



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

CITY OF PORTSMOUTH, NEW HAMPSHIRE

Vulnerability Assessment

of projected sea-level rise and coastal storm surge flooding



Prepared by the
Rockingham Planning Commission

September 2015

ACKNOWLEDGEMENTS

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Cover Photo Credit: Steve Miller

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

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MAPPING AND ASSESSMENT

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. 2011 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.

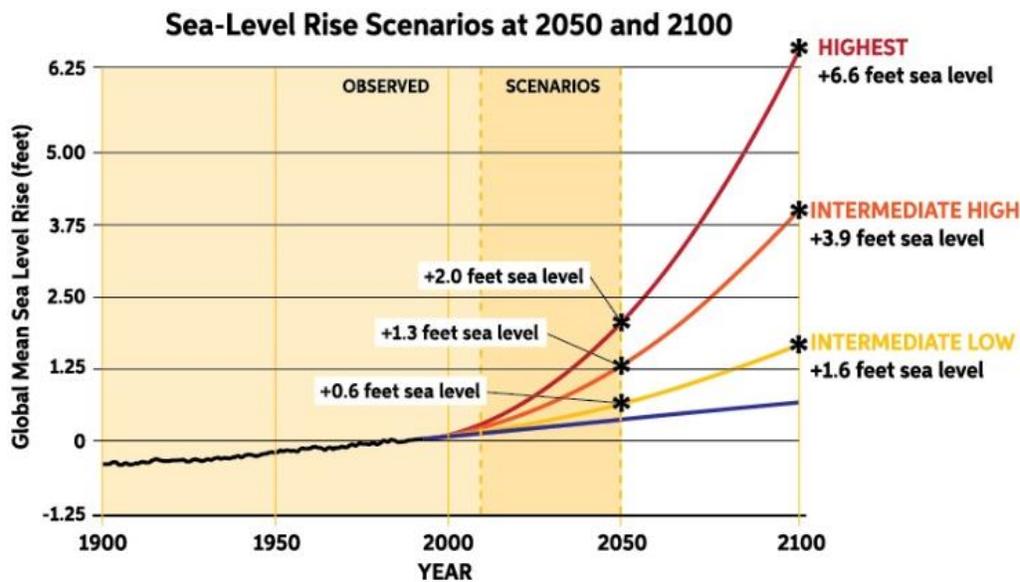


Figure 3. 2014 Sea-Level Rise Scenarios (based on greenhouse gas emissions)

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

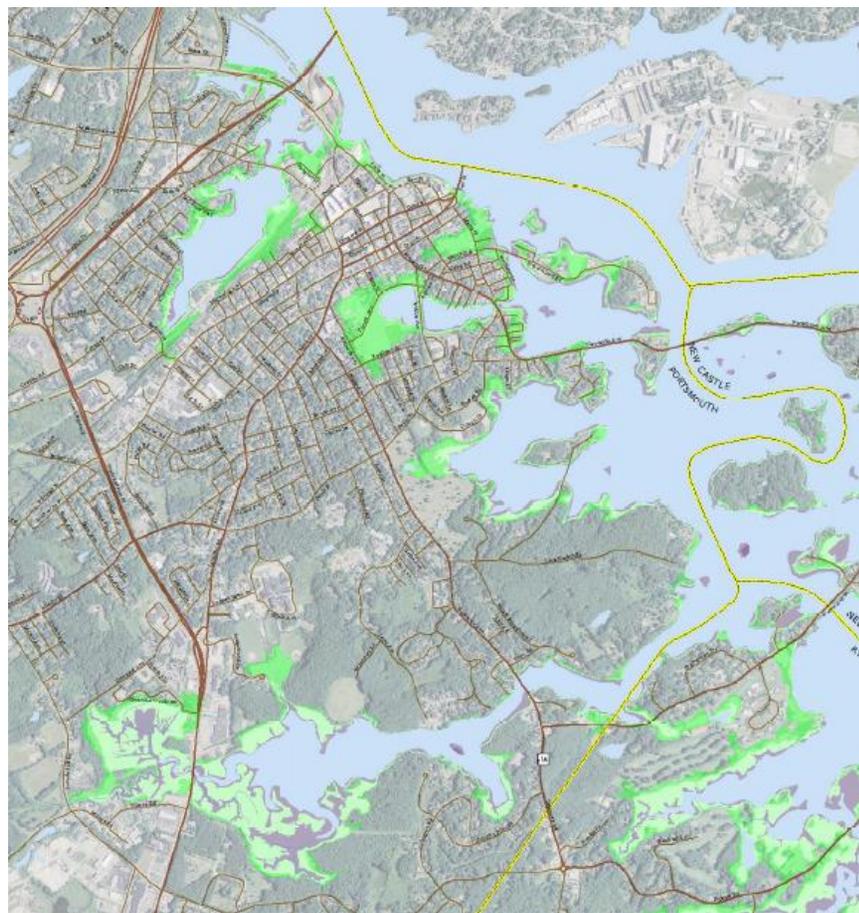
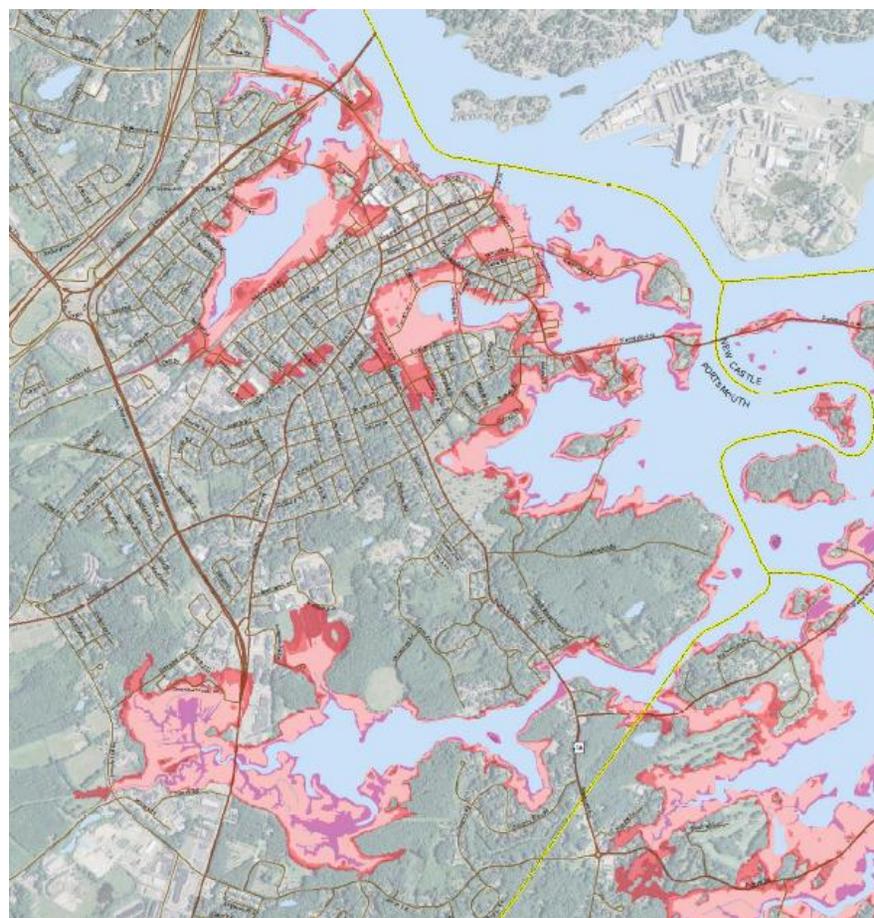


Figure 5.
Sea-Level Rise Scenarios 1.7 feet, 4.0 feet and 6.3 feet plus storm surge



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



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OVERVIEW

The City of Portsmouth is located along the north coastal area of New Hampshire comprising 10,763.4 acres including 7,669.9 acres of upland and 3,096.5 acres of water and wetlands. With a population of 20,779 (2010), Portsmouth is the most populated of the seven coastal municipalities. The city's coastal area includes its downtown central business district, historic district, parks, high-density residential neighborhoods, and recreational marinas and boating facilities.

In 2012, Portsmouth was one of five communities selected for a pilot program with \$30,000 in funding from the Gulf of Maine Council, through a grant from the National Oceanic and Atmospheric Administration (NOAA). This grant funded a research study, the "Coastal Resilience Initiative" prepared for the City by a team of researchers from the University of New Hampshire and the Rockingham Planning Commission. This detailed, 50-page report provides the starting point for understanding the impacts of flooding caused by climate change and offers a number of possible adaptation measures that the City can take over time to protect private property and public infrastructure. The report and maps are available on the city's website at <http://www.planportsmouth.com/cri/>.

Vulnerability Assessment Results

Key findings for the City of Portsmouth 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.

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)	23	30	35	33	40	54
Critical Facilities (# of sites)	0	0	11	8	11	11
Roadways (miles)	1.06	2.15	4.92	4.21	7.54	11.01
Upland (acres)	104.5	197.3	313.9	287.7	406.6	534.6
Freshwater Wetlands (acres)	1.2	8.6	11.1	10.7	11.8	14.5
Tidal Wetlands (acres)	87.3	94.4	96.3	96.0	97.1	97.9
Conserved and Public Lands (acres)	52.2	64.7	76.1	73.6	85.0	95.4
100-year floodplain (acres)	927.3	1,017.8	1,023.1	1,022.8	1,023.9	1,023.8
500-year floodplain (acres)	927.3	1,017.9	1,028.8	1,028.0	1,030.8	1,031.3

Notes: Storm surge is the area flooded by the 100-year/1% chance storm event. Upland refers to land above mean higher high water (highest tidal extent) and excluding wetlands. 500-year floodplain impacts were calculated based on flooding beyond the extent of the 100-year floodplain impacts.

Compared with other coastal municipalities Portsmouth's vulnerability to flooding from sea-level rise and storm surge is low for most assets and resources evaluated. The assessment shows that the greatest flood impacts will be to upland areas (particularly within the 100-year floodplain), tidal wetlands and conserved lands with moderate flood impacts to roadways and critical facilities. Critical facilities impacted by flooding are sewage pump stations and stormwater outfalls. The City is in the process of evaluating how to flood-proof and in some case redesign or relocate these facilities that are in the highest risk locations.

Geographically, flooding from both the sea-level rise and storm surge scenarios will impact areas surrounding North Mill Pond, South Mill Pond, the South End, Peirce Island, Little Harbour and Sagamore Creek. These areas contain significant historical and cultural resources, including Strawberry Banke and the Historic District, and the downtown business district which is central to the city's port, recreation, tourism and fisheries based economy.

The complete assessment information is provided beginning on page 3 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.

State and municipal culverts and bridges are the infrastructure types most affected by projected sea-level rise and coastal storm surge flooding. Portsmouth is responsible for maintaining roads and their infrastructure associated with state roads within its urban compact area which includes the downtown business district and historic district. Most of the area affected by the scenarios evaluated in this study are located in the city’s urban compact area with the exception of upper portions of the Sagamore Creek drainage. A number of projects included in the state’s Ten Year Plan and Long Range Plan are affected by projected by sea-level rise and coastal storm surge flooding, however no analysis has been done to determine to what degree they might be impacted.

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 local)	7	9	11	11	12	16
Dams	0	0	0	0	0	0
National Historic Register	0	1	1	1	1	1
Powerstations and Substations	0	0	0	0	0	1
Transportation Infrastructure (# of facilities)						
Bridges	8	9	11	9	13	18
Harbor/Marina	2	2	2	2	3	3
Signs, Lights, Signals, Beacons, and Other	1	1	1	1	1	3
NHDOT Stormwater Structures	1	1	1	1	1	1
Ten Year and Long Range Plan Projects	4	4	5	5	6	8
Total	23	30	35	33	40	54

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.

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
Mill Pond Way Pump Station	--	--	Flood	--	Flood	Flood
NE Utility Service	--	--	Flood	--	Flood	Flood
Leslie Drive Pump Station	--	--	Flood	Flood	Flood	Flood
Mechanic Street Pump Station	--	--	Flood	Flood	Flood	Flood
Portsmouth Middle School	--	--	Flood	Flood	Flood	Flood
Rail Yard	--	--	Flood	Flood	Flood	Flood
Market St Sewage Pump Station	--	--	Flood	Flood	Flood	Flood
Northwest St Pump Station	--	--	Flood	Flood	Flood	Flood
Deer St. Pump Station	--	--	Flood	Flood	Flood	Flood
Rail Yard	--	--	Flood	Flood	Flood	Flood
Marcy Street Pump Station	--	--	Flood	--	Flood	Flood
Total - Sites	0	0	11	8	11	11

Note: Municipal Critical Facilities as identified in the city’s Natural Hazards Mitigation Plan.

The majority of municipal critical facilities are stormwater and wastewater infrastructure that are connected to the city’s wastewater treatment plant on Peirce Island. Although this assessment finds the wastewater treatment plant is not affected by projected sea-level rise and coastal storm surge flooding, much of the surrounding land and access to the plant is susceptible to flooding at the 4.0 feet and 6.3 feet sea-level rise scenarios. All of the municipal critical facilities are susceptible to projected sea-level rise and coastal storm surge flooding at the 6.3 feet sea-level rise scenario and the three storm surge scenarios.

The Fire Station on Court Street (the building) is not affected by flooding, however the parking lot is affected by the 6.3 feet sea-level rise scenario and the three storm surge scenarios.

Historical Resources and Assets

The vulnerability assessment identified ten National Historic Register properties that are affected by the sea-level rise and coastal storm surge scenarios evaluated. These properties and their supporting lands are affected to the greatest extent at the 4.0 feet sea-level rise plus storm surge and 6.3 feet sea-level rise plus storm surge scenarios.

TABLE 5. NATIONAL HSITORIC REGISTER PROPERTIES

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
Strawberry Banke Historic District	0	1	1	1	1	1
Richard Jackson House	1	1	1	1	1	1
Old North Cemetery	0	0	0	0	0	1
George Rogers House	0	0	0	0	0	1
Gov. John Wentworth House	0	0	0	0	1	1
General Porter House	0	0	0	0	0	1
Haven-White House	0	0	0	0	0	1
Wentworth-Gardner and Tobias Lear Houses	0	0	0	0	1	1
Total Properties	1	2	2	2	4	8

The Wentworth-Coolidge Mansion and Wentworth-Gardner House are not directly impacted by flooding from the six flood scenarios however the surrounding lands are impacted.

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 6 reports the miles of state and local roadways affected by each flood scenario.

The roadway class most impacted under all scenarios are municipal roadways. However, portions of key state roads are impacted under all scenarios including Route 1, Route 1A, the approaches to Memorial Bridge and Sarah Long Bridge, and the access road to Peirce Island, the location of city’s wastewater treatment plant. Collectively these roadway impacts will isolate certain sections of the south end from the roadway network during daily tidal conditions due to projected sea-level rise and from evacuation routes during a 100-year storm event. The majority of roadways impacted are located in the City’s urban compact area where they assume management of both local and state roadways.

TABLE 6. 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						
Interstate	0.14	0.14	0.14	0.14	0.14	0.14
Local	0.19	1.19	3.38	2.85	5.75	8.83
State	0.21	0.27	0.63	0.59	0.73	0.98
US route	0.53	0.56	0.77	0.64	0.92	1.06
Total Road Miles	1.06	2.15	4.92	4.21	7.54	11.01
Guardrail	0.0	0.0	0.0	0.0	0.0	0.1
Bike Routes	0.4	0.6	1.0	1.0	1.4	1.9
Evacuation Routes	0.9	1.0	1.8	1.5	2.8	3.6

NATURAL RESOURCES

Freshwater wetlands, tidal wetlands and conserved lands will be most impacted by flooding from sea-level rise and storm surge. There is potential for conversion of freshwater wetlands to tidal marshes and for tidal marshes to migrate into upland areas as sea-levels rise. Freshwater wetlands and salt marshes provide natural protection against flooding from sea-level rise and storm surge. Although freshwater wetland to tidal marsh conversion and tidal marsh migration will help retain some flood storage capacity in coastal areas, there is also potential for loss of flood storage by conversion of mud flats and low/high marsh to open water permanently.

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 7 reports the number of acres for each natural resource affected by each sea-level rise and coastal storm surge scenario.

Portsmouth has conserved and holds ownership of significant acreage within its coastal area. Retaining these lands in a natural undeveloped state helps to reduce the city’s risk and vulnerability to projected sea-level rise and coastal flooding. The city may consider aligning its land protection strategies by incorporating criteria in its selection process that takes into account the value and benefits to both humans and ecosystems of increasing land protection efforts in areas projected to have high flood risk in the future.

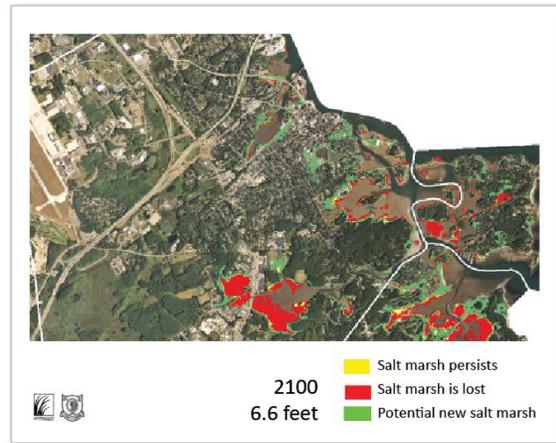
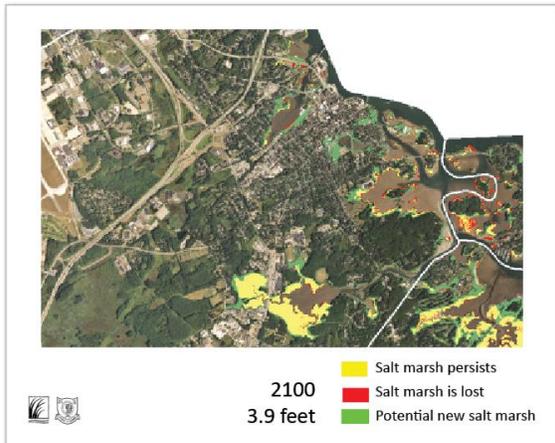
TABLE 7. NATURAL RESOURCES (acres)

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
Resource Type						
Surface Water	0.1	0.6	0.7	0.7	0.7	0.7
Aquifers	0.9	1.8	2.7	2.4	3.7	5.5
Freshwater Wetlands	1.2	8.6	11.1	10.7	11.8	14.5
Tidal Wetlands	87.3	94.4	96.3	96.0	97.1	97.9
Wildlife Action Plan – Tier 1 and Tier 2 habitat	170.4	202.0	226.2	221.5	244.7	264.2
Coastal Conservation Plan Focus Areas	0.0	0.0	0.0	0.0	0.0	1.1
Conserved and Public Lands	52.2	64.7	76.1	73.6	85.0	95.4
Ag Soils (All Types)	0.9	5.6	9.4	8.5	13.1	18.8

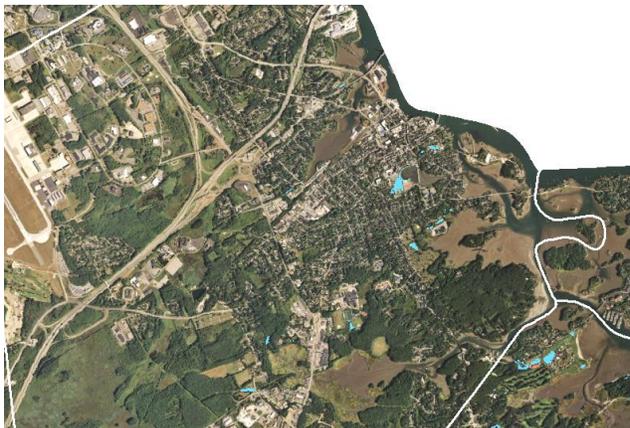
SEA LEVEL AFFECTING MARSHES MODEL (SLAMM): A CITY OF PORTSMOUTH

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

Currently, 167 acres of salt marsh lie within Portsmouth. At the 3.9 feet sea level rise by 2100 scenario there is potential for 160 acres of new marsh to form and at the 6.6 feet scenario there is potential for 210 acres.



Protecting land where salt marsh can potentially migrate is a good strategy to enhance coastal resiliency. Although opportunities for conservation are limited due to the developed nature of Portsmouth, there are potential areas, particularly along Sagamore Creek. Of those available, the areas circled on the map at left might be a priority for conservation as they are currently mainly undeveloped and are robust as they remain under the highest sea level rise scenario modeled.



There are several opportunities to remove or modify barriers to tidal flow, although not all will be logistically feasible. Potential opportunities are shown in blue on the map at left. The largest is on the southwest edge of South Mill Pond. However, because of local development it is recognized this is not likely to take place.

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 8 reports the number of acres of upland affected by each flood scenario.

Portsmouth’s coastal area has some lying areas mainly in the south end and surrounding North and South Mill Pond, however much of the city’s downtown historic district is located at elevations outside the current 100-year floodplain and areas flooded by projected sea-level rise. Historically, coastal development extended upland by filling tidal marshes around the North and South Mill Ponds and south end which are the lands most sensitive to flooding.

TABLE 8. 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	104.5	197.3	313.9	287.7	406.6	534.6
% Upland	1.0	2.0	3.1	2.9	4.1	5.3

Total Upland in Portsmouth = 10,006 acres. Upland refers to land above mean higher high water (highest tidal extent) excluding wetlands.

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 9 reports the number of acres for each land use/land cover type affected by each flood scenario.

Developed land uses most impacted by sea-level rise and storm surge flooding are residential, industrial/commercial, recreation and transportation. Undeveloped land uses most impacted by sea-level rise and storm surge flooding are forest, other/idle, water and wetlands.

TABLE 9. 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
Land Use						
Active Agricultural	0.0	0.0	0.0	0.0	0.2	0.6
Aux. Transportation	0.2	0.5	1.3	1.0	1.8	2.6
Farmsteads	0.0	0.0	0.0	0.0	0.0	0.0
Forested	8.6	31.2	51.7	47.1	68.5	90.9
Industrial/Commercial	3.3	17.1	51.4	43.7	74.0	97.7
Mixed Urban	0.0	0.9	2.4	2.0	3.5	5.8
Other/Idle	3.6	9.2	16.4	15.0	22.0	26.9
Playing fields / Recreation	2.7	24.2	39.6	37.1	47.6	63.4
Railroad	0.0	0.0	0.8	0.6	1.7	3.0
Residential	5.7	22.9	48.0	41.9	73.8	116.2

Transportation	0.4	4.4	14.7	12.1	24.4	35.3
Utilities	0.4	2.4	4.9	4.5	6.4	7.9
Water and Wetlands	82.2	90.0	91.2	91.0	92.0	94.5

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 10 reports the acres within each zoning district affected by each flood scenario. Zoning districts are superimposed over land use and land cover.

Zoning districts most impacted by sea-level rise and storm surge flooding are open space/conservation, mixed urban and high density residential. This is not surprising given the majority of flooding impacts are located in urbanized areas in the central business district and historic district. Impacts to open space/conservation areas reflect the amount of conservation lands located within the Sagamore Creek drainage which is dominated by freshwater and tidal systems.

TABLE 10. 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
Zoning / Land Use						
Commercial	0.8	4.7	8.9	8.1	10.7	12.6
Industrial	2.3	9.2	26.0	22.6	37.0	47.8
Mixed Urban	22.8	36.4	59.5	53.7	79.6	105.8
Open Space/Conservation	63.0	103.2	136.4	129.4	158.3	188.5
Residential - High Density	10.7	28.2	49.6	44.4	70.6	102.2
Residential - Low Density	2.1	5.8	9.7	8.8	13.4	23.2
Residential - Med Density	3.1	12.0	27.1	23.9	40.9	59.0

Parcels and Assessed Value

TABLE 11. ASSESSMENT OF PARCELS AND ASSESSED VALUES

Refer to Portsmouth’s Community Resilience Initiative report for an analysis of structures and assessed values affected by a range of flood levels. The report and maps are available on the city’s website at <http://www.planportsmouth.com/cri/>.

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 12 reports the acreage within the current 100-year and 500-year floodplains affected by each flood scenario.

The majority of land affected by projected sea-level rise and coastal storm surge flooding is located within the current 100-year floodplain with minor extension of flooding into the 500-year floodplain. The

occurrence of the three sea-level rise scenarios within the 100-year floodplain provides the rationale to implement climate adaptation strategies within the current 100-year floodplain that will create resiliency to protect against long term impacts from projected sea level rise at 2050 and 2100.

TABLE 12. 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	927.3	1,017.8	1,023.1	1,022.8	1,023.9	1,023.8
100-year floodplain - Coastal Region	8,179.5	9,631.1	9,593.2	9,639.0	9,765.8	9,818.0
500-year floodplain	927.3	1,017.9	1,028.8	1,028.0	1,030.8	1,031.3
100-year floodplain - Coastal Region	1.1	7.3	244.4	240.8	249.5	251.5

Floodplain assessment based on Preliminary Flood Insurance Rate Maps (FIRMs) released by FEMA in 2014.

ISSUES AND CONSIDERATIONS

Refer to Portsmouth's Community Resilience Initiative (CRI) report for a detailed description of the issues and considerations related to coastal flooding identified by city staff during development of the CRI report and assessment. The report and maps are available on the city's website at <http://www.planportsmouth.com/cri/>.

RECOMMENDATIONS

The following recommendations are short-term climate adaptation actions that can be included in the town's Natural Hazards Mitigation Plan, 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.

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. Incentives to further protect wetlands may include applying increased buffers and setbacks as mitigation for wetlands impacts from development

PLANNING AND POLICY

P1 - Natural Hazards Mitigation Plan. Incorporate the vulnerability assessment information and recommendations from the Tides to Storms profile report in the city'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 Report.

P3 - FEMA Community Rating System. Incentives to reduce flood insurance rate costs could be modeled after climate adaptation actions recommended by FEMA's Community Rating System (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.

P5 – Retreat Through 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.

- Identify lands in high risk areas to purchase for the purpose of removing development and infrastructure and restoring the land to a natural condition. This is a way to gradually retreat from areas highly susceptible to coastal flooding.
- 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 purchase.

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.

COMMUNITY OUTREACH AND ENGAGEMENT

O1 – NH Coastal Adaptation Workgroup. The NH Coastal Adaptation Workgroup (CAW) is a voluntary collaborative advocacy group consisting of members from federal and state agencies, regional and non-profit organizations, municipalities, academia, and private businesses. 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 stakeholders throughout the coastal watershed, especially in regard to research, programs and other efforts designed to help preserve, protect, and strengthen the Great Bay and Hampton-Seabrook Estuary. CAW can assist the city with outreach, planning and regulatory activities involving climate adaptation implementation.

- Continue supporting work of the NH Coastal Adaptation Workgroup.
- Continue the city’s partnership with NH Coastal Adaptation Workgroup in climate adaptation activities that facilitate, coordinate, provide technical information, and convene public outreach events.

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.

O3 - Coastal Flood Hazard Overlay Map. 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.

O5 – Historical and Cultural Resources Inventory. Inventorying historical and cultural resources is the first step toward developing strategies to protect and preserve them.

Refer to Portsmouth’s Natural Hazards Mitigation Plan and Community Resilience Initiative (CRI) report for additional recommendations for outreach and engagement activities.

Refer to Portsmouth’s Community Resilience Initiative (CRI) report for additional recommendations for outreach and engagement activities. The report and maps are available on the city’s website at <http://www.planportsmouth.com/cri/>.

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