A Monte Carlo Simulation Model for Beach Fill Optimization

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Purpose

• An integrated coastal engineering – economics analytical framework for evaluating the life-cycle physical performance and economic costs of beach nourishment projects along sandy shores
San Clemente, CA
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Previous Corps R/U Models

- Storm Damage Model – Jacksonville
- GRANDUC – Wilmington
- “Becky” – Corps R&D
WENDY

- Wave-induced
- Economic
- Net
- Damage
- Yields
WENDY

- Excel Spreadsheet
- @Risk – Monte Carlo Simulation Generator
- Inputs: Engineering & Economic
- Outputs: Economic
Engineering Inputs

- Beach Morphology
- Structure Information
- Water Level (tide+surge+SLC)
- Wave Info (height, period)
- Shoreline Erosion Rates
Engineering Inputs

- Lognorm(0.74448, 0.38759) Shift=+0.13308
  - X <= 0.000: 0.0%
  - X <= 2.600: 99.6%

- Triang(-0.46, -0.21, 0.38)
  - X <= -0.460: 0.0%
  - X <= 0.380: 100.0%

Significant Wave Height, m

Probability Density

Without-Project Long Term Erosion Rate, m/yr

Probability Density
Economic Inputs

- Real Estate Valuations
- Costs
- Recreation
- Interest Rates

- Unit Prices
Model Logic

GENERAL MODEL FLOW

Simulation Control: First model simulation is WITHOUT-project. Model simulations 2-N are for each project alternative. Simulation controlled in FXN using macro: Alternatives.

Engineering Processes

Economic Processes

Economic Summary: First model simulation computes Total WITHOUT-project damages and recreational value. Output written internally to model (INPUT_ECON) becomes input for WITH-project analysis. WITH-project costs calculated. No benefits and/or B/C ratios computed.
Structure Damages
Railroad Damages
Model

| A   | B       | C   | D   | E   | F   | G   | H   | I   | J   | K   | L   | M   |
|-----|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 6   |         |     |     |     |     |     |     |     |     |     |     |     |     |
| 7   | Year    | Year| Year| Year| Year| Year| Year| Year| Year| Year| Year| Year| Year|
| 9   | 1       | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  |
| 10  | Long Term Erosion | -0.1 | -1.1 | 0.8 | 0.1 | 0.1 | 0.1 | -0.7 | -0.2 | 0.2  | -0.4 | 0.4  |
| 11  | Storm Erosion | 5    |      |     |     |     |     |     |     |     |     |     |     |
| 12  | Period   | 13   |      |     |     |     |     |     |     |     |     |     |     |
| 13  | Water Level | 6.3  |      |     |     |     |     |     |     |     |     |     |     |
| 14  | Beach Slope | 7    |      |     |     |     |     |     |     |     |     |     |     |
| 15  | Lo       | 866  |      |     |     |     |     |     |     |     |     |     |     |
| 16  | Hs       | 9.0  |      |     |     |     |     |     |     |     |     |     |     |
| 17  | SurfSimBeach | 1.40 |      |     |     |     |     |     |     |     |     |     |     |
| 18  | Runup 2% Beach | 16.9 |      |     |     |     |     |     |     |     |     |     |     |
| 19  | L @ Revet | 185  |      |     |     |     |     |     |     |     |     |     |     |
| 20  | H @ Revet | 3.8  |      |     |     |     |     |     |     |     |     |     |     |
| 21  | SurfSimRevet | 4.67 |      |     |     |     |     |     |     |     |     |     |     |
| 22  | Runup1/3 Revet | 11.1 |      |     |     |     |     |     |     |     |     |     |     |
| 23  | MF       | 1.00 |      |     |     |     |     |     |     |     |     |     |     |
| 24  | H.L      | 0.020|      |     |     |     |     |     |     |     |     |     |     |
| 25  | Runup Revet 2% Hughes | 17.8 |      |     |     |     |     |     |     |     |     |     |     |
| 26  | Sea Level Rise (cum) |      |     |     |     |     |     |     |     |     |     |     |     |

**Coastal Engineering Input and Parameter Calculations**

**Define Distribution for C12**

ROUND(RiskLogistic(13.2336, 1.3463), RiskTruncate(10, 20), 0)

Logistic(13.2336, 1.3463)

Truncate(10, 20)
Project

- 56 Alternatives
  - 4 base beach widths
  - 14 sacrificial beach widths

- <1 sec per simulation
- <1000 simulations to achieve numerical stability
Economic Outputs

Benefit - Cost Ratio

Mean = 1.69958

X <= 0.74 5%

X <= 2.82 95%

% Occurrence

BC Ratio

0 0.1 0.2 0.3 0.4 0.5 0.6

0 1 2 3 4 5 6
Economic Outputs

Distribution for Annual Net Benefits

Mean = 751541.9

X <= -318513.19
5%

X <= 1933586.56
95%

Annual Net Benefits ($, Millions)

% Occurrence

Mean = 751541.9
Project Results

[Graph showing the relationship between sacrificial beach width (m) and annual net benefits ($). The graph indicates different net benefits based on the width of the sacrificial beach, with symbols representing different widths: 0 m, 10 m, 20 m, and 30 m.]
Conclusion

- Monte Carlo Simulation Model
- Engineering – Economics
- Simple or Complex
- Customizable
- Fear not - you can do this too
Post Script

- Beach-fx, 2007