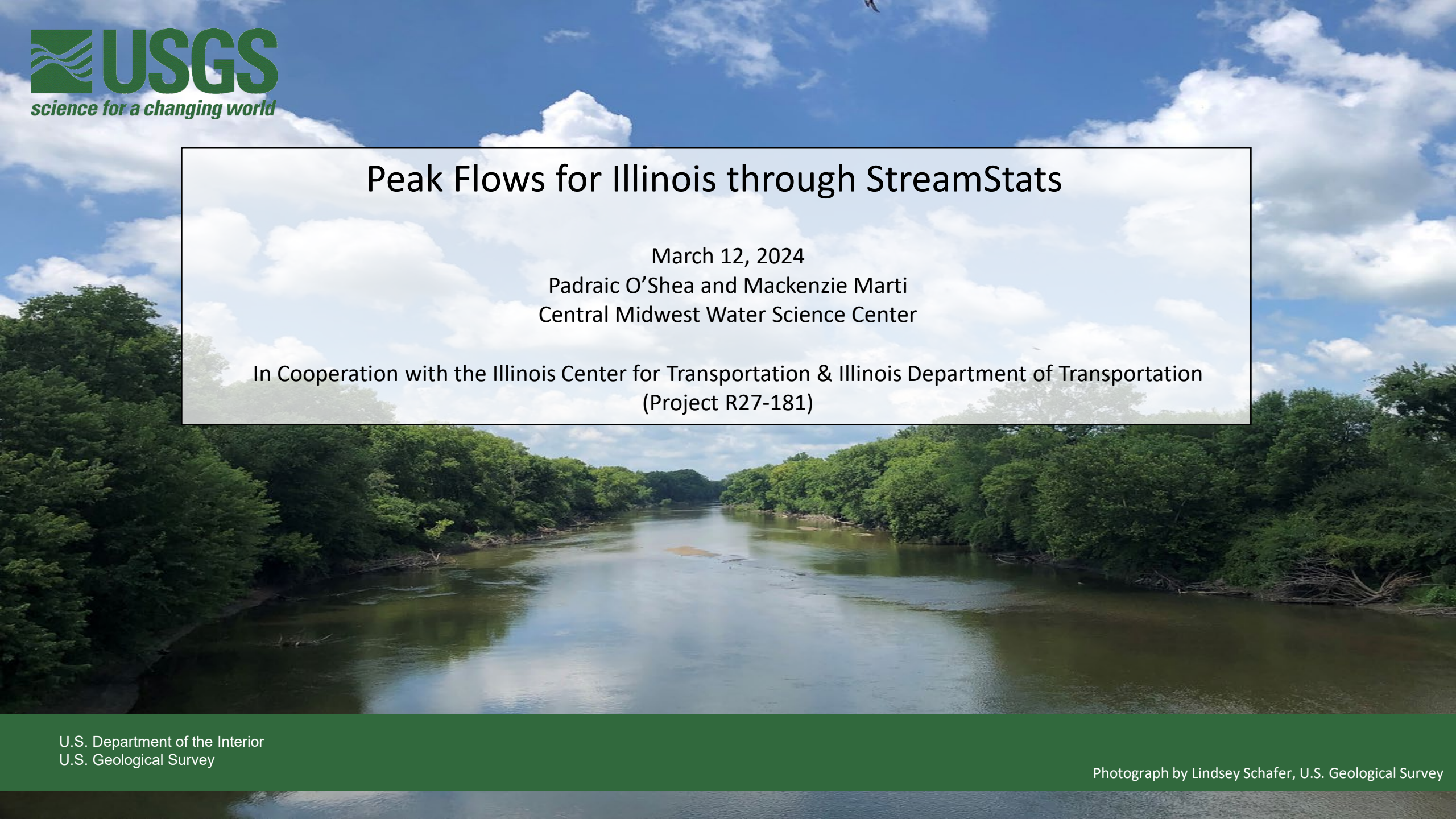


Peak Flows for Illinois through StreamStats

March 12, 2024

Padraic O'Shea and Mackenzie Marti
Central Midwest Water Science Center

In Cooperation with the Illinois Center for Transportation & Illinois Department of Transportation
(Project R27-181)

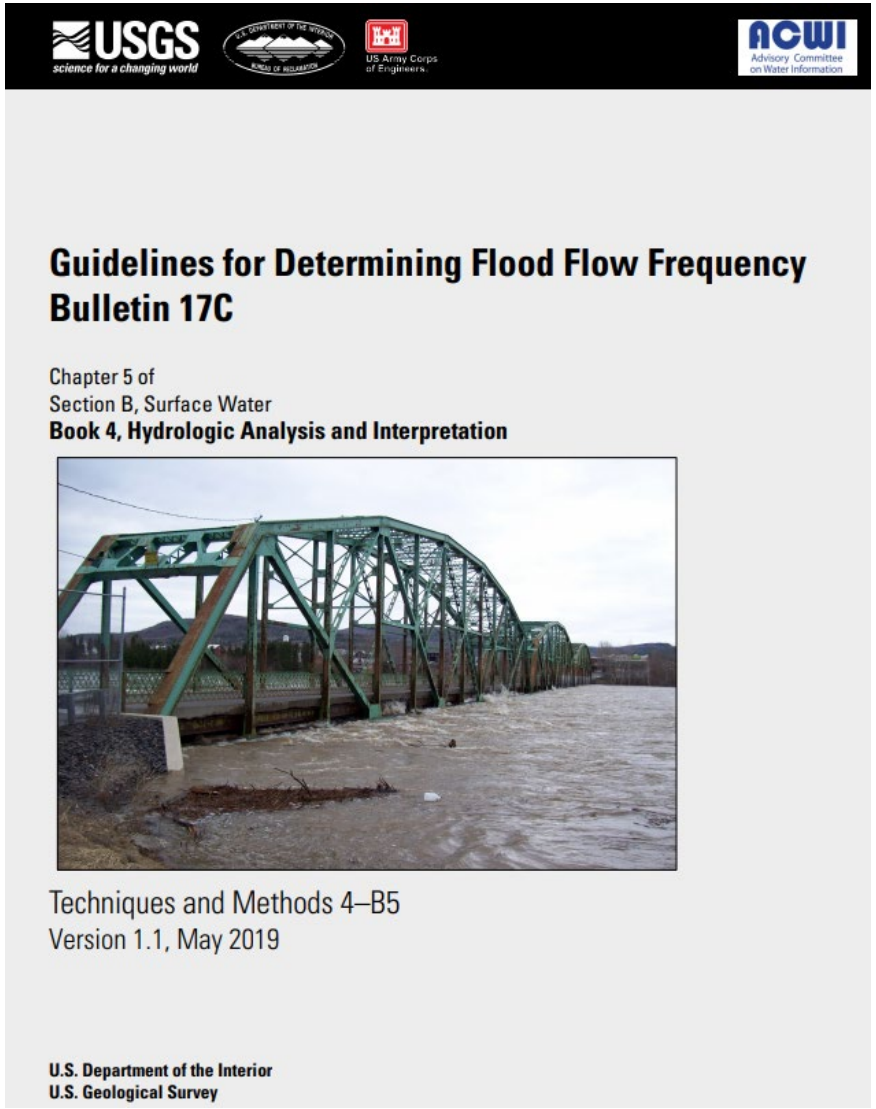
U.S. Department of the Interior
U.S. Geological Survey

Photograph by Lindsey Schafer, U.S. Geological Survey

Step 1: Updating peak flow quantile estimates at streamgages in Illinois

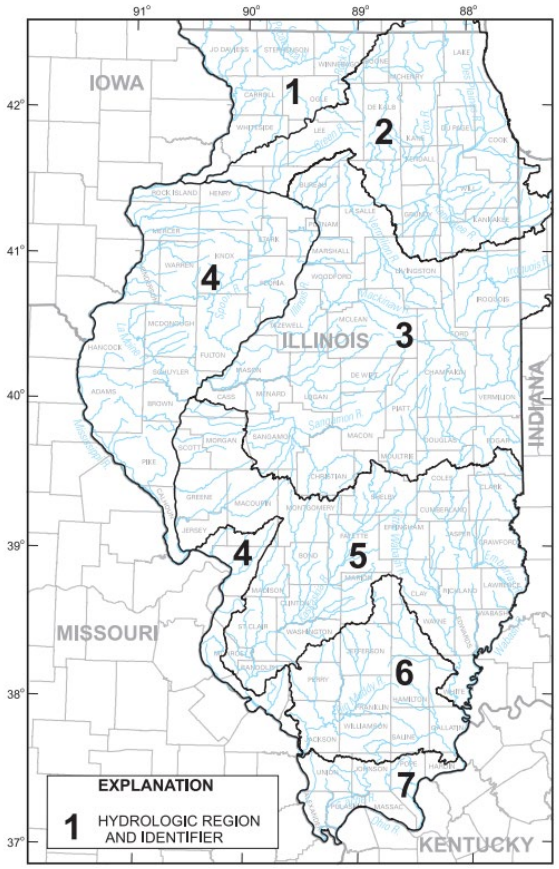
- Peak-flow frequency analysis is a statistical technique used to estimate annual exceedance probabilities associated with peak flows

- The federal guidelines for peak-flow frequency analysis are defined in Bulletin 17C



https://doi.org/10.3133/tm4B5

Step 2: Regional regression equations for estimating peak flow quantiles in ungaged basins



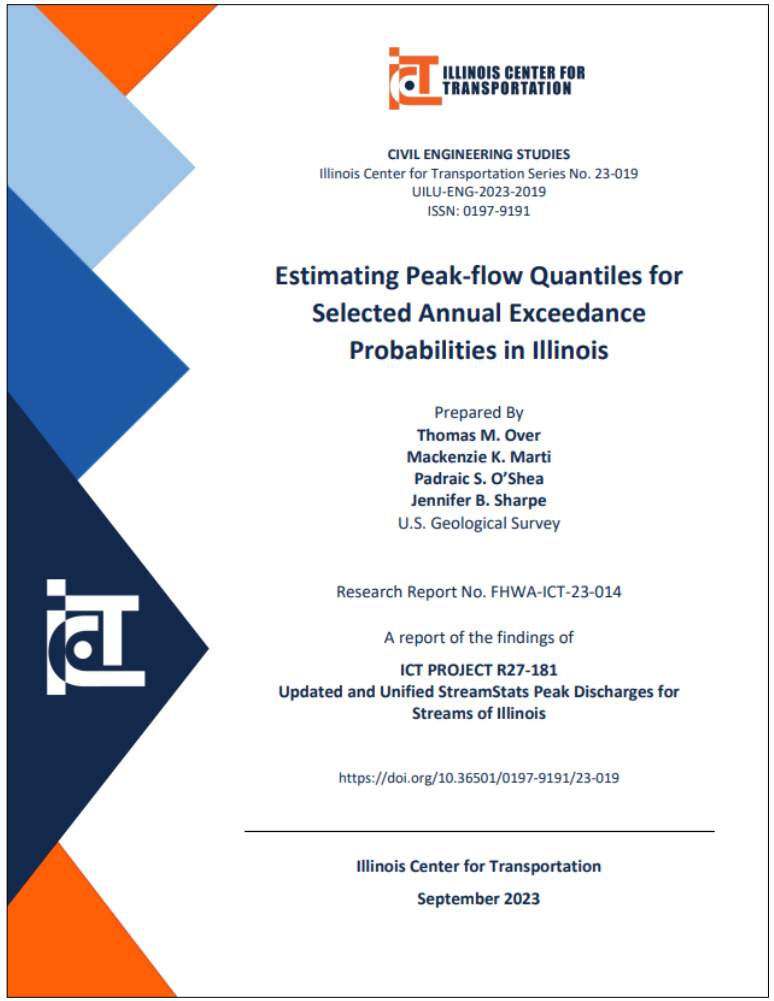
Regression equations are developed using observed peak flows from USGS streamgages as the dependent variable and basin characteristics (BCs) as the independent variable

$$Q_p = 10^{a_{0,p}} (drainage\ area)^{a_{1,p}} (slope)^{a_{2,p}}$$

USGS

New 2023 report
Data through water year 2017

https://doi.org/10.36501/0197-9191/23-019



ILLINOIS CENTER FOR TRANSPORTATION

CIVIL ENGINEERING STUDIES
Illinois Center for Transportation Series No. 23-019
UILU-ENG-2023-2019
ISSN: 0197-9191

Estimating Peak-flow Quantiles for Selected Annual Exceedance Probabilities in Illinois

Prepared By
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Mackenzie K. Marti
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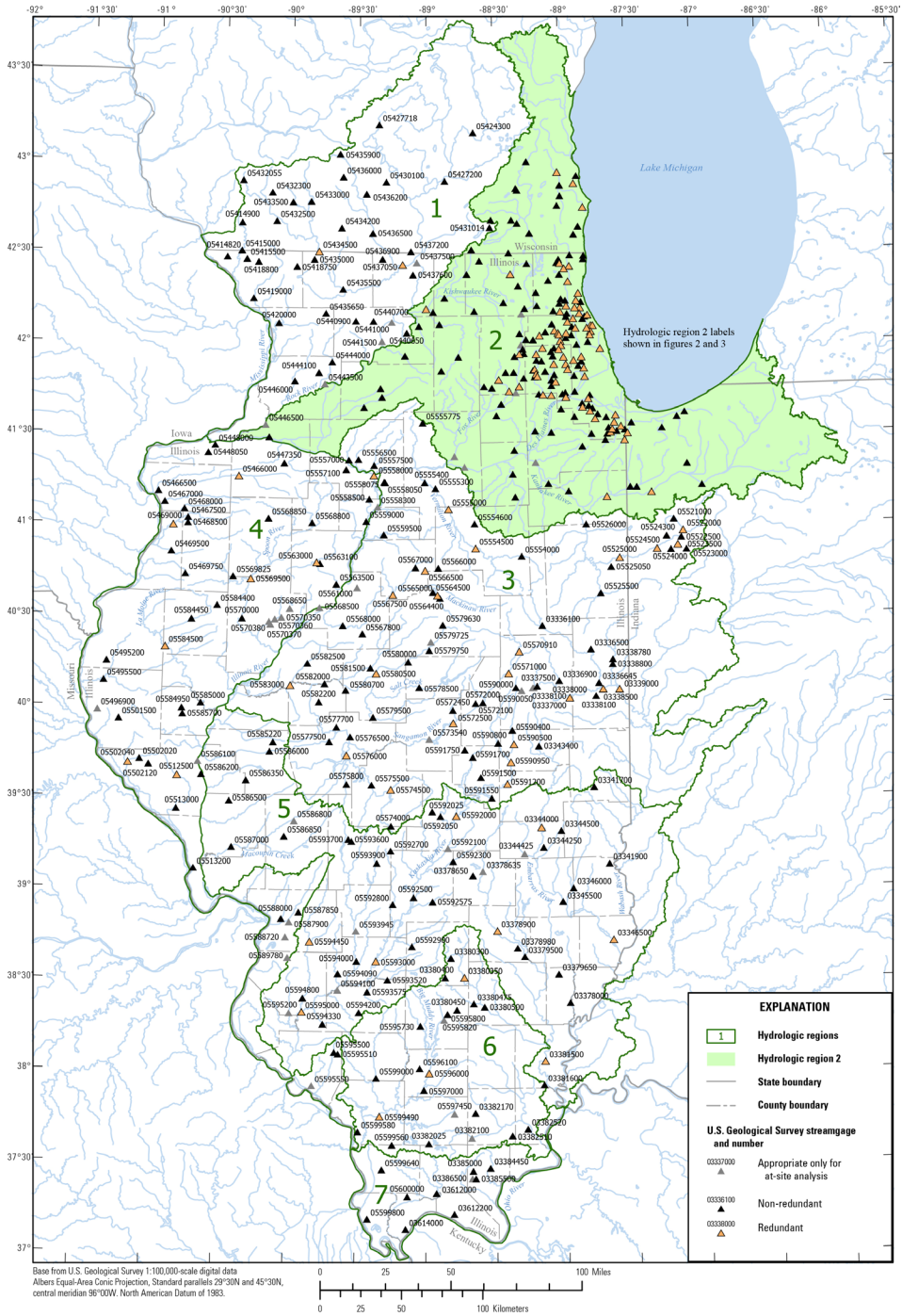
Jennifer B. Sharpe
U.S. Geological Survey

Research Report No. FHWA-ICT-23-014

A report of the findings of
ICT PROJECT R27-181
Updated and Unified StreamStats Peak Discharges for Streams of Illinois

https://doi.org/10.36501/0197-9191/23-019

Illinois Center for Transportation
September 2023



USGS

Final regression equations

Annual exceedance probability (AEP), in percent
50
20
10
4
2
1
0.5
0.2

Region	Equation
1	$Q_p = 10^{(a_{0,p} - 3.2259 a_{2,p})} (DA)^{a_{1,p}} (TPI)^{a_{2,p}}$
2	$Q_p = 10^{a_{0,p}} (DA)^{a_{1,p}} 10^{a_{2,p}\sqrt{NLCD\_22\_23\_24}} 10^{a_{3,p}\sqrt{DrainageClass1a}} (DEM\_1\_0\_P)^{a_{4,p}}$
3	$Q_p = 10^{a_{0,p}} (DA)^{a_{1,p}} 10^{a_{2,p}(DEM\_Slope - 55.329)} 10^{a_{3,p}((TPI - 1823.4)/4758.3)}$
4	$Q_p = 10^{a_{0,p}} (DA)^{a_{1,p}} (Soil\_Slope)^{a_{2,p}}$
5	$Q_p = 10^{a_{0,p}} (DA)^{a_{1,p}} 10^{a_{2,p}(DEM\_Slope - 55.329)}$
6	$Q_p = 10^{a_{0,p}} (DA)^{a_{1,p}}$
7	$Q_p = 10^{a_{0,p}} (DA)^{a_{1,p}}$

Regression equation coefficient values in Table DR-7

Q = discharge, *p* = annual exceedance probability, *a* = regression intercept or coefficient

USGS

https://doi.org/10.36501/0197-9191/23-019

Publications

- Report
  - Over, T.M., Marti, M.K., O'Shea, P.S., Sharpe, J.B., 2023, **Estimating peak-flow quantiles for selected annual exceedance probabilities in Illinois** (Report No. FHWA-ICT-23-014). Illinois Center for Transportation, https://doi.org/10.36501/0197-9191/23-019

- USGS data releases
  1. Marti, M.K., Over, T.M., and O'Shea, P.S., 2023, **Data for estimating peak-flow quantiles for selected annual exceedance probabilities in Illinois**: U.S. Geological Survey data release, https://doi.org/10.5066/P9XPWUMI
  2. O'Shea, P.S., 2023, **Peak-flow frequency analysis for 464 U.S. Geological Survey streamgages in Illinois, Indiana, and Wisconsin, based on data through water year 2017**: U.S. Geological Survey data release, https://doi.org/10.5066/P9XUH9SR
  3. Schafer, L.A., Sharpe, J.B., Marti, M.K., 2023, **Geographic Data for the Estimation of Peak Flow Statistics for Illinois**: U.S. Geological Survey data release, https://doi.org/10.5066/P9ZAMASB
  4. Schafer, L.A., and Sharpe, J.B., 2023, **Elevation, Flow Accumulation, Flow Direction, and Stream Definition Data in Support of the Illinois StreamStats Upgrade to the Basin Delineation Database**: U.S. Geological Survey data release, https://doi.org/10.5066/P9YIAUZQ

USGS

USGS data releases

1. **Marti, M.K., Over, T.M., and O'Shea, P.S., 2023**
   - “Report data release”
   - Streamgage information and basin characteristic values
   - Regression equation coefficients and goodness-of-fit statistics
   - At-site, regional regression, and weighted peak-flow estimates
2. **O'Shea, P.S., 2023,**
   - “PeakFQ data release”
   - Input and output data for the USGS PeakFQ software
3. **Schafer, L.A., Sharpe, J.B., Marti, M.K., 2023**
   - Basin characteristics GIS grids used in StreamStats for running regression equations
4. **Schafer, L.A., and Sharpe, J.B., 2023**
   - StreamStats GIS high-resolution base layers

USGS

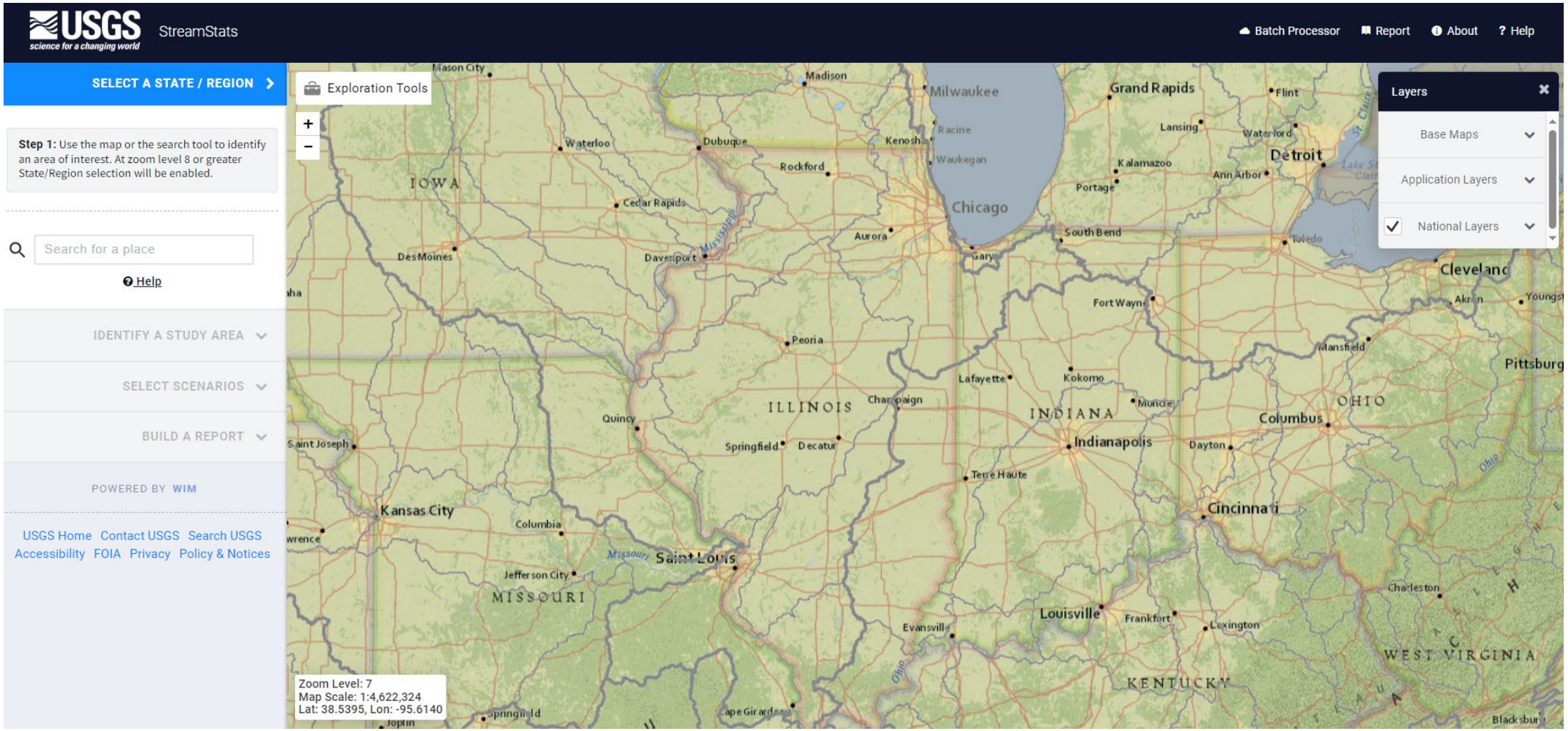
Attached Files

Click on title to download individual files attached to this item or download all files listed below as a compressed file.

FFA_LandingPage.xml *Original FGDC Metadata*	View	79.22 KB	application/fgdc+xml
Figure1.jpg		5.26 MB	image/jpeg
Table_DR-5_streamgageInfo_used.csv		95.89 KB	text/csv
Table_DR-6_streamgageInfo_notUsed.csv		5.26 KB	text/csv
Table_DR-7_WREG_coefs.csv		8.23 KB	text/csv
Table_DR-8_WREG_GOF.csv		4.14 KB	text/csv
Table_DR-9_WREG_CovMatrix.csv		13.39 KB	text/csv
Table_DR-10_AEP_Qestimates_byStreamgage.csv		116.73 KB	text/csv
Table_DR-11_Q_VoP_byStreamgage.csv		130.73 KB	text/csv

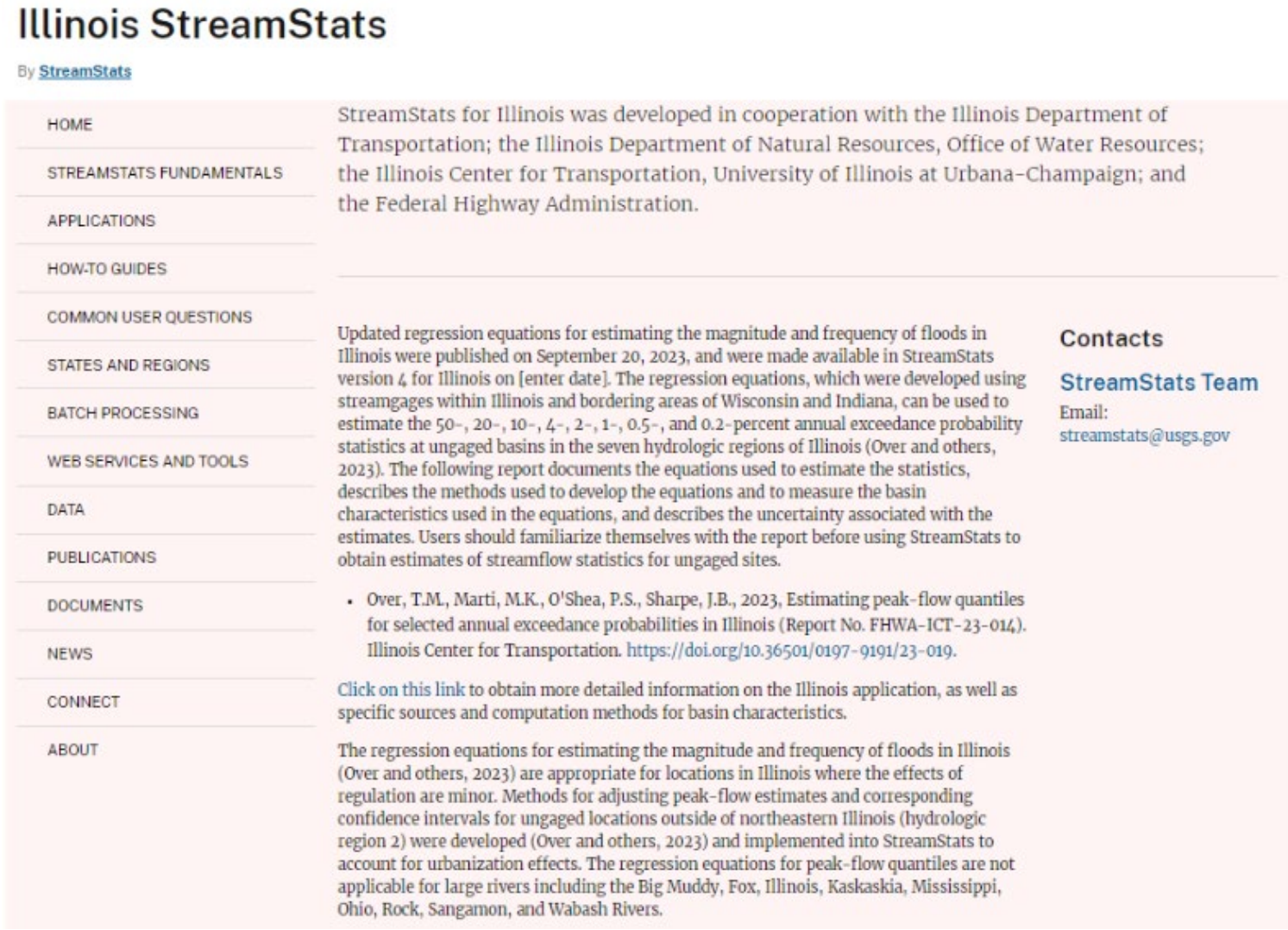
USGS

USGS StreamStats https://streamstats.usgs.gov/ss/



USGS

Illinois StreamStats (https://www.usgs.gov/streamstats/illinois-streamstats)



Illinois StreamStats

By StreamStats

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StreamStats for Illinois was developed in cooperation with the Illinois Department of Transportation; the Illinois Department of Natural Resources, Office of Water Resources; the Illinois Center for Transportation, University of Illinois at Urbana-Champaign; and the Federal Highway Administration.

Updated regression equations for estimating the magnitude and frequency of floods in Illinois were published on September 20, 2023, and were made available in StreamStats version 4 for Illinois on [enter date]. The regression equations, which were developed using streamgages within Illinois and bordering areas of Wisconsin and Indiana, can be used to estimate the 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent annual exceedance probability statistics at ungaged basins in the seven hydrologic regions of Illinois (Over and others, 2023). The following report documents the equations used to estimate the statistics, describes the methods used to develop the equations and to measure the basin characteristics used in the equations, and describes the uncertainty associated with the estimates. Users should familiarize themselves with the report before using StreamStats to obtain estimates of streamflow statistics for ungaged sites.

- Over, T.M., Marti, M.K., O'Shea, P.S., Sharpe, J.B., 2023, Estimating peak-flow quantiles for selected annual exceedance probabilities in Illinois (Report No. FHWA-ICT-23-014). Illinois Center for Transportation. https://doi.org/10.36501/0197-9191/23-019.

Click on this link to obtain more detailed information on the Illinois application, as well as specific sources and computation methods for basin characteristics.

The regression equations for estimating the magnitude and frequency of floods in Illinois (Over and others, 2023) are appropriate for locations in Illinois where the effects of regulation are minor. Methods for adjusting peak-flow estimates and corresponding confidence intervals for ungaged locations outside of northeastern Illinois (hydrologic region 2) were developed (Over and others, 2023) and implemented into StreamStats to account for urbanization effects. The regression equations for peak-flow quantiles are not applicable for large rivers including the Big Muddy, Fox, Illinois, Kaskaskia, Mississippi, Ohio, Rock, Sangamon, and Wabash Rivers.

Contacts

StreamStats Team

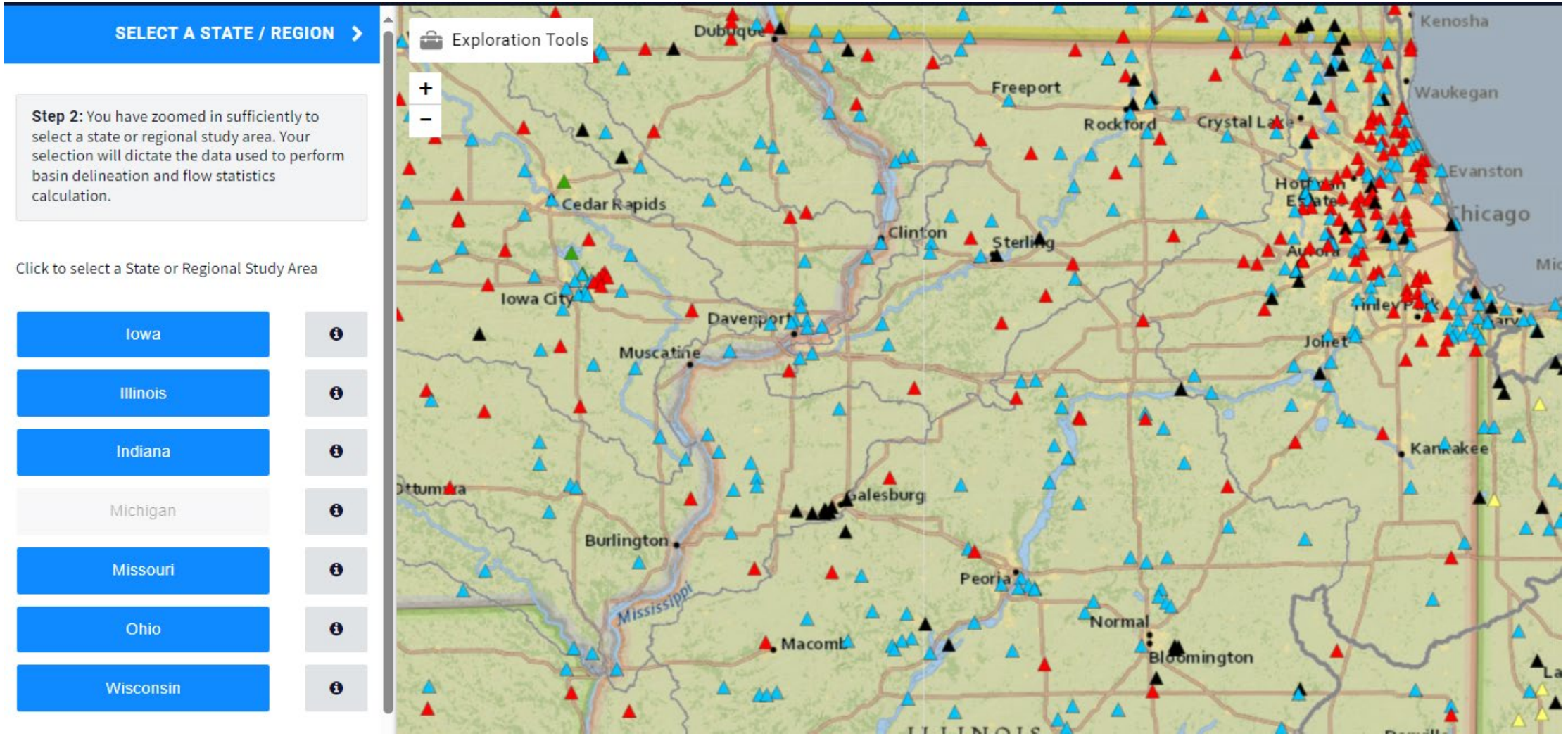
Email:
streamstats@usgs.gov

Illinois StreamStats Updates December 2023

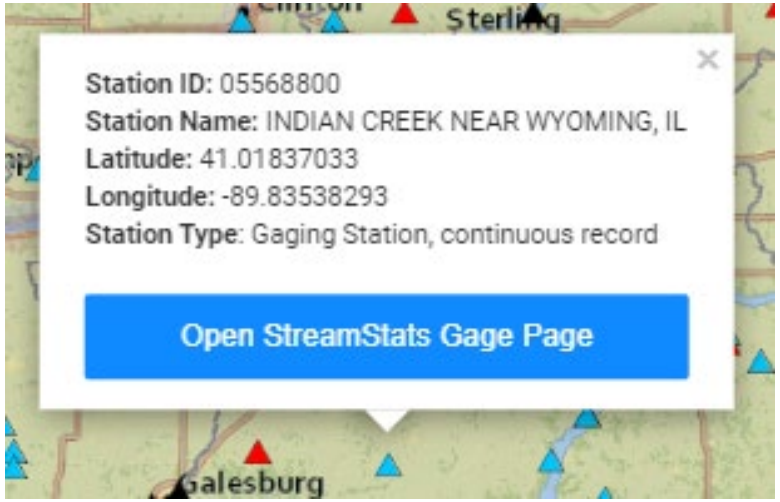
- Updated base digital elevation model (DEM) from 30-meter to 10-meter DEM
- Updated streamlines from medium-resolution National Hydrography Dataset (NHD) to high-resolution NHD
- Added updated at-streamgage peak flow quantiles
- Added new regression equations for estimation of peak flow quantiles in ungaged basins

USGS

StreamStats Navigation



At-streamgage information



StreamStats Data-Collection Station Report

Name	Value
USGS Station Number	05568800
Station Name	INDIAN CREEK NEAR WYOMING, IL
Station Type	Gaging Station, continuous record
Latitude	41.01837033
Longitude	-89.83538293
NWIS Latitude	41.01869444
NWIS Longitude	-89.8357222
Is regulated?	false
Agency	United States Geological Survey
NWIS Discharge Period of Record	09/30/1959 - 11/25/2023

Physical Characteristics

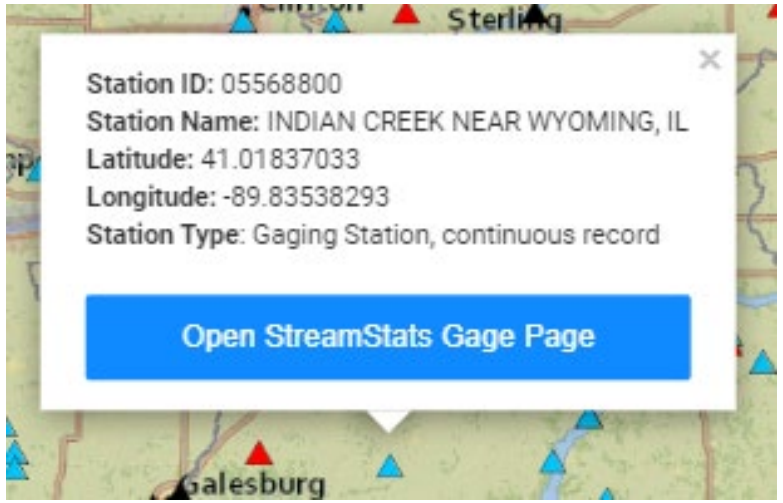
Filter By Statistic Group: Select Filter By Citation: Select

Streamflow Statistics

Filter By Statistic Group: Select Filter By Citation: Select Show Only Preferred

Peak-Flow Statistics

At-streamgage Peak-flow Statistics



Streamflow Statistics

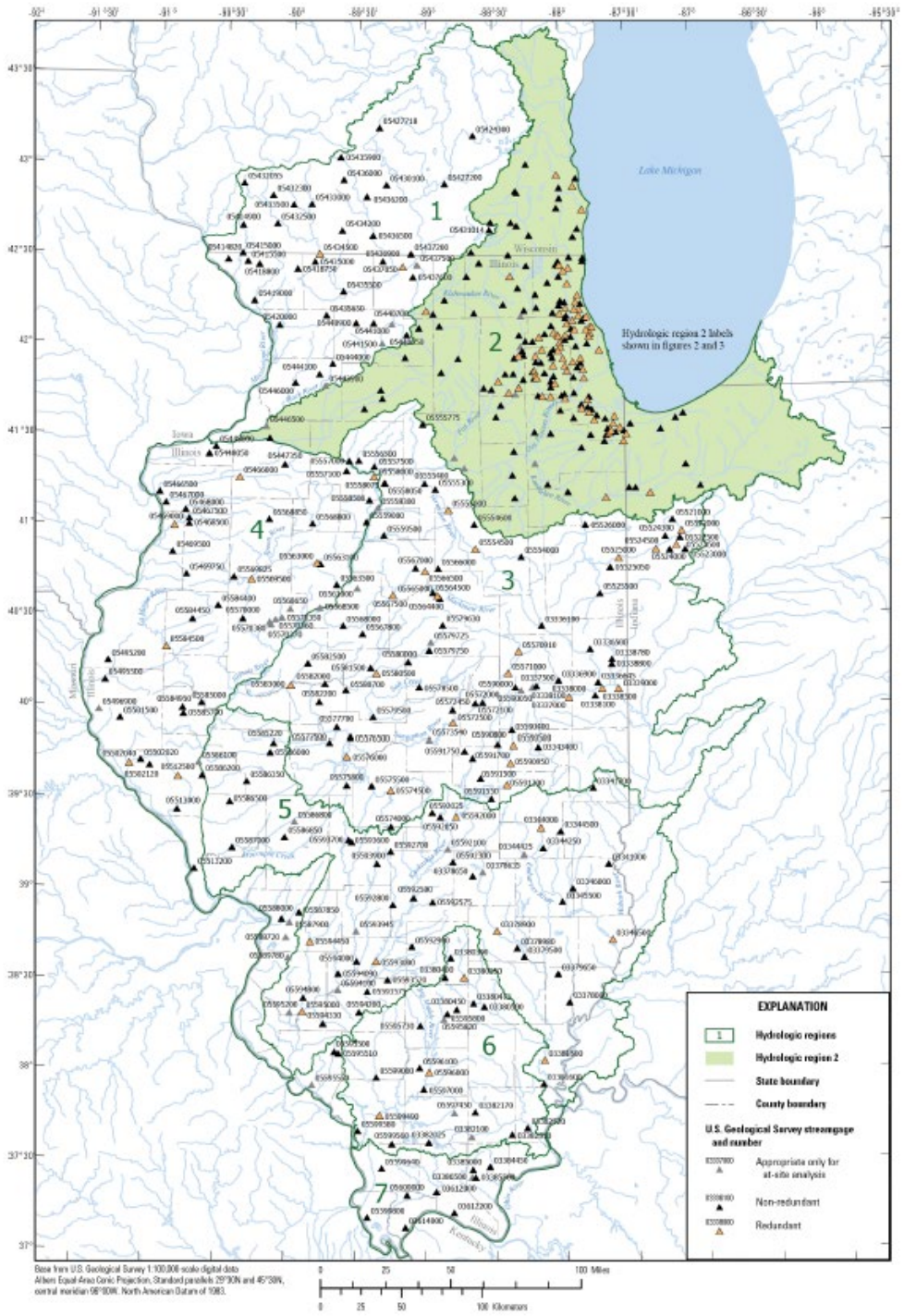
Filter By Statistic Group: Select | Filter By Citation: Select | Show Only Preferred

Peak-Flow Statistics

Statistic Name	Value	Units	Preferred?	Years of Record	Standard Error, percent	Variance	Lower 90% Prediction Interval	Upper 90% Prediction Interval	Citation	Comments
1-percent AEP flood	7520	cubic feet per second		58		0.0082			236	Statistic Date Range: 1960 - 2017. null
0.5-percent AEP flood	8980	cubic feet per second		58		0.0108			236	Statistic Date Range: 1960 - 2017. null
0.2-percent AEP flood	11200	cubic feet per second		58		0.0149			236	Statistic Date Range: 1960 - 2017. null
Regression est 1-percent AEP flood	9100	cubic feet per second				0.0162			236	
Regression est 0.5-percent AEP flood	10500	cubic feet per second				0.015			236	
Regression est 0.2-percent AEP flood	12300	cubic feet per second				0.0139			236	
Weighted 1-percent AEP flood	8020	cubic feet per second	✓			0.0054			236	
Weighted 0.5-percent AEP flood	9570	cubic feet per second	✓			0.0063			236	
Weighted 0.2-percent AEP flood	11700	cubic feet per second	✓			0.0072			236	

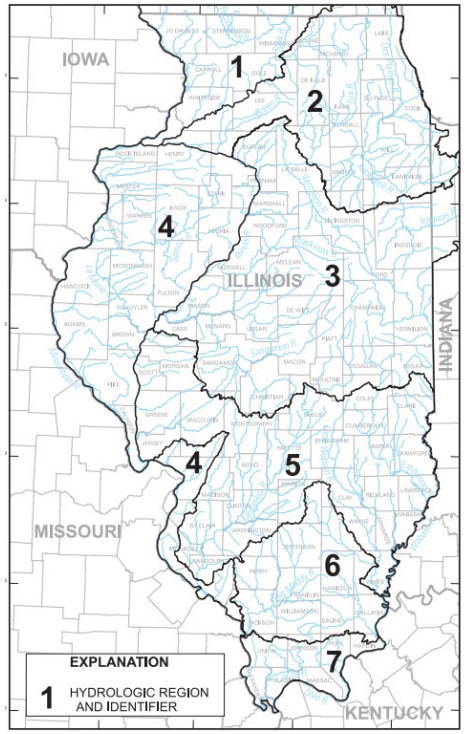
USGS

Hydrologic Regions of Illinois



https://doi.org/10.36501/0197-9191/23-019

Final regression equations



Region	Equation
1	$Q_p = 10^{(a_{0,p} - 3.2259 a_{2,p})} (DA)^{a_{1,p}} (TPI)^{a_{2,p}}$
2	$Q_p = 10^{a_{0,p}} (DA)^{a_{1,p}} 10^{a_{2,p}\sqrt{NLCD\_22\_23\_24}} 10^{a_{3,p}\sqrt{DrainageClass1a}} (DEM\_1\_0\_P)^{a_{4,p}}$
3	$Q_p = 10^{a_{0,p}} (DA)^{a_{1,p}} 10^{a_{2,p}(DEM\_Slope - 55.329)} 10^{a_{3,p}((TPI - 1823.4)/4758.3)}$
4	$Q_p = 10^{a_{0,p}} (DA)^{a_{1,p}} (Soil\_Slope)^{a_{2,p}}$
5	$Q_p = 10^{a_{0,p}} (DA)^{a_{1,p}} 10^{a_{2,p}(DEM\_Slope - 55.329)}$
6	$Q_p = 10^{a_{0,p}} (DA)^{a_{1,p}}$
7	$Q_p = 10^{a_{0,p}} (DA)^{a_{1,p}}$

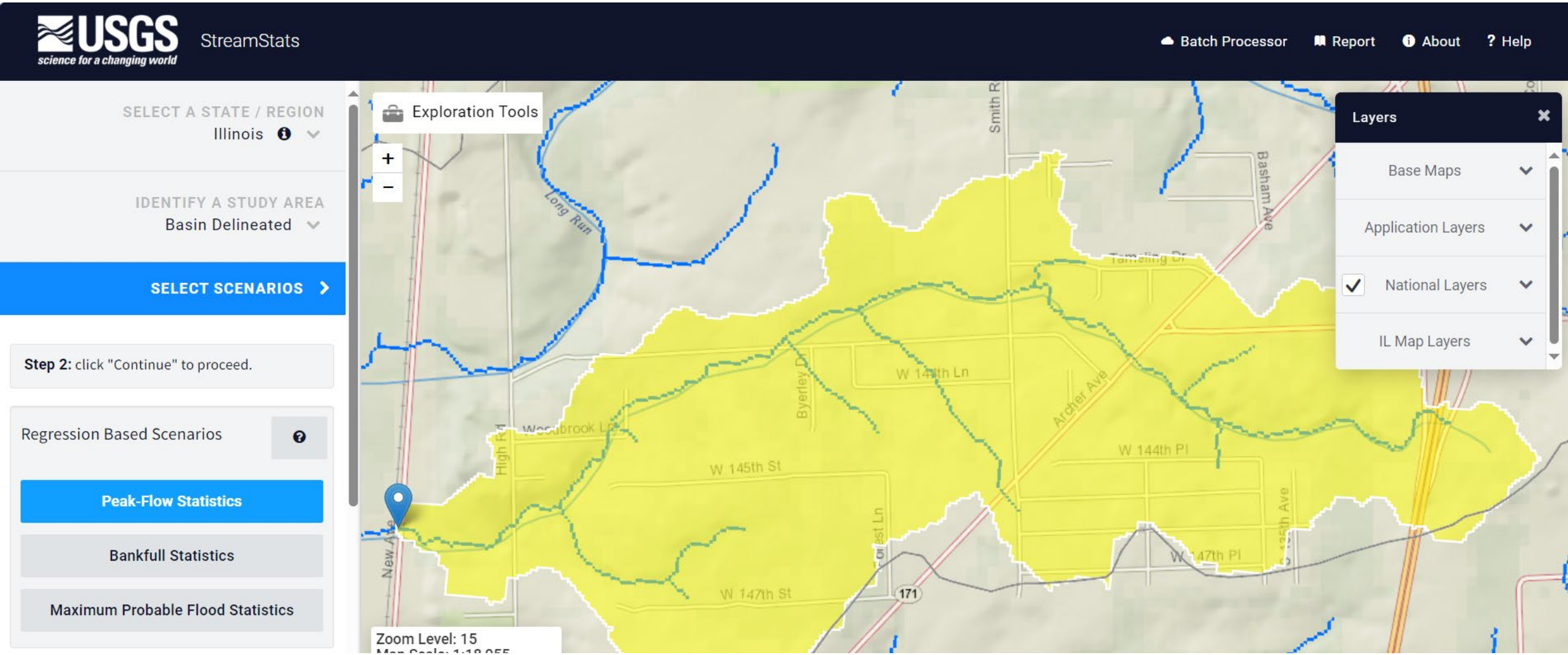
USGS

Regression equation coefficient values in Table DR-7

Q = discharge, *p* = annual exceedance probability, *a* = regression intercept or coefficient

https://doi.org/10.36501/0197-9191/23-019

Ungaged Location Region 2



USGS

Ungaged Location Region 2

Peak-Flow Statistics

Peak-Flow Statistics Parameters [IL Peakflow Region 2 ICT-23-014]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.122	square miles	0.07031	1352
FLC16DVLMH	Frac_Lo_Med_Hi_Developed_from_NLCD2016	0.296	decimal fraction	0.002045	0.9692
FSSURGDC78	Fraction_SSURGO_Drainage_Classes_7_and_8	0.003	decimal fraction	0	0.2506
RELRELF	Relative Relief	22.65	feet per mi	0.8122	35.97

Peak-Flow Statistics Flow Report [IL Peakflow Region 2 ICT-23-014]

PIL: Lower 90% Prediction Interval, PIU: Upper 90% Prediction Interval, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

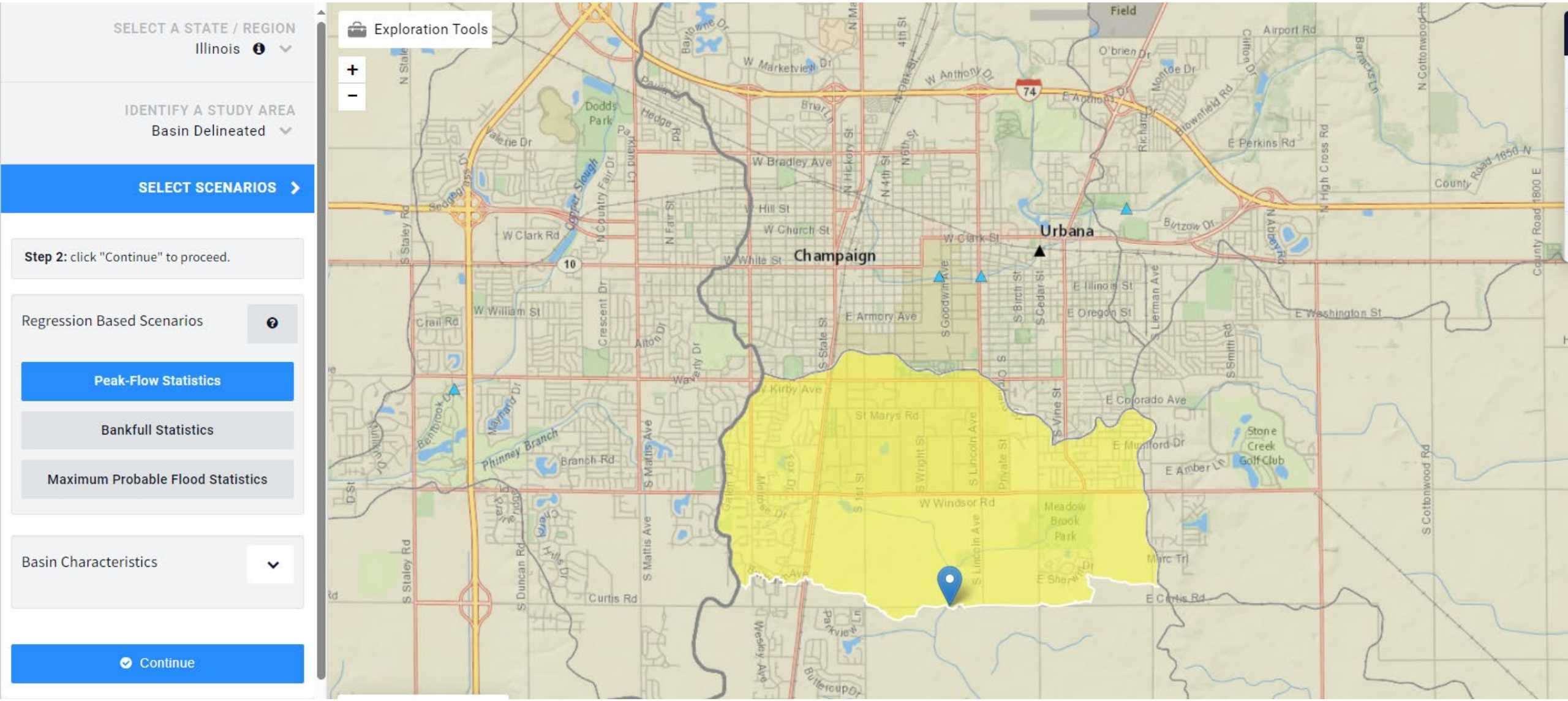
Statistic	Value	Unit	PIL	PIU	ASEp
50-percent AEP flood	112	ft^3/s	52.7	238	46.9
20-percent AEP flood	204	ft^3/s	94.5	440	47.9
10-percent AEP flood	278	ft^3/s	125	618	49.9
4-percent AEP flood	386	ft^3/s	166	895	52.8
2-percent AEP flood	475	ft^3/s	197	1140	55.6
1-percent AEP flood	571	ft^3/s	229	1420	58
0.5-percent AEP flood	674	ft^3/s	261	1740	60.5
0.2-percent AEP flood	823	ft^3/s	306	2210	63.4

Peak-Flow Statistics Citations

Over, T.M., Marti, M.K., O'Shea, P.S., Sharpe, J.B.2023, Estimating peak-flow quantiles for selected annual exceedance probabilities in Illinois (Report No. FHWA-ICT-23-014). Illinois Center for Transportation.

USGS

Ungaged Location Outside Region 2 (Region 3)



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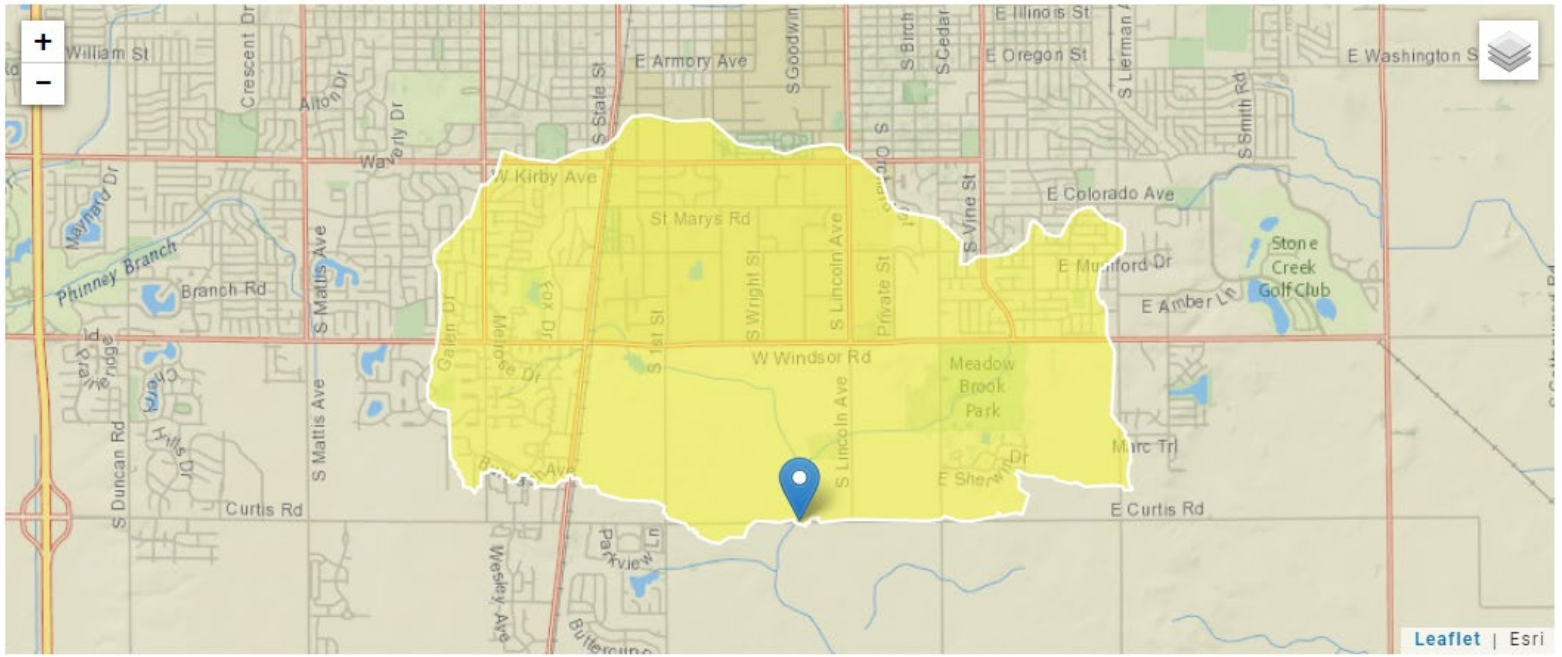
Ungaged Location Region 3



Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DEMSLX100	Average slope of 10-meter DEM cells, using a vertical exaggeration factor of 100, computed using Slope tool in ArcMap	53.25	degrees
DRNAREA	Area that drains to a point on a stream	6.884	square miles
TPISTATSGO	computed as 100*(percent sand) + 10*(percent silt) + (percent clay), using soil texture fractions from STATSGO	2345.11	percent
URBTHE2010	Fraction of drainage area that is in urban classes 7 to 10 from Theobald 2010	0.471	dimensionless

USGS

Ungaged Location Region 3

Peak-Flow Statistics Flow Report [IL Peakflow Region 3 ICT-23-014]

PIL: Lower 90% Prediction Interval, PIU: Upper 90% Prediction Interval, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIL	PIU	ASEp
50-percent AEP flood	707	ft^3/s	363	1380	41.4
20-percent AEP flood	1190	ft^3/s	622	2280	39.9
10-percent AEP flood	1590	ft^3/s	825	3060	40.5
4-percent AEP flood	2080	ft^3/s	1060	4060	41.3
2-percent AEP flood	2430	ft^3/s	1230	4820	42.3
1-percent AEP flood	2800	ft^3/s	1380	5690	42.4
0.5-percent AEP flood	3180	ft^3/s	1560	6490	43.5
0.2-percent AEP flood	3720	ft^3/s	1790	7740	44.9

Peak-Flow Statistics Citations

Over, T.M., Marti, M.K., O'Shea, P.S., Sharpe, J.B.2023, Estimating peak-flow quantiles for selected annual exceedance probabilities in Illinois (Report No. FHWA-ICT-23-014). Illinois Center for Transportation.

USGS

Ungaged Location Region 3 Adjustment

Region	Equation
3	$Q_p = 10^{a_{0,p}} (DA)^{a_{1,p}} 10^{a_{2,p}(DEM\_Slope - 55.329)} 10^{a_{3,p}((TPI-1823.4)/4758.3)}$

1% Annual Exceedance Probability (AEP)
Unadjusted Peak Flow
$Q'_{0.01} = 2,090$ cubic feet per second (cfs)

DA = drainage area, *DEM_Slope* = land surface slope, *TPI* = texture permeability index

Q = discharge, *p* = annual exceedance probability, *a* = regression intercept or coefficient

Ungaged Location Region 3 Adjustment

Region	Equation
3	$Q_p = 10^{a_{0,p}} (DA)^{a_{1,p}} 10^{a_{2,p}(DEM\_Slope - 55.329)} 10^{a_{3,p}((TPI-1823.4)/4758.3)}$

1% Annual Exceedance Probability (AEP)
Unadjusted Peak Flow

$$\boldsymbol{Q'_{0.01}} = \mathbf{2,090}\ \text{cfs}$$

Urbanization Adjusted Peak Flow

$$log_{10}Q_{0.01} = log_{10}\boldsymbol{Q'_{0.01}} + (b_U)_{0.01}(\boldsymbol{U} - \boldsymbol{U_0})$$

$(b_U)_{0.01}$ temporal urbanization coefficient (report Table 11)
** U present or hypothetical future urban fraction in basin*
** U_0 baseline urban fraction of the region 3 (report Table 12)*

https://doi.org/10.36501/0197-9191/23-019

USGS

Ungaged Location Region 3 Adjustment

Region	Equation
3	$Q_p = 10^{a_{0,p}} (DA)^{a_{1,p}} 10^{a_{2,p}(DEM\_Slope - 55.329)} 10^{a_{3,p}((TPI-1823.4)/4758.3)}$

1% Annual Exceedance Probability (AEP)
Unadjusted Peak Flow

$$Q'_{0.01} = 2,090 \text{ cfs}$$

Urbanization Adjusted Peak Flow

$$log_{10}Q_{0.01} = log_{10}Q'_{0.01} + (b_U)_{0.01}(U - U_0)$$

$(b_U)_{0.01}$ temporal urbanization coefficient (report Table 11)
** U present or hypothetical future urban fraction in basin*
** U_0 baseline urban fraction of the region 3 (report Table 12)*

U_0= 0.01037 U = 0.471

USGS

Ungaged Location Region 3Adjustment

Unadjusted 1% AEP

$Q'_{0.01} = 2{,}090$ cfs

Urban-Adjusted 1% AEP

$Q_{0.01} = 2{,}800$ cfs

Peak-Flow Statistics Flow Report [IL Peakflow Region 3 ICT-23-014]

PIL: Lower 90% Prediction Interval, PIU: Upper 90% Prediction Interval, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIL	PIU	ASEp
50-percent AEP flood	707	ft^3/s	363	1380	41.4
20-percent AEP flood	1190	ft^3/s	622	2280	39.9
10-percent AEP flood	1590	ft^3/s	825	3060	40.5
4-percent AEP flood	2080	ft^3/s	1060	4060	41.3
2-percent AEP flood	2430	ft^3/s	1230	4820	42.3
1-percent AEP flood	2800	ft^3/s	1380	5690	42.4
0.5-percent AEP flood	3180	ft^3/s	1560	6490	43.5
0.2-percent AEP flood	3720	ft^3/s	1790	7740	44.9

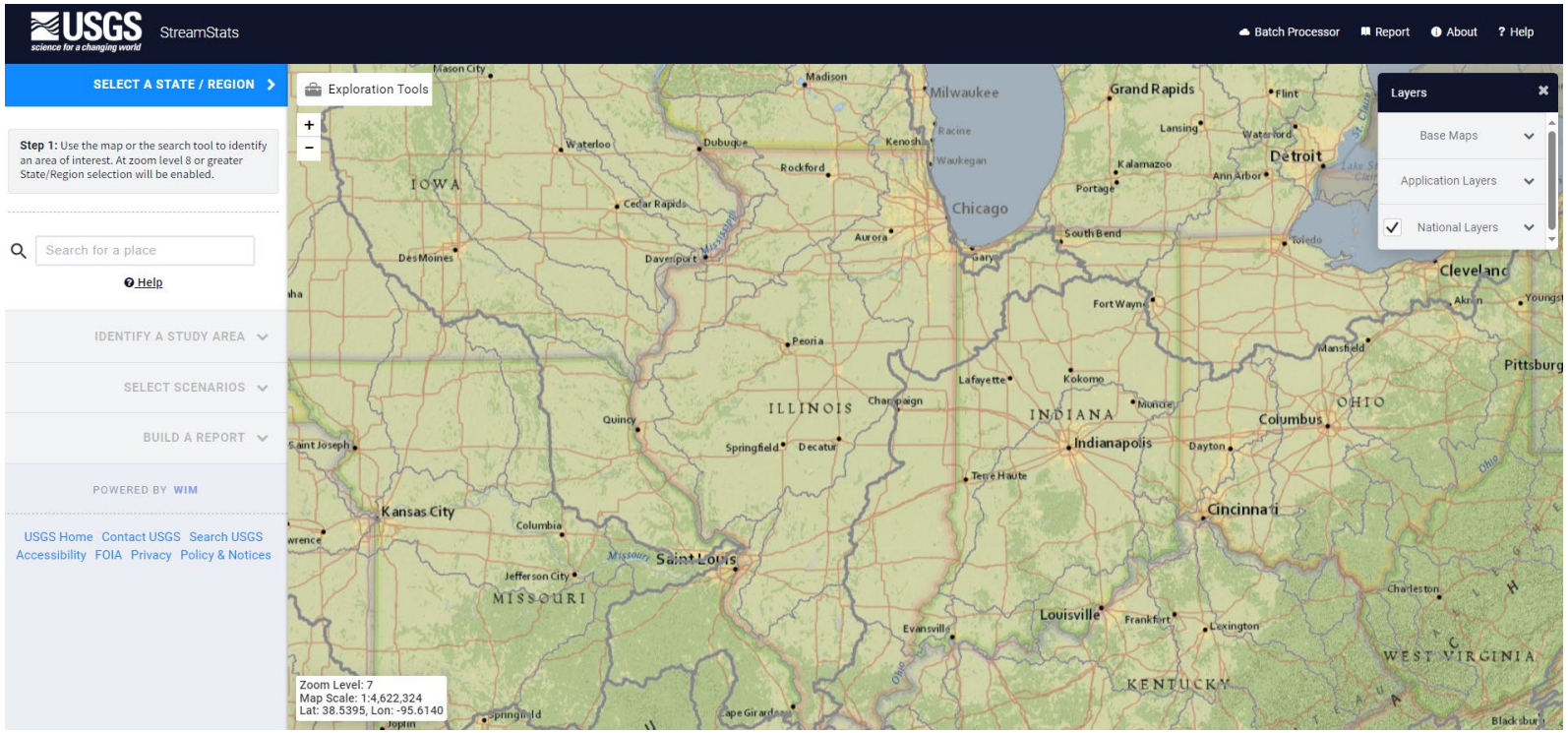
Peak-Flow Statistics Citations

Over, T.M., Marti, M.K., O'Shea, P.S., Sharpe, J.B.2023, Estimating peak-flow quantiles for selected annual exceedance probabilities in Illinois (Report No. FHWA-ICT-23-014). Illinois Center for Transportation.

USGS

Questions?

- https://streamstats.usgs.gov/ss/
- Thomas Over (tmover@usgs.gov)
- Mackenzie Marti (mmarti@usgs.gov)
- Padraic O'Shea (poshea@usgs.gov)



USGS