Risk-Informed Decision Making for Flood Risk Assessment and Management

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Presentation Overview

Introduction

Why → What → How

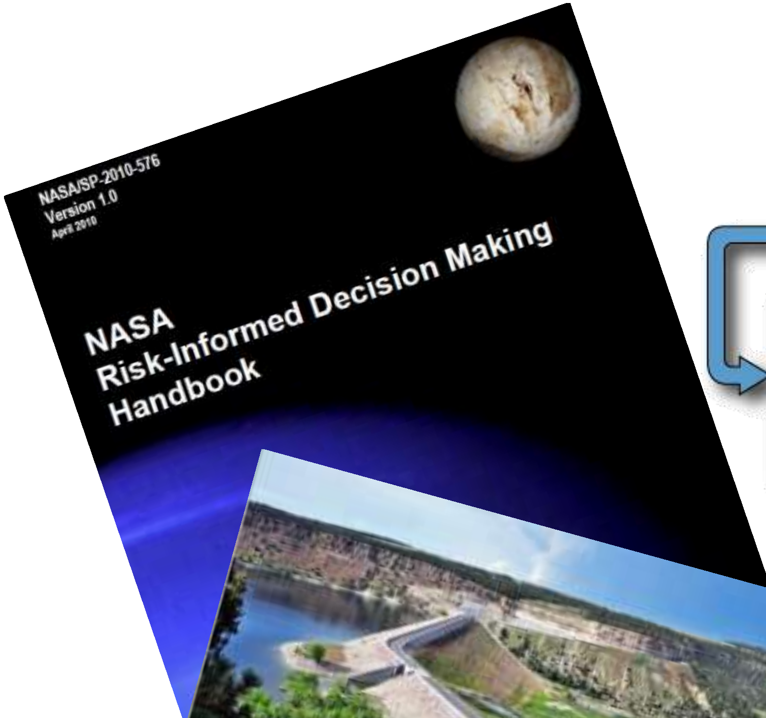
Case Study

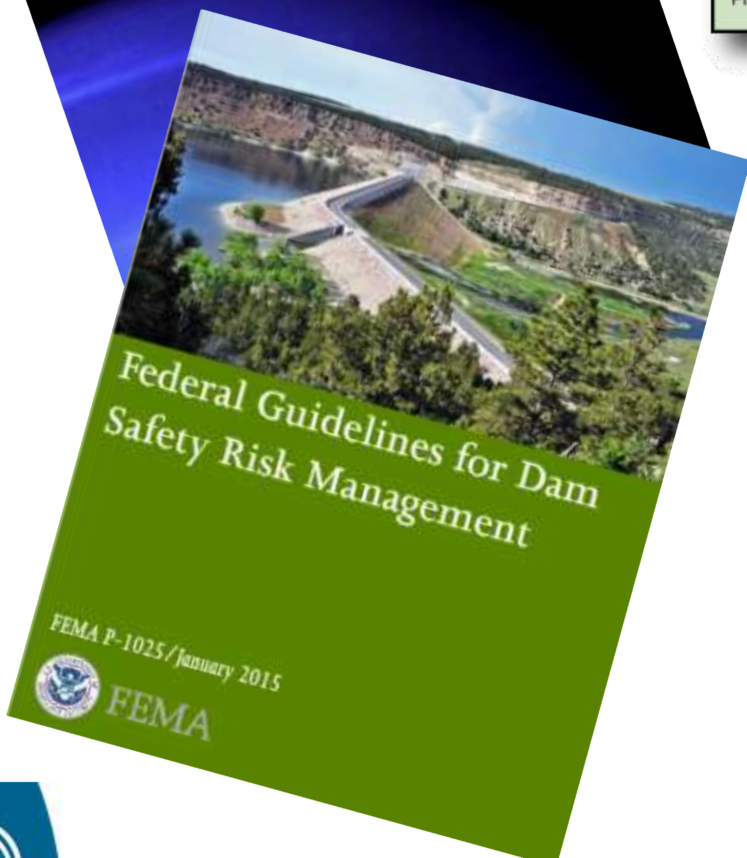
Plum Island Beach Erosion Evaluation

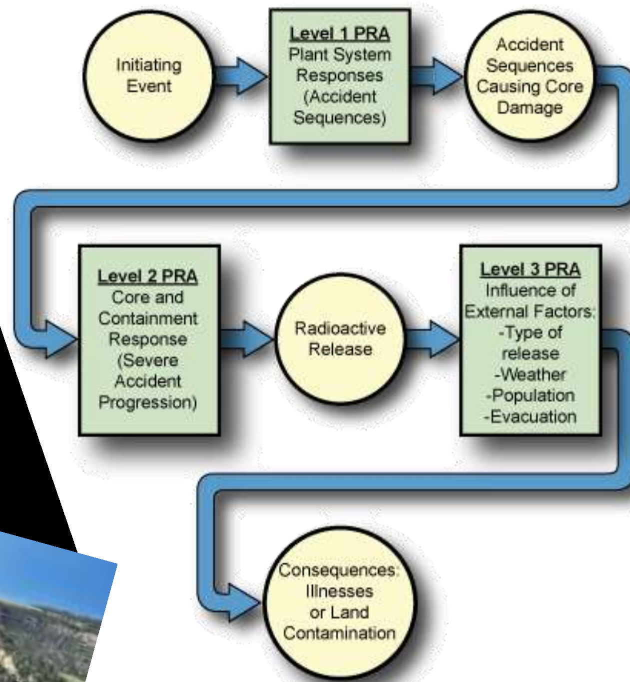
Discussion

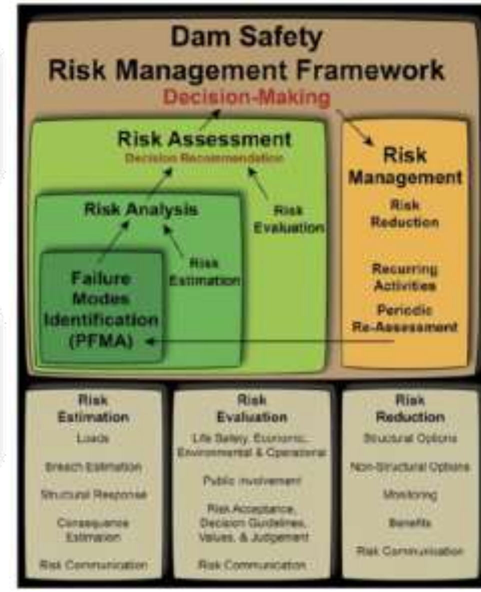
Players

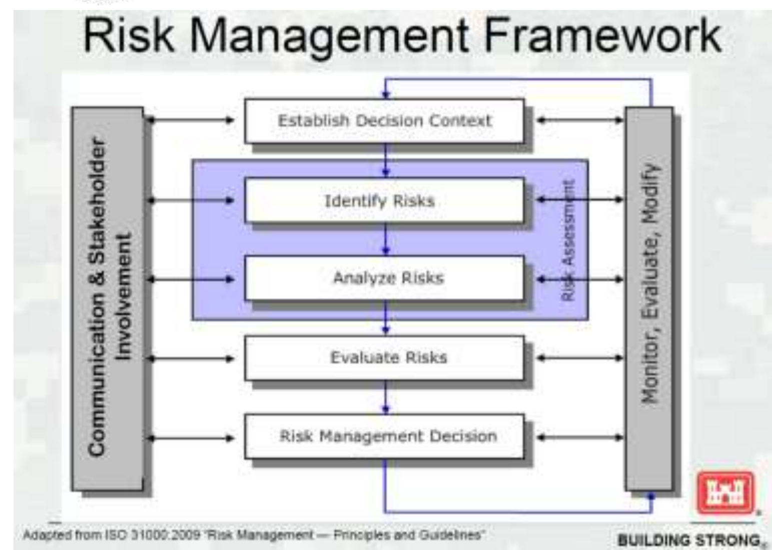
- National Aeronautics and Space Administration (NASA)
- U.S. Nuclear Regulatory Commission (NRC)
- U.S. Environmental Protection Agency (EPA)
- Federal Energy Regulatory Commission (FERC)
- Federal Emergency Management Agency (FEMA)
- U.S. Army Corps of Engineers (USACE)
- U.S. Bureau of Reclamation (USBR)


NASA/SP-2010-576
Version 1.0
April 2010
NASA
Risk-Informed Decision Making
Handbook


Federal Guidelines for Dam Safety Risk Management
FEMA P-1025/January 2015
FEMA


Initiating Event
Level 1 PRA
Plant System Responses (Accident Sequences)
Accident Sequences Causing Core Damage
Level 2 PRA
Core and Containment Response (Severe Accident Progression)
Radioactive Release
Level 3 PRA
Influence of External Factors:
-Type of release
-Weather
-Population
-Evacuation
Consequences: Illnesses or Land Contamination


Dam Safety
Risk Management Framework
Decision-Making
Risk Assessment
Risk Management
Risk Analysis
Risk Evaluation
Risk Reduction
Failure Modes Identification (PFMA)
Risk Estimation
Recurring Activities
Periodic Re-Assessment
Risk Estimation
Risk Evaluation
Risk Reduction


Risk Management Framework
Communication & Stakeholder Involvement
Establish Decision Context
Identify Risks
Analyze Risks
Risk Assessment
Evaluate Risks
Risk Management Decision
Monitor, Evaluate, Modify
Adapted from ISO 31000:2009 "Risk Management — Principles and Guidelines"
BUILDING STRONG

Why Risk-Informed Decision Making?

- ✓ Required for certain types of projects (e.g., FERC guidance for dams; USACE for levees, dams and coastal works; FEMA for flood vulnerability assessment and mitigation design)
- ✓ Example applications:
  - Marine, waterfront and coastal structures
  - Shoreline management
  - Geohazards analysis (e.g., earthquakes, land slides)
  - Construction cost and scheduling estimating
- ✓ Useful for other applications such as financial decisions, loss prevention and all applications with uncertainty – provides transparent, structured, defensible decision.
- ✓ Projects are getting more complex – beyond intuitive decision making
- ✓ Future of engineering analyses and design.

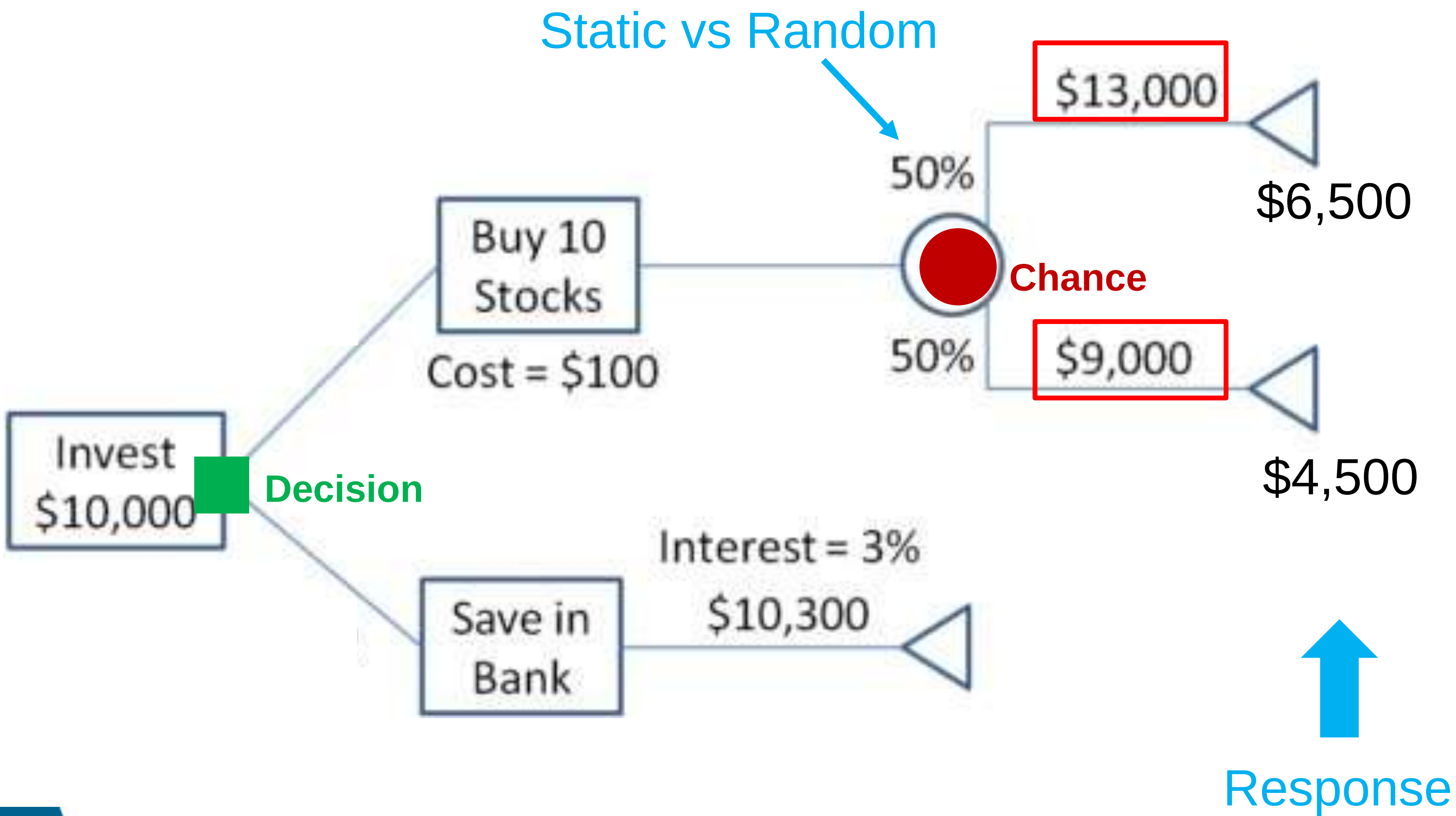
What is Risk Informed Decision Making?

Risk = probability of an event · consequences

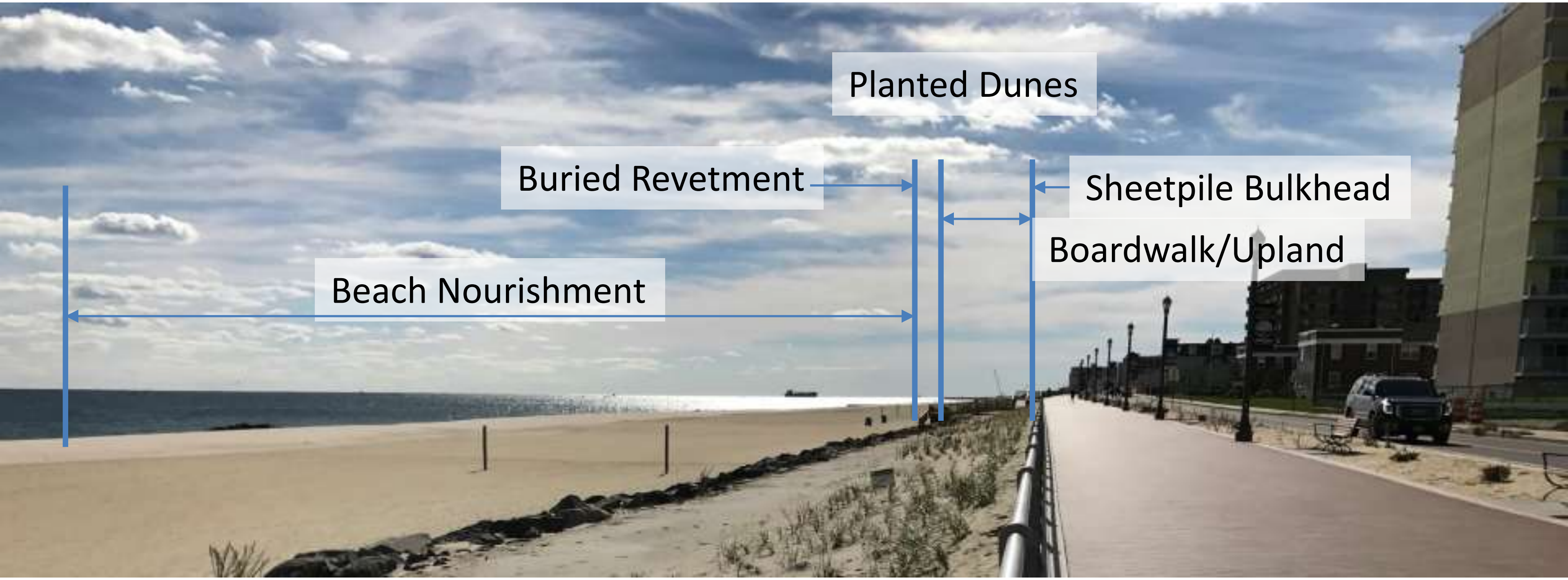
Decision Making = The act of making up your mind about something, or
a position or opinion or judgment.

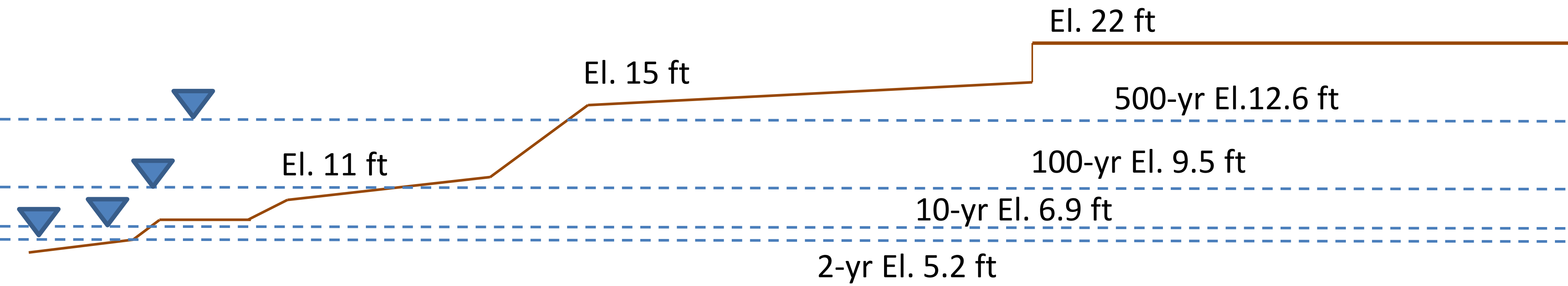
Basis for risk management planning; project engineering and design

Example: Decision Tree - Investment



Complex multi-component system





Numerical Circulation, Wave Models → Detailed Water Level, Wave, Current Output

Risk-based Decision Making

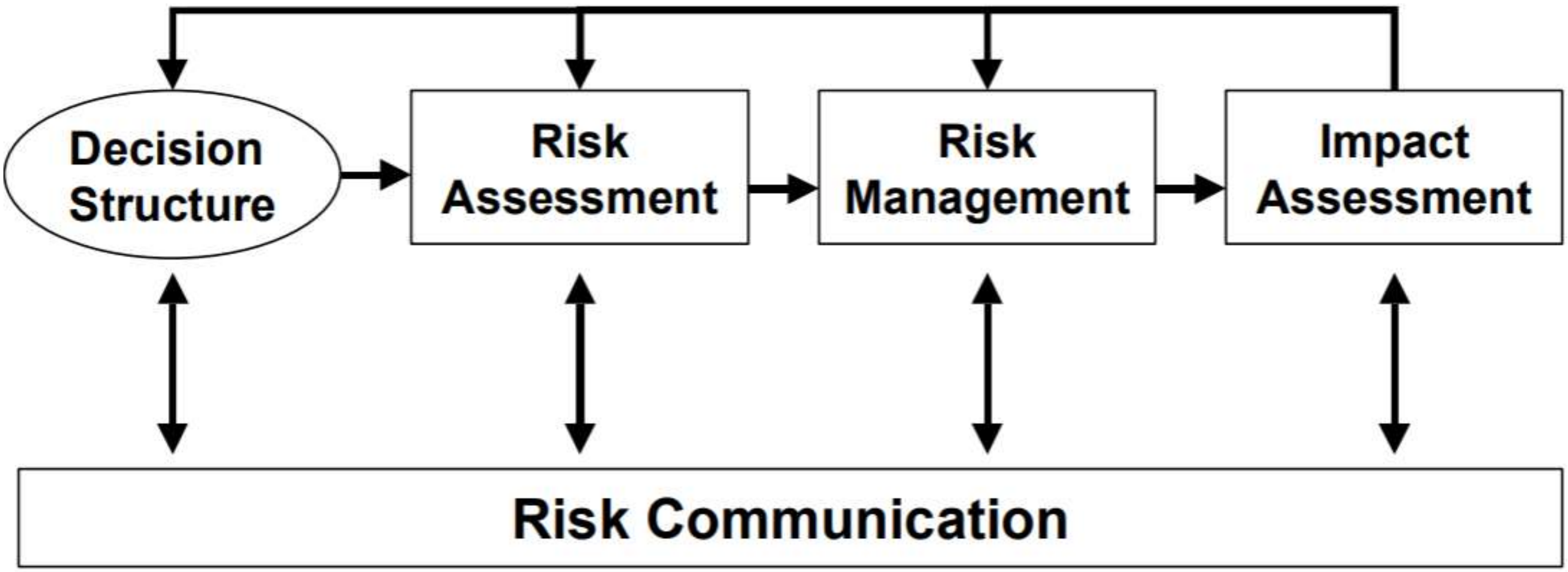


Figure 1 Risk-based Decision-making Process

Ref: "Quick-reference Guide to Risk-based Decision Making (RBDM): A Step-by-step Example of the RBDM Process in the Field "

Example: USACE Fire Island Inlet to Montauk Point Hurricane Sandy General Evaluation Project

Fire Island Inlet to Montauk Point

New York

Draft General Reevaluation Report

U.S. Army Corps of Engineers

New York District

July 2016

Example: USACE Fire Island Inlet to Montauk Point Hurricane Sandy General Evaluation Project

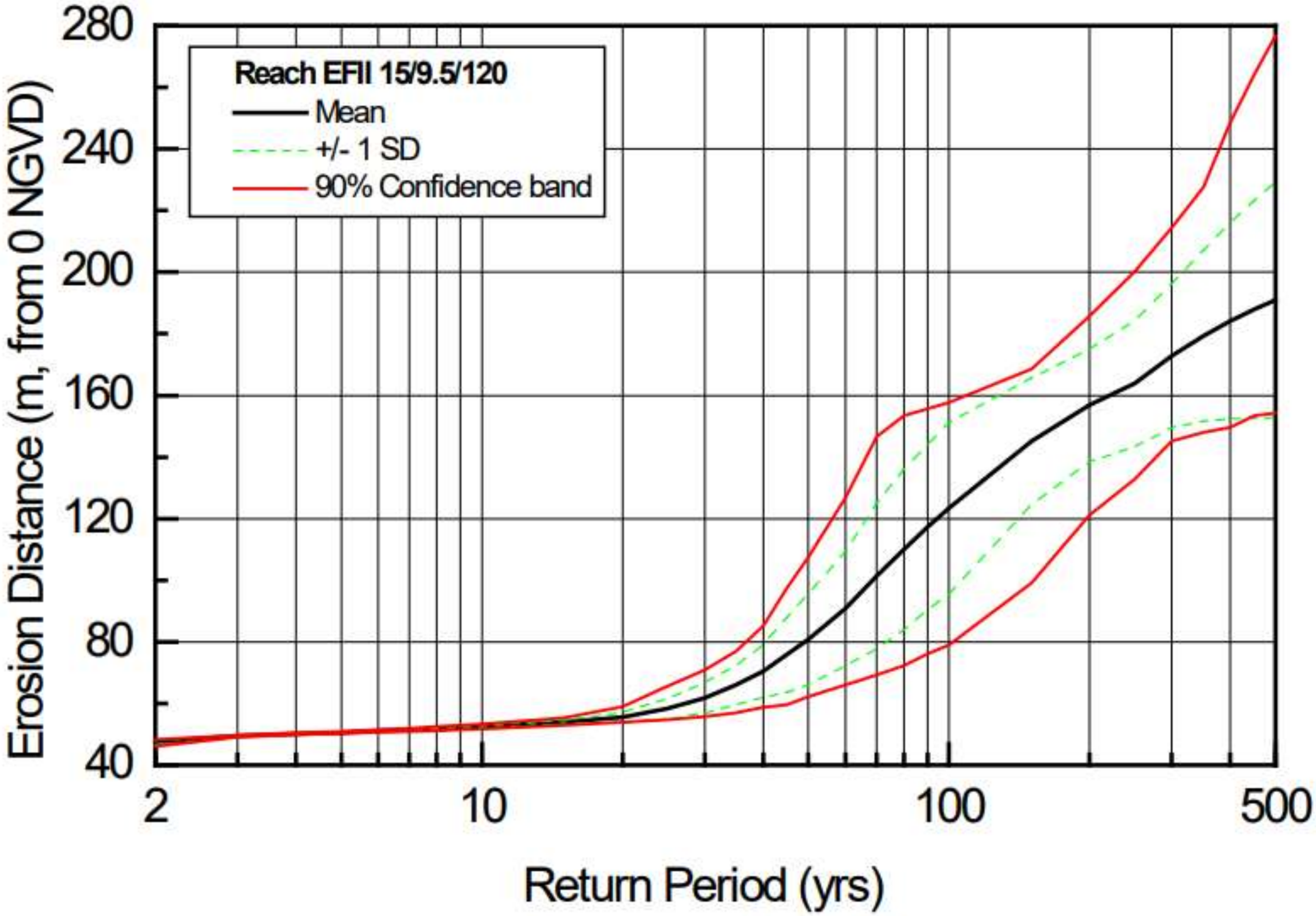
Technical Report CHL-99-21
December 1999

US Army Corps of Engineers
Engineer Research and Development Center

Use and Application of the Empirical Simulation Technique: User's Guide

by Norman W. Scheffner, James E. Clausner, Adele Militello, ERDC
Leon E. Borgman, University of Wyoming
Billy L. Edge, Texas A&M University
Peter J. Grace, Jacksonville District

Example: USACE Fire Island Inlet to Montauk Point Hurricane Sandy General Evaluation Project



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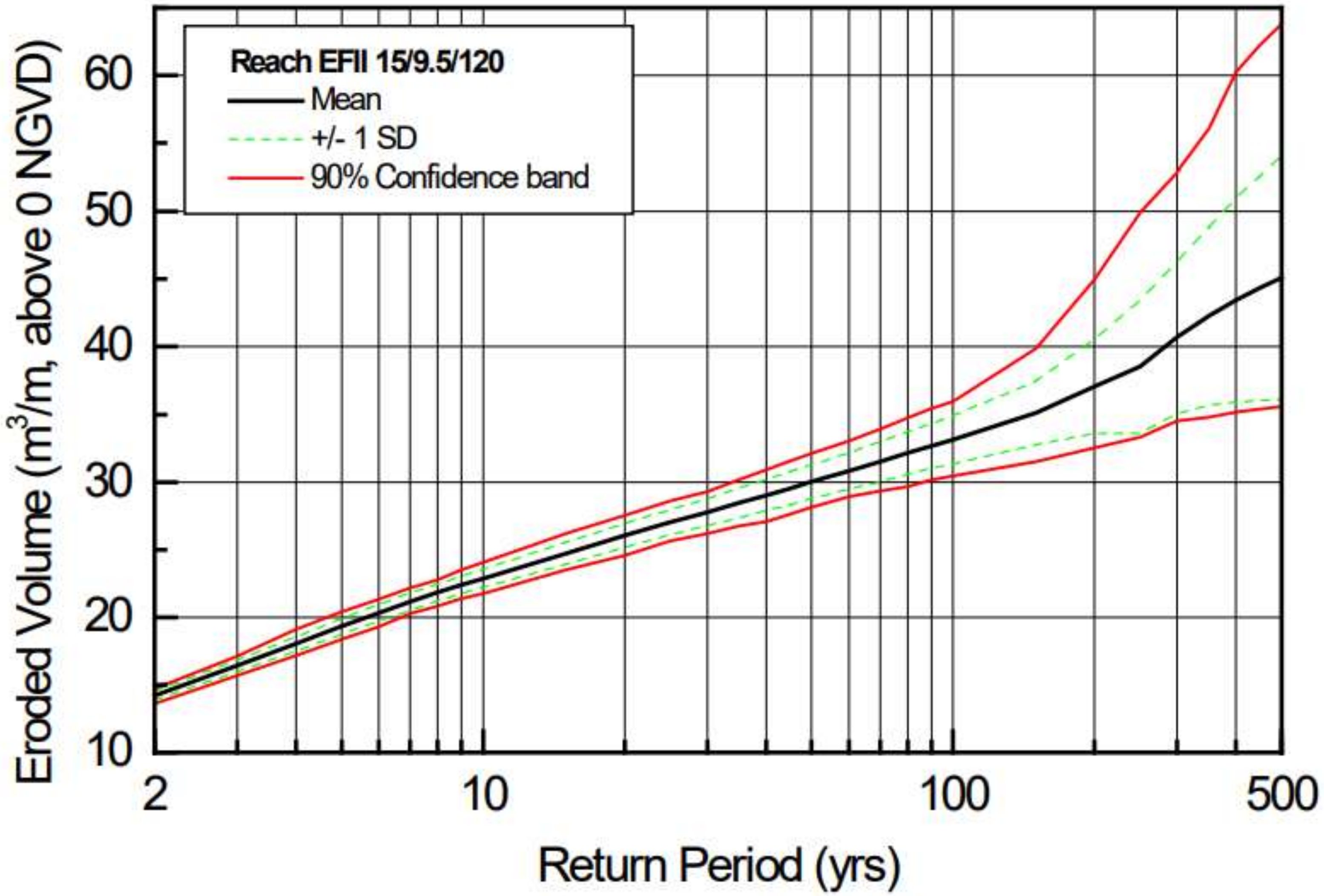


Case Study

Plum Island Beach Erosion

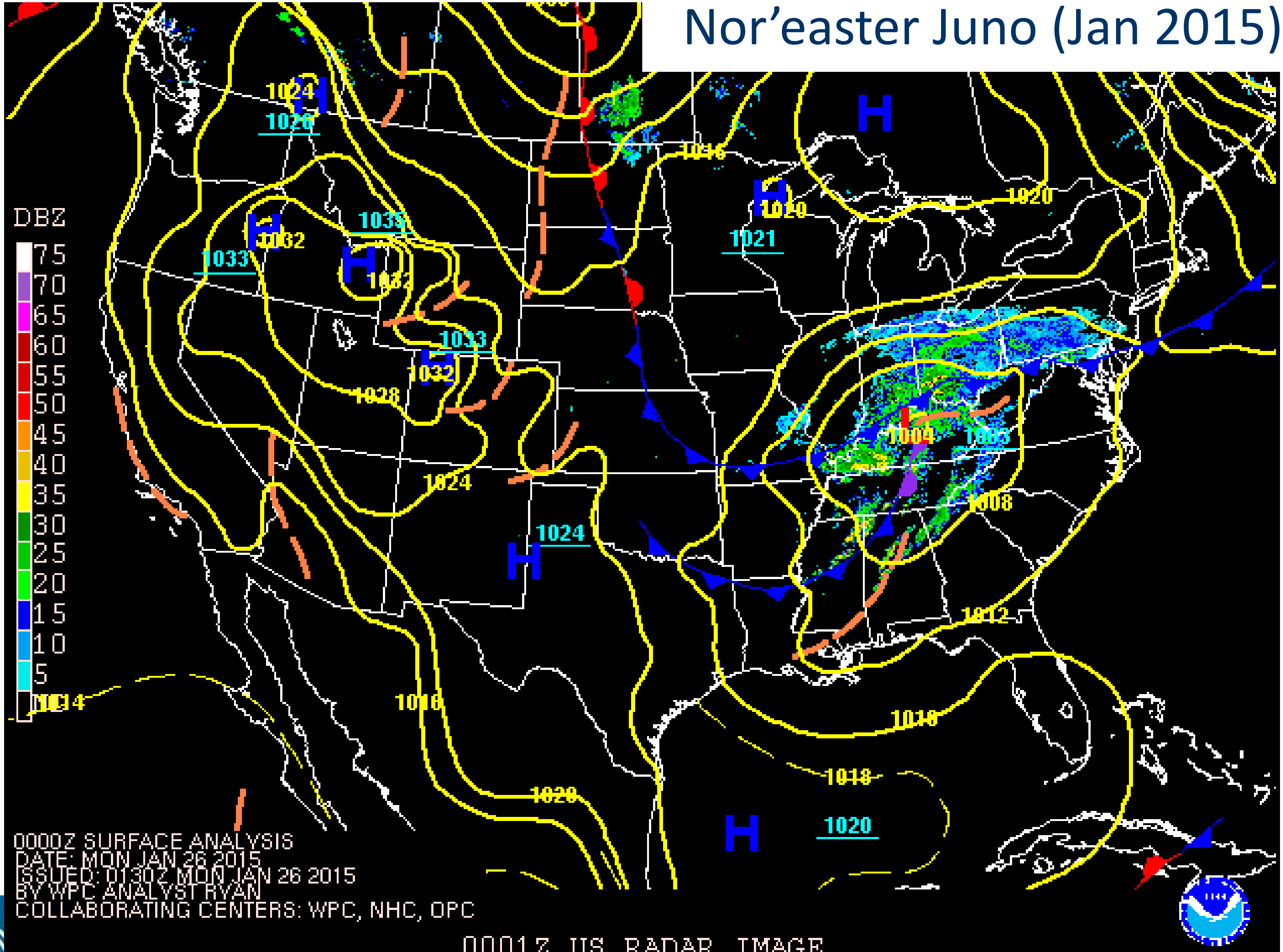
Site Location

Shoreline Erosion Risks

1. Loss of beach
2. Loss of dune habitat
3. Effects on inlet performance
4. Inlet sedimentation / dredging
5. Encroachment on developed area
6. Impacts to buildings and infrastructure
7. Increased flood risk

Observed Shoreline Change

Nor’easter Juno (Jan 2015)



Wave Direction: Peak Storm Surge (Juno 2015)

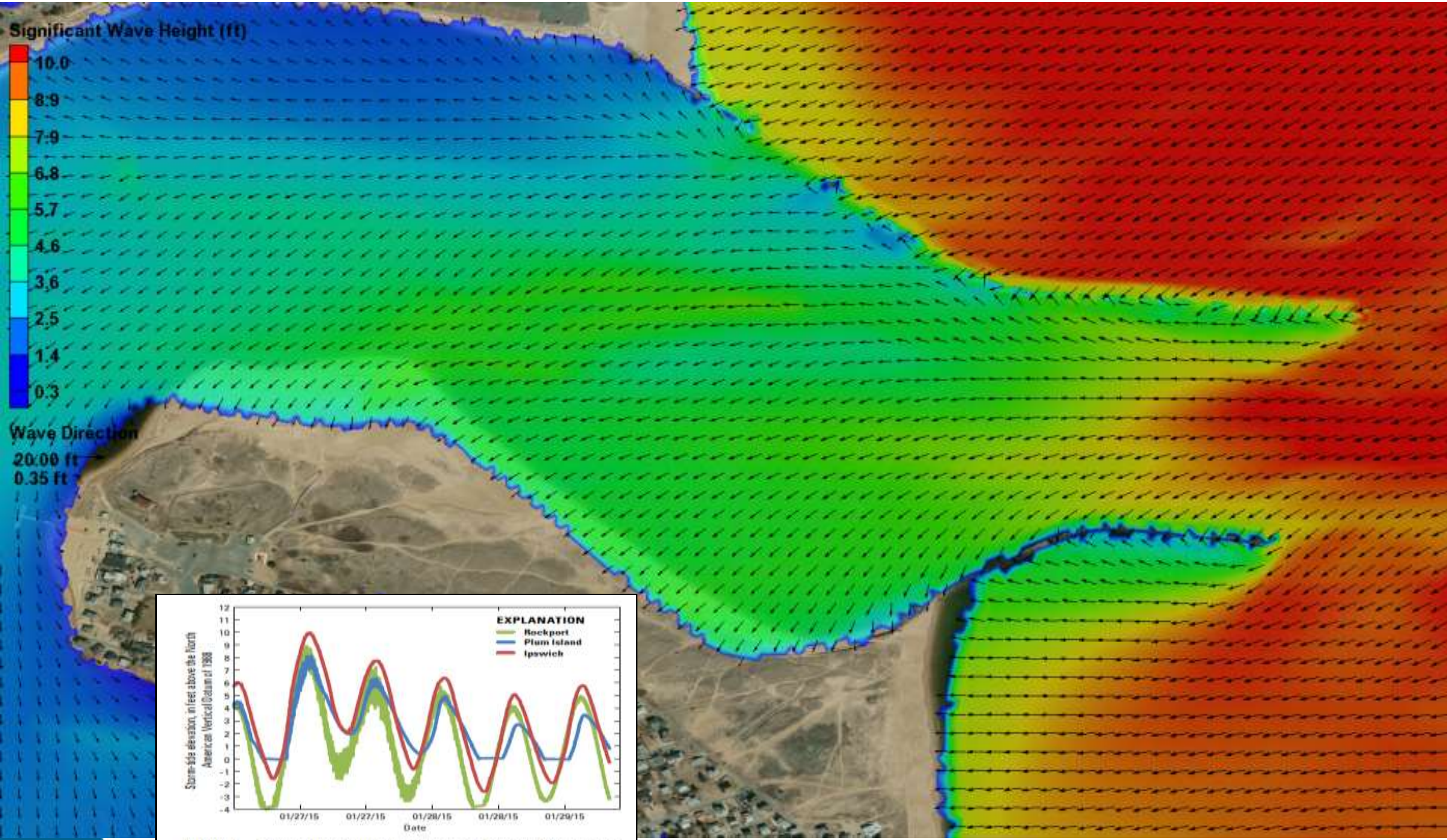
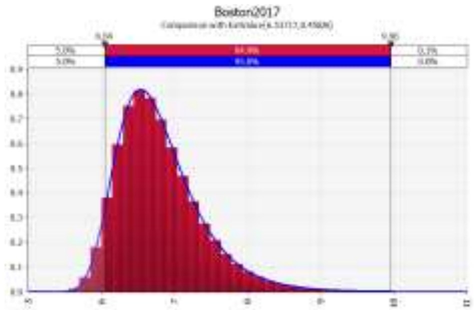


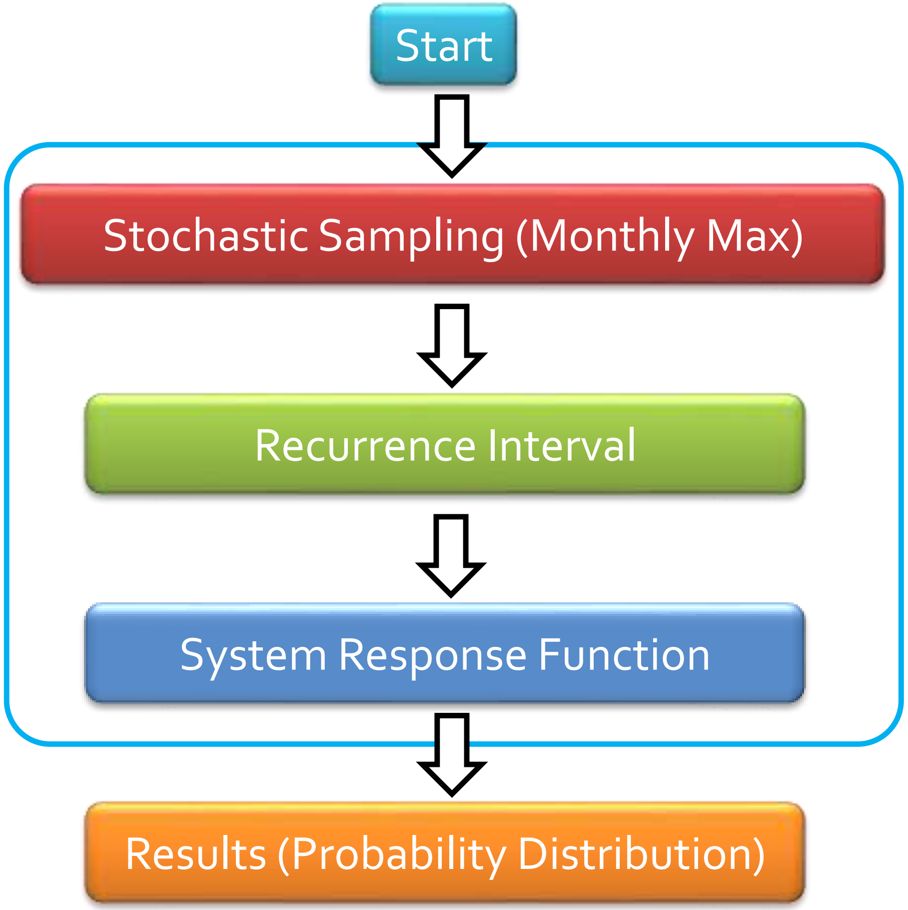
Figure 3. Storm tide elevation recorded at Rockport, Plum Island, and Ipswich on the northern shore of eastern Massachusetts during the blizzard of January 26–28, 2015.

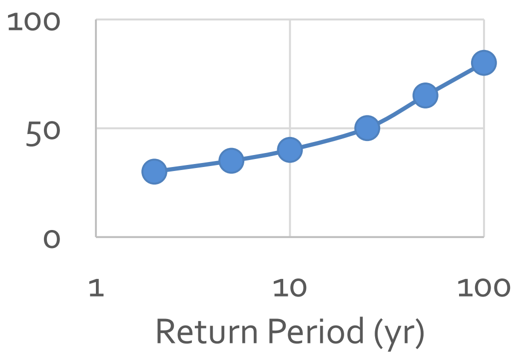
Sample questions to be answered:

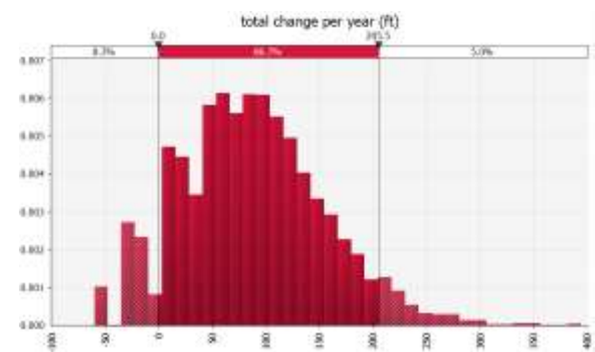
- Average annual loss of shoreline
- Expected replacement amount each year
- Approximate return period of a certain erosion event

Flow Chart



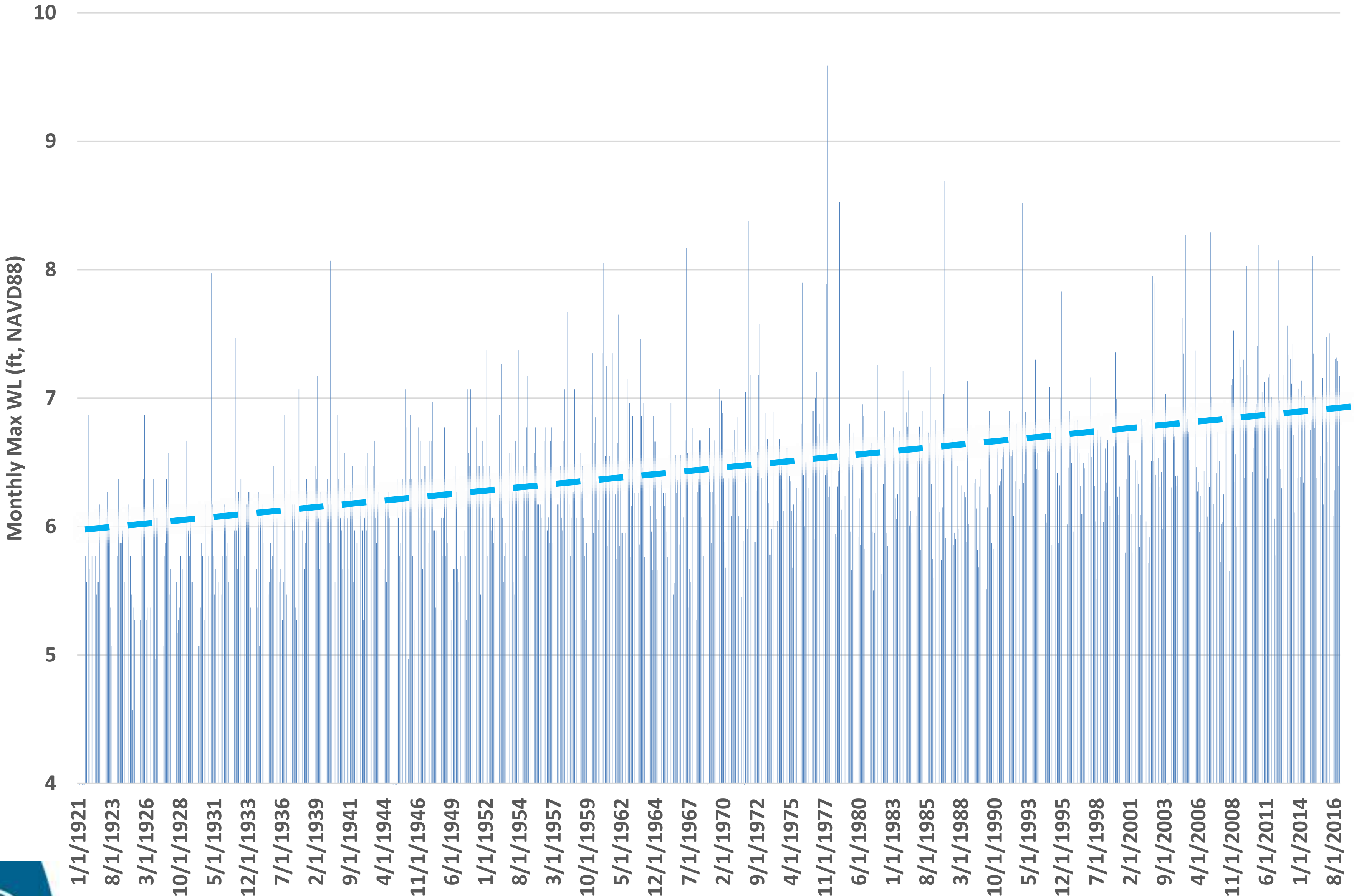




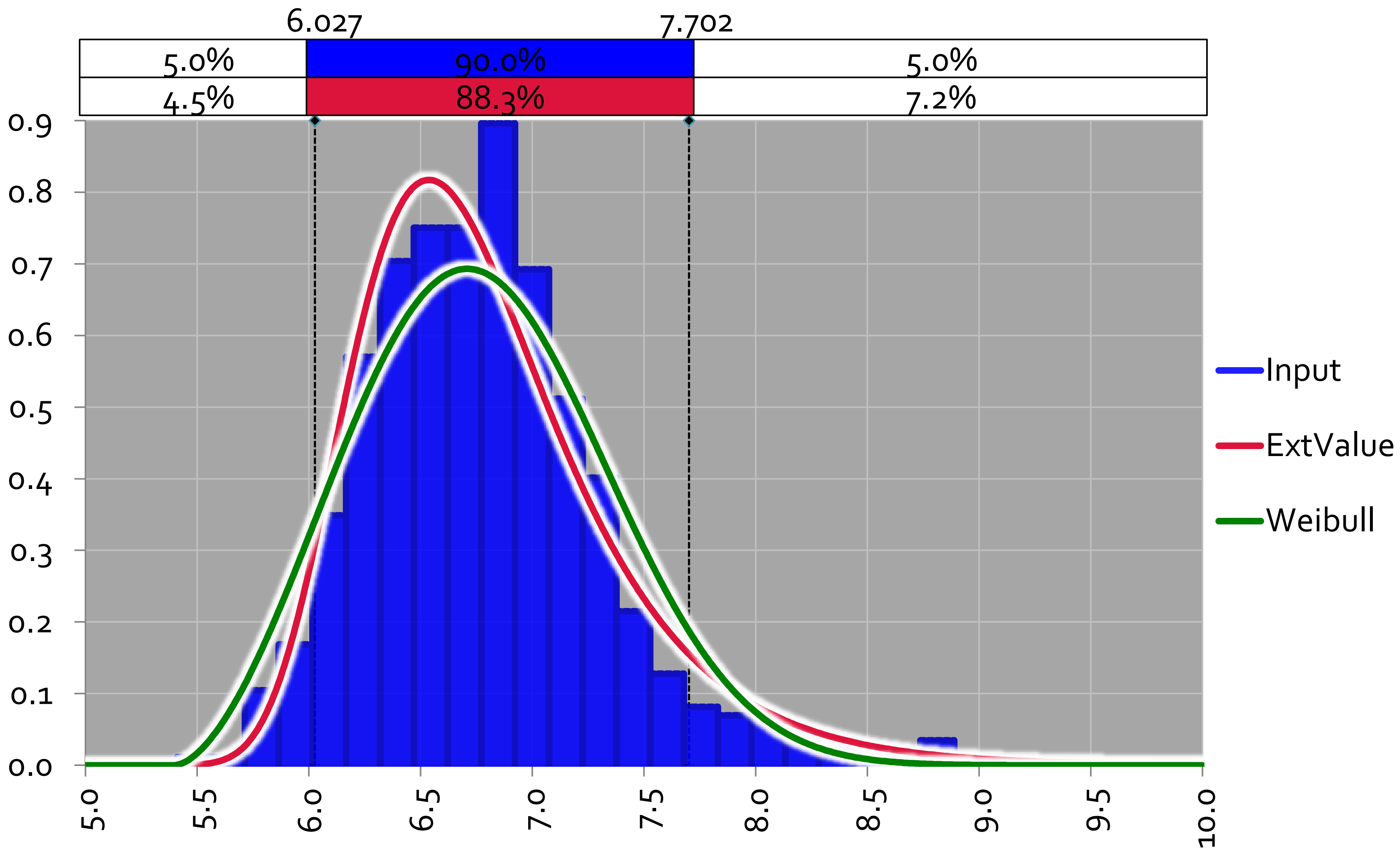


Palisade @Risk
(Monte Carlo Simulation)

Boston Tide Gage Monthly Maximum (ft, NAVD88) 1921 – 2017 (Original Data)

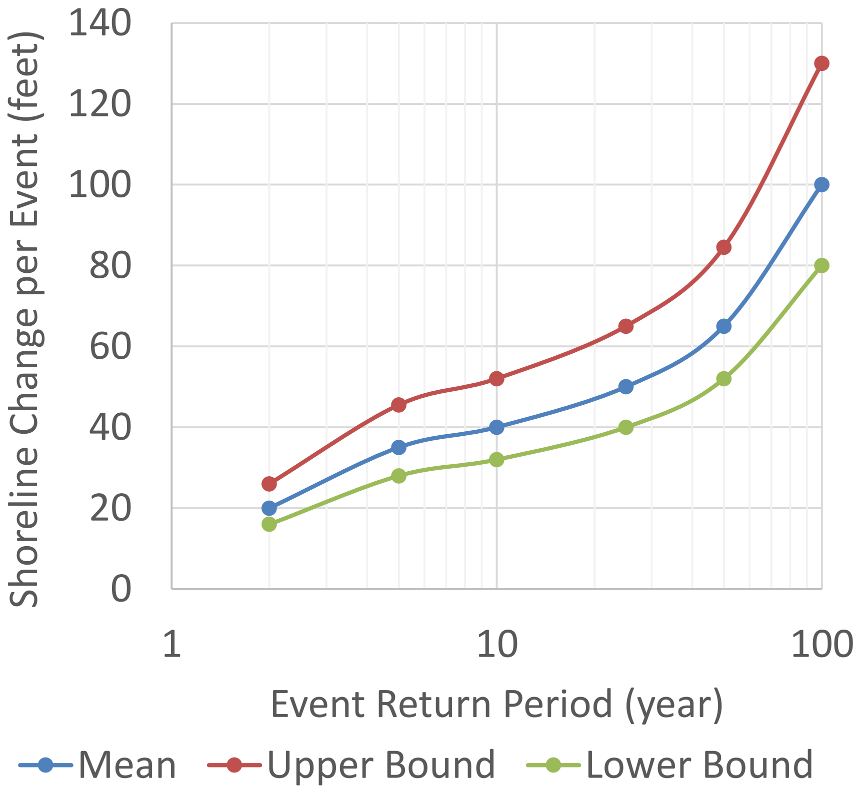


Fit Comparison for Boston2017
RiskExtValue(6.53717,0.45026)
RiskWeibull(2.7082,1.5553,RiskShift(5.3967))

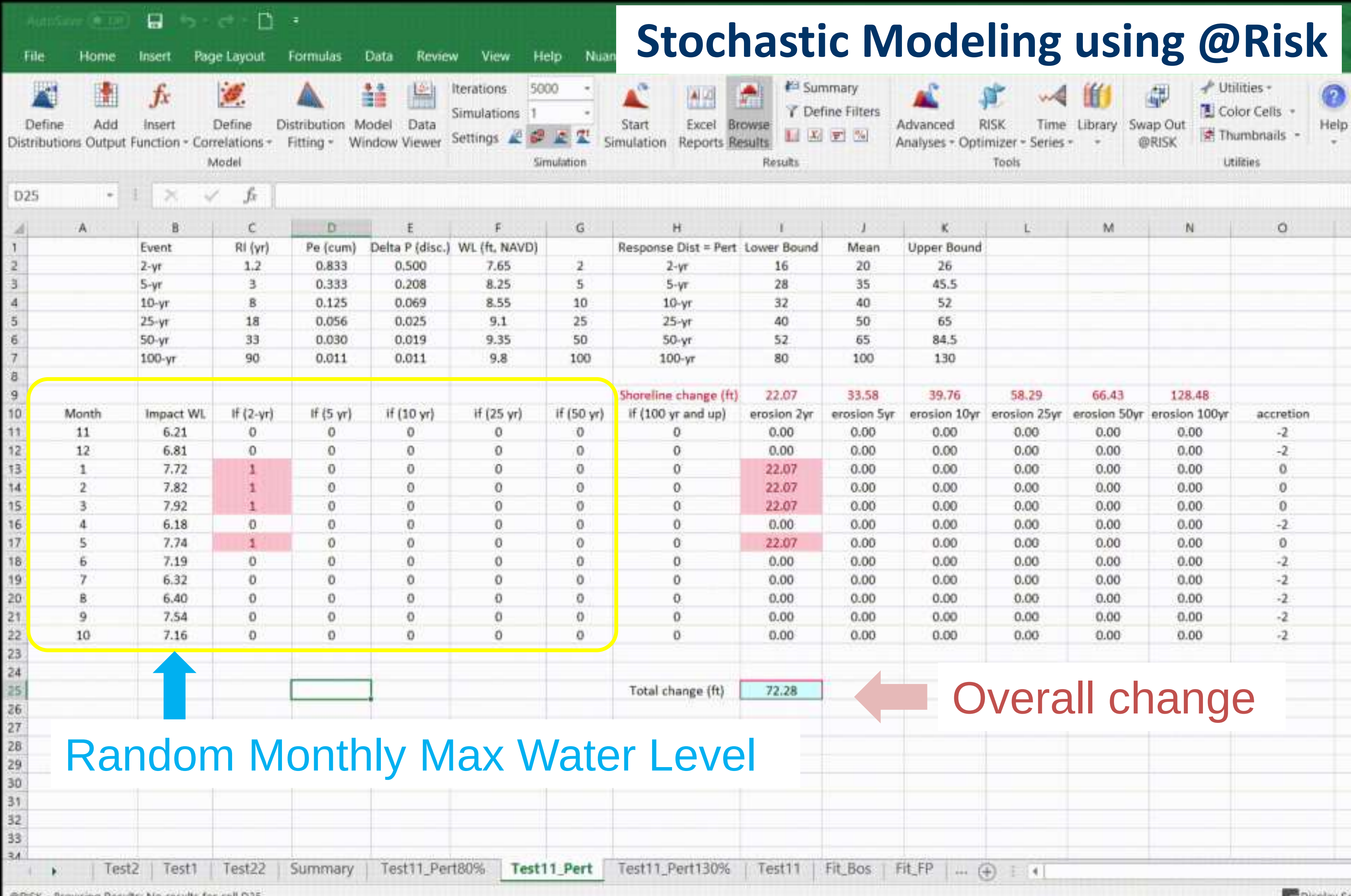


Shoreline Change Response Functions

Event Recurrence Interval	Shoreline Erosion per Event (ft)	Basis
No Extreme Event	-2 (accretion) / month	Estimated based on long term data
2-year	20	Erosion based on Xbeach model results
5-year	35	
10-year	40	
25-year	50	
50-year	65	
100-year	80	



Stochastic Modeling using @Risk

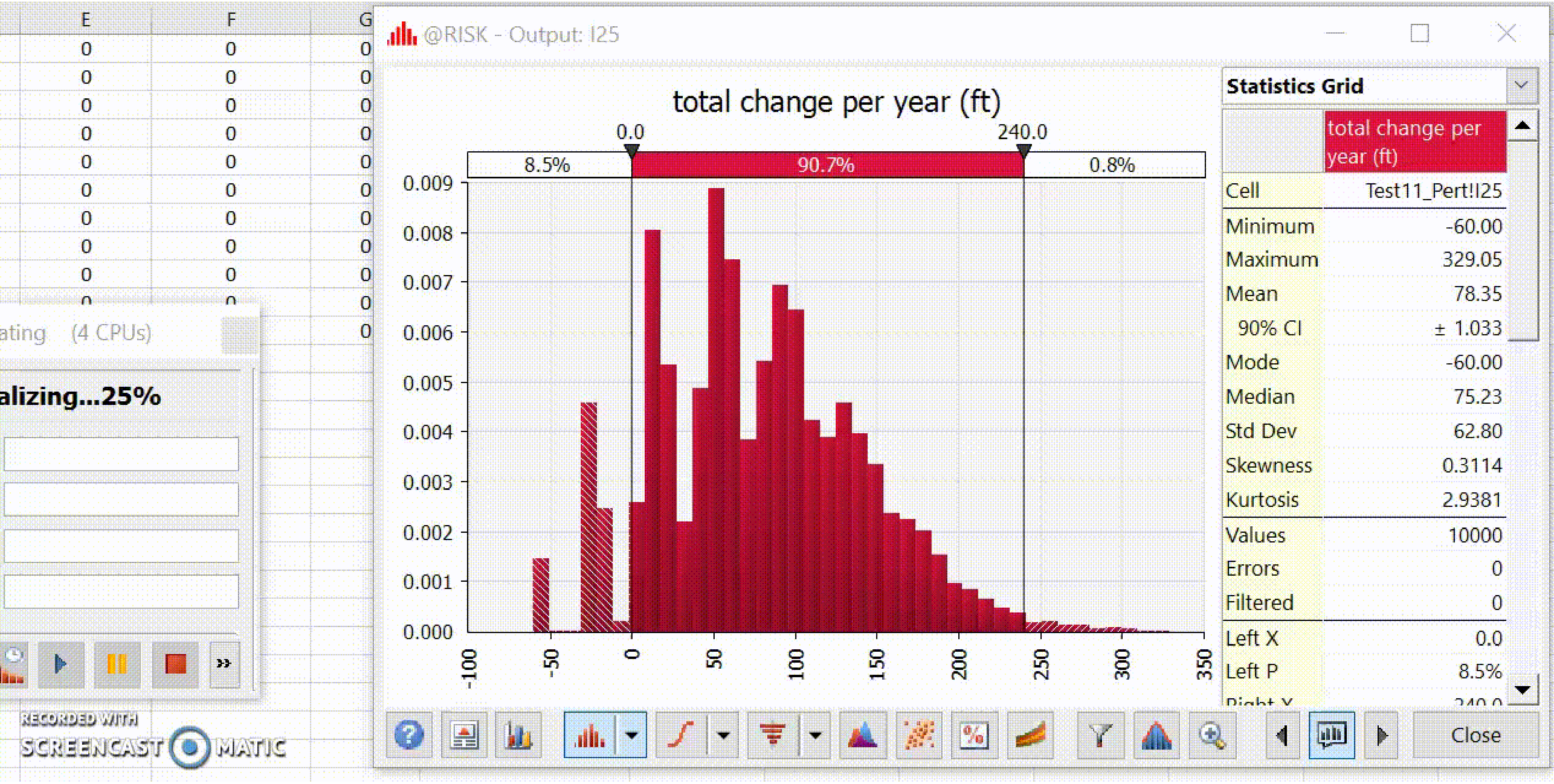


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1		Event	RI (yr)	Pe (cum)	Delta P (disc.)	WL (ft, NAVD)		Response Dist = Pert	Lower Bound	Mean	Upper Bound				
2		2-yr	1.2	0.833	0.500	7.65	2	2-yr	16	20	26				
3		5-yr	3	0.333	0.208	8.25	5	5-yr	28	35	45.5				
4		10-yr	8	0.125	0.069	8.55	10	10-yr	32	40	52				
5		25-yr	18	0.056	0.025	9.1	25	25-yr	40	50	65				
6		50-yr	33	0.030	0.019	9.35	50	50-yr	52	65	84.5				
7		100-yr	90	0.011	0.011	9.8	100	100-yr	80	100	130				
8															
9								Shoreline change (ft)	22.07	33.58	39.76	58.29	66.43	128.48	
10	Month	Impact WL	if (2-yr)	if (5 yr)	if (10 yr)	if (25 yr)	if (50 yr)	if (100 yr and up)	erosion 2yr	erosion 5yr	erosion 10yr	erosion 25yr	erosion 50yr	erosion 100yr	accretion
11	11	6.21	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	-2
12	12	6.81	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	-2
13	1	7.72	1	0	0	0	0	0	22.07	0.00	0.00	0.00	0.00	0.00	0
14	2	7.82	1	0	0	0	0	0	22.07	0.00	0.00	0.00	0.00	0.00	0
15	3	7.92	1	0	0	0	0	0	22.07	0.00	0.00	0.00	0.00	0.00	0
16	4	6.18	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	-2
17	5	7.74	1	0	0	0	0	0	22.07	0.00	0.00	0.00	0.00	0.00	0
18	6	7.19	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	-2
19	7	6.32	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	-2
20	8	6.40	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	-2
21	9	7.54	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	-2
22	10	7.16	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	-2
25								Total change (ft)	72.28						

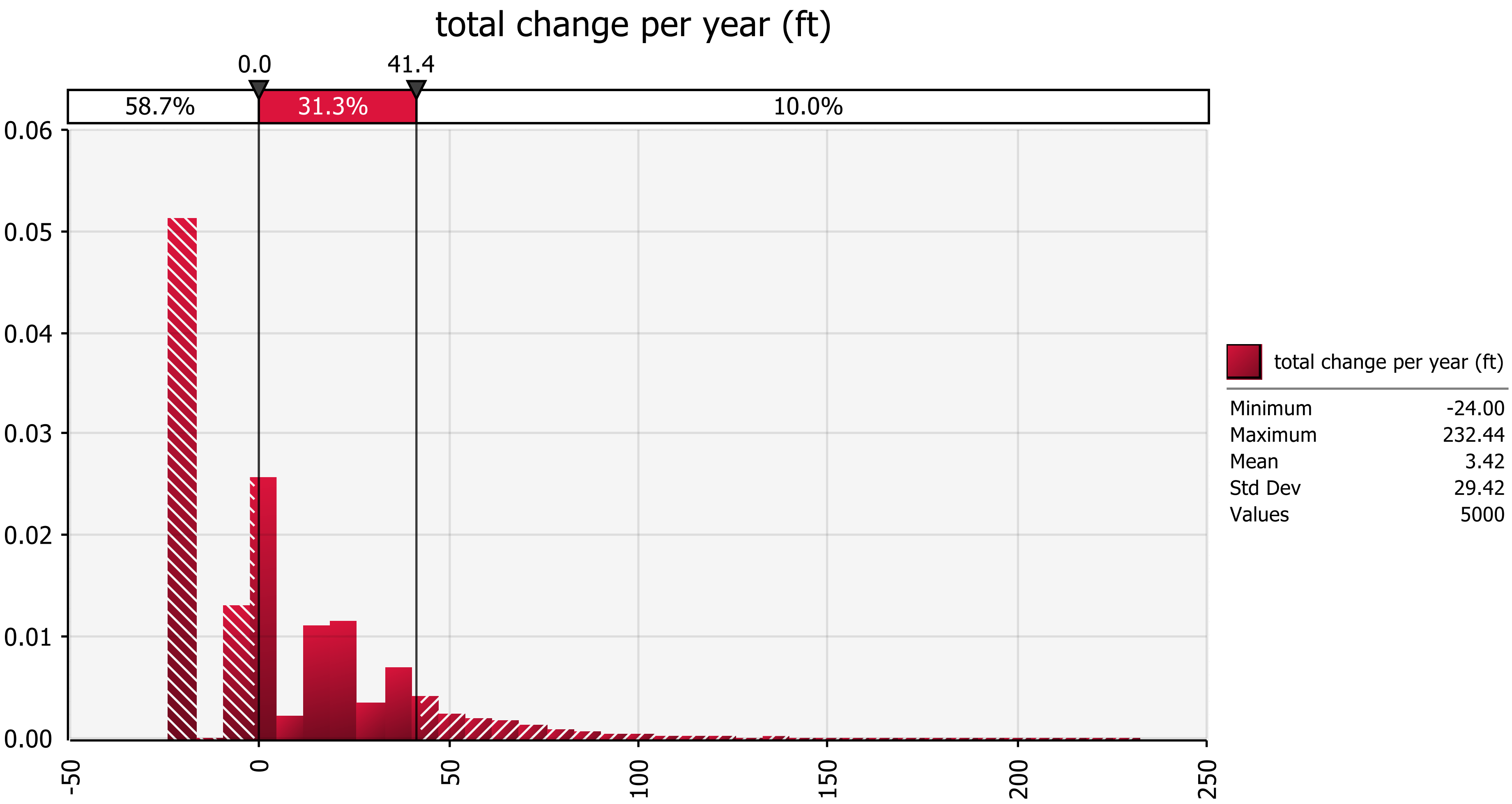
Overall change

Random Monthly Max Water Level

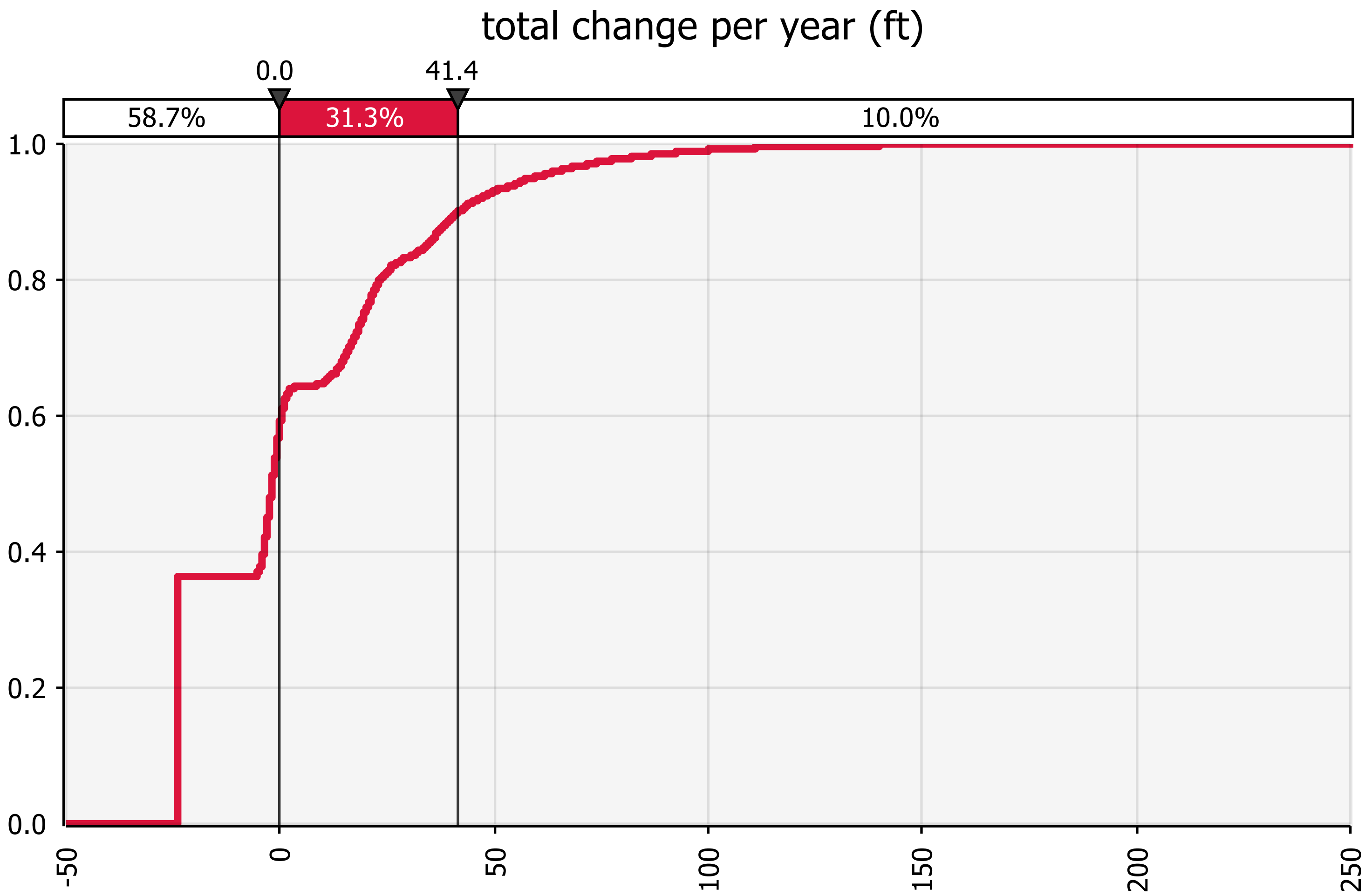
Stochastic Modeling



Results

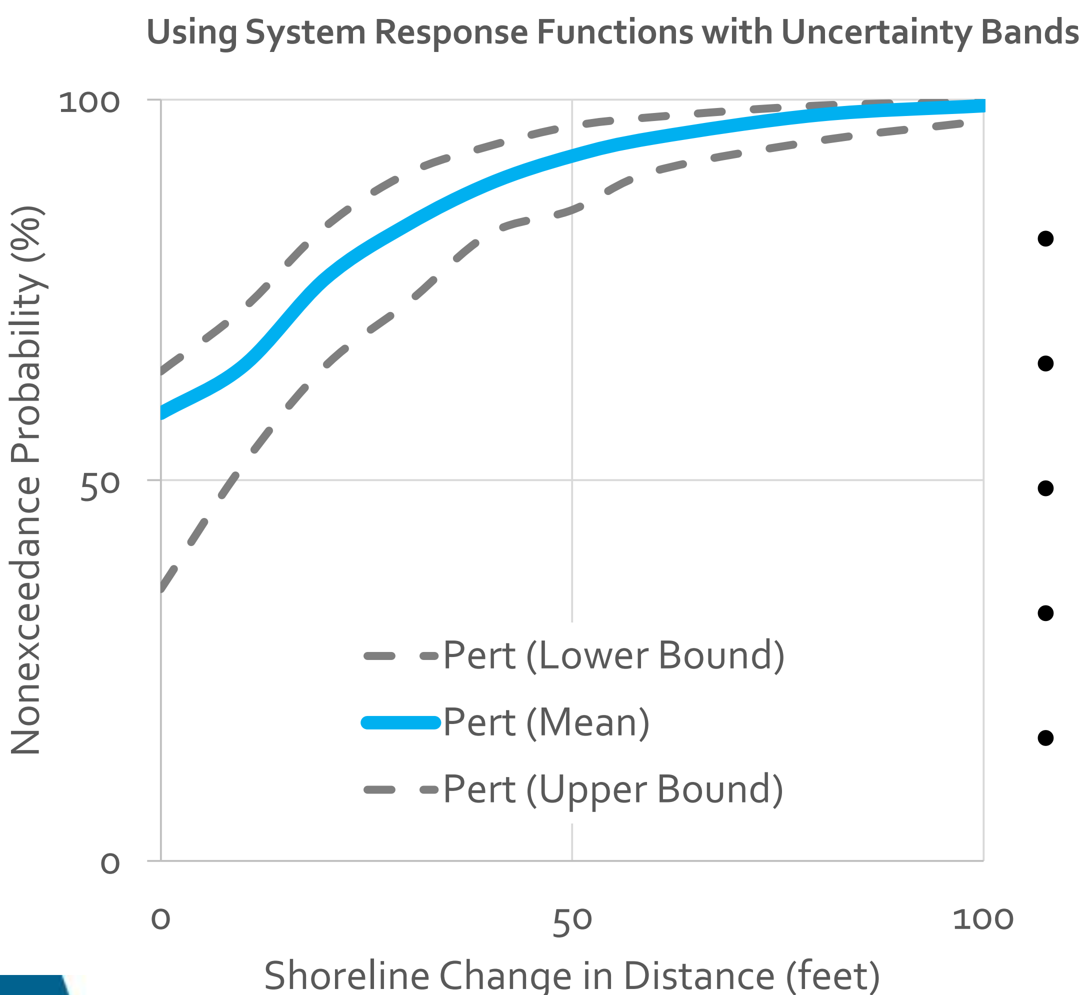

total change per year (ft)
0.0
41.4
58.7%
31.3%
10.0%
0.06
0.05
0.04
0.03
0.02
0.01
0.00
-50
0
50
100
150
200
250
total change per year (ft)
Minimum -24.00
Maximum 232.44
Mean 3.42
Std Dev 29.42
Values 5000

Results



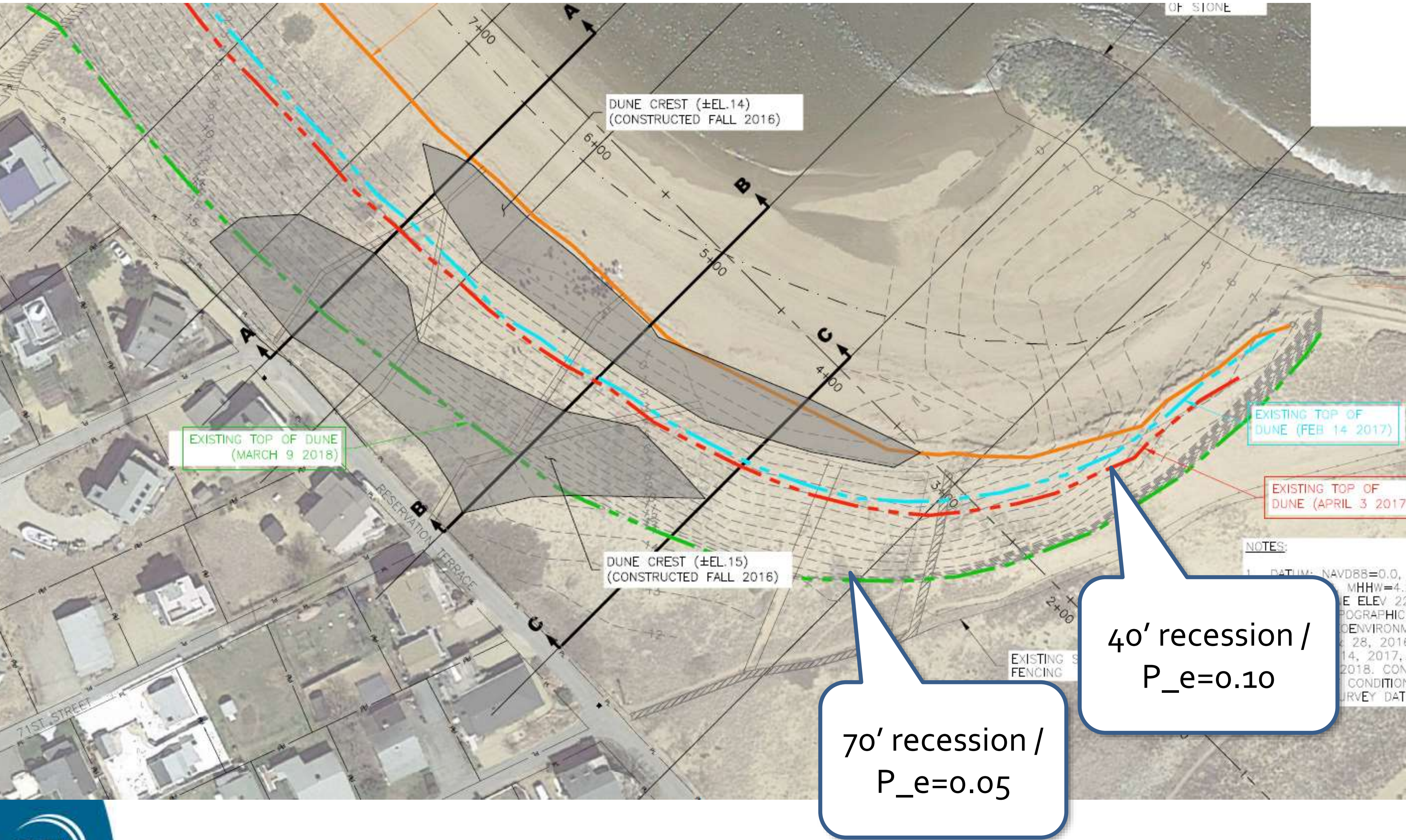
total change per year (ft)	
Minimum	-24.00
Maximum	232.44
Mean	3.42
Std Dev	29.42
Values	5000

Shoreline Change Frequency Curve (Risk)



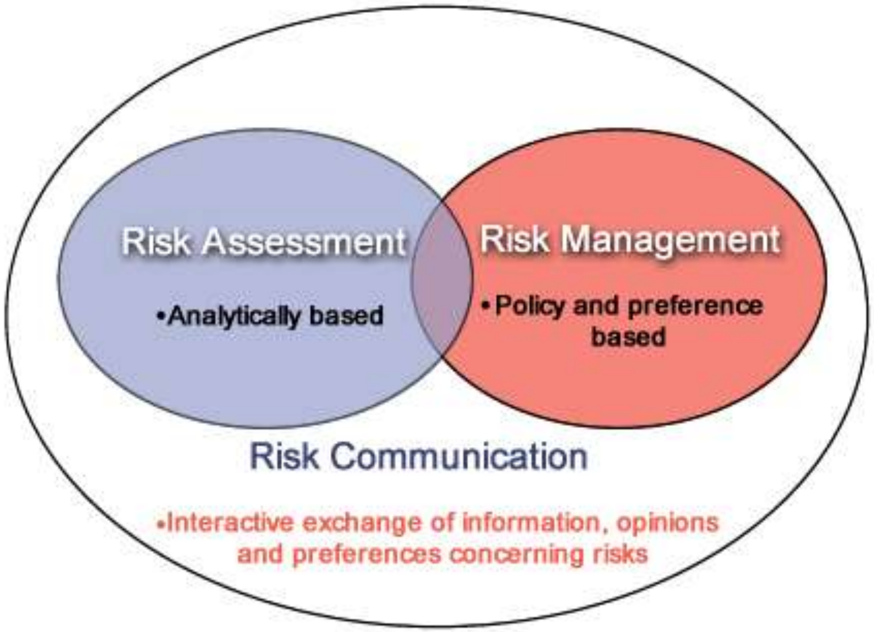
- Financial evaluation;
- Risk management;
- Outreaching;
- Project management;
- Budget planning;

Comparisons with Observations



Takeaways

- Diverse applications;
- Complex multi-component system;
- Quantification of epistemic uncertainties;
- Excellent tool for risk communication
- …



USACE Risk Analysis Gateway

Parking lot submerged under ocean water, January 2018
Patch.com

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