Mississippi River Sedimentation Study

Investigators

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Mississippi River HEC-6T Sediment Study

Purpose of Study

To identify the effects of planned Mississippi River and Tributaries Project features and dredging strategies on long-term sedimentation trends between Cario, Illinois and East Jetty, Louisiana

Mississippi River HEC-6T Sediment Study

Study Approach

- HEC-6T numerical model.
- This model has been applied successfully to evaluate long-term sedimentation responses to various engineering projects along the Lower Mississippi River. These applications have included river response to dredging, flow diversions through distributaries, construction of a low-flow sediment sill and contraction works.

Mississippi River HEC-6T Sediment Study

Study Approach

- It is recognized that river response to dikes, especially overtopping dikes, is not strictly a one-dimensional, steady-flow, problem; however, it is hypothesized that one-dimensional effects are dominant and that careful application of the numerical model will be useful in determining appropriate lengths, heights, and longitudinal extent for dike field construction and long-term sedimentation trends in the river

HEC-6T GENERAL CAPABILITIES

- Calculates one-dimensional cross-section averaged hydraulic and sediment parameters in a single channel or stream network including divided flow
- Couples sedimentation processes with system hydraulics
- Accounts for stream bed armoring and hydraulic sorting of grain sizes
- Maintains sediment continuity by size class

HEC-6T GENERAL CAPABILITIES

- Calculates by particle size from clay through cobbles
- Provides 19 sand sediment transport functions
- Allows tributary inflows and/or diversions
- Calculates dredging volumes
- Calculates sediment delivery
- Will model up to 1200 cross sections, 20 grain sizes, a 50 segment network and 50 local inflow points per segment

Coding Enhancements Beyond HEC-6 Significant to this Study

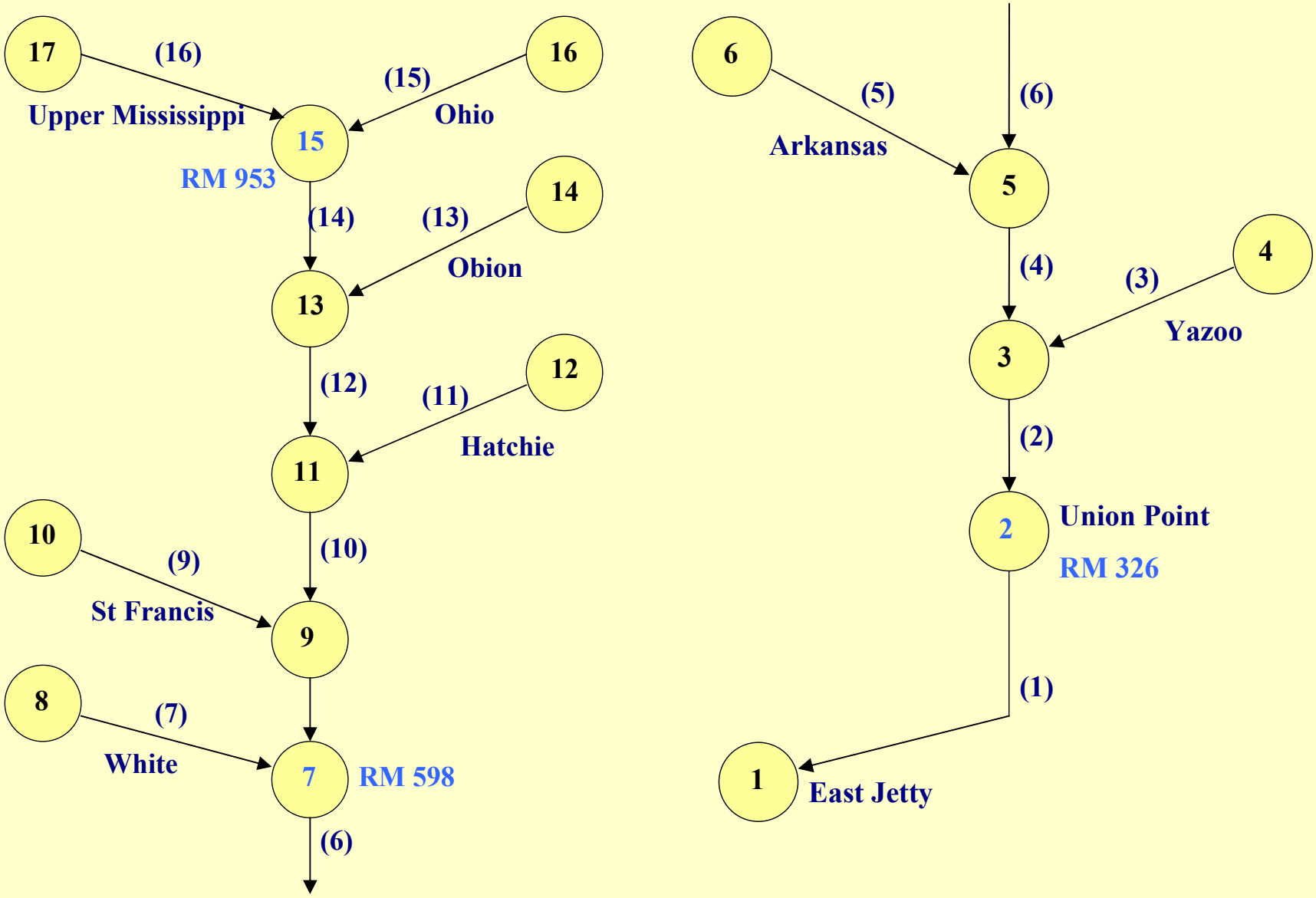
- Graphical User Interface
- Hotstart file
- Vary n value with depth
- Vary n laterally across the cross-section
- Flow around islands
- Separate erosion and deposition widths

Mississippi River HEC-6T Sediment Study

Study Characteristics

- The model will consider reaches of the river (2-4 miles) and not try to study specific areas.
- The model will be developed as one model from the upstream boundary to the downstream boundary.
- The model will be constructed so that it can be refined with more detail to study specific problem areas.

HEC-6T Network



Percent of Annual Discharge At Vicksburg 1989-2003

• Ohio River	46.6
• Upper Mississippi River	35.5
• Arkansas River	8.0
• White River	4.4
• Yazoo River	3.2
• St Francis River	1.3
• Hatchie River	0.6
• Obion River	0.4

Input Data Requirements

- Geometry
  - HEC-2 or HEC-RAS geometry file
  - Width and depth of bed sediment reservoir
- Sediment
  - Properties of the bed sediment reservoir
  - Inflowing sediment load
- Hydrology
  - Discharge
  - Duration – Computational time step

HEC-6T Geometry General

- Channel Geometry developed from 1988-92 hydrographic surveys.
- Overbank geometry developed from surveys and USGS quads
- Dikes constructed up to 1992 coded at top of crest
- Overbank roughness calculated using conveyance method
- Channel roughness calculated using equal velocity method varied by discharge.

HEC-6T Geometry
Mississippi River

- New Orleans channel and overbank from 1991-1992 hydrographic survey.
- Vicksburg channel and overbank from HEC-2 model based on 1988-89 hydrographic survey.
- Memphis channel from 1988-89 hydrographic survey. Overbank from 1988-89 surveys and USGS quads.
- St Louis channel and overbank from 1988 hydrographic survey.

HEC-6T Geometry
Yazoo River

- Cross Sections at RM 1.51 and 3.69 from 1988-89 Mississippi River hydrographic survey.
- Cross Section at RM 16.7 from Redwood Discharge Range.
- Big Sunflower River Confluence (RM 44.4) to Yazoo City (RM 75.6) from 1990 Post Construction survey HEC-2 model.

HEC-6T Geometry Arkansas River

- Cross Sections from Little Rock District HEC-RAS Model.
- Channel surveys 2003.
- Overbank data from USGS quads and 1992 Mississippi River hydrographic survey.
- Arkansas River confluence moved to RM 580.5 from RM 585 as per 1995 survey. Cutoff was in 1989.
- 28.2 Miles simulated to Dam No. 2.

HEC-6T Geometry White River

- Channel from 1997-98 hydrographic survey.
- Overbank from 2000 surveys and USGS quads
- 100 River Miles

HEC-6T Geometry
Obion and Hatchie Rivers

- Channel cross sections from discharge range. Elevations estimated by translation using valley slope. Widths adjusted using aerial photos
- Overbanks from USGS quads
- 0.2 miles simulated

HEC-6T Geometry
Saint Francis River

- Cross Sections from 2000 HEC-6T Model.
- Channel surveys 1997-98.
- Overbank data from 1997-98 survey and USGS quads.
- 57.9 miles modeled

HEC-6T Geometry Ohio River

- Geometry from Louisville District HEC-2 model based on mid-1960's survey data.
- 59.2 River miles simulated - RM 1014 upstream from Cario

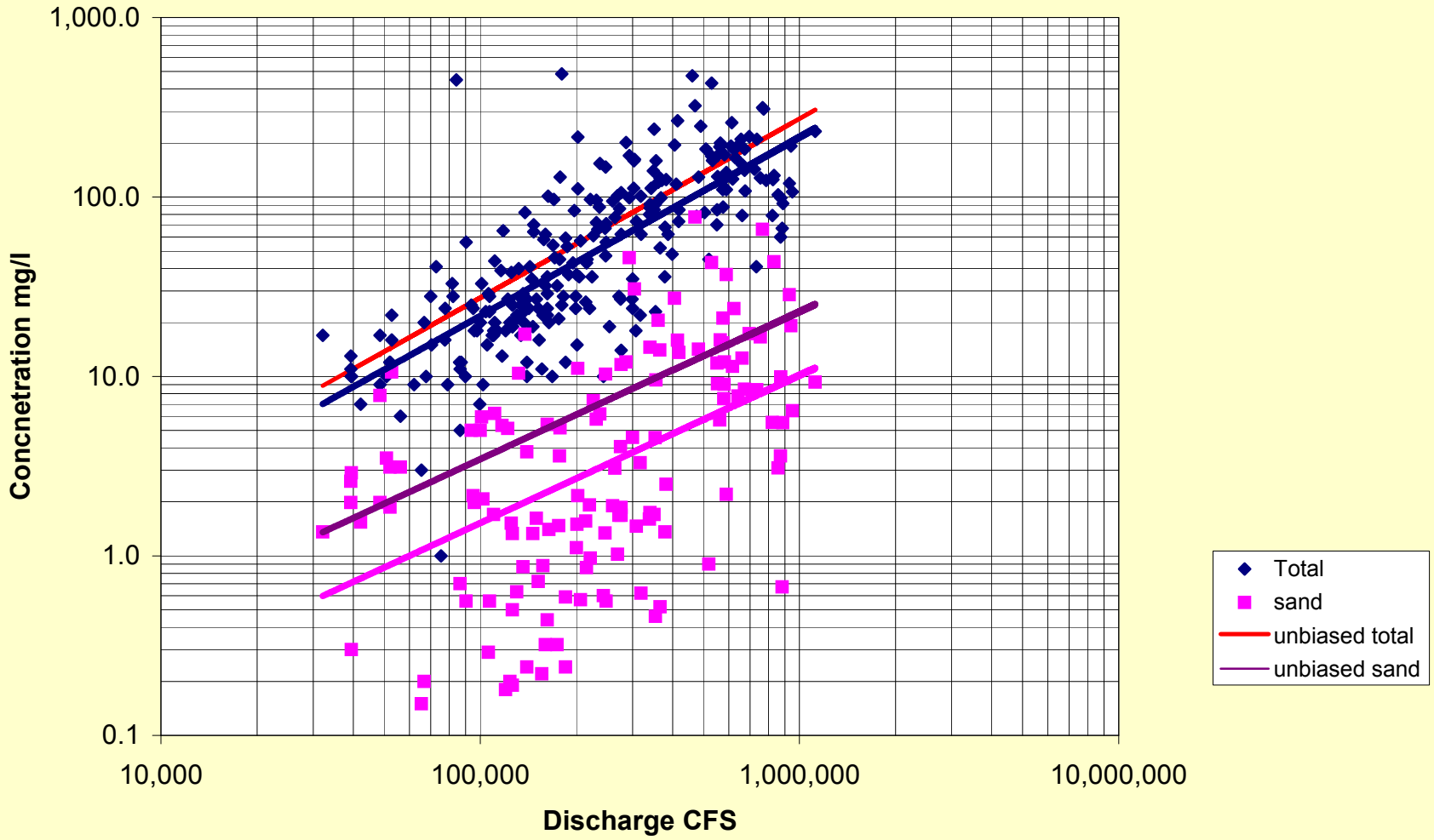
Sediment Inflow

- Combination of Measured and Calculated Data
- Measured data for wash load and suspended bed-material load
- Calculated data for bed-material load
- Where data are not available, assumed values will be checked during calibration phase of study

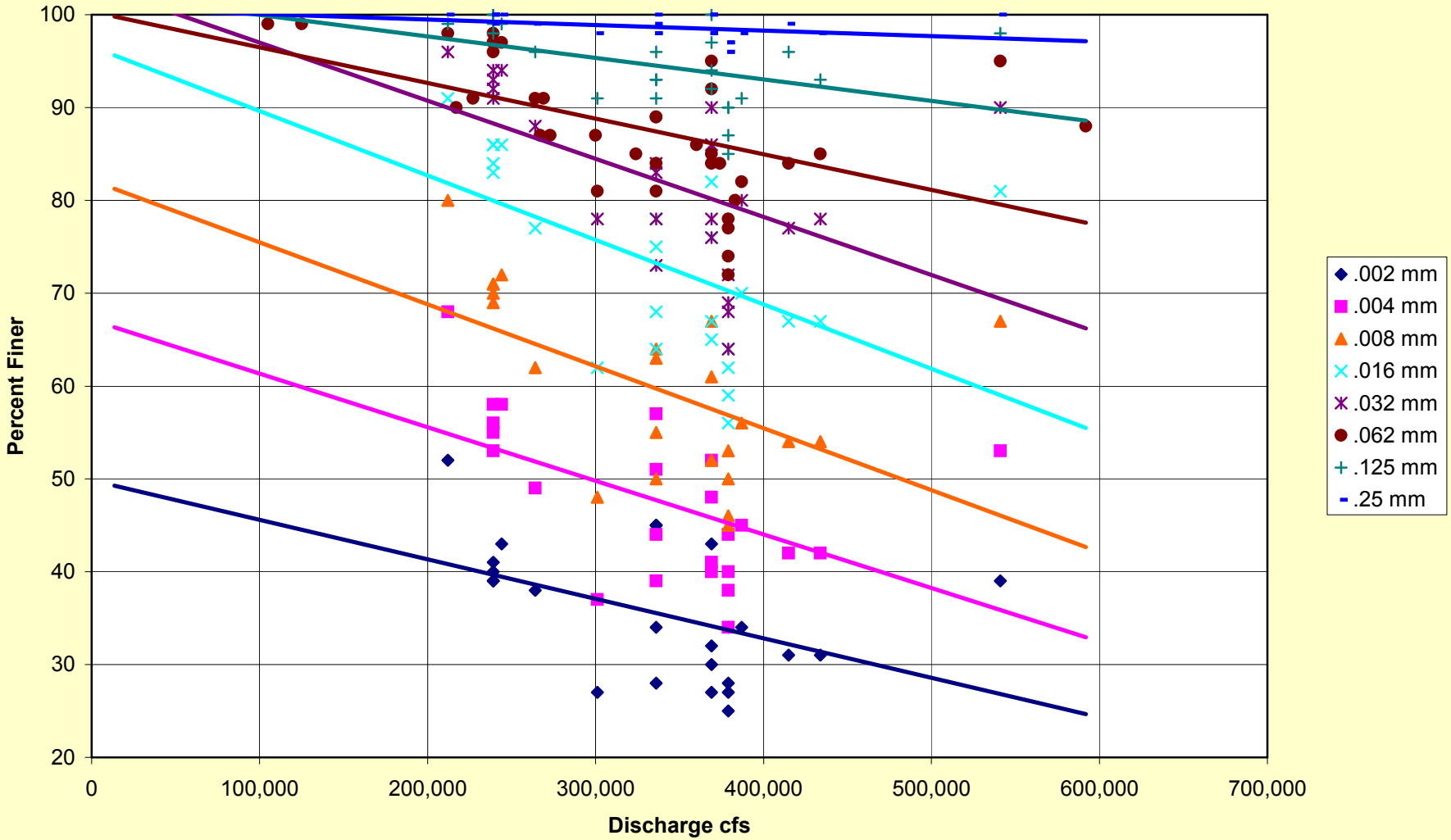
Sediment Inflow
Ohio River

- Measured fine and sand suspended loads at Lock and Dam No. 53 - RM 17 (USGS)
- Measured size class distributions at Louisville (USGS 1978-82)
- Calculated bed-material load using bed gradations from Louisville District from three transects.

Measured Suspended Sediment
Ohio River at Lock and Dam 53 near Grand Chain, Illinois 1973-2001



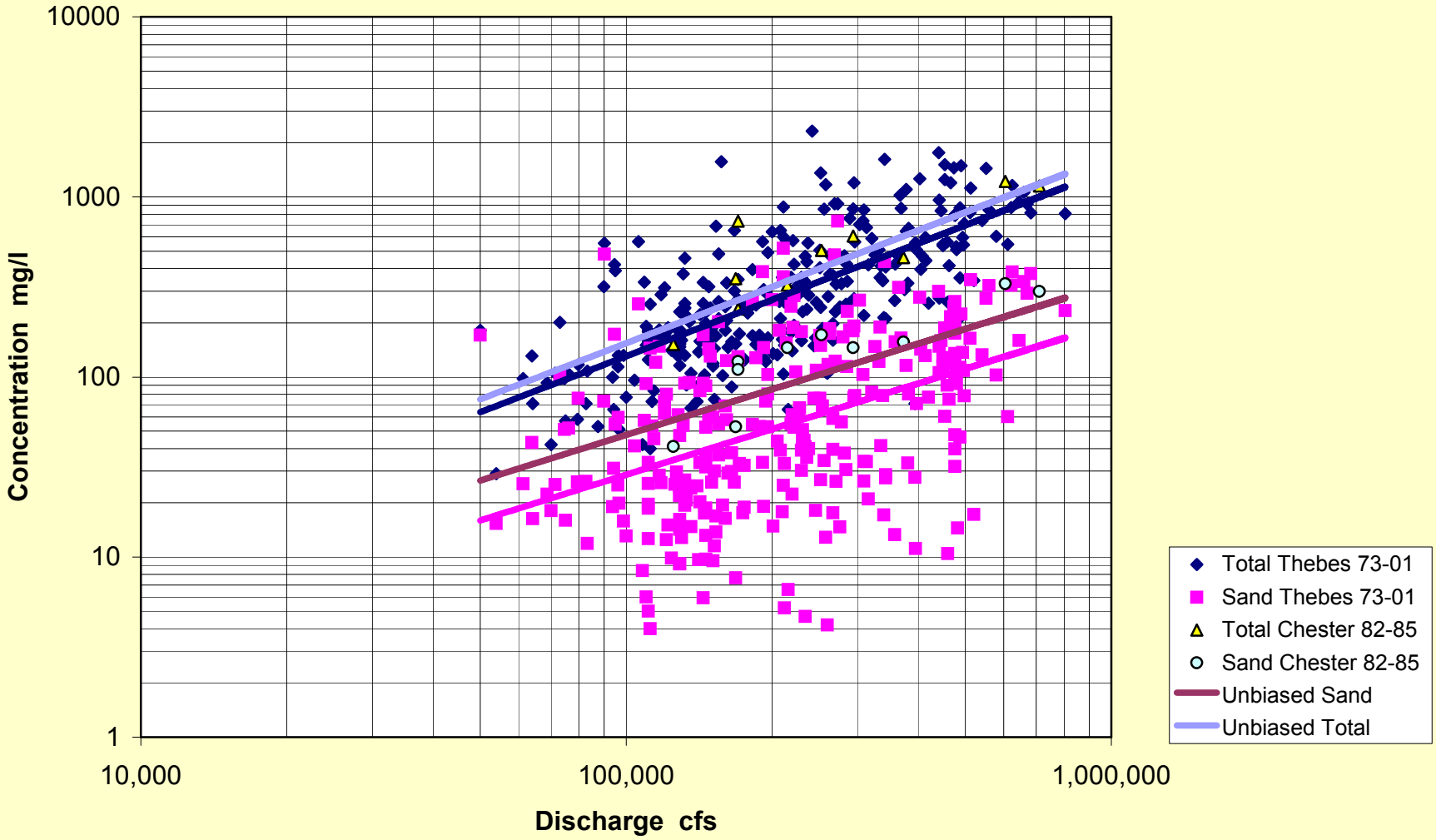
Suspended Sediment Particle Size Percentages
Ohio River at Louisville

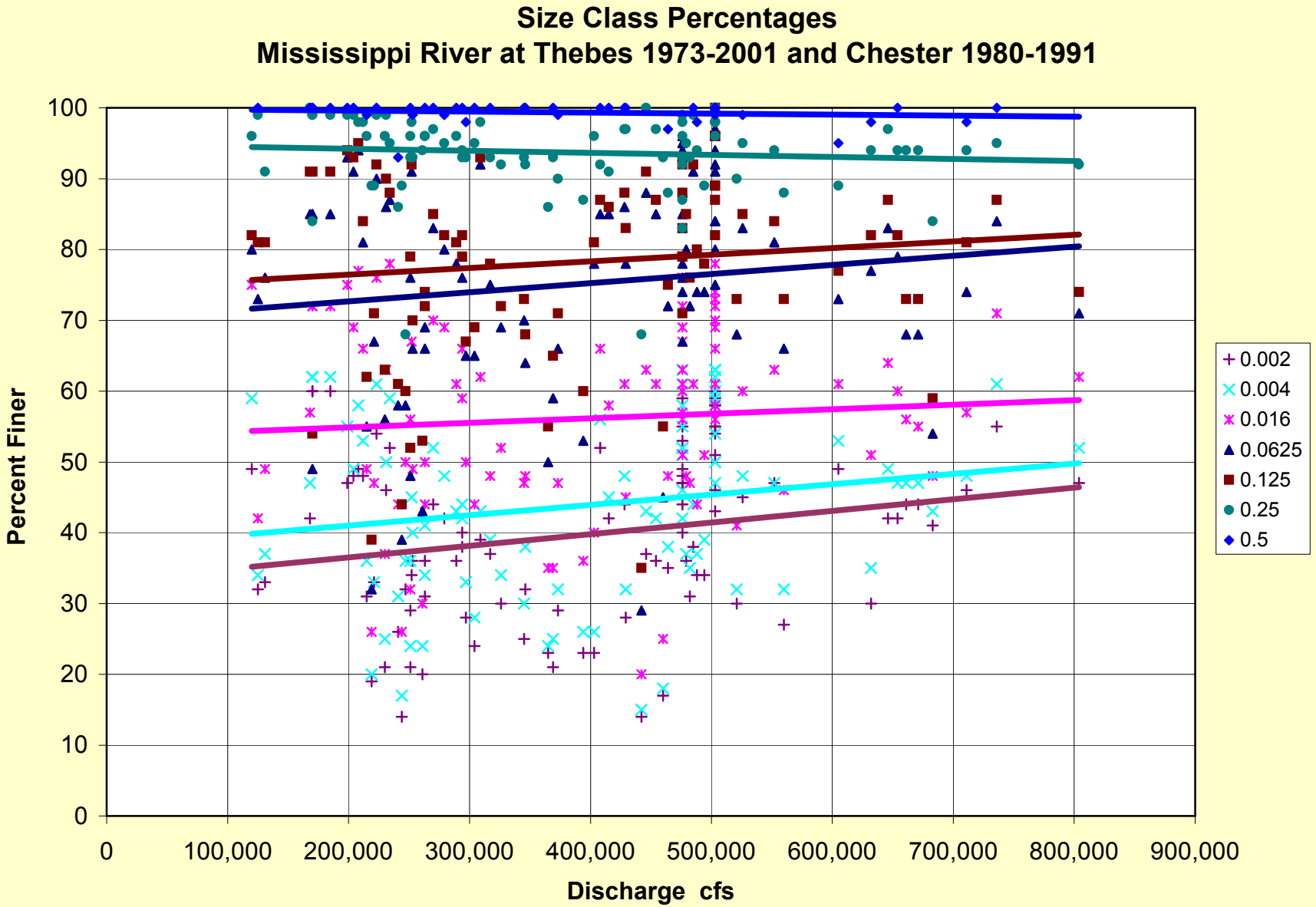


Sediment Inflow Upper Mississippi River

- Measured suspended loads, including size class distributions, at Thebes and Chester - RM 43.7 and 109.9 (USGS)
- Calculate bed-material load using bed gradations from Thebes gage (USGS)

Measured Suspended Sediment
Mississippi River at Thebes, Ill 1973-2001




Size Class Percentages
Mississippi River at Thebes 1973-2001 and Chester 1980-1991
Percent Finer
100
90
80
70
60
50
40
30
20
10
0
0
100,000
200,000
300,000
400,000
500,000
600,000
700,000
800,000
900,000
Discharge cfs
0.002
0.004
0.016
0.0625
0.125
0.25
0.5

Sediment Inflow St Francis River

- Measured fine and sand suspended loads from 1998 HEC-6T study (USGS measurements)
- Measured bed load and size class distributions from 1998 HEC-6T study (USGS measurements)
- Bed gradations collected for 1998 HEC-6T study.

Sediment Inflow Arkansas River

- Combination of measured fine and sand suspended loads at Dam No. 2 and Terry Lock and Dam - RMs 28.2 and 124.2 (USGS)
- Calculated bed-material load and size class distributions using bed gradations from Little Rock District.
- Assumed size class distribution for wash load will be verified during calibration.

Sediment Inflow White River

- Combination of measured fine and sand suspended loads at Newport, Devalls Bluff and Clarendon – RM's 257.6, 125.3 and 99.9 (USGS)
- Calculated bed-material load and size class distributions using bed gradations from Little Rock District at RM 4 (2003) and Memphis District at RMs 50 and 99 (2005).
- Assumed size class distribution for wash load will be verified during calibration..

Sediment Inflow Yazoo River

- Combination of measured fine and sand suspended loads at Steel Bayou (USGS)
- Calculated bed-material load and size class distributions using bed gradations collected at two transects in 2005.
- Assumed size class distribution for wash load will be verified during calibration.

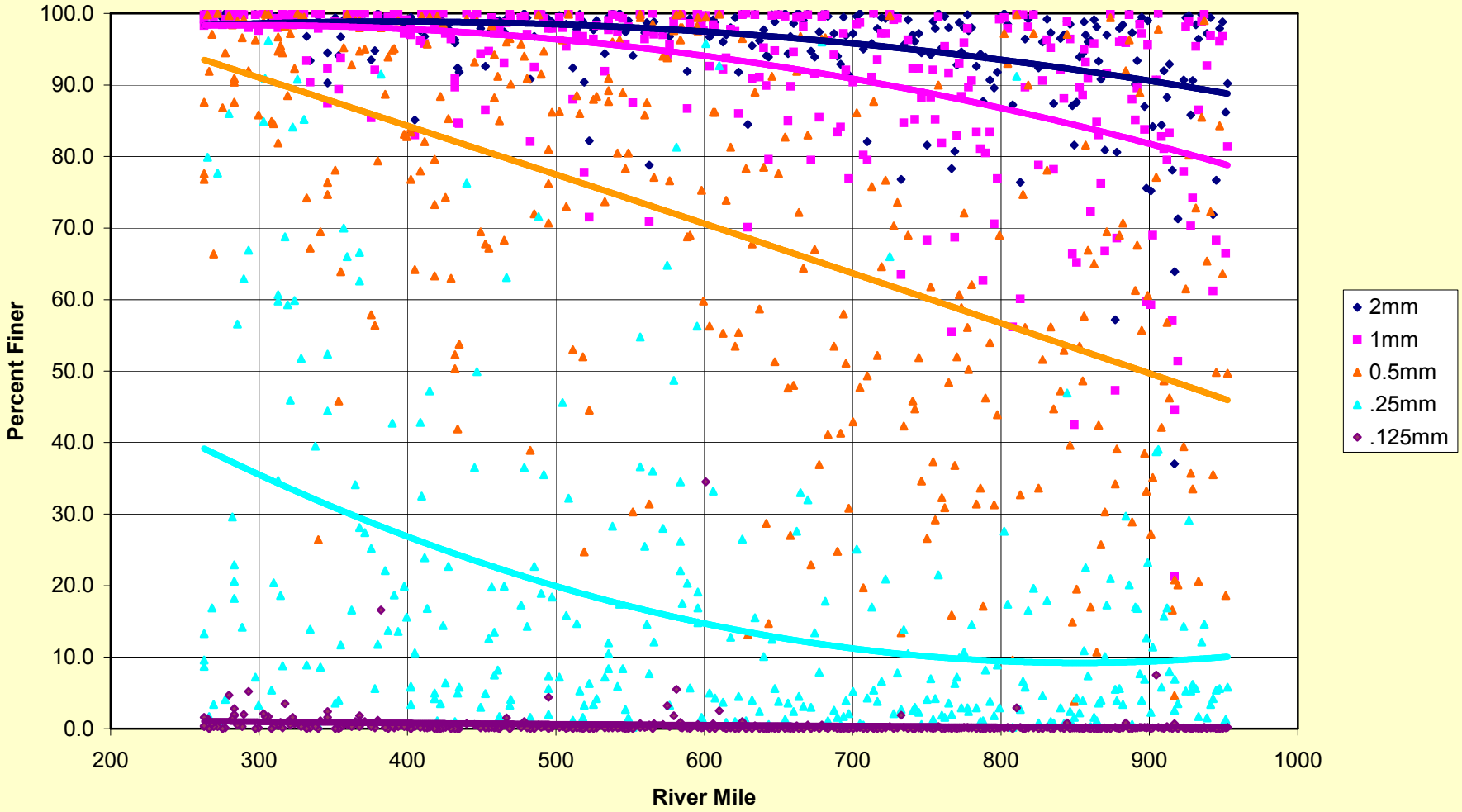
Sediment Inflow Obion and Hatchie Rivers

- Calculated bed-material load and size class distributions using bed gradations collected at two transects in each river in 2005.
- Assumed size class distribution for wash load will be verified during calibration.

Initial Bed Material Gradations

- 1989 Mississippi River thalweg sampling by Carl Nordin from Head of Passes to Cario.
- Calibrated so that changes are insignificant with constant bankfull discharge

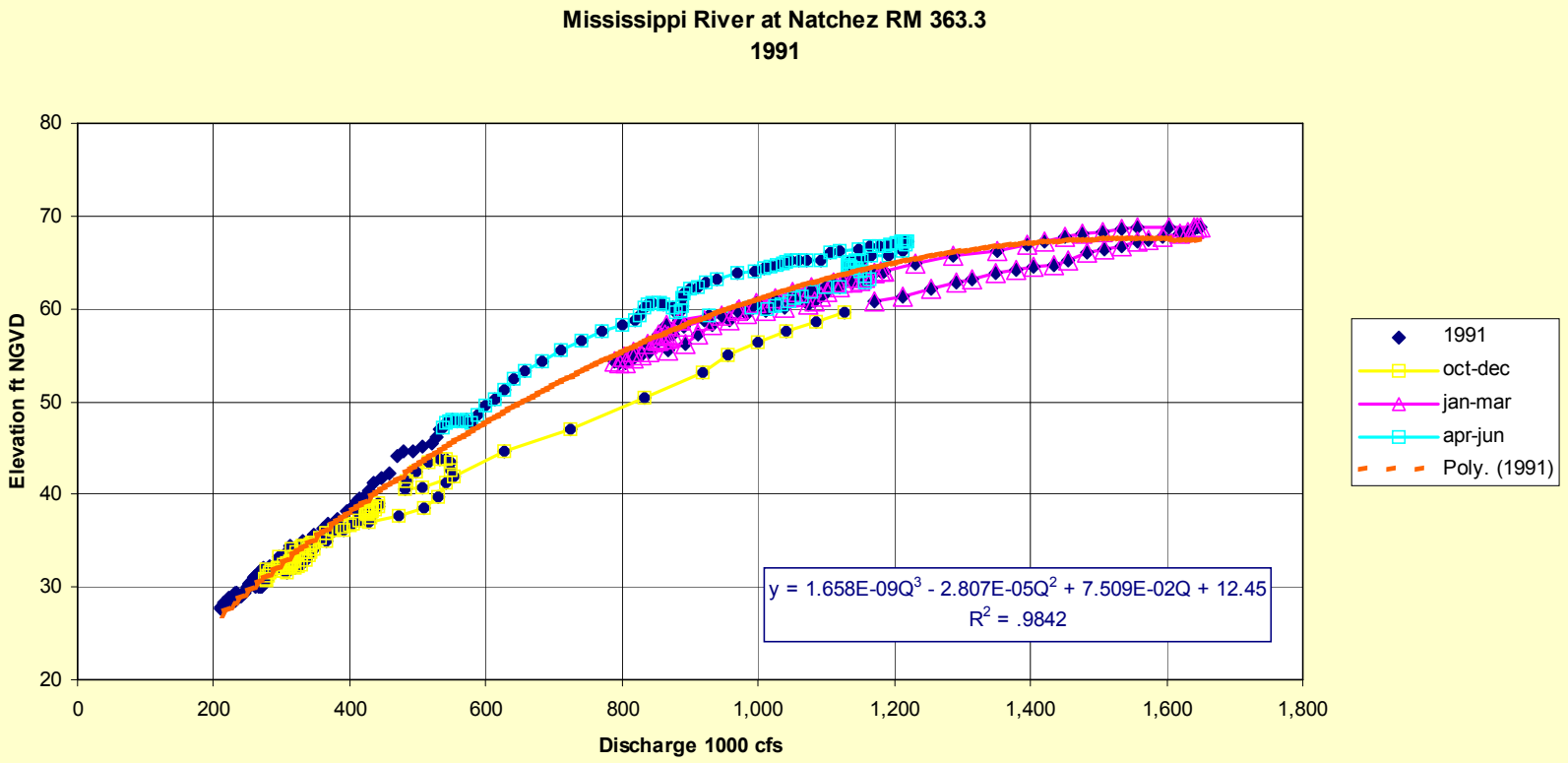
Mississippi River Bed Gradations
Nordin (1989)
Outliers Removed



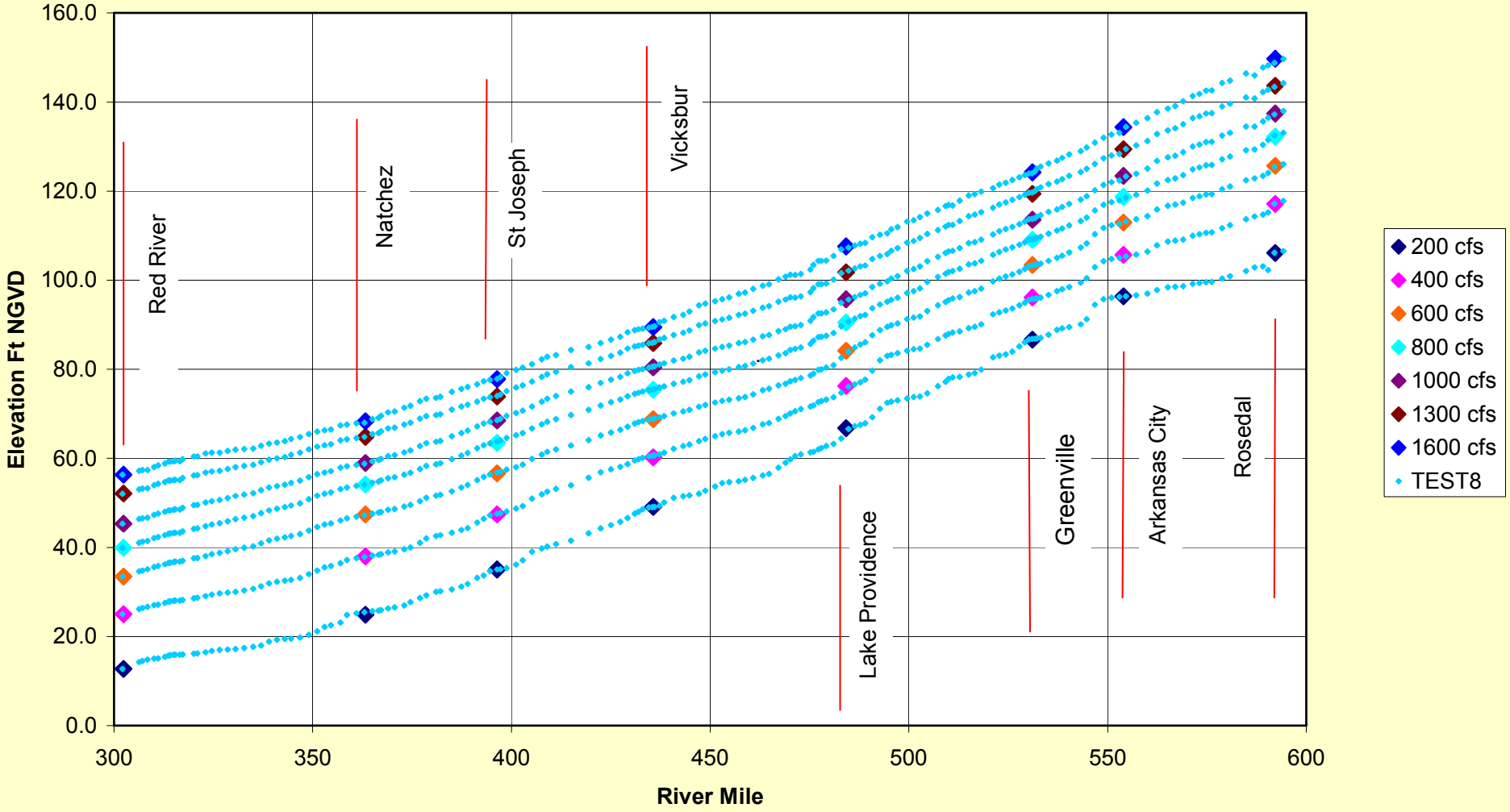
Model Calibration

- Water surface elevation
- Sediment transport at intermediate gages
  - Memphis
  - Vicksburg
  - Natchez
  - Tarbert Landing
- Specific gage trends

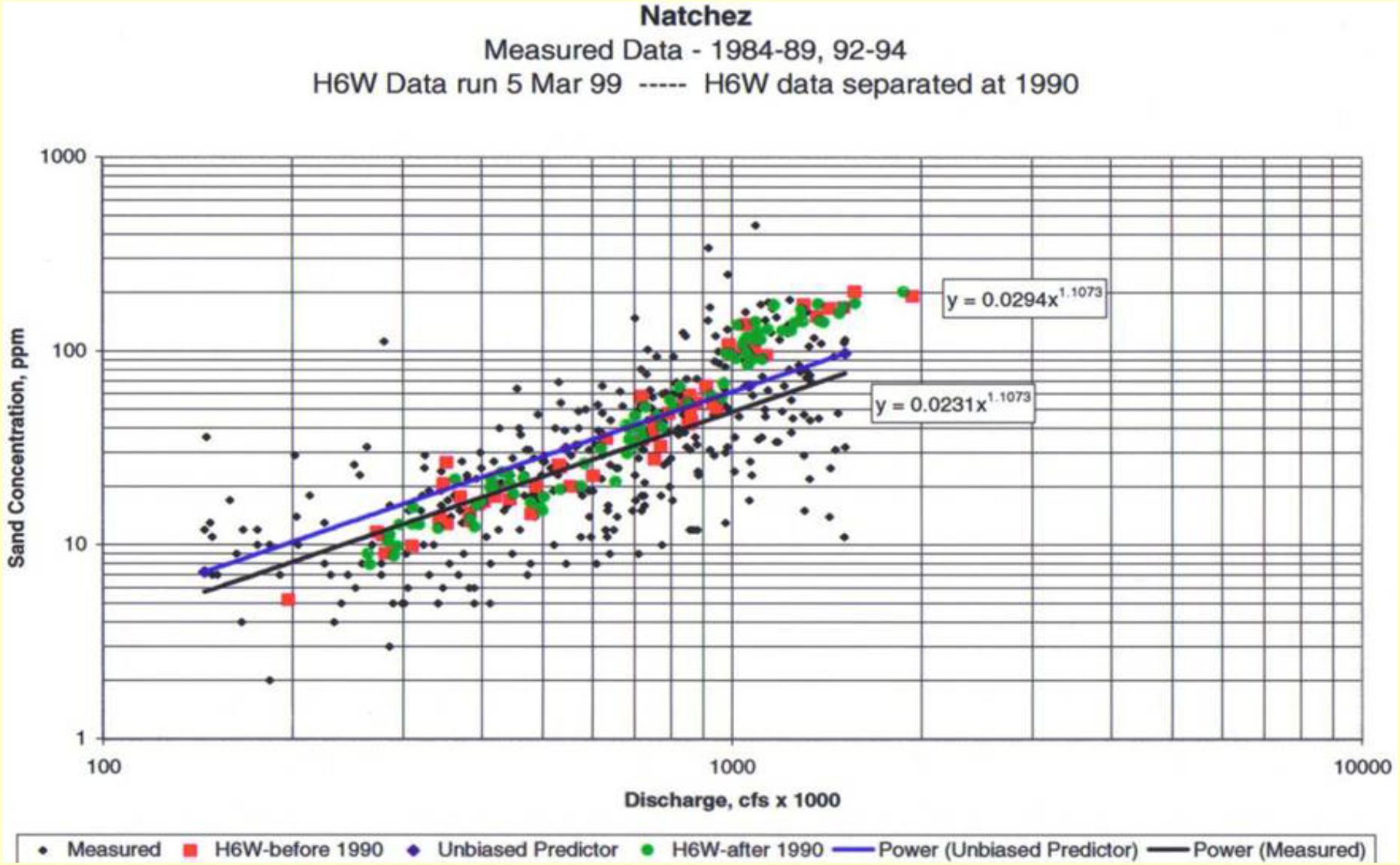
Water Surfaces Calibrated to Average Stage Rating Curves



Mississippi River
Calibrated WSEL's 1989
Discharge at Vicksburg 1,000 cfs



Verification to Measured Sediment Transport

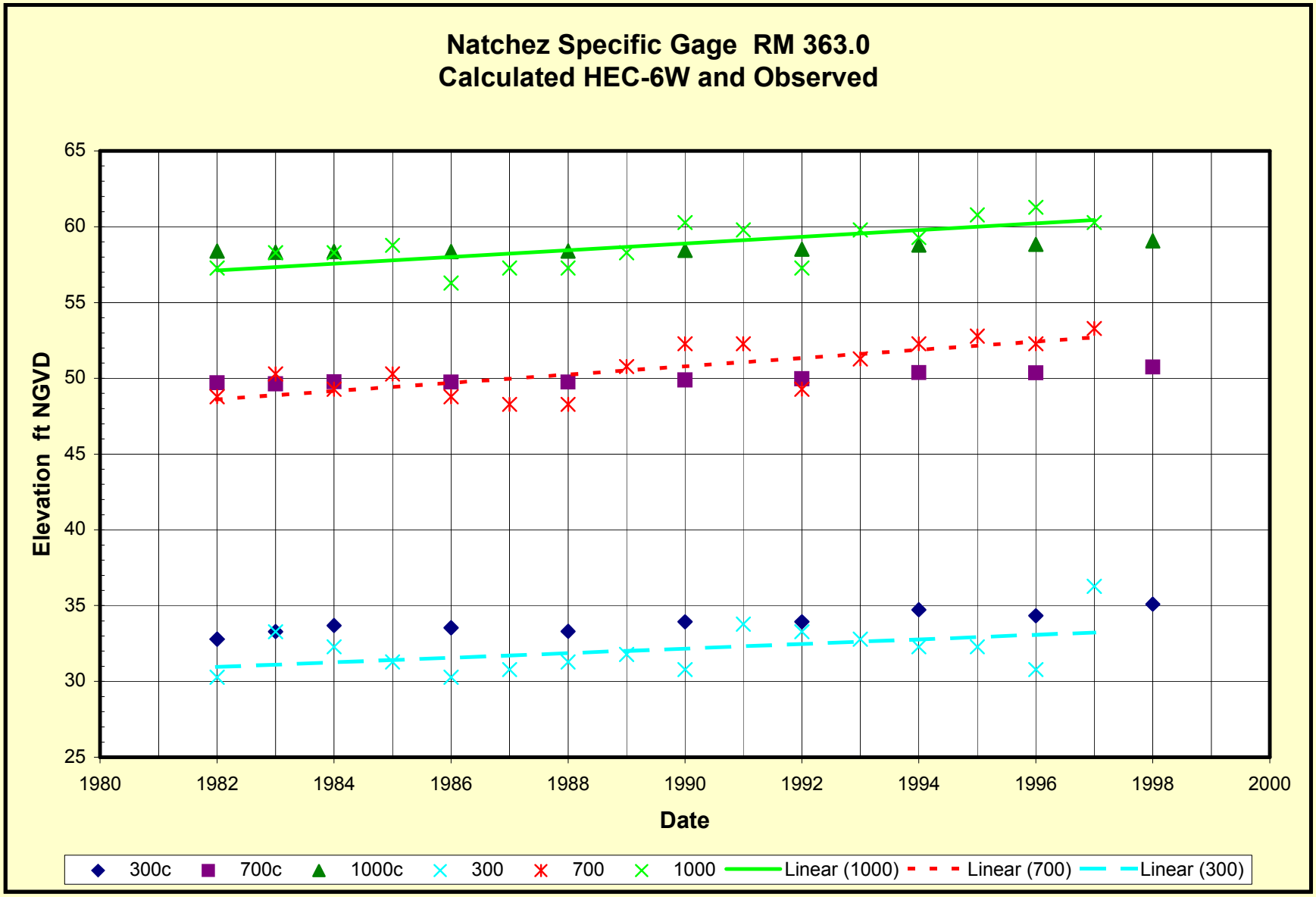


Verification to Measured Size Class Distributions

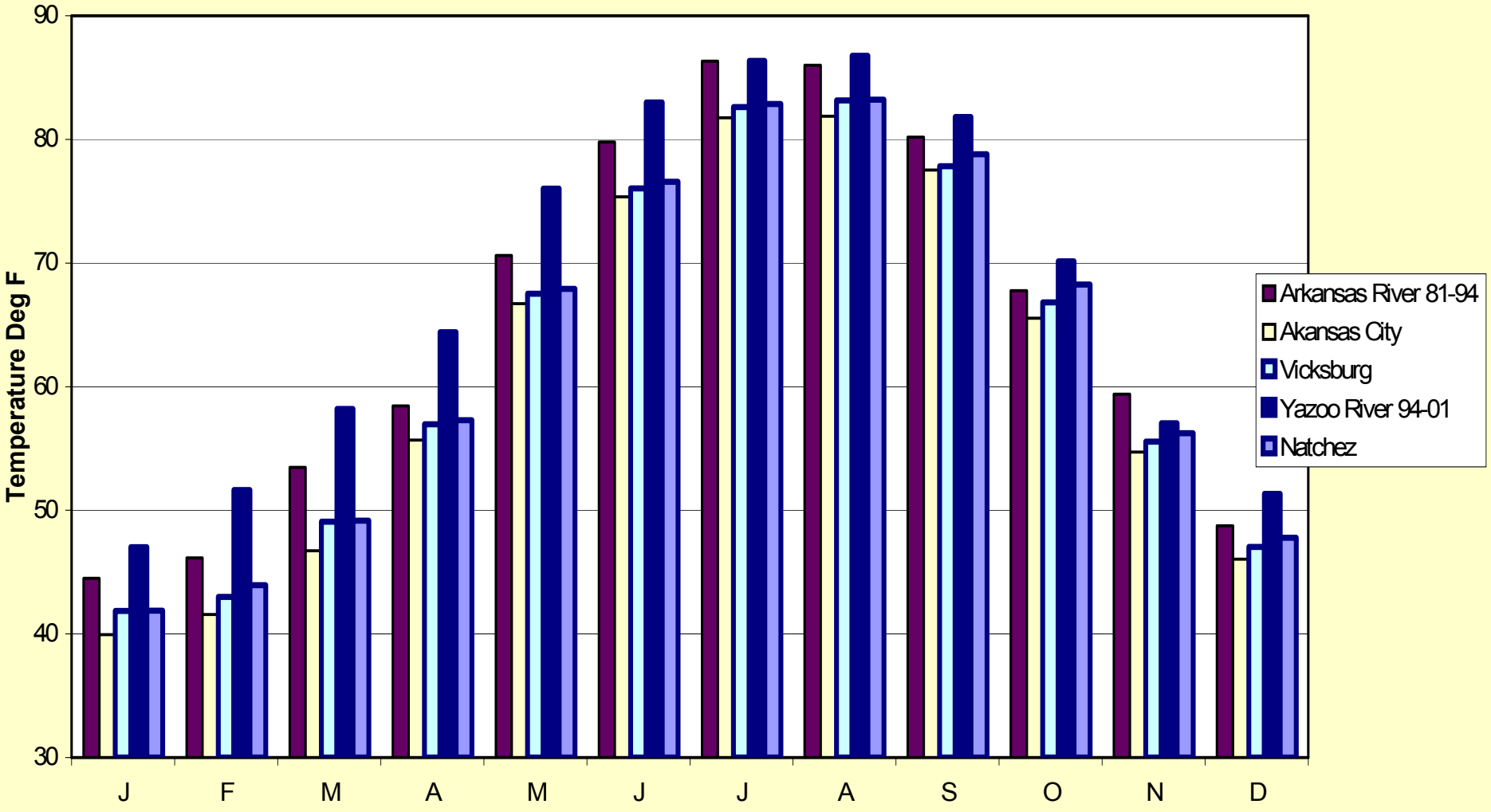
Size Class Distributions

Tarbert Landing RM 306.3				Coochie/Union Point RM 317.3		
Grain Size	**Calculated** Total Sand Load 1982-1998 fractions	**Measured** Sand Load 1982-1996 fractions		Grain Size	**Calculated** Total Sand Load 1982-1998 fractions	**Measured** Sand Load 1982-1996 fractions
VFS	0.36	0.35		VFS	0.38	0.35
FS	0.48	0.55		FS	0.48	0.54
MS	0.15	0.09		MS	0.13	0.10
CS	0.01	0.01		CS	0.01	0.01

Verification to Measured Specific Gage Curves



Average Monthly Temperatures



Model Predictions

- Long-term aggradation and degradation trends in response to MR&T Project construction
- Bed changes during a flood event
- Aid in designing features to enhance backwater reaches
- Effects of various project features – channel constriction, channel straightening, and dredging
- Effect of reducing or increasing sediment supply both upstream and through diversions

Status of Study

- Each District has calibrated a fixed-bed hydraulic model.
- The hydraulic model is calibrated for flow distribution across each cross section and water-surface elevation for a range of discharges.
- Sediment inflow has been determined for boundaries with measured data.

Mississippi River Sediment Study

Suggestions?

HEC-6T MAINTENANCE AND SUPPORT

- Documented
- Maintained
- Supported
- Consulting Services

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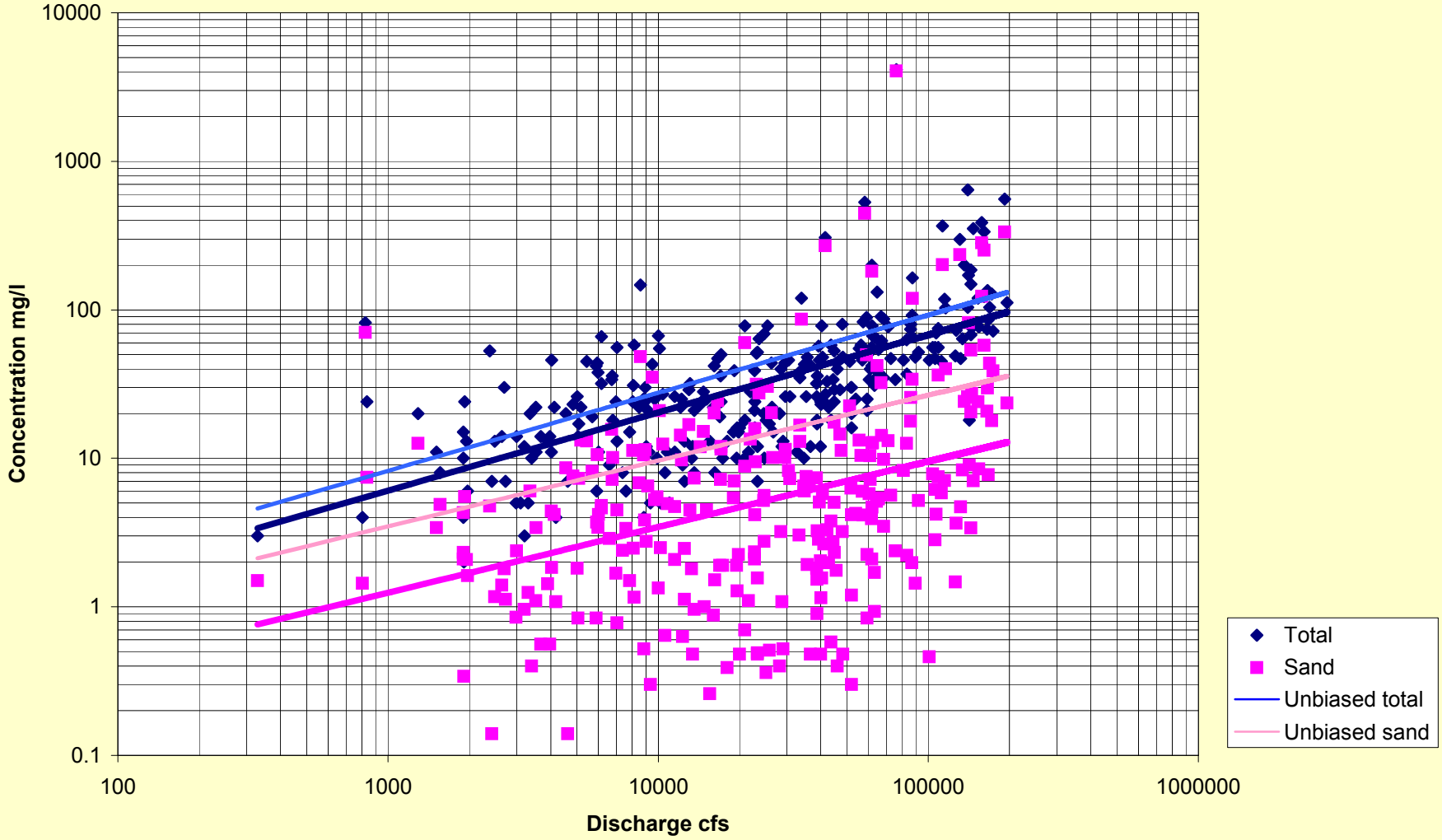
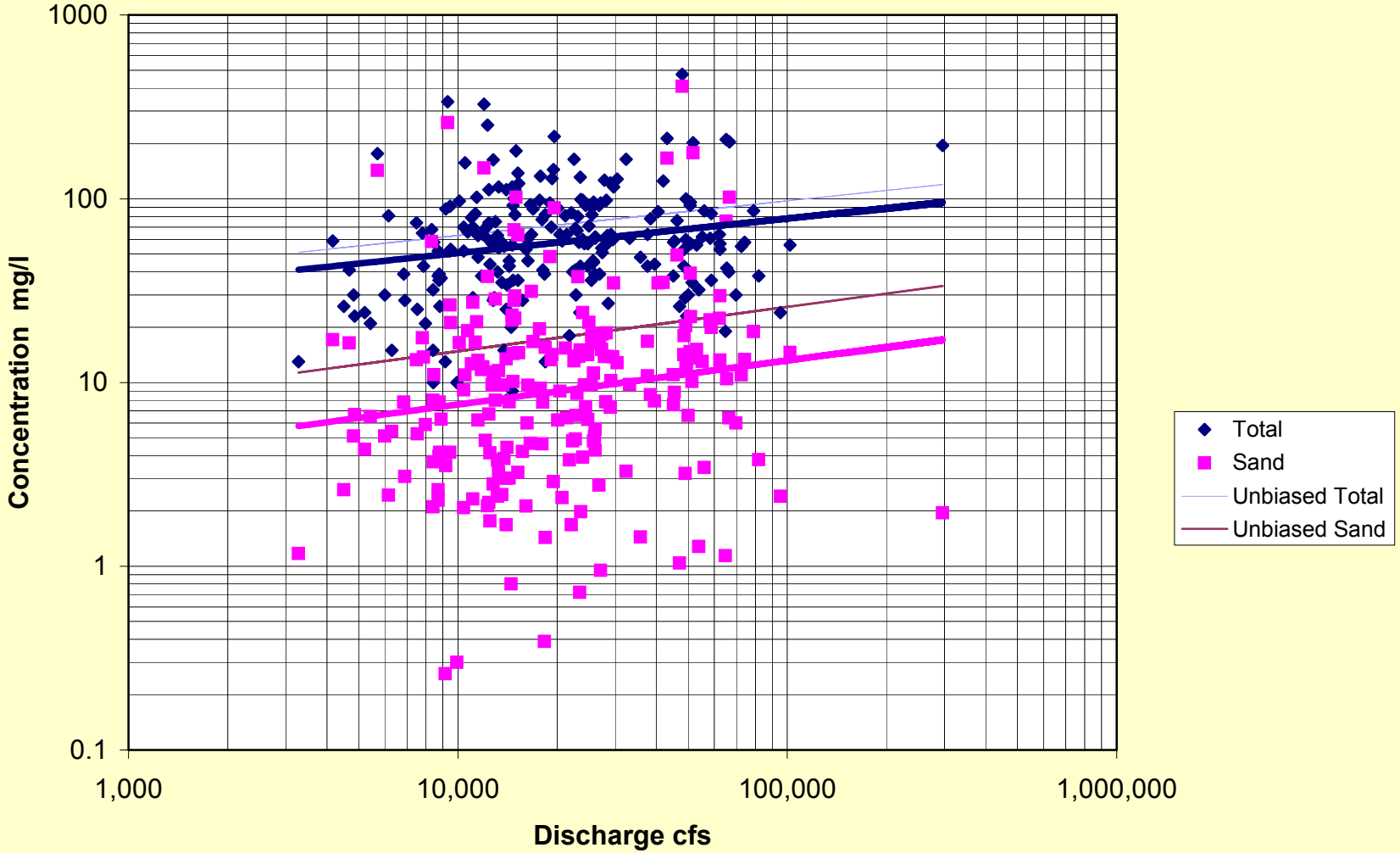
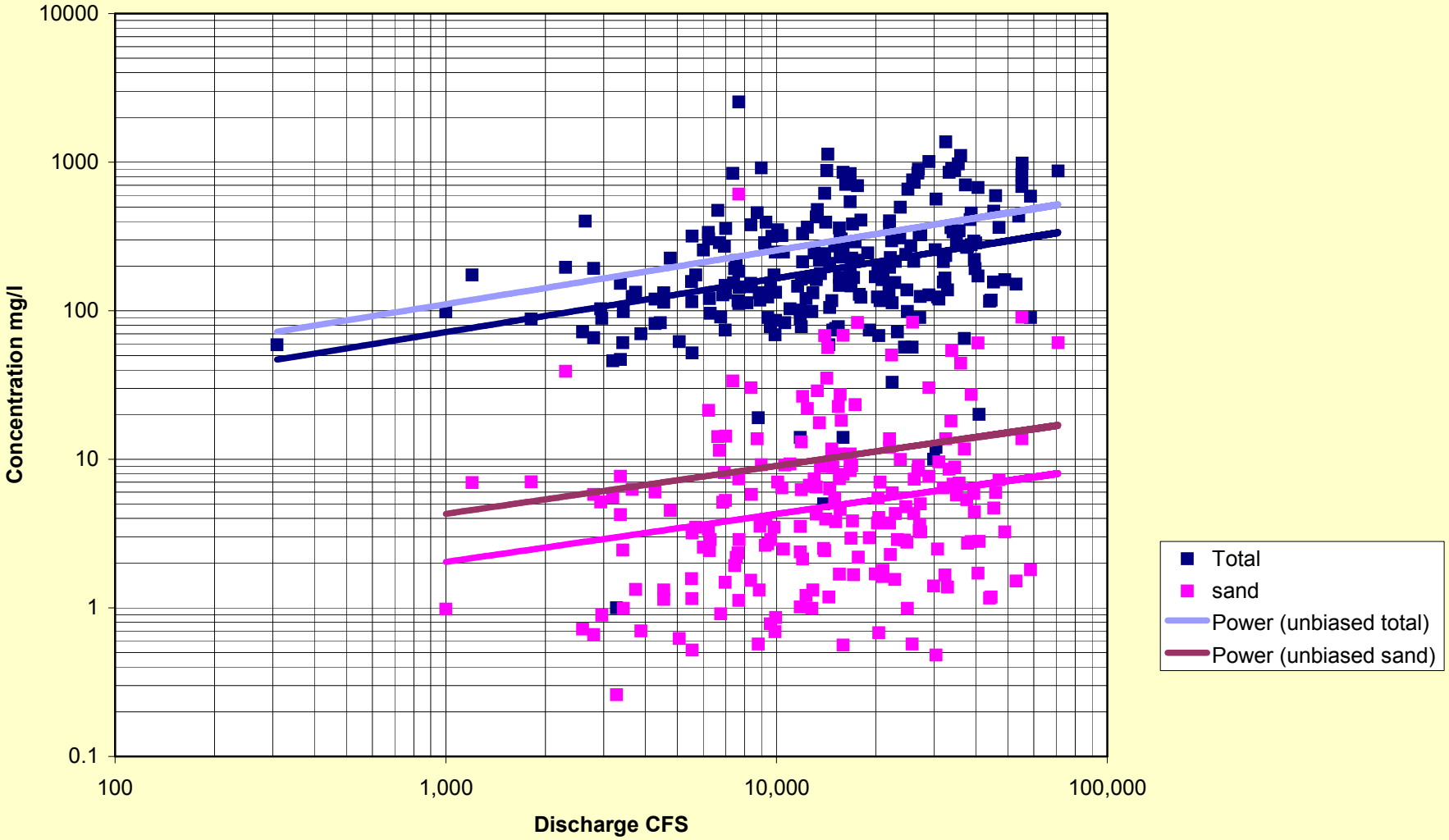
Meausred Suspended Sediment
Arkansas River Terry L&D and Dam No. 2

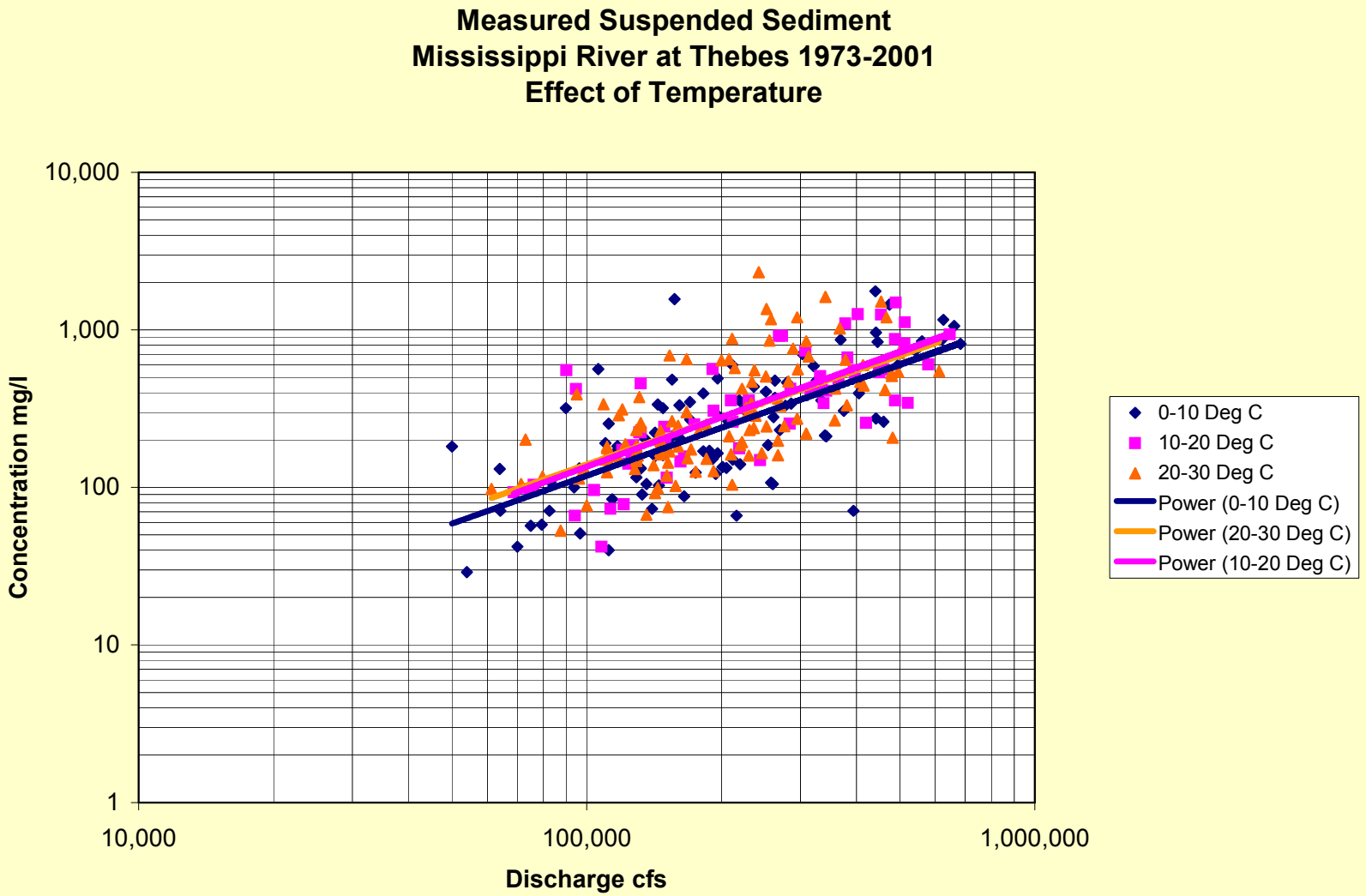


Combined Measured Sediment
White River at Newport, Devalls Bluff and Claredon



Measured Sediment Concentration
Yazoo River Redwood and Steel Bayou




Measured Suspended Sediment
Mississippi River at Thebes 1973-2001
Effect of Temperature
10,000
1,000
100
10
1
Concentration mg/l
10,000
100,000
1,000,000
Discharge cfs
0-10 Deg C
10-20 Deg C
20-30 Deg C
Power (0-10 Deg C)
Power (20-30 Deg C)
Power (10-20 Deg C)