Geomorphic Overlays

Using SAM to Determine the "Effective Discharge"

Geomorphic Overlays

- Part 1
  - Quick Introduction to Single Representative Discharges
- Part 2
  - Using SAM to Determine the "Effective Discharge"

A River in Europe

Sabine River Downstream from HYW 12

Charley River–USGS Alaska

Illinois River

Mississippi River

Tensas River

The Point

- An alluvial stream will adjust the dimensions of its channel to the wide range of flows that mobilize its boundary sediments
- Research has shown that in many rivers a single discharge can be used to determine a stable channel geometry

Single Representative Discharge

- Foundation is in "Regime" and "hydraulic geometry" theories
- The Single Representative Discharge is Sometimes called
  - Dominant Discharge
  - Channel Forming Discharge
  - Effective Discharge
  - Bankfull Discharge

Single Representative Discharge

- For my talk Channel-forming Discharge and dominant discharge are equivalent
  - The theoretical discharge that if maintained indefinitely would result in the same channel geometry as the existing channel geometry with the natural range of flow events.

Channel Width vs. Bankfull Discharge

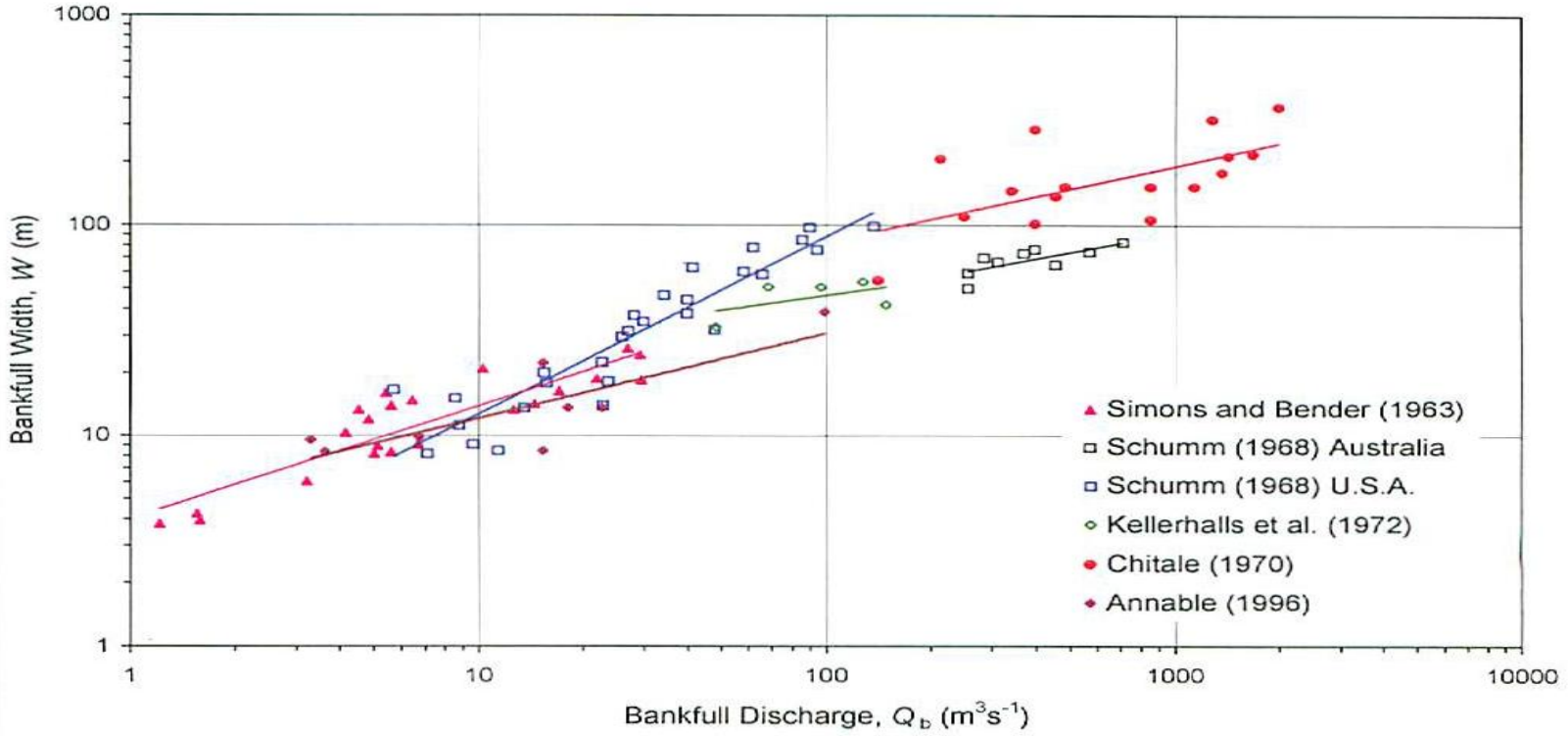


Figure 5.2 Downstream width-discharge relationships in sand-bed streams based on data from various sources.

Regime Equations

- Regime Equations from Julien and Wargadalam
  - $W \approx 0.512 Q^{0.53} d_s^{-.33} T_*^{-0.2}$
  - $V \approx 14.7 Q^{0.07} d_s^{.33} T_*^{0.47}$
  - $h \approx 0.133 Q^{0.40} T_*^{-0.2}$
  - $S \approx 14.7 Q^{-.0.4} d_s T_*^{1.2}$
- Where: Q = dominant flow discharge, $d_s = d_{50}$ of the bed material, τ_* = Shields parameter S = slope, V= velocity h= depth

Terms and Definitions

EFFECTIVE DISCHARGE:

Effective discharge is defined as the mean of the discharge increment that transports the largest fraction of the annual sediment load over a period of years (Andrews 1980). It is calculated by integrating the flow-duration curve and a bed-material-sediment rating curve. (USACE 2000)

Terms and Definitions

EFFECTIVE DISCHARGE:

The effective discharge incorporates the principle prescribed by Wolman and Miller (1960) that the channel-forming discharge is a function of both the magnitude of the event and its frequency of occurrence.

Terms and Definitions

- **Bed Load**: Component of the total sediment load made up of sediment moving in frequent, successive contact with the bed (Bagnold 1966)

- **Bed-Material Load**: Portion of the total sediment Load composed of grain size found in appreciable quantities in the stream bed, in sand-bed streams significant quantities of bed-material load move as suspended load.

Terms and Definitions

- **Fine Material Load (Wash Load)** Portion of the total sediment load composed of particles finer than those found in the stream bed, frequently assumed to be the fraction finer than .0625mm

- **Suspended Load (Total Suspended Load**) is the Suspended bed material load Plus the Fine material Load

Terms and Definitions

Total Bed Material Load: is Suspended Bed Material Load Plus the Bed load

Total Sediment Load: is Bed Material Load Plus the Wash Load

Terms and Definitions

- Effective discharge is calculated using only the *Total Bed Material Load*

- *Wash Load* is not included in computations

Required Data For SAM Computations of Effective Discharge

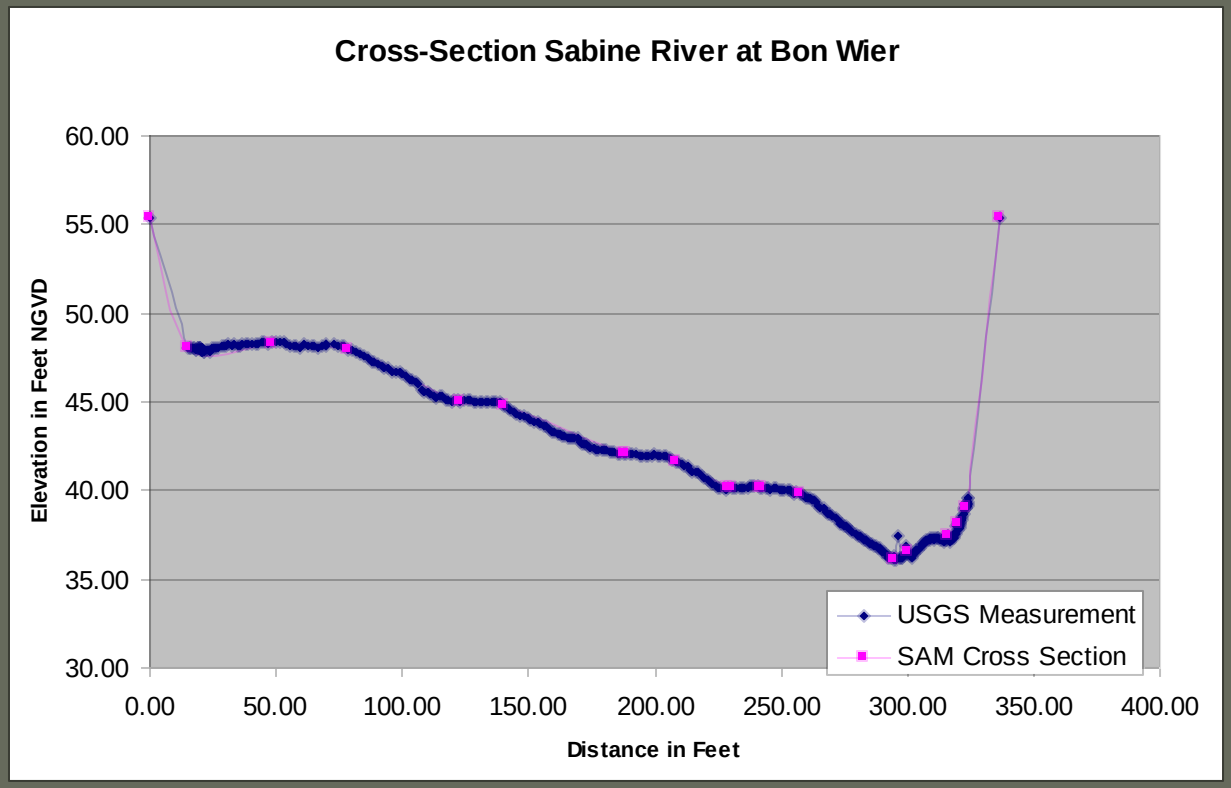
Channel Cross Section

Bed Material Gradation

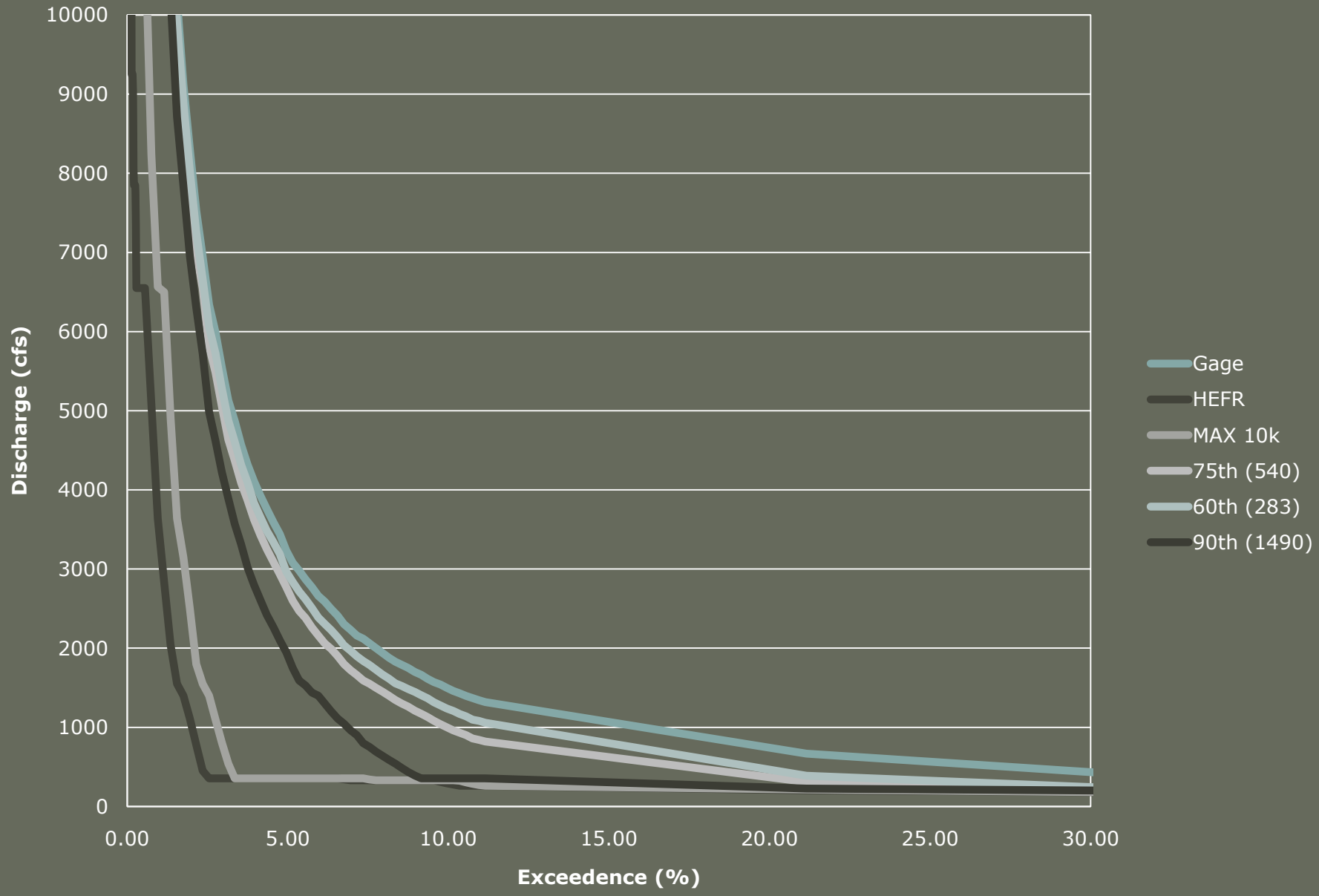
Channel Bed Slope

Flow Duration Curve

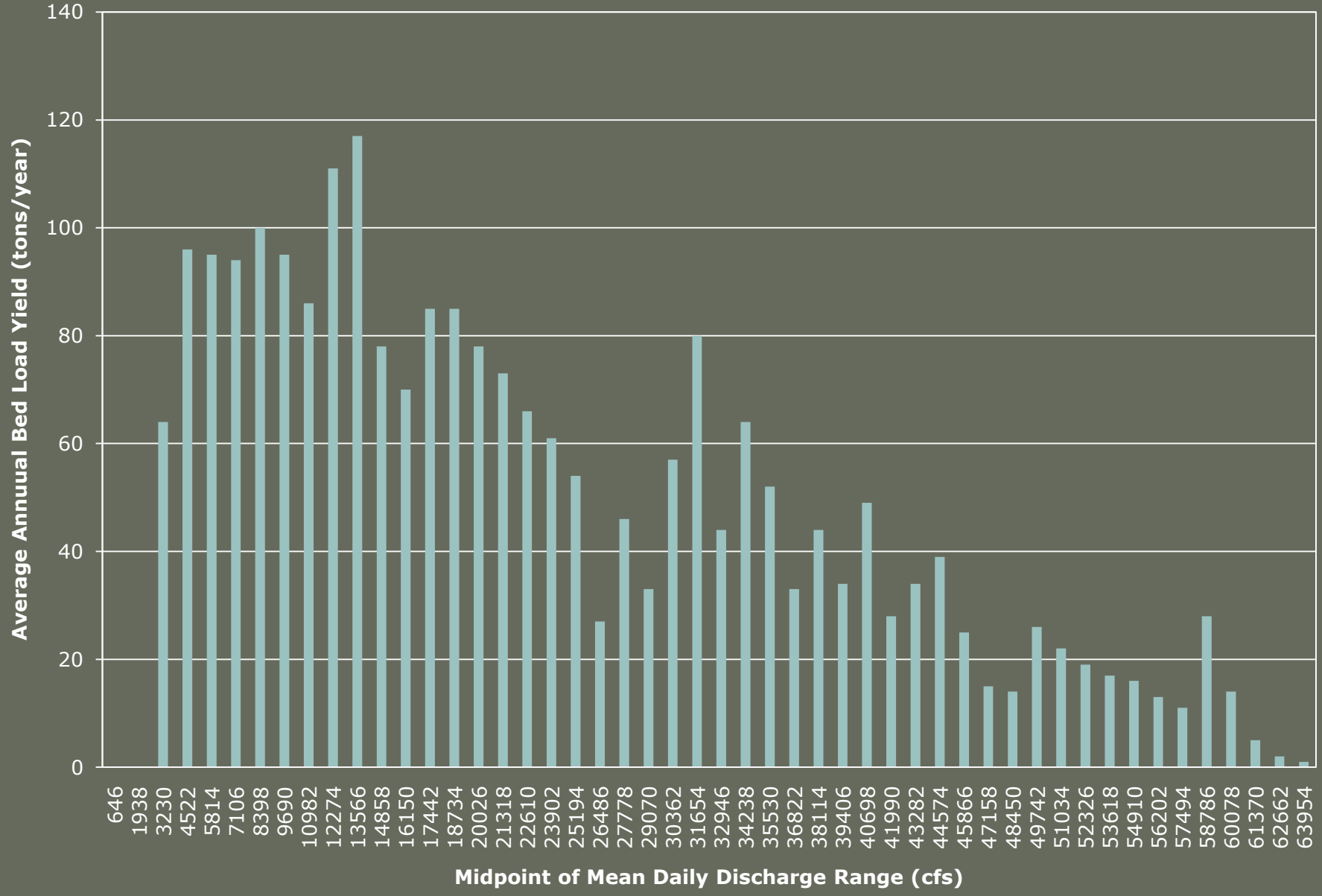
Sam Inputs


Cross-Section Sabine River at Bon Wier
Elevation in Feet NGVD
60.00
55.00
50.00
45.00
40.00
35.00
30.00
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
400.00
Distance in Feet
USGS Measurement
SAM Cross Section

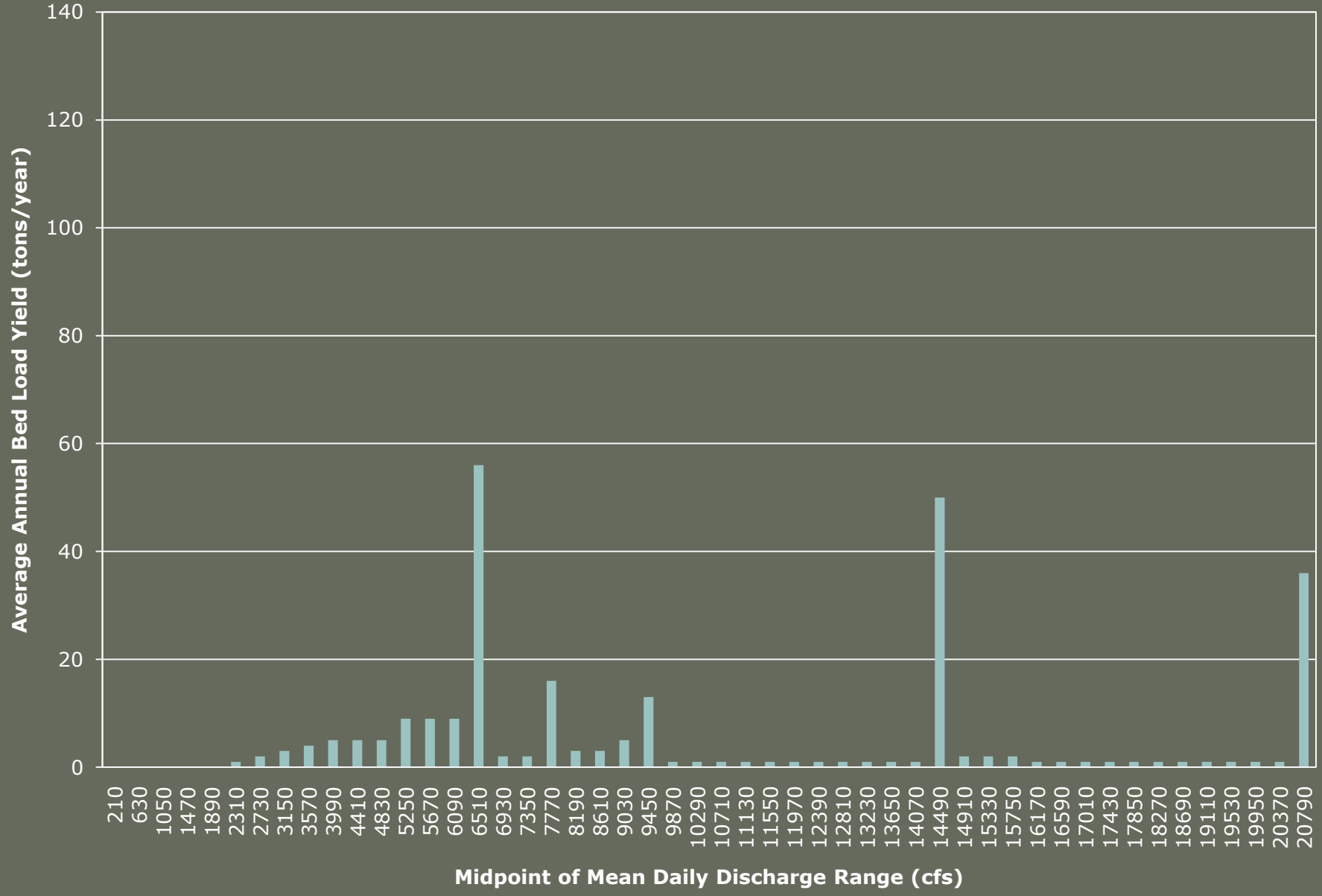
Colorado River nr. San Saba - Flow Duration Curves



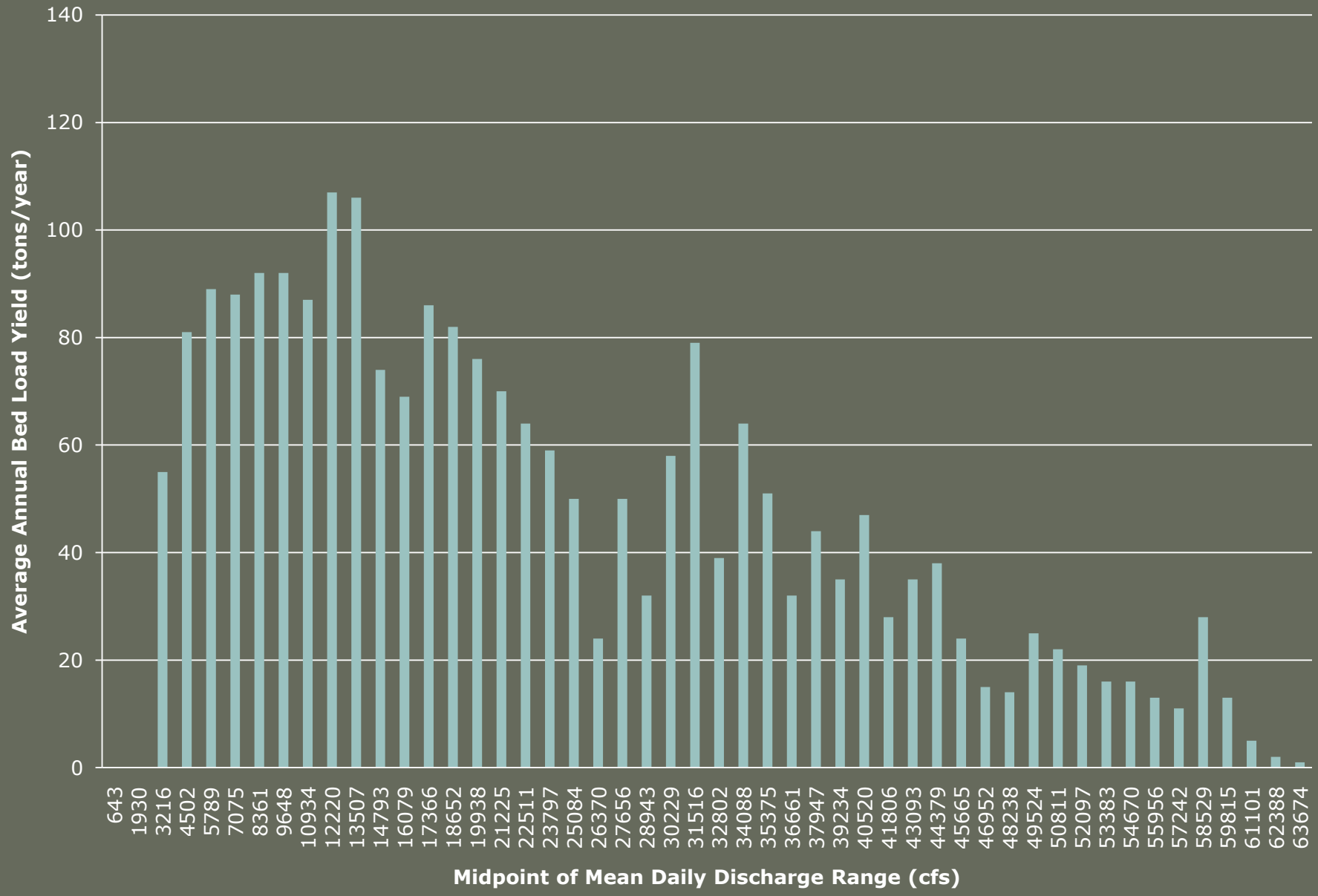
Colorado River nr. San Saba - Existing Gage Data



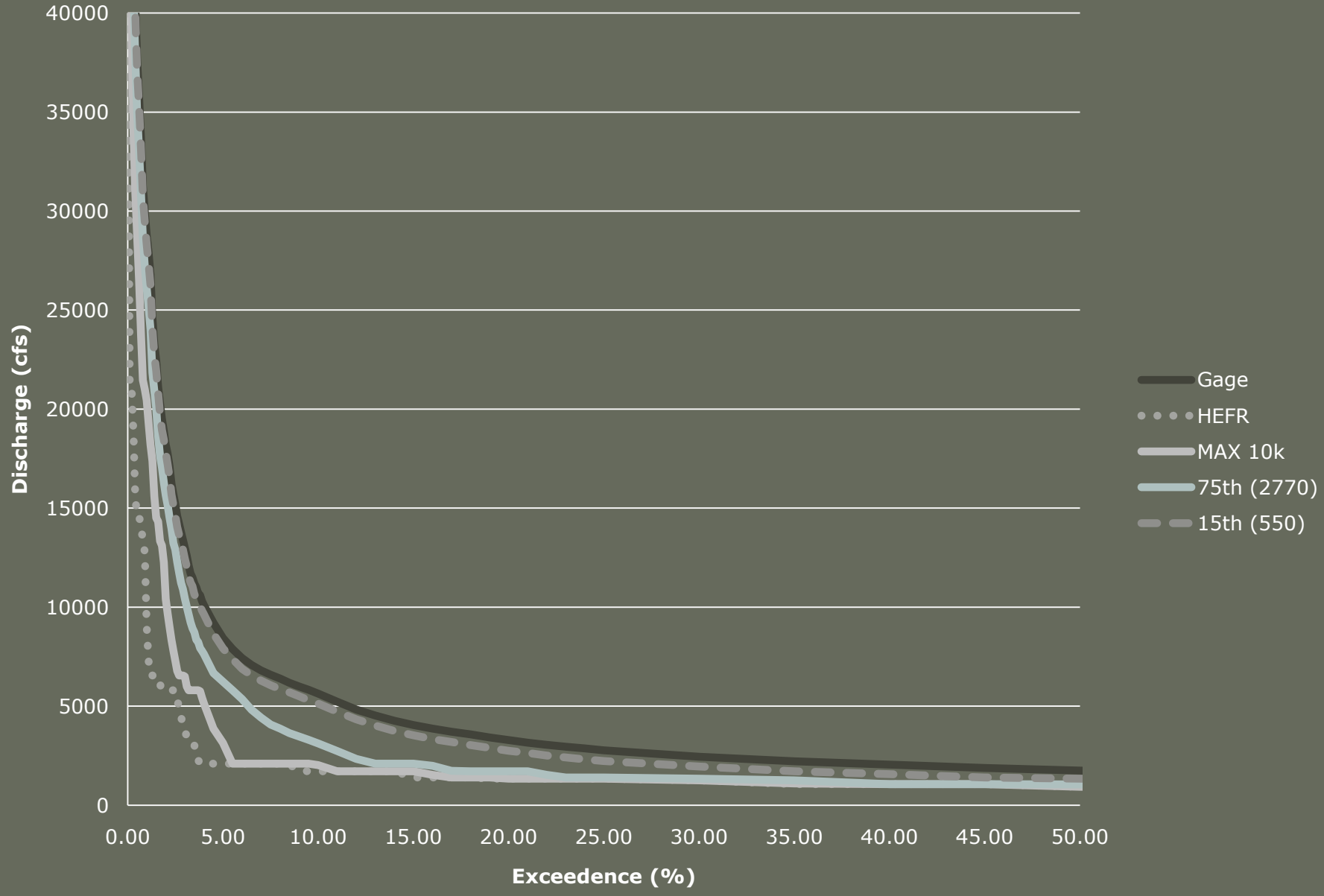
Colorado River nr. San Saba - HEFR Regime



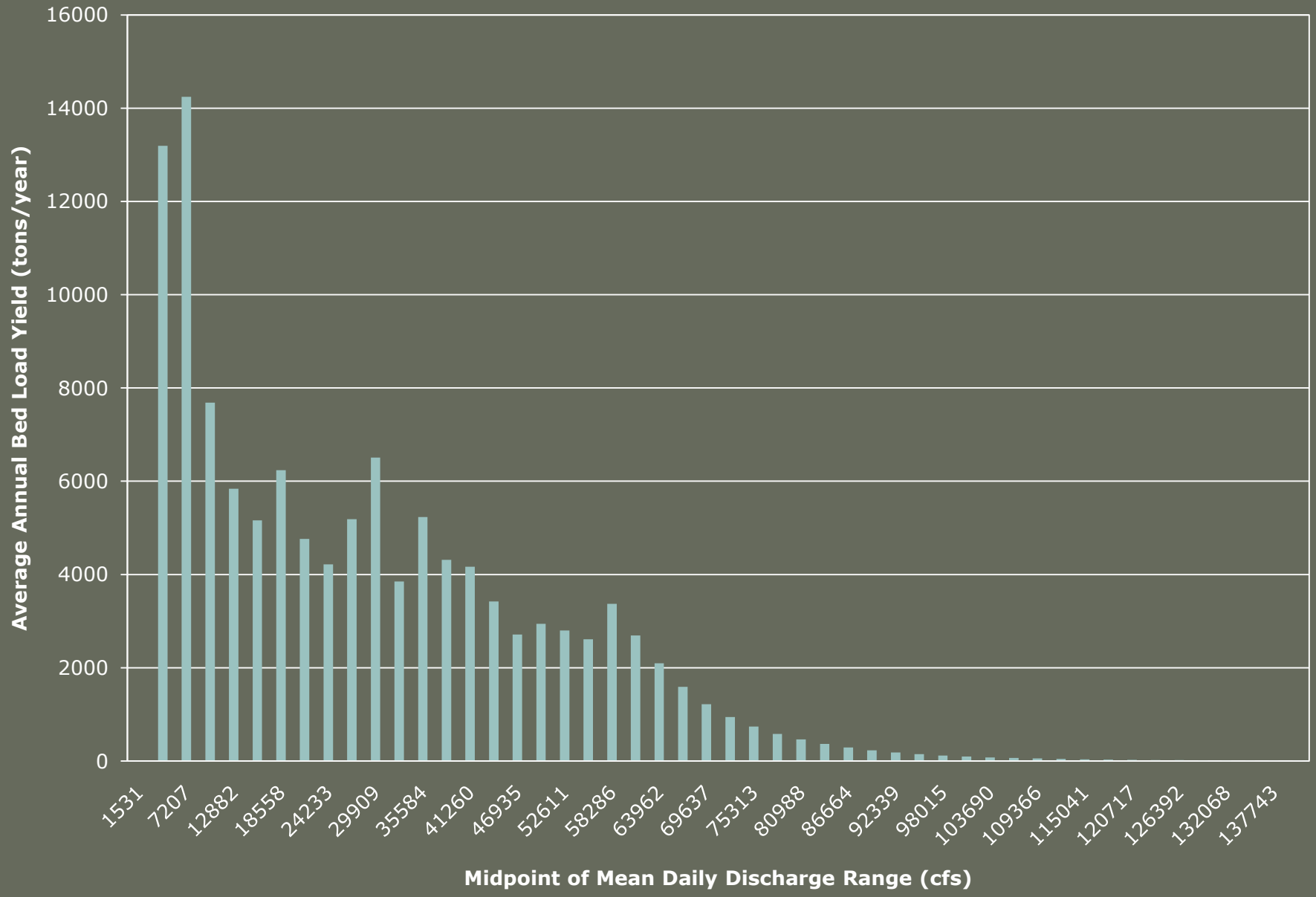
Colorado River nr. San Saba - 60th Percentile Max



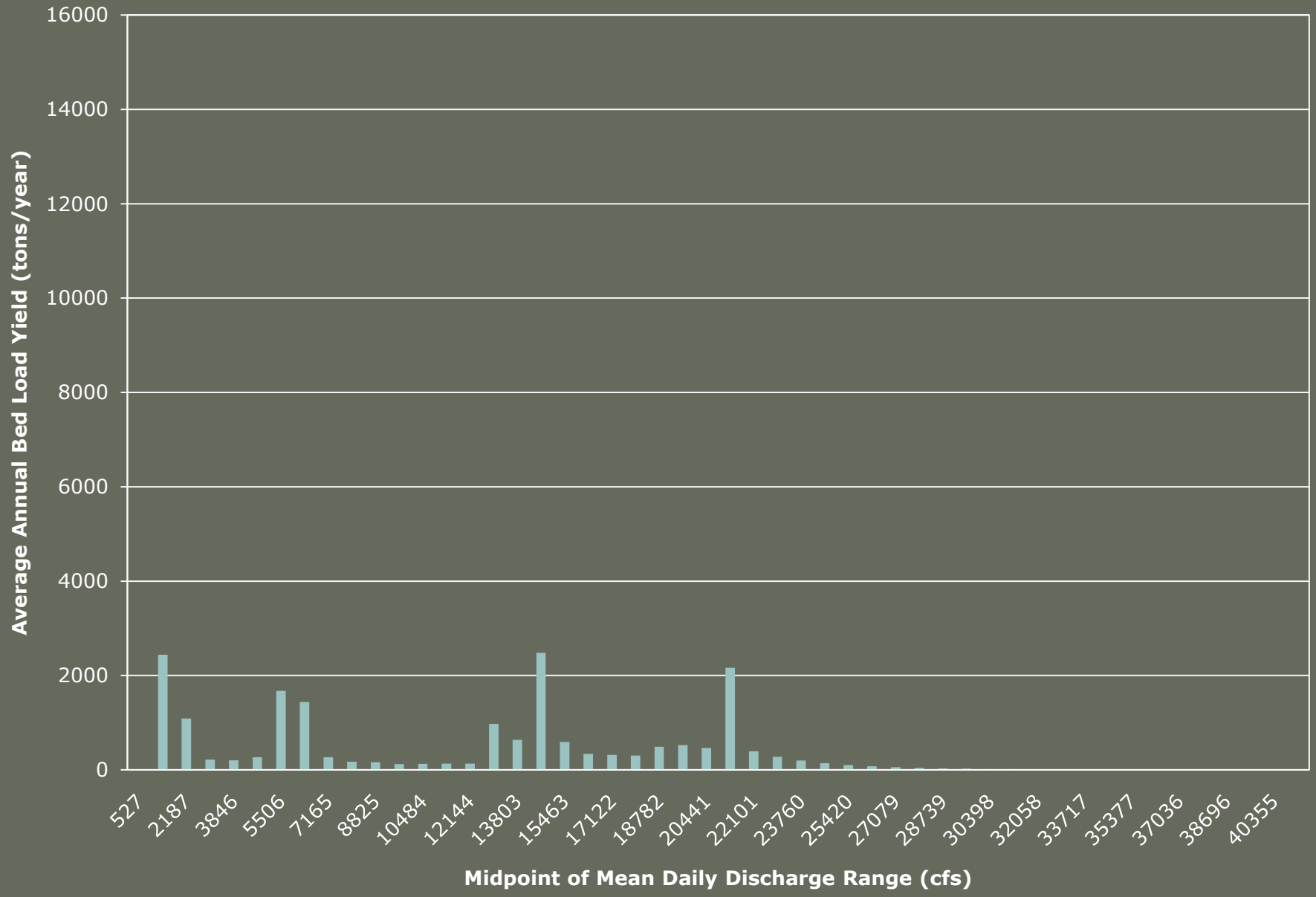
Colorado River at Columbus - Flow Duration Curves



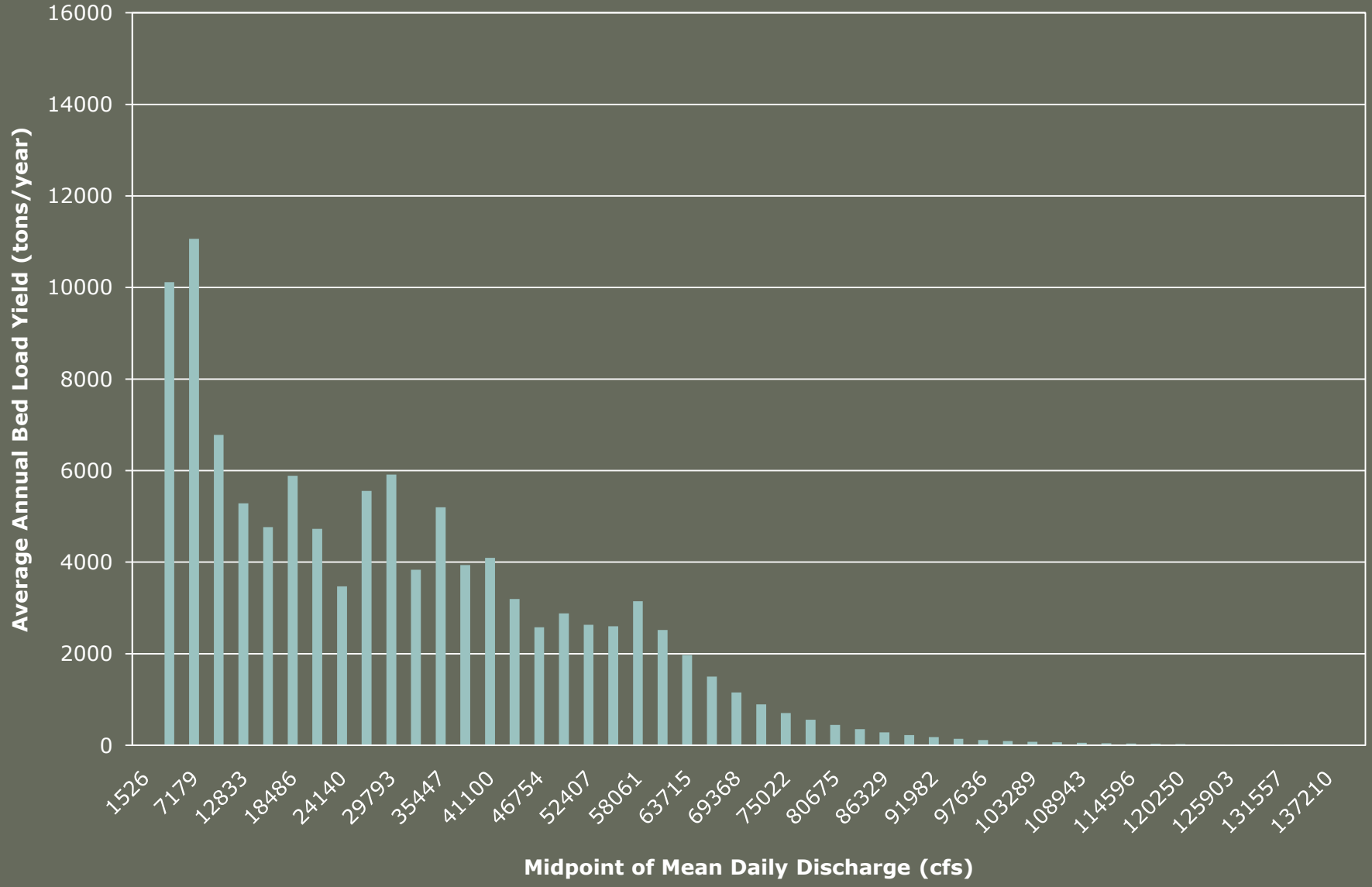
Colorado River at Columbus - Existing Gage Data



Colorado River at Columbus - HEFR Regime



Colorado River at Columbus - 15th Percentile Max Diversion



Comparison of Results

- Decrease in discharge and Bed material Load can lead to:
  - Reduction in width
  - Depth changes (+/-)
  - Decrease in width-depth ratio
  - Slope changes (+/-)
  - Increase in Sinuosity
    - From Stan Schumm (1969)

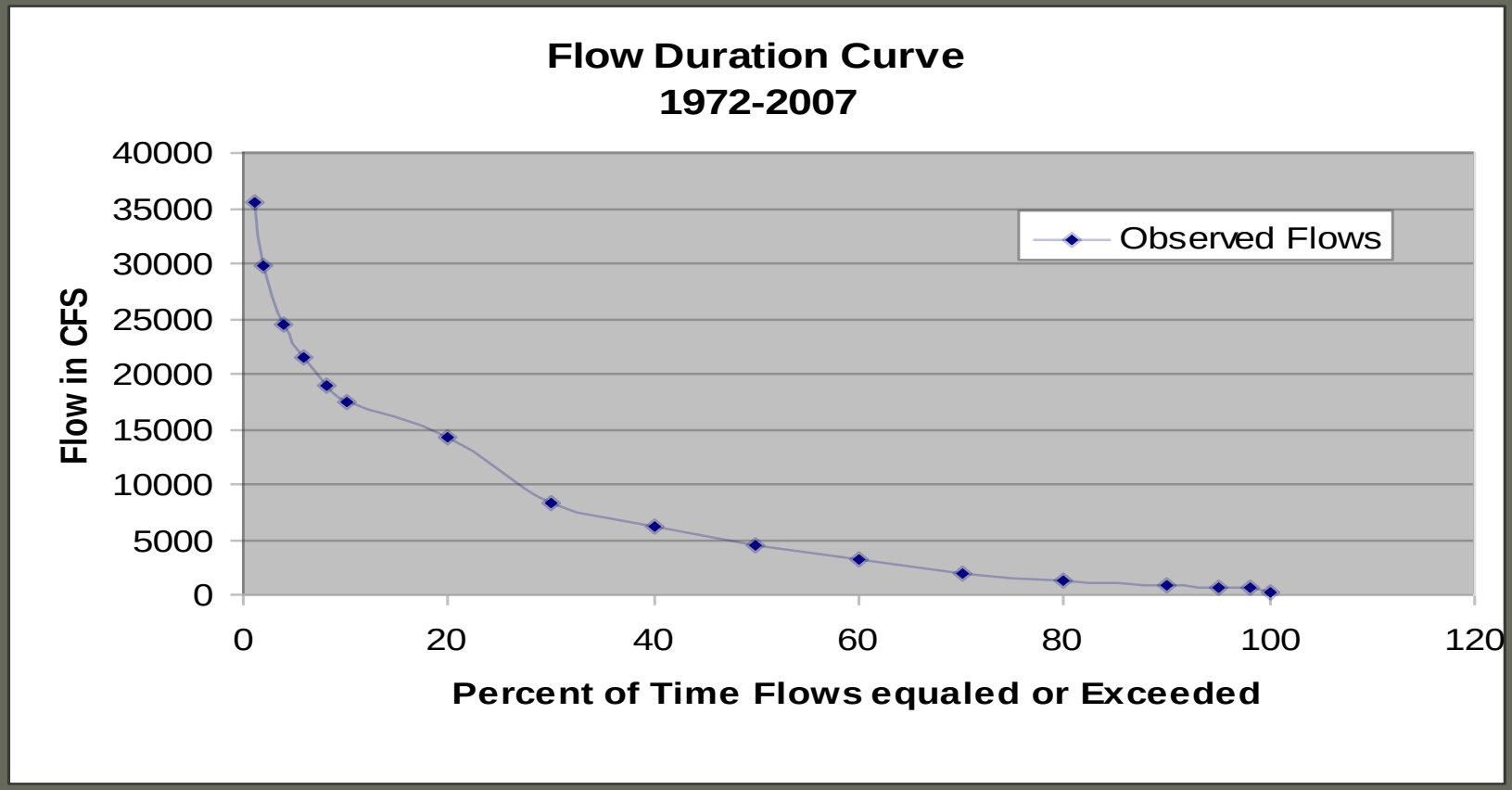
Sam Input
Bed Material Gradation

- From USACE Report
- D16 = .0625 mm
- D50 = .14 mm
- D84 = .30 mm
- D100 = .5 mm

- Channel Bottom Slope = .00014 ft/ft or about .75 Ft per mile

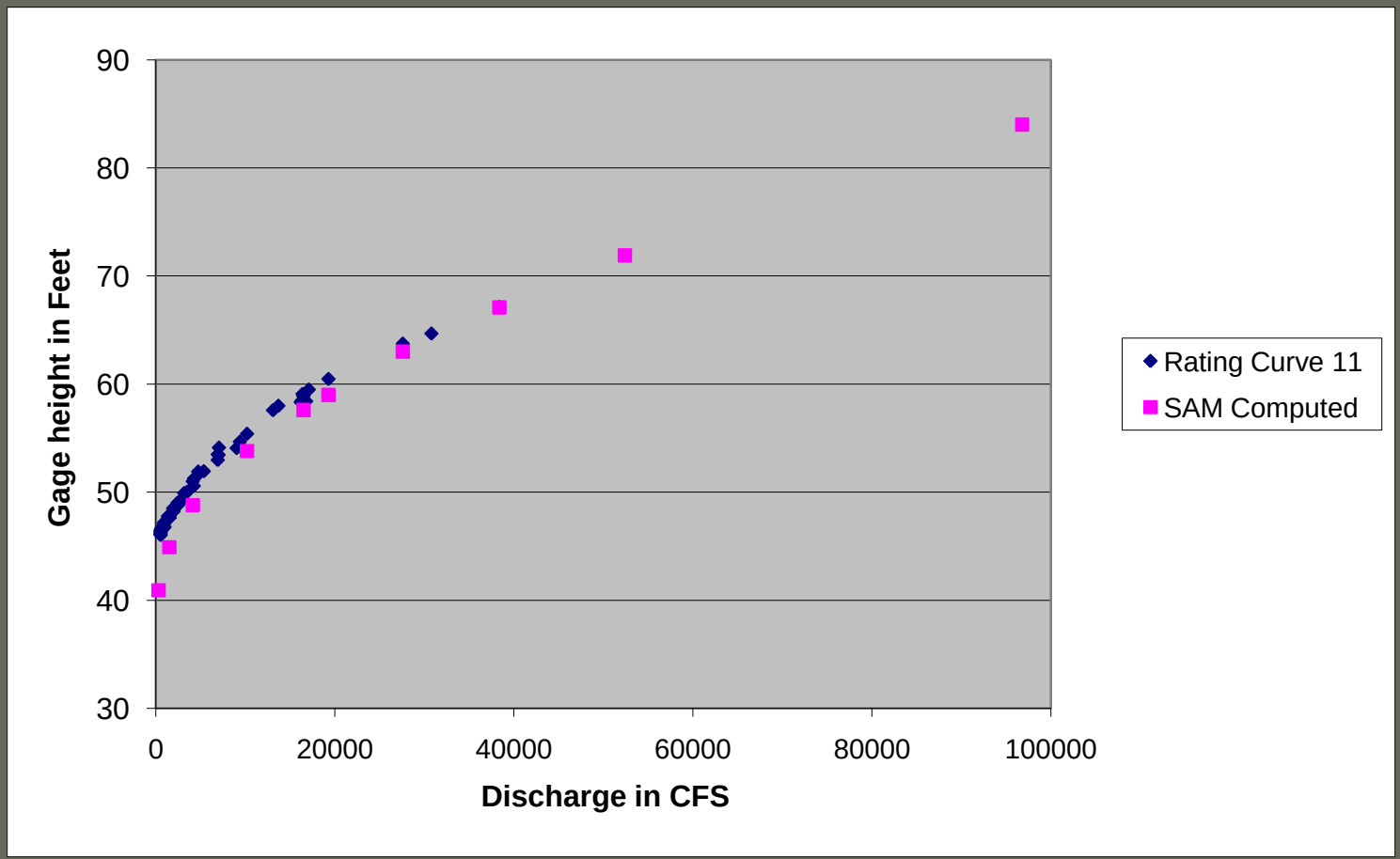
SAM Input

- Flow duration Curve

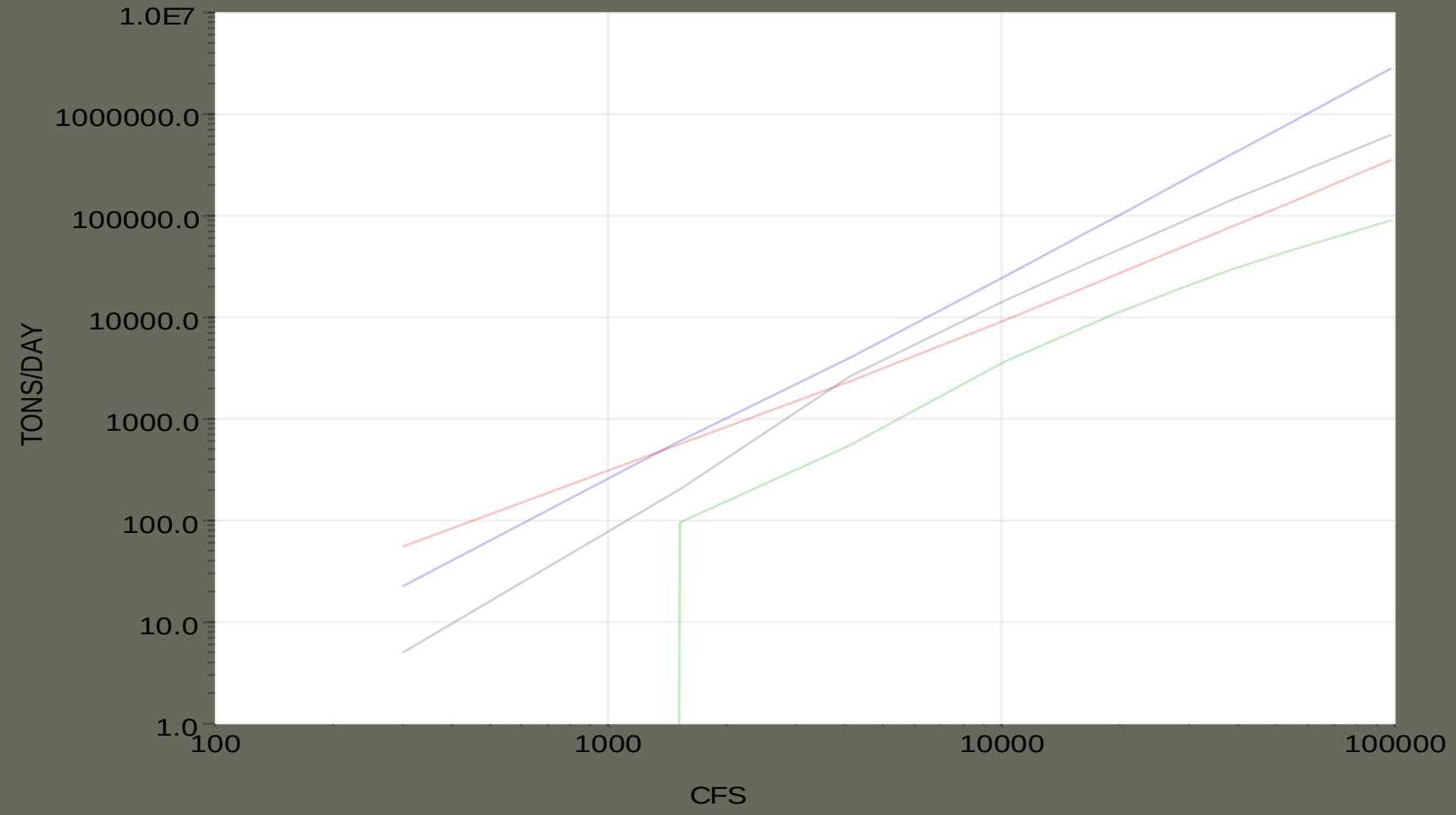


Sam output

- Hydraulics



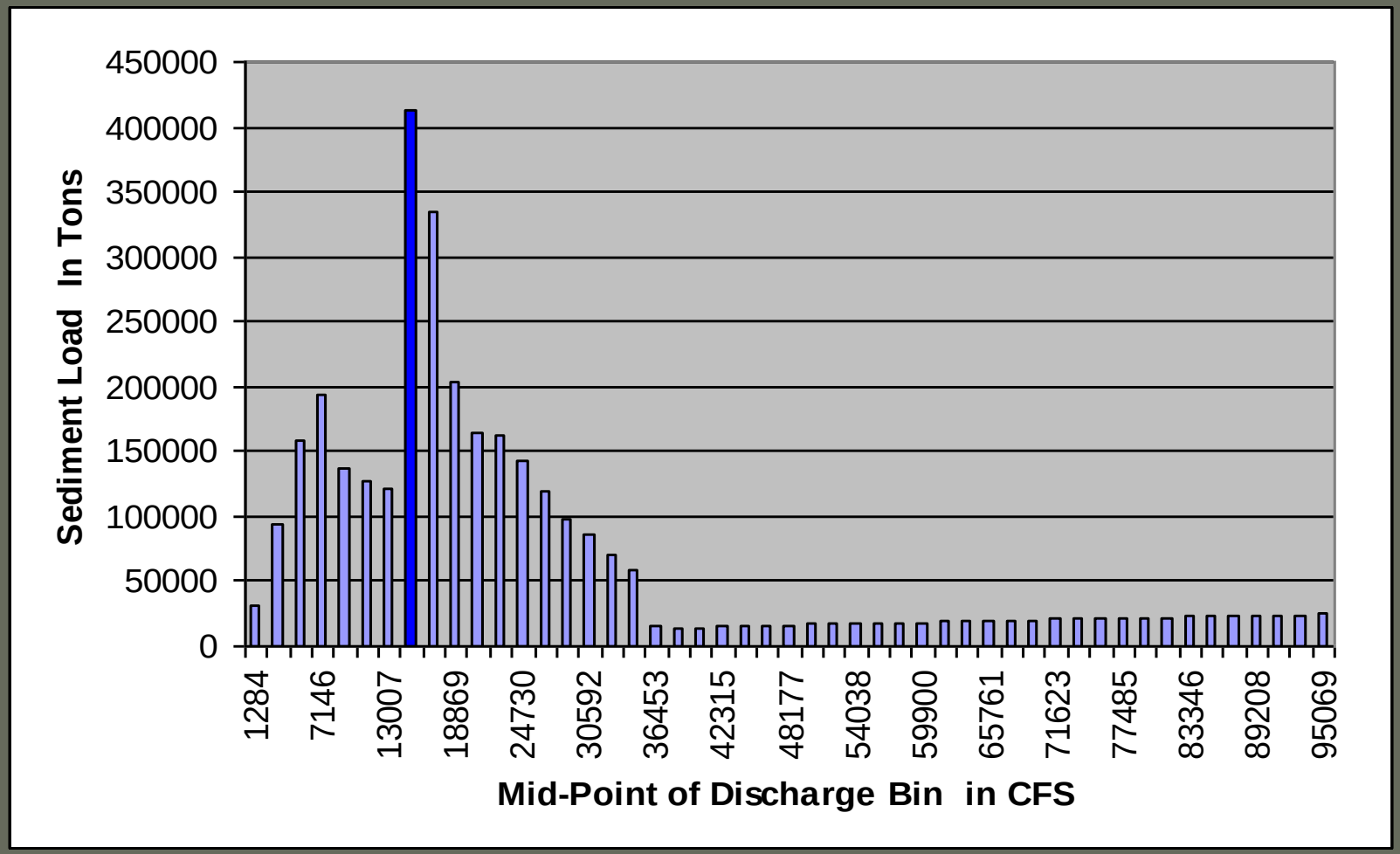
Sediment Rating Curve



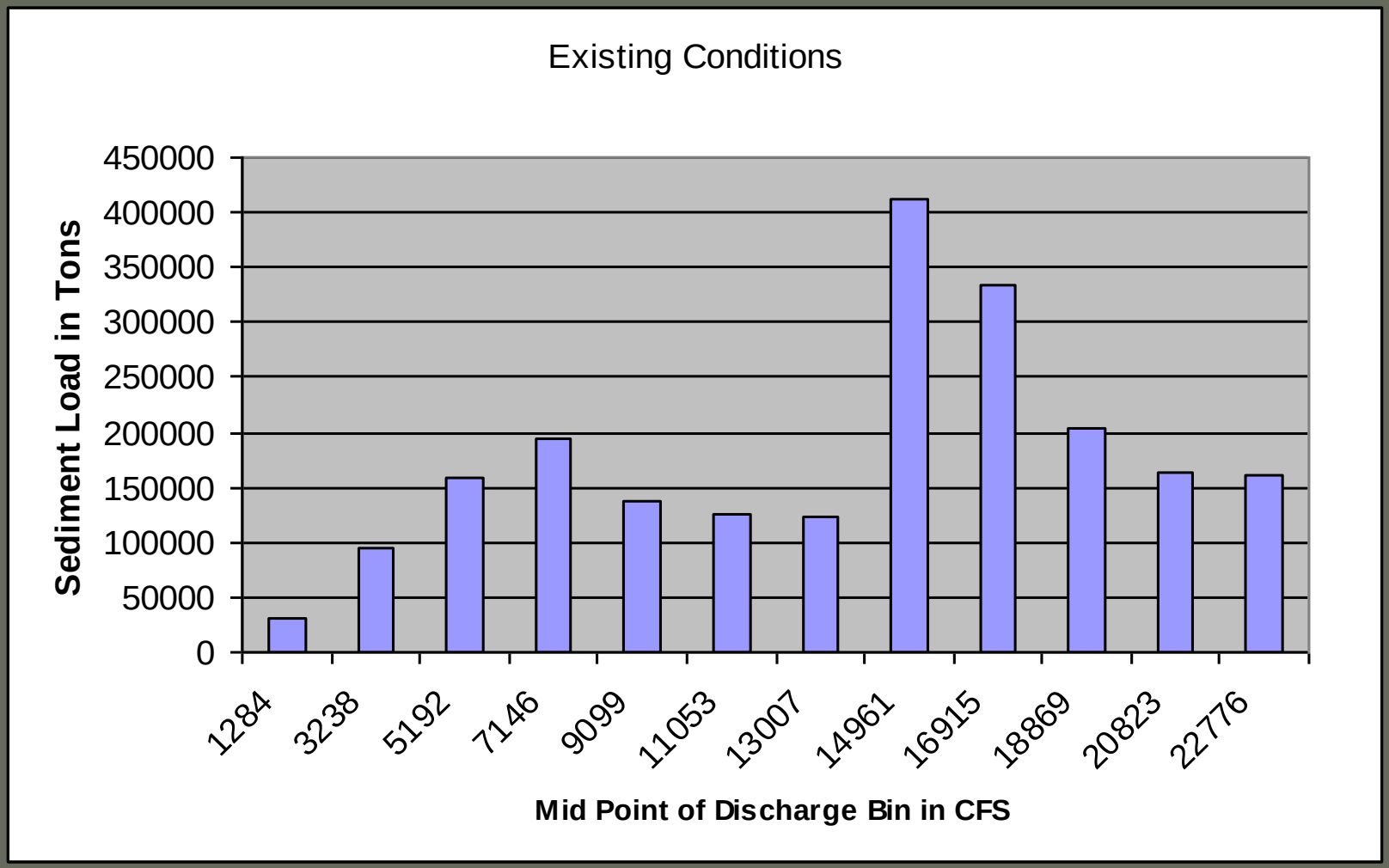
SAM OUTPUT

- Observed Hydrologic Regime
  - Annual Water Yield = 5,465,145 AC FT
  - Annual Sediment Yield = 3,342,038 Tons

Sediment Histograms



Sediment Histograms



Effective Discharge After HEFR Implemented

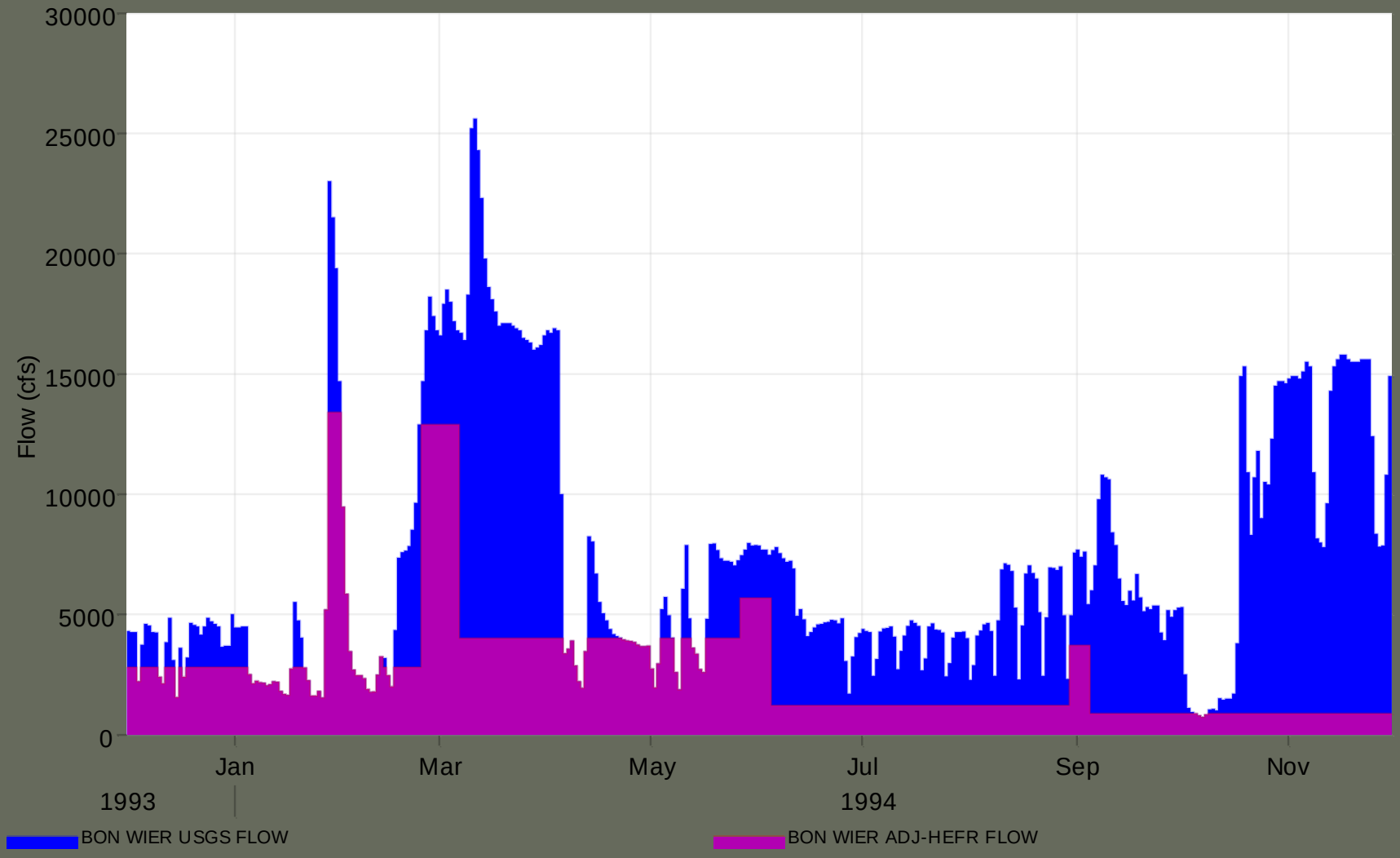
- Adjusted the yearly Hydrographs From 1972-2007 to reflect full implementation of the HEFR Flow regime

HEFR FLOWS

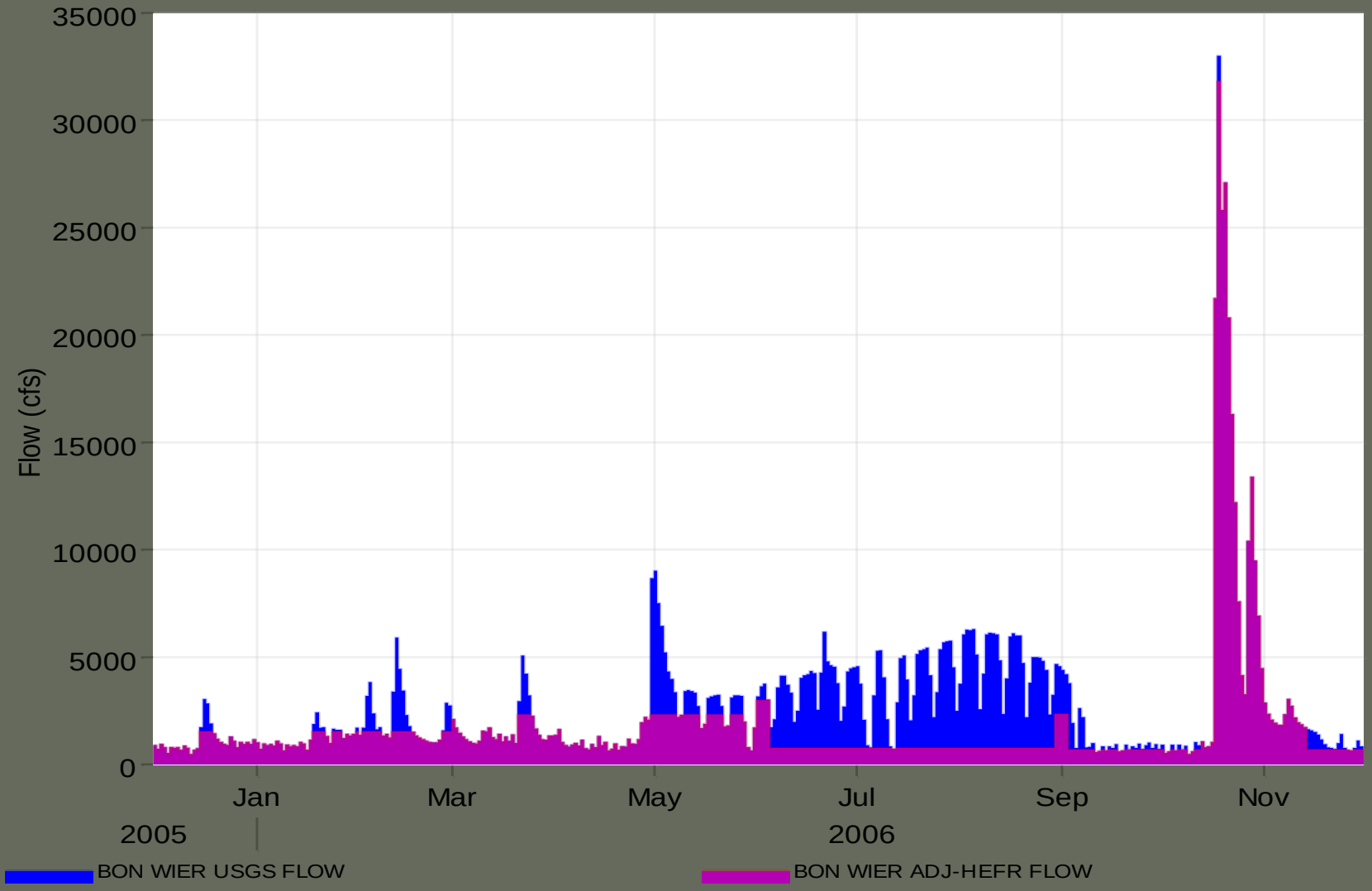
Overbank Flows	Return Period (R) : 0.8 (years)				Duration (D) : 32 (days)			
	Volume (V) : 1353987 (ac-ft)				Peak Flow (Q) : 31800 (cfs)			
High Flow Pulses	F: 1	D: 18	F: 1	D: 16	F: 0	D: 12	F: 0	D: 10
	Q: 19000	V: 416351	Q: 17400	V: 384814	Q: 11900	V: 120397	Q: 7135	V: 82354
	F: 1	D: 12	F: 1	D: 11	F: 0	D: 9	F: 1	D: 6
	Q: 13400	V: 207868	Q: 12900	V: 191207	Q: 5690	V: 67716	Q: 3705	V: 37964
	F: 1	D: 6	F: 1	D: 6	F: 0	D: 4	F: 1	D: 4
	Q: 8690	V: 87610	Q: 10700	V: 98500	Q: 2995	V: 24258	Q: 2350	V: 17009
Base Flows (cfs)	6110		6640		2190		1430	
	2800		4000		1220		870	
	1540		2340		770		703	
Subsistence Flows (cfs)	703		703		703		703	

Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov

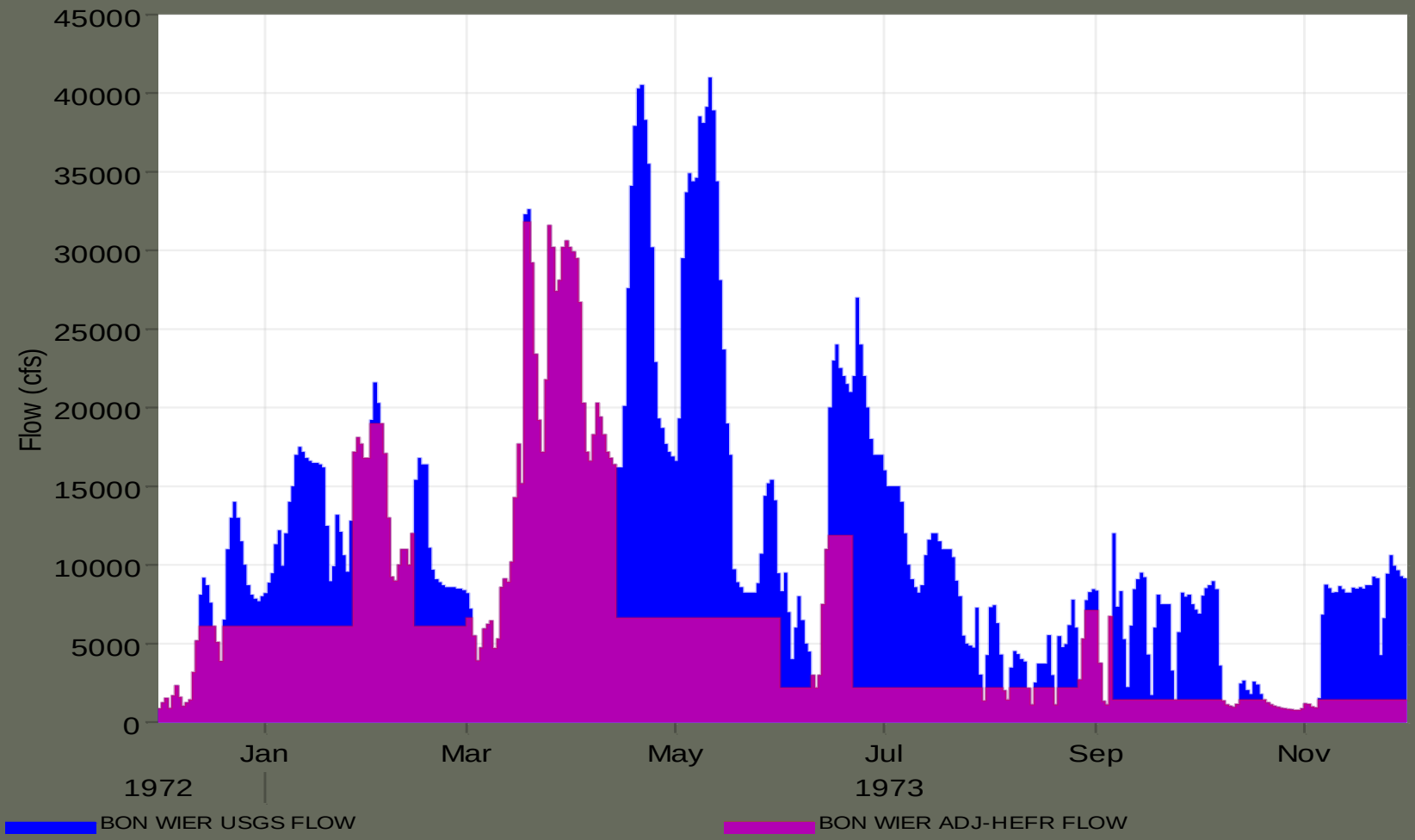
Average Hydrodrograph



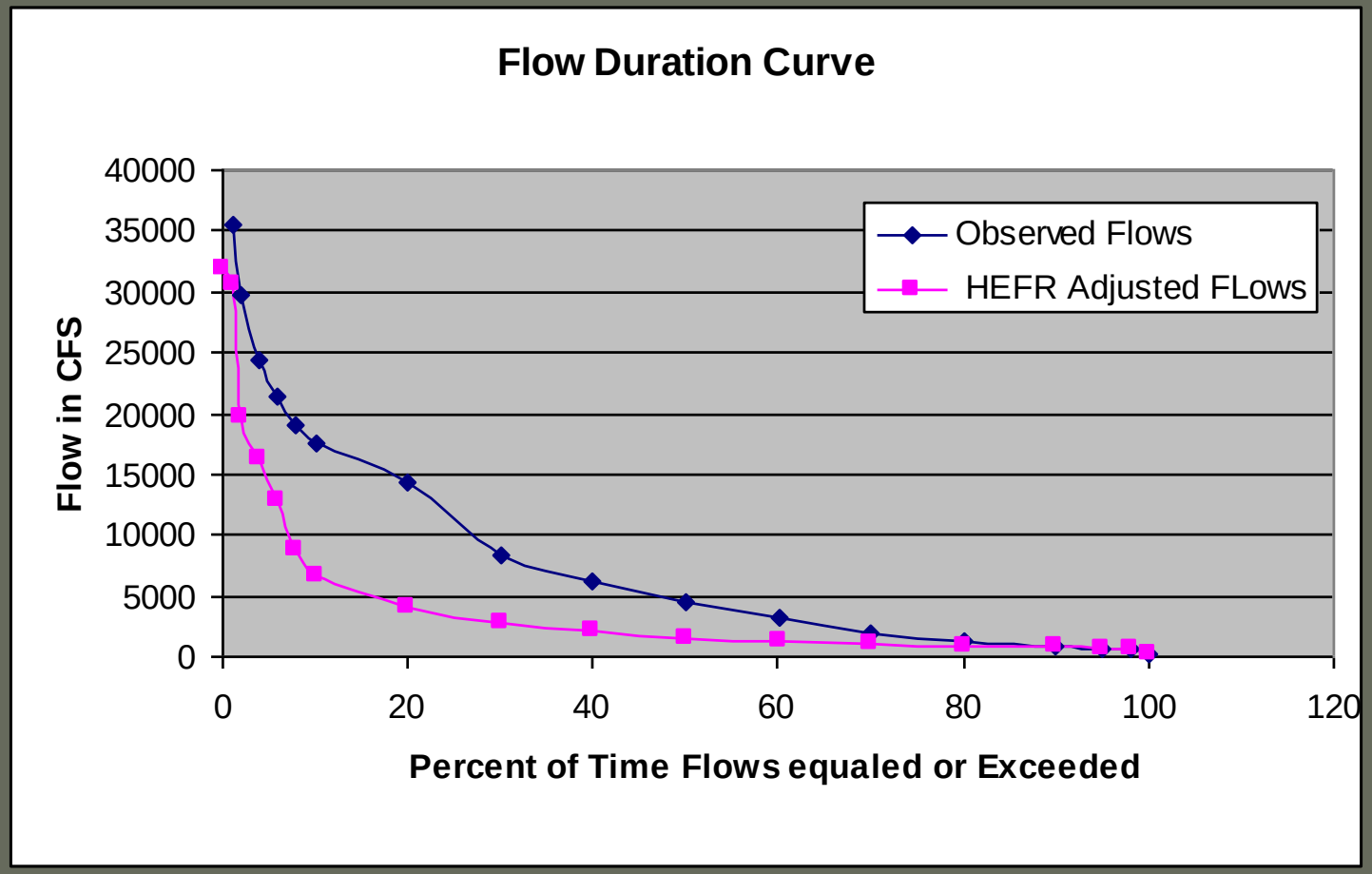
Dry Hydrograph



Wet Hydrograph



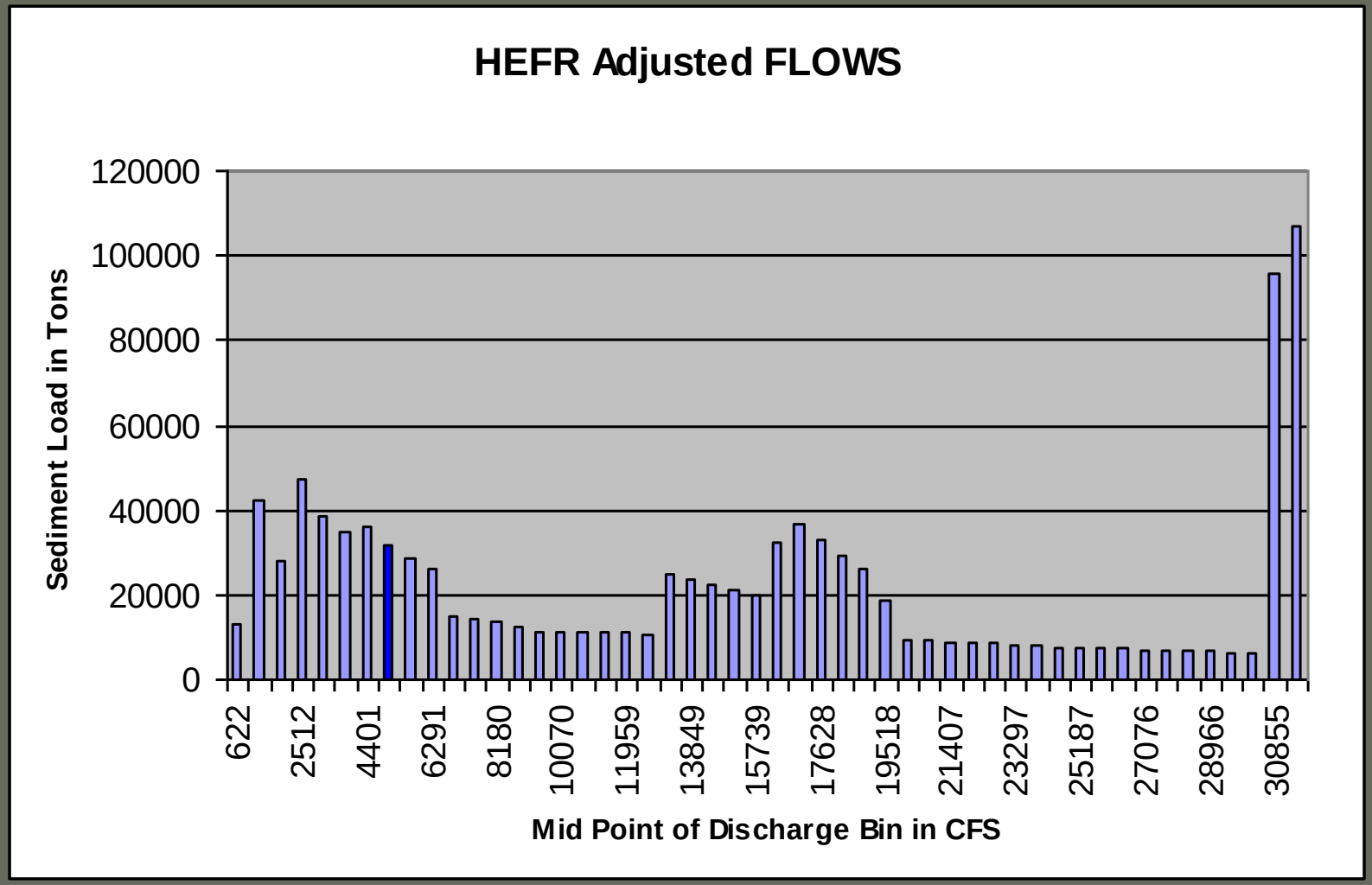
New Flow duration Curve



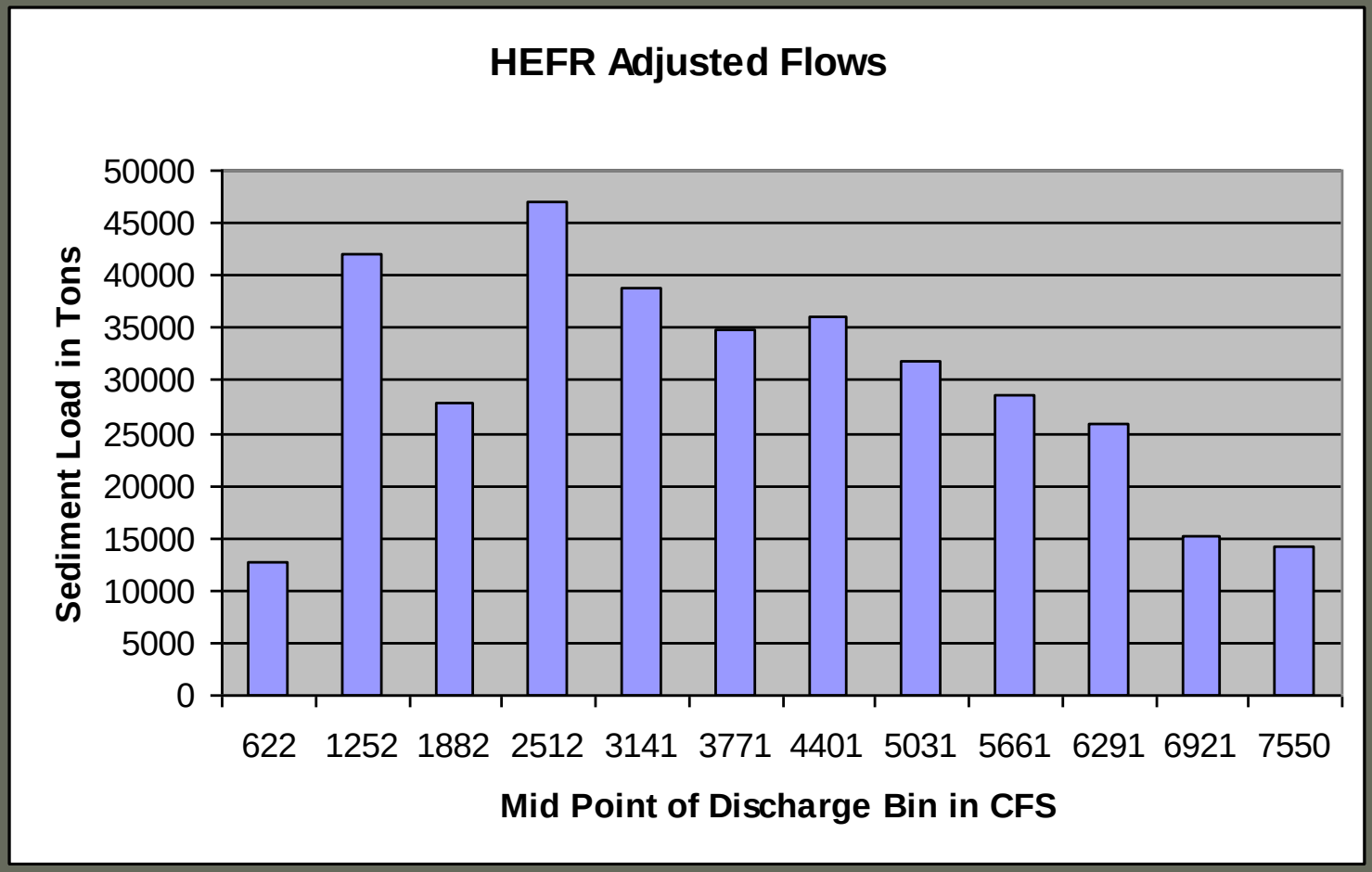
SAM OUTPUT

- HEFR Hydrologic Regime
  - Annual Water Yield = 2,397,320 AC FT
  - Annual Sediment Yield = 1,068,724 Tons

Sediment Histograms



Sediment Histograms



Comparison of Results

- Significant Decrease in Water and Sediment Yield
- Water Yield
  - 5.5 to 2.4 Million ac-ft.
- Sediment Yield
  - 3.3 to 1.0 tons annually
- Significant Changes in Effective Discharge

Comparison of Results

- Decrease in discharge and Bed material Load can lead to:
  - Reduction in width
  - Depth changes (+/-)
  - Decrease in width-depth ratio
  - Slope changes (+/-)
  - Increase in Sinuosity
    - From Stan Schumm (1969)

Channel Incision