Modeling Alternatives to Reduce Channel Shoaling at Bolivar Flare of Gulf-Intracoastal Waterways in Galveston Bay, Texas

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Outline

- Background & Objectives
- Numerical Models & Settings
- Hydro, Wave, and Sediment Transport Simulations
- Modeling Alternatives
- Summary & Conclusions
The Gulf Intracoastal Waterways (GIWW), a light-draft inland channel mainly for barge transportation, runs along the lower side of Galveston Bay, Texas.

Extensive shoaling in the GIWW Bolivar Flare, east of junction with Houston Ship Channel, in recent years has resulted in the need for more frequent dredging.

USACE Galveston District considered structural alternatives to reduce high shoaling rate in the Bolivar Flare.

RSM and CIRP assisted in the studies.
Galveston Bay System

Multi-inlet system:
1. Galveston Bay Entrance
2. San Luis Pass
3. Rollover Pass

Four subbays:
1. Galveston Bay
2. Trinity Bay
3. East Bay
4. West Bay (WGB)

Two main channels:
1. GIWW
2. Houston Ship Channel (HSC)

Galveston Bay on average 7-9’ deep; WGB ~ 5-7’ deep
GIWW, 125’ wide, 12’ deep; HSC, 530’ wide, 45’ deep
GIWW Stationing & Placement Areas (PA)

Regional context of the study area

Bolivar Flare and PAs 41, 42, and 43
Numerical Models

Coastal Modeling System (CMS)

CMS-Wave
Diffraction, Reflection, Run-up, Setup, Overtopping,
Wave Generation, Structures (breakwaters, jetties, groins, etc),
Nested Grids

CMS-Flow
Hydrodynamics
Tide, Current, Wind, River
Morphology
Morphologic Constraints

Current, Water Level, Morphology Change
Wave Info
Wave Height, Direction, Period, Dissipation, Radiation Stresses

Salinity Transport
Sediment Transport

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CMS Grid and Water Level Input

Model Calibration: June 2010

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Wind Wave Input & Model Calibration

Model Calibration: June 2010
CMS Model Domains & Bathymetry

Regional Model Domain
(85 km x 95 km)

Local Model Domain
(30 km x 30 km)
Mixed Sediment Transport Modeling

Sediment Transport Modeling: 1-yr Simulation: 2010
Typical Flood and Ebb Current Fields

11 Jan. 2010 @ 00:00 GMT

18 Jan. 2010 @ 00:00 GMT
Example Model Storm Wind Wave Fields

16 Jan. 2010 @ 00:00 GMT

30 June 2010 @ 00:00 GMT
Model Sediment Transport Rate

Grain size data along navigation channels

Hourly averaged transport rate
11:00 GMT @ 16 May 2010

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Averaged Sediment Transport Rate in 2010

Averaged transport rate of Jan 2010

1-yr (2010) averaged transport rate
Shoaling reduction alternatives

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Configuration</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alt 0</td>
<td>Existing condition</td>
<td>Present bay and channel geometry</td>
</tr>
<tr>
<td>Alt 1</td>
<td>Extend PA43 structure northeastwards</td>
<td>Extend PA43 structure* by 1,500 m (5,000 ft) along PA43 nearshore boundary</td>
</tr>
<tr>
<td>Alt 2</td>
<td>Add an open-water sediment trap</td>
<td>Build a sediment trap, 800-m (2,600 ft) long, 120-m (400 ft) wide, 4-m (13 ft) deep, south of the Bolivar Flare</td>
</tr>
<tr>
<td>Alt 3</td>
<td>Extend PA43 structure southwestwards</td>
<td>Extend PA43 structure* by 1,200 m (4,000 ft) southwestwards along north side of Bolivar Flare channel</td>
</tr>
</tbody>
</table>

* The crest elevation of structure extension is 1.5 m (5 ft) above MTL.
1-Yr (2010) Model Morphology Change (m)

Color code:
Red – accretion
Blue - erosion
Model Volume Change
6 Channel Sections, (A) to (F)

A: Bolivar Flare
B: Bolivar Flare to Rollover
C: Outer Channel
D: Inner Bar Channel
E: Bolivar Rd to Exxon Dock
   (Galveston Harbor E Channel)
F: HSC
## Model 1-Yr Sediment Accumulation (CY)

<table>
<thead>
<tr>
<th>Channel Area</th>
<th>Area Description</th>
<th>Alt 0</th>
<th>Alt 1</th>
<th>Alt 2</th>
<th>Alt 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A)</td>
<td>Bolivar Flare</td>
<td>141,780</td>
<td>135,840</td>
<td>127,258</td>
<td>22,140</td>
</tr>
<tr>
<td>(B)</td>
<td>GIWW East of Bolivar Flare</td>
<td>15,560</td>
<td>15,690</td>
<td>15,424</td>
<td>540</td>
</tr>
<tr>
<td>(C)</td>
<td>GEC Outer Channel</td>
<td>800,840</td>
<td>800,120</td>
<td>800,700</td>
<td>645,500</td>
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<tr>
<td>(D)</td>
<td>GEC Inner Bar Channel</td>
<td>286,930</td>
<td>286,390</td>
<td>286,760</td>
<td>214,260</td>
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<tr>
<td>(E)</td>
<td>GHC Eastern Channel</td>
<td>152,050</td>
<td>151,480</td>
<td>151,890</td>
<td>90,255</td>
</tr>
<tr>
<td>(F)</td>
<td>HSC South of GIWW</td>
<td>210,500</td>
<td>211,090</td>
<td>210,130</td>
<td>291,400</td>
</tr>
</tbody>
</table>
Summary & Conclusions

• US Army Engineer RSM, CIRP and Galveston District are teamed up to investigate beneficial solutions to reduce the excessive channel shoaling in the GIWW Bolivar Flare at the lower Galveston Bay, Texas.

• A Coastal Modeling System (CMS) is used to simulate mixed sediment transport in Galveston Bay multi-bay-and-inlet system. The CMS performance is validated by current and wave field data collected in June 2010.

• High shoaling rate at Bolivar Flare is mainly caused by across-channel sediment transport under combined longshore and tidal currents.

• Based on model results, Alts 1 and 2 are ineffective at reducing shoaling at the Bolivar Flare. Alt 3 would substantially reduce channel shoaling but can impact regional hydrodynamics with low BCR score.
Thank you!

Questions?

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