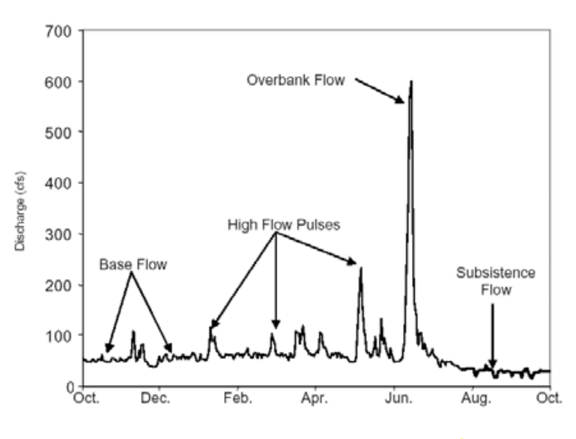
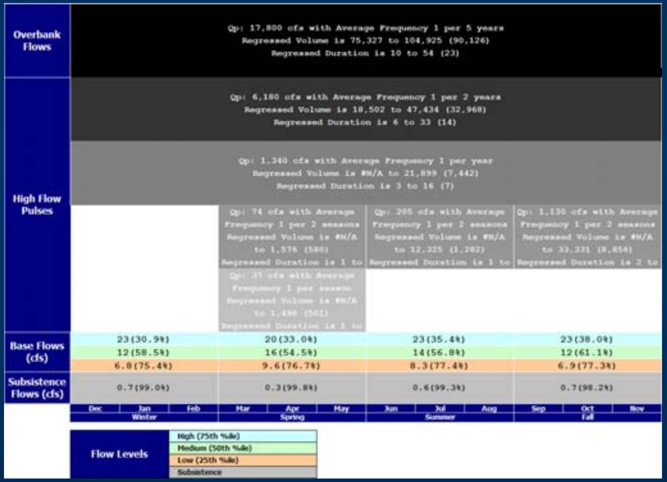
Note:

In the original presentation, I had an error in the Consensus (CCEFN) calculations. That error has been fixed in this version of the presentation.

Hydrologic Methods for Environmental Flows

- with emphasis on HEFR -





Dan Opdyke, TPWD

Presentation at HEFR workshop

June 10, 2010

TEXAS PARKS & WILDLIFE

Utility

Hydrologic Methods can be useful

- If data and information are limited
- As part of a larger effort incorporating other scientific disciplines

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:
  - 50^{th} %ile, 25^{th} %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

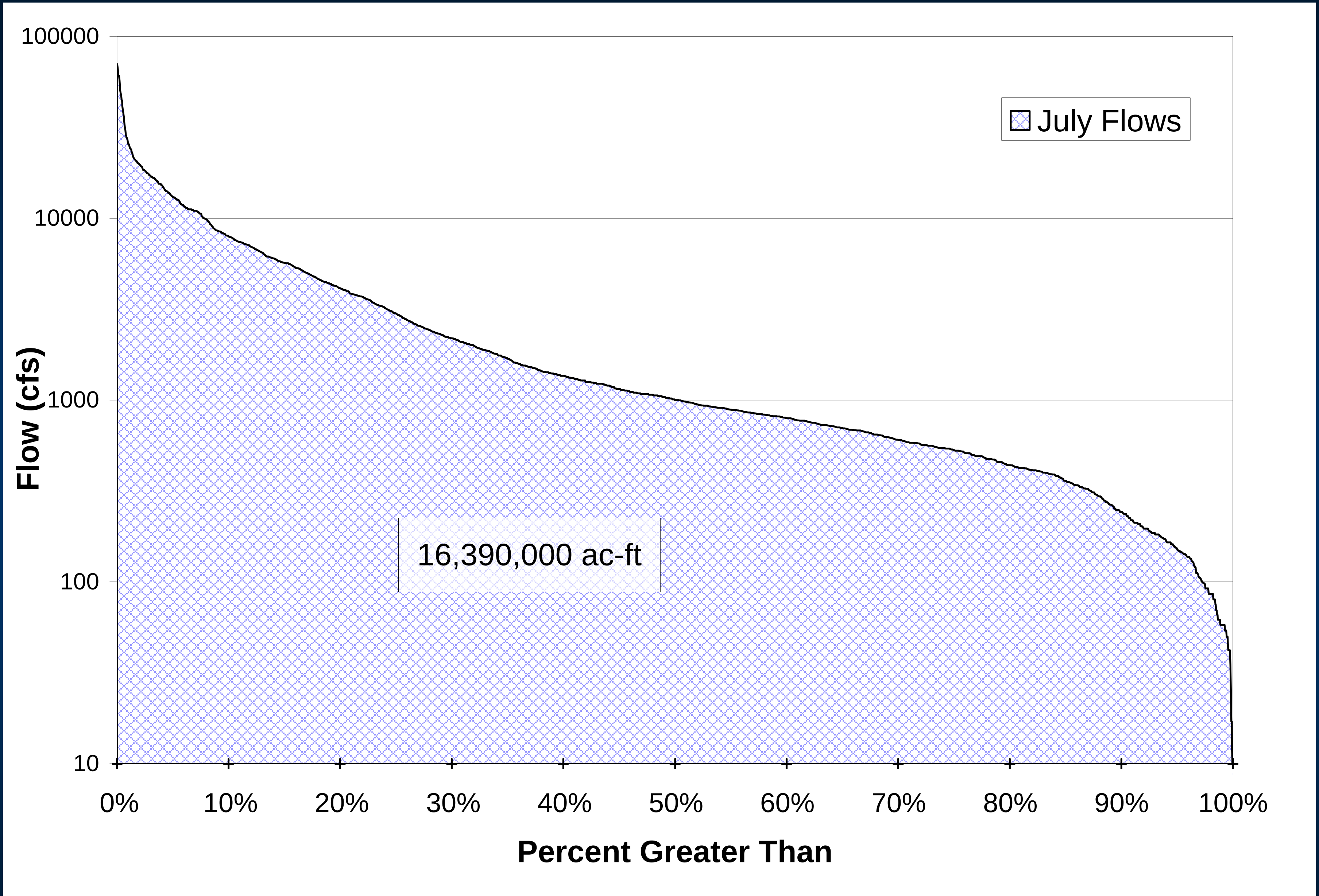
7Q2, Lyons, and CCEFN calculations are prescriptive, i.e., no flexibility

HEFR has multiple input parameters at the disposal of the analyst

All are based on historical (or naturalized) flows

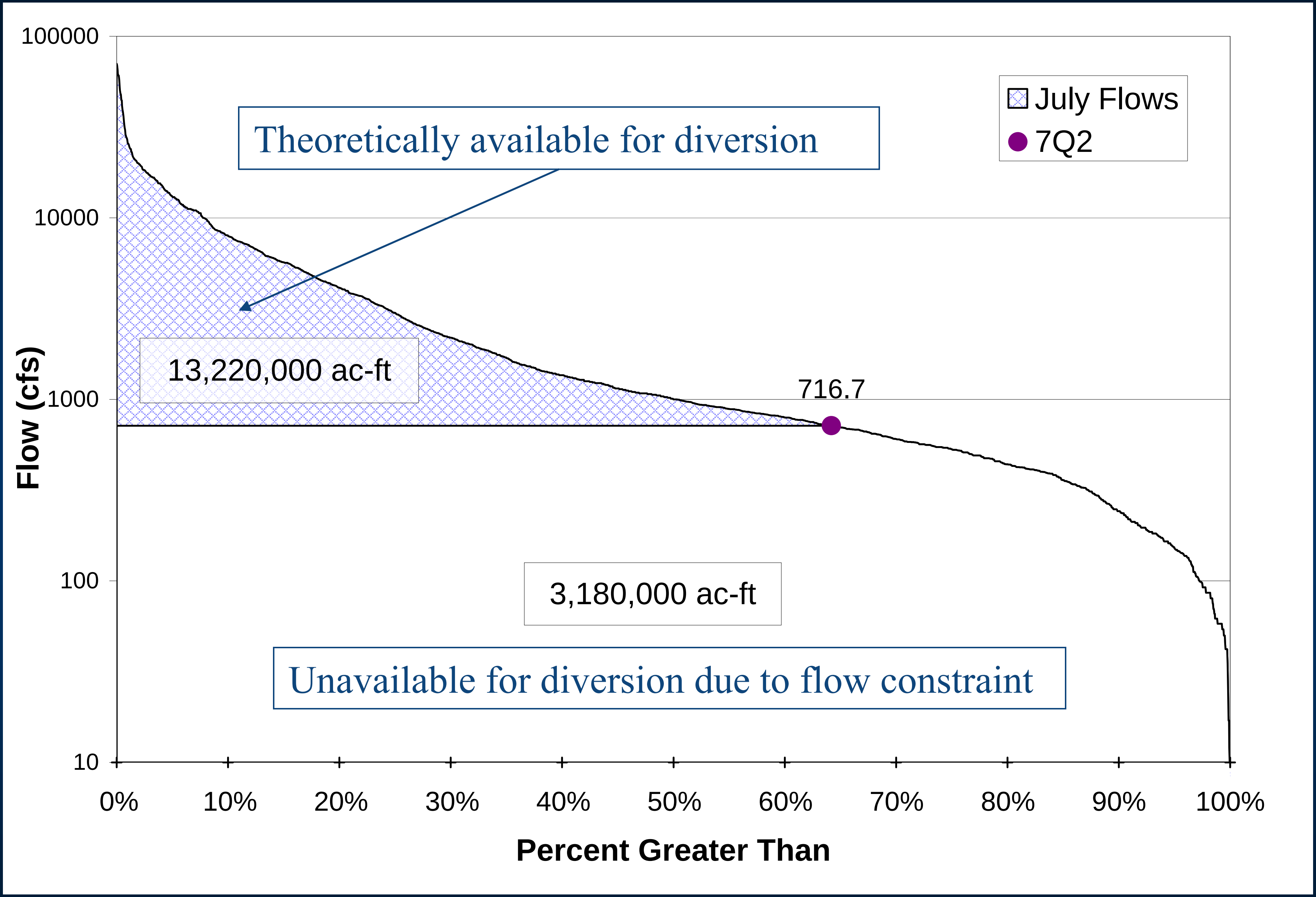
The following slides have a visual comparison of these hydrologic calculations

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

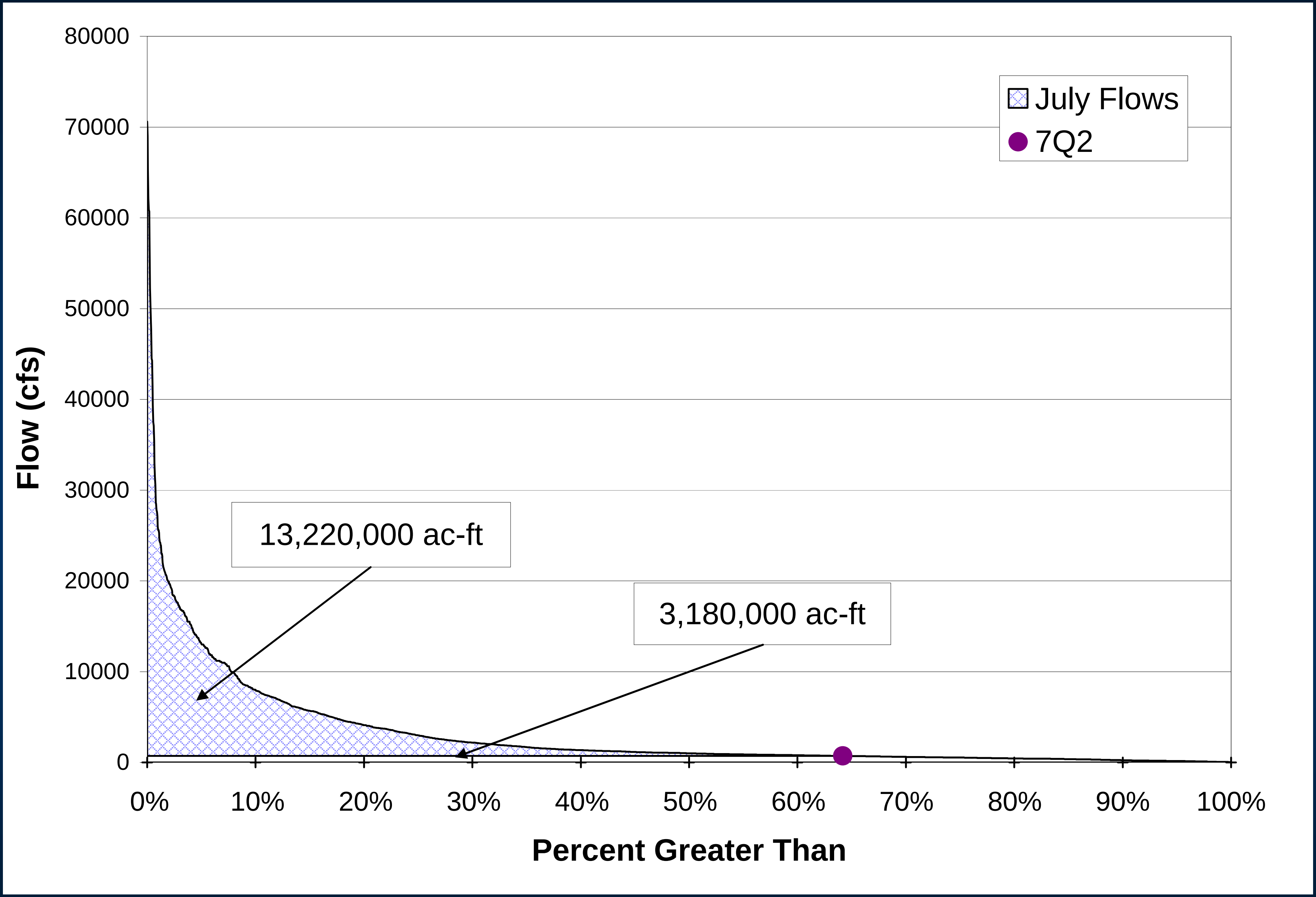


Note: Linear x axis, Log y axis

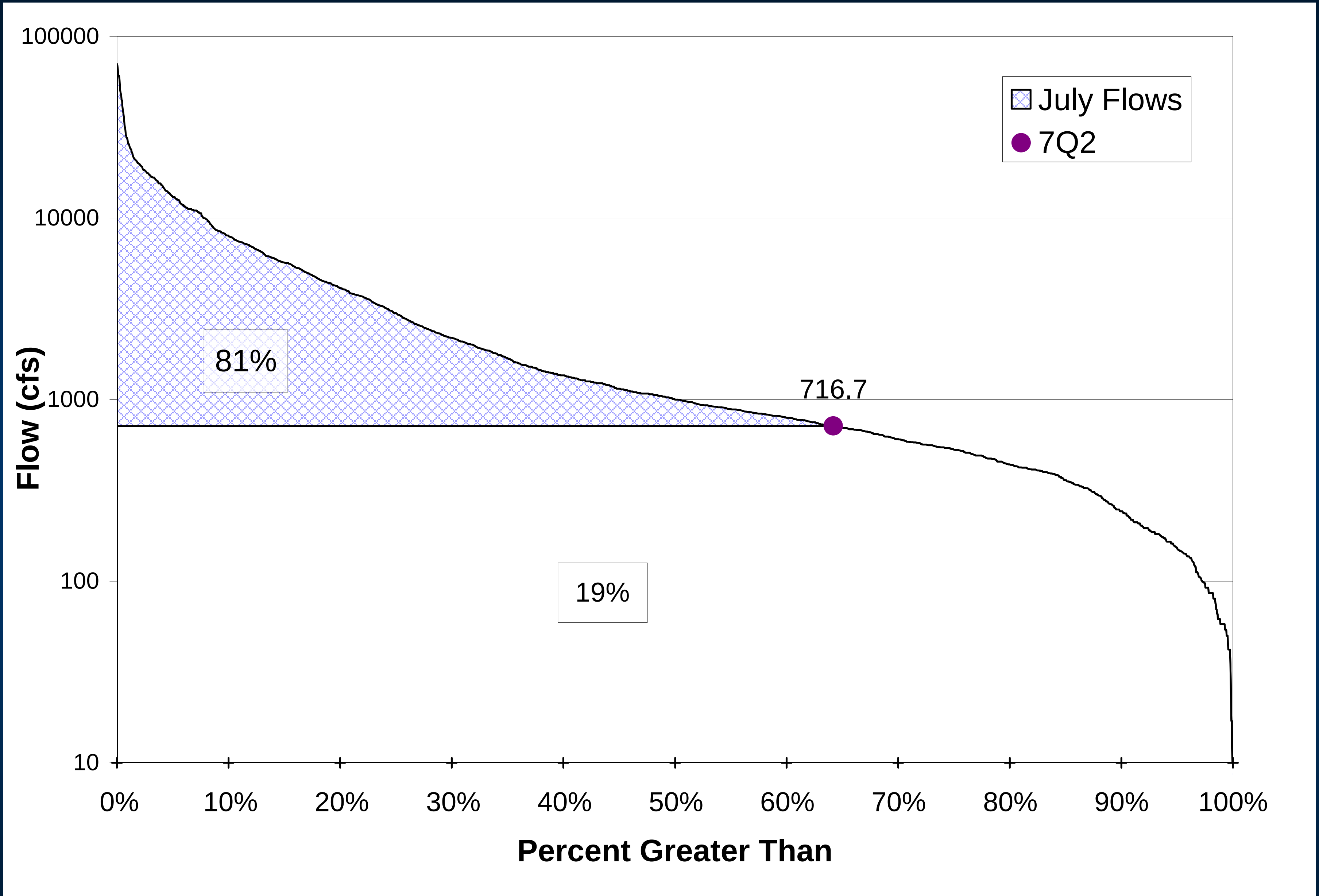
Approximately 16M ac-ft total volume over 86 years of Julys



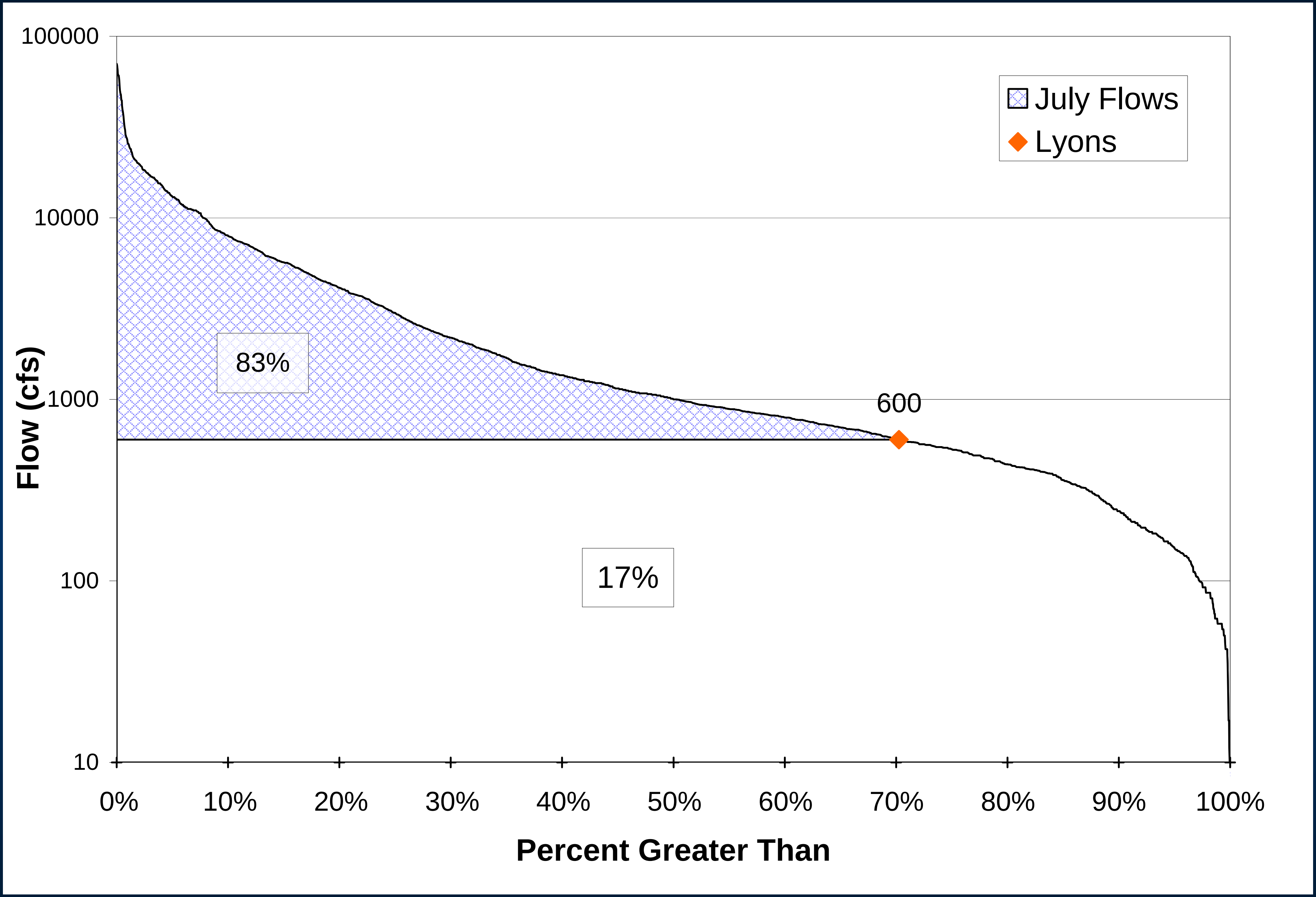
Note: 7Q2 from TCEQ website (1979-1996 only)



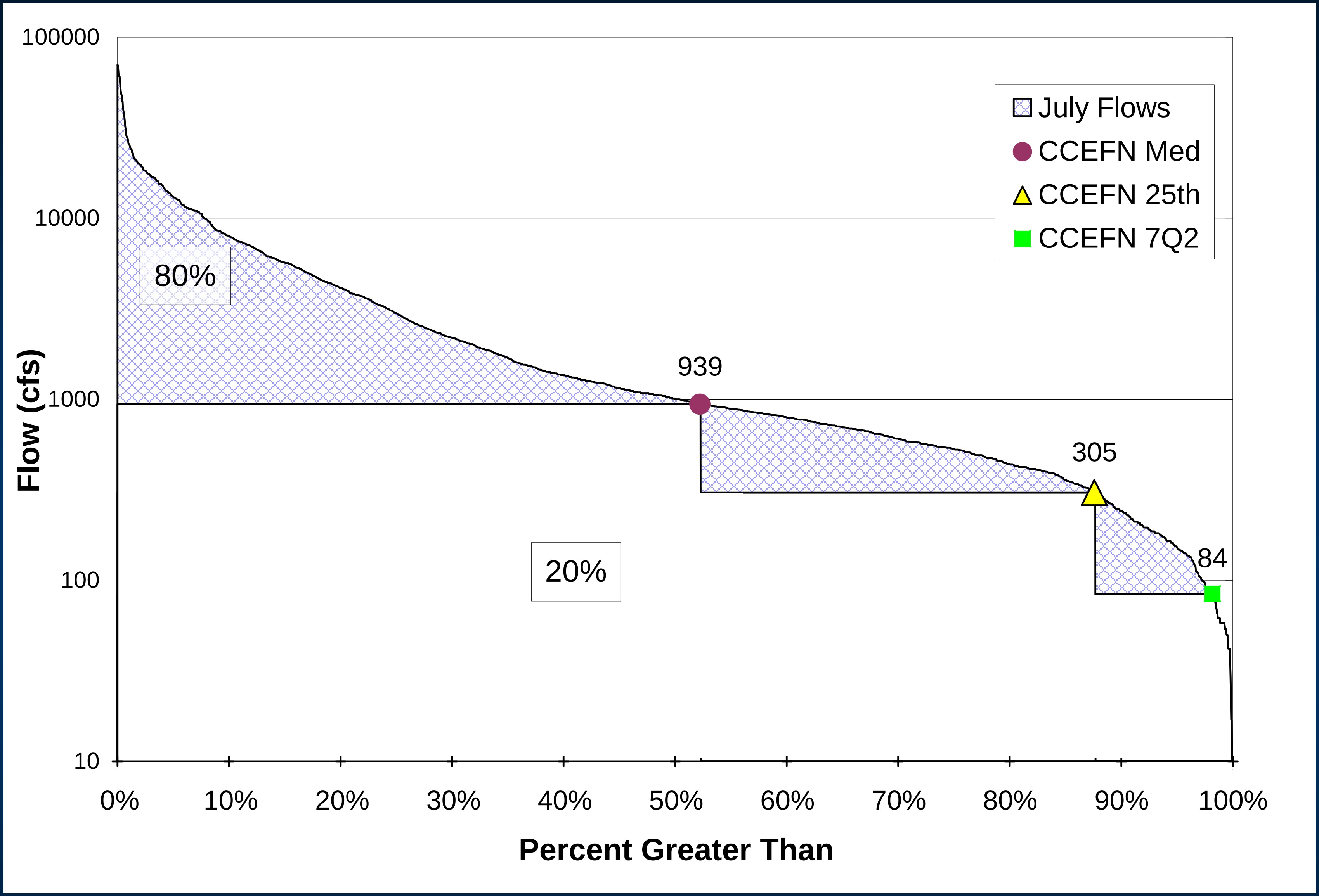
Note: Same plot as previous slide, except linear y axis.
Blue area can be visually compared to white area in this plot



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)

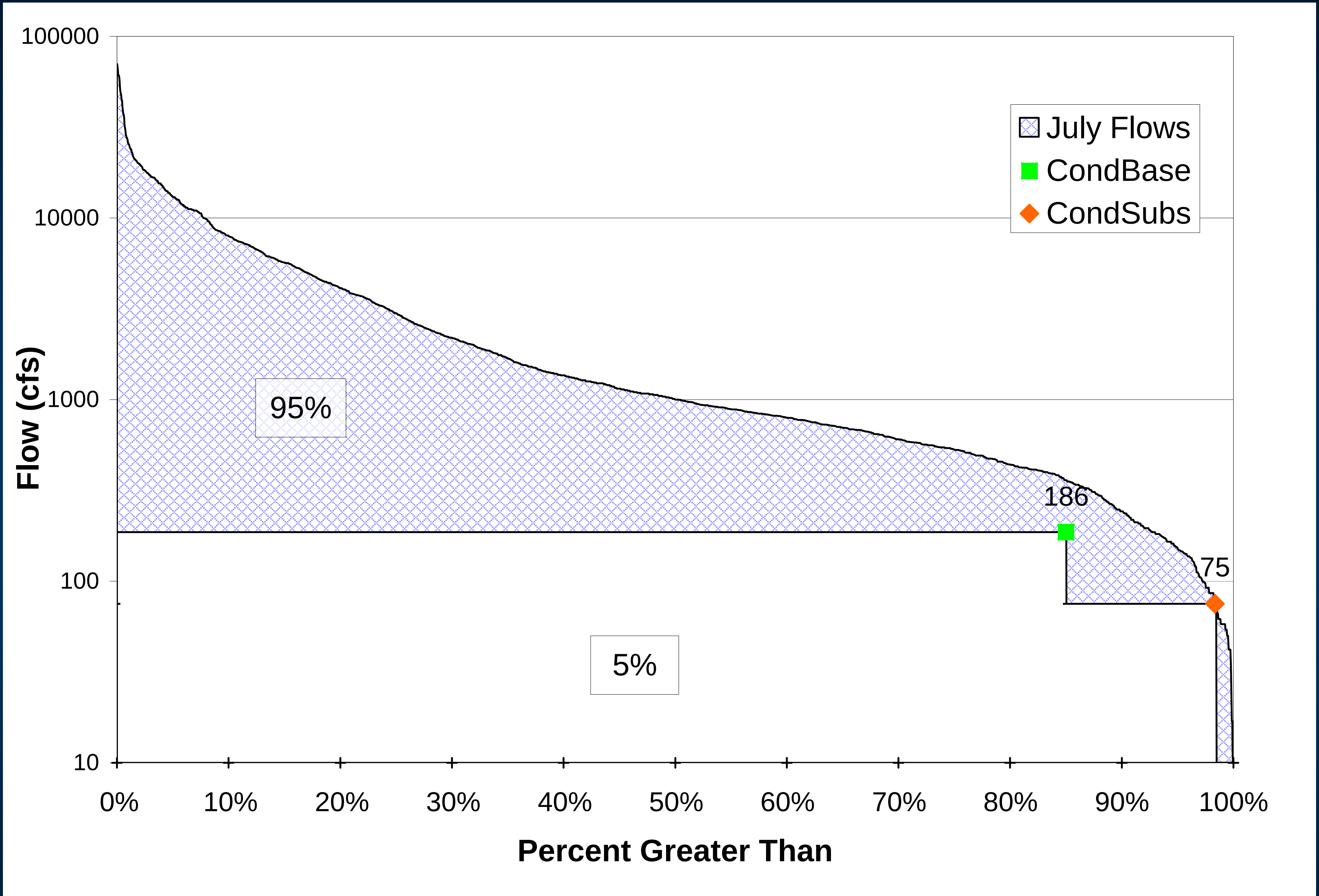


Note: Consensus Criteria for Environmental Flow Needs (CCEFN).

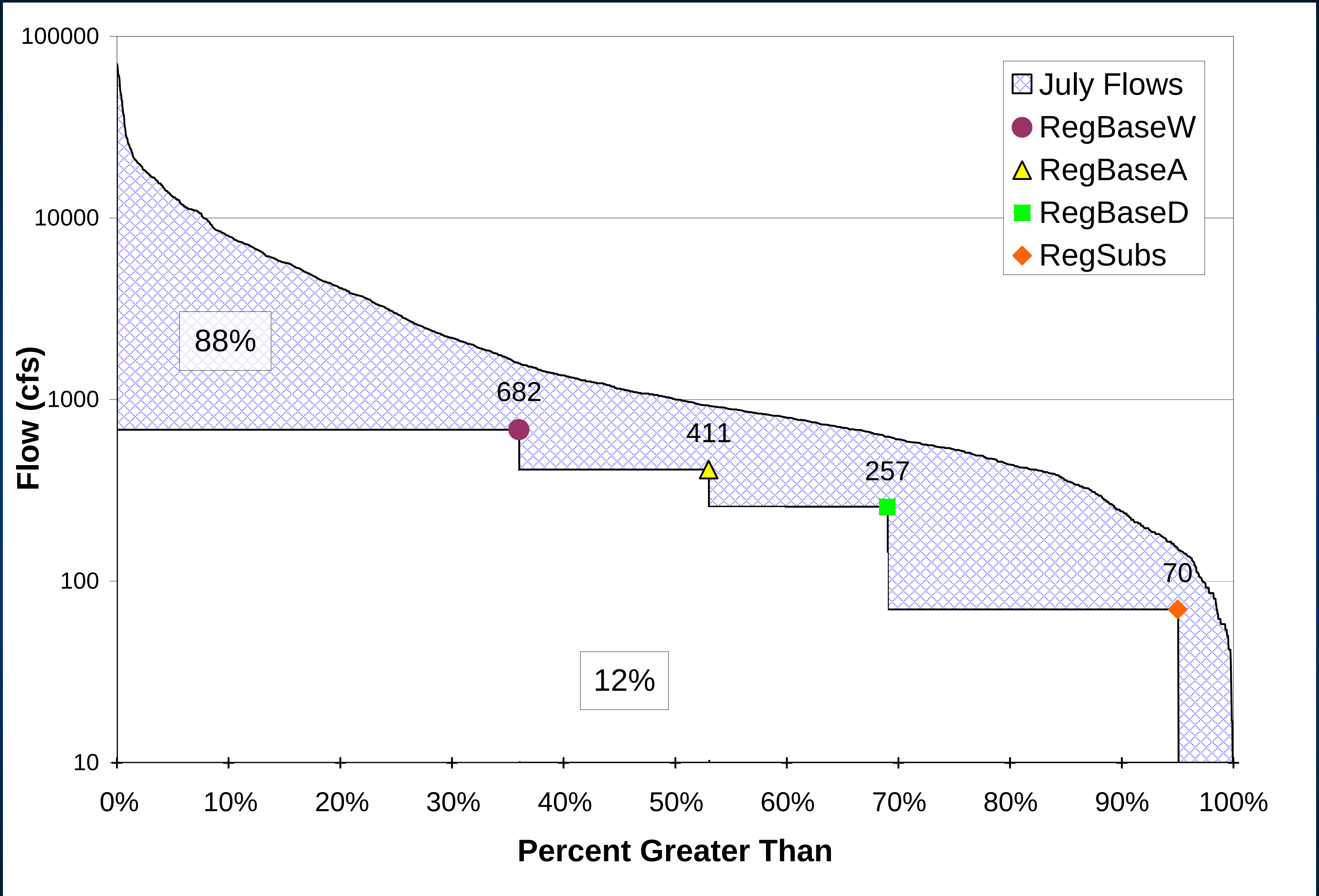
Assuming a direct diversion project, 1940-1996 naturalized flows.

Median and 25th %ile based on daily July flows, 7Q2 based on all daily flows.

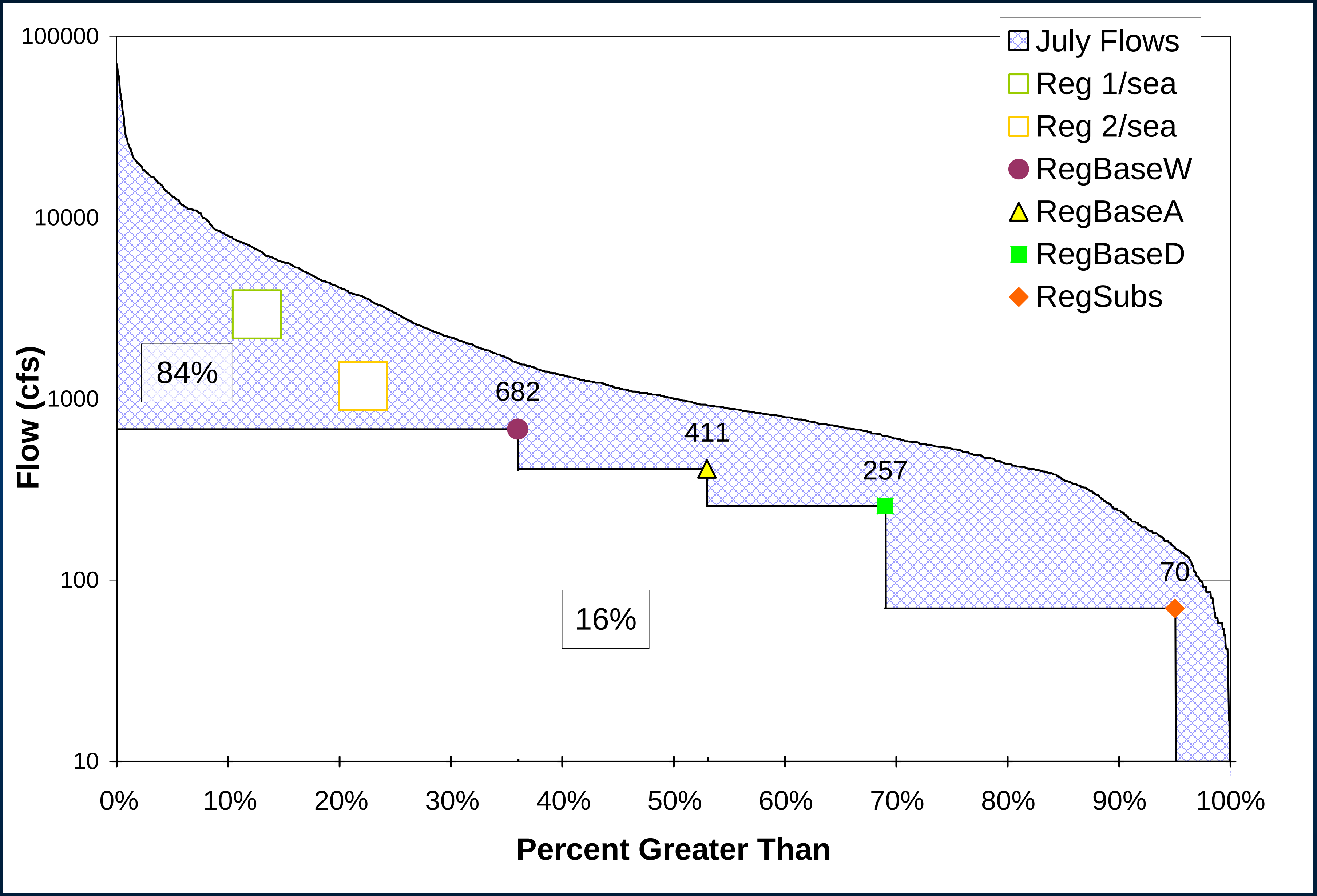
TCEQ may use published 7Q2 (716.7cfs) as floor. I did not in this chart.



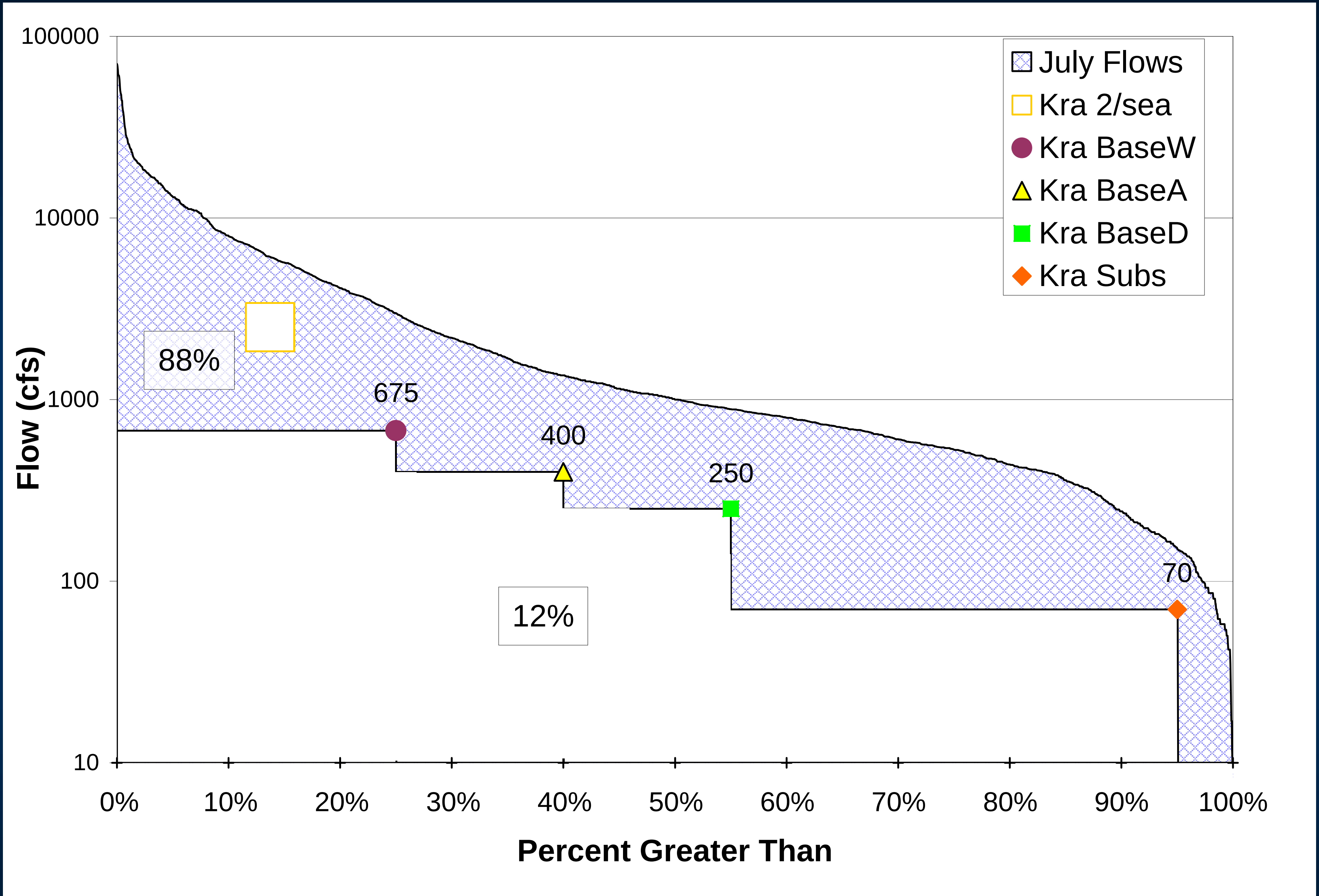
Note: Trinity-San Jacinto BBEST Conditional Phased Group.
Flow recommendations based on 1924-1964 gaged flows.



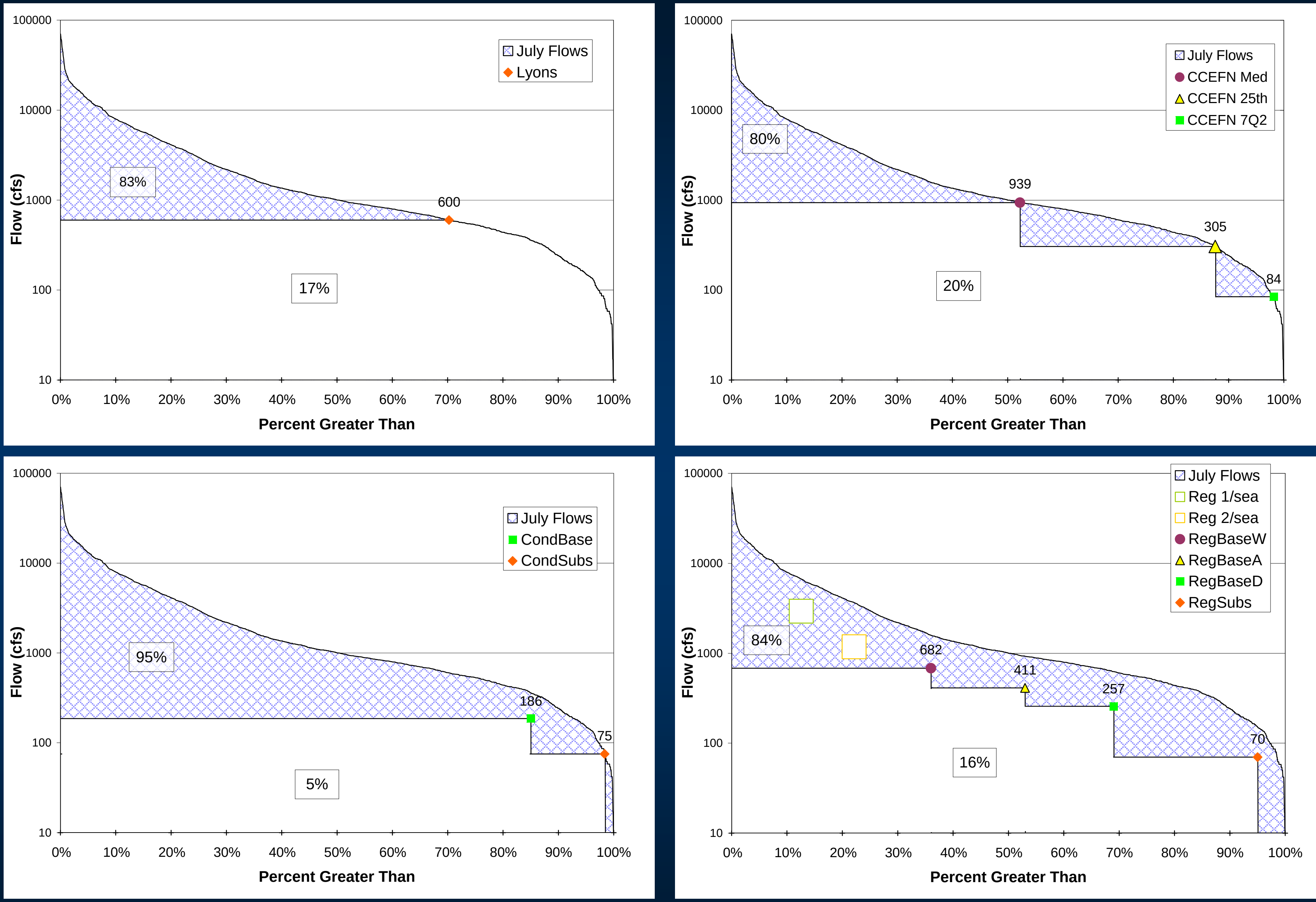
Note: Trinity-San Jacinto BBEST Flow Regime Group without High Flow Pulses.
Flow recommendations based on 1924-1964 gaged flows.



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 ≈ Reg

but note that Reg allows diversions at lower flows.

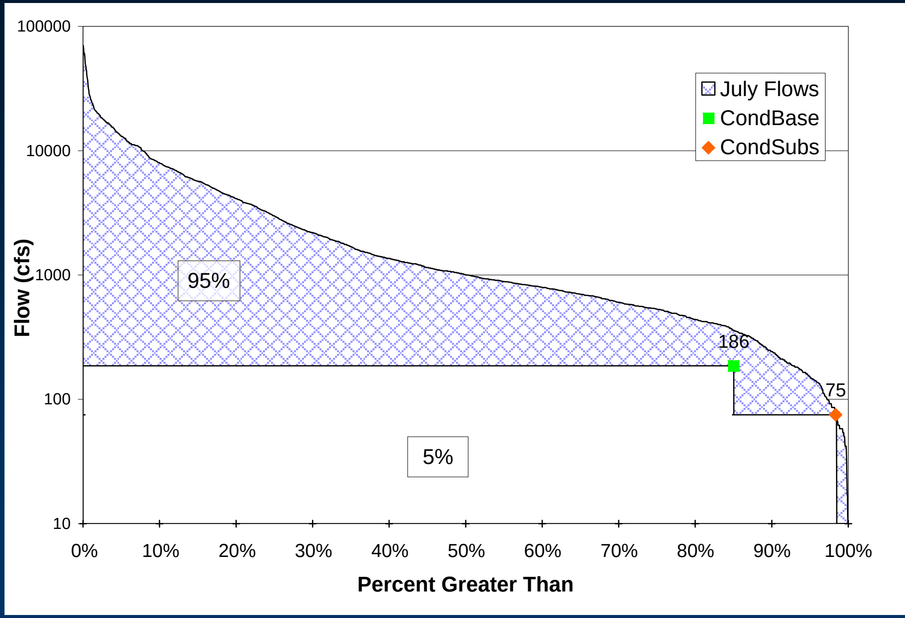
Caveats

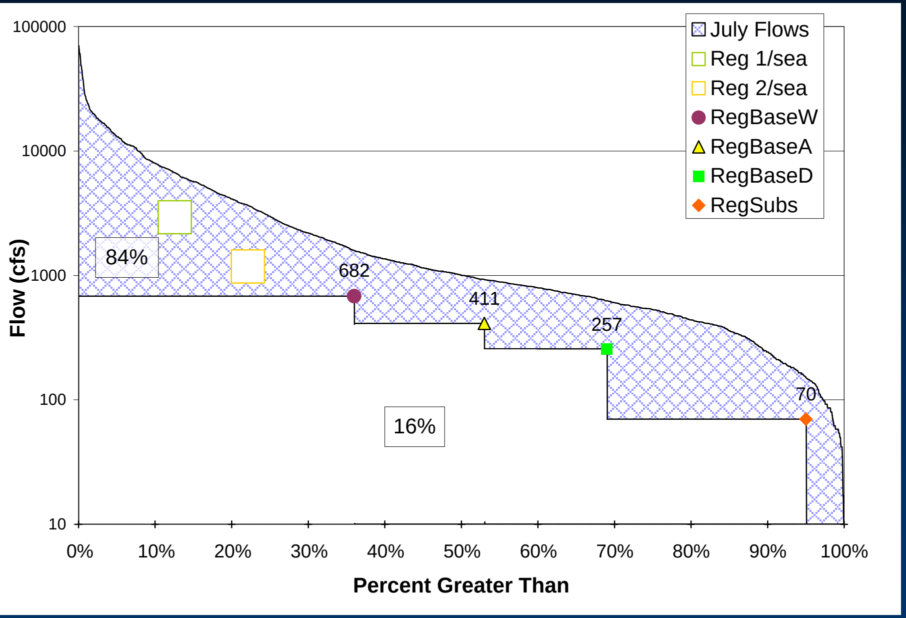
7Q2 is not seasonal, therefore the flow conditions are high relative to July flows

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

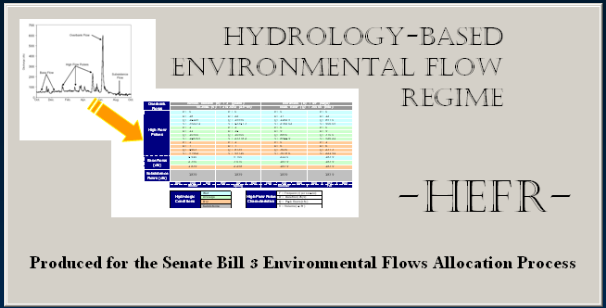
Different months will have different results





So how did HEFR help generate some of these numbers?

HEFR Basics



- Uses hydrologic data
- Computations are rapid
- Populates a flow regime matrix

(1) Select Flow Gage

↓

(2) Select Period of Record

↓

(3) Separate (parse) Hydrograph into Flow Components

↓

(4) Generate Statistical Summaries in Excel

A hydrological tool for an ecological purpose

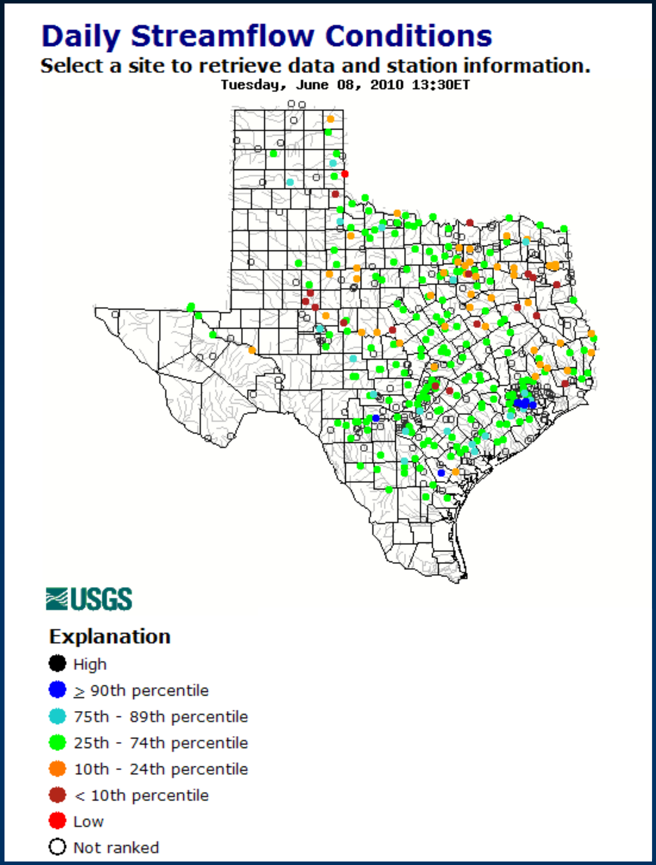
(1) Select Flow Gage

- Many to choose from

- SAC has “Geographic Scope” guidance

- USGS TX “Core” Network documented here:

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



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

(2) Select Period of Record

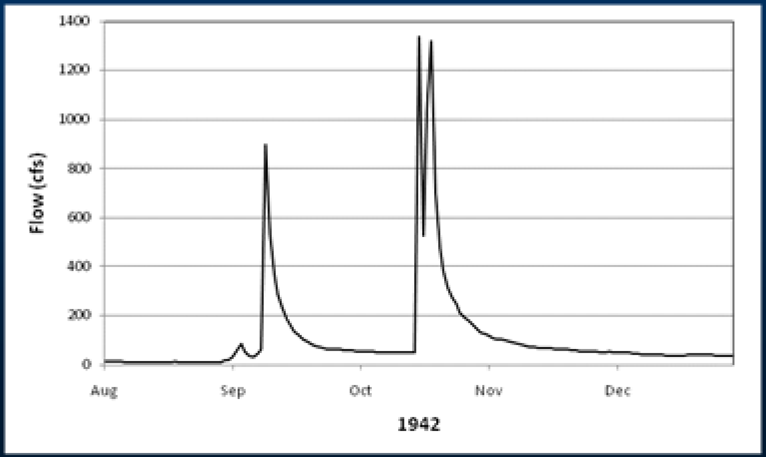
- May vary by gage
- Some discussion in Section 4 of Hydrologic Methods document, LSWP docs, etc.
- Many debates among older BBESTs

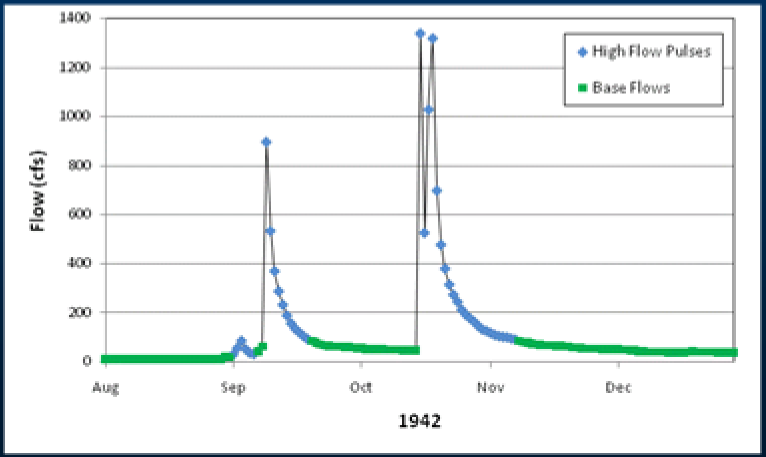
(3) Separate (parse) Hydrograph

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

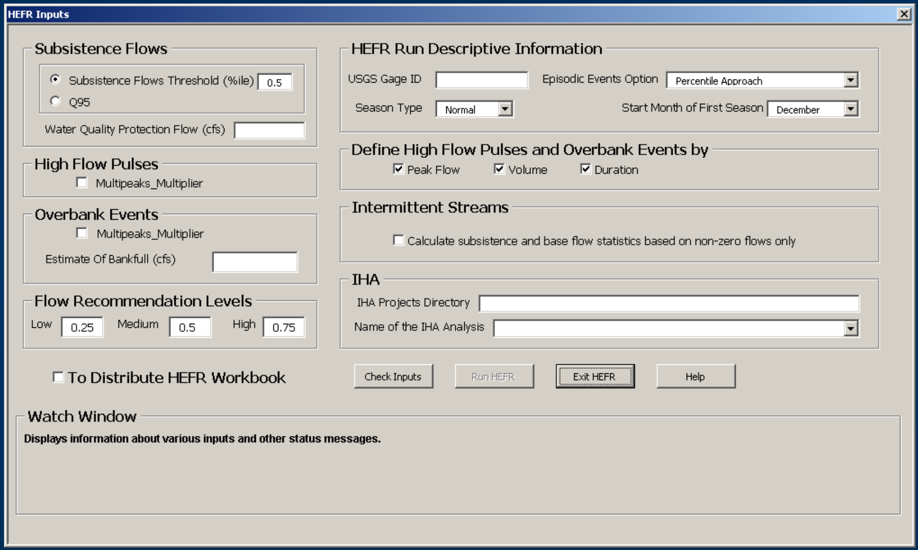
- Each day has only one component
- Emphasis is on dominant ecologic function
  - Instream habitat, spawning cues, sediment transport, etc.
  - Flow magnitude perhaps more important than rate of change

(4) Generate Statistical Summaries in Excel

HEFR uses Excel to generate summary statistics of each IFC

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

HEFR Input Window



Outputs may include: flow, volume, duration, frequency

Subsistence Flows

Ecological Roles

- Protect water quality and critical habitat during very dry times

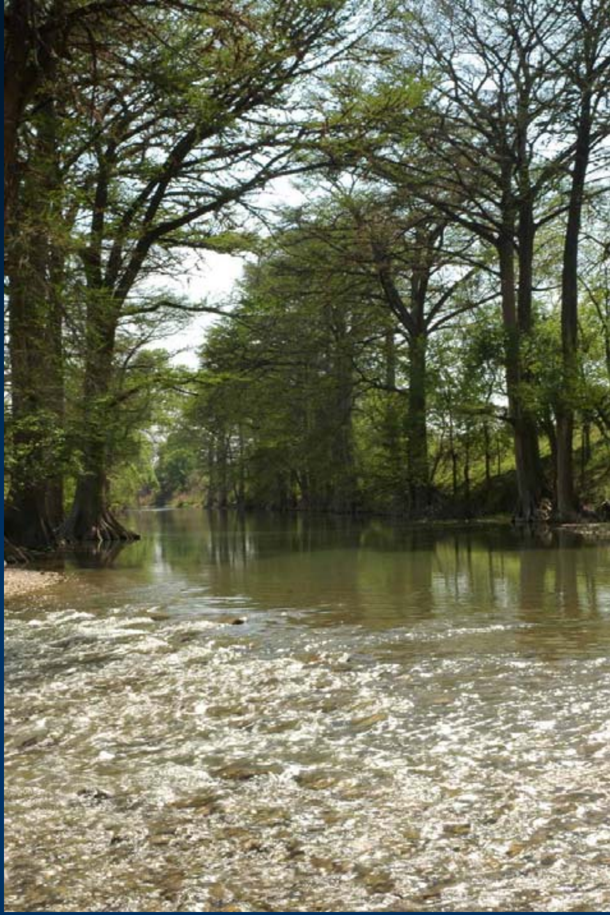
HEFR can calculate a statistic based on historically observed very low flows

~or~

User can input a recommendation based on other information

- For example, flow expected to protect water quality or maintain necessary habitat

Base Flows



Ecological Roles

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

HEFR calculates statistics seasonally and monthly, at three user-specified percentiles:

~~Dry~~Low	~~Average~~Medium	~~Wet~~High

High Flow Pulses

Ecological Roles

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

HEFR has two options

- “Percentile Approach”
  - More prescriptive, seasonal basis only
- “Frequency Approach”
  - More flexible, can handle multi-year intervals

Overbank Flows

Ecological Roles

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

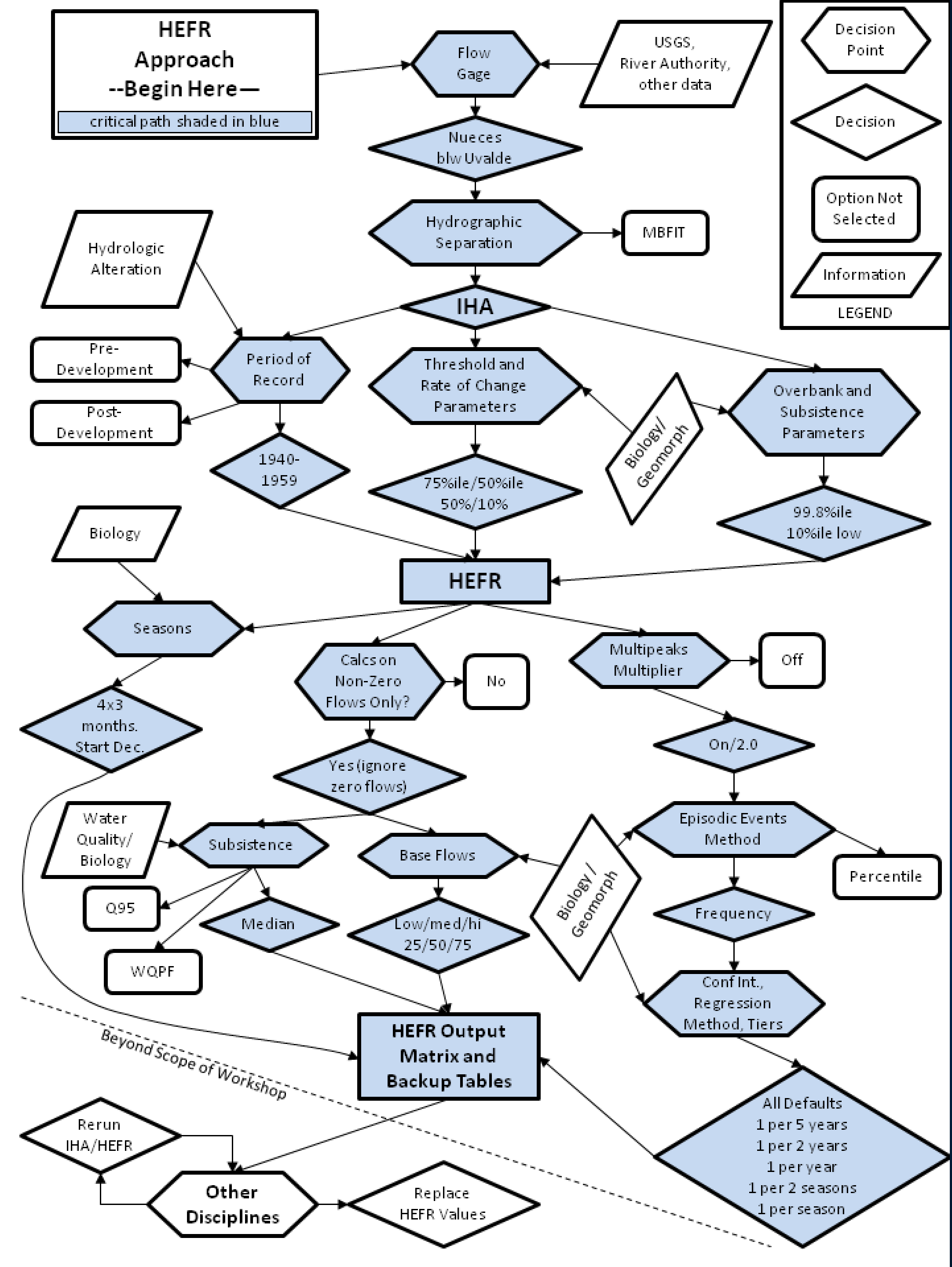
HEFR has two options

- "Percentile Approach"
  - Median of historical overbank flows
- "Frequency Approach"
  - More flexible

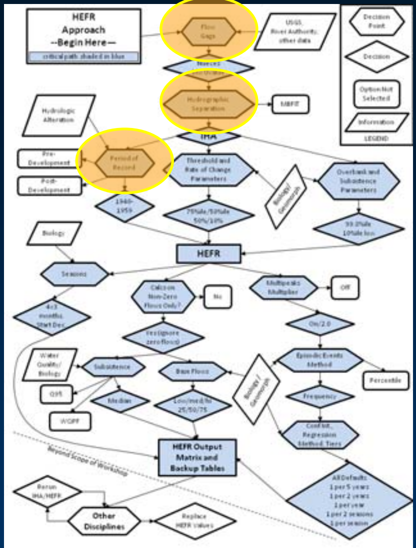
Decision Points

- Key decision points that will be expanded upon in subsequent presentations

View Decision Tree


HEFR
Approach
--Begin Here—
critical path shaded in blue
Flow
Gage
USGS,
River Authority,
other data
Decision
Point
Decision
Option Not
Selected
Information
LEGEND
Nueces
blw Uvalde
Hydrographic
Separation
MBFIT
Hydrologic
Alteration
IHA
Pre-
Development
Post-
Development
Period of
Record
Threshold and
Rate of Change
Parameters
Biology/
Geomorph
Overbank and
Subsistence
Parameters
1940-
1959
75%ile/50%ile
50%/10%
99.8%ile
10%ile low
Biology
HEFR
Seasons
Calcs on
Non-Zero
Flows Only?
No
Multipeaks
Multiplier
Off
4x3
months.
Start Dec.
On/2.0
Yes (ignore
zero flows)
Water
Quality/
Biology
Subsistence
Base Flows
Biology /
Geomorph
Episodic Events
Method
Percentile
Q95
Median
Low/med/hi
25/50/75
Frequency
WQPF
Conf Int.,
Regression
Method, Tiers
Beyond Scope of Workshop
HEFR Output
Matrix and
Backup Tables
All Defaults
1 per 5 years
1 per 2 years
1 per year
1 per 2 seasons
1 per season
Rerun
IHA/HEFR
Other
Disciplines
Replace
HEFR Values

Brief Overview of Decision Points



Location

- Data availability

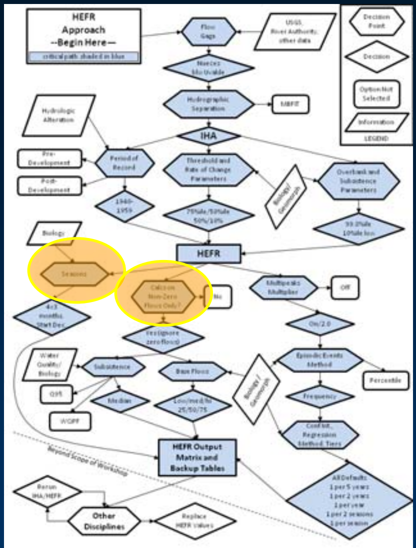
Period of Record

- More years = better
- Consider hydrologic alterations

Hydrographic Separation

- Separate hydrograph into flow components
- One (and only one) assignment for each day

Brief Overview of Decision Points



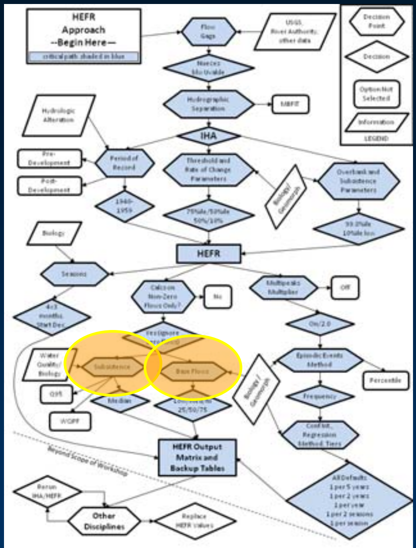
Seasons

- 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



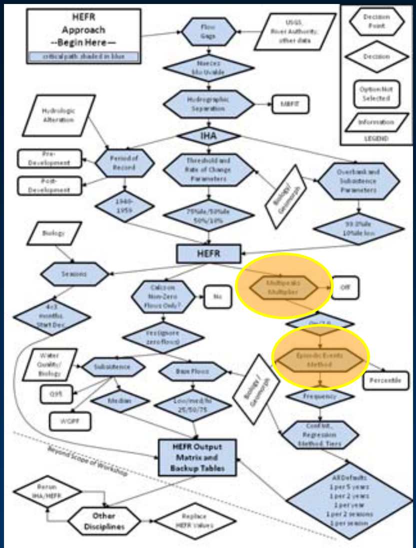
Subsistence

- 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

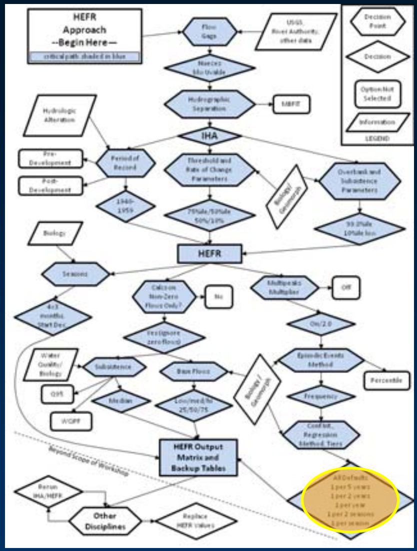
Brief Overview of Decision Points



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

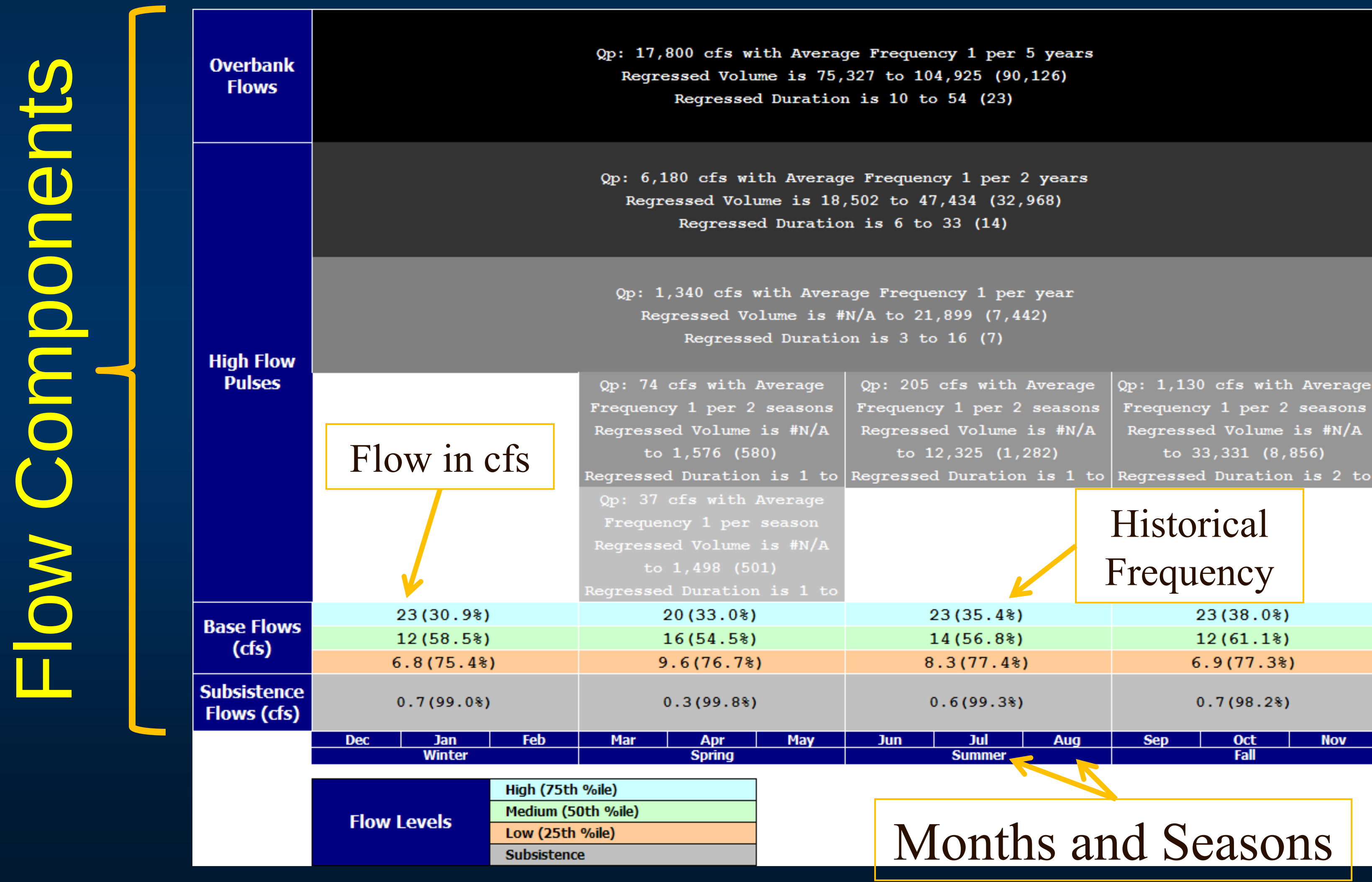
Brief Overview of Decision Points



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



Conclusions

- **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.**