2018

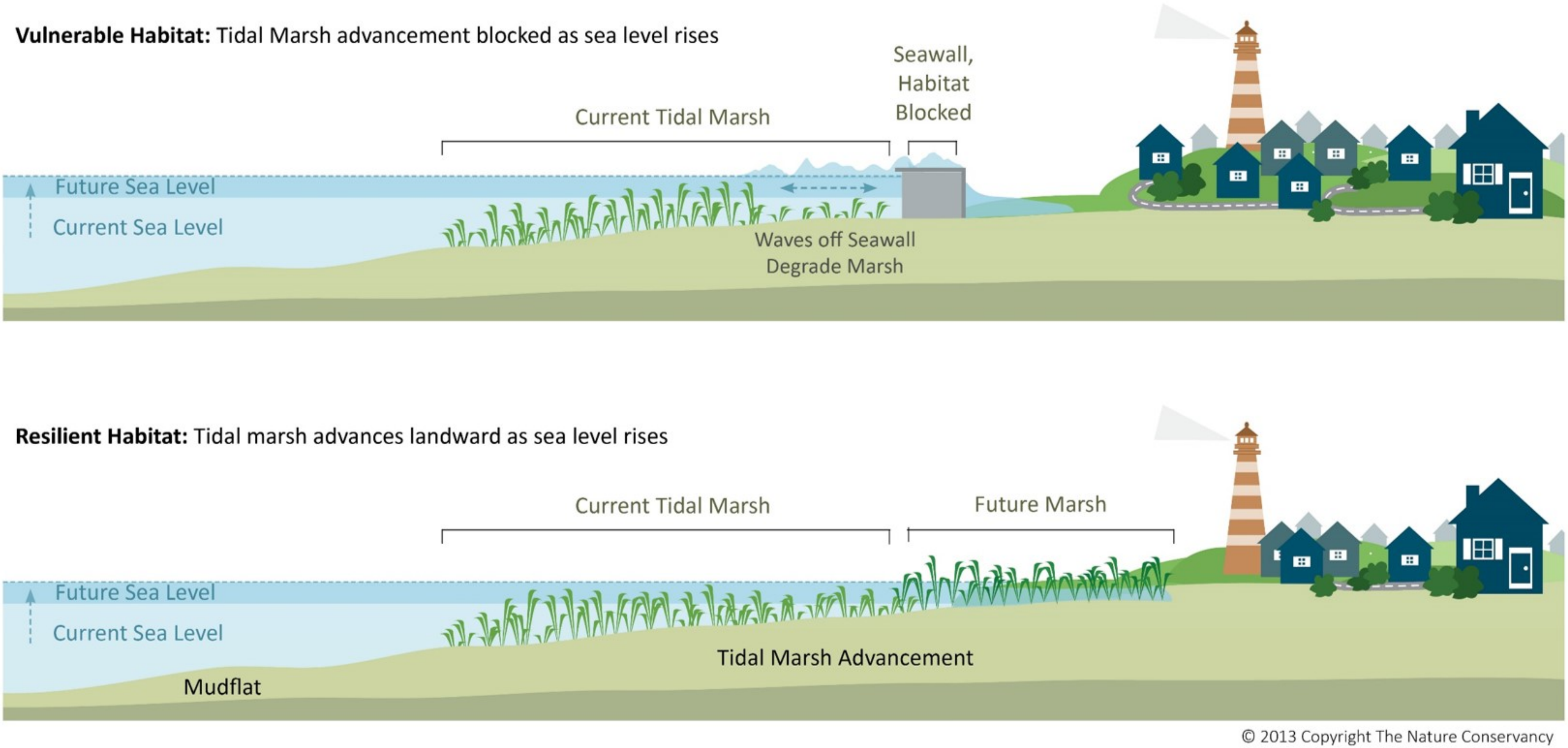
Marsh Response to Sea Level Rise in Virginia Beach

Alaurah Moss

Marsh Response to Sea Level Rise in Virginia Beach

October 19, 2018

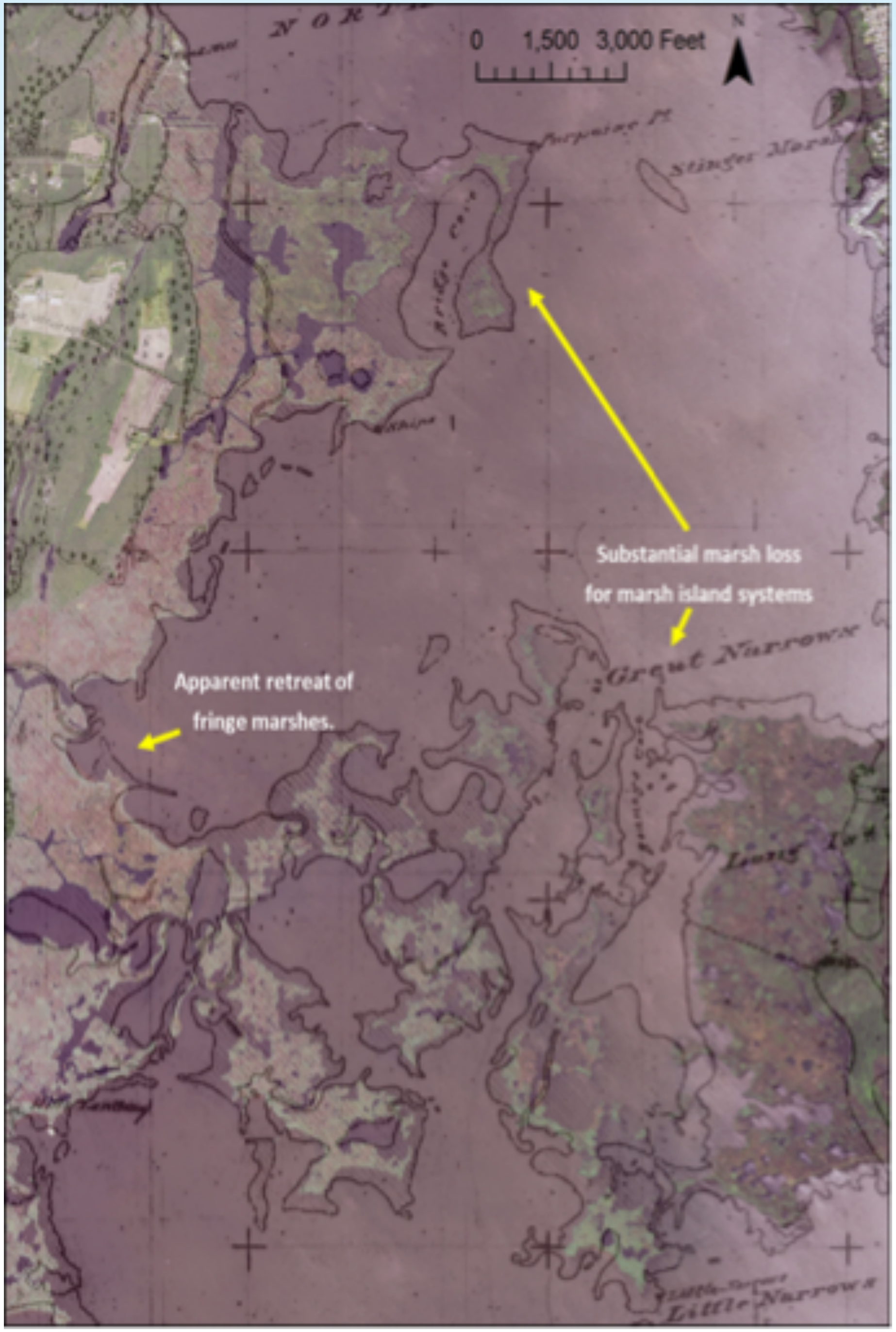
Background



VB Sea Level Wise
A vibrant future for Virginia Beach

What can history tell us?

- 1869's vs Today



What can history tell us?

VB Sea Level Wise
A vibrant future for Virginia Beach

What the data says to expect:

Boon et al. 2018

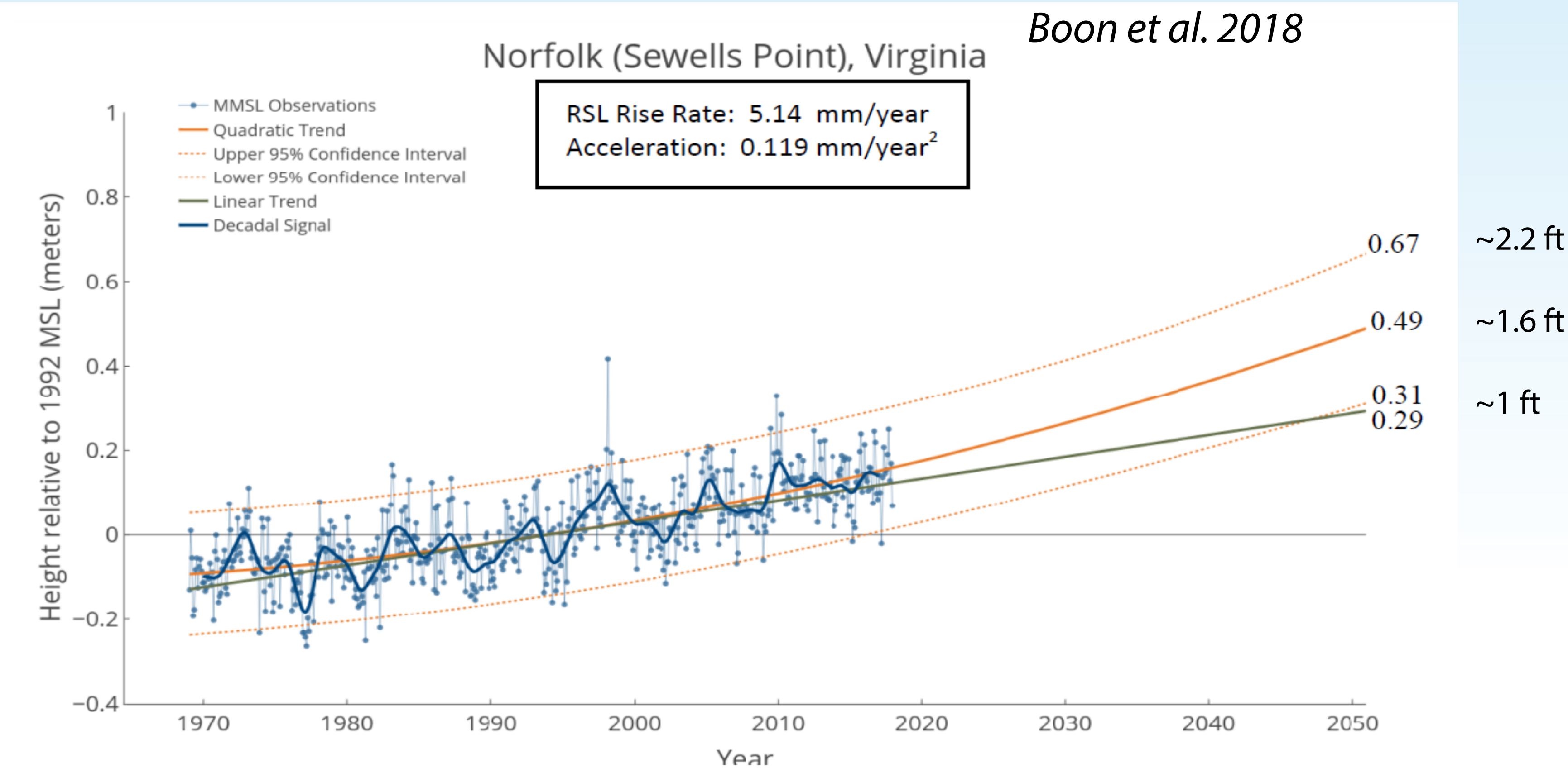


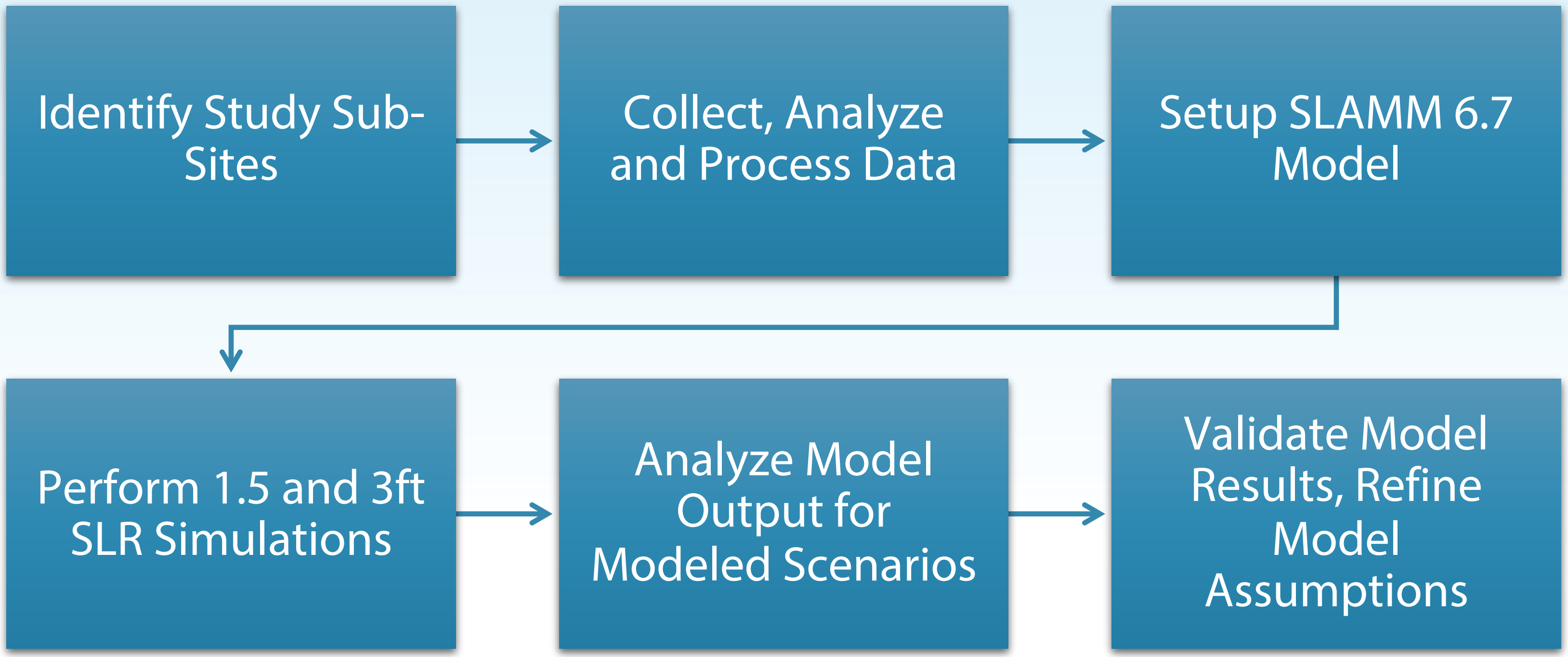
Figure III-4. Relative sea level trends, Norfolk, Virginia, 1969-2017 series

Sea Level Wise
A vibrant future for Virginia Beach

Objectives

- Which marsh types are most vulnerable to SLR?
- Which marsh types are more resilient to SLR?
- Which areas within the City are projected to experience marsh loss or marsh gain, and what are the general patterns in marsh habitat change?
- How could changes in marsh habitat as a result of SLR impact ecosystem services these systems provide in VB?
- What are some potential strategies that could be implemented to mitigate some of the forecasted impacts of marsh loss?

Approach


Identify Study Sub-Sites
Collect, Analyze and Process Data
Setup SLAMM 6.7 Model
Perform 1.5 and 3ft SLR Simulations
Analyze Model Output for Modeled Scenarios
Validate Model Results, Refine Model Assumptions

SLAMM Data Inputs

Elevation Data	Wetland Coverage	Tide Range
Impervious Area	Salt Elevation	Erosion
Accretion	SLR Scenarios/Time Horizons	Subsidence

VB Sea Level Wise
A vibrant future for Virginia Beach

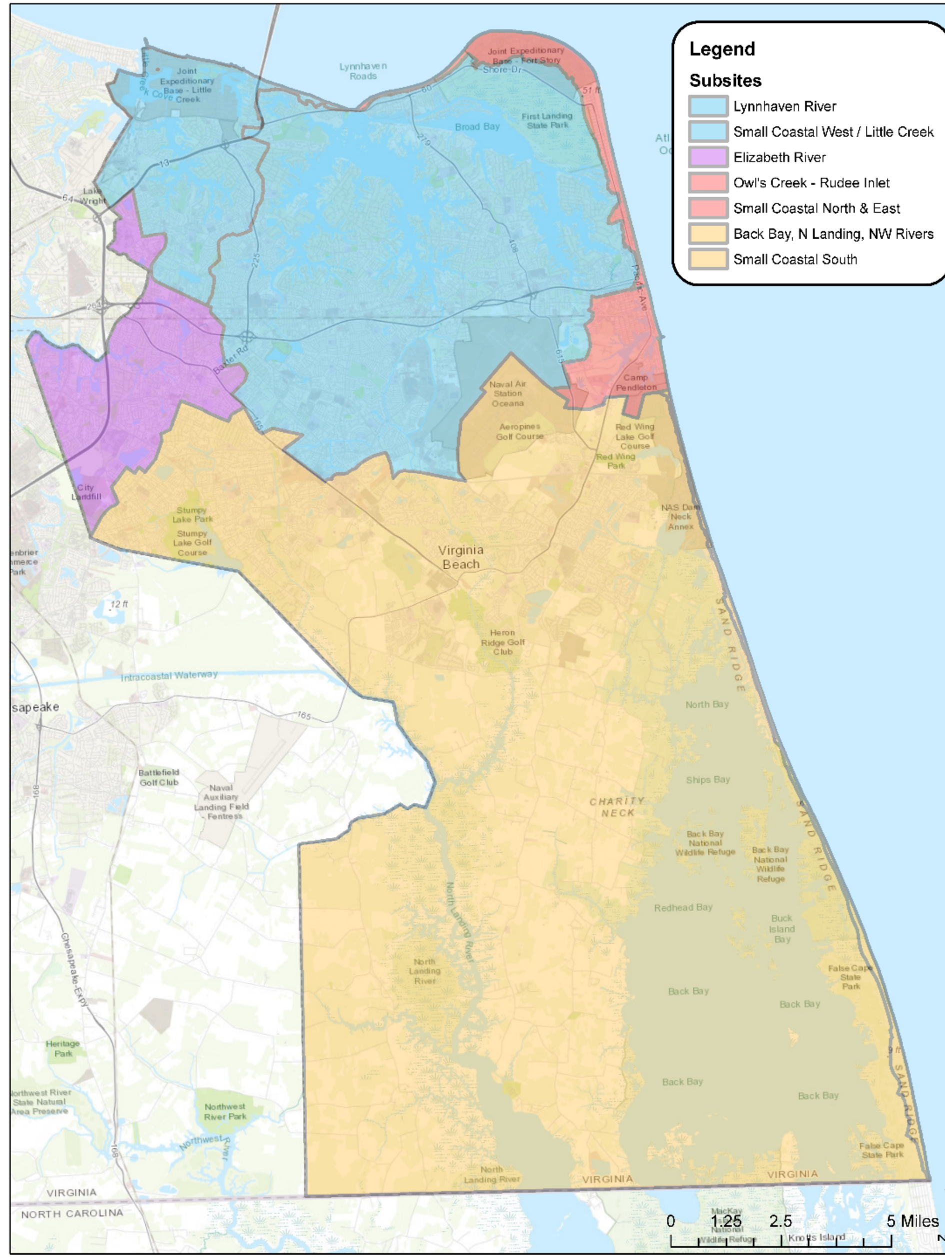
Data Sources

Data	Source/Description
Wetlands	Downloaded NWI Data • Northern watersheds based on imagery from 2000 • Southern watersheds based on imager from 2009 Converted to SLAMM categories using lookup tool.
Dikes	Extracted WNI classes with a classification of '-h' in code
Elevation Data	Converted 2013 LiDAR data from NAVD88 to MTL using VDATUM. Correction factor ranges from 0.18 to 0.71 feet.
Slope	Calculated from DEM
Great Diurnal Tide Range (GT)	MHHW and MLLW rasters obtained from NOAA. • GT = MHHW – MLLW • Calculated average GT within each sub-site.
Erosion	Obtained data from VIMS Shoreline Studies Program shoreline evolution database (1937-2009). • Calculated average erosion within the Lynnhaven watershed = 0.19 ft/yr, or 0.06 m/yr. Applied to all sub-sites.
Accretion	Used same values used in the Warren Pinnacle 2011 study for the Back Bay NWR.
Salt Elevation	Tide gauge analysis of the 30-day inundation value based on 4 gages: • Chesapeake Bay Bridge Tunnel • Duck, NC • Sewells Point, VA • Oregon Inlet Marina For Rudee Inlet, looked at harmonic constituents

VB Sea Level Wise
A vibrant future for Virginia Beach

Model Subsites

- Lynnhaven
  - Lynnhaven River
  - Small Coastal West / Little Creek
- Elizabeth River
- Oceanfront
  - Owl's Creek / Rudee Inlet
  - Small Coastal North and East
- Southern Rivers
  - Back Bay \ North Landing River\ Northwest River
  - Small Coastal South



Sea Level Wise
A vibrant future for Virginia Beach

Model Assumptions

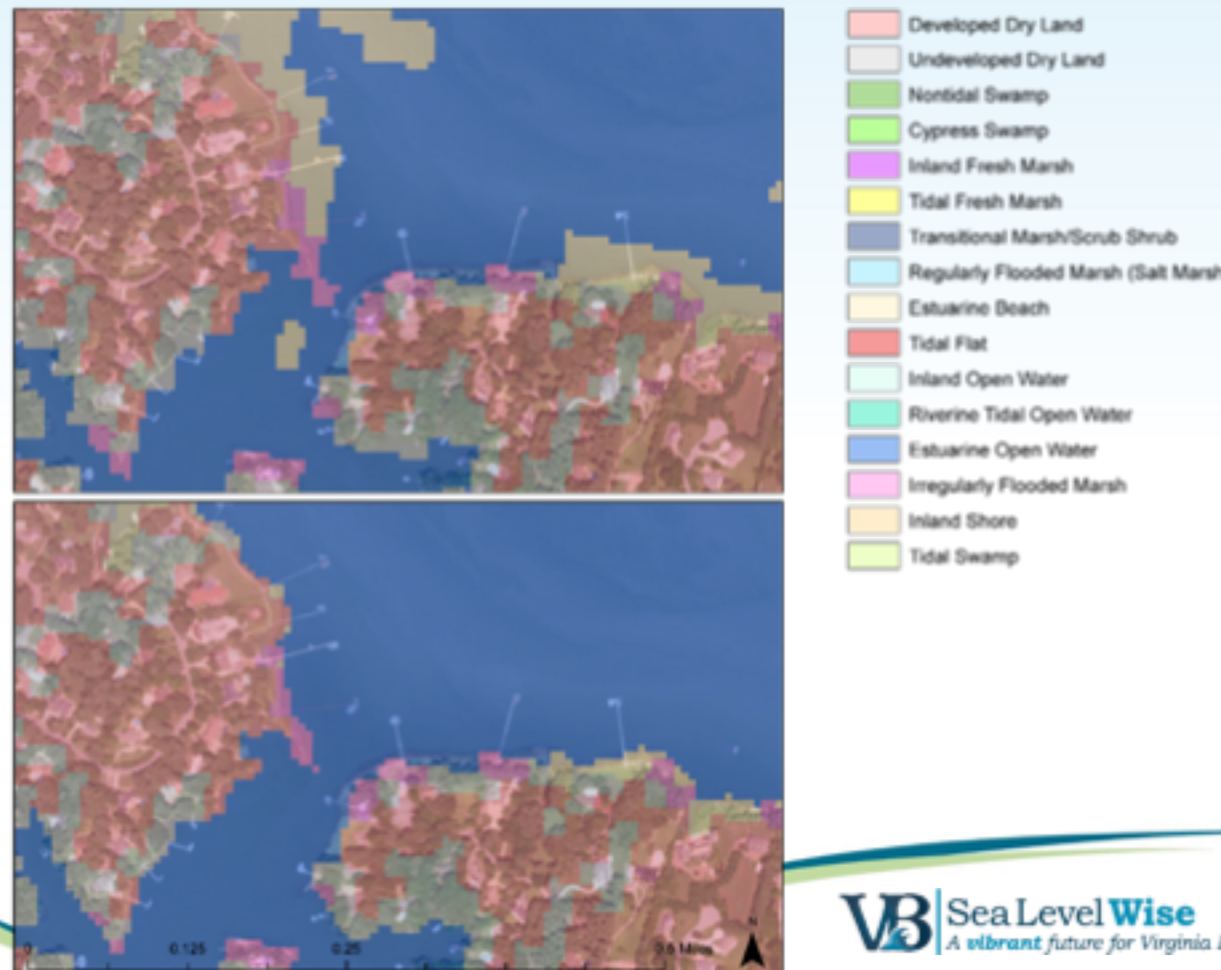
- Wetland inhabit a range of vertical elevations that are a function of tide range

Wetland Type	Minimum Elevation	Maximum Elevation
Reg. Flooded Marsh	MTL	120% of MHHW
Trans. Salt Marsh	MHHW	Salt Boundary
Irreg. Flooded Marsh	Average (MHHW, MTL)	Salt Boundary
Tidal Flat	MLLW	MTL

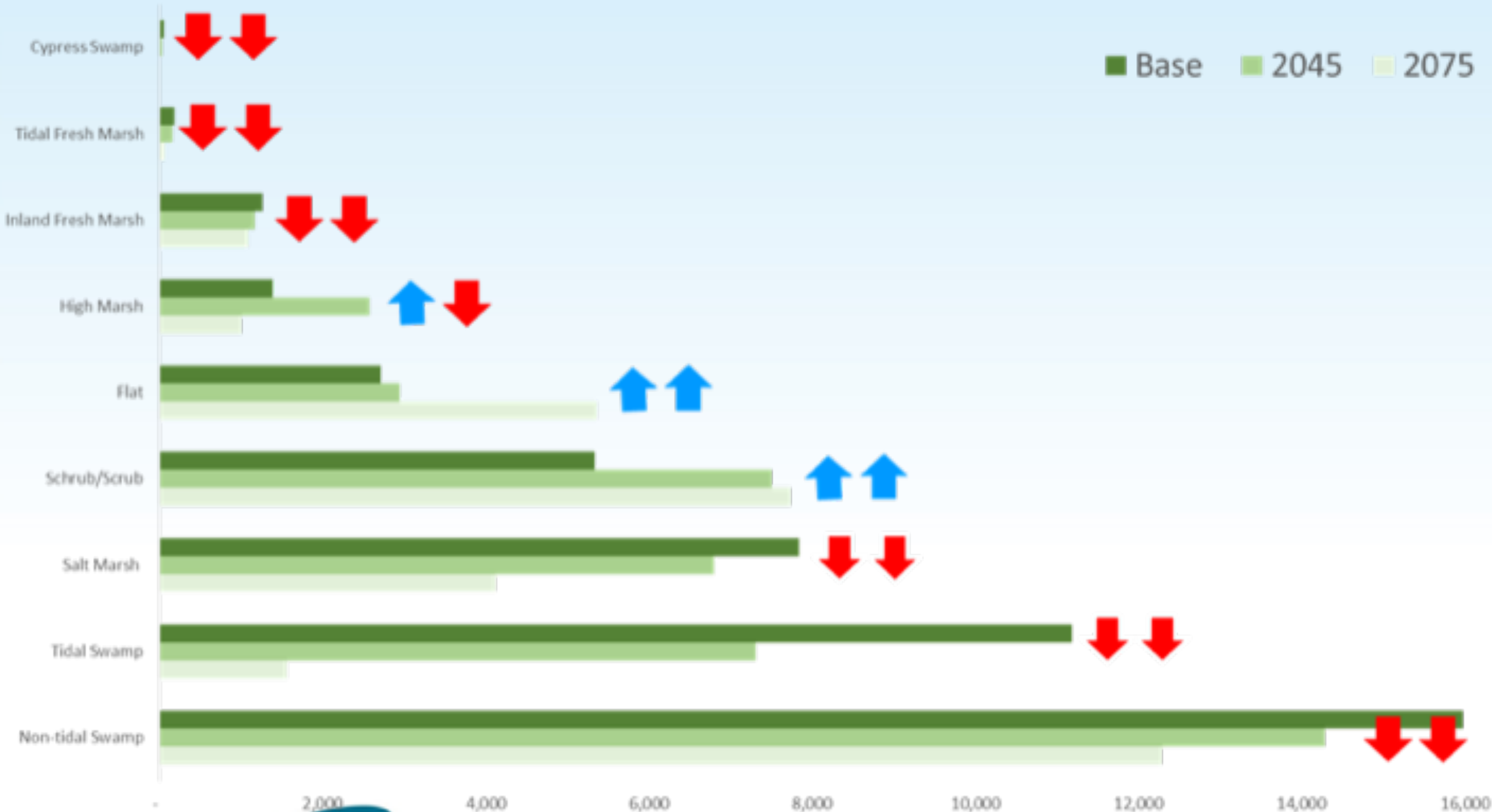
Calibration and Validation

1. Elevation analysis

2. Does the baseline wetland cover match present day conditions?



City-Wide Results



Sea Level Wise
A vibrant future for Virginia Beach

Results

http://www.vbgov.com/pwSLR

https://vbgov.maps.arcgis.com/apps/MapSeries/index.html?appid=c8b60ccd21bc457d9b23223d20414595

Click to go back, hold to see history

Virginia Beach Comprehensive Sea Level Rise and Flooding Response Plan

Department of Public Works

Stormwater Engineering Center

Study Motivation | History & Geographic Significance | A Resilient Future | Watershed Diversity | Get Involved

Study Goals and Outcomes

3.5x increase 15x increase

Projected Changes in Flood Loss

Wetland Response to Sea Level Rise

The impact assessment phase also looks at how wetlands will respond to sea level rise. Wetlands provide habitat, improve water quality, and also reduce local flooding by reducing waves and slowing down flood waters. Because of these benefits, it is important to understand how wetlands will response to increased sea levels.

Use the map to the right by clicking on the 1, 2, 3 bullets to see how wetlands are projected to respond to the 1.5 and 3 foot sea level rise scenarios.

Stormwater Master Plan Update

In addition to the above efforts, the city is in the process of updating its **Stormwater Master Plan.** This involves a taking a detailed inventory of the City's stormwater system, assessing the system's performance, and then identifying any deficiencies or needed improvements.

The results of the Stormwater Master Plan update and the Sea Level Rise Study will be reviewed together to ensure that the City understands the bigger picture concerning the flooding issues that we are facing. For example, the City can use the results from the

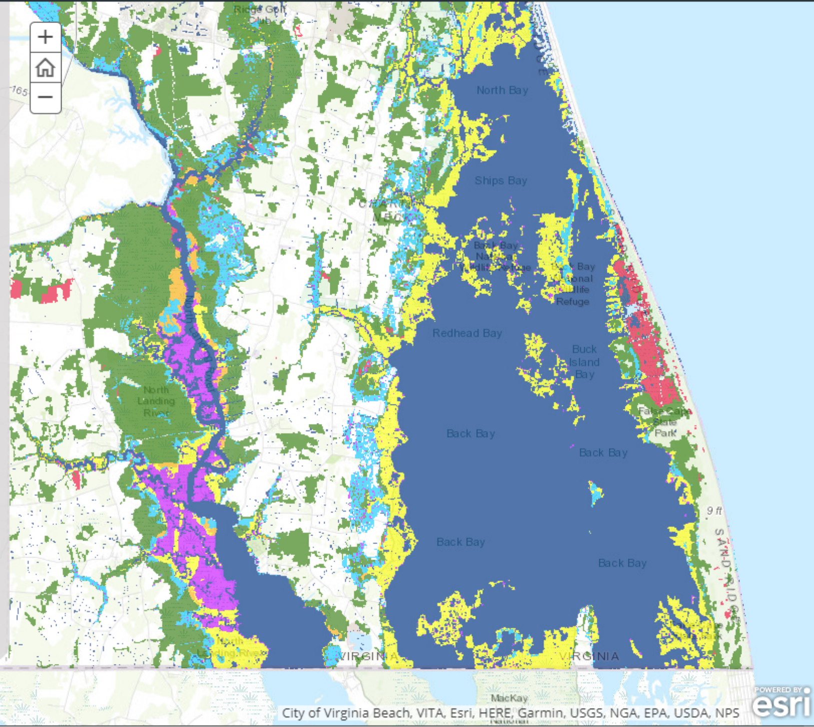
Wetland Change

1 2 3

This map shows today's wetland land cover. Use the map to pan around and zoom in and out to see wetland coverage in different areas across Virginia Beach.

Legend

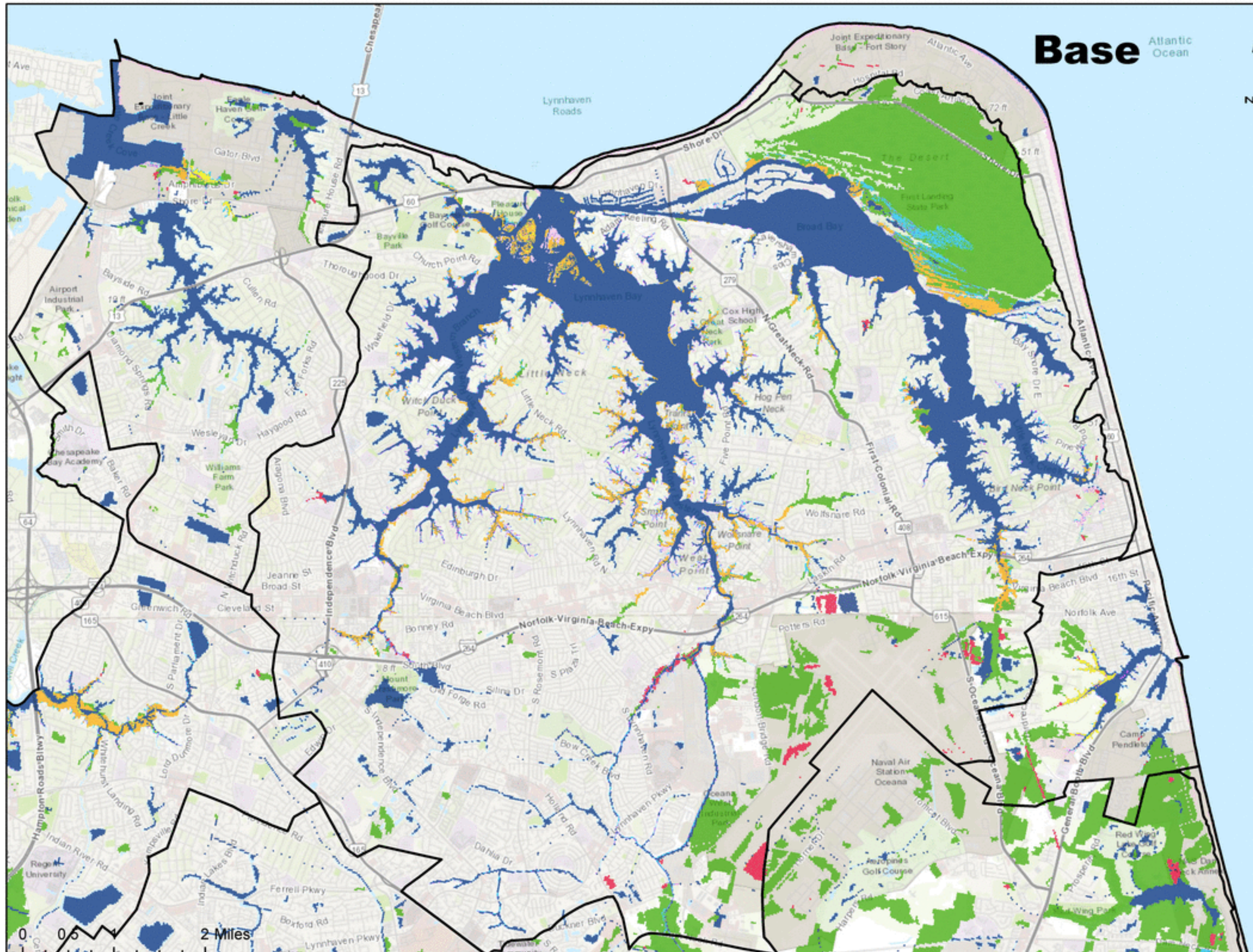
- Upland
- Swamp (Woody Wetlands)
- Fresh Marsh
- Shrub/Scrub
- Salt Marsh
- Beach
- Flat
- Water
- High Marsh



Sea Level Wise
A vibrant future for Virginia Beach

Northern Watersheds

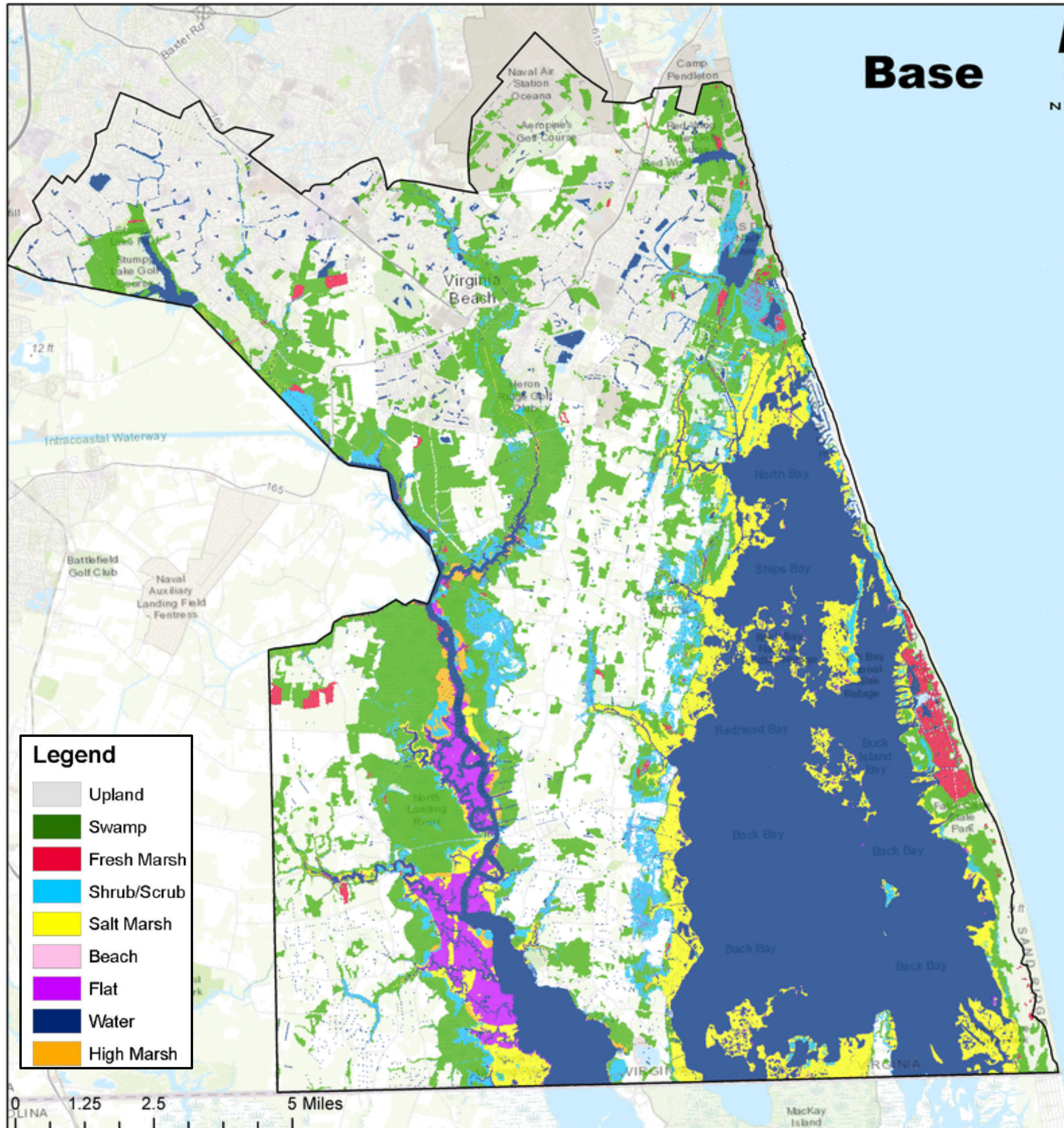
- Fastest rates of high marsh loss (~20% decrease by 2045 and 61% decrease by 2075)
- Salt marsh somewhat resilient



VB Sea Level Wise
A vibrant future for Virginia Beach

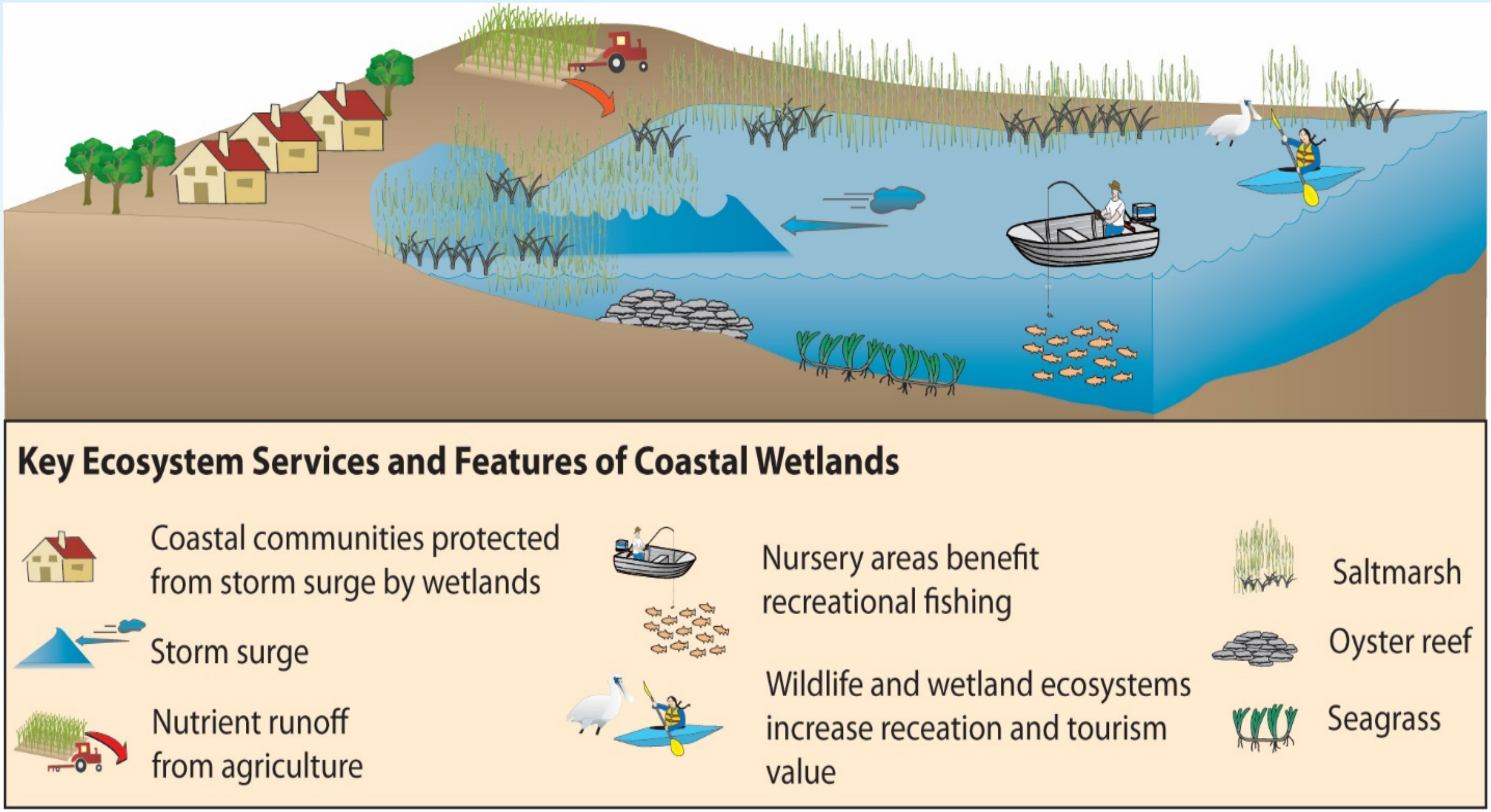
Southern Watershed

- Substantial loses in salt marsh (~55% decrease by 2075)
- Expansion of open water (~40% increase by 2075)
- Tidal swamp losses (~90% decrease by 2075)

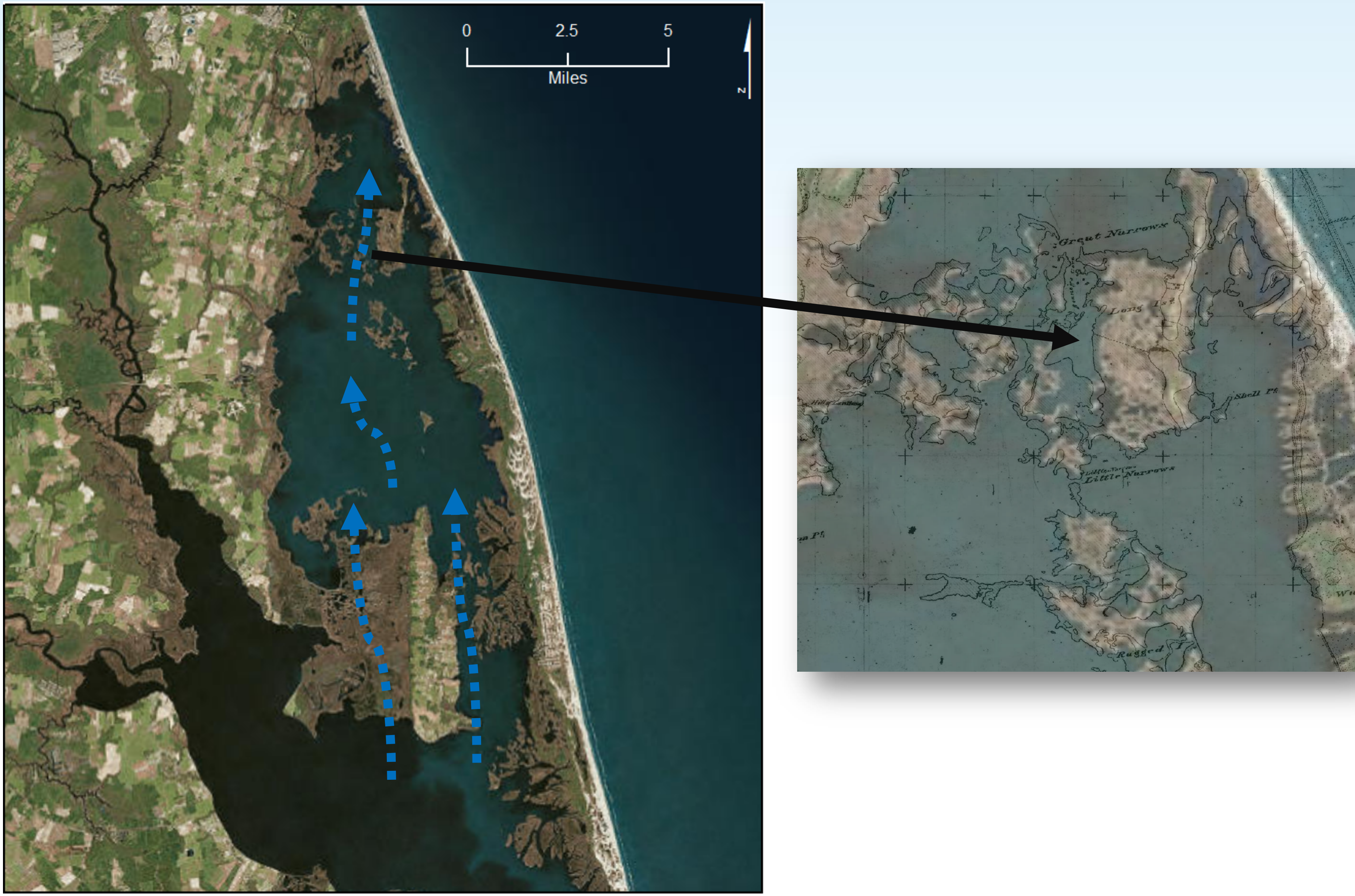


Sea Level Wise
A vibrant future for Virginia Beach

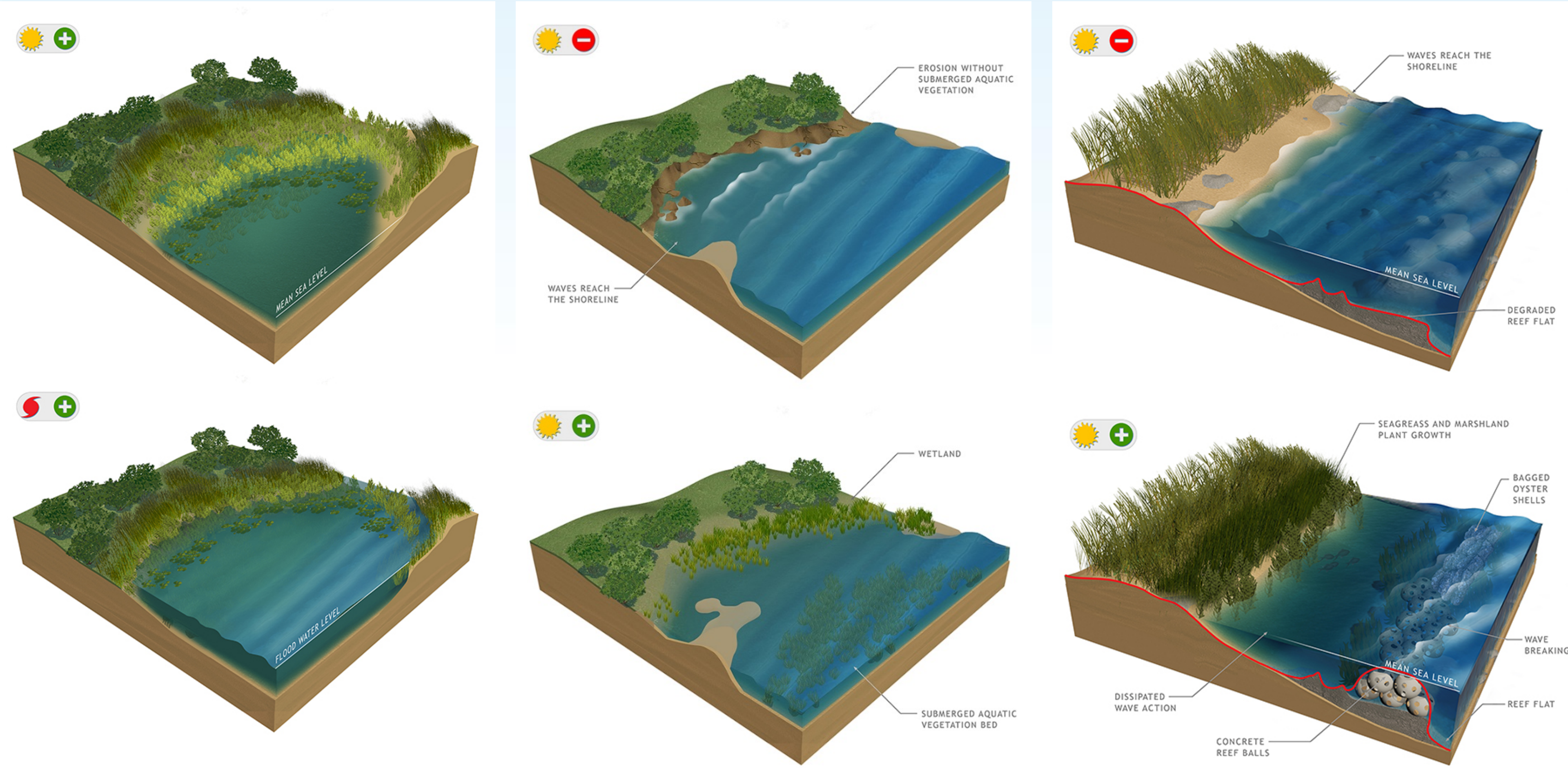
What benefits do wetlands provide?



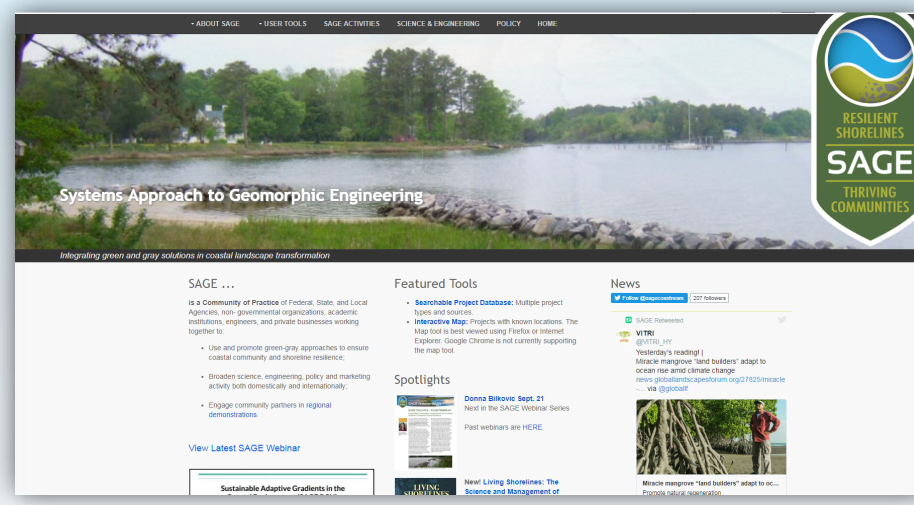
Natural Lines of Defense

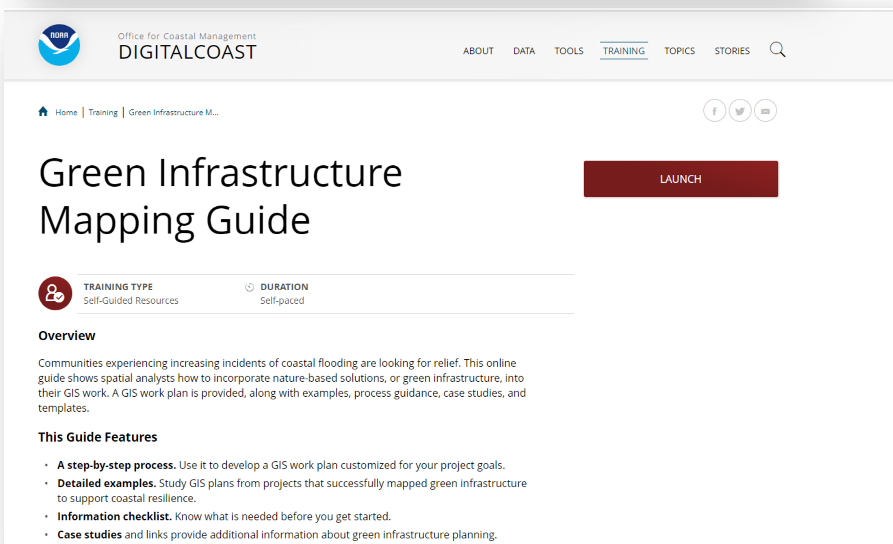


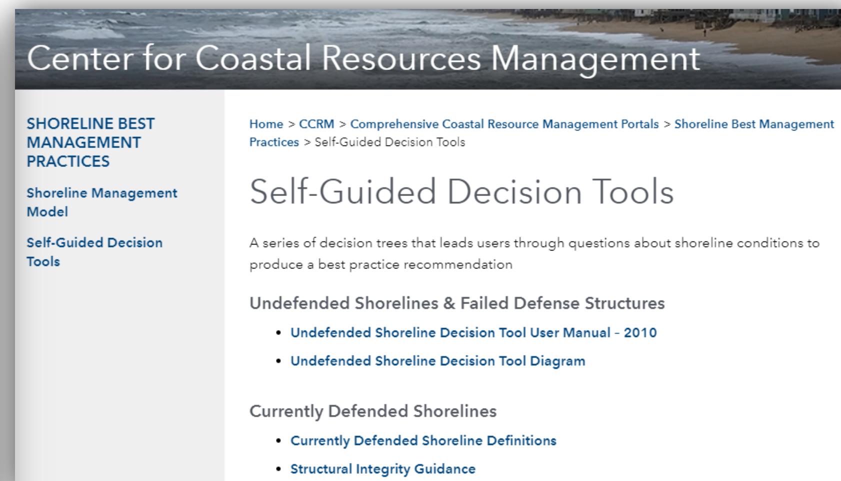
Natural and Nature-Based Features (aka NNBF)



Quantifying Benefits of NNBF







Storm surge reduction potential of wetlands

Nat Hazards (2016) 80:839–861
DOI 10.1007/s11069-015-2000-7

CrossMark

ORIGINAL PAPER

Assessing the relevance of wetlands for storm surge protection: a coupled hydrodynamic and geospatial framework

Jana Haddad[1] · Seth Lawler[1] · Celso M. Ferreira[1]

Received: 16 April 2015 / Accepted: 24 September 2015 / Published online: 9 October 2015

Abstract The expectation that wetlands can protect coastal communities has been a major topic in the effort to evaluate innovative methods of mitigating coastal impacts from storm surge. Recent investigations have shown that there is a potential flood mitigation benefit to be gained from the presence of marshes. Though the extent of that benefit is not yet clearly defined, prioritizing wetland systems for coastal protection requires a consideration of the interactions between communities at risk of storm surge damage and wetland areas of sufficient spatial scales to reliably attenuate storm surge. Here, a framework is proposed for geospatial characterization of these interactions based on numerical model results and is applied to Virginia's Chesapeake Bay region. Spatial identification of Chesapeake Bay wetlands was derived from four nationally available datasets (National Wetland Inventory, National Land Cover Dataset, Coastal Change Analysis Program, and NOAA's Wetland Potential database). Maps of maximum storm tides for four historical storms were generated based on a coupled hydrodynamic wave model (ADCIRC–SWAN), validated for those storms with a mean root mean square error of 0.44 m. Population information was extracted from US Census block data in FEMA's HAZUS Multi-Hazard geodatabase. Results from geospatial analysis of the relationships between wetland land cover, inundation, and population were used to identify where interactions with coastal populations are relevant for the study area when spatial limitations are considered. Approximately 1160 sq. km of wetlands were inundated by all four storms. Total population present in a range of proximities (200, 400, and 600 m) to flooded wetlands was used as a metric to evaluate the effect of a range of limitations on wetland size (5–50 sq. km) on

Estuaries and Coasts (2017) 40:930–946
DOI 10.1007/s12237-016-0190-1

CrossMark

Quantification of the Attenuation of Storm Surge Components by a Coastal Wetland of the US Mid Atlantic

Anne-Eleonore Paquier[1] · Jana Haddad[1] · Seth Lawler[1] · Celso M. Ferreira[1]

Received: 12 May 2016 / Revised: 31 October 2016 / Accepted: 8 November 2016 / Published online: 18 November 2016

Abstract Coastal wetlands are receiving increased consideration as natural defenses for coastal communities from storm surge. However, there are gaps in storm surge measurements collected in marsh areas during extreme events as well as understanding of storm surge processes. The present study evaluates the importance and variation of different processes (i.e., wave, current, and water level dynamics with respect of the marsh topography and vegetation characteristics) involved in a storm surge over a marsh, assesses how these processes contribute to storm surge attenuation, and quantifies the storm surge attenuation in field conditions. During the Fall of 2015, morphology and vegetation surveys were conducted along a marsh transect in a coastal marsh located at the mouth of the Chesapeake Bay, mainly composed of *Spartina alterniflora* and *Spartina patens*. Hydrodynamic surveys were conducted during two storm events. Collected data included wave characteristics, current velocity and direction, and water levels. Data analysis focused on the understanding of the cross-shore evolution of waves, currents and water level, and their influence on the overall storm surge attenuation. Results indicate that the marsh area, despite its short length, attenuates waves and reduces current velocity and water level. Tides have a dominant influence on current direction and velocity, but the presence of vegetation and the marsh morphology contribute to a strong reduction of current velocity over the marsh platform relative to the currents at the marsh front. Wave attenuation varies across the tide cycle which implies a link between wave attenuation and water level and, consequently, storm surge height. Storm surge reduction, here assessed through high water level (HWL) attenuation, is linked to wave attenuation across the front edge of the marsh; this positive trend highlights the reduction of water level height induced by wave setup reduction during wave propagation across the marsh front edge. Water level attenuation rates observed here have a greater range than the rates observed or modeled by other authors, and our results suggest that this is linked to the strong influence of waves in storm surge attenuation over coastal areas.

Keywords Storm surge attenuation · Water level · Waves · Currents · Coastal wetland · Nature-based defenses

Introduction

Tropical cyclones are one of the most costly natural hazards in the United States (Lott and Ross 2006), and examples in recent history, such as Katrina (2005), Ike (2008), or Sandy (2012), demonstrate the magnitude of infrastructure losses and societal impacts in some of the most developed regions of the country. Salt marshes, besides their well-documented ecological functions (Lavoie et al. 2016; Xue et al. 2008), have gained increased recognition as nature-based strategies for reducing the risks faced by coastal communities from sea level rise and coastal storms (Arkema et al. 2013; Spalding et al. 2014b). The move toward integrating green infrastructure as a component of coastal resiliency efforts has gained traction at the highest levels in the United States. For instance, the US Executive Office of the President (National Science

Communicated by David K. Ralston

✉ Anne-Eleonore Paquier
eleonorepaquier@gmail.com

1 Civil, Environmental and Infrastructure Engineering, Volgenau School of Engineering, Department of Civil, Environmental and Infrastructure Engineering, George Mason University, 4400 University Drive, MS 6C1, Nguyen Engineering Bldg, Fairfax, VA 22030, USA

Potential Strategies

https://vbgov.maps.arcgis.com/apps/MapSeries/index.html?appid=c8b60ccd21bc457d9b23223d20414595

Virginia Beach Comprehensive Sea Level Rise and Flooding Response Plan

Department of Public Works

Stormwater Engineering Center

Study Motivation | History & Geographic Significance | A Resilient Future | Watershed Diversity | Get Involved

Study Goals and Outcomes

Adaptation Strategies

In order to address existing flood risk and reduce short- and long-term flood exposure, the City is considering a wide range of possible strategies. Our strategy approach falls into two main categories –

1. Policy, Planning, and Regulation
2. Engineering

Engineering solutions are costly and cannot solve the City's flood risk problems alone. We must think long-term and instill smart planning and decision-making into City operations and planning. The combination of these approaches will create the best solution for Virginia Beach. **Explore the tabs to the right to learn more about these strategies.**

The Comprehensive Sea Level Rise and Recurrent Flooding Response Plan study team is reviewing the City's policies and regulations, engaging department representatives, and working to help tailor the strategies and how to best apply them to each of the City's four diverse major watersheds. These include the Oceanfront, Lynnhaven, Elizabeth River, Southern Rivers and Back Bay watersheds. **Click the Watershed Diversity tab to explore each of the City's four major watersheds.**

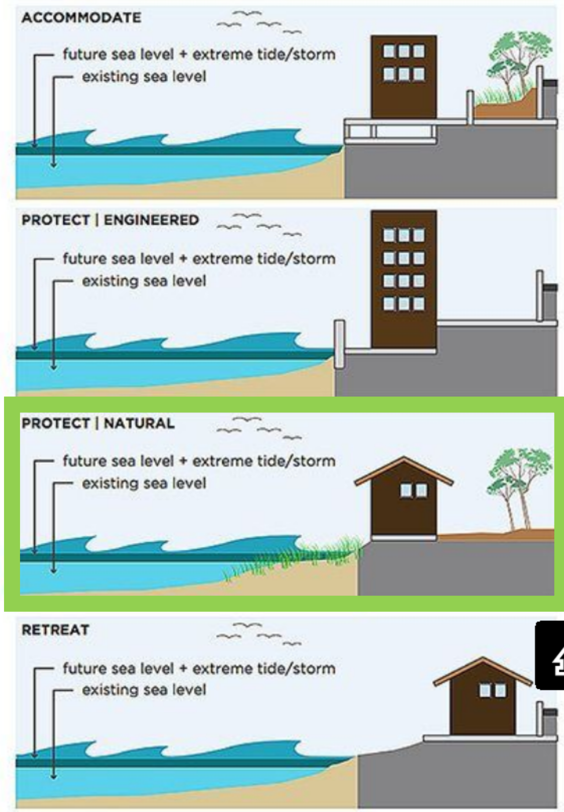
Feasibility					
Technical	Administrative	Political	Legal	Fiscal	Environmental

General Adaptation Strategies

There are many different ways to adapt to sea level rise and recurrent flooding. This graphic from the San Francisco Planning Department shows the four main types of adaptation strategies. Explore these strategies in more detail by scrolling down.

Engineering Strategies

The City has a robust Capital Improvement Program which has already been successful in reducing flood risk to areas of our City. The Resort Area boardwalk and stormwater improvements are proven examples. As part of the Comprehensive Sea level Rise and Recurrent Flooding Response Plan, the City is evaluating the possible



Points of Contact

http://www.vbgov.com/pwSLR

City of Virginia Beach
Department of Public Works

Toni Alger, P.E.
757-385-4131
talger@vbgov.com

Greg Johnson, P.E.
757-385-4131
gjohnson@vbgov.com

Sue Kriebel, P.E.
757-385-3934
skriebel@vbgov.com

Consultant:

Dewberry

Brian Batten, Ph.D., CFM
804-823-6981
bbatten@dewberry.com

Alaurah Moss
757-754-2500
amoss@dewberry.com

Sea Level Wise
A vibrant future for Virginia Beach