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Economic Consequences of Failing to Adapt to Sea Level Rise in the Hampton Roads Region

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Economic Impacts Forum

Virginia Modeling and Simulation Center

RTI INTERNATIONAL

Overview of the Study

- **Main Objective**: Assess the potential costs and economic impacts of not adapting to sea level rise in the Hampton Roads region
- **Two key questions**:
  - What types and magnitude of property damages are likely to occur if a "business as usual" approach is used?
  - How would these damages affect the economic performance of the regional economy?

Two Main Components of Analysis

- Task 1: Analysis of Damage Costs Due to Sea Level Rise

- Task 2: Analysis of the Regional Economy-wide Impacts of Sea Level Rise

Key Objectives for Task 1

- Estimate expected (probability-weighted) damages to residential properties for future sea level rise scenarios
  - Overlay sea level and storm surge height estimates on parcel location, elevation, type, and value data
  - Apply risk-based approach to compare expected annual damages with and without sea level rise
- Develop county-level estimates of direct building losses and business interruption losses from damages to residential, commercial, industrial and government sector structures
  - Apply FEMA's HAZUS model for selected sea level rise and storm event (e.g. 10 and 100 year floods) scenarios

Expected Impacts on Residential Property Values

R_t = expected sea level rise (feet) in period t *(VIMS, 2012)*

S = storm surge level (feet above sea level)

$p(S_{it})$ = probability that highest storm surge at parcel i in year t is S feet. *(NOAA)*

E_i = elevation of parcel i above current sea level L^0 (feet) *(county parcel data, LIDAR)*

P_{i0} = current property value of parcel i ($s) *(county parcel data)*

$E(P_{it})$ = *expected* property value of parcel i in future period t ($s)

F_{it} = max flood depth at parcel i in period t (in feet above E_i) $F_{it} = R_t + S_t - E_i$

$d(F_{it})$ = percent (%) of property value lost with respect to F_{it} *(USACE depth-damage functions)*

<u>If the elevation of parcel *i* falls at or below the expected sea level rise in period *t*</u>

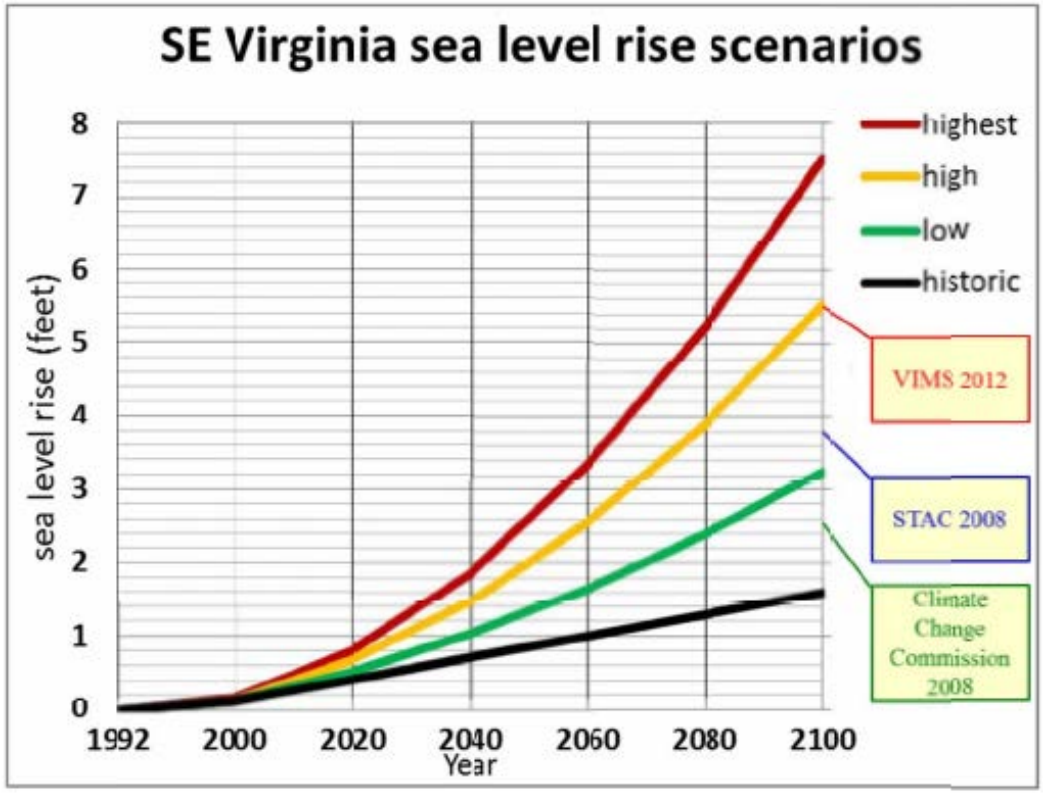
If $E_i \leq R_t$ then $E(P_{it}) = 0$

<u>If the elevation of parcel *i* falls above the expected sea level rise in period *t*</u>

If $E_i > R_t$ then $E(P_{it}) = P_{i0} * \left[1 - \sum_{S_t=0}^{Smax} p(S_t) * d(R_t + S_t - E_i)/100\right]$

Sea Level Risk Projections

- Based on recommendations to the Secure Commonwealth Panel (2014)
  - 1.5 ft by 2040
  - 2.5 ft by 2060



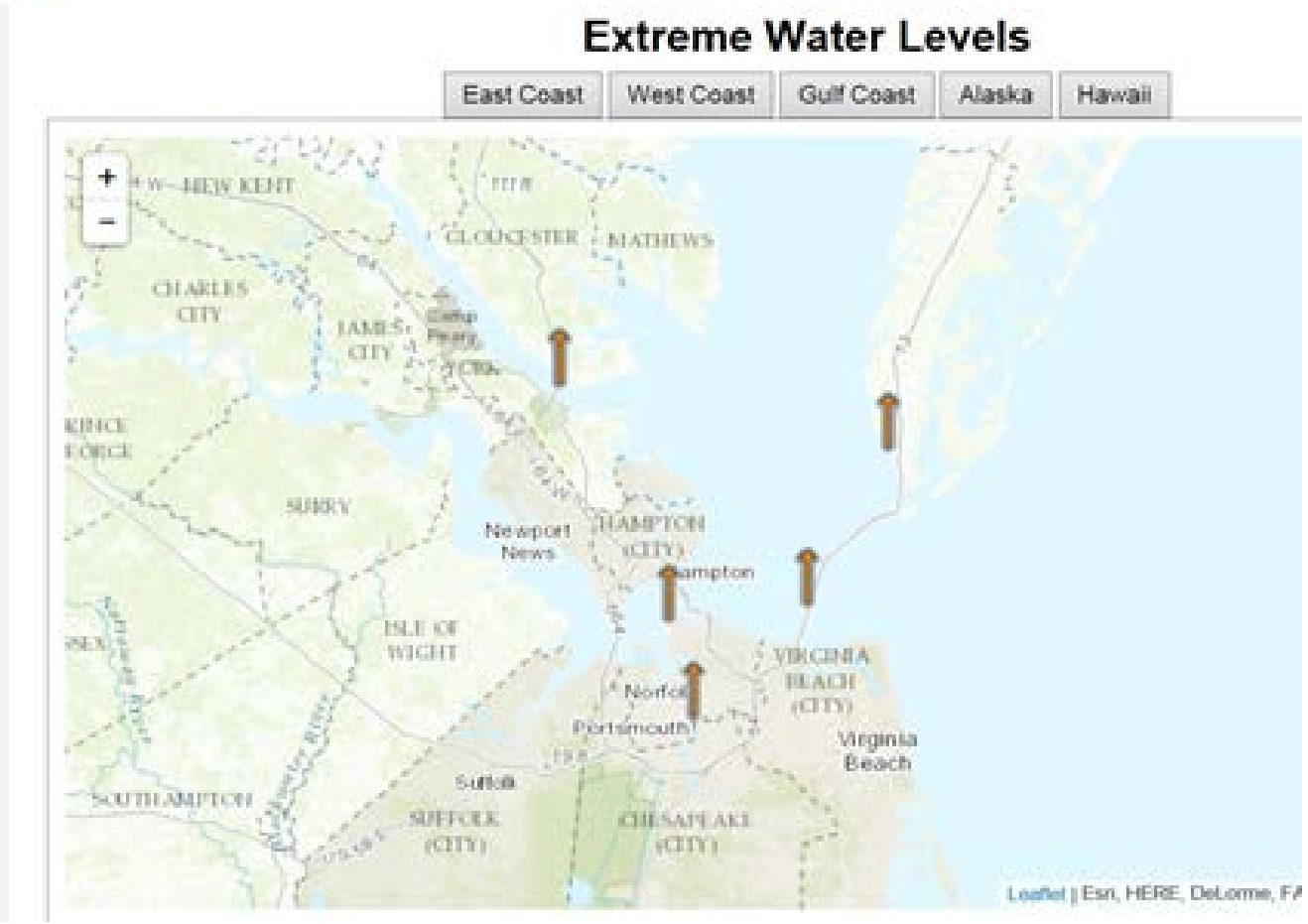
Source: Dr. Carl Hershner, Virginia Institute of Marine Science, 2012

Based on the graph above, there seems to be the greatest level of confidence in VIMS' 1.5' rise in sea level by the year 2040. (Note: 4-6' expected by 2100…).

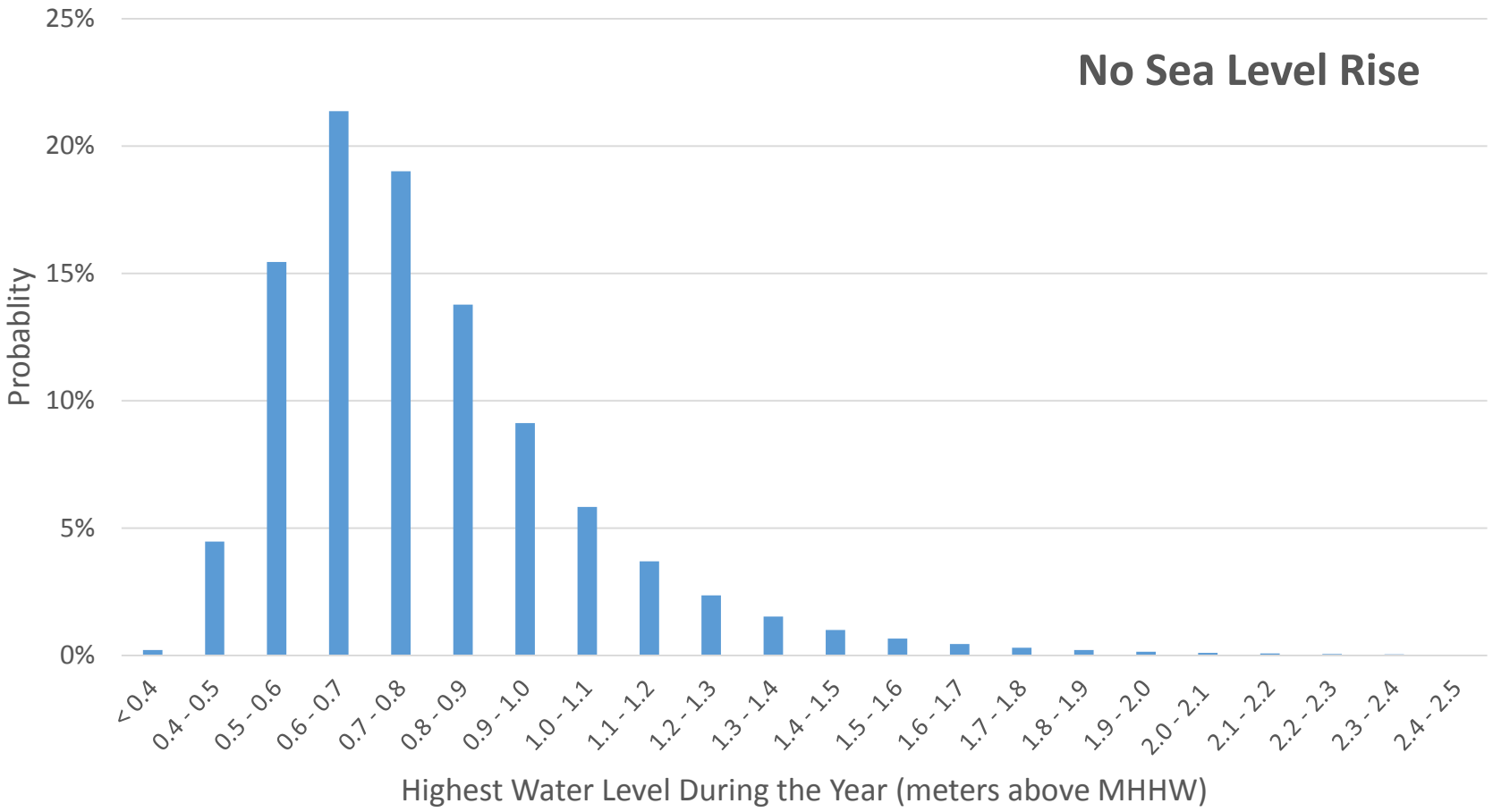
Storm Surge Exceedance Probabilities

4 main NOAA stations for the study area:

- Gloucester Point
- Sewells Point
- Portsmouth
- Chesapeake Bay Bridge Tunnel



Sewells Point Storm Surge Probabilities



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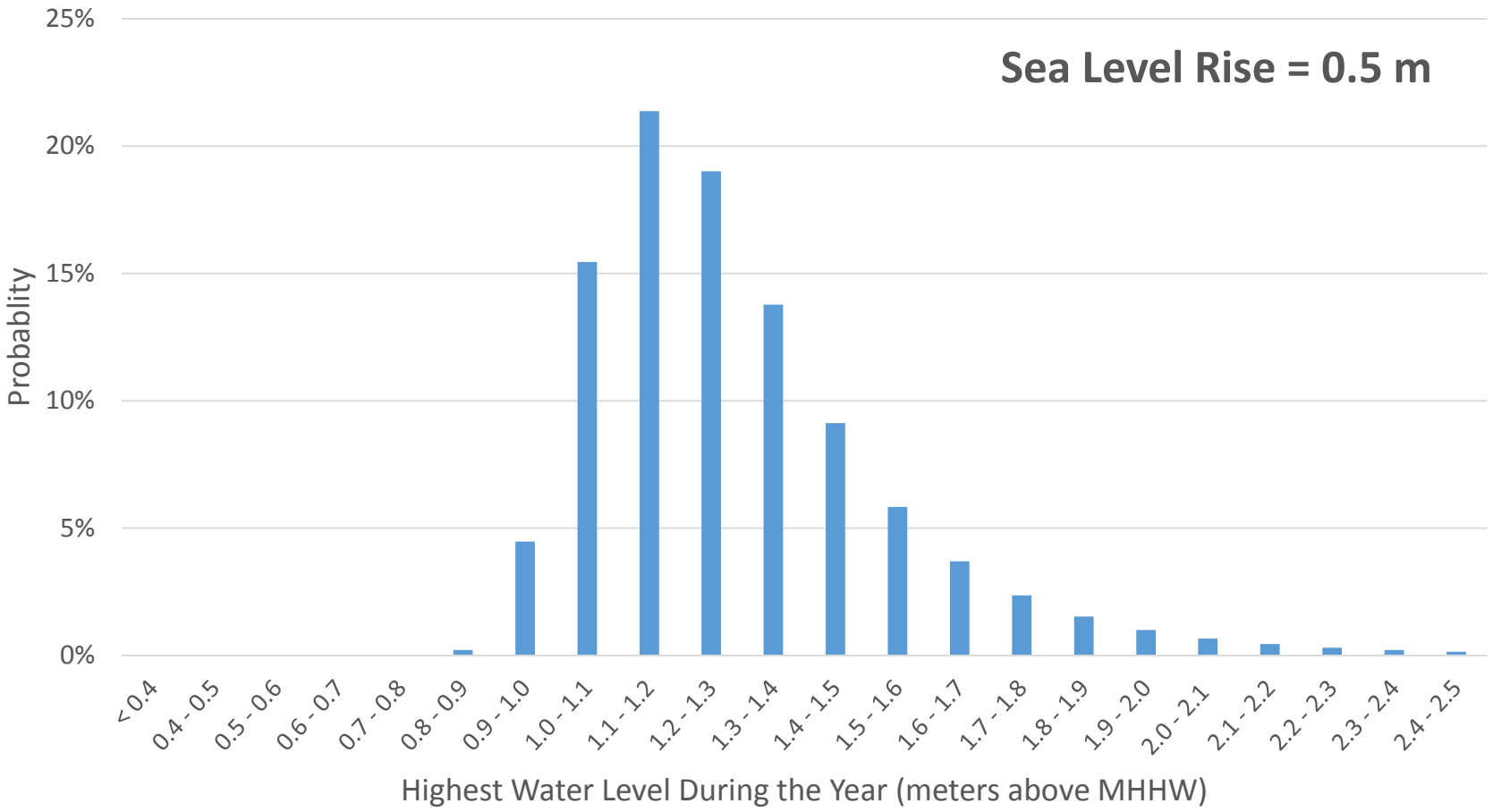
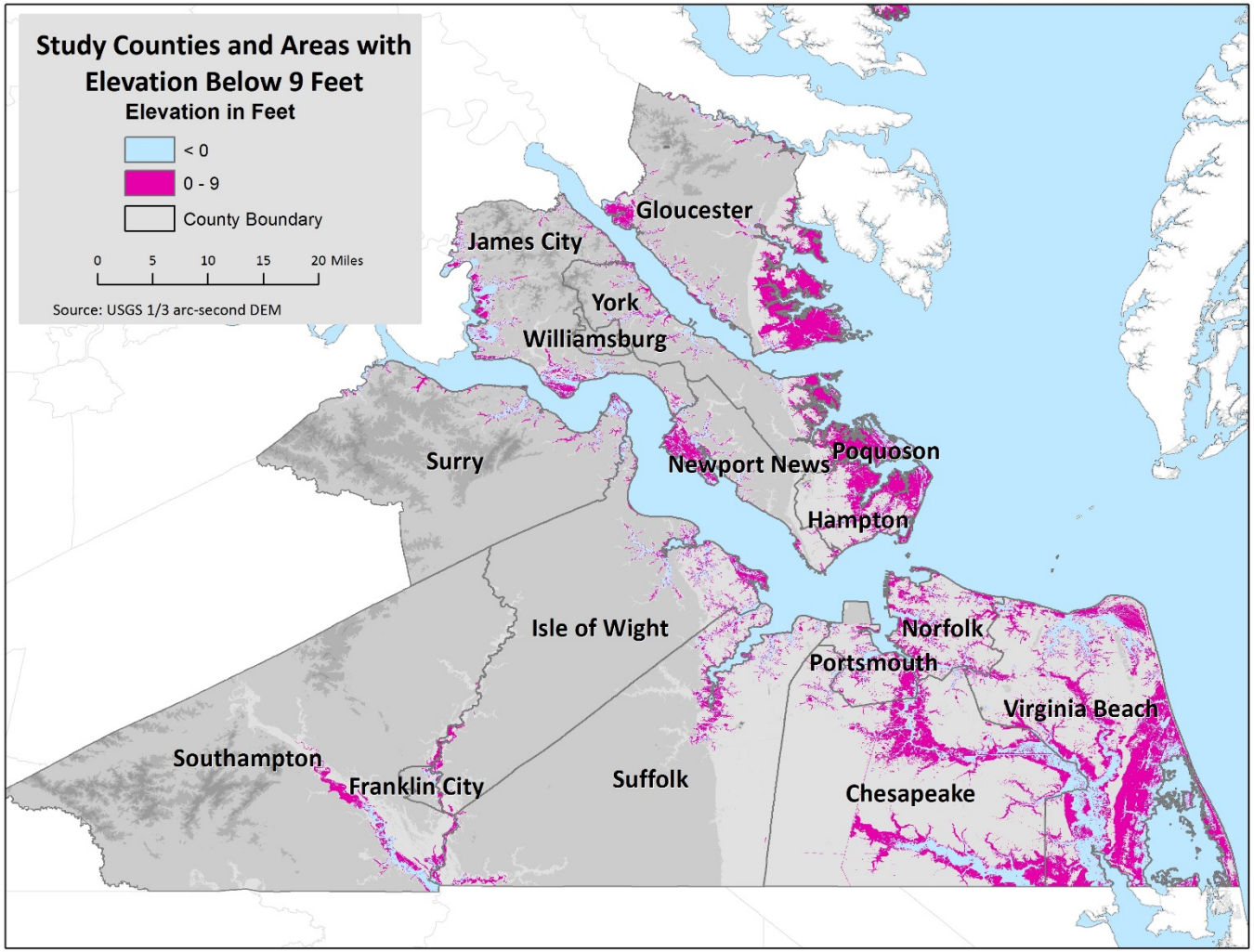


Elevation Mapping for the Study Area



Status of Parcel-Level Data Collection

County/City	Data Received	Parcel Value Data		Stories	Basement	Property Type
		Total	Building			
City of Chesapeake	•	•	•	•	•	•
City of Norfolk	•	•	•	•	•	•
City of Poquoson	•	•	•	•	•	•
City of Virginia Beach	•	•	•			•
City of Williamsburg	•	•		•	•	•
Isle of White County	•	•	•			•
James City County	•	•	•	•	•	•
Surry County	•	•	•			
York County	•	•	•	•	•	•
Gloucester County	•	•	•	•	•	•
City of Hampton	•	•	•	•	•	•
City of Newport News	•	•	•			
City of Portsmouth	•	•	•	•	•	•
City of Suffolk	•					
Southampton County						
City of Franklin						

Summary Statistics for Residential Structures

County/City	Number of Residential Parcels	% Missing # Stories	% Missing Basement	Structure Value (Mean)	Structure Value (Median)
City of Chesapeake	72,615	0%	0%	$ 171,670	$ 136,500
City of Norfolk	53,636	91%	99%	$ 180,912	$ 112,200
City of Poquoson	4,440	1%	0%	$ 183,411	$ 161,500
City of Williamsburg	2,993	3%	19%	$ 384,364	$ 176,000
James City County	24,372	0%	91%	$ 240,611	$ 204,100
York County	23,295	2%	10%	$ 188,806	$ 170,300
Gloucester County	14,649	1%	3%	$ 160,779	$ 137,960
City of Hampton	46,031	2%	6%	$ 127,289	$ 102,900
City of Portsmouth	33,255	1%	0%	$ 116,589	$ 104,040
City of Virginia Beach	173,882	100%	100%	$ 2,723,504	$ 140,400
Isle of Wight County	12,961	100%	100%	$ 172,519	$ 156,900
Surry County	TBD	TBD	TBD	TBD	TBD
City of Newport News	49,012	100%	0%	$ 206,990	$ 138,600

Norfolk Properties by Elevation Zone

Zone	Property Tytpe	Count	Structure Value (Mean)	Structure Value (Median)
1	Single Family	34	$ 268,847	$ 226,300
1	Multiple Family	6	$ 270,617	$ 220,050
2	Single Family	11479	$ 184,755	$ 151,600
2	Multiple Family	1914	$ 655,357	$ 143,200
3	Single Family	36002	$ 120,429	$ 103,900
3	Multiple Family	4302	$ 464,913	$ 126,400
		53737		

Zone 1: MEAN parcel elevation < 0.3 m
Zone 2: MEAN parcel elevation > 0.3 m and <= 2.8 m
Zone 3: MEAN parcel elevation > 2.8 m

Key Questions for Task 2

- What types of questions can be answered through economy-wide modeling?
- Sea level rise brings about local damages.
  - Do damages spread or ripple through the broader economy?
  - Do ripples move in unexpected ways?
  - How significant are these secondary effects? Are we talking about ripples or waves?
  - Are there some sectors and income classes overly harmed (or helped)?

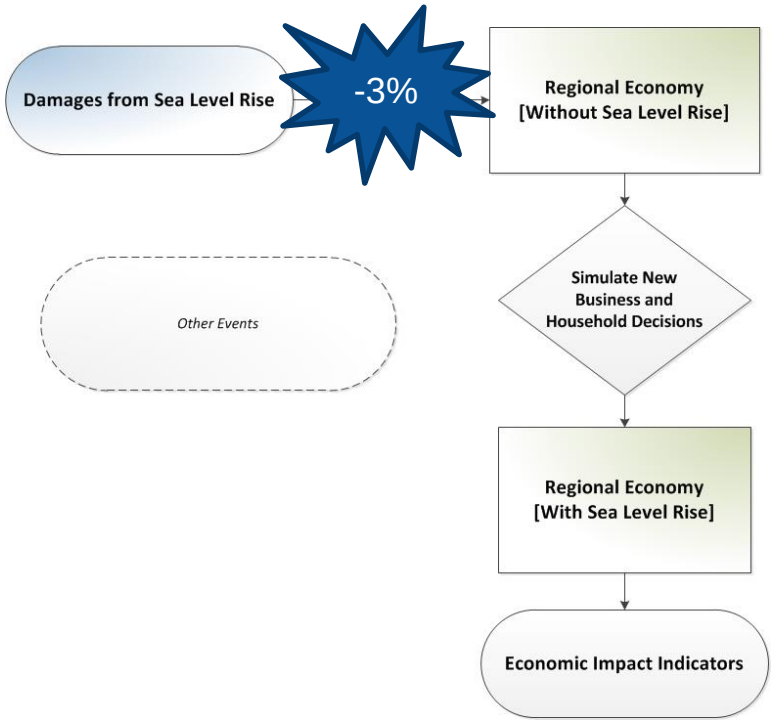
Synthesis of Economic Stories to Date

- 7 peer-reviewed sea level rise studies to date → According to Bosello and De Cian (2014), Darwin and Tol's (2001) paper is the influential paper in this literature.
- Local capital losses are the most important damage category. Focus on these damages likely to provide the most information to stakeholders.
- Key general equilibrium story, expected business interruptions can lead to higher market prices. Large price increases provide businesses and households with incentives to seek out substitute opportunities.
- Economies tend to shrink but there are a wide range of estimates of the size this effect.
- Tourism impacts are difficult to measure but can be important

Example Model Run: 100-Year Flood

- Based on HAZUS-MH model runs for coastal flooding in 12 counties, estimated building value loss of about 3%
- Modeled these impacts as a 3% reduction in capital available to Hampton Roads Economy

Measuring Differences Between Two Conditions of the Virginia Economy



Economic Impact Indicators : Real GDP

- Virginia economy shrinks
  - State of Virginia: $4.0 billion loss
    - Hampton Roads: $0.8 billion loss
    - Rest of Virginia: $3.2 billion loss

Economic Impact Indicators: Consumer Prices

- Average consumer prices rise
  - Hampton Roads: increase by 3.4%
  - Rest of Virginia: 1.4%

Economic Impact Indicators: Equivalent Income Change

- State Income levels divided into nine income classes
  - VA Equivalent Household Income Loss: $940 million
  - Range: -4.6 billion to +$15 billion

Income Class	Value ($million)
HHl	-$117
HH10	-$125
HH15	-$449
HH25	-$821
HH35	-$1,886
HH50	-$4,590
HH75	-$3,900
HH100	-$4,093
HH150	$15,038