Geomorphic Overlays

Using SAM to Determine the "Effective Discharge"

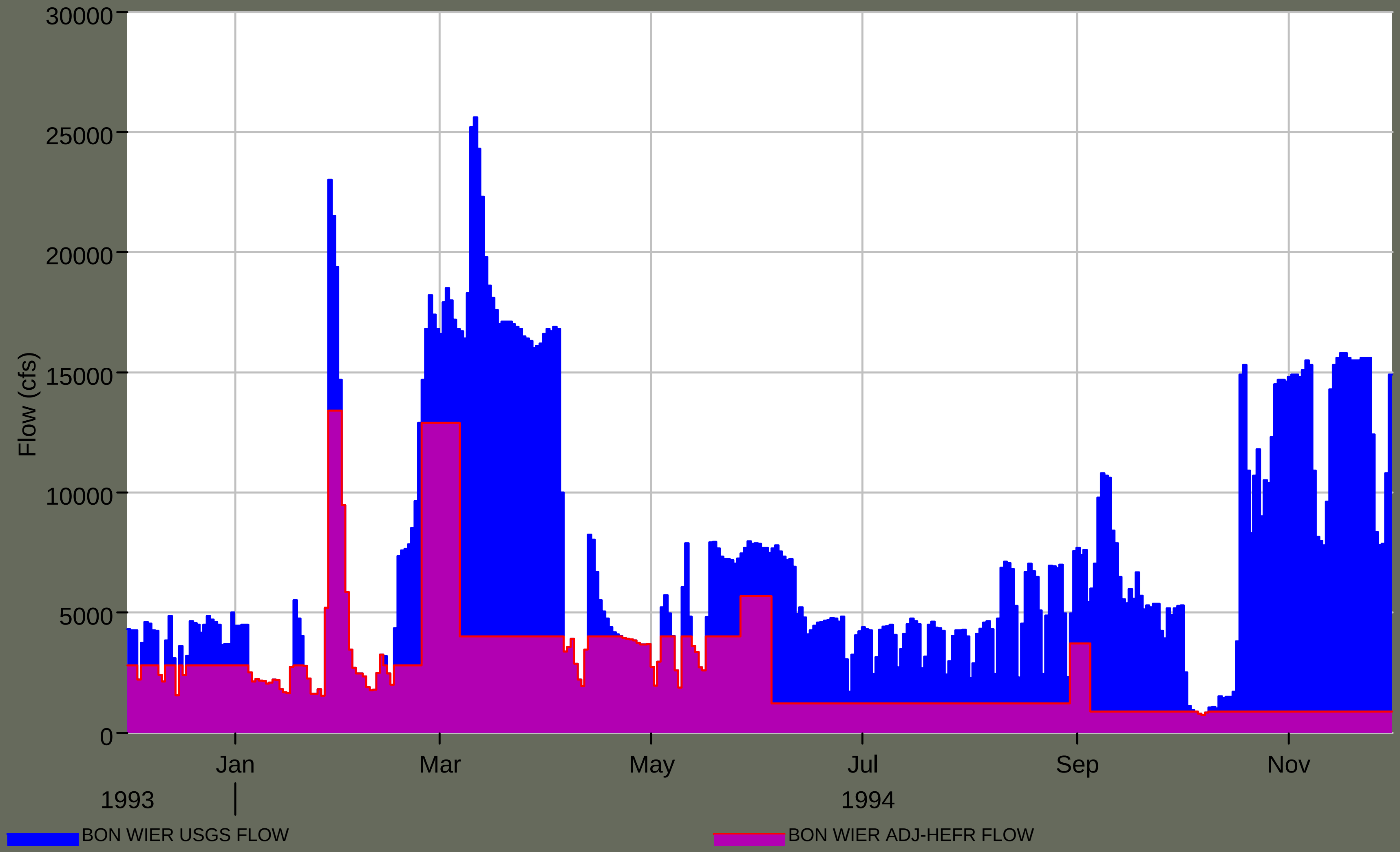
Geomorphic Overlays

- Part 1
  - HEFR Adjustments to Daily Flows
- Part 2
  - Quick Introduction to Single Representative Discharges
- Part 3
  - Using SAM to Determine the “Effective Discharge”

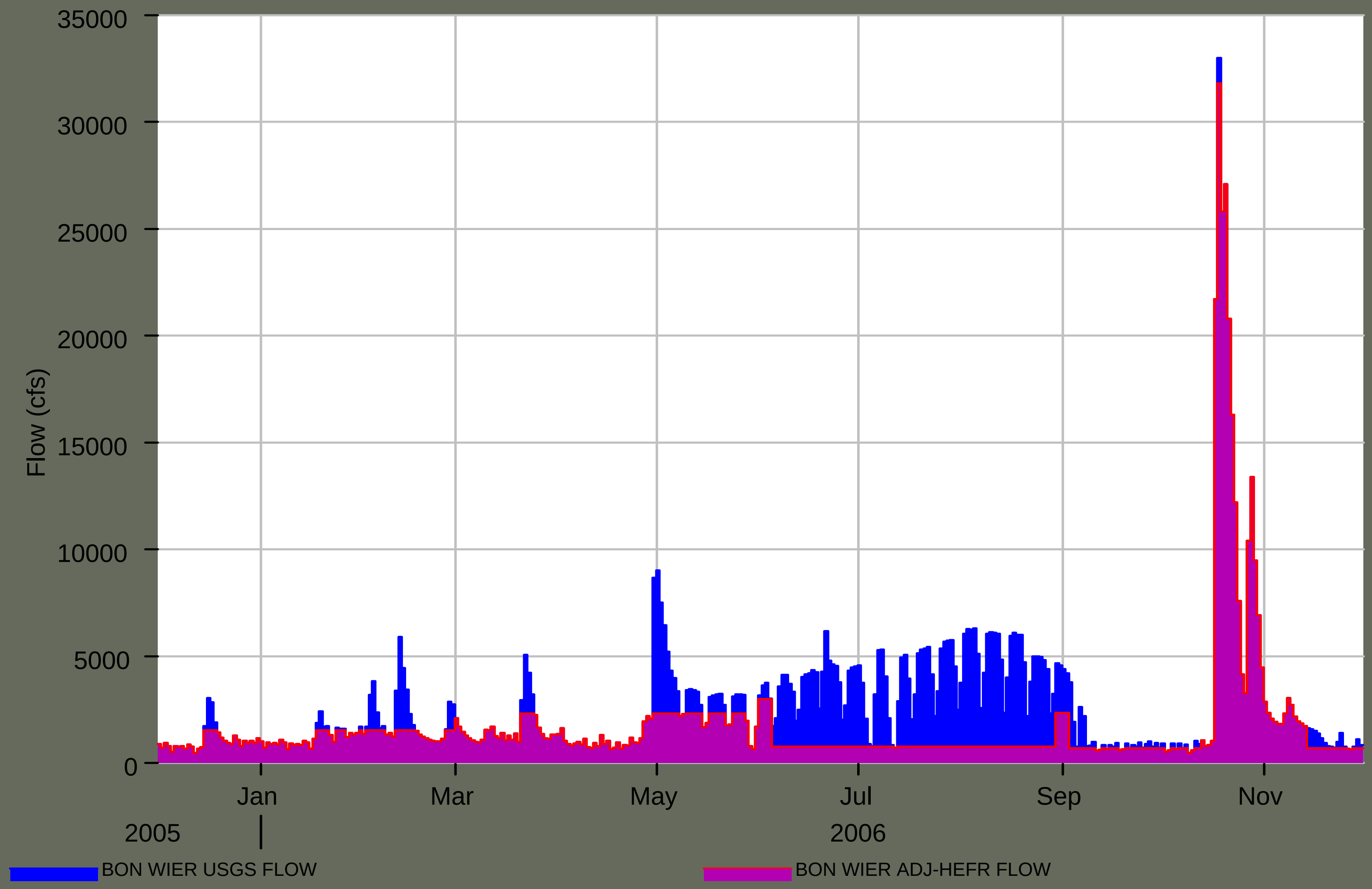
HEFR FLOWS

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

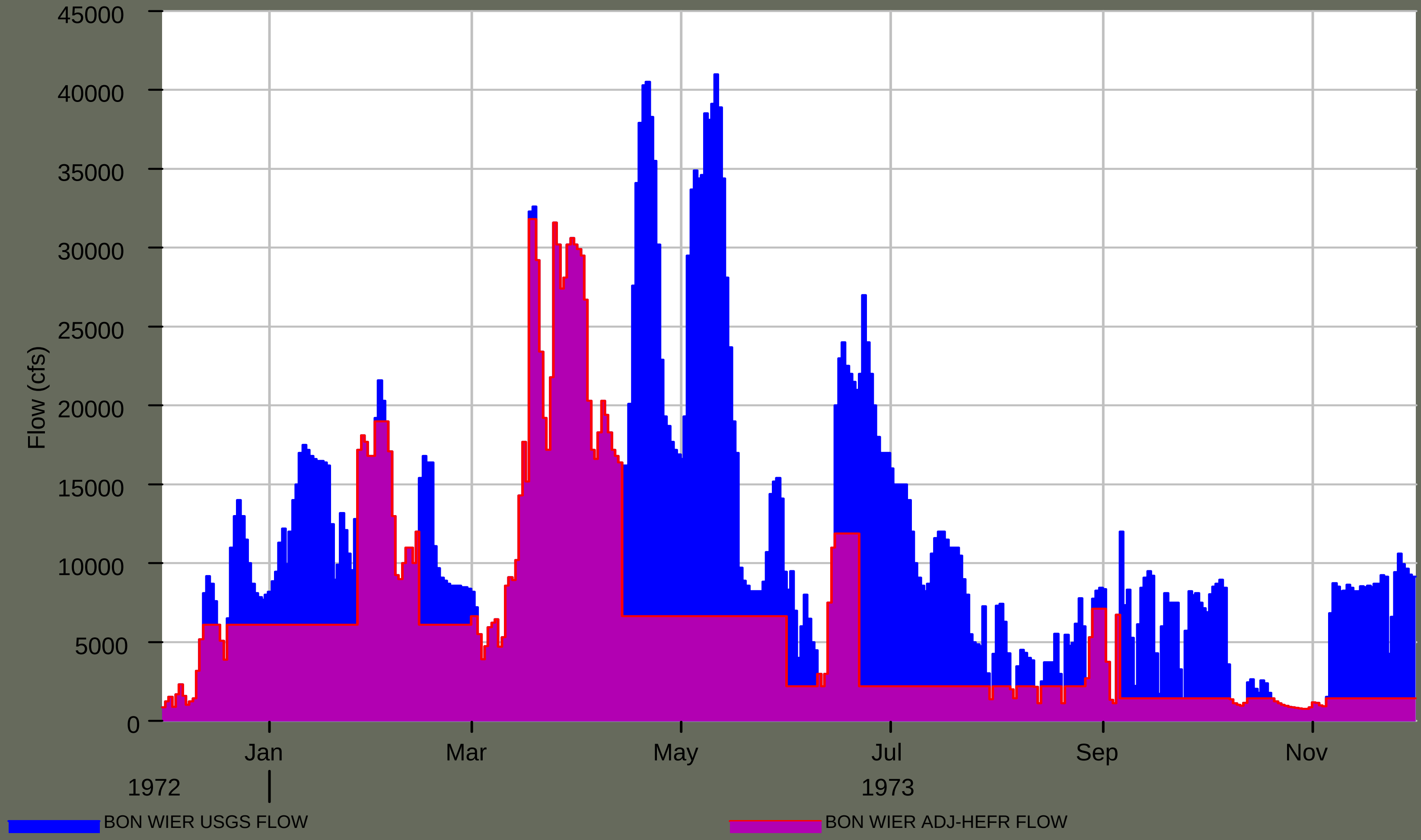
Average Hydrodrograph



Dry Hydrograph



Wet Hydrograph



Charley River–USGS Alaska

A River
in Europe

Mississippi River

Tensas River

Sabine River Downstream from HYW 12

The Point

- An alluvial stream will adjust the dimensions of its channel to the wide range of flows that mobilize its boundary sediments
- Will Sabine or Neches Rivers change as a result of Proposed Environmental Flow regime?

Single Representative Discharge

- Research has shown that in many rivers a single discharge can be used to determine a stable channel geometry

- 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.

Single Representative Discharge

- Three methods for determining Channel Forming Discharge
  - Bankfull
  - Specified recurrence interval discharge
  - Effective Discharge

Channel Width vs. Bankfull Discharge

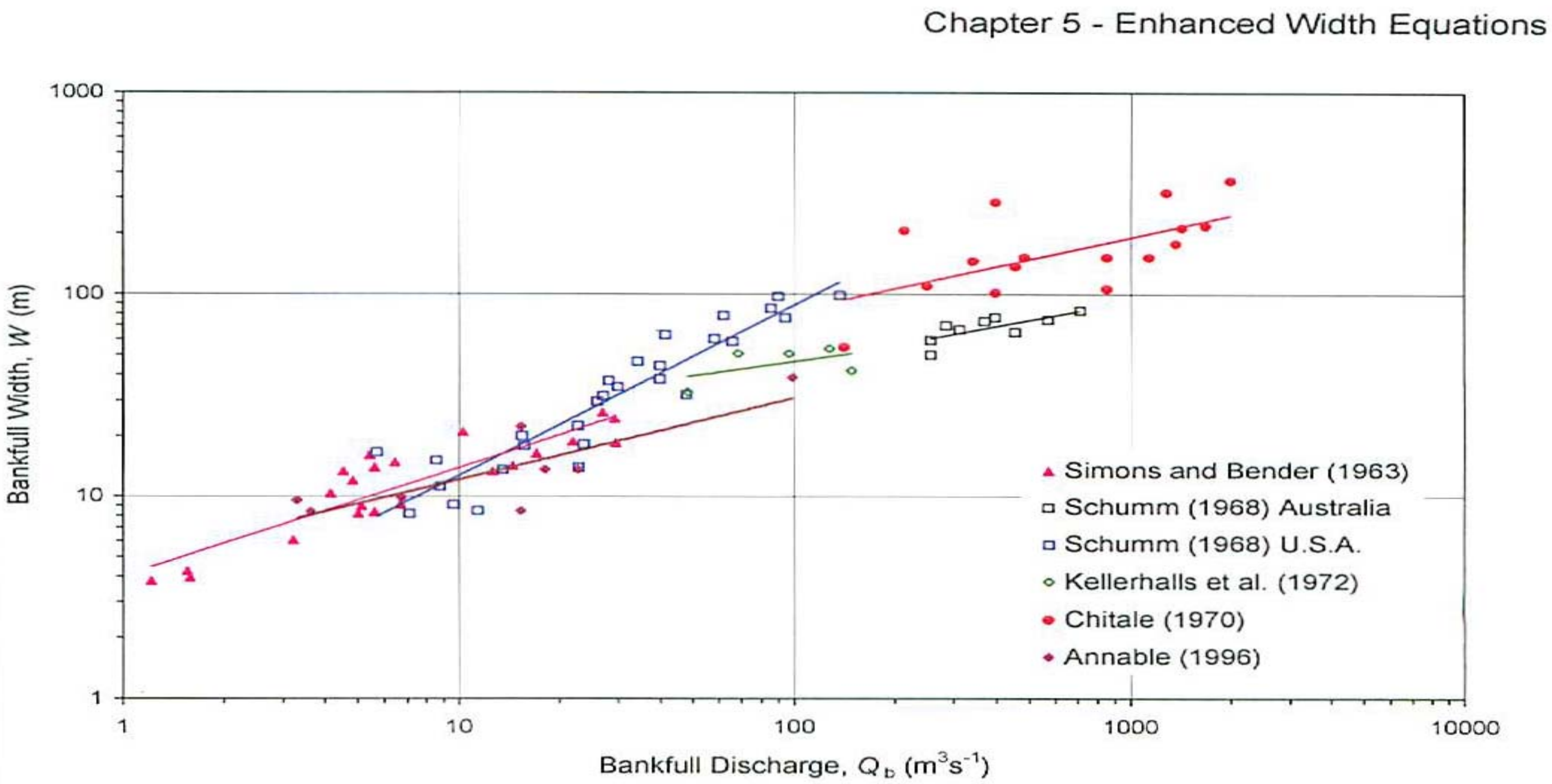


Figure 5.2 Downstream width-discharge relationships in sand-bed streams based on data from various sources.

Regime Equations

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

PART 2
Using SAM to Determine the "Effective Discharge"

- **What is Effective Discharge?**
- **Terms and Definitions**
- **What is SAM?**
- **Example Application of SAM to the Sabine River at Bon Wier for development of a Geomorphic Overlay**

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

- Effective discharge is calculated using only the *Total Bed Material Load*
- *Wash Load* is not included in computations

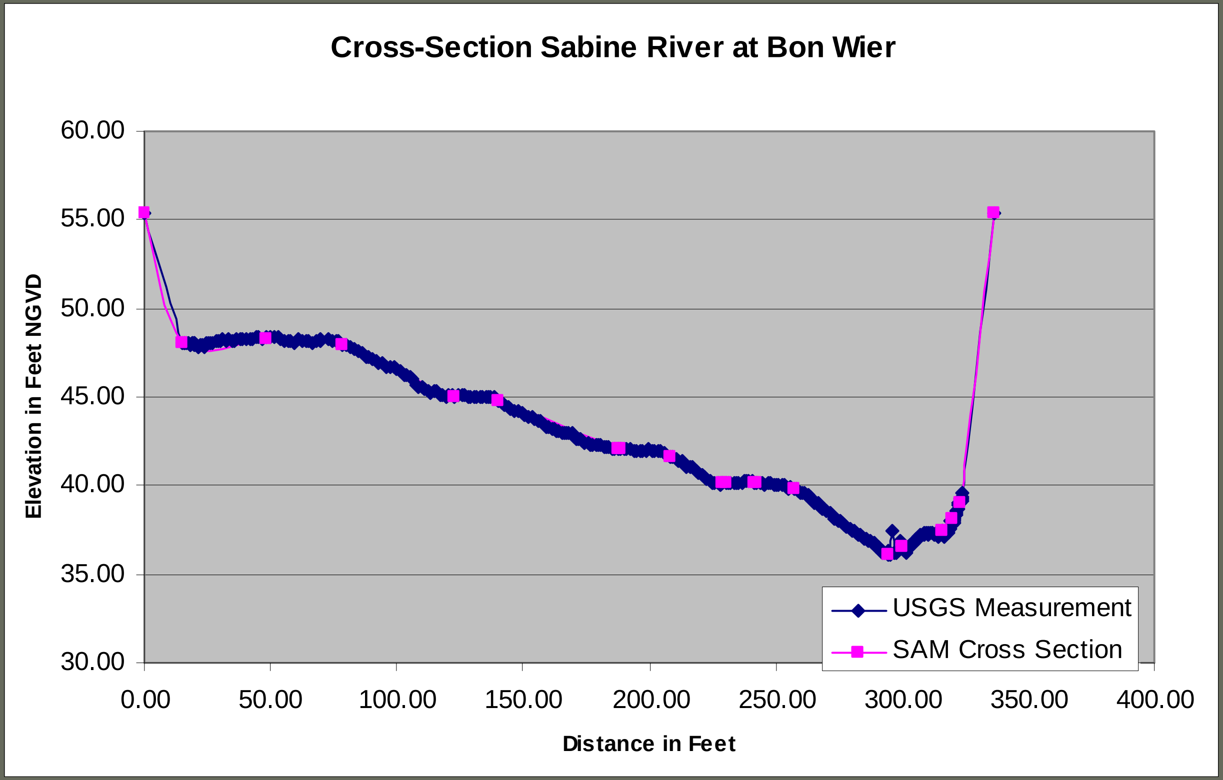
SAM
Hydraulic Design Package for Channels

- The SAM package is designed to provide hydraulic engineers smooth transition from making hydraulic calculations to calculating sediment transport capacity to making sediment yield determinations.

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

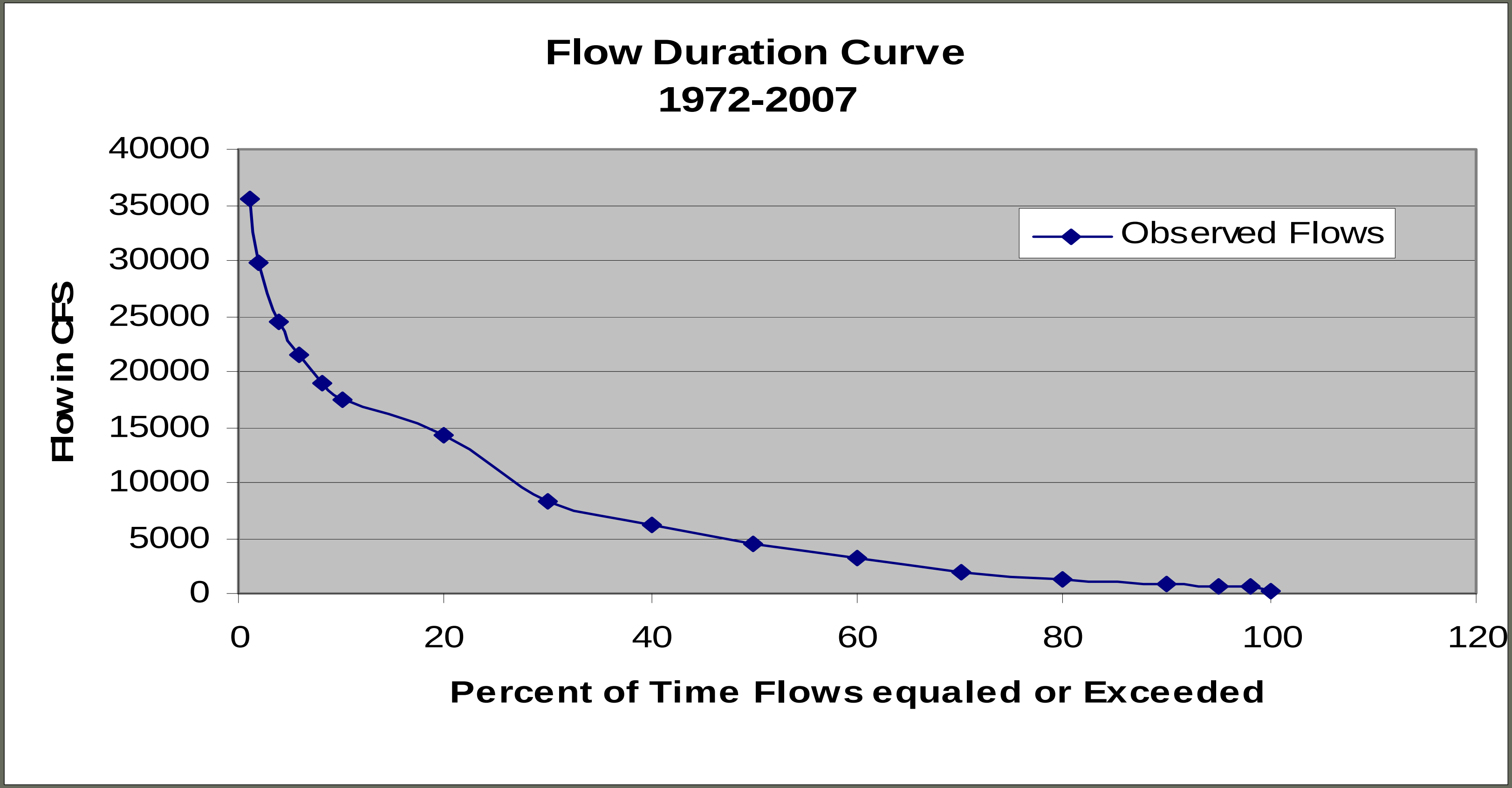
Sam Input
Bed Material Gradation

- 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

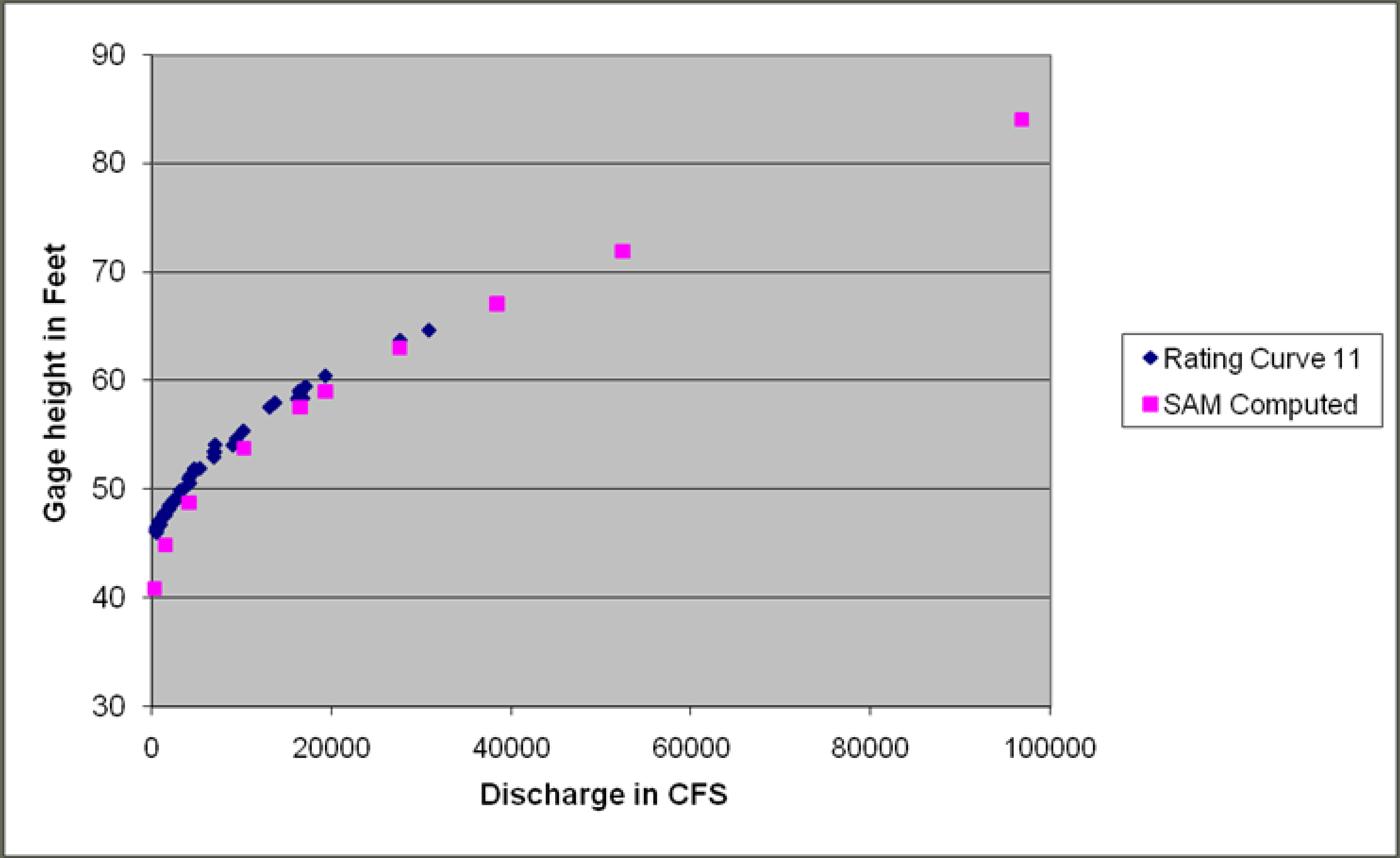
SAM Input

- Flow duration Curve

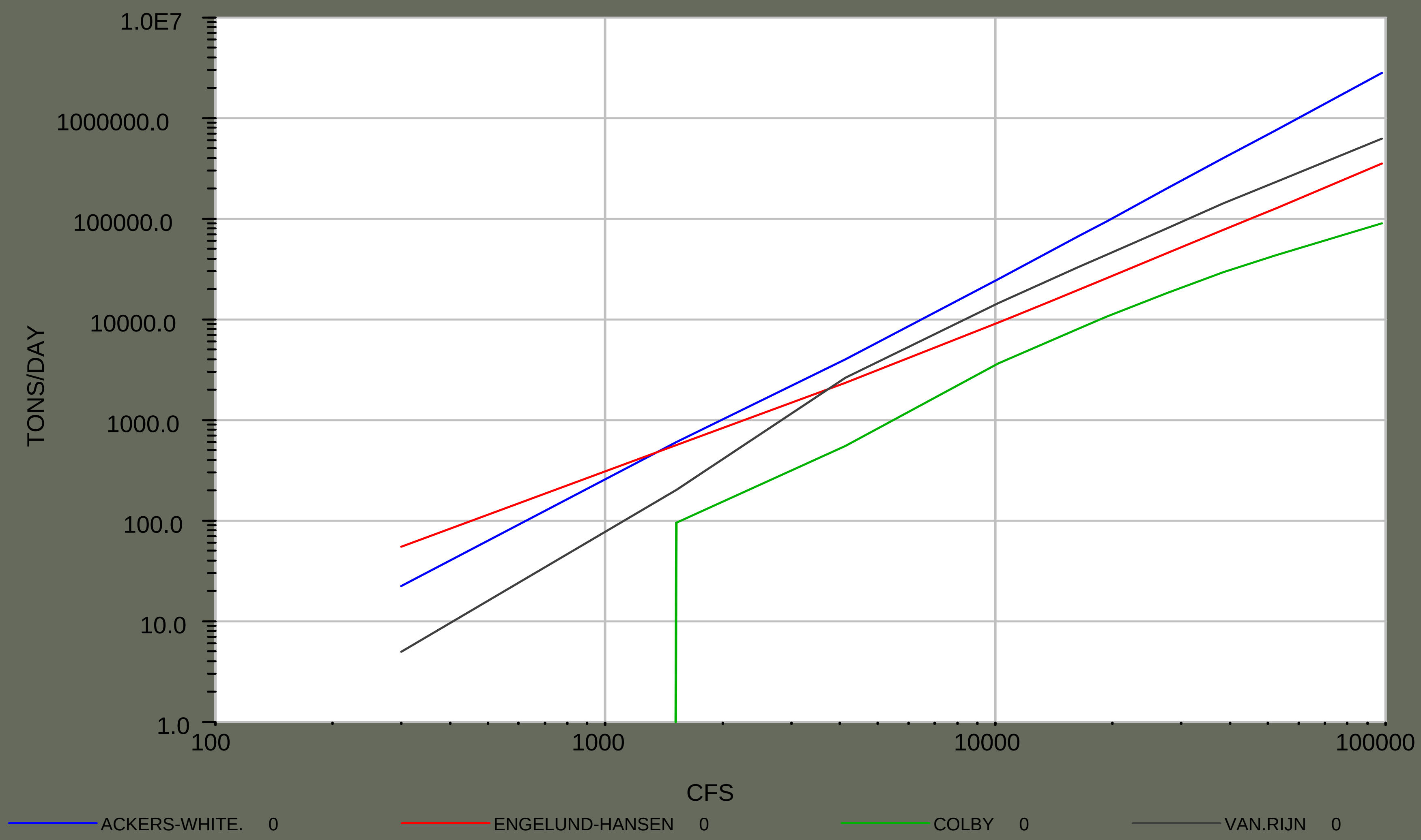


Sam output

- Hydraulics



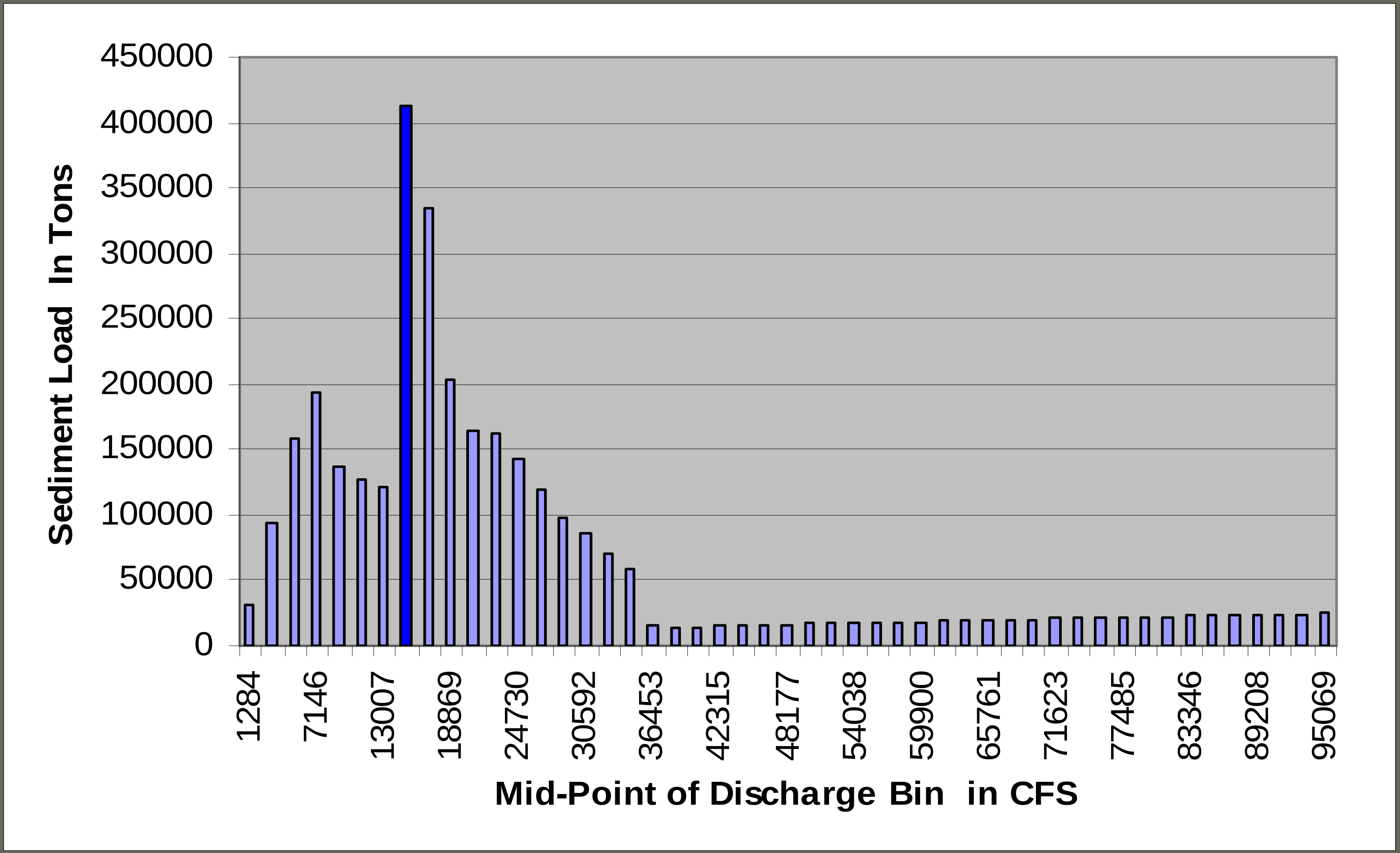
Sediment Rating Curve



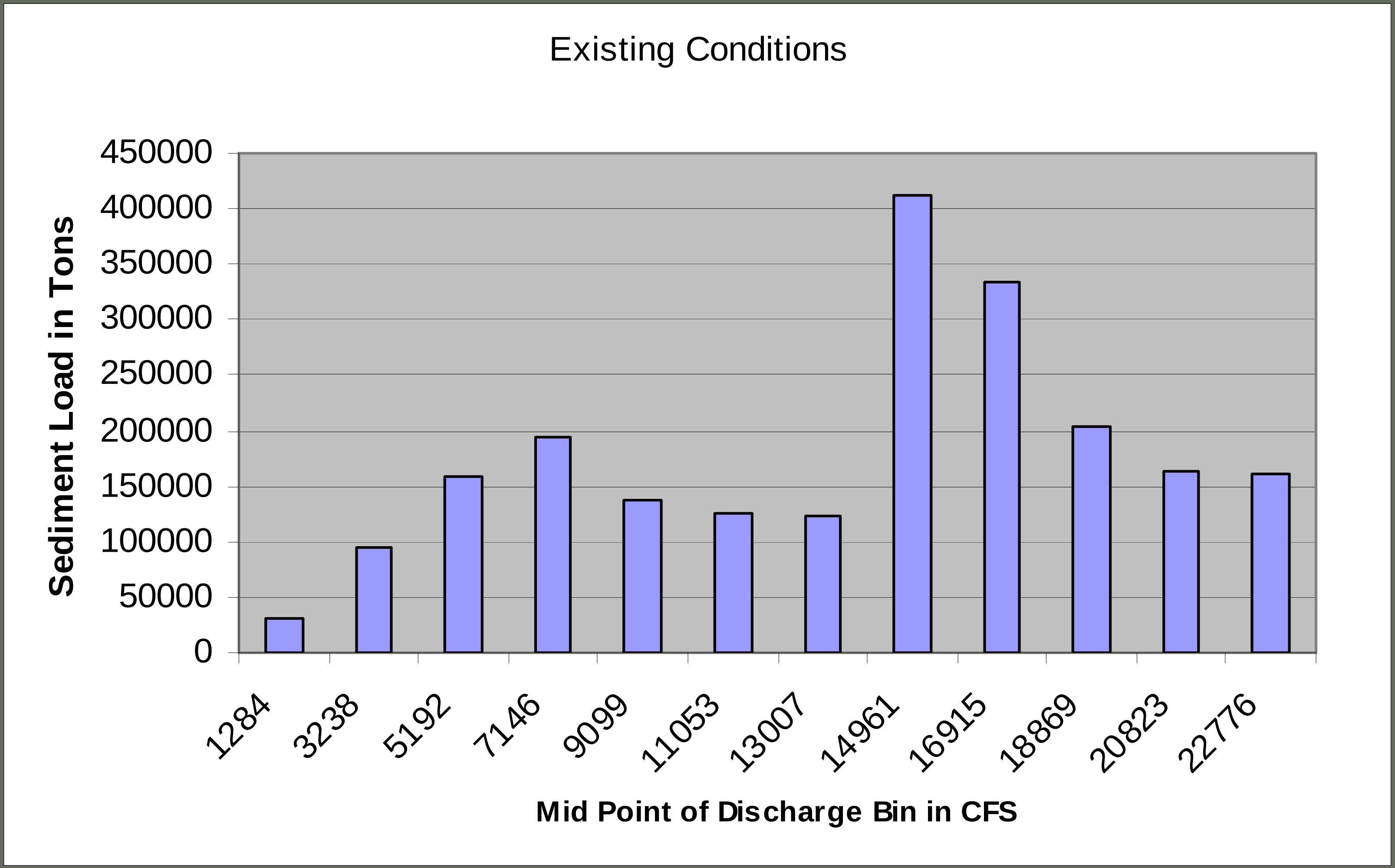
SAM OUTPUT

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

Sediment Histograms



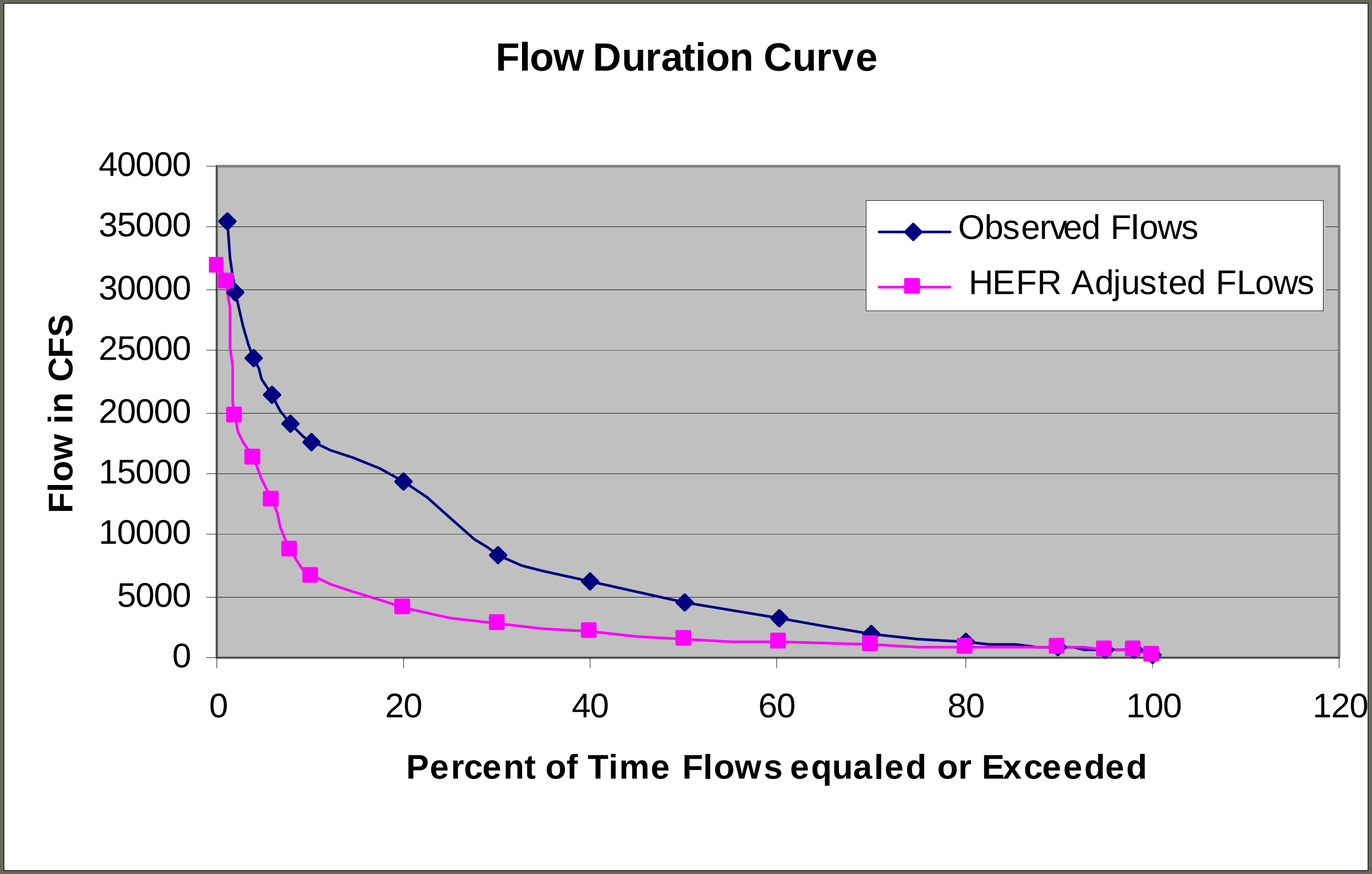
Sediment Histograms



Effective Discharge After HEFR Implemented

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

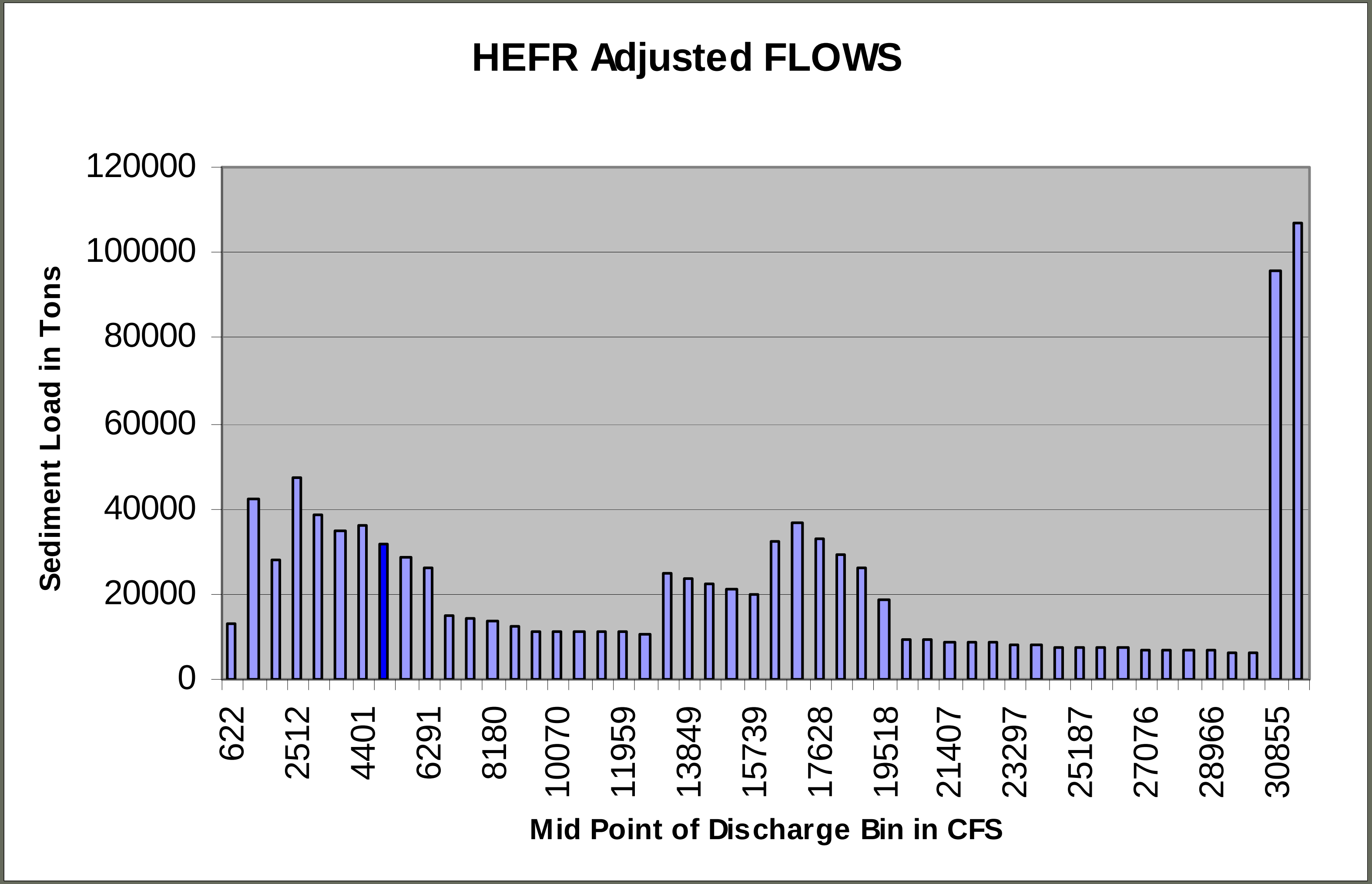
New Flow duration Curve



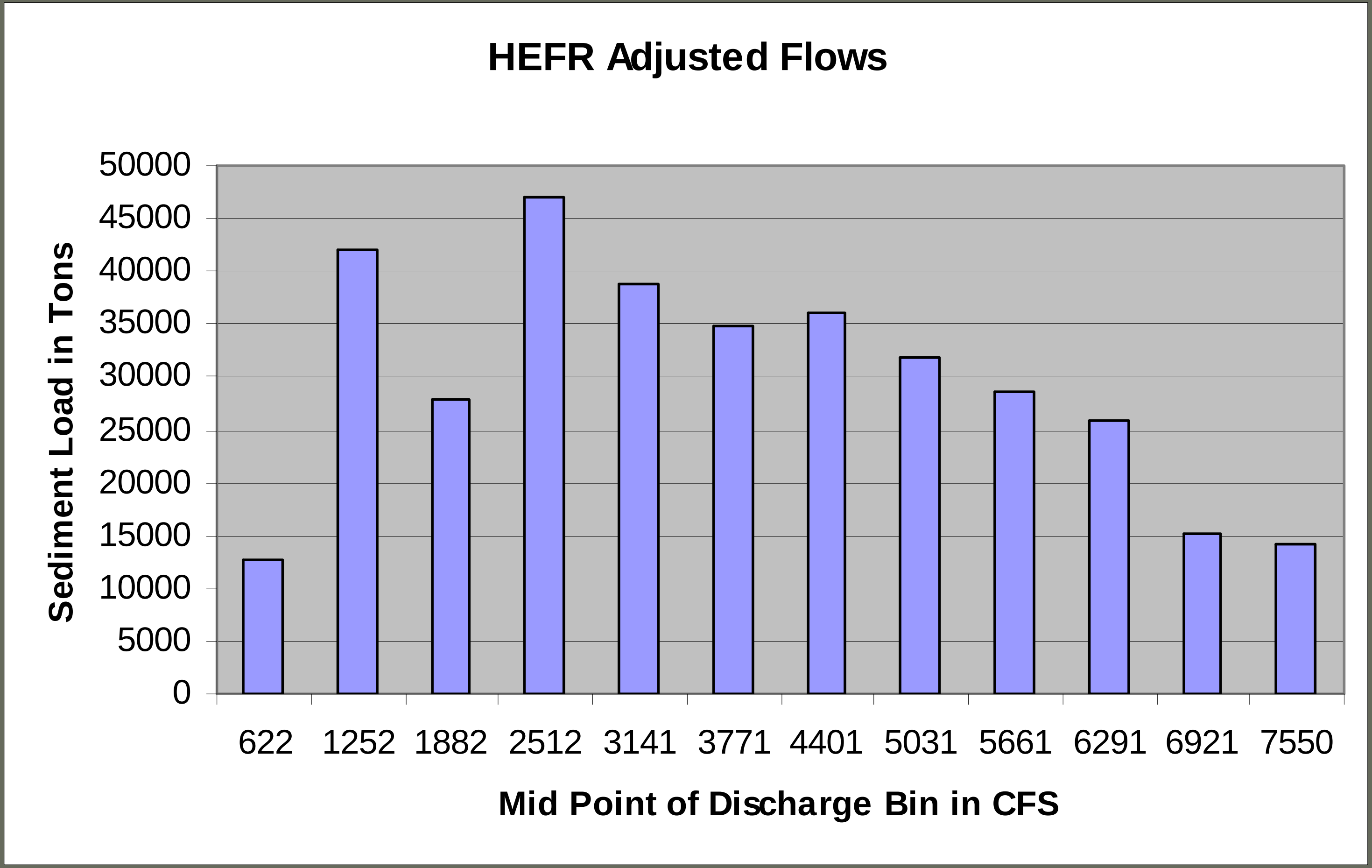
SAM OUTPUT

- 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

- Now, if I wanted to be one of those ponderous scientific people, and 'let on' to prove ……. In the space of one hundred and seventy-six years the Lower Mississippi has shortened itself two hundred and forty-two miles.
  ….. Therefore, any calm person, who is not blind or idiotic can see that in the Old Oolitic Silurian Period,' just a million years ago next November, the Lower Mississippi River was upwards of one million three hundred thousand miles long, and stuck out over the Gulf of Mexico like a fishing-rod. ….. that seven hundred and forty-two years from now the Lower Mississippi will be only a mile and three-quarters long, and Cairo and New Orleans will have joined their streets together ….. There is something fascinating about science One gets such wholesale returns of conjecture out of such a trifling investment of fact.
- “Life on the Mississippi” Mark Twain

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

SAM Hydraulics Module

- The Hydraulics Module calculates normal depth and composite hydraulic parameters from distributed roughness, including bed roughness predictors

SAM Sediment Module

- The Sediment Transport Module calculates bed material discharge curves using sediment transport theories.

Sedient Yield Module

- The Sediment Yield Module calculates sediment yield using the Flow-Duration Sediment-Discharge Rating Curve Method.

Sediment Transport Function Selection

- SAM provides guidance in the selection of the most applicable sediment transport function for a given stream using bed-material gradations and hydraulic parameters for that stream.

SAM
Hydraulic Design Package for Channels

- Hydraulics Module
- Sediment Transport Module
- Sediment Yield Module
- SAM.AID