Hydrodynamic and Sediment Transport Modeling using FLOW-3D for Siting and Optimization of the LCA Medium Diversion at White Ditch

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Acknowledgements:

This work was completed in collaboration with:
OUTLINE

- Approach
- Model Validation
- Analyses
- Findings
STUDY AREA

About 14 to 28 miles from New Orleans

Sediment Intake Diversion Locations Identified in the Feasibility Study (adapted from LCA Ecosystem Restoration Study).
PURPOSE

- Identify the most promising location for the diversion based on river hydraulics and sediment supply

- Evaluate the best alignment and sill elevation for the diversion

- Investigate variations in the structure’s design and associated sediment capture
APPURCH

- A 3-D, Computational Fluid Dynamics (CFD) model was used to simulate flow and sediment transport

- The *FLOW-3D* program was selected:
  - Free surface flow
  - Closed conduit flow
  - Particle tracking capabilities
  - Results are easily compared to field observations
HYDRODYNAMICS

- Three-dimensional equations of fluid motion
- Steady flow analysis
  - Discharge in the Mississippi River varies
  - Structure designed to divert up to 35,000 cfs
- Area of Interest
  - River Mile 56 to 76
SEDIMENT TRANSPORT

- Lagrangian particle tracking
- Seven different sediment size classes

<table>
<thead>
<tr>
<th>Sediment Classification (microns)</th>
<th>Size Range in Computations (microns)</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1 - 3</td>
<td>Clay</td>
</tr>
<tr>
<td>8</td>
<td>4 - 15</td>
<td>Silt</td>
</tr>
<tr>
<td>32</td>
<td>16 - 63</td>
<td>Silt</td>
</tr>
<tr>
<td>64</td>
<td>64 - 78</td>
<td>Very Fine Sand</td>
</tr>
<tr>
<td>96</td>
<td>79 - 113</td>
<td>Very Fine Sand</td>
</tr>
<tr>
<td>125</td>
<td>114 - 187</td>
<td>Very Fine / Fine Sand</td>
</tr>
<tr>
<td>250</td>
<td>188 - 250</td>
<td>Fine Sand</td>
</tr>
</tbody>
</table>
VALIDATION

- Model velocities compared to vessel-based Acoustic Doppler Current Profiler (ADCP) measurements at three locations
VALIDATION

Strong recirculation at the left descending bank

Cross-section velocity showing secondary circulation

Model Captures Complex Flow Patterns in the Mississippi River
ANALYSIS

- Five Locations
- Flow Rates
  - 700,000 to 1,000,000 cfs in River
  - 15,000 to 35,000 cfs in Diversion
- Structure Type
  - Culverts, Open Channel, and Gated
- Invert Elevations (ft., NAVD88)
  - -16, -25, -30, -40
- River Angle Intersection
  - 45, 90, 135
- Various Approach Geometry
ANALYSIS

- Verification of Feasibility Study Results
  - Location 3
  - Structure Design

- Alternative Site Selection
  - Alternative Locations 1, 2, 2.5, and 4
  - Optimized Design from Location 3 used in all Analyses
  - Location 1 Selected

- Location 1 Design Optimization
  - Sediment Capture Analysis
  - Flow Patterns (Approach Flows)
ANALYSIS – Streamlines

Colored by Vertical Position

Location 3
SITE SELECTION: Sediment Capture

Location 1
250 Microns

Location 2
250 Microns

Location 2.5
250 Microns

Location 3
250 Microns

Location 4
250 Microns

Not to scale
LOCATION 1 - Approach Geometry
FINDINGS

- Location 1 was determined to be the best location for sediment capture, associated cost, and impact to the nearby community.

- The performance of the structure was improved by lowering the sill elevation and adjusting the alignment and shape of the approach channel.

- Open channels were used in the recommended diversion design.

- The recommended design, due to optimal sediment capture, approach flow patterns, and cost, was selected.
Imagine the result
Bullpen
CALIBRATION AND VALIDATION

- Suspended sand calibration at MGup and MGdown
ANALYSIS – Location 3 Model Setup

Portion of Mississippi River

Diversion Structure

Outfall Channel
ANALYSIS – Model Bathymetry

- Colored by elevation

- Location 3

- Diversion intake structure
ANALYSIS – Location 1

- Bathymetry colored by elevation

![Bathymetry colored by elevation](image-url)
LOCATION 1 - Particle Distribution

8-micron particles

96-micron particles

125-micron particles

250-micron particles
LOCATION 1 – Gate Operation