

11-2016

Preparing New Hampshire for Projected Storm Surge, Sea-Level Rise, and Extreme Precipitation: Final Report and Recommendations

New Hampshire Coastal Risk and Hazards Commission

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Preparing New Hampshire for Projected Storm Surge, Sea-Level Rise, and Extreme Precipitation



The final report of the New Hampshire
Coastal Risk and Hazards Commission,
**Preparing New Hampshire for Projected Storm Surge,
Sea-Level Rise and Extreme Precipitation,**
is available for download on the Commission's website:
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Please cite this report as follows:

New Hampshire Coastal Risk and Hazards Commission (2016). Preparing New Hampshire
for Projected Storm Surge, Sea-Level Rise and Extreme Precipitation.
<http://www.nhcrhc.org/wp-content/uploads/2016-CRHC-final-report.pdf>

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ⁱ Commission Alternates and former members are listed in [Appendix B](#).

ACKNOWLEDGEMENTS

The New Hampshire Coastal Risk and Hazards Commission (Commission) would like to acknowledge the following individuals and organizations who contributed to the development and completion of this publication, *Preparing New Hampshire for Projected Storm Surge, Sea-Level Rise, and Extreme Precipitation: Final Report and Recommendations*. The Commission's Steering Committee members dedicated significant time to overseeing the Commission's process and activities. Steering Committee members include Senator David Watters (District 4), Senator Nancy Stiles (District 24), Representative Fred Rice (District 21), Representative Renny Cushing (District 21), Cliff Sinnott, Chair (RPC), Cory Riley (NHFG), Sherry Godlewski (NHDES), Jennifer Gilbert (NHOEP), Roger Stephenson (Town of Stratham), Dr. Cameron Wake (UNH), Steve Couture (NHDES), and Ann Scholz (NHDOT). Additionally, Commission member Peter Kinner (Town of Greenland) committed significant time to chair a recommendation working group. Julie LaBranche (RPC), Kirsten Howard (NHDES), Cathy Coletti (NHDES), and Nathalie Morison (NHDES) provided staff support, including coordinating the writing and production of this publication. The NHDES Coastal Program also provided financial support for materials associated with this publication.

The Commission would like to recognize and extend gratitude to the members of the Science and Technical Advisory Panel (STAP) who compiled the 2014 STAP report for the Commission, entitled *Sea-level Rise, Storm Surges, and Extreme Precipitation in Coastal New Hampshire: Analysis of Past and Projected Future Trends*. Members of the STAP included Frederick Chormann (NHGS), Rob Flynn (USGS), Dr. Matt Huber (UNH), Dr. Paul Kirshen (Chair, UNH), Dr. Kevin Knuuti (USACE), Steve Miller (NHFG), Ann Scholz (NHDOT), Dr. Mary Stampone (UNH and NH State Climate Office), Dr. Cameron Wake (UNH), Thomas Wismuller (Colderside.com), and Sherry Godlewski (NHDES). The New Hampshire Fish & Game Department Great Bay National Estuarine Research Reserve (NHFG-GBNERR) provided funds through a New Hampshire Charitable Foundation grant for outreach materials associated with the STAP report.

The New Hampshire Coastal Adaptation Workgroup (NHCAW), co-chaired by Commission members Sherry Godlewski and Steve Miller, dedicated resources and valuable expertise to organize the Community Discussion Groups. As part of these efforts, Amanda Stone of the University of New Hampshire Cooperative Extension Natural Resources Outreach Coalition provided significant support to plan and execute the Discussion Groups which produced valuable local feedback on the recommendations. The Commission would like to thank the municipal staff, volunteers, and residents who participated in the Discussion Groups.

The Commission would also like to extend its gratitude to the many scientific experts, state agency representatives, municipal officials, industry representatives, and other stakeholders who presented valuable information to the Commission at meetings and in the form of background resources.

Finally, the Commission would also like to give special thanks to the NHFG-GBNERR and Seacoast Science Center for hosting the Public Information & Comment Meetings and to all members of the public who provided thoughtful comments on the public draft of this report.

The development of this final report was funded in part by NOAA's Office for Coastal Management under the Coastal Zone Management Act and in conjunction with the New Hampshire Department of Environmental Services Coastal Program.

EXECUTIVE SUMMARY

Coastal hazards associated with storm surge, sea-level rise, and extreme precipitation events can be devastating to human health and safety, public and private structures and facilities, and the economies of coastal communities. Coastal New Hampshire was fortunate to experience minimal damage from Tropical Storm Irene in 2011 and Superstorm Sandy in 2012. Nevertheless, the impacts of these storms on neighboring states and the more extreme local impacts from storms such as the Mother's Day storm of 2006, the Patriots' Day storm of 2007, and Winter Storm Nemo in 2013 have reinforced our knowledge that strong storm systems are capable of causing immense damage in areas on or near the coast. New Hampshire's coastal exposure to current and future flood risks is significant. As of 2016, the state's 17 coastal zone municipalities are home to approximately 11 percent of the state population, host over 100,000 jobs, and generated a 2014 Gross Regional Product of approximately \$11 billion.^{1,2}

Where and how we build and rebuild as the coastal population and economy continue to grow have critical implications for how coastal New Hampshire will withstand projected coastal hazards. Should we choose to build using the same strategies and techniques as we have in the past, we will exacerbate our exposure to these hazards by placing structures, facilities, and people directly at risk. Alternatively, if we incorporate projected flood risks into our planning, design, construction, and conservation practices today, we will greatly reduce exposure to flood hazards, resulting in saved lives and property and lower response and recovery costs.

Recognizing the need to prepare for existing and projected coastal flood hazards, in July 2013 the State Legislature enacted Senate Bill 163, introduced by Senator David Watters (District 4), which established the New Hampshire Coastal Risk and Hazards Commission to "recommend legislation, rules, and other actions to prepare for projected sea-level rise and other coastal and coastal watershed hazards such as storms, increased river flooding, and stormwater runoff, and the risks such hazards pose to municipalities and the state assets in New Hampshire." In response to this legislative mandate, the Commission puts forward a final report and set of recommendations for state legislators, state agencies, and coastal municipalities to help these audiences better prepare for and minimize coastal risks and hazards. The report presents a summary of the best available science and vulnerability information followed by recommendations for action.

Understanding What We Are Facing

To lay the foundation for our understanding of coastal hazards and flood risks, the Commission established a Science and Technical Advisory Panel (STAP) to review existing science and analyze historic trends and projections for the years 2050 and 2100 for storm surge, sea-level rise, and extreme precipitation in coastal New Hampshire.³ Some of the key scientific findings summarized in the STAP report include:

- Global and regional sea levels have been rising for decades, though not uniformly.
- Using mean sea level in 1992 as a starting point, New Hampshire sea levels are expected to rise between 0.6 and 2.0 feet by 2050 and between 1.6 and 6.6 feet by 2100.
- Today's extreme storm surge events will have a significantly greater inundation extent and destructive impact due to higher sea levels.
- It is likely that coastal storms will be more severe as a result of warmer oceans and other changes in climate systems, but at the time of the STAP report publication, the research continues to be uncertain about whether storm frequency will change in the future.
- Annual precipitation is expected to increase by as much as 20 percent by the end of the 21st century compared to the late 20th century, and extreme precipitation events are projected to increase in frequency and in the amount of precipitation produced.

Understanding Our Risks and Vulnerabilities

The Commission's report summarizes vulnerabilities to projected coastal flood hazards and how these hazards could impact different sectors of our life in the coastal region. Recent and ongoing assessments of the Atlantic Coast and Great Bay communities identify valuable assets at risk of different coastal hazards, evaluate the exposure and sensitivity of those assets to coastal hazards, and assess existing capacity for managing and reducing vulnerabilities. While additional assessments are needed to more fully understand New Hampshire's coastal vulnerabilities, especially in the Great Bay communities and at the site-specific scale, significant progress is underway. Some key findings from regional assessments are presented in this report, focusing on vulnerabilities specific to our economy, our built landscape, our natural resources, and our heritage.

Our Economy

A review of key indicators reinforces the growing importance of the coastal region to the economic vitality of the State. The coastal region hosts 11 percent of the state's population, accounts for 15 percent of total state employment, and generates a disproportionate share of statewide tourism revenue as measured in Meals and Rooms tax revenue.^{4,5,6} The Tides to Storms vulnerability assessment conducted for the seven Atlantic Coast municipalities reported that just over 7,000 parcels will be partially or wholly affected under the 6.3 feet sea-level riseⁱⁱ plus storm surge scenario, putting approximately \$4.4 billion, or 35 percent, of total assessed property value at risk of flooding.⁷ Similarly, the Climate Risk in the Seacoast (C-RiSe) vulnerability assessment conducted for the ten Great Bay municipalities suggests that nearly 1,600 parcels will be partially or wholly affected under the 6.3 feet sea-level rise plus storm surge scenario, putting over \$805 million, or 8.5 percent, of total assessed property value at risk of flooding.⁸

Our Built Landscape

State and local roadways throughout the coastal region are vulnerable to flooding and damage due to 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. The Tides to Storms vulnerability assessment conducted for the seven Atlantic Coast communities reported that, under an intermediate sea-level rise scenario of 4.0 feet, 90 public infrastructure sites, 33 critical facilities, and nearly 24 miles of state and local roads could be subject to daily tidal flooding by 2100.⁹ Under the same 4.0 feet sea-level rise scenario, the C-RiSe vulnerability assessment conducted for the ten Great Bay municipalities reported that 23 public infrastructure sites, zero critical facilities, and only one mile of state and local roads could be subject to daily tidal flooding by 2100.¹⁰

Our Natural Resources

As reported in the 2015 Wildlife Action Plan, sea-level rise will alter the function of coastal habitats such as salt marshes and estuaries, habitat availability, and the timing of nesting and migration for seabirds.¹¹ Total habitat and species losses will likely be greater in developed areas where there is no space for natural habitats to retreat or migrate inland. Modeling results suggest that salt marshes will likely reach a tipping-point under the highest sea-level rise scenario, with 95 percent of salt marshes potentially disappearing by 2100.¹² In addition to long-term sea-level rise, extreme storm events can pose significant risks to coastal systems by altering hydrology, sedimentation, and land forming processes. Coastal dune sediments will be driven inland by storm surges, and dune degradation will further exacerbate the impacts of storms. As dune systems migrate landward they will compete with developed landscapes and, as a result, the remaining dunes could eventually be lost completely.

ii The 6.3 feet sea-level rise map was developed prior to the STAP report summary and therefore used slightly different estimates for sea-level rise. The maps do not show significant difference in inundated area due to the resolution of the elevation data.

Our Heritage

Cultural, historic, and recreational resources and amenities are vital assets in the coastal region, in part because they support the tourism industry, as well as a sense of place for New Hampshire residents and visitors alike. Regional-scale vulnerability analyses have identified some vulnerable recreational destinations, however less than 11 percent of the coastal region has been inventoried for historic architectural resources.¹³ Much less of the coastal region has been evaluated for archaeological resources, though we know that at least 102 archaeological sites, most of which are historic Native American sites, are already situated below mean sea level.

Understanding What We Need To Do

This report is the start of a critical and ongoing effort in the state to embrace a proactive approach that is responsive to changing conditions and societal and ecological needs. Planning for coastal hazards will evolve with research and as creative adaptation strategies are implemented here and around the country. State, municipal, and private sector responses will likely combine *defending* certain key assets and resources from loss, *accommodating* new flood extent and risk, and *retreating* from areas where the frequency or severity of impacts are too great to defend against or accommodate. The appropriateness of responses will vary by location and will change over time as flood risk and exposure changes, requiring the State and municipalities to periodically reassess their responses.

Given this uncertainty and need for flexibility, we present six guiding principles that should be applied at both state and municipal levels to plan for coastal risks and hazards, followed by our goals to achieve a resilient New Hampshire and a summary of the recommendations for action.

Our Guiding Principles

Act Early

By starting now, the normal cycles of reconstruction, replacement and redevelopment can gradually replace vulnerable facilities and construction not designed for future conditions, often at minimal added cost and resulting in long-term cost savings.

Respond Incrementally

Given uncertainties about future flood risk, strategies can be implemented in increments, allowing multiple opportunities to refine and correct actions as understanding of future coastal hazards improves.

Revisit and Revise

Actions must keep pace with observed changes and improved scientific understanding, therefore it is important that state and municipal officials periodically revisit projections and assumptions as the science becomes more certain and adjust their course of action accordingly.

Collaborate and Coordinate

The state and municipalities share assets and infrastructure on the coast that are systematically and functionally linked and as such, they need to work together to align policies, assumptions, and responses about future coastal flood hazards.

Incorporate Risk Tolerance in Design

The acceptable loss or damage to an asset should be considered in determining the most appropriate design standards for protection, with more critical, expensive, and long-lasting structures and facilities having low risk tolerance and lower value, easily replaced structures and facilities having higher risk tolerance.

Make No Regrets Decisions

By preparing for future impacts from uncertain coastal hazards, often the results will be beneficial even if those future hazards turn out to be less extreme than anticipated.

Our Goals

We present four goals intended to help achieve our vision for a resilient coastal New Hampshire. These goals form the SAIL framework: Science, Assessment, Implementation, and Legislation.

1. **Science:** To research, understand, establish, and use best available science about current and future coastal hazards.
2. **Assessment:** To identify our assets that are vulnerable to current and future coastal hazards and evaluate existing policies to identify ways to reduce vulnerabilities.
3. **Implementation:** To implement strategies to enable the state and coastal communities to protect, adapt, and sustain our assets.
4. **Legislation:** To recommend legislation that leads to actions to reduce vulnerability and adapt to current and future coastal hazards.

Recommendation Highlights

We propose extensive and detailed recommendations and associated actions that should be implemented to prepare for projected sea-level rise and other coastal watershed hazards. Highlights from the recommendations are summarized below and form a high-level to do list for New Hampshire's state legislature, state agencies, and coastal municipalities.

- Review and evaluate the current state of climate change science in order to periodically update storm surge, sea-level rise, extreme precipitation, and other relevant climate projections; and provide planning guidance.
- Identify vulnerable state and municipal economic assets; structures and facilities; natural resources; and recreational and cultural resources at regional, municipal, and site-specific scales.
- Amend statutes, ordinances, rules and regulations, policies, programs, and plans to incorporate and consider the best available science and vulnerability information.
- Secure funding sources and develop funding mechanisms, including incentives and market-based tools, to pay for vulnerability assessments and implement climate adaptation strategies.
- Encourage businesses to create preparedness plans in order to minimize economic disruptions and ensure continuity of services to essential facilities, people, businesses, and employment centers.
- Make existing structures and facilities more resilient to flooding, acquire properties in high risk areas, and avoid exposing new structures and facilities to current and future flood risks.
- Protect and restore vulnerable natural resources, and consider how natural resources reduce the impacts of flooding in state and municipal planning efforts.
- Develop plans and implement strategies to prepare and adapt recreational and cultural resources vulnerable to climate impacts.

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1. Introduction

Coastal hazards such as coastal storms and extreme precipitation events can be devastating to human health and safety, public and private structures and facilities, and the economies of coastal communities, and these hazards will only get worse as they are exacerbated by sea-level rise. Tropical Storm Irene in 2011 and Superstorm Sandy in 2012 demonstrated the immense destruction that strong storm systems can cause in both rural and urban settings in the Northeast. As of 2016, New Hampshire's 17 coastal zone municipalities are home to approximately 11 percent of the state population, support more than 100,000 jobs, and account for a 2014 Gross Regional Product of approximately \$11 billion.^{14,15} As the coastal population and economy expand, where and how we build will have critical implications for how coastal New Hampshire will withstand projected coastal hazards associated with storm surge, sea-level rise, and extreme precipitation events. The crowding of our coastlines and waterfront has become a hazard unto itself, as we continue to put people and the built landscape directly in harm's way.

Preparing for coastal hazards will save lives, money, and natural resources that are critical to maintaining the quality of life on the seacoast. According to the U.S. Chamber Foundation's Business Civic Leadership Center preliminary estimates, Superstorm Sandy negatively affected between 60,000 and 100,000 small businesses, and as many as 30 percent of those companies were projected to fail as a direct result of the storm.¹⁶ A study completed in 2005 by the Multi-Hazard Mitigation Council of the National Institute of Building Sciences concluded that when it comes to infrastructure, every dollar spent on mitigation saves society an average of four dollars.¹⁷ Climate impacts could drown the majority of New Hampshire's salt marshes by 2100¹⁸ but recent studies conducted locally indicate that proactive planning for the eventual landward migration of salt marshes (i.e., protecting undeveloped uplands) will help ensure their persistence in the face of rising sea levels.

In recognition of the need to prepare for existing hazards and the increased risks associated with climate change, the State Legislature established the New Hampshire Coastal Risk and Hazards Commission in 2013 to "recommend legislation, rules and other actions to prepare for projected sea-level rise and other coastal watershed hazards such as storms, increased river flooding and stormwater runoff, and the risks such hazards pose to municipalities and state assets in New Hampshire" (see [Appendix A](#)). For nearly two years, the Commission gathered data and summarized the best available peer-reviewed science to understand current and projected risks posed by coastal hazards to New Hampshire's coastal region and to establish planning assumptions such as the range of likely sea-level rise, and changes in storm surge and intensity. The Commission then evaluated potential impacts of these risks and discussed ongoing efforts to understand and plan for impacts. Finally, the Commission discussed existing knowledge and policy gaps and needs and developed recommendations for municipalities, legislators, and state agencies.

This report summarizes the activities carried out by the Commission as well as the key scientific findings and impact analyses that the Commission used to inform the recommendations and actions laid out in Section 6. The report is divided into several key sections: Section 2 describes the background on the Commission's establishment, membership, scope, and process; Section 3 summarizes the best available climate science as presented by the Science and Technical Advisory Panel report (STAP report); Section 4 presents an overview of known coastal vulnerabilities in the areas of Our Economy, Our Built Landscape, Our Natural Resources, and Our Heritage; Sections 5 and 6 present the Commission's recommendations and suggested actions for state agencies, municipalities, and the New Hampshire legislature; and Section 7 outlines existing mechanisms and suggests next steps to ensure continuity and implementation beyond the Commission's sunset on December 1, 2016.

2. Coastal Risk and Hazards Commission

2.1 Establishment

The New Hampshire Coastal Risk and Hazards Commission was proposed in Senate Bill 163, introduced by Senator David Watters (District 4), and established by the State Legislature through RSA 483-E on July 2, 2013 (see [Appendix A](#)). The legislation arose from concerns that neither the state nor coastal municipalities are adequately prepared for projected coastal flooding risks associated with a changing climate. The purpose of the Commission, as stated in the law, is to “recommend legislation, rules and other actions to prepare for projected sea-level rise and other coastal watershed hazards such as storms, increased river flooding and storm water runoff, and the risks such hazards pose to municipalities and the state assets in New Hampshire.” Further, in carrying out this charge, the Commission is specifically directed to “review National Oceanic and Atmospheric Administration and other scientific agency projections of coastal storm inundation and flood risk to determine the appropriate information, data, and property risks” to incorporate into its recommendations. By law, the Commission was scheduled to sunset on December 1, 2016.

2.2 Membership

RSA 483-E established a broad-based membership for the Commission representing both state and local government, as well as other stakeholders in the coastal watersheds. The 37 members include representatives from the New Hampshire Senate and House of Representatives; key New Hampshire state agencies, including the Department of Environmental Services (NHDES), Department of Transportation (NHDOT), Department of Resources and Economic Development (DRED), Fish and Game Department (NHFG), Department of Cultural Resources (NHDCR), and Office of Energy and Planning (NHOEP); the University of New Hampshire; all 17 Coastal Zone municipalities; and the two regional planning commissions covering the tidal communities. Other stakeholder groups represented on the Commission include the NH Public Risk Management Exchange, Seacoast Board of Realtors and the NH Home Builders Association. Membership participation and engagement has been consistently strong throughout the Commission’s activities, which were led by a Steering Committee made up of a subset of the membership.

2.3 Scope

One of the Commission’s first activities was to define its scope and establish a strategy to accomplish its charge within the limits of its voluntary and unfunded status. The Commission determined that its charge was to help the state and its municipalities interpret the best available peer-reviewed science, including empirical data and modeled information. This information would enhance the Commission’s understanding of expected future conditions and form the basis for the recommendations.

Based on the language of RSA 483-E and the focus on coastal geography, the Commission interpreted its mandate to focus on the risks and hazards that uniquely or particularly affect coastal watersheds, and less on other climate related impacts such as drought, heat stress, agricultural shifts, and snow cover changes. While these impacts are important to plan for, they are not specific to the coast. Thus, increased coastal flooding hazards associated with storm surge, sea-level rise, and extreme precipitation events were the Commission’s primary focus.

Finally, the Commission agreed that its work would be synthesized in one or more reports directed at three audiences: the State Legislature, key state agencies, and municipalities.

2.4 Activities

The Commission, led by a volunteer Steering Committee, conducted work in four phases: fact finding, assessing vulnerability, obtaining stakeholder input, and developing recommendations. Key steps in fact finding included reviewing relevant documents and reports, presentations from agencies, communities and other stakeholders, and the commissioning of a Science and Technical Advisory Panel (STAP) to review available scientific information about coastal hazards and flood risks in New Hampshire.

With limited resources, the Commission relied heavily on existing data and reports, as well as studies that were underway. Peer-reviewed scientific sources are referenced in the Commission's STAP report.¹⁹ The Commission also reviewed existing guidance and actions to prepare for climate change impacts at federal agencies and in New Hampshire state agencies, summarized in [Appendix C](#). A few of the most relevant sources referenced by the Commission are:

- High resolution coastal LIDAR, a remote sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light, enabling detailed topographic mapping of low lying coastal areas²⁰
- Sea-level rise scenario mapping for 2050 and 2100²¹ and FEMA Flood Insurance Rate Maps for coastal New Hampshire
- New Hampshire Wildlife Action Plan²²
- From Tides to Storms²³ and C-RiSe²⁴ sea-level rise and coastal storm surge vulnerability assessments conducted for the Atlantic Coast and Great Bay municipalities
- Economic flood vulnerability assessment for Hampton-Seabrook estuary using the COAST model²⁵
- Community vulnerability assessments and plans from Portsmouth²⁶, Durham²⁷, and Dover²⁸
- Region-specific research and modeling on changes in precipitation²⁹
- Sea level affecting marshes models showing how NH salt marshes could retreat with sea-level rise³⁰
- Municipal hazard mitigation plans and assessor databases
- NH Climate Action Plan: A Plan for New Hampshire's Energy, Environmental and Economic Development Future³¹

Town of Newmarket Envisions a Future with Fewer Floods

In 2015, after more than ten years, the Town of Newmarket evaluated its community vision and future direction as part of the Town's master planning process (this chapter was last updated in 2001). With support from the Strafford Regional Planning Commission, the Town developed and implemented a process to engage residents in envisioning the Town's future. This process enabled Newmarket to gain a better understanding of residents' near- and long-term views of the community and provided ideas for addressing current and future challenges. Through a combination of interactive forums, small group discussions, live polling, and an online survey, input from over 455 residents was used to develop a robust set of visionary statements and strategies.



Overturned Jeep on Prescott St. in Newmarket during May 2006 flooding event. (Photo credit: Town of Newmarket)

As a result of this effort, Newmarket's overall vision statement guides the Town in becoming more resilient against coastal and riverine flooding through local land use policies and regulations that reduce risk and vulnerability. The Town also supports the integration of climate adaptation measures into municipal programs, policies, and operations, as well as promotes smart development and greater resilience against adverse impacts and infrastructure vulnerability associated with climate changes, such as sea-level rise and increased flooding.

2.4.1 Presentations

In addition to written sources, the Commission was fortunate to observe various presentations by Commission members and outside experts and stakeholders. Through these presentations, Commission members engaged in discussions about the issues facing various stakeholder groups. Presentations to the Commission included:

Data Resources for Assessing Coastal Risk and Hazards

- *Coastal Change Analysis Using Airborne LIDAR Data and Historic Aerial Photographs* by Neil Olson, NHDES/NH Geological Survey (July 2015)
- *Tides to Storms Community Vulnerability Assessments*, by Julie LaBranche, RPC (July 2015)
- *The New Hampshire Coastal Viewer* by Kirsten Howard, NHDES Coastal Program (July 2015)
- *NOAA Flood Exposure Risk Mapper* by Jamie Carter, NOAA (February 2015)
- *Climate Trends in New Hampshire and Its Impact on Storm and Riverine Flood Behavior* by David R. Vallee, NOAA/NWS Northeast River Forecast Center (February 2015)
- *FEMA Preliminary Maps for Coastal NH* by Jennifer Gilbert, NH Program Manager for National Flood Insurance Program (April 2014)

Stakeholder Perspectives on Coastal Risk and Hazards

- *Homebuilder Industry Perspective on Future Coastal Risks and Hazards* by Robert Cormier, Homebuilders and Remodelers Association of NH (May 2014)
- *Role of Insurance in Managing Risk from Natural Hazards* by Jonathan Kipp, Primex (April 2014)

Coastal Risk and Hazard Planning in Other States

- *New York Climate Risk and Resilience Act* by Steve Couture, NHDES Coastal Program (December 2014)
- *State of Maryland Climate Change and Infrastructure Siting and Design Guidelines* by Cliff Sinnott, RPC (December 2014)
- *Other State Sea-Level Rise Planning Efforts* by Kirsten Howard, NHDES Coastal Program (July 2014)

State Agency Reports on Coastal Risk and Hazards

- *Division of Parks and Recreation, DRED* by Gail Wolek, DRED (January 2014)
- *Division of Forests and Lands, DRED* by Sabrina Stanwood, Natural Heritage Bureau (January 2014)
- *Cultural Resources and Climate Change, NH Department of Cultural Resources* by Edna Feighner, Division of Historical Resources (January 2014)
- *NH Office of Energy and Planning*, by Jennifer Gilbert, NH Program Manager for the National Flood Insurance Program (January 2014)
- *NH Department of Environmental Services*, by Ted Diers, NHDES Watershed Management Bureau (November 2013)
- *NH Department of Transportation*, by Kevin Nyhan, NHDOT Bureau of the Environment & Ann Scholz, NHDOT Bureau of Materials and Research (November 2013)
- *NH Fish and Game Dept.*, by Cory Riley, Great Bay National Estuarine Research Reserve (November 2013)

Regional Efforts to Address Coastal Hazards

- *New Hampshire Coastal Adaptation Workgroup Initiatives*, by Sherry Godlewski, NHDES (October 2013)
- *Tides to Storms – Coastal Vulnerability Assessment and Response Planning*, by Julie LaBranche, RPC (October 2013)

Municipal Efforts to Address Coastal Hazards

- *New England Climate Adaptation Project – Climate Change Risk Assessment for Dover, NH*, by Steve Bird, Dover; Danya Rumore, New England Climate Adaptation Project; and Carri Hulet, Consensus Building Institute (April 2014)
- *Portsmouth Coastal Resilience Initiative*, by Peter Britz, City of Portsmouth (October 2013)

Coastal Risk and Flooding Related Programs

- *National Flood Insurance Program*, by Jennifer Gilbert, NH Program Manager, National Flood Insurance Program (March 2014)
- *Summary of the New Hampshire Flood Management Study Commission (HB648) Report*, by Steve Couture, NHDES Coastal Program (March 2014)

As needs and possible strategies became evident from information sources and stakeholder presentations, the Commission began developing draft recommendations. Commission members divided into three recommendation working groups: Great Bay communities, Coastal communities, and State and Legislative issues. Initial recommendations from the groups were refined and revised to reduce duplication and to incorporate new information as it became available.

2.4.2 Public Input

A thorough public process was conducted to gather input on the Commission's draft report and recommendations. In December 2015, the Commission partnered with NHCAW to hold three discussion groups for coastal municipal officials to provide input on initial draft recommendations, which was later considered by the Commission and incorporated where appropriate into its draft report.

Following unanimous approval, the Commission released its draft report for public review and comment on March 18, 2016. In addition to soliciting written comments, the Commission held two Public Information and Comment meetings in order to provide information, answer questions, and receive comments on its draft report. The Public Information and Comment meetings were held at the Hugh Gregg Coastal Conservation Center, Great Bay National Estuarine Research Reserve in Greenland, NH on May 26, 2016 and at the Seacoast Science Center at Odiorne State Park in Rye, NH on June 1, 2016. The Public Information and Comment meetings attracted 70 attendees and yielded 25 verbal comments. A detailed summary of the Commission's responses to these and the 20 written comments received is available as a supplement to this report.³²

3. Understanding What We Are Facing

While New Hampshire has been very fortunate to have avoided the most extreme impacts of recent events like Tropical Storm Irene in 2011 and Superstorm Sandy in 2012, the state has experienced other significant weather events in the coastal region. We have seen intense Nor'easters like Winter Storms Juno in 2015 and Nemo in 2013, the October 2011 Snowstorm, and others that have had large and lasting impacts on our communities. These types of storms will have even greater impacts with projected sea level rise and an increase in the frequency and severity of extreme rain events will lead to more floods. While some additional climate change related impacts are now unavoidable due to past emissions of heat-trapping greenhouse gases (and the long lifetime of these gases in the atmosphere), the amount of future climate change and the extent of damaging impacts will depend on the amount of greenhouse gases that continue to accumulate in the atmosphere. As a result, efforts to reduce emissions or remove carbon dioxide from the atmosphere will not only reduce the amount and speed of climate change, but will also reduce the amount of adaptation needed. Although the Commission's mission and report are focused on adaptation, we recognize that efforts to reduce greenhouse gas emissions and adaptation are intrinsically linked, and therefore support continued action to reduce the drivers of climate change in New Hampshire, including implementation of the New Hampshire Climate Action Plan.³³ The Commission also recognizes that we must continue to track the evolving science regarding atmospheric concentrations of greenhouse gases and associated projected impacts. Understanding the best science behind projected risks and hazards is essential to enabling our coastal communities to be as prepared as possible to avoid costly impacts and the potential loss of life.

3.1 Science and Technical Advisory Panel

The Commission created a Science and Technical Advisory Panel (STAP) to review available scientific information about coastal hazards and flood risks in New Hampshire. Comprised of scientists and experts in the fields of meteorology, engineering, climate, hydrology, and other related sciences, the Panel's charge was to:

1. Ensure the Commission is aware of and is using the best available and relevant scientific and technical information to inform its recommendations; and
2. Assist the Commission in interpreting and reconciling conflicting projections, scenarios and probabilities about future conditions.

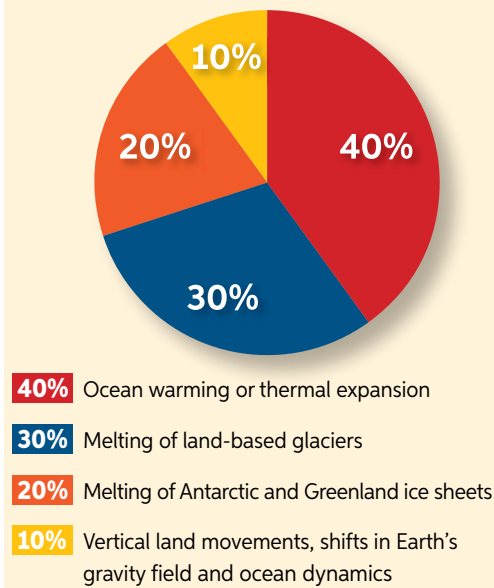
The Panel analyzed the latest published data on historic trends and projections for the years 2050 and 2100 for sea-level rise, coastal storms, and extreme precipitation. These findings were summarized in an externally-reviewed STAP report entitled, *Sea-level Rise, Storm Surges, and Extreme Precipitation in Coastal New Hampshire: Analysis of Past and Projected Future Trends*,³⁴ which the Commission unanimously adopted after careful and deliberate discussion in July 2014 and used to develop its recommendations to assist in planning and preparation for the changing climatic conditions in coastal areas of the state. The Panel recommends the STAP report be updated regularly as new research and data become available.

While a changing climate, melting ice sheets, and warmer ocean temperatures are enhancing coastal storms and extreme precipitation hazards, and are contributing to sea-level rise, it is important to note that our current and historical development patterns also contribute to the coastal risks and hazards we are facing. We have historically developed along rivers and shorelands. We continue to encroach on natural buffers with development that is, as a result, at risk from flooding. The increases in pavement and other impervious surfaces associated with development cause an increase in runoff and flooding due to the inability of these surfaces to absorb rain and snow melt. These development patterns exacerbate the climatic impacts and contribute to changing floodplains.

3.2 Science and Technical Advisory Panel Report

The following section is a summary of the information presented in the STAP report. A condensed two-page summary of the STAP report is provided in [Appendix D](#). It is important to note that while projections for storm surge, sea-level rise, and extreme precipitation are described independently below, they are not mutually exclusive. In fact, the combined occurrence of heavy rainfall and storm surge, together with sea-level rise, will likely increase flooding in coastal regions. Additionally, present-day storm surge already poses an immediate threat to our coastal region during Nor'easters and tropical storms. Both episodic and unpredictable in nature, storm surge presents a hazard we must remain vigilant about and must continue to plan for carefully. Finally, mapping efforts conducted by the Rockingham Planning Commission and the New Hampshire Geographically Referenced Analysis and Information Transfer System (NH GRANIT) show that projected sea-level rise is largely contained within the current 100-year floodplain.³⁵ As a result, communities that adopt and enforce floodplain management activities within the current 100-year floodplain will also be preparing for and building resilience against projected sea-level rise related impacts in the long term.

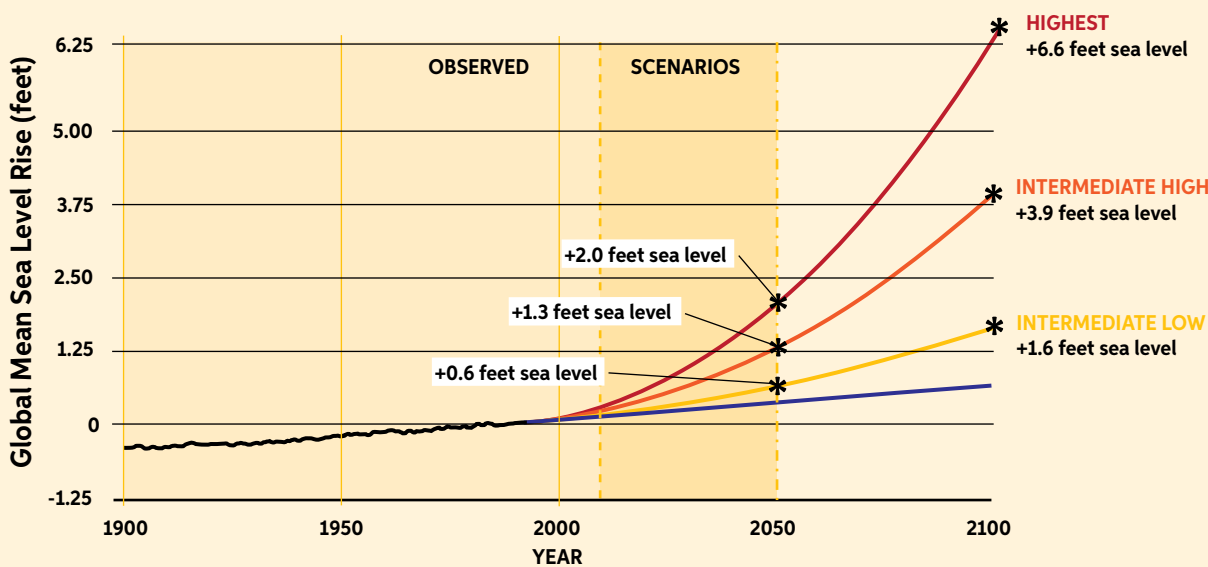
FIGURE 1. Processes causing sea levels to rise from 1990-2012. Source: NHCRHC STAP (2014).



Sea-Level Rise

Forecasting rates of global greenhouse gas emissions is challenging, but research shows that current greenhouse gas concentrations and current or accelerated emissions rates will continue to influence sea levels in the future. Planning for a 100-year flood now can also prepare us for mid-century sea-level rise. Figure 1 illustrates the processes contributing to sea-level rise and their proportions over the period from 1990-2012. Figure 2 shows the projected sea-level rise for the years 2050 and 2100 under different greenhouse gas emissions scenarios as reported in the National Climate Assessment published in 2014. These scenarios assume intermediate-low greenhouse gas emissions, intermediate-high emissions, and the highest emissions conceivable.

FIGURE 2. Sea-level rise scenarios under different emission levels in 2050 and 2100. Source: Adapted from NHCRHC STAP (2014).



Based on local tide gauge data, sea levels in New Hampshire have been rising by an average of 0.7 inches per decade since 1900. The rate of sea-level rise has increased to approximately 1.3 inches per decade since 1993. Using 1992 sea levels as a baseline, New Hampshire sea levels are expected to rise between 0.6 and 2.0 feet by 2050 and between 1.6 and 6.6 feet by 2100.

Storm Surge

Considering changes in water levels due to sea-level rise alone, today's extreme storm surge events (i.e. 1-percent-annual-chance flood /100-year flood) will have a greater inundation extent and occur more frequently over time. Due to increased coastal development, there has been a significant increase in impacts from hurricanes nationwide over the 20th Century. However, there is some uncertainty in the projection of trends in hurricane frequency and intensity in any given region, and no research consistently finds a trend in the frequency and intensity of Nor'easters.



Photo credit: Ron Sher

Annual and Extreme Precipitation

Annual precipitation is expected to increase by as much as 20 percent by the end of the 21st century compared to the late 20th century. Most of the precipitation increases are expected to be in winter and spring in the form of rain or snow. Fall and summer are expected to experience less of an increase.

Extreme precipitationⁱⁱⁱ events are projected to increase in frequency and in the amount of precipitation produced. In particular, the rainfall amount produced by hurricanes is projected to increase. However, current climate models and analyses are not as good at projecting future changes in the frequency or magnitude of extreme precipitation events.

Other Hazards and Risks

The Commission recognizes that New Hampshire's coastal communities face additional coastal risks and hazards that were not explicitly summarized by the Science and Technical Advisory Panel or by the Commission's recommendations. The Commission limited its focus based on the legislative mandate, available information, and resources, however additional coastal hazards pose serious risks and should be studied further and acted upon, where deemed necessary. Some of these hazards include increases in average temperatures; drought; snowfall; seasonal shifts; potential air quality issues; saltwater intrusion and rising groundwater tables from sea-level rise; ocean acidification and the impacts on habitats and fisheries; and other impacts to well-being and quality of life, including the health of New Hampshire coastal residents. [Appendix E](#) highlights some of the additional hazards that should be studied in future iterations of the STAP report and discussed in future Commission efforts. These hazards have significant and increasing health implications as they are exacerbated by climate change, and though efforts have begun in the State to better understand health impacts, this needs to be a continuing focus of study.

Based on this summary of the science, the STAP offered planning guidance for adapting to storm surge, sea-level rise, and changes in annual and extreme precipitation. This guidance is summarized in Section 5.2.

ⁱⁱⁱ For the purposes of this report, "extreme precipitation" is defined as the largest one percent of daily events in a year. This definition comes from the 2014 National Climate Assessment, however many other valid definitions of the term "extreme precipitation" exist.

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.

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

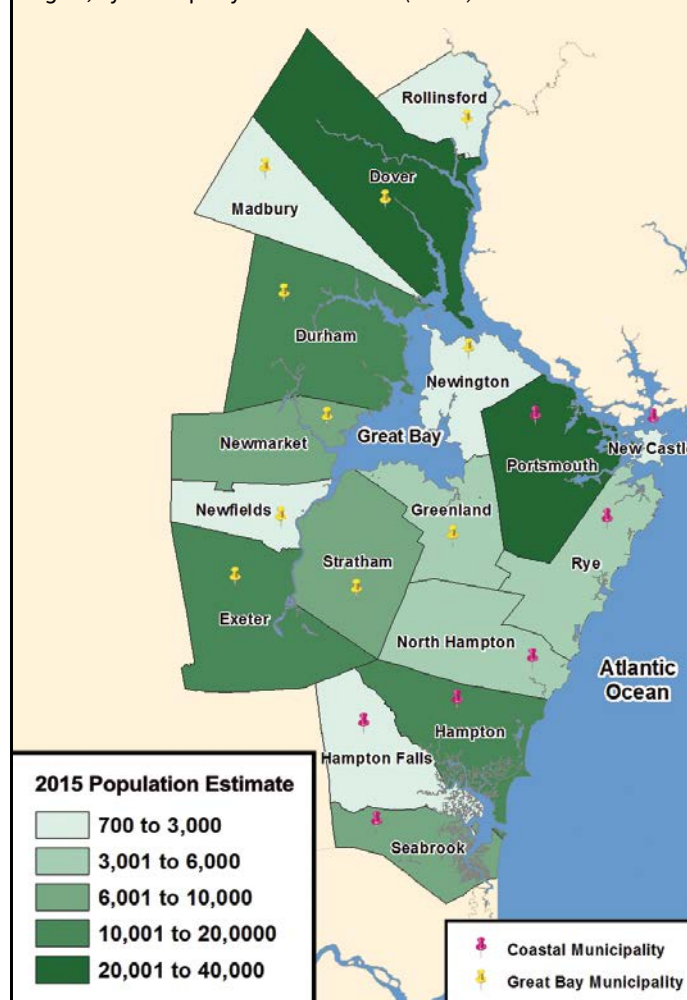
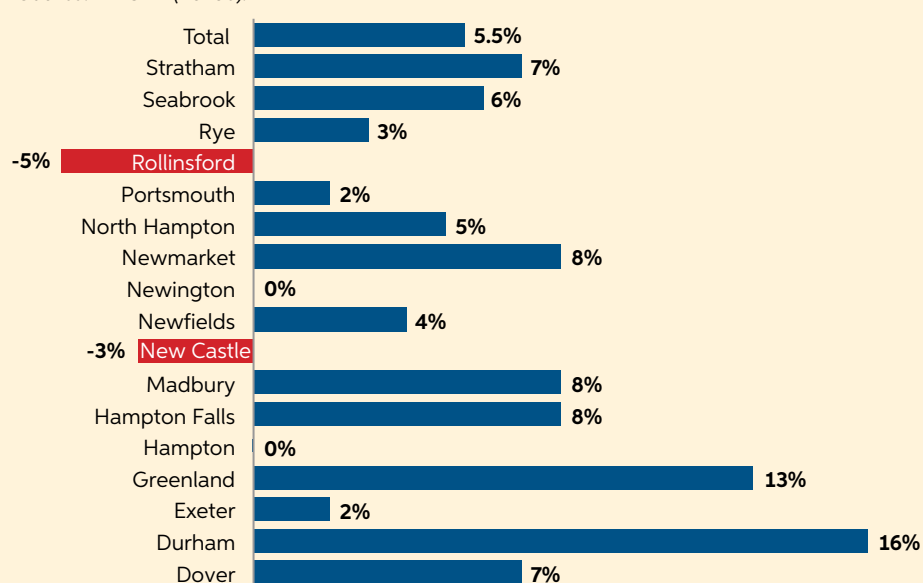


FIGURE 4. Population projections by coastal zone municipality for period 2015 through 2025. Source: NHOEP (2016b).



^{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 project⁴² 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.



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 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).

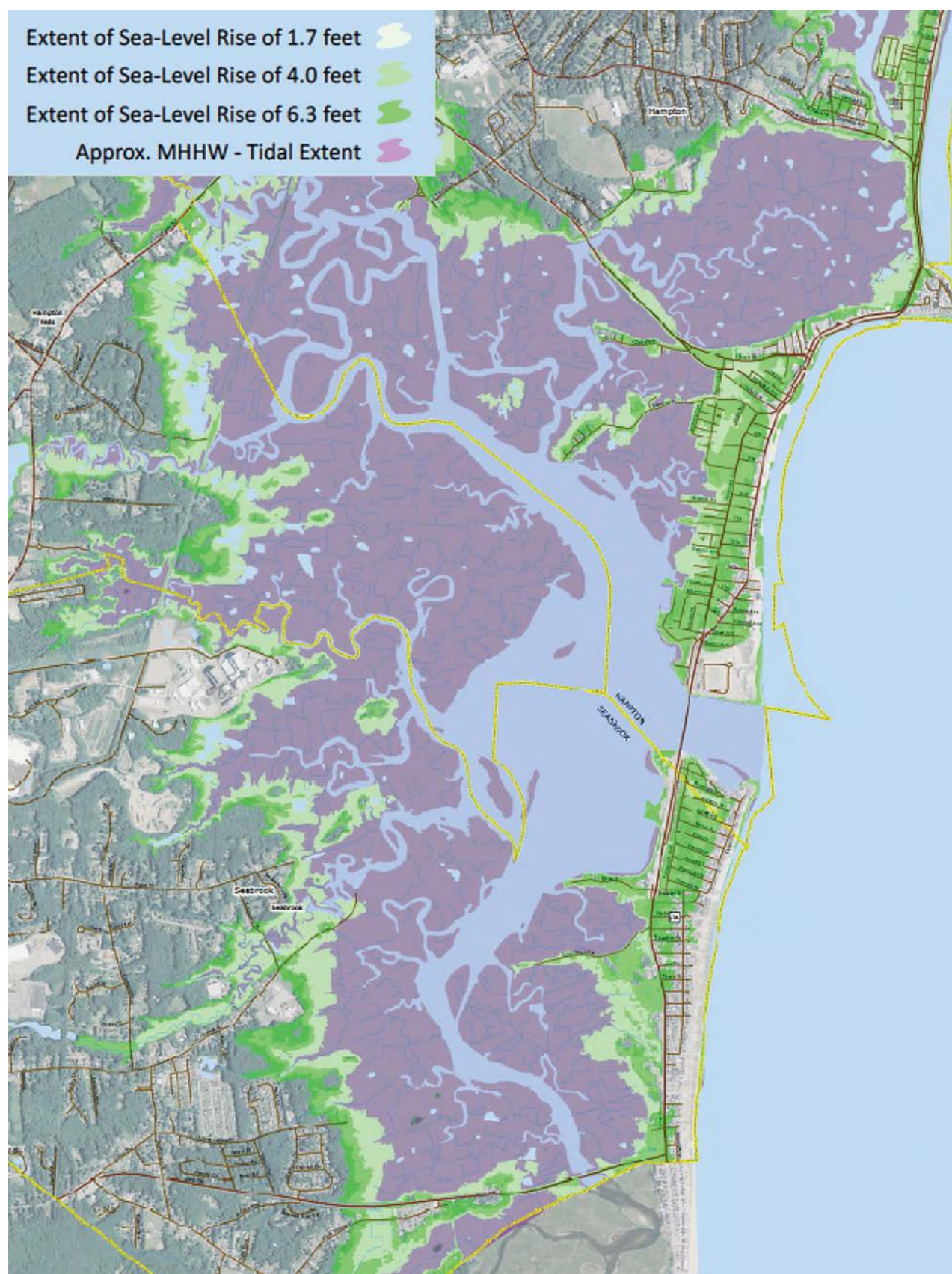
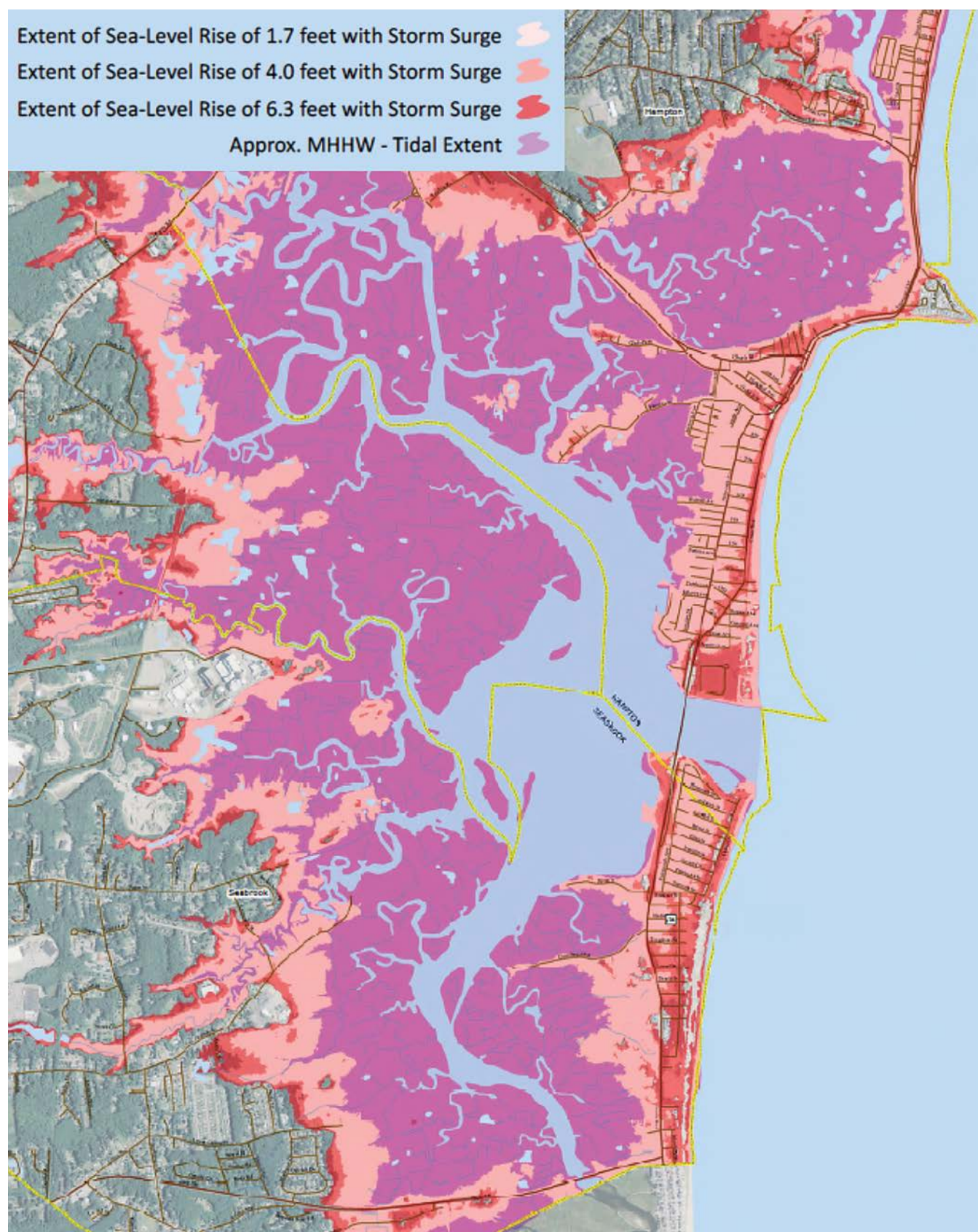


FIGURE 6. Illustration of the extent of flooding from three sea-level rise scenarios with a 100-year (one-percent-annual-chance) storm surge in the Hampton-Seabrook estuary. *Source: RPC (2015).*



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.

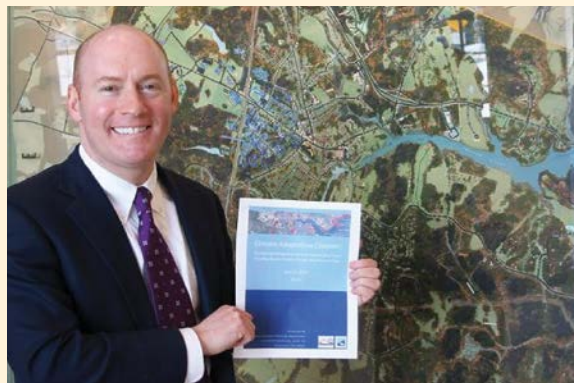
Most of the Great Bay communities lie within the Piscataqua River Basin through which flow a number of coastal rivers, including the Cocheco, Lamprey, Oyster, Exeter, Winnicut, and Salmon Falls. The Salmon Falls flows south into the Piscataqua River and acts as the boundary between New Hampshire and 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.

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 Administration, 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.

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.

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).

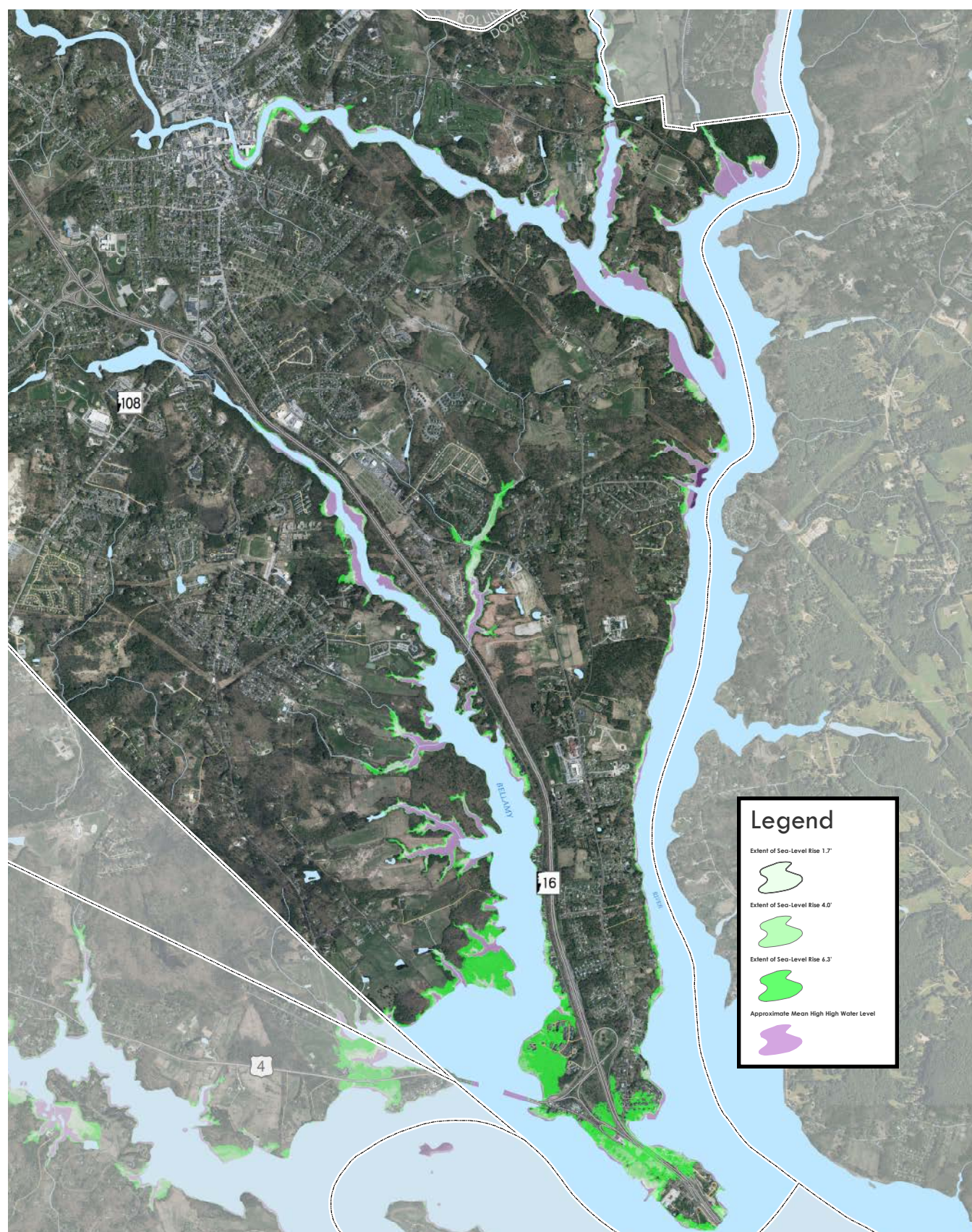


FIGURE 8. Illustration of the extent of flooding from three sea-level rise scenarios with a 100-year (one-percent-annual-chance) storm surge in the City of Dover, NH. Source: NHDES et al. (In-Progress).

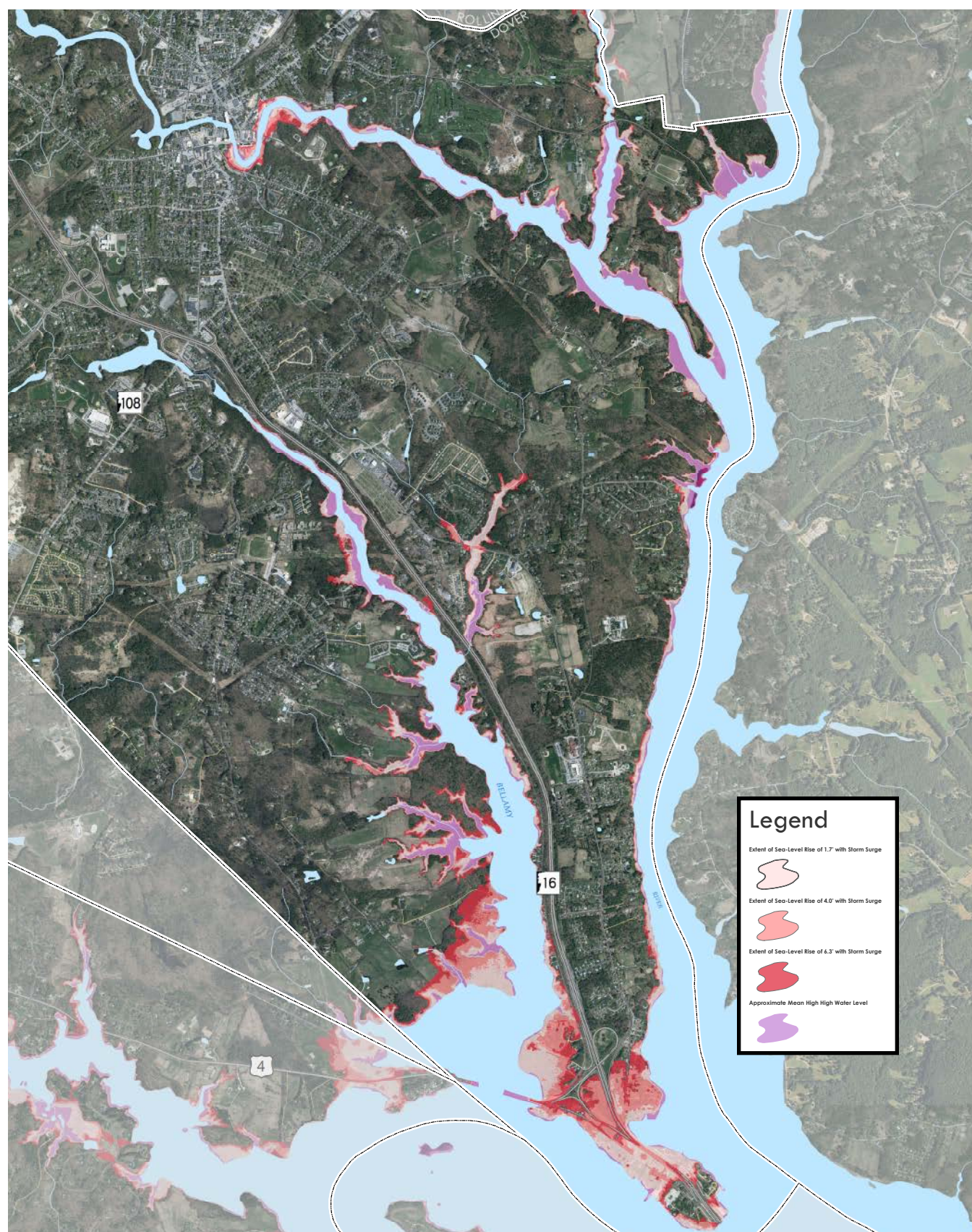


Table 2 provides a statistical overview of the flood impacts to specific assets and resources under the various sea-level rise and storm surge scenarios evaluated for the ten Great Bay municipalities as part of the C-RiSe project. The ten Great Bay municipalities combined have 86,210 acres of upland (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.

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



Photo credit: UNH Stormwater Center

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

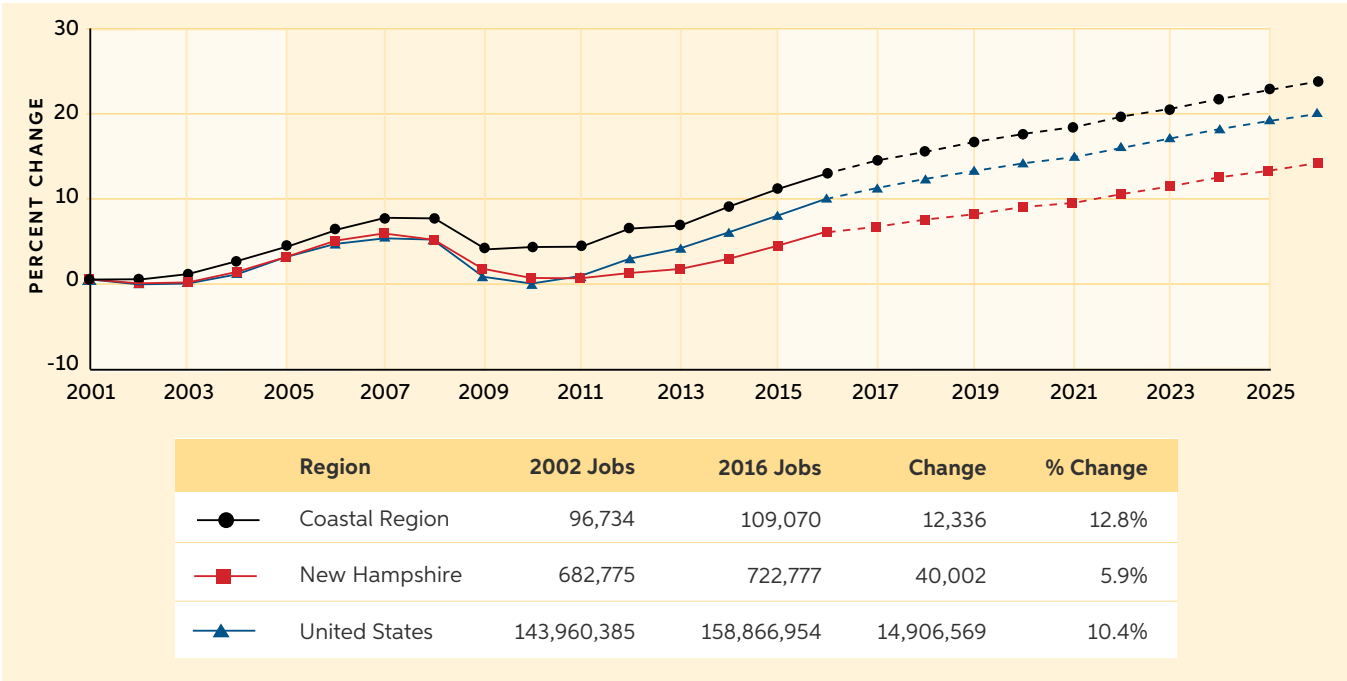
When it comes to assessing the vulnerability of the coastal region to coastal risks and hazards, the regional economy must be considered in two ways. First, research shows that communities with diversified economies and established institutions have a greater capacity to protect and prepare their assets, 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).*



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).

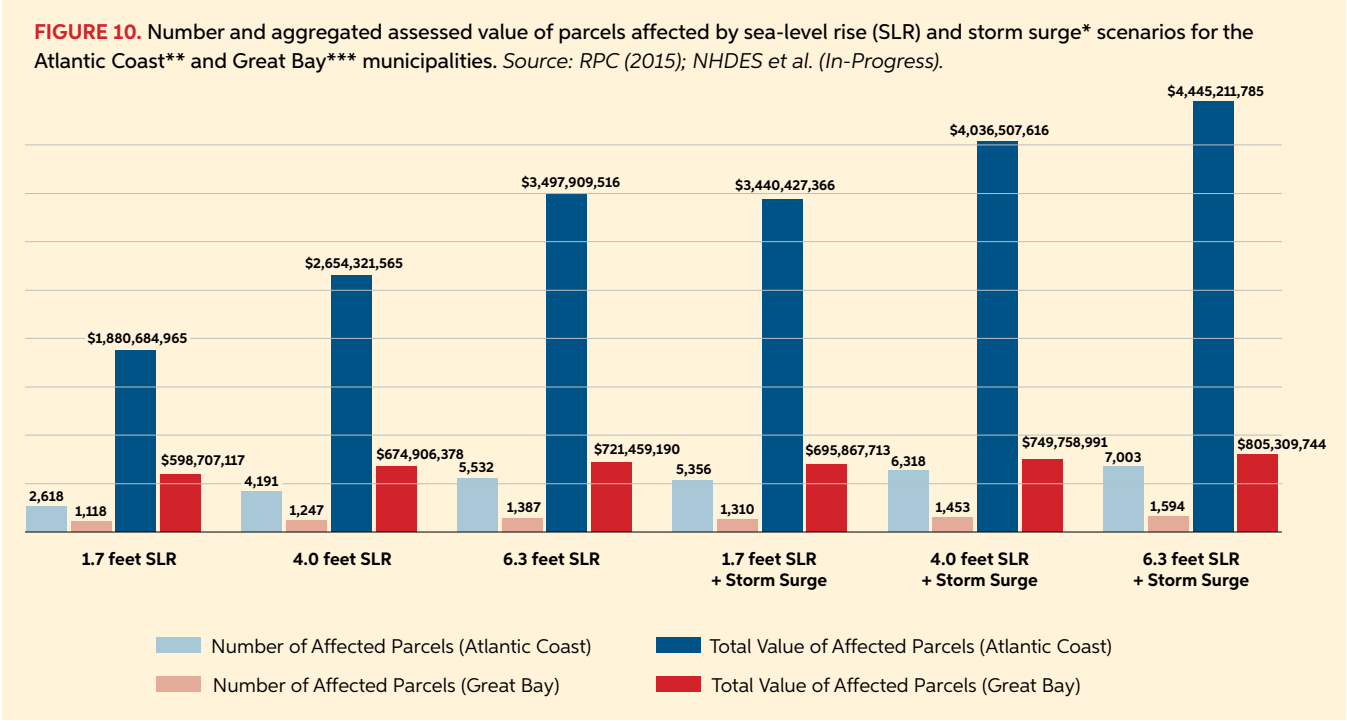
from property taxes (based on assessed valuation), potential losses to their tax base resulting from increased coastal flooding could have a significant impact on municipal budgets throughout the coastal region.

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



* 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



Photo credit: Amy Hansen

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.

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?

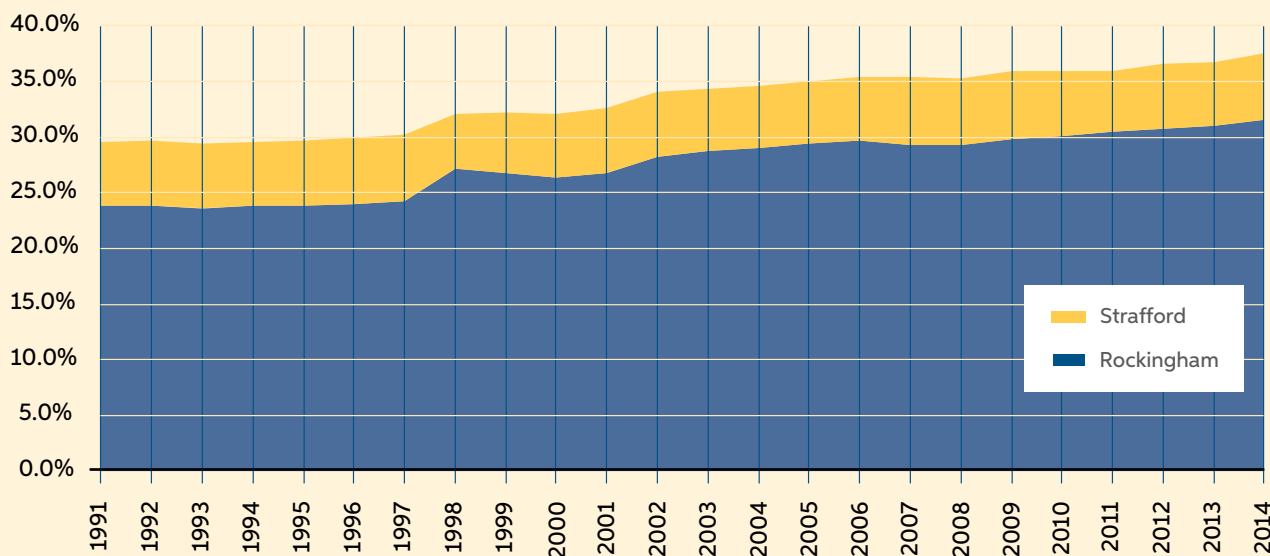
Answers to these questions are speculative at this point and require better understanding of both science and behavior. Without more extensive study of the seacoast real estate market, together with more precise estimates of the damage that various flooding scenarios might produce, we cannot make definitive 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 Strawberry 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.

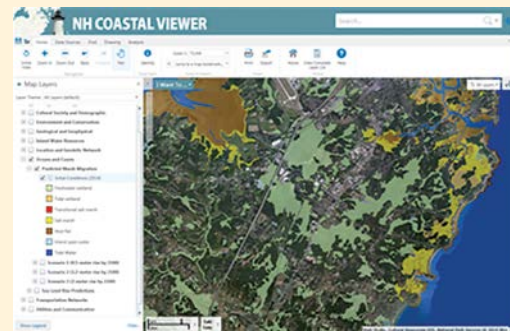
Throughout the Atlantic Coast municipalities, Route 1-A provides the vital transportation link on the coast and is essential to coastal communities for access, safety, livability, recreation and for the continued viability of the coastal tourist economy. With its direct shoreline exposure, it comes as 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 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

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/>.

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 Storms⁶² and C-RiSe⁶³ 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.

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.

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).



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).

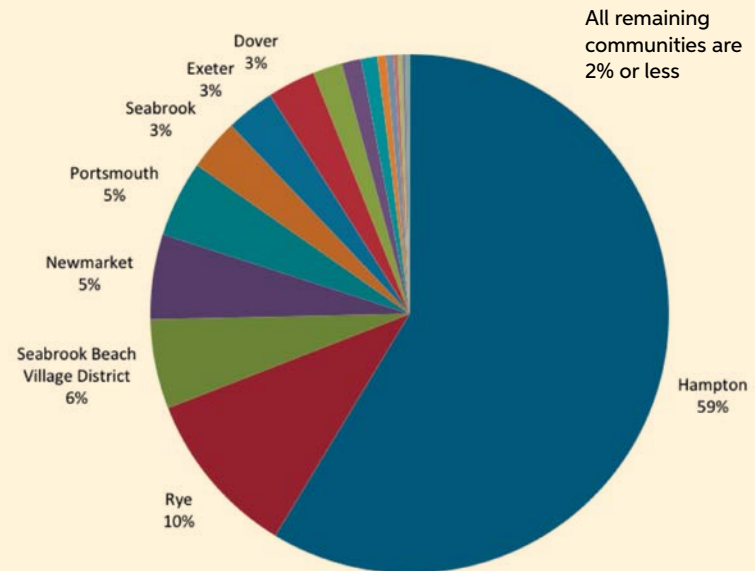
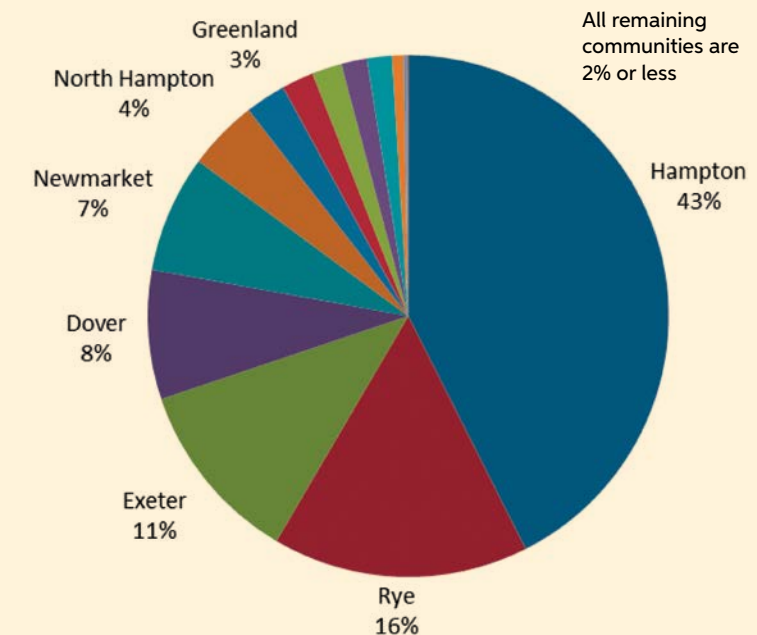


FIGURE 13. Percent of total NFIP paid loss amounts in Coastal New Hampshire since 1978. Source: NHOEP (2016c).



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.

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.

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](#)

Extreme Precipitation Impacts on Natural Systems

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.

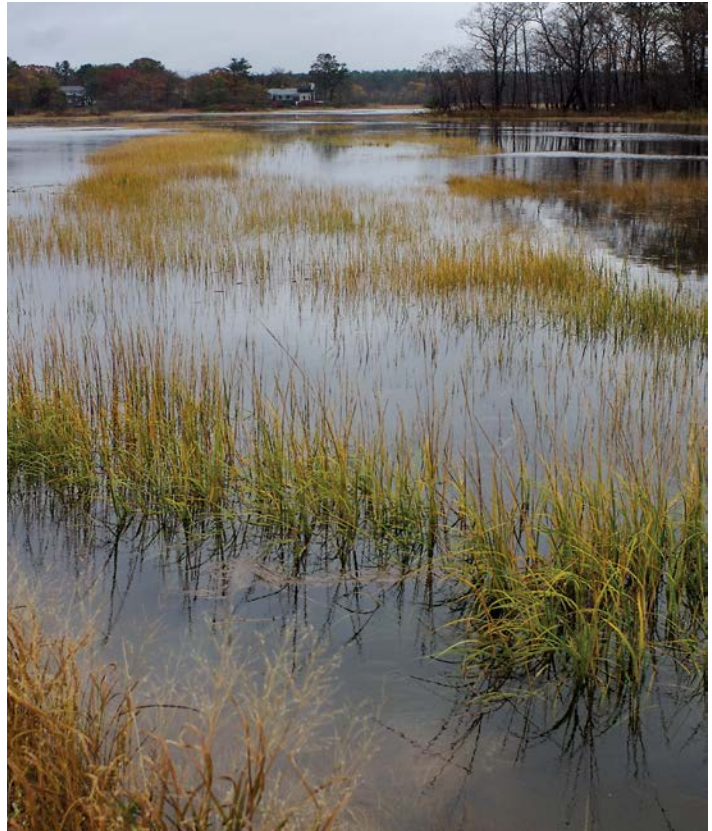


Photo credit: Tricia Miller

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

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



Photo credit: JoAnn Theriault

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).

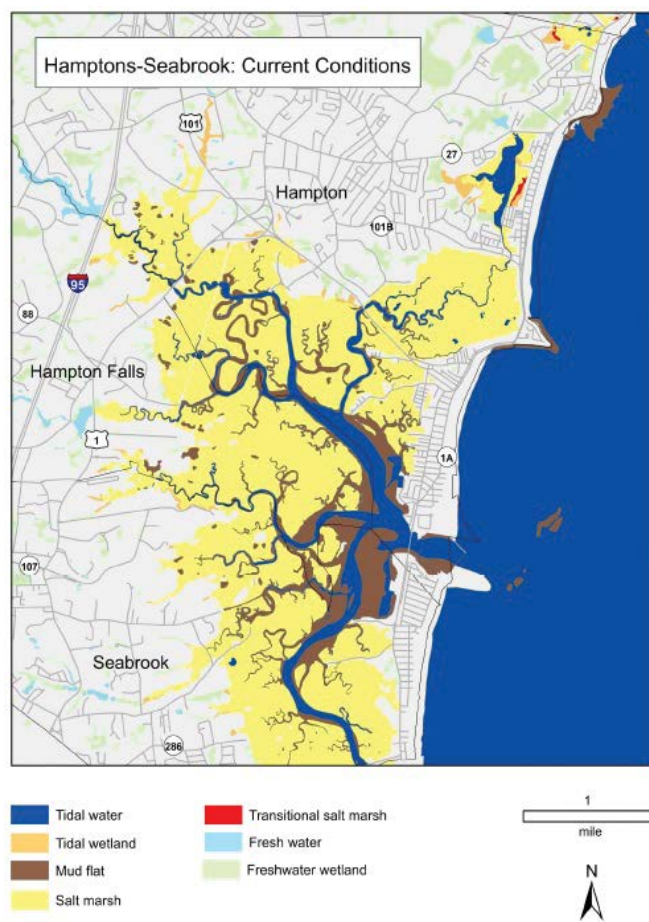
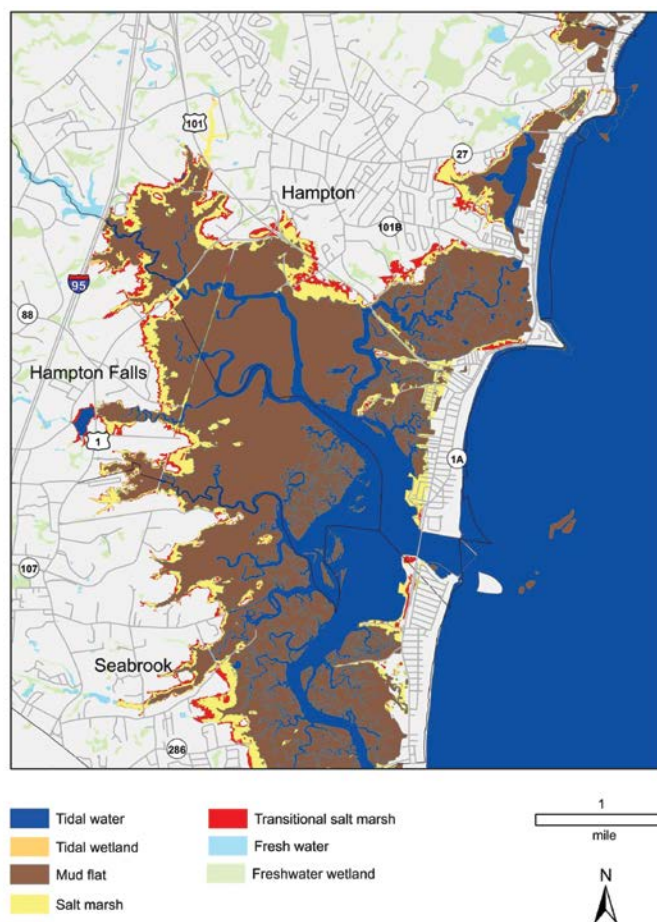


FIGURE 15. Modeled Hampton-Seabrook Estuary tidal wetlands in 2100 with 6.6 feet of sea-level rise. Source: NHFG (2014).



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. <i>[Lead: State Agencies].</i>
NR2.	Develop natural resource restoration plans that explicitly consider future coastal risk and hazards, and the ecological services that they provide. <i>[Lead: State Agencies; Municipalities].</i>
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. <i>[Lead: State Legislature; State Agencies; Municipalities].</i>
NR4.	Encourage State agencies and municipalities to consider ecosystem services provided by natural resources in land use planning, master plans, and asset decisions. <i>[Lead: State Agencies; Municipalities].</i>
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. <i>[Lead: State Agencies].</i>
NR6.	Assess current conditions of groundwater resources and impacts from best available climate science. <i>[Lead: State Agencies].</i>
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. <i>[Lead: State Agencies].</i>

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.

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).

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.

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.

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



Harry Hu/Shutterstock.com

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 Strawberry 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
Odiome 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

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



Photo credit: Todd Selig

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).

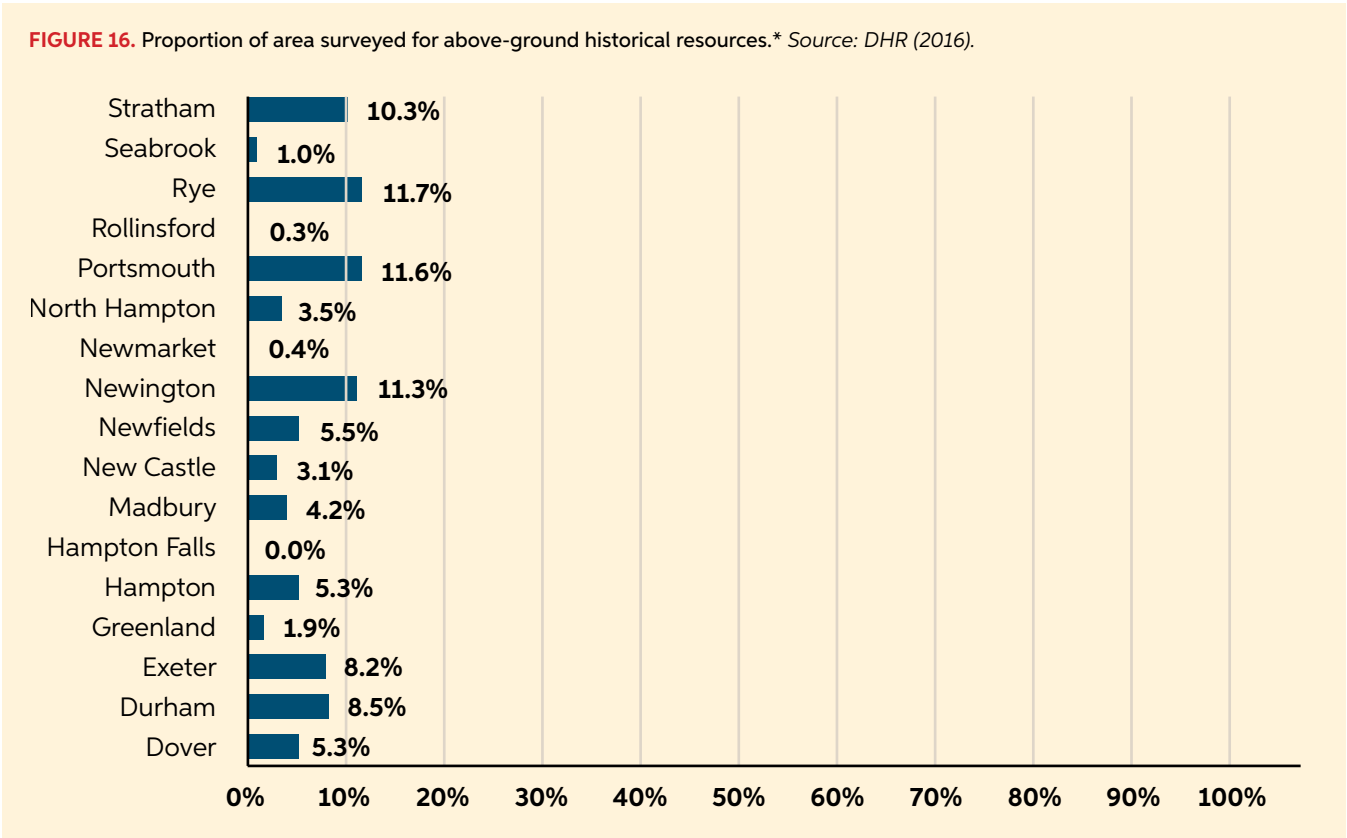
Sea-Level Rise (SLR) Scenarios	1.7 feet SLR	4.0 feet SLR	6.3 feet SLR	1.7 feet SLR + storm surge	4.0 feet SLR + storm surge	6.3 feet SLR + storm surge
National Register of Historic Places	4	4	4	4	5	5
NH State Register of Historic Places	0	0	0	0	0	0
Town of Dover						
Back River Farm	1	1	1	1	1	1
Town 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.



* 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. <i>[Lead: State Agencies; Municipalities].</i>
H2.	Develop plans and implement strategies to prepare and adapt recreational resources based on best available climate science. <i>[Lead: State Agencies; Municipalities].</i>
H3.	Identify and survey cultural and historic resources and assess their vulnerability to coastal risk and hazards based on best available climate science. <i>[Lead: State Agencies; Municipalities].</i>
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. <i>[Lead: State Agencies; Municipalities].</i>
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. <i>[Lead: State Legislature].</i>

5. Understanding What We Need To Do

5.1 General Guidance for Responding to Coastal Flood Risk

In formulating its recommendations, the Commission considered existing approaches to establishing general design and construction standards for structures and facilities that have been considered and enacted in New Hampshire, other states, and at the Federal level. These guidance resources have been summarized in [Appendix C](#). Based on that research, the Commission lays out general guidance and planning principles for responding to coastal flood risk in New Hampshire.

Options for Responses

The increased risk of exposure to coastal flooding from storm surge, sea-level rise, and extreme precipitation raises a number of important issues that should be considered at the state, regional, and local levels. There are considerations that apply to our collective approach and response to this challenge as a state and as communities, as well as responses that apply to the specific asset classes affected (e.g. our economy, our built landscape, our natural resources, and our heritage). The options for responses can be divided into three categories.

1. Defend

This response employs primarily engineered solutions whereby specific sections or features of coastline are protected to prevent coastal erosion and the loss of structures and facilities from flooding—to “keep the water out.” Defense techniques can include natural and built systems. Examples of natural systems include creating, protecting, or refurbishing existing sand dunes, vegetated and appropriately sized buffers along rivers and streams and intact wetland systems that can serve to absorb flood waters and wave energy. Built structures include seawalls, dikes, revetments, and ablative defenses such as beach nourishment. There are also hybrids of built and natural defense strategies. Other states have utilized sea walls that incorporate vegetated sections in certain areas. This approach enhances the look of the structure and offers additional benefits from natural defenses and other ecosystem services that vegetation can provide (habitat, food, shading, etc.). Defensive strategies may be appropriate where total cost is not excessive relative to the value of the assets being protected or where safety of populations is at stake. In the case of continuing sea-level rise, the cost effectiveness of this strategy can be expected to decline over time as the cost to defend fixed assets and populations becomes progressively greater. At some point, safety may no longer be reasonably assured regardless of the built and natural defenses.

Adapting Our Coastal Communities Together

The New Hampshire Coastal Adaptation Workgroup (NHCAW) is a collaboration of 22 partners and organizations working to help communities in southeastern New Hampshire prepare for the effects of extreme weather events and other effects of long term climate change.



Photo credit: Cathy Coletti

Since inception in 2010, NHCAW has led numerous projects and events that have elevated discussions about climate preparedness at municipal, state, and regional levels. NHCAW partners incorporate peer-reviewed science and research in the development of tools and technical guidance, and outreach in the coastal watershed to help communities better prepare for the effects of a changing climate in order to protect their social, economic, human and environmental health. For more information, refer to NHCAW’s website at www.nhcaw.org.

2. Accommodate

Accommodation combines engineered, natural, behavioral, and land use solutions to minimize flooding and, where possible, “live with water.” Common accommodate examples include elevating structures on pilings in flood prone areas and designing buildings to allow flood waters to enter the lowest floor while relocating vulnerable systems (heating/cooling units, electricity, and plumbing) to upper floors to avoid damage. Another accommodate strategy is the use of cleared natural drainage corridors for storm driven waves



Photo credit: Daniel Gobbi

between the ocean and back channel sides of barrier islands. Accommodation usually happens incrementally in response to changing conditions; however, this incremental approach presents significant challenges in the case of linear facilities such as roads, sewer lines, and other utilities. They must be modified in logical segments requiring a coordinated approach. The mix of accommodate strategies can be expected to change incrementally as some strategies decline in effectiveness as the severity of the flooding impact progresses.

3. Retreat

This response involves abandoning or converting areas where the frequency and severity of flooding impacts are such that permanent settlement is no longer viable or desirable. This response could be undertaken quickly as the consequence of a government buyout or resettlement program (e.g., immediately after a severe flood), or it could occur slowly – the result of a growing inability to provide essential services and of many independent decisions made over time by individual property owners to leave a vulnerable area because of rising costs, repeated loss, or unacceptable risk. Innovative regulatory methods such as rolling easements can facilitate incremental retreat by allowing the existing use of properties for as long as use remains viable, but prohibiting any shoreline armoring or other engineered protections.

In New Hampshire, and likely in other coastal states, the approach taken will be a combination of all three options. Appropriate strategies will likely change over time as the degree of flood risk and exposure rises, requiring the State and municipalities to periodically reassess their responses.

Guiding Principles

Based on the science reviewed and documented in the STAP report, flood risk in the coast is rising, but the rate of that rise is uncertain. A response to defend a segment of coast that is sensible and cost effective in 2050 may become untenable in 2100. Making sensible long-term recommendations with this uncertainty is challenging, and requires flexible approaches. Nevertheless, there are some general guidelines and principles that are useful in making the best possible decisions along the way.

Act Early

Responding now to the future threat of coastal flooding will maximize long-term cost savings that result from building more resilient communities. Resilience is achieved in part by ensuring all current and future investments in facilities and structures can accommodate increases in flood levels expected over their design life without

sustaining large losses. If all future new construction and major renovations in vulnerable areas incorporate resilient designs appropriate to the risk expected within the facility's design life, communities can become incrementally more resilient over time. By starting now, the normal cycles of construction, replacement, and redevelopment can be harnessed to gradually replace substandard designs, often at minimal additional costs.

Communities that implement climate adaptation actions early may see many benefits, including but not limited to:



Photo credit: Laura Fallis

- Enhanced preparedness and community awareness of future flood risks,
- Early identification of cost-effective measures to protect and adapt to changing conditions,
- Improved resiliency of facilities, structures, and other community investments, and
- Protected life, property, and local economies,
- Protected coastal natural resources and the critical services they provide,
- Preserved historical assets and unique community character, and
- Additional credit points awarded through the NFIP Community Rating System (CRS), which provides flood insurance premium discounts for residents in participating communities.

Respond Incrementally

The most difficult circumstance under which to take action in response to a future threat is when there is uncertainty about the degree of risk from that threat. This is especially true when the threat is distant in time and the cost of responding is high – such as with the coastal flooding threat from climate change. In coastal flooding there is risk both in over- and under-estimating the threat. If overestimated, actions may be taken that are unnecessarily expensive and disruptive. If underestimated significant losses in property, resources, and even lives could result.

In these circumstances, an incremental and iterative approach is best, allowing multiple opportunities to refine and correct actions as understanding improves. An incremental approach can adjust to either gradual or catastrophic sea-level rise. At this juncture wholesale investment in hardened shoreline protection structures and major efforts to retreat are not necessary, though these strategies may be appropriate in select, isolated locations. Instead, improving resiliency and the ability to adapt to a wide range of scenarios is the best course of collective action.

Revisit and Revise

Over time, we expect projections of sea-level rise and other contributors to coastal flooding to become more certain, and as they do, we will be better able to predict both the rate at which and by how much sea level is expected to rise. This refinement will allow estimates of vulnerability to become more precise. Likewise, our responses must keep pace with changes in understanding. It is vitally important that state and municipal officials periodically revisit these projections and assumptions and adjust the report's recommendations accordingly.

Collaborate and Coordinate

The State and municipalities share built and natural assets on the coast, and as a result, they need to align policies, assumptions, and responses about future coastal flood hazards to the greatest extent possible. Failure to coordinate such policies and actions will increase the cost and decrease the effectiveness of planning and preparation. Long-term planning and actions to prepare for future flood risk should be developed collaboratively between state, regional, and local governments.

Incorporate Risk Tolerance in Design

With respect to future coastal flood risk, structures, facilities, and other resources should be designed with high safety margins, however, in preparing for future hazards, not all situations warrant the same precautions. Risk tolerance is an important concept in creating sensible and flexible building and design standards. Buildings and facilities that are critical to public functions or safety, that are intended to last a very long time, or that are very expensive to replace should be considered to have low risk tolerance. Facilities and assets with low risk tolerance include (but are not limited to) hospitals, water treatment facilities, bridges, and utilities, as well as irreplaceable or unique historic sites, essential ecosystems, and high value economic assets. In other words, these are assets we can't afford to lose. Design standards should be high for facilities that have low risk tolerance, even if cost is higher to build or maintain them – because as a society we can't afford to do otherwise. Conversely, facilities and structures that are low value, short-lived, easily replaced, or that don't serve a critical function have a high risk tolerance. They do not necessarily require as much concern and can be designed to lower standards.



Photo credit: Nathalie Morison

Make No Regrets Decisions

Generally a no regrets policy or approach refers to actions that yield multiple benefits even under the lowest sea-level rise scenario.^{vii} More often than not, acting in ways that improve a community's resilience to present-day risk and hazards will enhance its adaptive capacity to address longer term climate change impacts. Additionally, no regrets decisions should incur relatively low costs or save money over the medium to long term. For example, elevating a pump station three feet above current base flood elevation will increase its ability to function during current coastal storm and flood events, regardless of how much sea level rises in the future. Not only will a functioning pump reduce flooding impacts, it may also remove the need and associated risk and costs for repairs or replacement during or immediately following an emergency or disaster.

5.2 Science and Technical Advisory Panel Guidance

As described in Section 3, The Science and Technical Advisory Panel (STAP) report synthesized the best available science regarding future estimates of storm surge, sea-level rise, and extreme precipitation. The STAP report includes several suggested planning guidelines for the three hazards: storm surge, sea-level rise, and extreme precipitation.

^{vii} The National Climate Assessment (2014) *lowest scenario* (0.7 feet by 2100), summarized by the STAP, assumes the historical rate of sea-level rise over the past century continues into the future and does not account for projected rapid changes in atmospheric and ocean temperatures over the 21st century, nor the projected rapid loss of ice from the Greenland and West Antarctic ice sheets.

5.2.1 Storm Surge

The STAP recommends using probabilities of storm frequency and magnitude embodied in updated FEMA Federal Insurance Rate Maps for coastal New Hampshire.

5.2.2 Sea-level Rise

The STAP recommends that for coastal locations where there is little tolerance for risk to a built or natural asset; the range of sea-level rise to consider in planning and design includes the ‘Intermediate High’ and ‘Highest’ scenarios (see Figure 2). The STAP suggests the following planning guidance to determine the appropriate range based on design life:

-
1. Determine the time period over which the system, structure, or facility is designed or desired to serve (either in the range 2014–2050, or 2051–2100).
-
2. If the design time period is 2014–2050, commit to manage to 1.3 feet of sea-level rise, but be prepared to manage and adapt to 2 feet if necessary.
-
3. If the design or desired time period is 2051–2100, commit to manage to 3.9 feet of sea-level rise, but be prepared to manage and adapt to 6.6 feet if necessary.
-
4. Be aware that the projected sea-level rise ranges may change and prepare to adjust design considerations if necessary. The choice of management strategies can include strategies to protect, accommodate, or retreat from the flood risk.
-

For example, in the case of a new tide gate intended to last until 2075, the gate could be constructed for the Highest scenario (6.6 feet) now, which would be the most robust approach, or constructed for 2 feet of future sea-level rise now but in a manner that would facilitate expanding and raising the gate to protect against 3.9 or 6.6 feet of sea-level rise, if future assessments indicate that is necessary. This could be accomplished by designing and constructing the gate foundation for the 6.6 feet sea-level rise scenario while only constructing the gate for a 2-foot sea-level rise scenario. The choice of management strategies can include strategies to protect, accommodate, or retreat from the threat.

5.2.3 Extreme Precipitation

For extreme precipitation the STAP recommends:

- If the design time period is 2014–2050, buildings and infrastructure should be designed to withstand extreme precipitation intensities based on the most current precipitation data^{viii}, with the assumption that a gradual increase in frequency of extreme precipitation events will occur over time.
- If the design period is 2051–2100, buildings and infrastructure should be designed to manage a 15 percent increase in the amount of precipitation produced during extreme precipitation events after 2050.

Over time, improved data collection, analysis, and modeling will provide better scientific understanding and higher confidence in projected future changes in storm surge, sea level, and extreme precipitation. Given the current limitations in providing narrow estimates of future conditions with high confidence, applying the concept of risk tolerance becomes important in determining how best to plan and design for the future. The STAP guidance strongly suggests that adaptive and flexible designs that anticipate future flood scenarios become standard procedures for construction within vulnerable areas.

^{viii} Current precipitation data can be taken from the NOAA Atlas 14 (<http://hdsc.nws.noaa.gov/hdsc/pfds/>), the Northeast Regional Climate Center (<http://www.nrcc.cornell.edu/>), or more up to date or better resolution sources.

6. Our Goals, Recommendations, and Actions



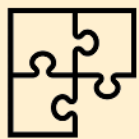
Four Goals for a Resilient Coastal New Hampshire – SAIL

The Commission has defined four goals for coastal New Hampshire that are paramount to managing our coastal risk and hazards so that municipalities along the Atlantic Ocean and surrounding the Great Bay estuary can be resilient in the face of climate changes, including changes in storm surge, sea level, and extreme precipitation. The four goals focus on science, assessment, implementation, and legislation – “SAIL,” in honor of the New Hampshire state seal which features the frigate Raleigh, a warship built in Portsmouth in 1776, and a granite boulder in the foreground that, according to seal law, is “symbolic of the Granite State’s rugged terrain and the character of its citizenry.”^v



Goal 1: SCIENCE

Research, understand, establish, and use the best available science about current and future coastal hazards in New Hampshire relating to storm surge, sea-level rise, and extreme precipitation.



Goal 2: ASSESSMENT

Identify assets and resources within our economy, our built landscape, our natural resources, and our heritage that are vulnerable to storm surge, sea-level rise, and extreme precipitation; understand the scope of that vulnerability; and evaluate existing statutes, ordinances, rules and regulations, policies, programs, and plans to determine whether changes should be made to reduce vulnerabilities.



Goal 3: IMPLEMENTATION

Identify and implement strategies that will enable the State and coastal municipalities to effectively protect, adapt, and sustain our current and future economy, built landscape, natural resources, and heritage.



Goal 4: LEGISLATION

Recommend timely considerations for legislation that leads to actions, both immediate and long-term, that reduce and/or eliminate vulnerability and result in adaptation to existing and future coastal hazards.

Who are these recommendations for and how will we achieve them?

Under each SAIL goal, the Commission identified key recommendations and actions that will help coastal New Hampshire prepare for and respond to coastal risk and hazards. In order to carry out the recommendations, and ultimately, achieve the SAIL goals, many different groups will need to work together. The recommendations are primarily directed to the State Legislature, State agencies, and municipal governments. Lead responsible parties – the entity or entities most likely to lead and coordinate efforts to achieve the recommendation – are identified under each recommendation in parentheses; however it is important to note that every recommendation will require collaboration and coordination between the three primary audiences and public and private stakeholders.

^v The State Seal history can be accessed at <https://www.nh.gov/nhinfo/seal.html>.

The Commission recognizes that many of the recommendations will take time to achieve and require new funding and expertise. In particular, municipalities will likely require targeted technical assistance in order to carry out the Commission's recommendations. Additionally, the Commission recognizes that state agencies, municipalities, and other stakeholders have already started to act on some of the recommendations listed. The recommendations and the associated actions should be prioritized by the lead responsible parties based on the risk associated with the hazard addressed, cost, and ease of implementation. Additional details concerning the target timeframe and estimated budget to complete each recommendation and the associated actions should also be developed by responsible parties as they prioritize recommendations for implementation.

How are these recommendations organized?

The Commission makes **five Science** recommendations and **30 Assessment and Implementation** recommendations. Of these 35 recommendations, **14** have **Legislative** implications. Assessment and Implementation recommendations are paired by subject and organized into four topic areas: **Our Economy**, **Our Built Landscape**, **Our Natural Resources**, and **Our Heritage**. **Cross-cutting** recommendations include recommendations that apply to all four of the topic areas. It is important to note that the topic areas overlap—some of the structures and facilities that comprise our built landscape may also be part of our heritage—so many recommendations could fit into multiple topic areas. These four topic areas help to organize the recommendations, but should not be seen as mutually exclusive categories.



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



OUR BUILT LANDSCAPE is the network of structures and facilities owned by state and municipal governments and private entities in coastal New Hampshire. Our built landscape must be prepared to adapt and respond to coastal risk and hazards.



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.



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 municipalities wish to protect from coastal risk and hazards.

6.1 Science Recommendations



GOAL 1 is to research, understand, establish, and use the best available science about current and future coastal hazards in New Hampshire relating to storm surge, sea-level rise, and extreme precipitation.



S1. Legislatively authorize a state agency to convene a Science and Technical Advisory Panel to review and evaluate the current state of climate change science in order to periodically update storm surge, sea-level rise, extreme precipitation and other relevant climate projections and provide planning guidance at least once every five years. [Lead: State Legislature].

ACTIONS:

- a. Establish a collaborative Science and Technical Advisory Panel and a lead state agency to coordinate updated information and recommendations.
- b. The Panel, lead agency, and other participating agencies develop a mechanism that ensures communication of the updated climate science and planning guidance to a wide range of stakeholders.

S2. Identify gaps in scientific information, work to fill existing scientific information gaps, and conduct quantitative analyses detailing coastal risk and hazards. [Lead: State Agencies].

ACTIONS:

- a. Improve coastal storm surge analysis by including wave effects and upland flooding impacts.
- b. Gather baseline data to improve analysis of coastal and riverine flood risks resulting from a combination of storm surge, sea-level rise, and extreme precipitation events in coastal areas directly exposed to the Atlantic Ocean and inland areas with tidal rivers, bays and marshes.
- c. Conduct additional applied research to better understand the following:
 - i. Flooding extent resulting from combined impacts of future climate and land use changes for upland and riverine communities and ecosystems.
 - ii. Capacity of natural resources like salt marshes and eelgrass beds to respond to projected changes in storm surge, sea level, and extreme precipitation.
 - iii. Changes in physical parameters, species composition, and ecological communities resulting from projected changes in storm surge, sea level, and extreme precipitation.
 - iv. Changes in the species food web that may endanger New Hampshire ecosystems resulting from projected changes in storm surge, sea level, and extreme precipitation.
 - v. Ecosystem services related to flood attenuation, physical protection from storms, and pollutant attenuation.
 - vi. Changes in frequency and severity of winter storm events resulting in large amounts of snow and ice pack and related impacts.
 - vii. Saltwater intrusion into coastal surface and ground water sources.
 - viii. Impacts of future drought conditions on groundwater and drinking water sources, natural resources, and other assets.
 - ix. Differential social impacts of storm surge, sea-level rise, and extreme precipitation, and appropriate adaptation strategies needed to better prepare socially vulnerable populations (i.e., social vulnerability analyses).

- d. Collaborate with science, planning and management professionals to determine current and future research gaps. The Panel established under Science Recommendation S.1 (a) could help coordinate this collaboration.

S3. Establish a central repository for spatial coastal hazards-related information, and assign and fund an entity to maintain and adapt this tool over time. [Lead: State Agencies].

ACTIONS:

- a. Identify the appropriate data repository for critical coastal information and a strategy for its funding and maintenance. Consider existing spatial databases, including the NH Coastal Viewer managed by NH GRANIT.
- b. Identify funding for on-going support of the coastal hazards data repository or database.
- c. Establish a mechanism to ensure adequate data sharing exists among state agencies and GRANIT for spatial coastal hazards-related information.

S4. Provide clear, concise, science-based information to inform and raise awareness of relevant audiences about the risks and vulnerabilities associated with coastal risk and hazards. [Lead: State Agencies].

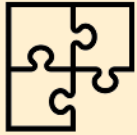
ACTIONS:

- a. Create and compile informational materials about coastal hazards, risks and vulnerability.
- b. Strengthen state, regional, and municipal capacities to better understand the best available science related to potential future impacts of climate change in order to improve decisions.
- c. Improve understanding of the concepts of uncertainty and risk and how they can be applied to decision-making and action planning.
- d. Partner with federal and state agencies as well as regional and local organizations to expand resources for education, outreach, and coordination.
- e. Identify and provide education and outreach to new groups (e.g., socially vulnerable populations, local businesses) by partnering with new entities, holding events at their established venues and meetings, and tailoring materials to meet their needs.
- f. Encourage the incorporation of climate science and information about the risks and hazards associated with changing climatic conditions in public school curriculum.
- g. Dedicate funding and technical support to implement science-based education and outreach efforts related to coastal risk and hazards.



S5. Augment state funding in support of applied research that improves understanding, modeling, and projections of current and future coastal risk and hazards in New Hampshire's coastal zone. [Lead: State Legislature].

6.2 Assessment & Implementation Recommendations: Cross-Cutting



GOAL 2 is to identify assets and resources within our economy, our built landscape, our natural resources, and our heritage that are vulnerable to storm surge, sea-level rise, and extreme precipitation; understand the scope of that vulnerability; and evaluate existing statutes, ordinances, rules and regulations, policies, programs, and plans to determine whether changes should be made to reduce vulnerabilities.



GOAL 3 is to Identify and implement strategies that will enable the State and coastal municipalities to effectively protect, adapt, and sustain our current and future economy, built landscape, natural resources, and heritage.



The Crosscutting recommendations below include assessment and implementation recommendations that apply to all four of the topic areas:

Our Economy,
Our Built Landscape,
Our Natural Resources,
and **Our Heritage.**



CC1. Secure new and allocate existing funding sources for state agencies and municipalities to conduct vulnerability assessments of assets at appropriate scales and to implement adaptation strategies. [Lead: State Legislature; State Agencies; Municipalities].

Note: This recommendation summarizes the funding-related actions found throughout the assessment and implementation recommendations.

ACTIONS:

- a. Fund coastal vulnerability assessments and dissemination of results (see CC2 and BL1 (b)).
- b. Fund state agency audits of existing statutes and administrative rules (see CC3).
- c. Dedicate funding and technical assistance for state agencies and municipalities to incorporate the Science and Technical Advisory Panel report, as amended, in development standards, land use policies, and plans (see CC5 (b)).
- d. Establish a funding mechanism to assist state agencies in covering the costs of emergency and disaster response and recovery (see CC 5 (e)).
- e. Apply for and utilize FEMA mitigation grants and other sources of funding to implement climate adaptation and planning strategies that reduce or eliminate flooding impacts (see CC6 (a)).
- f. Create and utilize a dedicated fund to acquire repetitive loss properties when structures and facilities are abandoned or destroyed (see CC6 (d)).
- g. Identify mechanisms to raise matching funds for FEMA and other grant programs, such as creating a dedicated state flood mitigation fund (see CC6 (e)).
- h. Establish stormwater utilities to fund retrofits to existing development and future improvements (see E3 (b)).
- i. Utilize existing funding sources for natural resource restoration (e.g. offset measures, state Aquatic Resource Mitigation fund) (see NR2 (d)).
- j. Establish dedicated funds and sources to support land preservation, restoration, acquisition of easements, and development rights to transfer vulnerable property to conservation lands (see NR3 (b)).
- k. 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 (see H5).



CC2. Identify vulnerable state and municipal assets at regional, municipal, and site-specific scales as appropriate. [Lead: State Agencies; Municipalities].

ACTIONS:

- a. Assess existing regional emergency services and evacuation routes and identify additional service needs, points, and routes where necessary.
- b. Collaborate with private sector representatives to evaluate and identify necessary improvements to emergency communications systems preparedness to ensure 911 and other critical communications services remain operational during emergencies and disasters.
- c. Develop site-specific vulnerability assessments for public assets at risk from increased coastal flooding based on the flooding scenarios presented in the Science and Technical Advisory Panel report, as amended.
- d. Provide local technical assistance to perform vulnerability assessments through collaborative partnerships and local and regional networks, such as the NH Coastal Adaptation Workgroup.
- e. Disseminate and share results from coastal vulnerability assessments with relevant audiences.
- f. Dedicate existing funding for coastal vulnerability assessments and dissemination of results.



CC3. Review whether existing state statutes and rules adequately permit state agencies and municipalities to prepare and adapt to best available climate science and impacts, and make recommendations for amendments or new regulations where necessary. [Lead: State Agencies].

ACTIONS:

- a. Require and provide funding for state agencies to evaluate and recommend necessary amendments to relevant statutes and administrative rules with respect to best available climate science, involving relevant stakeholders as appropriate. Relevant statutes and administrative rules include, but are not limited to, the following: RSA 483-B Shoreland Water Quality Protection Act, RSA 482-A Fill and Dredge in Wetlands, 485-A:29-39 Subsurface Systems, 485-A:17 Terrain Alteration, RSA 230:78 State Highways, RSA 230:79 Liability of NHDOT, and RSA 79-A Current Use.
- b. Review current practices to determine the most appropriate buffer and setback distances, freeboard, shoreline treatment, and other design standards and approaches needed to provide adequate levels of risk reduction and protection for at risk structures and facilities.
- c. Develop an approach to consolidate RSA 483-B Shoreland Water Quality Protection Act and RSA 482-A Fill and Dredge in Wetlands to create permitting efficiencies and allow for comprehensive management of tidal resources.
- d. Assess the status of existing state agency, municipal, and other disaster response and recovery plans, and determine whether new procedures or regulations are necessary to enable response and recovery planning at state and municipal levels.
- e. Identify and recommend modifications to state and local building codes necessary to protect against likely changes in flooding and other coastal hazards.



CC4. Amend state laws and rules to incorporate consideration of best available climate science and weather-related data. [Lead: State Legislature].

ACTIONS:

- a. Adopt amendments to state statutes and administrative rules identified under Cross-cutting Recommendation CC3, including, but not limited to: RSA 483-B Shoreland Water Quality Protection Act, RSA 482-A Fill and Dredge in Wetlands, 485-A:29-39 Subsurface Systems, 485-A:17 Terrain Alteration, RSA 230:78 State Highways, RSA 230:79 Liability of NHDOT, and RSA 79-A Current Use Taxation.



CC5. By 2019^{vi}, state agencies will consider and use best available climate science in their activities and plans. [Lead: State Legislature].

ACTIONS:

- a. Establish the Science and Technical Advisory Panel report (see Science Recommendation S1), as amended, as state agency and municipal guidance about anticipated future climate and coastal flooding conditions.
- b. Dedicate funding and technical assistance for state agencies and municipalities to incorporate the Science and Technical Advisory Panel report, as amended, in development standards, land use policies, and plans.
- c. Establish a mechanism to monitor state agency and municipal use of Science and Technical Advisory Panel findings and recommended approaches to risk management.
- d. Require state agencies to address current and future coastal risk and hazards in preparation, response, and recovery plans.
- e. Establish a funding mechanism to assist state agencies in covering the costs of emergency and disaster response and recovery.
- f. Integrate social vulnerability information in adaptation planning, emergency preparedness strategies, and public health interventions.



CC6. Make existing structures and facilities more resilient and acquire properties in high risk areas in order to reduce or eliminate flooding impacts. [Lead: State Legislature; State Agencies; Municipalities].

ACTIONS:

- a. Apply for and utilize FEMA mitigation grants and other sources of funding to implement climate adaptation and planning strategies that reduce or eliminate flooding impacts.
- b. Elevate existing at-risk structures and implement higher freeboard standards above the Base Flood Elevation on new and substantially reconstructed structures and facilities to protect from future flood risks (see BL2 for more detail).
- c. Acquire at-risk and repetitive loss properties to create buffers and open space that facilitate restoration of floodplain functions.
- d. Create and utilize a dedicated fund to acquire repetitive loss properties when structures and facilities are abandoned or destroyed.
- e. Identify mechanisms to raise matching funds for FEMA and other grant programs, such as creating a dedicated state flood mitigation fund.

^{vi} This timeframe was determined to be acceptable by the state agencies on the NH Coastal Risk and Hazards Commission.



CC7. Encourage municipalities to incorporate coastal hazards, risks and vulnerability in policies, plans and investments. [Lead: Municipalities].

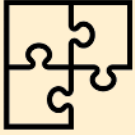
ACTIONS:

- a. Evaluate deficiencies and barriers in municipal regulations, plans and policies, and their implications for regional vulnerability.
- b. Incorporate coastal hazards and risks assessments, including social vulnerability information, in municipal hazard mitigation plans, natural hazards and climate change adaptation Master Plan chapters, and emergency management plans.
- c. Encourage municipalities to develop detailed preparation, response and recovery plans that build on existing plans and initiatives.
- d. Encourage municipalities to adopt buffers and setbacks that better account for risk and vulnerability of structures, facilities, and natural resources and maintain ecosystem services (e.g. flood storage, storm surge attenuation, reduced impacts to public structures and facilities, and private property).
- e. Incorporate vulnerability assessment information and adaptation strategies for structures and facilities planning and investment for long term capital projects in municipal Capital Improvement Programs (CIPs).
- f. Improve connections between municipal hazard mitigation plans, master plans and capital improvement plans.
- g. Identify and reduce existing inconsistencies between municipal plans and state plans, such as hazard mitigation plans, building codes, design standards, and evacuation plans.
- h. Consider the concepts of uncertainty and risk in decision-making and action planning.
- i. Encourage communities that conduct floodplain management activities that exceed the minimum requirements of the National Flood Insurance Program (NFIP) to consider joining and participating in the Community Rating System (CRS), which provides discounts to annual flood insurance premiums for some residents and businesses as a reward for their community's activities.



CC8. Establish an adaptation coordinator to monitor and coordinate implementation of the NH Coastal Risk and Hazards Commission recommendations. [Lead: State Legislature].

6.3 Assessment & Implementation Recommendations: Our Economy



Identify economic assets that are vulnerable to storm surge, sea-level rise, and extreme precipitation; understand the scope of that vulnerability; and evaluate existing statutes, ordinances, rules and regulations, policies, programs, and plans to determine whether changes should be made to reduce vulnerabilities.



Identify and implement adaptation strategies that will enable the State and coastal municipalities to protect, adapt, and sustain our current and future 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 risk and hazards in order to create and sustain jobs and a high quality of life in coastal New Hampshire.



- 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].**

ACTIONS:

- Encourage private property owners and businesses to incorporate best available climate science and vulnerability assessments in their decision making and preparedness plans.
- Consider vulnerabilities of local tax base, state economic development plan, retention or replacement of economic resources, at risk populations and population migration.
- Improve management, coordination and delivery mechanisms to ensure continuity of services to essential facilities, people, businesses and employment centers.



- 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].**

ACTIONS:

- Align land acquisition and easement programs to transfer vulnerable properties into conservation.
- Establish stormwater utilities to fund retrofits to existing development and future improvements.
- Develop and utilize tools to identify cost effective strategies and public investments for adapting to increased flood risk in vulnerable areas.
- Develop special overlay districts, tax credits and revolving loan funds as mechanisms to discourage development in vulnerable areas.

- e. Implement voluntary transfer of development rights programs and other economic incentives to acquire or conserve property in high risk areas.
 - f. Create statewide and municipal funding programs for climate adaptation strategies.
 - g. Adapt economic development planning approaches to respond to changing environmental conditions and leverage shifting opportunities.
 - h. Promote resilience and sustainability planning as economic development strategies.
-

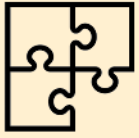


E4. Improve information available to property owners and prospective buyers about coastal hazards and vulnerabilities. *[Lead: State Agencies; Municipalities].*

ACTIONS:

- a. Improve consumer protection disclosure of properties vulnerable to coastal flooding.
 - b. Distribute flood protection safety information to property owners in high-risk areas.
 - c. Encourage homeowners in moderate- to low-risk areas to purchase Preferred Risk NFIP Policies.
-

6.4 Assessment & Implementation Recommendations: Our Built Landscape



Identify assets (i.e., structures and facilities) in our built landscape that are vulnerable to storm surge, sea-level rise, and extreme precipitation; understand the scope of that vulnerability; and evaluate existing statutes, ordinances, rules and regulations, policies, programs, and plans to determine whether changes should be made to reduce vulnerabilities.



Identify and implement strategies that will enable the State and coastal municipalities to effectively protect, adapt, and sustain our current and future built landscape.



Our Built Landscape is the network of structures and facilities owned by state and municipal governments and private entities in coastal New Hampshire. Our built landscape must be prepared to adapt and respond to coastal risk and hazards.



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].

ACTIONS:

- Use initial assessments to identify need for more detailed assessments.
- Require and secure funding for state agencies to conduct vulnerability assessments of state-owned structures and facilities located in the coastal zone at regional, municipal, and/or site-specific scales as appropriate.



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].

ACTIONS:

- Adopt amendments to state and local building codes recommended under Cross-cutting Recommendation CC3.
- Require state agencies, through legislation or amendment to NH Executive Order 96-4^{vii}, to use one of the following approaches ^{viii}, ix, x for determining a higher vertical flood elevation and expanded corresponding horizontal floodplain than the current base flood elevation and floodplain to address current and future flood risk for state-funded new construction, substantial improvement, or repairs to substantially-damaged structures and facilities:

^{vii} NH Executive Order 96-4 directs State agencies to comply with the floodplain management requirements of all local communities participating in the NFIP in which State-owned properties are located.

^{viii} See Federal Executive Order 13690, Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Input.

^{ix} See Guidelines for Implementing Executive Order 13690.

^x See [Appendix F](#) for State of New Hampshire comments on Draft Guidelines for Implementing Executive Order 13690.

- i. *Climate-informed Science Approach* – use the best available, actionable hydrologic and hydraulic data and methods that integrate current and future changes in flooding based on climate science.^{xi}
 - ii. *Freeboard Value Approach* – use the freeboard value, reached by adding an additional two (2) feet to the base flood elevation for non-critical structures and facilities and from adding an additional three (3) feet to the base flood elevation for critical^{xii} structures and facilities.
 - iii. *The 0.2-percent-annual-chance Flood Approach* – use the 0.2-percent-annual-chance flood elevation (also known as the 500-year flood elevation).
- c. Encourage municipalities to use one of the following three approaches^{xiii,xiv,xv} for determining a higher vertical flood elevation and expanded corresponding horizontal floodplain than the current base flood elevation and floodplain to address current and future flood risk for new construction, substantial improvement, or repairs to substantially-damaged municipal and private structures and facilities:
 - i. *Climate-informed Science Approach* – use the best available, actionable hydrologic and hydraulic data and methods that integrate current and future changes in flooding based on climate science.^{xvi}
 - ii. *Freeboard Value Approach* – use the freeboard value, reached by adding an additional two (2) feet to the base flood elevation for non-critical structures and facilities and from adding an additional three (3) feet to the base flood elevation for critical^{xvii} structures and facilities.
 - iii. *The 0.2-percent-annual-chance Flood Approach* – use the 0.2-percent-annual-chance flood elevation (also known as the 500-year flood elevation).
- d. Develop model regulations for municipalities to consider adopting into their existing floodplain management regulations, which can assist municipalities in becoming more flood resilient by addressing current and future flood conditions using the best available flood risk and climate science information.
- e. Amend the New Hampshire Stream Crossing Guidelines to incorporate anticipated future stormwater flows based on best available climate science.
- f. Incorporate the Science and Technical Advisory Panel report information, as amended, into benefit-cost analyses for applications submitted under FEMA Hazard Mitigation Assistance and Public Assistance grant programs. In relevant cases, consider timeframes for potential future relocation or retreat by acquiring at-risk properties.
- g. Require, through legislation or other means, that the New Hampshire Site Evaluation Committee and Public Utilities Commission take future sea-level rise and coastal flooding into account in project siting decisions and other planning.

^{xi} An acceptable source of climate science for New Hampshire includes the Coastal Risk and Hazards Commission Science and Technical Advisory Panel report, Sea-level Rise, Storm Surges, and Extreme Precipitation in Coastal New Hampshire: Analysis of Past and Projected Trends, as amended.

^{xii} Any activity for which even a slight chance of flooding would be too great. For expanded description of “critical action” see Part I, Section 6 of Guidelines for Implementing Executive Order 13690.

^{xiii} See Federal Executive Order 13690, Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Input.

^{xiv} See Guidelines for Implementing Executive Order 13690.

^{xv} See [Appendix F](#) for State of New Hampshire comments on Draft Guidelines for Implementing Executive Order 13690.

^{xvi} An acceptable source of climate science for New Hampshire includes the Coastal Risk and Hazards Commission Science and Technical Advisory Panel report, Sea-level Rise, Storm Surges, and Extreme Precipitation in Coastal New Hampshire: Analysis of Past and Projected Trends, as amended.

^{xvii} Any activity for which even a slight chance of flooding would be too great. For expanded description of “critical action” see Part I, Section 6 of Guidelines for Implementing Executive Order 13690.



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].

ACTIONS:

- a. Use the Lamprey River Watershed study or other similar methods for projecting future riverine floodplain extents and vulnerabilities for rivers within the coastal watershed and apply results as appropriate in municipal policy and planning (see BL4 (b) for more detail).



BL4. Integrate comprehensive land use and environmental planning with floodplain management approaches that prevent and minimize impacts from coastal hazards. [Lead: State Agencies; Municipalities].

ACTIONS:

- a. Establish minimum regulations at state and municipal levels that consider vulnerability assessment information to support appropriate amendments to building codes, floodplain management, fluvial erosion hazard zones, and stormwater management.
- b. Create and encourage adoption of local flood hazard overlay districts that include higher development standards that minimize impacts from natural hazards and climate change.
- c. Promote land development regulations that reduce vulnerability and protect ecosystem services (e.g. open space/cluster development).
- d. Prepare watershed-based plans that address comprehensive water resource management principles focused on changes in hydrologic systems resulting from climate change.
- e. Consider prohibiting development in areas destroyed by storms, experiencing repetitive loss of structures, and subject to chronic flooding and erosion. Consider adaptive reuse and/or acquisition of at-risk private properties.



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].

ACTIONS:

- a. Establish a beach monitoring program to collect long-term data regarding beach erosion, sea-level rise, landform changes, and sediment characteristics and processes.
- b. Identify areas where erosion and shoreline instability exist.
- c. Identify potential sites for nature-based approaches to shoreline stabilization.
- d. Prioritize areas for beach nourishment and other shoreline stabilization techniques.

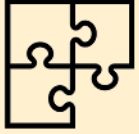


BL6. Develop a comprehensive, integrated New Hampshire Tidal Shoreline Management Plan (TSMP) that presents general priorities for tidal shoreline management, as well as site-specific and place-based strategies including, where appropriate, protection, adaptation, and abandonment. [Lead: State Agencies].

ACTIONS:

- a. Convene a tidal shoreline management planning team comprised of the NH Department of Environmental Services and other agencies and organizations as appropriate to develop a tidal shoreline management plan for New Hampshire based on, but not limited to, the information developed under Recommendation BL5.

6.5 Assessment & Implementation Recommendations: Our Natural Resources



Identify our natural resources that are vulnerable to storm surge, sea-level rise, and extreme precipitation; understand the scope of that vulnerability; and evaluate existing statutes, ordinances, rules and regulations, policies, programs, and plans to determine whether changes should be made to reduce vulnerabilities.



Identify and implement strategies that will enable the State and coastal municipalities to effectively protect, adapt, and sustain our current and future 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, and recreation opportunities.



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

ACTIONS:

- Identify where habitats and biological populations would naturally shift in response to best available climate science to prioritize areas and species for protection or restoration.
- Map natural resources that also protect critical built landscapes.
- Utilize marsh migration modeling to identify and prioritize marsh migration areas for conservation and restoration.
- Identify potential changes, and in particular losses, to ecosystem services as a result of sea-level rise and storm surges and compare to current conditions.



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].

ACTIONS:

- Include protection of natural systems and services, human well-being and protection of built environments in natural resource restoration plans (i.e. water quality, habitat, flood storage).
- Provide recommendations and incentives for removal or modification of structures and facilities, such as freshwater and tidal crossings, that create barriers to tidal flow and habitat migration, particularly those that will be impaired or severely impacted by sea-level rise, storm surge, or extreme precipitation.
- Engage in best practices for invasive species planning and removal and incorporate climate considerations in invasive species removal plans.
- Utilize existing funding sources for natural resource restoration (e.g. offset measures, state Aquatic Resource Mitigation fund).
- Invest in coastal dune restoration projects.
- Evaluate and apply sediment application techniques, where feasible, to maintain tidal marsh systems.



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].

ACTIONS:

- a. Use emerging habitat science to prioritize land and resource conservation projects.
- b. Establish dedicated funds and sources to support land preservation, acquisition of easements, and development rights to transfer vulnerable property to conservation lands.
- c. Prioritize land conservation efforts to adequately account for future sea-level rise and coastal flooding.
- d. Establish buffer requirements for setbacks to rivers, shorelines, and wetlands that include consideration of climate change and create a dedicated fund to support local enforcement.
- e. Encourage landowners to preserve the beneficial functions of natural features like wetlands and to restore and protect coastal dune habitat.
- f. Align land acquisition and conservation easement programs to protect important natural resources and ecosystem services.
- g. Protect future marsh migration areas identified by marsh migration modeling.
- h. Establish and share municipal inventories of land available for mitigation and conservation in areas that reduce flooding and promote the migration of species and habitat.



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].

ACTIONS:

- a. Modify NHDES permit requirements and municipal standards to require implementation of stormwater best management practices (BMPs) and low impact development (LID) management systems to minimize impacts and maintain aquatic habitats.
- b. Implement strategies and tools (such as land regulations, incentives, building regulations) designed to maintain or restore pervious surfaces, provide nutrient barriers, protect vegetated buffers and maintain wildlife passage.
- c. Recommend standards for state-issued permits and municipal zoning regulations that protect natural floodplain functions.
- d. Develop watershed-based comprehensive water resource management plans that consider impacts of climate change.
- e. Develop best management practices for shoreline buffers, including information on appropriate use of shoreline hardening, bank stabilization, vegetation restoration and agricultural practices.
- f. Explore options to minimize shoreline hardening and promote natural or hybrid shoreline protection strategies.
- g. Create shoreline management standards that help stabilize banks for more frequent storm events, wave impacts, or higher volume flows (e.g. by using natural vegetation and proper building setbacks).
- h. Develop guidelines and provide incentives for communities to incorporate climate adaptation actions for wildlife protection in master plans, hazard mitigation plans, and zoning ordinances.



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].

ACTIONS:

- a. Continue the NHDES freshwater culvert inventory program (SADES).
- b. Develop methodology for assessing tidal crossings and implement assessment protocol throughout coastal NH.
- c. Prioritize tidal crossing replacement projects and restoration opportunities based on environmental and resiliency criteria.
- d. Conduct feasibility analysis and due diligence inquiries on prioritized tidal crossing projects.
- e. Assess the impacts of future increased precipitation and stormwater on surface water resources.



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

ACTIONS:

- a. Assess location, quality and quantity of groundwater under current and future climate conditions.

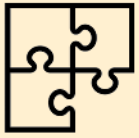


NR7. Restore or maintain natural flow regimes (groundwater, surface water and wetlands) to increase ecosystem resilience to extreme weather events and other coastal hazards, including floods, drought, and sea-level rise. [Lead: State Agencies].

ACTIONS:

- a. Improve designs for dams, culverts and bridges to maintain existing function and reconnect fragmented surface waters (wetlands, lakes, ponds, rivers and streams) to provide higher quality habitat for aquatic organisms and the ability to improve resilience of these systems.
- b. Work with Federal Energy Regulatory Commission, NHDES Wetlands, Dam and Watershed Management Bureaus to ensure habitat connectivity and resilience to help sustain intact coastal ecosystems.
- c. Adopt ecosystem-friendly approaches in the placement and design of freshwater and tidal stream crossing facilities. For example, appropriate sizing for new culverts, identify undersized culverts, and identify dams that need improvements to protect aquatic habitats.
- d. Comprehensively manage groundwater resources to consider infiltration and recharge, water quality, and changes to groundwater levels and salinity from sea-level rise.

6.6 Assessment & Implementation Recommendations: Our Heritage



Identify our recreational, cultural, and historic resources, including economic resources and elements of the built landscape, that are vulnerable to storm surge, sea-level rise, and extreme precipitation; understand the scope of that vulnerability; and evaluate existing statutes, ordinances, rules and regulations, policies, programs, and plans to determine whether changes should be made to reduce vulnerabilities.



Identify and implement adaptation strategies that will enable the State and coastal municipalities to effectively protect, adapt, and sustain current and future recreational and cultural resources.



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 municipalities wish to protect from coastal risk and hazards.



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].

ACTIONS:

- a. Conduct public information hearings to understand the impacts of proposed climate adaptation strategies.
- b. Assess existing and future recreational areas for their potential to provide storage for flood waters and stormwater runoff.
- c. Preserve open space and recreational areas that serve to minimize climate change impacts.
- d. Integrate recreational and open space planning into climate adaptation planning and the Tidal Shoreline Management Plan.
- e. Integrate protection of recreational resources into land use and management, engineering, regulatory components of state and municipal plans including the Tidal Shoreline Management Plan, hazard mitigation plans, Master Plans, and design standards.



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].

ACTIONS:

- a. Map all currently surveyed cultural and historical resources.
- b. Identify asset types that may also be cultural and historic resources.
- c. Use reconnaissance level survey and vulnerability assessments to identify high priority areas for intensive survey.



- 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].**



ACTIONS:

- a. Create or modify adaptation strategies for cultural and historic buildings affected by climate change, including plans for protecting or relocating resources.
- b. Integrate protection of cultural and historical resources into land use and management, engineering, regulatory components of state and municipal plans including the Tidal Shoreline Management Plan, hazard mitigation plans, Master Plans, and design guidelines.
- c. Establish expert group to create a decision-making process for property owners and municipalities to determine when and how to mitigate sites that will be lost.
- d. Establish guidelines for adaptation or risk reduction of cultural resources in state ownership.
- e. Create programmatic strategies to compensate for the loss of historic asset types that will be replaced in order to adapt to climate change impacts.
- f. Modify the Land and Cultural Heritage Investment Program (LCHIP) to include selection criteria that incentivize funding for climate adaptation actions.



-
- 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].**
-



6.7 Legislation Recommendations



Goal 4 is to recommend timely considerations for legislation that leads to actions, both immediate and long-term, that reduce and/or eliminate vulnerability and result in adaptation to existing and future coastal hazards.



- S1. Legislatively authorize a state agency to convene a Science and Technical Advisory Panel to review and evaluate the current state of climate change science in order to periodically update storm surge, sea-level rise, extreme precipitation and other relevant climate projections and provide planning guidance at least once every five years. [Lead: State Legislature].**

ACTIONS:

- a. Establish a collaborative Science and Technical Advisory Panel and a lead state agency to coordinate updated information and recommendations.
- b. The Panel, lead agency, and other participating agencies develop a mechanism that ensures communication of the updated climate science and planning guidance to a wide range of stakeholders.



- S5. Augment state funding in support of applied research that improves understanding, modeling, and projections of current and future coastal risk and hazards in New Hampshire's coastal zone. [Lead: State Legislature].**



- CC1. Secure new and allocate existing funding sources for state agencies and municipalities to conduct vulnerability assessments of assets at appropriate scales and to implement adaptation strategies. [Lead: State Legislature; State Agencies; Municipalities].**

Note: This recommendation summarizes the funding-related actions found throughout the assessment and implementation recommendations.

ACTIONS:

- a. Fund coastal vulnerability assessments and dissemination of results (see CC2 and BL1 (b)).
- b. Fund state agency audits of existing statutes and administrative rules (see CC3).
- c. Dedicate funding and technical assistance for state agencies and municipalities to incorporate the Science and Technical Advisory Panel report, as amended, in development standards, land use policies, and plans (see CC5 (b)).
- d. Establish a funding mechanism to assist state agencies in covering the costs of emergency and disaster response and recovery (see CC5 (e)).
- e. Apply for and utilize FEMA mitigation grants and other sources of funding to implement climate adaptation and planning strategies that reduce or eliminate flooding impacts (see CC6 (a)).
- f. Create and utilize a dedicated fund to acquire repetitive loss properties when structures and facilities are abandoned or destroyed (see CC6 (d)).
- g. Identify mechanisms to raise matching funds for FEMA and other grant programs, such as creating a dedicated state flood mitigation fund (see CC6 (e)).

- h. Establish stormwater utilities to fund retrofits to existing development and future improvements (see E3 (b)).
- i. Utilize existing funding sources for natural resource restoration (e.g. offset measures, state Aquatic Resource Mitigation fund) (see NR2 (d)).
- j. Establish dedicated funds and sources to support land preservation, restoration, acquisition of easements, and development rights to transfer vulnerable property to conservation lands (see NR3 (b)).
- k. 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 (see H5).



CC3. Review whether existing state statutes and rules adequately permit state agencies and municipalities to prepare and adapt to best available climate science and impacts, and make recommendations for amendments or new regulations where necessary. [Lead: State agencies].

ACTIONS:

- a. Require and provide funding for state agencies to evaluate and recommend necessary amendments to relevant statutes and administrative rules with respect to best available climate science, involving relevant stakeholders as appropriate. Relevant statutes and administrative rules include, but are not limited to, the following: RSA 483-B Shoreland Water Quality Protection Act, RSA 482-A Fill and Dredge in Wetlands, 485-A:29-39 Subsurface Systems, 485-A:17 Terrain Alteration, RSA 230:78 State Highways, RSA 230:79 Liability of NHDOT, and RSA 79-A Current Use.
- b. Review current practices to determine the most appropriate buffer and setback distances, freeboard, shoreline treatment, and other design standards and approaches needed to provide adequate levels of risk reduction and protection for at risk structures and facilities.
- c. Develop an approach to consolidate RSA 483-B Shoreland Water Quality Protection Act and RSA 482-A Fill and Dredge in Wetlands to create permitting efficiencies and allow for comprehensive management of tidal resources.
- d. Assess the status of existing state agency, municipal, and other disaster response and recovery plans, and determine whether new procedures or regulations are necessary to enable response and recovery planning at state and municipal levels.
- e. Identify and recommend modifications to state and local building codes necessary to protect against likely changes in flooding and other coastal hazards.



CC4. Amend state laws and rules to incorporate consideration of best available climate science and weather-related data. [Lead: State Legislature].

ACTIONS:

- a. Adopt amendments to state statutes and administrative rules identified under Cross-cutting Recommendation CC3, including, but not limited to: RSA 483-B Shoreland Water Quality Protection Act, RSA 482-A Fill and Dredge in Wetlands, 485-A:29-39 Subsurface Systems, 485-A:17 Terrain Alteration, RSA 230:78 State Highways, RSA 230:79 Liability of NHDOT, and RSA 79-A Current Use Taxation.



CC5. By 2019^{xviii}, state agencies will consider and use best available climate science in their activities and plans. [Lead: State Legislature].

ACTIONS:

- a. Establish the Science and Technical Advisory Panel report (see Science Recommendation S1), as amended, as state agency and municipal guidance about anticipated future climate and coastal flooding conditions.
- b. Dedicate funding and technical assistance for state agencies and municipalities to incorporate the Science and Technical Advisory Panel report, as amended, in development standards, land use policies, and plans.
- c. Establish a mechanism to monitor state agency and municipal use of Science and Technical Advisory Panel findings and recommended approaches to risk management.
- d. Require state agencies to address current and future coastal risk and hazards in preparation, response, and recovery plans.
- e. Establish a funding mechanism to assist state agencies in covering the costs of emergency and disaster response and recovery.
- f. Integrate social vulnerability information in adaptation planning, emergency preparedness strategies, and public health interventions.



CC6. Make existing structures and facilities more resilient and acquire properties in high risk areas in order to reduce or eliminate flooding impacts. [Lead: State Legislature; State Agencies; Municipalities].

ACTIONS:

- a. Apply for and utilize FEMA mitigation grants and other sources of funding to implement climate adaptation and planning strategies that reduce or eliminate flooding impacts.
- b. Elevate existing at-risk structures and implement higher freeboard standards above the Base Flood Elevation on new and substantially reconstructed structures and facilities to protect from future flood risks (see BL2 for more detail).
- c. Acquire at-risk and repetitive loss properties to create buffers and open space that facilitate restoration of floodplain functions.
- d. Create and utilize a dedicated fund to acquire repetitive loss properties when structures and facilities are abandoned or destroyed.
- e. Identify mechanisms to raise matching funds for FEMA and other grant programs, such as creating a dedicated state flood mitigation fund.



CC8. Establish an adaptation coordinator to monitor and coordinate implementation of the NH Coastal Risk and Hazards Commission recommendations. [Lead: State Legislature].



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].

ACTIONS:

- a. Use initial assessments to identify need for more detailed assessments.
- b. Require and secure funding for state agencies to conduct vulnerability assessments of state-owned structures and facilities located in the coastal zone at regional, municipal, and/or site-specific scales as appropriate.

^{xviii} This timeframe was determined to be acceptable by the state agencies on the NH Coastal Risk and Hazards Commission.



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].

ACTIONS:

- a. Adopt amendments to state and local building codes recommended under Cross-cutting Recommendation CC3.
- b. Require state agencies, through legislation or amendment to NH Executive Order 96-4,^{xix} to use one of the following approaches^{xx,xxi,xxii} for determining a higher vertical flood elevation and expanded corresponding horizontal floodplain than the current base flood elevation and floodplain to address current and future flood risk for state-funded new construction, substantial improvement, or repairs to substantially damaged structures and facilities:
 - i. *Climate-informed Science Approach* – use the best available, actionable hydrologic and hydraulic data and methods that integrate current and future changes in flooding based on climate science.^{xxiii}
 - ii. *Freeboard Value Approach* – use the freeboard value, reached by adding an additional two (2) feet to the base flood elevation for non-critical structures and facilities and from adding an additional three (3) feet to the base flood elevation for critical^{xxiv} structures and facilities.
 - iii. *The 0.2-percent-annual-chance Flood Approach* – use the 0.2-percent-annual-chance flood elevation (also known as the 500-year flood elevation).
- c. Encourage municipalities to use one of the following three approaches^{xxv,xxvi,xxvii} for determining a higher vertical flood elevation and expanded corresponding horizontal floodplain than the current base flood elevation and floodplain to address current and future flood risk for new construction, substantial improvement, or repairs to both municipal and private structures and facilities:
 - i. *Climate-informed Science Approach* – use the best available, actionable hydrologic and hydraulic data and methods that integrate current and future changes in flooding based on climate science.^{xxviii}
 - ii. *Freeboard Value Approach* – use the freeboard value, reached by adding an additional two (2) feet to the base flood elevation for non-critical structures and facilities and from adding an additional three (3) feet to the base flood elevation for critical^{xxix} structures and facilities.

^{xix} NH Executive Order 96-4 directs State agencies to comply with the floodplain management requirements of all local communities participating in the NFIP in which State-owned properties are located.

^{xx} See Federal Executive Order 13690, Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Input.

^{xxi} See Guidelines for Implementing Executive Order 13690.

^{xxii} See [Appendix F](#) for State of New Hampshire comments on Draft Guidelines for Implementing Executive Order 13690.

^{xxiii} An acceptable source of climate science for New Hampshire includes the Coastal Risk and Hazards Commission Science and Technical Advisory Panel report, Sea-level Rise, Storm Surges, and Extreme Precipitation in Coastal New Hampshire: Analysis of Past and Projected Trends, as amended.

^{xxiv} Any activity for which even a slight chance of flooding would be too great. For expanded description of “critical action” see Part I, Section 6 of Guidelines for Implementing Executive Order 13690.

^{xxv} See Federal Executive Order 13690, Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Input.

^{xxvi} See Guidelines for Implementing Executive Order 13690.

^{xxvii} See [Appendix F](#) for State of New Hampshire comments on Draft Guidelines for Implementing Executive Order 13690.

^{xxviii} An acceptable source of climate science for New Hampshire includes the Coastal Risk and Hazards Commission Science and Technical Advisory Panel report, Sea-level Rise, Storm Surges, and Extreme Precipitation in Coastal New Hampshire: Analysis of Past and Projected Trends, as amended.

^{xxix} Any activity for which even a slight chance of flooding would be too great. For expanded description of “critical action” see Part I, Section 6 of Guidelines for Implementing Executive Order 13690.

- iii. *The 0.2-percent-annual-chance Flood Approach* – use the 0.2-percent-annual-chance flood elevation (also known as the 500-year flood elevation).
- d. Develop model regulations for municipalities to consider adopting into their existing floodplain management regulations, which can assist municipalities in becoming more flood resilient by addressing current and future flood conditions using the best available flood risk and climate science information.
- e. Amend the New Hampshire Stream Crossing Guidelines to incorporate anticipated future stormwater flows based on best available climate science.
- f. Incorporate the Science and Technical Advisory Panel report information, as amended, into benefit-cost analyses for applications submitted under FEMA Hazard Mitigation Assistance and Public Assistance grant programs. In relevant cases, consider timeframes for potential future relocation or retreat by acquiring at-risk properties.
- g. Require, through legislation or other means, that the New Hampshire Site Evaluation Committee and Public Utilities Commission take future sea-level rise and coastal flooding impacts into account in project siting decisions and other planning.



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].

ACTIONS:

- a. Use emerging habitat science to prioritize land and resource conservation projects.
- b. Establish dedicated funds and sources to support land preservation, acquisition of easements, and development rights to transfer vulnerable property to conservation lands.
- c. Prioritize land conservation efforts to adequately account for future sea-level rise and coastal flooding.
- d. Establish buffer requirements for setbacks to rivers, shorelines, and wetlands that include consideration of climate change and create a dedicated fund to support local enforcement.
- e. Encourage landowners to preserve the beneficial functions of natural features like wetlands and to restore and protect coastal dune habitat.
- f. Align land acquisition and conservation easement programs to protect important natural resources and ecosystem services.
- g. Protect future marsh migration areas identified by marsh migration modeling.
- h. Establish and share municipal inventories of land available for mitigation and conservation in areas that reduce flooding and promote the migration of species and habitat.



H2. Develop plans and implement strategies to prepare and adapt recreational resources based on best available climate science. [Lead: State Agencies; Municipalities].

ACTIONS:

- a. Conduct public information hearings to understand the impacts of proposed climate adaptation strategies.
- b. Assess existing and future recreational areas for their potential to provide storage for flood waters and stormwater runoff.

- c. Preserve open space and recreational areas that serve to minimize climate change impacts.
- d. Integrate recreational and open space planning into climate adaptation planning and the Tidal Shoreline Management Plan.
- e. Integrate protection of recreational resources into land use and management, engineering, regulatory components of state and municipal plans including the Tidal Shoreline Management Plan, hazard mitigation plans, Master Plans, and design standards.



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].

ACTIONS:

- a. Create or modify adaptation strategies for cultural and historic buildings affected by climate change, including plans for protecting or relocating resources.
- b. Integrate protection of cultural and historical resources into land use and management, engineering, regulatory components of state and municipal plans including the Tidal Shoreline Management Plan, hazard mitigation plans, Master Plans, and design guidelines.
- c. Establish expert group to create a decision-making process for property owners and municipalities to determine when and how to mitigate sites that will be lost.
- d. Establish guidelines for adaptation or risk reduction of cultural resources in state ownership.
- e. Create programmatic strategies to compensate for the loss of historic asset types that will be replaced in order to adapt to climate change impacts.
- f. Modify the Land and Cultural Heritage Investment Program (LCHIP) to include selection criteria that incentivize funding for climate adaptation actions.



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].

7. Where We Go From Here

The Commission was established to develop guidance and recommendations for New Hampshire that will set our state on a responsible path toward enhancing coastal community and watershed resilience to the effects of storm surge, sea-level rise, and extreme precipitation. Because the timing and magnitude of these changes are uncertain, so are the assumptions on which we base our recommendations. While it is true that our level of understanding and degree of certainty about the impacts of climate change will improve over time, we know more than enough now to recognize that we cannot afford to wait for certainty to act. The key to managing economic and social costs and risks of climate-related impacts in the coastal region is to begin early and adapt incrementally.

Our central message is this: **begin now**. Even though we expect most of the impacts from climate change to be gradual, instances of severe flooding from

extreme precipitation and storm events will occur, as they always have, and are likely to worsen with changes in storm surge and sea level. Actions taken now, even costly ones, will more than likely pay for themselves in the form of reduced losses and greater resilience. In addition, the normal cycles of reconstruction, replacement and redevelopment can be utilized to introduce more resilient design into structures and facilities.



Photo credit: Ralph Morang

7.1 Actions Already Underway

The Commission's report and recommendations are the culmination of a collaborative process that recognized a diversity of views and came to a strong consensus about common sense actions to be taken to move New Hampshire forward on a path to coastal resilience. Consensus was achievable in large part because of the work on this issue done by various parties in various coastal communities that preceded the Commission. The Commission is also aware that the difficult and vital work of **implementation** is yet to come and its members are committed to supporting implementation efforts beyond the Commission's sunset on December 1, 2016. As of this publication, the Commission has already taken several actions and identified existing mechanisms to ensure continuity and implementation of the recommendations.

1. As a first step towards implementation of the Commission's recommendations, Senator Watters (District 4), Senator Stiles (District 24), Senator Fuller Clark (District 21), Representative Rice (Rockingham 21), Representative Cushing (Rockingham 21), and Representative Borden (Rockingham 24) introduced two pieces of legislation in the fall of 2015 that have since both passed into law: Chaptered Law 121 / SB 374 and Chaptered Law 195 / SB 452.
 - [Chaptered Law 121 / SB 374](#) implements Recommendation S1 and requires the NH Department of Environmental Services to regularly update the storm surge, sea-level rise, precipitation and other relevant projections recommended in the Commission's 2014 Science and Technical Advisory Panel (STAP) Report at least every five years, commencing July 1, 2019. SB 374 was signed by the Governor on May 20, 2016, effective July 19, 2016.

- [Chaptered Law 195 / SB 452](#) implements Recommendation CC3 and requires certain state agencies to conduct an audit of existing state statutes, rules, and agency policies governing state properties, projects, and actions in coastal and Great Bay regions to determine if any changes are necessary to enable appropriate state and local actions to prepare for projected coastal flood risks. Additionally, Chaptered Law 195 / SB452 also requires state agencies involved in planning, siting, and design of state-funded structures and facilities, public works projects, and transportation projects, as well as land acquisition and management, and other environmental activities in the coastal and Great Bay regions to reference the 2014 STAP Report, as updated, for guidance on all potentially affected activities. SB 452 was signed by the Governor on June 6, 2016, effective immediately.
2. A State Agency Climate Change Work Group has been formed to coordinate agency actions, enhance New Hampshire's capability to reduce the causes of and prepare for the impacts of climate change, and better serve our agencies and the citizens of NH. This group will be instrumental in carrying out Recommendation CC3 and Chaptered Law 195 / SB 452, which requires certain state agencies to conduct an audit of laws governing coastal regions to enable the state and municipalities to take appropriate actions.
 3. The NH Department of Environmental Services Coastal Program and partners have secured funding from the National Oceanic and Atmospheric Administration Office for Coastal Management to support outreach and begin implementation of the Commission's recommendations. Broadly, this project, entitled NH Setting SAIL, seeks to achieve the following goals:
 - Ensure through education and outreach that the CRHC recommendations are understood and championed by state, municipal, and regional stakeholders;
 - Assist Great Bay coastal municipalities to prioritize and implement actions that meet their unique needs, including the development of a climate adaptation chapter for the City of Dover Master Plan (similar to what has been done for the Atlantic Coast municipalities under the Tides to Storms 2 project funded by the Northeast Regional Ocean Council); and
 - Provide capacity for the State Agency Climate Change Work Group to coordinate audits of existing state statutes, rules, and agency policies as required by Chaptered Law 195 / SB 452; complete inventories of vulnerable state assets; and conduct other implementation activities.
 4. Commission members have begun exploring opportunities to establish a climate adaptation coordinator (see Recommendation CC8) within a state agency/office to coordinate implementation of the Commission's recommendations and other recommendations that follow.
 5. The ongoing work of New Hampshire Coastal Adaptation Workgroup (NHCAW) and its member communities and agencies will be instrumental in ensuring continued coordination and implementation of the Commission's recommendations. NHCAW assists communities in New Hampshire's coastal watershed prepare for the effects of extreme weather and long term climate change by providing resources, facilitation, and guidance that enhance readiness and resilience. A list of NHCAW-related projects is included in [Appendix G: Related Projects](#).
 6. Finally, it is important to acknowledge that many coastal municipalities have begun taking initial steps toward implementing climate adaptation actions. These steps include, but are not limited to, coastal hazards and climate adaptation master plan chapters, enhanced standards for floodplain development and shoreline buffers, and outreach to raise awareness of the importance of coastal buffers in protecting life and property. These "first responders" have repeatedly sought technical assistance and committed dollars and staff time to their efforts with the goal of creating more resilient and sustainable communities and local economies. We hope their actions will serve as encouraging examples for other municipalities to act.

7.2 Suggested Next Steps

Drawing on the recommendations and actions presented in this report, the Commission suggests the following next steps for state legislators, state agencies, and municipalities to get started.

1. State legislators, state agencies, and municipalities should familiarize themselves with all of the Commission recommendations and actions and identify, prioritize, and implement those recommendations and actions most relevant to their needs.
2. State agencies should implement all laws enacted to carry out the Commission's recommendations, including Chaptered Laws 121 and 195.
3. State legislators, state agencies, and municipalities should identify financial resources and mechanisms needed at state and municipal levels to address storm surge, sea-level rise, and extreme precipitation events.
4. State agencies and municipalities should conduct broad-based public education and outreach to raise awareness of flood hazards and risk, and strategies to protect property and investments.
5. State agencies and municipalities should undertake detailed analyses to determine site-specific vulnerabilities and appropriate management actions for state and municipal structures and facilities, including historical resources, and other key assets.
6. State agencies and municipalities should work cooperatively to develop integrated response, recovery, and continuity plans to reduce and recover from impacts of severe coastal flooding.
7. State agencies and municipalities should conduct planning, siting, design and construction of publicly funded or supported structures, facilities, public works projects and transportation projects in a manner that is consistent with the findings and guidance of the 2014 Science and Technical Advisory Panel Report, as updated.
8. Municipalities should strengthen land use and development standards (e.g., flood hazard overlay districts, building codes, and floodplain management) to reduce vulnerability of existing and future development in areas with highest flood risk.
9. State agencies and municipalities should take immediate action to protect and restore natural resource assets that provide flood storage, erosion protection, hydrologic connectivity, migration opportunities for fish and wildlife and maintain other critical and important services.
10. State agencies and municipalities should accelerate and broaden existing efforts to develop a tidal shoreline management plan that will identify appropriate strategies and conceptual plans to increase resiliency in New Hampshire's most vulnerable sections of shoreline.
11. Finally, state legislators, state agencies, and municipalities should regularly review the recommendations and actions in this report to ensure implementation progresses where needed and the recommendations themselves are refined or replaced as new information and better understanding comes to light. Given the dynamic nature of climate change and the threats it poses to New Hampshire's coastal region, this guidance needs to be treated as a living, evolving document.

8. Definitions and Acronyms

Definitions

Atlantic Coast Municipalities	The seven New Hampshire municipalities in the coastal zone that are directly exposed to the Atlantic Ocean. Includes Hampton, Hampton Falls, North Hampton, New Castle, Portsmouth, Rye, and Seabrook.
Adaptation	Adjustment in natural or human systems to a new or changing environment that exploits beneficial opportunities or moderates negative effects.
Adaptive Capacity⁸²	The combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities.
Built Landscape	The network of structures and facilities owned by state and municipal governments and private entities in coastal New Hampshire.
Climate Adaptation	A response or action that seeks to reduce the vulnerability of social and biological systems to the impacts of climate change.
Climate Effect	A direct result of climate change (e.g., an effect of climate change is that the average annual temperature is rising).
Climate Impact	A consequence of one or more climate change effects (e.g., rising average annual temperature (climate effect) may lengthen the agricultural growing season (climate impact) in some regions).
Climate-Ready	The state of being able to prepare for, adapt to, and respond after expected impacts of climate change. This can refer to a variety of entities, including a program, regulation, or entity like a municipality or State agency.
Coastal Hazard	Natural or human-induced physical events (e.g., hurricanes, nor'easters, storm surge, sea-level rise, extreme precipitation) that may cause loss of life, injury or other health impacts, as well as damage and loss to property, facilities, livelihoods, and natural resources.
Coastal Risk⁸³	The probability that coastal hazards will adversely affect a coastal area as determined by the combination of physical hazards and vulnerabilities of exposed elements.
Coastal Zone	New Hampshire's coastal zone includes the 17 coastal municipalities bordering tidal waters in New Hampshire. Represents the geographical scope of the Coastal Risk and Hazards Commission.
Critical Action⁸⁴	Any action for which even a slight chance of flooding is too great. Critical actions include, but are not limited to, those which create or extend the useful life of structures or facilities: <ul style="list-style-type: none">a. Such as those which produce, use or store highly volatile, flammable, explosive, toxic or water reactive materials;b. Such as hospitals and nursing homes, and housing for the elderly, which are likely to contain occupants who may not be sufficiently mobile to avoid the loss of life or injury during flood and storm events;c. Such as emergency operation centers, or data storage centers which contain records or services that may become lost or inoperative during flood and storm events; and such as generating plants, and other principal points of utility lines.

Cultural and Historic Resources	A district, site, building, structure or object that is significant in the history, architecture, engineering, archaeology or culture of this state, its communities, or the nation.
Ecosystem Services	The benefits humans derive from nature such as food and water, erosion and flood control, nutrient cycling, and recreation.
Exposure⁸⁵	The presence of people, livelihoods, environmental services and resources, structures, facilities, or economic, social, or cultural assets in places that could be adversely affected by physical events and which, thereby, are subject to potential future harm, loss, or damage.
Extreme Precipitation	Precipitation falling as extreme events, defined by the 2014 National Climate Assessment and in this report as the largest one percent of daily events in a year. There are many other definitions of “extreme precipitation.”
Facility	Any man-made or man-placed item other than a structure. ⁸⁶ Examples include, but are not limited to, bridges and roads. The term “structure” is defined later in the glossary.
Great Bay Municipalities	The ten New Hampshire municipalities in the coastal zone that are not directly exposed to the Atlantic Ocean, but whose boundaries are exposed to tidal waters along Great Bay and its tributaries. Includes Dover, Durham, Exeter, Greenland, Madbury, Newfields, Newington, Newmarket, Rollinsford, and Stratham.
Infrastructure	A subset of the term “facilities,” as defined in this glossary. Often refers to roads and other transportation assets, wastewater and stormwater management facilities, and other facilities. Can also refer to natural resources that provide services similar to manmade infrastructure. For example, a salt marsh that cleans and provides flood storage for stormwater is a type of natural infrastructure.
Mean Higher-High Water	The average of all the higher of the two daily high water heights recorded at a particular point or station over a considerable period of time, usually 19 years.
Mean High Water	The average of all the high water heights recorded at a particular point or station over a considerable period of time, usually 19 years.
Mitigation	Any action taken to reduce or eliminate long term risk to people and property from natural hazards. For the purposes of this report, the term mitigation should not to be confused with climate change mitigation, which refers to efforts to reduce or prevent greenhouse gas emissions.
Natural Resources	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.
Nature-based Approaches	Features (sometimes referred to as green infrastructure or natural infrastructure) designed to mimic natural processes and provide specific services such as reducing flood risks and/or improving water quality. Nature-based approaches are created by human design (in concert with and to accommodate natural processes) and generally, but not always, must be maintained in order to reliably provide the intended level of service.
New Construction	The construction of a new structure (including the placement of a mobile home) or facility, or the replacement of a structure or facility which has been totally destroyed or is being upgraded. This definition does not override existing or future municipal definitions of this term.

Piscataqua Region (Coastal) Watershed	The land area from which water drains through the Hampton-Seabrook and Great Bay estuaries out to the Atlantic Ocean. Includes 42 municipalities in New Hampshire and portions of Maine and Massachusetts.
Resilience	The ability to avoid, minimize, withstand, and recover from the effects of adversity, whether natural or manmade, under all circumstances of use.
Sea-level Rise	The increase in sea level primarily caused by two factors related to climate change: the added water from melting land ice and the expansion of sea water as it warms. The acronym SLR stands for sea-level rise.
Science	The NH Coastal Risk and Hazards Commission defines science as the knowledge about or study of the natural world based on facts learned through experiments and observation and published in peer-reviewed academic journals. Peer review is the evaluation of research methods and results by one or more people of similar competence (peers) to the producers of the research. Reviews are often completed anonymously. Peer review constitutes a form of self-regulation by qualified members of a profession within the relevant field. Peer review is used to maintain standards of quality, improve performance, provide credibility, and reduce the dissemination of unsubstantiated results and unacceptable interpretations. Publications that have not undergone peer review are regarded with a higher degree of skepticism by academics and scientists. Sources and additional resources can be found at: Merriam-Webster Dictionary, Science Magazine, Proceedings of the National Academy of Sciences
Storm Surge⁸⁷	The sea height during storms such as hurricanes that is above the normal expected at that time and place based on the tides alone.
Structures	Walled or roofed buildings, including mobile homes and gas or liquid storage tanks. ⁸⁸ The related term “facility” is defined earlier in the glossary.
Upland	Land currently above mean high-high water line (i.e., shoreline).
Vulnerability	The propensity or predisposition to be adversely affected, which results from diverse historical, social, economic, political, cultural, institutional, natural resource, and environmental conditions and processes.

Acronyms

CRHC	New Hampshire Coastal Risk and Hazards Commission
DHR	New Hampshire Division of Historical Resources (within NHDCR)
DRED	New Hampshire Department of Resources and Economic Development
FEMA	Federal Emergency Management Agency
FFRMS	Federal Flood Risk Management Standard
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
GBNERR	Great Bay National Estuarine Research Reserve (within NHFG)
HSEM	New Hampshire Department of Homeland Security and Emergency Management
LIDAR	Light Detection and Ranging
NHCAW	New Hampshire Coastal Adaptation Workgroup
NHDCR	New Hampshire Department of Cultural Resources
NHDES	New Hampshire Department of Environmental Services
NHDOT	New Hampshire Department of Transportation
NHFG	New Hampshire Fish and Game Department
NFIP	National Flood Insurance Program
NHOEP	New Hampshire Office of Energy and Planning
NOAA	National Oceanic and Atmospheric Administration
PREP	Piscataqua Region Estuaries Partnership
RPC	Rockingham Planning Commission
SLR	Sea-level rise
SRPC	Strafford Regional Planning Commission
STAP	Science and Technical Advisory Panel
UNH	University of New Hampshire
USACE	United States Army Corps of Engineers
USDOT	United States Department of Transportation
USGCRP	United States Global Change Research Program
USGS	United States Geological Survey

9. Appendices

APPENDIX A: RSA 483-E

TITLE L

WATER MANAGEMENT AND PROTECTION

CHAPTER 483-E

COASTAL RISK AND HAZARDS COMMISSION

Section 483-E:1

[RSA 483-E:1 repealed by 2013, 188:2, effective December 1, 2016.]

483-E:1 Commission Established. –

There is established a coastal risk and hazards commission.

Source. 2013, 188:1, eff. July 2, 2013.

Section 483-E:2

[RSA 483-E:2 repealed by 2013, 188:2, effective December 1, 2016.]

483-E:2 Membership and Compensation. –

I. The members of the commission shall be as follows:

- (a) Two members of the house of representatives, appointed by the speaker of the house of representatives.
 - (b) Two members of the senate, appointed by the president of the senate.
 - (c) The commissioner of the department of environmental services, or designee.
 - (d) The executive director of the fish and game department, or designee.
 - (e) The administrator of the division of public works design and construction in the department of administrative services, or designee.
 - (f) The commissioner of the department of transportation, or designee.
 - (g) The director of the division of parks and recreation, or designee.
 - (h) The director of the division of historical resources, or designee.
 - (i) The president of the Seacoast Board of Realtors, or designee.
 - (j) The director of the New Hampshire Sea Grant, or designee.
 - (k) A representative of the New Hampshire Public Risk Management Exchange, appointed by the exchange.
 - (l) The director of the office of energy and planning, or designee.
 - (m) The president of the Homebuilders and Remodelers Association of New Hampshire, or designee.
 - (n) The commissioner of the department of resources and economic development, or designee.
 - (o) The president of the university of New Hampshire, or designee.
 - (p) A representative of the New Hampshire Municipal Association, appointed by that organization.
 - (q) A representative of the Strafford regional planning board, appointed by that body.
 - (r) A representative of the Rockingham regional planning board, appointed by that body.
 - (s) One representative of each of the following towns, appointed by his or her town's governing body: Rollinsford, Greenland, Stratham, Exeter, Newfields, Newmarket, Portsmouth, Rye, North Hampton, Hampton, Dover, Hampton Falls, Seabrook, Newington, New Castle, Madbury, and Durham.
- II. Legislative members of the commission shall receive mileage at the legislative rate when attending

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to the duties of the commission.

III. The members of the commission shall elect a chairperson from among the members. The first meeting of the commission shall be called by the first-named house member. The first meeting of the commission shall be held within 45 days of the effective date of this section. Eighteen members of the commission shall constitute a quorum.

Source. 2013, 188:1, eff. July 2, 2013. 2014, 327:68, eff. Aug. 2, 2014.

Section 483-E:3

[RSA 483-E:3 repealed by 2013, 188:2, effective December 1, 2016.]

483-E:3 Duties. –

I. The commission shall recommend legislation, rules, and other actions to prepare for projected sea level rise and other coastal and coastal watershed hazards such as storms, increased river flooding, and storm water runoff, and the risks such hazards pose to municipalities and state assets in New Hampshire.

II. The commission shall review National Oceanic and Atmospheric Administration and other scientific agency projections of coastal storm inundation, and flood risk to determine the appropriate information, data, and property risks.

III. The commission shall meet 4 times per year.

IV. The commission shall annually report its findings and any recommendations for proposed legislation to the speaker of the house of representatives, the president of the senate, the house clerk, the senate clerk, the governor, and the state library on or before November 1.

Source. 2013, 188:1, eff. July 2, 2013.

To access the online version of this document, go to <http://www.gencourt.state.nh.us/rsa/html/l/483-E/483-E-mrg.htm>

APPENDIX B: Commission Alternates and Former Members

Alternates

Members	Representation
Peter Bowman	New Hampshire Department of Resources and Economic Development
Steve Couture	New Hampshire Department of Environmental Services
Liz Durfee	Strafford Regional Planning Commission
Brian Fitzgerald	Town of Rye
Mary Kate Ryan	New Hampshire Division of Historical Resources
Ann Scholz	New Hampshire Department of Transportation

Former Members

Members	Representation
Dr. Mimi Becker	Town of Exeter
Robert Cormier	New Hampshire Home Builders Association
Dr. Paul Kirshen	University of New Hampshire
Thomas Morgan	Town of Newington
Former Rep. Christopher Muns	New Hampshire House of Representatives
Dr. Jonathan Pennock	New Hampshire Sea Grant
Vicki Quiram	New Hampshire Department of Environmental Services
Raymond Smith	Town of Seabrook
Former Rep. David Wood	Town of Hampton

APPENDIX C: Federal, New Hampshire, and Other State Guidance on Climate Change

As scientific findings have continued to emerge and modeling has improved, federal, New Hampshire, and other state government agencies have developed guidance and taken action to both reduce greenhouse gas emissions and prepare for the inevitable impacts expected as a result of climate change. This section summarizes some of the guidance and initiatives underway in federal agencies and in our state.

National Guidance and Actions on Climate Change

U.S. Global Change Research Program (USGCRP) and the National Climate Assessment

The U.S. Global Change Research Program (USGCRP) was established by Presidential Initiative in 1989 and mandated by Congress in the Global Change Research Act (GCRA) of 1990 to “assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change.” The GCRA requires that the USGCRP produce a National Climate Assessment every four years. The 2014 National Climate Assessment⁸⁹ synthesizes the current science and understanding about what climate changes are occurring, what future conditions are expected and how they may affect the United States. The 2014 Assessment is a coordinated, interagency resource that can be used to compare and estimate impacts and assess vulnerability.

Federal Flood Risk Management Standard (FFRMS)

The FFRMS was established by Executive Order 13690 in 2015 establishing new management guidelines for federal investments and programs that involve exposure to future flood risk. It serves as a set of general design standards for federally-funded projects (“Federal actions”) subject to coastal flooding and sea-level rise. The FFRMS establishes new criteria for determining future flood risk and requires federally funded projects and other actions to be designed to anticipate future expected flood conditions in addition to existing flood hazards; it anticipates these hazards to increase over time due to the effects of climate change and other threats. The key provision of the new policy is a change in the way federal agencies will determine whether or not a proposed federal “action” (e.g. federally funded and/or permitted projects) would be located within a flood hazard area. This determination is to be made using one of three methods:

1. climate informed science (state or regional-specific estimate of future flood exposure);
2. the minimum freeboard value, adding from 2 to 3 feet of additional elevation from existing base flood levels (depending on risk tolerance of the facility)
3. use the 0.2-percent-annual-chance (500-year) flood elevation as an interim planning value for future flood levels

The FFRMS, also incorporates a process by which an exception to these standards can be made under certain circumstances, relating to emergency, national security and in circumstances where their implementation would be counterproductive.

FEMA Climate Change Adaptation Policy

In January 2012, the Federal Emergency Management Agency (FEMA) issued a policy statement that established an agency-wide directive to integrate climate change considerations, adaptation planning and actions into FEMA’s programs and policies. The policy explicitly recognizes that the potential impacts from climate change may affect FEMA’s ability to effectively manage emergencies. The policy statement contains several key elements that the agency will employ to improve its capacity to manage in the face of climate change.

The key policy elements are to:

1. Enhance climate research, monitoring and adaptation capabilities.
2. Study the specific impacts of climate change on the National Flood Insurance Program (NFIP) and incorporate climate change considerations in future NFIP reform.
3. Evaluate how climate change considerations can be incorporated into grant programs and strategies, and especially on infrastructure.
4. Engage local communities in addressing and supporting climate change efforts.
5. Promote updated building standards and practices that consider the future impacts of climate change.

In March 2015, FEMA issued new guidance for the minimum required content of State Hazard Mitigation Plans. State plans must now consider the projected effects of climate change on natural hazards such as more intense storms, frequent heavy precipitation, heat waves, drought, extreme flooding, and higher sea levels because of their potential to significantly alter the types and magnitudes of hazards impacting states in the future. Specifically, the new guidance requires state plans to include climate projections and data, and to consider climate change effects in evaluating the probability of future hazard events.

Federal Highway Administration (FHWA) Guidance

As of the publication of this report, the Federal Highway Administration (FHWA) had not established design standards or guidelines that require projected acceleration of sea-level rise to be taken into account in highway and bridge design. FHWA has developed planning tools to facilitate consideration of climate change impacts in transportation systems design, including consideration of heat, precipitation, sea-level rise and storm surge.

In 2012 FHWA developed the **Climate Change and Extreme Weather Vulnerability Assessment Framework**, a voluntary process to help transportation agencies assess transportation asset vulnerability to climate change and extreme weather events. It recommends key steps to be followed in conducting vulnerability assessments and incorporating results into decision-making and provides modules and tools to aid in the assessment process. The framework encourages incorporating the results of the vulnerability assessment into the agency's decision-making process to ensure that the information is used in practice.

In 2008, FHWA published the **Highways in the Coastal Environment, Second Edition**⁹⁰ which reviews special factors to consider when designing transportation facilities in coastal areas, including areas prone to flooding and extreme events. The historical eustatic sea-level rise rate is reviewed as well as the possibility that these rates will accelerate as a consequence of ocean warming, however no recommended eustatic sea-level rise levels or scenarios for design purposes are provided.

FHWA's Climate Change Adaptation website provides resources, tools, and guidance to help local and regional transportation agencies implement the FHWA [**Climate Change and Extreme Weather Vulnerability Assessment Framework**](#), a guide to assessing the vulnerability of transportation assets to climate change and extreme weather events. The FHWA also provides a Virtual Framework for Vulnerability Assessment – [**Modules**](#).

U.S. Department of Transportation (USDOT)

In 2013 the U.S. Department of Transportation Volpe National Transportation Systems Center and the Office of Research, Development and Technology published a report entitled, "Climate Change Adaptation Support for Transportation Practitioners." The report lays the groundwork to support state and local practitioners as they proactively (or reactively) adapt to climate change impacts by:

- Developing a comprehensive database of relevant resources
- Categorizing and tagging those resources to make them more searchable
- Developing an “Expert System” concept to help practitioners quickly identify the resources most relevant to them, through a step-by-step guided approach
- Gathering feedback from USDOT agencies and practitioners to help refine the concept
- Presenting the concept to USDOT agencies and assisting with implementation

U.S. Army Corps of Engineers (USACE)

The U.S. Army Corps of Engineers was one of the first Federal agencies to develop guidance requiring project planning and design to anticipate sea-level rise. The 2011 Circular (revised slightly in 2013) was developed with the aid of other agency experts from the National Oceanic and Atmospheric Administration and U.S. Geological Survey and incorporates sea-level change scenarios into its design requirements.⁹¹ The policy explicitly anticipates the continued acceleration of global mean sea-level rise. Key requirements are:

- Relative sea level change must be considered in all USACE coastal activities within the extent of tidal influence.
- Base level sea-level rise is to be considered from the history of recorded changes for a specific site.
- Project planning and design must consider how sensitive and adaptable natural and managed ecosystem, and human engineered systems are to predicted sea level change and what design or operations and maintenance measures should be implemented to adapt.
- Project development must include consideration of a multiple scenario approach to deal with future condition uncertainty.
- Project alternatives are to be formulated and evaluated for the entire range of future rates of sea level change scenarios using low, medium and high scenario ranges, based on National Research Council's sea-level rise scenarios (SLR values for the NH coast in 2100 are 0.4, 1.5 and 4.8 feet).

New Hampshire Guidance and Activities on Climate Change

New Hampshire Climate Action Plan

In 2009, the Governor’s Climate Change Policy Task Force released the New Hampshire Climate Action Plan⁹² containing 10 overarching strategies necessary to meet the State’s greenhouse gas reduction and climate change related goals. The Plan describes in detail the benefits of planning for and adapting to climate change and how this may be achieved to minimize impacts to the economy, human health, natural systems, and infrastructure. The New Hampshire Climate Action Plan has helped guide many research and planning initiatives, policy decisions, and audits of the existing regulatory standards and procedures by State agencies to address climate change. The plan envisions that all stakeholders throughout the state would contribute to implementation of its recommendations.

New Hampshire Department of Environmental Services

In September 2015, NHDES published a report summarizing the Department Climate Initiative.⁹³ NHDES recognizes that climate change is real, serious, and substantially man-made and that New Hampshire’s residents, environment and economy are already experiencing its effects. NHDES has a responsibility to respond by taking steps to reduce the causes of climate change locally and regionally, as well as to prepare for the current and projected impacts that a changing climates poses to New Hampshire’s residents, visitors, communities, and natural resources.

In response, the NHDES incorporated the need to address climate change in its 2010-2015 Strategic Plan goals. The NHDES Climate, Land-Use, Energy And Natural Resources (CLEANR) Team convened in 2010 as an ad-hoc cross-media staff working group, representing all three divisions and the commissioner's office, to support the implementation of the interrelated land-use and climate goals contained in the strategic plan. The team played an invaluable role in guiding the early implementation of the strategic plan through a phased-in approach that built on the success of small pilots to pave the way for more extensive projects and activities.

In 2013, under the guidance of the CLEANR Team and with the full support of its senior leadership, NHDES launched the "Department Climate Initiative" (DCI) to engage agency leadership, middle management and key staff in a strategic review of NHDES's programs and activities. The goal of the DCI is to make coordinate changes to department outreach activities, grants, and regulatory programs that: account for changing climate and environmental conditions; and promote the reduction of greenhouse gases (e.g., carbon dioxide, methane, ozone, black carbon) from all sources. To do so, each bureau in the department has been assessing their programs and activities in order to identify actions they can take to reduce emissions of greenhouse gases within New Hampshire and prepare for the impacts of a changing climate.

Even as the department-wide planning effort has been underway, considerable progress has been made across the agency. The document is the first periodic review of NHDES's efforts to incorporate considerations of climate change into all of its programs and activities. The purpose of the review is to reflect on the work done during 2014 and previously related to the goals NHDES has set for climate change, land use and energy in the 2010-2015 Strategic Plan.

New Hampshire Department of Homeland Security and Emergency Management

The New Hampshire Department of Homeland Security and Emergency Management (HSEM) is responsible for preparing the state's hazard mitigation plan, coordinating the state's response to natural disasters, and administering Hazard Mitigation Assistance programs that fund development of comprehensive hazard mitigation plans and projects to protect citizens, and their property from exposure to all hazards including: natural, human caused, and technological. The New Hampshire Multi-Hazard Mitigation Plan⁹⁴, (last updated in 2013) lays out goals and recommendations to protect the state, municipalities and residents from impacts from natural and human caused hazards. In 2009 the Plan incorporated for the first time goals to address climate change impacts including technical support, planning, assessment of risk and vulnerability, and adaptation statewide. For more information about programs and assistance refer to the Homeland Security and Emergency Management HSEM website at <http://www.nh.gov/safety/divisions/hsem/>. Key goals and objectives from the NH Multi-Hazard Mitigation Plan relating to climate change are:

- Reduce the potential impact of natural and human caused disasters on New Hampshire's Critical Support Services, Critical Facilities and Infrastructure.
- Sustain the NHDES Coastal Program's participation and support of the Coastal Adaptation Workgroup to address hazard and mitigation needs relative to state and community infrastructure.
- Address the challenges posed by climate change as they pertain to increasing risk to the state's infrastructure and natural environment.
- Support efforts to characterize and identify risks posed by climate change especially as it relates to changing precipitation patterns, storm event frequency, and sea-level rise.
- Encourage coastal communities to incorporate mitigation planning in master plans, zoning, land use and resource regulations and other planning studies and initiatives that address the existing and potential future threats related to climate change and sea-level rise.

New Hampshire Department of Transportation

Transportation excellence in New Hampshire is fundamental to the state's sustainable economic development and land use, enhancing the environment, and preserving the unique character and quality of life. The New Hampshire Department of Transportation (NHDOT) will provide safe and secure mobility and travel options for all of the state's residents, visitors, and goods movement, through a transportation system and services that are well maintained, efficient, reliable, and provide seamless interstate and intrastate connectivity. NHDOT uses guidance from the FHWA (see above). The NHDOT also puts forward several manuals for designing structures, including:

- Bridge Design Manual – [Design Guide](#)
- Manual on Drainage Design for Highways

The NH Department of Transportation (NHDOT) has conducted an assessment of its assets, programs, policies, and activities to determine what is at risk due to changing climate stressors. The NHDOT issued a plan that identifies short-, mid-, and long-term steps to develop adaptive strategies to counter the effects. An internal climate change committee meets quarterly to discuss state and federal activities dealing with resiliency and adaptation plans.⁹⁵ For additional NHDOT resources, visit: www.nh.gov/dot/climate-change.

New Hampshire Department of Administrative Services

The Department of Administrative Services (DAS) oversees energy efficiency and renewable energy efforts in all of the state facilities, coordinating the development of the agency energy conservation plans and the state energy conservation plan. They also oversee energy-use data management by tracking energy consumption and cost for all state agencies, and analyze and report on the State's progress in achieving its goal of reducing fossil-fuel energy-use intensity by 25 percent by 2025 as laid out in Executive Order 2011-131 and Senate Bill 73 (2010).⁹⁶

New Hampshire Office of Energy & Planning

The NH Office of Energy & Planning (NHOEP) is collaborating on a variety of energy efficiency and renewable energy efforts, and is working with local communities and property owners to implement changes to the Federal Emergency Management Agency (FEMA) flood maps, and to educate the public about the associated risks and insurance implications. The NHOEP Energy Division is tasked with: promoting energy efficiency to reduce energy usage and costs; administering federally-funded fuel assistance and weatherization assistance programs; working to make state government buildings more efficient; exploring opportunities to expand the use of renewable, domestic energy resources such as biomass, wind and solar energy; and administering state and federal programs related to energy.

The Floodplain Management Program offers technical assistance to all stakeholders regarding floodplain management regulations, flood insurance, and floodplain mapping. NHOEP is also charged with assisting municipalities with planning issues, supporting implementation of state smart growth policies, and supporting land conservation, all valuable tools in minimizing the causes of climate change and providing protection from its impacts.⁹⁷

New Hampshire Department of Health and Human Services

In 2013, the Division of Public Health Services (DPHS) in the NH Department of Health and Human Services (DHHS) received a Center for Disease Control and Prevention (CDC) grant to further prepare New Hampshire for the health impacts due to climate change. The grant is part of a CDC-funded national collaboration called the Climate Ready States and Cities Initiative (CRSCI). The goal is to help local communities prepare for climate-related public health impacts such as pollen and asthma, extreme heat, or changing habitat and Lyme disease by assessing the connections between climate change and health impacts and helping public health networks develop plans to keep our citizens prepared and healthy. The DPHS is collaborating with the NHDES Coastal Program and the USGS to assess the impact of climate change on watersheds in the state, and estimate the state's changing vulnerability to flood or drought over the next century.⁹⁸

New Hampshire Department of Cultural Resources

The NH DCR Division of Historical Resources (DHR) is offering a new grant program to repair historical properties that were damaged by Superstorm Sandy in October 2012. Grants will support projects that repair damage caused by the storm. Properties receiving funds must be listed on or eligible for listing on the National Register of Historic Places. Another important component of the disaster planning program will be the creation of a statewide online Geographic Information System of historical properties throughout the state. An important component of the program in the upcoming grant round will be a focus on pre-disaster planning for historic and cultural resources. DHR will be looking for proposals that increase community awareness of historic and cultural resources through initiatives that identify vulnerable historic properties and that develop strategies to protect a community's historic assets.⁹⁹

New Hampshire Fish & Game Department

The NH Fish and Game Department is engaged in an update to its Wildlife Action Plan with assistance from other natural-resource-based organizations in New Hampshire. The update includes the impacts from climate change on ecosystems and various species that are more vulnerable. The update is based on the Commission's amendment to a 2006 Plan: the Ecosystems and Wildlife: Climate Change Adaptation Plan. This amendment was created with input from 59 state and federal agencies, researchers, non-profits, consulting biologists and towns and addresses actions to assist wildlife and ecosystems in staying healthy in the face of climate change.

New Hampshire Coastal Adaptation Workgroup

The New Hampshire Coastal Adaptation Workgroup (NHCAW) is a collaboration of 22 partners and organizations working to help communities in southeastern New Hampshire prepare for the effects of extreme weather events and other effects of long term climate change. Since inception in 2010, NHCAW has led numerous projects and events that have elevated discussions about climate preparedness at municipal, state, and regional levels. NHCAW partners incorporate peer-reviewed science and research in the development of tools and technical guidance, and outreach in the coastal watershed to help communities better prepare for the effects of a changing climate in order to protect their social, economic, human and environmental health. For more information, refer to NHCAW's website at www.nhcaw.org.

Regional Planning Commissions and Municipal Efforts

The Rockingham Regional Planning Commission and the Strafford Regional Planning Commission have been working directly with coastal communities since 2009 to provide downscaled data related to coastal risks and hazards from climate change that can be used by town official for planning purposes. In many cases the planning commissions have played instrumental roles in providing technical and planning expertise to municipal governments for updating Hazard Mitigation Plans, Master Plans, and other planning efforts. In other cases communities have applied for external grant sources to fund community vulnerability assessments that incorporate sea-level rise mapping. For a list of local climate change adaptation planning projects along with other project-based efforts, see [Appendix G](#).

Other State Guidance and Activities on Climate Change

Guidance and activities in several other states, including New York, Delaware, and Maryland, informed the Commission recommendations. As one example of this guidance, the Maryland Coast Smart Guidelines are summarized here.

Maryland Coast Smart – Construction and Infrastructure Siting and Design Guidelines

In 2014, the State of Maryland released its CoastSmart guidelines for the design, siting and construction to be used for new construction, reconstruction and rehabilitation of State structures and major infrastructure improvements within the State's defined coastal zone. It also called for similar measures to be applied to non-State projects if they are partially or fully funded by State agencies or located on State lands. These guidelines are tied to the State's Sea-level rise Projections made in 2008 and revised in 2013 by the Maryland Climate Change Commission. The key design guidelines include the following:

- New and reconstructed state structures are to be avoided within areas likely to be inundated [daily] by sea-level rise in 50 years, and should be designed to avoid or minimize future impacts over their design life.
- New State critical or essential facilities shall not be constructed within NFIP Special Flood Hazard Areas and should be designed such as to be protected from damage and loss of access resulting from a 500-year (0.2-percent-annual-chance) storm.
- New, reconstructed and rehabilitated State structures shall be constructed with a minimum of two (2) feet of freeboard above the 100-year (1-percent-annual-chance) base flood elevation, as defined by NFIP.
- Ecological features that buffer future impacts from sea-level rise and storm-surge shall be identified protected and maintained.

The Maryland example, like the FFRMS, also incorporates a process by which exceptions to these guidelines can be made under certain circumstances.

New York – Community Risk and Resiliency Act

New York State enacted the Community Risk and Resiliency Act in 2014 to strengthen preparedness for the effects of climate change and to help protect communities against severe weather and sea-level rise. The legislation requires that applicants for state funding or permits consider impacts from storm surge, sea-level rise and flooding. It is the only legislation in the nation that requires climate impacts to be considered in all state planning, permitting, and funding approval processes. The law charges the State's environmental agency (Department of Environmental Conservation) to:

- Adopt a set of sea-level projections and update them every five years.
- Adopt regulations establishing science-based state sea level rise projections based on NOAA predictions and recommendations from a state Sea Level Rise Task Force.
- Develop model climate change adaptation zoning laws for use by municipalities;
- Require companies and communities seeking certain state permits or funding to incorporate the adopted sea level projections, as well as forecasts covering heavy rainfall and storm surges, into project designs.

In addition the law amends numerous other state statutes and state agency rules to require the explicit consideration of future climate change risk, in the administration of laws governing such subjects as agriculture, public infrastructure, energy and waste facility siting and acquisition of land for the conservation of open space, recreation and natural, cultural or historic resources.

APPENDIX D: Science and Technical Advisory Panel (STAP) Report Summary

2014 SCIENCE AND TECHNICAL ADVISORY PANEL REPORT SUMMARY

Sea-level Rise, Storm Surges, and Extreme Precipitation in Coastal New Hampshire: Analysis of Past and Projected Future Trends

Climate change is expected to have significant impacts on critical infrastructure and natural and cultural resources in coastal New Hampshire over the next century and beyond.

This report is intended to help municipal and state decision-makers prepare for projected sea-level rise and other coastal hazards and minimize the risks those hazards pose to municipalities and state assets.



SEA-LEVEL RISE

Global sea levels have been rising and are expected to continue rising well beyond the end of the 21st century. Rising seas pose significant risks to our communities and ecosystems, cultural resources and other coastal property and infrastructure.

PROJECTIONS

Forecasting rates of global greenhouse gas emissions is challenging, but research shows that current greenhouse gas concentrations and current or accelerated emissions will continue to influence sea levels in the future.

PRECIPITATION

Mean annual precipitation in the northeastern United States increased by approximately 5 inches (more than 10%) between 1895 and 2011.

PROJECTIONS

Annual precipitation is expected to increase by as much as 20% between 2071 and 2099 compared to the late 20th century. Most of the precipitation increases will be in winter and spring in the form of rain or snow. Fall and summer will experience less of an increase.

EXTREME PRECIPITATION

The Northeast experienced a 50% increase in total annual precipitation from storms classified as extreme events between 1901 and 2012. Here, "extreme" is defined as the number of times each year that the 24-hour rainfall amount exceeds the largest 1% of precipitation events in that year.

PROJECTIONS

Extreme precipitation events are projected to increase in frequency and in the amount of precipitation produced. In particular, the rainfall amount produced by hurricanes is projected to increase. However, current climate models and analyses are not as good at projecting future changes in the frequency or magnitude of extreme precipitation events.

SEA-LEVEL RISE SCENARIOS AT 2050 AND 2100

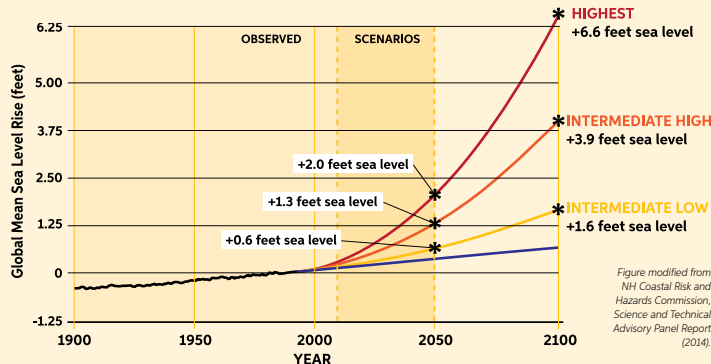
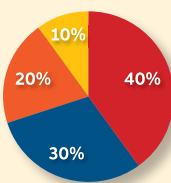


Figure modified from
NH Coastal Risk and
Hazards Commission,
Science and Technical
Advisory Panel Report
(2014).

PROCESSES CAUSING SEA LEVELS TO RISE



- 40% Ocean warming or thermal expansion
- 30% Melting of land-based glaciers
- 20% Melting of Antarctic and Greenland ice sheets
- 10% Vertical land movements, shifts in Earth's gravity field and ocean dynamics

STORM SURGE

The New Hampshire coast is significantly impacted by both Nor'easters and hurricanes. Winds from these storms drive ocean water towards the land, resulting in the short-term rise in water levels called storm surge. The actual height of a flood is determined by factors such as storm intensity, forward speed, storm area size, coastline characteristics, and angle of approach to the coast, in addition to tide height. Nor'easters can impact the region for several days and produce a storm surge with or without the addition of inland runoff from heavy precipitation. Over the past ten years the largest storm surges observed in New Hampshire occurred during Nor'easters.



PROJECTIONS

Considering changes in water levels due to sea-level rise alone, today's extreme storm surge events (i.e. 100-year flood) will have a greater inundation extent and occur more frequently over time. Due to increased coastal development, there has been a significant increase in impacts from hurricanes nationwide over the 20th century. However, there is some uncertainty in the projection of trends in hurricane frequency and intensity in any given region, and no research consistently finds a trend in the frequency and intensity of Nor'easters.

REVISED NOVEMBER 2016

To access this document, visit <http://www.nhcrhc.org/wp-content/uploads/2014-STAP-report-summary.pdf>.

USING THIS REPORT:

How to Prepare for the Changing Climatic Conditions in Coastal New Hampshire

PREPARING FOR SEA-LEVEL RISE

For coastal locations where the need to protect existing coastal development, infrastructure or ecosystems is high, sea level estimates should be applied as follows:

1. **Determine the time period** over which the system is designed to serve (either in the range 2014–2050, or 2051–2100).
2. **If the design time period is 2014–2050**, commit to manage to 1.3 feet of sea-level rise, but be prepared to manage and adapt to 2 feet if necessary.
3. **If the design time period is 2051–2100**, commit to manage to 3.9 feet of sea-level rise, but be prepared to manage and adapt to 6.6 feet if necessary.
4. **Be aware that the projected sea-level rise ranges may change** and prepare to adjust design considerations if necessary. The choice of management strategies can include strategies to protect, accommodate, or retreat from the flood risk.

EXAMPLES OF PREPARING FOR SEA-LEVEL RISE

A building or facility with an anticipated lifespan beyond 2050 could be constructed today:

- For the highest sea-level rise scenario of **6.6 feet** (the most protective approach).
- OR
- For **2 feet of future sea-level rise** —but designed to allow modifications sometime in the future to protect against 3.9 or 6.6 feet of sea-level rise.

HISTORIC SEA LEVELS

Based on local tide gauge data, sea levels in New Hampshire have been rising by an average of **0.7 inches per decade since 1900**. The rate of sea-level rise has increased to approximately **1.3 inches per decade since 1993**.

FUTURE SEA LEVELS

Using 1992 sea levels as a baseline, New Hampshire sea levels are expected to rise **0.6 – 2.0 feet by 2050** and **1.6 – 6.6 feet by 2100**.

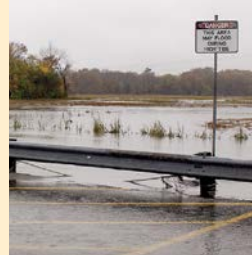


Photo credit: Tricia Miller

PREPARING FOR CHANGES IN PRECIPITATION

Consideration of historical increases in precipitation and projected future precipitation should be applied as follows:

- **If the design time period is 2014–2050**, buildings and infrastructure should be designed to withstand extreme precipitation intensities based on the most current precipitation data.
- **If the design time period is 2051–2100**, buildings and infrastructure should be designed to manage a 15 percent increase in the amount of precipitation produced during extreme precipitation events after 2050.



Photo credit: UNH Stormwater Center

PREPARING FOR CHANGES IN STORM SURGES

Coastal projects should be designed to consider future flood risks by adding projected sea-level rise heights to current storm surge heights, as measured by the 100-year and 500-year floods.



Photo credit: UNH Stormwater Center

ABOUT THIS REPORT AND THE NEW HAMPSHIRE COASTAL RISK AND HAZARDS COMMISSION

This Science and Technical Advisory Panel report is intended to guide the New Hampshire Coastal Risk and Hazards Commission in its development of recommendations to assist in planning and preparation for the changing climatic conditions in coastal areas of the state.

The New Hampshire Coastal Risk and Hazards Commission was established by the New Hampshire Legislature on July 2, 2013 by RSA 483E. The Commission is required to consider key scientific research on current and future coastal risks and hazards and is charged with recommending legislation, rules and other actions.

The Commission created a Science and Technical Advisory Panel to review available scientific information about coastal hazards and flood risks in New Hampshire.

The Panel analyzed the latest published data on historic trends and projections for the years 2050 and 2100 for sea-level rise, coastal storms, and extreme precipitation.

These findings were summarized in a peer-reviewed report, which the Commission unanimously adopted in July 2014 and used to develop its final report and recommendations released in November 2016. The Panel suggests this assessment and report be updated at least every two years as new research and data become available.

To learn more about the New Hampshire Coastal Risk and Hazards Commission, go to www.nhcrhc.org.

For information or questions about the Commission, contact Cliff Sinnott, Commission Chair at **603-778-0885** or csinnott@rpc-nh.org.

To download the complete Science and Technical Advisory Panel report, go to www.nhcrhc.org.

THE DESIGN AND PRINTING OF THIS SUMMARY WERE PAID FOR IN PART BY A GRANT FROM THE NEW HAMPSHIRE CHARITABLE FOUNDATION.

REVISED NOVEMBER 2016

To access this document, visit <http://www.nhcrhc.org/wp-content/uploads/2014-STAP-report-summary.pdf>.

APPENDIX E: Other Hazards and Risks

Appendix E summarizes some of the limited information known about several important hazards and risks posed to coastal New Hampshire as a result of changes in climate. Existing and emerging science and assessments should be reviewed further in future updates to the Science and Technical Advisory Panel report or in other venues.

Temperature, Drought, Snowfall, and Seasonal Shifts

As our climate continues to change we can expect warmer winters with 25-50 fewer days per year below freezing and 20-60 day increase in summer days with temperatures above 90 degrees Fahrenheit.¹⁰⁰ In addition to the extreme changes in temperature will lead to a shorter winter and a longer growing season.¹⁰¹ The coastal watershed is expected to experience an increased frequency of hot days. On those days heat stress and its associated heat injuries and deaths become more probable.¹⁰² Even with changes in precipitation trends, shifting seasons and extreme temperatures, New Hampshire's coastal watershed is expected to see only a slight decrease to no change in the frequency of drought.¹⁰³

As noted in the STAP, there is an anticipated increase in extreme precipitation events. This could translate to an increase in extreme snow events and total winter snow fall. However, the combination of warmer winter and spring temperatures will lead to a decrease in the number of winter days with snow cover. In addition, as winters continue to warm over the century, a larger portion of winter precipitation will likely fall as rain. The Piscataqua/Great Bay region is expected to see a three-week to one-month decrease in snow covered days.¹⁰⁴

Due to the combination of warmer temperatures and a longer growing season, New Hampshire is expected to see an increase in number of unhealthy air quality days. The unhealthy air quality days will result from an increase in pollen production and ozone (a form of air pollution) and lead to an increase in asthma cases and cardiorespiratory illnesses respectively.¹⁰⁵

Saltwater Intrusion and Groundwater Tables

Sea-level rise combined with land subsidence are already resulting in incidents of saltwater intrusion where saline ocean water infiltrates the groundwater table along the coast. This issue needs further study to identify how saltwater is likely to change the salinity of existing freshwater sources along the coast. Additionally, as sea levels rise, groundwater table elevations are pushed upward, resulting in higher groundwater elevations at significant distances from the coast. Ongoing groundwater modeling at the University of New Hampshire is investigating the effects of climate change, including sea-level rise, precipitation and temperature, on groundwater levels and the impacts to roads in coastal New Hampshire. The groundwater modeling study will have broader applications as it can be expanded to investigate the effects of climate change on drinking water supply, base flow to streams, and the hydrology of wetlands.

Ocean Chemistry

Ocean acidification in the Gulf of Maine is the result of at least two factors: increasing CO²—carbon dioxide levels in the atmosphere, and more intense and frequent rain events.¹⁰⁶ The ocean absorbs more carbon dioxide from the atmosphere as carbon dioxide levels increase in the air, and this causes the pH of the sea water to decrease. Recent studies have shown that the Gulf of Maine may be particularly sensitive to watershed influences on ocean acidification. In acidic seawater conditions it is difficult for organisms to build and maintain shells.¹⁰⁷ Up to 90 percent of the marine resource economy of the region is dependent on harvesting shelled animals like lobsters, clams, and oysters.

Impacts to Our Well-Being and Assets

These coastal hazards will result in impacts to a variety of resources and assets in the state of New Hampshire. Increases in average temperature and resulting seasonal shifts will have impacts on agriculture, tourism, and other industries. These climatic changes will lead to more invasive species and expanded ranges for vector-borne diseases like Lyme disease and other pests, not to mention general shifts in native species composition and ecological diversity. Access to clean drinking water will likely be impacted by saltwater intrusion. Additionally, rising groundwater tables will result in more vulnerable roads and new freshwater wetlands where the groundwater table is already close to the surface. Water quality issues arising from changes in ocean chemistry and temperature are likely to arise, including increased instances of cyanobacteria at beaches and nuisance algae growth in estuarine waters. This list of impacts is not exhaustive and there are likely many impacts that researchers and others have yet to predict, therefore additional research and analysis is needed to identify, understand, and prepare for both known and unknown impacts.¹⁰⁸

APPENDIX F: State of New Hampshire Comments on the Draft Guidelines for Implementing the Federal Flood Risk Management Standard



MARGARET WOOD HASSAN
GOVERNOR

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May 6, 2015

Regulatory Affairs Division
Office of Chief Counsel
Federal Emergency Management Agency
500 C Street, SW
Washington, DC 20472

Re: Docket ID No. FEMA-2015-0006, Comments on the Draft *Guidelines for Implementing the Federal Flood Risk Management Standard*

Dear Office of Chief Counsel,

On behalf of the State of New Hampshire, the Office of Energy and Planning is submitting for your consideration comments on the draft *Guidelines for Implementing the Federal Flood Risk Management Standard* developed by the New Hampshire Coastal Risks and Hazard Commission, which includes representatives from the New Hampshire State Legislature, the New Hampshire Department of Transportation, the New Hampshire Department of Environmental Services, the New Hampshire Office of Energy and Planning, the New Hampshire Division of Historic Resources, and the New Hampshire Department of Resources and Economic Development, among other state, regional and local stakeholders.

In New Hampshire, we have experienced a number of significant flooding events in recent years and the new standard proposed by President Obama in Executive Order 13690 is a crucial step to improving our preparedness and resilience. The State of New Hampshire appreciates the opportunity to provide comments prior to the implementation of the Federal Flood Risk Management Standard. If you need additional information please contact Jennifer Gilbert, New Hampshire's National Flood Insurance Program Coordinator at 603-271-1762 or Jennifer.gilbert@nh.gov.

Sincerely,

Meredith A. Hatfield
Director

Enclosure: State Comments

TDD Access: Relay NH 1-800-735-2964

COMMENTS TO THE FEDERAL EMERGENCY MANAGEMENT AGENCY
ON THE DRAFT GUIDELINES FOR IMPLEMENTING
THE FEDERAL FLOOD RISK MANAGEMENT STANDARD

WHEREAS, New Hampshire faces increasing flood risk due to several factors including land use change, extreme precipitation, storm surge and sea level rise, it is imperative that its communities, agencies, institutions and businesses prepare for these conditions by creating greater resilience to flooding; and

WHEREAS, it is essential for communities to begin acting now to adapt to these projected conditions, and to do so using multiple measures, including resilient building, landscape and infrastructure design, protection and enhancement of natural shoreline features, and strategic shoreline protection or retreat; and

WHEREAS, creating more resilient communities, both in the built and natural environment, will help protect life, and property and economic vitality from the effects of future flood risk; and

WHEREAS, to establish greater resiliency, the design and construction of public infrastructure that is built or rebuilt from this point forward should anticipate future flood conditions to ensure that such investments are not subject to unnecessary damage or loss; and

WHEREAS, higher flood management standards will increase the short term capital costs for building and infrastructure, if the standards are reasonably established and based on sound science, they will also reduce the long term costs for maintaining, repairing and replacing buildings and infrastructure due to flood damage; and

WHEREAS, in 2013 the State of New Hampshire established a Coastal Risks and Hazards Commission (CRHC) under RSA 483-E to advise the state and its coastal municipalities on policies and actions with regards to increasing coastal flood hazards; and

WHEREAS, the New Hampshire Coastal Risks and Hazards Commission subsequently established a Science and Technical Advisory Panel (STAP) to advise it on the expected sea level rise and other future flood hazards specific to New Hampshire based on the best currently available climate science, and that Panel issued its report in August 2014; and

WHEREAS, it is advisable to establish state and national standards for flood risk management to protect public investment in infrastructure, and to ensure consistency in planning and design across agencies and localities;

THEREFORE, the State of New Hampshire supports the establishment and implementation of new Federal Flood Risk Management Standards:

1. We affirm the need for a Federal Flood Risk Management Standard (FFRMS) and support the proposed framework which allows flexibility in choosing the standard that will apply in specific circumstances (including the climate-informed science approach, the freeboard value approach and the 500 year flood elevation approach). We also support the inclusion of exceptions to the standards for certain emergencies, mission critical actions, national security concerns, and where application of the standard is 'demonstrably inappropriate'.

2. The FFRMS should incorporate the timeframe of anticipated increases in flood risk along with the design life and risk sensitivity of the facility or action being proposed to determine appropriate flood management standards.
3. The FFRMS should include periodic revaluation of the standards to incorporate updated science based understanding and projections of sea level rise and other sources of flood risk.
4. Increased cost of project design and construction resulting from higher flood standards should be accommodated in the available federal funding for such projects.
5. Clear guidance should be provided for qualifying a state or region-specific 'climate science based standard' (such as the CRHC STAP report) into the FFRMS and clarifying under what circumstances higher state or local standards will take precedence over Federal standards.
6. Special attention should be given in the FFRMS implementing guidelines concerning how the standards will be applied to regulated actions pertaining to historic and archeological properties and sites.
7. The guidance to Federal agencies provided through FFRMS should seek to avoid the development of rules and standards that conflict when applied to projects that are subject to the jurisdiction of multiple agencies.

APPENDIX G: Related Projects

Since 2009, partner organizations of the New Hampshire Coastal Adaptation Workgroup (NHCAW) have worked together and partnered with communities on 70 projects totaling \$6,511,292 in grant funding. This is a list of completed and ongoing projects that NHCAW partner organizations work on to help New Hampshire coastal communities become more resilient to coastal risks and hazards exacerbated by climate change. Projects are organized chronologically by start date. This is not a comprehensive list of all projects related to coastal risks and hazards in the New Hampshire region. For more information about NHCAW or any of the projects listed below, please contact the NHCAW co-chairs Sherry Godlewski of the New Hampshire Department of Environmental Services (sherry.godlewski@des.nh.gov) and Steve Miller of the Great Bay National Estuarine Research Reserve (steve.miller@wildlife.nh.gov).

New Hampshire Setting SAIL: Acting on the Coastal Risk and Hazards Commission, Science, Assessment, Implementation, and Legislation Recommendations (“NH Setting SAIL”)

Project Period: October 2016 to March 2018

This project seeks to implement the New Hampshire Coastal Risk and Hazards Commission’s (CRHC) final recommendations at state and local levels. The project is divided into three tracks: 1) strategically designed outreach to state agencies and municipalities about the CRHC recommendations; 2) technical assistance to implement municipal projects; and 3) a coordinated effort to ensure that state agencies identify their vulnerable assets and necessary policy changes to improve preparedness. Together, these tracks will ensure that the CRHC’s recommendations move forward and that coastal New Hampshire takes key steps toward becoming more resilient in the face of climate change.

Incentivizing Resiliency through Implementation Plans in one of coastal New Hampshire’s Fastest Growing Communities: Exeter

Project Period: October 2016 to March 2018

The project partners are working with community leaders in the Town of Exeter, NH to incentivize resilient development strategies through the development of a subwatershed scale implementation plan and climate adaptation policies combined with innovative communications that illustrate the economic benefits of flood adaptation. The RPC regional planner will work with the Town of Exeter to develop community-tailored Climate Adaptation Policies. The process will be guided by a Steering Committee to provide formative direction throughout. A vulnerability analysis of municipal drainage infrastructure and shorelands will be conducted in combination with an examination of flooding extent and climate adaptation strategies at the subwatershed scale for the purpose of developing site-specific implementation plans and construction ready designs. Lastly the [project will engage coastal zone communities with an outreach effort using innovative messaging to communicate the social, economic and environmental impacts from flooding to the public in vulnerable areas. Innovative visualization tools and approaches will be installed in key public places to illustrate climate vulnerability in both physical terms, such as flood elevations with high water marks, and economic terms such as the risk to the local economy and fiscal impacts.

Portsmouth Historic Resource Vulnerability Assessment

Project Period: September 2016 to September 2017

This project has not yet been approved by NH Governor’s Executive Council. If approved the project will focus on the historic resources within the City’s South End and quantify the value of these resources and prioritize their protection through a number of adaptation measures. The project will received input and support for a local advisory committee to assist with the creation of an adaptation plan for the historic district.

Wagon Hill Farm Erosion Control

Project Period: August 2016 to June 2017

This project seeks to assess the erosion issue at the Wagon Hill Farm shoreline in Durham. The Town of Durham will work with the NH Department of Environmental Services Coastal Program and the University of New Hampshire to monitor and assess and design alternatives for erosion control and shoreline protection.

NH Volunteer Beach Profile Monitoring Program

Project Period: July 2016 to June 2017

This project seeks to establish a volunteer beach profile monitoring program. Quantifying changes in beach contours over time will provide increased understanding of responses to storms as well as seasonal and long-term trends of erosion and accretion. In addition, the program will provide important educational experience to volunteers about beach dynamics and the response of beaches to storms. Results will provide municipal and state decision makers with important information on coastal processes for guiding beach management. In addition, beach profiles will provide critical data to inform storm surge forecasting models currently in development by the National Weather Service.

Coastal Risk and Hazards Commission

Project Period: July 2016 to December 2017

NH Department of Environmental Services Coastal Program technical assistance funds are provided to Rockingham Planning Commission, Strafford Regional Planning Commission, and the Natural Resources Outreach Coalition to fund participation and assist with outreach related to the final report and recommendations of the NH Coastal Risk and Hazards Commission.

Durham Flood Overlay District

Project Period: July 2016 to December 2017

Strafford Regional Planning Commission is funded to work with the Durham Leadership Team to develop an extended coastal flood hazard overlay district, which would apply higher standards for building freeboard height and other provisions to lessen vulnerability of new buildings and facilities to flooding due to sea level rise. This effort would build off past and existing efforts, including the Durham Climate Adaptation Chapter and the C-RiSe vulnerability assessment. This work supports Objective #1 of the NH Section 312 Metrics regarding creating informed and resilient coastal communities and Objective #2 of the NH Section 312 Metrics regarding the reduction of future risk and damage from coastal hazards.

Library project in Rockingham

Project Period: July 2016 to December 2017

The Natural Resources Outreach Coalition (NROC) team will engage with teachers as well as students and their parents in a collaborative process for gaining and demonstrating community support on municipal climate resiliency. This will involve identifying school teachers to partner with and lead the classroom activities, while NROC will lead planning and facilitating a community event to bring together students to present findings and local concerns about climate change to parents and municipal leaders at a public space such as a library. This program would likely be incorporated into the classroom in Spring, 2017, with the public presentation sessions occurring later in the season. Lessons learned from implementing this program in Durham (2015-2016) will be transferred to this project. NROC will collaborate with the Strafford Regional Planning Commission on this project.

Groundwater modeling to investigate the effect of sea level rise on saltwater intrusion and drinking water wells in the Town of Newmarket

Project Period: June 2016 to June 2017

The Strafford Regional Planning Commission, in partnership with the University of New Hampshire, will use NH Department of Environmental Services grant funds to conduct an investigation of the vulnerability of public drinking water supplies in Newmarket to saltwater intrusion. The project will include groundwater modeling, data analysis and mapping, public outreach and education, and preparation of a final report with recommended next steps

NOAA Regional Resilience Grant

Project Period: May 2016 to May 2018

This project seeks to accomplish two key objectives. First, it will improve the resolution and accuracy of inundation modeling in the Great Bay estuary through development of an unstructured grid modeling platform. Second, it will explore and promote best practices for green infrastructure installations that promote flood resiliency and shoreline protection in the Great Bay estuary and coordinate outreach through workshops and other materials. The New Hampshire project team is part of a larger regional team that includes the Northeast Regional Ocean Council, the Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOO), and representatives from research institutions and state Coastal Zone Management programs from all states in the Northeast Region.

Cutts Cove Restoration Project

Project Period: April 2016 to December 2017

The Cutts Cove Shoreline Restoration Project will restore shoreline that was filled and armored with rip-rap up to 12 feet above mean high tide. The entire right of way adjacent to Market Street Extension is vacant; with plans to create a city park landward of the restoration area. Our project will restore the hardened shoreline into a living shoreline, creating tidal buffer zone, intertidal marsh, and a short (18-20 inch) sill of repurposed stone from the rip-rap wall.

NHCAW Coastal Resilience Portal

Project Period: March 2016 to May 2017

This project will result in the development of a Coastal Resilience Portal website, upgrading the existing NHCAW website and integrating several other existing resilience efforts.

NH Coastal Viewer Enhancement

Project Period: February 2016 to June 2017

This project ensures that the NH Coastal Viewer is able to continue operating to support municipal officials and other users. Funds provided cover approximately 18 months of maintenance, new tool development, training resources, and user evaluation for the NH Coastal Viewer. The goal of the proposed project is to maintain, enhance, and promote the NH Coastal Viewer to 1) build community resilience to impacts of coastal erosion, flooding, and storms, and 2) enhance collaborative actions on coastal ecosystem planning.

Tides to Storms 2 - Adaptation Implementation: Hampton

Project Period: November 2015 to September 2016

The Rockingham Planning Commission (RPC) has received a grant from the Northeast Region Ocean Council to provide technical assistance to the seven Atlantic coastal municipalities \$6000 in direct technical assistance to implement recommended strategies from the Tides to Storms Vulnerability Assessment. The project goal is to focus municipal efforts to adopt or implement adaptation strategies, improve municipal and community resilience to coastal flooding, protect public health and safety, and increase awareness of coastal flood risks and hazards. This assistance can include support for one or several ongoing or new projects providing the projects can be accomplished within the grant period and within available funding limits. Portsmouth is evaluating the options for incorporating freeboard for different types of structures and settings. Hampton chose to make revisions to existing floodplain management standards in their zoning ordinance.

Tides to Storms 2 - Adaptation Implementation: Hampton Falls

Project Period: November 2015 to September 2016

The Rockingham Planning Commission (RPC) has received a grant from the Northeast Region Ocean Council to provide technical assistance to the seven Atlantic coastal municipalities \$6000 in direct technical assistance to implement recommended strategies from the Tides to Storms Vulnerability Assessment. The project goal is to focus municipal efforts to adopt or implement adaptation strategies, improve municipal and community resilience to coastal flooding, protect public health and safety, and increase awareness of coastal flood risks and hazards. This assistance can include support for one or several ongoing or new projects providing the projects can be accomplished within the grant period and within available funding limits. Portsmouth is evaluating the options for incorporating freeboard for different types of structures and settings. Hampton Falls chose to make revisions to Building Codes to require freeboard for residential structures in existing/future floodplains (Tides to Storms mapping) and conduct community outreach about flood hazards and options for protecting property and structures.

Tides to Storms 2 - Adaptation Implementation: New Castle

Project Period: November 2015 to September 2016

The Rockingham Planning Commission (RPC) has received a grant from the Northeast Region Ocean Council to provide technical assistance to the seven Atlantic coastal municipalities \$6000 in direct technical assistance to implement recommended strategies from the Tides to Storms Vulnerability Assessment. The project goal is to focus municipal efforts to adopt or implement adaptation strategies, improve municipal and community resilience to coastal flooding, protect public health and safety, and increase awareness of coastal flood risks and hazards. This assistance can include support for one or several ongoing or new projects providing the projects can be accomplished within the grant period and within available funding limits. Portsmouth is evaluating the options for incorporating freeboard for different types of structures and settings. New Castle chose to make revisions to existing buffer standards, complete community outreach about flood impacts, and review zoning and regulations to identify ways to incorporate climate adaptations.

Tides to Storms 2 - Adaptation Implementation: North Hampton

Project Period: November 2015 to September 2016

The Rockingham Planning Commission (RPC) has received a grant from the Northeast Region Ocean Council to provide technical assistance to the seven Atlantic coastal municipalities \$6000 in direct technical assistance to implement recommended strategies from the Tides to Storms Vulnerability Assessment. The project goal is to focus municipal efforts to adopt or implement adaptation strategies, improve municipal and community resilience to coastal flooding, protect public health and safety, and increase awareness of coastal flood risks and hazards. This assistance can include support for one or several ongoing or new projects providing the projects can be accomplished within the grant period and within available funding limits. Portsmouth is evaluating the options for incorporating freeboard for different types of structures and settings. North Hampton chose to make revisions to existing buffer standards in their zoning ordinance.

Tides to Storms 2 - Adaptation Implementation: Portsmouth

Project Period: November 2015 to September 2016

The Rockingham Planning Commission (RPC) has received a grant from the Northeast Region Ocean Council to provide technical assistance to the seven Atlantic coastal municipalities \$6000 in direct technical assistance to implement recommended strategies from the Tides to Storms Vulnerability Assessment. The project goal is to focus municipal efforts to adopt or implement adaptation strategies, improve municipal and community resilience to coastal flooding, protect public health and safety, and increase awareness of coastal flood risks and hazards. This assistance can include support for one or several ongoing or new projects providing the projects can be accomplished within the grant period and within available funding limits. Portsmouth chose to evaluate the options for incorporating freeboard for different types of structures and settings.

Tides to Storms 2 - Adaptation Implementation: Rye

Project Period: November 2015 to September 2016

The Rockingham Planning Commission (RPC) has received a grant from the Northeast Region Ocean Council to provide technical assistance to the seven Atlantic coastal municipalities \$6000 in direct technical assistance to implement recommended strategies from the Tides to Storms Vulnerability Assessment. The project goal is to focus municipal efforts to adopt or implement adaptation strategies, improve municipal and community resilience to coastal flooding, protect public health and safety, and increase awareness of coastal flood risks and hazards. This assistance can include support for one or several ongoing or new projects providing the projects can be accomplished within the grant period and within available funding limits. Portsmouth is evaluating the options for incorporating freeboard for different types of structures and settings. Rye chose to write a Climate Adaptation and Coastal Hazards Chapter, Master Plan.

Tides to Storms 2 - Adaptation Implementation: Seabrook

Project Period: November 2015 to September 2016

The Rockingham Planning Commission (RPC) has received a grant from the Northeast Region Ocean Council to provide technical assistance to the seven Atlantic coastal municipalities \$6000 in direct technical assistance to implement recommended strategies from the Tides to Storms Vulnerability Assessment. The project goal is to focus municipal efforts to adopt or implement adaptation strategies, improve municipal and community resilience to coastal flooding, protect public health and safety, and increase awareness of coastal flood risks and hazards. This assistance can include support for one or several ongoing or new projects providing the projects can be accomplished within the grant period and within available funding limits. Portsmouth is evaluating the options for incorporating freeboard for different types of structures and settings. Seabrook chose to write a Climate Adaptation and Coastal Hazards Chapter for their Master Plan.

Community Resilience in the Seacoast (C-RiSe)

Project Period: September 2015 to March 2017

This project team is assessing climate change impacts to natural systems and the built environment for ten coastal municipalities. Results of the assessment will help municipalities apply climate impact data directly into programmatic changes such as facilities (infrastructure upgrades and priorities), permit processes, codes, and regulations. The project results will be built into a developing web-based platform (NH Coastal Viewer). The UNH Stormwater Center, Rockingham Planning Commission (RPC) and Strafford Regional Planning Commission (SRPC) will assess the impact of climate change on culvert performance, and natural resources and infrastructure due to tidal changes from sea level rise and storm surge and produce mapping and assessment tools to inform municipal plans and decision making. RPC and SRPC will complete a vulnerability analysis of sea-level rise and storm flooding, working closely with each of their municipalities to incorporate information into hazard mitigation plans. The UNH Stormwater Center will complete a culvert analysis based on future climate conditions including projected increases in the frequency and magnitude of extreme precipitation events.

Buffers on the Bay (BOB)

Project Period: September 2015 to August 2017

This project's goal is to enhance stakeholder capacity to make informed decisions related to the protection and restoration of buffers around New Hampshire's Great Bay Estuary. The project will be integrating existing geospatial information and the best available buffer science with economic valuation data about the benefits of buffers. This watershed scale information will then be used to select a subwatershed to work within to determine what combination of incentive and regulatory solutions can best promote good buffers around Great Bay.

Piscataqua Regional Environmental Planning Assessment (PREPA) Grant: Berwick, ME

Project Period: August 2015 to October 2016

This project addresses three of the four recommendations for Berwick, ME following the publication of the 2015 Piscataqua Region Environmental Planning Assessment. The project has three goals: (1) increase shoreland setbacks for primary structures to 100'; (2) adopt 100' fertilizer application buffers on lakes and ponds; (3) adopt managed buffer width of 100'. Each of these goals will increase protection for water quality and build resiliency for the Town of Berwick in response to increase precipitation associated with climate change.

Piscataqua Regional Environmental Planning Assessment (PREPA) Grant: Exeter, NH

Project Period: August 2015 to October 2016

Nitrogen loading in the Great Bay Estuary and associated tributaries is a concern for many communities within the Piscataqua Region watershed. With increasing precipitation from climate change, Exeter aims to improve fertilizer application setbacks within their community to reduce nitrogen loading. This project addresses one of the four recommendations for Exeter, NH from the 2015 PREPA report.

Piscataqua Regional Environmental Planning Assessment (PREPA) Grant: Greenland, NH

Project Period: August 2015 to October 2016

Greenland, NH will be working to adopt the Southeast Watershed Alliance model stormwater ordinance. The model ordinance aims to consider projected changes in climate within the design, siting and implementation of stormwater infrastructure. Adopting the model ordinance will increase resiliency within Greenland in response to climate change.

Piscataqua Regional Environmental Planning Assessment (PREPA) Grant: Hampton, NH

Project Period: August 2015 to October 2016

Hampton will strengthen its commitment to better floodplain management and implement positive measure to reduce flood risks associated with sea-level rise and coastal storms through participation in the FEMA Community Rating System (CRS). The CRS is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum National Flood Insurance Program requirements. Additionally, participation in the CRS will create strong incentives among town residents to improve buffer protection and management—key PREPA action items identified for Hampton, NH.

Piscataqua Regional Environmental Planning Assessment (PREPA) Grant: Kittery, ME

Project Period: August 2015 to October 2016

The Town of Kittery Public Works and Code Enforcement Offices plan to complete a full assessment of the stream and river crossing culverts between 1' and 3' diameter on Town of Kittery maintained roadways. Preliminary field assessments have indicated that many of these smaller culverts are undersized leading to a potential threat to human health and water quality. Culverts will be assessed on location, stability, and sizing as it related to increased precipitation events relating to climate change. The culverts will be prioritized (high, medium, low) for the need for replacement.

Piscataqua Regional Environmental Planning Assessment (PREPA) Grant: New Castle, NH

Project Period: August 2015 to October 2016

The New Castle Conservation Commission proposes to focus on the top priority action to increase buffers to 100' for all waterbodies as listed under the 2015 PREPA recommendations. The Conservation Commission also proposes to increase protection efforts for the Lavenger Creek salt marsh that will involve proposing more stringent regulatory standards and/or prime wetlands designation. This project builds upon the work to reduce and manage invasive species cover around the Lavenger Creek salt marsh.

Piscataqua Regional Environmental Planning Assessment (PREPA) Grant: North Hampton, NH

Project Period: August 2015 to October 2016

The 2015 PREPA identified adoption of the Southeast Watershed Alliance model stormwater ordinance as one of the four priority actions for North Hampton, NH. The model ordinance aims to consider projected changes in climate within the design, siting and implementation of stormwater infrastructure. Adopting the model ordinance is a proactive and cost effective way for the town to address stormwater pollution and increased runoff from projected increases in precipitation associated with climate change.

Piscataqua Regional Environmental Planning Assessment (PREPA) Grant: Rollinsford, NH

Project Period: August 2015 to October 2016

The 2015 PREPA identified adoption of the Southeast Watershed Alliance model stormwater ordinance as one of the four priority actions for Rollinsford, NH. The model ordinance aims to consider projected changes in climate within the design, siting and implementation of stormwater infrastructure. Adopting the model ordinance is a proactive and cost effective way for the town to address stormwater pollution and increased runoff from projected increases in precipitation associated with climate change. Throughout the process Rollinsford also plans to inventory stormwater related issues and assess current stormwater management practices.

Piscataqua Regional Environmental Planning Assessment (PREPA) Grant: Rye, NH

Project Period: August 2015 to October 2016

Rye will institutionalize its commitment to better floodplain management—a critical focus as sea levels continue to rise and coastal storms intensify—through participation in the FEMA Community Rating System (CRS). The CRS is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum National Flood Insurance Program requirements. Additionally, participation in the CRS will create strong incentives among town residents to improve buffer protection and management—key PREPA action items identified for Rye, NH.

Piscataqua Regional Environmental Planning Assessment (PREPA) Grant: Somersworth, NH

Project Period: August 2015 to October 2016

The City of Somersworth proposes to complete a natural resource inventory to guide short and long term land conservation priorities. A natural resource inventory is a tool for communities to gain a better understanding of their existing natural resource values and to establish a sustainable approach for land use planning and management in response to climate change.

Piscataqua Regional Environmental Planning Assessment (PREPA) Grant: Stratham, NH

Project Period: August 2015 to October 2016

Stratham proposes to explore all four of the proposed recommendations from the 2015 Piscataqua Region Environmental Planning Assessment and adopt as appropriate. The four recommendations are: (1) increase buffers to 100' for tidal wetlands; (2) increase septic and structure setbacks to 100' for freshwater wetlands; (3) adopt fertilizer application setbacks for all waterbodies; and (4) adopt model stormwater management regulations. Each of these goals will increase protection for water quality and build resiliency for the Town of Stratham in response to increase precipitation associated with climate change.

Library project in Durham

Project Period: July 2015 to December 2016

The Natural Resources Outreach Coalition (BROC) team engaged with teachers as well as students and their parents in a collaborative process for gaining and demonstrating community support on municipal climate resiliency. NROC led planning and facilitated a community event to bring together students to present findings and local concerns about climate change to parents and municipal leaders at a public space such as a library. This program would likely be incorporated into the classroom in Spring, 2016, with the public presentation sessions occurring later in the season.

Cochecho Waterfront Development, Dover, NH

Project Period: June 2015 to June 2018

This is a multi-phase project that will occur over several years involving a mixed use development of multiple stories with an architectural character and quality to conform to the appearance of surrounding downtown Dover buildings. The site consists of a 29-acre parcel with over a half mile of frontage along the Cochecho River on its westerly and northerly boundary with approximately 14.5 acres suitable for development. To the south is a residential neighborhood and Henry Law Park, to the east is Maglaras Park, and frontage on the Cochecho River. The project involves several key elements including shoreland blended with a city park and boat house, and a combination of residential and commercial properties intended to create an attractive neighborhood and park space. Project design considerations include naturalized shoreline and park space and developed areas planning for 2100 projections for sea level rise and the resultant 100-year flood plain.

NH Shoreline Structure Inventory

Project Period: May 2015 to October 2015

The NH Department of Environmental Services Coastal Program is creating a spatial inventory of engineered shoreline structures along the New Hampshire tidal shoreline. This inventory will be developed for the NH Coastal Viewer, to include information about the structure type, elevation, and size, among other attributes. The inventory will be used to inform vulnerability assessments for these structures in the future.

Analysis of Water Resources to Supplement the Land Conservation Plan for New Hampshire's Coastal Watershed

Project Period: May 2015 to May 2016

This project builds upon and provides an update to The Land Conservation Plan for New Hampshire's Coastal Watersheds (2006), which identified land protection priorities on a watershed scale. The purpose of this project is to conduct spatial analyses to identify lands that, if protected, will (1) benefit water quality in the coastal watershed, (2) attenuate flood flows and mitigate flood risks, and (3) secure public drinking water supplies. The results of this project include new data showing land protection priorities that would mitigate flood risk, reduce pollution and improve the protection of drinking water supplies for planners, municipal staff, volunteer board members, land trusts, agency staff, and others.

Building Resilience to Flooding and Climate Change in the Moonlight Brook Watershed of Newmarket

Project Period: May 2015 to June 2016

Moonlight Brook is an important tributary of the Lamprey River drainage basin. Several flood resiliency and risk studies have been performed in the Lamprey River watershed including the Moonlight Brook subwatershed. The project team is conducting a two part effort to: 1) to study flood risk associated with climate change as well as how future development and build out of the community affect these risks, and 2) design robust green infrastructure practices within the Moonlight Brook watershed to help reduce risk of flooding while reducing pollutant load into the Brook and further downstream into the Lamprey River and ultimately Great Bay.

Implementing Phase I of the Lubberland Creek Culvert Restoration and Initiating the Development of NH's Tidal Culvert Assessment Protocol

Project Period: February 2015 to May 2016

Culvert replacement at the Bay Road crossing of Lubberland Creek in Newmarket achieves three primary goals: (1) restoration of aquatic connectivity at the system's tidal/freshwater interface allowing diadromous fish passage at the perched Bay Road culvert, (2) enhancement of the resilience of Lubberland Creek salt marsh by removal of the existing tidal restriction at Bay Road with a structure that allows upstream salt marsh migration as sea levels continue to rise, and (3) remediation of the flood hazard of this road-stream crossing, which overtops during major flood events and thereby compromises public safety. Task 2 – Initiation of the Development of NH's Tidal Culvert Assessment Protocol: Creation of a tidal culvert assessment protocol via review of best practices for tidal culvert assessments through existing literature, computer models and expert interviews, as well as the assembly of a group of experts in an effort to build consensus and justification for characteristics measured as part of a field-based tidal assessment protocol.

Assessment of Hydrologic Change due to Climate Change in New Hampshire: Simulation of Current and Future Water Streamflow, Snowmelt, and Groundwater Recharge Using the Precipitation Runoff Modeling System

Project Period: February 2015 to June 2016

This project builds on work already completed that developed a watershed runoff model for the Long Island Sound Watershed, including the Connecticut, Thames, and Housatonic Rivers (Bjerklie and others, 2011), and a U.S. Geological Survey (USGS) New England Regional Precipitation Runoff Modeling System (PRMS) model that has been developed as part of a USGS effort to build a continental scale National Hydrology Model (Lauren Hay and Steve Markstrom, personal communication 2014). The models run in New Hampshire for current and future climate change scenarios, giving users an enhanced understanding of possible changes to streamflow, snowmelt, and groundwater recharge to be expected in New Hampshire as a result of climate change.

Piscataqua Region Environmental Planning Assessment

Project Period: October 2014 to March 2015

The 2015 Piscataqua Region Environmental Planning Assessment (PREPA) is designed to provide an updated information base to inform ongoing and emerging planning and environmental protection efforts, and to identify gaps and inconsistencies in the standards of environmental protection reflected in the current ordinances, development regulations, and natural resource protection strategies in each of the 52 municipalities. The 2015 PREPA also gathered information on municipal land use policies and adaptation planning strategies designed to mitigate the impacts of climate change on the Piscataqua Region watershed.

Climate Adaptation for Road Infrastructure in Coastal New Hampshire

Project Period: October 2014 to September 2016

This research will assess the impacts of climate change and sea-level rise on road infrastructure in select coastal communities. Specific attention is given to reduction in pavement performance with rising ground water, temperatures, and extreme precipitation events. The research will develop the data and tools needed to assess climate impacts on roadways and will investigate various adaptation strategies through case studies. A NH Seacoast Transportation Climate Working Group

consisting of regional planners, transportation engineers and road agents has been established to inform the research and to make the results available and useful for regional stakeholders.

RiskMAP FY14 - Developing Areas of Mitigation Interest and Conducting Discovery

Project Period: October 2014 to September 2016

This award comprises two distinct project activities. The first activity was to generate an “Areas of Mitigation Interest” data set for the 13 communities in Rockingham County and 4 communities in Strafford County that are within the footprint of the NH Coastal Mapping project described below. The data are being developed based on accessing existing statewide, regional, and community data sets, as well as collecting current localized knowledge from community officials. The data for the 4 Strafford County communities are complete, were incorporated in the FEMA Flood Risk Database submitted to Map Service Center in the spring of 2016, and will become available shortly. Data for Rockingham County are in progress. The second activity was conducting “Discovery” in the 13 communities in Rockingham, Strafford, and Carroll Counties that are part of the Piscataqua/Salmon Falls Basin but outside of the footprint of the NH Coastal Mapping project. The goal of this effort was to work closely with the individual communities to help identify areas at risk for flooding and possible solutions for reducing that risk. New Zone A (approximate) flood zone boundaries will be generated as part of this effort and will be compared to the effective data. This information, along with additional input provided by the project communities, will be used to determine priorities for future floodplain mapping.

Technical Assistance to SHEA

Project Period: July 2014 to December 2015

The Natural Resources Outreach Coalition (NROC) worked with Hampton, Hampton Falls or Seabrook to provide hands-on assistance in preparedness for climate change with activities such as development of board/community outreach materials, delivery of the 2014 PREPA Study results to the community, assessing where community vulnerabilities to climate change exist, presentation of the NH Coastal Viewer, assisting with the Community Rating System in order to reduce flood risk, stormwater management, and/or implementing climate adaptation strategies.

Sustaining Champions of Climate Adaptation in Coastal Communities: A Northern New England Study

Project Period: June 2014 to September 2014

In this study, community members identified by others as “climate adaptation champions” from coastal areas in northern Massachusetts to southern Maine were interviewed. The interviews were designed to reveal what motivates and sustains these champions, what challenges and accomplishments they claim and what professional adaptation assistance providers can do to help support champions in implementing climate adaptation at the local level. A total of eight findings were developed from the champions’ responses during the interviews as well as a set of recommendations for professional climate adaptation assistance providers. The study was conducted by a UNH undergraduate student, Alexandra Phillip, with assistance from four mentors affiliated with NH’s Coastal Adaptation Workgroup. The final report, including findings and recommendations, can be found here:

https://seagrant.unh.edu/sites/seagrant.unh.edu/files/media/pdfs/extension/climate_champions_2014.pdf

The Hard and Soft of Shoreline Management: Conference and Follow-up Outreach

Project Period: May 2014 to August 2015

In December 2014 the Great Bay National Estuarine Research Reserve, and our partners in CAW hosted a conference focused on improving shoreline management in NH. 121 individuals attended this conference including coastal decision makers from the NH Coastal Risks and Hazards Commission, state agencies, municipalities, and NOAA, as well as shoreline professionals and experts such as engineers, environmental consultants, and researchers. Conference participants learned about and discussed how and why we manage shorelines in NH and explored how we can better manage shorelines to protect the natural, cultural, and economic resources that are impacted by shoreline management decisions. The centerpiece of the conference was a presentation on “living shoreline” treatments that have been tested in New York and New Jersey. Conference development was informed by a needs assessment conducted by GBNERR. The conference was followed by a half day workshop where select partners, presenters, and conference participants debriefed the workshop and discussed what shoreline management topics still need outreach support in NH. To continue the dialog that was started at the conference, CAW has been and will continue holding workshops that target specific shoreline management topics including: wetland and shore and permitting in NH, protecting coastal cultural resources, and a field based workshop focused on the protection provided by dunes. More follow-up workshops are expected in 2016. Additionally, CAW members are publishing an ongoing Shoreline Management Story Series to highlight how and why shoreline management is done in coastal NH. These articles have been and will continue to be published on NHCAW.org.

Hampton-Seabrook Estuary Sand Dune Restoration

Project Period: March 2014 to June 2015

NH Sea Grant/UNH Cooperative Extension (NHSG/UNHCE) and the University of New Hampshire (UNH) work to build coastal resilience to climate change and enhance landforms and wildlife habitat through the restoration of several dune habitats in the Hampton-Seabrook Estuary watershed. Vegetation is critical to the growth and the stability of dunes; therefore, a revegetation program engaging community members and NH Sea Grant's Coastal Research Volunteers focuses on the impacted areas. Efforts to limit pathways for beach access through all project areas include extensive outreach, educational signs, and structural fencing to divert pedestrians to designated pathways. Local citizens are engaged throughout the project in order to accomplish on the ground restoration goals and to create a network of informed citizens and landowners.

Resilient NH Coasts

Project Period: October 2013 to April 2015

This project advanced resiliency and adaptation planning for climate change related hazards by integrating tools, research, outreach, and technical assistance in the Hampton-Seabrook estuary, Dover, and Portsmouth. Outreach was also conducted to business groups throughout NH Seacoast communities. New information generated by this project included updated and expanded Sea Level Affecting Marsh Migration (SLAMM) model outputs, and current information about Fluvial Erosion Hazards. The project's integrated and innovative approach enabled project partners to learn how communities want to use and access coastal data and GIS tools in hazards and climate adaptation planning, and what steps can be taken to ensure that climate related science is relevant to local needs. The project partners collaborated on a NH Coastal Viewer product that incorporates data to help planning state agencies, commissions, municipalities, and businesses visualize what areas in their communities are the most vulnerable to coastal hazards, including sea level rise and river flooding.

<http://des.nh.gov/organization/divisions/water/wmb/coastal/resilient-coast.htm>

Crossing Boundaries: Integrated Planning in the Exeter-Squamscott Watershed

Project Period: September 2013 to August 2014

This project developed the foundation for an Exeter-Squamscott Watershed Integrated Plan for the communities of Exeter, Stratham, and Newfields in southern New Hampshire. The Plan helped communities meet new wastewater and stormwater permit requirements and improve water quality in the Squamscott River and the Great Bay, while supporting the economic viability of participating communities. This project developed a management plan for three communities that allows them to evaluate and manage water quality and climate impacts at the scale of the Exeter/Squamscott subwatershed project area.

New Hampshire Great Bay Estuary Ecosystem Services Assessment

Project Period: September 2013 to November 2016

This project helps to build a spatial planning framework for the Great Bay estuary, with an emphasis on successfully utilizing ecosystem services modeling to better integrate and scale-up ongoing estuarine habitat restoration work while minimizing conflicts with siting and permitting decisions pertaining to other space-dependent estuarine uses (e.g. mooring fields, marinas, aquaculture leases). The project integrates existing spatial information on climate change vulnerability into the estuarine spatial planning framework. This objective ensures that a recently completed effort to generate high quality coastal vulnerability maps for every coastal town in New Hampshire under scenarios of sea level rise and storm surge is incorporated into holistic spatial planning efforts for the state's estuaries. Blue carbon is estimated as an ecosystem service.

Climate Change and Human Health in New Hampshire: An Impact Assessment

Project Period: July 2013 to December 2014

This report provides an overview of past and future climate across New Hampshire has changed, and the potential impact of future climate change on human health in New Hampshire based on the Centers for Disease Control and Prevention – Building Resilience Against Climate Effects (BRACE) framework. The report is organized by the type of health impact:

- Temperature, heat events, and heat stress injury/death
- Extreme weather and injury/death
- Temperature, air quality, and respiratory and cardiovascular illness
- Pollen, mold, and allergies
- Temperature, precipitation, and vector-borne diseases
- Temperature, precipitation, severe weather, and foodborne diseases
- Temperature, precipitation, and waterborne diseases
- Climate change, health behaviors, and chronic disease
- Climate change, mental health, and stress-related disorders

<http://www.climatesolutionsne.org/sites/climatesolutionsne.org/files/candhreport4.30.pdf>

Lee Floodplain Mapping

Project Period: July 2013 to December 2014

SRPC will work with the Lee Conservation Commission, Emergency Management Director and the Planning and Zoning Department to produce a series of maps with the new floodplain data produced for the Lamprey River Watershed. The maps will be used for land use planning and to aid in emergency response activities. SRPC will provide education and outreach assistance to the community of Newmarket on stormwater impacts and best management practices, including low impact development, to alleviate harmful pollutants discharging to the Lamprey River. These outreach efforts will target businesses, local decision-makers, public works staff and town residents. SRPC will gather municipal data from a variety of land use documents including the master plan, zoning ordinance, site plan and subdivision regulations, and other planning documents and studies in order to complete the Indicator Form and update the Piscataqua Region Environmental Planning Assessment (PREPA), which will now have a climate change component. SRPC staff will collect municipal data and fill out and update the PREPA Indicator Form.

Preparing for Climate Change in Rye

Project Period: July 2013 to December 2015

Project staff and a local steering committee organized a workshop series about climate change in Rye. The workshops introduced the science and local impacts of climate change, delivered an overview of planning tools to adapt to climate change, hosted a walking tour to understand how salt marshes are affected by sea level rise and how they contribute to resiliency, and transitioned the town's participation into a follow up project (Tides to Storms). In addition to reported increases in knowledge, the community generated a list of prioritized concerns and began a dialogue about possible action items to adapt to climate change.

Tides to Storms

Project Period: November 2012 to September 2015

This project includes 1) Production of a regional vulnerability assessment report and map set for NH coastal communities, utilizing the best available information to assess the impacts of climate change on land, natural resources and infrastructure, and provide detailed maps, risk and impact analyses, and adaptation and mitigation strategies to address the projected future effects of sea level rise and storm surge; 2) Development of a model Coastal Flood, Hazards and Adaptation Chapter to be incorporated within coastal community Hazard Mitigation Plans; 3) Local Hazard Mitigation Plan updates in each eligible coastal community to specifically incorporate the vulnerability assessment including development of adaptation and mitigation strategies that address the projected future effects of sea level rise and storm surge; 4) Development of outreach and guidance tools to enhance preparedness, create capacity and improve resiliency in the built environment, human health and safety, and natural systems; 5) Incorporation of Coastal Flood, Hazards and Adaptation Chapter into local Hazard Mitigation Plans and other state plans.

Building the Capacity of Coastal Communities to Address Climate Change Risks Through the Use of Role-Play

Simulations: Dover

Project Period: September 2012 to August 2014

The Massachusetts Institute of Technology Science Impact Collaborative worked with four National Estuarine Research Reserve (NERR) sites, and the Consensus Building Institute to test an innovative way to help coastal communities understand and prepare for the potential impacts of climate change. The team engaged four at-risk New England towns in testing the use of role-play simulations as a means to educate the public about climate change threats and to help communities explore ways of decreasing their vulnerability and enhancing their resilience. The findings of this project provided valuable insights into techniques for engaging communities in public learning, risk management, and collaborative decision-making around science-intensive public disputes. They also informed the development of a model approach that communities in New England and elsewhere can use to address climate change. In NH, this project worked with the City of Dover.

Collaborative Planning for Climate Change Adaptation: A Case Study for Exeter in the Great Bay National Estuarine Research Reserve

Project Period: September 2012 to August 2014

The project undertook a collaborative planning effort to develop an integrated climate change adaptation plan for a land area exhibiting a range of land uses and location on a major tributary to the Great Bay Estuary. While the focus is on climate change, the project also considered the exacerbation, and remedies, for related challenges of stormwater, nonpoint source pollution, land use/development and the protection and restoration of habitat (marshes and fisheries habitat). The case study area is the Town of Exeter within the Exeter/Squamscott River Basin, which includes most of the town's area just upstream of Great Bay. However, because portions of other towns share the watershed, their contributions to the targeted impacts on the

river system were assessed to provide a comprehensive analysis that will yield an integrated management strategy. Benefits include an adaptation strategy for Exeter that can be incorporated into zoning ordinances, and site regulations that benefit not only the town but also Great Bay, and serve as a transferable model for collaborative and integrated adaptation planning.

Green Infrastructure for Sustainable Coastal Communities

Project Period: September 2012 to August 2014

The project proposed to build municipal capacity in coastal watershed communities for Green Infrastructure by engaging local and regional stakeholders in a planning and implementation process that was supported by technical resources and current, relevant information. The goal of creating a collaborative process was to build community resilience and improve capacity for managing water resources and related ecosystem services. The project provided a wide range of resources and numerous models and examples of regulatory and technical approaches for the implementation of green infrastructure (GI). Drawing upon knowledge gained from previously funded programs, we worked with local community leaders, regional officials, and representatives of the development community, local businesses, a local watershed entity, Low Impact Development (LID) experts, design firms and nurseries. The project implemented priorities identified by the intended users that would best develop municipal capacity for GI.

Portsmouth Coastal Resilience Initiative

Project Period: July 2012 to August 2013

This project utilized consulting services to supplement City staff hours to provide an inventory, analysis and recommendations that were easily integrated into the Master Plan update process (scheduled to start in July 2012), the building code, and the City's capital improvement plan. This project also utilized scenario planning to explore uncertainty about the future consequences of climate change on the City (both for the short-term and long-term.) This scenario planning approach sought to avoid adverse impacts on the built environment and natural resources by considering a few potential futures (in this case low, medium, and high risk scenarios). Scenario planning for this project incorporated both quantitative and qualitative information in the decision-making process. This process enabled the City to undertake a focused outreach around climate adaptation, without encumbering the Master Plan process. <http://www.planportsmouth.org/cr.html>

Navigating from Concern to Action Using the NOAA Roadmap in New Hampshire's Small Coastal Communities: Newfields

Project Period: July 2012 to June 2013

This project helped a small NH coastal community (Newfields) with a volunteer-board government move climate preparedness from concern to action by using the NOAA Roadmap for Adapting to Coastal Risks (NOAA Roadmap). The Roadmap is a community-driven process that expanded capacity in Newfields to respond to climate preparedness through (1) increased knowledge about vulnerabilities of community assets, and (2) awareness of climate adaptation options. As a result, the community has updated their stormwater management regulations, implemented an emergency generator purchasing and installation program for community members, developed and distributed a local extreme weather preparedness calendar, and more.

Climate Adaptation Chapter: Town of Durham

Project Period: July 2012 to June 2013

Stafford Regional Planning Commission assisted the Town of Durham in developing a climate adaptation chapter that was adopted as a subset of their Hazard Mitigation Plan. The chapter provides adaptation strategies to protect areas of the town that are at risk of flooding due to climate change and sea level rise, and identifies various regulatory and non-regulatory options that can be considered by Durham from this potential risk. With collaboration from Town officials and staff from the University of New Hampshire, SRPC delivered a product that provided information on how best to plan and act to address the impacts of climate change, thus protecting coastal infrastructure and resources.

Update of the Master Plan Vision Chapter: Town of Newmarket

Project Period: July 2012 to June 2013

Stafford Regional Planning Commission (SRPC) assisted the Town of Newmarket in preparing an update of the Town's Vision Chapter of the Master Plan. The process was prepared collaboratively by SRPC and a designated Master Plan subcommittee. SRPC organized and facilitated two visioning forums to solicit comments and ideas from residents for addressing current issues and challenges pertaining to various aspects of the community, including: housing, recreation, land use, zoning, business and industry, community facilities, infrastructure, and natural and cultural resources. The community was asked to consider the integration of climate adaptation measures into municipal programs, policies, and operations to reduce community risk and vulnerability.

Effects of anthropogenic change on salt marsh microbial structure and function

Project Period: June 2012 to May 2013

The goal of this project was to expand our understanding of saltmarsh microbial community structure and function and response to impending sea level rise and increasing levels of nutrient pollution. The repercussions of human activities may combine (or counteract each other) to yield unexpected effects of altered microbial activity on saltmarsh resiliency to change. This understanding informs management decisions by: 1) Guiding short-term management decisions on saltmarsh preservation more effectively through improved understanding of ecological responses to stress; and 2) Shaping long-term management goals and activities through a better understanding of environmental changes and adaptation management tools that will build saltmarsh resiliency against change.

Coastal Flooding and Erosion Forecast - Hampton, NH

Project Period: February 2012 to December 2012

An empirical relationship exists between storm tide, waves and coastal flooding or splash-over damage (NWS coastal flood study). Knowing this relationship helps predict when flooding and splash-over events (such as beach erosion) might occur based on forecast water level (tide height) and wave height data. Scientists from the University of Massachusetts at Boston, center for Coastal Environmental Sensing Networks (CESN) installed a state-of-the-art tide gauge at the Hampton Fire and Rescue pier on Hampton Harbor to support the project. The installation of the gauge was funded via a generous donation by NextEra Energy Seabrook Station. Working with the National Weather Service in Gray, Maine, NERACOOS and modelers in the Northeast region, a working prototype was developed using a water level model (NECOFS/FVCOM) and wave model (Wave Watch3). This prototype was working for Hampton, New Hampshire and Scituate, Massachusetts locations. We hope to expand to other regions depending on need. This product could be used by emergency managers, coastal homeowners and other users with interest and concern about beach erosion from large-wave storms. The capacity for the Coastal Flooding and Erosion Forecast system to predict damage days in advance of storms is extremely important to coastal property owners and emergency responders, resulting in dollars and lives saved.

NH Coastal Risk MAP Product Development

Project Period: September 2011 to December 2017

The objective of this project is to produce a suite of non-regulatory, Risk MAP products to accompany the updated floodplain maps described below for the NH Coastal Mapping project. Collectively, they extend the utility of the maps and reports, encourage community utilization and understanding, and facilitate more efficient floodplain management. Products developed include Changes Since Last DFIRM (a comparison of the new floodplain data relative to the previously effective data), Limit of Moderate Wave Action (an informational layer on the floodplain maps that defines the landward limit of the 1.5 foot wave), Coastal Flood Depth Grids (containing coastal water depths for the one-percent-annual-chance Base Flood Elevation), Riverine Flood Depth Grids (containing riverine water depths), Static Sea Level Rise, and the results of Hazus analyses for Rockingham and Strafford Counties (showing potential annualized losses from flooding). These non-regulatory products will be entered into a Flood Risk Map, Report, and Database, all of which will be available from the FEMA Map Service Center.

Stimulate innovation and increase the pace of municipal responses to a changing climate in the coastal zone of the Northeast and Bay of Fundy

Project Period: September 2011 to April 2013

This project included three components: 1) Research and documentation of the best practice/innovative municipal adaptation approaches in the Northeast; 2) Municipal technical assistance through a small grant program; and 3) Adaptation/resilience communications development in collaboration with CA-CP and partners. <http://cpo.noaa.gov/cpo>

New Flood Plain Maps for Coastal New Hampshire and Questions of Legal Authority, Measures and Consequence

Project Period: March 2011 to February 2012

Questions of Legal Authority, Measures, and Consequences assesses various types of legal risks communities in the Lamprey River Watershed may be concerned about as a result of adopting new flood management regulations and policies. To assess these risks we identified four potential legal challenges related to: (1) municipal liability, (2) enabling authority, (3) the use of climate maps as evidence, and (4) takings. In general, the risk of municipal liability is low, so long as municipalities follow sound planning principles. Not only is the level of risk low, the federal government encourages communities to enact certain types of regulations designed to reduce flood hazards. This encouragement provides states and municipalities an additional layer of assurance with respect to adopting and defending revised or new flood regulations. Under federal floodplain guidelines, states and municipalities are encouraged to establish more stringent regulations above and beyond minimum federal requirements. For example, the Federal Emergency Management Agency (FEMA) advises communities to enact

stricter regulations through a program called the Community Rating System.¹ This document, provides a list of additional regulatory and non-regulatory tools communities can use to both help reduce risk of flood hazards and avoid legal quandary. http://100yearfloods.org/resources/pdf/2012_VermontLawSchool_LampreyRiverReport.pdf

NH Coastal Mapping Project

Project Period: September 2010 to December 2017

The objective of this project is the creation of new Digital Flood Insurance Rate Maps (DFIRMs) and Flood Insurance Studies (FISs) for the downstream portions of the Piscataqua/Salmon Falls Basin (HUC 8 Watershed 01060003), including the ocean coastline in New Hampshire. The study area comprises 239 square miles, and includes the 17 communities that lie within New Hampshire's designated Coastal Zone. High resolution LIDAR topographic data was used to support new and/or updated modeling and mapping of the study area. The new DFIRMs and FIS were released for the Strafford County portion of the project area on September 30, 2015. Rockingham County products are in progress.

Assessment of Climate Change in Coastal New Hampshire

Project Period: August 2010 to July 2011

Produced a detailed assessment of climate change for coastal New Hampshire that describes how the region's climate has changed over the past century, and how climate may change over the course of this century based on different global greenhouse gas emission scenarios. The results were detailed in a report and series of presentations titled "Climate Change in the NH Coastal Watershed: Past, Present, and Future". Adapting to a changing climate requires both data and information at a spatial and temporal scale that is relevant to decision making. Unfortunately, information provided by existing national and broad regional climate change impact assessments are not sufficiently detailed to provide municipal and regional decision makers with key decision relevant information. This climate assessment provided decision-relevant information on a regional scale to individual, municipal, regional, and state decision-makers. The information compiled in this climate assessment provides the foundation for developing local adaptation plans to a changing climate and this project disseminated this information to seacoast municipalities as well as regional and state organizations. <http://CarbonSolutionsNE.org>

Sea Level Rise and Storm Surge Adaptation Analysis via COAST

Project Period: July 2010 to December 2012

The primary objective of this project was to provide support for climate adaptation planning processes in South Portland, ME and the Hampton/Seabrook estuary in NH. Working in partnership with PREP and CBEP, the New England Environmental Finance Center (EFC) provide visual, numeric, narrative, and presentation-based products based on the COAST decision-support tool. It was anticipated these products can help galvanize support for processes underway and represent specific action items stakeholders can evaluate. At public meetings of local stakeholder groups the EFC provided 1) single-event snapshot visualizations of 3D extruded values for each action and no-action scenario; 2) multi-decade tallies of cumulative expected damages under each adaptation scenario; and 3) interpretation of avoided costs associated with each adaptation action under consideration. Dialogue was solicited about implications for possible subsequent local action.

Seabrook Pilot Project

Project Period: July 2008 to June 2010

RPC will work with Seabrook to develop strategies/ methods to identify and protect areas of increased risk from coastal flooding due to climate change. Products will include a final report to summarize the work, and maps of areas vulnerable to flooding, as well as suggestions to regulate future development of these areas. RPC will then apply this pilot study to all RPC-member coastal communities, followed by a regional forum to describe final results. RPC will also assist those who request adaptation planning experience.

10. Endnotes

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The final report of the New Hampshire
Coastal Risk and Hazards Commission,
**Preparing New Hampshire for Projected Storm Surge,
Sea-Level Rise and Extreme Precipitation,**
is available for download on the Commission's website:
<http://www.nhcrhc.org>
