KEY CONTROLS ON SEDIMENT BUDGETING IN THE MISSISSIPPI RIVER FROM SOURCE TO SINK

Mead Allison
The Water Institute of the Gulf & Tulane University
What Controls the Availability of Sediment in the “Restoration Reach”

- Catchment alterations (dams, soil conservation, river channel improvements)
- Flood control river levees in LA
- Diversion of water and sediment for flood control in LA
- Diversion of water for non-flood purposes (navigation, etc.) in LA
- Volume of stored (relict sand) sediment
WHERE IS THE NEED FOR SEDIMENT FOR COASTAL RESTORATION?

Predicted Land Change over the Next 50 Years

HIGHLY THREATENED AREA

2012 State of LA Master Plan
HOW DOES THE STATE MASTER PLAN RESPOND TO THIS NEED BY USING MISSISSIPPI RIVER SEDIMENT?

Project Types

Distribution of Funding by Project Type (Approximately $50 billion)

- **Barrier Island** $1.7 billion
- **Hydrologic Restoration** $0.7 billion
- **Marsh Creation** $20 billion
- **Nonstructural Protection** $10.2 billion
- **Other Protection & Restoration Projects** $3.0 billion
- **Sediment Diversion** $3.8 billion
- **Structural Protection** $10.9 billion

**DIRECT SOURCING OF RIVER WATER**

**RIVERINE SAND (or offshore) MINING**
HOW DOES THE STATE MASTER PLAN RESPOND TO THIS NEED BY USING MISSISSIPPI RIVER SEDIMENT?

Sediment Diversions

Riverine Sand Mining
HOW DOES THE STATE MASTER PLAN RESPOND TO THIS NEED BY USING MISSISSIPPI RIVER SEDIMENT?

- **Sourced from Upstream (renewable) Supply from Suspension**
- **Sourced from Lateral Bars**

Sediment Diversions

Riverine Sand Mining
WHAT IMPACTS THE MASS OF SEDIMENT REACHING AND AVAILABLE IN THE “RESTORATION REACH” OF THE RIVER?

reaching = suspended + bedload flux,
available = sus + bedload + stored on channel floor

1. “Natural” - catchment denudation rates
   - floodplain and channel storage/incision rates, etc.

2. Catchment Modifications
   - dams
   - soil conservation
   - bank stabilization
   - river training

3. Flood Control Diversion
4. Atchafalaya (Old River Control) Diversion
5. MR&T Artificial Levees
   - overbank flow
   - crevassing

6. Channel Bed Aggradation/Degradation
Mississippi River Sediment loads ~50% of Historical Loads

- Dam Construction on the Missouri (1950’s) and Arkansas (1940’s)
- Soil Conservation Measures instituted in the 1930’s
- River Control (limiting bank erosion by bank armoring, etc.)
2. Net Catchment Modifications

Mississippi River Sediment loads ~50% of Historical Loads

LOWER RIVER STATIONS 1981-2007

From Horowitz (2010)
2. Net Catchment Modifications

Mississippi River Sediment loads ~50% of Historical Loads

MISSOURI RIVER DAM EFFECT

Gavins Point Dam (constructed 1952-6)

Lewis and Clark Lake

Yankton SD

10 km

WATER DISCHARGE (cfs)

DATE

Sioux City, Iowa
Yankton, South Dakota
2. Net Catchment Modifications

Mississippi River Sediment loads ~50% of Historical Loads

MISSOURI RIVER DAM EFFECT

Lewis and Clark L.

Yankton

Gayville

Sioux City

30 km

(1-30 mg/l)
2. Net Catchment Modifications

Mississippi River Sediment loads ~50% of Historical Loads

MISSOURI RIVER DAM EFFECT

Lewis and Clark L.
Yankton
Gayville
Sioux City

30 km

(200-2000 mg/l)
Mississippi River Sediment loads ~50% of Historical Loads

MISSOURI RIVER DAM EFFECT

2. Net Catchment Modifications

Lewis and Clark L.

Yankton

Gayville

Yankton

GAYVILLE

Sioux City

30 km

STAGE (feet)

DATE

STAGE (feet)

DATE
Mississippi River Sediment loads ~50% of Historical Loads

2. Net Catchment Modifications

LAND USE CHANGE

% of Arable Land in Agriculture

Maizel et al. (1998)
Mississippi River Project Flood
3 million cfs (84,951 cms)

Memphis 2,410,000
Natchez 2,720,000
Baton Rouge 2,100,000
New Orleans 1,250,000
Morgan City 1,060,000
Morgansport 620,000
Old River 350,000
Above Old River 680,000

Project Flood flow, cfs

USACE (2008)
3. Flood Control Diversion (continuous)

How much sediment is diverted to the Atchafalaya?

DIVERTED (Outfall Channel)
- TOTAL: 29 – 40 MT/y
- SAND: 3.3 – 6.4 MT/y

DOWNRIVER (Tarbert Landing)
- TOTAL: 137 – 178 MT/y
- SAND: 62 – 79 MT/y

FRACTIONAL
- MUD: 24 – 29%
- SAND: 5 – 8%
4. Mississippi versus Red Contribution to Atchafalaya

Mississippi River Contribution to the Atchafalaya 1964-2012

Red River Discharge 1964-2012 (Simmesport - Old River Outfall)
3. Flood Control Diversion (episodic)

- Bathymetry: June 2011
- Change: May 2011 - June 2011
- Change: June 2011 - June 2012

**2011 Bonnet Carre Spillway Opening**

- **B): OPENING**
  - 9.1 MT in 42 d

- **C): AFTER 1 yr**
  - 69% remob

from:

J. of Hydrology Allison et al. (2013)
### 3. Flood Control Diversion
#### Bonnet Carre Spillway Openings

<table>
<thead>
<tr>
<th>Year</th>
<th>Days</th>
<th>Bays Opened</th>
<th>(%) Opened</th>
<th>Ideal flow capacity</th>
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<tbody>
<tr>
<td>1937</td>
<td>48</td>
<td>285</td>
<td>81.4%</td>
<td>203,571 cu ft/s</td>
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<tr>
<td>1945</td>
<td>57</td>
<td>350</td>
<td>100%</td>
<td>250,000 cu ft/s</td>
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<tr>
<td>1950</td>
<td>38</td>
<td>350</td>
<td>100%</td>
<td>250,000 cu ft/s</td>
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<td>1973</td>
<td>75</td>
<td>350</td>
<td>100%</td>
<td>250,000 cu ft/s</td>
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<tr>
<td>1975</td>
<td>13</td>
<td>225</td>
<td>64.3%</td>
<td>160,714 cu ft/s</td>
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<tr>
<td>1979</td>
<td>45</td>
<td>350</td>
<td>100%</td>
<td>250,000 cu ft/s</td>
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<td>1983</td>
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<td>1997</td>
<td>31</td>
<td>298</td>
<td>85.1%</td>
<td>212,857 cu ft/s</td>
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<tr>
<td>2008</td>
<td>31</td>
<td>160</td>
<td>45.7%</td>
<td>114,286 cu ft/s</td>
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<tr>
<td>2011</td>
<td>42</td>
<td>330</td>
<td>94.3%</td>
<td>235,714 cu ft/s</td>
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</tbody>
</table>
3. Flood Control Diversion (continuous)

Effect of Old River Control Diversion?

From Little and Biedenharn (2014)
3. Flood Control Diversion (continuous)

From Little and Biedenharn (2014)
3. Flood Control Diversion (continuous)

From Little and Biedenharn (2014)
5. MR&T Artificial Levees

- stop overbank flooding
- limit crevassing and lateral land-building

973 miles of levees in New Orleans District

Old River Control
Morganza Floodway
Bonnet Carre Spillway
5. MR&T Artificial Levees

LANDSAT 10 March 1989 (high discharge) 4 January 2003 (low discharge)

OVERBANK SEDIMENT SUPPLY

from (Allison et al., 2012)
5. MR&T Artificial Levees

CREVASSE SPLAY
SEDIMENT SUPPLY
5. MR&T Artificial Levees

Nita Crevasse (1890) – Measured 402,500 cfs during a 1.2 million cfs flood (Okerson, 1914)

Outlets for Reducing Flood Heights (Mississippi River Commission)
6. Channel Bed Aggradation/Degradation

From Little and Biedenharn (2014)
6. Channel Bed Aggradation/Degradation

Effect of Natural and Man-made Exits?

From Suir et al. (2014)
6. Channel Bed Aggradation/Degradation

Effect of Natural and Man-made Exits?

Channel Bed Storage 1993-2004

From Allison et al. (2012)
100 YEARS AGO

PRESENT

CREVASSE
SPLAY
OVERBANK
FLOW

SEDIMENT
LOAD
FLOOD
SEDIMENT