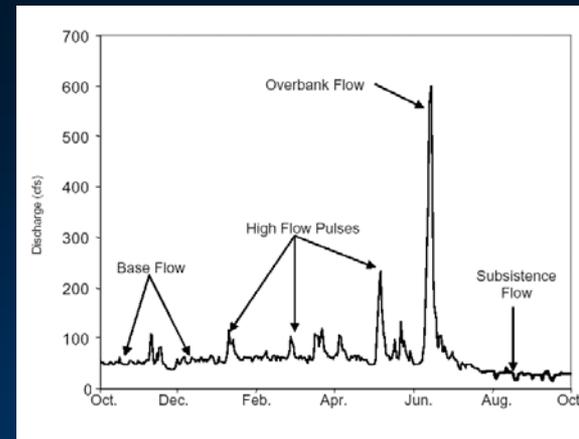


Introduction to the Hydrology-based Environmental Flow Regime Method



Flow Category	Flow Statistics											
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Overbank Flows	Qp: 17,800 cfs with Average Frequency 1 per 5 years Regressed Volume is 75,227 to 104,925 (90,126) Regressed Duration is 10 to 54 (23)											
High Flow Pulses	Qp: 6,180 cfs with Average Frequency 1 per 2 years Regressed Volume is 18,502 to 47,434 (32,968) Regressed Duration is 6 to 33 (14)											
	Qp: 1,340 cfs with Average Frequency 1 per year Regressed Volume is #N/A to 21,939 (7,442) Regressed Duration is 3 to 16 (7)											
	Qp: 74 cfs with Average Frequency 1 per 2 seasons Regressed Volume is #N/A to 1,578 (1088) Regressed Duration is 1 to #N/A	Qp: 205 cfs with Average Frequency 1 per 2 seasons Regressed Volume is #N/A to 12,325 (11,282) Regressed Duration is 1 to #N/A	Qp: 1,130 cfs with Average Frequency 1 per 2 seasons Regressed Volume is #N/A to 39,231 (9,854) Regressed Duration is 1 to #N/A									
Base Flows (cfs)	23 (30.9%) 12 (58.5%) 6.8 (75.4%)	20 (33.0%) 16 (54.5%) 9.6 (76.7%)	23 (35.4%) 14 (56.8%) 8.3 (77.4%)	23 (38.0%) 12 (61.1%) 6.9 (77.3%)								
Subsistence Flows (cfs)	0.7 (99.0%)	0.3 (99.8%)	0.6 (99.3%)	0.7 (98.2%)								
Flow Levels	High (75th %ile) Medium (50th %ile) Low (25th %ile) Subsistence											

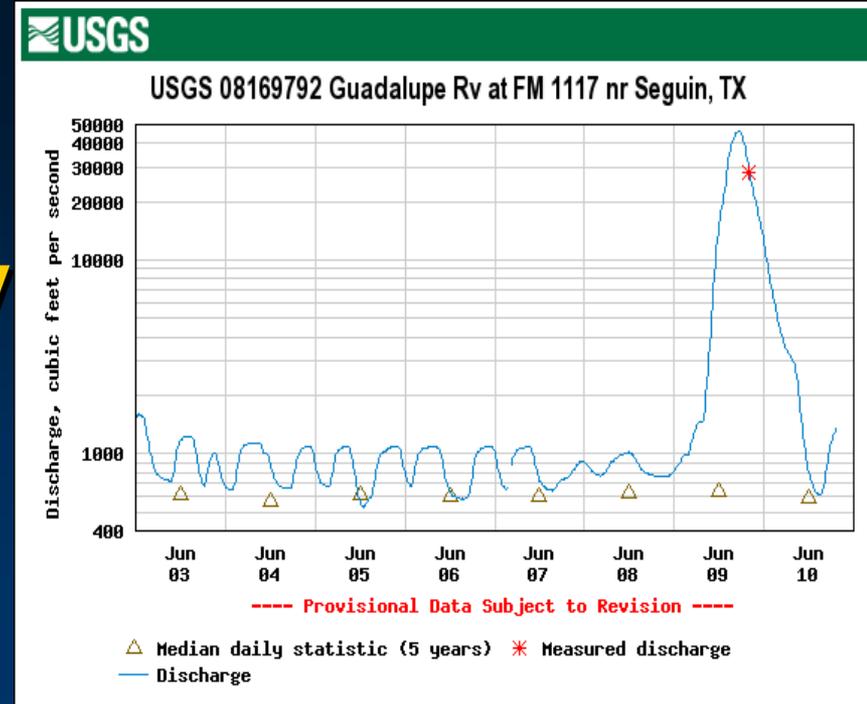
Dan Opdyke, TPWD

Presentation to Guadalupe-San Antonio BBEST
June 11, 2010



Rationale for Using Hydrology

- SB 3 timelines are aggressive and budgets are tight
- Hydrology has been considered the "master variable" (Poff et al., 1997 as cited in NRC, 2005)
- Hydrologic data are
 - Widely available for a long period of time
 - Consistently measured
 - Fairly easy to work with
- Most appropriate in context of larger multidisciplinary effort



SAC Hydrology Guidance

Use of Hydrologic Data in the Development of Instream Flow Recommendations for the Environmental Flows Allocation Process and the Hydrology-Based Environmental Flow Regime (HEFR) Methodology

- **From the cover letter:**
 - *Hydrologic data analysis is an important first step in developing an environmental flow regime, but it provides only an initial estimate of flow requirements.*
 - *The SAC believes that the HEFR methodology might prove useful as a first step in developing instream flow recommendations, and we recommend that the BBESTs consider its utility...*

Texas Instream Flow Program

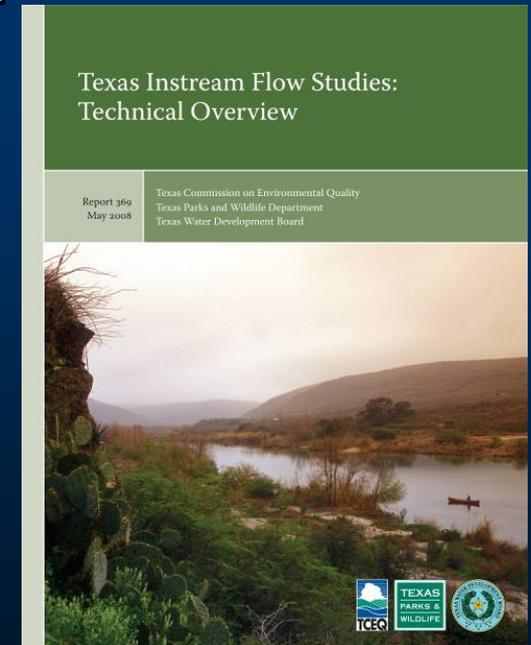


<http://www.twdb.state.tx.us/instreamflows/index.html>

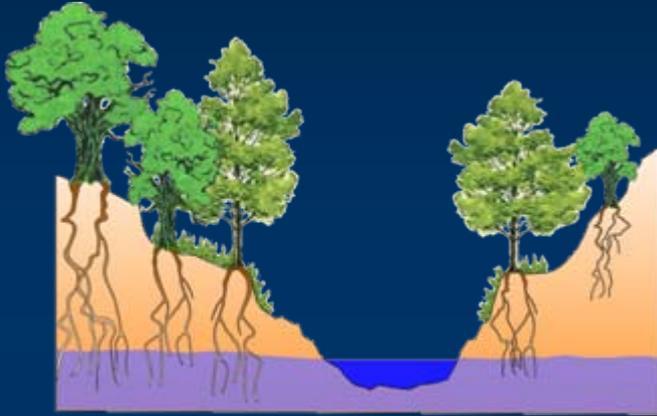
Program reviewed by NAS

Technical Overview Document

- Includes four flow components
 - Subsistence flows
 - Base flows
 - High Flow Pulses
 - Overbank Events



Subsistence Flows



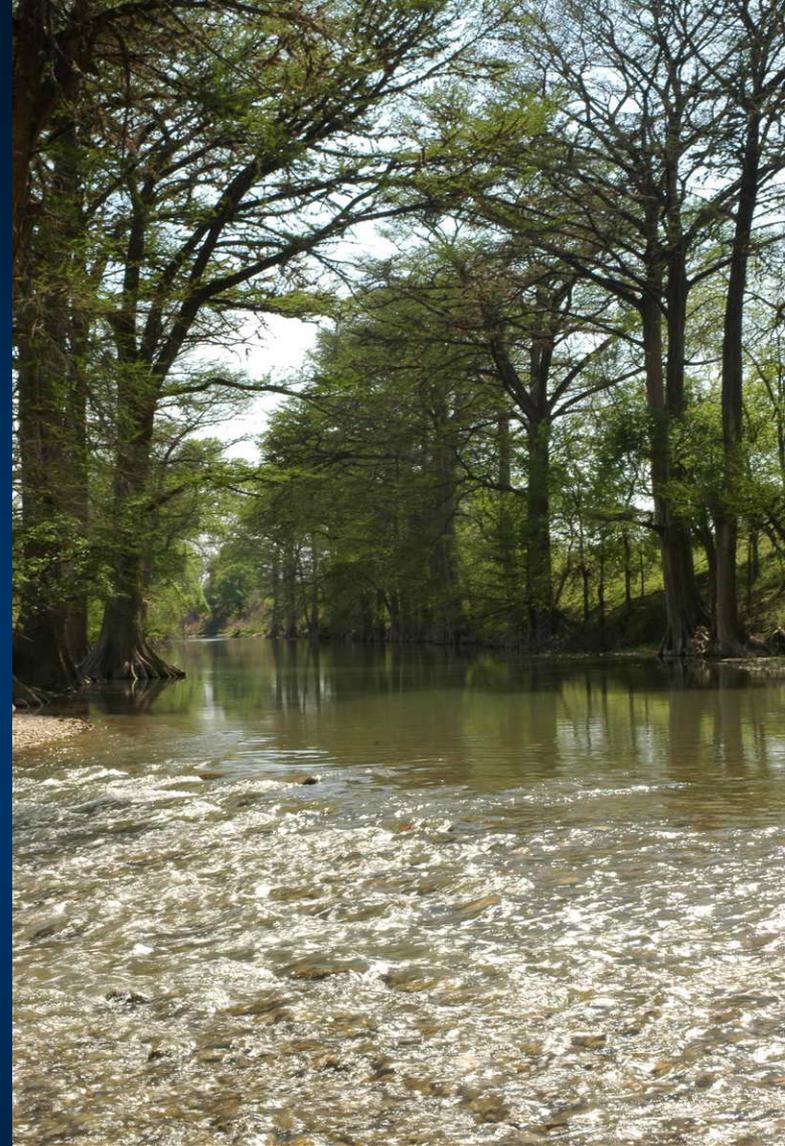
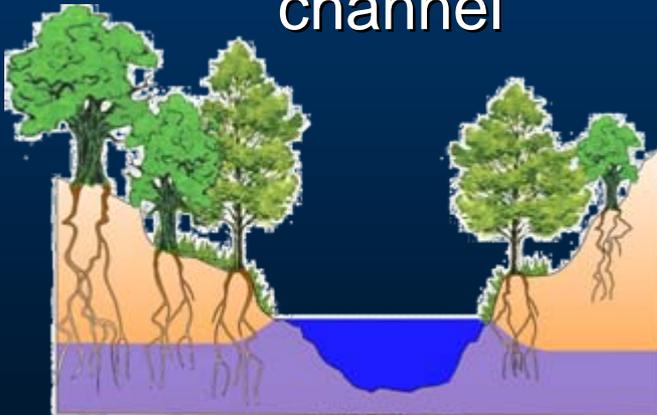
Ecological Roles

- Protect water quality and critical habitat during very dry times
- Provides limited connectivity

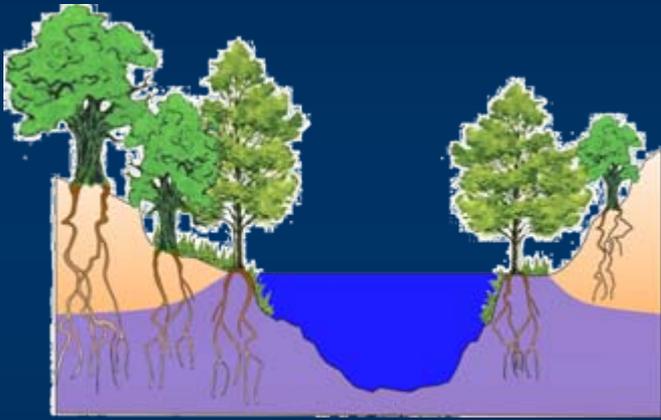
Base Flows

Ecological Roles

- Provide suitable habitat
- Maintain diversity
- Maintain water table for riparian vegetation
- Provide connectivity along channel



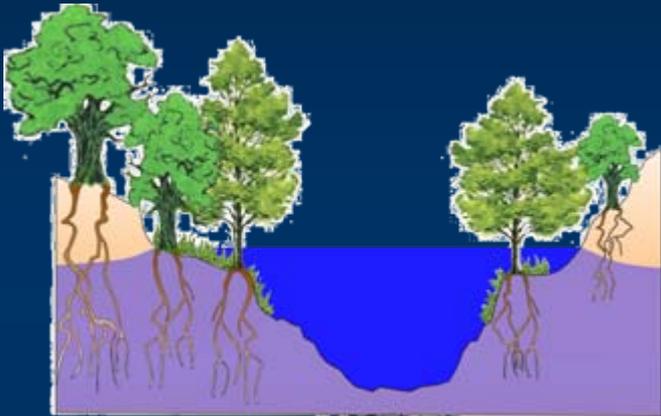
High Flow Pulses



Ecological Roles

- Provide spawning cues
- Prevent riparian vegetation from encroaching into channel
- Restore water quality following drought

Overbank Events



Ecological Roles

- Shape physical habitats
- Provide migration and spawning cues
- Facilitate exchange of nutrients, sediments, woody debris

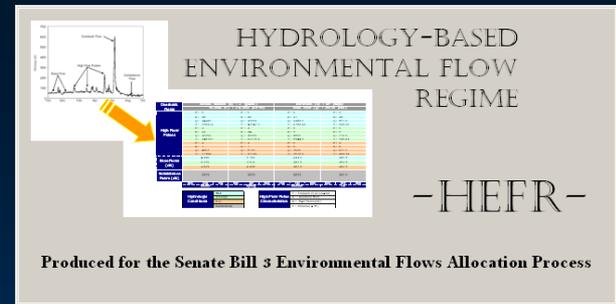
HEFR Basics

Uses hydrologic data

Computations are rapid

Populates a flow regime matrix

A hydrological tool for
an ecological purpose



(1) Select Flow Gage

(2) Select Period of Record

(3) Separate (parse) Hydrograph into Flow Components

(4) Generate Statistical Summaries in Excel

(1) Select Flow Gage

Many to choose from

SAC has “Geographic Scope” guidance

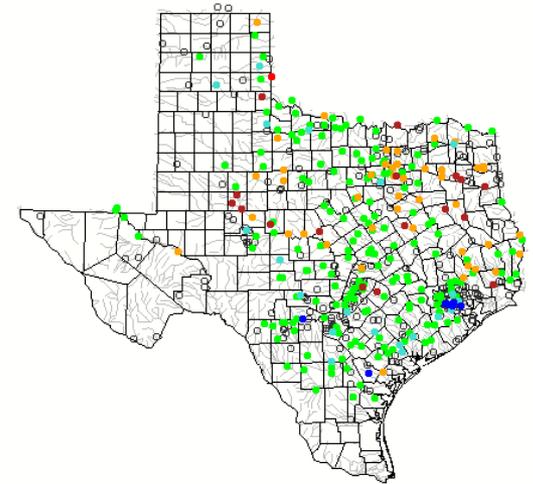
USGS TX “Core” Network documented here:

<http://pubs.usgs.gov/wri/wri014155/>

Daily Streamflow Conditions

Select a site to retrieve data and station information.

Tuesday, June 08, 2010 13:30ET



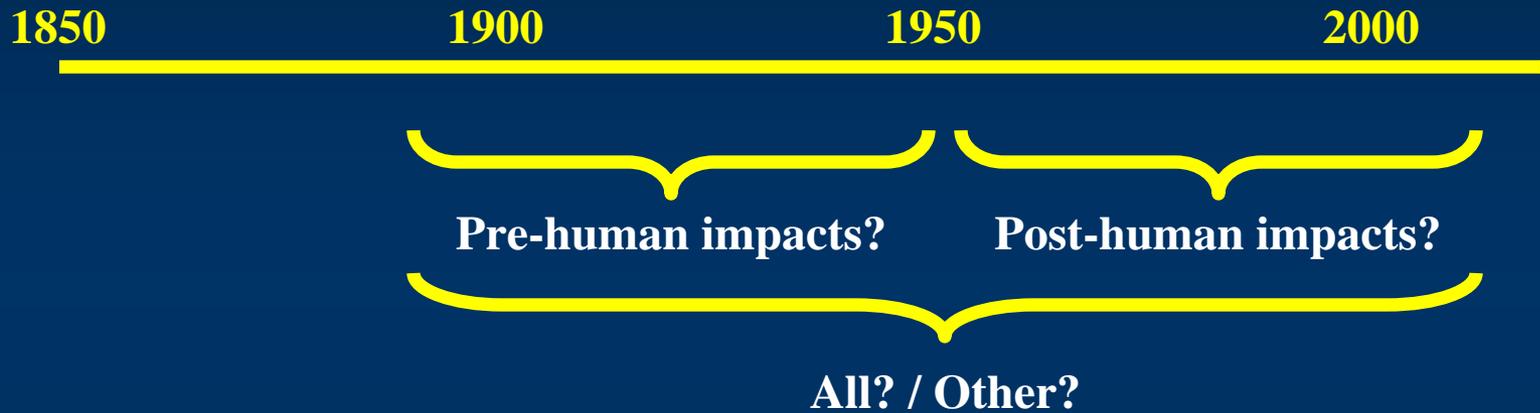
USGS

Explanation

- High
- ≥ 90 th percentile
- 75th - 89th percentile
- 25th - 74th percentile
- 10th - 24th percentile
- < 10 th percentile
- Low
- Not ranked

<http://waterdata.usgs.gov/tx/nwis/rt>

(2) Select Period of Record



May vary by gage

Consider human influences and climate change

Some discussion in Section 4 of Hydrologic Methods document, LSWP docs, etc.

Many debates among older BBESTs

(3) Separate (parse) Hydrograph

Two Options

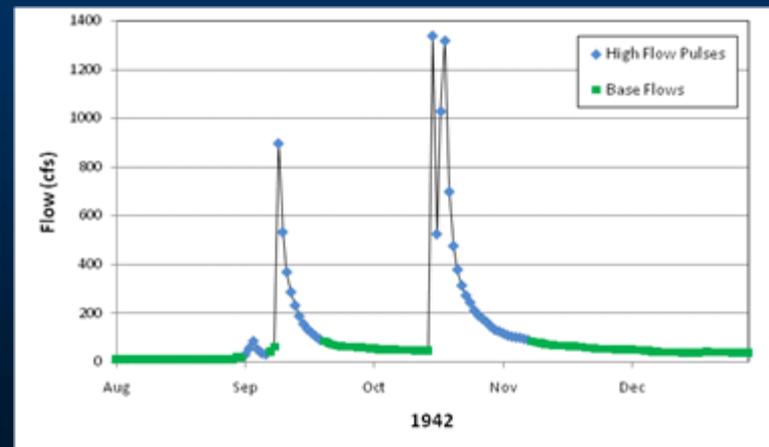
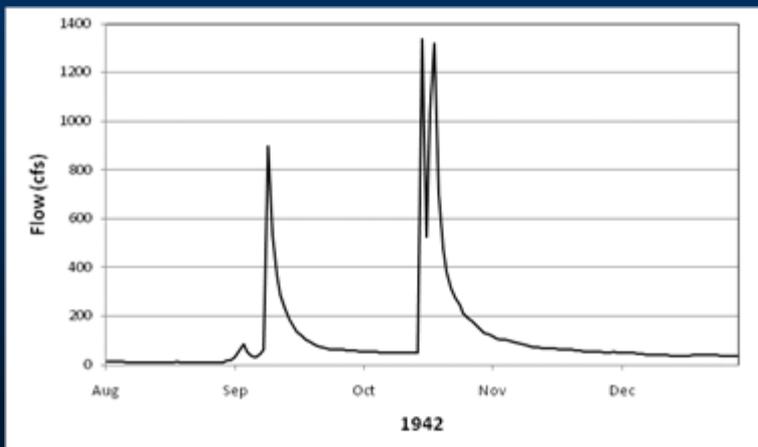
1. Indicators of Hydrologic Alteration (IHA)

- Environmental Flow Components function

2. Modified Base Flow Index with Threshold (MBFIT)

- Bureau of Reclamation method with modifications for SB 3

Both split the hydrograph into IFCs



(3) Separate (parse) Hydrograph

Traditional Base Flow Separation

- Each day has both a base flow and runoff component
- Emphasis is on dominant source of water
 - Rate of change perhaps more important than flow magnitude

Hydrographic Separation for Env Flows

- Each day has only one component
- Emphasis is on dominant ecologic function
 - Instream habitat, spawning cues, sediment transport, etc.
 - Flow magnitude perhaps more important than rate of change

(4) Generate Statistical Summaries in Excel

HEFR uses Excel to generate summary statistics of each IFC

- Subsistence
- Base Flow
- High Flow Pulses
- Overbank Events

Outputs may include:
flow, volume, duration, frequency

HEFR Input Window

The screenshot shows the HEFR Inputs window with the following sections and controls:

- Subsistence Flows:** Radio buttons for "Subsistence Flows Threshold (%ile)" (set to 0.5) and "Q95". A text box for "Water Quality Protection Flow (cfs)".
- High Flow Pulses:** A checkbox for "Multipeaks_Multiplier".
- Overbank Events:** A checkbox for "Multipeaks_Multiplier" and a text box for "Estimate Of Bankfull (cfs)".
- Flow Recommendation Levels:** Radio buttons for "Low" (0.25), "Medium" (0.5), and "High" (0.75).
- HEFR Run Descriptive Information:** Text boxes for "USGS Gage ID" and "Start Month of First Season" (set to December). A dropdown for "Episodic Events Option" (set to Percentile Approach) and a dropdown for "Season Type" (set to Normal).
- Define High Flow Pulses and Overbank Events by:** Checkboxes for "Peak Flow", "Volume", and "Duration".
- Intermittent Streams:** A checkbox for "Calculate subsistence and base flow statistics based on non-zero flows only".
- IHA:** Text boxes for "IHA Projects Directory" and "Name of the IHA Analysis".
- Buttons:** "Check Inputs", "Run HEFR", "Exit HEFR", and "Help".
- Watch Window:** A section for displaying information about various inputs and other status messages.

Brief Overview of Decision Points

Seasons

- Highly flexible
- Consider flow patterns, spawning, temperature

Non-Zero flows only

- Use to limit flow computations to days with measured flows
- Zero flow frequencies and durations handled separately

Brief Overview of Decision Points

Subsistence

- User-specified percentile of subsistence flow days
- Q95
- Water Quality Protection Flow

Base Flows

- Up to three levels: low, medium, high
- Percentiles assigned by analyst

Brief Overview of Decision Points

High Flow Pulses and Overbank Events

- **Multipeaks_Multiplier**
 - IHA will not identify discrete pulses or events unless separated by a base flow day
 - Using M_M, HEFR will identify discrete pulses and events
- **Methodology**
 - Percentile Approach
 - Frequency Approach

Brief Overview of Decision Points

Frequency Approach

- Tiers
 - For example, “one per two years” event
- Regression forms
 - For volume and duration characteristics
 - Log/Log or quadratic
 - Confidence level

Illustrative HEFR Output

Flow Components

Overbank Flows	Qp: 17,800 cfs with Average Frequency 1 per 5 years Regressed Volume is 75,327 to 104,925 (90,126) Regressed Duration is 10 to 54 (23)											
	Qp: 6,180 cfs with Average Frequency 1 per 2 years Regressed Volume is 18,502 to 47,434 (32,968) Regressed Duration is 6 to 33 (14)											
High Flow Pulses	Qp: 1,340 cfs with Average Frequency 1 per year Regressed Volume is #N/A to 21,899 (7,442) Regressed Duration is 3 to 16 (7)											
	Qp: 74 cfs with Average Frequency 1 per 2 seasons Regressed Volume is #N/A to 1,576 (580) Regressed Duration is 1 to			Qp: 205 cfs with Average Frequency 1 per 2 seasons Regressed Volume is #N/A to 12,325 (1,282) Regressed Duration is 1 to			Qp: 1,130 cfs with Average Frequency 1 per 2 seasons Regressed Volume is #N/A to 33,331 (8,856) Regressed Duration is 2 to					
	Qp: 37 cfs with Average Frequency 1 per season Regressed Volume is #N/A to 1,498 (501) Regressed Duration is 1 to						Historical Frequency					
	23 (30.9%)			20 (33.0%)			23 (35.4%)			23 (38.0%)		
	12 (58.5%)			16 (54.5%)			14 (56.8%)			12 (61.1%)		
Base Flows (cfs)	6.8 (75.4%)			9.6 (76.7%)			8.3 (77.4%)			6.9 (77.3%)		
Subsistence Flows (cfs)	0.7 (99.0%)			0.3 (99.8%)			0.6 (99.3%)			0.7 (98.2%)		
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
	Winter			Spring			Summer			Fall		
Flow Levels	High (75th %ile)											
	Medium (50th %ile)											
	Low (25th %ile)											
	Subsistence											

Flow in cfs

Historical Frequency

Months and Seasons

How Does HEFR Compare to Other Methods?

Hydrologic Methods used in Texas

7Q2

- lowest average stream flow for seven consecutive days with a recurrence interval of two years
- A water quality metric – generally not recommended for environmental flows

Lyons

- 40% of monthly median Oct-Feb
- 60% of monthly median Mar-Sep
- Has been considered the “default” TCEQ approach

Hydrologic Methods used in Texas - Continued

Consensus (CCEFN)

- Direct Diversion:
 - 50th %ile, 25th %ile, 7Q2, all based on naturalized flows
- Often used in regional water planning

HEFR

- Used by previous BBESTs
- A precursor of HEFR contributed to the BRA System Operations draft permit

How Do These Compare

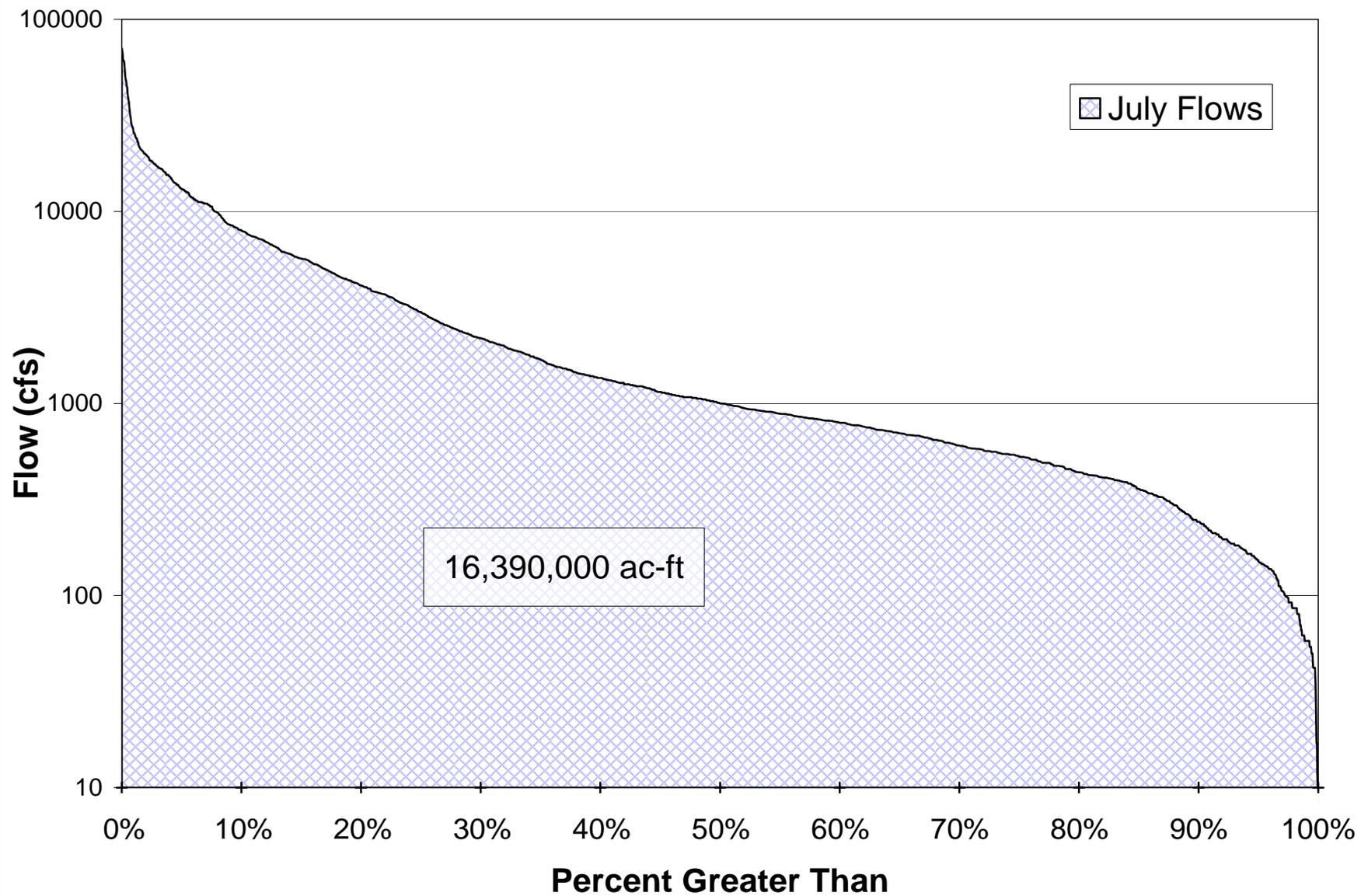
7Q2, Lyons, and CCEFAN calculations are prescriptive,
i.e., no flexibility

HEFR has multiple input parameters at the disposal of
the analyst

All are based on historical (or naturalized) flows

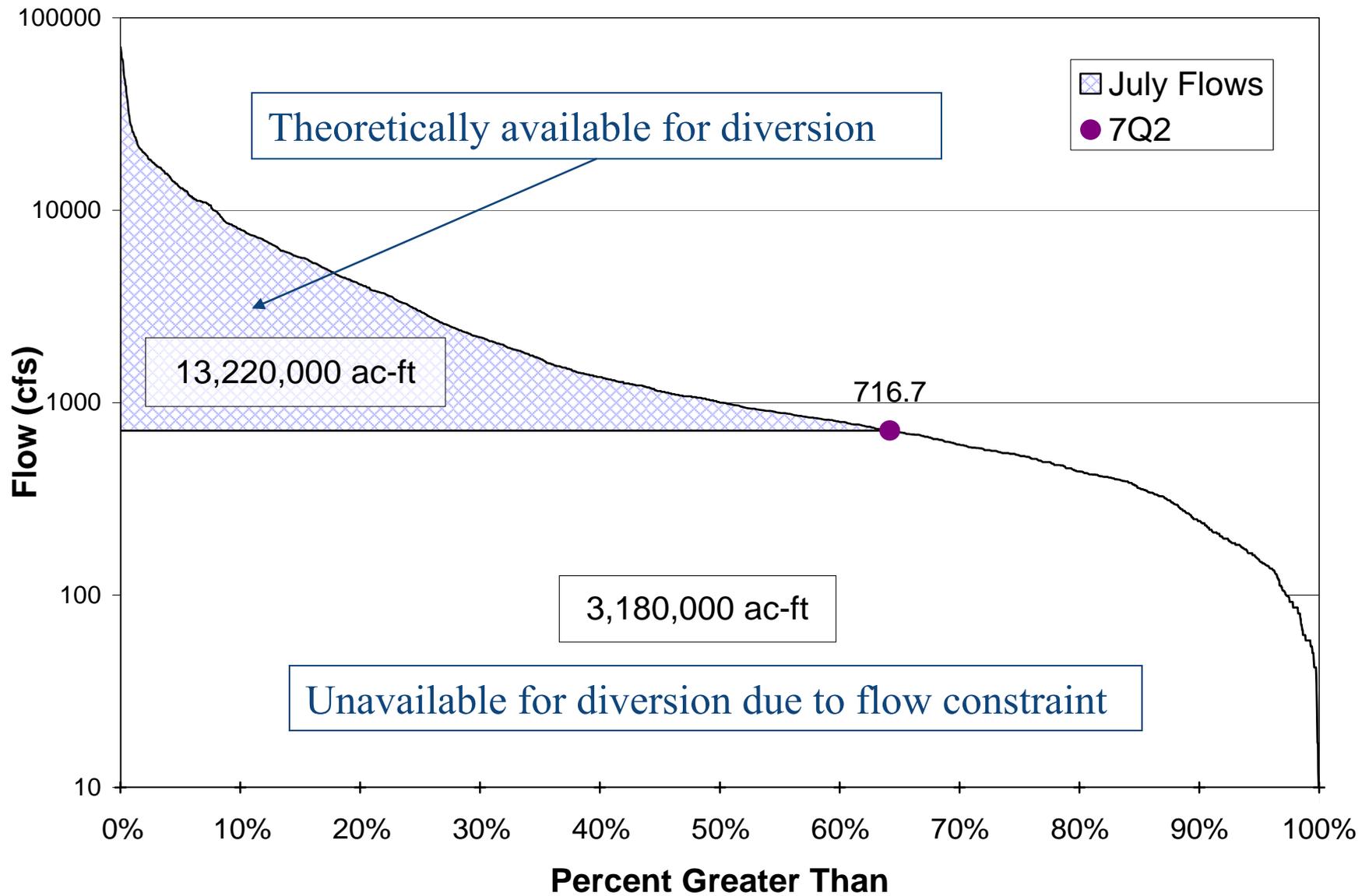
The following slides have a visual comparison of these
hydrologic calculations

- Trinity River at Oakwood
- Full period of record (1924-2009, 86 years) July flows
only

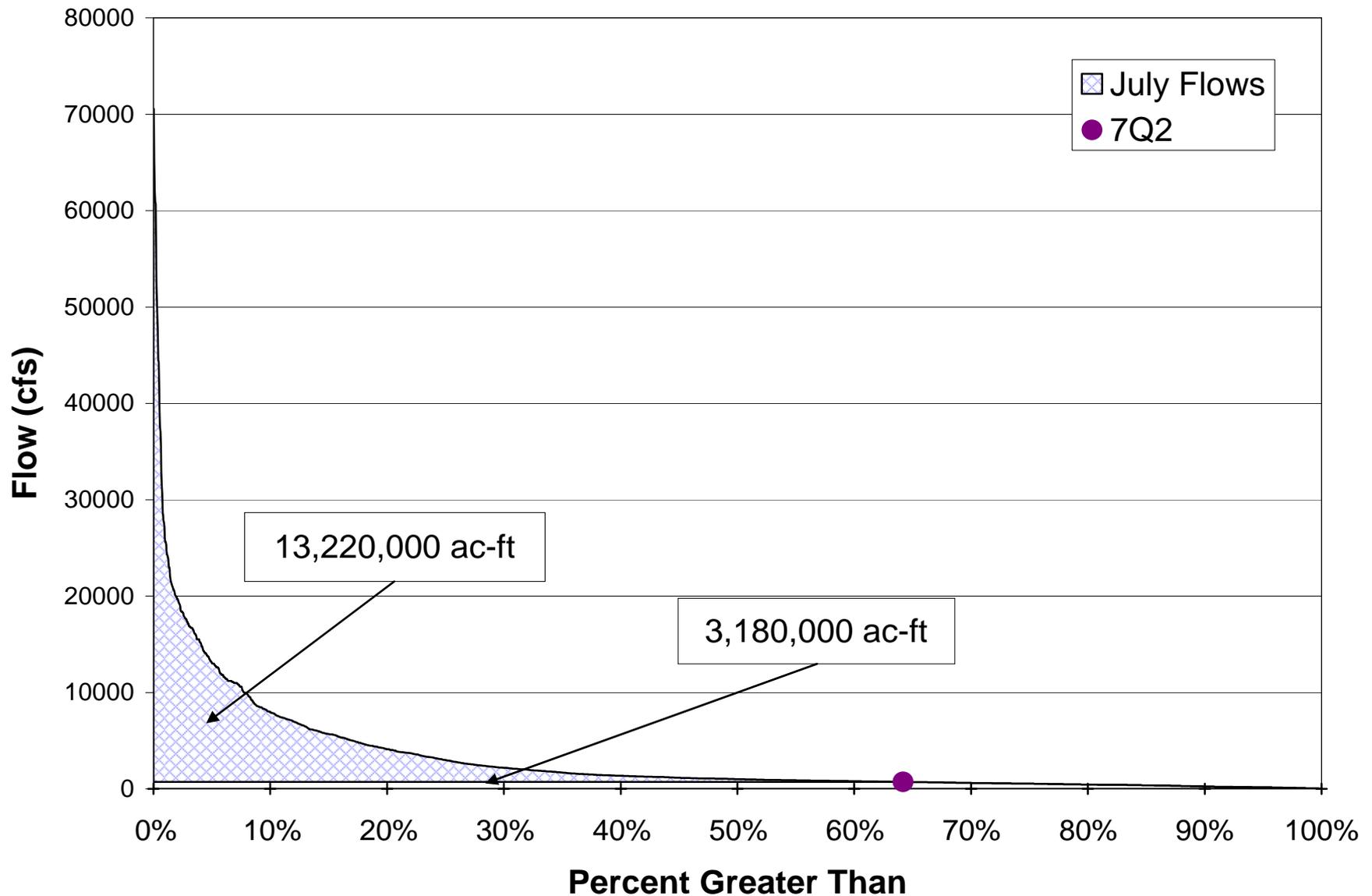


Note: Linear x axis, Log y axis

Approximately 16M ac-ft total volume over 86 years of Julys

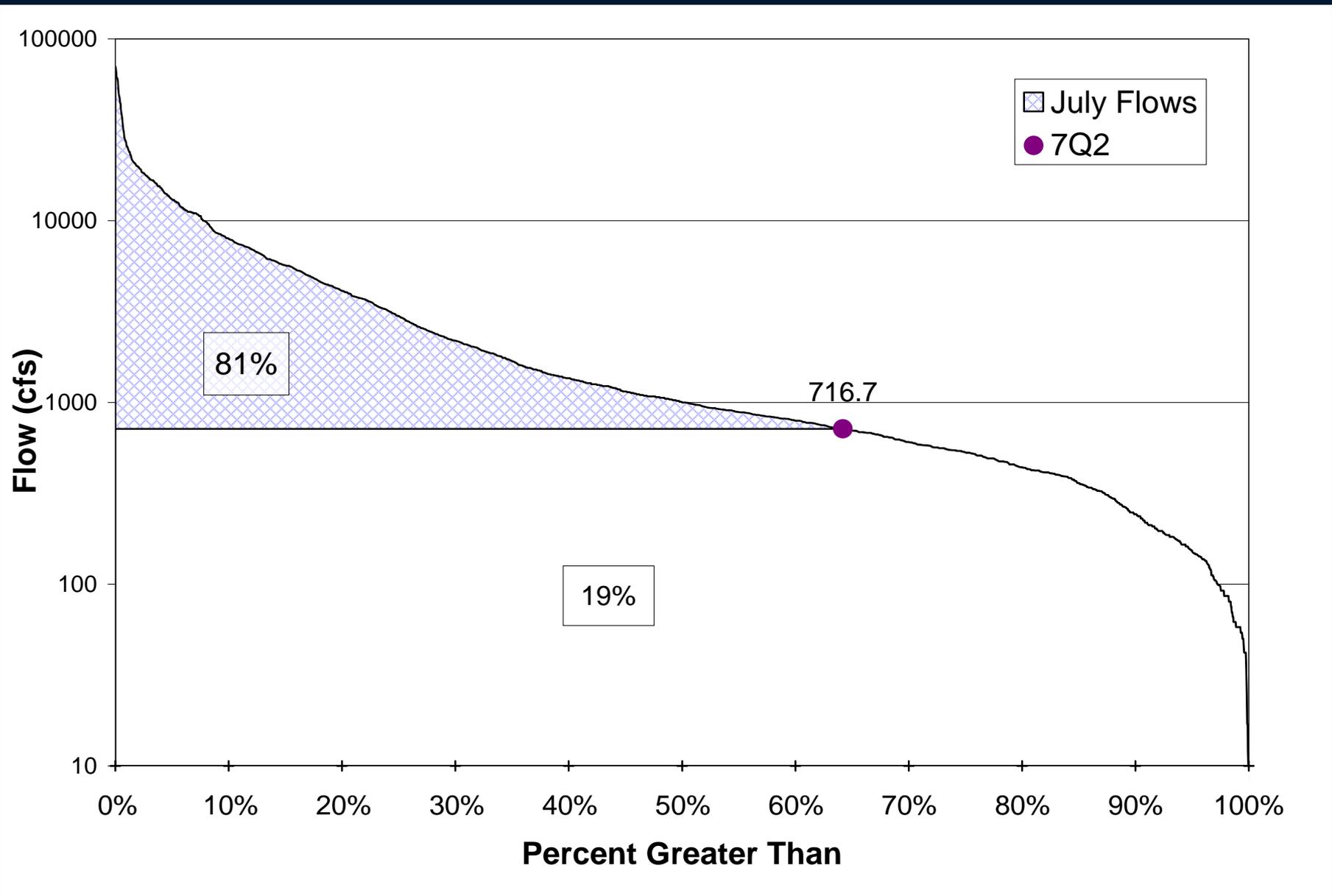


Note: 7Q2 from TCEQ website (1979-1996 only)

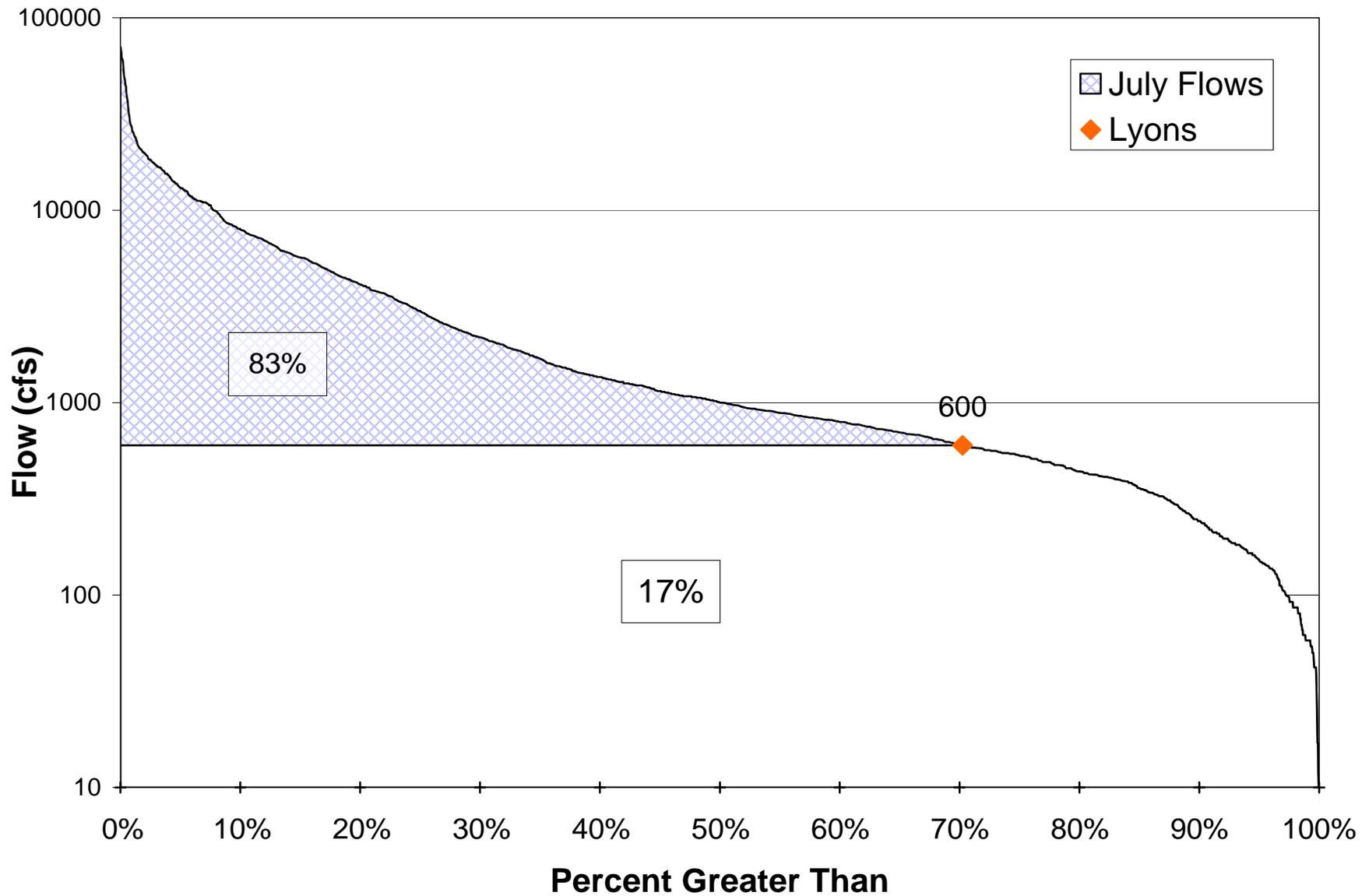


Note: Same plot as previous slide, except linear y axis.

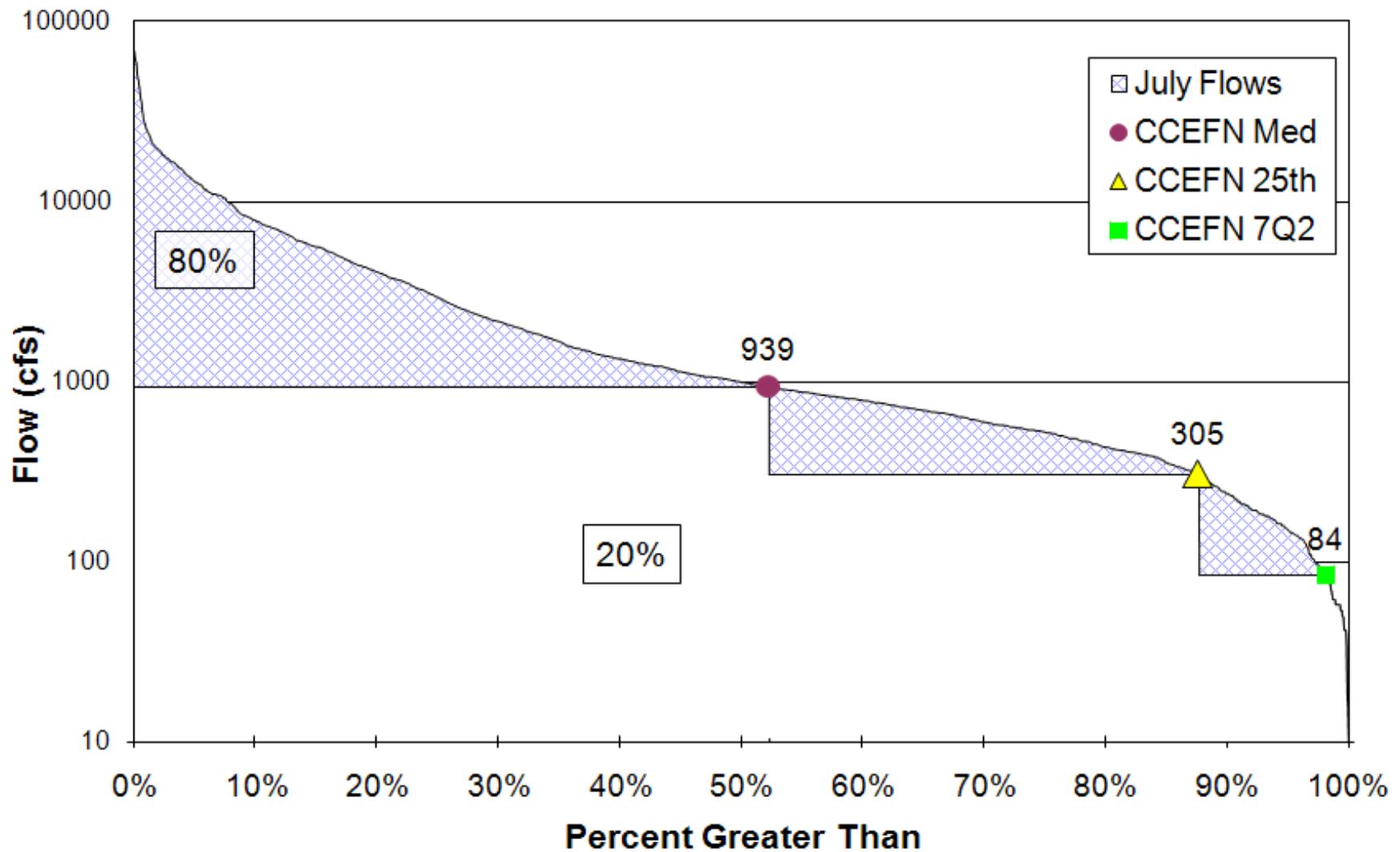
Blue area can be visually compared to white area in this plot



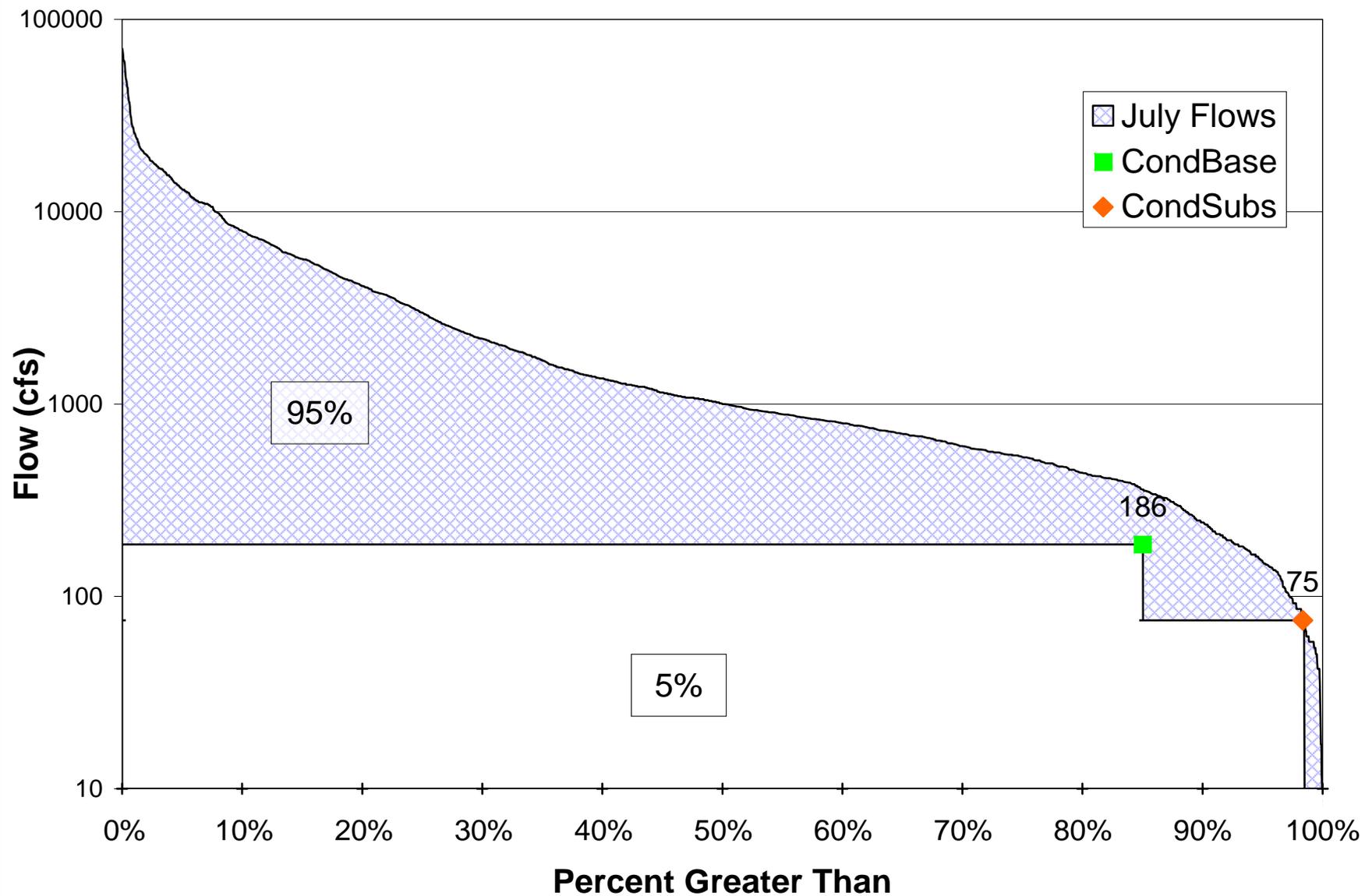
Note: Same plot as previous two slides, except back to log y axis and showing percentages of total water instead of volumes.



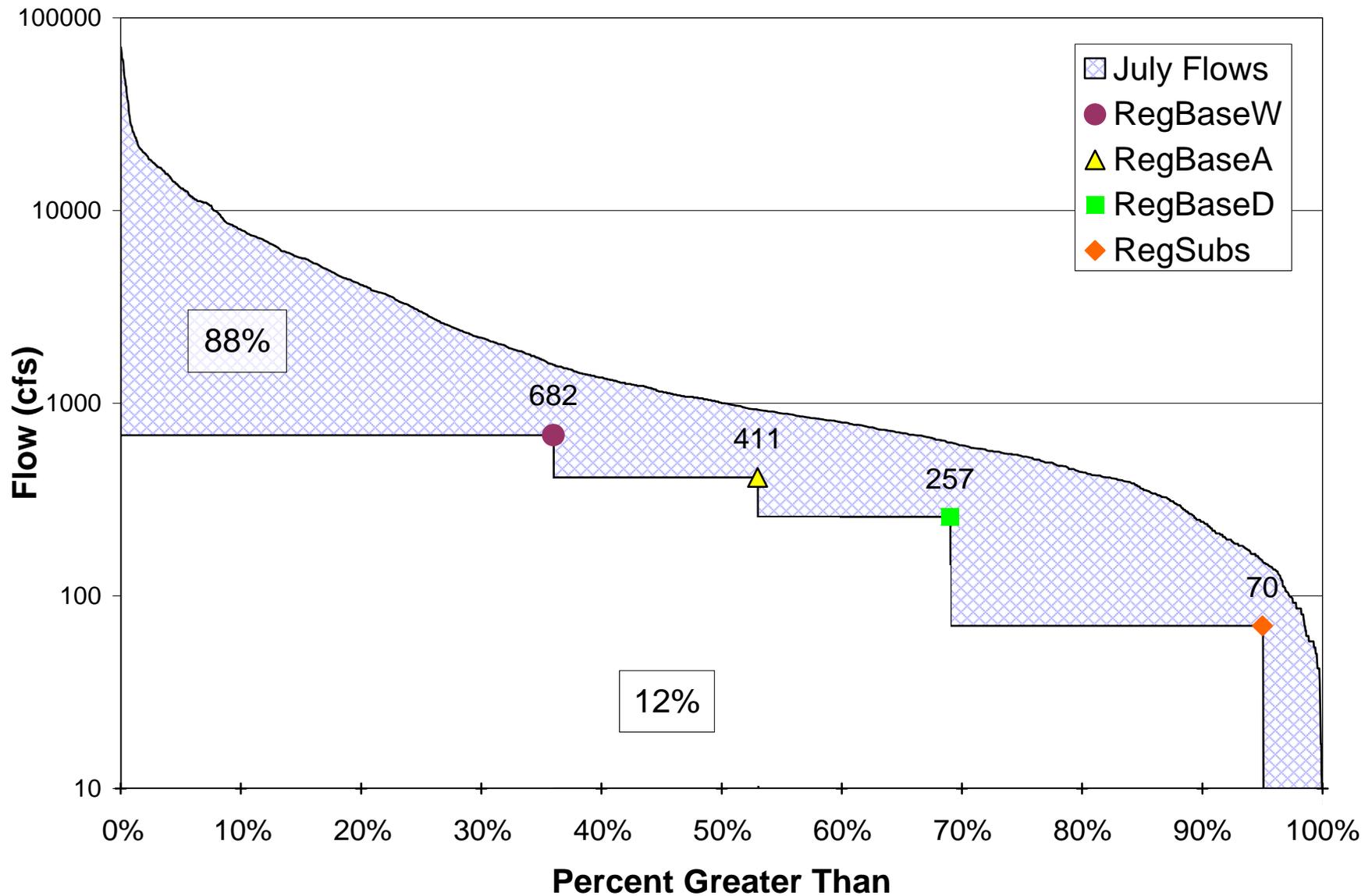
Note: Lyons flow conditions with percentages of total volume.
Lyons calculation using entire gaged period of record (1924-2009)



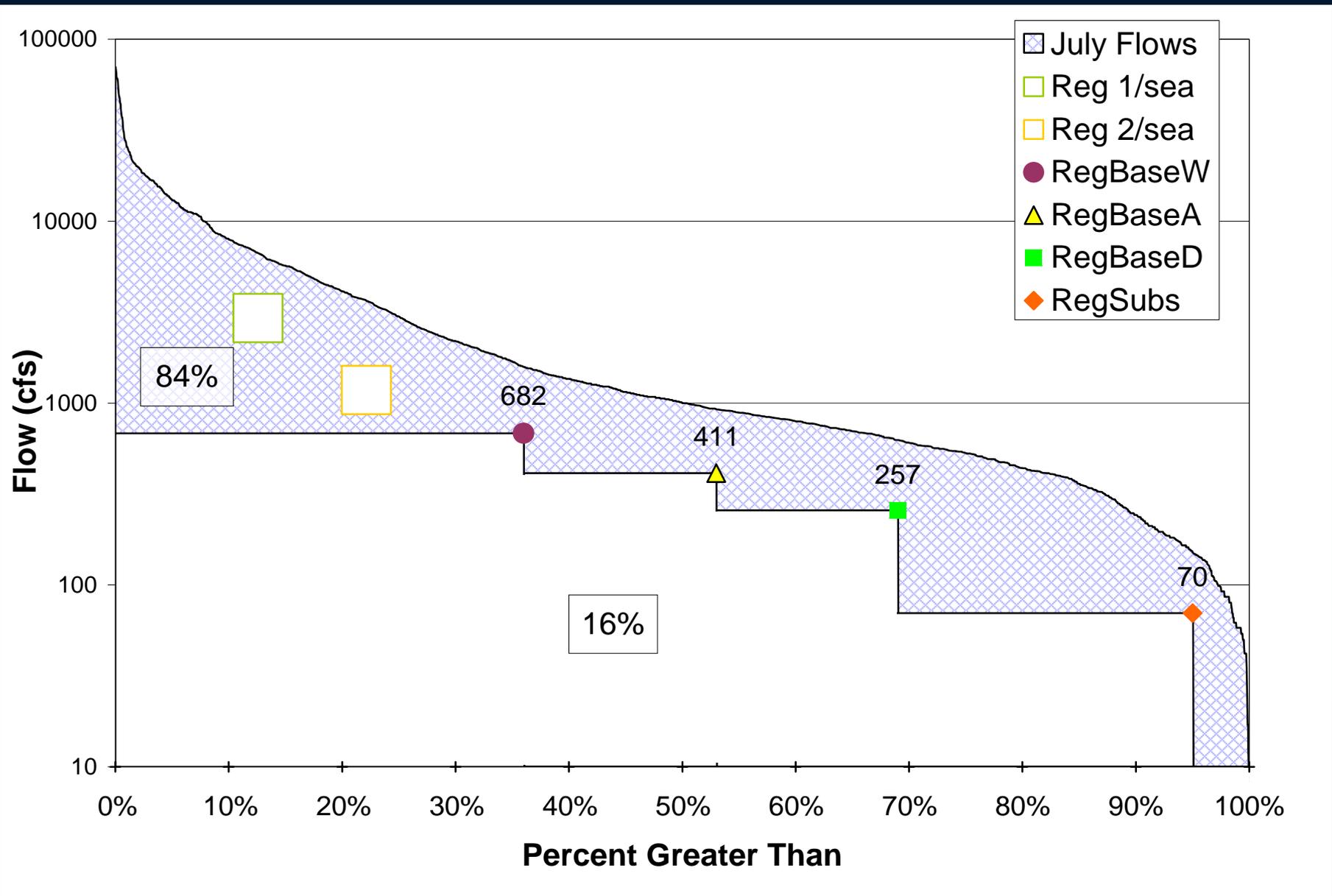
Note: Consensus Criteria for Environmental Flow Needs (CCEFN).
 Assuming a direct diversion project, 1940-1996 naturalized flows.
 Median and 25th %ile based on daily July flows, 7Q2 based on all daily flows.
 TCEQ may use published 7Q2 (716.7cfs) as floor. I did not in this chart.



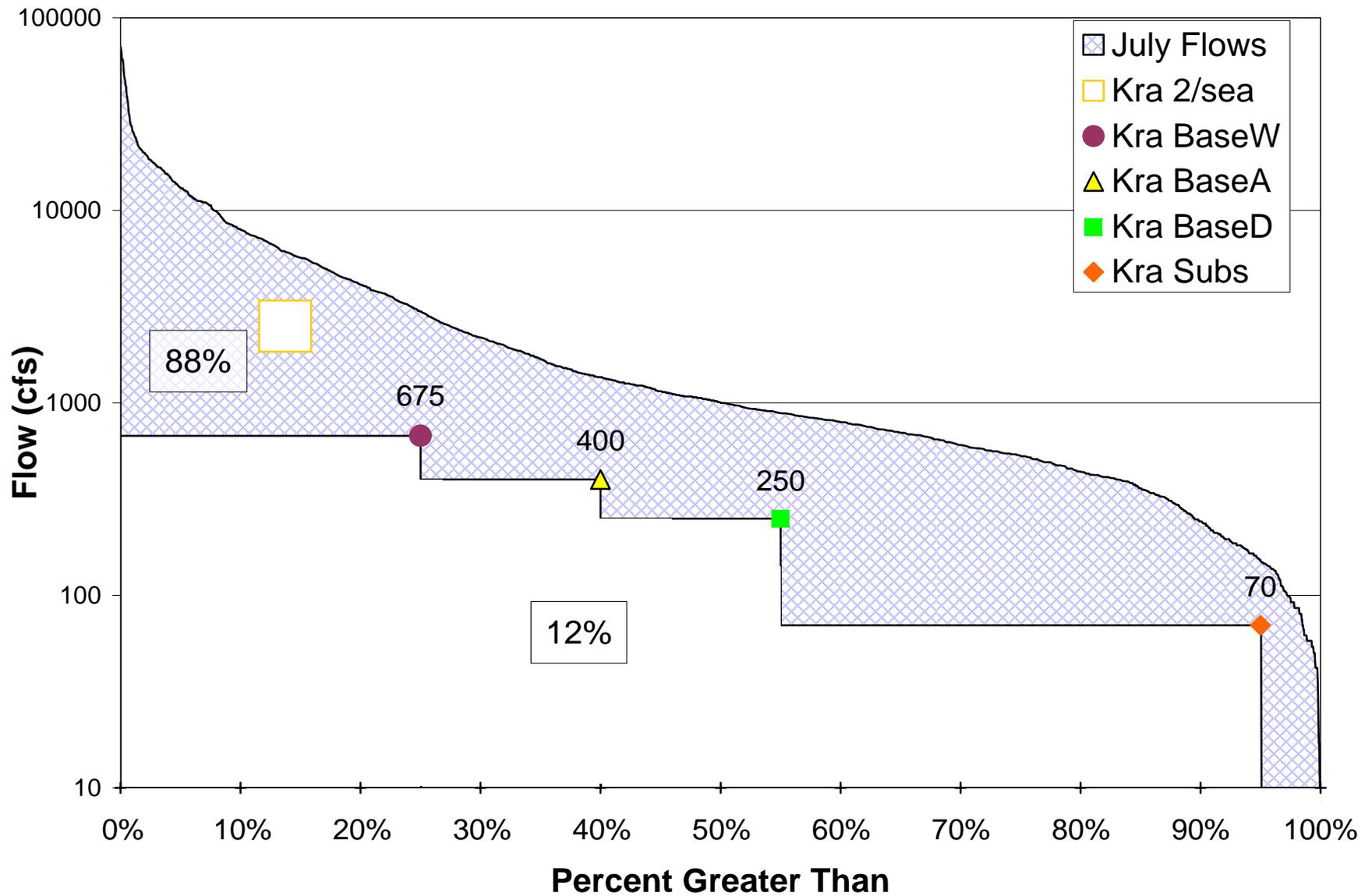
Note: Trinity-San Jacinto BBEST Conditional Phased Group.
 Flow recommendations based on 1924-1964 gaged flows.



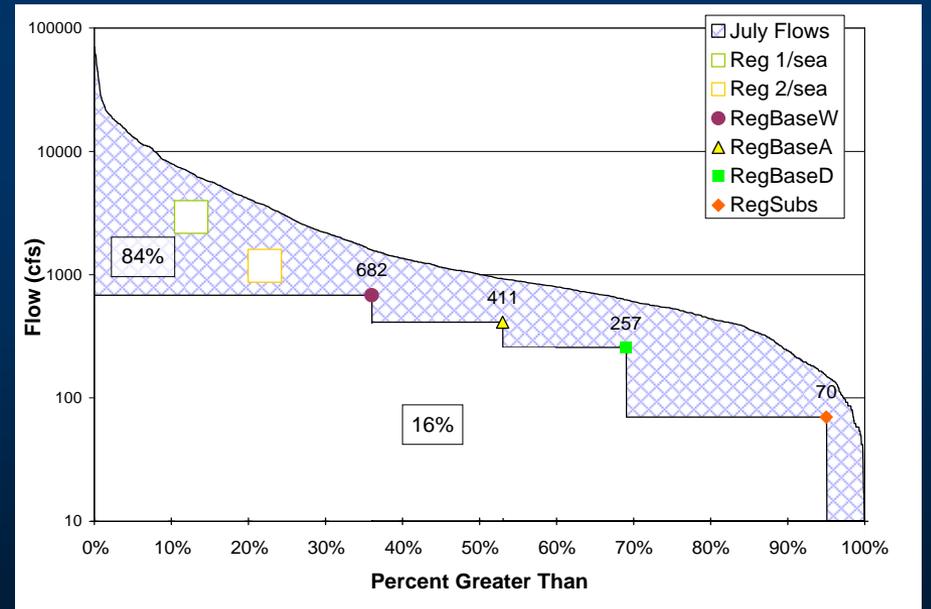
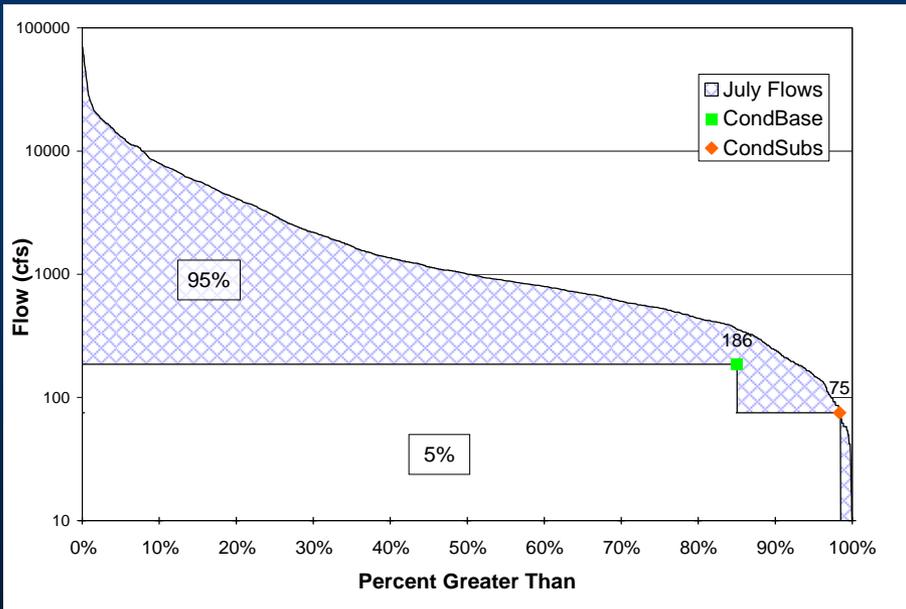
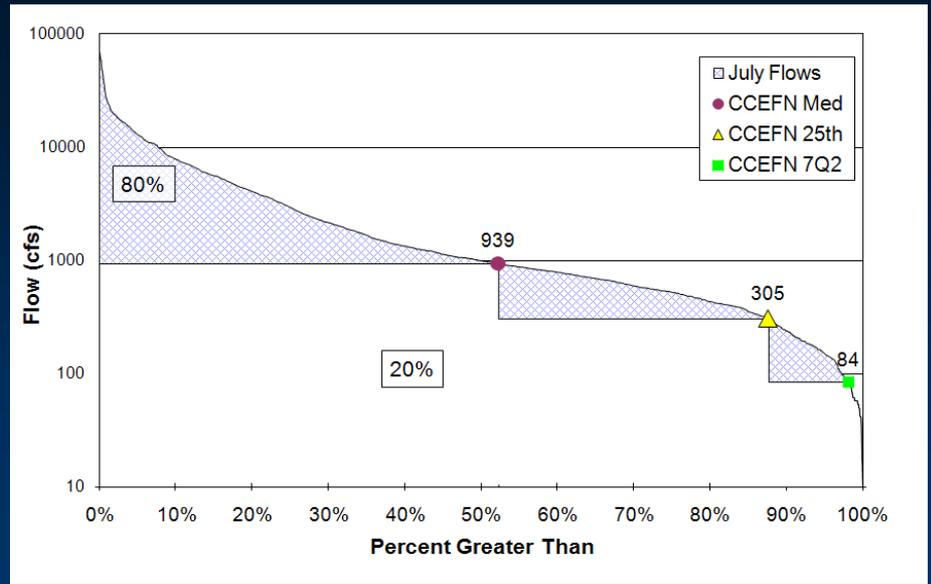
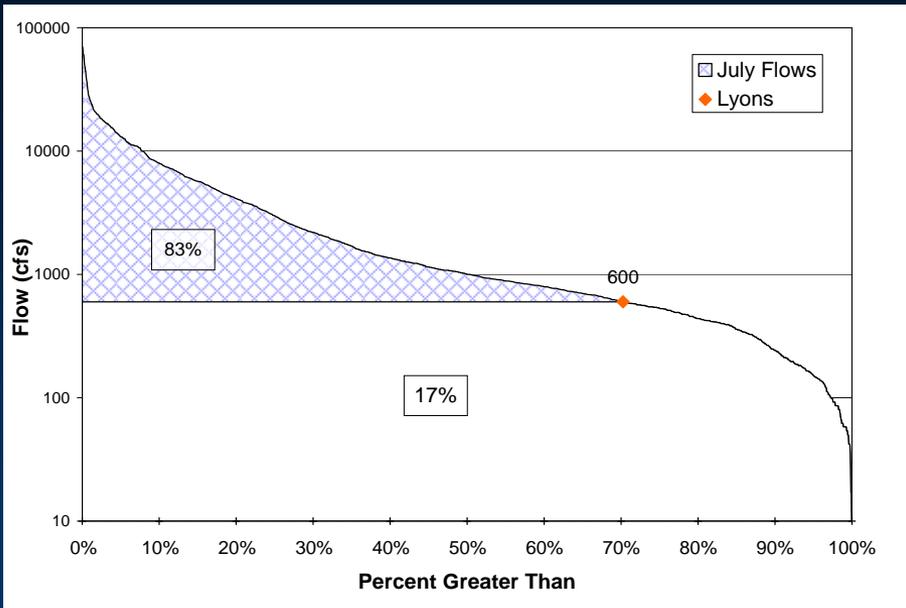
Note: Trinity-San Jacinto BBEST Flow Regime Group without High Flow Pulses.
 Flow recommendations based on 1924-1964 gaged flows.



**Note: Flow Regime Group with seasonal High Flow Pulses.
Flow recommendations based on 1924-1964 gaged flows.**



Note: Trinity-San Jacinto BBASC Kramer et al proposal.



Note: Lyons % numerically \approx Reg
but note that Reg allows diversions at lower flows.

Caveats

7Q2 is not seasonal, therefore the flow conditions are high relative to July flows

Much of “blue hatched” water is either already appropriated or may not be permittable (e.g., too unreliable)

Different periods of record among calculations are important

Different months will have different results

Conclusions

- While HEFR is based on historical flows, it does not attempt to protect all historical flows.
- Flexibility = Decisions Required
- Need to keep ecological goals front and center
- HEFR can efficiently populate a flow matrix to generate a first cut
- Other disciplines are necessary before reaching a final instream flow recommendation
 - Biology – SAC guidance released September 1, 2009
 - Geomorphology – SAC guidance released May 29, 2009
 - Water Quality – SAC guidance released November 3, 2009
- These disciplines can be used to guide HEFR parameter selection or as direct replacement of HEFR-generated flow recommendations.