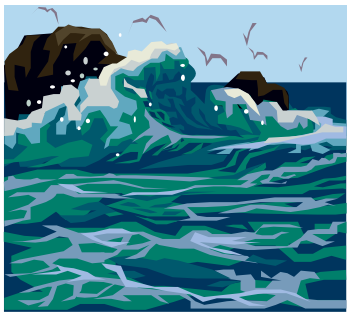

TIDES TO STORMS

PREPARING FOR NEW HAMPSHIRE'S FUTURE COAST

Assessing Risk and Vulnerability of Coastal Communities to Sea Level Rise and Storm Surge

Seabrook - Hampton Falls – Hampton - North Hampton – Rye - New Castle - Portsmouth

TOWN OF HAMPTON, NEW HAMPSHIRE

Vulnerability Assessment

of projected sea-level rise and coastal storm surge flooding

Prepared by the
Rockingham Planning Commission

September 2015

ACKNOWLEDGEMENTS

The Rockingham Planning Commission gratefully acknowledges the participation of Town of Hampton staff, board and commission members:

Town Manager:
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Conservation Commission:
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Planning Department:
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Police Department:
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Department of Public Works:
Chris Jacobs-Director and Jennifer Hale-Deputy Director

Cover Photo Credit: Steve Miller

Notes on Use and Applicability of this Report and Results:
The purpose of this vulnerability assessment report is to provide a broad overview of the potential risk and vulnerability of state, municipal and public assets as a result of projected changes in sea-levels and coastal storm surge. This report should be used for preliminary and general planning purposes only, not for parcel level or site specific analyses. The vulnerability assessment performed was limited by several factors including the vertical accuracy of elevation data (derived from LiDAR) and the static analysis applied to map coastal areas subject to future flooding which does not consider wave action and other coastal dynamics. Also, the estimated flood impacts to buildings and infrastructure are based upon the elevations of the land surrounding them, not the elevation of any structure itself.

PLANNING TO REDUCE RISK AND VULNERABILITY

New Hampshire coastal municipalities are confronted by land use and hazard management concerns that include extreme weather events, storm surges, flooding and erosion. These issues are only intensified by recent increases in the frequency and intensity of extreme storm events and increases in sea level.

New Hampshire's economy and quality of life have historically been linked to its shores, its vast expanses of productive saltmarshes and sandy beaches. Increased flooding has the potential to place coastal populations at risk, threaten infrastructure, intensify coastal hazards and ultimately impact homes, businesses, public infrastructure, recreation areas, and natural resources. Accounting for changes in sea level and coastal storms will help lead to informed decisions for public and private investments by minimizing risk and vulnerability.

What is a Vulnerability Assessment?

A vulnerability assessment identifies and measures impacts of flooding from sea level rise and storm surge on built structures, human populations and natural environments. Factors that influence vulnerability include development patterns, natural features and topography. The assessment evaluates existing and future conditions such as:

- inland extent and depth of flooding
- impacts to natural and human systems
- changes in impacts between different flood levels

How can the vulnerability assessment be used?

Information from a vulnerability assessment can help guide common sense solutions, strategies and recommendations for local governments, businesses, and citizens to enable them to adopt programs, policies, business practices and make informed decisions.

Planning for the long-term effects of sea level rise may also help communities better prepare in the short-term for periodic flooding from severe coastal storms.

How will the vulnerability assessment benefit the community?

The Tides to Storms assessment is intended to assist coastal NH communities to take actions to prepare for increase flood risk, including:

- Enhance preparedness and raise community awareness of future flood risks.
- Identify cost-effective measures to protect and adapt to changing conditions.
- Improve resiliency of infrastructure, buildings and investments.
- Protect life, property and local economies
- Protect services that natural systems provide
- Preserve unique community character

Results from a vulnerability assessment can be incorporated into various municipal planning, regulatory and management documents such as:

Master Plan	Capital Improvement Plan	Land Conservation Plan
Zoning Ordinance	Site Plan Review Regulations	Subdivision Regulations
Roadway Management Plan	Stormwater Management Plan	Facilities Management Plan

TABLE OF CONTENTS

ROCKINGHAM PLANNING COMMISSION
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This project is funded by New Hampshire Homeland Security and Emergency Management (HSEM) through a Pre-Disaster Mitigation Grant from the Federal Emergency Management Agency (FEMA).

Additional funding for this project provided by the NH Department of Transportation through Federal Highways Administration.

MAPPING AND ASSESSMENT OVERVIEW

1. VULNERABILITY ASSESSMENT: SEA LEVEL RISE AND STORM SURGE SCENARIOS

The *Tides to Storms* coastal vulnerability assessment project produced maps and statistical data about the potential impacts to New Hampshire's seven coastal municipalities from sea-level rise and storm surge to infrastructure, critical facilities transportation systems, and natural resources. Three sea-level scenarios were evaluated accounting for a range from the intermediate-low to the highest projected sea-levels at the year 2100.

Figure 1. Sea-Level Rise and Storm Surge Scenarios

Sea-Level Rise (SLR) Scenarios	SLR 1.7 feet	SLR 4.0 feet	SLR 6.3 feet	SLR 1.7 feet + storm surge	SLR 4.0 feet + storm surge	SLR 6.3 feet + storm surge
Sea Level Rise	1.7 feet	4.0 feet	6.3 feet	--	--	--
Sea-level Rise + Storm Surge	--	--	--	1.7 feet + Storm Surge	4.0 feet + Storm Surge	6.3 feet + Storm Surge

Note: Storm surge is the area flooded by the 100-year/1% chance storm event.

Baseline: Flooding from the sea-level rise scenarios and sea-level rise plus storm surge scenarios evaluated in this study were mapped from Mean Higher High Water (MHHW) which is 4.4 feet in the coastal region of NH. ***Mean Higher High Water is the average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch. The National Tidal Datum Epoch (NTDE) refers to the specific 19-year period adopted by the National Ocean Service as the official time segment over which tide observations are taken. The present NTDE is 1983 through 2001 and is considered for revision every 20-25 years (the next revision would be in the 2020-2025 timeframe).***[1]

Storm Surge: ***Storm surge is the rise of water level accompanying intense coastal storm events such a tropical storm, hurricane or Nor'easter, whose height is the difference between the observed level of the sea surface and the level that would have occurred in the absence of the storm event.***[2] Storm surge is mapped using the 100-year/1% chance flood events from the Preliminary Flood Insurance Rate Maps (FIRMs) released by FEMA in 2014. The preliminary FIRM's account for the limit of moderate wave action in coastal areas, however this assessment does not take into account additional flooding and impacts related to more severe wave action, wind action, erosion and other dynamic coastal processes.

Sea-Level Rise Scenarios

The sea-level rise projections used in this study are based on an earlier study completed in 2011 by Wake et al but are similar to a more recent report issued by the NH Coastal Risks and Hazards Commission's Science and Technical Advisory Panel in 2014. As shown in the graphics below, while slightly different than the scenarios cited in the 2014 report, the sea level rise scenarios used in the Tides to Storms assessment yield coverage estimates of flooding that are within the mapping margin of error for the scenarios in both the 2011 and 2014 reports.

[1] NOAA website at http://tidesandcurrents.noaa.gov/datum_options.html
[2] EPA website at http://epa.gov/climatechange/glossary.html

Figures 2 and 3 below document how the scenarios used in this report relate to 2011 by Wake et al but are similar to a more recent report issued by the NH Coastal Risks and Hazards Commission's Science and Technical Advisory Panel in 2014.

	Lower Emissions (B1)		Higher Emissions (A1fi)	
	2050	2100	2050	2100
Current Elevation of MHHW [a,b]	4.43	4.43	4.43	4.43
100-Year Flood Height	7.78	7.78	7.78	7.78
Subsidence	0.012	0.016	0.012	0.016
Eustatic SLR	1.0	2.5	1.7	6.3
Total Stillwater Elevation [a,c]	**13.2**	**14.7**	**13.9**	**18.5**

a - NAVD: North American Vertical Datum of 1988
b - MHHW: Mean Higher High Water at Fort Point, NH
c - Total Stillwater Elevation may not equal total of components due to rounding

Table 13. Preliminary estimates of future 100-year flood Stillwater elevations at the Fort Point Tide gauge under lower and higher emission scenarios (feet relative to NAVD[a]).

Figure 2. 2014 Sea-Level Rise Scenarios (based on greenhouse gas emissions)

Source: Wake CP, E Burakowski, E Kelsey, K Hayhoe, A Stoner, C Watson, E Douglas (2011) *Climate Change in the Piscataqua/Great Bay Region: Past, Present, and Future*. Carbon Solutions New England Report for the Great Bay (New Hampshire) Stewards.

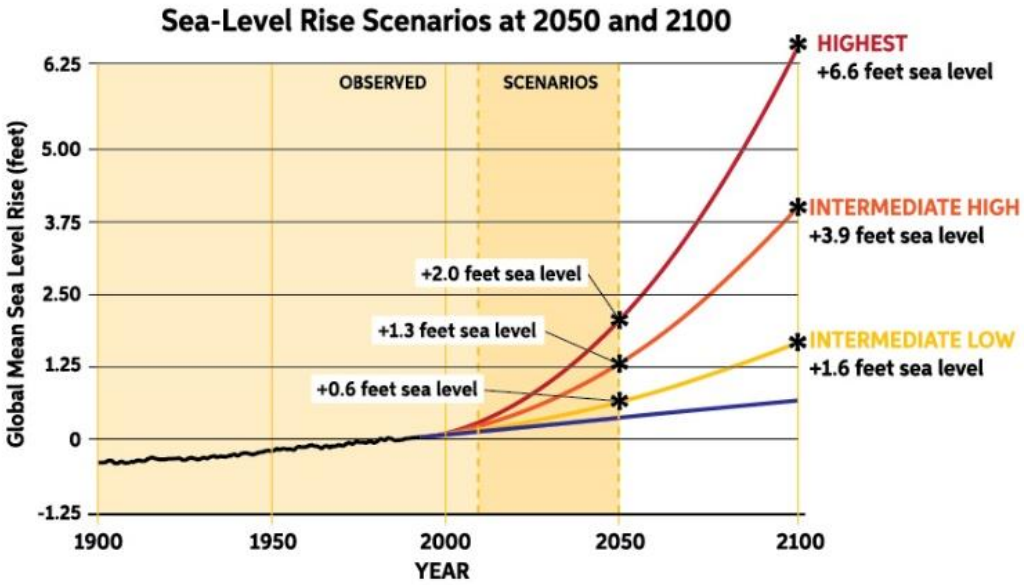


Figure 3. 2014 Sea-Level Rise Scenarios (based on greenhouse gas emissions)

Source: Wake CP, Kirshen P, Huber M, Knuuti K, and Stampone M (2014) *Sea-level Rise, Storm Surges, and Extreme Precipitation in Coastal New Hampshire: Analysis of Past and Projected Future Trends*, prepared by the Science and Technical Advisory Panel for the New Hampshire Coastal Risks and Hazards Commission.

2. ASSETS AND RESOURCES EVALUATED

Table 1 lists the three major categories and a detailed list of the assets and resources evaluated as part of the Tides to Storms vulnerability assessment. The assets and resources evaluated are listed in subsequent tables in this report only if they are affected by one or more of the sea-level rise and/or coastal storm surge scenarios.

TABLE 1. ASSETS AND RESOURCES EVALUATED FOR THE VULNERABILITY ASSESSMENT

CATEGORY	ASSETS AND RESOURCES
INFRASTRUCTURE AND CRITICAL FACILITIES	Municipal Critical Facilities (identified in Hazard Mitigation Plans) NHDOT Transportation Infrastructure State and Municipal Culverts Federal and State Historic Register Properties Other Assets: fire and police stations, graveyards, schools, dams, power stations and substations, public water supply wells, harbors, bridges NHDOT Ten-year and Long Range Plan Projects
ROADWAYS AND TRANSPORTATION ASSETS	State and Local Roadways Regional and Municipal Evacuation Routes Urban Compact Areas
NATURAL RESOURCES	Freshwater and Tidal Wetlands Aquifers and Wellhead Protection Areas Land Conservation Plan for NH's Coastal Watershed – Core Focus Areas Wildlife Action Plan – Tier 1 and Tier 2 habitats

3. MAP DESIGN AND ORGANIZATION

The Tides to Storms map set is comprised of two components: a map depicting the extent of projected flooding from the three sea-level rise scenarios in shades of green, and a map depicting the three sea-level rise plus storm surge scenarios in shades of pink. Each of the asset categorized evaluated are displayed on these two maps. Examples of the two scenario maps are shown on the following page.

Extent of Flooding from Sea-Level Rise and Storm Surge

The green and pink color schemes are arranged from lightest to darkest with increasing flood levels and extents.

Figure 4.
Sea–Level Rise Scenarios 1.7 feet, 4.0 feet and 6.3 feet

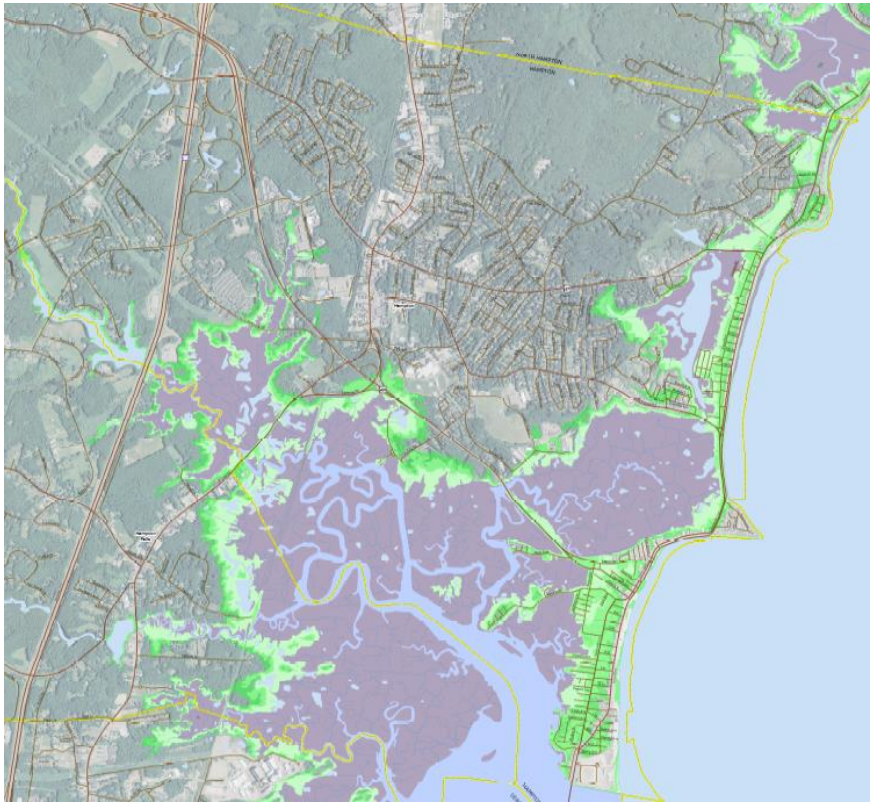
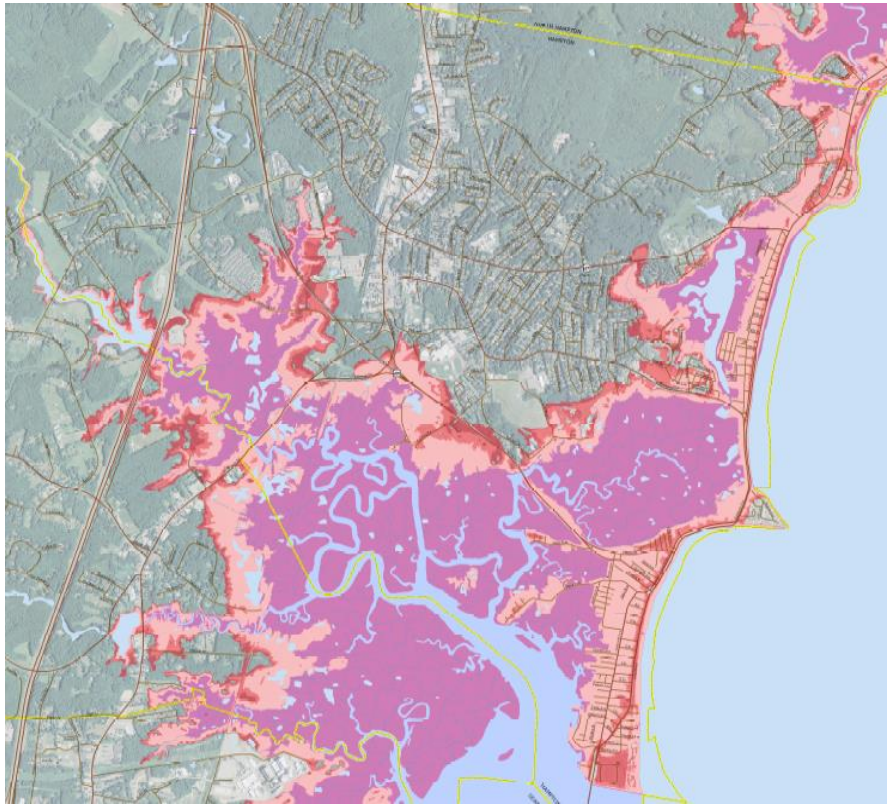
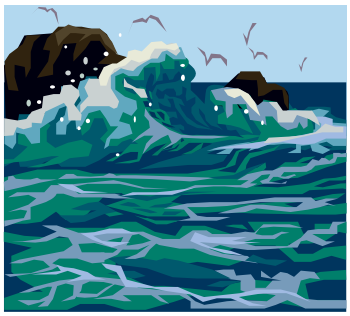


Figure 5.
Sea–Level Rise Scenarios 1.7 feet, 4.0 feet and 6.3 feet plus storm surge



Note: Storm surge = 100-year /1% chance flood.



TIDES TO STORMS

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TOWN OF HAMPTON, NEW HAMPSHIRE

OVERVIEW

The Town of Hampton is located along the south coastal area of New Hampshire comprising 5,762.9 acres of land and 3,309.9 acres of water and wetlands. With a population of 15,430 (2010), Hampton is the second most populated of the seven coastal municipalities. The coastal portion of Hampton is known for its seasonal recreation and tourism amenities including its beaches, harbors, marinas, parks and hospitality industry. These low lying areas are located within the coastal floodplain making them highly susceptible to flooding from seasonal high tides, coastal storms and sea-level rise.

In 2014, Hampton received a grant from the Piscataqua Region Estuaries Partnership to prepare an application to FEMA's National Flood Insurance Program's (NFIP) Community Rating System (CRS). CRS is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. As a result, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community actions meeting the three goals of the CRS:

1. Reduce flood damage to insurable property;
2. Strengthen and support the insurance aspects of the NFIP, and
3. Encourage a comprehensive approach to floodplain management.[3]

Vulnerability Assessment Results

Key findings for the Town of Hampton are reported in the table below based on evaluation of the 1.7 feet intermediate-low, 4.0 feet intermediate, and 6.3 feet highest sea-level rise projections at the year 2100 and these sea-level rise projections with the 100-year storm surge.

The data indicates that in Hampton state and local roadways, infrastructure, upland, and freshwater and tidal wetlands are most vulnerable to flooding from sea level rise and coastal storm surge. In Hampton, the 100-year floodplain is highly sensitive to flooding from sea-level rise: 75 percent at 1.7 feet sea-level rise, 86 percent at 4.0 feet sea-level rise, and 87 percent at 6.3 feet sea-level rise.

As shown on ***Maps 5 and 6***, certain segments of state roads Route 1A, Route 101 and Route 1, and the municipal roadway network are particularly sensitive to flooding at the 4.0 sea level rise scenario and current 100-year storm surge. Local roadways and lands behind Route 1A at Hampton Beach and North Beach are highly vulnerable to flooding at the 4.0 foot sea-level rise scenario. Observed flooding of the roadway network also impacts designated evacuation routes as segments of the network both within Hampton and adjacent towns become impacted.

[3] From FEMA's website at http://www.fema.gov/national-flood-insurance-program-community-rating-system

As shown on ***Maps 1 and 2***, low-lying upland areas behind Route 1A and interior fringe areas in the upper portions of the Hampton-Seabrook Estuary are susceptible to moderate flooding from the 1.7 foot sea-level rise scenario and a nearly doubling of acres flooded at the 4.0 foot sea-level rise scenario. *Maps 9 and 10* show the extent of flooding of estuarine and marine wetlands and adjacent freshwater wetlands. Increased daily tidal flooding of tidal marsh systems diminishes their flood storage capacity during storm events, although this may be partially offset by inundation of freshwater wetlands. Models indicate potential for migration of tidal marsh systems inland (see the Natural Resources section for key findings).

TABLE 2. SUMMARY OF ASSESSMENT DATA

Sea-Level Rise (SLR) Scenarios	SLR 1.7 feet	SLR 4.0 feet	SLR 6.3 feet	SLR 1.7 feet + storm surge	SLR 4.0 feet + storm surge	SLR 6.3 feet + storm surge
Infrastructure (# of sites)	18	43	71	76	87	107
Critical Facilities (# of sites)	0	2	2	2	2	2
Roadways (miles)	3.4	13.2	20.6	20.7	26.7	30.8
Upland (acres)	319.4	632.3	897.8	879.7	1,123.5	1,321.2
Freshwater Wetlands (acres)	56.8	79.8	102.7	97.6	121.4	135.5
Tidal Wetlands (acres)	181.7	202.9	223.8	235.6	236.9	237.3
Conserved and Public Lands (acres)	39.5	59.9	87.9	107.9	123.9	150.3
100-year floodplain (acres)	2,393.0	2,738.3	2,810.9	2,836.2	2,865.8	2,872.9
500-year floodplain (acres)	2,393.0	2,739.1	2,886.0	2,910.4	2,941.7	2,948.9

Note: Upland refers to land above mean higher high water (highest tidal extent). 500-year floodplain impacts were calculated based on flooding within the extent of the 500-year floodplain.

The complete detailed vulnerability assessment information and recommendations are provided in the following sections of this report.

SUMMARY OF VULNERABILITY ASSESSMENT RESULTS BY ASSET TYPE

INFRASTRUCTURE AND CRITICAL FACILITIES

Maps 3 and 4 Critical Facilities and Infrastructure shows state and municipal infrastructure types affected by sea-level rise and coastal storm surge flooding. Table 3 reports when specific infrastructure types are affected by each sea-level rise and coastal storm surge scenario.

Culverts are the most frequently impacted type of infrastructure from both projected sea-level rise and coastal storm surge flooding. Of particular concern are those culverts that currently function as freshwater conveyance systems that may be impacted by tidal flooding in the future. Freshwater culverts are not designed for bi-direction flow or to accommodate the volume of water resulting from tidal flooding.

TABLE 3. INFRASTRUCTURE

Sea-Level Rise (SLR) Scenarios	SLR 1.7 feet	SLR 4.0 feet	SLR 6.3 feet	SLR 1.7 feet + storm surge	SLR 4.0 feet + storm surge	SLR 6.3 feet + storm surge
State and Municipal Infrastructure (# of facilities)						
Culverts (state and municipal)	7	24	42	46	53	66
Dams	2	4	4	4	5	7
NH Historic Register	0	1	1	1	1	1
Power stations and Substations	0	1	1	1	1	1
Public Water Supply, Pump Houses, Wells	4	4	6	6	6	8
Bridges	3	3	5	5	6	7
Harbor/Marina	0	1	1	1	1	1
Signs, Lights, Signals, Beacons	0	2	8	7	10	11
Ten Year and Long Range Plan Projects	2	3	3	3	4	4
Total # of Sites	**18**	**43**	**71**	**76**	**87**	**107**

Dams. Dam locations indicted on the Tides to Storms maps are based on data maintained by NHDES Dam Bureau of all dams in the state and represent both active and inactive dams that require regular state inspections, and those dams that are in ruins or exempt from state inspections due to small size and hazard status (most of these dams impound stormwater detention ponds). Additional information in this data layer include the dam name, impounded waterbody, drainage area, impoundment acreage, dam height, dam construction type, ownership (state, municipal, or private), dam status (active, inactive, ruins, exempt), and hazard classification. Dam hazard classifications are a ranking of the potential for the loss of life of property damage if a dam were to fail; there are no dams within the focus area of this project ranks as high hazard dams. Additional information regarding dams can be found at http://des.nh.gov/organization/divisions/water/dam/index.htm.

Definition of a Bridge. Per RSA 234:2, a bridge defines a bridge as a structure, having a clear span of 10 feet or more measured along the center line of the roadway at the elevation of the bridge seats, spanning a watercourse or other opening or obstruction, on a public highway to carry the traffic across, including the substructure, superstructure and approaches to the bridge. This definition includes a combination of culverts constructed to provide drainage for a public highway with an overall combined span of 10 feet or more and a distance between culverts of half the diameter or less of the smallest culvert.

Bridges Evaluated. Bridges identified as "impacted" by sea-level rise and/or storm surge scenarios indicates that the bridge and its infrastructure are located within the extent of the scenario. There has been no analysis to determine if the bridge, or any part of its structure is impacted.

Municipal Critical Facilities

Maps 3 and 4 Critical Facilities and Infrastructure shows the municipal critical facilities affected by sea-level rise and coastal storm surge flooding. Table 4 reports when specific municipal critical facilities are affected by each sea-level rise and coastal storm surge scenario.

Hampton maintains flapper tide gates at the terminus of Tuttle Avenue, Mooring Avenue, Shaw Street, Brown Avenue at the police station, Ashworth Avenue parking lot, and Toppan Lane. The town also maintains a tide gate at Brown Avenue and Highland Avenue intersection. These tide gates are closed during storm events to prevent flooding of adjacent areas (residential areas, roads, a parking lot), stormwater management systems, and wetlands east of Brown Avenue.

The police station and fire station are located on Brown Avenue, an area that is low-lying and already impacted by tidal and storm related flooding. These facilities are impacted at sea-level rise of 4.0 feet and above and by coastal storm surge. The roads and parking areas surrounding these facilities are impacted today by seasonal flooding and storm events including freshwater and tidal flooding.

TABLE 4. MUNICIPAL CRITICAL FACILITIES (# of facilities)

Sea-Level Rise (SLR) Scenarios	SLR 1.7 feet	SLR 4.0 feet	SLR 6.3 feet	SLR 1.7 feet + storm surge	SLR 4.0 feet + storm surge	SLR 6.3 feet + storm surge
Fire Station	0	1	1	1	1	1
Police Station	0	1	1	1	1	1
Wastewater Treatment Plant (see notes below)	0	0	0	0	0	1
Total - Sites	**0**	**2**	**2**	**2**	**2**	**3**

Note: Municipal Critical Facilities as identified in the town's Hazard Mitigation Plan.

During discussions with municipal staff, the town's waste water treatment plant, high school, landfill and transfer station were recognized critical facilities that are impacted by flooding from sea-level rise and storm surge. The school's buildings are not directly impacted the supporting facilities including recreational fields and uplands are impacted. The main structures of the wastewater treatment plant are not impacted however the operations and management offices and contact chlorination tanks are impacted at the lowest sea-level rise scenario of 1.7 feet. Although the landfill is capped and no longer an active facility, there are concerns about potential impacts on water quality from saturation at the base of the landfill from rising groundwater levels as sea-levels rise. The access road of the transfer station, an active municipal facility, is susceptible to flooding at the highest 6.3 foot sea-level rise scenario.

TRANSPORTATION

Maps 5 and 6 Road and Transportation Assets show the state and municipal roadways affected by sea-level rise and coastal storm surge flooding. Table 5 reports the miles of state and local roadways affected by each flood scenario.

TABLE 5. STATE AND MUNICIPAL ROADWAYS AND INFRASTRUCTURE (miles)

Sea-Level Rise (SLR) Scenarios	SLR 1.7 feet	SLR 4.0 feet	SLR 6.3 feet	SLR 1.7 feet + storm surge	SLR 4.0 feet + storm surge	SLR 6.3 feet + storm surge
Roadway Type						
Local	2.8	10.1	14.8	13.9	17.2	19.9
State	0.6	2.8	5.1	6.2	8.5	9.7
US Route	0.0	0.3	0.7	0.6	1.0	1.2
Total Road Miles	**3.4**	**13.2**	**20.6**	**20.7**	**26.7**	**30.8**
Culverts (state and local)	**7**	**24**	**42**	**46**	**53**	**66**
Guardrail	0.2	0.5	0.7	1.6	1.9	2.2
Bike Routes	0.4	1.5	2.9	4.1	5.3	6.2
Evacuation Routes	0.6	2.1	3.4	3.2	4.0	4.8

The municipal roadway network is particularly sensitive to sea-level rise and coastal storm flooding, with impacts increasing sharply at 4.0 feet of sea-level rise flooding. Map ___ shows that most of the local roadway network landward of Route 1A at Hampton Beach, North Beach and the near the North Hampton border and Route 1 south of the Route 101 interchange is impacted at 6.3 feet of sea-level rise.

Culverts are supporting infrastructure for the roadway network that are also highly susceptible to flooding impacts. As sea levels rise in the future, some tidal culverts may become submerged by flooding even at low tide and freshwater culverts will be influenced by tidal flooding, creating hydrologic conditions these drainage systems were not designed for.

NATURAL RESOURCES

Maps 7 and 8 Conservation Areas and ***Map 9 and 10 Wetlands, Aquifers, Wellhead Protection Areas*** show natural resources affected by sea-level rise and coastal storm surge flooding. Table 6 reports the number of acres for each natural resource affected by each sea-level rise and coastal storm surge scenario.

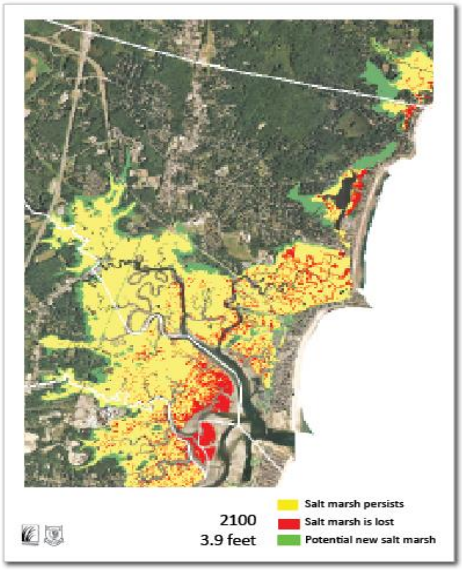
TABLE 6. NATURAL RESOURCES (acres)

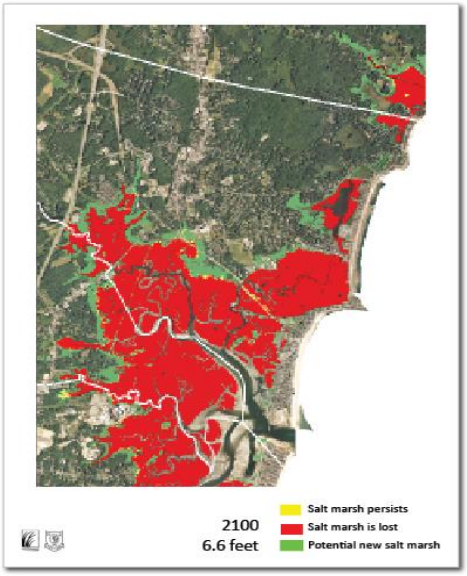
Sea-Level Rise (SLR) Scenarios	SLR 1.7 feet	SLR 4.0 feet	SLR 6.3 feet	SLR 1.7 feet + storm surge	SLR 4.0 feet + storm surge	SLR 6.3 feet + storm surge
Surface Water		32.6	33.7	33.0	34.5	35.0
Stratified Drift Aquifers	6.9	20.0	49.4	42.2	77.0	108.0
Freshwater Wetlands	56.8	79.8	102.7	97.6	121.4	135.5
Tidal Wetlands	181.7	202.9	223.8	235.6	236.9	237.3
Wildlife Action Plan – Tier 1 and Tier 2 habitat	795.3	916.3	995.1	995.6	1,064.3	1,109.1
Coastal Conservation Plan Focus Areas	179.0	281.6	349.1	340.7	391.2	417.9
Conserved and Public Lands	39.5	59.9	87.9	107.9	123.9	150.3
Ag Soils (All Types)	26.0	83.3	153.3	135.4	214.3	286.3

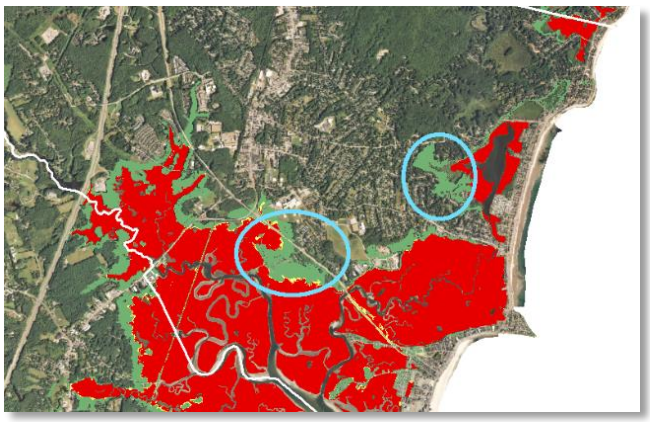
SEA LEVEL AFFECTING MARSHES MODEL (SLAMM): HAMPTON

From: A Natural Choice: Conservation and Restoration Options to Enhance Coastal Resiliency in New Hampshire (NH Fish & Game, DRAFT September 2015)

Currently, 1,497 acres of salt marsh lie within Hampton. At the 3.9 feet sea level rise by 2100 scenario there is potential for 310 acres of new marsh to form and at the 6.6 feet scenario there is potential for 344 acres.







Hampton currently has the most salt marsh in New Hampshire and is the community with the second greatest potential area of new salt marsh. Protecting land where salt marsh can potentially migrate is a good strategy to enhance coastal resiliency. Of the opportunities available, the areas circled above are some of the priority areas for conservation as they are particularly large, currently mainly undeveloped, and are robust as they remain under the highest sea level rise scenario modeled.

There are several opportunites to remove or modify barriers to tidal flow, although not all will be logistically feasible. Potential opportunites are show in blue in the figure above. The Taylor River is one of two large tidal connection restorations in the state

that are particularly robust in terms of likely duration.

Salt marsh, sand dunes and sand beaches provide natural protection against floods and storm surge. Maps 9 and 10 indicate that tidal wetland systems and freshwater wetlands will be heavily impacted by flooding from sea-level rise. Changes in the daily tidal condition and seasonal high tides will affect the stability of these systems and their ability to sustain surface elevations that keep pace with rising water levels.

LAND USE

Maps 1 and 2 Extent of Flooding show upland affected by sea-level rise and coastal storm surge flooding above mean higher high water. Table 7 reports the number of acres of upland affected by each flood scenario.

Low-lying upland areas behind Route 1A and in interior fringe areas of the Hampton-Seabrook Estuary are highly susceptible to flooding even at the lowest 1.7 foot sea-level rise scenario. Much of these uplands are the result of filling tidal marshes decades ago to create developable land. Over time, the underlying marsh sediments and material continue to subside lowering the land elevation. Residents in these low-lying residential neighborhoods behind Ashworth Avenue have expressed interest in the construction of berms to alleviate current nuisance flooding at highest tides and prevent flooding during coastal storms, however no further discussion has taken place about the extent of structures needed and their construction cost.

TABLE 7. UPLAND (acres)

Sea-Level Rise (SLR) Scenarios	SLR 1.7 feet	SLR 4.0 feet	SLR 6.3 feet	SLR 1.7 feet + storm surge	SLR 4.0 feet + storm surge	SLR 6.3 feet + storm surge
Acres	319.4	632.3	897.8	879.7	1,123.5	1,321.2
% Upland	3.9	7.7	10.9	10.7	13.6	16.0

Total Upland in Hampton = 8,257.7 acres. Upland refers to land above mean higher high water (highest tidal extent).

Land Use/Land Cover

Map 14 Regional Land Use shows land use/land cover types affected by sea-level rise and coastal storm surge flooding. Table 8 reports the number of acres for each land use/land cover type affected by each flood scenario.

The land use types most impacted by both sea-level rise and coastal storm surge flooding are residential development and wetland systems. The majority of development at North Beach and Hampton and in interior fringe areas of the Hampton-Seabrook Estuary are residential structures, both permanent owner-occupied dwellings and seasonal rental units. Although less severely impacted, commercial development at North Beach and Hampton Beach are susceptible to flooding from the 4.0 foot sea-level rise scenario and by coastal storms. Forested areas are mainly impacted in the interior fringe areas of the Hampton-Seabrook Estuary at the 4.0 foot sea-level rise scenario and by coastal storms. Town residents have

observed impacts to trees in the areas as seasonal tidal flooding reaches into upland areas and freshwater wetlands.

TABLE 8. LAND USE/LAND COVER (acres)

Sea-Level Rise (SLR) Scenarios	SLR 1.7 feet	SLR 4.0 feet	SLR 6.3 feet	SLR 1.7 feet + storm surge	SLR 4.0 feet + storm surge	SLR 6.3 feet + storm surge
Active Agricultural	0.6	2.9	6.3	5.6	8.8	10.3
Aux Transportation	0.6	5.9	8.7	13.9	17.3	21.8
Farmsteads	0.0	0.0	0.0	0.0	0.0	0.0
Forested	13.5	54.8	97.9	89.2	135.6	176.1
Industrial/Commercial	5.3	29.9	49.5	46.0	63.3	79.4
Mixed Urban	0.0	0.6	1.6	1.5	2.6	2.8
Other/Idle	11.4	32.1	64.5	79.6	94.9	104.0
Playing fields / Recreation	10.6	19.4	26.7	27.2	32.6	49.5
Railroad	0.0	0.0	0.3	0.1	0.5	0.7
Residential	50.9	179.6	287.1	269.8	365.3	431.6
Transportation	6.0	34.7	57.9	62.2	81.5	97.5
Utilities	2.0	6.2	14.1	12.0	20.8	27.2
Water	1.6	33.4	34.7	33.7	35.5	35.7
Fresh/Tidal Wetlands	233.4	280.9	309.1	303.1	330.7	351.5

Note: Auxiliary Transportation refers to small pieces of land adjacent to transportation assets.

Zoning

Map 13 Regional Zoning shows local zoning districts affected by sea-level rise and coastal storm surge flooding. Table 9 reports the acres within each zoning district affected by each flood scenario. Zoning districts are superimposed over land use and land cover.

Zoning districts are superimposed over land use and land cover reported in Table 8. Flood impacts in existing zoning districts follows a similar pattern to land use impacts by category with single-family and high-density residential and commercial development showing sensitivity at the lowest 1.7 foot sea-level rise scenario and all storm surge scenarios.

TABLE 9. ZONING DISTRICTS (acres)

Sea-Level Rise (SLR) Scenarios	SLR 1.7 feet	SLR 4.0 feet	SLR 6.3 feet	SLR 1.7 feet + storm surge	SLR 4.0 feet + storm surge	SLR 6.3 feet + storm surge
Commercial	43.4	123.5	186.5	197.0	232.0	245.5
General/Single Zone	83.7	172.9	226.0	215.9	268.2	331.3
Industrial	5.3	11.4	29.2	24.2	54.1	88.9
Residential - High Density	202.8	367.1	510.9	500.9	628.5	715.5
Residential - Med Density	0.3	4.5	4.7	4.6	4.9	5.1

Parcels and Assessed Value

Table 10 reports the number of parcels affected by for each of the six scenarios evaluated and the aggregated assessed value of these parcels. The degree to which the parcel and any development on the parcel is affected by sea-level rise or storm related flooding was not analyzed. Affected parcels were identified based on their location either partially or fully within the extent of the scenarios evaluated. The data may include a number of high value parcels under state and municipal ownership.

For Hampton, the largest increase in the number of affected parcels is the extent of flooding from 1.7 feet of sea-level rise to 4.0 feet of sea-level rise. There is a 76.5 percent increase in the number of affected parcels and nearly a $288 million increase in assessed value from the 1.7 feet to the 4.0 feet sea-level rise scenarios. There is a 31 percent increase in the number of affected parcels and approximately a $300 million increase in assessed value from the 4.0 feet to the 6.3 feet sea-level rise scenarios

TABLE 10. PARCELS AND ASSESSED VALUE BY SCENARIO

Sea-Level Rise (SLR) Scenarios	Number of Parcels Affected by scenario	Aggregate Value of Affected Parcels
1.7 feet SLR	1,149	$414,879,900
4.0 feet SLR	2,028	$703,144,400
6.3 feet SLR	2,664	$1,005,790,500
1.7 feet SLR + storm surge	2,607	$1,003,687,600
4.0 feet SLR + storm surge	2,898	$1,116,615,500
6.3 feet SLR + storm surge	3,065	$1,188,484,400

FEMA Flood Hazard Areas

Maps 23 and 24 Preliminary FEMA Flood Hazard Areas show areas within the 100-year and 500-year floodplain affected by sea-level rise and coastal storm surge flooding. Table 11 reports the acreage within the current 100-year and 500-year floodplains affected by each flood scenario.

The three sea-level rise scenarios generally fall within the current 100-year floodplain, extending beyond into the 500-year floodplain in certain areas. From a floodplain management perspective, creating more resilient development within the current 100-year floodplain will provide protection against flood impacts from long term sea level rise.

In Hampton, the 100-year floodplain is highly sensitive to flooding from sea-level rise: 75 percent at 1.7 feet sea-level rise, 86 percent at 4.0 feet sea-level rise, and 87 percent at 6.3 feet sea-level rise.

TABLE 11. FEMA FLOOD HAZARD AREAS (acres)

Sea-Level Rise (SLR) Scenarios	SLR 1.7 feet	SLR 4.0 feet	SLR 6.3 feet	SLR 1.7 feet + storm surge	SLR 4.0 feet + storm surge	SLR 6.3 feet + storm surge
100-year floodplain	**2,393.0**	**2,738.3**	**2,810.9**	**2,836.2**	**2,865.8**	**2,872.9**
100-year floodplain - Coastal Region	8,179.5	9,361.1	9,593.2	9,639.0	9,765.8	9,818.0
500-year floodplain	**2,393.0**	**2,739.1**	**2,886.0**	**2,910.4**	**2,941.7**	**2,948.9**
100-year floodplain - Coastal Region	8,180.6	9,368.4	9,837.6	9,879.8	10,015.3	10,069.5

Area of the 100-year floodplain = 3,168.0 acres. Area of the 500-year floodplain = 3,301.0 acres.
Floodplain assessment based on Preliminary Flood Insurance Rate Maps (FIRMs) released by FEMA in 2014.

ISSUES AND CONSIDERATIONS

The following issues and considerations were identified during project meetings with municipal staff and land use board and commission members.

- Improvements to the state roadway network (elevating, enlarging culvert and bridges) may affect local connector roads, driveway access points and connecting infrastructure and utilities.

- Although roadways, buildings and infrastructure can be protected by raising them above projected sea-level rise elevations, supporting land and land based uses may be impacted by daily tidal flooding from projected sea-level rise.

- Planning for long term sea-level rise can be integrated with existing regulatory and management frameworks for the current 100-year floodplain.

- Ownership of transportation infrastructure and assets by multiple state agencies (roadways, culverts, state parks, parking areas) and town responsibility for management of assets (sidewalks, roads in urban compact areas) creates complexity in comprehensively managing these systems and implementing climate adaptation strategies.

- Flooding from sea-level rise and coastal storm surge impacting the state and local roadway network adjacent to the Route 1A and Route 1 south of the Route 101 interchange disrupt the designated evacuation network in Hampton and connections to evacuation routes in adjacent towns.

- Providing information about potential flood hazards to businesses and residents, and early notification of flood risk during a coastal storm event would enhance public safety and preparedness.

- Meadow Pond lacks storage capacity to accommodate tidal flooding and stormwater drainage during most storm events.

- Long term infrastructure management would benefit from an analysis of the costs necessary to improve roads and drainage infrastructure to withstand projected sea-level rise elevations at 2050 and 2100.

RECOMMENDATIONS

The following recommendations are short-term climate adaptation actions that can be included in the town's Natural Hazards Mitigation Plans, Master Plan and other planning and policy documents. These actions are focused on strengthening land use development standards, resource protection, municipal policy and plans, and public support to create more resilient development, infrastructure and natural systems. *Refer to Appendix B for an expanded list of climate adaptation strategies.*

REGULATORY

R1 - Elevate Structures 2 feet Above Base Flood Elevation. Adopt standards in floodplain zoning and/or Site Plan Review and Subdivision Regulations that require all new development and redevelopment to be elevated 2 feet above the base flood elevation. Two feet of additional elevation will ensure that structures are protected from flooding based on the highest sea-level rise projection of 2 feet by 2050.

R2 - Coastal Flood Hazard Overlay District. Adopt in the town's zoning ordinance a Coastal Flood Hazard Overlay District that includes performance based standards that protect against flood impacts from sea-level rise and coastal storm surge. Establish the overlay district boundaries based on current flood hazard areas on FEMA Flood Insurance Rate Maps and projected future high risk flood areas mapped by the Tides to Storms Vulnerability Assessment. (Also see similar recommendation in the Community Outreach and Engagement section below.)

R3 - Coastal Buffers and Tidal Marshes. Adopt buffers and setbacks that adequately separate development and infrastructure from tidal wetlands, freshwater wetlands and surface waters to sustain flood storage capacity, and allow for inland migration of tidal marsh systems and conversion of freshwater systems to tidal systems to accommodate projected changes in sea-levels.

PLANNING AND POLICY

P1 - Natural Hazards Mitigation Plan. Incorporate the vulnerability assessment information and recommendations from the Tides to Storms Hampton profile report in the town's 2015/2016 Natural Hazards Mitigation Plan update. Continue revising and updating the assessment information and climate adaptation recommendations in future updates of the Plan.

P2 - Master Plan Coastal Hazards Chapter. Adopt a Coastal Hazards Chapter in the town's Master Plan that incorporates information and recommendations from the Tides to Storms Vulnerability Assessment Profile for Hampton.

P3 - FEMA Community Rating System. Support implementation of climate adaptation actions that will qualify the town for FEMA's Community Rating System (CRS) program or increase its rating in the CRS program. Climate adaptation implementation includes planning and policy, regulatory, non-regulatory, and community outreach and engagement activities.

P4 - Capital Infrastructure and Investments. Incorporate consideration of impacts from sea-level rise and coastal storm surge flooding in current and future capital infrastructure projects. Incorporate the Tides to Storms vulnerability assessment information into infrastructure management plans and capital

improvement plans. Evaluate the extent of sea-level rise and storm surge flooding on individual facilities (e.g. wastewater treatment plant, transfer station, high school).

P5 - Land Conservation. Land conservation offers the greatest opportunities to provide for adaptation to the effects of sea-level rise and coastal storm flooding and climate change impacts.

- Adopt a targeted scoring framework or incorporate new scoring criteria into existing land conservation prioritization efforts that consider climate adaptation benefits when evaluating land for conservation purposes.
- Increase funding and resources for land conservation, land management programs, and land stewardship activities. (Note: Land conservation scores very high as an activity in the FEMA Community Rating System program.)
- Support retreat from high risk areas by buying properties and restoring them to a natural condition.

P6 - Wetlands Mitigation Site Inventory. Identify and inventory lands where protection of tidal and freshwater wetlands would provide tangible benefits to protect against flooding, and restoration opportunities to remove barriers to tidal function and marsh and migration. This inventory will allow the town to pre-identify and prioritize sites that can be permanently preserved as a mitigation strategy for wetland impacts from development in high risk coastal areas.

P7 - Evacuation Planning. Prepare evacuation plans and coordinate these plans with towns in the coastal region to implement timely and comprehensive planning and notification for coastal storm events. Mark evacuation routes with signage and communicate these routes to the public with information on the town's website and printed maps.

COMMUNITY OUTREACH AND ENGAGEMENT

O1 - Seabrook-Hamptons Estuaries Alliance. The Seabrook-Hamptons Estuaries Alliance (SHEA) is a voluntary collaborative advocacy group consisting of members from Hampton, Hampton Falls and Seabrook. The group's focus is to: 1) pursue activities that improve the resilience of natural systems, infrastructure and development to the impacts of climate change; and 2) facilitate communication and cooperation among the three towns, especially in regard to research, programs and other efforts designed to help preserve, protect, and strengthen the Estuary. SHEA can assist the town with outreach, planning and regulatory activities involving climate adaptation implementation.

- Continue participating in and supporting the Seabrook-Hamptons Estuaries Alliance.
- Continue SHEA's and the town's partnership with NH Coastal Adaptation Workgroup in climate adaptation activities that facilitate, coordinate, provide technical information, and convene public outreach events for the Estuary towns.

O2 - Implement FEMA's High Water Mark Initiative. Communities implement the High Water Mark Initiative by providing information on past floods, such as documenting high water marks in public places, and posting maps and photographs of past floods on their websites. High water marks can be displayed on public buildings or on permanently installed markers.

O3 - Coastal Flood Hazard Overlay District. Use the Coastal Flood Hazard Overlay District as a tool to inform property owners of existing and future risks and hazards based on projected sea-level rise and coastal storm surge flooding.

O4 - Living Shorelines and Landscaping. Maintaining natural shorelines is an effective way to preserve the functions of shoreline systems (marshes, dunes, estuaries) in providing valuable services including flood storage, recreational areas, and commercial harvesting of fish and shellfish.

- Provide information to property owners about living shorelines and the importance of retaining the functions of natural shorelines, and implementing landscaping best practices.
- Implement living shorelines projects on town lands to demonstrate best practices, and the benefits and effectiveness of living shorelines approaches.

Refer to Hampton's Natural Hazards Mitigation Plan for additional recommendations for outreach and engagement activities.

APPENDIX A – MAP SET

Map 1 Extent of Projected Tidal Flooding - SLR 1.7', 4.0' and 6.3'
Map 2 Extent of Projected Tidal Flooding - SLR + Storm Surge
Map 3 Critical Facilities and Infrastructure - SLR 1.7', 4.0' and 6.3'
Map 4 Critical Facilities and Infrastructure - SLR + Storm Surge
Map 5 Roads and Transportation Assets - SLR 1.7', 4.0' and 6.3'
Map 6 Roads and Transportation Assets - SLR + Storm Surge
Map 7 Existing and Recommended Conservation Areas - SLR 1.7', 4.0' and 6.3'
Map 8 Existing and Recommended Conservation Areas - SLR + Storm Surge
Map 9 Wetlands, Aquifers, Wellhead Protection Area - SLR 1.7', 4.0' and 6.3'
Map 10 Wetlands, Aquifers, Wellhead Protection Area - SLR + Storm Surge
Break in map numbering.
Map 13 Zoning Districts - SLR 1.7', 4.0' and 6.3'
Map 14 Land Use/Land Cover - SLR 1.7', 4.0' and 6.3'
Break in map numbering.
Map 17 Depth of Flooding - Sea-Level Rise 1.7'
Map 18 Depth of Flooding – Sea-Level Rise 4.0'
Map 19 Depth of Flooding – Sea-Level Rise 6.3'
Map 20 Depth of Flooding – Sea-Level Rise 1.7' + Storm Surge
Map 21 Depth of Flooding - Sea-Level Rise 4.0' + Storm Surge
Map 22 Depth of Flooding – Sea-Level Rise 6.3' + Storm Surge
Map 23 Preliminary FEMA Flood Hazard Areas - SLR 1.7', 4.0' and 6.3'
Map 224 Preliminary FEMA Flood Hazard Areas - SLR + Storm Surge