

The basin characteristics computed by ILSS should be compared to the range of basin characteristics used in developing the flood-frequency regional regression equations.

This comparison is facilitated by the information provided in the ILSS output, showing the range. Extrapolations outside the range of values should be avoided. Although, in general, the user must determine whether a desired site is outside the range of applicability of the regional regression equations (for reasons such as regulation or urbanization), the application is not implemented for the Illinois, Mississippi, Ohio, and Wabash Rivers. The basin characteristics are based on the geospatial data sets and the computer algorithms as described in this report and are subject to the differences that are described in the sections on the evaluation and adjustment of basin characteristics. ILSS appears to be an accurate, reliable, and effective tool for flood-quantile estimates and the determination of a consistent set of basin characteristics.

REFERENCES CITED

Berk, K.N., and Carey, P., 2004, Data analysis with Microsoft Excel: Brooks/Cole—Thomson Learning, 579 p.

ESRI, Inc., 2005, Arc Hydro tools overview—Version 1.1 final, July 2005, accessed April 8, 2009, at *http://www.crwr.utexas.edu/gis/gishydro06/ArcHydro/ArcHydroTools/Doc/Arc%20Hydro%20Tools%20-%20Overview.pdf*

Harvey, C.A., and Eash, D.A., 1996, Description, instructions, and verification for BasinSoft, a computer program to quantify drainage-basin characteristics: U.S. Geological Survey Water-Resources Investigations Report 95–4287, 25 p.

Helsel, D.R., and Hirsch, R.M., 2002, Statistical Methods in Water Resources: U.S. Geological Survey Techniques of Water-Resources Investigations, book 4, (Hydrologic Analysis and Interpretation), 510 p.

Jennings, M.E., Thomas, W.O., Jr., and Riggs, H.C., 1994, Nationwide summary of U.S. Geological Survey regional regression equations for estimating magnitude and frequency of floods for ungaged sites, 1993, U.S. Geological Survey Water-Resources Investigations Report 94–4002, 194 p.

Natural Resources Conservation Service, 1993, State soil geographic base (STATSGO): U.S. Department of Agriculture, Miscellaneous Publication No. 1492, 110 p., and computer data.

Ries III, K.G., 2007, The national streamflow statistics program: A computer program for estimating streamflow statistics for ungaged sites: U.S. Geological Survey Techniques and Methods 4-A6, 37 p.

Ries, K.G., III, Guthrie, J.G., Rea, A.H., Steeves, P.A., Coles, J.D., and Stewart, D.W., 2008, StreamStats—A water resources web application: U.S. Geological Survey Fact Sheet FS 2008–3067, 6 p.

Schlotzhauer, S.D., and Littell, R.C., 1987, SAS system for elementary statistical analysis: Cary, N.C., SAS Institute, 410 p.

Soong, D.T., Ishii, A.L., Sharpe, J.B., and Avery, C.F., 2004, Estimating flood-peak discharge magnitudes and frequencies for rural streams in Illinois: U.S. Geological Survey Scientific Investigations Report 2004–5103, 147 p.

Wolock, D.M., 2003a, Flow characteristics at U.S. Geological Survey streamgages in the conterminous United States: U.S. Geological Survey Open-File Report 03–146, digital data set, accessed May 11, 2009, at *http://water.usgs.gov/lookup/getspatial?qsitesdd*

Wolock, D.M., 2003b, Base-flow index grid for the conterminous United States: U.S. Geological Survey Open-File Report 03–263, digital data set, accessed May 11, 2009, at *http://water.usgs.gov/lookup/getspatial?bfi48grd*

Illinois Department of Transportation

ILLINOIS

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN