Addressing Nearshore Placement Near Lake Worth Inlet, FL

Drew Condon, Ph. D., P.E.
Coastal Engineer
Coastal Design Section - SAJ
20 April 2017
Background – Lake Worth Inlet

- Federally maintained inlet since 1934
  - North and south jetties, channel, turning basin, inlet revetments, and settling basin
- Final Integrated Feasibility Report and EIS (Jan 2014) report shoaling rates of approximately 117,500 cy/yr
- Beach quality material placed either on the dry beach or in the nearshore below MHW to the -17 ft MLW contour between 500 ft south of R-76 to R-79
- Where is optimal placement?
To create wave regime in Nearshore: Hypercube method adopted from South Palm Beach Island Comprehensive Shoreline Stabilization Project: EIS by CB&I

- Based on WIS data
- Offshore dir. Bands generating 95% of the nearshore energy (5° to 155°)
- Six directional bins ~ equal wave energy
- Each bin → three height classes ~ equal wave energy in shallow water
- 18 wave cases plus calm

<table>
<thead>
<tr>
<th>Wave Case</th>
<th>Hs (m)</th>
<th>Tp (sec)</th>
<th>Wave Dir. (°)</th>
<th>% Occur. In One Year</th>
<th>Days in Model in One Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.89</td>
<td>9.35</td>
<td>37.93</td>
<td>5.52</td>
<td>20.15</td>
</tr>
<tr>
<td>2</td>
<td>1.13</td>
<td>5.64</td>
<td>119.07</td>
<td>4.11</td>
<td>15.00</td>
</tr>
<tr>
<td>3</td>
<td>2.98</td>
<td>10.09</td>
<td>18.06</td>
<td>0.93</td>
<td>3.39</td>
</tr>
<tr>
<td>4</td>
<td>1.84</td>
<td>10.10</td>
<td>29.55</td>
<td>1.53</td>
<td>5.58</td>
</tr>
<tr>
<td>5</td>
<td>2.06</td>
<td>6.98</td>
<td>74.42</td>
<td>1.11</td>
<td>4.05</td>
</tr>
<tr>
<td>6</td>
<td>1.59</td>
<td>7.80</td>
<td>51.83</td>
<td>1.84</td>
<td>6.72</td>
</tr>
<tr>
<td>7</td>
<td>1.04</td>
<td>7.60</td>
<td>16.90</td>
<td>8.26</td>
<td>30.15</td>
</tr>
<tr>
<td>8</td>
<td>2.54</td>
<td>9.87</td>
<td>37.90</td>
<td>0.67</td>
<td>2.45</td>
</tr>
<tr>
<td>9</td>
<td>0.68</td>
<td>5.30</td>
<td>119.89</td>
<td>11.75</td>
<td>42.89</td>
</tr>
<tr>
<td>10</td>
<td>1.86</td>
<td>8.72</td>
<td>17.13</td>
<td>2.44</td>
<td>8.91</td>
</tr>
<tr>
<td>11</td>
<td>1.92</td>
<td>6.51</td>
<td>121.16</td>
<td>1.17</td>
<td>4.27</td>
</tr>
<tr>
<td>12</td>
<td>0.81</td>
<td>7.01</td>
<td>77.08</td>
<td>7.45</td>
<td>27.19</td>
</tr>
<tr>
<td>13</td>
<td>2.67</td>
<td>10.84</td>
<td>29.20</td>
<td>0.7</td>
<td>2.56</td>
</tr>
<tr>
<td>14</td>
<td>1.68</td>
<td>9.58</td>
<td>38.03</td>
<td>1.57</td>
<td>5.73</td>
</tr>
<tr>
<td>15</td>
<td>1.01</td>
<td>8.78</td>
<td>26.61</td>
<td>5.31</td>
<td>19.38</td>
</tr>
<tr>
<td>16</td>
<td>2.38</td>
<td>8.56</td>
<td>51.10</td>
<td>0.75</td>
<td>2.74</td>
</tr>
<tr>
<td>17</td>
<td>1.37</td>
<td>6.51</td>
<td>76.13</td>
<td>2.91</td>
<td>10.62</td>
</tr>
<tr>
<td>18</td>
<td>0.89</td>
<td>8.36</td>
<td>52.20</td>
<td>5.43</td>
<td>19.82</td>
</tr>
<tr>
<td>Calm</td>
<td>0.30</td>
<td>6.00</td>
<td>20.00</td>
<td>36.55</td>
<td>133.41</td>
</tr>
</tbody>
</table>
Coastal Modeling System

Flow
- Telescoping grid
- 12.5 m to 800 m resolution
- 167,232 cells
- Tidal forcing – NOAA Lake Worth Pier Constituents

Wave
- 10 m to 200 m resolution
- 32,538 cells

Elevation
- PBH surveys
- Beach profiles
- AIWW survey
- Lidar
- NOAA Palm Beach, FL DEM
- Referenced to MSL
Calibration / Validation

- Limited data available
  - Calibration to water levels:
    • NOAA Port of Palm Beach
  - Validation with ADCP data
    • Collected over Spring and Neap periods in 2008
- Current magnitude slightly underestimated
  - Doubled tidal amplitude to “bracket” expected conditions
Calibration / Validation

Spring Tide

Neap Tide

Lake Worth Inlet Thrust:

Current Magnitude (m/s)

0 0.2 0.4 0.6 0.8 1 1.2 1.4
09/20 09/21

ICW near Peanut Island:

Current Magnitude (m/s)

0 0.2 0.4 0.6 0.8 1 09/20 09/21

Palm Beach Harbor:

Water Level (m)

-1 -0.5 0 0.5 1 1.5 06/30 06/31

NOAA Vetted
NOAA Predicted
CMS Model

Lake Worth Inlet Thrust:

Current Magnitude (m/s)

0 0.2 0.4 0.6 0.8 1 09/23 09/24

ICW near Peanut Island:

Current Magnitude (m/s)

0 0.2 0.4 0.6 0.8 1 09/23 09/24

Palm Beach Harbor:

Water Level (m)

-1 -0.5 0 0.5 1 1.5 09/23 09/24

NOAA Vetted
NOAA Predicted
CMS Model
Production Runs

- CMS model run for year-long simulations
  - Both regular tidal constituents and double-amplitude constituents
  - 3 hour wave coupling
  - 3 different randomizations of the wave climate with yearly percent occurrence as presented
  - Total of 6 year long simulations

- Cumulative velocities analyzed to identify nodal point
Nodal Point Analysis

Cumulative U Velocity

Cumulative V Velocity

Nearshore Placement Area

Nearshore Placement Area
Nodal Point Analysis

Cumulative U Velocity

Cumulative V Velocity

Nearshore Placement Area

Nearshore Placement Area
Nodal Point Analysis

Regular Amplitude

Double Amplitude

Nearshore Placement Area

Team of Professionals Making Tomorrow Better
Wave Energy Analysis

- ~ 120,000 cy/yr should be dredged from the channel and placed in the nearshore
- Four nearshore placement scenarios were developed to replicate placement of approximately 120,000 cy
  - Alternative 1: Between R-77 and R-78, 4 ft added between the -10 and -17 ft MSL contours
  - Alternative 2: Between R-77 and R-79, 2.5 ft added between the -10 and -17 ft MSL contours
  - Alternative 3: Between R-77 and R-79, 4 ft added between the -12 and -17 ft MSL contours
  - Alternative 4: Between R-78 and R-79, 6 ft added between the -8 and -17 ft MSL contours
Wave Energy Analysis

Wave Alternative 1

Wave Alternative 2

Wave Alternative 3

Wave Alternative 4

Nearshore Placement Area

Alternative Bathymetry

Northing (m)

Easting (m)

Depth (m)
Wave Energy Analysis

- Total cumulative wave energy was estimated as the square of the wave height
- Approximated along a north-south running profile at the -5 ft MSL water depth
Alternatives

Alt. 1
Cumulative Wave Energy Change

Alt. 2
Cumulative Wave Energy Change
Alternatives

Alt. 3

Cumulative Wave Energy Change

Alt. 4

Cumulative Wave Energy Change
Mobilization of Sediment

- Sediment Mobility Tool applied at 7 different cross-shore depths assuming median grain size, $d_{50}$, of 0.14 mm

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Freq. of Sediment Mobility</th>
<th>Mean Mobility Score &lt;M&gt;</th>
<th>Freq. of Sediment Mobility</th>
<th>Mean Mobility Score &lt;M&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.04</td>
<td>99.9%</td>
<td>3.61</td>
<td>100%</td>
<td>4.69</td>
</tr>
<tr>
<td>4.57</td>
<td>99.9%</td>
<td>2.15</td>
<td>99.9%</td>
<td>3.53</td>
</tr>
<tr>
<td>6.10</td>
<td>93.6%</td>
<td>1.45</td>
<td>99.9%</td>
<td>2.84</td>
</tr>
<tr>
<td>7.62</td>
<td>93.6%</td>
<td>1.01</td>
<td>99.9%</td>
<td>2.29</td>
</tr>
<tr>
<td>9.14</td>
<td>93.5%</td>
<td>0.67</td>
<td>93.6%</td>
<td>1.87</td>
</tr>
<tr>
<td>10.67</td>
<td>82.0%</td>
<td>0.43</td>
<td>93.6%</td>
<td>1.53</td>
</tr>
<tr>
<td>12.19</td>
<td>41.3%</td>
<td>0.25</td>
<td>93.6%</td>
<td>1.26</td>
</tr>
</tbody>
</table>

- Dean number used to predict cross-shore sediment migration

<table>
<thead>
<tr>
<th>$d_{50}$ (mm)</th>
<th>Predicted Sediment Migration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>72% Erosive, Offshore Migration</td>
</tr>
<tr>
<td>0.14</td>
<td>84% Accretion, Onshore Migration</td>
</tr>
<tr>
<td>0.2</td>
<td>97% Accretion, Onshore Migration</td>
</tr>
<tr>
<td>0.3</td>
<td>100% Accretion, Onshore Migration</td>
</tr>
<tr>
<td>0.4</td>
<td>100% Accretion, Onshore Migration</td>
</tr>
<tr>
<td>0.5</td>
<td>100% Accretion, Onshore Migration</td>
</tr>
</tbody>
</table>
Conclusion

- North – South velocity nodal point located around R-77
  - Material placed north of this will likely end up in the inlet
  - Nearshore placement should be confined between R-77 and R-79
- Reduction of wave energy varies by placement layout, between 5 and 75%
  - Smaller the negative freeboard, the greater the energy reduction
- Sediment is likely to mobilize and move onshore
  - SMT predicts mobilization is highly probable
  - Dean number predicts that when mobilized sediment will migrate onshore
- Wave climate randomizations all produced similar average and cumulative current results
Questions

- Thank you!
References


- U.S. Army Corps of Engineers Jacksonville District. 2014. *Final integrated feasibility report and environmental impact statement: Lake Worth Inlet, Palm Beach Harbor, Palm Beach County, Florida*.