4. Understanding Our Risks and Vulnerabilities

To prepare wisely for and reduce our risks to coastal hazards, the scope of vulnerability needs to be assessed and understood. Vulnerability is the likelihood that an asset will experience harm due to exposure to coastal hazards, as well as historical, social, economic, political, cultural, institutional, natural resource, and environmental conditions and processes. To determine vulnerability, the following questions are asked:

1. What assets are we interested in understanding and protecting?

In this report, we have identified four types of assets that are important to protect: our economy, our built landscape, our natural resources, and our heritage.

2. How exposed are our assets to coastal hazards?

To understand exposure, we look at the presence of people, livelihoods, environmental services and resources, structures and facilities, or economic, social, or cultural assets in places that could be adversely affected by storm surge, sea-level rise, and extreme precipitation and which, thereby, are subject to potential future harm, loss or damage.[36] For example, the more homes and people located in the floodplain, the greater the potential for harm from flooding. Additionally, understanding which critical structures and facilities are exposed, and the degree of that exposure, can help reduce or eliminate service interruptions and costly reconstruction. Finally, communities with more natural areas and less development within floodplains typically have lower exposure to flooding. Communities that monitor land cover changes within the floodplain can detect important trends that indicate whether flood exposure is increasing or decreasing. Armed with this information, local leaders can take steps to improve their safety and resilience.[37]

3. How sensitive are our assets to coastal hazards?

Sensitivity is a measure of how severe of an impact a hazard will have on an asset. Sensitivity, combined with adaptive capacity, determines how vulnerable assets are. For example, while structures and facilities located in the floodplain may be similarly exposed to coastal flooding, the quality and condition of some structures and facilities may make them more sensitive to coastal flood damage than others (e.g. manufactured homes or homes with basements). Similarly, certain groups of people are particularly sensitive to coastal hazards, such as the elderly, the infirm, children, native and tribal groups, non-English speaking individuals, and low-income populations, who may be less likely to cope with and recover from the impacts of coastal hazards without increased or targeted assistance. It is therefore especially important to consider the differential social and infrastructure impacts of storm surge, sea-level rise, and extreme precipitation in order to identify the needs of sensitive populations and infrastructure and develop effective adaptation strategies.

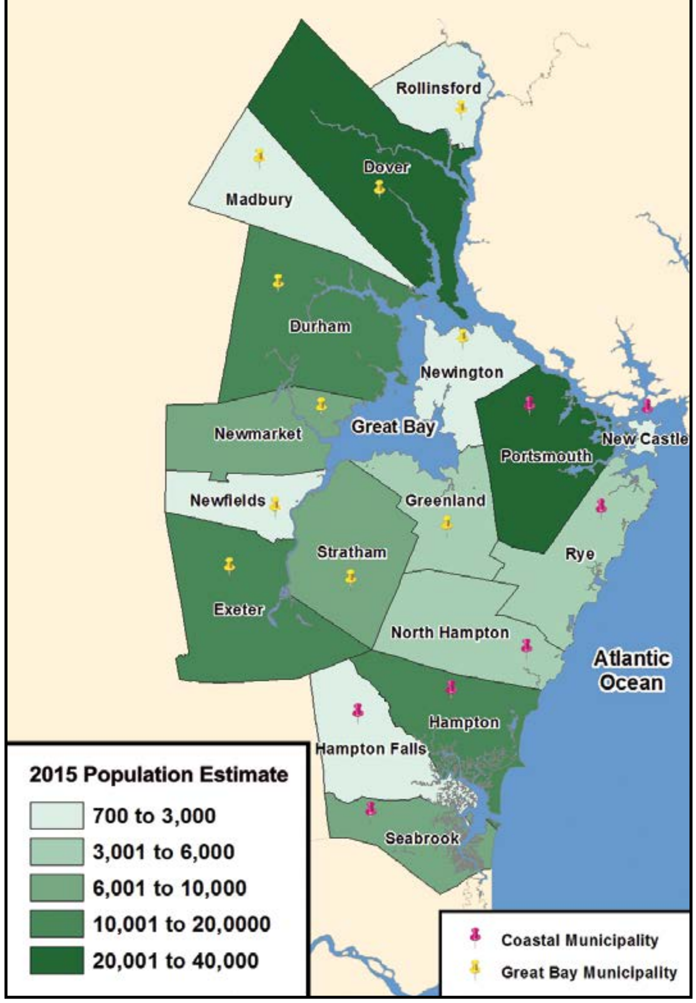
4. Can our assets adapt or be adapted to coastal hazards?

Lastly, vulnerability is influenced by how easily an asset can adapt or be adapted to a change. For example, salt marshes are expected to respond to sea level rise by migrating towards higher elevations; however, the presence of coastal development may limit the amount of space available and obstruct wetland migration inland, resulting in the total loss of wetlands in some areas. Similarly, structures and facilities in the built landscape may be elevated or designed to accommodate increased flooding (e.g., add freeboard to elevate structures above base flood elevation; increase culvert size). Existing building standards (e.g., height restrictions), replacement costs, and secondary impacts to other assets (e.g., increased downstream flooding) may reduce an asset's adaptive capacity and require modification to allow for flexibility in design.

Once the important assets are identified and exposure, sensitivity, and adaptive capacity are ascertained, strategies can be identified to prepare for coastal hazards based on the vulnerability assessment. For example, in the case of a salt marsh, the selected strategy might be to ensure conditions are appropriate to allow for marsh migration as sea levels rise. These adaptation strategies will vary depending on the asset and hazards in question.

While additional research is needed to establish a more complete picture of the vulnerability of specific assets along New Hampshire's coast, particularly as it relates to asset sensitivity and adaptability, significant progress has been made to identify and map important assets and assess their exposure to specific hazards like storm surge and sea-level rise. This section summarizes some of the existing information about our coastal vulnerabilities to some hazards. Section 4.1 presents a summary of the Coastal Region followed by four sections representing the key asset areas[iv] identified by the Commission: Our Economy (4.2), Our Built Landscape (4.3), Our Natural Resources (4.4), and Our Heritage (4.5). Each section summarizes and provides references about our known vulnerabilities and explains critical gaps in our understanding about the vulnerabilities for each topic area. The vulnerabilities outlined in these sections are not a comprehensive assessment of vulnerable assets in coastal New Hampshire, but rather they illustrate some of the known vulnerabilities that exist in the region.

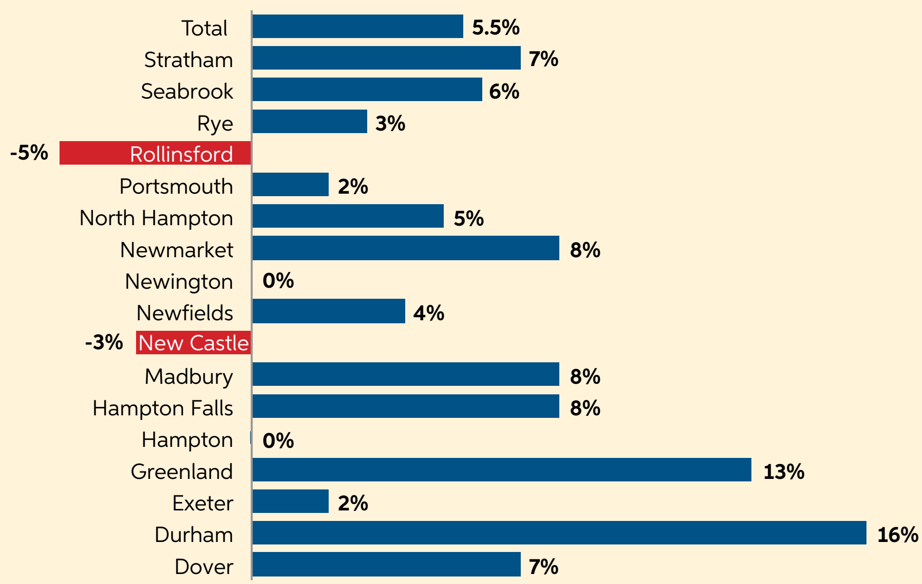
FIGURE 3. 2015 population estimates for New Hampshire coastal region, by municipality. *Source: NHOEP (2016a).*



4.1 Summary of the Coastal Region

According to the NH Office of Energy and Planning (NHOEP) 2015 population estimates, 146,721 people live in New Hampshire's 17 coastal zone municipalities, comprising approximately 11 percent of the state's population.[38] Population in the coastal region has increased 2.5 percent from 2010 to 2015, compared to statewide population growth of 1.1 percent.[39] NHOEP estimates that coastal population will increase an additional 5.5 percent over the next ten years.[40] Figure 3 shows the current distribution of population across coastal municipalities, while Figure 4 illustrates how coastal population is expected to change over the next decade.

FIGURE 4. Population projections by coastal zone municipality for period 2015 through 2025. *Source: NHOEP (2016b).*



[iv] The four asset areas are also used to organize the recommendations presented in Section 6.

As population increases in New Hampshire's coastal communities, more people live, work, and own property in areas prone to coastal risks and hazards. Additionally, scientists have posited that future climate changes may result in an additional population increase as people migrate away from water-starved western United States as well as other countries.[41] These historical population trends and possible future migration, and the development trends that inevitably follow, give added importance to ongoing efforts to identify coastal vulnerabilities and take action to reduce those vulnerabilities.

As we think about vulnerability, it is important to recognize the diversity of New Hampshire's coast. There are two distinct geographic areas that are impacted by coastal hazards and risks: the municipalities that directly border the Atlantic Ocean and those that surround Great Bay and its tidal tributaries.

4.1.1 Atlantic Coast Municipalities

New Hampshire's seven Atlantic Coast communities include Hampton, Hampton Falls, North Hampton, New Castle, Portsmouth, Rye, and Seabrook. These communities are located in the southeastern corner of the state directly exposed to the Atlantic Ocean. The Atlantic Coast is characterized by tidal and riverine systems and landforms. The southern Atlantic Coast consists of a barrier beach system including the extensive salt marshes of the Hampton-Seabrook Estuary, a broad sand beach at Hampton, and dune systems in Hampton and Seabrook. The northern Atlantic Coast is marked by prominent bedrock headlands, small cove beaches and tidal waterways that extend far inland. The primary inland riverine systems include the Taylor River and Winnicut River.

The Atlantic Coast municipalities have a distinct and pressing need to address existing and future impacts relating to climate change, particularly relating to coastal flooding from storm surge and sea-level rise. Without proactive solutions to address the expected impacts of climate change, these communities face a multitude of challenges to ensure the security, health and welfare of their citizens and provide for a stable and viable economic future. In September 2015 the Rockingham Planning Commission (RPC) completed the Tides to Storms project[42] to assess the vulnerability of roadways and supporting transportation assets, critical facilities, and natural resources to flooding from expected increases in storm surge and rates of sea-level rise in the seven Atlantic Coast communities. This study is the first statistical and spatial analysis of its kind conducted for New Hampshire communities. It used a uniform methodology to identify specific state and municipal assets that are vulnerable to flooding under different storm surge and sea-level rise scenarios. The study did not include an assessment of the specific degree of damage nor estimate monetary losses to specific sites or properties. Further depth-damage analyses of affected assets using the flood depth maps may yield some of this information in follow-up work.

Portsmouth Coastal Resilience Initiative

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 (CRI)" prepared for the City by a team of researchers from the University of New Hampshire and the Rockingham Planning Commission. This detailed report provides the starting point for understanding the impacts of climate change and offers a number of possible adaptation measures that the City can take over time to protect private property and public facilities. The report evaluated potential impacts from sea-level rise and storm related flooding on critical facilities, buildings and salt marshes. The City is actively implementing measures to adapt its stormwater drainage facilities to increases in extreme precipitation and rising sea levels.

PREPARE. PROTECT. PORTSMOUTH.

The City's current climate initiative "Prepare. Protect. Portsmouth." showcases the CRI report and information about what residents and businesses can do to prepare for climate change. Find more information on the Prepare. Protect. Portsmouth. website at **http://www.planportsmouth.com/cri/.**

Flooding scenario maps were based on the 2014 National Climate Assessment, 2014 (Preliminary) Flood Insurance Rates Maps released by the Federal Emergency Management Agency (FEMA),[43] and high resolution digital elevation data. Data sources and assumptions that underlie the flood scenarios used in this assessment are explained more fully in the Tides to Storms final report.[44]

Key findings of this assessment are based on evaluation of the extent of inundation that would result under three scenarios of sea-level rise: 1.7 feet, 4.0 feet, and 6.3[v] feet for the year 2100 and three additional scenarios that pair the sea-level rise combined with the 100-year storm surge. For example, Figure 5 shows the extent of projected tidal flooding from 1.7 feet, 4.0 feet, and 6.3 feet of sea-level rise scenarios for the Hampton-Seabrook Estuary and surrounding areas. The green color scheme is arranged from lightest to darkest with increasing flood extent.

Figure 6 shows the extent of projected tidal flooding from 1.7 feet, 4.0 feet, and 6.3 feet of sea-level rise plus storm surge scenarios for the Hampton-Seabrook Estuary and surrounding areas. The pink color scheme is arranged from lightest to darkest with increasing flood extent.

Table 1 provides a statistical overview of the flood impacts to specific assets and resources from the sea-level rise and storm surge scenarios evaluated for the seven Atlantic Coast municipalities. The seven Atlantic Coast municipalities combined have 49,266 acres of upland (land currently above mean higher-high water). At the 1.7-foot sea-level rise scenario, about 3 percent (1,485 acres) of this upland will be inundated by tides on a regular basis; at the 4.0-foot scenario, 5.3 percent (2,602 acres) of upland would be regularly flooded by tides; and at the 6.3-foot sea-level rise scenario, 7.3 percent or 3,615 acres would be affected. Upland impacts are greater in Rye than in other communities because of the extensive low-lying areas around the marshes west of Odiorne Point. Additional findings from the Tides to Storms project are summarized throughout Section 4 of this report. A summary of flood impacts from sea-level rise and storm surge scenarios for the ten Great Bay communities is provided in Table 2.

TABLE 1. Summary of flood impacts from sea-level rise and storm surge scenarios* for the seven Atlantic Coast municipalities**
Source: RPC (2015).

Sea-Level Rise (SLR) Scenarios	1.7 feet SLR	4.0 feet SLR	6.3 feet SLR	1.7 feet SLR + Storm Surge	4.0 feet SLR + Storm Surge	6.3 feet SLR + Storm Surge
Upland* (acres)**	1,485	2,602	3,615	3,474	4,439	5,298
BUILT LANDSCAPE						
Infrastructure (# of sites)	37	90	135	137	162	190
Critical Facilities (# of sites)	13	33	48	44	64	98
Roadways – Local (miles)	4	17	29	33	39	51
Roadways – State (miles)	2	7	14	19	22	26
Transportation Assets (# of sites)	35	50	68	65	78	90
100-year floodplain (acres)	8,180	9,361	9,593	9,639	9,766	9,818
NATURAL RESOURCES						
Freshwater Wetlands (acres)	184	396	519	489	593	661
Tidal Wetlands (acres)	235	257	264	267	268	269
Conserved Lands (acres)	493	717	873	883	1,007	1,131
Land Protection Priorities (acres)	4,022	4,851	5,469	5,385	5,948	6,458
Critical Wildlife Habitat (acres)	1,081	1,600	1,915	1,865	2,112	2,310

* Storm surge = 100-year (one-percent-annual-chance) flood event.

** The seven Atlantic Coast communities include Hampton, Hampton Falls, New Castle, North Hampton, Portsmouth, Rye, and Seabrook.

*** Upland refers to land above mean higher high water (highest tidal extent). The seven coastal region municipalities have approximately 49,266 acres of upland.

[v] These sea-level rise maps were developed prior to the STAP report summary and therefore used slightly different estimates for sea-level rise. The maps do not show a significant difference in inundated area due to the resolution of the elevation data.

FIGURE 5. Illustration of the extent of flooding from three sea-level rise scenarios in the Hampton-Seabrook estuary. *Source: RPC (2015).*

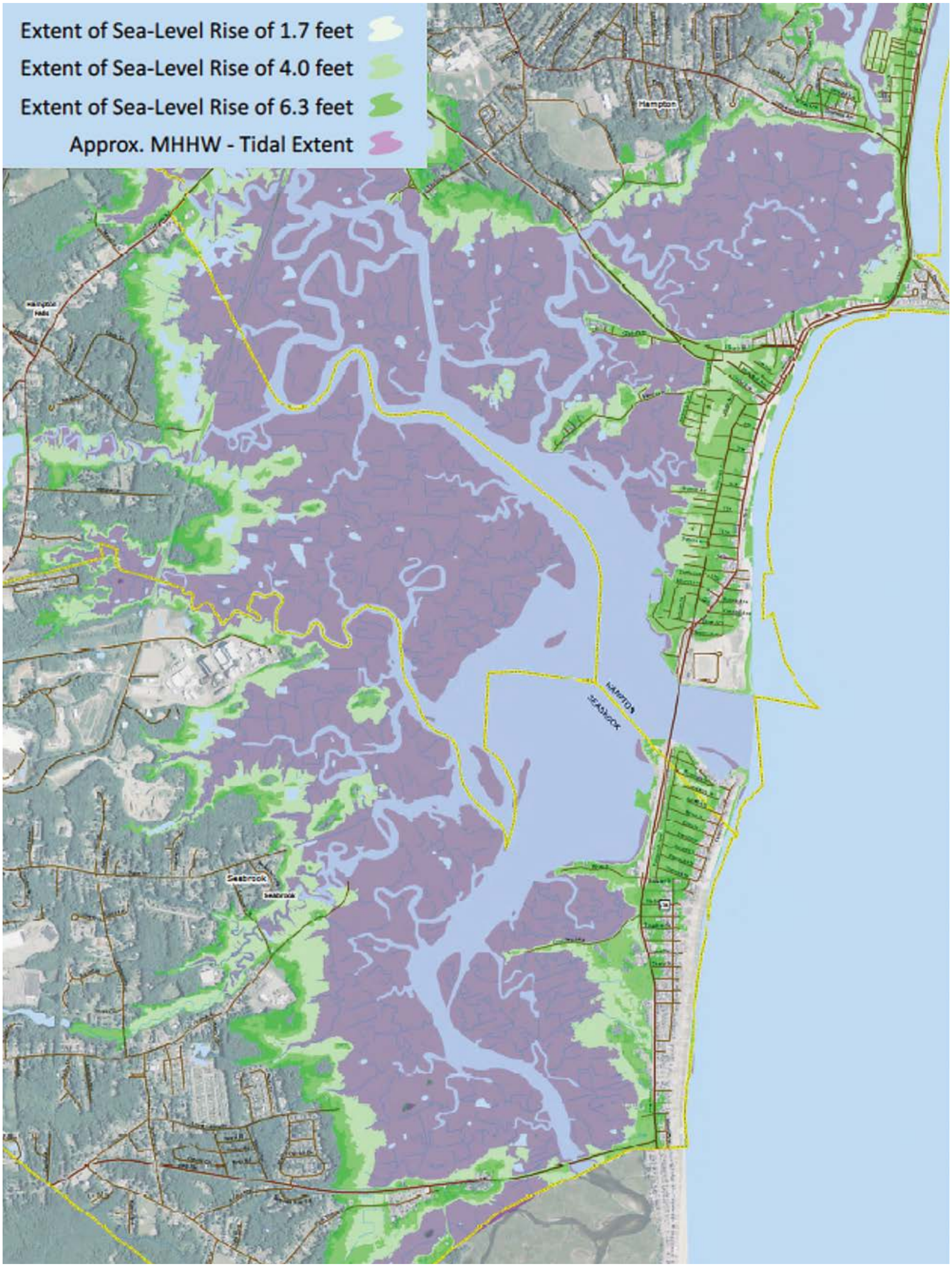
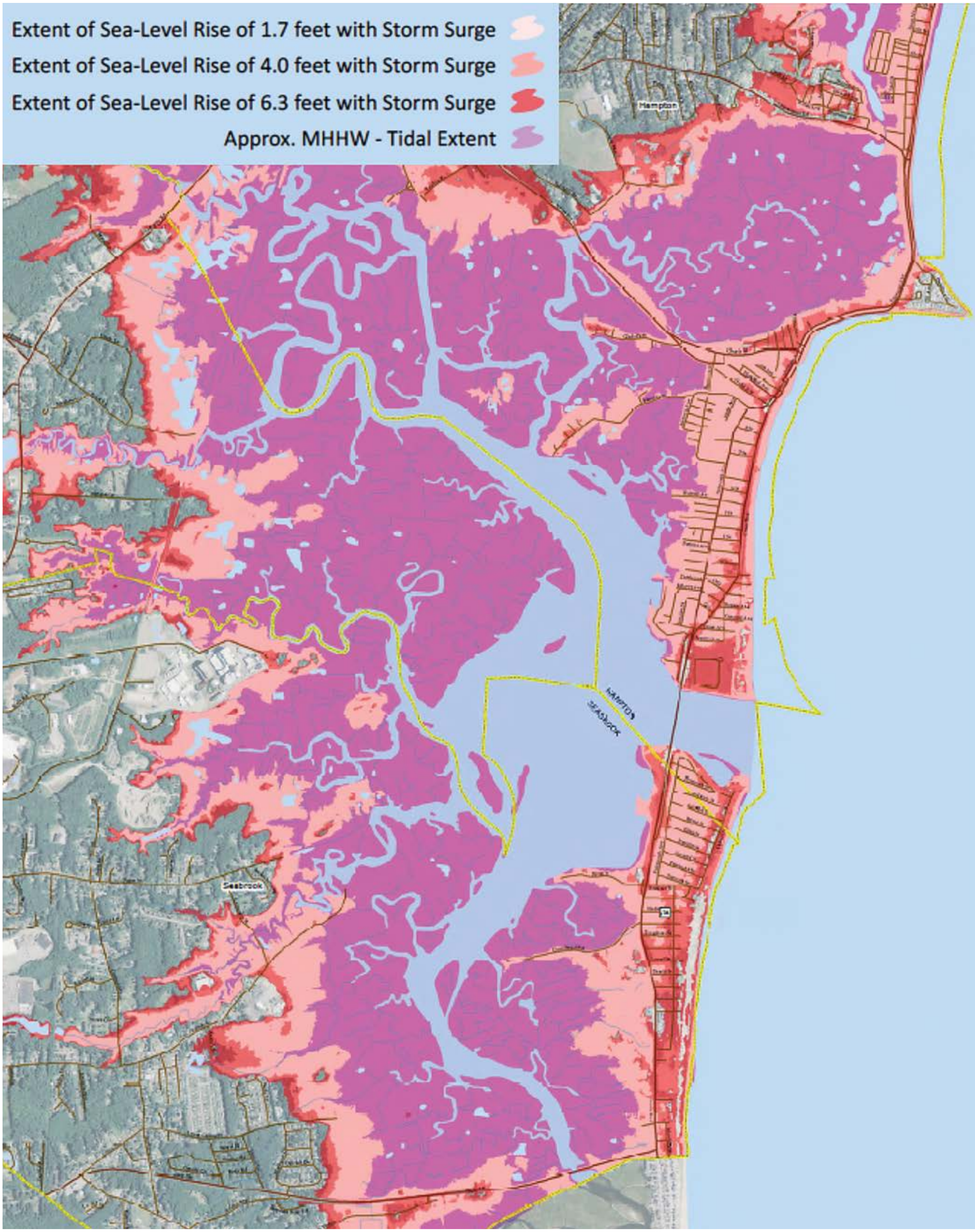


FIGURE 6. Illustration of the extent of flooding from three sea-level rise scenarios with a 100-year (one-percent-annual-chance) storm surge in the Hampton-Seabrook estuary. *Source: RPC (2015).*



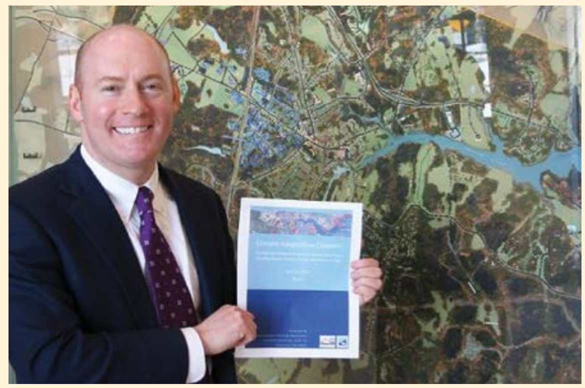
4.1.2 Great Bay Municipalities

New Hampshire's Great Bay municipalities include Dover, Durham, Exeter, Greenland, Madbury, Newfields, Newington, Newmarket, Rollinsford, and Stratham. These communities are located in the southeastern corner of the state surrounding Great Bay, which is a nationally recognized Estuarine Research Reserve. This area is set apart by its beautiful natural resources, diverse urban and rural communities, and rich cultural heritage. Established during the Industrial Revolution as a hub of textile production within the northeast, these communities continue to be defined by traditional mill-town development, built upon the veins of the many coastal rivers leading south to the port of Portsmouth. However, with the increased frequency of severe storm events combined with an increase in impervious surfaces resulting from extensive development over the past four decades, communities have experienced substantial economic losses and damages to critical facilities from major flooding events. The Mother's Day (2006) and Patriots' Day (2007) floods are two examples of catastrophic flooding that wreaked havoc on municipalities in the coastal watershed.

Most of the Great Bay communities lie within the Piscataqua River Basin through which flow a number of coastal rivers, including the Cocheco, Lamprey, Oyster, Exeter, Winnicut, and Salmon Falls. The Salmon Falls flows south into the Piscataqua River and acts as the boundary between New Hampshire and Maine before draining into the Gulf of Maine through Portsmouth Harbor. Influenced by historic development patterns and significant changes in land use, as well as extreme precipitation and coastal surge, these complex freshwater river systems have experienced much more flooding during storm events in recent years. These contributing factors translate into the Great Bay communities being vulnerable to both salt water and freshwater flooding.

A Master Plan for Climate Change in Durham

In 2013, the Town of Durham, in partnership with the Strafford Regional Planning Commission, underwent a process in which the community evaluated their risks to climate change and its associated impacts. Durham specifically focused on future changes in extreme temperature and precipitation, sea-level rise, and coastal flooding. This process resulted in the development of the Town's **Climate Adaptation Chapter** and provides a list of recommendations as to the kinds of steps Durham should be taking over the next several decades.



Durham Town Administrator Todd Selig holds up the town's climate adaptation chapter. (photo credit: Fosters.com)

In 2014, Durham was awarded the NOAA Walter B. Jones Memorial Award for Excellence in Local Government, which is awarded to five towns across the country every two years. The award is given to local governments that have created positive change in coastal management.

The NHDES Coastal Program, New Hampshire Geographically Referenced Analysis and Information Transfer System (NH GRANIT), Rockingham Planning Commission, Strafford Regional Planning Commission, and the University of New Hampshire Stormwater Center are in the process of conducting a detailed statistical and spatial analysis for the ten Great Bay municipalities based on the Tides to Storms methodology. Funded by the National Oceanic and Atmospheric Adminstration, the Climate Risk in the Seacoast (C-RiSe): Assessing Vulnerability of Municipal Resources to Climate Change project will provide Great Bay municipalities with maps and assessments of flood impacts to key state and municipal assets and natural resources under various sea-level rise and storm surge scenarios.[45]

Similar to the Tides to Storms project, the C-RiSe map set is comprised of two components: maps depicting the extent of projected flooding from the three sea-level rise scenarios in shades of green, and maps depicting the three sea-level rise plus storm surge scenarios in shades of pink. Examples of the sea-level rise and storm surge maps produced for the City of Dover are provided in Figure 7 and Figure 8, respectively.

FIGURE 7. Illustration of the extent of flooding from three sea-level rise scenarios in the City of Dover, NH. *Source: NHDES et al. (In-Progress).*

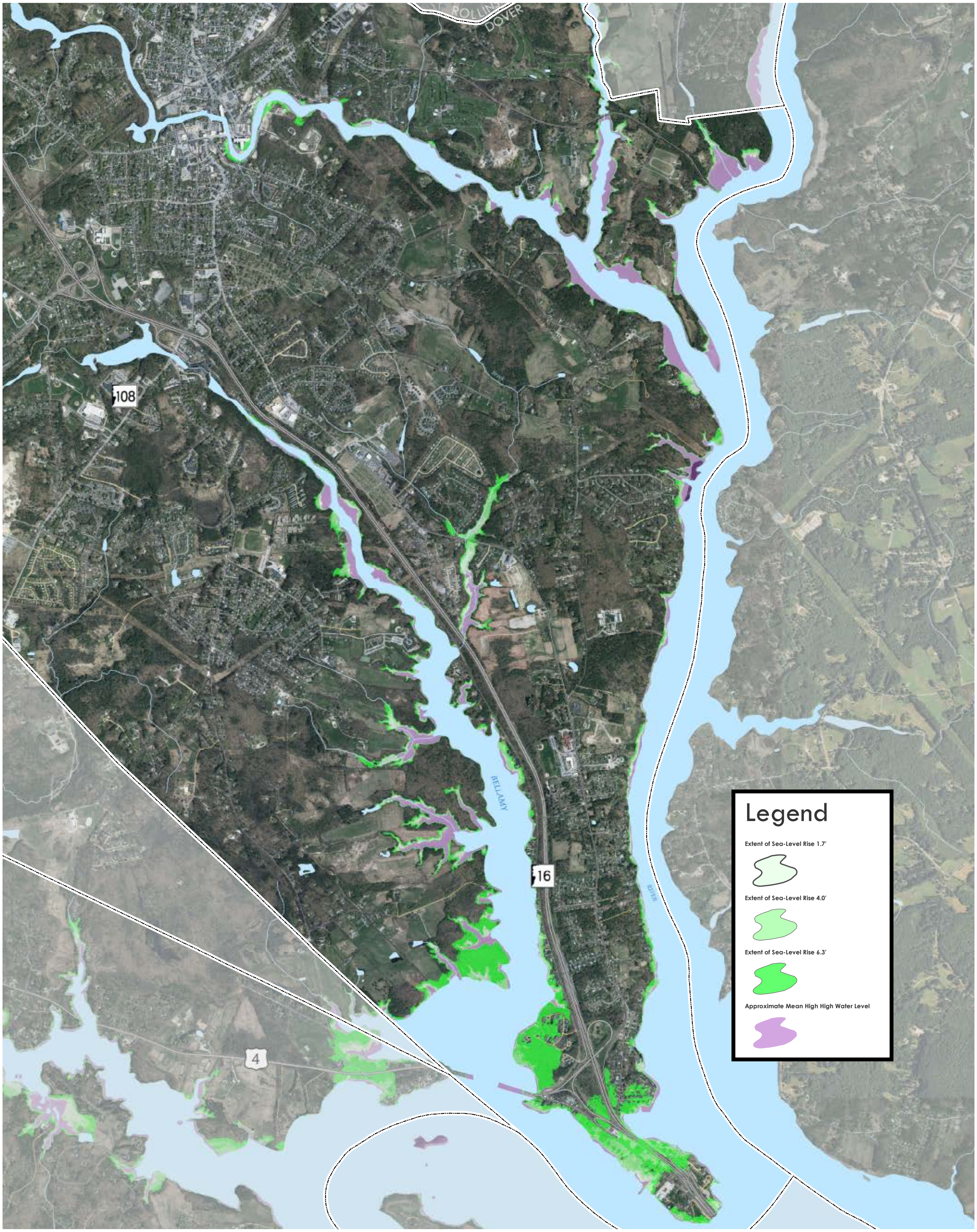


FIGURE 8. Illustration of the extent of flooding from three sea-level rise scenarios with a 100-year (one-percent-annual-chance) storm surge in the City of Dover, NH. *Source: NHDES et al. (In-Progress).*

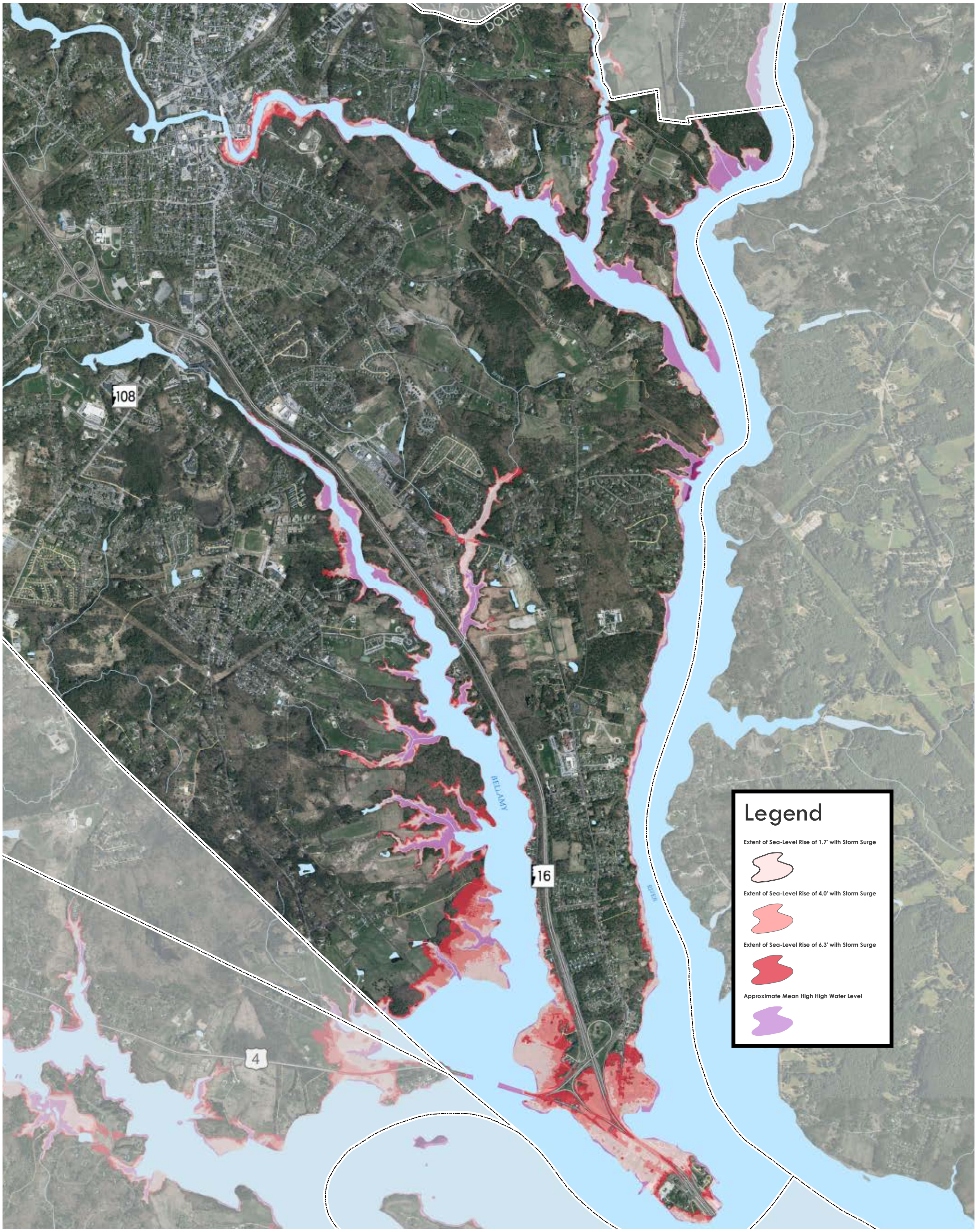


Table 2 provides a statistical overview of the flood impacts to specific assets and resources under the various sea-level rise and storm surge scenarios evaluated for the ten Great Bay municipalities as part of the C-RiSe project. The ten Great Bay municipalities combined have 86,210 acres of upland (land currently above mean higher-high water). Between 914 acres (1.1 percent) and 2,309 acres (2.7 percent) of upland will be regularly flooded by tides under the 1.7 feet and 6.3 feet sea-level rise scenarios; and up to 3,343 acres (3.9 percent) of uplands will be affected under the 6.3 feet sea-level rise plus storm surge scenario. Additional findings from the C-RiSe project are summarized throughout Section 4 of this report.

Photo credit: UNH Stormwater Center

While this report is focused on coastal hazards associated with storm surge, sea-level rise, and extreme precipitation, many of the Great Bay municipalities are also at risk of flooding "above the dams" in purely freshwater (i.e., riverine) systems. For example, a UNH-led research project investigated how flooding in the Lamprey River may change in the future based on scenarios of land cover change and climate change. The research relied upon rainfall-runoff models used by FEMA to define one-percent-annual-chance floods (100-year floods).[46]

TABLE 2. **Summary of flood impacts from sea-level rise and storm surge* scenarios for the ten Great Bay municipalities****
Source: NHDES et al. (In-Progress).

Sea-Level Rise (SLR) Scenarios	1.7 feet SLR	4.0 feet SLR	6.3 feet SLR	1.7 feet SLR + Storm Surge	4.0 feet SLR + Storm Surge	6.3 feet SLR + Storm Surge
Upland*** (acres)	914	83	2,309	1,894	2,604	3,343
BUILT LANDSCAPE						
Infrastructure (# of sites)	4	23	115	69	167	304
Critical Facilities (# of sites)	0	0	1	0	1	4
Roadways – Local (miles)	0	1	3	2	4	5
Roadways – State (miles)	0	0	1	1	2	4
Transportation Assets (# of sites)	46	46	49	47	52	57
100-year floodplain (acres)	739	1,234	1,355	1,316	1,397	1,461
NATURAL RESOURCES						
Freshwater Wetlands (acres)	59	182	259	222	306	413
Tidal Wetlands (acres)	754	834	851	845	855	860
Conserved Lands (acres)	304	610	928	758	1,026	1,277
Land Protection Priorities (acres)	625	1,040	1,474	1,244	1,610	1,978
Critical Wildlife Habitat (acres)	721	1,204	1,723	1,447	1,895	2,357

* Storm surge = 100-year (one-percent-annual-chance) flood event.
** The ten Great Bay municipalities include Dover, Durham, Exeter, Greenland, Madbury, Newfields, Newington, Newmarket, Rollinsford, and Stratham.
*** Upland refers to land above mean higher high water (highest tidal extent). The ten Great Bay municipalities have approximately 86,210 acres of upland.

Results clearly show that the one-percent-annual-chance floodplain, peak flood water discharge, and flood water surface elevations have increased significantly over the past four decades and will continue to increase in the future under the build-out and climate scenarios developed for the research project (Table 3). Low impact development zoning was shown to have its greatest mitigation value in terms of resiliency in high impervious cover areas.[47] This increase in the one-percent-annual-chance floodplain and one-percent-annual-chance flood discharge has important ramifications for natural resources, the built landscape, public health and safety, emergency management, and planning. In addition, the risk of municipal legal liability associated with using the new one-percent-annual-chance floodplain maps is low, so long as municipalities follow sound planning principles.[48]

TABLE 3. Potential change in the area of one-percent-annual-chance* floodplains on the main stem of the Lamprey Rivers based on climate and land use change scenarios. *Source: Wake, C. et al. (2013).*

Town	Total acreage in watershed	One-Percent-Annual-Chance Floodplains (acres)		Percent increase in one-percent-annual-chance floodplain area 2100 vs. 2005
		2005 Flood Insurance Rate Map (FIRM)	2100 'Conventional' Buildout**	
Durham	4,984	499	625	20%
Epping	16,752	899	1,026	12%
Lee	7,927	551	916	40%
Newmarket	6,559	450	741	39%
Raymond	12,277	874	1,113	21%
Total	**48,499**	**3,273**	**4,421**	**26%**

*The one-percent-annual-chance floodplain or storm is the more accurate term preferred by FEMA for what is more commonly known of as the 100-year floodplain or storm.

**Projected residential and nonresidential development scenario for 2100 based on historical 1962-2005 residential and nonresidential developed land data.

4.2 Our Economy

OUR ECONOMY is the systematic and productive exchange and flow of goods, services, and transactions that must be intact, functioning, and resilient to coastal risks and hazards in order to create and sustain a high quality of life in coastal New Hampshire.

4.2.1 How We Assess Vulnerability

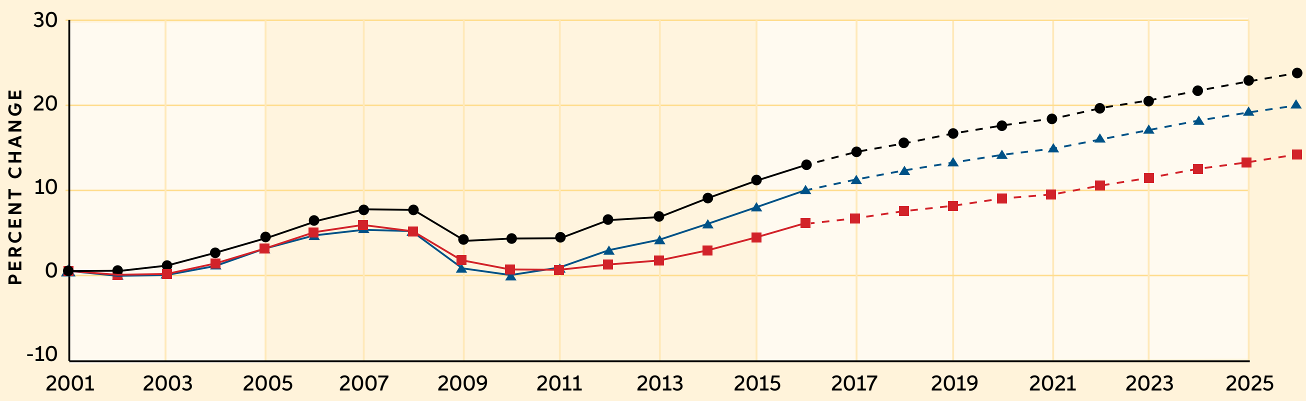
When it comes to assessing the vulnerability of the coastal region to coastal risks and hazards, the regional economy must be considered in two ways. First, research shows that communities with diversified economies and established institutions have a greater capacity to protect and prepare their assets, including the built environment, natural resources, and heritage against coastal risks and hazards. As a result, vulnerability is likely higher in municipalities with fewer financial resources, less stable economic activity, and lower average incomes.[49]

The second consideration is that key components of the economy may be vulnerable to climate change impacts like storms and sea-level rise. A significant portion of the economy in New Hampshire's coastal region is related to coastal industries that may inherently be vulnerable to storms and sea-level rise. For example, the Port of Portsmouth and Piscataqua River terminal operators make important contributions to the economies of New Hampshire and Maine, contributing $275 million in value added and generating 2,350 jobs in 2011. Of the total 2011 employment, income, and value added benefits, approximately 90 percent were experienced in New Hampshire and 10 percent were experienced in Maine.[50]

According to New Hampshire Sea Grant, in 2010 New Hampshire's commercial fisheries industry had a catch value of approximately $17 million.[51] Additionally, businesses that may not deal directly with coastal goods and services may have supply chains, customers, and other resources that are vulnerable to hazards like coastal storms.[52]

New Hampshire's coastal region is an important economic driver for the state and consistently ranks above the national average for job growth. The Gross Regional Product of the coastal region totaled approximately $11 billion in 2014, with 16 percent derived from the finance and insurance industry and 13 percent coming from the manufacturing industry. Between 2002 and 2016 job growth for the coastal region was 12.8 percent, outpacing both the state and national job growth rates of 5.9 and 10.4 percent, respectively. As of the third Quarter of 2016, the coastal municipalities supported 109,070 jobs[vi]. Figure 9 shows the percent change in jobs from 2002 to the third Quarter of 2016 and projected percent change out to 2025 for New Hampshire's coastal municipalities compared to the state and nation.[53]

FIGURE 9. **Regional, state, and national percent change in jobs for period 2002-2016 and projected out to 2025.** *Source: NHDED (2016).*



Region	2002 Jobs	2016 Jobs	Change	% Change
Coastal Region	96,734	109,070	12,336	12.8%
New Hampshire	682,775	722,777	40,002	5.9%
United States	143,960,385	158,866,954	14,906,569	10.4%

In 2014, the coastal region exported $15.5 billion worth of goods and services, imported $14.1 billion worth of goods and services, and produced and consumed $5.9 billion worth of goods and services locally, making the region a net exporter of goods and services.[54] Commuting patterns based on 2010 Census data show that the coastal region has a net inflow of jobs with 86 percent of all jobs in the area filled by people who live outside of the coastal region. These data suggest that both the economic importance and vulnerability of the coastal region extend beyond the borders of its municipalities to the significant number of people who live elsewhere but depend on the area for employment as well as goods and services.[55]

4.2.2 Highlights of Vulnerabilities

One of New Hampshire's key economic vulnerabilities resulting from increased coastal flooding is the potential loss in overall property valuation – both from actual flood related property losses and from the perception that coastal properties are at risk. Since New Hampshire's coastal municipalities derive a large majority of their revenue

vi Economic data as reported by the NH Division of Economic Development includes all 17 coastal municipalities as well as the towns of Brentwood and Kensington. Economic Modeling Specialists Inc. (EMSI) reports include regional information based on Zip Codes. These towns share the same Zip Code (03833) as the Town of Exeter. The Town of Newington also shares a Zip Code with the City of Portsmouth (03801).

from property taxes (based on assessed valuation), potential losses to their tax base resulting from increased coastal flooding could have a significant impact on municipal budgets throughout the coastal region.

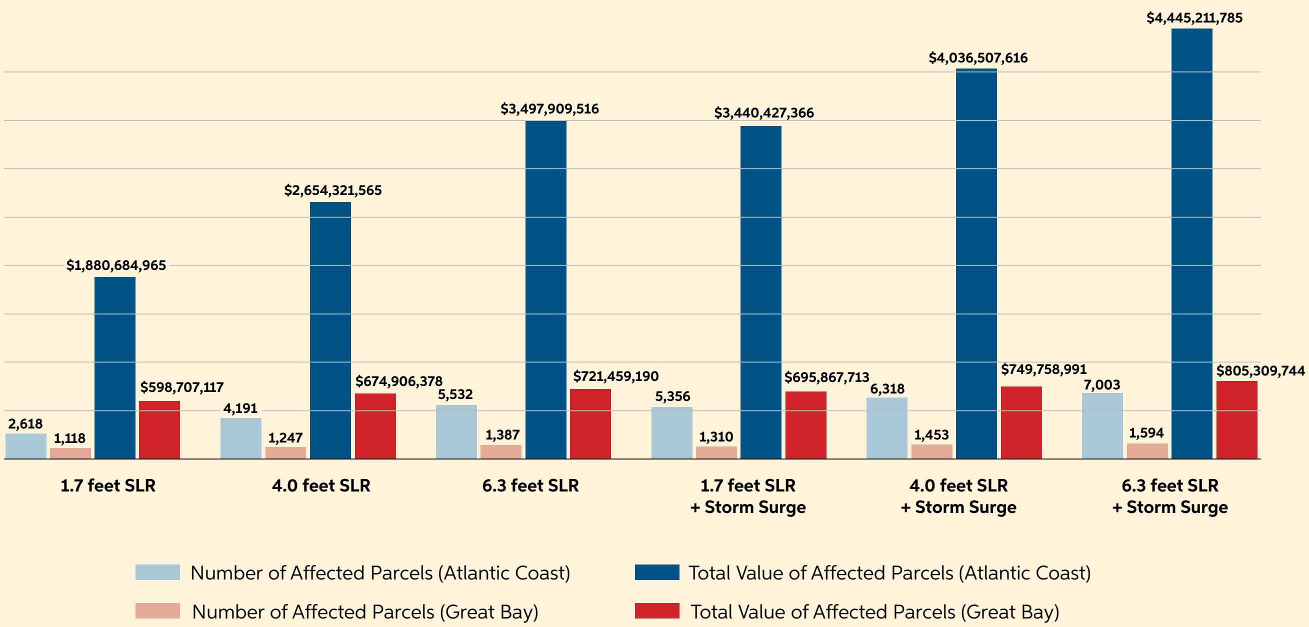
After reviewing the available research as well as the Tides to Storms and C-RiSe vulnerability assessments prepared for the Atlantic Coast and Great Bay municipalities, respectively, we are unable to make a definitive estimate of property valuation impacts. There are several factors that contribute to this uncertainty. First, the uncertainty of the timing and extent of future flooding makes actual damage difficult to assess. Second, the complexity and dynamics of coastal real estate markets are such that we are not able know with any certainty how housing, insurance, and lending markets will respond to projected coastal increases in coastal flood risk. Third, without better understanding, it is impossible to predict the extent to which properties will be rebuilt or replaced after an extensive flooding event, or series of extensive flooding events.

The Commission was able to quantify the general magnitude of property valuation that is at potential risk by estimating how many properties are physically affected under various sea-level rise and storm surge scenarios. As shown in Figure 10, the Tides to Storms and C-RiSe projects analyzed the number and aggregated assessed value of tax parcels in the seven Atlantic Coast and ten Great Bay municipalities affected by each of the six sea-level rise and storm surge scenarios.

In the seven Atlantic Coast municipalities, between 2,618 and 5,532 parcels will be partially or wholly affected under the 1.7 feet and 6.3 feet sea-level rise scenarios, respectively; up to 7,003 parcels will be affected when storm surge is added, putting over $4.4 billion, or 35 percent, of total assessed property value at risk of flooding under the 6.3 feet of sea-level rise plus storm surge scenario.[56]

In the ten Great Bay municipalities, between 1,118 and 1,387 parcels will be partially or wholly affected under the 1.7 feet and 6.3 feet sea-level rise scenarios, respectively; up to 1,594 parcels will be affected when storm surge is added, putting over $805 million, or 8.5 percent, of total assessed property value at risk of flooding under the 6.3 feet of sea-level rise plus storm surge scenario.[57]

FIGURE 10. **Number and aggregated assessed value of parcels affected by sea-level rise (SLR) and storm surge* scenarios for the Atlantic Coast** and Great Bay*** municipalities.** *Source: RPC (2015); NHDES et al. (In-Progress).*



* Storm surge = 100-year (one-percent-annual-chance) flood event.
** The seven Atlantic Coast municipalities include Hampton, Hampton Falls, New Castle, North Hampton, Portsmouth, Rye, and Seabrook.
***The ten Great Bay municipalities include Dover, Durham, Exeter, Greenland, Madbury, Newfields, Newington, Newmarket, Rollinsford, and Stratham.

It is important to stress that parcels were identified as affected if they were found to be partially or fully located within the flooding extent of the scenarios evaluated. The extent to which the parcel or any structure or development on the parcel would be damaged by sea-level rise or storm related flooding was not analyzed. For example, if the flood impact to a property was a flooded parking lot and no permanent damage to its principle structure, it would still be considered affected even though the property valuation may not change. It is also important to note that the data include a number of high value parcels under state and municipal ownership in addition to private property. As a result, the aggregated assessed values of affected parcels provided in Figure 10 are likely overestimates of the impact to actual property value, at least over the time period of the next several decades. More accurately, the assessed values represent the value of the properties that may be exposed to some flooding in the different scenarios and do not necessarily represent a cost estimate of potential flood damages or losses.

Photo credit: Amy Hansen

While we cannot precisely quantify the amount of assessed property value that is at risk given the information available today, the Commission acknowledges the potential devastating loss of revenue for municipalities should a significant portion of vulnerable coastal properties suffer permanent and irreparable damages, or total losses.

Further progress can be made in quantifying property valuation risk by undertaking depth-damage analyses for flooding scenarios through which damage to structures can be estimated and degree of loss can be determined based on the depth of flooding. This process can be integrated into hazard mitigation planning at the local level and will help communities become better informed as to their specific risk to losses in property valuation.

Even with better vulnerability information, however, several questions will remain, including:

- Will New Hampshire's highly-sought-after waterfront properties continue to attract investment and appreciate in value even in the face of significant risk of repetitive losses in the coming decades?
- Will repetitive losses in New Hampshire and elsewhere influence demand for New Hampshire coastal real-estate and availability of National Flood Insurance Program (NFIP) funds to insure those New Hampshire properties at risk of flooding?
- At what point will the risk from coastal flooding become high enough to cause coastal property values to decline from falling demand and discouraged investment?
- Will properties destroyed by coastal flooding continue to be rebuilt, and if so will the reconstructed buildings be of greater or lesser value than those that preceded them?
- When and to what extent will bank lending practices change to become less supportive of coastal real estate investment?
- What is the role of insurance in enabling reinvestment? Will the phasing out of the most highly subsidized insurance categories in the NFIP result in disinvestment in high risk areas or will property owners simply self-insure?

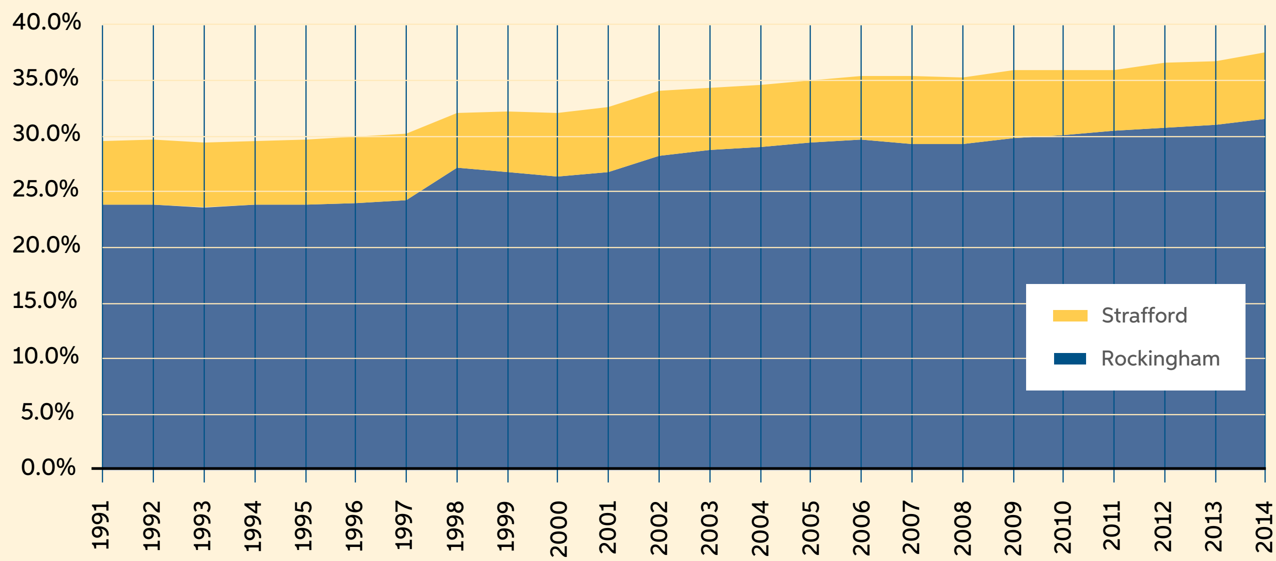
Answers to these questions are speculative at this point and require better understanding of both science and behavior. Without more extensive study of the seacoast real estate market, together with more precise estimates of the damage that various flooding scenarios might produce, we cannot make definitive assessments of the change in property valuation, or of the overall economic impact. Nevertheless, two important generalizations can be made:

- First, the number of properties affected by flooding dramatically increases between the lowest sea level rise scenario and the higher ones. For example, data from the Tides to Storms project show a 60 percent increase in the number of affected parcels and a $773 million increase in assessed value of affected parcels when comparing the 1.7 feet to the 4.0 feet sea-level rise scenario, and an additional 32 percent increase in the number of affected parcels and $843 million increase in the assessed value of affected parcels when comparing the 4.0 feet to the 6.3 feet sea-level rise scenario.[58] This suggests that if changes in sea level reach the higher scenarios, the consequence for property loss will be proportionately much greater.
- Second, sound planning to adapt to increased flood risk can help minimize future property valuation losses. Communities that have improved their resiliency by adjusting building standards, improving infrastructure, communicating flood risk, and preventing further development and redevelopment in the most vulnerable places, will help maintain property values both because flood damage will be less, and because owners and investors will have greater confidence in the continued viability of the community.

Coastal Tourism

County meals and rooms tax revenue data are considered some of the most important indicators for the tourism sector, as they provide the basis for estimating other tourism indicators such as traveler counts and spending. Counties that are visited by large numbers of tourists generate much of the revenue under New Hampshire's meals and rooms tax, which is collected from the patrons of hotels, restaurants, and car rental agencies. In particular, Rockingham and Strafford Counties, which include 13 and four coastal zone municipalities respectively, continue to generate significant revenue for the state under the meals and rooms tax. As shown in Figure 11, Rockingham and Strafford counties contributed 37.5 percent of the total state meals and room tax revenue in fiscal year 2014, accounting for $104.7 million.[59] These data suggest that the coastal tourism economy in Rockingham County continues to be a valuable state asset.

FIGURE 11. Percentage of state total meals and rooms tax generated by Rockingham and Strafford counties from 1991-2014.
Source: NHOEP (2015).



The tourism and recreation sectors would likely be severely impacted by a major coastal storm and may be impacted more gradually over the long-term by sea-level rise. Key tourism destinations like Hampton Beach and Strawbery Banke Museum are known to be vulnerable to storm surge and sea-level rise.[60] Additional research is needed, however, to determine specific vulnerabilities within the tourism sector and to identify specific strategies to deal with those vulnerabilities.

Photo credit: Christopher Harmon

4.2.3 Relevant Recommendations

KEY COMMISSION RECOMMENDATIONS: Our Economy

E1.	Identify vulnerability of sector-based economic assets, including but not limited to tax base, workforce and jobs, property values, insurance costs, trade facilities, and public recreational facilities based on best available climate science. [*Lead: State Agencies; Municipalities].*
E2.	Incorporate best available climate science and vulnerability assessment information in state, regional, and municipal economic development plans. *[Lead: State Agencies; Municipalities].*
E3.	Use appropriate and available mechanisms, including but not limited to incentives and market-based tools to fund climate adaptation strategies. *[Lead: State Agencies; Municipalities].*
E4.	Improve information available to property owners and prospective buyers about coastal hazards and vulnerabilities. *[Lead: State Agencies; Municipalities].*

4.3 Our Built Landscape

OUR BUILT LANDSCAPE is the network of structures and facilities owned by state and local governments and private entities in coastal New Hampshire. Our built environment must be prepared, adaptive, and responsive to coastal risks and hazards.

4.3.1 How We Assess Vulnerability

A number of methodologies can be used to assess the vulnerabilities in the built landscape, and these methods vary based on the type of built asset and the level of detail desired. In coastal New Hampshire, we benefit from high quality spatial data for roads, critical facilities, and other important built assets. To date, preliminary assessments have overlaid sea-level rise and storm surge inundation maps with mapped roadways and buildings to determine which areas are likely to flood under different scenarios. Many of these mapping resources are publicly available on the New Hampshire Coastal Viewer. These preliminary vulnerability assessments are useful for highlighting patterns, summary statistics, and planning implications for municipalities, however, in most cases more detailed assessments are needed to identify site-specific vulnerabilities and possible adaptation strategies or solutions.

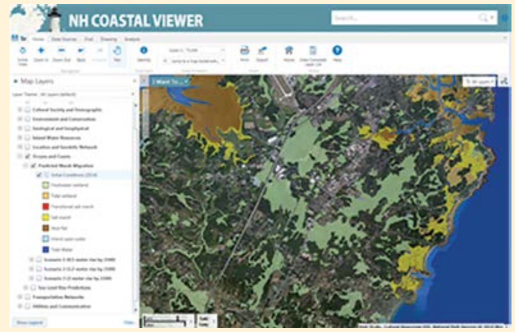
4.3.2 Highlights of Vulnerabilities

Roadways and Transportation Assets

State and local roadways throughout the coastal region are vulnerable to flooding and damage from storm surge, sea-level rise, and extreme precipitation. In many municipalities, flooding is magnified by the combination of tidal or storm related flooding and freshwater flooding. Additionally, ongoing analysis of pavement profiles with changing groundwater levels demonstrates that the service life of pavement systems is reduced as groundwater rises with sea-level rise.

Throughout the Atlantic Coast municipalities, Route 1-A provides the vital transportation link on the coast and is essential to coastal communities for access, safety, livability, recreation and for the continued viability of the coastal tourist economy. With its direct shoreline exposure, it comes as no surprise that Route 1-A is the transportation asset most vulnerable to coastal flooding and disruption from sea-level rise. Route 1-A and any connecting streets and roads are significantly affected by sea-level rise in the 4.0 feet and 6.3 feet sea-level rise scenarios. In addition to Route 1-A, local roads are highly vulnerable to sea-level rise and storms. In all of the seven Atlantic Coast municipalities, the miles of local roadways impacted by flooding are at least double the miles of state roadways affected under all six scenarios. To a great extent, local responses on municipal roads will depend on State plans for improving the resilience of Route 1-A and Route 1, and will require extensive regional coordination.

The New Hampshire Coastal Viewer: You Can Map Vulnerabilities Too!



The NH Coastal Viewer is an online mapping tool that brings coastal resources spatial data, hazards-related spatial data, and other spatial data sets within NH's 42 coastal watershed communities together in one place. Users can search for available data sets; display the data sets in multiple ways; and create, print, and share customized maps. The Coastal Viewer endeavors to serve as a one-stop shop for all coastal resources and hazards-related spatial data in NH's coastal watershed; to improve access to new and existing spatial data sets; and to provide information about coastal resources, hazards, and opportunities to reduce risk from these hazards and increase coastal resiliency. The Coastal Viewer was developed by NH GRANIT and the NHDES Coastal Program and funded by the National Oceanic and Atmospheric Administration's Office for Coastal Management. You can access the Coastal Viewer to explore data and make maps focused on understanding local vulnerability to coastal hazards at http://granit.unh.edu/nhcoastalviewer/.

The Great Bay communities are closely tied together by a dense network of state highway and local road systems. The primary state highways serving these communities are Interstate 95 and Routes 1, 1A, 4, 16, 33, 101, 108, and 125, all of which have sections that traverse tidal waters and freshwater bodies.

Table 4 reports the miles of state and local roadways affected by each of the sea-level rise and storm surge scenarios for the seven Atlantic Coast municipalities as identified in the Tides to Storms vulnerability assessment. Similarly, Table 5 reports the miles of state and municipal roadways affected by each of the sea-level rise and storm surge scenarios for the ten Great Bay municipalities as identified in the C-RiSe vulnerability assessment. By a wide margin, state and local roadways in Great Bay municipalities are at much lower risk from sea-level rise and storm surge flooding than in the Atlantic Coast municipalities. This is in part because there is enough topographic relief along the interior coastline to prevent widespread flooding and historic settlement patterns were focused upriver from coastal areas.

In addition to road surfaces, road crossing facilities such as culverts and bridges are vulnerable to flooding from coastal storms, sea-level rise, and extreme precipitation and damage to crossings can cause significant impacts

TABLE 4. Miles of state and local roadways affected by sea-level rise and storm surge* scenarios for the seven Atlantic Coast municipalities.**
Source: RPC (2015).

Sea-Level Rise (SLR) Scenarios	1.7 feet SLR	4.0 feet SLR	6.3 feet SLR	1.7 feet SLR + storm surge	4.0 feet SLR + storm surge	6.3 feet SLR + storm surge
ROAD TYPE						
State	1.6	6.6	14.1	18.7	21.8	25.6
Local	3.5	17.0	29.4	32.8	38.8	50.5
TOTAL MILES	5.1	23.6	43.6	51.5	60.6	76.1
Portsmouth	1.1	2.2	4.9	4.2	7.5	11.0
New Castle	0.1	0.5	1.4	1.5	1.8	2.8
Rye	0.2	4.5	9.5	10.6	14.1	17.1
North Hampton	0.0	0.7	1.3	1.4	2.6	3.0
Hampton	3.4	13.2	20.6	25.8	26.7	31.3
Hampton Falls	0.0	0.1	0.3	0.2	0.4	0.7
Seabrook	0.4	2.4	5.7	7.8	7.5	10.3

* Storm surge = 100-year (one-percent-annual-chance) flood event.
**The seven Atlantic Coast municipalities include Hampton, Hampton Falls, New Castle, North Hampton, Portsmouth, Rye, and Seabrook.

TABLE 5. Miles of state and municipal roadways affected by sea-level rise and storm surge* scenarios for the ten Great Bay municipalities.**
Source: NHDES et al. (In-Progress).

Sea-Level Rise (SLR) Scenarios	1.7 feet SLR	4.0 feet SLR	6.3 feet SLR	1.7 feet SLR + storm surge	4.0 feet SLR + storm surge	6.3 feet SLR + storm surge
ROAD TYPE						
State	0.2	0.4	1.2	0.7	1.8	3.5
Local	0.0	0.8	2.6	1.5	3.6	5.3
Private	0.0	0.4	1.8	1.1	2.3	3.4
Not Maintained	0.0	0.1	0.1	0.1	0.1	0.2
TOTAL MILES	0.2	1.7	5.7	3.4	7.8	12.4
Dover	0.0	0.3	1.8	0.9	3.1	5.5
Durham	0.0	0.3	0.7	0.4	0.9	1.6
Exeter	0.0	0.6	1.1	0.8	1.2	1.4
Greenland	0.0	0.0	0.2	0.0	0.5	0.7
Madbury	0.0	0.0	0.0	0.0	0.0	0.0
Newfields	0.0	0.0	0.0	0.0	0.0	0.0
Newington	0.0	0.1	0.7	0.5	1.0	1.3
Newmarket	0.0	0.1	0.4	0.2	0.4	0.7
Rollinsford	0.0	0.1	0.2	0.1	0.2	0.3
Stratham	0.2	0.3	0.6	0.5	0.6	0.9

* Storm surge = 100-year (one-percent-annual-chance) flood event.
**The ten Great Bay municipalities include Dover, Durham, Exeter, Greenland, Madbury, Newfields, Newington, Newmarket, Rollinsford, and Stratham.

downstream of roadways. Efforts are ongoing to identify and assess the tidally-influenced culverts at risk of sea-level rise and additional flooding from extreme precipitation. Some red-listed bridges in the Coastal Region may also be at risk of sea-level rise and storm surge, including bridges in Hampton, New Castle, Dover, and the Portsmouth US1 Bypass over the Piscataqua River, however more analysis is needed to understand the scope of that vulnerability.[61]

Critical Structures and Facilities

Communities recognize the importance of ensuring that emergency facilities and shelters be located in places that are secure and accessible. A preliminary assessment of some critical facilities shows a few examples at risk of sea-level rise and storm surge. If a one-percent-annual-chance-storm occurred on top of 6.3 feet of sea-level rise, facilities that may be vulnerable include the Hampton Police Station and Fire Station; the Hampton and Seabrook wastewater treatment facilities; the Durham primary sewer lift station; and the Riverwalk/Schanda Park and the Creighton Street Pump Station, both in Newmarket.

By a wide margin, critical structures and facilities in the Great Bay municipalities are at much lower risk from sea-level rise and storm surge flooding than those in the Atlantic Coast municipalities according to the findings of the Tides to Storms[62] and C-RiSe[63] vulnerability assessments. Again, this is in part because there is enough topographic relief along the interior coastline to prevent widespread flooding and historic settlement patterns were focused upriver from coastal areas.

Madbury and Dover: Leaders in Floodplain Management

Two coastal municipalities currently enforce regulations that exceed the National Flood Insurance Program minimum standards. In 2009, Madbury adopted freeboard regulations, which require the lowest floor of new residential structures and manufactured homes to be elevated one foot above the base flood elevation. Madbury also adopted regulations that prohibit new buildings and certain other development in special flood hazard areas.

In 2015, Dover adopted freeboard regulations, which require the lowest floor of residential and non-residential structures that are new construction or substantial improvements to be elevated two feet above base flood elevation.

(Left: Floodplain management brochure distributed by the City of Dover to residents).

Energy facilities fuel our economy and are uniquely important as they power most other critical structures and facilities, including those emergency facilities and shelters that we rely upon during coastal storms and floods. The electrical grid is especially vulnerable to extreme weather events.[64] On average, over 300,000 people were affected by electricity outages between 2008 and 2013 across New Hampshire; the leading causes of electricity outages were weather and falling trees.[65] Following the massive power outages that occurred in 2011 after a large snowfall event in October, utility companies across the region have worked to improve the resilience of the electrical grid. However, additional assessment is needed to better understand the vulnerability of the electrical grid in New Hampshire, and in particular, the vulnerability of large power transformers and substations.

Similar to energy systems, communication systems are an integral component of our economy and provide critical services required to support daily operations in business, government, education, and public safety organizations.[66] Over the last 25 years, the communications sector has evolved into a highly interconnected sector that relies upon terrestrial, satellite and wireless transmission systems; we now rely heavily on cellular networks and the internet. Private sector entities are the primary owners and operators of the majority of our communications infrastructure, and are responsible for protecting communication assets and maintaining overall function of the system. Additional information is required to determine system vulnerabilities to projected flood risks in coastal New Hampshire. As with the electrical grid and energy systems, this vulnerability assessment will require collaboration with the private sector.

Private Property and the National Flood Insurance Program

Floodplain management is one of the most useful existing regulatory frameworks intended to identify existing flood vulnerabilities in the built environment and reduce negative impacts from flooding. The National Flood Insurance Program (NFIP) is a voluntary program administered by the Federal Emergency Management Agency (FEMA) in which communities agree to adopt and enforce at least the minimum requirements established under the NFIP for all development in mapped special flood hazard areas which encompass the one-percent-annual-chance flood area (or 100-year flood). All residents in NFIP communities are then eligible to purchase flood insurance whether the structure is located in or outside a special flood hazard area as shown on FEMA's Flood Insurance Rate Maps (FIRMs). Anyone who owns property with a structure in a special flood hazard area and has a federally-backed mortgage is required to purchase NFIP flood insurance.

All 17 coastal zone municipalities participate in the NFIP and all but two communities have only adopted the NFIP minimum standards, which offer structures some protection from flood damage. It is important for municipalities to consider adopting additional floodplain regulations, which will not only make their municipalities more flood resilient, but can also reduce flood insurance costs for property owners. One of the most common higher standards adopted by communities is known as freeboard, which is an additional height requirement for the lowest floor of a structure to be above the base flood elevation (i.e., the elevation to which floodwaters are expected to rise during a one-percent-annual-chance-flood). The additional height provides a margin of safety against extraordinary or unknown risks and can reduce the property owner's flood insurance premium.

The rising cost of NFIP flood insurance is a concern for most owners of structures located in a special flood hazard area especially since 2013 when FEMA began implementing two flood insurance reform acts, passed by Congress. The new laws aim to gradually eliminate a variety of existing flood insurance subsidies and establish new flood insurance premium rates that reflect the true flood risk to a property and full actuarial rate. As a result, flood insurance premium rates on many properties in special flood hazard areas will likely increase. Certain categories of structures are seeing a faster rise in their flood insurance costs. These structures include business properties, non-primary residences, and properties that have experienced severe repetitive flood losses. Property owners can take action to reduce these costs by making modifications to their structures that will reduce their flood risk.

Communities that conduct floodplain management activities that exceed the NFIP minimum requirements can also assist some of their residents and businesses with rising flood insurance costs by participating in the Community Rating System (CRS). CRS is a voluntary incentive program administered by FEMA. NFIP communities in good standing can apply to join and actively participate in CRS. A community that conducts floodplain management activities can earn points for each activity. The number of points a community accumulates determines the percent discount some of their residents and businesses will receive on their annual flood insurance premiums.

Examples of CRS activities that a community can receive credit for, specifically related to coastal areas, future conditions, and climate change impacts include:

- Provide information about non-mapped areas that are predicted to be susceptible to flooding in the future,
- Advise prospective buyers of a property of the potential for flooding due to climate changes and/or sea level rise,
- Base community regulatory map on future-conditions hydrology, including sea-level rise, by adopting an overlay,
- Adopt community stormwater program that regulates runoff from future development,
- Preserve open space in the floodplain, and
- Pass community regulation to protect shorelines in their natural state.

Currently in New Hampshire, four communities outside of the coastal region (Keene, Marlborough, Peterborough, and Winchester) participate in CRS. Two of these communities receive a 10-percent discount and the other two communities receive a five-percent discount. The coastal towns of Rye and Hampton are currently working on their applications to join CRS. Communities that are not interested in joining CRS but want to improve their floodplain management programs can use the CRS information as guidance.

As of August 2016, there were a total of 3,039 NFIP flood insurance policies in effect in New Hampshire's coastal zone with a total insured value of over $645 million, both of which are approximately 35 percent of the state totals. Figure 12 shows that Hampton holds 59 percent of those policies followed by Rye with 10 percent and Seabrook Beach Village District with 6 percent. Since 1978, there have been a total of over $10 million in NFIP paid losses in the 17 coastal zone municipalities—approximately 20 percent of the state's total. As shown in Figure 13, Hampton has 43 percent of those losses followed by Rye with 16 percent and Exeter with 11 percent.[67]

While FEMA-mapped FIRMs only consider historical flood extent, the 1.7 feet sea-level rise scenario map is mostly contained within the current 100-year floodplain, with minor incursions into the 500-year floodplain and other low lying areas. Flooding expands beyond the 100-year floodplain under higher sea-level rise scenarios. This means that if sea-level rise reaches higher projections, today's one-percent-annual-chance floods could occur twice every day and the new one-percent-annual-chance floods will likely reach further upland. Table 1 reports the acreage within the current 100-year floodplain impacted by projected sea-level rise and coastal storm surge in the seven Atlantic Coast municipalities, increasing from 8,180 acres under the 1.7 feet sea-level rise scenario to 9,818 acres under the 6.3 feet sea-level rise plus storm surge scenario. Similarly, Table 2 reports the acreage within the current 100-year floodplain impacted by projected sea-level rise and coastal storm surge in the ten Great Bay municipalities, increasing from 739 acres under the 1.7 feet sea-level rise scenario to 1,461 acres under the 6.3 feet sea-level rise plus storm surge scenario.

FIGURE 12. Percent of total NFIP policies in Coastal New Hampshire in September 2015. *Source: NHOEP (2016c).*

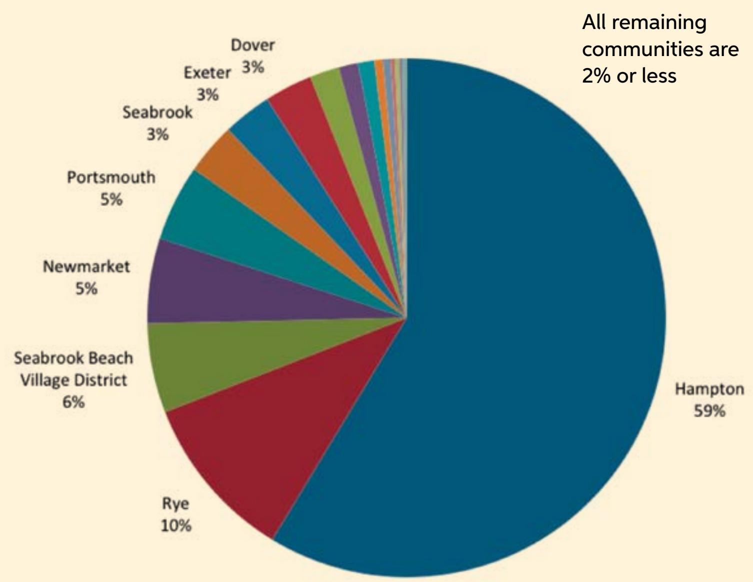
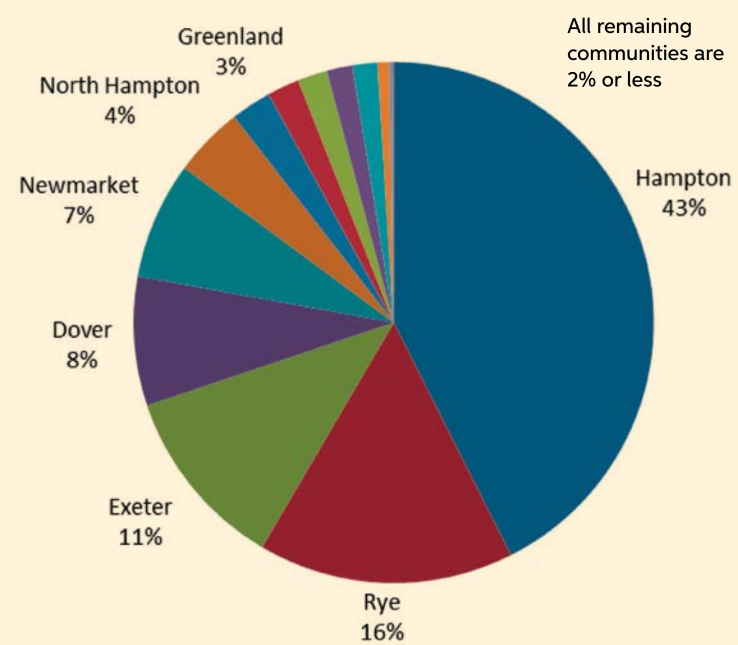


FIGURE 13. Percent of total NFIP paid loss amounts in Coastal New Hampshire since 1978. *Source: NHOEP (2016c).*



4.3.3 Relevant Recommendations

KEY COMMISSION RECOMMENDATIONS: Our Built Landscape	
BL1.	Encourage state agencies and municipalities to complete vulnerability assessments for state, municipal, and regulated private structures and facilities. *[Lead: State Legislature; State Agencies; Municipalities].*
BL2.	Implement regulatory standards and/or enact enabling legislation to ensure that the best available climate science and flood risk information are used for the siting and design of new, reconstructed, and rehabilitated state-funded structures and facilities, municipal structures and facilities, and private structures. *[Lead: State Legislature; State Agencies; Municipalities].*
BL3.	Map the plausible future changes in freshwater and coastal floodplain extent and depth based on best available information about future precipitation and land use for all municipalities. *[Lead: State Agencies].*
BL4.	Integrate comprehensive land use and environmental planning with floodplain management approaches that prevent and minimize impacts from coastal hazards. *[Lead: State Agencies; Municipalities].*
BL5.	Document coastal and riverine shoreline conditions and assess vulnerability of natural features and engineered structures that protect people, structures, and facilities under current and future conditions. *[Lead: State Agencies].*
BL6.	Develop a comprehensive, integrated New Hampshire Tidal Shoreline Management Plan (TSMP) that presents general priorities for coastal shoreline management, as well as site-specific and place-based strategies including, where appropriate, protection, adaptation, and abandonment. *[Lead: State Agencies].*

4.4 Our Natural Resources

OUR NATURAL RESOURCES are the natural systems that support important species and biodiversity in coastal New Hampshire and provide critical and important services to coastal New Hampshire like food, flood protection, fresh water, raw materials, and recreation opportunities.

4.4.1 How We Assess Vulnerability

The natural resources that draw residents, visitors, and businesses to southeastern New Hampshire are a cornerstone of our quality of life. Residents, visitors, and businesses depend on clean water for drinking, swimming, and boating; floodplains and wetlands provide water storage in extreme weather events and as water levels rise; oyster reefs and dune systems provide physical barriers to coastal storms; salt marshes and eelgrass beds are critical habitat for our commercial and recreational fisheries; our beaches draw hundreds of thousands of visitors that boost our state economy and tax income; and our forests and lands provide materials for heating, building and construction, and farm and food products like maple syrup. Together, our coastal natural resources provide important benefits to the people who live here.

Maintaining these benefits is critical to our economy, health, and safety. Yet, as our rivers, estuaries and ocean waters are impacted by storm surge, sea-level rise, extreme precipitation, and other climate impacts, the physical and biological character of our coast is expected to change. Persistent coastal flooding and large storms events already pose risks to the built landscape. Coastal natural resources like salt marshes and near shore ecosystems may be particularly affected due to their close proximity to various components of the built landscape such as roads, drainage facilities, buildings and utilities. Future decisions about how best to manage the built landscape may require trade-offs between public benefits and natural resource protection as both compete for space to adapt to changing conditions.

Sea-Level Rise Impacts on Species and Habitats

Higher water levels will drown salt marshes, deepen estuarine waters, and convert salt marsh to mudflats and mudflats to subtidal zones. Salt marshes are among the most productive ecosystems in the world, and in addition to wildlife habitat, they provide multiple benefits to humans including flood storage, healthy fisheries, storm protection, and long term carbon storage. Salt marshes may be able to migrate where the shore has a gentle, undeveloped slope, but otherwise will not be able to keep up with sea-level rise and will disappear.[68] Modeling can indicate where ecosystems like salt marshes and eelgrass are most likely to be successful under future sea-level rise scenarios. To invest in restoration wisely, we will want to make sure the habitats we restore will survive future conditions.

Running Out of Room: Saltmarsh Sparrows and Sea-level Rise

New Hampshire has three species of sparrows that depend on salt marsh habitat to survive: the saltmarsh sparrow, the seaside sparrow and Nelson's sparrow. All three species build their nests in the salt marsh, right on the high tide line. When there are unusually high tides, the birds' nests flood and their breeding success is compromised. As sea level rises, the critical breeding habitat for these birds is threatened if salt marshes cannot migrate inward. And if more extreme events cause higher water levels from precipitation or storm surge, the nests' position at the high tide line makes them extremely vulnerable.

Photo credit: Magnus Manske / **Creative Commons License**

Deeper estuarine waters will deplete eelgrass beds because the light necessary for eelgrass growth and survival will no longer penetrate to the estuarine floor. Rocky intertidal zones will migrate landward where conditions are favorable and disappear where conditions are unfavorable. Changing water levels may impact where fish and waterfowl feed and breed, and saltwater intrusion may change freshwater wetlands to brackish wetlands – altering the types of flora and fauna those systems can support. Rising groundwater levels and saltwater intrusion due to changes in sea level may also impact water resources including local aquifers and drinking water sources (municipal, private and commercial supplies), agricultural lands, and, later, the hydrology of forest ecosystems, and riparian ecosystems.

Storm Surge Impacts to Dunes, Salt Marshes, and Estuaries

Storm surges disrupt dunes, salt marshes, and estuaries. These habitat types are critical to rare species like the saltmarsh sparrow and the piping plover. The sudden changes in salinity, water level, and sedimentation that storm surge causes can be devastating to coastal plants and animals and the habitat types that they depend on. Dunes protect structures and facilities as well as the habitat that lies behind them, and major storm surges would naturally push dunes "back." When dunes do not have a natural path to retreat, they disappear and/or erode. High tides and storm surges will move dunes and may lead to barrier beaches being breached by large storm events. A major breach would change the salt marsh habitat behind the dunes, as well as the beach itself, and sedimentation from large storm events could also smother eelgrass and shellfish beds.

Extreme Precipitation Impacts on Natural Systems

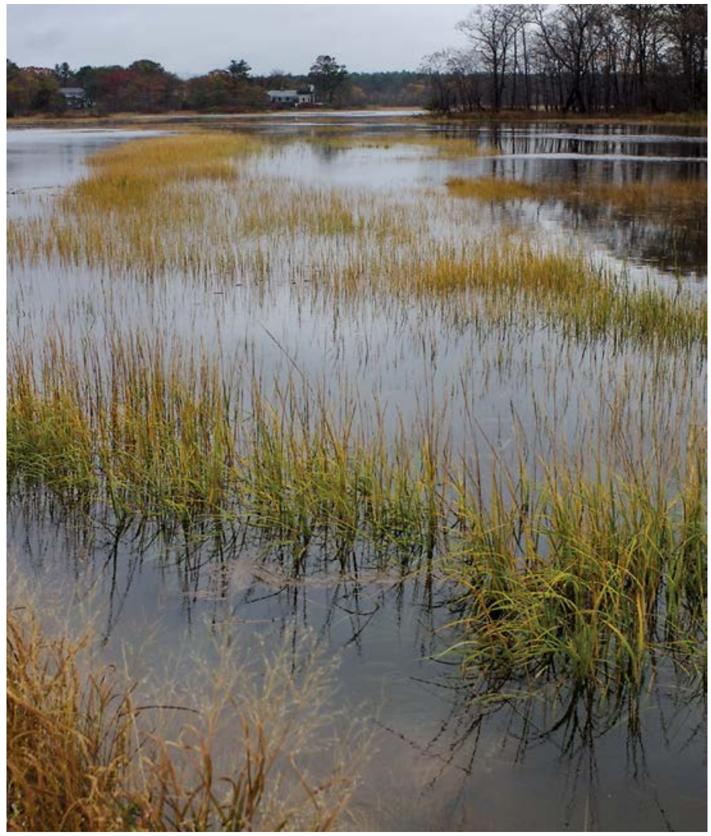


Photo credit: Tricia Miller

Extreme precipitation will change the temporal distribution of fresh water to river and estuarine systems. In the marine environment, freshwater pulses may impact the timing and abundance of algal blooms and influence which species can enter the estuary to breed or feed. This could lead to changes in freshwater wetland systems, an important habitat for many southern New Hampshire birds and amphibians. Increases in episodic water flow in floodplains may change the types of plants and animals that can live in and along our rivers. For example, many fish are sensitive to water temperature which is related both to storm events and to the types of shrubs and trees that live along the bank. With increased flooding both the shoreline species and the in-water species will need to be able to adapt to a wider range of salinity and temperature conditions. Increased precipitation will also lead to an increase in untreated stormwater and, potentially, wastewater when combined sewer outflows are overwhelmed. Increased precipitation, coupled with rising groundwater levels, could compromise the function of individual septic systems and both private and municipal stormwater management facilities. These system failures may result in increased transfer of pollutants to groundwater, surface waters, wetlands, and estuarine systems. Pollutants adversely affect all natural systems and can lead to fish kills, oyster die offs, smothered eelgrass beds, and noxious algal blooms. Freshwater pulses and decaying algal blooms also contribute to ocean acidification. As the ocean becomes more acidic, shellfish and other marine organisms face mortality and reduced fertility.

Human Response to At-Risk Coastal Habitats

Natural systems are inherently adaptive. Most species and habitats can move, accommodate change and adapt to new surroundings if they have intact natural systems around them. Therefore the way that people react to rising seas, coastal storms, and riverine flooding can lead to the most serious threats to coastal ecology. Hardening shorelines to defend structures and facilities against flood and storm surge hazards alters the natural system and prevents habitats and species from migrating landward as sea levels rise and coastal flooding occurs. Hardened structures also alter the hydrology of natural systems, diverting water and increasing runoff. Polluted runoff will increase as precipitation events increase, compounding the damage to natural systems. Human response to extreme coastal flooding or storm surge also compromises living resources, often deploying heavy equipment and structures intended to protect human lives and property.

The cumulative impact of these threats, in combination with climate-driven threats, will result in different conditions along the coast. In some cases, the species that have thrived in southeastern New Hampshire will have a difficult time adapting to changes in water level, salinity, sedimentation, and temperature. At the same time, opportunistic invasive species are likely to gain advantage over native species. This loss of biodiversity has a cascading effect on the natural system's ability to recover from disruption and maintain the functions (flood attenuation, recreational benefits, fisheries habitat, etc.) that people value.

4.4.2 Highlights of Vulnerabilities

Photo credit: JoAnn Theriault

Much work is being done to determine which natural coastal resources are vulnerable to climate change impacts in New Hampshire and to identify strategies to minimize risk to those natural resources. The 2015 NHFG Wildlife Action Plan presents substantial information about the vulnerabilities faced by New Hampshire species and ecosystems.[69]

In one specific example, NHFG ran a Sea Level Affecting Marshes Model (SLAMM) in 2014 to determine how coastal habitats, and specifically salt marshes, might respond to different sea-level rise scenarios. The model demonstrates where marshes have the ability to migrate landward, and if they will have the chance to do so before being drowned by rising water levels. Model results indicate that if sea level rises 6.6 feet by 2100, 240 acres of existing salt marsh will likely be lost by 2025 and only 300 acres will likely remain by 2100, amounting to a 95 percent loss of salt marsh.[70]

Figure 14 demonstrates current habitat distribution in the Hampton-Seabrook Estuary: the yellow color represents salt marsh and the brown color represents mudflat.[71] Modeling indicates that under a scenario of 6.6 feet of sea-level rise by 2100, the habitat distribution changes dramatically, as seen in Figure 15 where there is almost no salt marsh present and the majority of the estuary is either open water or mudflat.[72]

FIGURE 14. Current Hampton-Seabrook Estuary tidal wetlands. *Source: NHFG (2014).*

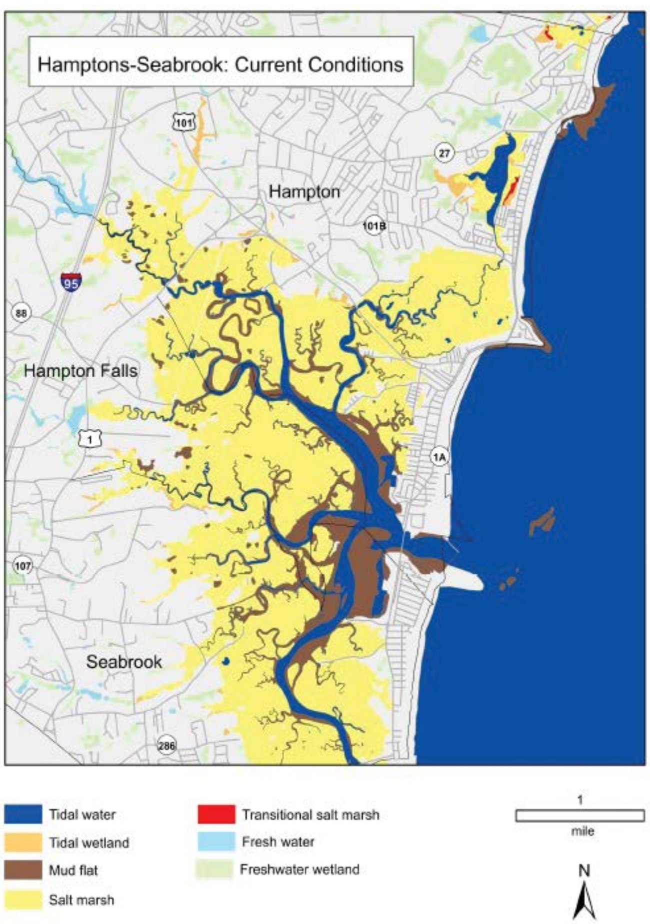
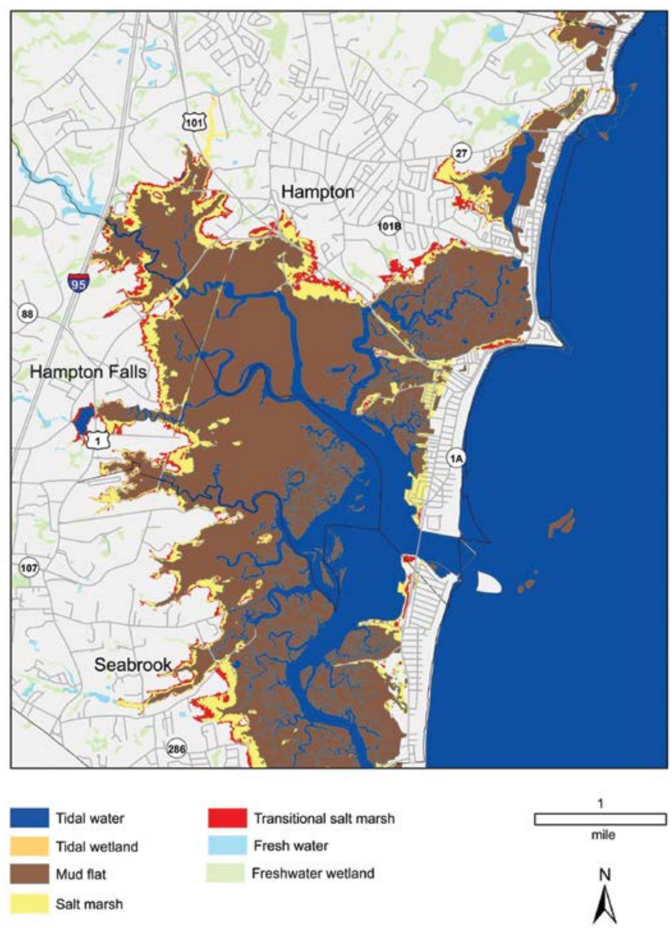


FIGURE 15. Modeled Hampton-Seabrook Estuary tidal wetlands in 2100 with 6.6 feet of sea-level rise. *Source: NHFG (2014).*



Impacts to the following natural resources were evaluated as part of the Tides to Storms vulnerability assessment for the Atlantic Coast municipalities: surface water; aquifers; freshwater and tidal wetlands; critical wildlife habitat; land protection priorities; conserved land; and agricultural soils. Table 6 reports the number of acres of each natural resource affected by each sea-level rise and coastal storm surge scenario for the seven Atlantic Coast municipalities as identified in the Tides to Storms vulnerability assessment. Impacts to the same categories of natural resources, with the exception of agricultural soils, were also evaluated as part of the C-RiSe vulnerability assessment for the Great Bay municipalities. Table 7 reports the acreage of each of the natural resources affected by each of the sea-level rise and storm surge scenarios for the ten Great Bay municipalities.

TABLE 6. Natural resources (acres) affected by sea-level rise and coastal storm surge* scenarios for the seven Atlantic Coast municipalities.**
Source: RPC (2015).

Sea-Level Rise (SLR) Scenarios	1.7 feet SLR	4.0 feet SLR	6.3 feet SLR	1.7 feet SLR + storm surge	4.0 feet SLR + storm surge	6.3 feet SLR + storm surge
Surface Water	49	134	144	144	152	156
Aquifers	8	24	56	48	87	122
Freshwater Wetlands	184	396	519	489	593	661
Tidal Water Wetlands	235	257	264	266	268	269
Critical Wildlife Habitat	4,022	4,851	5,469	5,385	5,948	6,458
Land Protection Priorities	1,081	1,600	1,915	1,865	2,112	2,310
Conserved Land	493	717	873	883	1,007	1,131
Agricultural Soils	123	378	678	620	937	1,238

* Storm surge = 100-year (one-percent-annual-chance) flood event.

** The seven Atlantic Coast municipalities include Hampton, Hampton Falls, New Castle, North Hampton, Portsmouth, Rye, and Seabrook.

TABLE 7. Natural resources (acres) affected by sea-level rise and storm surge* scenarios for the ten Great Bay municipalities.**
Source: NHDES et al. (In-Progress).

Sea-Level Rise (SLR) Scenarios	1.7 feet SLR	4.0 feet SLR	6.3 feet SLR	1.7 feet SLR + storm surge	4.0 feet SLR + storm surge	6.3 feet SLR + storm surge
Surface Water	572	709	772	742	805	861
Aquifers	47	142	340	245	430	596
Freshwater Wetlands	59	182	259	222	306	413
Tidal Water Wetlands	754	834	851	845	855	860
Critical Wildlife Habitat	721	1204	1723	1447	1895	2357
Land Protection Priorities	625	1040	1474	1244	1610	1978
Conserved Land	304	610	928	758	1026	1277
Agricultural Soils	N/A***					

* Storm surge = 100-year (one-percent-annual-chance) flood event.

** The ten Great Bay municipalities include Dover, Durham, Exeter, Greenland, Madbury, Newfields, Newington, Newmarket, Rollinsford, and Stratham.

***This analysis was not completed for the ten Great Bay municipalities as part of the C-RiSe project.

The Tides to Storms vulnerability assessment of natural resources indicates that habitat types are likely to shift as a result of sea-level rise and coastal storm surge. Some tidal wetlands will be submerged, some will migrate inland, and some freshwater wetlands and rivers are likely to see brackish or saltwater flooding. Impacted freshwater river systems include Cains Brook in Seabrook, Taylor River in Hampton, Little River in North Hampton, and Eel Pond in Rye. The Tides to Storms project also recognizes conserved and public land as natural resources, regardless of the habitat types they contain. Portsmouth, Rye, Hampton, and Seabrook have the greatest amount of conserved and public land within the coastal floodplain. Although these lands will be impacted by sea-level rise and coastal storm surge flooding, they serve as important flood storage areas and provide space for future habitat conservation and salt marsh migration.[73]

By a wide margin, surface waters and tidal wetlands are at higher risk of flood impacts in Great Bay municipalities than in Atlantic Coast municipalities according to preliminary C-RiSe findings. This is largely due to the expansive tidal wetlands along Great Bay and its tidal tributaries and the denser network of freshwater rivers and streams in the upper reaches of the coastal region. Freshwater wetlands located in riverine floodplains are also at high risk of inundation by saltwater from rising seas and storm surge. Conservation lands located in projected flood areas will serve important flood storage functions and will help buffer impacts from sea-level rise and storm surge. Critical wildlife habitat located in flood sensitive areas, such as wetlands and floodplains, may be highly impacted by projected changes in hydrology and environmental conditions resulting from inundation by rising seas and periodic flooding from storm surge. If stratified drift aquifers (shallow deposits of sand gravel glacial materials) are impacted by salt water intrusion as sea level rises, this would compromise municipal and residential drinking water sources.[74]

To protect the plants, animals, and natural systems that New Hampshire values, we need to understand how coastal hazards and risks might impact natural resources and prioritize management actions. Some actions, like land protection, suggested in this report can protect multiple species from both known and unknown impacts of climate change. It is important to recognize that some of the most significant threats to our natural resources may be associated with climate-related threats that are not investigated by this Commission; such as changes in air and water temperatures and water chemistry.

4.4.3 Relevant Recommendations

KEY COMMISSION RECOMMENDATIONS: Our Natural Resources

NR1. Identify and map natural resources that are vulnerable to current and future coastal risk and hazards. *[Lead: State Agencies].*

NR2. Develop natural resource restoration plans that explicitly consider future coastal risk and hazards, and the ecological services that they provide. *[Lead: State Agencies; Municipalities].*

NR3. Protect land that allows coastal habitats and populations to adapt to changing conditions and also provides ecosystem services that protect people, structures, and facilities. *[Lead: State Legislature; State Agencies; Municipalities].*

NR4. Encourage State agencies and municipalities to consider ecosystem services provided by natural resources in land use planning, master plans, and asset decisions. *[Lead: State Agencies; Municipalities].*

NR5. Assess the impact of freshwater and tidal crossings on adjacent tidal wetlands, aquatic organism passage, and public safety under existing and future climate conditions. *[Lead: State Agencies].*

NR6. Assess current conditions of groundwater resources and impacts from best available climate science. *[Lead: State Agencies].*

NR7. Restore or maintain natural flow regimes (groundwater, surface water and wetlands) to increase ecosystem resilience to extreme weather events and other coastal hazards, including floods, drought, and sea-level rise. *[Lead: State Agencies].*

4.5 Our Heritage

OUR HERITAGE encompasses the abundance of recreational, cultural, and historic resources, including economic assets and elements of the built landscape, in coastal New Hampshire that our state and communities wish to protect in the face of coastal risk and hazards.

4.5.1 How We Assess Vulnerability

Recreational Resources

Recreational destinations can be directly vulnerable to coastal storm surges, sea-level rise, and extreme precipitation. Because the resources vary significantly, vulnerabilities can and should be assessed in a variety of ways. Depending on their geology, public coastal beaches may be at risk of long-term erosion from sea-level rise and extreme short-term erosion in coastal storms. Our public parks located near tidal waters may be vulnerable to sea-level rise and storm surge; however they may also serve as intentional flood storage areas during extreme events, particularly ones in low lying areas with extensive open space.

Impacts to recreational resources will also affect their use by residents and tourists. If coastal habitats disappear with sea-level rise or more intense storms, then recreational fishing and birding that are supported by those habitats may also diminish.

In order to fully understand how recreational resources are vulnerable to coastal risks and hazards, an assessment should evaluate the physical exposure of recreational destinations to direct impacts, their sensitivity or capacity to bounce back after a shock, and finally, whether those resources can adapt to changes. For example, in the event that a beach destination is eroding, we must understand whether that beach should be renourished and if so, for how long. We could also evaluate whether alternative beach locations exist that could accommodate the recreational demand if that particular beach were to disappear.

The Wentworth-Coolidge Mansion: A Vulnerable Historic Landmark

Photo credit: Andy Willey

The 18th-century Wentworth-Coolidge Mansion was home to New Hampshire's first Royal Governor Benning Wentworth from 1753 to 1767. It is the only surviving residence of a Royal Governor in the United States. The mansion, listed in the National Register of Historic Places, sits on the banks of Little Harbor. Sea-level rise and storm mapping show that the grounds and part of the mansion are exposed to sea-level rise and storm surge. The site is managed by the New Hampshire Department of Resources and Economic Development (DRED) as a State Park. It is a popular tourist destination within the City of Portsmouth. DRED has identified the site as a priority for a detailed vulnerability analysis and preparedness planning.

Cultural and Historic Resources

Cultural and historic resources are not a stand-alone or separate resource type and include historic buildings and districts, archaeological sites, and institutions such as museums and libraries. These are all places that physically represent our histories and cultures. Cultural resources often survive because of the value in their ongoing uses (e.g., how Main Street areas of towns and cities have adapted over time). Many of these resources have economic value as well as historic value (e.g. Main Street stores), recreational value (e.g. museums, parks), or functional value (e.g. bridges, dams, culverts).

New Hampshire towns typically center on a few key public or semi-public buildings. The Meetinghouse represents the need for communal gathering places for both decision-making and socializing. Granges and libraries represent movements for education and social and political outlets. Domestic buildings, including factory worker housing, elaborate estates, and every variation in between are represented in the housing stock of each town. Factory and mill buildings remain from the industries that drove the economies of many towns, and Main Street commercial districts continue to offer business opportunities. The transportation and communication networks that tied these communities together have evolved over time, leaving physical remnants of their evolution. All of these features and more represent the tangible, irreplaceable heritage of our state and serve to make each community a unique representation of its own history and that history's reuse today.

Harry Hu/Shutterstock.com

Coastal New Hampshire contains a rich assortment of such resources, including some of the oldest indigenous settlements in the state dating back 12,500-13,000 years before present (B.P.). During the earliest years of settlement the environment consisted of open tundra and lower sea levels than present day. It is suspected that many of the earliest sites dating to 10,000 B.P. along the Seaboard Lowland lie just offshore and are inundated. The remaining periods of Native American occupation and settlement from 8,000 years B.P. to European contact are well-represented in the archaeological record within the New Hampshire coastal region. With exploration by the English beginning around 1603 in the region, and settlement beginning in the 1620s and 1630s, the cultural and historical resources of the Atlantic Coast and Great Bay regions of New Hampshire are rich traditions that are key to the identity of New Hampshire.

While the value of archaeological sites is partly scientific, revealing new information about the past, it is also social, providing opportunities for education, recreation, and reflection. Archaeological properties range from larger native village sites, historic forts, and tidal mills to smaller sites such as temporary encampments of native populations. Archaeological research carried out to date has identified 102 sites along New Hampshire's coastal margins and surrounding the Great Bay. The majority of sites relate to Native American occupation, but sites relating to European settlement are also represented. The identification of sites and systematic archaeological excavations and research have occurred only sporadically in this region through the years. Reliable reconstruction of the past depends on the recovery and examination of a range of archaeological sites from different periods across varying landscapes along coastal margins. Archaeological sites have revealed evidence of fishing practices and storage methods. Natural resources were also attractive and plentiful, including: fish, shellfish, crustaceans, birds, fish eggs, and marine mammals. Europeans rapidly adapted Native American knowledge of fishing and seafood collection for subsistence. All of this information can be verified and expanded through the archaeological record.

This multi-layered resource type makes historic resources even more valuable when looking at disaster recovery. Research shows that communities that retain a strong sense of place have a leg up on recovery efforts, as people will return to and invest in places where they have strong emotional and interpersonal ties.[75] A strong sense of place comes, in part, from a connection to the history of this place, demonstrated by the use of community landmarks. Historic buildings and neighborhoods and archaeological sites are irreplaceable history, creating a sense of place in New Hampshire communities. Replacing them with modern buildings will not recreate the heritage; when they are lost, they are lost forever. Therefore, protecting these resources protects the sense of place within communities and can accelerate recovery after a disaster.

4.5.2 Highlights of Vulnerabilities

Recreational Resources

While no comprehensive analysis has been done to understand the vulnerability of coastal recreational resources to climate change impacts, it is clear that some important recreation destinations are at risk of sea-level rise and coastal storms, including State and Town-owned beaches and public access points, outdoor destinations like Strawbery Banke Museum in Portsmouth, and exposed downtown areas such as Hampton's Ocean Boulevard strip.[76] In addition, the Tides to Storms vulnerability assessment reported between 493 and 873 acres of existing conserved and public lands in the seven Atlantic Coast municipalities could be impacted under the 1.7 feet and 6.3 feet sea-level rise scenarios by the year 2100. In a future one-percent-annual-chance storm event, the number of acres impacted could reach up to 1,131.[77] Similarly, preliminary C-RiSe findings indicate that between 304 and 928 acres of existing conserved and public lands in the ten Great Bay municipalities could be impacted under the 1.7 feet and 6.3 feet sea-level rise scenarios, and up to 1,277 acres could be affected when storm surge is added.[78] These estimates indicate potentially serious implications for publicly accessible recreation amenities. Adverse storm and sea-level rise impacts to natural resources like fisheries and bird habitat could also have detrimental effects on recreational activities in coastal New Hampshire.

A more detailed assessment of recreational resources is needed to better understand specific exposure, sensitivity, and adaptive capacity of these resources; and to prioritize areas for preparedness and improve their resilience to coastal flooding.

Cultural and Historic Resources

In order to determine the vulnerability of cultural and historic resources to coastal area risks, data on surveyed resources and risk assessments will need to be compared. These assessments would yield hazards to known resources, as well as potentially at-risk areas about which little or nothing is known. Above-ground (architectural) and below-ground (archaeological) resources are different data sets and are therefore addressed separately.

Above-ground Resources (Architectural)

In general, above-ground resources are vulnerable to anything that may cause moisture damage, particularly extreme storms and flooding. Historic buildings may be more vulnerable than newer buildings in several respects. While they have stood the test of time, many older buildings may have deferred maintenance issues which can be worsened by storm-driven moisture. The high winds that come with extreme storms are also potentially damaging to structures and facilities. Additionally, historic neighborhoods in New Hampshire, especially the oldest developments along the coast, are along water ways, as these were primary transportation corridors. These areas pre-date zoning, flood mapping, and other safety-minded planning concerns, which may mean they were built in areas that did not flood frequently, but also may mean that they are more vulnerable having been "grandfathered" into current rules. With expected sea-level rise due to climate change, the historic floodplains are changing, and more buildings may be at risk of flood damage.

Assessing the vulnerability of historic and cultural resources poses a unique challenge compared to most other asset types. That is, there are many cultural and historic sites that have not been identified, surveyed or mapped, although many properties have been identified through compliance driven surveys and are considered "eligible" for the National or State Registers of Historic Places. Any assessment therefore is partial and incomplete at best. Recognizing this, the Commission did review the vulnerability information included in both the Tides to

Storms and C-RiSe assessments, which included data from the National Register of Historic Places and the New Hampshire State Register of Historic Places to assess which of these known historic resources are affected by coastal flooding under the established sea-level rise and storm surge scenarios. The Tides to Storms vulnerability assessment identified a total of 51 National Register properties and 16 State Register of Historic Place properties in the seven Atlantic Coast municipalities. As shown in Table 8, 17 of those are shown in the mapping analysis to be potentially affected under the 6.3 feet sea-level rise plus storm surge scenario.[79]

TABLE 8. National and New Hampshire State Register of Historic Places properties affected by sea-level rise and storm surge* scenarios for the seven Atlantic Coast municipalities.** *Source: RPC (2015).*

Sea-Level Rise (SLR) Scenarios	1.7 feet SLR	4.0 feet SLR	6.3 feet SLR	1.7 feet SLR + storm surge	4.0 feet SLR + storm surge	6.3 feet SLR + storm surge
National Register of Historic Places	2	3	4	4	6	12
NH State Register of Historic Places	0	4	4	4	5	5
Town of Hampton						
Hampton Beach Fire Station	0	1	1	1	1	1
City of Portsmouth*****						
Strawbery 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
General Porter House	0	0	0	0	0	1
Haven-White House	0	0	0	0	0	1
Wentworth-Coolidge Mansion	0	0	0	0	0	1
Gov. John Wentworth House	0	0	0	0	1	1
Wentworth-Gardner and Tobias Lear Houses	**0**	**0**	**0**	**0**	**1**	**1**
Portsmouth Marine Railway	0	1	1	1	1	1
Shaw Warehouse	**0**	**1**	**1**	**1**	**1**	**1**
Sheafe Warehouse	0	1	1	1	1	1
Town of New Castle						
Portsmouth Harbor Light	0	0	1	1	1	1
New Castle Cong. Church*****	0	0	0	0	0	0
New Castle Town Hall*****	0	0	0	0	0	0
Town of North Hampton						
Little Boar's Head Historic District****	1	1	1	1	1	1
Town of Rye						
St. Andrew's By-The-Sea	0	0	0	0	0	1
Pulpit Rock Base-End Station*****	0	0	0	0	0	0
Goss Farm	0	0	0	0	1	1
Odiorne Farm	0	0	0	0	0	0

* Storm surge = 100-year (one-percent-annual-chance) flood event.
** The seven Atlantic Coast municipalities include Hampton, Hampton Falls, New Castle, North Hampton, Portsmouth, Rye, and Seabrook.
*** It is expected that a new National Register listing, the "Portsmouth Downtown Historic District" consisting of more than 1200 properties will be added to the National Register in 2016 or 2017.
**** Historic District listings are counted by the National Park Service as one property but include multiple properties and structures.
***** The registered structure is not affected, but access to it will be limited by flooding of the surrounding landing.

As shown in Table 9, the C-RiSe vulnerability assessment has identified a total of 40 National Register properties and four State Register properties in the ten Great Bay municipalities, of which five are shown as potentially affected under the highest flooding scenario.[80]

Photo credit: Todd Selig

It is important to note that the designation of these properties does not come from a systematic review of the resources at hand but rather from the limited sample of properties that appear on either the National Register and New Hampshire State Register of Historic Places, which are based on voluntary property nominations. While this limited assessment serves to highlight a few of the recognized assets that may be at risk, it in no way provides a true assessment of the overall risk to historic properties. A vulnerability assessment based on a more systematic and comprehensive survey of historical resources is needed to understand the full scope of the vulnerability of historic and cultural resources and to prioritize areas for preparedness actions.

Reinforcing this point, research into the New Hampshire Division of Historical Resources' (DHR) town file databases (above-ground survey of buildings, structures, and districts) shows that, for above-ground resources (buildings, districts, structures), 15,034 acres of land have been surveyed in the 17 coastal zone municipalities,

TABLE 9. National and New Hampshire State Register of Historic Places properties affected by sea-level rise and storm surge* scenarios for the ten Great Bay municipalities. ** *Source: NHDES et al. (In-Progress).*

Sea-Level Rise (SLR) Scenarios	1.7 feet SLR	4.0 feet SLR	6.3 feet SLR	1.7 feet SLR + storm surge	4.0 feet SLR + storm surge	6.3 feet SLR + storm surge
National Register of Historic Places	4	4	4	4	5	5
NH State Register of Historic Places	0	0	0	0	0	0
Town of Dover						
Back River Farm	1	1	1	1	1	1
Town of Durham						
Durham Historic District***	0	0	0	0	1	1
Town of Newington						
Margeson, Richman, Estate	1	1	1	1	1	1
Town of Exeter						
Exeter Waterfront Commercial Historic District***	1	1	1	1	1	1
Front Street Historic District	1	1	1	1	1	1

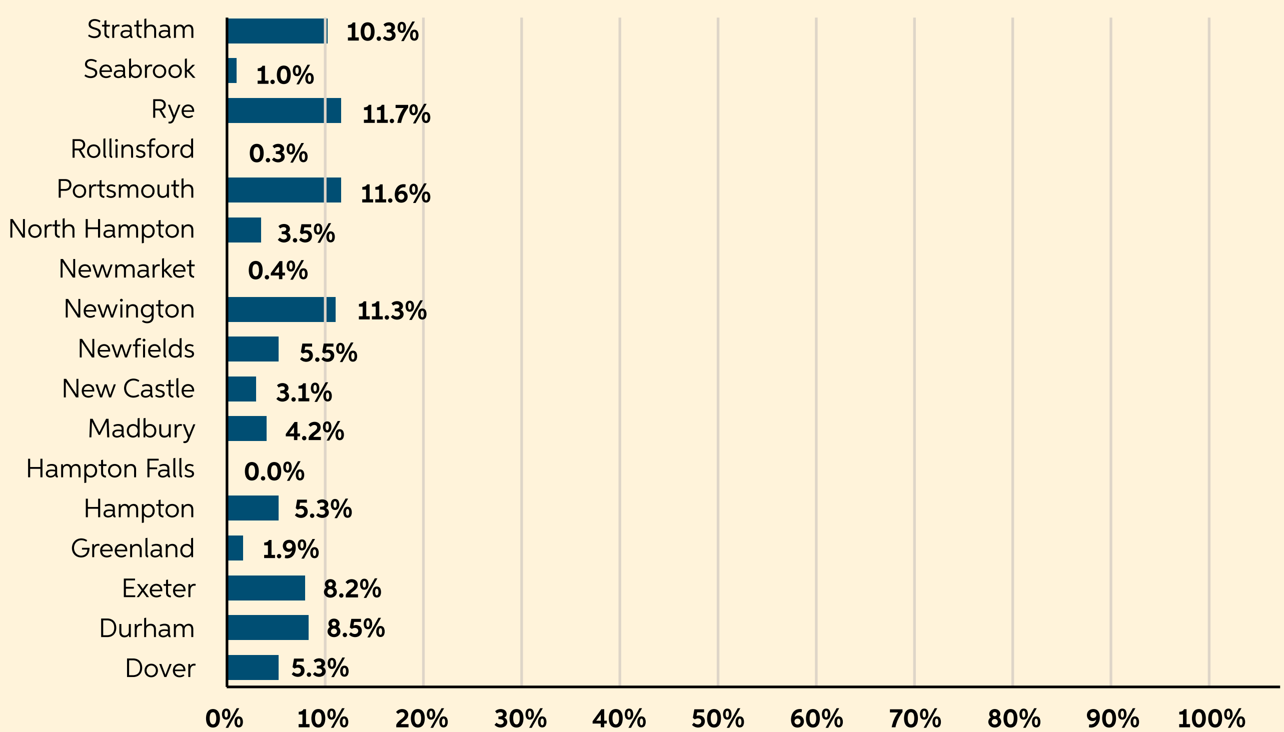
* Storm surge = 100-year (one-percent-annual-chance) flood event.

** The ten Great Bay municipalities include Dover, Durham, Exeter, Greenland, Madbury, Newfields, Newington, Newmarket, Rollinsford, and Stratham.

***Historic District listings are counted by the National Park Service as one property but include multiple properties and structures.

representing only 10.8 percent of the total area that could be surveyed.[81] Figure 16 shows the proportion of area surveyed for above-ground historical resources. This does not mean that all of the unsurveyed areas contain historical resources. It means that at this time, we lack information to determine the presence of historic resources, and that basic baseline data is needed to fully assess the vulnerability of above-ground historical resources in the coastal region.

FIGURE 16. Proportion of area surveyed for above-ground historical resources.* *Source: DHR (2016).*



* Data does not include all National Register-listed properties, and includes only information in the databases as of this report publication. Dataset should not be considered complete and is included for informational purposes only.

Below-ground Resources (Archaeological)

Archaeological sites also are vulnerable to coastal hazards. For most sites, gradual change in sea-level rise is of less concern than some of the other consequences of climate change. Currently underwater sites may survive intact. Most negative effects will come from higher storm surges, changes in storm tide levels, changing wave dynamics, extreme precipitation events, and flooding. These all have the potential to cause erosion, which exposes and damages or even destroys archaeological sites.

There are 581 archaeological properties recorded in Rockingham and Strafford Counties; of these properties, 102 sites are located below the 20 foot mean sea level and are threatened by climate change and its effects. The coast has always been an attractive settlement location and these resources represent the only record of the rich Native American cultures that once lived there.

Ultimately, the biggest vulnerability of cultural and historic resources is our limited knowledge of what cultural and historic resources exist and where they are located throughout the coastal region. Many towns rely on the memories of local long-time citizens, volunteers in their historical societies, and heritage commissions. These are valuable sources of information, but not easily accessible to emergency planners, creators of hazard mitigation plans, or emergency responders, and the data aren't available in digital or mapped formats. The DHR has been collecting information on historic resources for over 40 years, but as budgets have not kept up with the pace of technology, most information is not available in digital or mapped format. The DHR is currently working on GIS maps and digitization of records for six of the ten New Hampshire counties with funding from a National Park Service grant. Strafford County, which includes four of the coastal zone municipalities, is among the counties not covered by this project.

Additionally, more survey is needed to understand where areas that have high potential for archaeological sites and/or historic buildings and structures may also be at high risk from natural disasters. Community hazard mitigation plans and master plans that include chapters on cultural resources may be helpful in allowing communities to target high risk/high potential areas for future survey. Funding is needed to allow communities to both gather and analyze this material so that mitigation and adaptation plans can be discussed for at-risk resources. Human response to climate change through adaptation and defense may also affect cultural resources if communities are unaware of their resources and their resource location. Including cultural resources in planning will be the best way to mitigate unintended damage during clean up or adaptation projects.

4.5.3 Relevant Recommendations

KEY COMMISSION RECOMMENDATIONS: Our Heritage	
H1.	Identify and survey recreational resources and assess their vulnerability to coastal risk and hazards based on best available climate science. *[Lead: State Agencies; Municipalities].*
H2.	Develop plans and implement strategies to prepare and adapt recreational resources based on best available climate science. *[Lead: State Agencies; Municipalities].*
H3.	Identify and survey cultural and historic resources and assess their vulnerability to coastal risk and hazards based on best available climate science. *[Lead: State Agencies; Municipalities].*
H4.	Require State agencies and encourage municipalities to develop long-term plans for protecting, adapting, or reducing risk to cultural resources affected by climate change. *[Lead: State Agencies; Municipalities].*
H5.	Allocate FY2018-2019 Biennial Budget funding and authority to expend funds for recreational and cultural resource vulnerability surveys, planning efforts, and implementation of the resulting plans. [*Lead: State Legislature].*