Community Engagement and Cost Benefit Analysis for Sea Level Rise and Storm Surge Adaptation

Methods, Case Studies, and Wetland-specific Opportunities

Samuel B. Merrill, Ph.D.
December 10, 2012

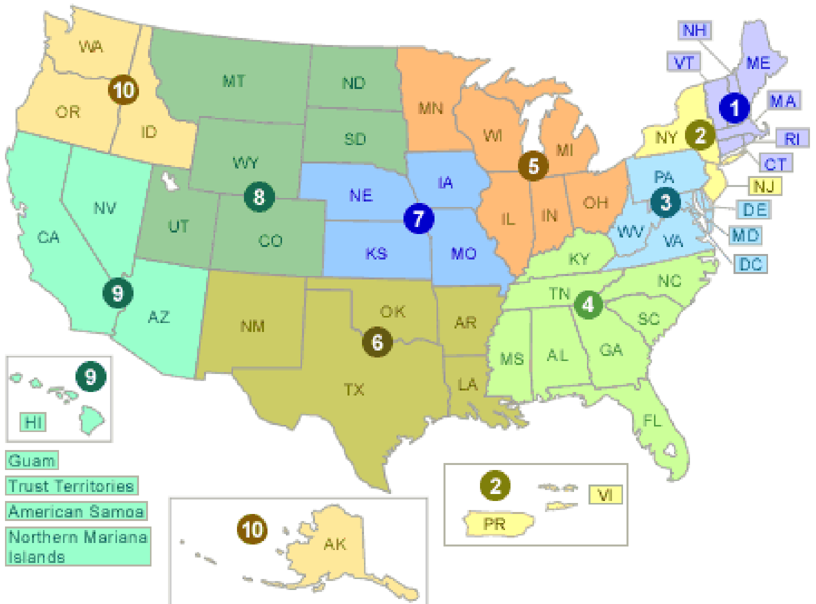
Muskie School of Public Service

University of Southern Maine
Portland, Maine

Environmental Finance Center Network

The EFCN is a university-based organization creating innovative solutions to managing costs of environmental protection and improvement. It consists of ten EFCs serving states in EPA's ten regions. By sharing information, tools and techniques, the EFCs help address difficult how-to-pay issues of providing environmental services.

http://www.epa.gov/efinpage/efcn.htm.



Catalysis Adaptation Partners, LLC

www.catalysisadaptation.com


Credit: Robin Utrecht/AFP/Getty Images

PRO-COMP
ULTRA-LITE
Auto Meter
RPM
THOUSANDS
0
1
2
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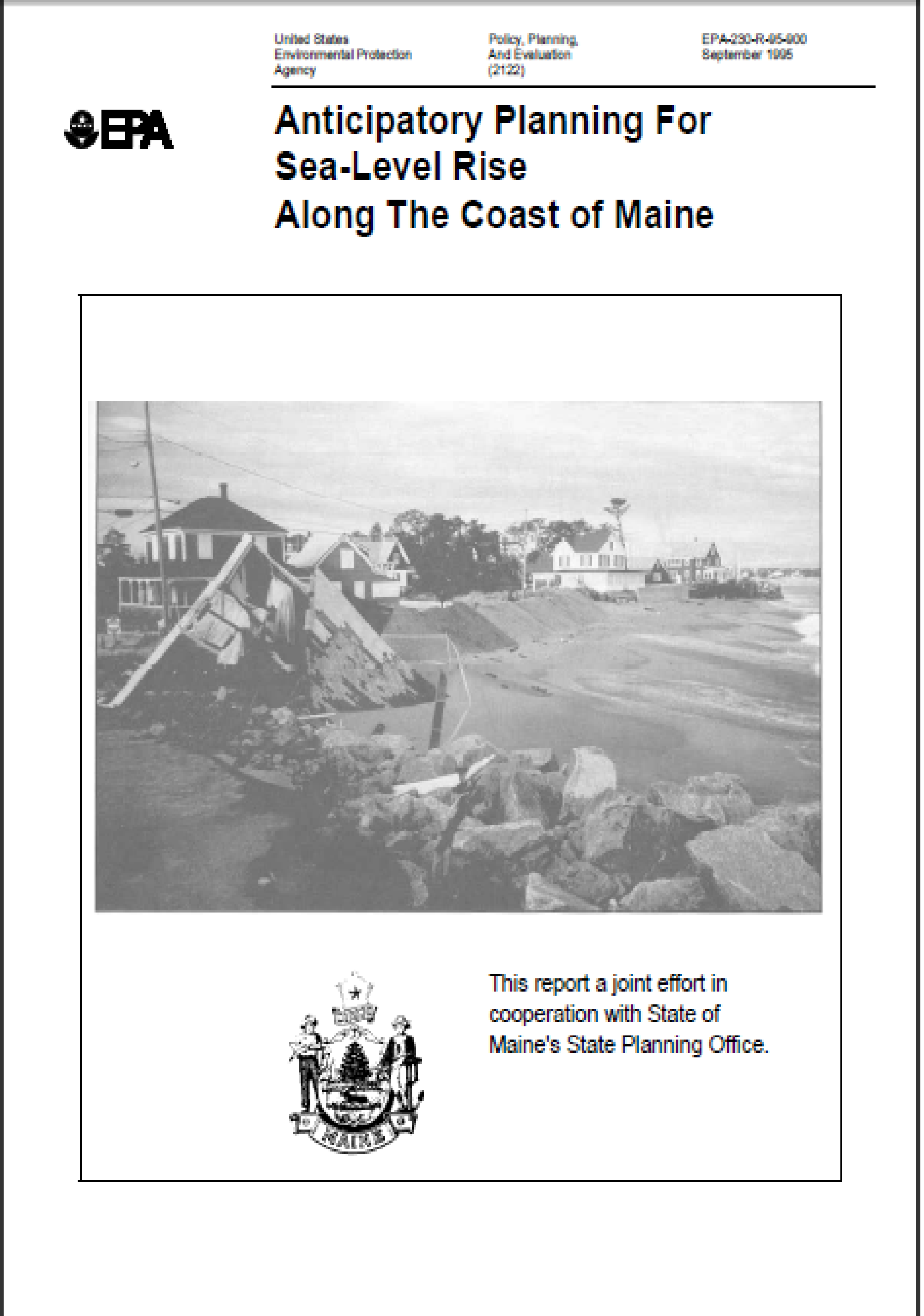
10



United States Environmental Protection Agency

Policy, Planning, And Evaluation (2122)

EPA-230-R-95-900
September 1995

EPA

Anticipatory Planning For Sea-Level Rise Along The Coast of Maine

This report a joint effort in cooperation with State of Maine's State Planning Office.

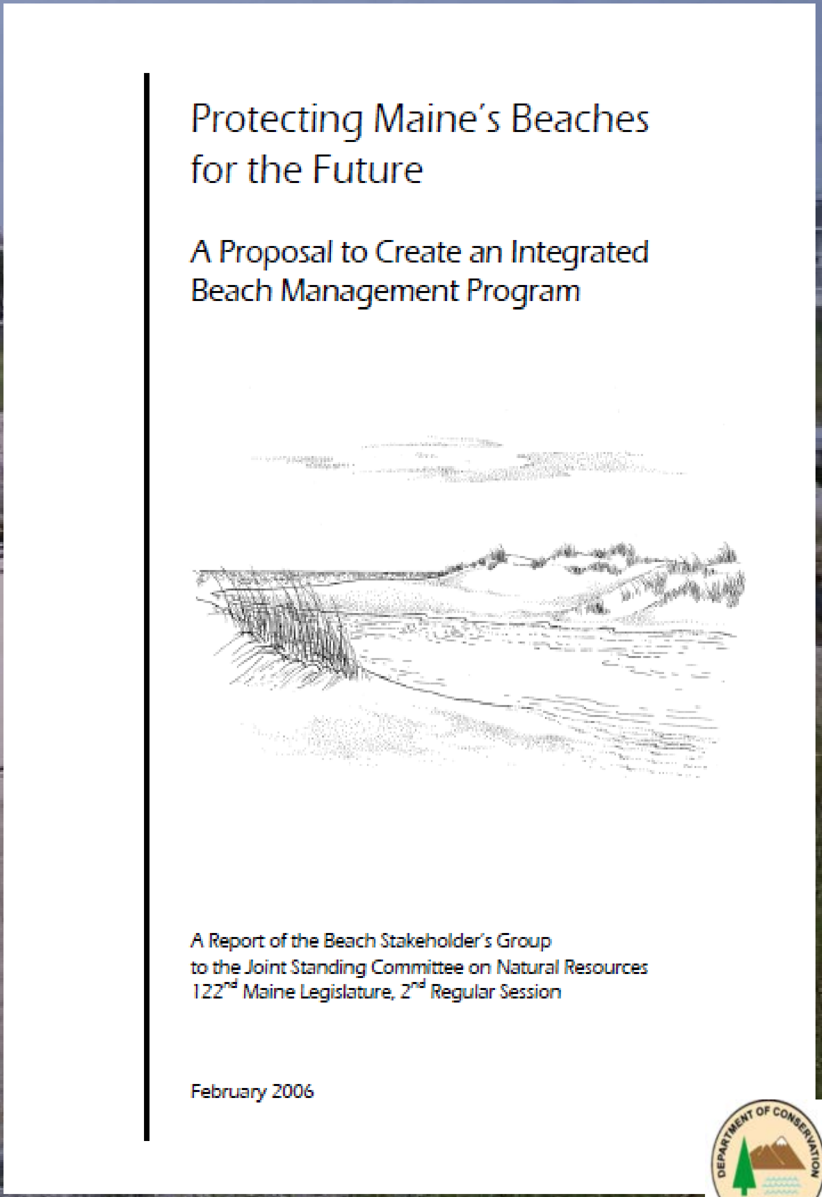
On the right track…

in 1995!

But it was never <u>brought to the local level</u>

So it was LOST in the archives.

More reports…and updated sea level regulations



Protecting Maine's Beaches for the Future

A Proposal to Create an Integrated Beach Management Program

A Report of the Beach Stakeholder's Group
to the Joint Standing Committee on Natural Resources
122nd Maine Legislature, 2nd Regular Session

February 2006

2006 - As the result of a 2 year stakeholder process, Maine adopted 2 feet of sea level rise over the next 100 years, which was a "middle-of-the road" prediction for global sea level rise, into its NRPA.

P.A. Slovinsky, MGS

Impacts from Flooding

Norbert Psuty

Michael Dwyer


Mon 65 : Newark Selectable
Cam 1420 : 1420-HBKN-E and D Elevator Platform
10/29/2012
20:23:34

Adaptation Works

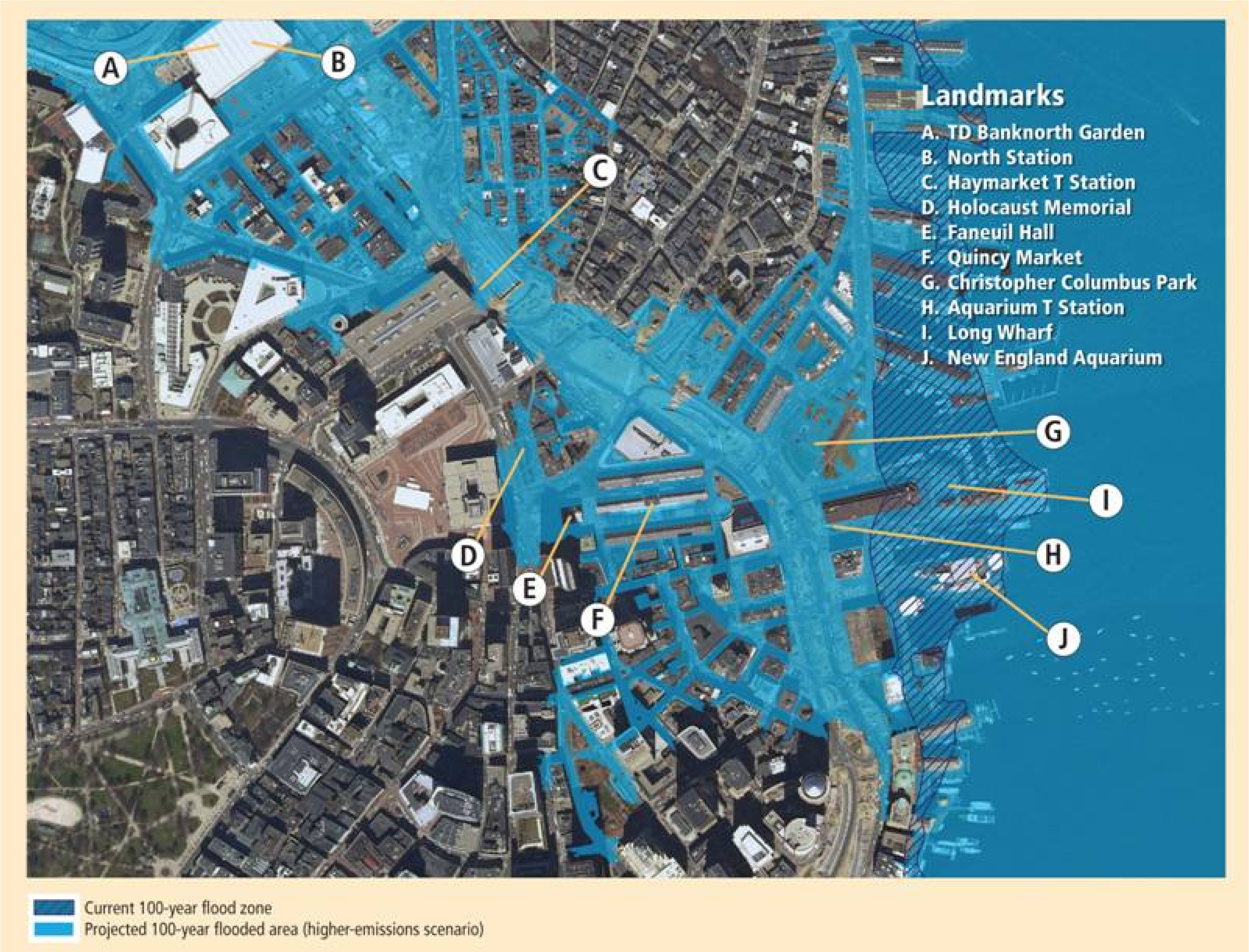
Homeowners in Florida could reduce losses from a severe hurricane by 61 percent, resulting in $51 billion in savings, simply by building to strong construction codes.

Wharton Risk Management and Decision Processes Center, University of Pennsylvania. "Managing Large Scale Risks in a New Era of Catastrophe." 2007

It is Difficult to Shift into Action Mode:

1) Consequences appear far off in time.
2) Cost-benefit relationships are ambiguous.
3) Possible actions are complex.
4) Doing nothing is far, far easier.

Coastal Flooding in Boston under Present and High Emission Sea Levels



There are only four options:

1) Do nothing (usually = remain in denial)
2) Fortify assets
3) Accommodate higher water levels
4) Relocate assets

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1) Do nothing (usually = remain in denial)
2) Fortify assets
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4) Relocate assets

>> COAST is a tool and approach to help evaluate costs and benefits of these options.

Possible Assets to Model

- Real estate values
- Economic output
- Public health impacts
- Displaced persons, vulnerable demographics
- Natural resources values
- Cultural resources values
- Community impacts
- Infrastructure (transportation, energy, facilities, telecommunications)

The COAST Process

Has been or **is being used** in

1. Old Orchard Beach, ME
2. Portland, ME
3. Falmouth, ME
4. East Machias, ME
5. Seabrook, NH
6. Hampton, NH
7. Hampton Falls, NH
8. **Tybee Island, GA**
9. **Cambridge, MA**
10. **Kingston, NY**
11. **Oxdford, MD**

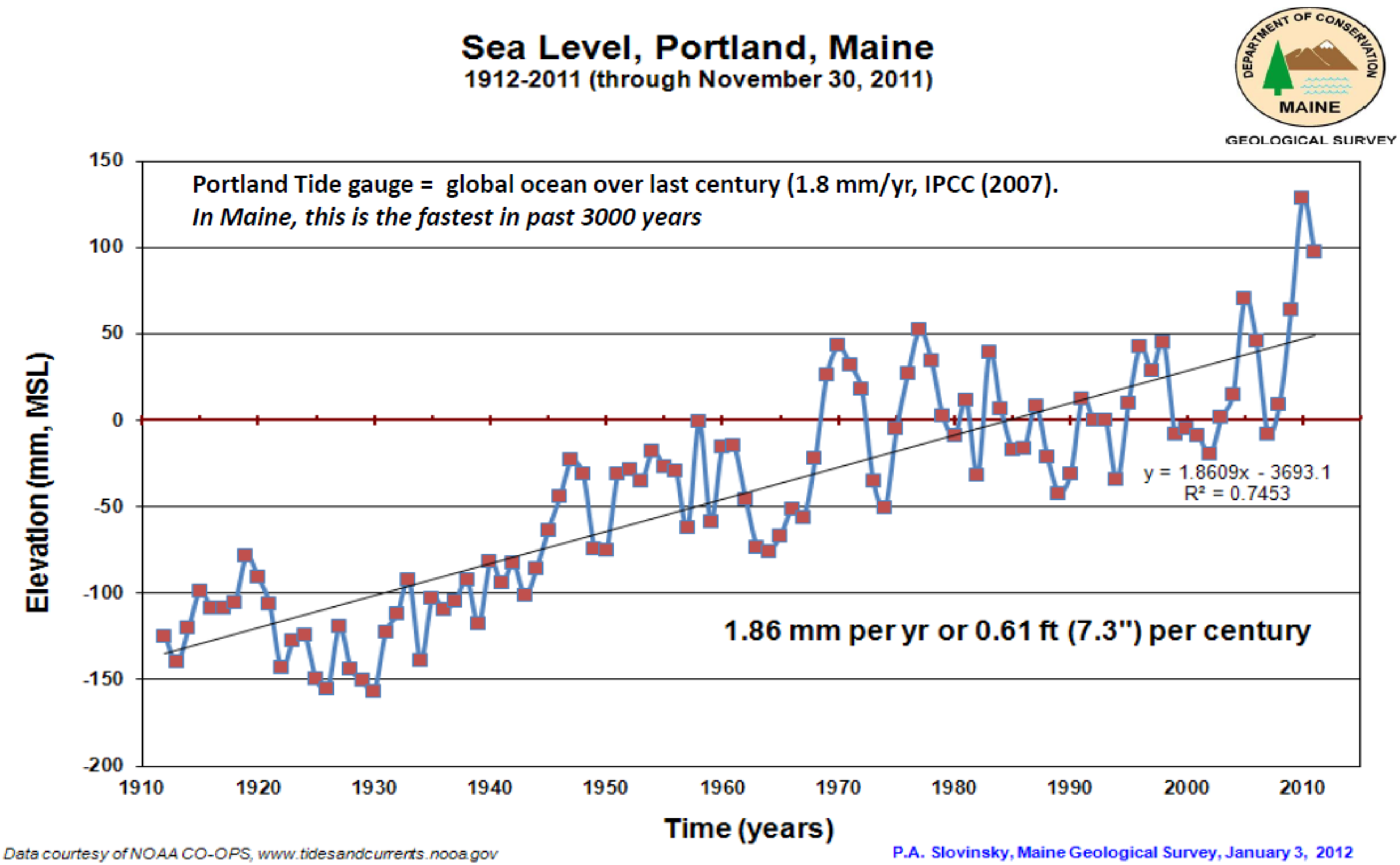
The COAST Strategy

1) Don’t discuss climate change.

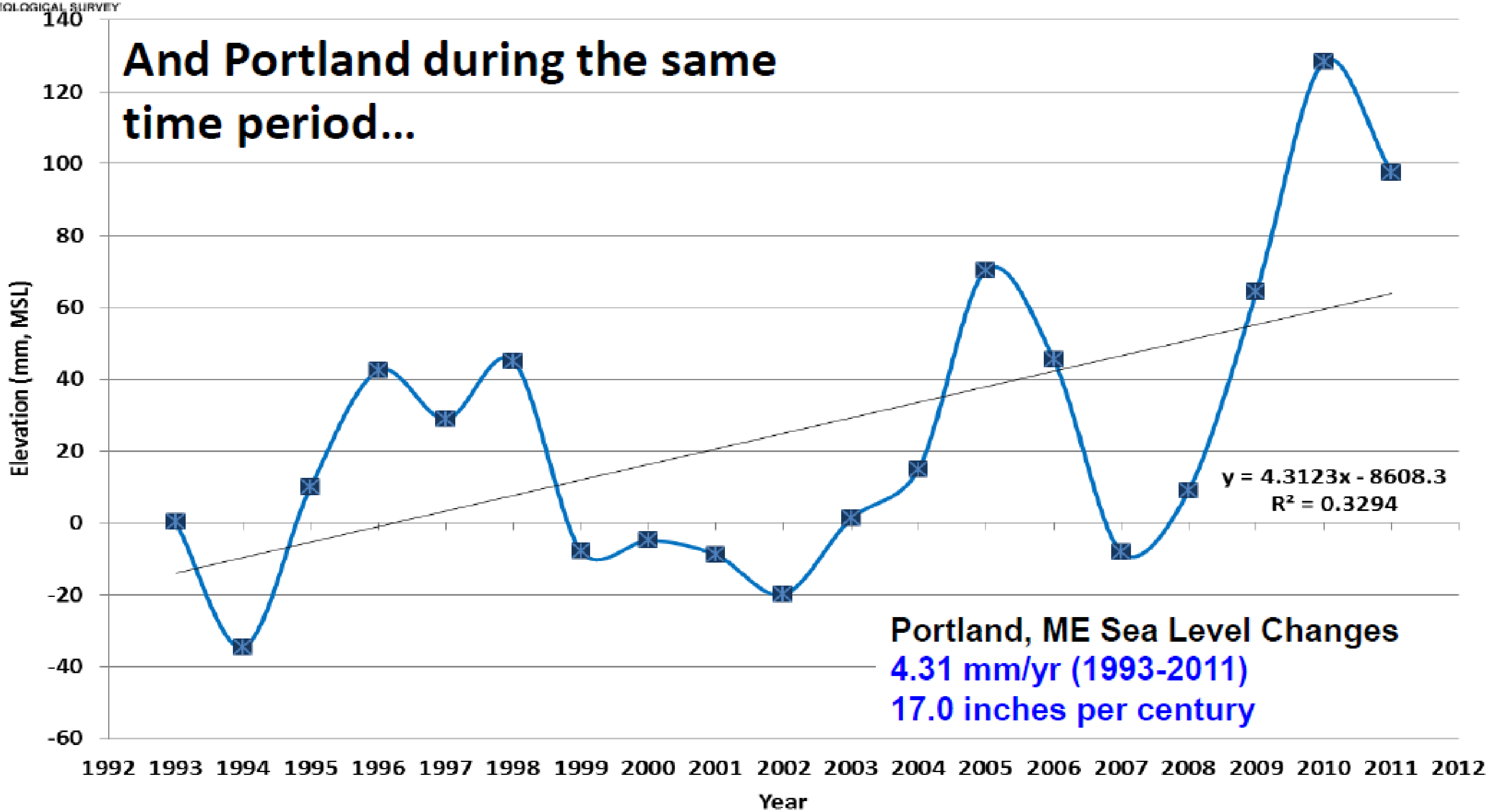
The COAST Strategy

1) Don’t discuss climate change.
2) Focus on observed, local data.

Patriot’s Day Storm 2007: York Beach


Sea Level, Portland, Maine
1912-2011 (through November 30, 2011)
DEPARTMENT OF CONSERVATION
MAINE
GEOLOGICAL SURVEY
Portland Tide gauge = global ocean over last century (1.8 mm/yr, IPCC (2007).
In Maine, this is the fastest in past 3000 years
y = 1.8609x - 3693.1
R² = 0.7453
1.86 mm per yr or 0.61 ft (7.3") per century
Elevation (mm, MSL)
Time (years)
150
100
50
0
-50
-100
-150
-200
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Data courtesy of NOAA CO-OPS, www.tidesandcurrents.noaa.gov
P.A. Slovinsky, Maine Geological Survey, January 3, 2012

Sea Level, Portland, Maine
1993-2011 (through November 30, 2011)



$1.00 DAILY
$1.75 SUNDAY
The Portland Press Herald
Most trips by fireboats unrelated to emergencies
DANIEL BURKE
Catch Up On YOUR LOCAL TEAMS
RED CLAWS
TO SUBSCRIBE CALL 791-6000

The Old Port, 10/11 at high tide (M. Craig)


NO
THRU
TRAFFIC
RESIDENT
AND
BUSINESS
TRAFFIC
ONLY
NO
THRU
TRAFFIC
ONLY
PRIVATE
PARKING


PRIVATE PARKING
PRIVATE PARKING
RIPPLE

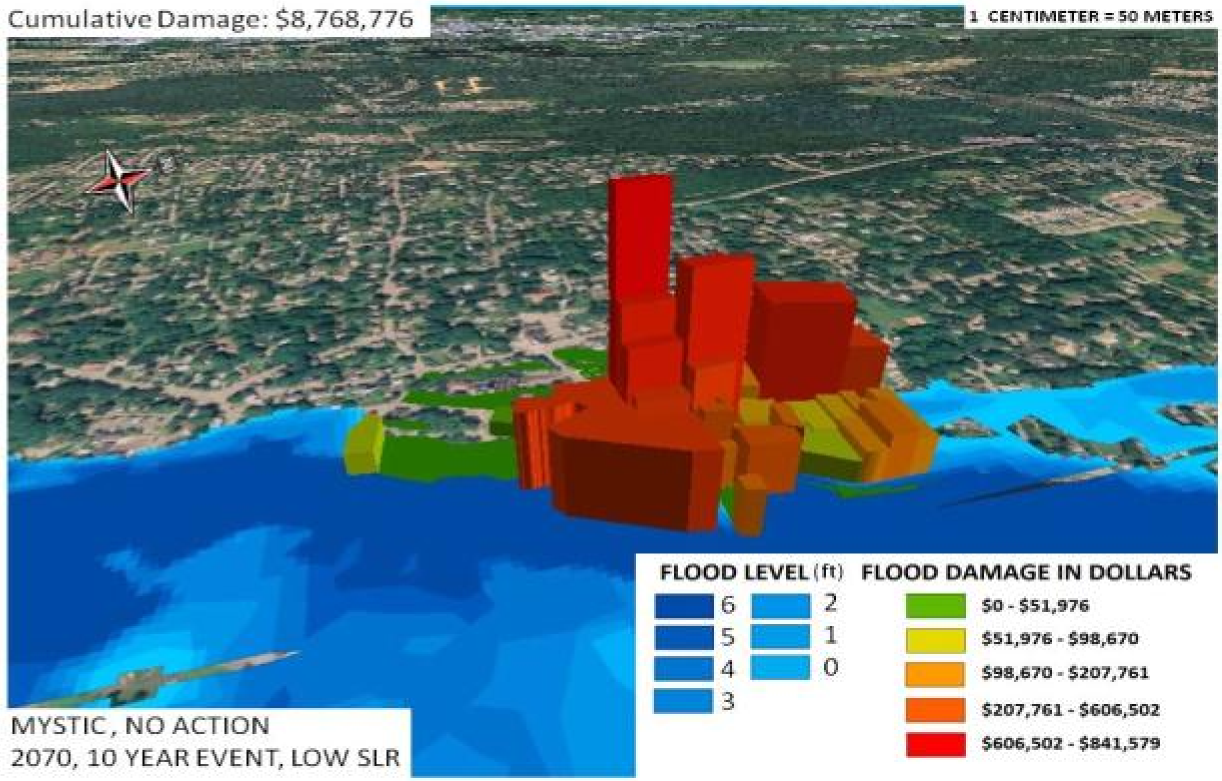
Marginal Way and Cove St., 9/10, New Moon J. Piribeck

Marginal Way and Cove St., 9/10, New Moon J. Piribeck

The Old Port, 3/10 at high tide (D. Yakovleff)

The COAST Strategy

1) Don't discuss climate change.
2) Focus on observed, local data.
3) Use 3D visualization.



The COAST Strategy

1) Don’t discuss climate change.
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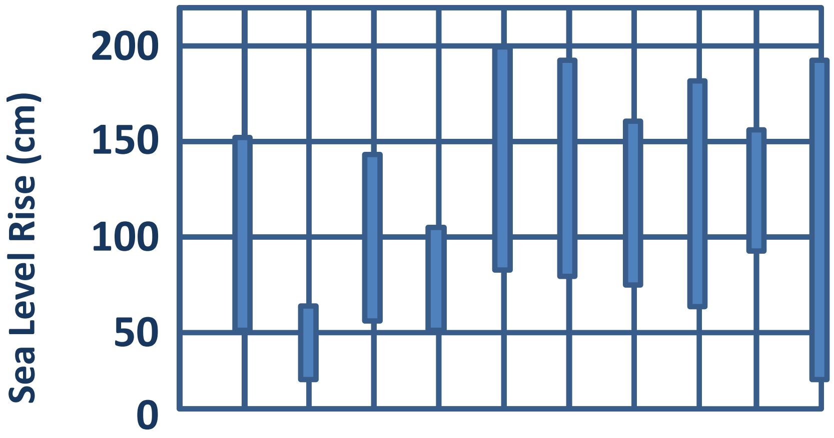
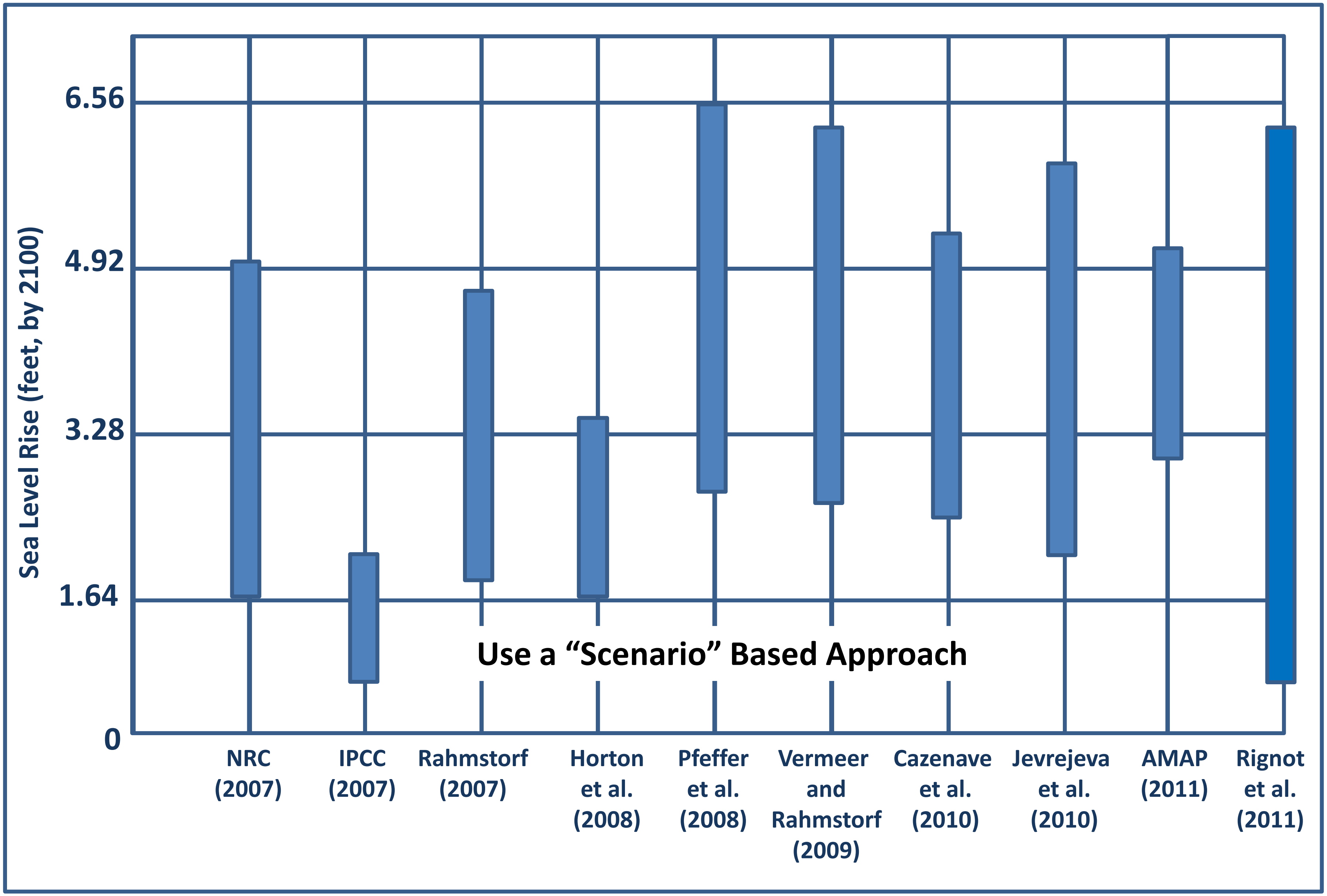
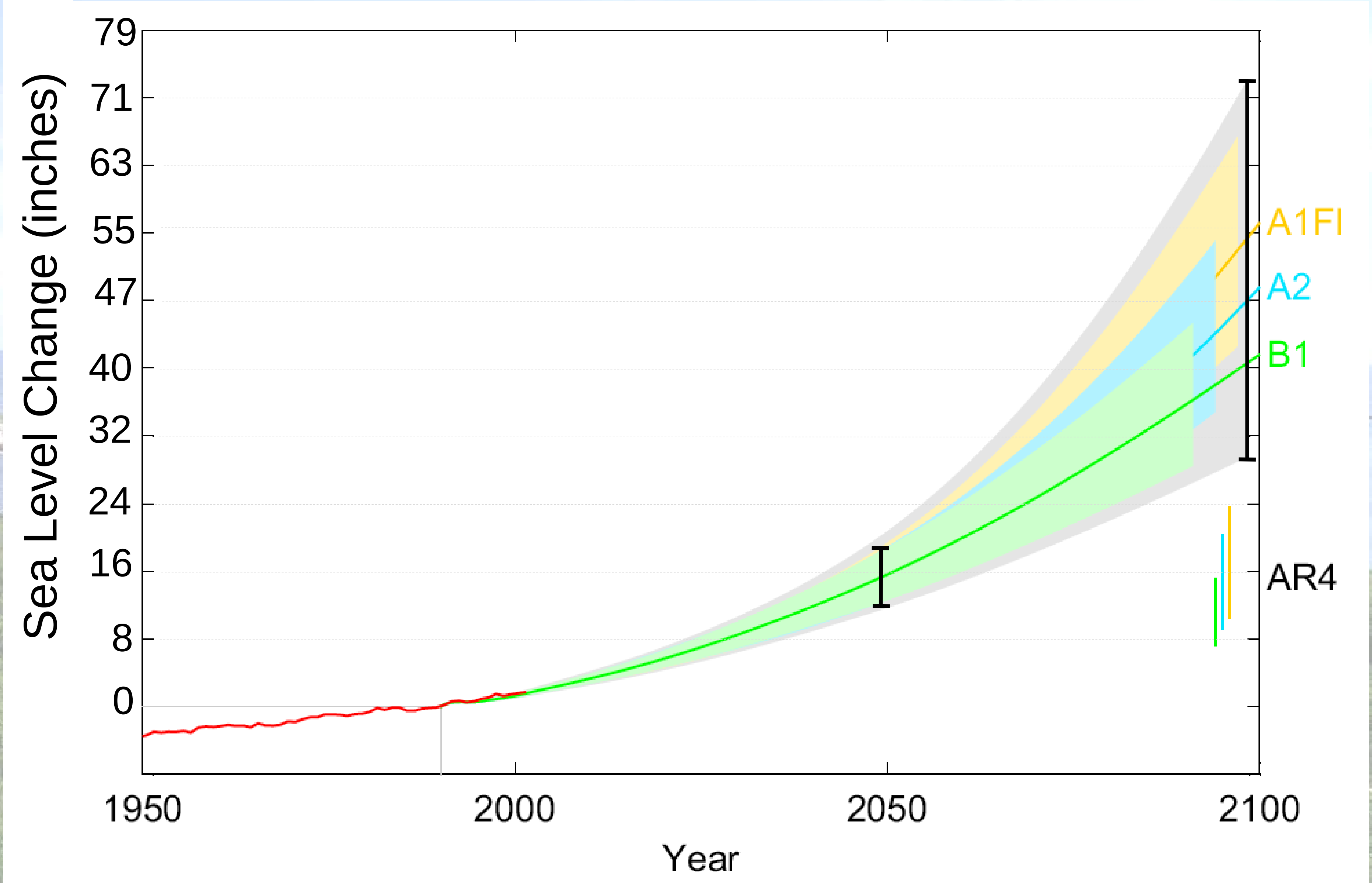


SLR Scenario Ranges



Adapted from Rahmstorf (2010); and Williams (2012)

Projection of Sea Level Rise from 1990 to 2100

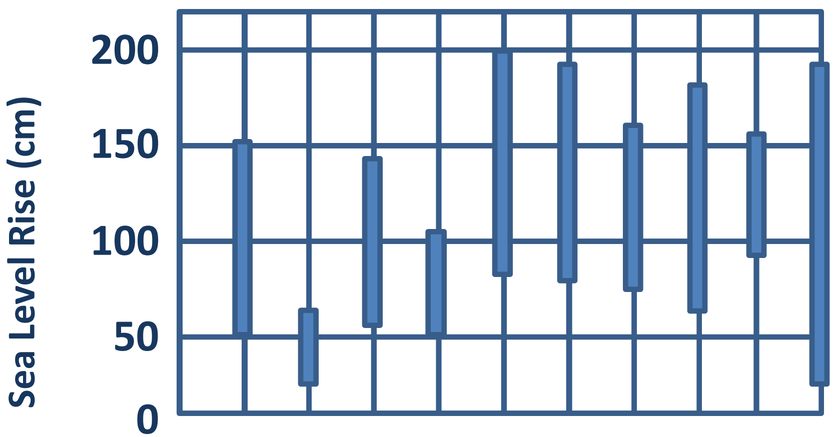


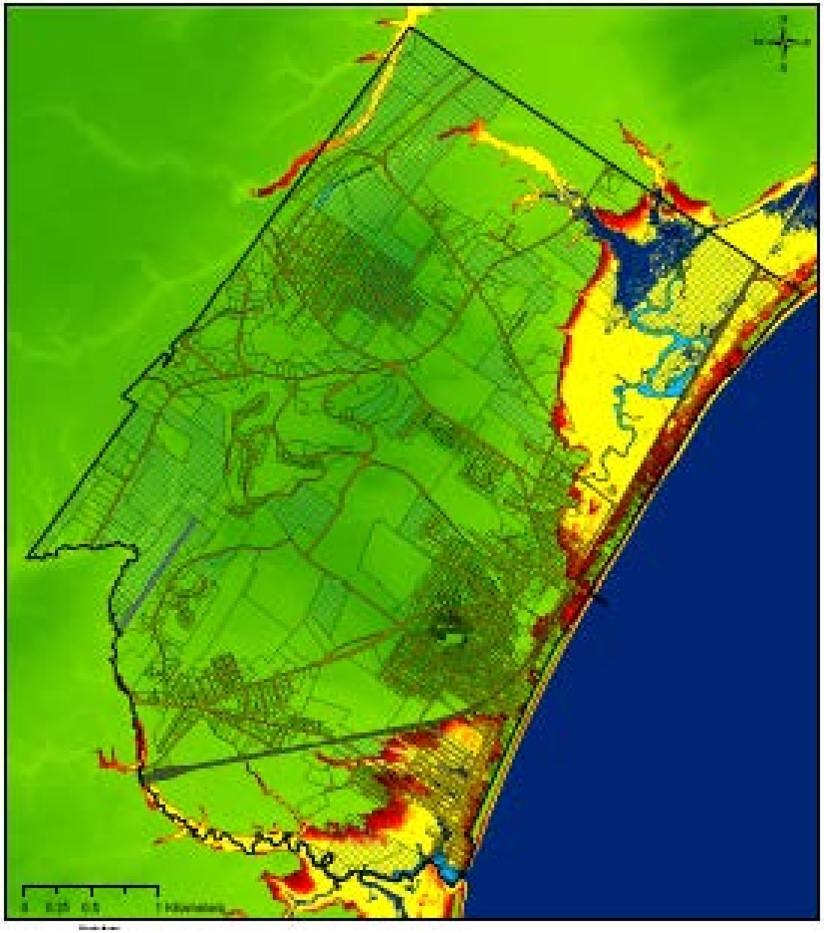
Vermeer and Rahmstorf (2009) Global sea level linked to global temperature. PNAS 106, 21527–21532.

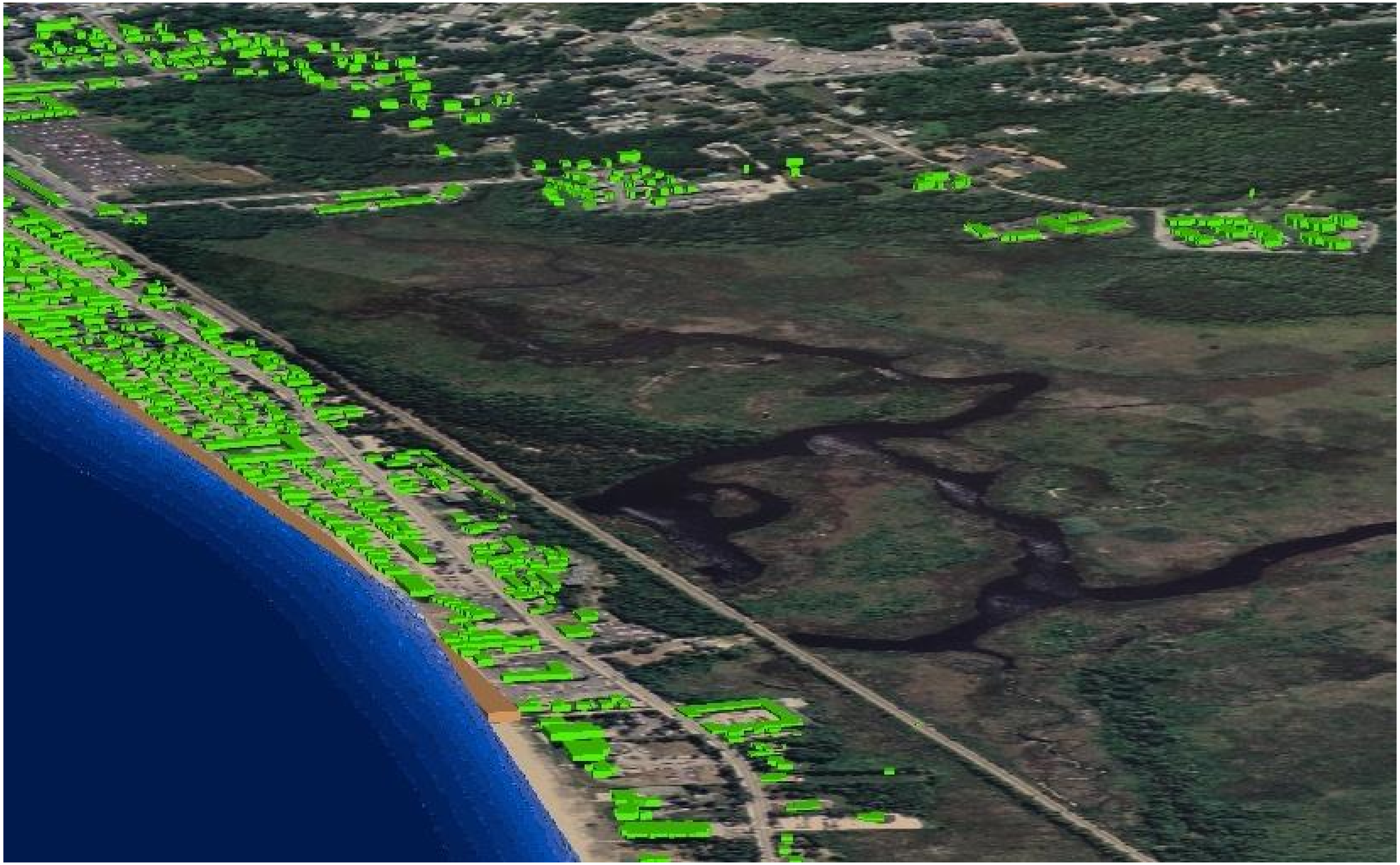
The COAST Strategy

1) Don't discuss climate change.
2) Focus on observed, local data.
3) Use 3D visualization.
4) Use a scenario-based approach.
5) Empower with a sense of possibility

   … then get out of the way.



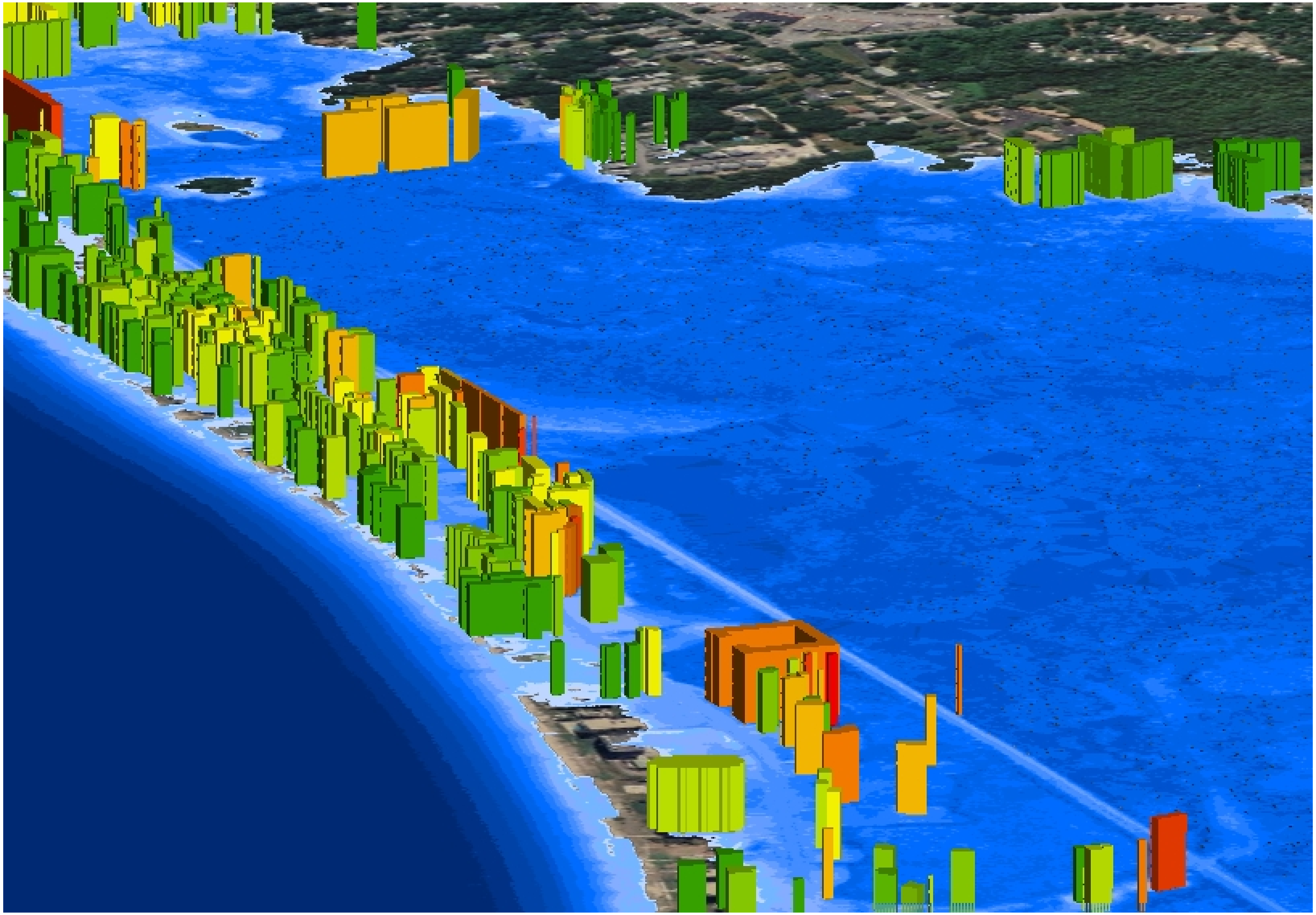




Data for Decision-Making

Damage Functions for Single Family Residential Structures with Basement

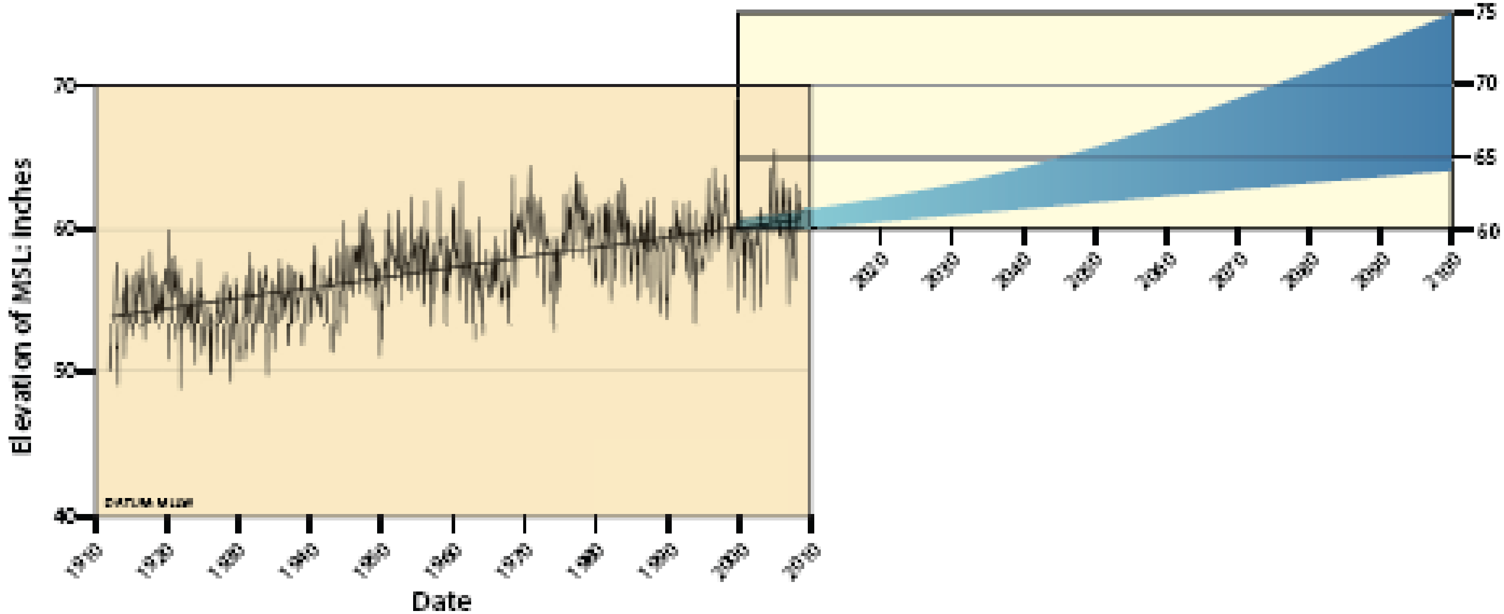
Depth (feet)	Mean of Damage
0	25.5%
1	32.0%
2	38.7%
3	45.5%
4	52.2%
5	58.6%
6	64.5%



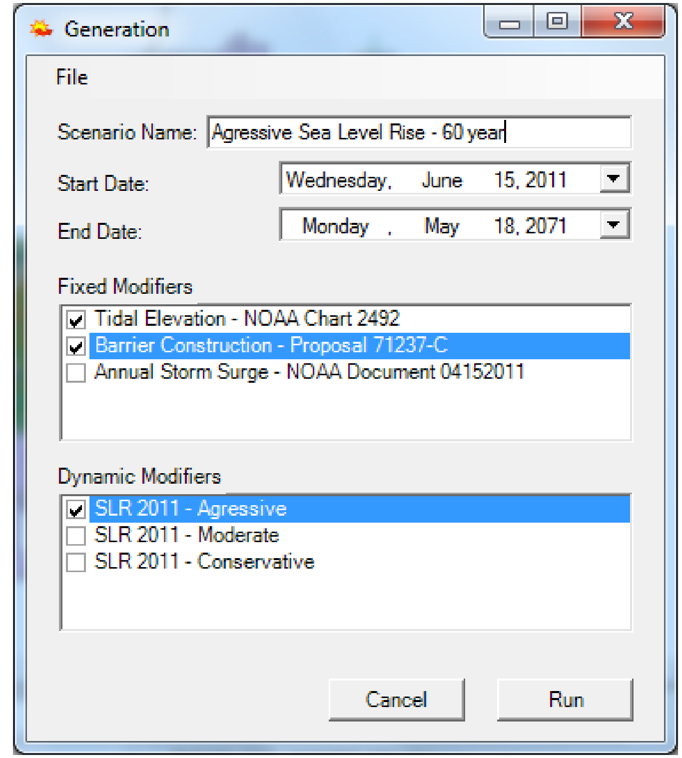
Expected costs and damages, 2010 - 2050

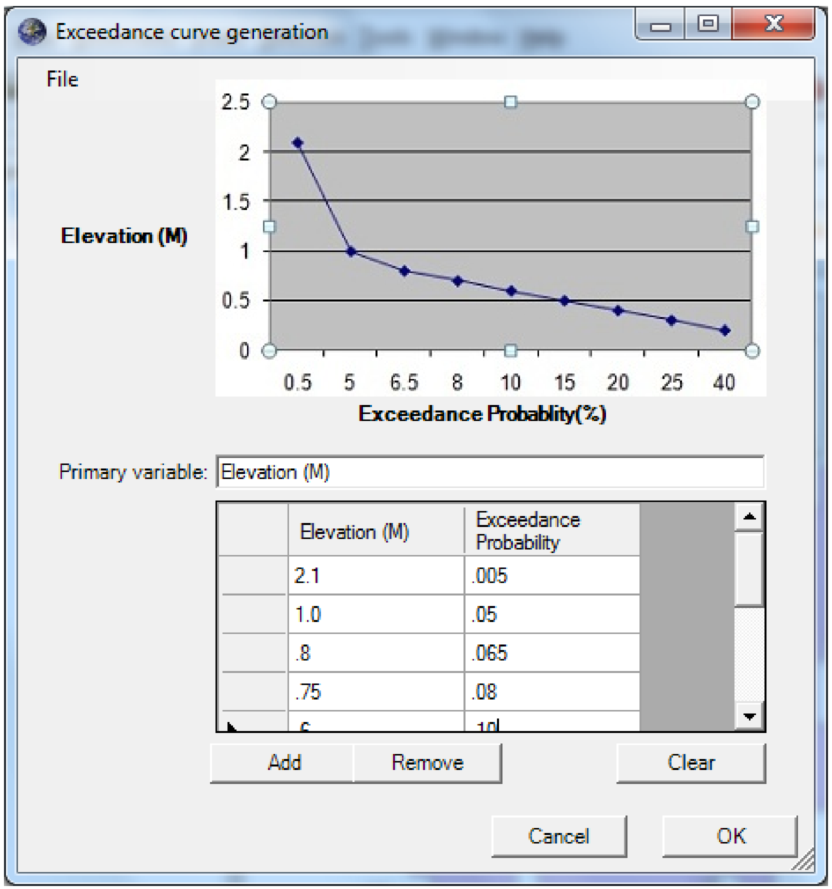
SLR Scenario	Adaptation	Residual Damages ($ million)	Adaptation Cost ($ million)	Total Damages and Costs ($ million)
No SLR	No Action	680	0	680
	50 yr flood	3.4	52.4	55.8
	100 yr flood	0	60	60
Low	No Action	899.3	0	899.3
	50 yr flood	28.3	52.4	80.7
	100 yr flood	0	60	60
High	No Action	1016.6	0	1016.6
	50 yr flood	67.8	52.4	120.2
	100 yr flood	37.6	60	97.6

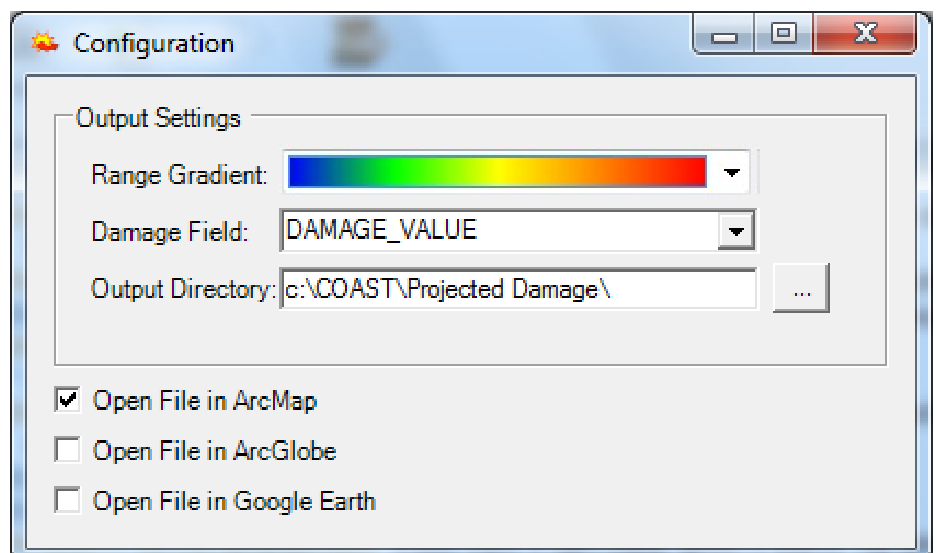
Maine Sea Level, 1912-2100




COAST


Generation
File
Scenario Name: Agressive Sea Level Rise - 60 year
Start Date: Wednesday, June 15, 2011
End Date: Monday, May 18, 2071
Fixed Modifiers
Tidal Elevation - NOAA Chart 2492
Barrier Construction - Proposal 71237-C
Annual Storm Surge - NOAA Document 04152011
Dynamic Modifiers
SLR 2011 - Agressive
SLR 2011 - Moderate
SLR 2011 - Conservative
Cancel
Run


Exceedance curve generation
File
Elevation (M)
2.5
2
1.5
1
0.5
0
0.5 5 6.5 8 10 15 20 25 40
Exceedance Probablity(%)
Primary variable: Elevation (M)
Elevation (M)
Exceedance Probability
2.1 .005
1.0 .05
.8 .065
.75 .08
Add
Remove
Clear
Cancel
OK


Configuration
Output Settings
Range Gradient:
Damage Field: DAMAGE_VALUE
Output Directory: c:\COAST\Projected Damage\
...
Open File in ArcMap
Open File in ArcGlobe
Open File in Google Earth

Climatic Change
DOI 10.1007/s10584-011-0379-z

Simplified method for scenario-based risk assessment adaptation planning in the coastal zone

Paul Kirshen · Samuel Merrill · Peter Slovinsky · Norman Richardson

Received: 16 November 2009 / Accepted: 14 November 2011

COAST Programming Status

- Currently runs as an extension in ArcMap v.9 and 10
- Currently requires Spatial Analyst

- Converting to a subset of Global Mapper, no Arc required
- <u>Will remain a free download</u>, on the NE/EFC website
- Expected online release date for v1.0: Q2 2013

BLUE MARBLE GEOGRAPHICS
MIND THE GAP BETWEEN WORLD AND MAP

The COAST Process

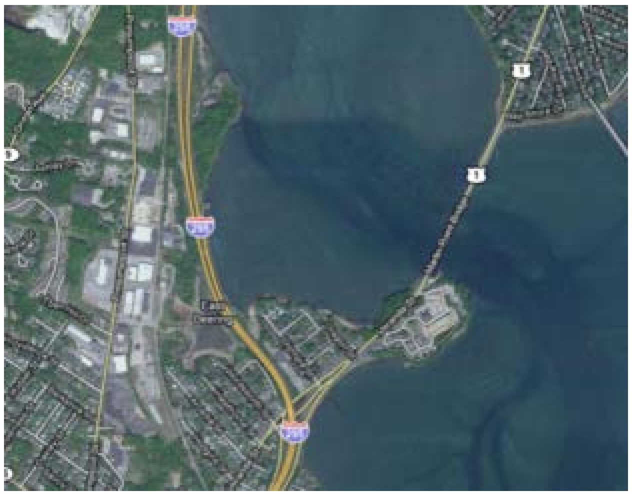
1. Specify location and vulnerable asset
2. Select time horizons, SLR and SS thresholds
3. Select adaptation action, estimate costs
4. Input Depth Damage Function
5. Input reference data (parcel, elevation, etc)
6. Run the model
7. Use maps and tables in public process

Possible Assets to Model

- Real estate values
- Economic output
- Public health impacts
- Displaced persons, vulnerable demographics
- Natural resources values
- Cultural resources values
- Community impacts
- Infrastructure (transportation, energy, facilities, telecommunications)

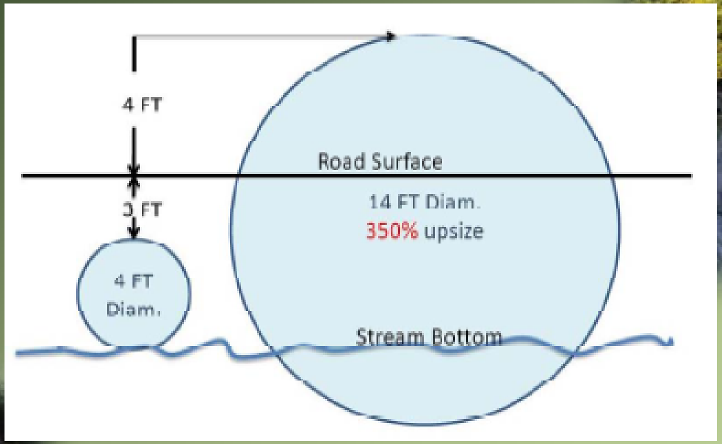
Machias Bridge, Machias

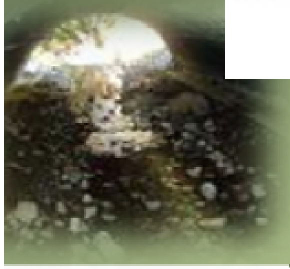
(pressure transducer placed in 8/11)



Martin's Point Bridge, Falmouth

A Financial Impact Assessment of LD 1725: Stream Crossings



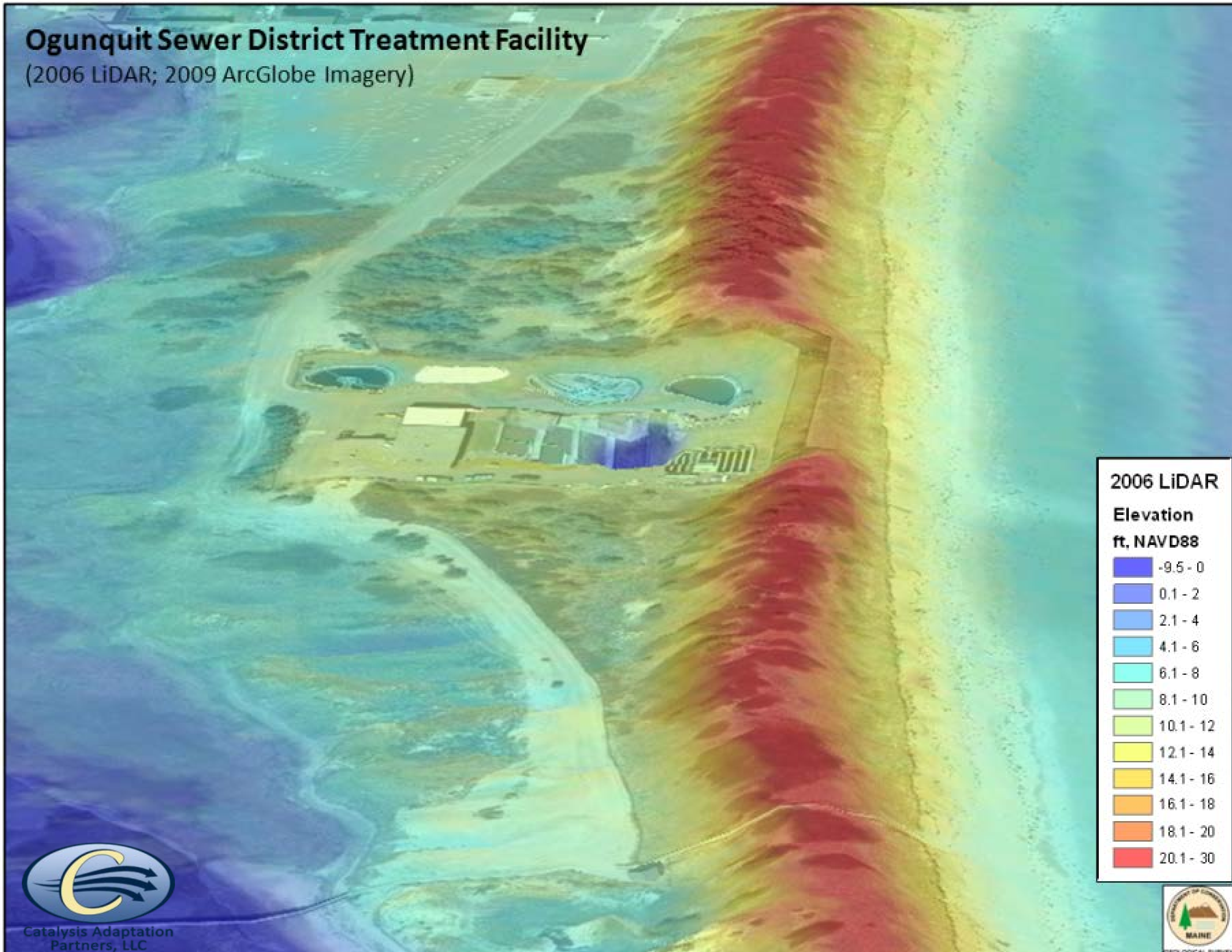


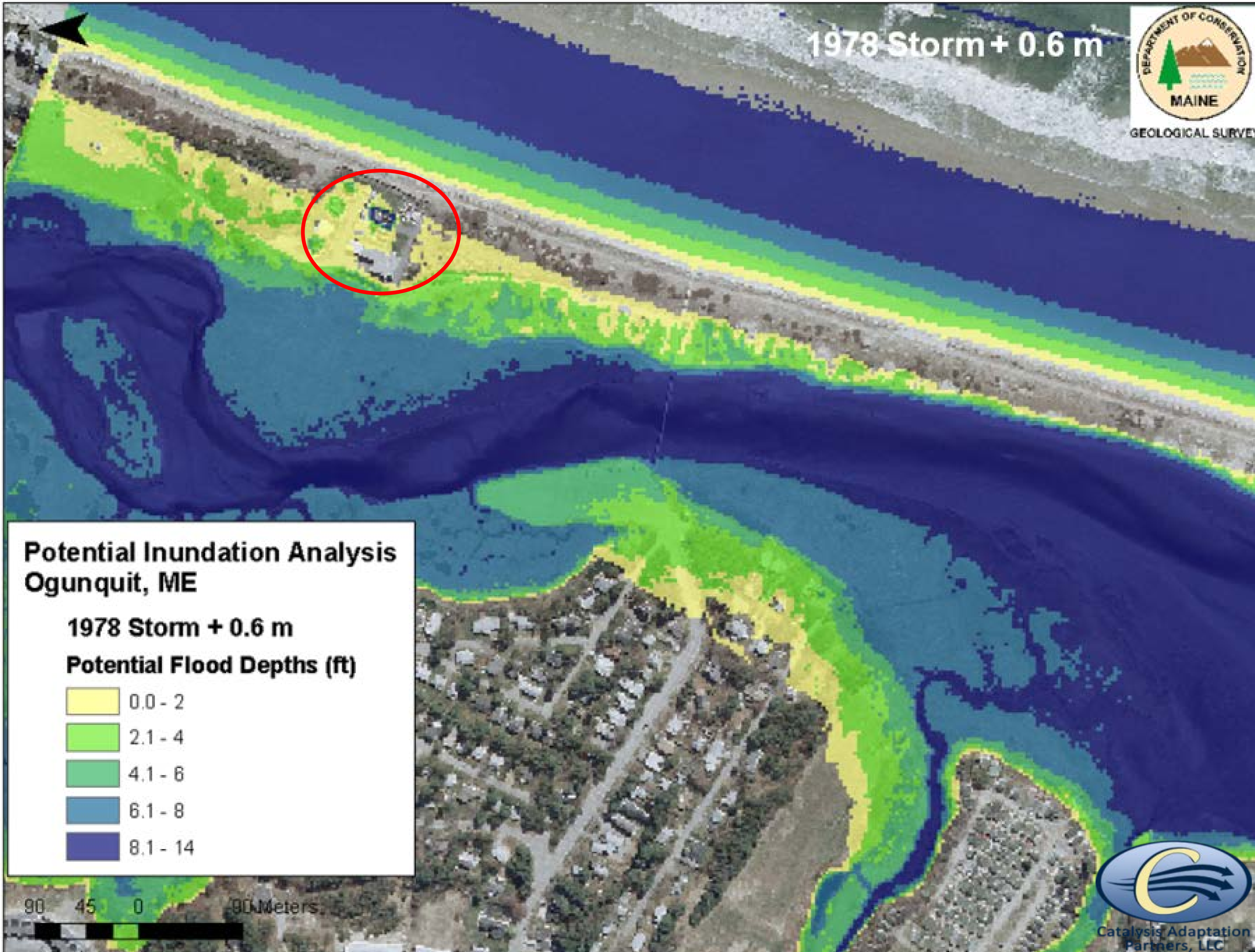
How much to upsize? Should we?

Prepared by: The New England Environmental Finance Center
For the Maine Department of Transportation Office of Environmental Planning

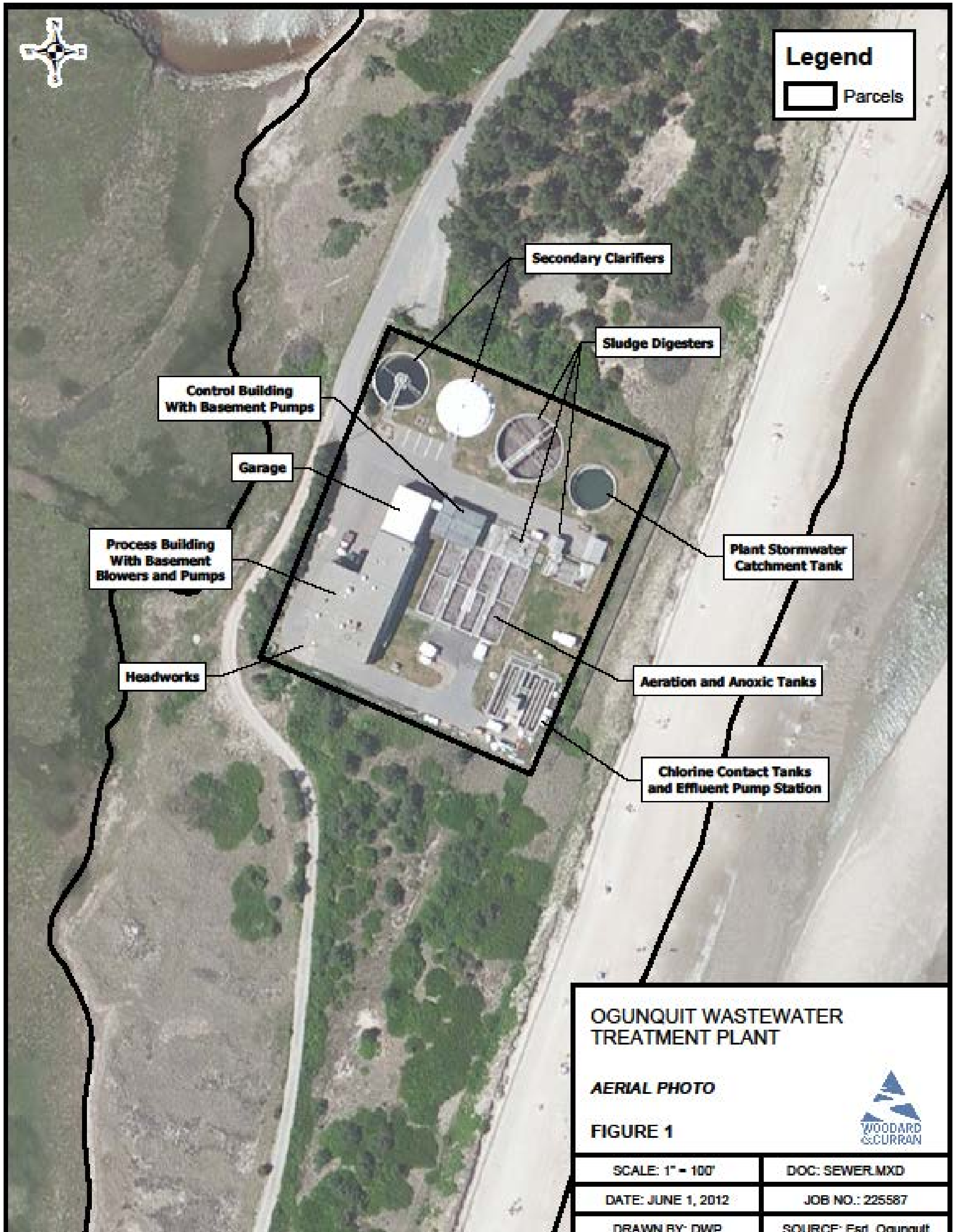

Treatment Plant
Ogunquit
Wells
Catalysis Adaptation Partners, LLC
E
N
S
W
SOUTHERN MAINE REGIONAL PLANNING COMMISSION
Ogunquit Sewage Treatment Plant
2006 Aerial Photography
1 inch = 50 feet
Feet
0
500


Pumping Sta. #1
Generator
View Across the Marsh
From Roof of Ogunquit
Sewage Treatment Plant
April 2007 Patriot's Day
Storm
Catalysis Adaptation Partners, LLC


Ogunquit Sewer District Treatment Facility
(2006 LiDAR; 2009 ArcGlobe Imagery)
2006 LiDAR
Elevation
ft, NAVD88
-9.5 - 0
0.1 - 2
2.1 - 4
4.1 - 6
6.1 - 8
8.1 - 10
10.1 - 12
12.1 - 14
14.1 - 16
16.1 - 18
18.1 - 20
20.1 - 30
Catalysis Adaptation Partners, LLC



For general planning purposes only.



OGUNQUIT WASTEWATER TREATMENT PLANT

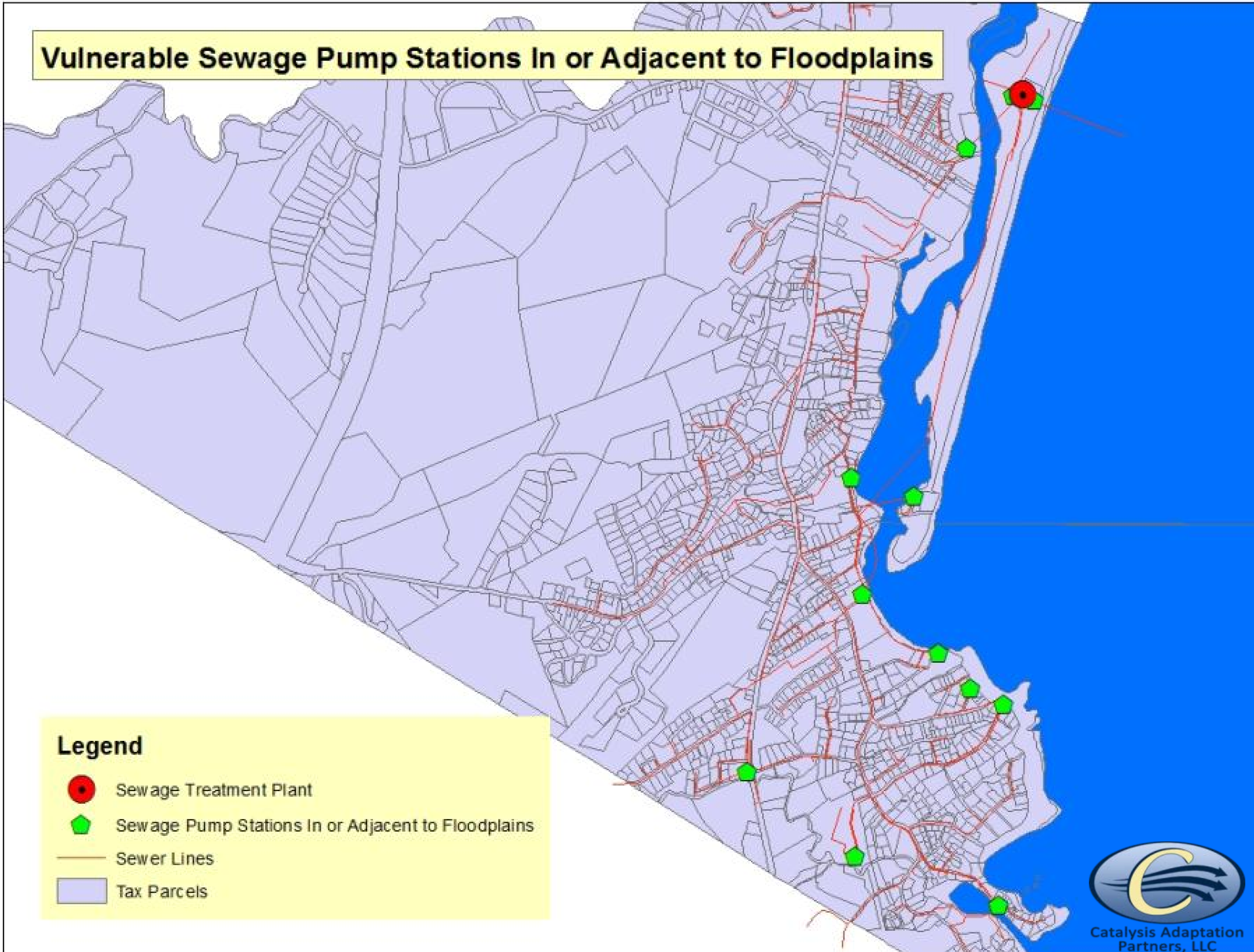
AERIAL PHOTO

FIGURE 1

WOODARD & CURRAN

SCALE: 1" = 100'	DOC: SEWER.MXD
DATE: JUNE 1, 2012	JOB NO.: 225587
DRAWN BY: DWP	SOURCE: Esri, Ogunquit

Catalysis Adaptation Partners, LLC


Vulnerable Sewage Pump Stations In or Adjacent to Floodplains
Legend
Sewage Treatment Plant
Sewage Pump Stations In or Adjacent to Floodplains
Sewer Lines
Tax Parcels
Catalysis Adaptation Partners, LLC

Controversial Adaptation Solution?

Adaptation Actions: Hard or Soft

- Revetments

Pea Patch Island, DE (Delaware River)

Wetland Impacts

"The impact of sea level rise on coastal wetlands will depend in large measure on whether developed areas immediately inland of the marsh are protected from rising sea level by levees and bulkheads. In a Charleston case study, protecting developed areas would increase an 80 percent wetland loss to 90 percent for a five-foot rise. In a nationwide analysis, structural protection would increase a 30-80 percent loss to 50-90 percent."

EPA's Office of Policy, Planning, and Evaluation
(http://papers.risingsea.net/Sea-level-rise-and-coastal-wetlands.html)

Adaptation Actions: Hard or Soft

- Revetments
- Geotextile tubes


Harwich Port
© 2010 Google
© 2010 Europa Technologies
©2009

Side Note: New Wetlands Projects Starting in 3 Maine Towns

- NOAA funded through Maine State Planning Office
- RFP out, town applications received.

Side Note: New Wetlands Projects Starting in 3 Maine Towns

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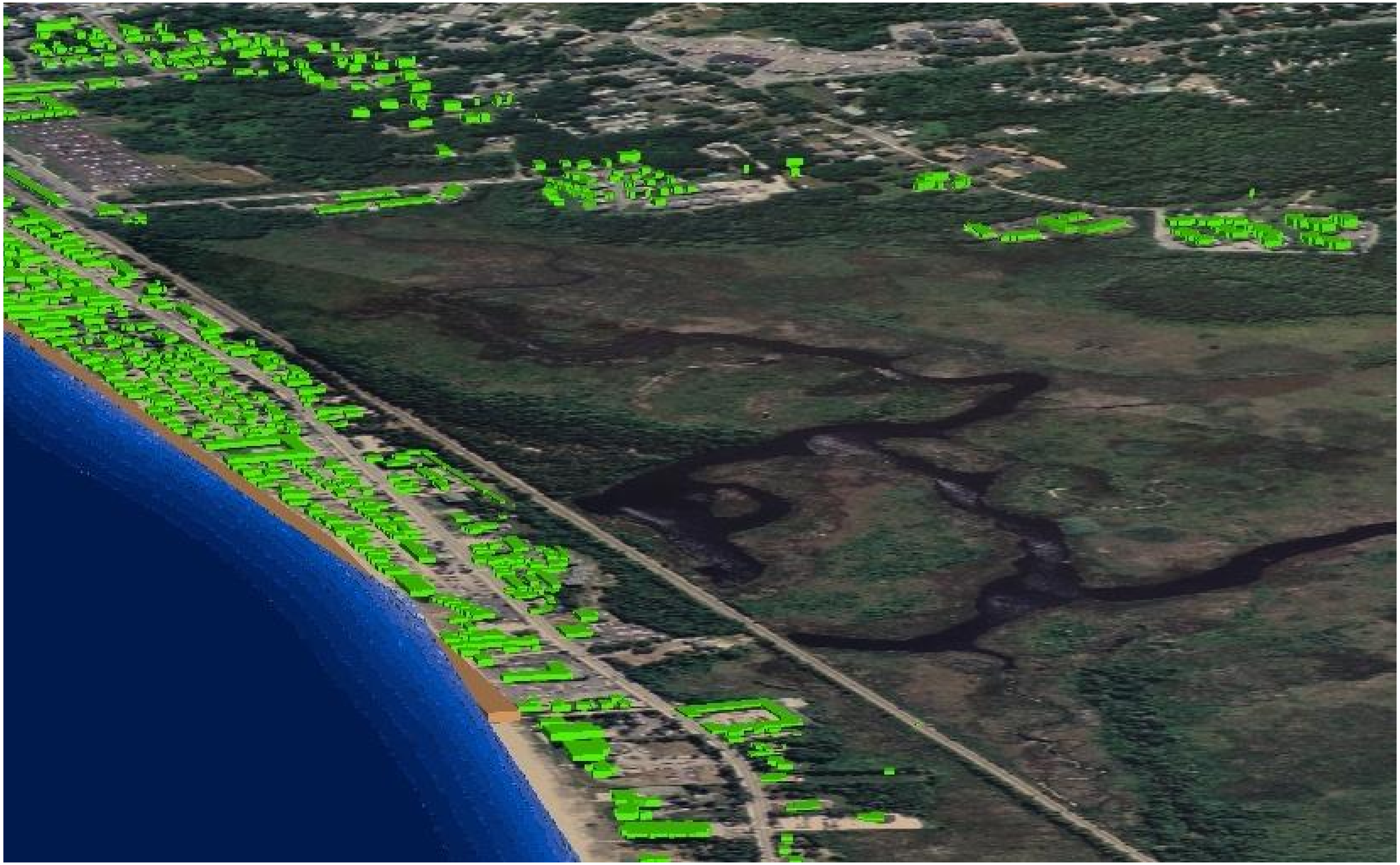
- RFP out, town applications received.
  - Conduct COAST runs to analyze <u>not vulnerability</u>, but
  - <u>Opportunity</u> for proactive creation of wetland function

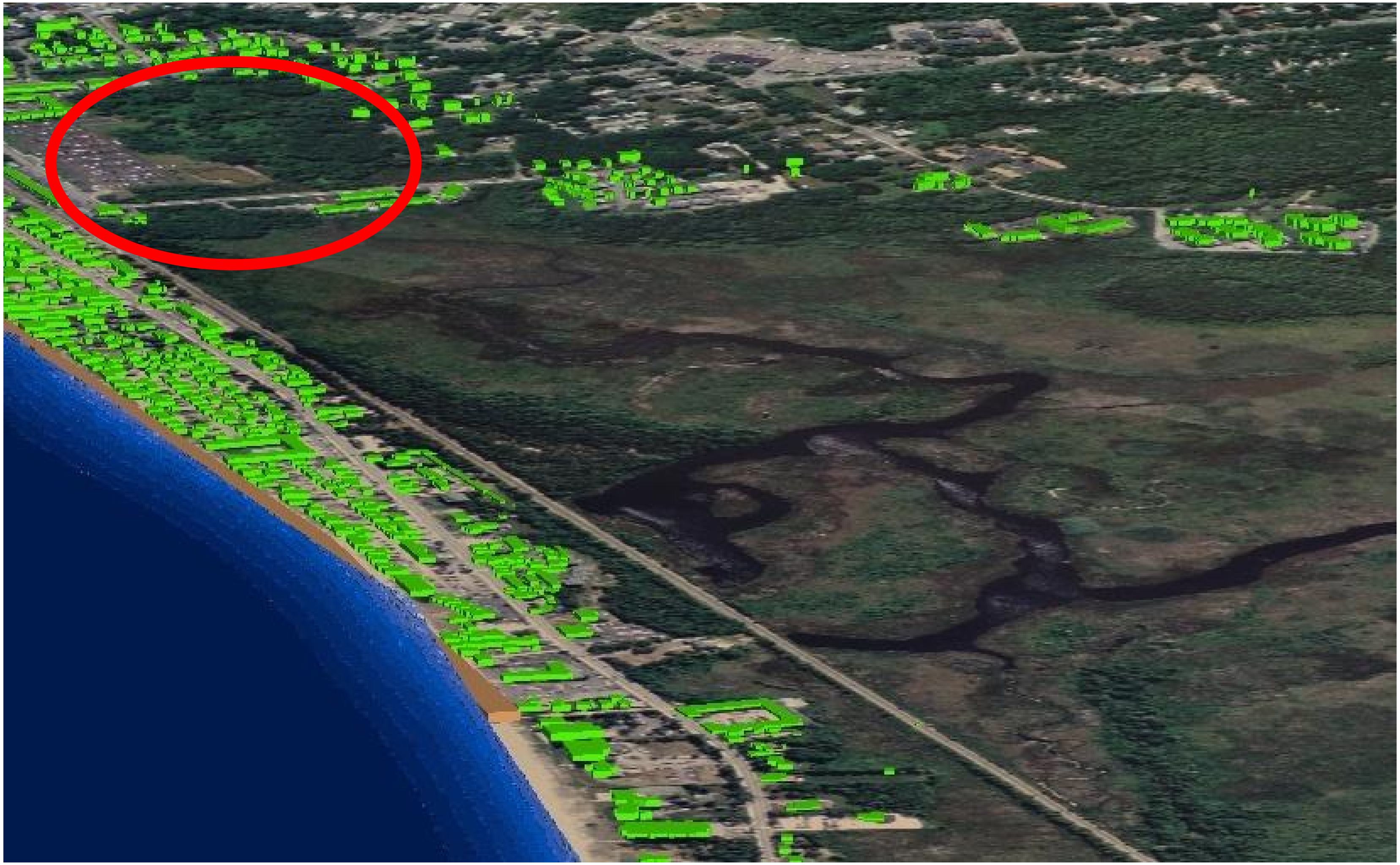
Side Note: New Wetlands Projects Starting in 3 Maine Towns

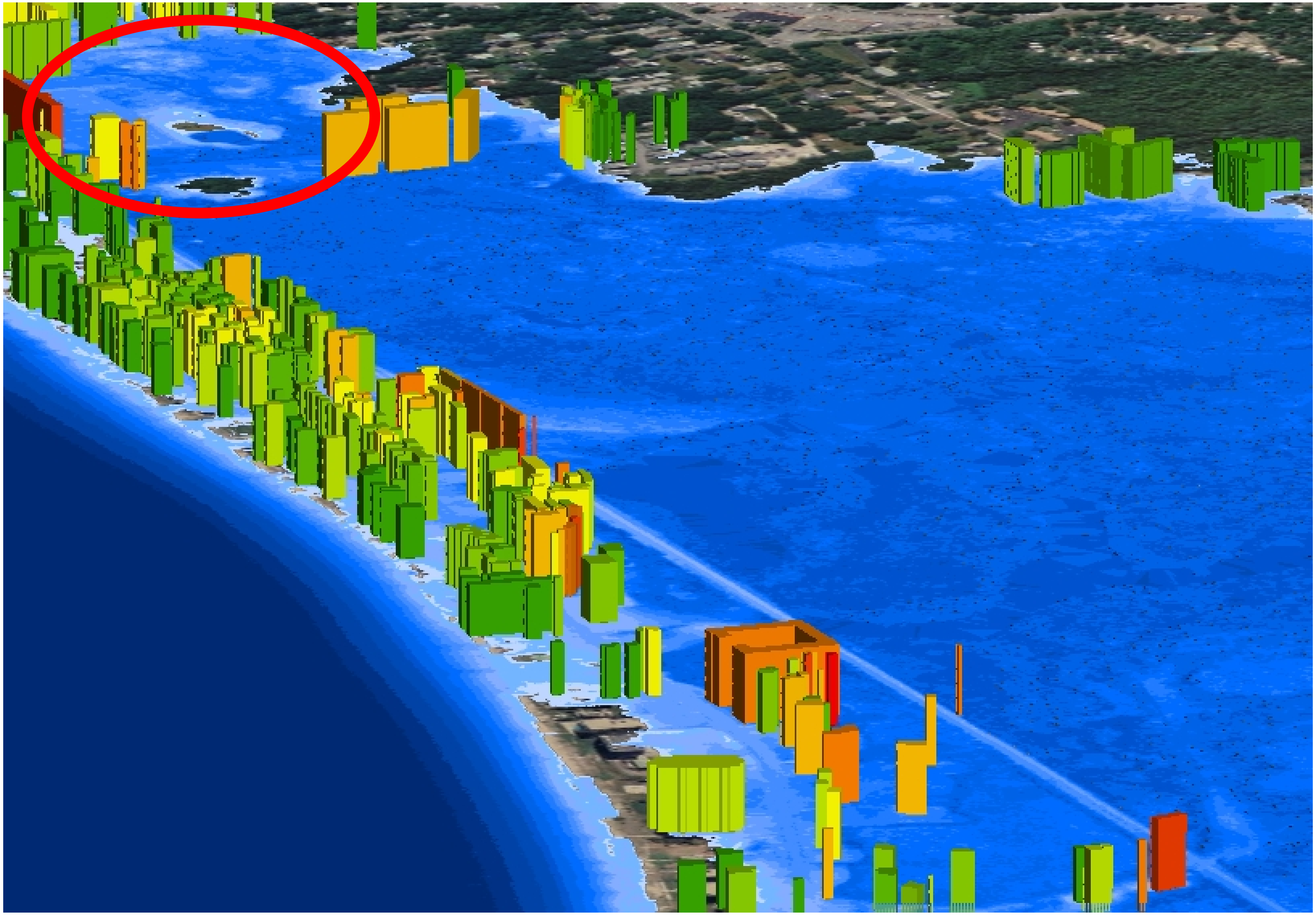
- NOAA funded through Maine State Planning Office
- RFP out, town applications received.

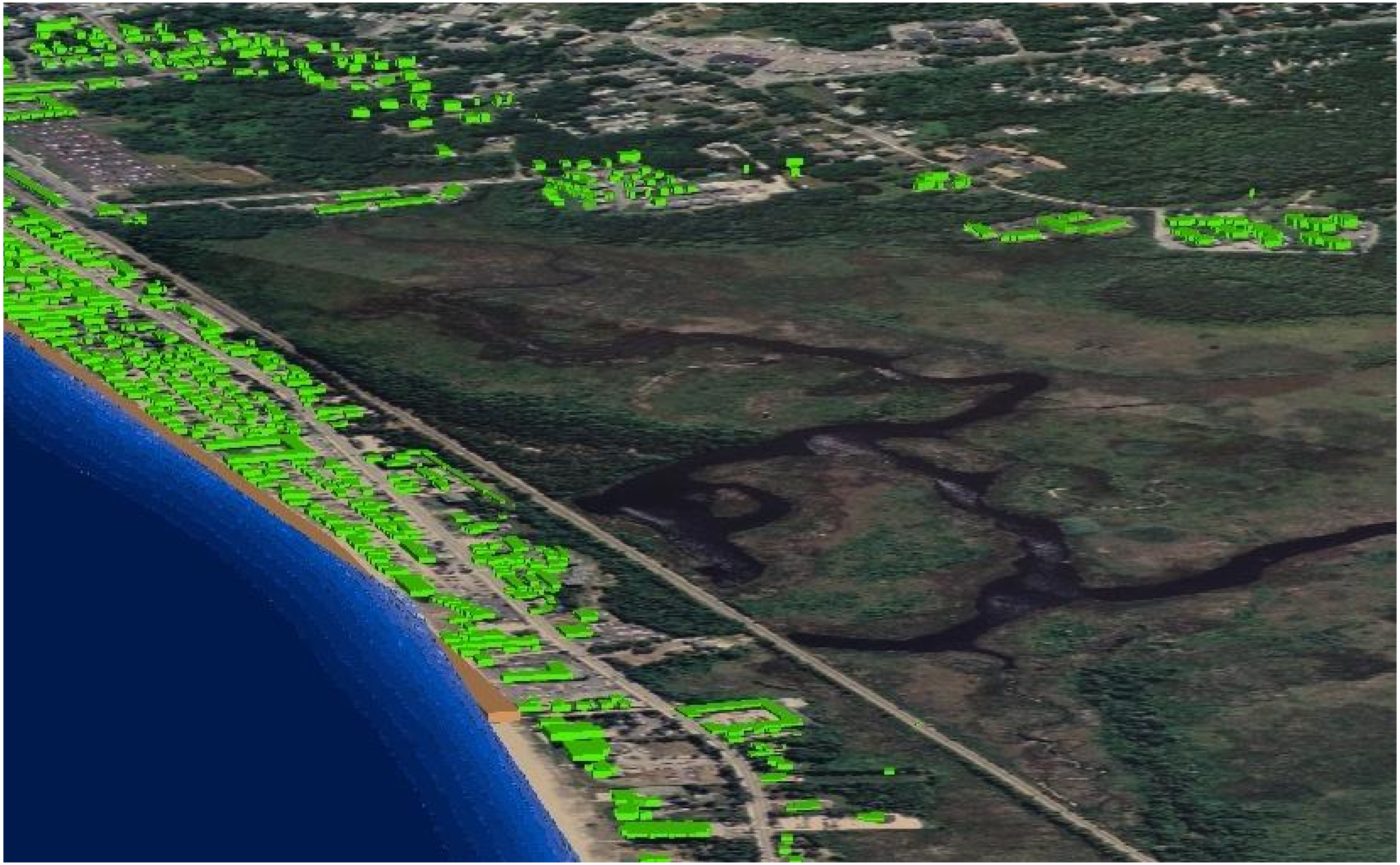
  – Conduct COAST runs to analyze not vulnerability, but
  – Opportunity for proactive creation of wetland function

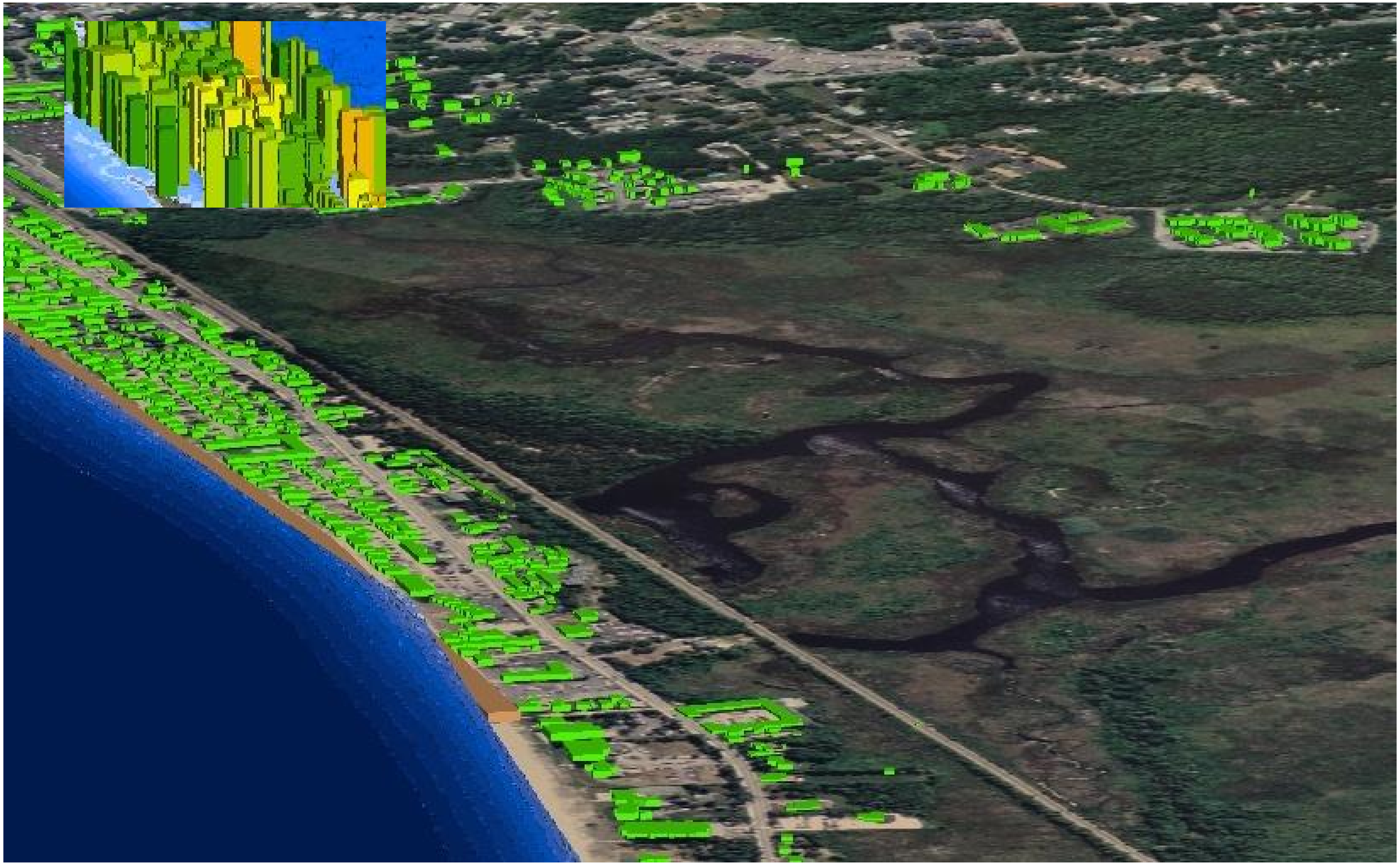
  – Not a depth damage function
  but a
  – Value creation function

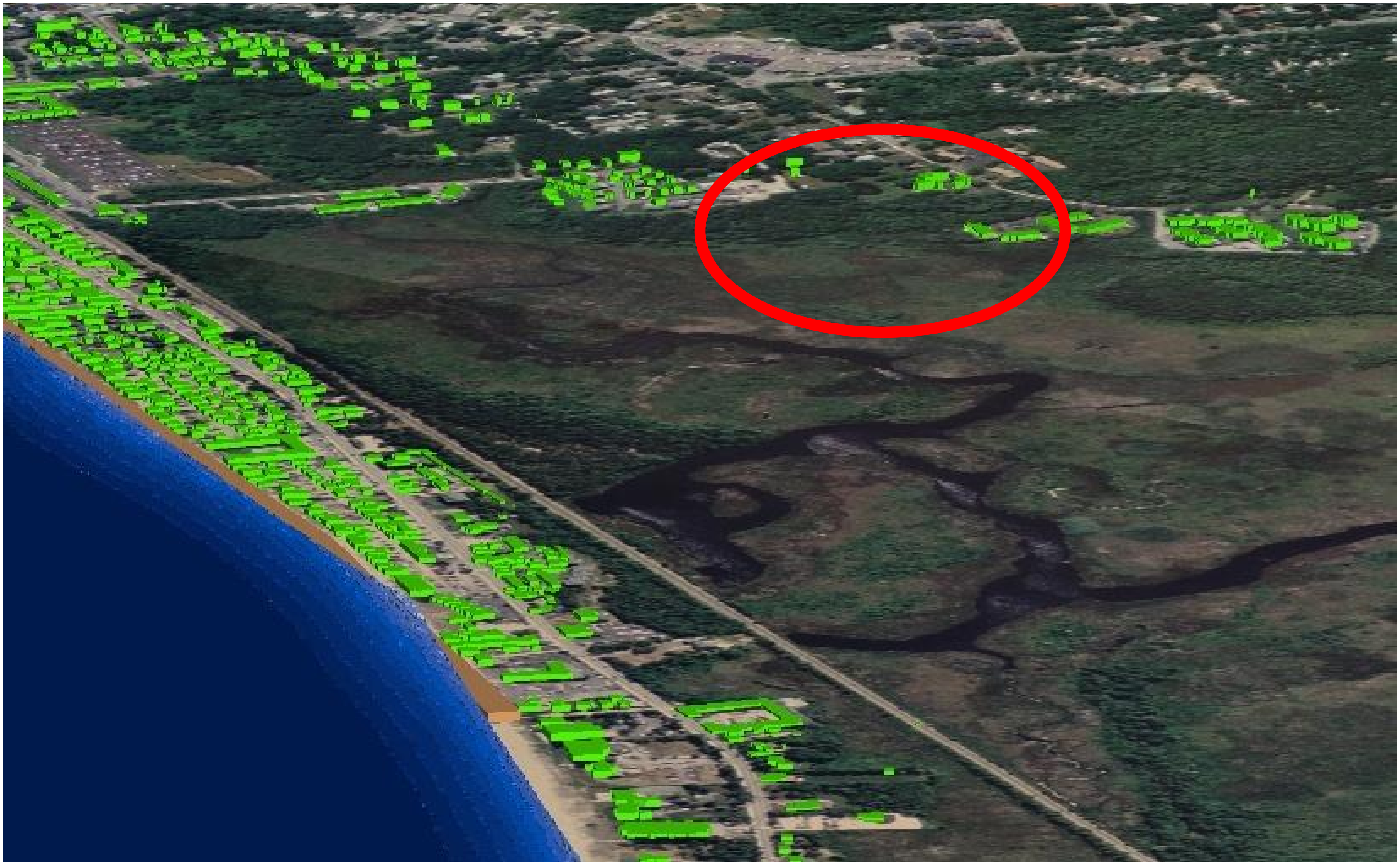


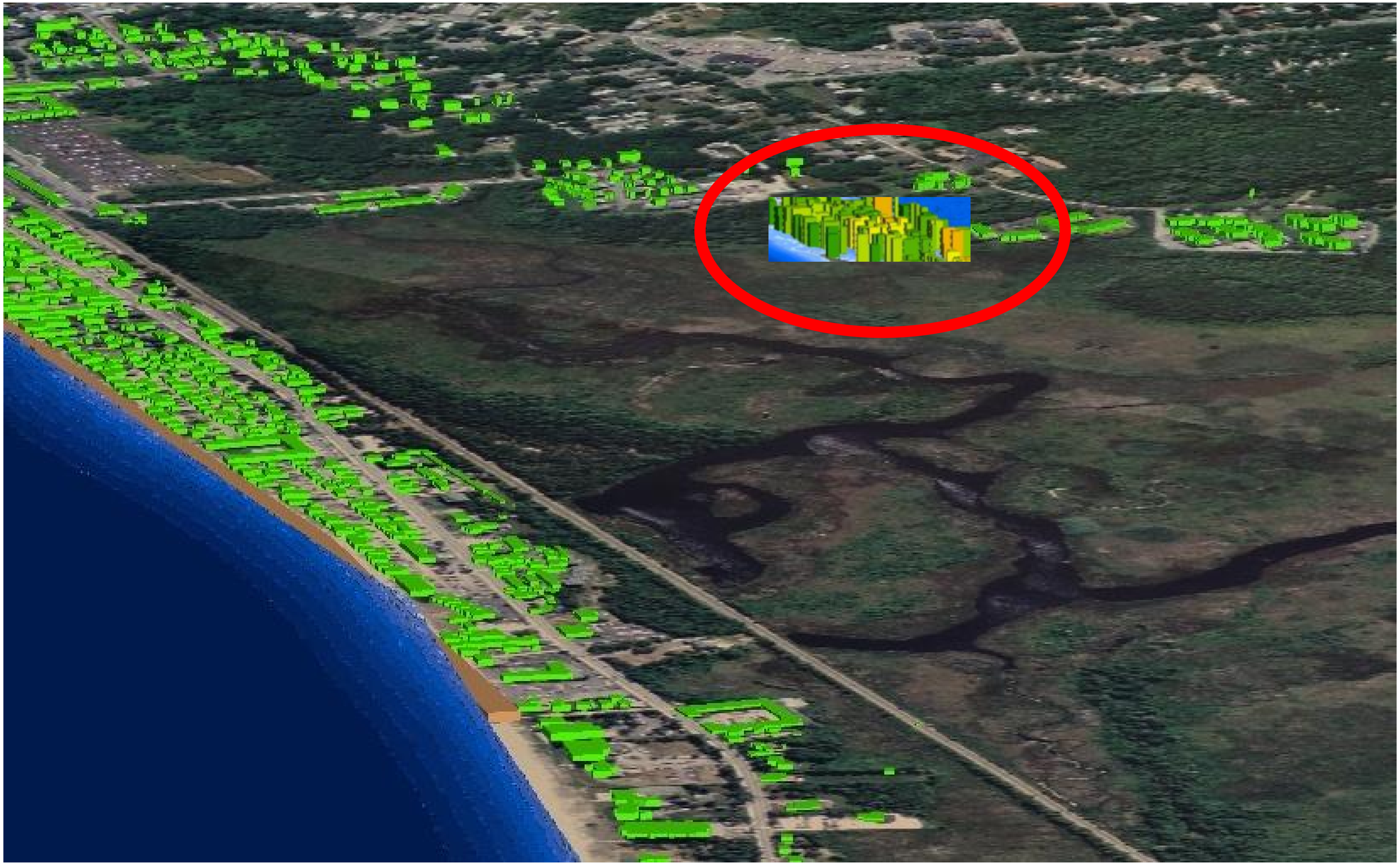






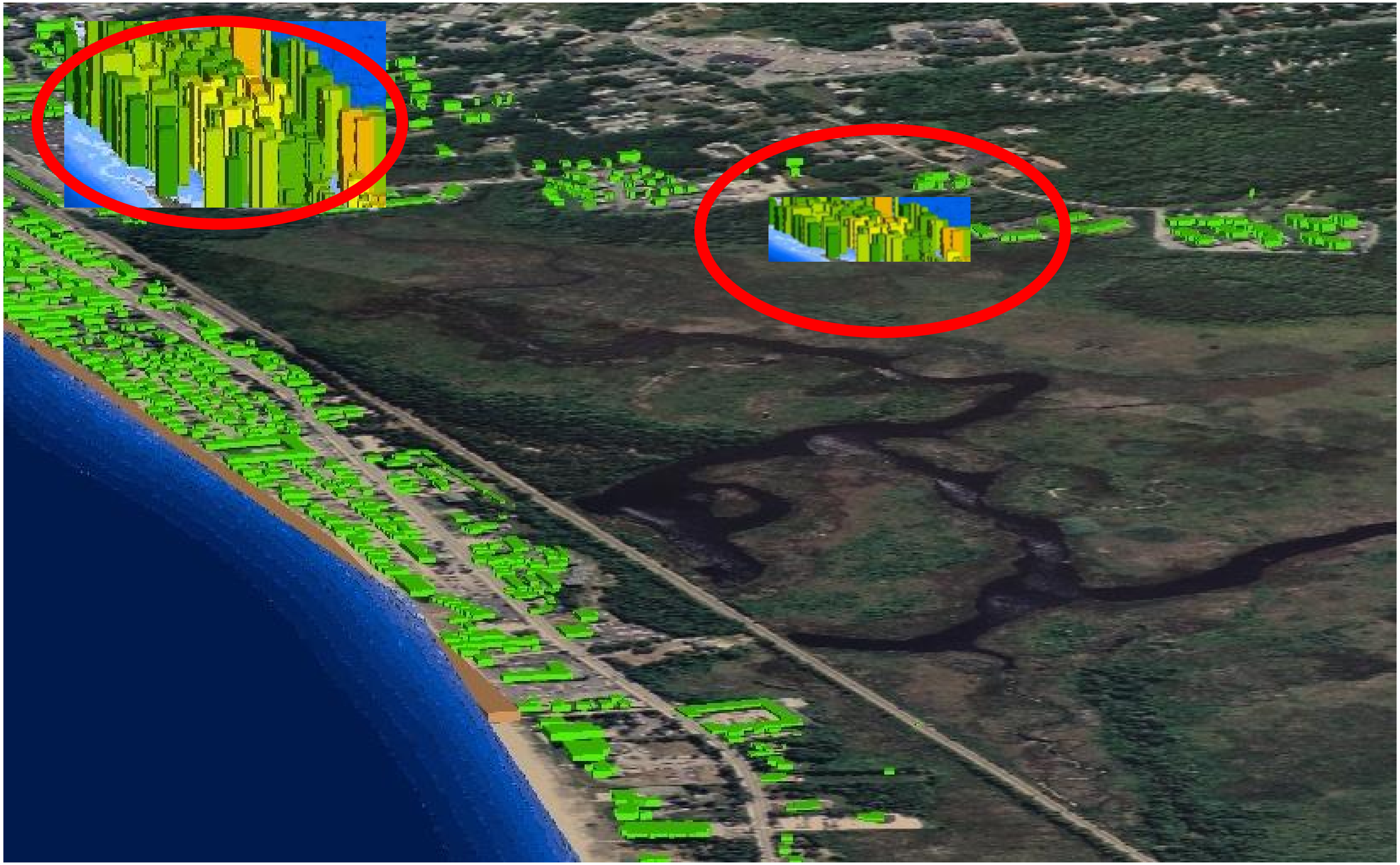






Adaptation Scenario 1

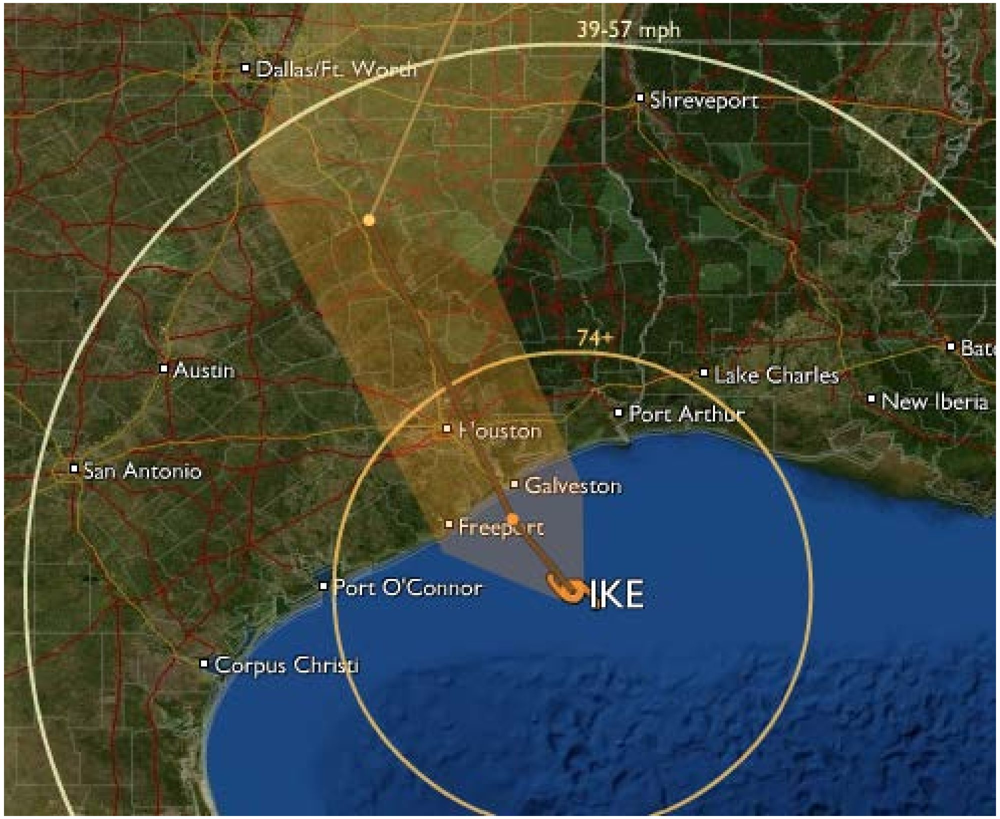
Adaptation Scenario 2



Adaptation Actions: Hard or Soft

- Revetments
- Geotextile tubes
- Sea walls





39-57 mph
Dallas/Ft. Worth
Shreveport
74+
Austin
Lake Charles
New Iberia
Port Arthur
Houston
San Antonio
Galveston
Freeport
Port O'Connor
IKE
Corpus Christi

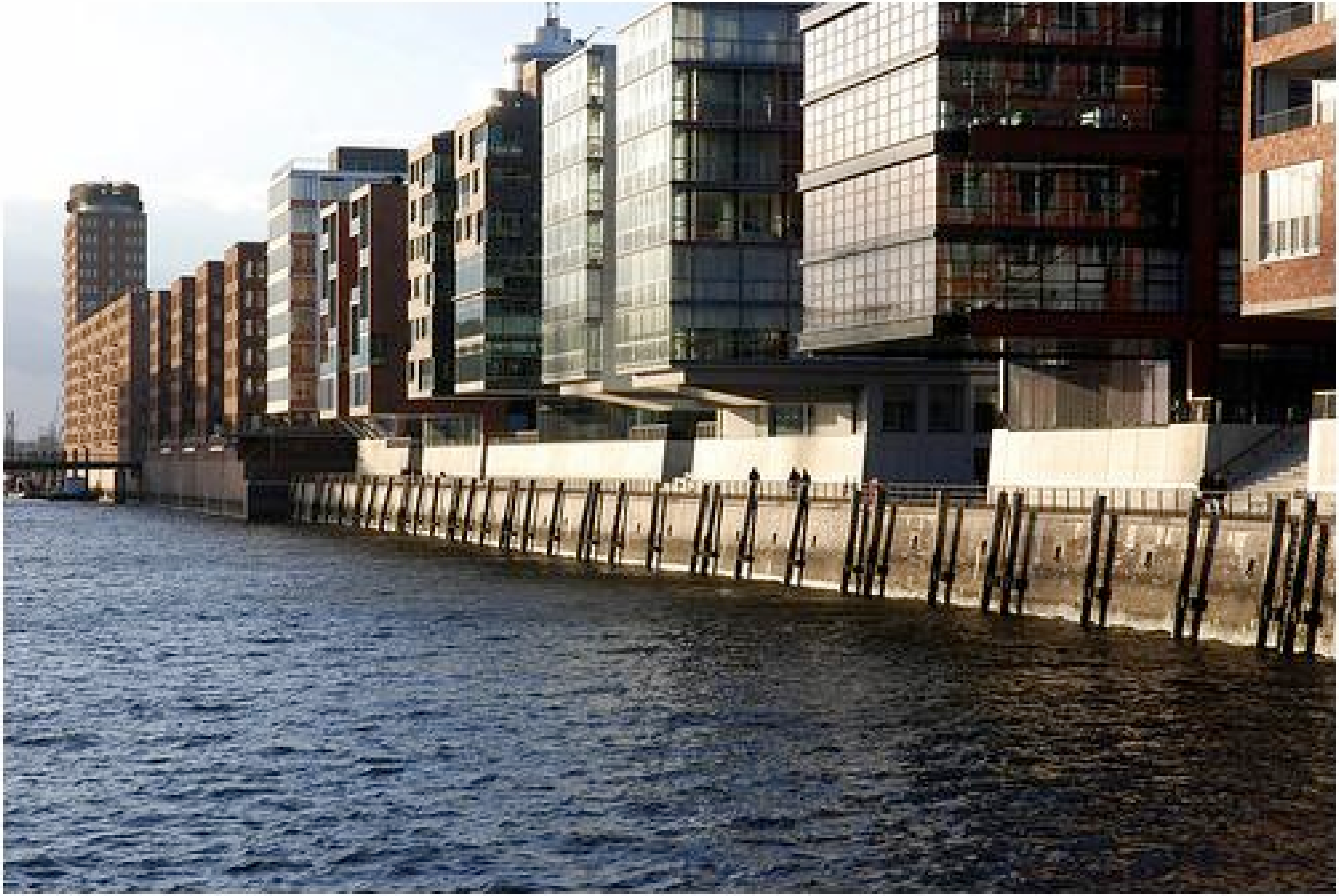
Input: a range of adaptation options

- Revetments
- Geotextile tubes
- Sea walls
- Jetties

Adaptation Actions: Hard or Soft

- Revetments
- Geotextile tubes
- Sea walls
- Jetties
- Other creative approaches

Floodwalls with removable aluminum or steel gates. Cologne, Germany (Rhine).



Buildings have a “hardened” 1st story along a wide pedestrian walkway.

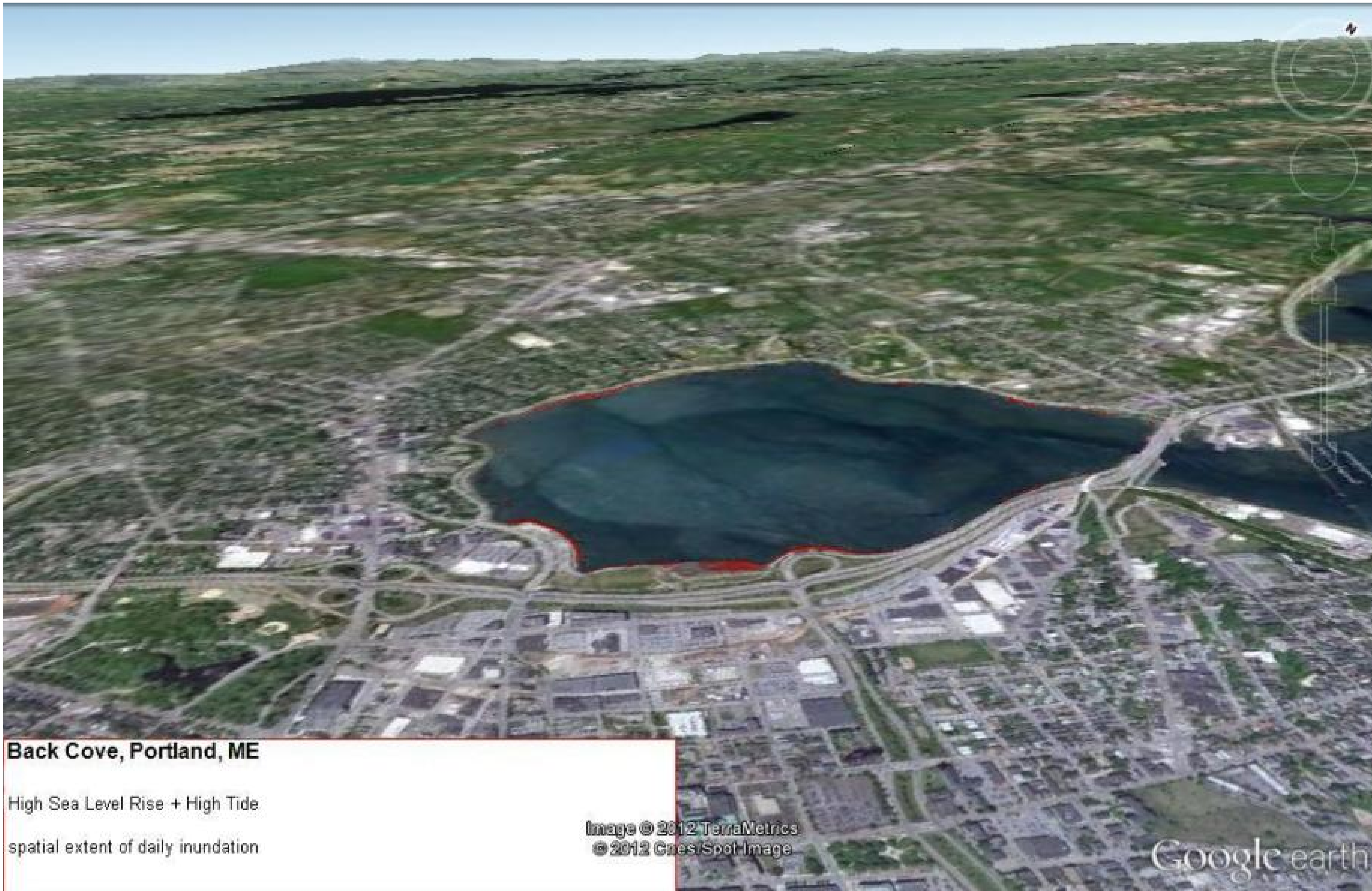
Urban design strategy: Hamburg, city on the water

Adaptation Actions: Hard or Soft

- Revetments
- Geotextile tubes
- Sea walls
- Jetties
- Other creative approaches

- Wet or dry floodproofing
- Incentives, zoning, and other regulatory changes

Back Cove, Portland Maine

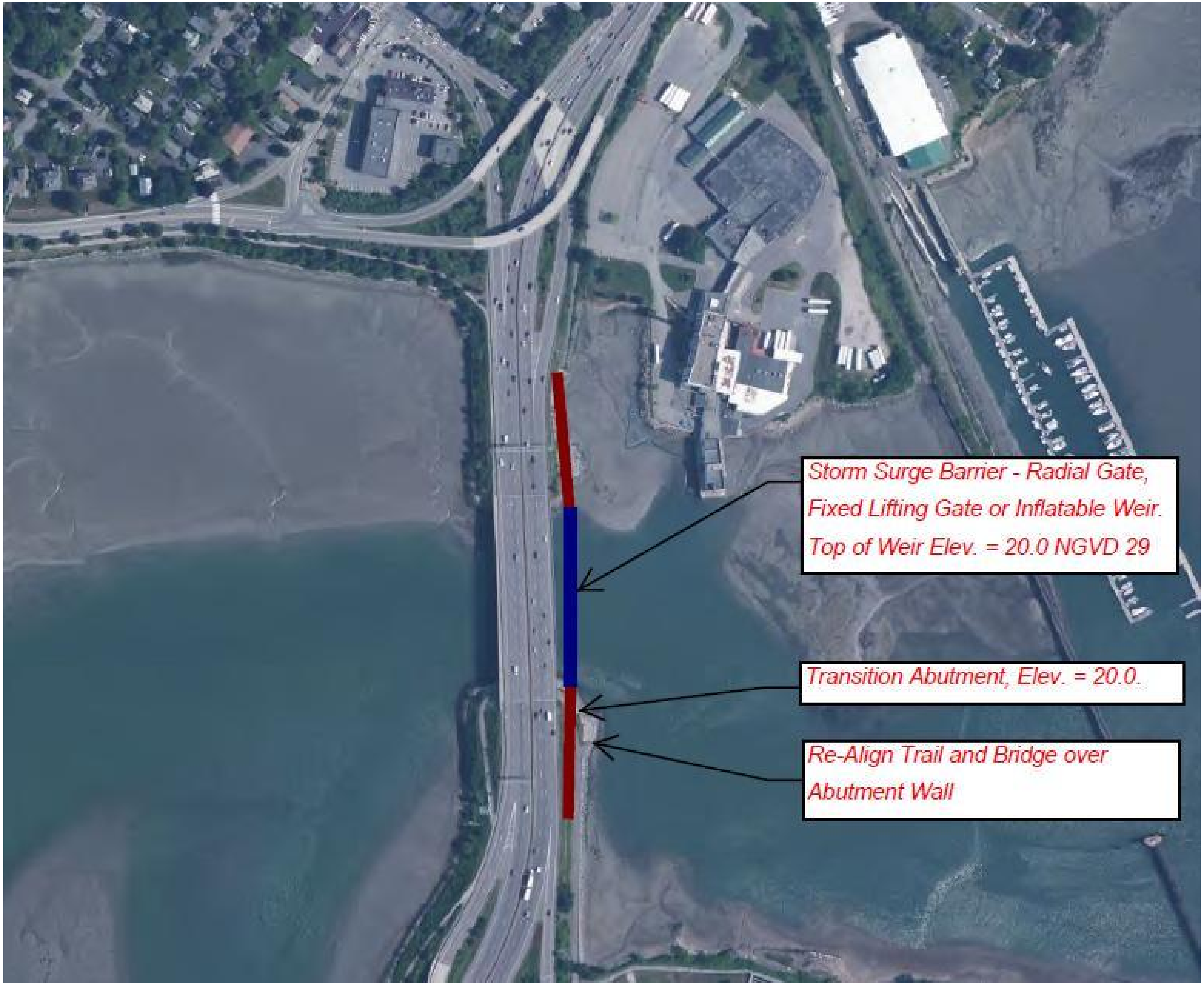


2100, high sea level rise and mean higher high water

Now the Portland Case:

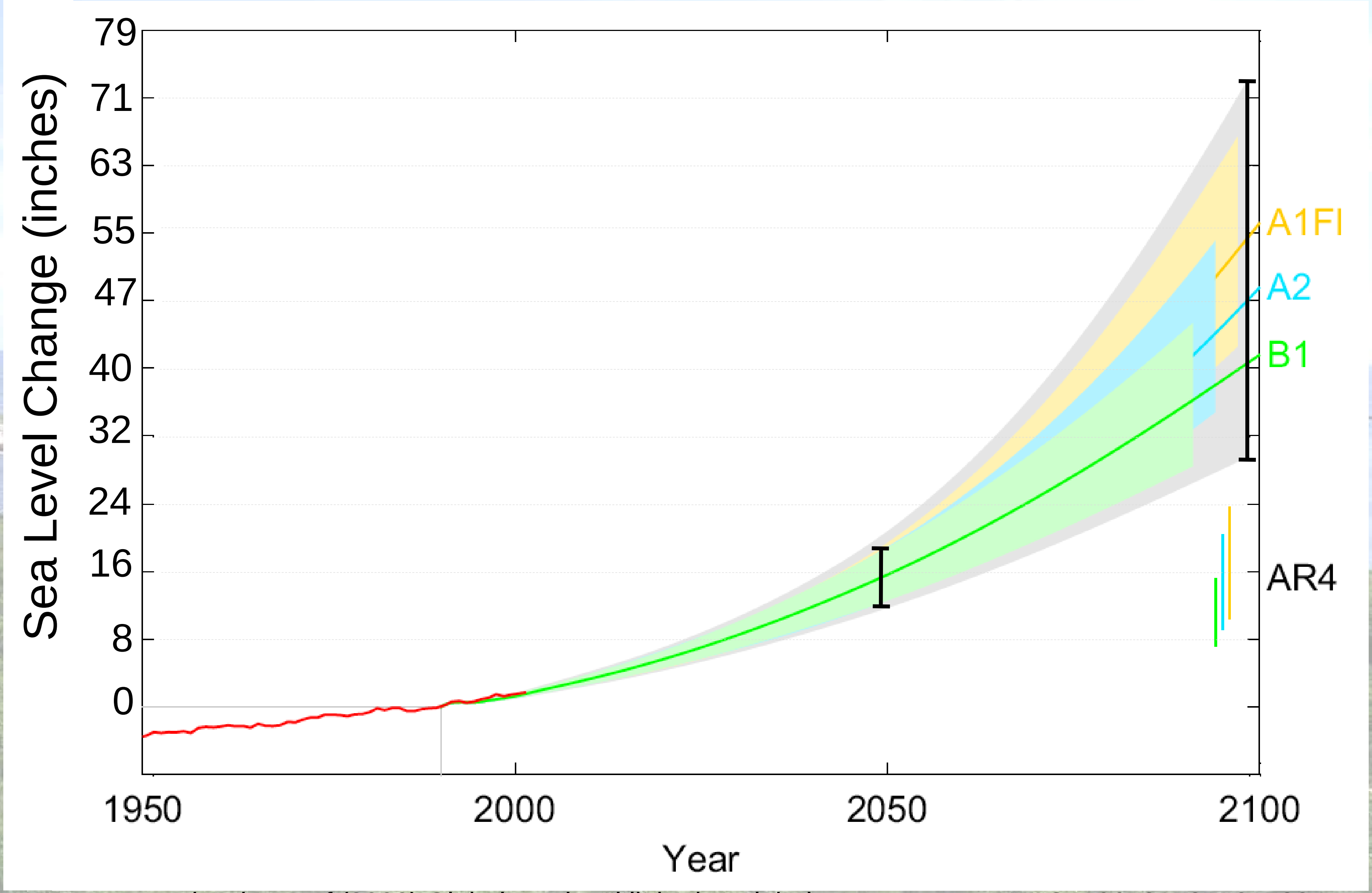
The four options:

1) Do nothing
2) Fortify assets
3) Relocate assets
4) Accommodate higher water levels


Storm Surge Barrier - Radial Gate,
Fixed Lifting Gate or Inflatable Weir.
Top of Weir Elev. = 20.0 NGVD 29
Transition Abutment, Elev. = 20.0.
Re-Align Trail and Bridge over
Abutment Wall

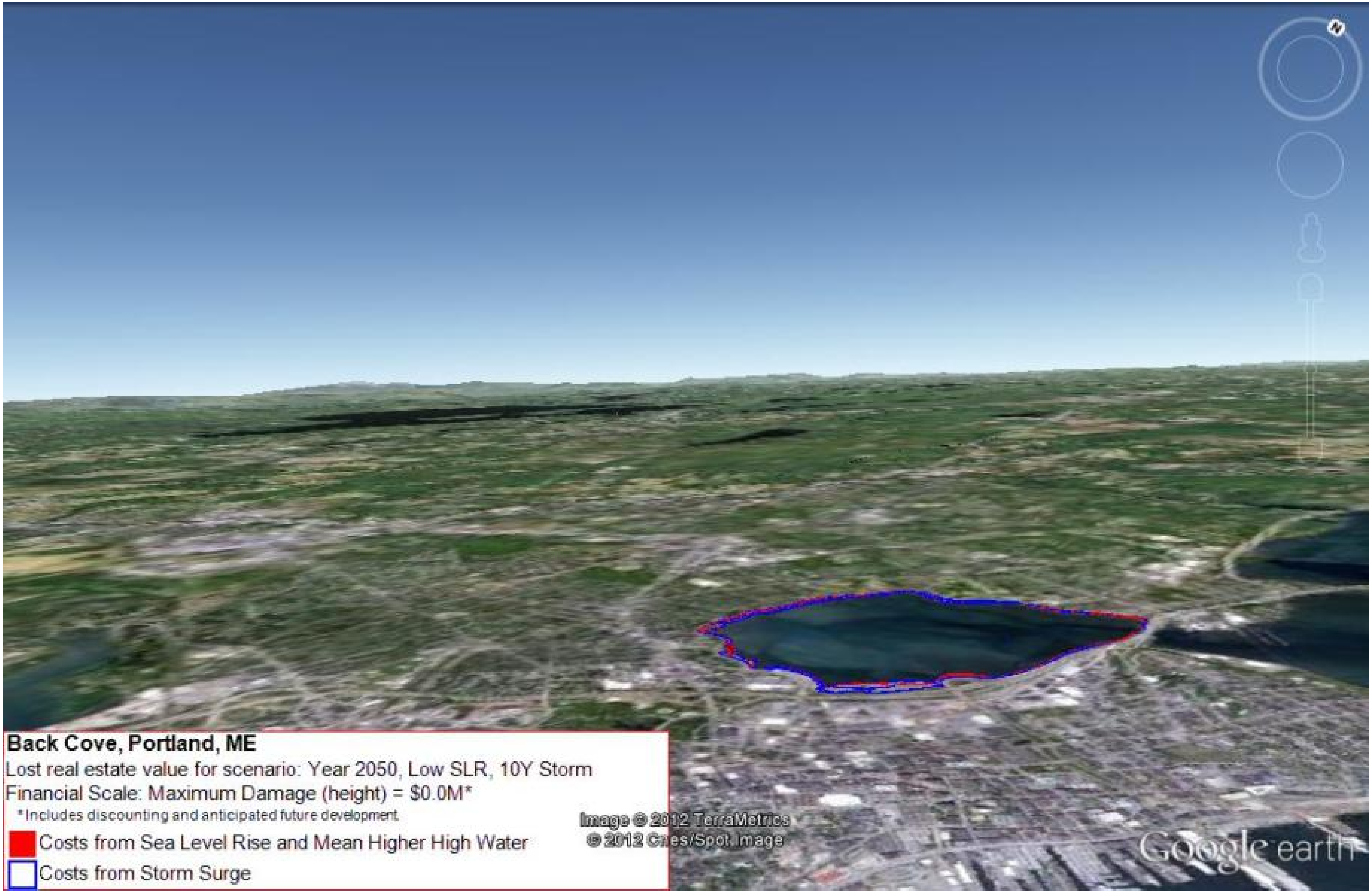

Levee Construction to Include Relocation of Back Bay Trail. Landside Stormwater Management System Also Required.
Storm Surge Barrier - Constructed at 2050 Condition
YEAR 2100 CONDITION
Levee Design Criteria - Mean High Higher Water (MHHW) + Sea Level Rise
Predicted Elevation = 7.85 to 11.30 feet NGVD 29
Levee Construction Expected Year 2100 Condition - Top of Berm Elevation = 14.0 (11.30 feet plus Wave Protection and Freeboard). Storm Surge Addressed at Tukey's Bridge Barrier

Projection of Sea Level Rise from 1990 to 2100

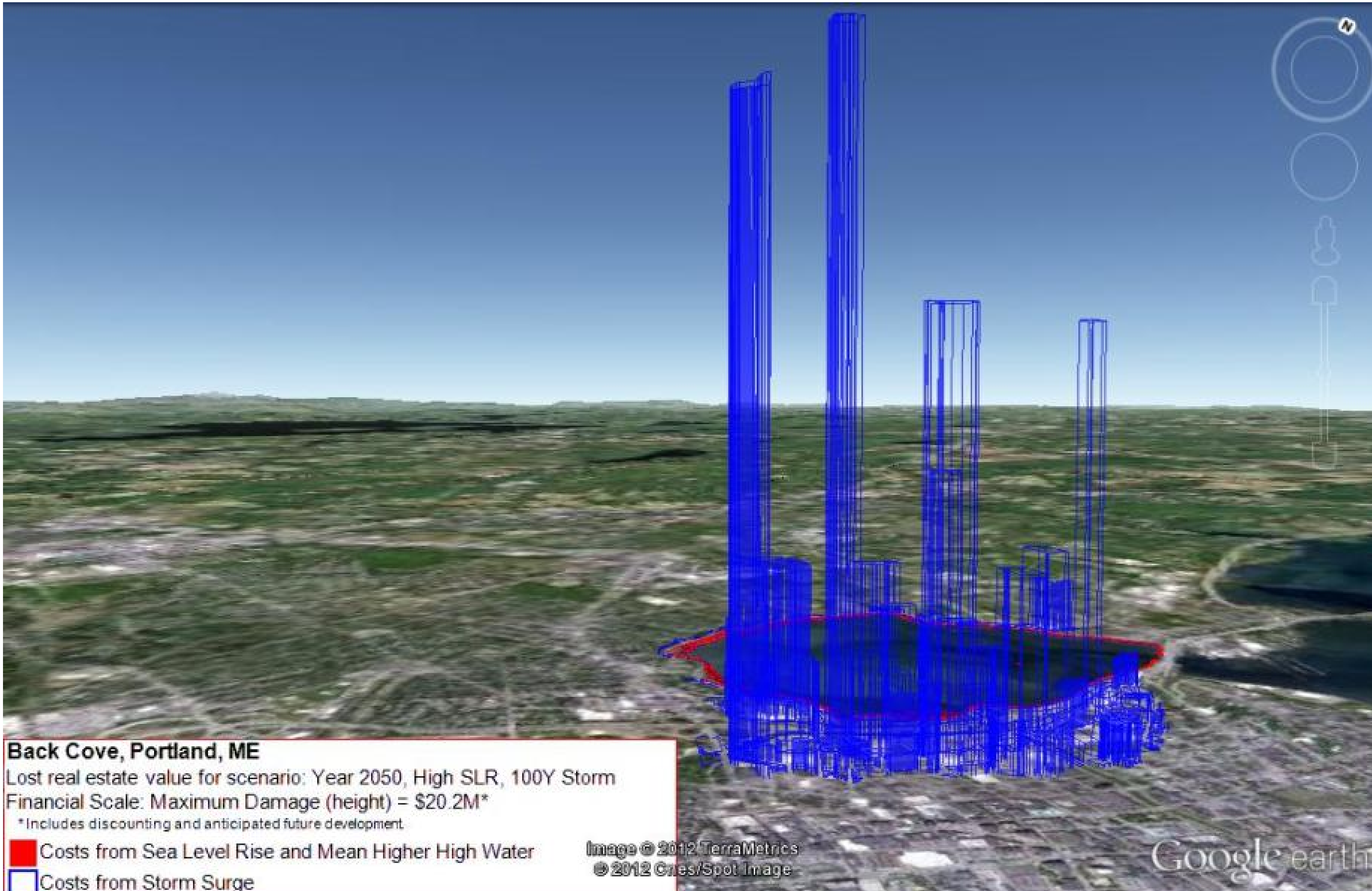


Vermeer and Rahmstorf (2009) Global sea level linked to global temperature. PNAS 106, 21527–21532.

2050, low sea level rise, 10 year storm



2050, high sea level rise, 100 year storm

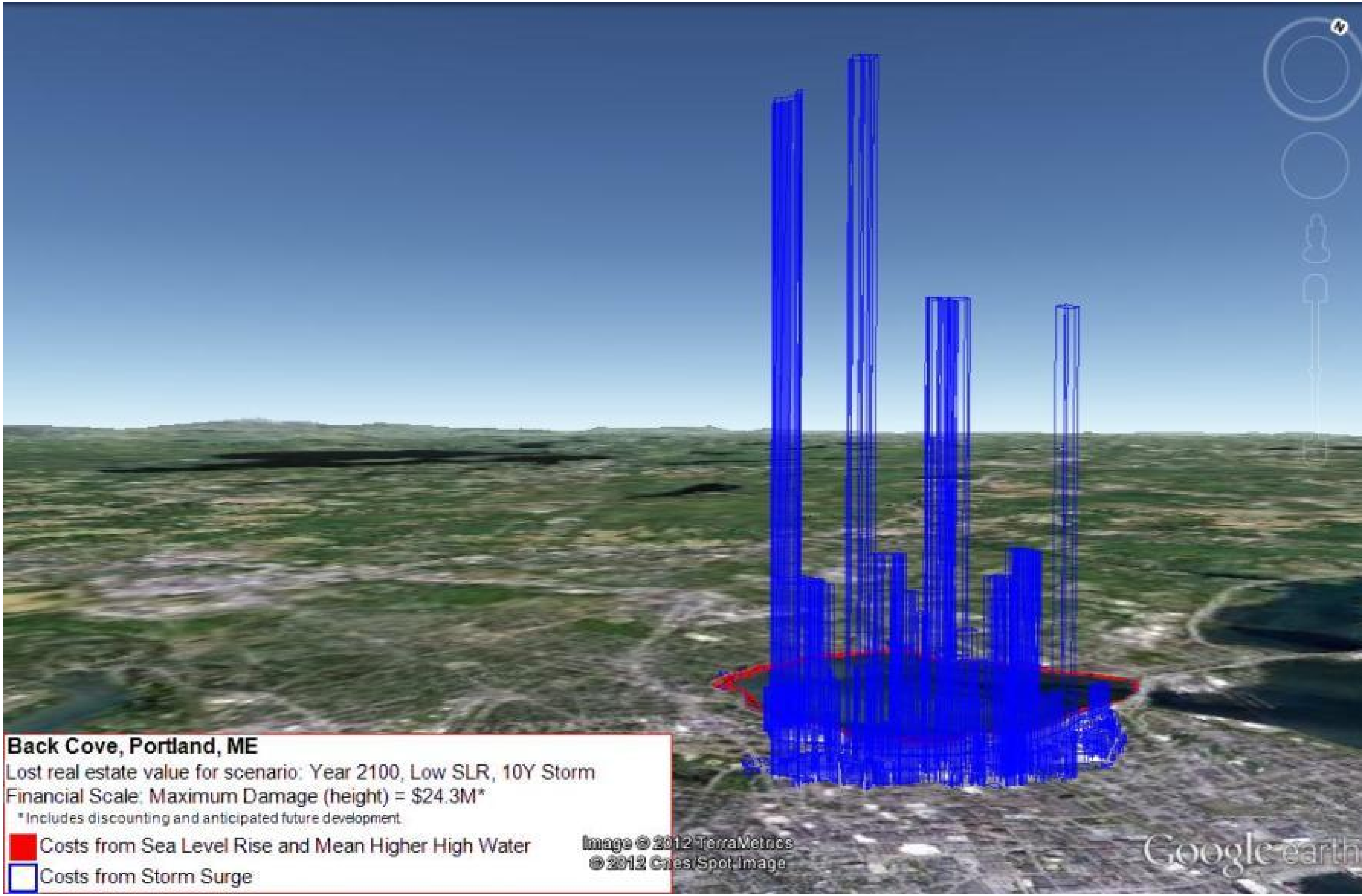


Back Cove, Portland, Maine

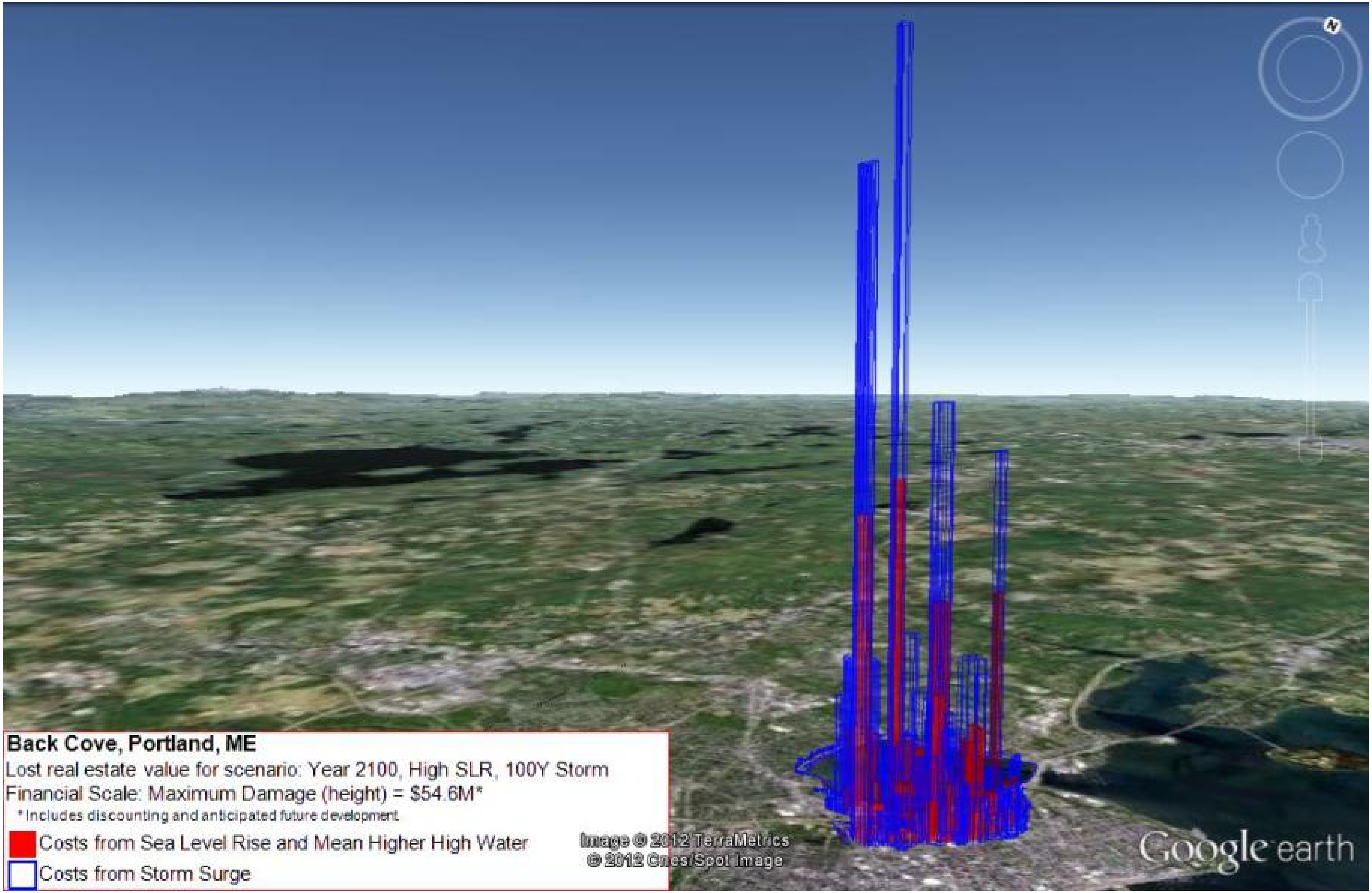
Adaptation Costs and Cumulative Expected Damages, through <u>2050</u>.

<u>2050</u> SLR Scenario	Adaptation	Cost (M)	Real Estate Damage (M)	Percent of damage from Storm surge	Percent of damage from SLR
No SLR	No Action	$0	$356	100%	0%
	Surge Barrier / Levee	$103 / $0	$0		
Low SLR	No Action	$0	$407	100%	0%
(7.9")	Surge Barrier / Levee	$103 / $0	$0		
High SLR	No Action	$0	$447	100%	0%
(19.7")	Surge Barrier / Levee	$103 / $0	$0		

2100, low sea level rise, 10 year storm



2100, high sea level rise, 100 year storm



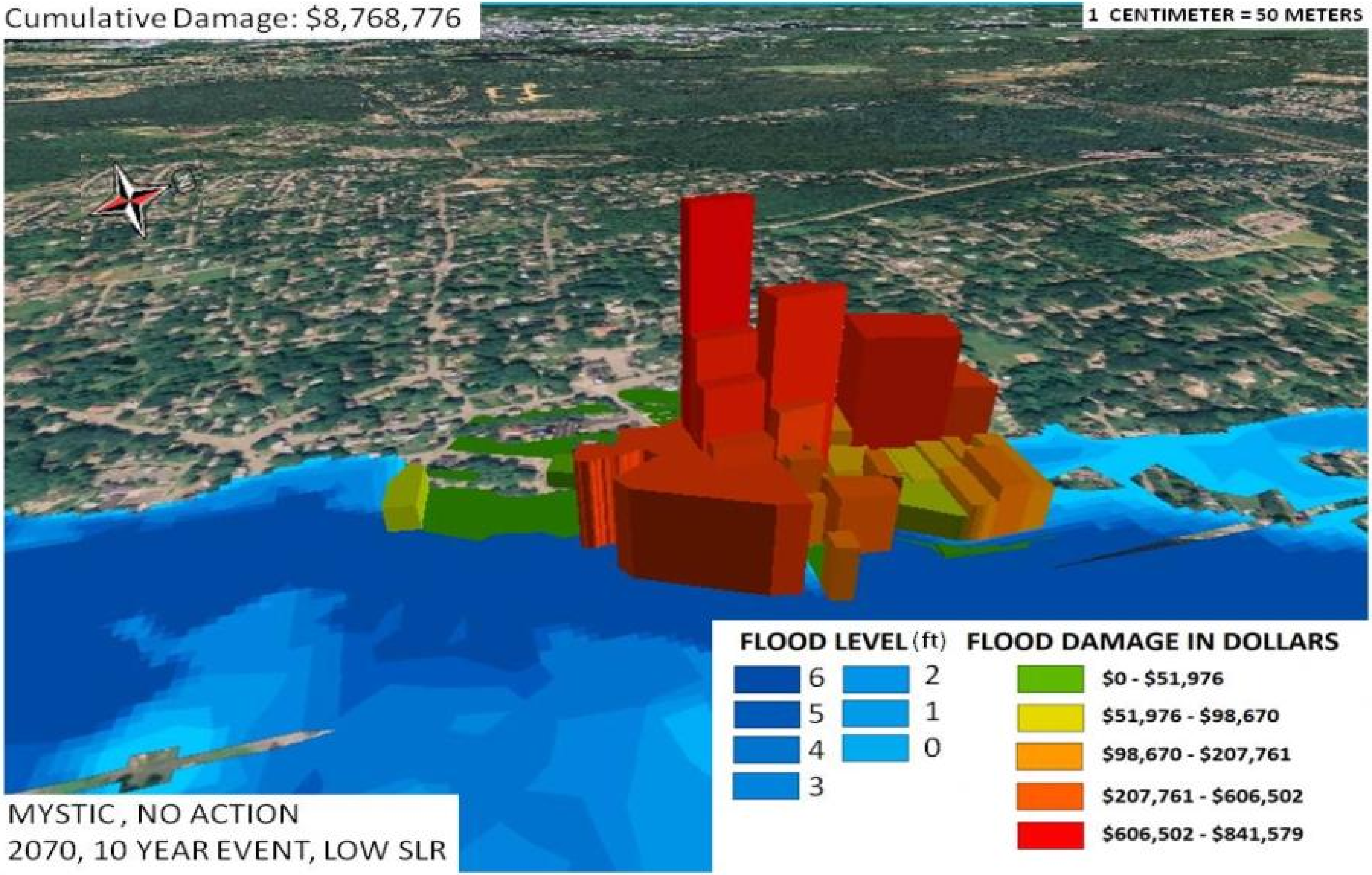
Back Cove, Portland, Maine

Adaptation Costs and Cumulative Expected Damages, through 2100.

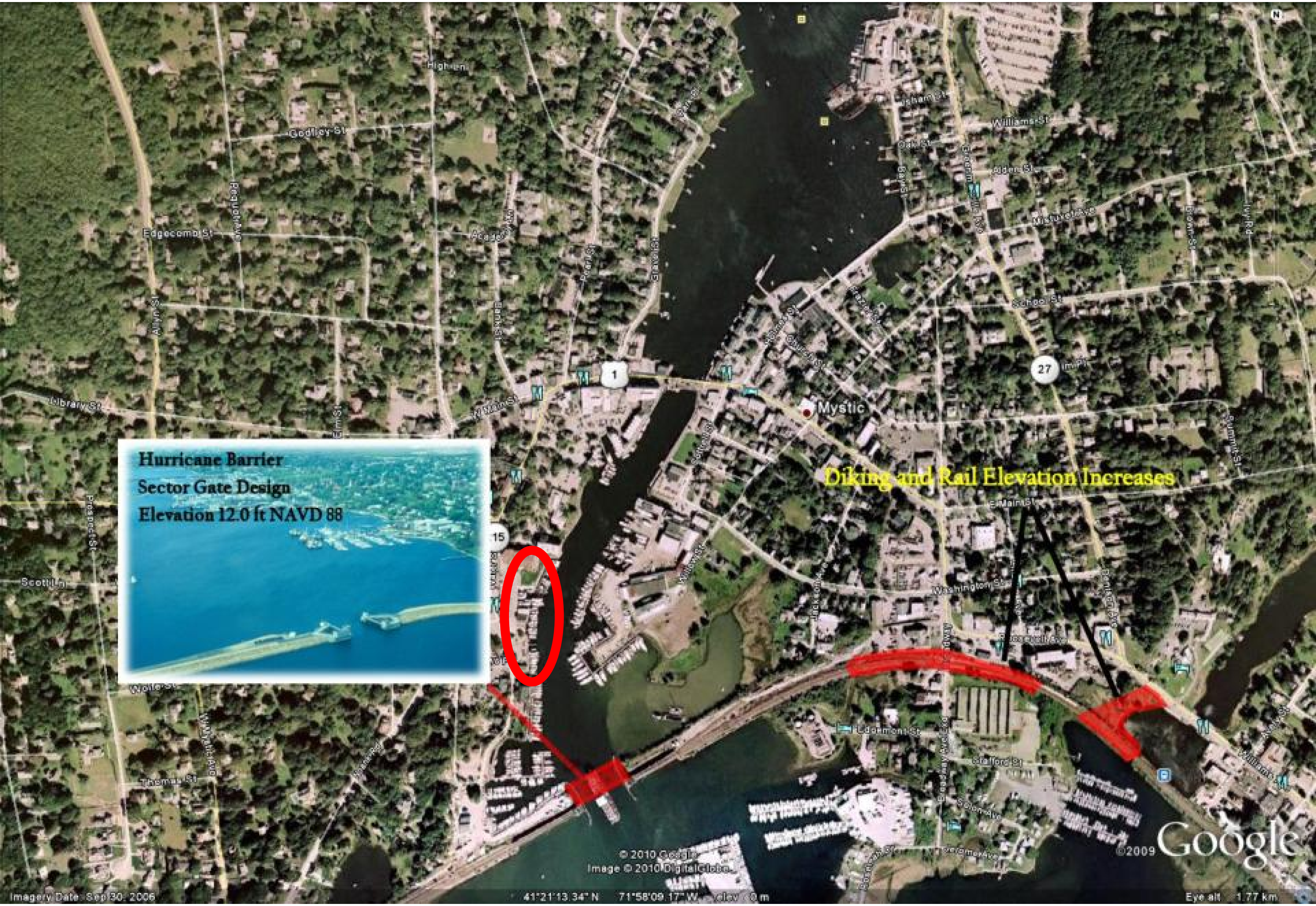
2100 SLR Scenario	Adaptation	Cost (M)	Real Estate Damage (M)	Percent of damage from Storm surge	Percent of damage from SLR
No SLR	No Action	$0	$1,791	100%	0%
	Surge Barrier / Levee	$0 / $40	$0		
Low SLR (27.6")	No Action	$0	$2,674	97%	3%
	Surge Barrier / Levee	$0 / $40	$0		
High SLR (70.9")	No Action	$0	$3,680	71%	29%
	Surge Barrier / Levee	$0 / $40	$0		


PORTLAND WATER DISTRICT
225 Douglass Street
Portland, ME 04104
Invert Data
Back Cove Intercepting
Sewer
October 24th, 2011
N
0
500
1,000
2,000
Feet
Baxter Blvd
Back Cove
10TH Mountain Division Hwy
Portland
Marginal Way
Washington Ave
Deering Oaks
Deering Ave
Forest Ave
State St
Park Ave
Bedford St
Loring Memorial Park
Ocean Ave
Clifton St
Mackworth St
Parsons Rd
Bay View Dr
Austin St
George St
Pye Rd
Bay St
Brookside Rd
Back Cove Estate
Front St
Randall St
Bates St
Baxter Circle
Anderson St
Cove St
Diamond St
Hammond St
Durham St
Falmouth St
Fessenden St
Pitt St
William St
Oakdale
Preble St Ext
Elm St
Lancaster St
Oxford St
Portland St
Brattle St
Parris St
Woodford St
Belmont St
Coyle St
Melrose St
Catalpa Dr
Ilsley St
Galvin St
Dartmouth St
Eastern Promenade
Sheridan St
North St
Walnut St


Consider hurricane barriers for storm surge protection
Stamford, CT
USACE



Cumulative Damage: $8,768,776
1 CENTIMETER = 50 METERS
FLOOD LEVEL (ft)
6
5
4
3
2
1
0
FLOOD DAMAGE IN DOLLARS
$0 - $51,976
$51,976 - $98,670
$98,670 - $207,761
$207,761 - $606,502
$606,502 - $841,579
MYSTIC, NO ACTION
2070, 10 YEAR EVENT, LOW SLR


Hurricane Barrier
Sector Gate Design
Elevation 12.0 ft NAVD 88
Diking and Rail Elevation Increases
Mystic
Godfrey St
Edgecomb St
Library St
W Main St
E Main St
Washington St
Williams St
Alder St
School St
Stafford St
Thomas St
Wolfe St
Scott Ln
Prospect St
1
27
15
© 2010 Google
Image © 2010 DigitalGlobe
©2009 Google
Imagery Date: Sep 30, 2006
41°21'13.34" N 71°58'09.17" W
Eye alt 1.77 km

<table>
<tr><th colspan="2">Scenarios</th><th>Max. Water Elev. (ft., NAVD88)</th><th>Engineering Options</th><th>Construction Costs</th><th>Annual Maintenance Costs</th></tr>
<tr><td rowspan="2">Sea level rise, normal tides</td><td>A</td><td>3.2 – 4.0</td><td>No action up to minimal flood proofing and infrastructure elevation along river.</td><td>Insignificant</td><td>Insignificant</td></tr>
<tr><td>B</td><td>5.5 – 6.5</td><td rowspan="4">Hurricane Barrier at Mystic River entrance.</td><td rowspan="4">$18 Million</td><td rowspan="4">$75,000</td></tr>
<tr><td rowspan="2">100-year storm event in 2010</td><td>C</td><td>5.4</td></tr>
<tr><td>D</td><td>7.4</td></tr>
<tr><td rowspan="2">10-year storm in 2070, Hi SLR</td><td>E</td><td>7.0</td></tr>
<tr><td>F</td><td>8.9</td><td rowspan="2">Hurricane Barrier at Mystic River entrance.

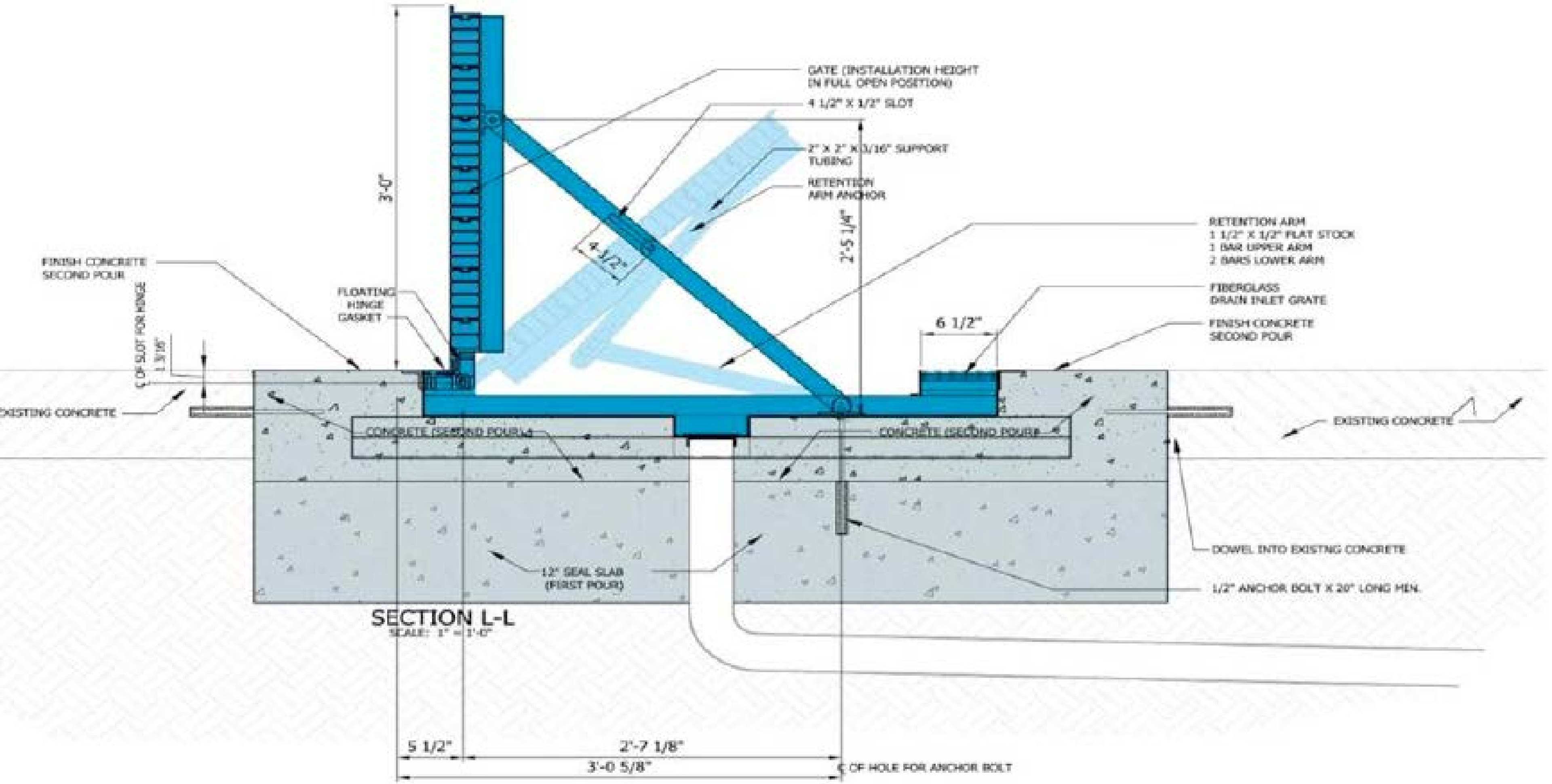
<u>ADDITIONAL FORTIFICATION</u> and elevating the railroad, as well as increased diking to east.</td><td rowspan="2">$27-30 Million</td><td rowspan="2">$100,000</td></tr>
<tr><td rowspan="2">100-year storm in 2070, Hi SLR</td><td>G</td><td>8.6</td></tr>
<tr><td>H</td><td>10.5</td><td>Hurricane Barrier at Mystic River entrance.

<u>FURTHER FORTIFICATION</u> and elevating the railroad, as well as increased diking to east.</td><td>$35 Million</td><td>$120,000</td></tr>
</table>

Transit Applications

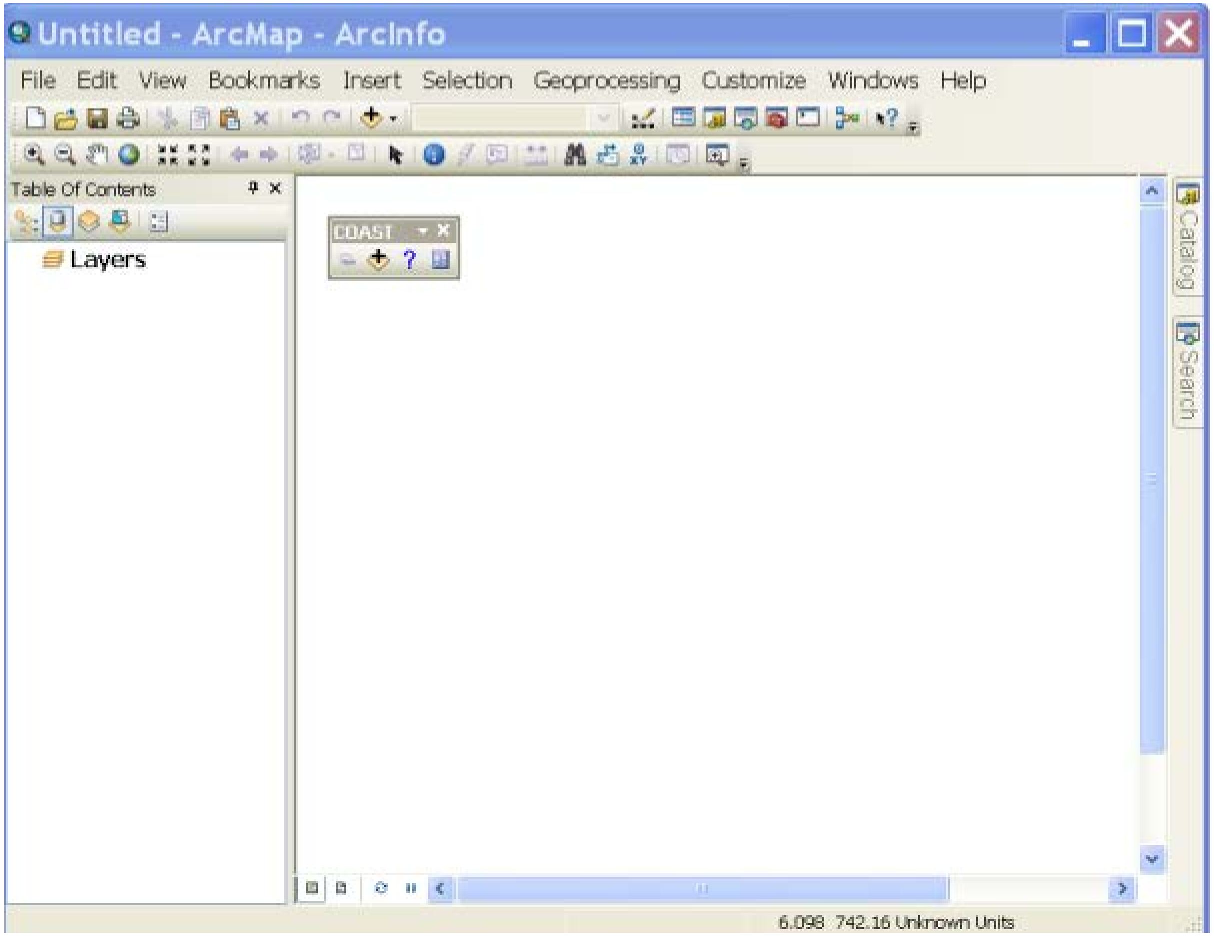
New England Environmental Finance Center


CLEARANCE 8'-2"

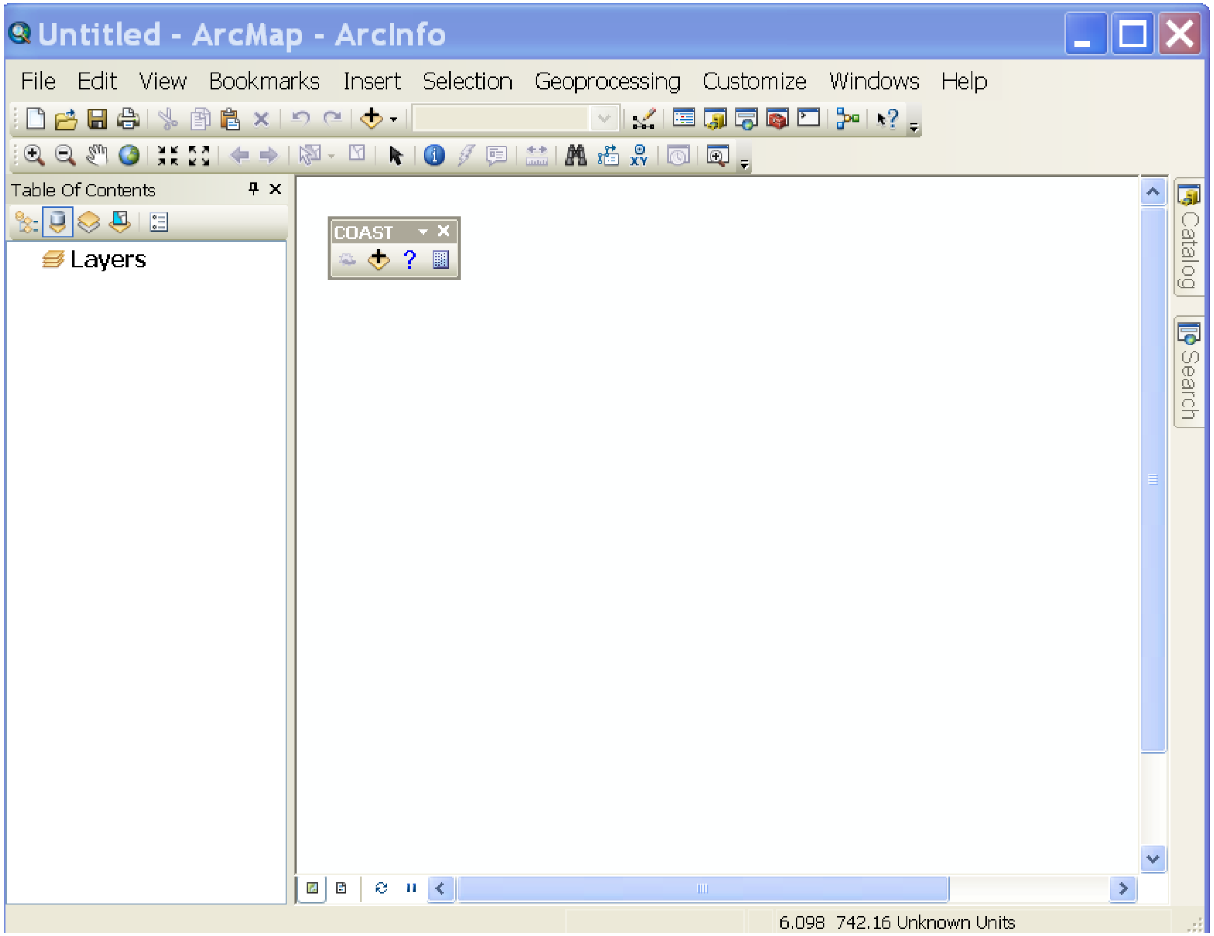


SECTION L-L

SCALE: 1" = 1'-0"


Untitled - ArcMap - ArcInfo
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
COAST
Catalog
Search
6.098 742.16 Unknown Units


COAST



Untitled - ArcMap - ArcInfo
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
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Layers
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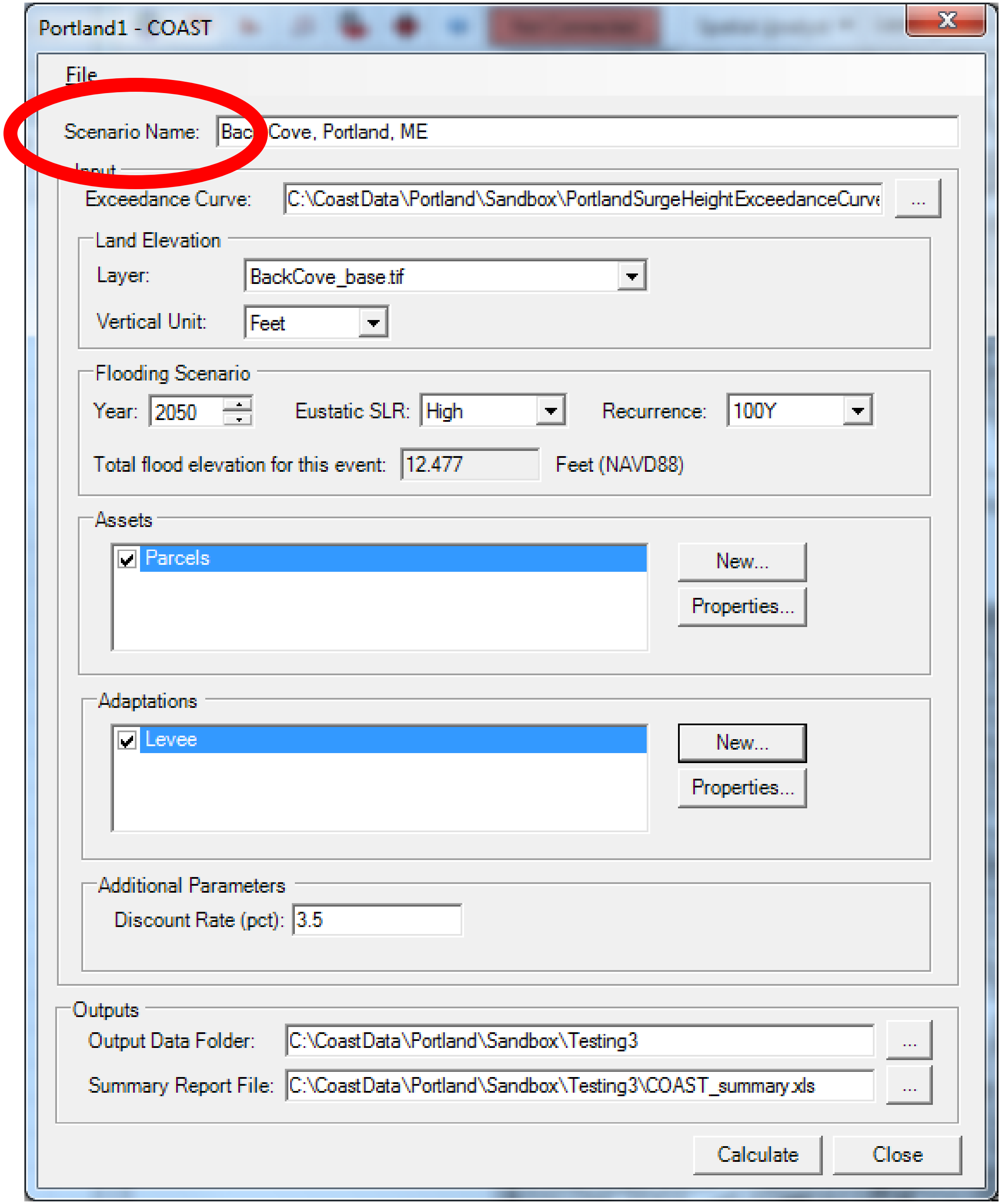
6.098 742.16 Unknown Units

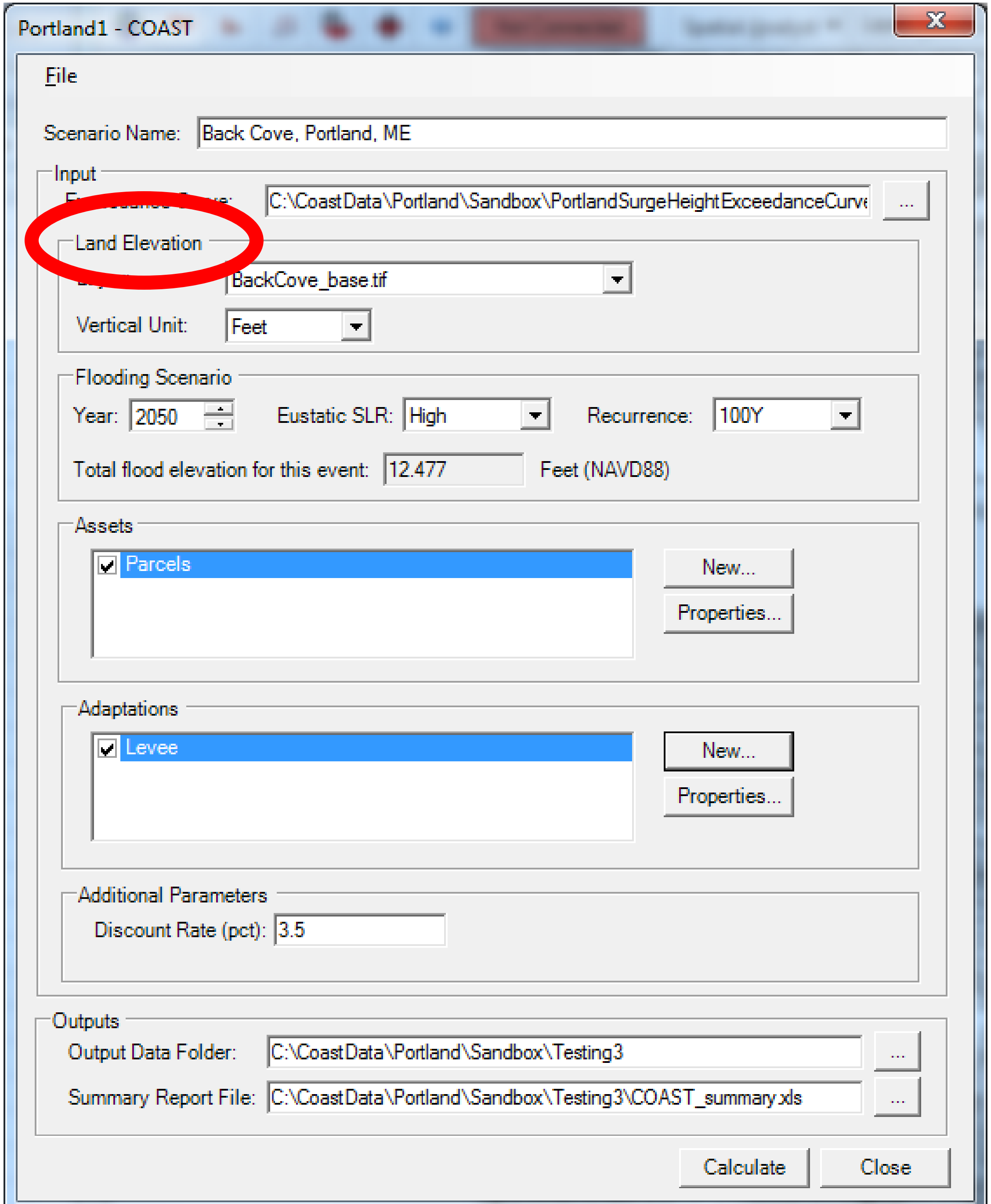
COAST



Portland1 - COAST
File
Scenario Name:
Bac
Cove, Portland, ME
Exceedance Curve:
C:\CoastData\Portland\Sandbox\PortlandSurgeHeightExceedanceCurve
...
Land Elevation
Layer:
BackCove_base.tif
Vertical Unit:
Feet
Flooding Scenario
Year:
2050
Eustatic SLR:
High
Recurrence:
100Y
Total flood elevation for this event:
12.477
Feet (NAVD88)
Assets
Parcels
New...
Properties...
Adaptations
Levee
New...
Properties...
Additional Parameters
Discount Rate (pct):
3.5
Outputs
Output Data Folder:
C:\CoastData\Portland\Sandbox\Testing3
...
Summary Report File:
C:\CoastData\Portland\Sandbox\Testing3\COAST_summary.xls
...
Calculate
Close

To set up a COAST scenario, needed are:

1. A base land elevation layer.

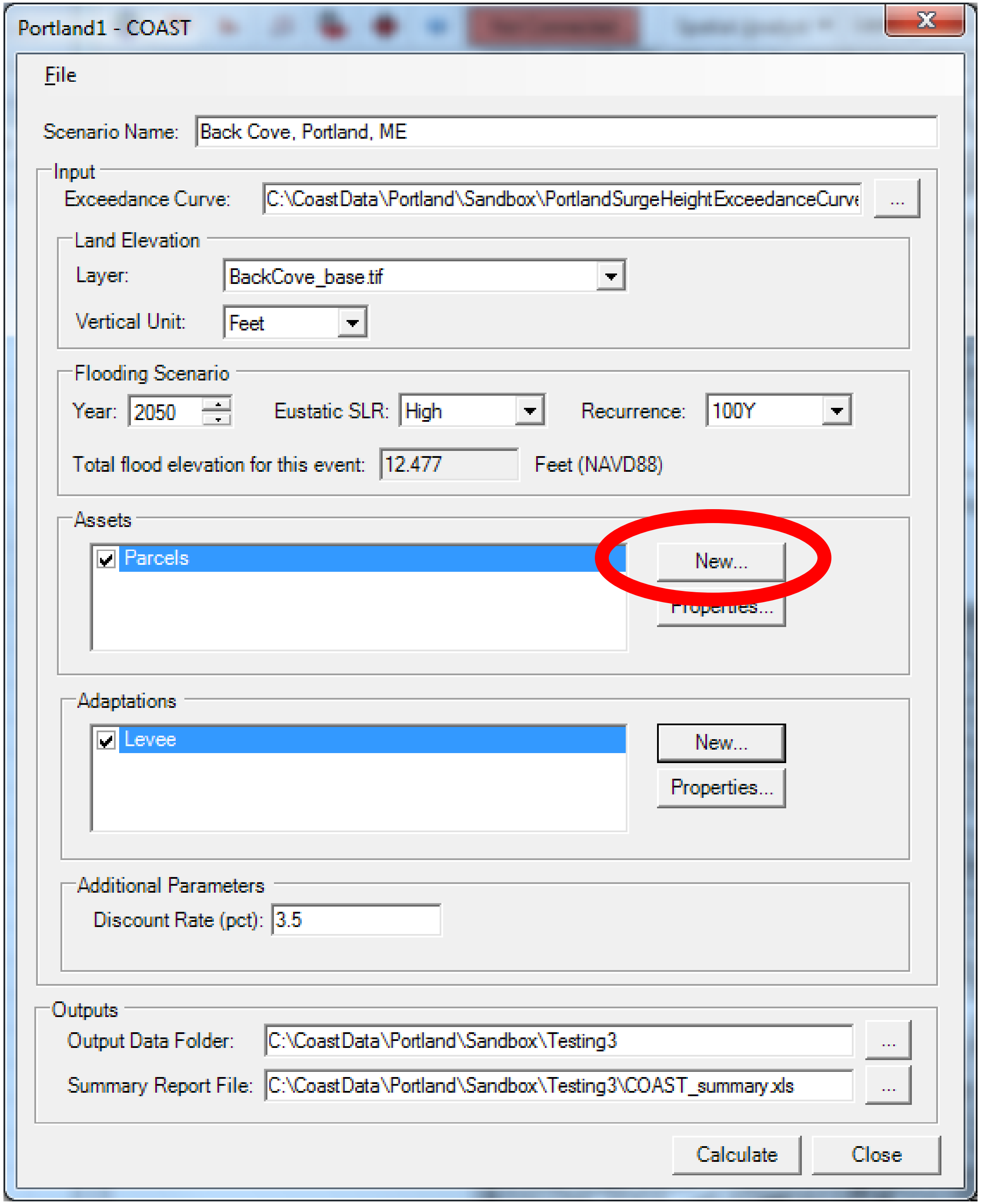


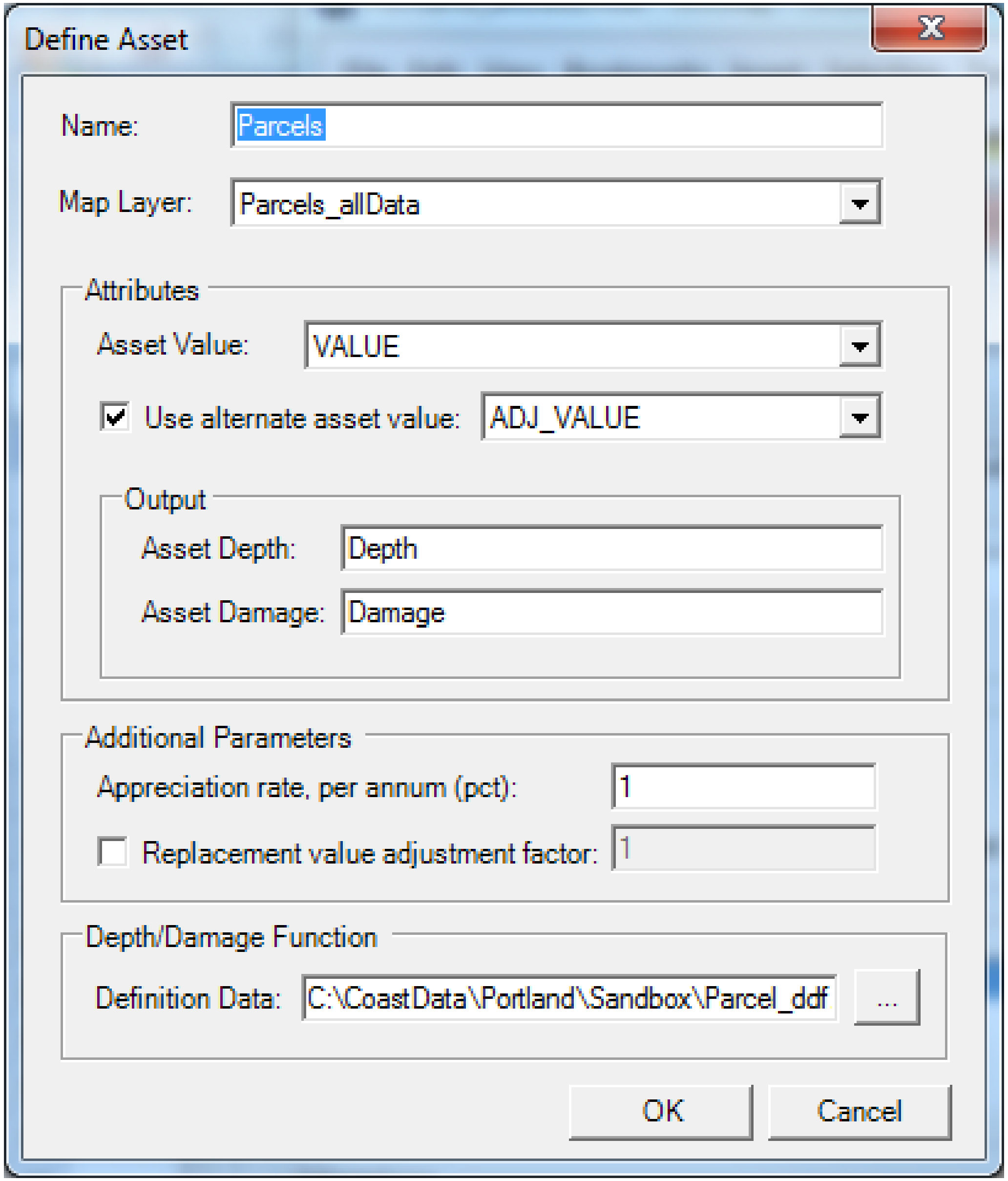
Portland1 - COAST
File
Scenario Name:
Back Cove, Portland, ME
Input
C:\CoastData\Portland\Sandbox\PortlandSurgeHeightExceedanceCurve
...
Land Elevation
BackCove_base.tif
Vertical Unit:
Feet
Flooding Scenario
Year:
2050
Eustatic SLR:
High
Recurrence:
100Y
Total flood elevation for this event:
12.477
Feet (NAVD88)
Assets
Parcels
New...
Properties...
Adaptations
Levee
New...
Properties...
Additional Parameters
Discount Rate (pct):
3.5
Outputs
Output Data Folder:
C:\CoastData\Portland\Sandbox\Testing3
...
Summary Report File:
C:\CoastData\Portland\Sandbox\Testing3\COAST_summary.xls
...
Calculate
Close

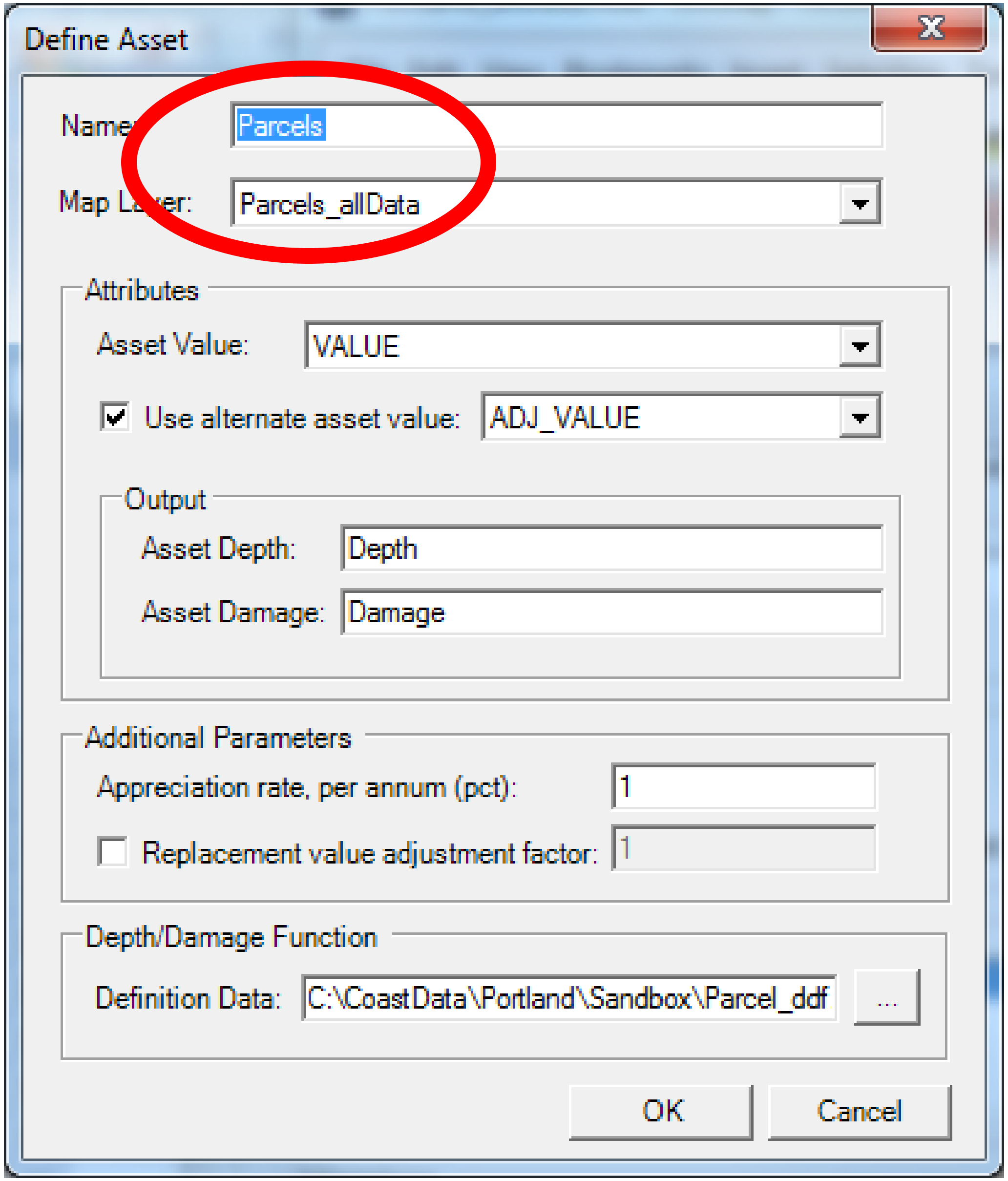
To set up a COAST scenario, needed are:

1. A base land elevation layer.

2. A base asset data layer. (Vector file with features for assets to be modeled. Can be a shapefile or a table in an Esri geodatabase).


Portland1 - COAST
File
Scenario Name:
Back Cove, Portland, ME
Input
Exceedance Curve:
C:\CoastData\Portland\Sandbox\PortlandSurgeHeightExceedanceCurve
Land Elevation
Layer:
BackCove_base.tif
Vertical Unit:
Feet
Flooding Scenario
Year:
2050
Eustatic SLR:
High
Recurrence:
100Y
Total flood elevation for this event:
12.477
Feet (NAVD88)
Assets
Parcels
New...
Adaptations
Levee
New...
Properties...
Additional Parameters
Discount Rate (pct):
3.5
Outputs
Output Data Folder:
C:\CoastData\Portland\Sandbox\Testing3
Summary Report File:
C:\CoastData\Portland\Sandbox\Testing3\COAST_summary.xls
Calculate
Close


Define Asset
Name:
Parcels
Map Layer:
Parcels_allData
Attributes
Asset Value:
VALUE
Use alternate asset value:
ADJ_VALUE
Output
Asset Depth:
Depth
Asset Damage:
Damage
Additional Parameters
Appreciation rate, per annum (pct):
1
Replacement value adjustment factor:
1
Depth/Damage Function
Definition Data:
C:\CoastData\Portland\Sandbox\Parcel_ddf
...
OK
Cancel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ADJ_VALUE
Output
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Damage
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Appreciation rate, per annum (pct):
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Replacement value adjustment factor:
1
Depth/Damage Function
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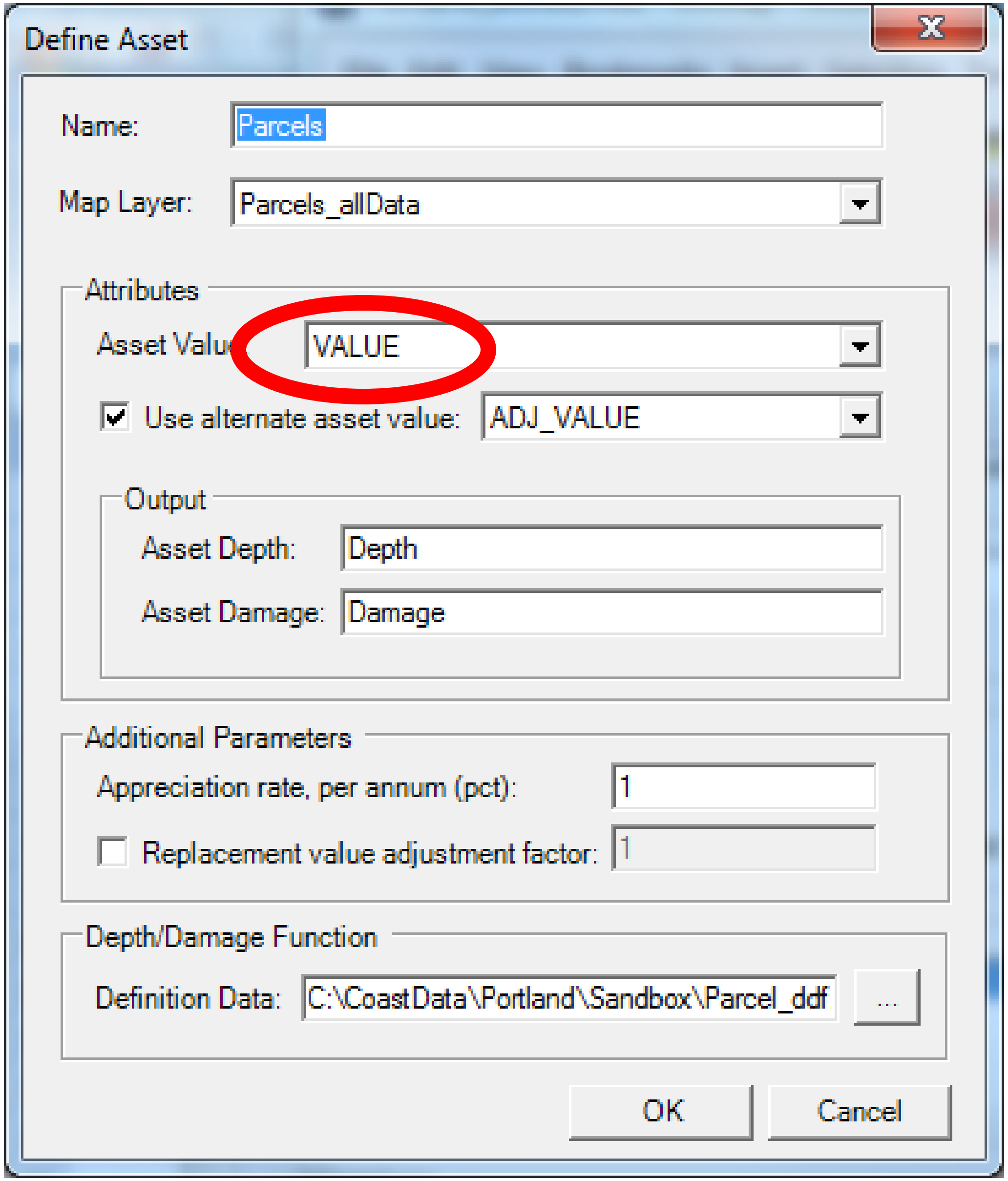
OK
Cancel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Map Layer:
Parcels_allData
Attributes
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Output
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Asset Damage:
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Appreciation rate, per annum (pct):
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Replacement value adjustment factor:
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Depth/Damage Function
Definition Data:
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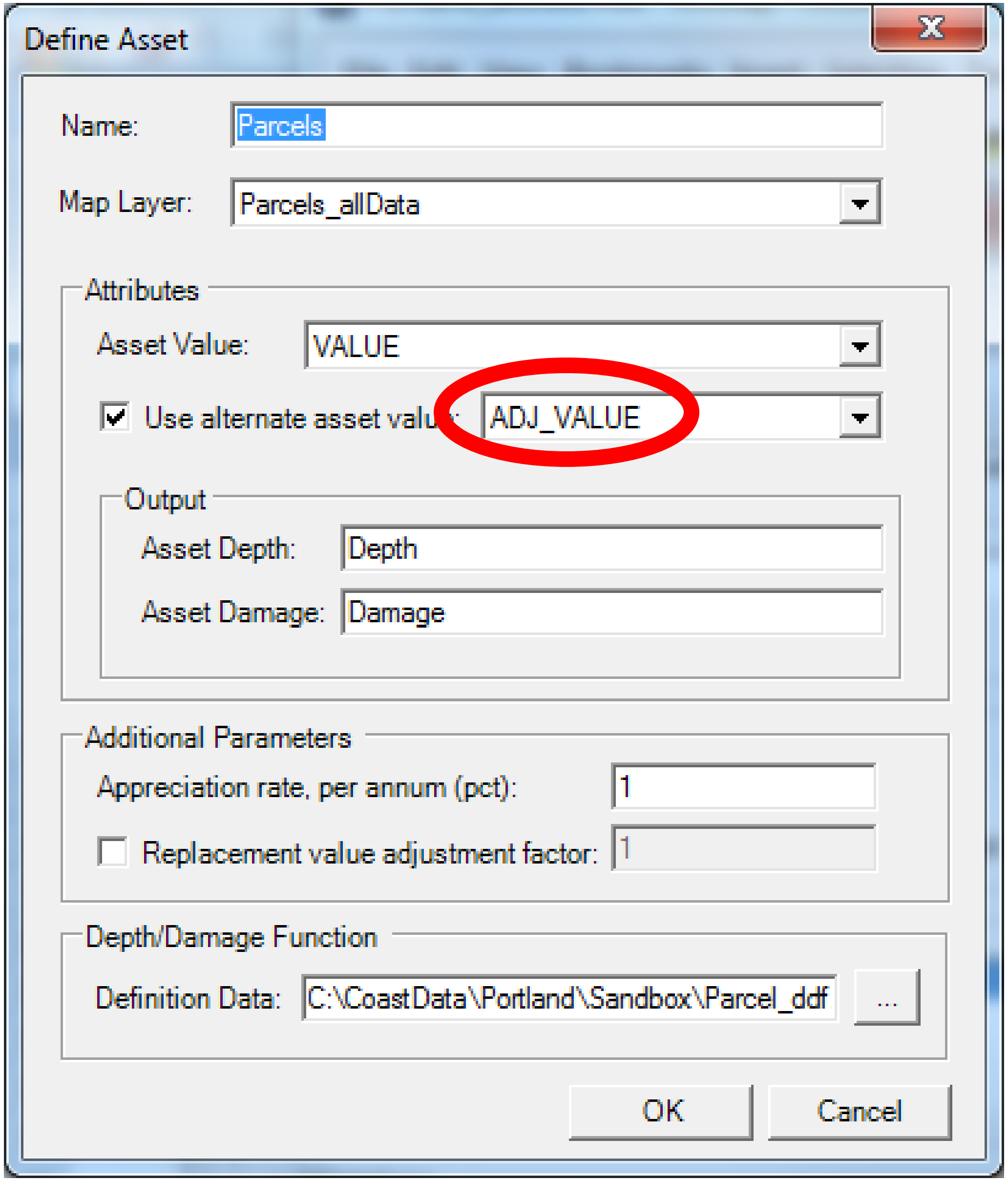
...
OK
Cancel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Asset Value:
VALUE
Use alternate asset valu
ADJ_VALUE
Output
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Depth
Asset Damage:
Damage
Additional Parameters
Appreciation rate, per annum (pct):
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Replacement value adjustment factor:
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Depth/Damage Function
Definition Data:
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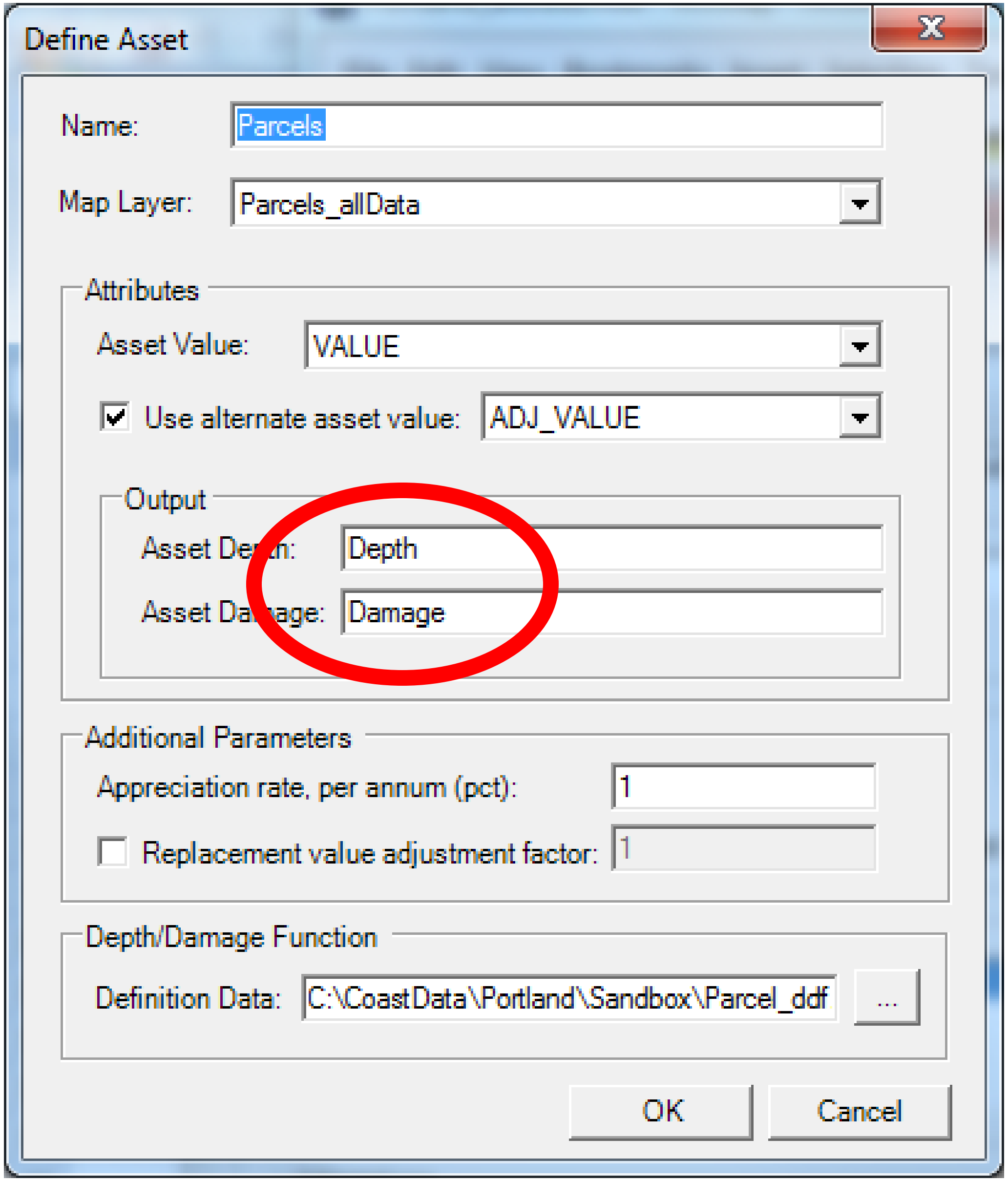
Cancel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Map Layer:
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ADJ_VALUE
Output
Depth
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Appreciation rate, per annum (pct):
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Replacement value adjustment factor:
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Depth/Damage Function
Definition Data:
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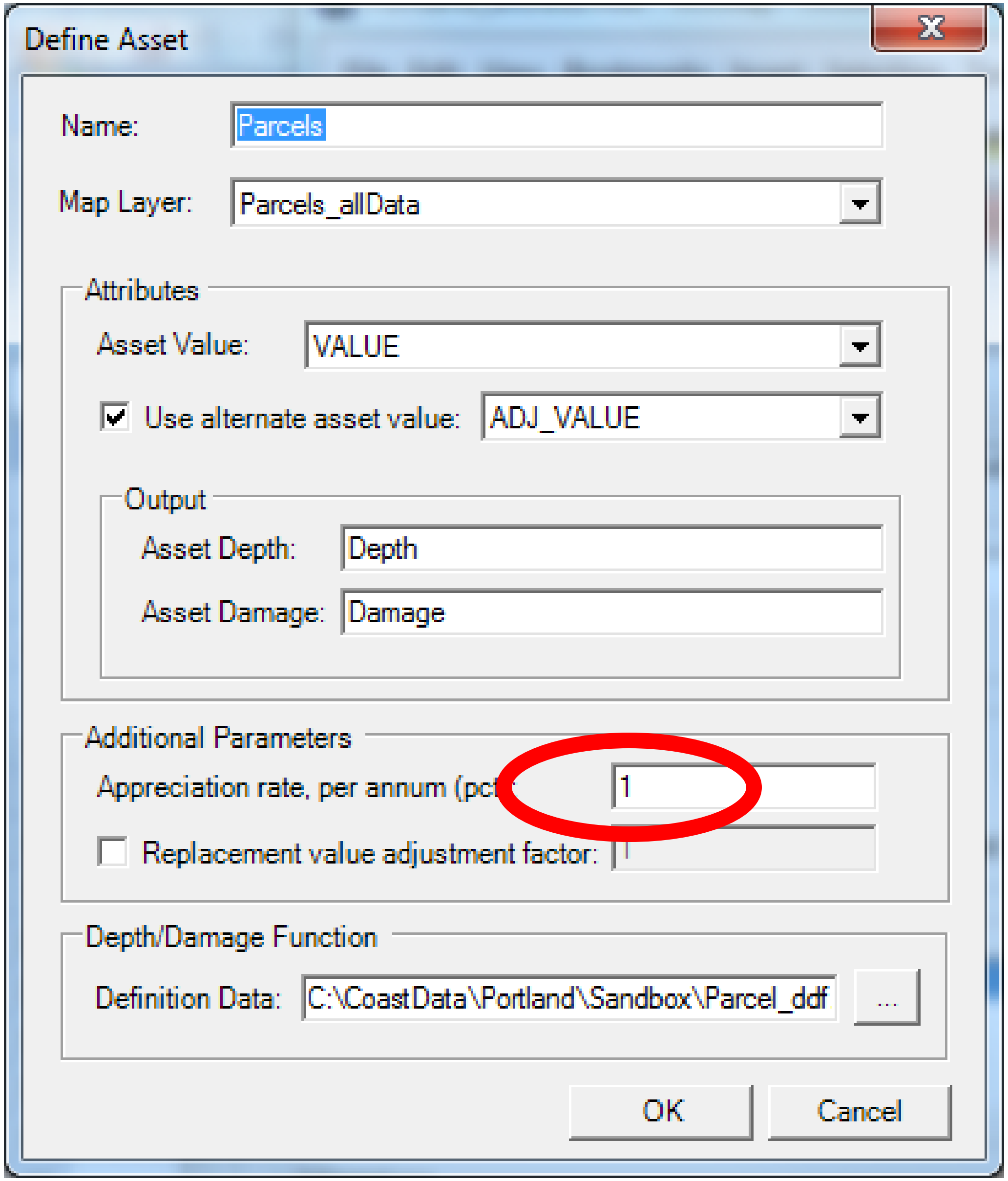
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Map Layer:
Parcels_allData
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Asset Value:
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Use alternate asset value:
ADJ_VALUE
Output
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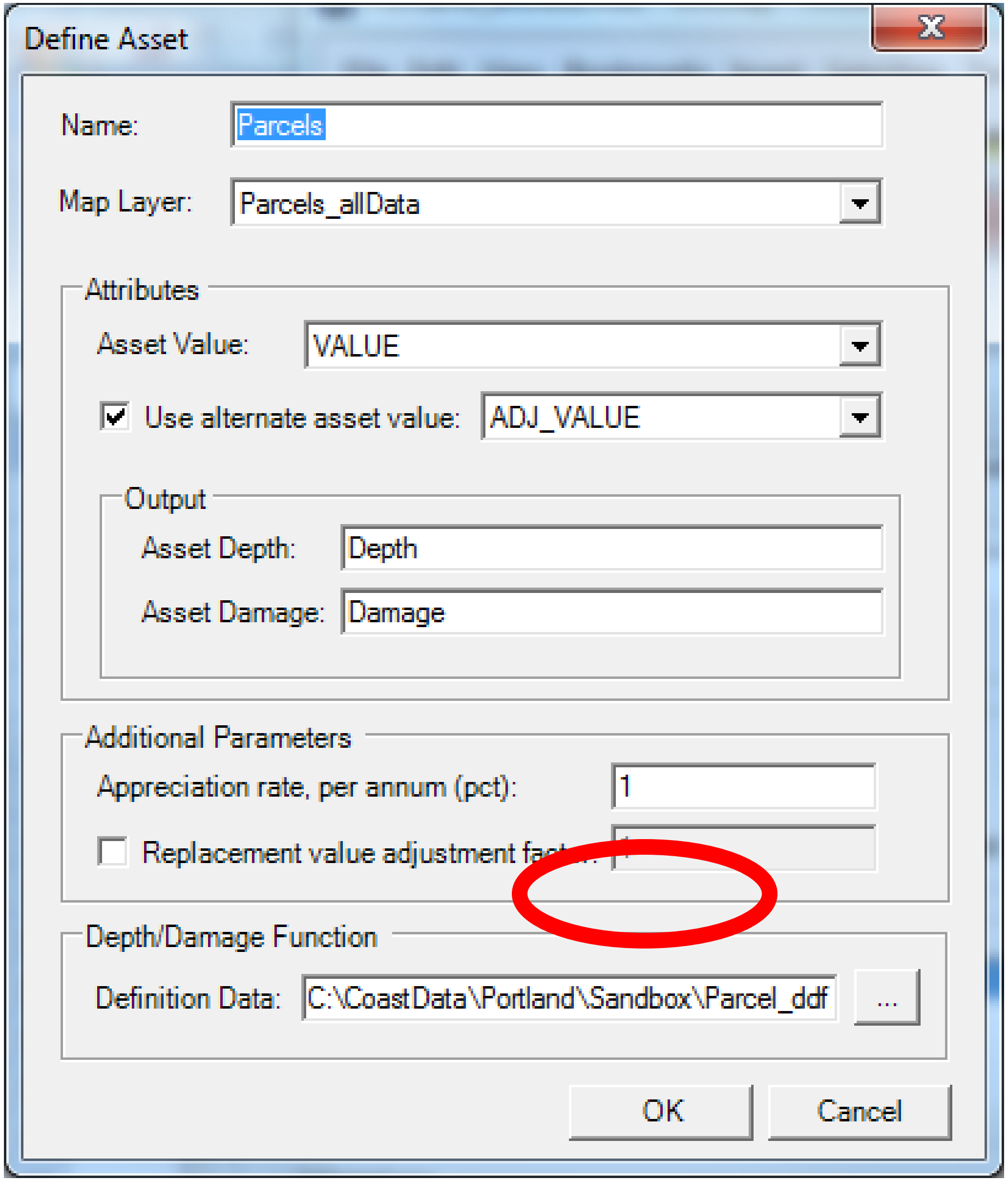
Depth
Asset Damage:
Damage
Additional Parameters
Appreciation rate, per annum (pct
1
Replacement value adjustment factor:
Depth/Damage Function
Definition Data:
C:\CoastData\Portland\Sandbox\Parcel_ddf
...
OK
Cancel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Parcels
Map Layer:
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Depth
Asset Damage:
Damage
Additional Parameters
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Replacement value adjustment fa
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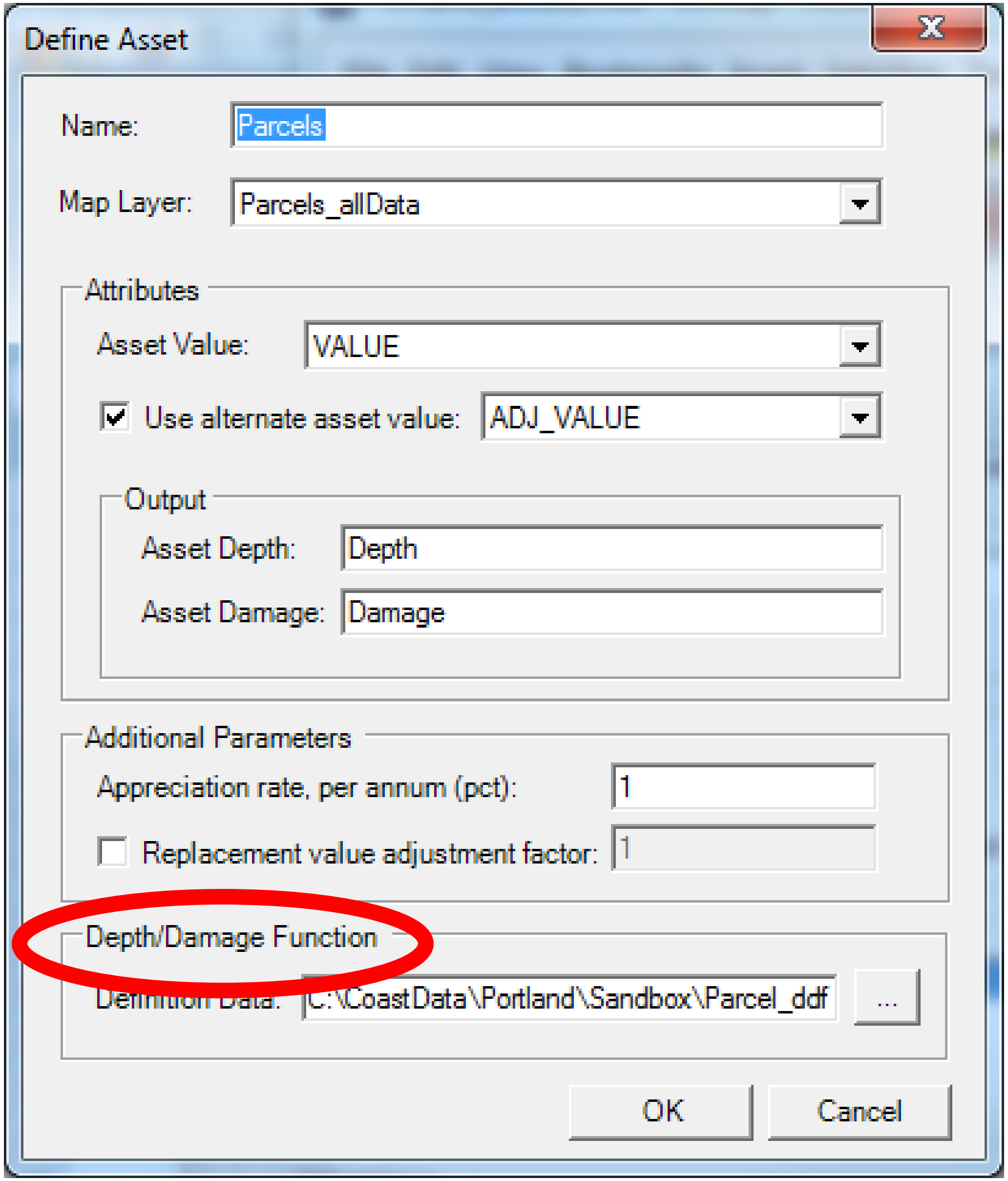
Define Asset
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Map Layer:
Parcels_allData
Attributes
Asset Value:
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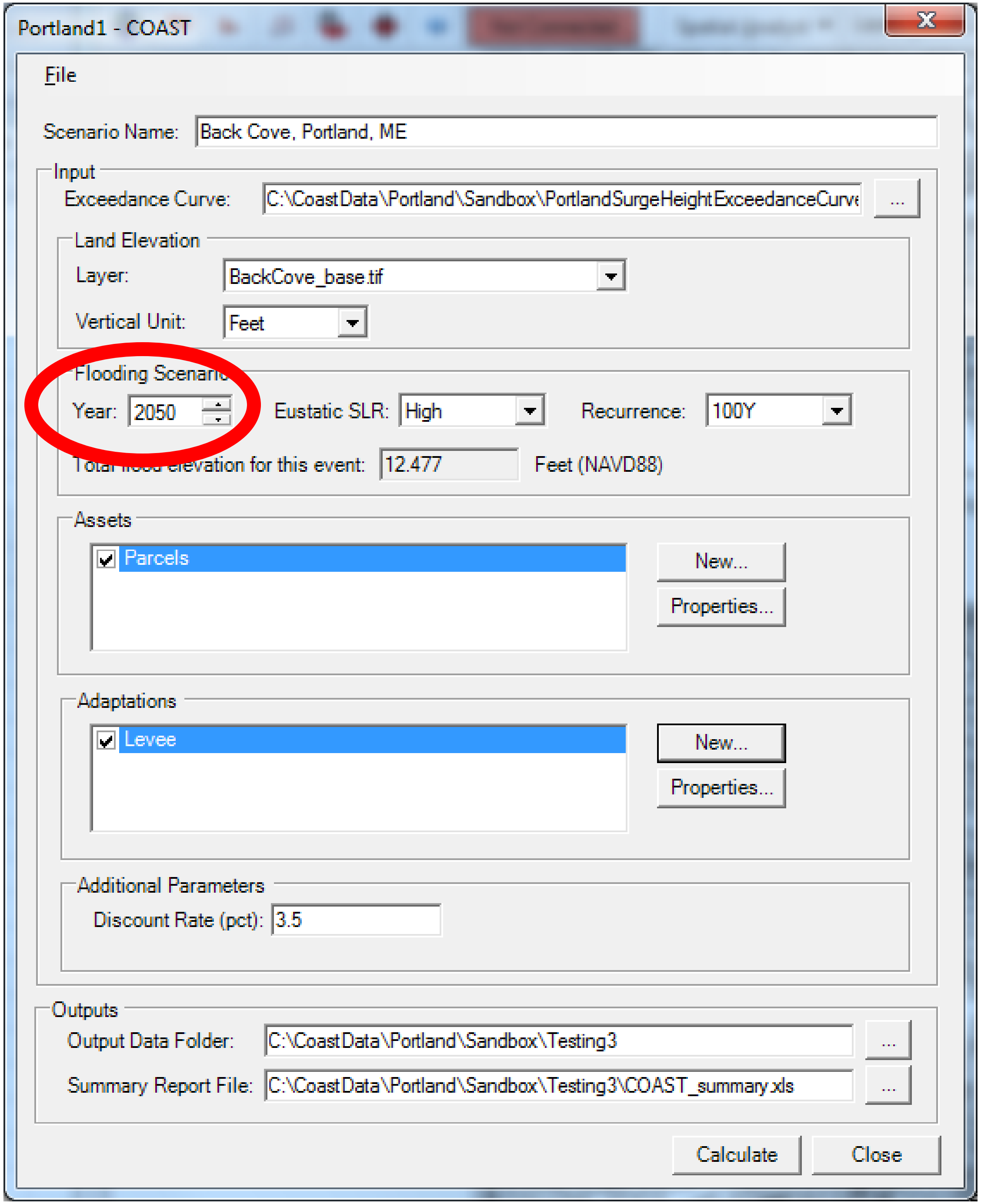
Use alternate asset value:
ADJ_VALUE
Output
Asset Depth:
Depth
Asset Damage:
Damage
Additional Parameters
Appreciation rate, per annum (pct):
1
Replacement value adjustment factor:
1
Depth/Damage Function
C:\CoastData\Portland\Sandbox\Parcel_ddf
...
OK
Cancel

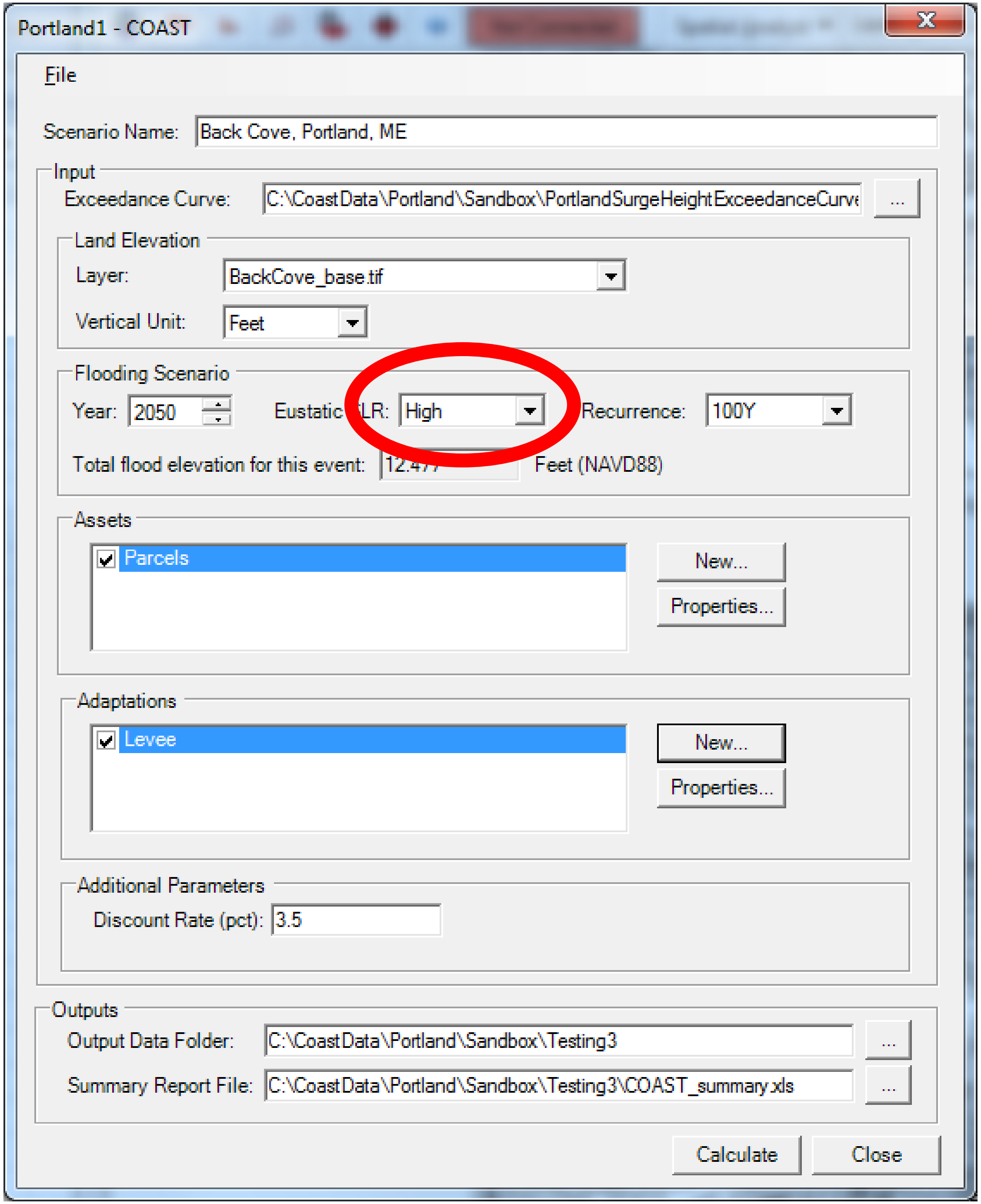
Data for Decision-Making

Damage Functions for Single Family
Residential Structures with Basement

Depth (feet)	Mean of Damage
0	25.5%
1	32.0%
2	38.7%
3	45.5%
4	52.2%
5	58.6%
6	64.5%



Portland1 - COAST
File
Scenario Name: Back Cove, Portland, ME
Input
Exceedance Curve: C:\CoastData\Portland\Sandbox\PortlandSurgeHeightExceedanceCurve
...
Land Elevation
Layer: BackCove_base.tif
Vertical Unit: Feet
Flooding Scenari
Year: 2050
Eustatic SLR: High
Recurrence: 100Y
elevation for this event: 12.477
Feet (NAVD88)
Assets
Parcels
New...
Properties...
Adaptations
Levee
New...
Properties...
Additional Parameters
Discount Rate (pct): 3.5
Outputs
Output Data Folder: C:\CoastData\Portland\Sandbox\Testing3
...
Summary Report File: C:\CoastData\Portland\Sandbox\Testing3\COAST_summary.xls
...
Calculate
Close


Portland1 - COAST
File
Scenario Name:
Back Cove, Portland, ME
Input
Exceedance Curve:
C:\CoastData\Portland\Sandbox\PortlandSurgeHeightExceedanceCurve
...
Land Elevation
Layer:
BackCove_base.tif
Vertical Unit:
Feet
Flooding Scenario
Year:
2050
Eustatic SLR:
High
Recurrence:
100Y
Total flood elevation for this event:
Feet (NAVD88)
Assets
Parcels
New...
Properties...
Adaptations
Levee
New...
Properties...
Additional Parameters
Discount Rate (pct):
3.5
Outputs
Output Data Folder:
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Calculate
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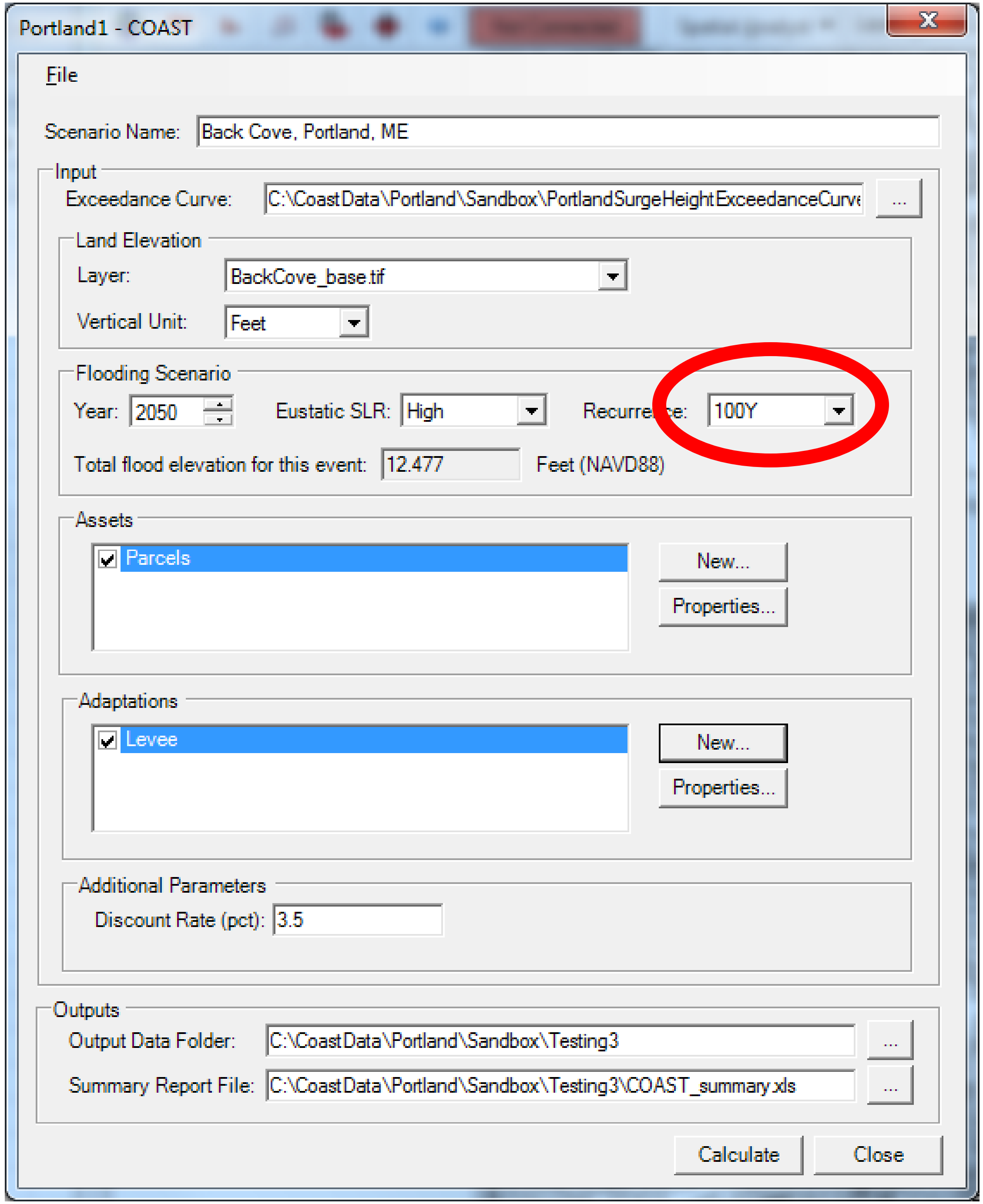
Portland1 - COAST
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Back Cove, Portland, ME
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Land Elevation
Layer:
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Vertical Unit:
Feet
Flooding Scenario
Year:
2050
Eustatic SLR:
High
Recurre ce:
100Y
Total flood elevation for this event:
12.477
Feet (NAVD88)
Assets
Parcels
New...
Properties...
Adaptations
Levee
New...
Properties...
Additional Parameters
Discount Rate (pct):
3.5
Outputs
Output Data Folder:
C:\CoastData\Portland\Sandbox\Testing3
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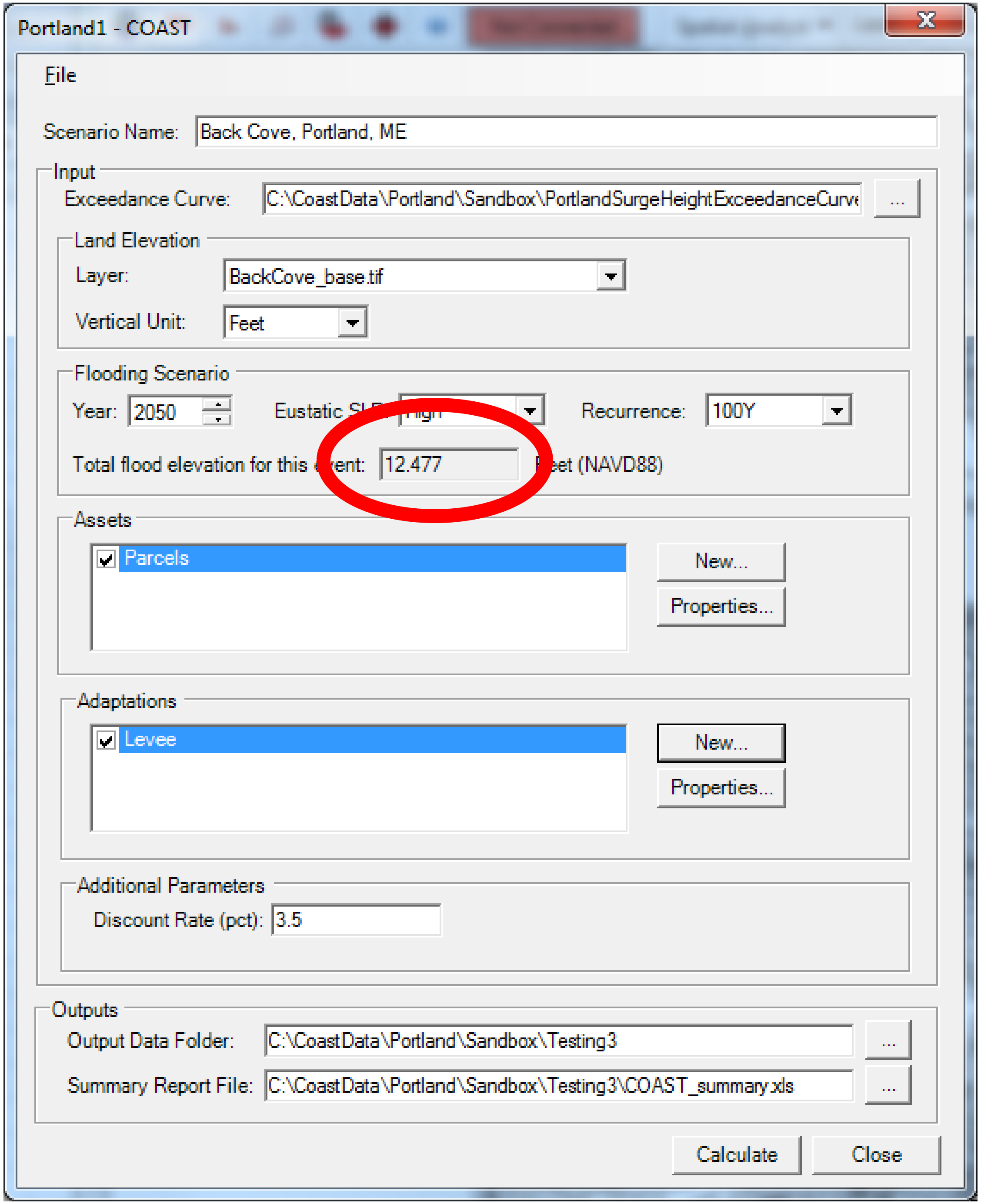
Summary Report File:
C:\CoastData\Portland\Sandbox\Testing3\COAST_summary.xls
...
Calculate
Close


Portland1 - COAST
File
Scenario Name:
Back Cove, Portland, ME
Input
Exceedance Curve:
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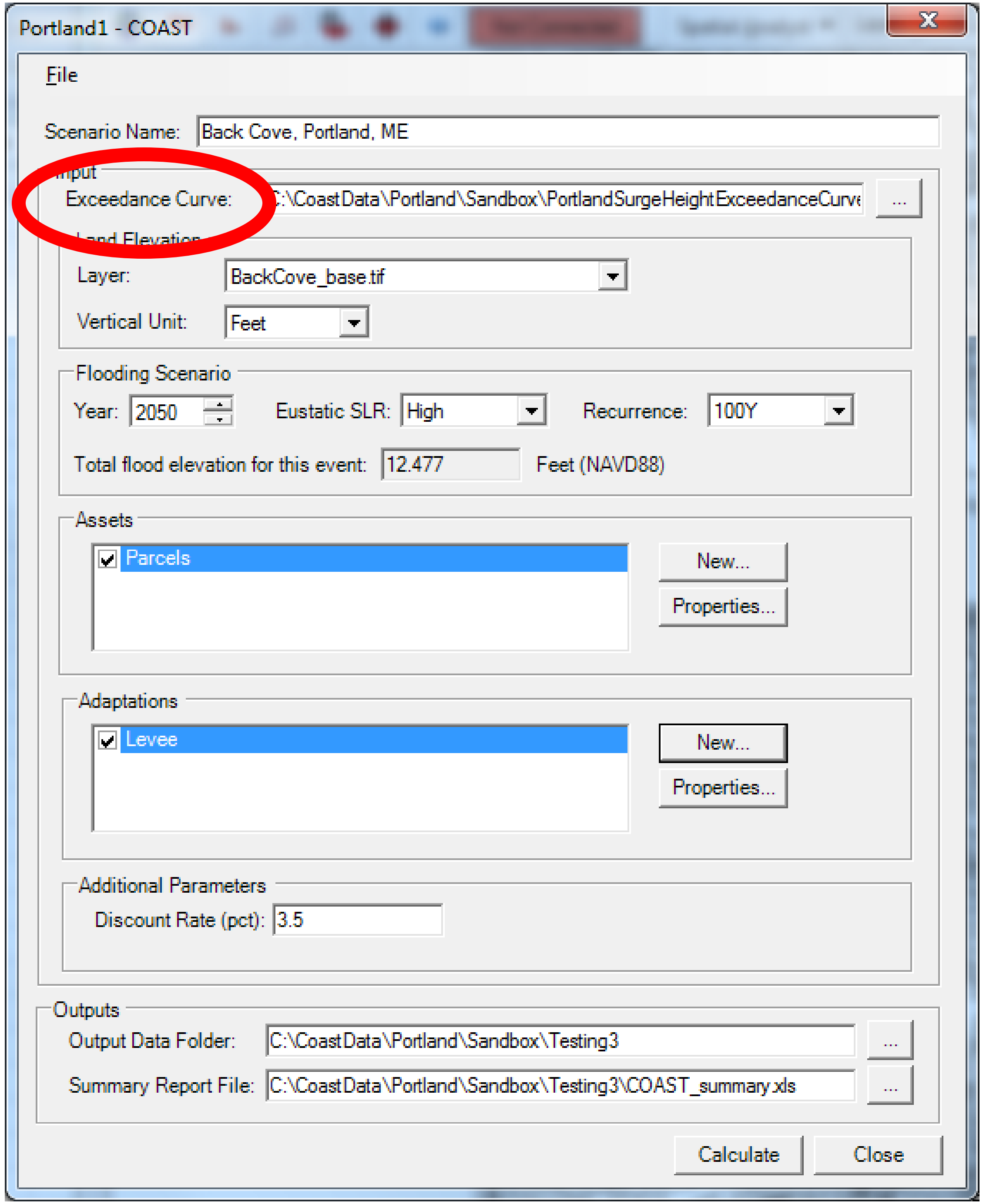
...
Land Elevation
Layer:
BackCove_base.tif
Vertical Unit:
Feet
Flooding Scenario
Year:
2050
Recurrence:
100Y
12.477
et (NAVD88)
Assets
Parcels
New...
Properties...
Adaptations
Levee
New...
Properties...
Additional Parameters
Discount Rate (pct):
3.5
Outputs
Output Data Folder:
C:\CoastData\Portland\Sandbox\Testing3
...
Summary Report File:
C:\CoastData\Portland\Sandbox\Testing3\COAST_summary.xls
...
Calculate
Close

To set up a COAST scenario, needed are:

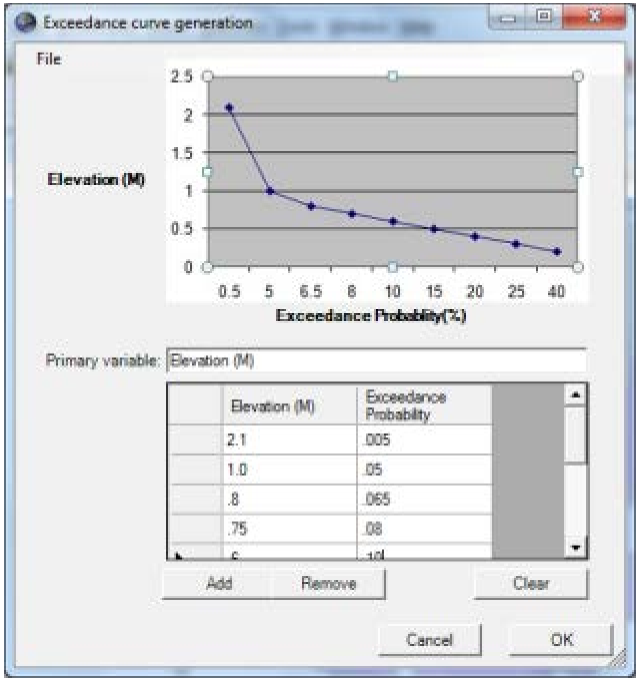
1. A base land elevation layer.
2. A base asset data layer. (Vector file with features for assets to be modeled. Can be a shapefile or a table in an Esri geodatabase).
3. An Excel spreadsheet containing the Depth Damage Function.
4. An Excel spreadsheet containing exceedance curve data.

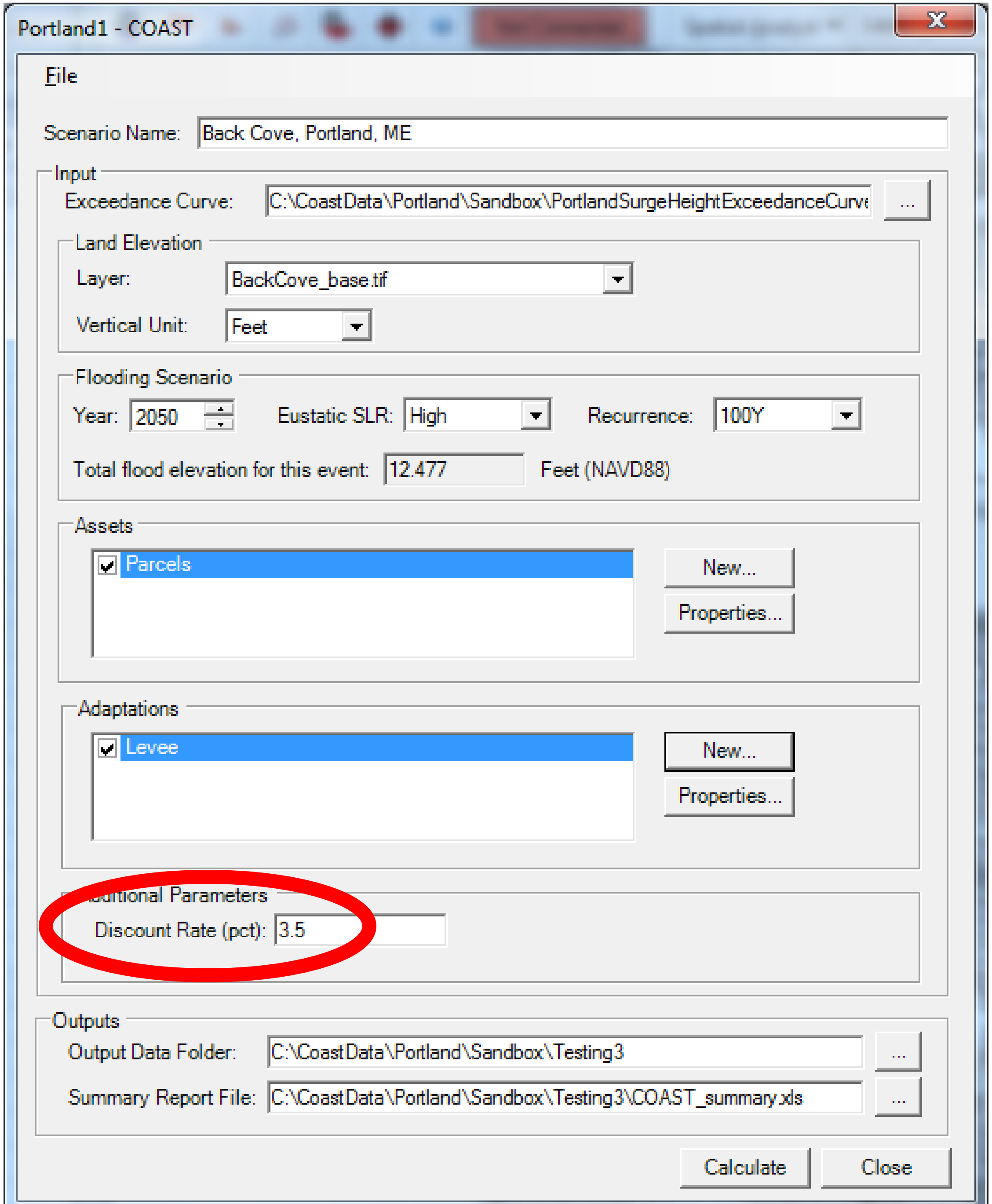

Portland1 - COAST
File
Scenario Name:
Back Cove, Portland, ME
Input
Exceedance Curve:
C:\CoastData\Portland\Sandbox\PortlandSurgeHeightExceedanceCurve
Land Elevation
Layer:
BackCove_base.tif
Vertical Unit:
Feet
Flooding Scenario
Year:
2050
Eustatic SLR:
High
Recurrence:
100Y
Total flood elevation for this event:
12.477
Feet (NAVD88)
Assets
Parcels
New...
Properties...
Adaptations
Levee
New...
Properties...
Additional Parameters
Discount Rate (pct):
3.5
Outputs
Output Data Folder:
C:\CoastData\Portland\Sandbox\Testing3
Summary Report File:
C:\CoastData\Portland\Sandbox\Testing3\COAST_summary.xls
Calculate
Close

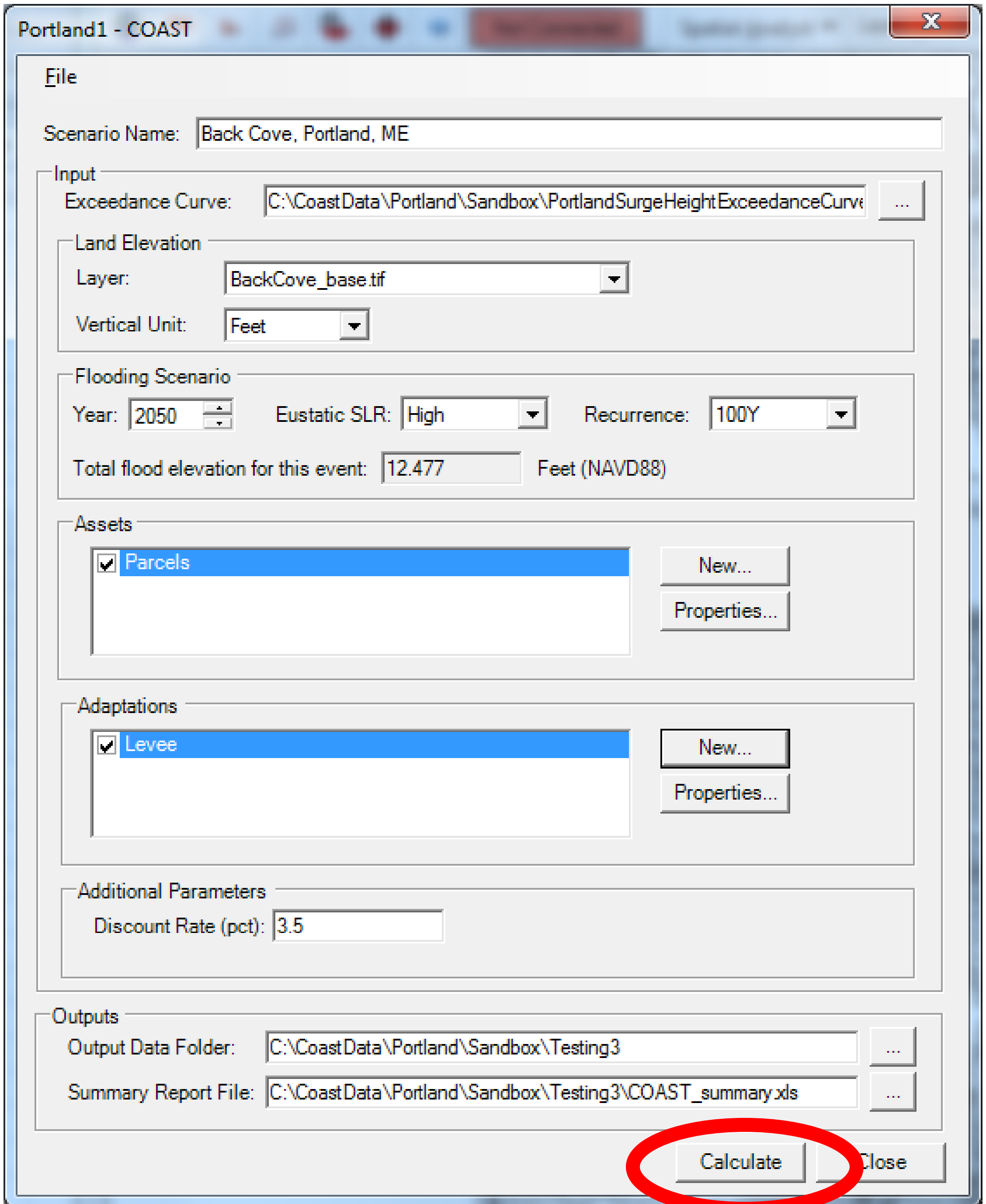
Exceedance Curves:

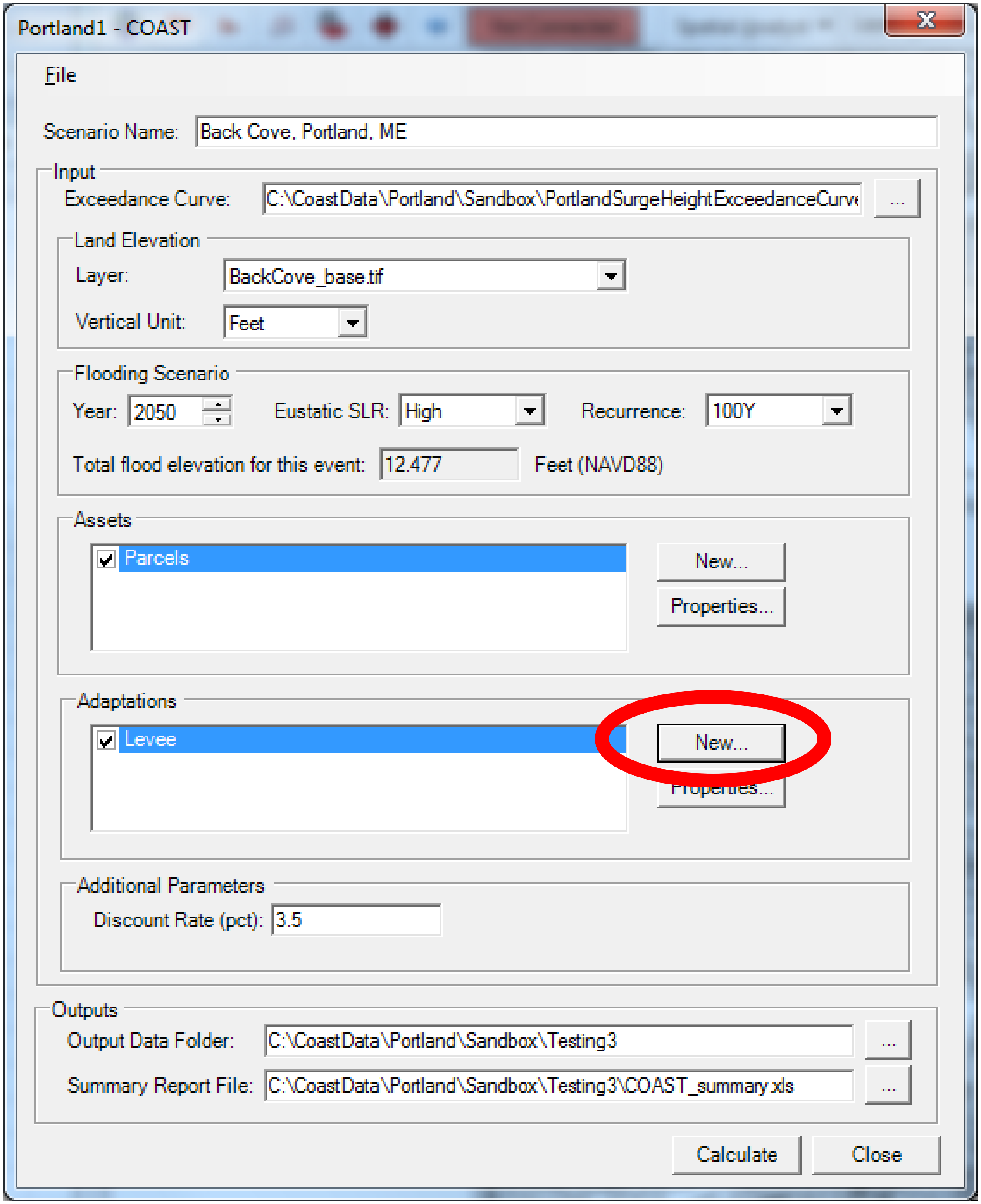
Specify the probability that various flood elevations will be exceeded.

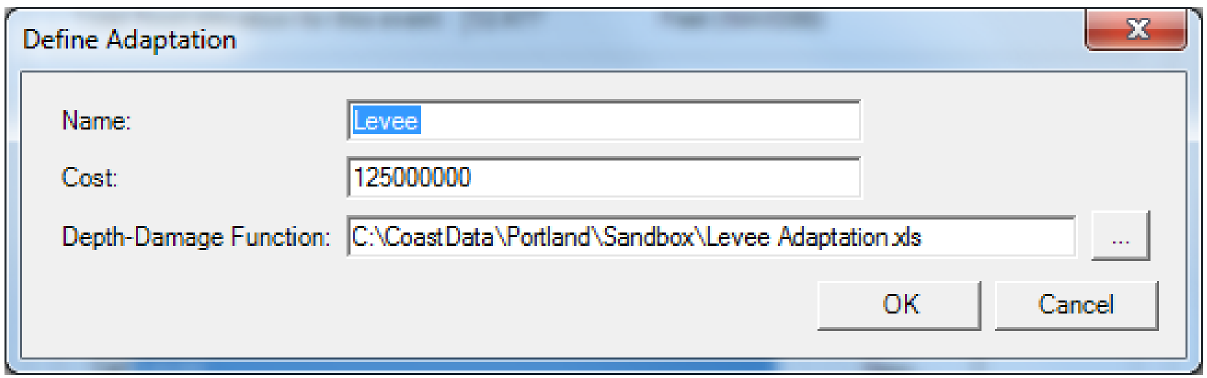
Probability	Description	Surge Height (ft)	MHHW (ft)	Local SLR (ft)
0.002	500 Y	9.153543	4.652231	0.000722
0.01	100 Y	6.496063		
0.02	50 Y	5.610236		
0.05	20 Y	4.593176		
0.1	10 Y	3.904199		

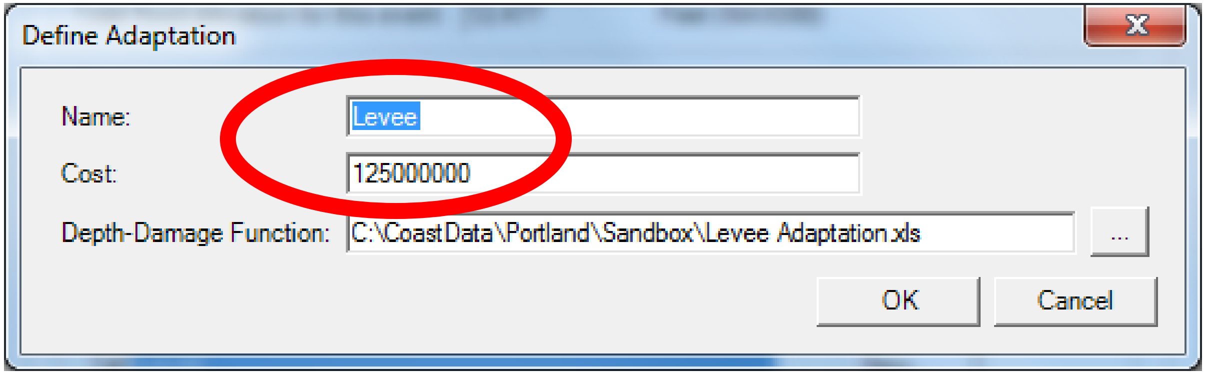


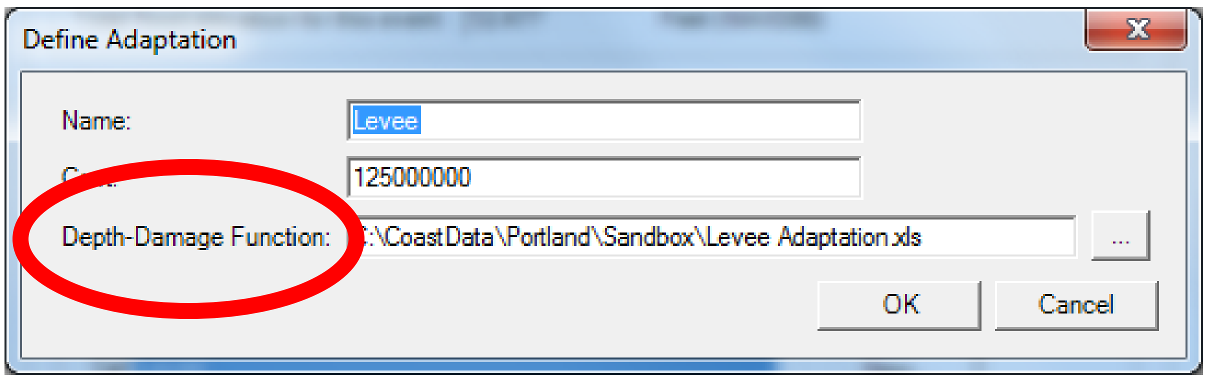

Portland1 - COAST
File
Scenario Name: Back Cove, Portland, ME
Input
Exceedance Curve: C:\CoastData\Portland\Sandbox\PortlandSurgeHeightExceedanceCurve
...
Land Elevation
Layer: BackCove_base.tif
Vertical Unit: Feet
Flooding Scenario
Year: 2050
Eustatic SLR: High
Recurrence: 100Y
Total flood elevation for this event: 12.477
Feet (NAVD88)
Assets
Parcels
New...
Properties...
Adaptations
Levee
New...
Properties...
Additional Parameters
Discount Rate (pct): 3.5
Outputs
Output Data Folder: C:\CoastData\Portland\Sandbox\Testing3
...
Summary Report File: C:\CoastData\Portland\Sandbox\Testing3\COAST_summary.xls
...
Calculate
Close

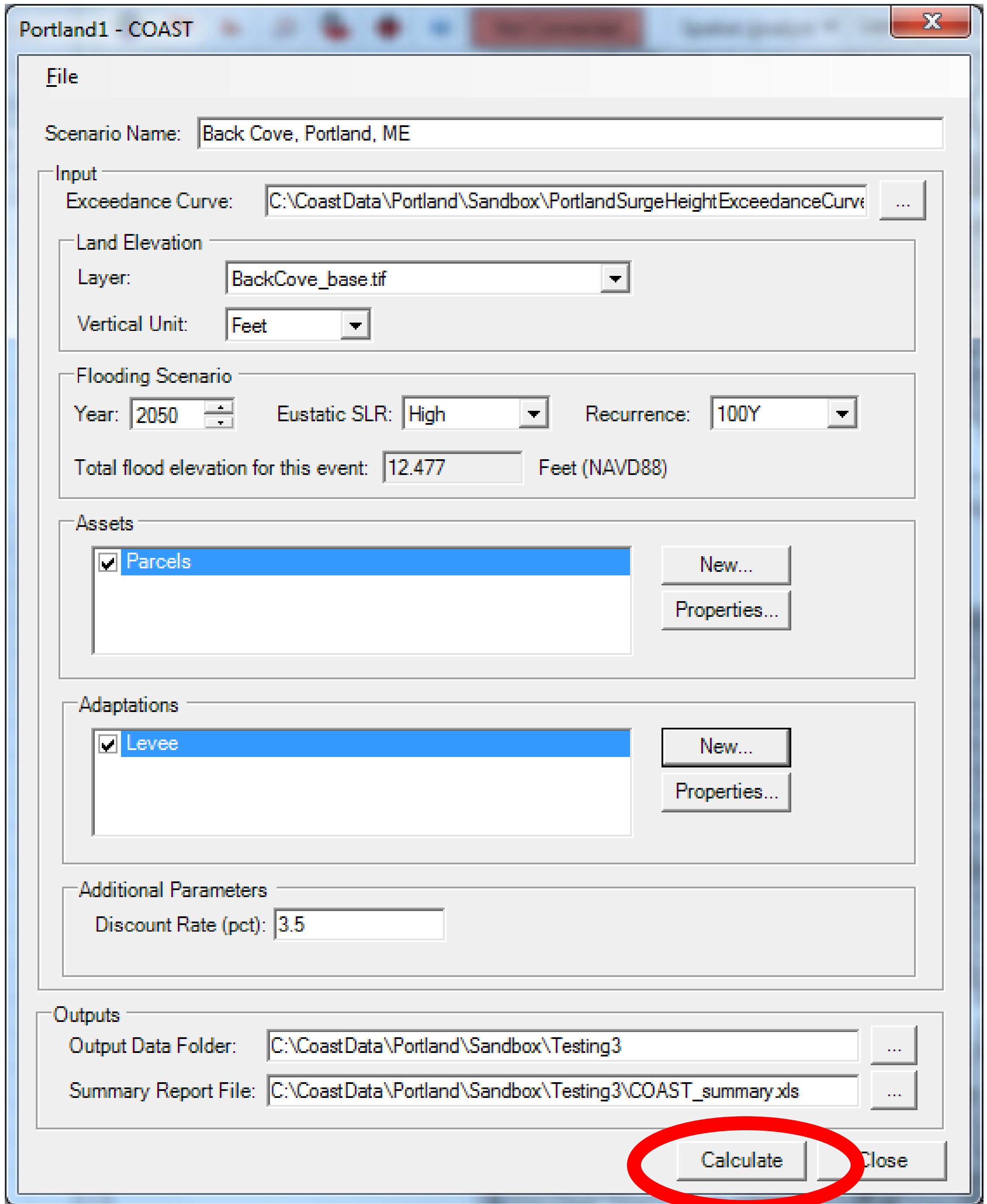

Portland1 - COAST
File
Scenario Name:
Back Cove, Portland, ME
Input
Exceedance Curve:
C:\CoastData\Portland\Sandbox\PortlandSurgeHeightExceedanceCurve
Land Elevation
Layer:
BackCove_base.tif
Vertical Unit:
Feet
Flooding Scenario
Year:
2050
Eustatic SLR:
High
Recurrence:
100Y
Total flood elevation for this event:
12.477
Feet (NAVD88)
Assets
Parcels
New...
Properties...
Adaptations
Levee
New...
Properties...
Additional Parameters
Discount Rate (pct):
3.5
Outputs
Output Data Folder:
C:\CoastData\Portland\Sandbox\Testing3
Summary Report File:
C:\CoastData\Portland\Sandbox\Testing3\COAST_summary.xls
Calculate
Close


Portland1 - COAST
File
Scenario Name:
Back Cove, Portland, ME
Input
Exceedance Curve:
C:\CoastData\Portland\Sandbox\PortlandSurgeHeightExceedanceCurve
Land Elevation
Layer:
BackCove_base.tif
Vertical Unit:
Feet
Flooding Scenario
Year:
2050
Eustatic SLR:
High
Recurrence:
100Y
Total flood elevation for this event:
12.477
Feet (NAVD88)
Assets
Parcels
New...
Properties...
Adaptations
Levee
New...
Additional Parameters
Discount Rate (pct):
3.5
Outputs
Output Data Folder:
C:\CoastData\Portland\Sandbox\Testing3
Summary Report File:
C:\CoastData\Portland\Sandbox\Testing3\COAST_summary.xls
Calculate
Close


Define Adaptation
Name:
Levee
Cost:
125000000
Depth-Damage Function:
C:\CoastData\Portland\Sandbox\Levee Adaptation.xls
...
OK
Cancel


Define Adaptation
Name:
Levee
Cost:
125000000
Depth-Damage Function:
C:\CoastData\Portland\Sandbox\Levee Adaptation.xls
...
OK
Cancel


Define Adaptation
Name:
Levee
125000000
Depth-Damage Function:
:\CoastData\Portland\Sandbox\Levee Adaptation.xls
...
OK
Cancel


Portland1 - COAST
File
Scenario Name: Back Cove, Portland, ME
Input
Exceedance Curve: C:\CoastData\Portland\Sandbox\PortlandSurgeHeightExceedanceCurve
...
Land Elevation
Layer: BackCove_base.tif
Vertical Unit: Feet
Flooding Scenario
Year: 2050
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Total flood elevation for this event: 12.477
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Assets
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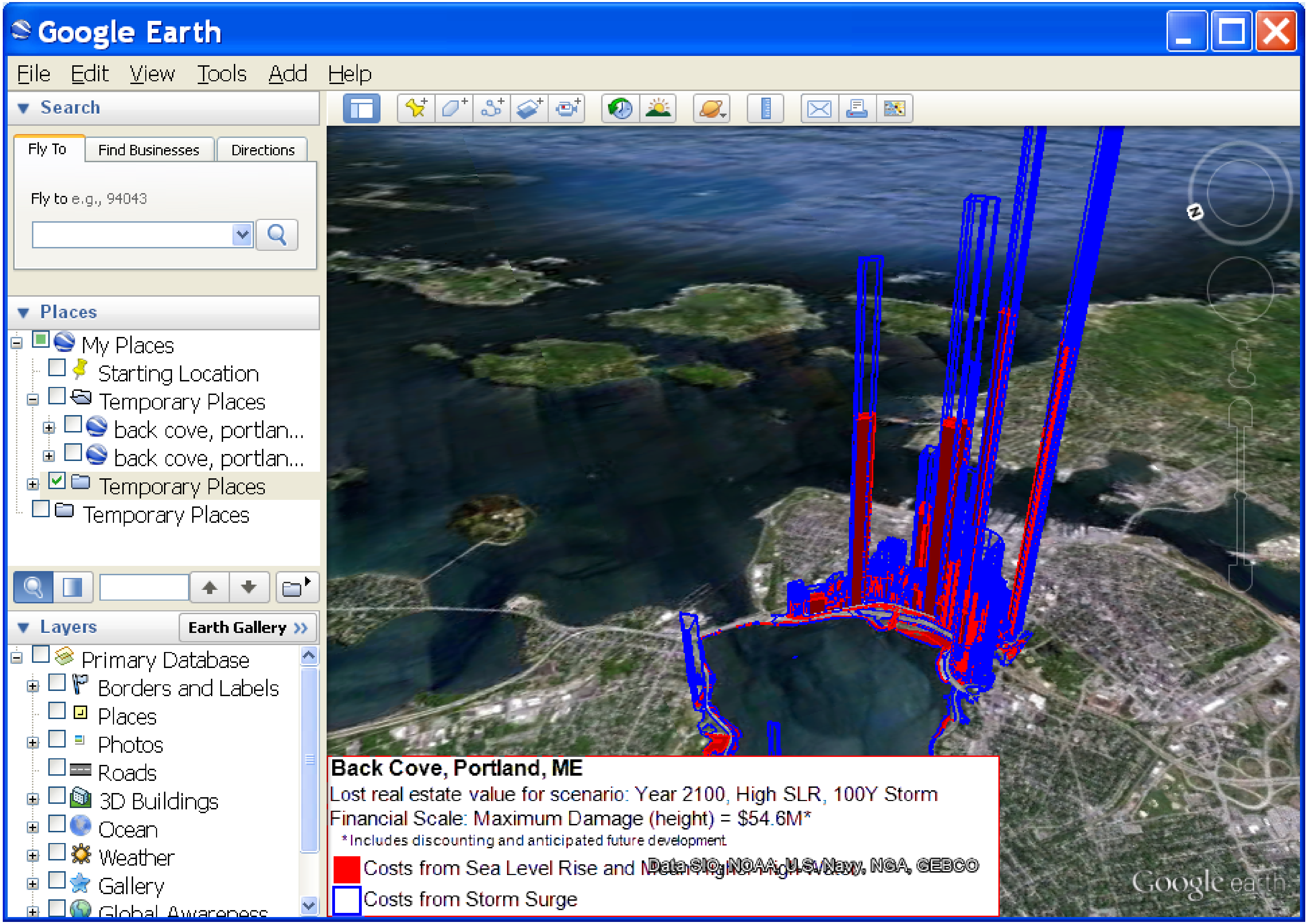
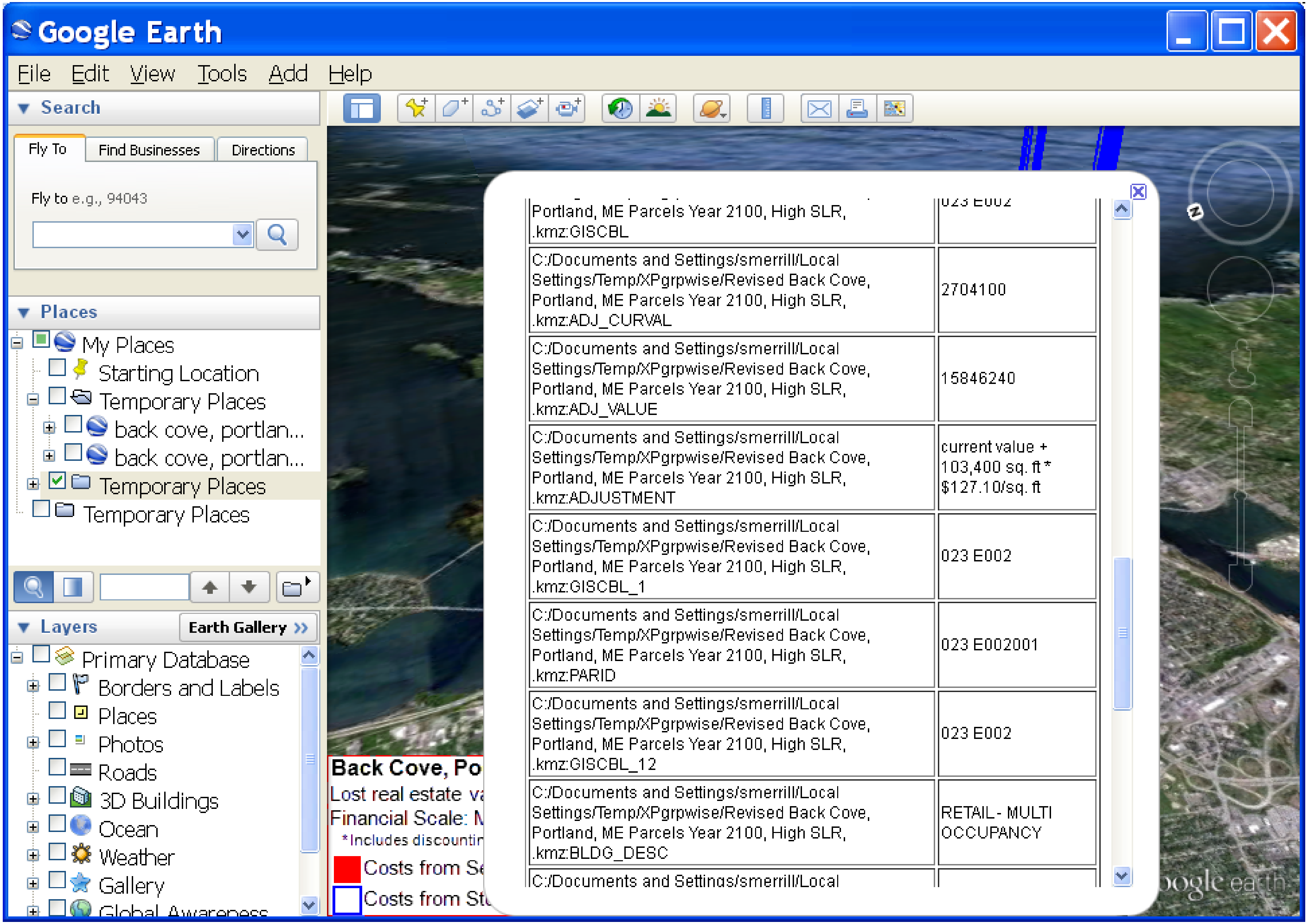
New...
Properties...
Adaptations
Levee
New...
Properties...
Additional Parameters
Discount Rate (pct): 3.5
Outputs
Output Data Folder: C:\CoastData\Portland\Sandbox\Testing3
Summary Report File: C:\CoastData\Portland\Sandbox\Testing3\COAST_summary.xls
Calculate
Close


Google™
Earth


Google Earth
File Edit View Tools Add Help
Search
Fly To
Find Businesses
Directions
Fly to e.g., 94043
Places
My Places
Starting Location
Temporary Places
back cove, portlan...
back cove, portlan...
Temporary Places
Temporary Places
Layers
Earth Gallery »
Primary Database
Borders and Labels
Places
Photos
Roads
3D Buildings
Ocean
Weather
Gallery
Back Cove, Portland, ME
Lost real estate value for scenario: Year 2100, High SLR, 100Y Storm
Financial Scale: Maximum Damage (height) = $54.6M*
*Includes discounting and anticipated future development
Costs from Sea Level Rise and M
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Costs from Storm Surge
Google earth


Google Earth
File Edit View Tools Add Help
Search
Fly To
Find Businesses
Directions
Fly to e.g., 94043
Places
My Places
Starting Location
Temporary Places
back cove, portlan...
back cove, portlan...
Temporary Places
Temporary Places
Layers
Earth Gallery »
Primary Database
Borders and Labels
Places
Photos
Roads
3D Buildings
Ocean
Weather
Gallery
Global Awareness
Portland, ME Parcels Year 2100, High SLR, .kmz:GISCBL
023 E002
C:/Documents and Settings/smerrill/Local Settings/Temp/XPgrpwise/Revised Back Cove, Portland, ME Parcels Year 2100, High SLR, .kmz:ADJ_CURVAL
2704100
C:/Documents and Settings/smerrill/Local Settings/Temp/XPgrpwise/Revised Back Cove, Portland, ME Parcels Year 2100, High SLR, .kmz:ADJ_VALUE
15846240
C:/Documents and Settings/smerrill/Local Settings/Temp/XPgrpwise/Revised Back Cove, Portland, ME Parcels Year 2100, High SLR, .kmz:ADJUSTMENT
current value + 103,400 sq. ft * $127.10/sq. ft
C:/Documents and Settings/smerrill/Local Settings/Temp/XPgrpwise/Revised Back Cove, Portland, ME Parcels Year 2100, High SLR, .kmz:GISCBL_1
023 E002
C:/Documents and Settings/smerrill/Local Settings/Temp/XPgrpwise/Revised Back Cove, Portland, ME Parcels Year 2100, High SLR, .kmz:PARID
023 E002001
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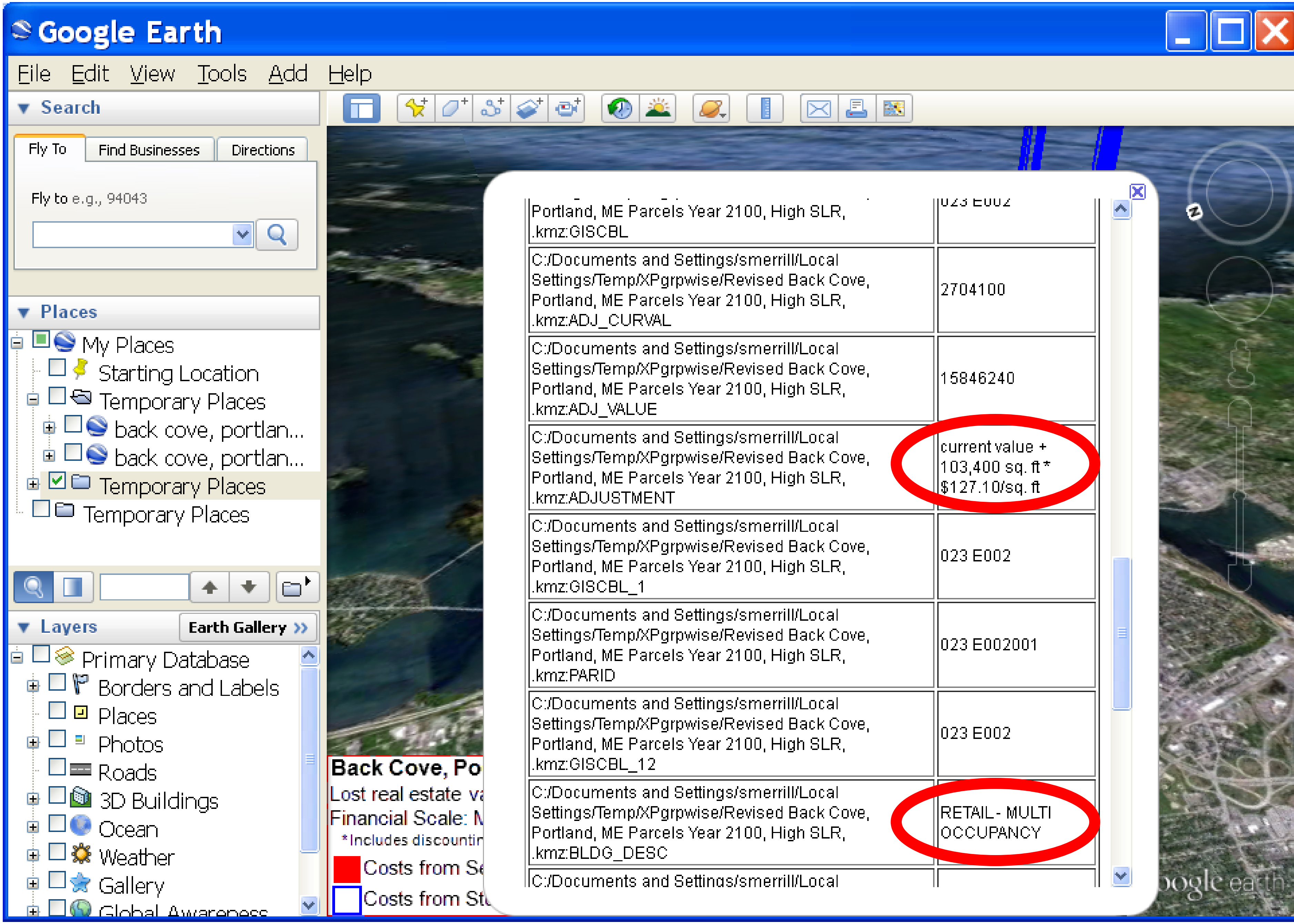
023 E002
C:/Documents and Settings/smerrill/Local Settings/Temp/XPgrpwise/Revised Back Cove, Portland, ME Parcels Year 2100, High SLR, .kmz:BLDG_DESC
RETAIL - MULTI OCCUPANCY
C:/Documents and Settings/smerrill/Local
Back Cove, Po
Lost real estate va
Financial Scale: M
*Includes discountin
Costs from Se
Costs from St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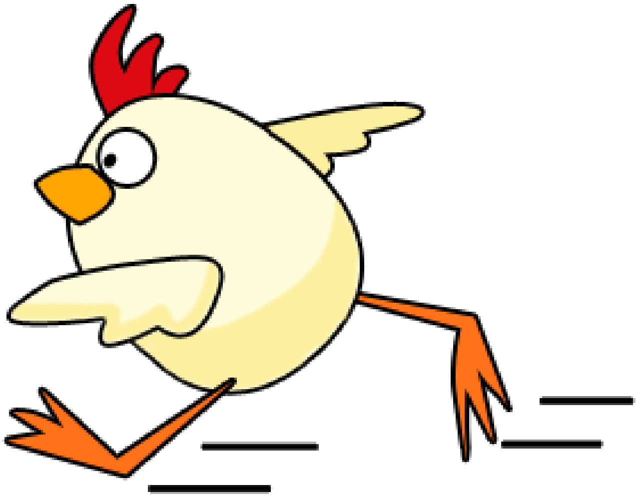
3D Buildings
Ocean
Weather
Gallery
Portland, ME Parcels Year 2100, High SLR, .kmz:GISCBL
C:/Documents and Settings/smerrill/Local Settings/Temp/XPgrpwise/Revised Back Cove, Portland, ME Parcels Year 2100, High SLR, .kmz:ADJ_CURVAL
2704100
C:/Documents and Settings/smerrill/Local Settings/Temp/XPgrpwise/Revised Back Cove, Portland, ME Parcels Year 2100, High SLR, .kmz:ADJ_VALUE
15846240
C:/Documents and Settings/smerrill/Local Settings/Temp/XPgrpwise/Revised Back Cove, Portland, ME Parcels Year 2100, High SLR, .kmz:ADJUSTMENT
current value + 103,400 sq. ft * $127.10/sq. ft
C:/Documents and Settings/smerrill/Local Settings/Temp/XPgrpwise/Revised Back Cove, Portland, ME Parcels Year 2100, High SLR, .kmz:GISCBL_1
023 E002
C:/Documents and Settings/smerrill/Local Settings/Temp/XPgrpwise/Revised Back Cove, Portland, ME Parcels Year 2100, High SLR, .kmz:PARID
023 E002001
C:/Documents and Settings/smerrill/Local Settings/Temp/XPgrpwise/Revised Back Cove, Portland, ME Parcels Year 2100, High SLR, .kmz:GISCBL_12
023 E002
C:/Documents and Settings/smerrill/Local Settings/Temp/XPgrpwise/Revised Back Cove, Portland, ME Parcels Year 2100, High SLR, .kmz:BLDG_DESC
RETAIL - MULTI OCCUPANCY
C:/Documents and Settings/smerrill/Local
Back Cove, Po
Lost real estate va
Financial Scale: M
*Includes discountin
Costs from Se
Costs from St


Sea Isle City, NJ
Geotextile Tubes

Facing the bluntness of reality is the highest form of sanity and enlightened vision.

- Chogyam Trungpa Rinpoche



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http://efc.muskie.usm.maine.edu

207-228-8596

Catalysis Adaptation Partners

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207-615-7523