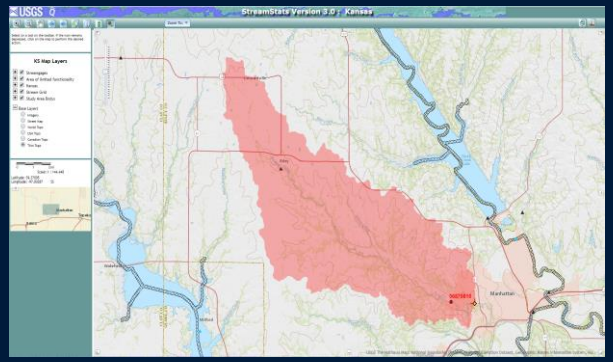
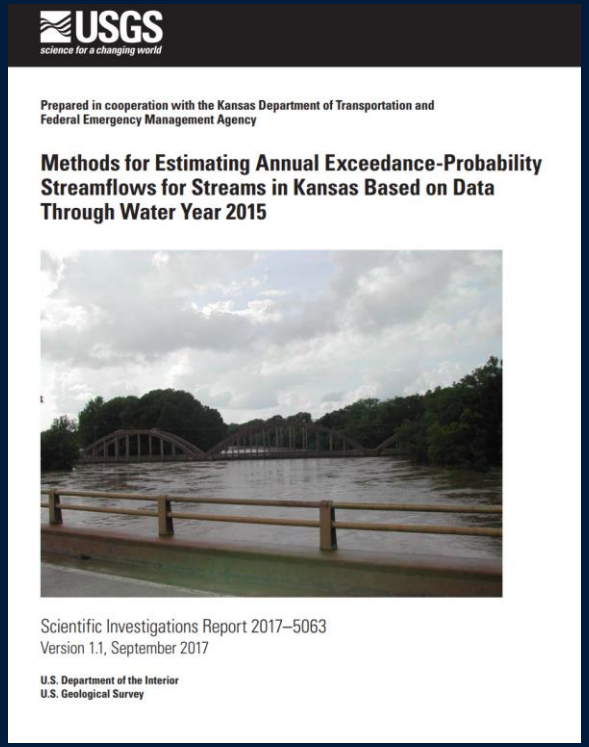
Updated Methods of Flood Frequency Calculation in Kansas

Colin Craig Painter
Supervisory Hydrologist
USGS Kansas Water Science Center

Three New Products





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Prepared in cooperation with the Kansas Department of Transportation and Federal Emergency Management Agency

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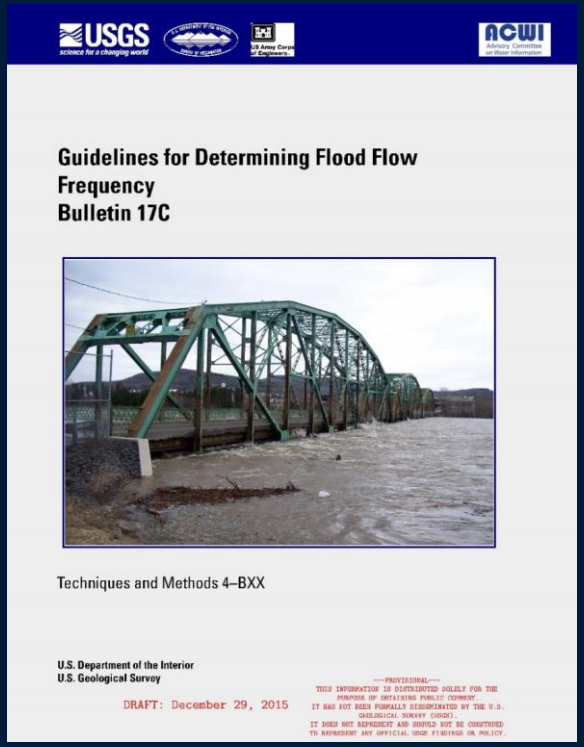

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ACWI
Advisory Committee on Water Information

Guidelines for Determining Flood Flow Frequency
Bulletin 17C

Techniques and Methods 4–BXX

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

DRAFT: December 29, 2015

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Built upon → Built upon →

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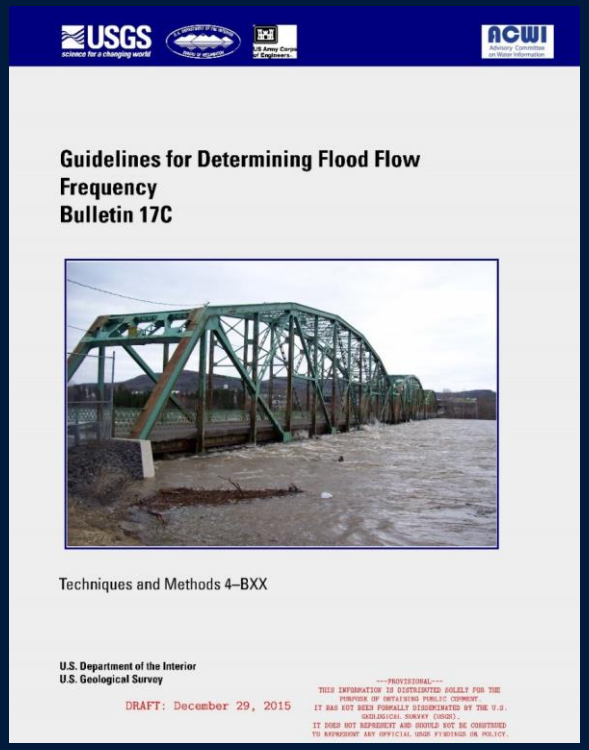
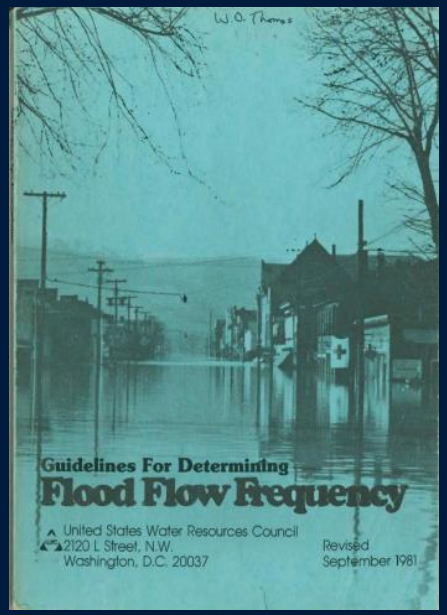
What is Bulletin 17C





Year	1966	1967	1976	1977	1981	2017
Bulletin	13	15	17	17A	17B	17C

WICP Water Information Coordination Program
ACWI Advisory Committee on Water Information

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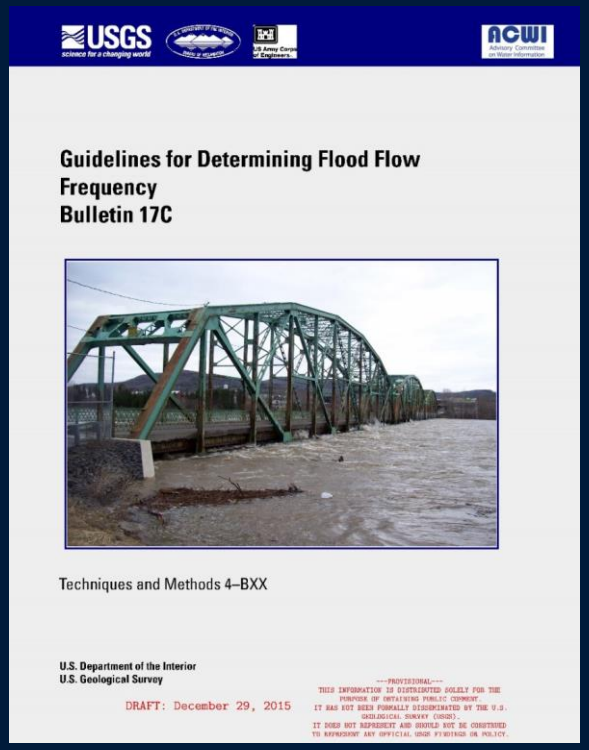

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Note: Bulletin 17C is not exclusively a USGS product, rather it is a product of a subcommittee of the Advisory Committee on Water Information. The USGS has chair members on these committees.

http://acwi.gov/hydrology/Frequency/b17c/index.html

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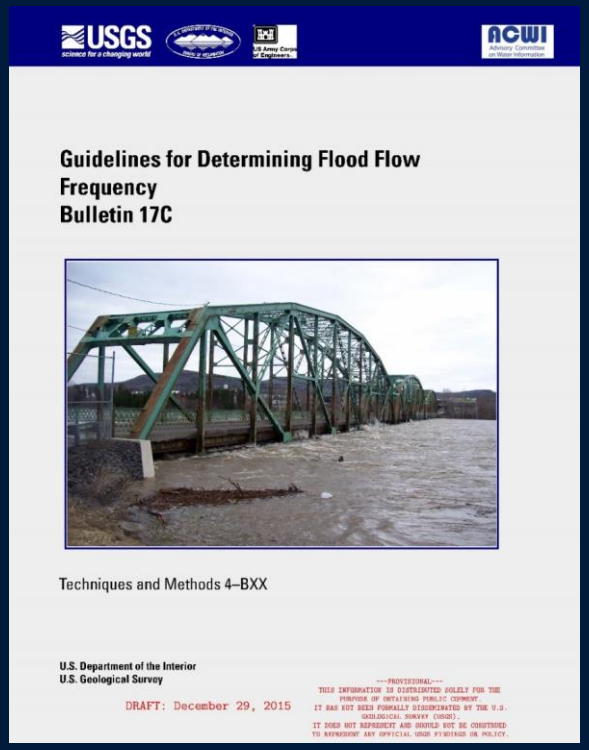
Bulletin 17C - Status



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B17B was published in 1982!

Received approval from Bureau Approving Official September 26, 2017

Next steps:

- Awaiting official release as a Techniques and Methods publication by USGS

http://acwi.gov/hydrology/Frequency/b17c/index.html

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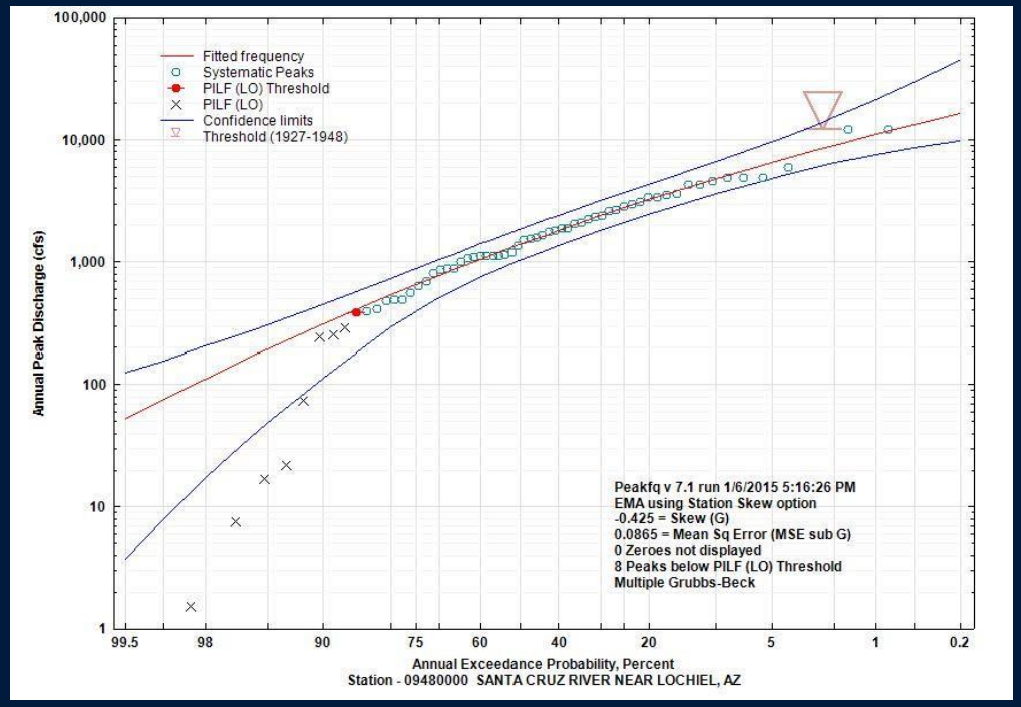
Bulletin 17C - Purpose

- National Guidelines for flood flow frequency
  - Uniform
  - Consistent
- Planning activities for flood risk management



B17B vs. B17C

What's new
and
what stayed the same?

USGS

Bulletin 17C principal changes:

1. **Generalized description** of at-site flow data
   - “Interval” vs.“point”, perception thresholds
2. **Expected Moments Algorithm** (EMA) for fitting the LP3 distribution
   - Improvements for historical info and low outliers
3. New procedure for detecting **“low outliers”**
   - potentially influential low floods, PILFs
4. Improved **regional skew** estimation
   - Bayesian GLS linear regression
5. **Uncertainty**
   - More accurate confidence intervals

USGS

Bulletin 17C has these changes:

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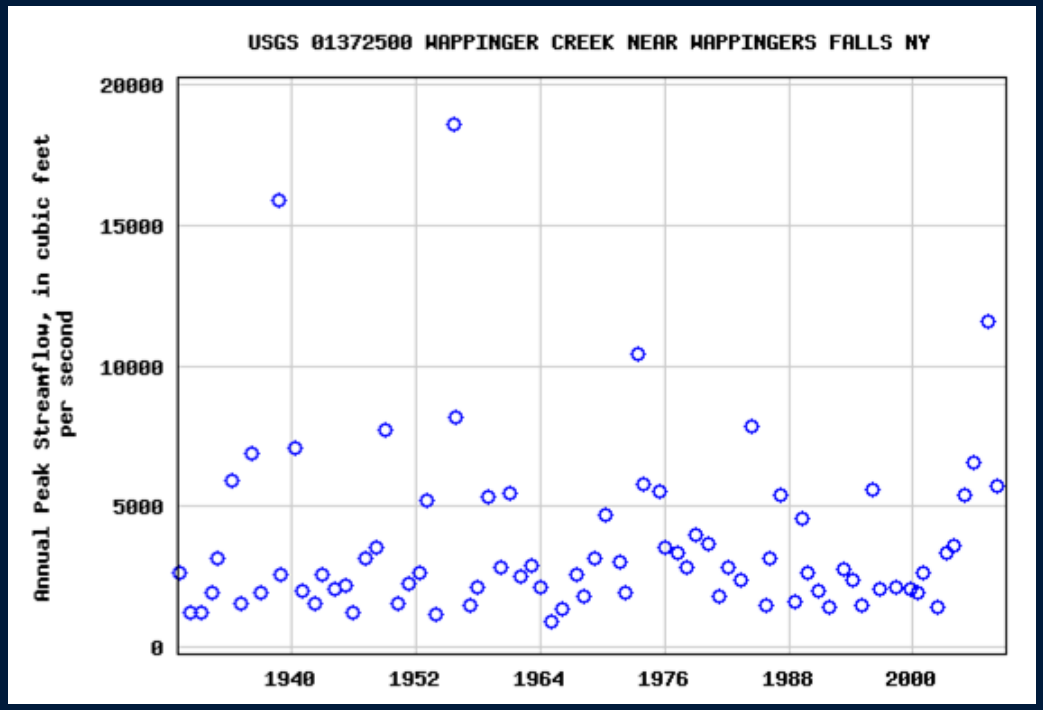
Annual Maximum Stream Flows

gaged flow measurements are POINT values



Sources of Flood Frequency Info

- Systematic Records at Streamgages and CSGs
- Historical Data
  - Reports documenting floods with high-water marks, pictures of damaged structures
- Regional Information—StreamStats
- Paleoflood Data

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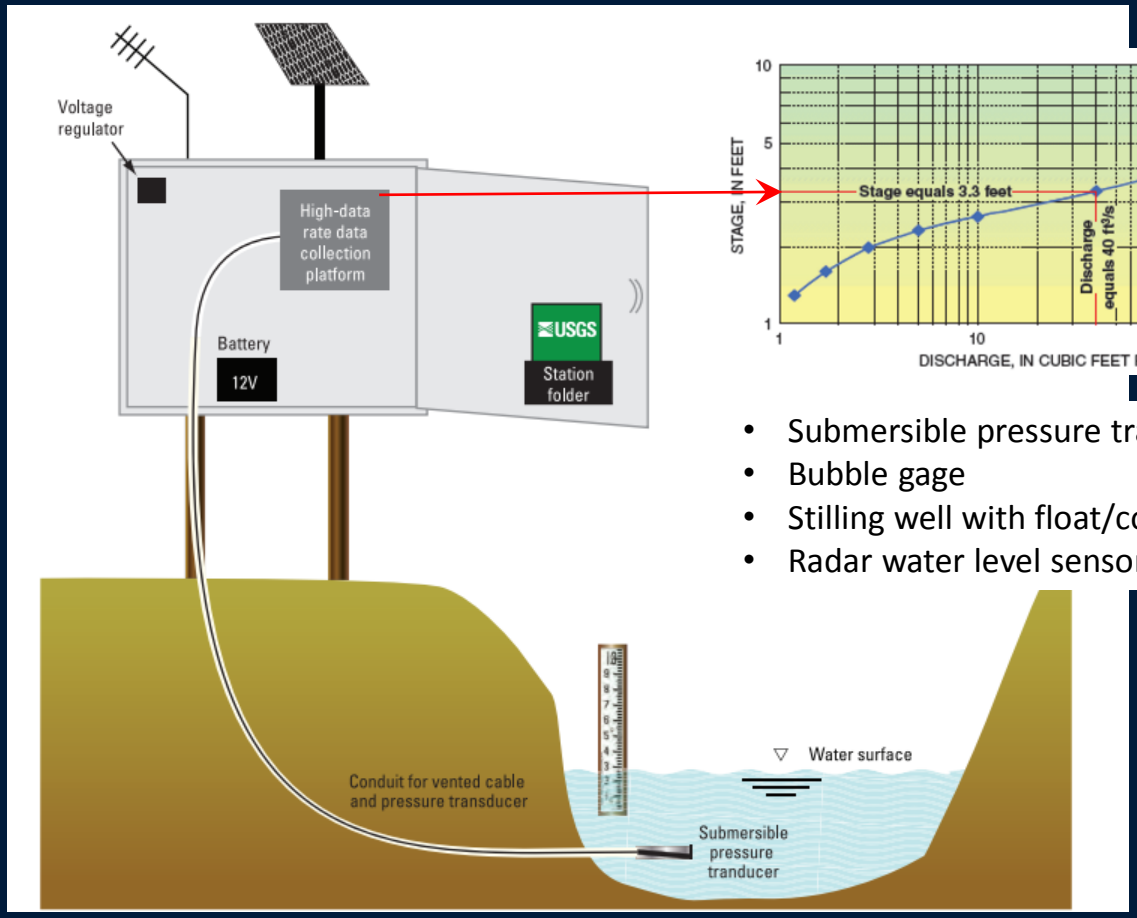
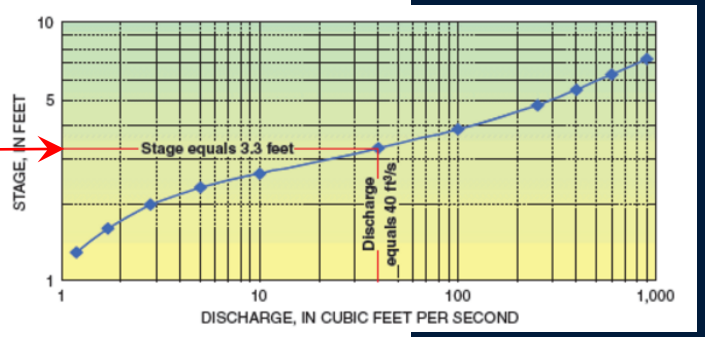
Streamgages: Water Levels to Flow





- Submersible pressure transducer
- Bubble gage
- Stilling well with float/counterweight
- Radar water level sensor

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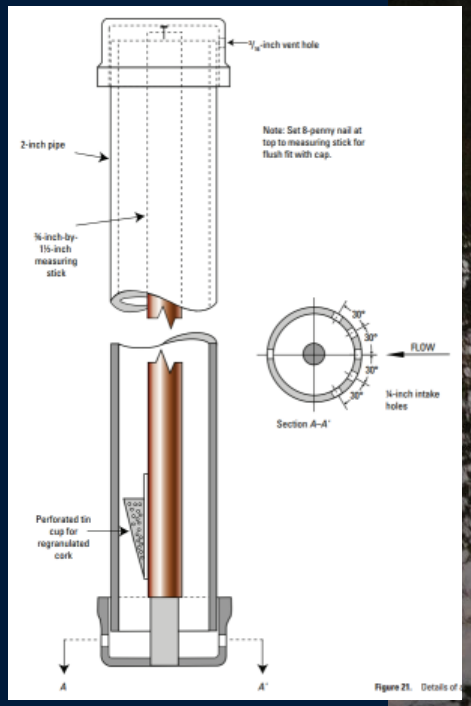
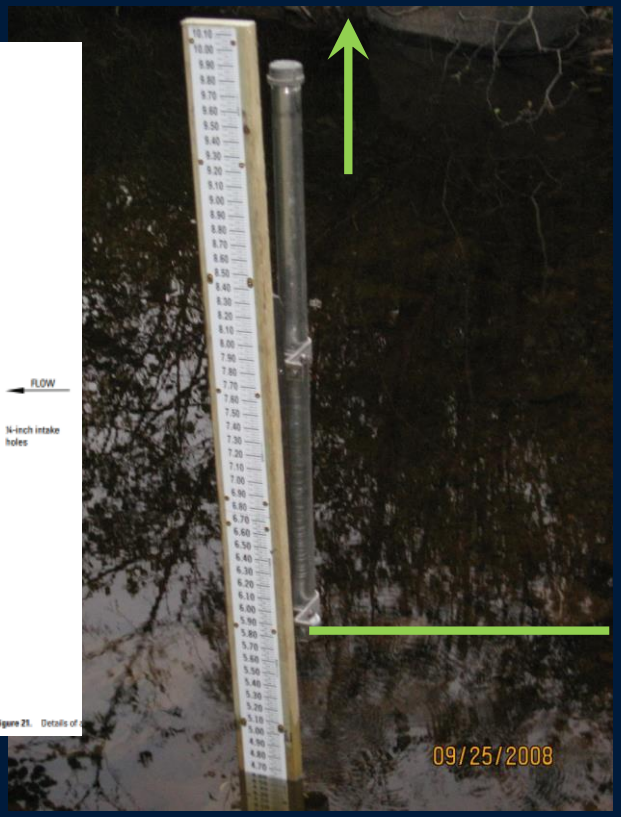
Streamgages and Crest Stage Gage (CSG)





$T_{S,upper} = \infty$, upper perception threshold of peak flows during periods of systematic records.

$T_{S,lower}$ = Lower perception threshold of peak flows during periods of systematic records. Generally 0 for continuous streamgages, may be greater than 0 for CSG.

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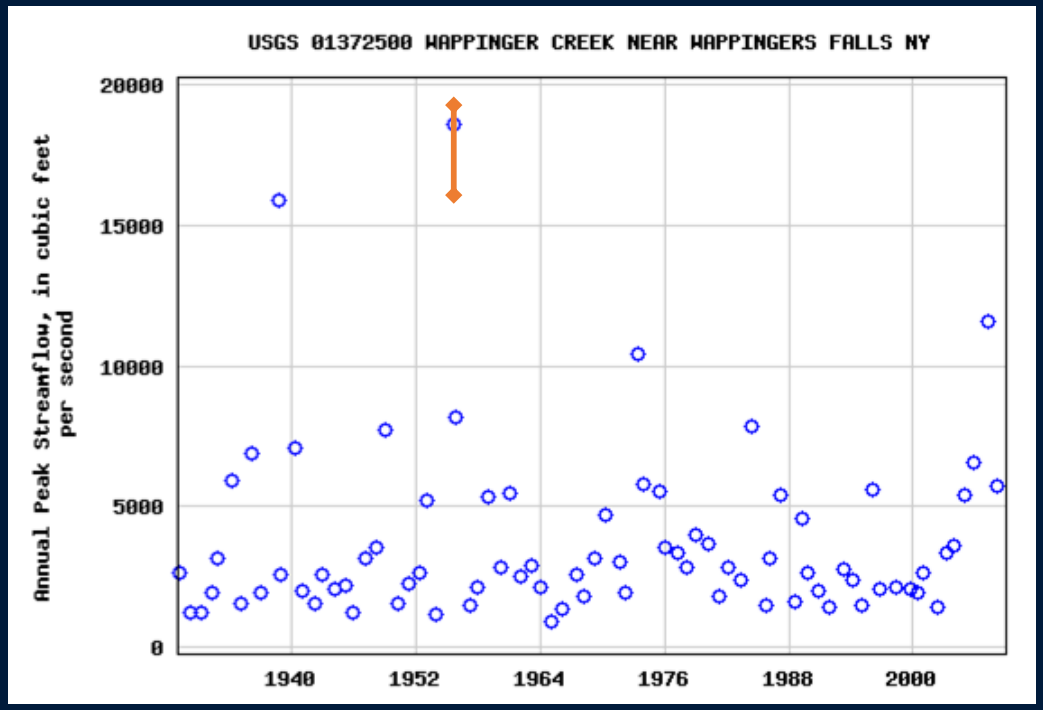
Annual Maximum Stream Flows

an uncertain estimate can be represented as an interval



Sources of Flood Frequency Info

- Systematic Records at Streamgages and CSGs
  - **Great network of streamgages… except when the record is intermittent due to the ebbs and tides in funding**
- Historical Data
  - Reports documenting floods with high-water marks, pictures of damaged structures
  - **Eastern half of Kansas has some historical reports going back to the 1840's**
- Regional Information—StreamStats
- Paleoflood Data
  - **Not of use throughout much of Kansas**

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Also now define “perceptible range”

What floods would we have noticed?

- During the gaged record, we typically notice everything.
  - For crest stage gages, we might only notice floods above a certain size.

- In a historical period, we would notice only very large floods. The small ones would go unnoticed, or at least unrecorded.

Using the new algorithm, every year in the record also requires that a perceptible range be defined.

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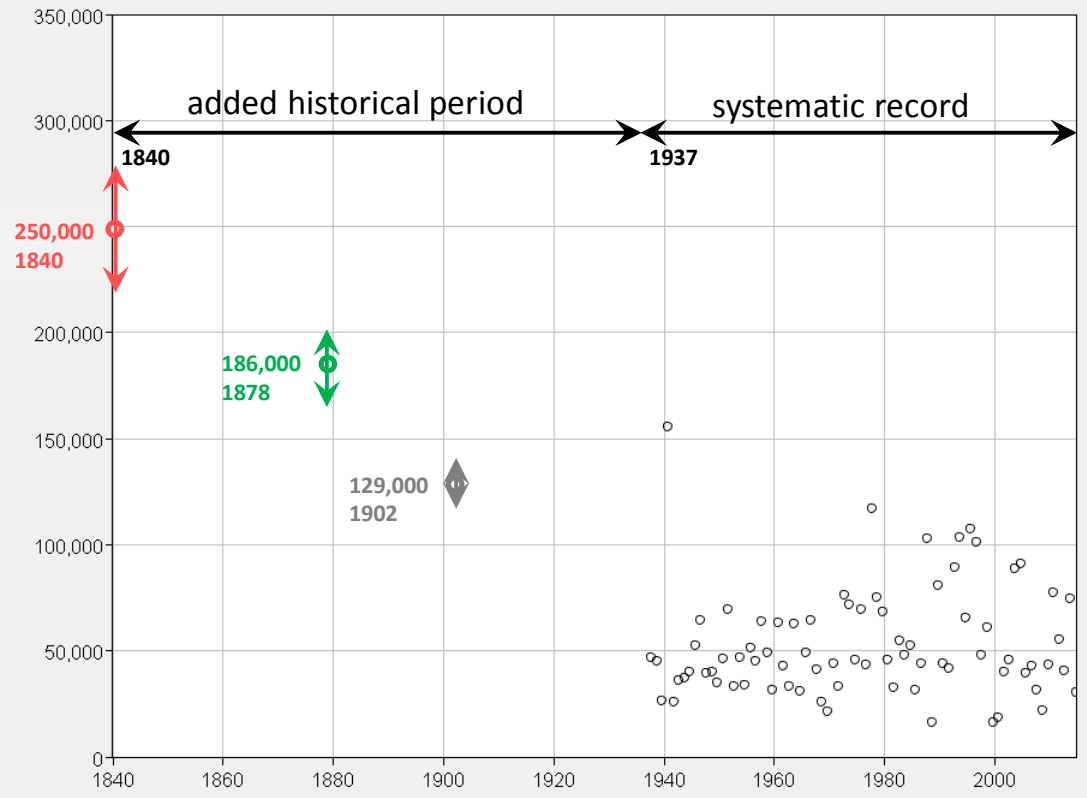
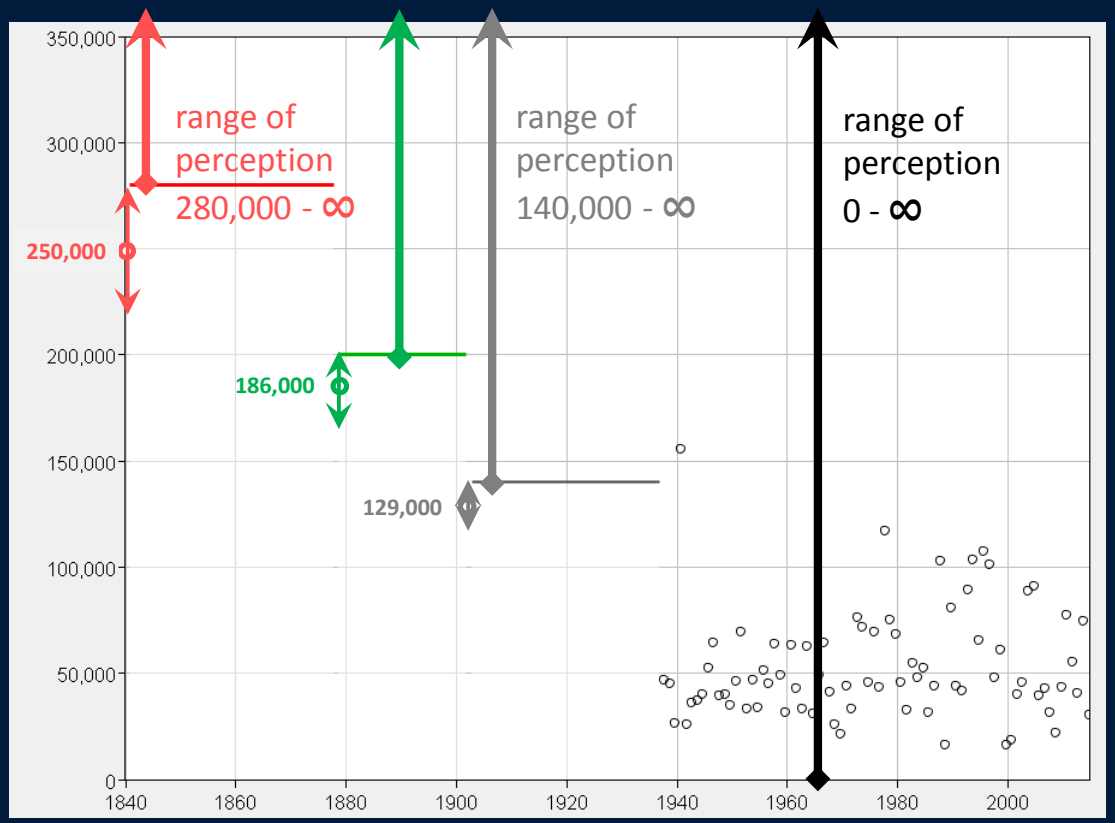
Perception Thresholds



Perception Thresholds



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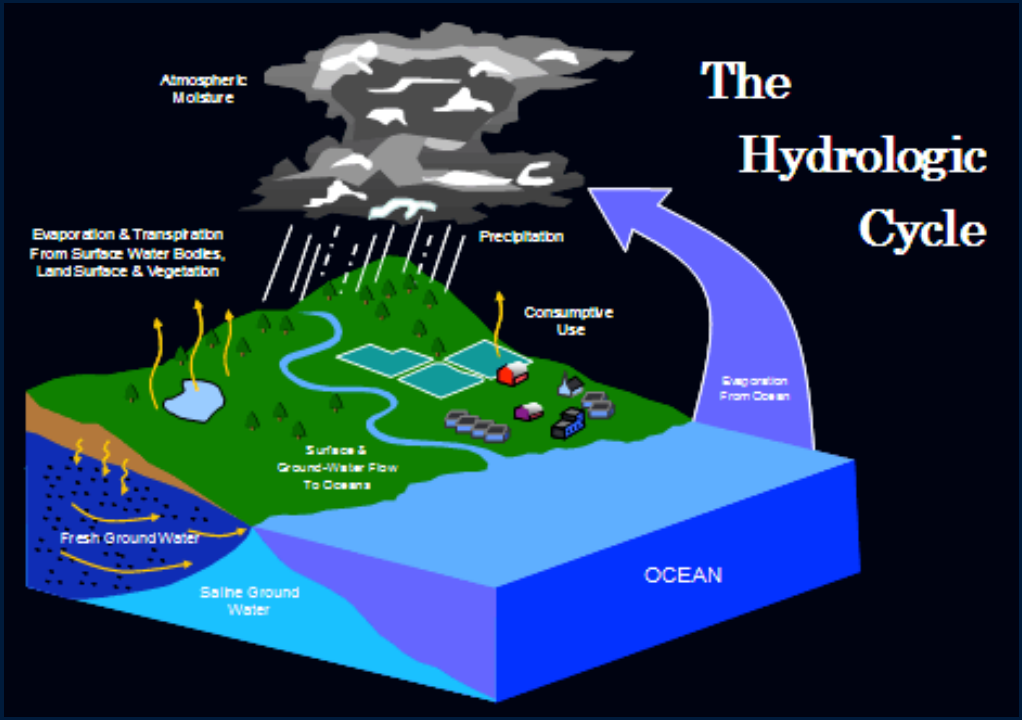
In the Humid East…



http://www.ecy.wa.gov/climatechange/reducedsnow_more.htm

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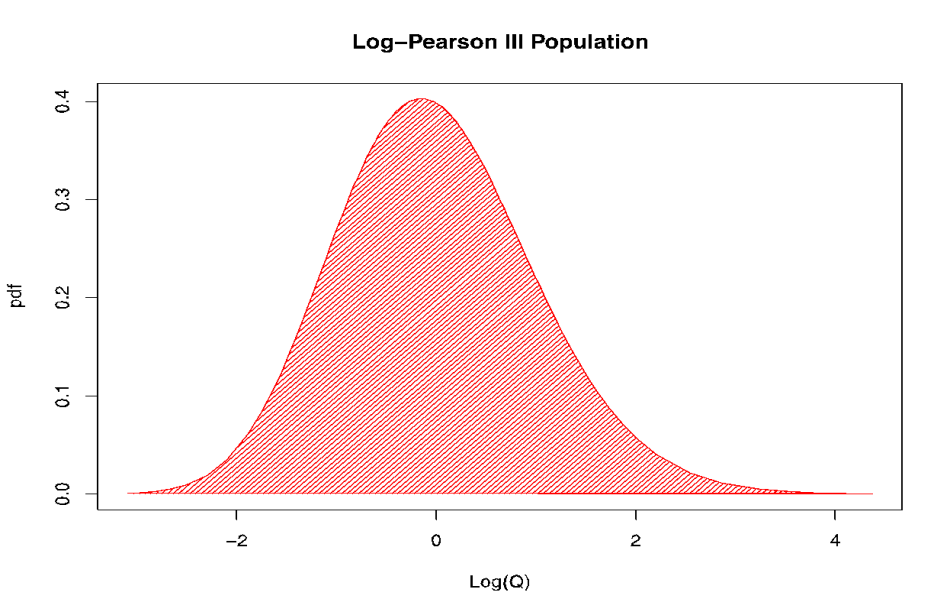
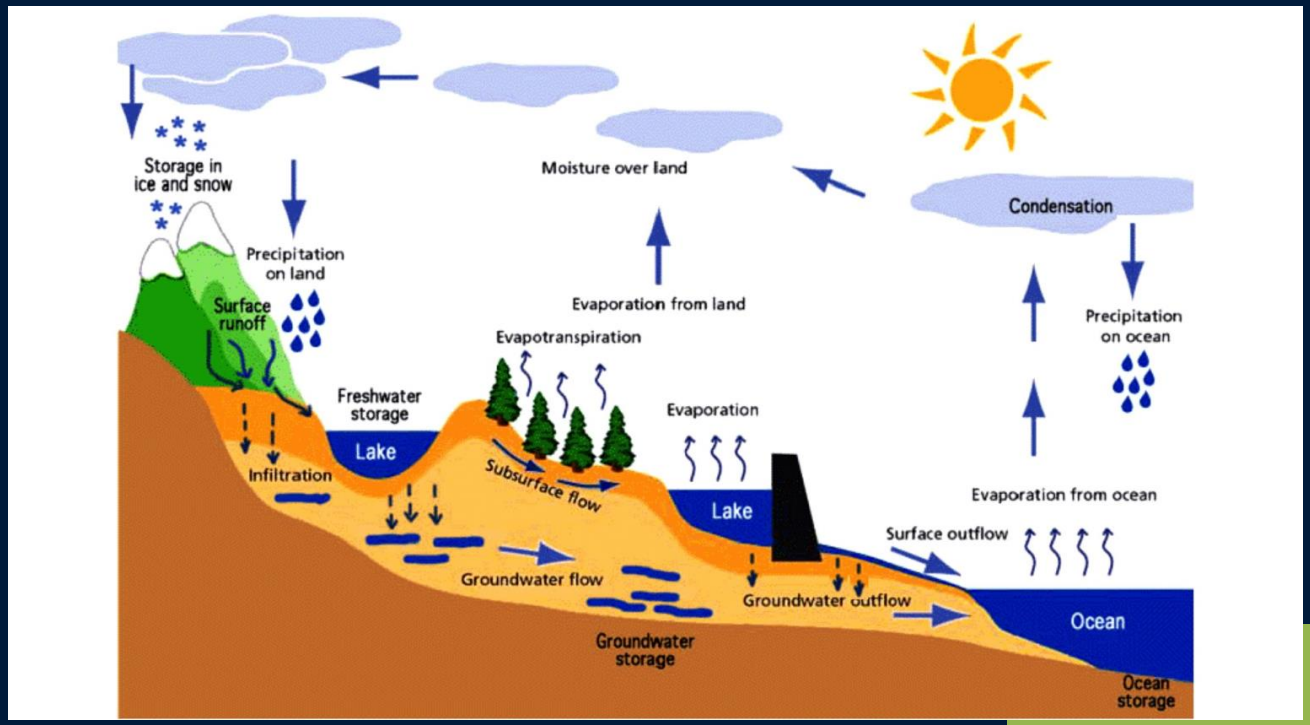
…LP3 Usually Fits



In the Arid West…



http://geofreekz.files.wordpress.com/2008/10/hydrologic_cycle.gif

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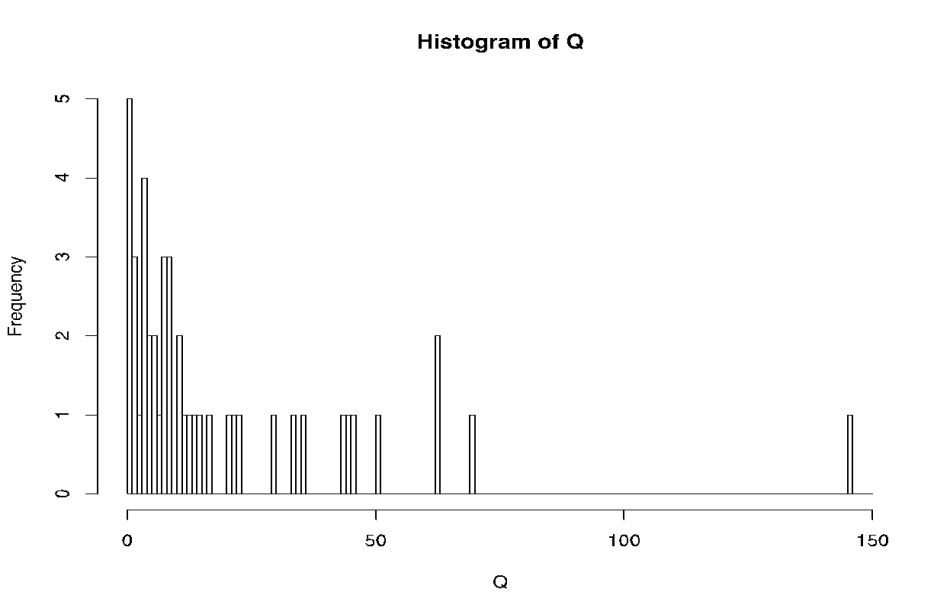
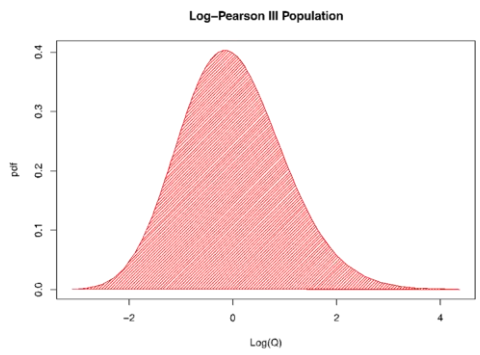
…things are more complicated



LP3 Does Not Generally Characterize Multiple Physical Processes



- Channel Losses

= Left-Hand Tail Problems

Multiple Grubbs-Beck Test (MGBT)

- B17B single Grubbs-Beck test is theoretically based on questioning the lowest value in the data set to define the low outlier threshold
- Presence of several low outliers can mask each other.
- 17C uses a more aggressive low outlier test. MGBT is more effective because it considers the possibility of any number of outliers
- EMA recodes Potentially-Influential Low Floods (PILFs) as censored values
  - values become intervals of (0, PILF-threshold)

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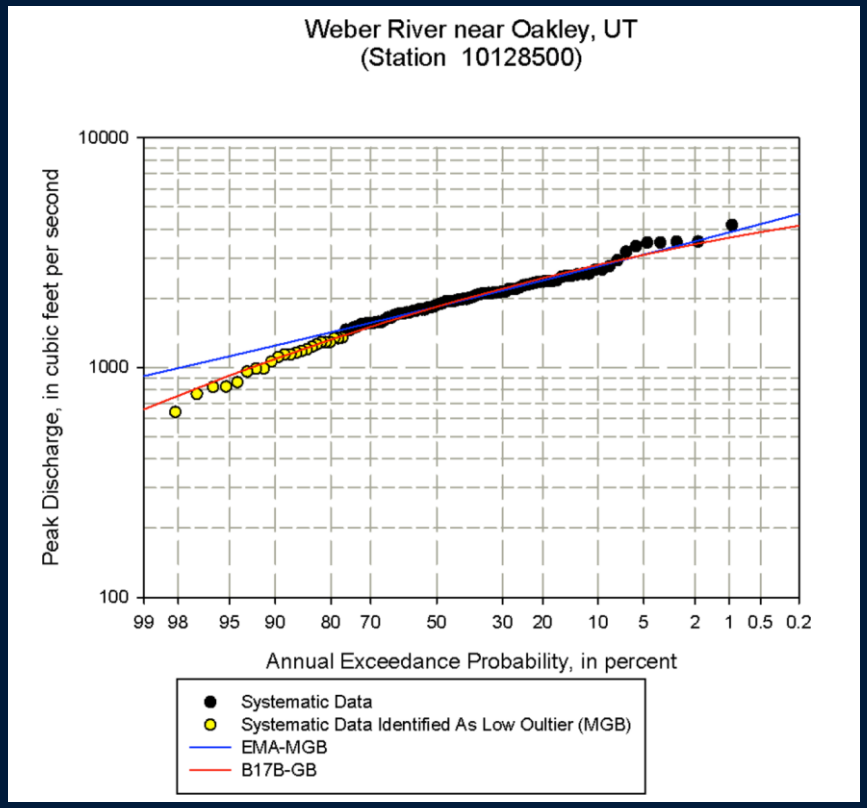
Comparison of B17B/GB (0) and EMA/MGB (24)



B17C predicts higher than B17B for big floods with the many PILFs removed

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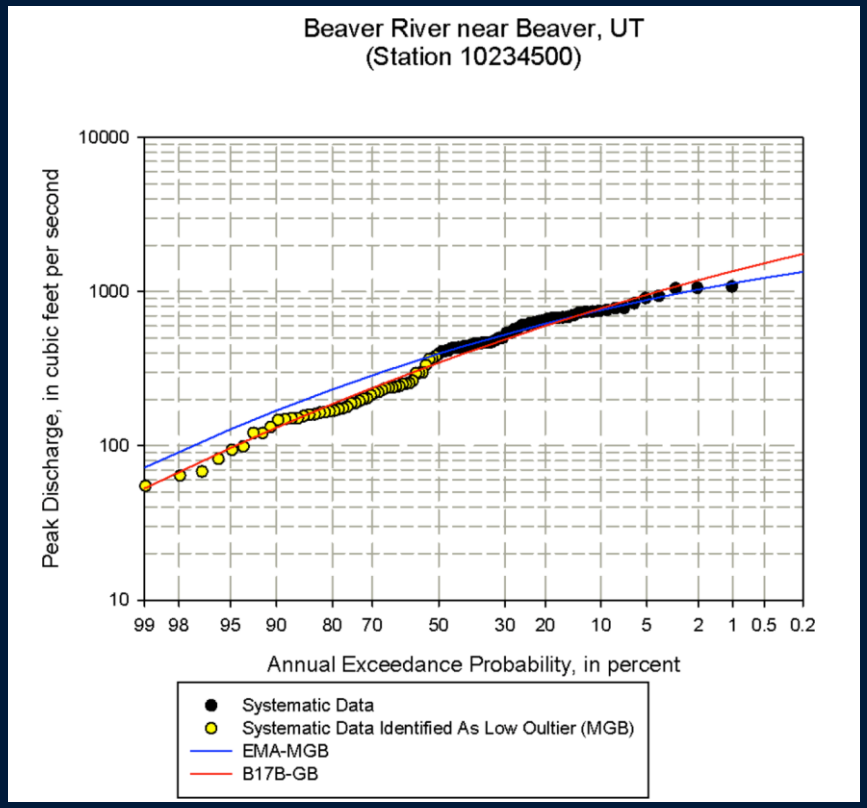
Comparison of B17B/GB (0) and EMA/MGB (48)



B17C predicts lower than B17B for big floods with the many PILFs removed

Confidence Intervals

B17B	B17C
Only considers uncertainty in mean and standard deviation.	Also includes uncertainty in skew.
Assumes one year of historical information is as valuable as a year of gaged record.	Assigns correct value to each year of historical information.

B17C confidence intervals are a big improvement over B17B.
(Borne out by Monte Carlo experiments.)

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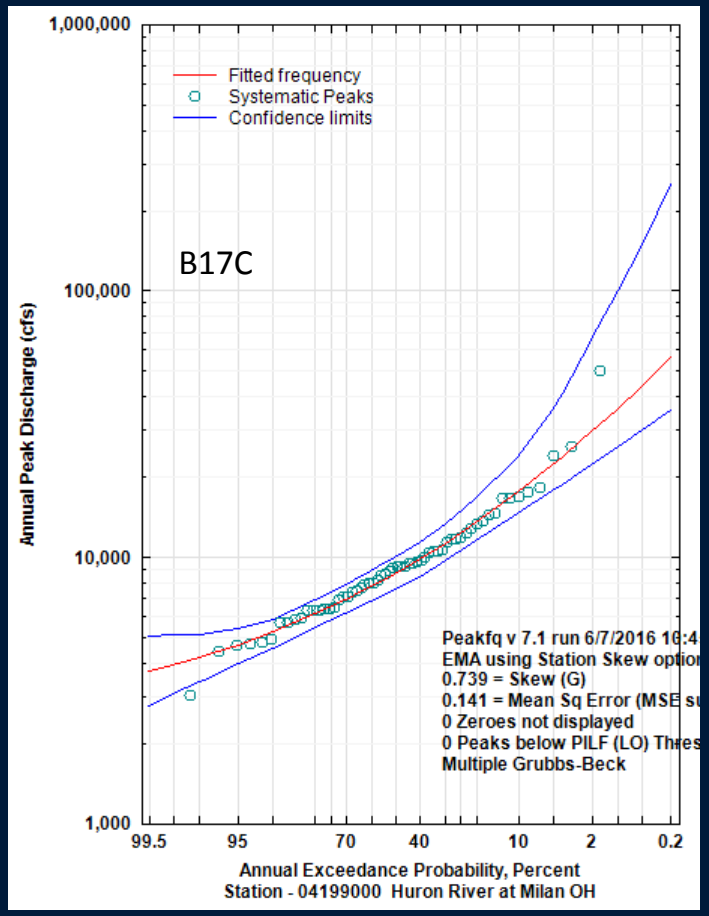
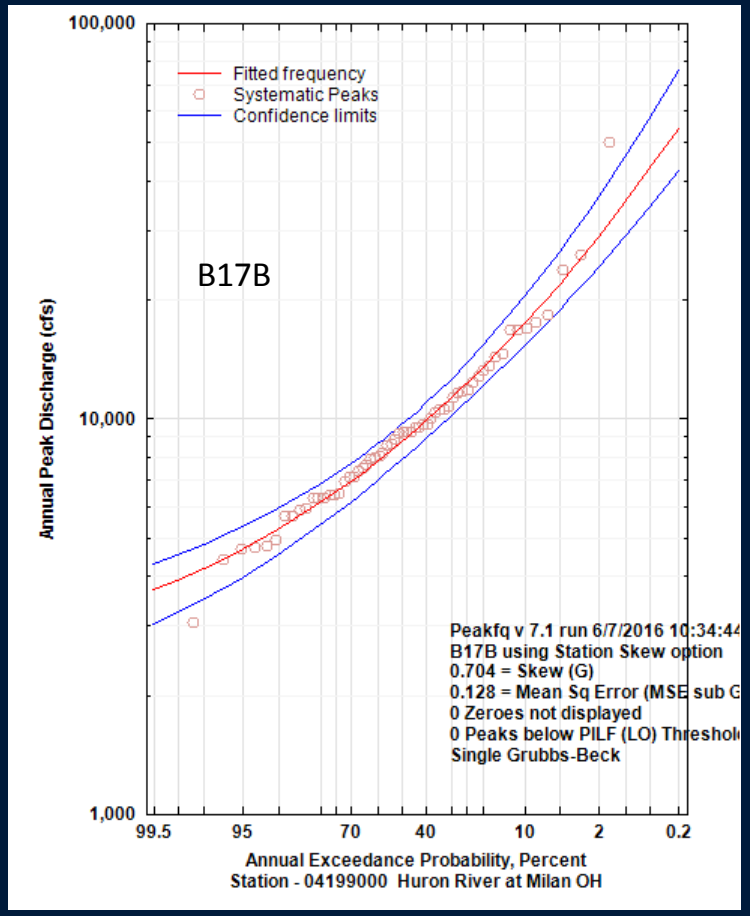
04199000 Huron River at Milan OH





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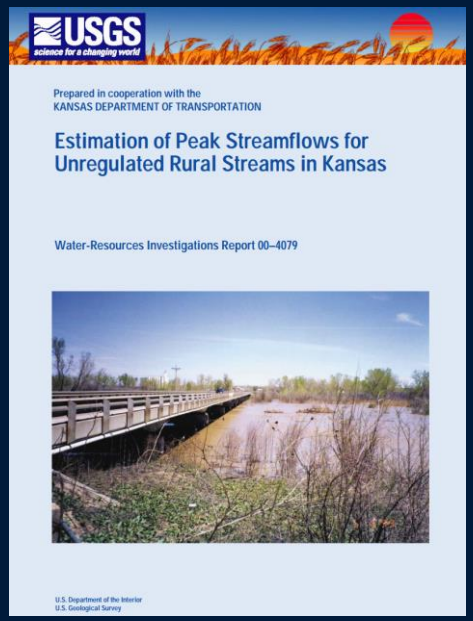
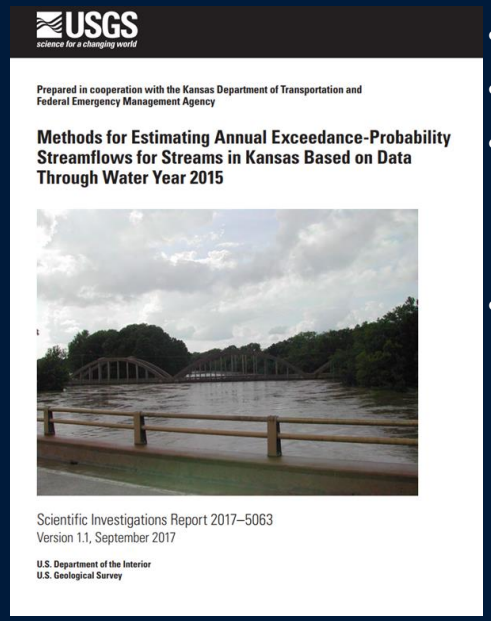
Update of Kansas Flood Frequency Equations

Published 2000

- Uses Bulletin 17B
- Data through 1997
- 253 total gaging stations analyzed
- No breakout regions



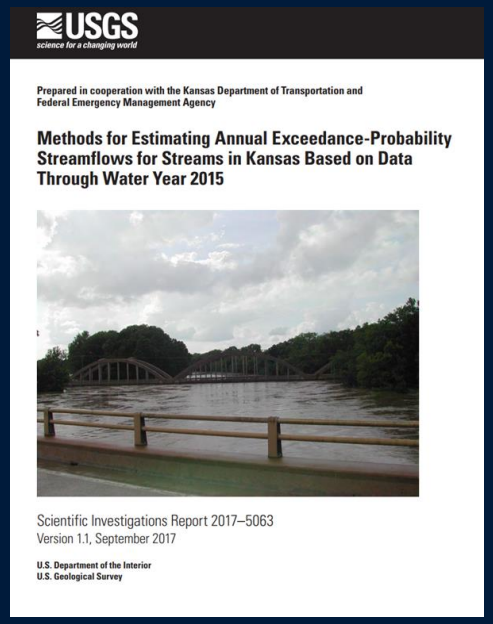


Published 2017

- Uses Bulletin 17C
- Data through 2015
- More aggressive screening for nested and redundant basins
- 151 total gaging stations analyzed

USGS

Update of Kansas Flood Frequency Equations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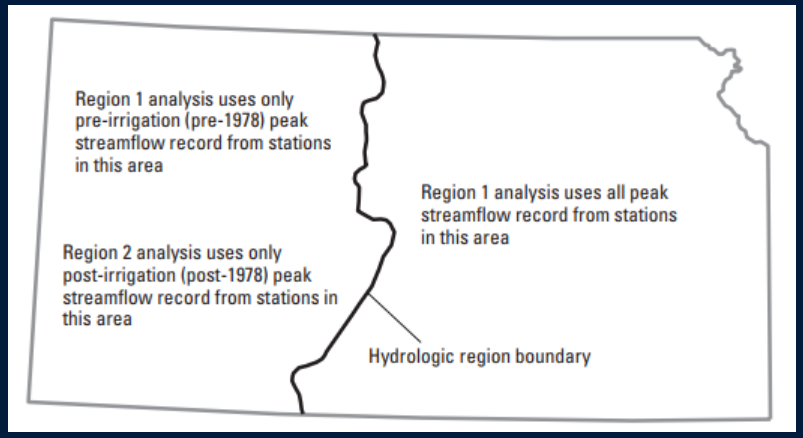
Breakout region divides irrigation affected flow region in the west and non irrigation affected region in the east with separate equations for each region.



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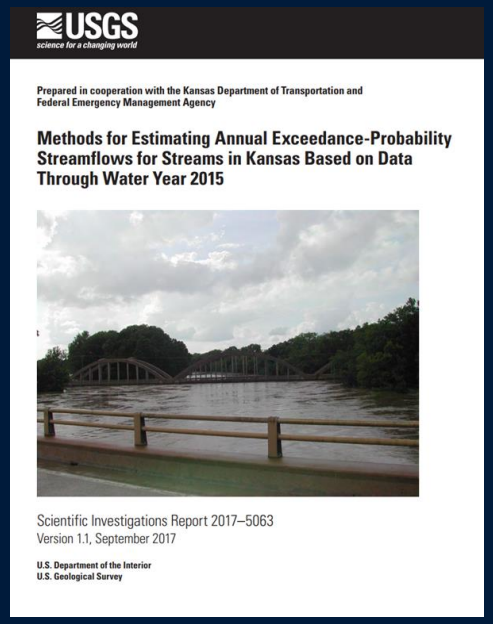
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- Fewer data points due to more thorough screening for multicollinearity.
- Better use of historical data for sites improves performance of prediction equations.
- Overall result is more accurate performance metrics for regression equations.

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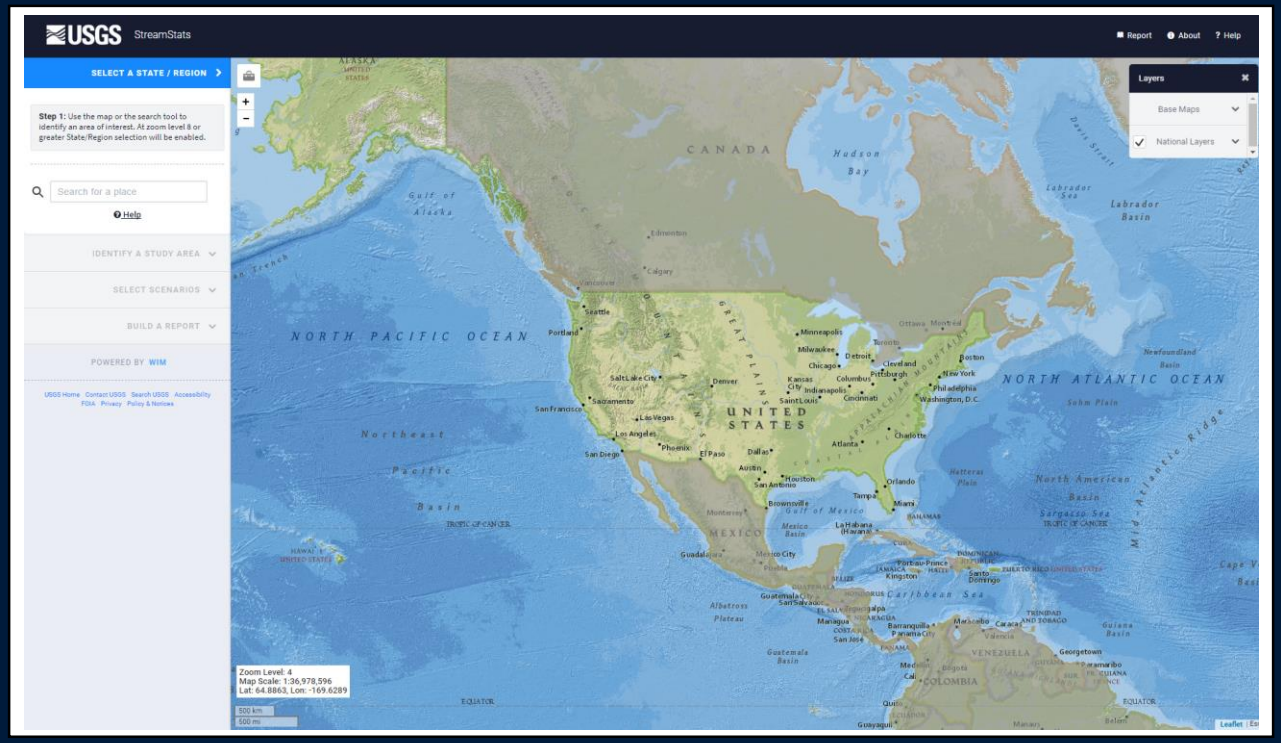
StreamStats



Interactive web application used for calculating basin characteristics and flow statistics for ungaged locations.

Current implementation for Kansas includes only flood frequency calculations, however capable of calculating other flow metrics.

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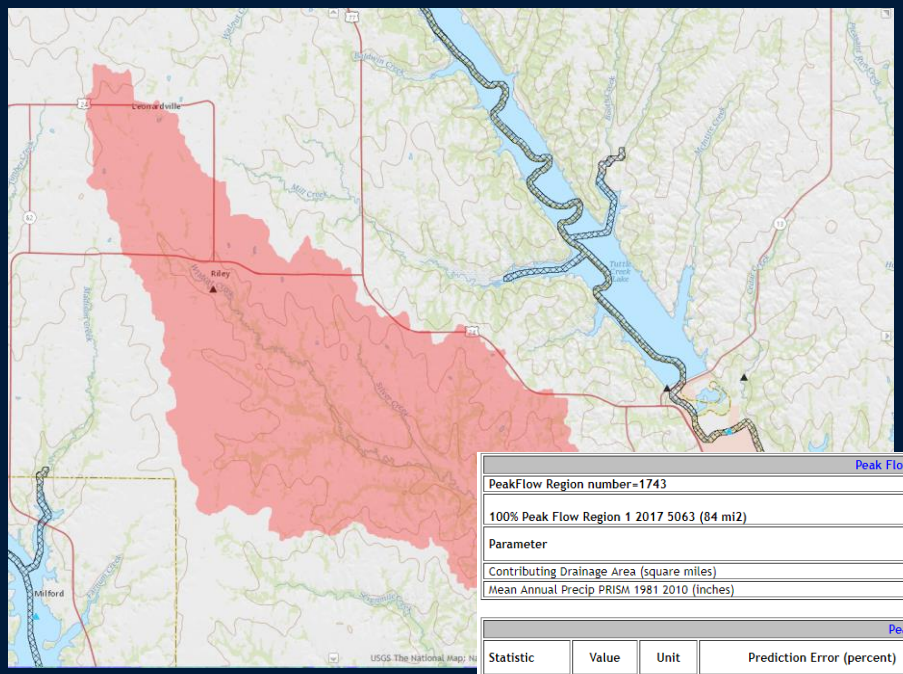
Assessing Peak Streamflow



Label	Value	Units	Definition
DRNAREA	92.07	square miles	Area that drains to a point on a stream
CONTDA	92.07	square miles	Area that contributes flow to a point on a stream (total drainage area minus non-contributing areas within basin)
NONCONTDA	0	square miles	Area within the delineated basin that does not contribute to the flow at the outlet of the basin
PRECPRIS10	33.1	inches	Basin average mean annual precipitation for 1981 to 2010 from PRISM
LC11BARSCB	0.03	percent	Percentage of barren and scrub land from NLCD classes 31, 51, and 52
LC11CRPHAY	18.4	percent	Percentage of cultivated crops and hay, classes 81 and 82, from NLCD 2011
LC11DEV	8.88	percent	Percentage of developed (urban) land from NLCD 2011 classes 21-24
LC11FOREST	13.411	percent	Percentage of forest from NLCD 2011 classes 41-43
LC11HERB	58.55	percent	Percentage of herbaceous from NLCD 2011 classes 71-74
LC11IMP	1.88	percent	Average percentage of impervious area determined from NLCD 2011 impervious dataset
LC11WATER	0.3	percent	Percent of open water, class 11, from NLCD 2011
LC11WETLND	0.43	percent	Percentage of wetlands, classes 90 and 95, from NLCD 2011
PCTREG1	100	percent	Percentage of drainage area located in Region 1
PCTREG2	0	percent	Percentage of drainage area located in Region 2
PKREGNO	1743		undefined

Peak Flows Region Grid Basin Characteristics

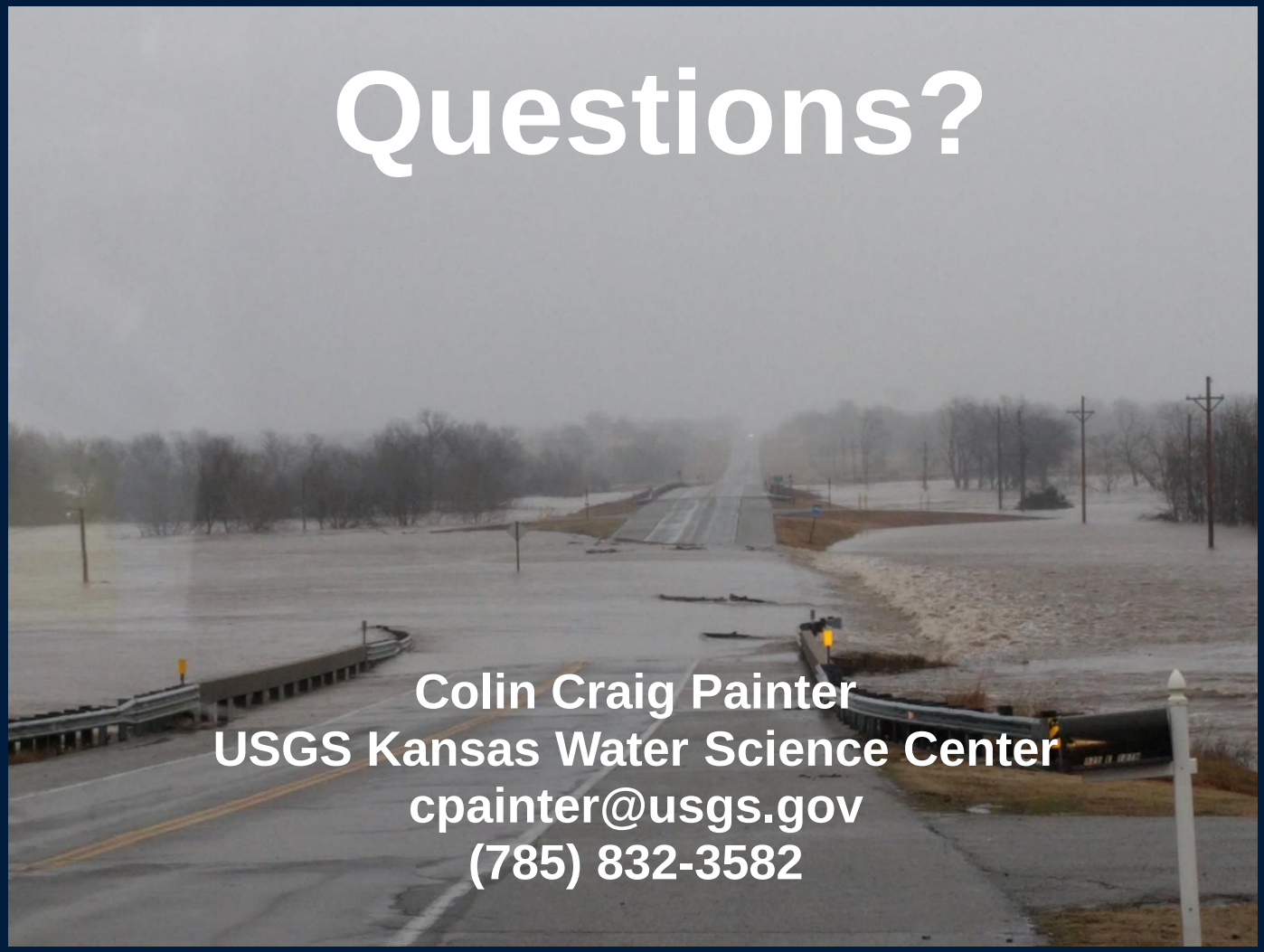
PeakFlow Region number=1743

100% Peak Flow Region 1 2017 5063 (84 mi2)

Parameter	Value	Regression Equation Valid Range	
		Min	Max
Contributing Drainage Area (square miles)	84	0.17	15000
Mean Annual Precip PRISM 1981 2010 (inches)	33	15.3	47

Peak Flows Region Grid Statistics

Statistic	Value	Unit	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
					Min	Max
PK2	2300	ft3/s	50			
PK5	4890	ft3/s	43			
PK10	7150	ft3/s	44			
PK25	10600	ft3/s	46			
PK50	13600	ft3/s	48			
PK100	16600	ft3/s	52			
PK200	20500	ft3/s	55			
PK500	25900	ft3/s	60			



Questions?

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