

# Updates Coming to Illinois StreamStats

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# Outline

- Introduction to StreamStats and history of Illinois StreamStats
- Update on current peak-flow frequency project
- Update on current flow-duration curves (FDCs) / daily streamflow project



## StreamStats (https://streamstats.usgs.gov/ss/)

- Map-based web application
- Delineate drainage basins
- Compute basin characteristics
- Flow statistics: Compute ungaged and serve gaged
- Additional tools



#### Status of participation of states and basins as of 3/1/2022



## History & status of IL StreamStats - I

- Phase I First Implementation:
  - Rural RREs and at-gage PFQs, AEPs from 0.5 to 0.002

RREs: Regional regression equations PFQs: Peak-flow quantiles AEPs: Annual exceedance probabilities

- based on peaks thru 1999 (Soong and others, 2004)
- first implemented in 2010 (Ishii and others, 2010)
- Cooperators: ICT-IDOT, IDNR-OWR

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: USGS SIR 2004-5103, 147 p.

Ishii, A.L., Soong, D.T., and Sharpe, J.B., 2010, Implementation and evaluation of the Streamflow Statistics (StreamStats) Web application for computing basin characteristics and flood peaks in Illinois: USGS SIR 2009–5197, 25 p.

Map of Illinois flood frequency regions (Soong and others, 2004)





## History / status of IL StreamStats - II

- Phase II Urban update (Region 2 = NE IL):
  - Based on peaks thru 2009, same AEPs (0.5 to 0.002)
  - Implemented in 2016, 2021 (Over and others, 2021)
  - Cooperators: ICT-IDOT, USACE-Chicago
  - Combined urban-rural equations for flood frequency region 2, e.g.:

 $Q_{0.01} = 95.5 * A^{0.766} * S^{0.50} * 10^{0.255*(U')} = -1.038*(W)^{0.5}$ 

where A is drainage area, S is slope, U is urbanized fraction (from NLCD 2011), W is water/wetland fraction.

• Urban adjustment coefficients for other regions, e.g.:

 $Q_{0.01}$ (adjusted) =  $Q_{100}$ (rural) \* 10<sup>0.312\*U</sup>

where *U* is urbanized fraction from Theobald (2005) (see slide 13).

• Outside region 2 there are two sets of estimates:

(1) Soong and others (2004) "rural" and (2) Urban adjustment of rural

 Over, T.M., Saito, R.J., Veilleux, A.G., O'Shea, P.S., Sharpe, J.B., Soong, D.T., and Ishii, A.L., 2021, Estimation of peak discharge quantiles for selected annual exceedance probabilities in northeastern Illinois (ver. 3.0, June 2021): USGS SIR 2016–5050, <u>https://doi.org/10.3133/sir20165050</u>. Also published as Illinois Center for Transportation Research Report No. FHWA-ICT-16-013, <u>https://doi.org/10.36501/0197-9191/16-014</u>.



Example report (Region 3) – basin delineation and basin characteristics (BCs)



#### StreamStats Report - Sugar Ck at 174, McLean County, IL

 Region ID:
 IL

 Workspace ID:
 IL20220307223952474000

 Clicked Point (Latitude, Longitude):
 40.47160, -89.03028

 Time:
 2022-03-07 16:40:15 -0600



#### **Basin Characteristics**

Parameter			11-13
Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	34.3	square miles
CSL10_85	Change in elevation divided by length between points 10 and 85 percent of distance along main channel to basin divide - main channel method not known	11.605	feet per mi
SOILPERM	Average Soil Permeability	1.122	inches per hour
ILREG3	Indicator variable for IL region 3, enter 1 if site is in region 3 else 0	1	dimensionless
URBTHE2010	Fraction of drainage area that is in urban classes 7 to 10 from Theobald 2010	0.744	dimensionless

Example report – rural and urbanadjusted PFQ estimates Peak-Flow Statistics Flow Report [Region 3 Peak Unadjusted SIR 2004 5103]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SE	ASEp	Equiv. Yrs.
50-percent AEP flood	1320	ft^3/s	709	2460	39.5	39.5	2.7
20-percent AEP flood	2430	ft^3/s	1300	4550	40	40	3.2
10-percent AEP flood	3270	ft^3/s	1710	6260	41.6	41.6	3.9
4-percent AEP flood	4410	ft^3/s	2220	8770	44.2	44.2	4.7
2-percent AEP flood	5300	ft^3/s	2580	10900	46.6	46.6	5.2
1-percent AEP flood	6200	ft^3/s	2920	13200	49	49	5.6
0.2-percent AEP flood	8430	ft^3/s	3670	19400	54.9	54.9	6.2

Peak-Flow Statistics Flow Report [Region 3 Peak Adjusted Using SIR 2016 5050]

Statistic	Value	Unit
Urban 50-percent AEP flood	3050	ft^3/s
Urban 20-Percent AEP flood	4860	ft^3/s
Urban 10-percent AEP flood	6390	ft^3/s
Urban 4-percent AEP flood	8150	ft^3/s
Urban 2-percent AEP flood	9340	ft^3/s
Urban 1-percent AEP flood	10600	ft^3/s
Urban 0.2-percent AEP flood	13900	ft^3/s

Note: Prediction intervals and other measures of uncertainty are not currently available in StreamStats for urban-adjusted peaks. SIR 2016-5050 shows how to compute them, and they are planned to be become available in the StreamStats report when it is updated with the results of this project.



# STREAMSTATS PHASE III: UPDATED AND UNIFIED STREAMSTATS PEAK DISCHARGES FOR STREAMS OF ILLINOIS

In cooperation with ICT-IDOT (Project R27-181)



## Features of Illinois StreamStats, Phase III

- At-site quantiles based on peak-flow data through water year (WY) 2017, analyzed with updated Bulletin 17C flood frequency methods, and using new regional skew coefficients (if available in time)
- 2. Based on updated high-resolution "blue lines" (1:24,000) and DEM (10m) [previously 1:100,000 and 30m]
- **3.** New rural (regions 1, 3-7) RREs computed with generalized least squares (GLS) on records through WY 2017.
- Updated region 2 RREs (same BCs, records extended through WY 2017)
- **5.** Tabulation and possible interpolation of PFQs on large or regulated rivers interpolated as in Soong and others (2004)
- **6.** Revisions to report generated by StreamStats

## **Project Status**

- 1. streamgage selection (including evaluation of regulation and urbanization): Completed
- **2.** Computation of PFQs: Ongoing
- **3.** Computation of candidate basin characteristics (BCs): Completed
- 4. Selection of BCs / Development of RREs: Awaiting completion of task 2.
- **5.** Revision of 2016 region 2 PFQs and RREs and StreamStats implementation: Completed July 2021
- 6. Report: Ongoing
- **7.** StreamStats implementation: Not started



## Site selection overview

- Importance: The set of streamgages used to develop RREs defines the domain of their applicability.
- Focused on:
  - Length of record (number of peaks)
  - Urbanization
  - Regulation
- Regional differences:
  - Region 2 (NE IL): Updating
  - nonRegion 2: "From scratch"
- Multiple outcomes:
  - Use in RREs: Stationary, unregulated, rural (except Region 2), >= 10 yrs of record
  - Tabulated PFQs only: Other stationary periods >= 10 yrs
  - Record not used: Other periods / entire streamgage records.



#### Site selection overview

- Minimum record length to be considered: 10 years
- Region 2
  - 181 streamgages used in SIR 2016-5050: Is 2010-17 data OK to use?
  - 19 additional streamgages with new record identified
- Non-Region 2
  - 324 streamgages identified for consideration
- Total of 524 streamgages considered





#### **Urbanization: Datasets used**

1940-2001: Theobald (2005) Censusbased housing density dataset



Figure 3, SIR 2016-5050

Undefined Chicago metropolitan counties

#### 2001-16: 2016 NLCD



#### https://www.mrlc.gov/viewer/





Theobald, D., 2005, Landscape patterns of exurban growth in the USA from 1980 to 2020: Ecology and Society, v. 10, no. 1, article 32, http://www.ecologyandsociety.org/vol10/iss1/art32/.

#### **Urbanization: Region 2 results**



- All 181 streamgages used in the prior Region 2 study were evaluated for changes in urbanization post-2009
  - 77 streamgages with additional record
  - Largest change: 2.85% at 04087250: Pike Creek near Kenosha, WI
  - -> All additional records were retained.



#### **Urbanization: Region 2 results**



Candidate additional Region 2 streamgages (19) were evaluated for any change of 15% or greater in urbanization over their entire period of record (POR).

2 streamgages had changes > 15% and were dropped.



### **Urbanization: non-Region 2**



#### **Streamgage Categorization:**

- Rural streamgage record suitable for RREs: >= 10 yrs with small (<15%) and stationary (△ <15%) urban fraction
- At-site only: >= 10 yrs stationary but urban fraction > 15%
- Excluded: Otherwise (non-stationary)

#### **Results:**

- 13 streamgages removed from use in RREs
- 8 of these used in 2004 report
- 5 of these removed entirely



## **Regulation: Datasets used**

- National Inventory of Dams (NID)-based national datasets (decadal) (Wieczorek et al. 2018, 2021) matched to National Hydrography Dataset (NHD) flowlines, allowing for calculation of total upstream storage (converted to inches).
- 2. Current mapping / Google Earth / historical topo / internet research for basins not matching NHD-based drainage area (e.g. small basins) and for precise timing of construction and filling of major reservoirs.
  - Wieczorek, M.E., and others, 2018, Select Attributes for NHDPlus Version 2.1 Reach Catchments and Modified Network Routed Upstream Watersheds for the Conterminous United States (ver. 3.0, January 2021): U.S. Geological Survey data release, https://doi.org/10.5066/F7765D7V.
  - Wieczorek, M.E., and others, 2021, Dam impact/disturbance metrics for the conterminous United States, 1800 to 2018: U.S. Geological Survey data release, https://doi.org/10.5066/P92S9ZX6.



NHD catchments

https://www.usgs.gov/core-science-systems/ngp/nationalhydrography/nhdplus-high-resolution



## **Regulation: Region 2 results**



181 streamgages used in the NE IL Region 2 (Rgn2) study, evaluated for change post-2009

- No streamgages exhibited substantial change
- 19 candidate additional streamgages
  - 2 streamgages removed due to large or changing storage



## **Regulation: non-Region 2 results**



Of **324** streamgages considered:

- 13 excluded from RRE development (8 of which used in 2004 study).
- Of those, 4 without 10-year stationary period so dropped from study.
- 9 will have at-site PFQs computed.



### Site Selection: Region 2 summary

#### For Region 2 RREs

- All 181 streamgages from prior Region 2
   study retained
  - 77 with extended record
- 19 additional streamgages considered, 6 added
  - 13 streamgages removed during Site Selection
    - 2 for urbanization change; 2 for storage; 6 on large, regulated river streamgages; and 3 POR and other.
- 187 streamgages remaining for consideration in RRE development;
  - 2004 study used 72 Rgn2 streamgages for RRE development.





#### Site Selection: non-Region 2 Summary

#### For non-Region 2 (NonRgn2) RREs:

- 324 streamgages considered
- 77 streamgages removed from consideration
- 247 streamgages eligible for use in RREs
  - 2004 study used 216 NonRgn2 streamgages for RREs





## Conclusions

- Developed methods to evaluate urbanization and regulation systematically to reduce (but not eliminate) judgment.
- Along with availability of additional years of record, after applying these methods to Illinois streamgages, we obtained more usable gages than prior studies (187 v. 181 in region 2; 247 v. 216 downstate).
- Computation of candidate BCs has been completed.
- Additional tasks remain to be completed but significant progress has been made on those as well.



# Implementation of flow-duration curves in StreamStats and daily streamflow estimation at ungaged basins in Illinois and Indiana

In cooperation with the U.S. Environmental Protection Agency, Region V, and the Indiana Department of Environmental Management



### **Products**

- Regional flow-duration curves (FDCs) for ungaged basins in IL and IN, implemented in StreamStats
- Estimation of daily streamflow at ungaged basins in IL and IN, implemented in StreamStats



### **FDCs in StreamStats**

 Revised regression equations from 2014 report for IL FDC Region 3 and IN FDC Region 2

**IL FDC Region 3** 

Basin characteristics used in equations: Drainage area, fall precipitation



#### **IN FDC Region 2**

Basin characteristics used: Drainage area, winter precipitation, surface sediment permeability, basin centroid latitude, soil permeability





### **FDCs in StreamStats**



Prepared in cooperation with the U.S. Environmental Protection Agency, Region V

#### Estimation of Regional Flow-Duration Curves for Indiana and Illinois



Scientific Investigations Report 2014–5177 Version 2.0

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

- Will be utilizing revised equations to be published in SIR 2014-5177 Version 2.0 (expected 2022)
- Flow-duration statistics will be implemented in StreamStats





#### **FDCs in StreamStats**

Statistic	Value
99_9_Percent_Duration_DA_Only_Regression	0.317
99_8_Percent_Duration_DA_Only_Regression	0.436
99_5_Percent_Duration_DA_Only_Regression	0.57
99_Percent_Duration_DA_Only_Regression	0.822
98_Percent_Duration_DA_Only_Regression	1.07
95_Percent_Duration_DA_Only_Regression	1.83
90_Percent_Duration_DA_Only_Regression	3.24
80_Percent_Duration_DA_Only_Regression	6.39
75_Percent_Duration_DA_Only_Regression	8.53
70_Percent_Duration_DA_Only_Regression	11.1
60_Percent_Duration_DA_Only_Regression	17.7
50_Percent_Duration_DA_Only_Regression	25.8
40_Percent_Duration_DA_Only_Regression	36.3
30_Percent_Duration_DA_Only_Regression	52.3
25_Percent_Duration_DA_Only_Regression	64.4
20_Percent_Duration_DA_Only_Regression	81.1
10_Percent_Duration_DA_Only_Regression	153
5_Percent_Duration_DA_Only_Regression	268
2_Percent_Duration_DA_Only_Regression	507
1_Percent_Duration_DA_Only_Regression	759
0_5_Percent_Duration_DA_Only_Regression	1040
0_2_Percent_Duration_DA_Only_Regression	1490









Note: "Reference gage" is another term for "index gage"





#### Estimation of daily streamflow in StreamStats



**<b>**€USGS

Preliminary information—subject to revision. Not for citation or distribution.

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#### **Estimation of daily streamflow in StreamStats**

Flow Duration Curve Transfer Method (also known as QPPQ)						
Select/Enter a date range. (Required)						
02/01/2022 - 03/02/202	22					
Select/Enter an index gage. (Required)						
Enter Station Number: O Go						
♀ Select From Map	Best Correlated	<b>Query Nearest Gages</b>				
Drainage area of clicked point: 114.8						



#### Estimation of daily streamflow in StreamStats

	Discharge (cfs)				Selected in	ndex gage	]
Date	Estimated	HICKORY CREEK N	EAR BROWNSTOWN	N, IL			-
2021/05/01	79.2	16.2					
2021/05/02	62.4	11.4					
2021/05/03	66.6	12.4					
2021/05/04	158	47.4					
2021/05/05	198	70.8					
2021/05/06	81.7	17					
2021/05/07	62.4	11.4	Estimated Flows				
2021/05/08	48.5	8.48			HICKORY CRE	EK NEAR B	stimated (at clicke
2021/05/09	49.8	8.75					
2021/05/10	44.7	7.68					
2021/05/11	39	6.57					
				05/14/202	0512512021	0610612021	07/01/2021



## Summary

When these projects are completed, USGS StreamStats for Illinois will host:

- RREs for and at-gage values of peak-flow quantiles from 0.50 to 0.002 AEP updated with data through WY 2017 including effect of urbanization.
- RREs for and at-gage values of daily FDCs for exceedance probabilities from 0.001 to 0.999 and ability to estimate daily streamflow using FDCs at ungaged locations.



## **Contact Info**

Contact us or StreamStats Help with questions or problems:

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https://www.usgs.gov/centers/cm-water/

