Developing a Sand Management Plan for Galveston Island

Ashley E. Frey, P. E.
Research Civil Engineer
Coastal & Hydraulics Laboratory
Engineer Research & Development Center

On behalf of the Project Team:
Andrew Morang, David King, and Robert Thomas

Sponsor:
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Outline

• Problem Statement and Approach
• Sediment Budget
• GenCade Calibration
• Sand Management Options at East Beach
• Large-Scale Beach Fill
• GenCade Alternatives
• Sand Management Alternatives and Plan
• Beach Nourishment Project
Problem Statement/Approach

Recommend a long-term plan of actions to better manage sands on Galveston Island

Initial Tasks – Understand physical processes
- Update sediment budget
- Update shoreline change model

Final Tasks
- Evaluate potential solutions/actions
- Formalize and document Galveston Island Sand Management Plan
Sediment Budget Objectives

• Identify sources and sinks of sediment in coastal system
  - Beach fills
  - Littoral and offshore sources
  - Dredge data

• Compute quantities

• Determine direction of movement using morphologic evidence

• Evaluate sand management alternatives to reduce costs and improve beach resources
Sediment Budget Equation and the Sediment Budget Analysis System (SBAS)

\[ \sum Q_{\text{source}} - \sum Q_{\text{sink}} - \Delta V + P - R = \text{Residual} \]

- \( Q_{\text{source}} \) and \( Q_{\text{sink}} \) = sources and sinks to each cell
- \( \Delta V \) = net change in volume in each cell
- \( P \) = material placed (beach fill)
- \( R \) = material removed (dredging)
Sediment Budget in SBAS

Legend

- **Galv_flux1 (yd^3/yr x 1000)**
- **Cells1 (Littoral Cell)**
- **RESIDUAL**
  - Cell Loss
  - Cell Balance
  - Cell Gain

Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community.
GenCade Modeling

- Integrated GENESIS and Cascade models for shoreline change and regional sediment calculation
- Connects inlets, navigation channels, ebb and flood shoals, and beaches in engineering activities in a regional framework
- Decision-making support for planning, operation, and engineering
- In SMS 11.1 and higher; PC, user-friendly interface for engineers & scientists

Purpose:
- Assess shoreline change and longshore transport
- Evaluate sediment management solutions
GenCade Calibration

GenCade Input:
- Two separate grids were used in order to improve results near the west end of the seawall and increase efficiency
- 1995 and 2000 shorelines
- Historical shorelines averaged and smoothed to create regional contour
- Cell spacing ranging from 50 ft (near groins) to 200 ft
- Galveston seawall, groins, and beach fills
- Waves (WIS 73067, 73070)
### GenCade Calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start Date</td>
<td>1/1/1995 0:00</td>
</tr>
<tr>
<td>End Date</td>
<td>12/31/1999 0:00</td>
</tr>
<tr>
<td>Time Step</td>
<td>0.1 hr</td>
</tr>
<tr>
<td>Recording Time Step</td>
<td>168 hr</td>
</tr>
<tr>
<td>Effective Grain Size, mm</td>
<td>0.17</td>
</tr>
<tr>
<td>Average Berm Height, ft</td>
<td>4</td>
</tr>
<tr>
<td>Average Depth of Closure, ft</td>
<td>20</td>
</tr>
<tr>
<td>Left Lateral Boundary Condition, Seawall Grid</td>
<td>Gated</td>
</tr>
<tr>
<td>Right Lateral Boundary Condition, Seawall Grid</td>
<td>Pinned</td>
</tr>
<tr>
<td>Left Lateral Boundary Condition, West End Grid</td>
<td>Moving, -18 ft</td>
</tr>
<tr>
<td>Right Lateral Boundary Condition, West End Grid</td>
<td>Moving, 780 ft</td>
</tr>
<tr>
<td>K1</td>
<td>0.4</td>
</tr>
<tr>
<td>K2</td>
<td>0.2</td>
</tr>
<tr>
<td>ISMOOTH</td>
<td>11</td>
</tr>
</tbody>
</table>
### GenCade Calibration: Shoreline Change Statistics

<table>
<thead>
<tr>
<th>Cell</th>
<th>Average Shoreline Change, ft/year</th>
<th>RMS Error, ft/year</th>
<th>Brier Skill Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Measured</td>
<td>Modeled</td>
<td></td>
</tr>
<tr>
<td>Jetty to first groin</td>
<td>18.2</td>
<td>15.1</td>
<td>3.8</td>
</tr>
<tr>
<td>Groin field</td>
<td>1.6</td>
<td>5.5</td>
<td>5.0</td>
</tr>
<tr>
<td>Seawall west of groin field</td>
<td>-3.4</td>
<td>0.5</td>
<td>4.0</td>
</tr>
<tr>
<td>West end (to 13 Mile Rd)</td>
<td>-8.1</td>
<td>-5.2</td>
<td>3.6</td>
</tr>
<tr>
<td>13 Mile Rd. to Jamaica Beach</td>
<td>-3.3</td>
<td>-2.9</td>
<td>1.3</td>
</tr>
<tr>
<td>Jamaica Beach</td>
<td>-0.7</td>
<td>-1.5</td>
<td>1.1</td>
</tr>
<tr>
<td>Jamaica Beach to Indian Beach</td>
<td>-3.3</td>
<td>-3.4</td>
<td>0.9</td>
</tr>
<tr>
<td>Indian Beach to Sea Isle</td>
<td>4.1</td>
<td>0.5</td>
<td>3.8</td>
</tr>
<tr>
<td>Sea Isle area</td>
<td>3.6</td>
<td>-0.4</td>
<td>4.1</td>
</tr>
<tr>
<td>West end 1</td>
<td>5.7</td>
<td>-1.2</td>
<td>4.7</td>
</tr>
<tr>
<td>West end 2</td>
<td>91.3</td>
<td>50.0</td>
<td>45.5</td>
</tr>
</tbody>
</table>

Innovative solutions for a safer, better world
GenCade Calibration: Net transport

![Graph showing net transport rates](image)

- Net Seawall
- Net West End
Sediment Management Options

1. Identify sand sources
   - Big Reef
   - East Beach
   - Offshore

2. Deposition basin off East Beach

3. Reduce trans. through S. jetty

4. Reduce Aeolian sand transport

5. Sand backpass system
Identifying Sand Sources

Big Reef and East Beach east of Boddeker Rd (without recreational or environmental restrictions) = 2+ million yd\(^3\) (Incl. offshore Big Reef: 3+ million yd\(^3\))

Heald Bank: 35 mi offshore with ~ 765,000,000 yd\(^3\)
Sabine Bank: 70 mi offshore with ~ 1,600,000,000 yd\(^3\)

### Potential Big Reef Mining Volumes

<table>
<thead>
<tr>
<th>Polygon</th>
<th>Area (m(^2))</th>
<th>Vol. 1.1 yd layer (yd(^3))</th>
<th>Vol. 2.2 yd layer (yd(^3))</th>
<th>Vol. 5.5 yd layer (yd(^3))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big Reef Area1</td>
<td>195,000</td>
<td>255,100</td>
<td>510,100</td>
<td>1,275,300</td>
</tr>
<tr>
<td>Big Reef Area2</td>
<td>19,660</td>
<td>25,800</td>
<td>51,400</td>
<td>128,600</td>
</tr>
<tr>
<td>East Beach Area1</td>
<td>60,900</td>
<td>79,700</td>
<td>159,300</td>
<td>398,300</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>275,560</strong></td>
<td><strong>360,600</strong></td>
<td><strong>720,800</strong></td>
<td><strong>1,802,200</strong></td>
</tr>
</tbody>
</table>
### Sediment Basin Parallel to East Beach

<table>
<thead>
<tr>
<th>East beach coverage (percent)</th>
<th>Length (yd)</th>
<th>1 yd depth initial volume (yd³)</th>
<th>2 yd depth initial volume (yd³)</th>
<th>Annual vol. trapped at 50% efficiency (yd³) (based on sed. budget)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>3000</td>
<td>450,000</td>
<td>900,000</td>
<td>90,000</td>
</tr>
<tr>
<td>75</td>
<td>4500</td>
<td>675,000</td>
<td>1,350,000</td>
<td>135,000</td>
</tr>
<tr>
<td>100</td>
<td>6000</td>
<td>900,000</td>
<td>1,800,000</td>
<td>180,000</td>
</tr>
</tbody>
</table>

Note: Initial dredged volume based on basin 150 yd wide
Reduce transmission through South Jetty

Options:
• Grout
• Geotube
• Sheetpile

Need to be mined regularly
Reduce Wind-Blown Sand

Options:
- Moisture
- Mechanical traps (fencing)
- Vegetation
- 22,000 ft fence or oats = 60-80,000 yd³/year
Sand Back-Passing/Pumping

Design:
- Annual vol.
- Intake location
- Distance
- Intake equipment
  - Movable
  - Fixed plant
- Outlets

Advantages:
- No trucks
- Steady use most of year
- Electric supply
- Paved roads
- No need to cross water

Note: similar plant at San Luis Pass not shown
Comprehensive Beach Fill

Proposed width:
- Dune: 100 ft
- Berm/beach: 200 ft
Reach 1: 1,900,000 yd³
Reach 2: 3,600,000 yd³
Reach 3: 2,500,000 yd³
Reach 4: 4,400,000 yd³
Reach 5: 500,000 yd³
Total: 13,000,000 yd³
Plus advance nourishment @50%:
19,500,000 yd³
GenCade Alternatives

- No Action
- Sand tighten jetty
- Beach fills
- Backpassing
Structural Alternatives

- Sand tightening the jetty advances the shoreline significantly and provides more material for backpassing and beach fills.
- Lengthening, shortening, or removing groins makes little difference in shoreline position after 50 years.
- If a beach fill is also constructed, shortened or existing groins will mostly be buried.
Beach Fill Alternatives (Seawall)

100,000 yd³, 500,000 yd³, and 2,000,000 yd³ every 5 years
(Top: Reach 1 only, Bottom: Reaches 1 and 2)
- Renourishment volume equal to initial fill volume
- 100,000 yd³ every 5 years (Reach 1 only) is enough sand to keep beach similar to present conditions
- 500,000 yd³ advances beach 200 ft after 50 years (Reach 1)
- Material not taken from near jetty (either channel dredging or offshore)
Backpassing (Seawall)

Top: 100,000 yd³/yr backpassed to Reach 1, with and without 1,900,000 yd³ initial beach fill
Bottom: 100,000, 250,000, and 356,000 yd³ backpassed with different rates of material moving onshore
Backpassing (Seawall)

100,000, 250,000, and 356,000 yd³ backpassed onto Reaches 1 and 2
- various rates of sand moving onshore to illustrate impact on shoreline
Beach Fills (West End)

Beach fills placed on Park Board property
- 20,000 yd$^3$ at each property = 80,000 yd$^3$ total per placement
- Placement every year = 4,000,000 yd$^3$ total; still more than 100 ft of erosion
Beach Fills (West End)

Beach fills along first 1.5 mi past seawall and along Reach 3
- 50,000 or 100,000 yd$^3$ placed every 2 years
- After 50 years, no alternative results in shoreline advance along Reach 3

![Graph showing shoreline change over distance]

After 10 years

After 50 years
Beach Fills (West End)

Beach fills along Reaches 3 and 4
• 250,000 or 1,000,000 yd³ placed every 2, 5, or 10 years
• After 50 years, the only alternative resulting in shoreline advance is 1,000,000 yd³ placed every 2 years
Backpassing (West End)

Backpassing to first 1.5 mi beyond seawall and to Reach 3
- 50,000 yd³/yr backpassed
- With and without initial beach fill along Reach 3 = 2,518,800 yd³
Backpassing (West End)

Backpassing to Reaches 3 and 4
- 150,000 and 300,000 yd³/yr backpassed
- With and without initial beach fill = 6,926,700 yd³

After 50 years
## Sand Management Alternatives

<table>
<thead>
<tr>
<th>Plan</th>
<th>Coverage</th>
<th>New Material (offshore or other sources)</th>
<th>Management and recycling of existing sand sources and dredge material</th>
<th>Performance monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehensive beach fill</td>
<td>Reaches 1-5</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Limited area beach fill</td>
<td>1, 2, 3(?)</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Systematic recycle</td>
<td>1, 2</td>
<td></td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Present action plan</td>
<td>1</td>
<td></td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>No action</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Sand Management Plan

- Make preliminary decisions on alternatives
  - Investigate funding sources
    - Additional studies
    - Public outreach
  - Design beach fill and backpassing plant
    - Construct beach fill for selected reach and reduce transport through south jetty
      - Monitor growth of fillet along jetty and monitor shoreline position along selected reach
  - Construct backpassing plant
    - Monitor backpassing and shoreline position for selected reach
      - Construct beach fill on next reach*
        - Monitor shoreline position for second selected reach*
          - Extend backpassing to second selected reach or renourish periodically*

* Continue process until all desired reaches are completed
Adaptive Management and Monitoring

• Implement adaptive management strategy
  - Construct limited fill and monitor to ensure it is responding as expected
  - Modify design if necessary
• Recommended monitoring actions
  - Beach profiles, lidar, and/or shoreline position should be collected prior to and every 6 months after construction
  - Georeferenced aerial photography once a year
Beach Nourishment Project

- Project began in August
- 725,000 yd³ dredged from Galveston Entrance Channel
- Placing material on Reach 2 (between 61st and 81st St.)
- Collaborative effort between Galveston Park Board, City of Galveston, Texas General Land Office, and U.S. Army Corps of Engineers, Galveston
- Channel dredged every 18 to 24 months and material will be placed on beach instead of offshore

http://www.galveston.com/sandcam
Questions?

Ashley Frey
Ashley.E.Frey@usace.army.mil
Phone: 601-634-2006