C-RiSe

CLIMATE RISK IN THE SEACOAST

Assessing Vulnerability of Municipal Assets and Resources to Climate Change

Rollinsford • Dover • Madbury • Durham • Newmarket • Newfields • Exeter • Stratham • Greenland • Newington

TOWN OF EXETER, NEW HAMPSHIRE

Vulnerability Assessment

of projected impacts from sea-level rise and coastal storm surge flooding

Prepared by the

Rockingham Planning Commission

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

Board of Selectmen

Planning Board

Conservation Commission

Exeter River Study Committee

Municipal Staff

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Cover Photo Credit: Rockingham Planning Commission

Notes on Use and Applicability of this Report and Results:

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

PLANNING TO REDUCE RISK AND VULNERABILITY

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

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

What is a Vulnerability Assessment?

A vulnerability assessment identifies and measures impacts of flooding from sea level rise and storm surge on built structures, human populations and natural environments. Factors that influence vulnerability include development patterns, natural features and topography. The assessment evaluates existing and future conditions such as: inland extent and depth of flooding; impacts to natural and human systems; and changes in impacts between different flood levels.

How can the vulnerability assessment be used?

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

Planning for the long-term effects of sea level rise may also help communities better prepare in the short-term for periodic flooding from severe coastal storms. Results from a vulnerability assessment can be incorporated into various municipal planning, regulatory and management documents.

How will the vulnerability assessment benefit the community?

The Climate Risk in the Seacoast assessment is intended to assist coastal NH communities to take actions to prepare for increase flood risk, including:

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

Zoning Ordinance	Land Conservation Plan	Capital Improvement Plan
Site Plan Regulations	Master Plan	Roadway Management
Subdivision Regulations	Hazard Mitigation Plan	Facilities Management Plan

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Project Partners:

MAPPING AND ASSESSMENT METHODS

Vulnerability Assessment: Sea Level Rise and Storm Surge Scenarios

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

FIGURE 1: Sea-Level and Storm Surge Scenarios in EXETER

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

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

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

Sea-Level Rise Scenarios

The sea-level rise projections used in this study are based on an earlier study completed in 2011 by Wake et al but are similar to a more recent report issued by the NH Coastal Risks and Hazards Commission's Science and Technical Advisory Panel in 2014. As shown in the graphics below, while slightly different than the scenarios cited in the 2014 report, the sea level rise scenarios used in the Climate Risk in the Seacoast assessment yield coverage estimates of flooding that are within the mapping margin of error for the scenarios in both the 2011 and 2014 reports.[2]

[1] NOAA website at http://tidesandcurrents.noaa.gov/datum_options.html

[2] For more information about how these sea-level rise scenarios were mapped, visit: http://granitweb.sr.unh.edu/MetadataForViewers/NHCoastalViewer/RelatedDocuments/Sea_Level_Rise_Narrative_rev20150106_FinalReport/pdf

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

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

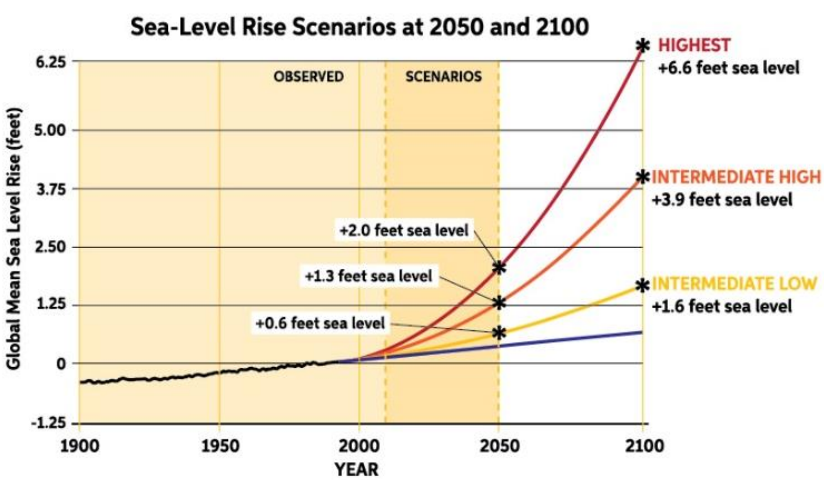
	Lower Emissions (B1)		Higher Emissions (A1fi)	
	2050	2100	2050	2100
Current Elevation of MHHW [a,b]	4.43	4.43	4.43	4.43
100-Year Flood Height	7.78	7.78	7.78	7.78
Subsidence	0.012	0.016	0.012	0.016
Eustatic SLR	1.0	2.5	1.7	6.3
Total Stillwater Elevation [a,c]	**13.2**	**14.7**	**13.9**	**18.5**

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

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

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

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



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

Storm Surge: ***Storm surge is the rise of water level accompanying intense coastal storm events such a tropical storm, hurricane or Nor'easter, whose height is the difference between the observed level of the sea surface and the level that would have occurred in the absence of the storm event.***[3] Storm surge is mapped using the 100-year/1% chance flood events from the Preliminary Flood Insurance Rate Maps (FIRMs) released by FEMA in 2014. The preliminary FIRM's account for the limit of moderate wave action in coastal areas, however this assessment does not take into account additional flooding and impacts related to more severe wave action, wind action, erosion and other dynamic coastal processes.

[3] EPA website at http://epa.gov/climatechange/glossary.html

Assets and Resources Evaluated

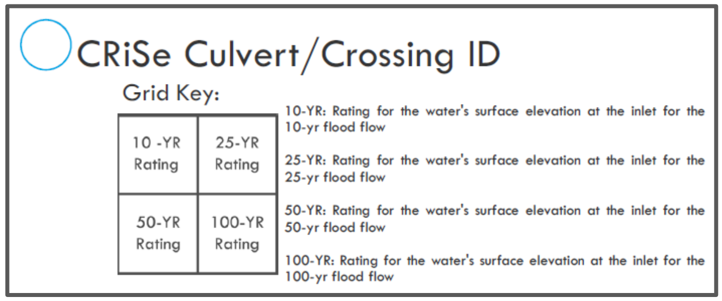
Figure 4 lists the three major categories and a detailed list of the assets and resources evaluated as part of the Climate Risk in the Seacoast vulnerability assessment. The assets and resources evaluated are listed in subsequent tables in this report only if they are affected by one or more of the sea-level rise and/or coastal storm surge scenarios.

FIGURE 4: Assets and Resources Evaluated for the Vulnerability Assessment

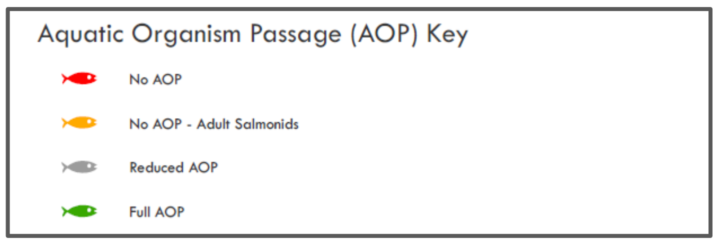
Category	Assets and Resources
State and Municipal Infrastructure	Municipal Culverts Federal and State Historic Register Properties Other Assets: graveyards, water access, transmission lines
Municipal Critical Facilities	Municipal Critical Facilities
Transportation Assets & Roadways	State and Local Roadways Bridges Regional and Municipal Evacuation Routes Urban Compact Areas NHDOT Transportation Infrastructure NHDOT Ten-year and Long Range Plan Projects
Natural Resources	Freshwater and Tidal Wetlands Aquifers and Wellhead Protection Areas Wildlife Action Plan – Tier 1 and Tier 2 habitats Floodplains
Land Use	Residential structures Assessed Value of Affected Parcels

Data, Methods and Results of Hydrologic and Hydraulic Modeling for Road Crossings

The hydrologic and hydraulic modeling of crossings was complete by the University of New Hampshire Stormwater Center. The C-Rise project assessed both aquatic organism passage capacity and hydraulic flow capacity of ten (10) road crossings in each of the ten Great Bay coastal municipalities. The assessment was based on runoff associated with the current 10-, 25-, 50- and 100-year storm events. For each storm, each crossing was assigned a hydraulic rating and an ***aquatic organism passage (AOP)*** rating; both ratings are described in greater detail below.

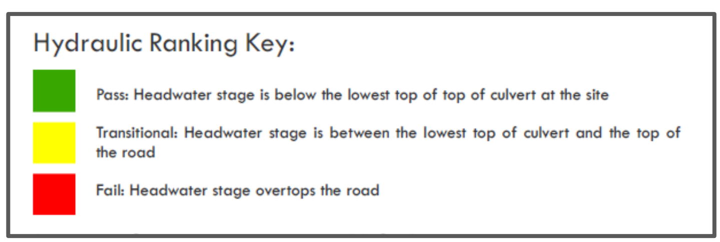


The AOP rating is labeled by color; Red, Orange, Gray, and Green. Ratings of Red and Orange mean that there is estimated to be little to no AOP at that crossing, with Red being no AOP for all species and Orange meaning no AOP for all species except for adult Salmonids. A rating of Gray means that there is reduced AOP at the crossing for all species. A rating of Green means that AOP is expected to be possible for all species.



The AOP ratings were developed using the New Hampshire protocol for assessment, which was borrowed directly from the Vermont Culvert Aquatic Organism Passage Screening Tool. This tool uses physical data collected at each crossing and may be used to rate each culvert at a crossing for AOP. At a crossing with multiple culverts, if one culvert is more passable than another, then that culvert is considered to be the path that organisms would utilize. Thus, the best rating for a culvert at a crossing is used as the rating for the crossing as a whole.

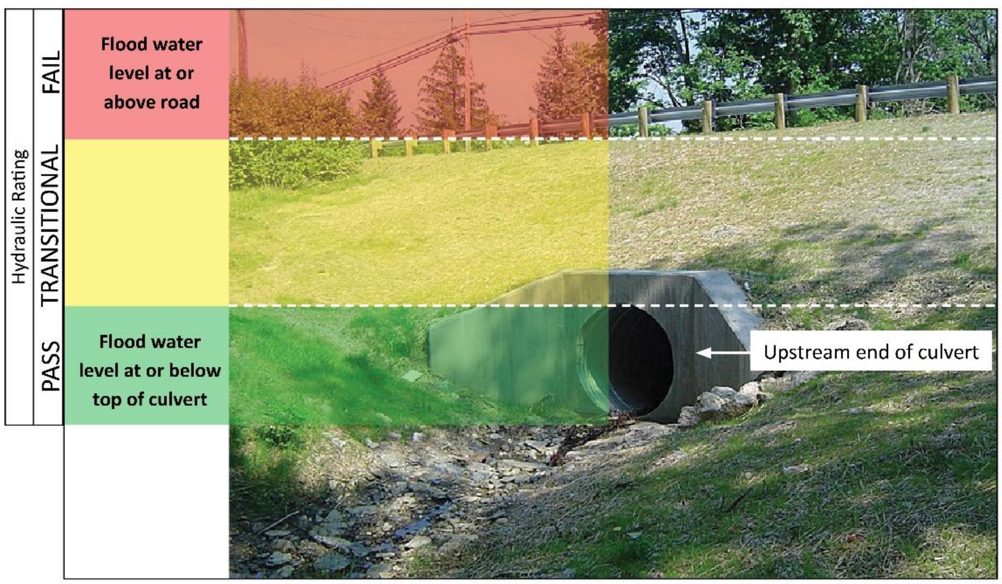
The hydraulic rating is color-coded similar to the AOP rating. The peak flows of the 10-, 25-, 50-, and 100-year storm events were used to assess the ability of the culvert to pass the flow (measured by the depth of water upstream of the culvert – known as the headwater depth) was determined and compared to culvert and road elevations. The ratings for hydraulics are: Pass (green), Transitional (yellow), and Fail (red). These ratings describe the depth of the water at the inlet (the Headwater) for the flows for each of the selected storm events compared to culvert and road elevations. A rating of Pass means that the headwater depth is below the lowest top-of-pipe elevation of any culvert at



the crossing; a rating of Fail means that the headwater depth is above the road surface; and a rating of Transitional means that the headwater depth is somewhere between these two elevations.

The hydraulic ratings describe the headwater depth (upstream of the culvert) for each storm event flood (see Figure 5). The headwater depths are calculated using field-collected culvert and crossing data. The flood flows were calculated by one of two methods: runoff from rainfall or regression equation. For all watershed areas smaller than one square mile, the Curve Number[4] method was used; and for watersheds larger than one square mile, flows were calculated using the Regression Equations[5] published by the USGS for New Hampshire. Once the flows at each crossing were calculated, they were input into the Federal Highway Administration's free culvert analysis software, HY-8, along with the necessary culvert and crossing data collected at each location. The program then calculated the headwater depth for each of the flows at each of the sites. This headwater depth is what is shown in the results, and are compared to the pipe crown and roadway elevations to determine the Hydraulic Ratings.

FIGURE 5: Example of how the hydraulic rating is applied to a culvert evaluation.



Map Design and Organization

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

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[4] A curve number is a number from zero to 100 that describes how much rainfall runs off versus how much is lost to infiltration. A high curve number implies most of the rainfall runs off.

[5] A regression equation describes a mathematical relationship between two variables in which one variable is used to predict the other.

Extent of Flooding from Sea Level Rise and Storm Surge

In Figures 6 and 7, the green and pink color schemes are arranged from lightest to darkest with increasing flood levels and extents. The complete C-RiSe map set for Exeter is available on the Rockingham Planning Commission website at http://www.rpc-nh.org/regional-community-planning/climate-change/resources.

Figure 6: Sea Level Rise Scenarios 1.7 feet, 4.0 feet, and 6.3 feet at year 2100.

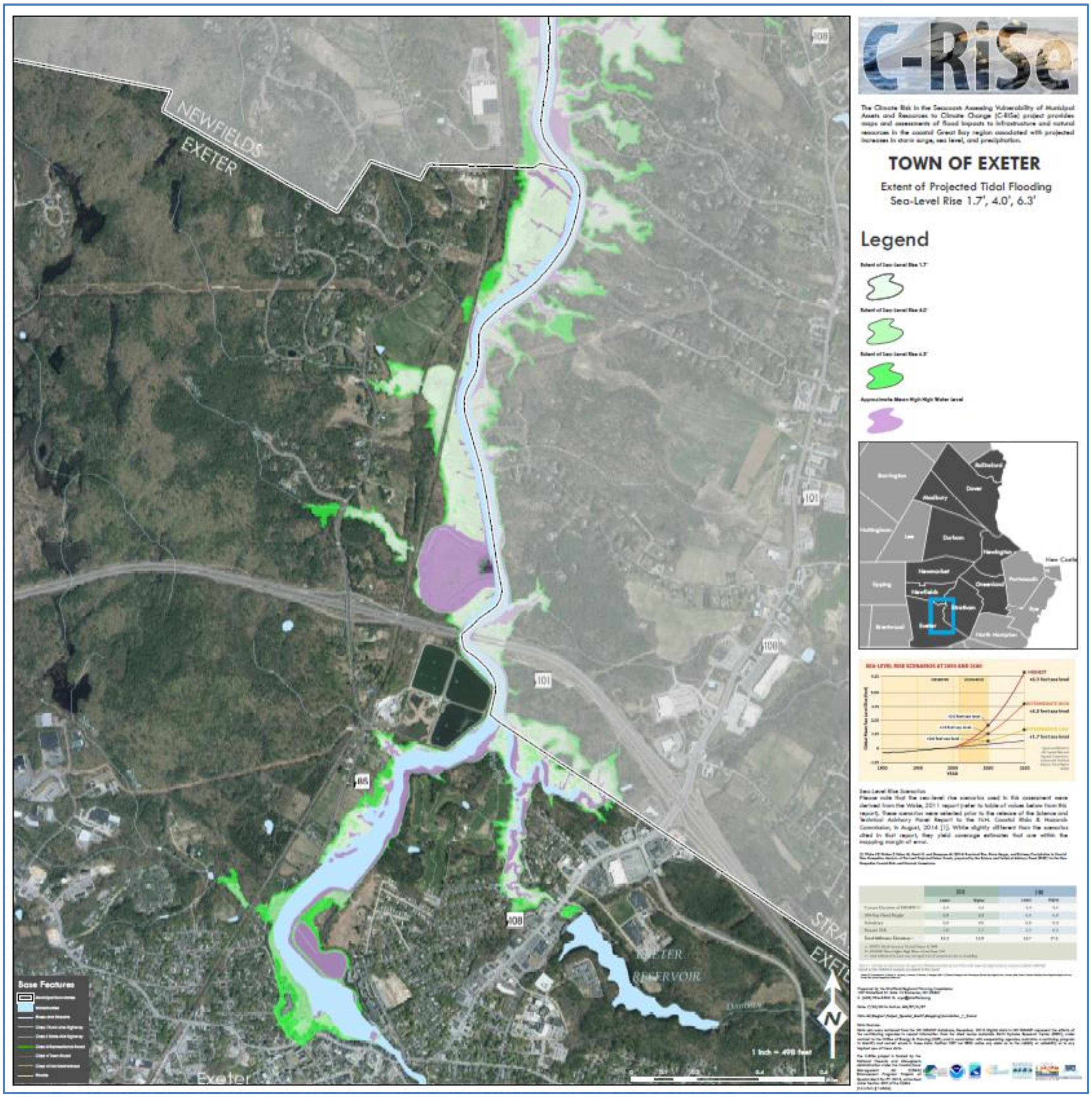
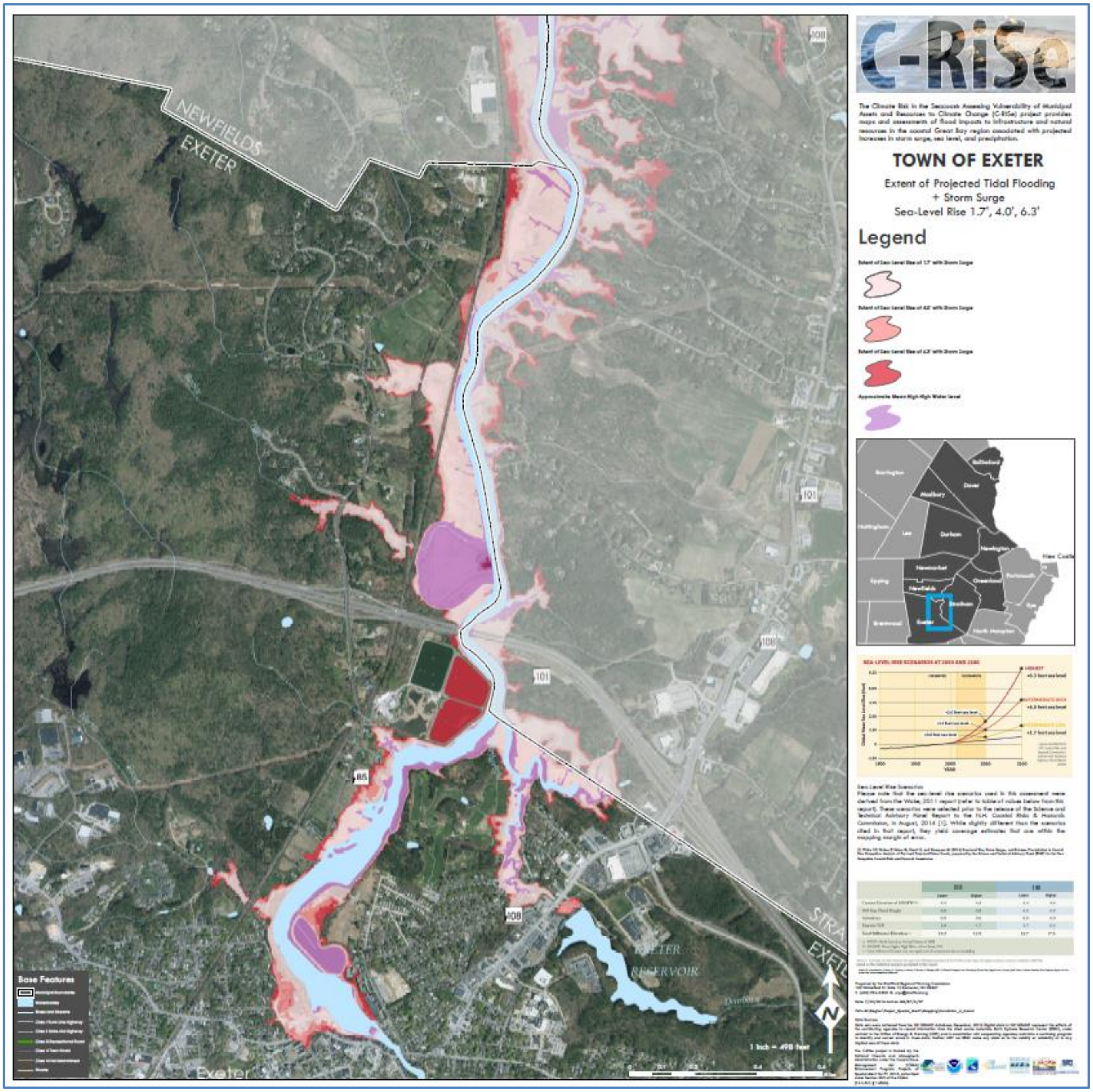


Figure 7: Sea Level Rise Scenarios 1.7 feet, 4.0 feet, and 6.3 feet + storm surge at year 2100.
Note: Storm surge = 100-year/1% chance storm event and flood elevation.



Report Acronyms

AOP	Aquatic Organism Passage
CAPE	Climate Adaptation Planning for Exeter
CAW	NH Coastal Adaptation Workgroup
C-RiSe	Climate Risk in the Seacoast
FEMA	Federal Emergency Management Agency
FIRMs	FEMA Flood Insurance Rate Maps
HY-8	Federal Highway Administration's fre culvert analysis software
LiDAR	Li(ght) + (ra)DAR – a mapping tool that uses infrared laser light
MHHW	Mean Higher High Water
NTDE	National Tidal Datum Epoch
Salmonids	family of fish including salmon, trout, chars and white fish
SLAMM	Sea Level Affecting Marshes Model

Glossary

100-year Coastal Floodplain

Includes flood hazard areas subject to tidal flooding and storm surge and identified on the FIRMs as a Special Flood Hazard Area (SFHA). SFHA are defined as the area that will be inundated by the flood event having a 1-percent chance of being equaled or exceeded in any given year. The 1-percent annual chance flood is also referred to as the base flood or 100-year flood. In coastal areas, these SFHAs are defined as specific zones on the FIRM's: In most communities, there are two areas or flood zones within the SFHA:

- A zone – an area subject to a 1 percent annual chance of a flood event but does not have a mapped elevation and;
- AE zone – an area that has the same 1 percent annual chance of a flood event and a corresponding mapped flood elevation of 9 feet.

Accommodate

Measures that manage risk by requiring development to be built and retrofitted to be more resilient to impacts and by limiting certain types or all development in highest risk areas, favoring adaptive uses (i.e. passive uses such as recreation) and gradual modification of structures and uses as conditions change over time.

Adaptation

Adaptation refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic change and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change. [http://unfccc.int/focus/adaptation/items/6999.php]

Climate Change

Climate change refers to any significant change in the measures of climate lasting for an extended period of time. In other words, climate change includes major changes in temperature, precipitation, or wind patterns, among others, that occur over several decades or longer.
[EPA http://epa.gov/climatechange/glossary.html]

Coastal Flooding

Upland areas inundated by tides, storm surge, and projected sea-level rise.

Mean Higher High Water (MHHW)

The average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch. The National Tidal Datum Epoch (NTDE) refers to the specific 19-year period adopted by the National Ocean Service as the official time segment over which tide observations are taken. The present NTDE is 1983 through 2001 and is considered for revision every 20-25 years (the next revision would be in the 2020-2025 timeframe).

Resilience

A capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment.
[EPA http://epa.gov/climatechange/glossary.html]

Retreat

Often the last action before abandonment, retreat follows an incremental path of planning for the eventual relocation of structures to upland areas as properties become threatened or directly impacted by rising sea level, erosion and coastal storms. Such measures may include rolling setbacks and buffers, transfer of development rights, and property acquisition/buyout programs.

Riverine (and Freshwater) Flooding

Areas inundated adjacent to freshwater drainage systems not affected by coastal flooding, including the 100-year flood plain and other areas subject to flooding from precipitation and snow melt.

Sea-level rise

Sea level is measured in various ways. *Relative Sea Level* refers the measurement of sea level at a local tide gauge station which is referenced relative to a specific point on land. These measurements at any given local tide gauge station include both measurements of global sea-level rise and local vertical land movement, such as subsidence, glacial rebound, or large-scale tectonic motion. Because the heights of both the land and the water are changing, the land-water interface can vary spatially and temporally and must be defined over time. The term *Mean Sea Level* (MSL) refers to a tidal datum (which a frame of vertical reference) defined by the average tide over a specific period of time. *Global Sea-level rise* (or eustatic sea-level rise) refers to the increase currently observed in the average *Global Sea Level Trend*, which is primarily attributed to changes in ocean volume due to two factors: ice melt and thermal expansion.
[NOAA http://www.tidesandcurrents.noaa.gov/est/faq]

Storm Surge

Storm surge is the rise of water level accompanying intense events such a tropical storm, hurricane or Nor'easter, whose height is the difference between the observed level of the sea surface and the level that would have occurred in the absence of the storm event.
[EPA http://epa.gov/climatechange/glossary.html]

Vulnerability Assessment

An evaluation of the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity. [www.ipcc.ch/pub/syrgloss.pdf]

PURPOSE AND APPLICATIONS OF THE VULNERABILITY ASSESSMENT

The *Climate Risk in the Seacoast* (C-RiSe) vulnerability assessment project produced maps and statistical data about the potential impacts from sea-level rise and storm related flooding to state and municipal infrastructure, critical facilities, transportation systems, and natural resources in New Hampshire's 10 Great Bay coastal municipalities. As shown in Figure 8, the assessment evaluated flood impacts from six sea-level rise and storm surge scenarios - 1.7 feet (intermediate-low), 4.0 feet (intermediate), and 6.3 feet (highest) sea-level rise projections at the year 2100 and these sea-level rise projections with the 100-year storm surge. These scenarios capture a range of plausible projections of sea levels at 2100, from the intermediate-low to the highest scenarios.

FIGURE 8: Sea-Level Rise (SLR) and Storm Surge Scenarios at year 2100

Sea Level (SLR) Scenarios	SLR Intermediate Low 2100	SLR Intermediate High 2100	SLR High 2100	SLR + storm surge 2100	SLR + storm surge 2100	SLR + storm surge 2100
Sea Level Rise	1.7ft	4.0ft	6.3ft	--	--	--
Sea Level Rise + Storm Surge	--	--	--	1.7 feet + storm surge	4.0 feet + storm surge	6.3 feet + storm surge

Note: Storm surge is the area flooded by the current 100-year/1% chance storm event as depicted on the FEMA Flood Insurance Rate Maps (preliminary maps, 2014).

The results of this vulnerability assessment can be incorporated into existing municipal plans including the Master Plan, Hazard Mitigation Plan, Road Improvement Plan, Infrastructure Management Plan, and Capital Improvement Plan. These results can also inform zoning amendments such as floodplain development standards and natural resource protection, and land development standards in site plan review regulations and subdivision regulations.

OVERVIEW OF EXETER

The Town of Exeter is an historic community located along the Exeter and Squamscott Rivers. The town's historic downtown is situated where the Exeter River flows into the Squamscott River and is characterized by historic buildings with commercial and residential uses. Exeter's land area covers roughly 19.8 square miles (12,672 acres), and water covers 0.3 square miles (192 acres). With an estimated population of 14,434 (2014), Exeter is the fourth most populated municipality in the Rockingham Planning Commission's region. Exeter has successfully protected approximately 29 percent of its land under some form of conservation or town ownership, much of it located in the riparian and river floodplain areas.

In 2015, the town worked with researchers from the University of NH on the Climate Adaptation Planning for Exeter (CAPE) project to evaluate potential future impacts of coastal flooding from sea-level rise, storm surge and increased precipitation. The report remains in draft form and has not been formally accepted by the town.

In 2016, Exeter launched a comprehensive update of its Master Plan. It is recommended that the findings of the C-RiSe vulnerability assessment be incorporated into this Plan as appropriate.

KEY FINDINGS OF THE VULNERABILITY ASSESSMENT

Land Area

The inland coastal portion of Exeter most susceptible to flooding is located in the 100-year floodplain and along the upper tidal reaches of the Squamscott River. Sections of Exeter's Historic District are within the coastal floodplain, making them particularly vulnerable to flooding from seasonal high tides, coastal storms, and sea-level rise. The impacted area is roughly 2 percent of the total land area of Exeter. The areas of highest risk for sea-level rise and storm surge flooding are:

- Swazey Parkway extending west to properties on Water Street and north on Route 85.
- Exeter Waterfront Commercial Historic District (waterfront side of buildings on Water Street).
- Wheelwright Creek drainage up to Portsmouth Avenue and the Exeter Reservoir, Norris Brook, Sloans Brook and Rocky Hill Brook.
- 121 parcels valued at 83.5 million and 21 homes valued at $32.5 million.

Figure 9 provides reports the total acres (land and water) affected by each sea-level rise and storm surge scenario. The total area affected by any scenario, even the high storm surge scenario, is less than 2 percent of the total area of Exeter.

FIGURE 9: Total acreage within each sea-level rise and storm surge scenario

Municipality	Sea-Level and Storm Surge Scenarios					
	1.7 feet SLR (acres)	4.0 feet SLR (acres)	6.3 feet SLR (acres)	1.7 feet SLR + storm surge (acres)	4.0 feet SLR + storm surge (acres)	6.3 feet SLR + storm surge (acres)
Exeter	89.0	129.0	168.5	146.8	178.9	221.3
% total area	0.7	1.0	1.3	1.1	1.4	1.7

Total area of Exeter = 12,864 acres.

Assets and Resources

Figure 10 reports summarizes impacts to assets and resources for each sea-level rise and coastal storm surge scenario. Infrastructure impacted by the highest sea-level rise and storm surge scenarios include: sewer pump stations at Wester Street and Main Street; Squamscott View elderly housing, PEA Daycare, and Fort Rock Farm (former Montessori School); Exeter boat launch at Squamscott River; and water and sewer lines at Swazey Parkway; wellhead protection areas for Exeter Hospital, Exeter Public Works Complex, Exeter Water Department, Stratham Crossing at Shaws Lane, and Stratham Woods at Bufferfield Lane; and residential structures at Swazey Parkway, Route 85 and Wheelwright Creek.

Exeter's existing wastewater treatment plant and well-head protection areas are located in areas at high risk for sea-level rise and coastal storm surge flooding. However, the proposed replacement wastewater treatment facility will be located at higher elevations on the existing sight and incorporate increased flood elevations in its design.

Tidal wetlands and saltmarsh in the Squamscott River floodplain may be affected by long term sea-level rise. Existing barriers to the inland migration of these systems include the railroad line, segments of state and local roads, and several manmade impoundments.

FIGURE 10: Summary of Asset and Resources Impact Data

Sea Level Rise (SLR) Scenarios	SLR 1.7 feet	SLR 4.0 feet	SLR 6.3 feet	SLR 1.7 feet + storm surge	SLR 4.0 feet + storm surge	SLR 6.3 feet + storm surge
State, Municipal and Private Assets						
Infrastructure (# of sites)	na	na	8	na	na	8
Residential Structures (# of homes)	na	na	16	na	na	26
Water/Sewer/Transmission lines (miles)	0.32	1.05	2.35	1.53	2.68	3.39
Roadways (miles)	.03	.55	1.07	.76	1.16	1.40
Assessed Value - Parcels Impacted	$559,200	$1,048,300	$5,273,700	$4,120,600	$27,638,000	$32,480,100
Historic/Recreation Sites	na	na	3	na	na	3
Natural Resource Assets						
Freshwater Wetlands (acres)	3.6	6.2	9.8	8.4	10.3	27.5
Tidal Wetlands (acres)	218.8	232.2	233.6	232.8	233.8	234.1
Aquifers (acres)	0	0	0	0	0	0
Wellhead Protection Areas (acres)	31.5	42.1	49.4	44.7	51.1	61.4
Conserved and Public Lands (acres)	58.09	74.23	89.24	81.15	92.82	102.93
Coastal Conservation Plan-focus areas	123.69	135.81	145.45	140.01	147.91	155.18
Wildlife Action Plan (acres)	175.14	196.35	208.45	202.27	211.36	221.42
100-year Floodplain (acres)	88.9	128.4	137.5	134.6	138.0	138.6

Notes: Storm surge is the area flooded by the 100-year/1% chance storm event. "na" = not assessed

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

DETAILED VULNERABILITY ASSESSMENT RESULTS BY ASSET TYPE

Culvert Assessment

Map: Climate Ready Culverts Assessment shows the hydraulic and aquatic organism passage function of fifteen culverts under existing precipitation conditions for the 10-year, 25-year, 50-year and 100-year storm event. Figure 11 reports the functional status of each culvert.

Of the fifteen culverts analyzed for hydraulic rating, three pass, six are transitional, and six fail under the 10-year storm event, and under the 100-year storm event eleven culverts fail. Culvert #98 is impacted by flooding from both sea level rise and storm surge scenarios. Thirteen culverts have either reduced or no Aquatic Organism Passage capability, and the remaining 2 culverts have full capability.

FIGURE 11 Assessment of Culvert Hydraulic and Aquatic Organism Passage (AOP) Function

Crossing #	Location	Hydraulic Rating				AOP Rating	
		10-year	25-year	50-year	100-year	Color	Rating
92	Watson Road-north	Transitional	Fail	Fail	Fail	GRAY	Reduced AOP
93	Beech Hill Road	Fail	Fail	Fail	Fail	GRAY	Reduced AOP
94	Birch Road	Pass	Pass	Pass	Pass	GREEN	Full AOP
95	Watson Road-south	Fail	Fail	Fail	Fail	GRAY	Reduced AOP
96	Dogtown Road	Fail	Fail	Fail	Fail	GRAY	Reduced AOP
97	Industrial Drive	Transitional	Transitional	Transitional	Transitional	GREEN	Full AOP
98	Portsmouth Ave-33	Pass	Pass	Pass	Pass	GRAY	Reduced AOP
99	Pickpocket Road	Pass	Transitional	Fail	Fail	GRAY	Reduced AOP
100	Tamarind Lane	Fail	Fail	Fail	Fail	GRAY	Reduced AOP
101	Nelson Drive	Transitional	Transitional	Transitional	Transitional	GRAY	Reduced AOP
102	Prentiss Way	Transitional	Fail	Fail	Fail	GRAY	Reduced AOP
103	Hampton Falls Road	Transitional	Fail	Fail	Fail	GRAY	Reduced AOP
104	High Street	Transitional	Fail	Fail	Fail	GRAY	Reduced AOP
105	John West Road	Fail	Fail	Fail	Fail	RED	No AOP
106	Powder Mill Road	Fail	Fail	Fail	Fail	GRAY	Reduced AOP

A rating of **Pass** means that the headwater depth is below the lowest top-of-pipe elevation of any culvert at the crossing; a rating of **Fail** means that the headwater depth is above the road surface; and a rating of **Transitional** means that the headwater depth is somewhere between these two elevations.

AOP = Aquatic Organism Passage is the degree to which aquatic organisms are able to pass through a crossing. Green = Full AOP, Gray = Reduced AOP, Pink = No AOP, for all species except Adult Salmonids, Pink = No AOP, for any species including Adult Salmonids.

Municipal Critical Facilities and Infrastructure

Map: Critical Facilities and Infrastructure show the municipal critical facilities affected by sea-level rise and coastal storm surge flooding. Figure 12 reports specific municipal critical facilities affected by each sea-level rise and coastal storm surge scenario. Luckily most of Exeter's critical facilities and infrastructure are not located in the floodplain or areas that may be subject to sea-level rise and storm related flooding in the future. Pump stations at Wheelwright Creek and are impacted by the highest sea-level rise and storm surge scenarios. The design of the town's new proposed wastewater treatment plant (located on the site of the existing waste water lagoons) will take into account increased coastal flooding by elevating the structure above the current 100-year flood elevation. The Department of Public Works manages water levels at the Exeter Reservoir by releasing water in advance of an impending storm event and associated high tides. Further evaluation of potential flood impacts is recommended for those facilities identified in high risk flood areas.

FIGURE 12: Municipal Critical Facilities (# of facilities)

Sea Level Rise (SLR) Scenarios	SLR 1.7 feet	SLR 4.0 feet	SLR 6.3 feet	SLR 1.7 feet + storm surge	SLR 4.0 feet + storm surge	SLR 6.3 feet + storm surge
Water Treatment Plant*	na	na	1	na	na	1
Squamscott View Elderly Housing	na	na	1	na	na	1
PEA Daycare Facility	na	na	1	na	na	1
Sewer Pump Stations (Webster St., Main St.)	na	na	2	na	na	2
Exeter Watefront Commercial Historic District, Front Street Historic District	na	na	2	na	na	2
Water Access	na	na	1	na	na	1
Total - Sites	na	na	8	na	na	8

"na" = not assessed

* Note – the sea-level rise and sea-level rise plus storm surge maps show the existing wastewater treatment lagoons as being impacted by flooding; however only the interior of lagoons are below the flood elevations.

Although the aerial extent of flooding is limited geographically, several high value assets are located in high risk flood areas including: Historic Register properties within the Exeter Waterfront Commercial Historic District and Front Street Historic District, the PEA Daycare facility, Squamscott View elderly housing facility, and a water access near the PEA boathouse are impacted by the 6.3 feet sea-level rise and 6.3 feet plus storm surge scenarios.

Transportation

Map: Transportation Assets show the state and municipal roadways affected by sea-level rise and coastal storm surge flooding. Figure 13 reports the miles of state and local roadways affected by each flood scenario. The municipal roadway network is the asset least impacted by sea-level rise and coastal storm flooding, with minimal impacts reported under all six scenarios mainly to Route 85, Water Street and Main Street, and minor impacts to adjacent local streets.

FIGURE 13: State and Municipal Roadways and Infrastructure (miles)

Sea Level Rise (SLR) Scenarios	SLR 1.7 feet	SLR 4.0 feet	SLR 6.3 feet	SLR 1.7 feet + storm surge	SLR 4.0 feet + storm surge	SLR 6.3 feet + storm surge
Roadway Type						
Local	.02	.48	.59	.52	.62	.68
State	.01	.07	.48	.24	.54	.72
Total Road Miles	.03	.55	1.07	.76	1.16	1.4
Bridges (# of sites)	na	na	1	na	na	1
Evacuation Routes	na	na	3.0	na	na	3.0
Urban Compact	na	na	77.9	na	na	93.3

"na" = not assessed

As reported in Figure 14, impacts to state, municipal and private roadways were assessed only for the 6.3 feet sea-level rise and 6.3 feet sea-level rise plus storm surge scenarios as total miles impacted are minimal under the lesser scenarios. Roads impacted by flooding are located at Swazey Parkway, Route 87, the approaches to the Route 101 overpass, and neighborhoods in the Wheelwright Creek subwatershed on the east side of the Squamscott River.

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

FIGURE 14: Impacts to State, Municipal and Private Roadways (miles)

Sea Level Rise (SLR) Scenarios	SLR 1.7 feet	SLR 4.0 feet	SLR 6.3 feet	SLR 1.7 feet + storm surge	SLR 4.0 feet + storm surge	SLR 6.3 feet + storm surge
Dewey Street	na	na	0.01	na	na	0.02
Green Street	na	na	0.01	na	na	0.02
Jady Hill Road	na	na	0.00	na	na	0.01
Sea Level Rise (SLR) Scenarios	SLR 1.7ft	SLR 4.0ft	SLR 6.3ft	SLR 1.7ft + storm surge	SLR 4.0ft + storm surge	SLR 6.3ft + storm surge
Main Street	na	na	0.06	na	na	0.00
Newfields Road	na	na	0.01	na	na	0.16
NH Route 101 E	na	na	0.02	na	na	0.02
NH Route 101 W	na	na	0.00	na	na	0.02
Park Street	na	na	0.01	na	na	0.01
Spring Street	na	na	0.04	na	na	0.04
String Bridge	na	na	0.49	na	na	0.04
Swazey Parkway	na	na	0.41	na	na	0.49

na = not assessed

Natural Resources

Map: Water Resources and *Map: Land Resources* show land and water-based natural resources affected by sea-level rise and coastal storm surge flooding. Figure 15 reports the number of acres for each natural resource affected by each sea-level rise and sea-level plus storm surge scenario.

The greatest impacts to wetland systems are in the tidal systems. Over time, low marsh may convert to mud flats and high marsh may convert to low marsh as these systems are inundated by rising seas. Significant acres of high quality habitat and natural resources identified in the NH Wildlife Action Plan and Land Conservation Plan for NH's Coastal Watershed, and conserved lands may be impacted by future flooding. These natural shorelands and riparian areas can act as critical flood storage areas to protect infrastructure and private property from rising seas and storm events.

Several freshwater systems – Wheelwright Creek, Rocky Hill Brook, Sloans Brook and Norris Brook - are impacted by both sea-level rise and storm surge flooding. Any culverts on these systems would be unable to function properly under tidal conditions. The freshwater ecosystem might also see transitions to brackish water flora and fauna as salt water flooding became persistent or permanent.

Significant acreage within wellhead protection areas adjacent to the Squamscott River and Wheelwright Creek are impacted by both sea-level rise and coastal storm surge flooding. These include wellhead protection areas for Exeter Hospital, Exeter Public Works Complex, Exeter Water Department, Stratham Crossing at Shaws Lane, and Stratham Woods at Bufferfield Lane.

FIGURE 15: Natural Resources (acres)

Sea Level Rise (SLR) Scenarios	SLR 1.7 feet	SLR 4.0 feet	SLR 6.3 feet	SLR 1.7 feet + storm surge	SLR 4.0 feet + storm surge	SLR 6.3 feet + storm surge
Stratified Drift Aquifers	0	0	0	0	0	0
Wellhead Protection Areas	31.5	42.1	49.4	44.7	51.1	61.4
Freshwater Wetlands (total)	3.6	6.2	9.8	8.4	10.3	27.5
Freshwater Emergent Wetland	2.41	2.55	2.74	2.56	2.74	2.74
Freshwater Forested/Shrub Wetland	0.96	2.87	5.90	4.83	6.32	7.15
Freshwater Pond	0.22	0.79	1.19	0.96	1.21	17.53
Lake	0.00	0.00	0.00	0.00	0.00	0.00
Riverine	0.00	0. 00	0.00	0.00	0.04	0.06
Tidal Wetlands (total)	218.8	232.2	233.6	232.8	233.8	234.1
Estuarine and Marine Deepwater	139.50	152.44	153.56	79.95	80.09	80.16
Estuarine and Marine Wetland	2.41	2.55	2.74	152.83	153.69	153.96
Wildlife Action Plan – Tier 1 and Tier 2 habitat	175.1	196.4	208.5	202.3	211.4	221.4
Coastal Conservation Plan Focus Areas	123.69	135.81	145.45	140.01	147.91	155.18
Conserved and Public Lands	58.09	74.23	89.24	81.15	92.82	102.93

The greatest impacts to wetland systems are in the tidal systems. Over time, low marsh may convert to mud flats and high marsh may convert to low marsh as these systems are inundated by rising seas. Significant acres of high quality habitat and natural resources identified in the NH Wildlife Action Plan and Coastal Conservation Plan, and Conserved lands may be impacted by future flooding.

Over time, as sea levels and groundwater levels rise saltwater intrusion may pose a threat to these existing drinking water source areas. The assessment reports the occurrence of sea-level rise and storm related flooding within designated wellhead protection areas. Evaluating the potential impact of such flooding was not within the scope of this assessment. It is recommended that the municipal drinking water facilities department complete further investigation of possible flood impacts to drinking water sources. Although stratified drift aquifers are reported within the high risk flood areas identified, the assessment did not evaluate potential impacts to private drinking water wells from salt water intrusion as sea-level rises.

The shores of the Great Bay and its tidal tributaries are fringed with saltmarsh and freshwater wetland systems. As sea levels rise, freshwater systems will transition to brackish and saltwater systems with daily tidal inundation. Saltmarsh may migrate inland with rising seas, depending on the ability of saltmarsh to keep pace with the rate of sea-level rise, the topography (gentle slopes versus steep banks), and the absence of physical barriers such as development, roads and railroad lines.

FIGURE 16: Conservation Lands (acres)

Resource Type	Name	Sea-Level Rise (SLR)			SLR + Storm Surge (SS)		
		SLR 1.7 feet	SLR 4.0 feet	SLR 6.3 feet	SLR 1.7 feet + SS	SLR 4.0 feet + SS	SLR 6.3 feet + SS
Conservation Lands	Allen St. Neighborhood Coalition	1.2	1.2	1.4	1.3	1.5	1.8
	Callahan	3.5	4.4	5.5	5.0	5.7	6.8
	Carlisle-Walters Way	0	0	1.88	1.14	2.25	3.22
	Exeter Country Club, Inc.	7.8	10.0	11.7	10.7	12.4	14.2
	Harrington	5.4	7.2	8.6	7.9	8.9	9.9
	Irvine Heirs	2.2	2.3	2.4	2.3	2.4	2.5
	Lee – Diller Land	10.1	10.6	11.4	10.9	11.8	13.3
	Molloy	0.2	0.4	0.5	0.4	0.6	0.8
	Oaklands Town Forest	0	0	0.02	0	0.1	0.3
	Oxbow	5.8	5.8	5.8	5.8	5.8	5.8
	Raynes Farm	7.4	9.9	13.3	11.2	13.8	15.2
	Renewable Resource Land	10.7	11.5	12.0	11.7	12.1	12.4
	Starry Brook	1.9	2.2	2.5	2.4	2.6	2.9
	Swasey Parkway	0.1	6.5	9.0	8.2	9.3	9.8
	Thomas	12.0	2.2	2.3	2.2	2.3	2.4
	Vaughn-Cusick	0	0	0.01	0	0.02	0.1
	Waterworks Land	0	0	0.93	0	1.05	1.52
Total Acres		**58.1**	**74.2**	**89.2**	**81.2**	**92.8**	**102.9**

Figure 17 report acres of conservation lands, NH Wildlife Action Plan high value habitat and Land Conservation Plan for NH's Coastal Watershed – Focus Areas affected by each of the sea-level rise and storm surge scenarios. Exeter has preserved substantial lands in its riparian corridors and shorelands. These lands will serve to accommodate flood waters and rising seas over time which will greatly reduce impacts to public and private assets. Based on the assessment, tidal marshes along the Squamscott River may become open water as sea level rises, unless the marshes are able to keep pace by building upward. A marsh migration model would need to be done to more accurately predict the condition of tidal marshes under different sea-level rise scenarios.

Over time, coastal flooding may impact sensitive habitats identified in the Land Conservation Plan for NH's Coastal Watershed (2006) and the NH Wildlife Action Plan (updated in 2015). Such habitats include nesting and breeding sites for shorebirds, tidal and freshwater wetlands, vernal pools, forests, scrub-shrub and meadow landscapes. The riparian corridors and shorelands on conserved lands will serve as barrier to floodwaters from rising seas and coastal storms. Over time, these lands will provide transitional habits for flora and fauna as ecosystem conditions change with inundation of daily tides.

FIGURE 17: Wildlife Action Plan and Land Conservation Plan for NH's Coastal Watershed (acres)

Resource Type		Sea-Level Rise			SLR + Storm Surge		
		SLR 1.7 feet	SLR 4.0 feet	SLR 6.3 feet	SLR 1.7 feet + storm surge	SLR 4.0 feet + storm surge	SLR 6.3 feet + storm surge
Wildlife	Tier 1 habitat	168.0	182.6	186.5	184.9	186.9	189.1
Action Plan	Tier 2 habitat	0.9	3.1	6.2	4.7	7.0	9.0
	Tier 3 habitat	6.2	10.7	15.8	12.7	17.4	23.4
Focus Areas - Land Conservation Plan for NH's Coastal Watershed	Squamscott River	123.69	135.81	145.45	140.01	147.91	155.18

Land Use

Map: Sea-Level Rise and Map: Sea-Level Rise + Storm Surge show upland affected by sea-level rise and coastal storm surge flooding above mean higher high water. Figure 18 reports the number of acres of upland affected by each flood scenario.

FIGURE 18: Uplands (acres)

Sea Level Rise (SLR) Scenarios	SLR 1.7 feet	SLR 4.0 feet	SLR 6.3 feet	SLR 1.7 feet + storm surge	SLR 4.0 feet + storm surge	SLR 6.3 feet + storm surge
Acres	34.6	68.4	104.8	84.2	114.3	141.0
% Upland Impacted	0.3	0.5	0.8	0.7	0.9	1.1

Total Upland in Exeter = 12,672 acres. Upland refers to land above mean higher high water (highest tidal extent).

Although the total acreage impacted under the six scenarios is a relatively low percentage of total upland in Exeter and limited in extent, areas that may be impacted by sea-level rise and storm related flooding are high value assets including public parks, historic resources, the Historic District along Water Street, and residential areas along the Squamscott River.

Parcels and Assessed Value

Figure 19 reports the number of parcels affected by each of the sea-level rise and storm surge scenarios and the aggregated assessed value of these parcels. For Exeter, the largest increase in the number of affected parcels is the extent of flooding from 4.0 feet and 6.3 feet of sea-level rise plus storm surge. There is a 40 percent increase in the number of affected parcels and approximately a $14 million increase in assessed value from the 1.7 feet to the 4.0 feet sea-level rise scenarios. It is important to note that flood impacts on many parcels are limited to undeveloped areas, particularly adjacent to the Squamscott River along Route 85 and along Wheelwright Creek. Other parcels have reported assessed value but are owned by tax exempt organizations or the town.

FIGURE 19: Parcels and Assessed Value by Scenario

Sea Level Rise (SLR) Scenarios	Number of Parcels Affected by Scenario	Aggregate Value of Affected Parcels	Percent Total Assessed Value
1.7 feet SLR	61	$37,198,247	2.8
4.0 feet SLR	86	$52,193,368	3.9
6.3 feet SLR	108	$64,400,173	4.8
1.7 feet SLR + storm surge	100	$59,125,413	4.4
4.0 feet SLR + storm surge	117	$76,158,213	5.7
6.3 feet SLR + storm surge	121	$83,471,100	6.3
The total assessed property value for Exeter = $1,329,346,187 (2016 town report)			

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

Figure 20 reports the number of residential structures affected by each of the sea-level rise and storm surge scenarios and the aggregated percent assessed value of these homes.

FIGURE 20: Residential Structures and Assessed Value by Scenario

Sea Level Rise (SLR) Scenarios	Number of Homes Affected by Scenario	Aggregate Value of Affected Parcels	Percent Total Assessed Value
1.7 feet SLR	1	$559,200	0.04
4.0 feet SLR	3	$1,048,300	0.08
6.3 feet SLR	11	$5,273,700	0.40
1.7 feet SLR + storm surge	8	$4,120,600	0.31
4.0 feet SLR + storm surge	15	$27,638,000	2.1
6.3 feet SLR + storm surge	21	$32,480,100	2.4
The total assessed property value for Exeter = $1,329,346,187 (2016 town report)			

FEMA Flood Hazard Areas

Map: Preliminary FEMA Flood Hazard Areas show areas within the 100-year floodplain affected by sea-level rise and coastal storm surge flooding. Figure 21 reports the acreage within the current 100-year and 500-year floodplains affected by each flood scenario.

> *From a floodplain management perspective, creating more resilient development within the current 100-year floodplain will provide protection against flood impacts from long term sea level rise.*

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

FIGURE 21: FEMA Flood Hazard Areas (acres)

Sea Level Rise (SLR) Scenarios	SLR 1.7 feet	SLR 4.0 feet	SLR 6.3 feet	SLR 1.7 feet + storm surge	SLR 4.0 feet + storm surge	SLR 6.3 feet + storm surge
100-year floodplain	88.9	128.4	137.5	134.6	138.0	138.6
Percentage of SLR within 100-year floodplain (FP)	99.9% (0.07 acres beyond FP)	99.6% (0.93 acres beyond FP)	81.4% (31.4 acres beyond FP)	91.7% (12.2 acres beyond FP)	77.1% (40.9 acres beyond FP)	62.6% (82.7 acres beyond FP)

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

ISSUES AND CONSIDERATIONS

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

- Improvements to the state roadway network (elevating, enlarging culvert and bridges) may affect local connector roads, driveway access points and connecting infrastructure and utilities.
- Although roadways, buildings and infrastructure can be protected by raising them above projected sea-level rise elevations, supporting land and land based uses may be impacted by daily tidal flooding from projected sea-level rise.
- Flooding from sea-level rise and coastal storm surge impacting the state and local roadway network at Route 85 and Route 101 could disrupt the designated evacuation network in Exeter and connections to evacuation routes in adjacent towns.
- Long term capital improvement investments would benefit from an analysis of the costs necessary to improve roads and drainage infrastructure to withstand projected sea-level rise elevations at 2050 and 2100.
- Planning for long term sea-level rise can be integrated with existing regulatory and management frameworks for the current 100-year floodplain.
- Providing information about potential flood hazards to businesses and residents, and early notification of flood risk during a coastal storm event would enhance public safety and preparedness.
- Identify barriers to saltmarsh migration (e.g. railroad corridor) and ways to enhance tidal flow. Utilize SLAMM results from NH Fish & Game to prioritize inland saltmarsh migration potential.
- Open space preservation in the floodplain reduces flood risks and gains points in the FEMA Community Rating System Program.
- Possible future impacts of saltwater intrusion to aquifers, private wells, and public water supplies.
- Public outreach to property owners in high risk flood areas along Route 85, Swazey Parkway and Exeter Waterfront Commercial Historic District.

- Document flood elevations for each flood event (e.g. on a fixed structure such as a building).
- Extreme precipitation exacerbates coastal flooding particularly with respect to managing stormwater and CSO outfalls in tidally influenced areas.
- Future sea-level rise and storm related flooding in Swazey Parkway might be prevented by raising the retaining wall along the Squamscott River; however freshwater flooding is inevitable when stormwater discharge from Norris Brook is prevented during high tide.

RECOMMENDATIONS

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

REGULATORY

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

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

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

PLANNING AND POLICY

P1 - Natural Hazards Mitigation Plan. Incorporate the vulnerability assessment information and recommendations from the Climate Risk in the Seacoast Vulnerability Assessment report and maps in the town's 2015/2016 Natural Hazards Mitigation Plan update. Continue revising and updating the assessment information and climate adaptation recommendations in future updates of the Plan.

P2 - Master Plan Coastal Hazards Chapter. Adopt a Coastal Hazards Chapter in the town's Master Plan that incorporates information and recommendations from the Climate Risk in the Seacoast Vulnerability Assessment report and maps.

P4 - Capital Infrastructure and Investments. Incorporate consideration of impacts from sea-level rise and coastal storm surge flooding in current and future capital infrastructure projects. Incorporate the Climate Risk in the Seacoast vulnerability assessment information into infrastructure management plans and capital improvement plans. Evaluate the extent of sea-level rise and storm surge flooding on individual facilities (e.g. wastewater treatment plant, transfer station, high school).

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

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

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

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

COMMUNITY OUTREACH AND ENGAGEMENT

O1 – NH Coastal Adaptation Workgroup. The NH Coastal Adaptation Workgroup (CAW) is a voluntary collaborative advocacy group consisting of members from federal and state agencies, regional and non-profit organizations, municipalities, academia, and private businesses. The group's focus is to: 1) pursue activities that improve the resilience of natural systems, infrastructure and development to the impacts of climate change; and 2) facilitate communication and cooperation among stakeholders throughout the coastal watershed, especially in regard to research, programs and other efforts designed to help preserve, protect, and strengthen the Great Bay and Hampton-Seabrook Estuary. CAW can assist the city with outreach, planning and regulatory activities involving climate adaptation implementation.

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

O2 - Implement FEMA's High Water Mark Initiative. Consider implementing the FEMA High Water Mark Initiative (HWMI) as a public outreach activity. The HWMI provides information on past floods, such as documenting high water marks in public places, and posting maps and photographs of past floods on their websites. High water marks can be displayed on public buildings or on permanently installed markers.

O3 - Coastal Flood Hazard Outreach. Use information from the C-RiSe Vulnerability Assessment to inform property owners of existing and future risks and hazards based on projected sea-level rise and coastal storm surge flooding.

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

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

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

Recommendations from the NH Coastal Risk and Hazards Commission Final Report (2016)

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.

ACTIONS:

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)).
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

CC2. Identify vulnerable state and municipal assets at regional, municipal, and site-specific scales as appropriate.

ACTIONS:

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.
e. Disseminate and share results from coastal vulnerability assessments with relevant audiences.

CC6. Make existing structures and facilities more resilient and acquire properties in high risk areas in order to reduce or eliminate flooding impacts.

ACTIONS:

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.

CC7. Incorporate coastal hazards, risks and vulnerability in policies, plans and investments.

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 communities' activities.

E2. Incorporate best available climate science and vulnerability assessment information in state, regional, and municipal economic development plans.

ACTIONS:

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

E3. Use appropriate and available mechanisms, including but not limited to incentives and market-based tools to fund climate adaptation strategies.

ACTIONS:

a. Align land acquisition and easement programs to transfer vulnerable properties into conservation.
b. Establish stormwater utilities to fund retrofits to existing development and future improvements.
c. Develop and utilize tools to identify cost effective strategies and public investments for adapting to increased flood risk in vulnerable areas.
d. 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.

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 Policy.

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.

ACTIONS:

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 Appro*ach – use the 0.2-percent-annual-chance flood elevation (also known as the 500-year flood elevation).

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.

BL4. Integrate comprehensive land use and environmental planning with floodplain management approaches that prevent and minimize impacts from coastal hazards.

ACTIONS:

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.

NR2. Develop natural resource restoration plans that explicitly consider future coastal risk and hazards, and the ecological services that they provide.

ACTIONS:

b. 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.
c. Engage in best practices for invasive species planning and removal and incorporate climate considerations in invasive species removal plans.
d. Utilize existing funding sources for natural resource restoration (e.g. offset measures, state Aquatic Resource Mitigation fund).

NR4. Consider ecosystem services provided by natural resources in land use planning, master plans, and asset decisions.

ACTIONS:

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.
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.

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.

H2. Develop plans and implement strategies to prepare and adapt recreational resources based on best available climate science.

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.

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. Develop long-term plans for protecting, adapting, or reducing risk to cultural resources affected by climate change.

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.
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.

APPENDIX – MAP SET

Map - Extent of Projected Tidal Flooding - SLR 1.7', 4.0' and 6.3'
Map - Extent of Projected Tidal Flooding - SLR + Storm Surge
Map - Infrastructure - SLR 1.7', 4.0' and 6.3'
Map - Infrastructure - SLR + Storm Surge
Map - Transportation Assets - SLR 1.7', 4.0' and 6.3'
Map - Transportation Assets - SLR + Storm Surge
Map – Water Resources 1.7', 4.0' and 6.3'
Map – Water Resources - SLR + Storm Surge
Map – Land Resources - SLR 1.7', 4.0' and 6.3'
Map – Land Resources - SLR + Storm Surge