

# Culvert Design Process

Hydrology

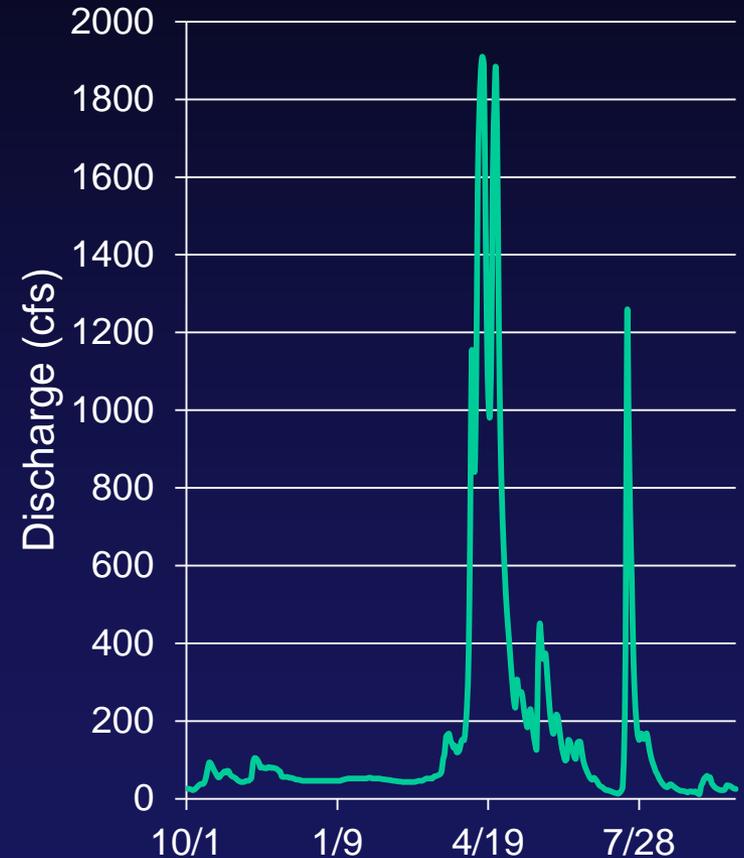
Site Assessment

Alignment and Profile

Bed and Banks

Structure

Sediment Mobility & Stability



# Hydrology

- Estimate flood flows
- Estimate by-pass flows

# Hydraulic analysis requires hydrologic data

- Wide range of flood flows to evaluate:
  - Peak hydraulic capacity, 100-yr flood
  - Sediment mobility and stability,  $<Q_{1.01}-Q_{500}$

100-yr flood = 1% exceedance probability each year

2-yr flood = 50% exceedance probability each year

- Hydrology data are also needed for:
  - By-pass flows during construction
  - Site assessment, Fishxing

# Hydrology concepts and terms

- Streamflow data
  - Collected at streamflow gaging stations
  - Used to estimate flows at ungaged sites
- Data are analyzed for:
  - Flood frequencies
  - Ave daily flows
  - Flow duration curves
  - Monthly flows

# National Streamflow Statistics (NSS) program



## The National Streamflow Statistics Program: A Computer Program for Estimating Streamflow Statistics for Ungaged Sites

Chapter 6 of  
Book 4, Hydrologic Analysis and Interpretation  
Section A, Statistical Analysis



Techniques and Methods 4-A6

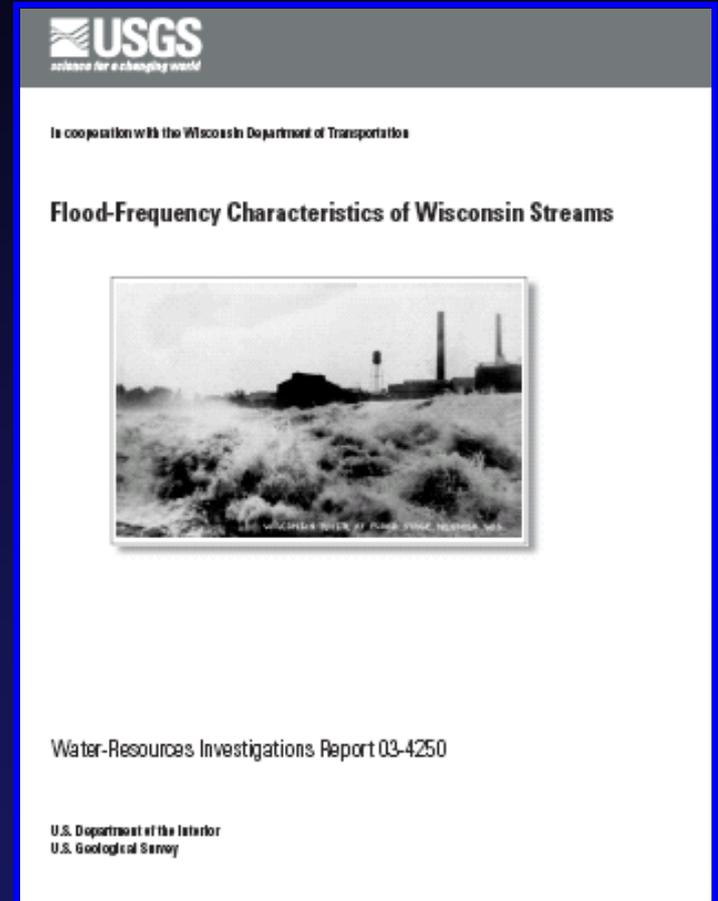
U.S. Department of the Interior  
U.S. Geological Survey

- Summary of flood frequencies at gage stations
- Methods for extrapolating data to ungaged sites
- Regional equations for flood frequencies and other streamflow statistics
- Computer Program: Version 4
  - Download software
  - Technical papers for each State
  - Latest equations for each State

<http://water.usgs.gov/osw/programs/nss.html>

# Technical publications for each state

Publications are available from the U.S. Geological Survey at the website listed below.



<http://water.usgs.gov/osw/programs/nss.html>



Location of Streamflow-Gauging Stations, Crest-Stage  
 Partial-Record Stations, and Regulated Stations in Wisconsin  
 by J.E. Walker and W.R. Krug, 2003

## Rural sites

Walker and Krug  
 (2003).

Flood Frequency  
 Characteristics  
 of Wisconsin  
 Streams.

USGS WRI-  
 Report 03-4250

## ESTIMATING MAGNITUDE AND FREQUENCY OF FLOODS FOR WISCONSIN URBAN STREAMS



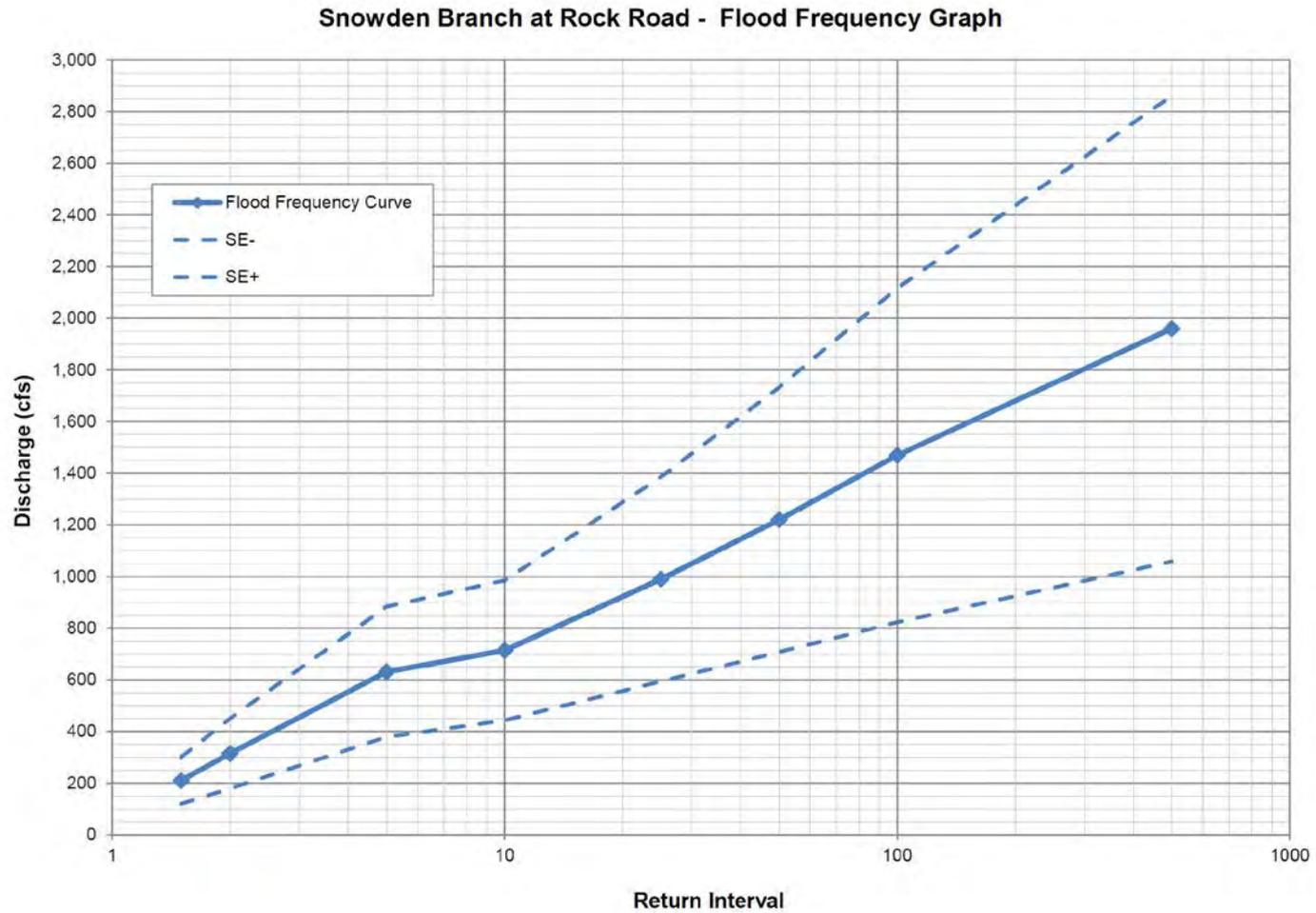
## Urban sites

Conger, D. H.  
(1986).

Estimating  
Magnitude and  
Frequency of  
Floods for  
Wisconsin  
Urban Streams.

USGS WRI-  
Report 86-4005

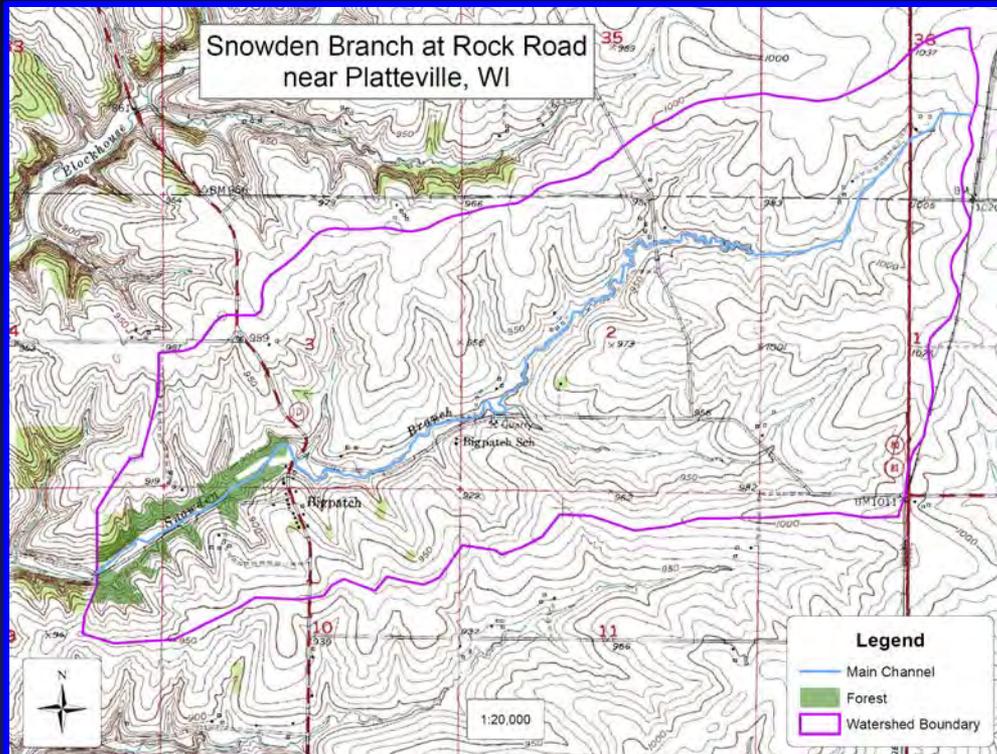
# Flood estimate and prediction error



# Hydrology

- Drainage Area
  - Delineate drainage area
  - Determine watershed characteristics
- Flood flow estimates
  - Estimate flood flows
  - Select design frequency

# WS area and characteristics



Drainage area = 3.48 sq mi

Forest = 2.41%

Channel slope = 41.2 ft/mi

Ppt 25-yr 24-hr = 5.29 in

# Snowden Branch at Rock Road

- WI Area 1

$$Q_2 = 99.9(A)^{0.652} \text{ FOR}^{-0.254} I_{25}^{7.52} \quad \text{SE: 43\%}$$

$$Q_{100} = 44.2(A)^{0.893} \text{ FOR}^{-0.312} I_{25}^{7.56} S^{0.571} \quad \text{SE: 44\%}$$

- Results:

- 100-yr = 1,470 cfs (422 cfsm)
- 2-yr = 315 cfs (91 cfsm)
- 1.5-yr = 210 cfs (60 cfsm)



**Table 5. Flood-frequency equations for Wisconsin urban areas**

Equation	Standard error of estimate (percent)
$Q_2 = 4.18 A^{0.706} / 1.02$	37
$Q_5 = 9.97 A^{0.739} / 0.910$	32
$Q_{10} = 14.7 A^{0.723} / 0.863$	32
$Q_{25} = 21.5 A^{0.712} / 0.818$	33
$Q_{50} = 27.0 A^{0.707} / 0.792$	35
$Q_{100} = 32.8 A^{0.704} / 0.770$	37

## Urban sites

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**Table 7. Total impervious area (percent) within land-use categories**

Land-use category	Typical values of total impervious area (percent)		
	Low	Intermediate	High
Single-family residential <sup>1</sup>	16	27	45
Multifamily residential <sup>2</sup>	50	60	70
Commercial <sup>3</sup>	80	88	96
Industrial <sup>4</sup>	60	75	90
Public facilities <sup>5</sup>	50	60	75
Parks and undeveloped land <sup>6</sup>	0	1	3

<sup>1</sup> Single-family residential—Single-family dwellings predominate.

<sup>2</sup> Multifamily residential—Multiple-family units predominate. These include duplexes, apartment buildings, and condominiums.

<sup>3</sup> Commercial—Zones consisting of various types of business.

<sup>4</sup> Industrial—Manufacturing complexes, railroad yards, and large utilities.

<sup>5</sup> Public facilities—Schools, hospitals, churches, airports, and other public buildings.

<sup>6</sup> Parks and undeveloped land—Parks, forests, and open undeveloped land.

# Flood flow exercise

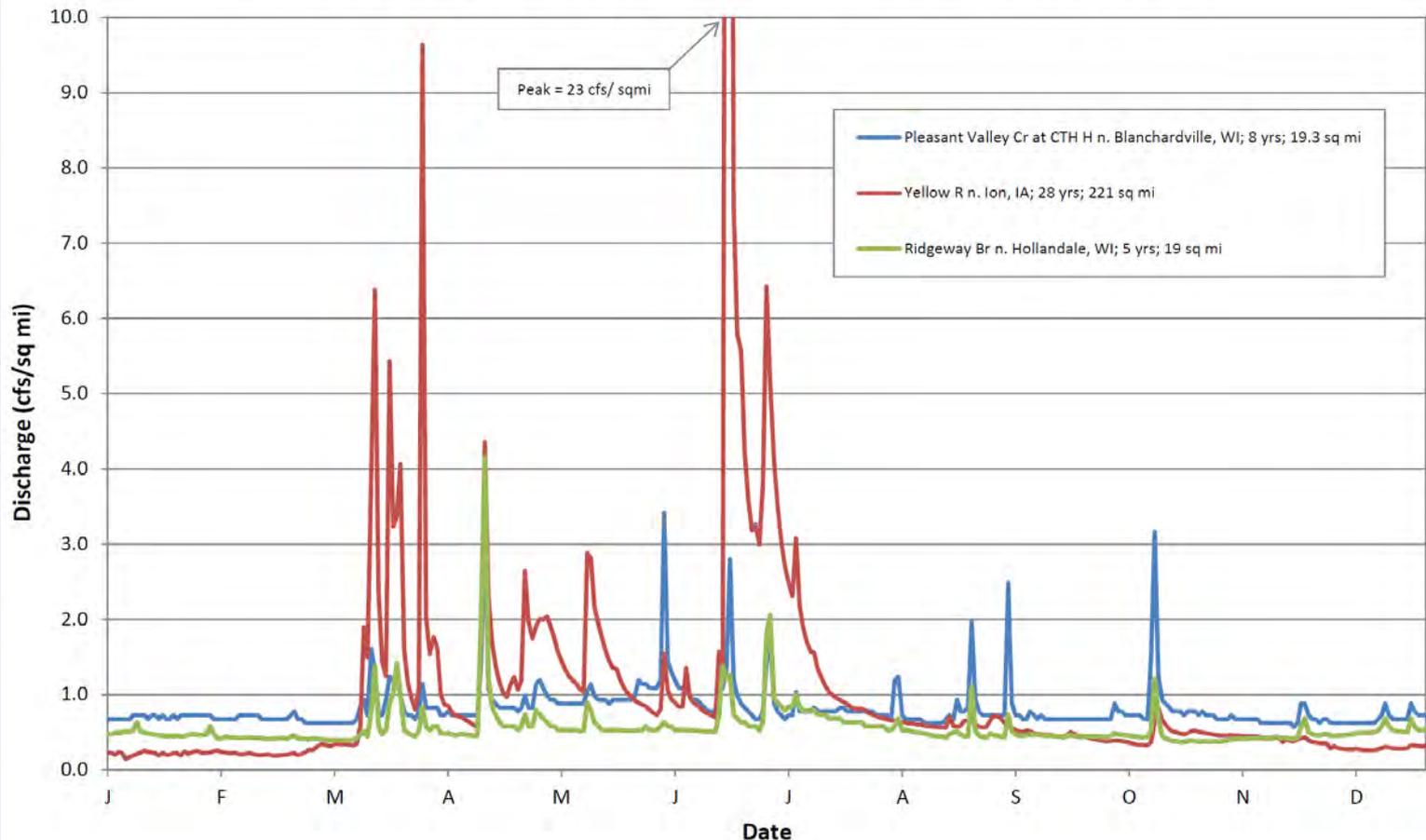
# Hydrology

## By-pass flows

- Determine construction period
- Select typical and upper by-pass flows from flow duration curve or monthly flows

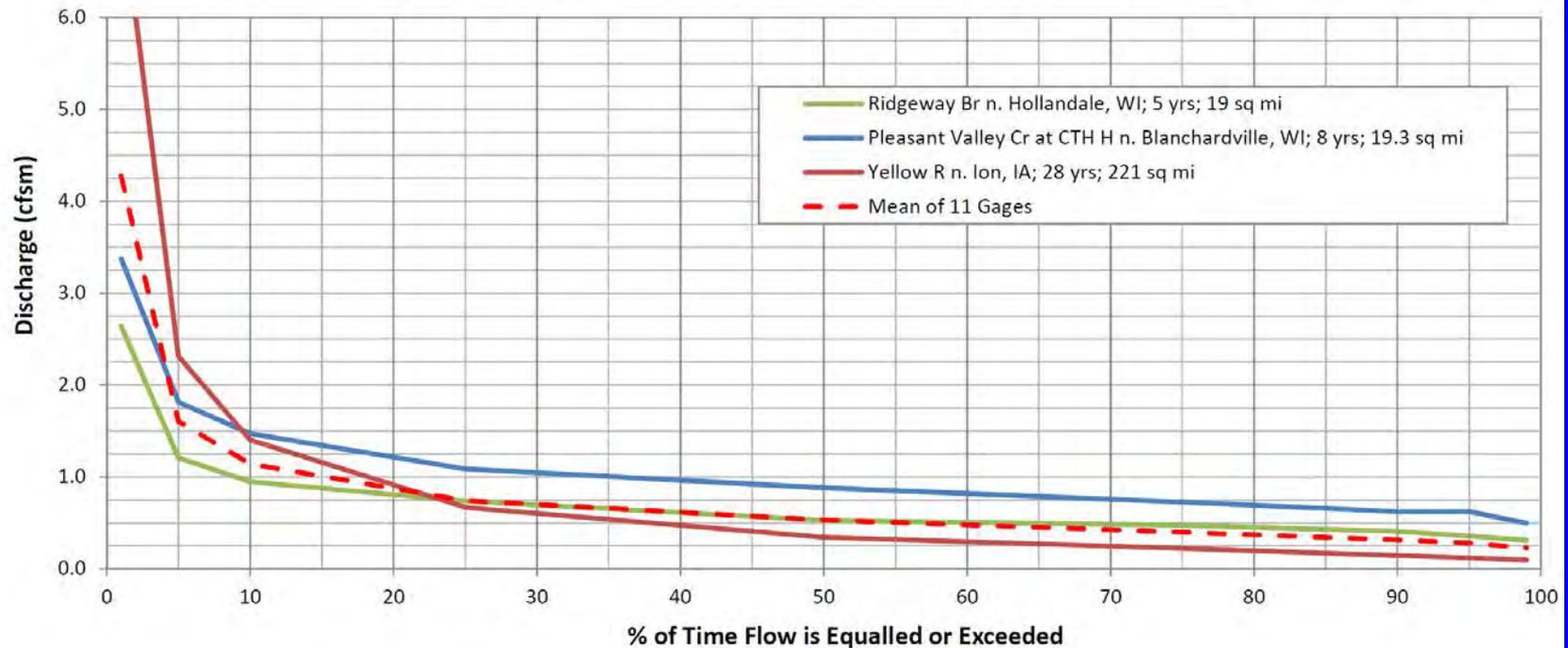
# Ave daily runoff for watersheds near Platteville WI

## Average Daily Flow for 3 Gages Near Platteville, WI for 2014



# Flow duration curves for USGS gages near Platteville, WI

## Flow Duration Curves for Platteville, WI Area



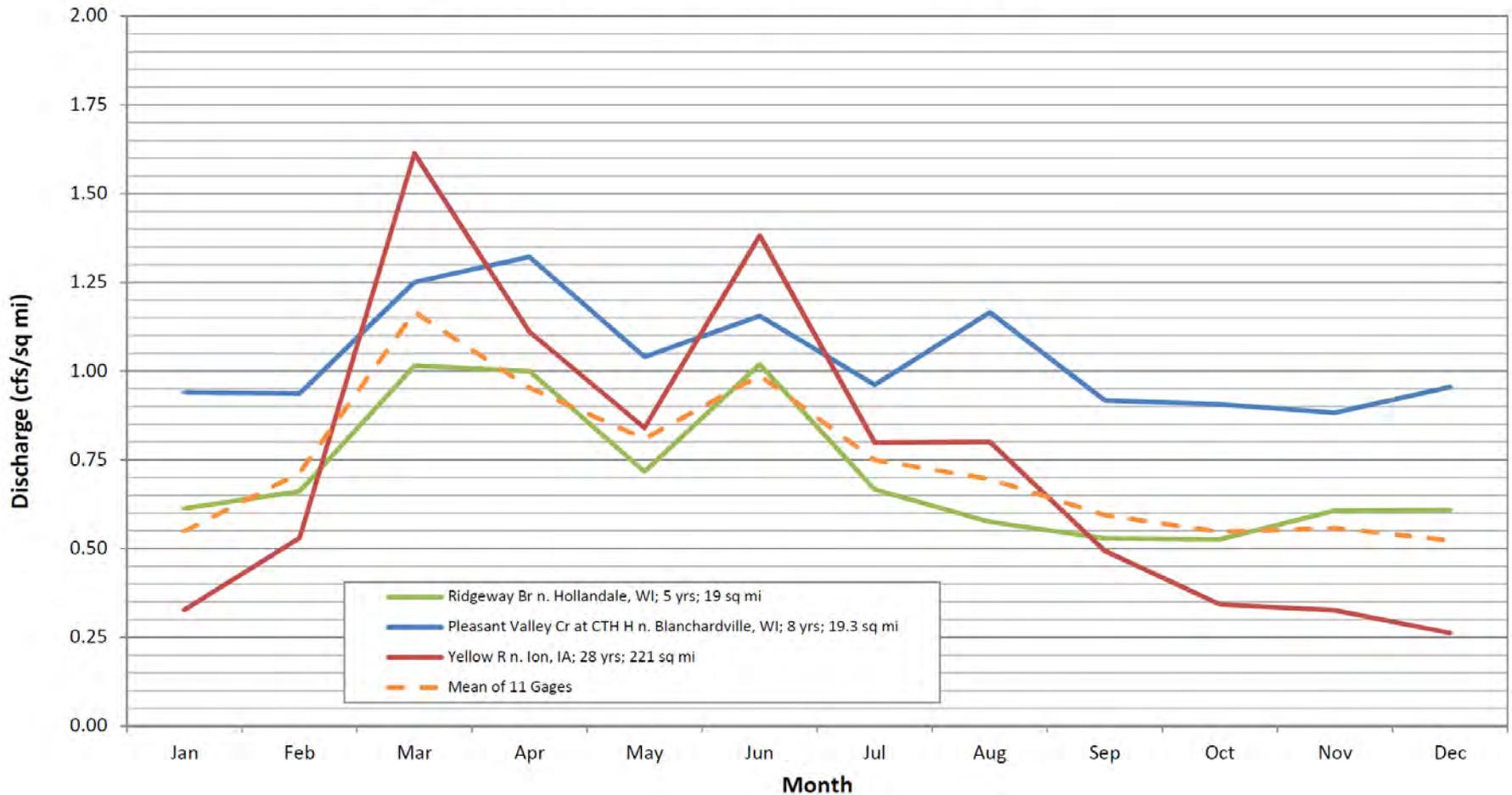
# By-pass flows

Rountree Trib Crossing Drainage Area = 0.64 sq mi

% Time Exceeded	Platteville Mean 11 Gages (cfsm)	Est Unt Rountree Flow (cfs)
1	4.28	2.64
5	1.60	1.03
10	1.14	0.73
50	0.53	0.34
90	0.31	0.20
95	0.28	0.18
99	0.23	0.15

# Ave monthly runoff near Platteville, WI

## Average Monthly Flows for Platteville, WI Area



# By-pass flow: Pumping estimate based on average monthly flow

Unt Rountree Site, Drainage Area = 0.64 sq mi

July Ave Flow =  $0.75 \text{ cfs/sq mi} \times 0.64 \text{ sq mi} = 0.48 \text{ cfs}$   
or 215 gal/min



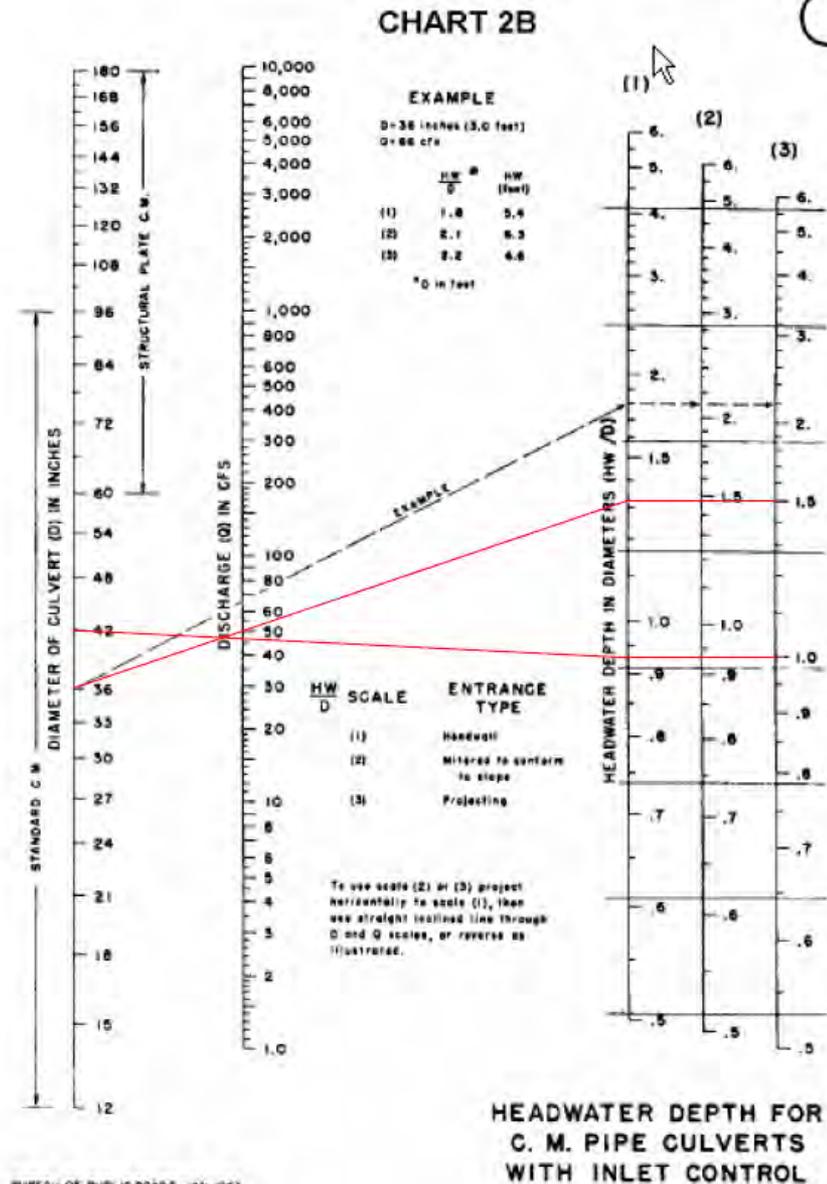
# By-pass flow: Diversion pipe

Trout Tributary at County U

Drainage area = 4.19 sq mi

$$Q_2 = 40 \text{ cfs}$$

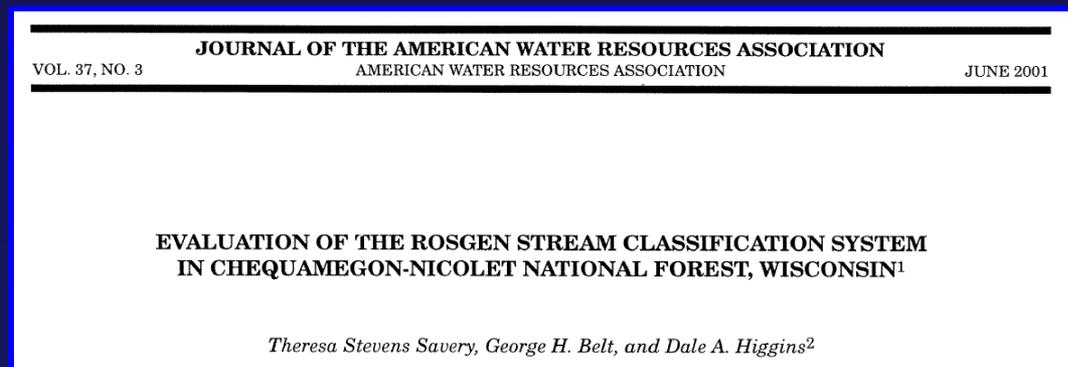
Trout Cr at Cty U Bypass



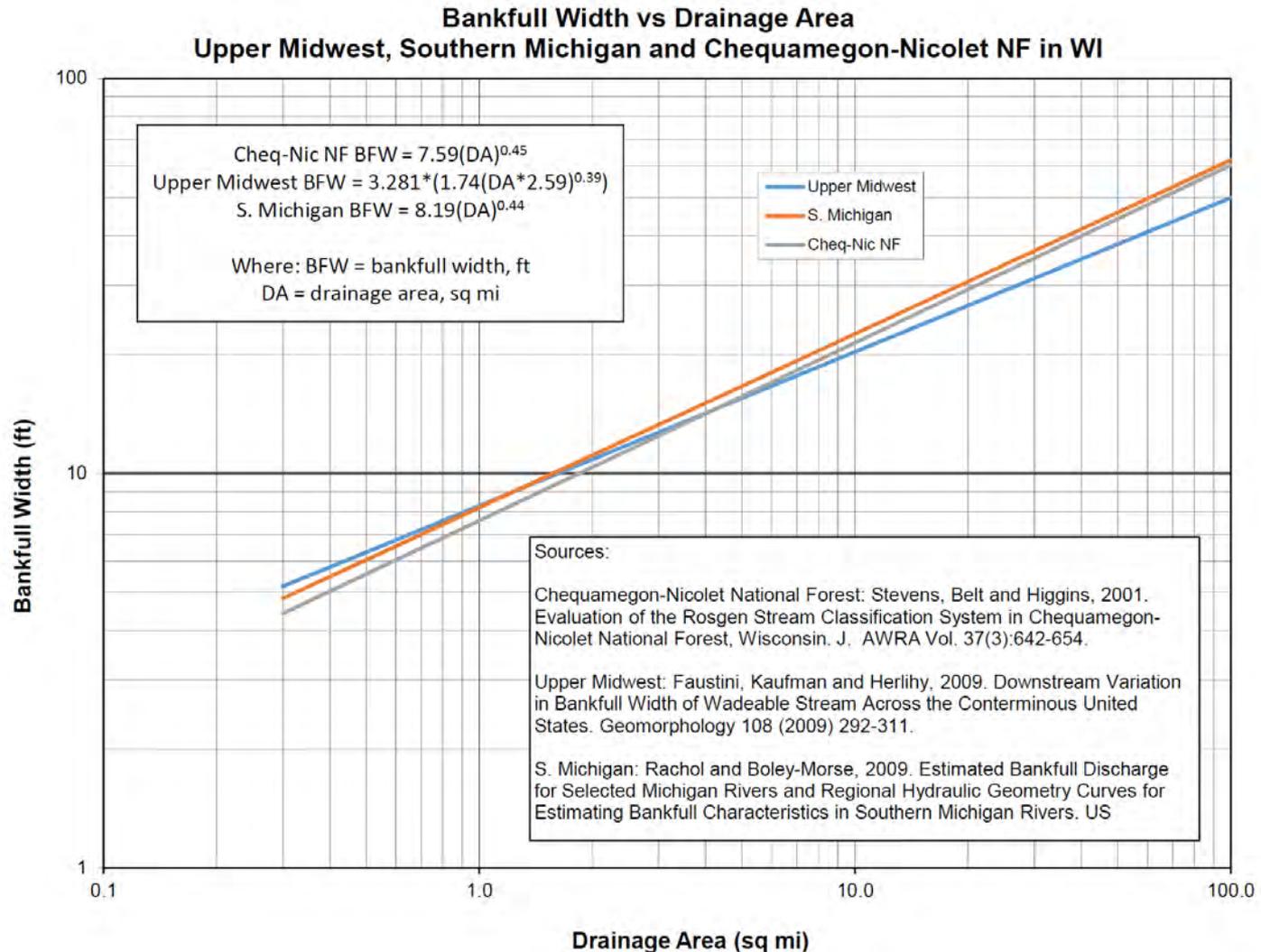
# Bankfull (BF) Channel Geometry Relations



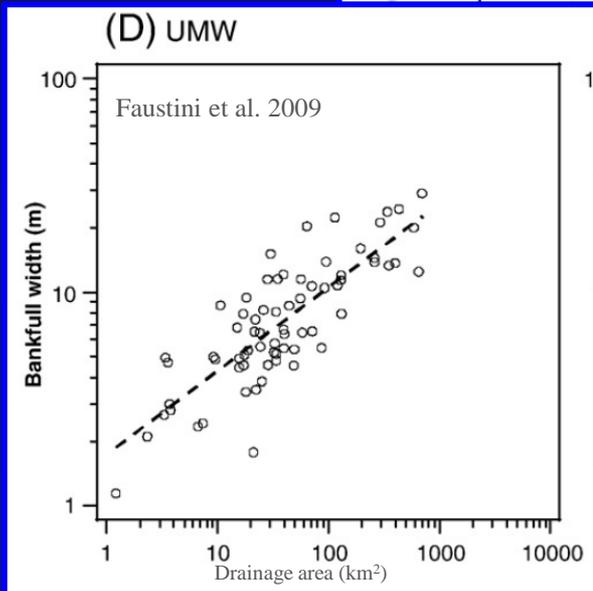
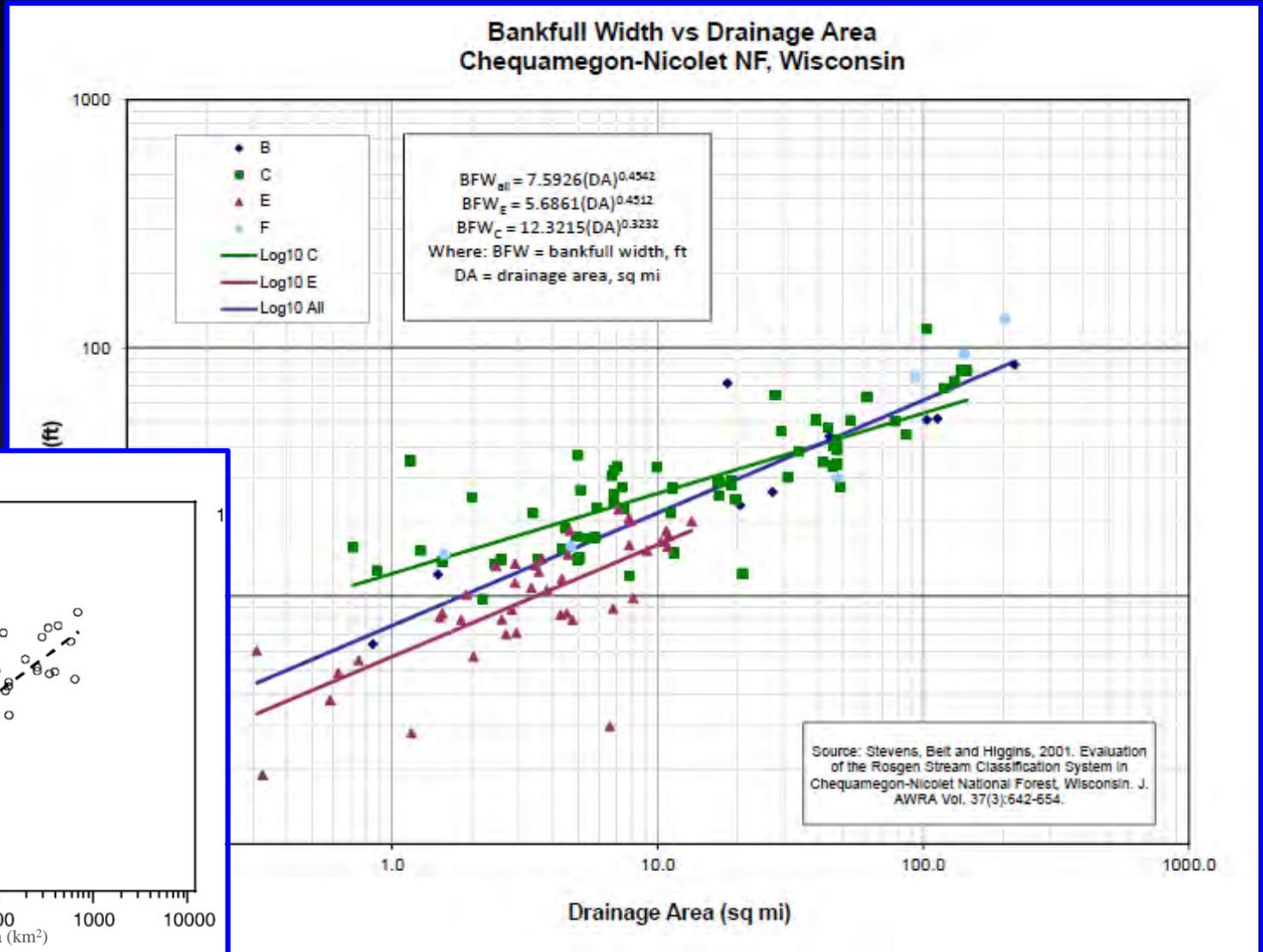
- Relate drainage area to BF channel dimensions
- Allow “office” estimates of BF width and depth
- Provide a starting point for field determination of BF
- Have scatter due differences in runoff rates and landforms



# Channel Geometry Relations



# Bankfull Channel Geometry Relations



# By-pass flow exercise