# Proposed Monitoring Network for Determination of Daily Sediment, Nutrient, and Sediment-Associated Chemical Concentrations and Loads for the Conterminous U.S. Piloted in the Mississippi River Basin

*USGS Ad Hoc Committee on Sediment*

**Missouri River Basin Interagency Roundtable Meeting**

**Denver, CO**

**January 10, 2011**

# Who Cares and Why?

- Sediment Damages in North America (mostly in US) total $20-$50 BILLION annually (ARS-USGS)
- As much as 25 $mi^2$ Louisiana Coast lost annually
- Northern Gulf of Mexico Hypoxia
- COE dredging programs in MRB alone total ~$1Billion annually
- Impacts on infrastructure in Missouri River Basin
- EPA, NOAA, USDA, others have major investments in MRB

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# Who Cares and Why?

- The Preliminary Sedimentation Assessment for the Upper Missouri River Basin (NRCS)
- Identified continued and excessive sediment loading in the mainstem reservoirs as a primary concern. Sediment accumulates in these reservoirs at the approximate rate of 92,500 acre feet per year. Negative impacts associated with high rates of sediment loading are:
- Loss of flood storage.
- Sediment may impact hydropower production.
- Lost recreational opportunities.

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# Who Cares and Why?

- Increased water treatment costs for municipal, rural, and industrial (MR&I) water systems and loss of capacity, which in some cases leaves people with no suitable water source.
- Navigation relies on a water flow.  Lost reservoir capacities may make river system operation difficult to provide adequate water supply.

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# Who Cares and Why?

- Personal property is being adversely affected by rising ground water in the upper reaches of the reservoirs.
- Irrigation and MRI water intakes will be impacted and may need to be relocated.

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# Who Cares and Why?

- **"Missouri River Planning: Recognizing and Incorporating Sediment Management"-NAS 2010**
- **"Sedimentary processes and sediment management issues are important along the entire length of the Missouri River. For example, large volumes of sediment are trapped in the Missouri River's upstream reservoirs and represent a substantial portion of sediment no longer available for transport to the Gulf of Mexico. Other sections of the report thus consider sediment processes, and data collection and evaluation systems, for the entire length of the river.**

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# Who Cares and Why?

- "Missouri River Planning: Recognizing and Incorporating Sediment Management"-NAS 2010
- "The Missouri River basin once was a site of major sediment research. Over time, however, priorities shifted, expertise on Missouri River sediment has dwindled, and there has been a decline in the attention paid to overall data collection, management, analysis, archiving, and access. Historical Missouri River sediment data are extensive, and there are important studies of

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# Who Cares and Why?

- "Missouri River Planning: Recognizing and Incorporating Sediment Management"-NAS 2010
- "sediment dynamics being conducted today in the basin, including ongoing collaborative efforts between Corps of Engineers and USGS scientists. In general, however, sediment-related data and studies are diffuse and scattered across the basin in a variety of locations and a variety of formats. A more systematic platform of sediment measurements, data archiving,

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# Who Cares and Why?

- "Missouri River Planning: Recognizing and Incorporating Sediment Management"-NAS 2010
- "and system-wide modeling knowledge will be necessary to support efficient decision making for ecosystem management initiatives. "
- "data generally provide an agreeable starting point for debate, which is lacking along the Missouri River."

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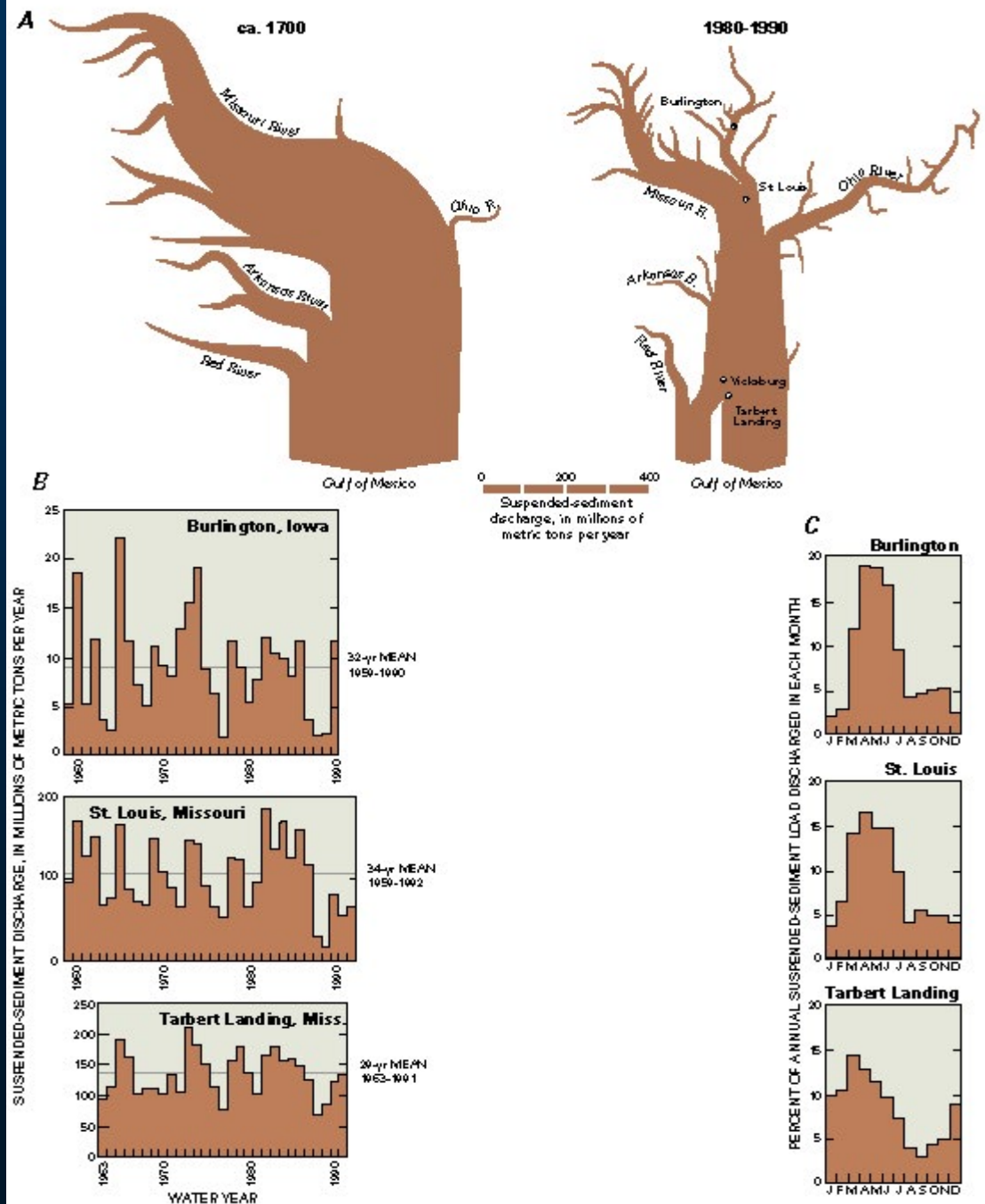
# Figure 6--*Suspended-Sediment Discharge*

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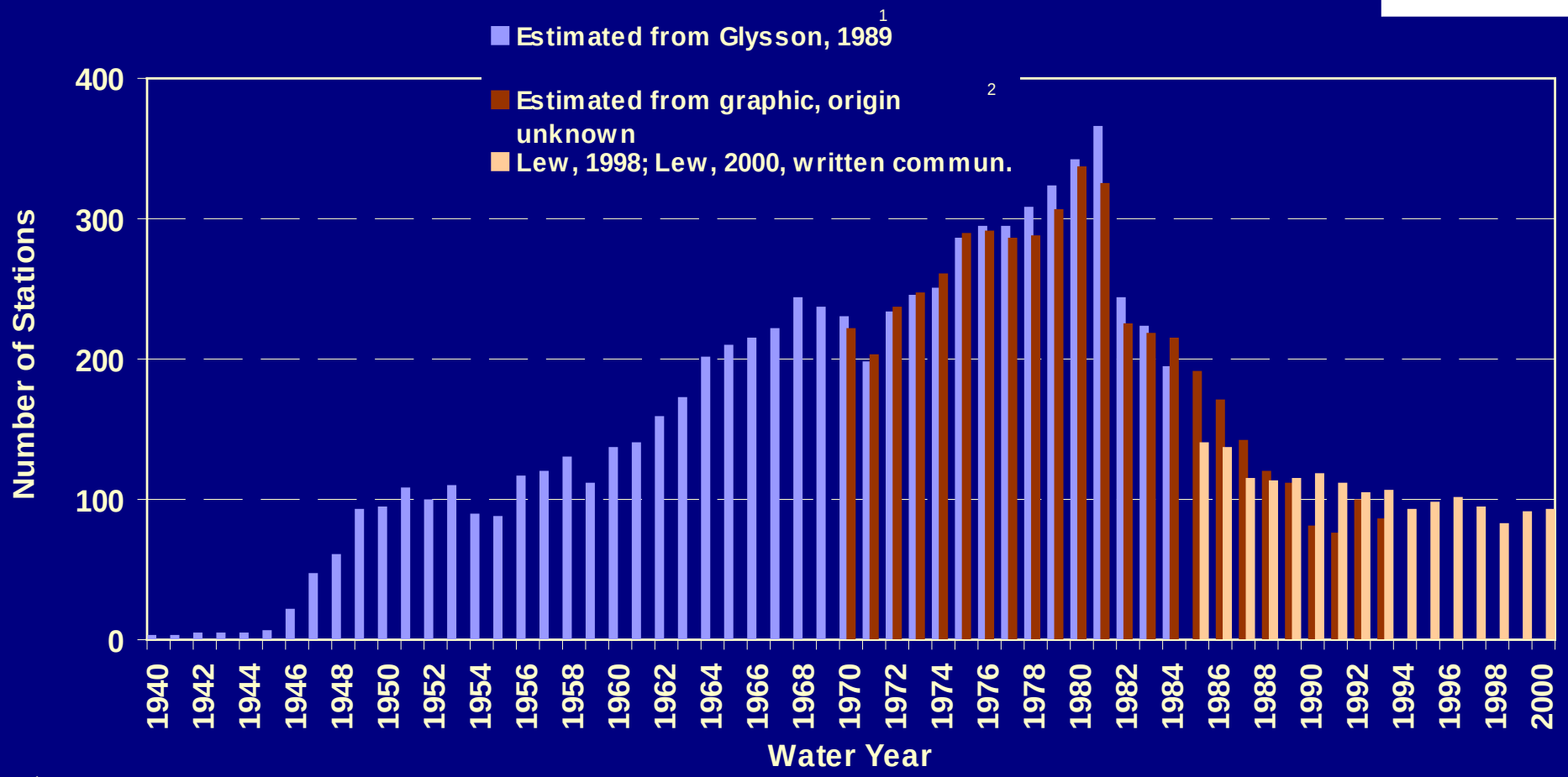
# USGS Daily Sediment Stations by Year 1940-2000




[1] Glysson, G.D., 1989, 100 Years of Sedimentation Study by the USGS, in, Proceedings of the International Symposium, Sediment Transport Modeling, Sam S.Y. Wang, ed.: American Society of Civil Engineers, New Orleans, August 14-18, 1989, pp. 260-265

[2] Lew, Melvin, 1998, Operation of Hydrologic Data-Collection Stations by the U.S. Geological Survey in 1997: U.S. Geological Survey Open-File Report 97-832, p.14. These data have been multiplied by a coefficient of 0.657 based on the relation between the red and tan bars for the period 1985-1993 in an attempt to render Lew's data comparable to the blue and red bars. Data depicted by the blue bars were dervied from the National Water Information System or its predessesor. Data depicted by the red bars, of unknown origin, also appear to be approximately derived from the National Water Information System. Almost half of the sediment stations operated in 2000 are in Puerto Rico

(John R. Gray and Roger K. Chang, USGS, OSW, October 2000)

# Past and Present Sediment Monitoring Locations on the Lower Missouri River

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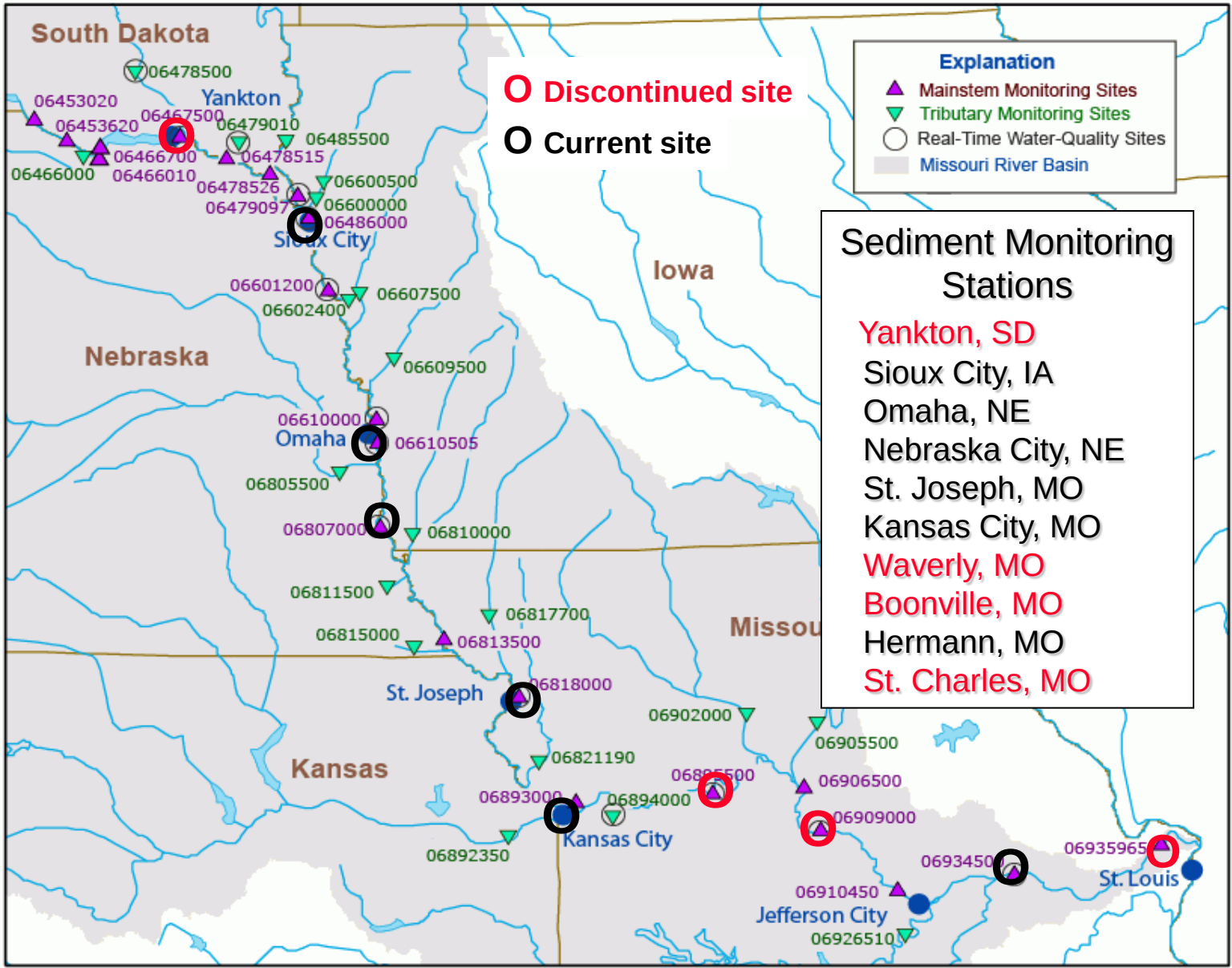


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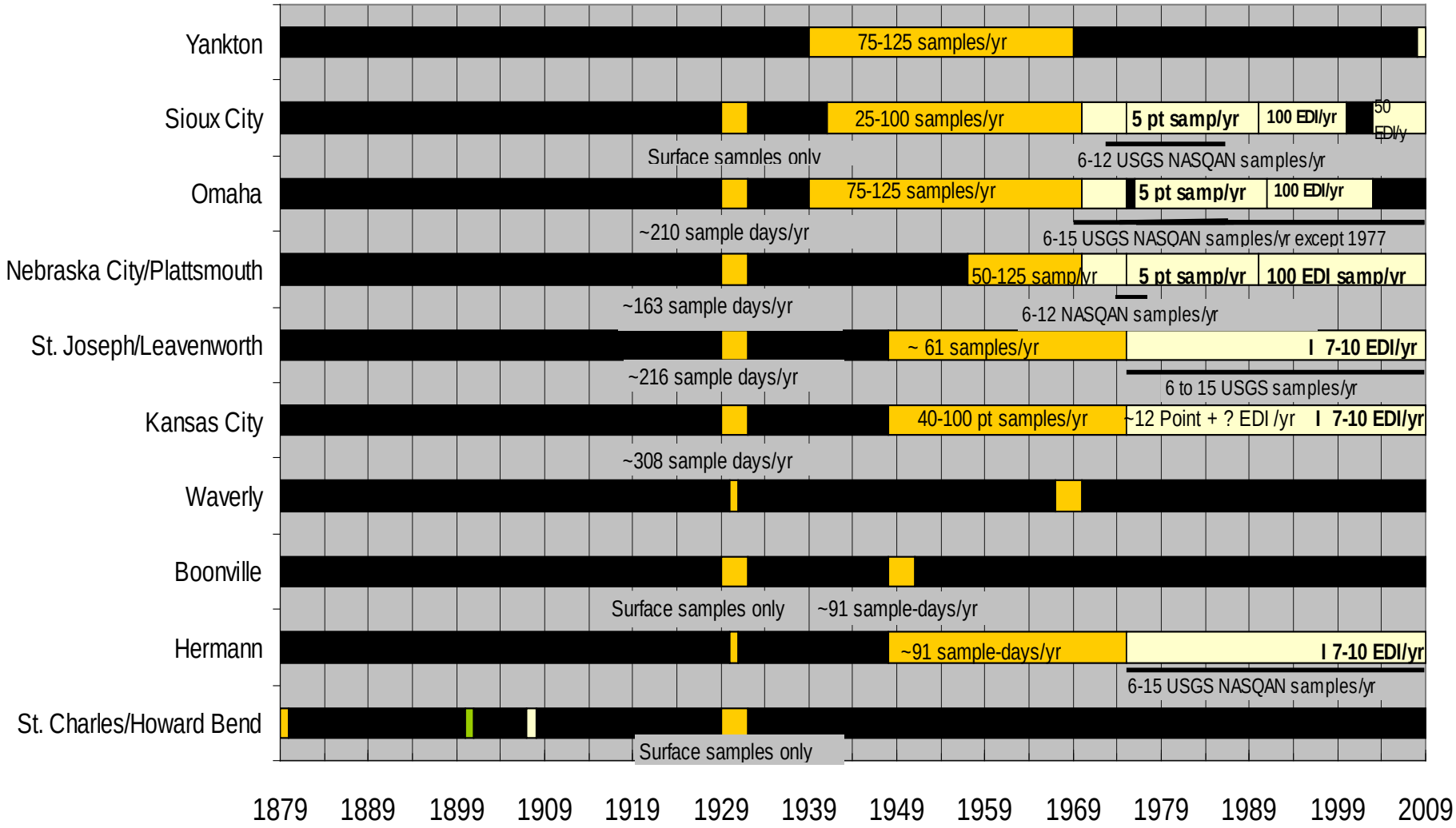
# Periods of Sediment Sample Collection on the Lower Missouri River




Isokinetic samplers used at all sites after Oct. 1, 1947 except as noted.

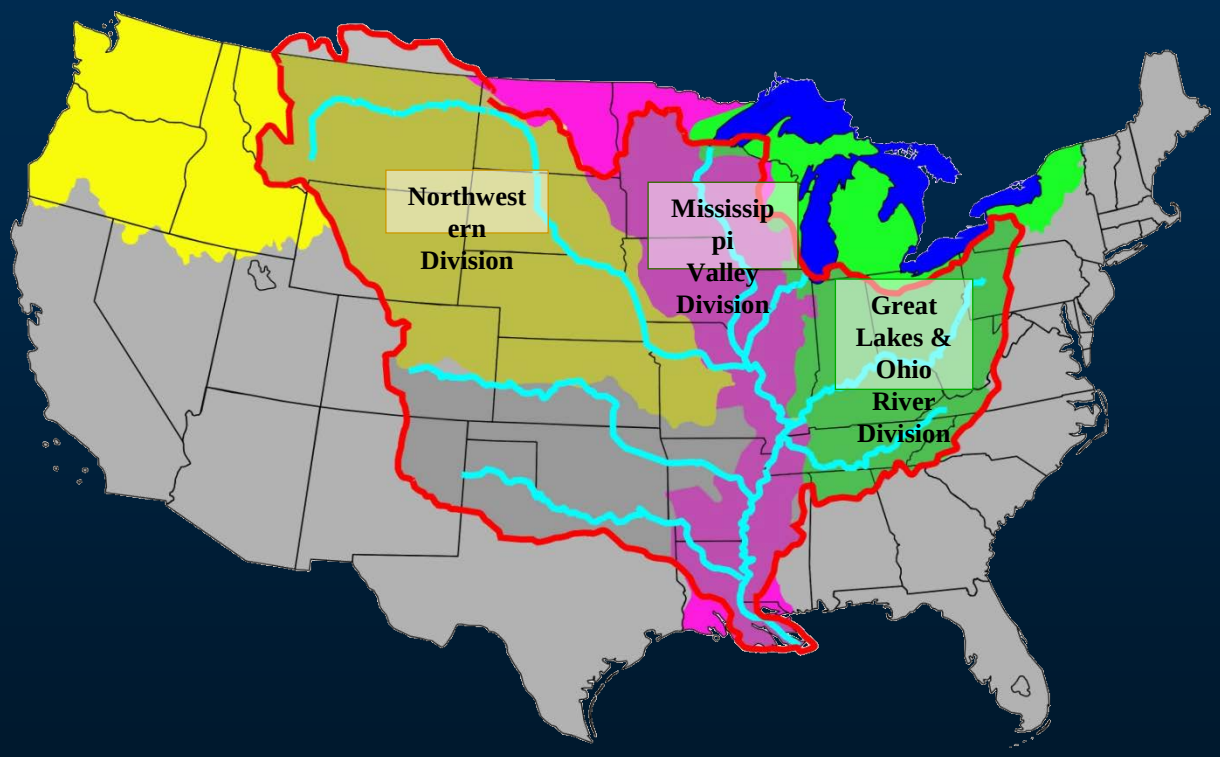
No Samples

Samples collected by USACE

Samples collected by USGS

Samples collected by others

# USGS/COE Proposal for a Long-Term National Monitoring Program initiated as a Mississippi River Basin Pilot Program




**A Proposal to Establish a Long-Term, Base-Funded, Network-Design National Monitoring Network to Generate Sediment, Nutrient, and Sediment-Associated Chemical Concentrations, Loads, Budgets and Temporal Trends**

**Integrated with existing and proposed networks such as HBN, NAWQA, and NASQAN**

U.S. Department of the Interior
U.S. Geological Survey
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# The Mississippi River Basin

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# MRB Pilot Program -- OBJECTIVES

1. Establish a sediment, nutrient, and solid-phase QW monitoring program on the Mississippi, Missouri, and Ohio Rivers, and selected tributaries to compute fluxes at key spatial and time scales.

2. Ascertain trends in sediment and constituent transport on selected economic, ecologic, and restoration activities in the MRB.

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# VISION: A NATIONAL Sediment & QW Monitoring Program Cost/Benefits

- $75-$90M annually, 400-450 stations
- Based on National Monitoring Network Design (ACWI)
- National Program cost <1% of estimated costs/sediment damages annually
- Ergo, 1% reduction in damages/costs will pay for the National Program

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# Pilot: Mississippi River Basin Pilot Program

- $17.6M in FY2012; ~$14M annually thereafter
- Based in part on National Monitoring Network Design (~50% of available NMN sites)
- The means for quantifying sediment and QW fluxes to address large-scale problems
- A framework for supporting "nested" sediment- & QW-flux research on smaller scales

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# Why Now?

- Because it wasn't done before…!
- Because it is necessary for making informed decisions on resources management.
- Because even modest returns on investment will pay for the program – likely many times over.
- Because reliable, network-design-based information will greatly increase the accuracy of our models.

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# MRB Pilot Program -- Scope

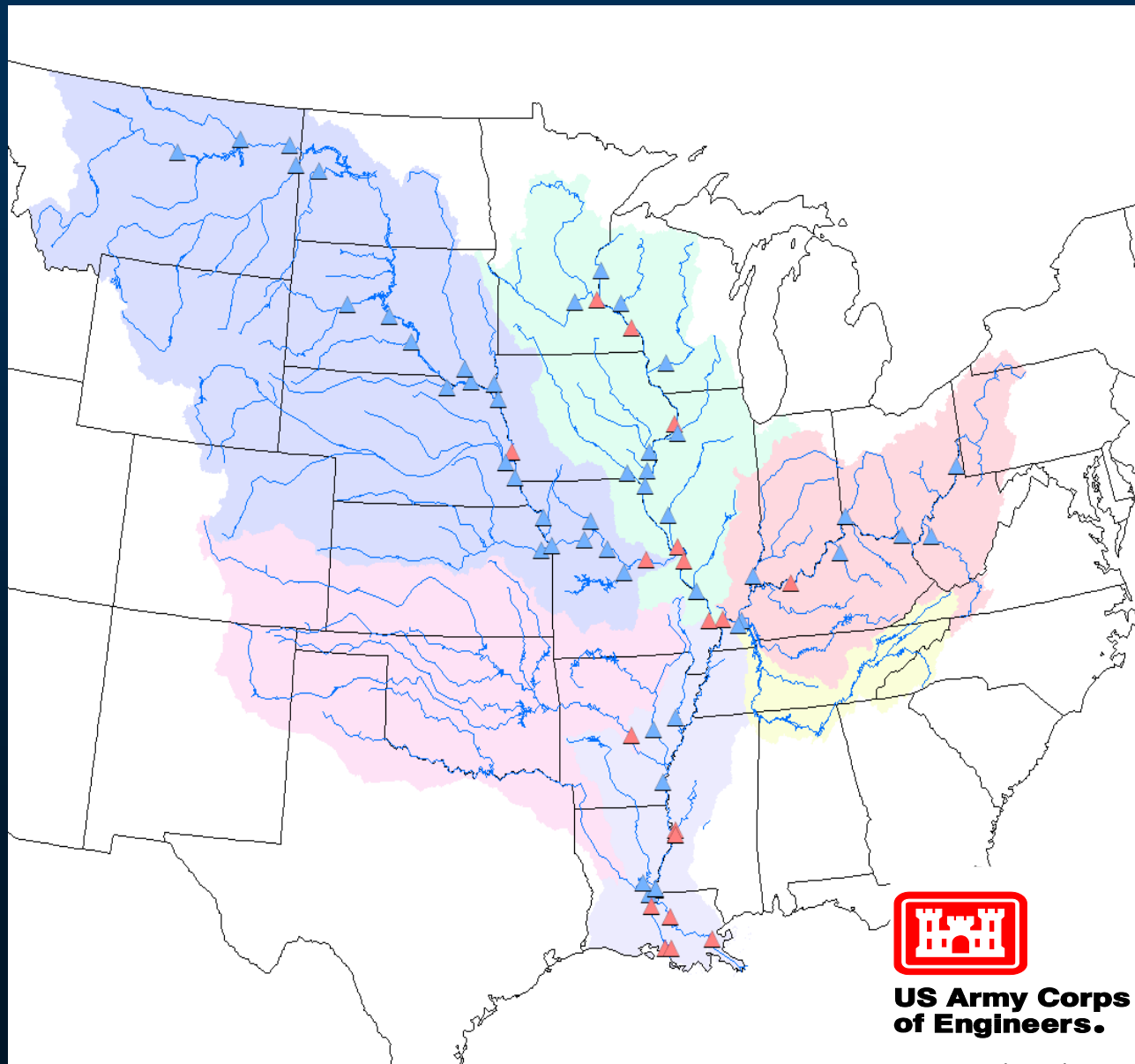
- **68 stations**
  - 20 priority 1
  - 48 priority 2
  - Max use of USGS gages & programs

**Priority 1:**

Large-scale processes

**Priority 2:**

Watershed proc./issues



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# MRB Pilot Program -- Constituents

- **Suspended Sediment (routine)**
  - Fluxes by size category (silt/clay vs sand)
  - Full gradation from samples
  - Nutrients, other QW
- **Filtered Water (routine)**
  - Nutrients, common ions, trace elem., pesticides, other
- **Bed Material (2/year)**
  - Gradation
  - Selected QW
- **Bedload (non-routine)**

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# Water Sample Collection on Rivers

- Objective – Collect samples representative of sediment concentration over entire cross section
- Suspended sediment concentrations vary 500 to 1000 percent from top to bottom and bank to bank
  - Equal-Discharge Increment samples
  - Equal-Width Increment samples
  - Depth-Integrated samples
  - Point samples
  - Surface sample – need additional EDI samples

B - not representative

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# Historical equipment and data

- Are data collected using historical equipment accurate and useful in predicting changes in suspended sediment concentrations and loads over time?

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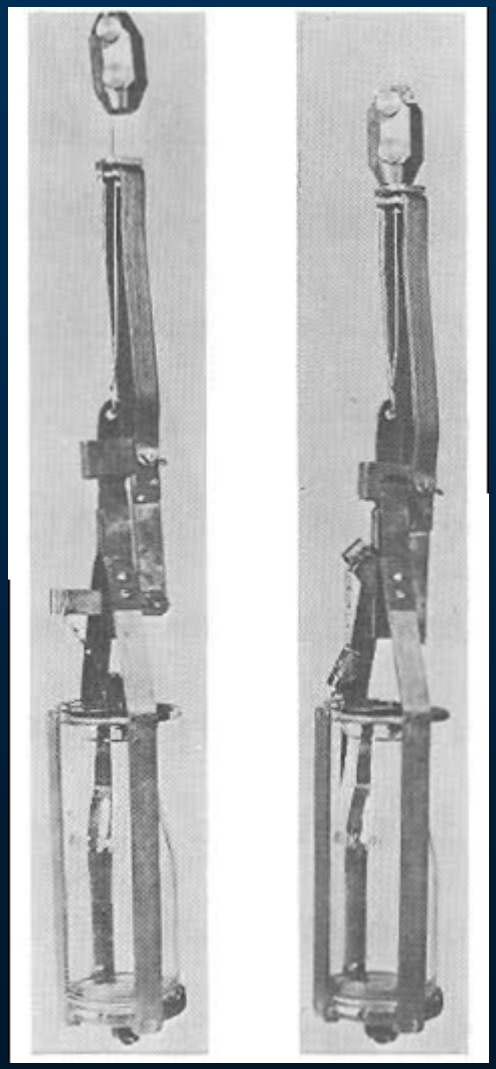
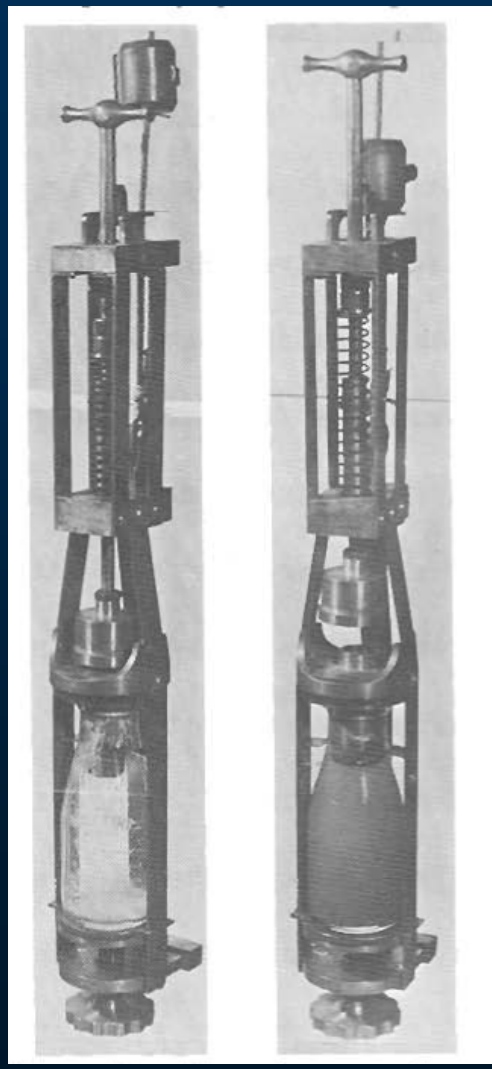
# Historical Suspended Sediment Samplers

- Primitive Straub. Vertical bottle with messenger, knife, and paper cap (1929-1932)
  - Overestimated sediment
- Omaha (1939-1948)
  - Overestimated sediment
- P43 (1948-1961)
  - isokinetic
- P61 (1962-present)
  - isokinetic



Colorado sampler



Straub sampler with valve

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# Omaha Sampler

- Years of Use
  - 1939-1948
  - 1939-1954 at some sites

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# Traditional equipment and Methods Currently Used

- Isokinetic equipment in use today are considered the “gold standard” for use in the collection of suspended sediment samples

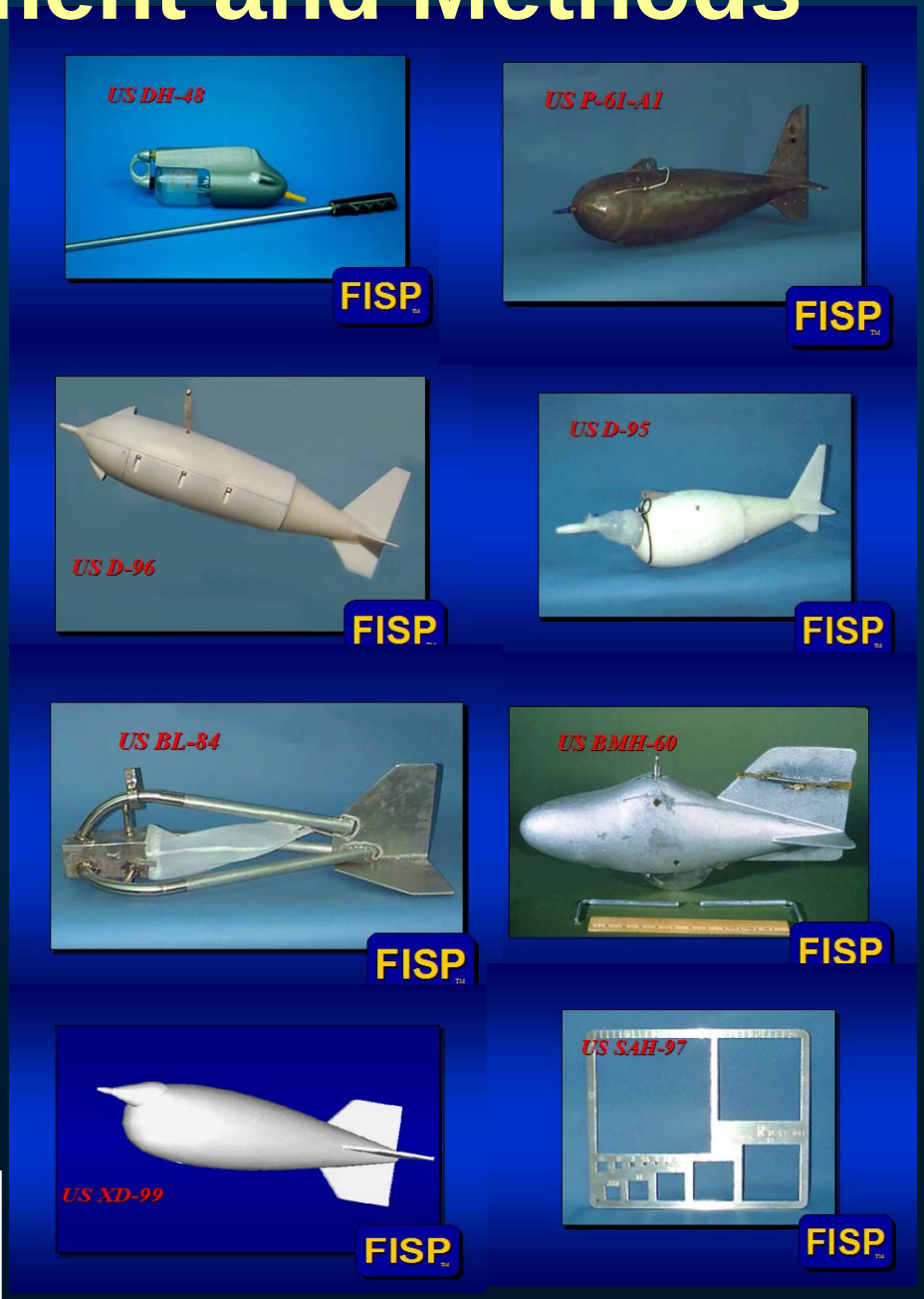
# Traditional Equipment and Methods

**Federal Interagency Sedimentation Project Samplers and Sampling Techniques Are the Standards**

**for quality-**

**assured data**

**USA, and International Standards Organization**

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# Point Samples

- Isokinetic P-61 Point Sampler lowered to desired depth with nozzle closed
- Sampler opened electronically with solenoid
- Sampler left open long enough to partially fill bottle inside and then closed
- Sample returned to surface and sent to laboratory for analysis
- Provides information about changes in sediment concentration with depth and laterally

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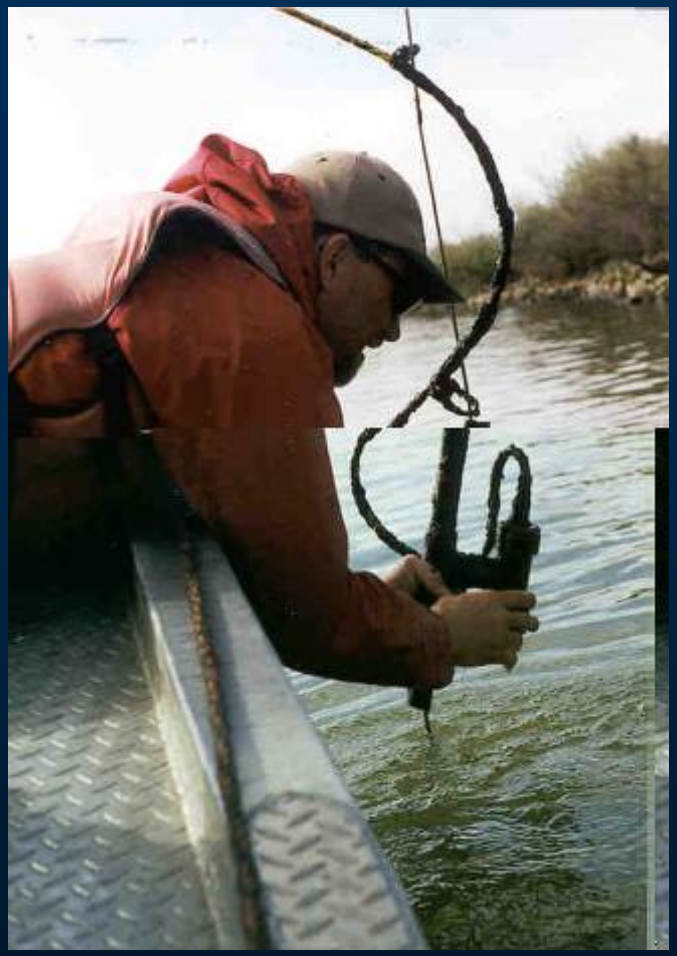
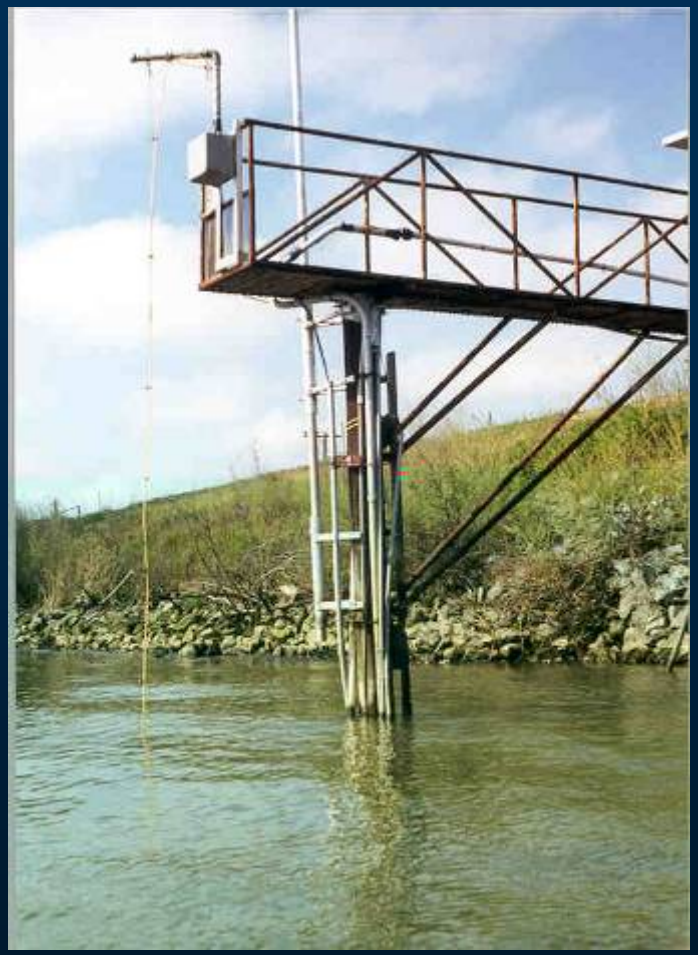
# New Technology

- Can new instruments/technology provide us with real-time concentrations, grain-size distribution loads, and still get accurate suspended-sediment data?
- Will this data be comparable to traditionally-collected samples
- New Capabilities that may Revolutionize Acquisition of Fluvial-Sediment and QW Data

# Optical Backscatterance & Turbidity





Paul Buchanan (USGS), San Francisco/Delta Bay, April 1999

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# Turbidity provides the best estimate of suspended-sediment concentrations

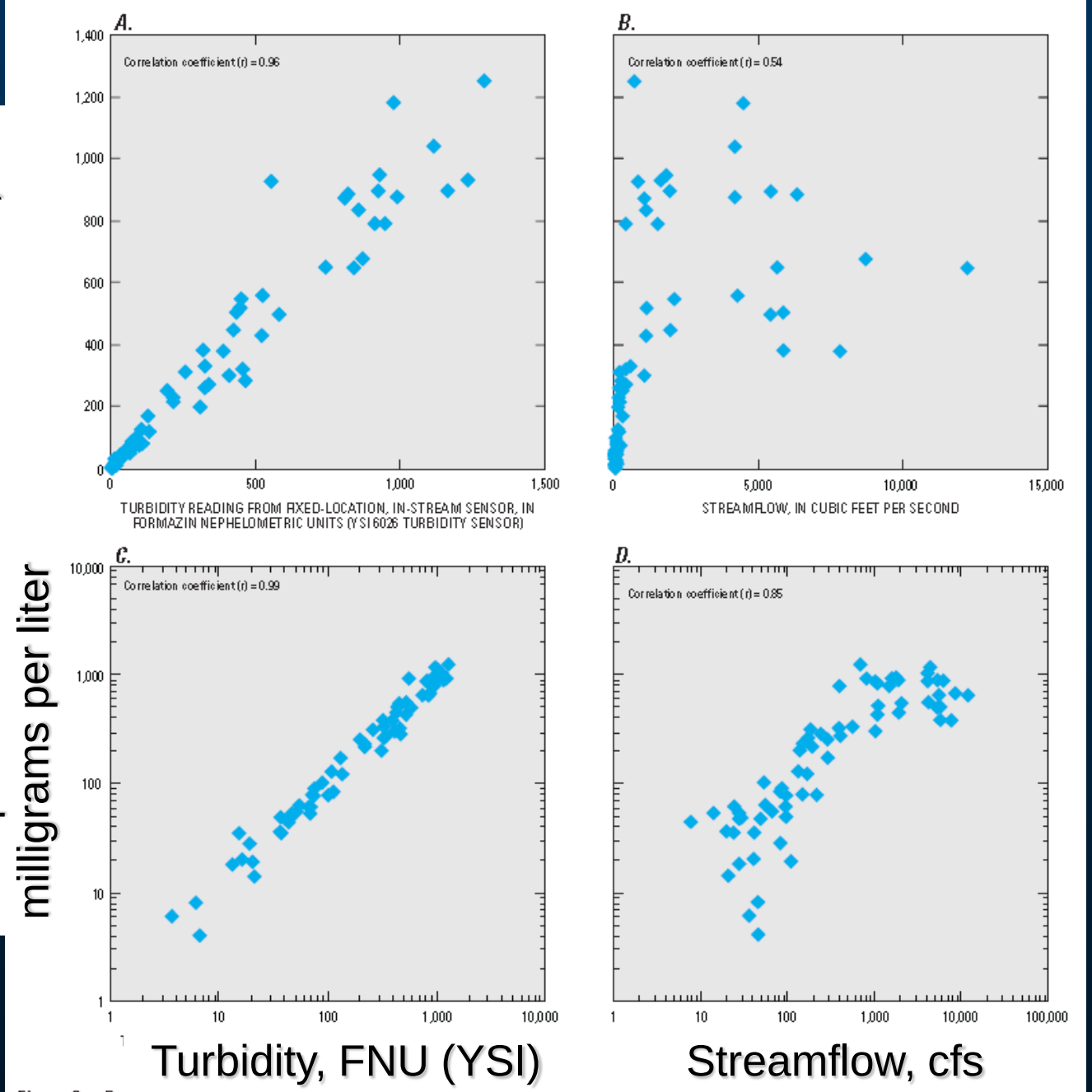


**Figure 8.** Relations between *(A)* turbidity and suspended-sediment concentration, *(B)* streamflow and suspended-sediment concentration in linear space, *(C)* turbidity and suspended-sediment concentration, and *(D)* streamflow and suspended-sediment concentration in $\log_{10}$ space for U.S. Geological Survey streamgage on Little Arkansas River near Sedgwick, Kansas, 1999–2005.

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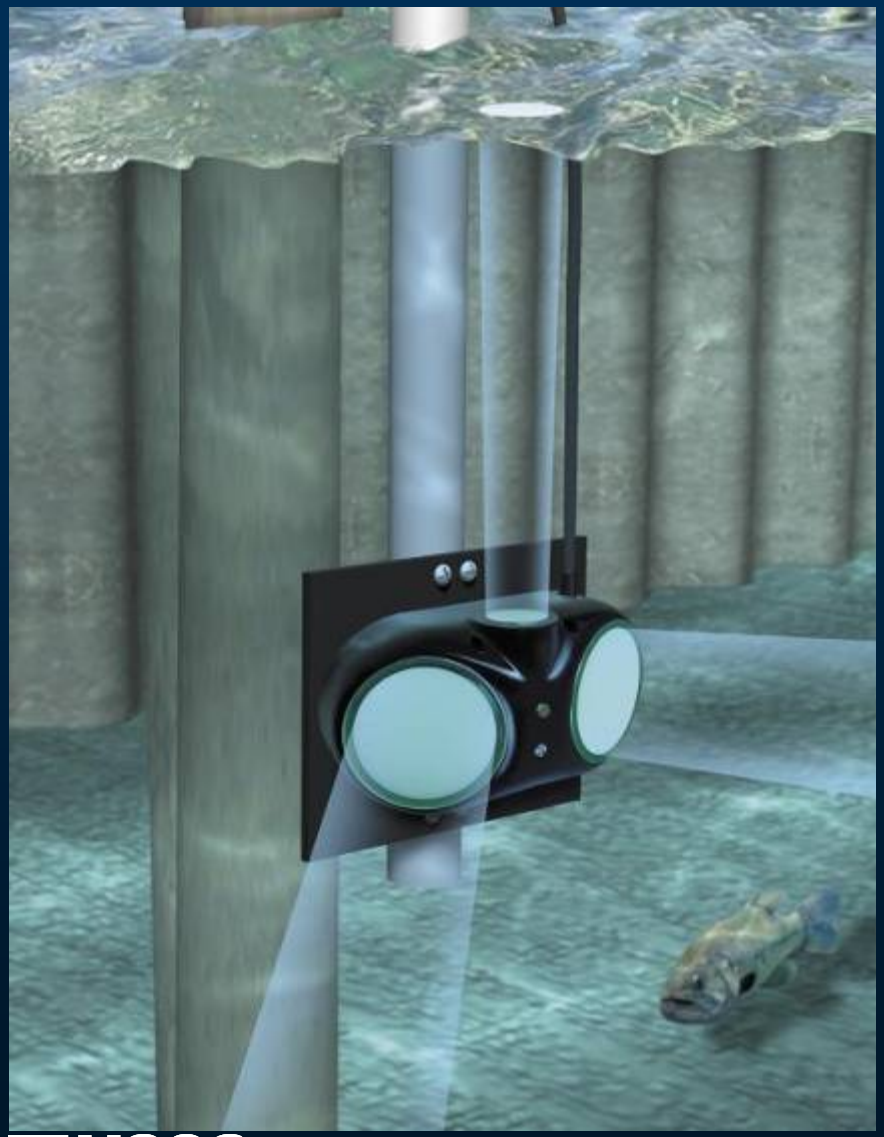
# Example:  Side-Looking ADV/ABS



Courtesy of Sontek/YSI, Inc.

Sontek Long-Range
Argonaut-SL Systems
Single Frequency

1.5 – 120 meter penetration

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# Hudson River – Hydroacoustic Equipment

- Two 600 kHz RDI Sentinel ADCPs used in rotation.
- Initial deployments were self contained, we've since moved to a 400' land line.

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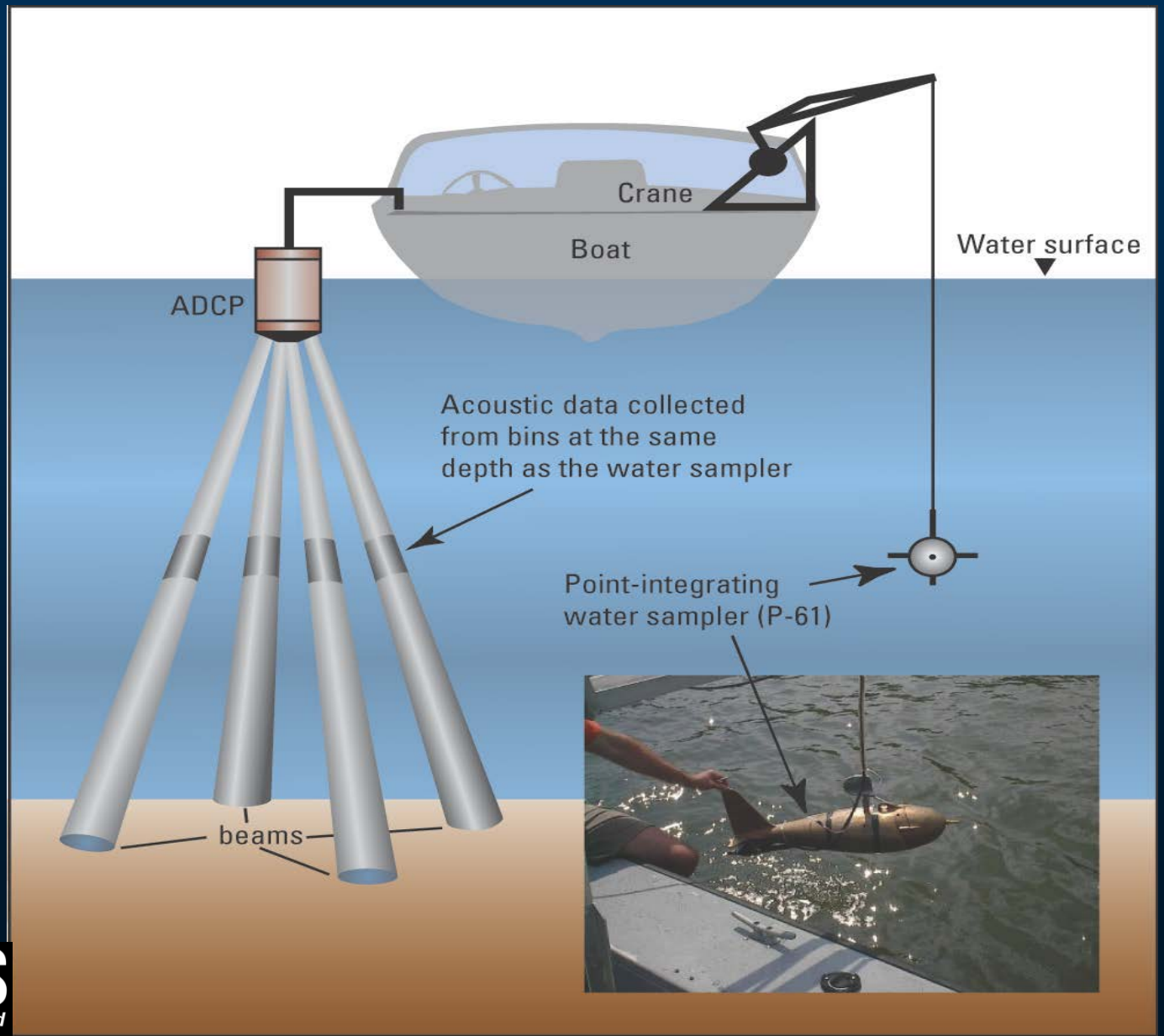
# Hudson River -- Calibrations

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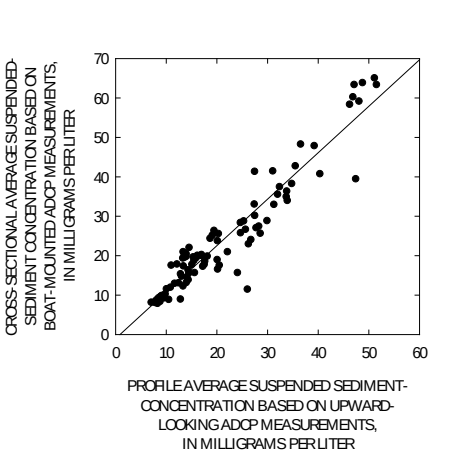
# Hudson River Cross-Section Adjustments

- Cross Sectional Adjustment:
  - "Box-coefficient" based on ADCP cross-sectional estimates of SSC

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# Isokinetic withdrawal LISST-SL

- Active control, pump-assisted isokinetic withdrawal
- Pitot tube velocity sensor
- 2-Wire communication
- $H_20$ Depth, Temp, Vel. meas. along with PSD, SSC
- Low drag permits low weight.

"Laser In-situ Scattering Transmissometer"

Cooperative Research and Development Project
Between Sequoia, Sci., Inc.,USGS, FISP

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# MRB Pilot Program – Synthesis

- ID Principal Sources/Sinks of sediment, nutrients, other QW constituents.
- Identify phase of transport of sediments as a function of location, flow, other variables.
- Calibrate model(s) to “allocate” sediment to source types based on digital coverages, thus enabling simulation of sediment transport by real or simulated land use.
- All data on-line/publically available.

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# MRB Pilot Program – Potential Partners

- EPA and NOAA have considerable interest in sources and transport mechanisms for nutrients.
- USDA likewise has interest in sediment and nutrient transport from farmlands to receiving waters.
- 31 MRB States have vested interests.

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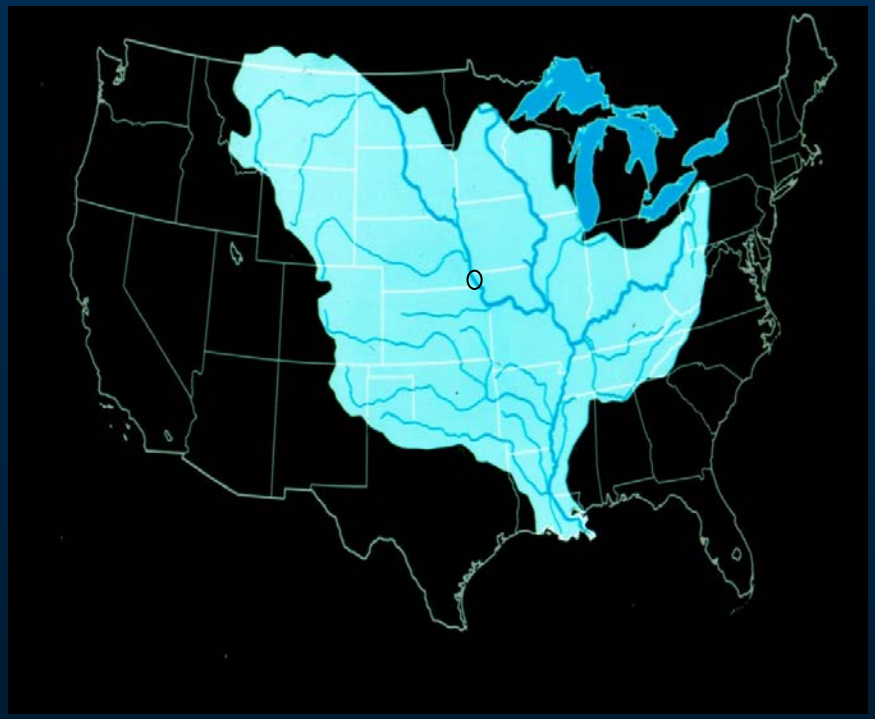
# Next Step?

- Full proposal and synopsis submitted by the COE and USGS development team.
- Both publically available.
- Shared with EPA, NOAA, USDA, and other potential partners.
- Build a synergistic relationship between existing and proposed programs such as HBN, NAWQA, and NASQAN with the USGS-COE sediment monitoring proposal such that sediment can be traced from headwaters to estuaries so informed management decisions can be made.



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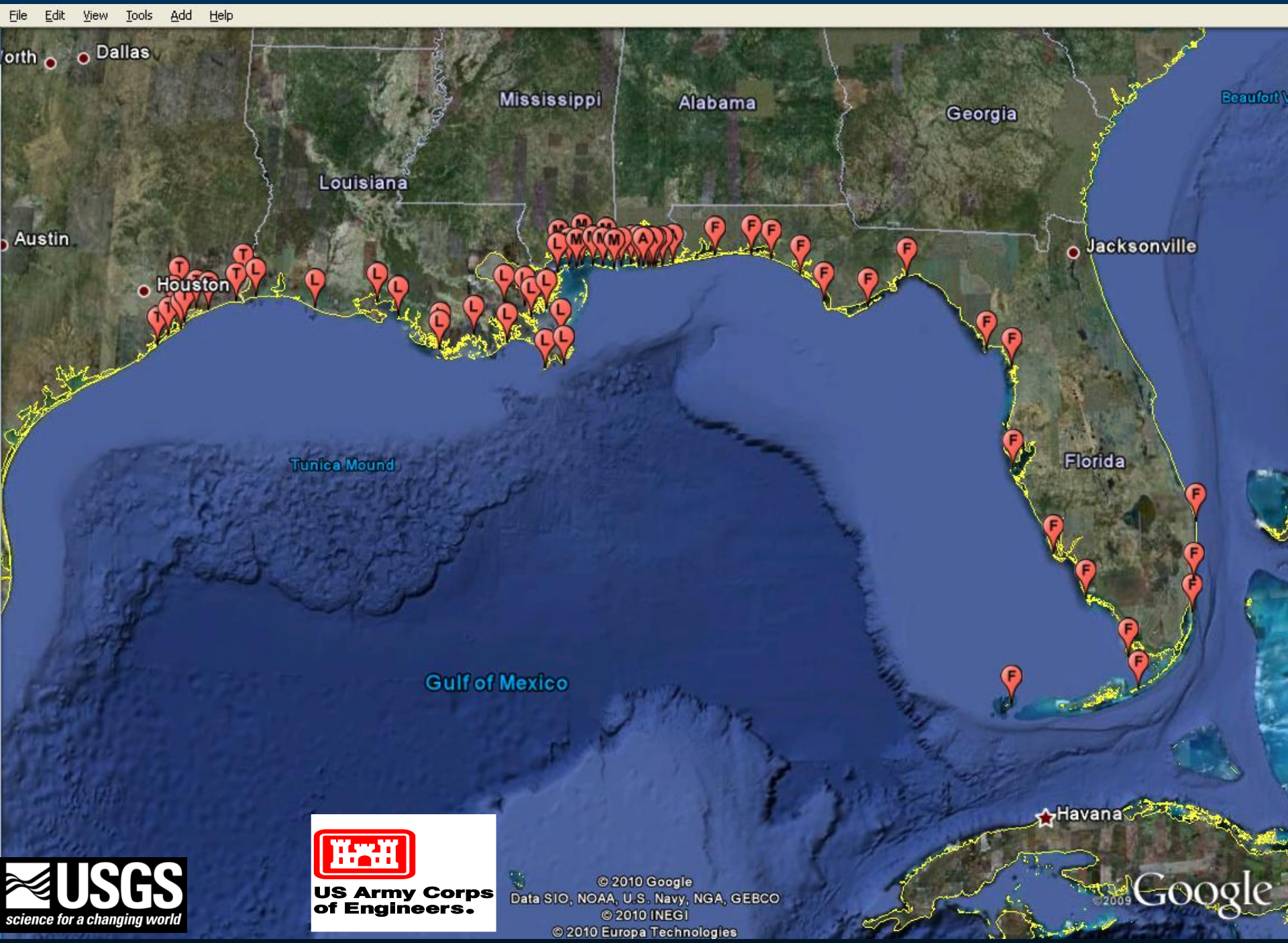
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**Samples to be collected are listed below:**

| | | | |
|---|---|---|---|
| Semi-Volatiles - PAH | Bottom Material | USGS NWQL (Denver CO) | GCMS - GS O-5506-06 |
| | Whole Water | USGS NWQL | GCMS - GS O-3116-87 |
| Oil & Grease | Whole Water | TEST AMERICA LABS | |
| | Bottom Material | TEST AMERICA LABS | |
| Volatiles- BTEX/VOCs | Whole Water | USGS NWQL | GCMS - GS O-4127-96 |
| DOC | Whole Water | USGS-G. Aiken. Boulder | |
| Toxicity | Whole Water | Columiba Envir.Res.Ctr | |
| | Bottom Material | Columbia Envir.Res.Ctr | |
| Surfactant | Whole Water | USGS NWQL, J. McCoy | Spectrophotometry - GS O-3128-95; MBAS LC 96 |
| Trace metals | Whole Water | USGS NWQL | ICP/MS |
| | Bottom Material | USGS Horowitz, Norcross | |
| Nutrients | Whole Water | USGS NWQL | EPA 350.1/GS Method ID: I-4515-91; I-4610-91 |
| Bacteria | Whole Water | USGS Lisle, St. Petersbg | |
| Oil fingerprinting | Bottom Material | USGS Rosenbauer, Menlo Pk | |
| Isomeric fingerprinting | Whole Water | USGS Eganhouse, Reston | |
| | Bottom Material | USGS Eganhouse, Reston | |

| USGS Laboratory | Analysis | Matrix | Sample Container | NWQL Schedule | Analytical method |
|---|---|---|---|---|---|
| National Water Quality Lab | Semi volatiles - PAHs- | Bottom Material | 1L glass bed organic bottle (wide-mouthed) - 100 grams | 5506 | GCMS - GS O-5506-06 |
| National Water Quality Lab | Semi volatiles - PAHs | Whole Water | 1 L narrow amber glass organic bottle | 1383 | GCMS - GS O-3116-87 |
| National Water Quality Lab | Trace metals | Whole Water | 1 125 ml acid-rinsed bottle | 2317 | ICP/MS – GS I-4471-97 |
| Dr. Art Horowitz, Norcross, GA | Trace metals | Bottom Material | 1 plastic (no color ) acid rinsed freezer carton | NA | |
| Test America Labs | Oil and Grease | Whole Water | 1 L narrow amber glass bottle | NA | |
| Test America Labs | Oil and Grease | Bottom Material | 1 500 ml amber glass organic bottle (wide-mouthed) | NA | |
| Columbia Environmental Research Center, Columbia, MO | Toxicity | Whole Water | 2 L narrow amber glass bottle-water | NA | |
| Columbia Environmental Research Center, Columbia, MO | Toxicity | Bottom Material | 1 L glass bed (organic, wide-mouthed) | NA | |
| Dr Robert Rosenbauer, Menlo Park, CA | Oil fingerprinting | Bottom Material | 2 500 ml amber bed glass organic bottle (wide-mouthed) | NA | |
| National Water Quality Lab | BTEX/VOCs | Whole Water | VOC septum vials | 2021 | GCMS - GS O-5506-06 |
| Dr. John Lisle, St. Petersburg, FL | Bacteria | Whole Water | 400 ml whirl pak sterile bag | NA | |
| National Water Quality Lab | Nutrients | Whole Water | 125 ml plastic (no color, chilled and lab will acidify) | LC2188, LC1986, LC1984 | EPA 350.1/GS Method ID: I-4515-91; I-4610-91 |
| Dr. Jeff McCoy, National Water Quality Lab | Surfactant | Whole Water | 1 Liter Glass | MBAS LC 96 | GCMS - GS O-3116-87 |
| Dr. Robert Eganhouse, Reston, VA | Isomeric fingerprinting | Whole Water | 1 Liter Glass | NA | |
| Dr. Robert Eganhouse, Reston, VA | Isomeric fingerprinting | Bottom Material | 8 oz wide-mouth glass | NA | |

| *In Situ* Measurements | Medium | On Site | Method Reference (http://water.usgs.gov/owq/FieldManual/) |
|---|---|---|---|
| pH | Whole Water | *In Situ* | NFM 6.3; 6.8 |
| Dissolved oxygen | Whole Water | *In Situ* | NFM 6.2; 6.8 |
| Salinity | Whole Water | *In Situ* | NFM 6.2; 6.8 |
| Temperature | Whole Water | *In Situ* | NFM 6.1; 6.8 |
| Specific Elec. Cond. | Whole Water | *In Situ* | NFM 6.1; 6.8 |
| Turbidity | | *In Situ* | NFM 6.7; 6.8 |
| GPS coordinates | | On Site | |

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