C-RiSe

CLIMATE ISK IN THE SEACOAST

Assessing Vulnerability of Municipal Assets and Resources to Climate Change

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TOWN OF NEWINGTON, NEW HAMPSHIRE

Vulnerability Assessment

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

Prepared by the
Rockingham Planning Commission

Mach 31, 2017

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The Rockingham Planning Commission gratefully acknowledges the participation of Town of Newington:

Gerald Coogan, Town Planner

John Stowell, Building Inspector

Andrew Head, Emergency Management Director

Leonard Thomas, Road Agent

Planning Board: Denis Hebert-Chair, Christopher Cross-Vice Chair, James Weiner, Bernard Christopher, Jack Pane, Kenneth Latchaw, Peter Welch, Mark Phillips

Cover Photo: Great Bay Marine, Fox Point, Stubbs Pond Outlet
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.

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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 1, 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 1: Sea-Level and Storm Surge Scenarios

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	1.7 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 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 NEWINGTON

The Town of Newington is situated along both tidal riverine and estuarine shorelines. Newington's land area covers roughly 8.2 square miles (5,248 acres) and 4.1 square miles (2,624 acres) of inland water area. With an estimated population of 800 (2014 Census), Newington is the least populated municipality in RPC's planning region. The inland coastal portion of Newington that is most susceptible to coastal flooding are low-lying areas along Little Bay, Great Bay and the Piscataqua River.

KEY FINDINGS OF VULNERABILITY ASSESSMENT RESULTS

KEY FINDINGS

Figure 2 reports the number of acres of land and inland water area affected under the sea-level rise and storm surge scenarios evaluated. The area impacted by flooding increases by 78 percent from 1.7 feet of sea-level rise to 4.0 feet of sea-level rise, then another 34 percent increase at 6.3 feet of sea level rise. Affected areas greatly increase under the storm surge scenarios which are infrequent events compared with daily flooding at high tide.

FIGURE 2: Total Acreage Affected by Sea Level Rise and Storm Surge Scenarios at year 2100

Municipality	Sea-Level Scenarios					
	SLR 1.7 feet Intermediate Low 2100	SLR 4.0 feet Intermediate High 2100	SLR 6.3 feet High 2100	SLR 1.7 feet + storm surge 2100	SLR 4.0 feet + storm surge 2100	SLR 6.3feet + storm surge 2100
Newington (acres)	123.2	219.6	294.7	252.9	325.6	404.3
% impacted	1.6	2.8	3.7	3.2	4.1	5.1

Total Area = 7,872 acres

Figures 2 and 3 provide an overview of impacts to land and specific assets affected by each sea-level rise and storm surge flooding.

Newington has significant miles of coastal tidally-influenced shoreline along the Great Bay and Little Great Bay, however due to the increase in elevation landward only certain areas are particularly vulnerable to flooding from seasonal high tides, coastal storms, and sea-level rise. These high risk flood areas include lands currently used for commercial, industrial, residential and recreational development, and small sections of local roads and state Route 16 at the Little Bay Bridges. The following areas are most susceptible to sea-level rise and storm related flooding:

- River Road/Piscataqua River waterfront commercial/industrial area
- Great Bay Marine and low-lying supporting lands
- Fox Point and Newington Town Park conservation lands
- Residential parcels and structures along the west and southwest shorelines
- Shattuck Way, a designated evacuation route
- Fabyan Point (future residential development potential)
- 9 parcels valued at $10.8 million and 9 homes valued at $1.3 million

FIGURE 3: Summary of Assessment Data

Sea Level Rise (SLR) Scenarios	SLR 1.7 feet Intermediate Low 2100	SLR 4.0 feet Intermediate High 2100	SLR 6.3 feet High 2100	SLR 1.7feet + storm surge 2100	SLR 4.0 feet + storm surge 2100	SLR 6.3 feet + storm surge 2100
Infrastructure and Critical Facilities						
Infrastructure-Water Pipes (miles)	0.01	0.1	0.3	0.2	0.4	0.6
Roadways (miles)	0.0	0.1	0.7	0.4	0.9	1.3
Critical Facilities (# of sites)	na	na	1	na	na	3
Residential Structures	0	0	3	2	6	8
Assessed Value - Parcels Impacted	$519,647,600	$120,940,300	$127,201,800	$131,327,200	$127,954,100	$135,065,400
Natural Resources						
Freshwater Wetlands (acres)	8.2	10.0	11.0	10.9	11.7	15.2
Tidal Wetlands (acres)	113.4	117.5	119.4	118.6	119.8	120.6
Wellhead Protection Areas (acres)	0	0	0	0	0	0
Conserved and Public Lands (acres)	20.8	104.4	159.3	126.5	177.1	229.4
Wildlife Action Plan (acres)	39.2	130.5	195.7	157.4	216.4	278.3
Coastal Conservation Plan-Focus Area – Fabyan Point	33.8	113.4	160.7	133.2	175.4	211.5
100-year Floodplain (acres)	123.2	208.8	217.6	214.8	219.1	222.5

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

Property assessed values in areas impacted by future flooding are confined to the 6.3-foot sea-level rise scenario and the three sea-level rise plus storm surge scenarios. No impacts are reported under the 1.7-foot and 4.0-foot sea-level rise scenario.

The complete detailed vulnerability assessment data are provided in the following section of this report.

DETAILED VULNERABILITY ASSESSMENT RESULTS BY ASSET TYPE

Culvert Assessment

Map: Culvert Assessment – Climate Ready Culverts and Figure 4 show the hydraulic and aquatic organism passage function of culverts under existing precipitation conditions for the 10-year, 25-year, 50-year and 100-year storm event.

The hydraulic, performance of more than half of the ten culverts evaluated in this assessment have moderate to poor function under existing storm conditions (10-year up to the 100-year storm event). Newington does not own and operate a tremendous amount of water or sewer infrastructure thus impacts to these assets are minimal to none under all scenarios evaluated. Of the ten culverts analyzed for hydraulic rating, five pass, 2 are transitional and three fail under the 10-year storm event. Culverts #38, #43, #42, #46 and #47 are impacted by sea-level rise and storm surge flooding. For Aquatic Organism Passage (AOP) rating, one culvert has full capability, and 9 have reduced or no capability.

FIGURE 4: Assessment of Culvert Hydraulic and Aquatic Organism Passage Function

Crossing #	Location	Hydraulic Rating				Aquatic Organism Passage Rating	
		10-year	25-year	50-year	100-year	Color	Rating
38	Fox Point Road	Fail	Fail	Fail	Fail	GRAY	Reduced AOP
39	Nimble Hill Road @ Coleman Drive	Fail	Fail	Fail	Fail	GRAY	Reduced AOP
40	Shattuck Way @ Lower Pickering Brook	Pass	Transitional	Transitional	Transitional	GREEN	Full AOP
41	Patterson Lane	Transitional	Transitional	Transitional	Fail	GRAY	Reduced AOP
42	Captains Landing	Transitional	Fail	Fail	Fail	GRAY	Reduced AOP
43	Fox Point Road @ Upper Pickering Brk.	Pass	Pass	Pass	Pass	GRAY	Reduced AOP
44	Fox Point Road @ Flagstone Ditch	Pass	Pass	Pass	Pass	RED	No AOP
45	Shattuck Way @ Paul Brook	Fail	Fail	Fail	Fail	GRAY	Reduced AOP
46	Newington Road@ McIntyre Brook	Pass	Pass	Pass	Pass	RED	No AOP
47	Newington Road @ Kennard Pond	Pass	Pass	Pass	Transitional	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 and Critical Facilities

Maps: Critical Facilities and Infrastructure show the municipal critical facilities affected by sea-level rise and coastal storm surge flooding. Figure 5 reports when specific municipal critical facilities are affected by each sea-level rise and coastal storm surge scenario. Only small segments of water distribution pipes are impacted by any of the six scenarios evaluated. Several dams might be at risk of both sea-level rise (4 dams) and storm related (6 dams) flooding. Three residential structures are located in flood areas associated with 6.3 feet of sea-level rise, and 9 residential structures are located in flood areas associated with 6.3 feet of sea-level rise plus storm surge.

FIGURE 5: Municipal Critical Facilities (# of facilities)

Sea Level Rise (SLR) Scenarios	SLR 1.7 feet Intermediate Low 2100	SLR 4.0 feet Intermediate High 2100	SLR 6.3 feet High 2100	SLR 1.7 feet + storm surge 2100	SLR 4.0 feet + storm surge 2100	SLR 6.3 feet + storm surge 2100
Sewer Pipes (miles)	0	0	0	0	0	0
Water Pipes (miles)	0.01	0.08	0.27	0.19	0.43	0.56
Transmission Lines (miles)	0	0	0	0	0	0
Analysis below for SLR 6.3 feet and SLR 6.3 feet + storm surge only						
Dams	Fuel Storage Corp. Holding Pond Lower Dunwoody Dam Lower Peverly Brook Dam Stubbs Pond Dam			Fuel Storage Corp. Holding Pond Lower Dunwoody Dam Lower Peverly Brook Dam Stubbs Pond Dam Barrott's Dam, Kennard Dam		
Residential Structures	3 (6.3 feet SLR)			9 (6.3 feet SLR+storm surge)		
Fuel Source/Storage	0			Pickering Stone		

Transportation

Maps: Road and Transportation Assets show the state and municipal roadways affected by sea-level rise and coastal storm surge flooding. Figure 6 reports the miles of state and local roadways affected by each flood scenario. Except in for the most extreme sea-level rise plus storm surge scenario, less than one mile of combined local, state and private roads are impacted by coastal flooding.

A small portion of Shattuck Way at the intersection of Route 16 is impacted by both sea-level rise and storm surge flooding which could be significant as it is a designated evacuation route. The town should evaluate

this flood risk and its implications for emergency access and response, and public safety in the event of an evacuation during a storm event.

FIGURE 6: State and Municipal Roadways and Infrastructure (miles)

Sea Level Rise (SLR) Scenarios	SLR 1.7 feet Intermediate Low 2100	SLR 4.0 feet Intermediate High 2100	SLR 6.3 feet High 2100	SLR 1.7 feet + storm surge 2100	SLR 4.0 feet + storm surge 2100	SLR 6.3 feet + storm surge 2100
Roadway Type						
Local	0.0	0.02	0.09	0.04	0.15	0.22
State	0.0	0.0	0.0	0.0	0.01	0.01
Private	0.0	0.06	0.60	0.41	0.79	1.05
Total Road Miles	0.0	0.08	0.69	0.45	0.95	1.28
Bridges	na	na	0	na	na	0
NH DOT 10-year Plan Projects	na	na	1	na	na	1
Evacuation Routes	na	na	1	na	na	1

na = not assessed

FIGURE 7: State, Municipal and Private Roadways (miles)

Sea Level Rise (SLR) Scenarios	SLR 1.7 feet Intermediate Low 2100	SLR 4.0 feet Intermediate High 2100	SLR 6.3 feet High 2100	SLR 1.7 feet + storm surge 2100	SLR 4.0 feet + storm surge 2100	SLR 6.3 feet + storm surge 2100
Arboretum Drive	na	na	0.04	na	na	0.11
Fabyan Point Road	na	na	0.06	na	na	0.17
Fox Point Road	na	na	0.00	na	na	0.01
General Sullivan Bridge Road	na	na	0.00	na	na	0.02
Merrimac Drive	na	na	0.08	na	na	0.12
No Name	na	na	0.42	na	na	0.63
Patterson Lane	na	na	0.04	na	na	0.05
Shattuck Way	na	na	0.04	na	na	0.16
Spaulding Turnpike N (state)	na	na	0.00	na	na	0.01
Spaulding Turnpike S (state)	na	na	0.00	na	na	0.01

na = not assessed

As reported in Figure 7, impacts to state, municipal and private roadways were assessed 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. Culverts are supporting infrastructure for the roadway network that are somewhat 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. As reported in Figure 6, the culvert analysis reports that four of the ten culverts analyzed in Newington fail under current conditions associated with the 10-, 25-, 50-, and 100-year storm events, and several others are marginally functional during these storm events.

Natural Resources

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

FIGURE 8: Natural Resources (acres)

Sea Level Rise (SLR) Scenarios	SLR 1.7 feet Intermediate Low 2100	SLR 4.0 feet Intermediate High 2100	SLR 6.3 feet High 2100	SLR 1.7 feet + storm surge 2100	SLR 4.0 feet + storm surge 2100	SLR 6.3 feet + storm surge 2100
Stratified Drift Aquifers	0.44	1.39	4.29	2.44	5.16	7.62
Freshwater Wetlands (total)	8.17	10.05	10.97	10.89	11.68	15.19
Freshwater Emergent Wetland	1.59	3.58	5.39	3.70	6.69	7.74
Freshwater Forested/Shrub Wetland	0.59	4.29	7.76	6.07	9.21	14.05
Freshwater Pond	0.00	0.00	0.00	0.00	0.00	1.76
Lake	0.00	48.13	48.93	48.73	48.93	48.93
Tidal Wetlands (total)	113.43	117.53	119.40	118.57	119.82	120.62
Estuarine and Marine Deepwater	80.93	80.98	81.01	81.01	81.01	81.01
Estuarine and Marine Wetland	32.50	36.55	38.39	37.56	38.81	39.61
Wildlife Action Plan – Tiers 1, 2 and 3 habitats	39.2	130.53	195.71	157.37	216.42	278.35
Coastal Conservation Plan Focus Area – Fabyan Point	33.83	113.39	160.76	133.25	175.45	211.53
Conserved and Public Lands	20.85	104.40	159.26	126.53	177.13	229.41
Wellhead Protection Areas	0	0	0	0	0	0

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. These natural shorelands can act as critical flood storage areas to protect infrastructure and private property from rising seas and storm events.

The shores of the Great Bay and Little Great Bay and their 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

No impact to designated wellhead protection areas, and although minimal impacts are reported for stratified drift aquifers, the assessment did not evaluate potential impacts to private drinking water wells from salt water intrusion as sea-level rises.

FIGURE 9: Conservation Lands (acres)

Resource Type	Sea-Level Rise			SLR + Storm Surge		
	SLR 1.7 feet Intermediate Low 2100	SLR 4.0 feet Intermediate High 2100	SLR 6.3 feet High 2100	SLR 1.7 feet + storm surge 2100	SLR 4.0 feet + storm surge 2100	SLR 6.3 feet + storm surge 2100
Conservation Lands						
Beals Tract	0.46	3.90	10.00	6.25	11.82	16.91
Beane Tract	0.02	0.10	0.22	0.15	0.26	0.42
Fox Point	0.92	1.74	3.01	2.28	3.41	6.36
Great Bay National Wildlife Refuge	15.27	89.00	128.94	105.02	142.31	181.30
Mazeau Tract	3.00	7.18	12.74	9.48	14.20	17.79
Town of Newington	0.02	0.09	0.18	0.12	0.21	0.28
White	1.16	2.39	4.17	3.23	4.92	6.35

Figures 9 and 10 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. The riparian corridors and shorelands surrounding Great Bay and Little Great Bay 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 Great Bay and Little Great Bay 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.

FIGURE 10: 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 Intermediate Low 2100	SLR 4.0 feet Intermediate High 2100	SLR 6.3 feet High 2100	SLR 1.7 feet + storm surge 2100	SLR 4.0 feet + storm surge 2100	SLR 6.3 feet + storm surge 2100
Wildlife Action Plan	Tier 1 habitat	38.93	129.88	194.02	156.43	214.20	272.10
	Tier 2 habitat	0.22	0.56	1.38	0.83	1.77	3.38
	Tier 3 habitat	0.05	0.09	0.31	0.11	0.45	2.87
Focus Areas -Land Conservation Plan for NH's Coastal Watershed	Fabyan Point	33.83	113.4	160.76	133.25	175.45	211.53

Land Use

Maps: Extent of Sea-Level Rise and Sea-Level Rise + Storm Surge Flooding show upland affected by sea-level rise and coastal storm surge flooding above mean higher high water. Figure 11 reports the number of acres of upland affected by each flood scenario. Under the 6.3 feet sea-level rise scenario, the majority of impacts to upland are located in the Knight Brook at Fox Point, Pickering Brook, and Paul Brook drainages, shorelands of the Great Bay National Wildlife Reserve, shoreland and waterfront facilities long the Piscataqua River, and agricultural lands at Lord Farm and Wild Iris Farm. Under the 6.3 feet sea-level rise scenario, additional upland impacts include industrial facilities along the Piscataqua River, and increased interior flooding at the site impacted under the 6.3 feet sea-level rise scenario.

FIGURE 11: Uplands (acres)

Sea Level Rise (SLR) Scenarios	SLR 1.7 feet Intermediate Low 2100	SLR 4.0 feet Intermediate High 2100	SLR 6.3 feet High 2100	SLR 1.7 feet + storm surge 2100	SLR 4.0 feet + storm surge 2100	SLR 6.3 feet + storm surge 2100
Acres	19.2	68.8	139.2	99.1	168.3	243.2
% Upland	0.37	1.34	2.72	1.93	3.28	4.74

Total Upland in Newington = 5,126 acres. Upland refers to land above mean higher high water (highest tidal extent) and excludes wetlands.

Parcels and Assessed Value

Parcels and Assessed Value

Figure 12 reports the number of parcels affected by for each of the six scenarios evaluated and the aggregated assessed value of these parcels. The degree to which the parcel and any development on the parcel is affected by sea-level rise or storm related flooding was not analyzed. Affected parcels were identified based on their location either partially or fully within the extent of the scenarios evaluated. The data may include a number of high value parcels under state and municipal ownership.

FIGURE 12: 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	110	$120,940,300	11.9
4.0 feet SLR	115	$127,201,800	12.5
6.3 feet SLR	121	$131,327,200	12.9
1.7 feet SLR + storm surge	118	$127,954,100	12.6
4.0 feet SLR + storm surge	123	$135,065,400	13.3
6.3 feet SLR + storm surge	128	$136,845,000	13.5
The total assessed property value for Newington = $1,013,624,828 (2016 town report)			

Figure 13 reports the number of homes affected by each of the sea-level rise and storm surge scenarios and the aggregated percent assessed value of these homes. No impacts are reported for the two lowest sea-level rise scenarios and modest impacts under all other scenarios.

FIGURE 13: Homes 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	0	$0	0
4.0 feet SLR	0	$0	0
6.3 feet SLR	3	$1,123,900	0.11
1.7 feet SLR + storm surge	2	$813,900	0.08
4.0 feet SLR + storm surge	6	$2,770,900	0.27
6.3 feet SLR + storm surge	8	$8,364,400	0.82
The total assessed property value for Exeter = $1,013,624,828 (2016 town report)			

For Newington, the number of affected parcels is quite low, reported as three structures impacted at 6.3 feet of sea-level rise. There is a 240 percent increase in the number of affected parcels and nearly a $2 million increase in assessed value from the 1.7 feet to the 4.0 feet sea-level rise plus storm surge scenarios.

There is a 200 percent increase in the number of affected parcels and approximately a $5.6 million increase in assessed value from the 4.0 feet to the 6.3 feet sea-level rise plus storm surge scenarios

FEMA Flood Hazard Areas

Maps: Preliminary FEMA Flood Hazard Areas show areas within the 100-year floodplain affected by sea-level rise and coastal storm surge flooding. Figure 14 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 Newington, the 100-year floodplain is highly vulnerable to flooding from storm surge, extending well beyond its boundary under the 4.0 fee and 6.3 feet sea-level rise plus storm surge scenarios. 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 14: FEMA Flood Hazard Areas (acres)

Sea Level Rise (SLR) Scenarios	SLR 1.7 feet Intermediate Low 2100	SLR 4.0 feet Intermediate High 2100	SLR 6.3 feet High 2100	SLR 1.7 feet + storm surge 2100	SLR 4.0 feet + storm surge 2100	SLR 6.3 feet + storm surge 2100
100-year floodplain	123.2	208.8	217.6	214.8	219.1	222.5
Percentage of SLR within 100-year floodplain (FP)	100% (0.07 acres beyond FP)	95% (0.07 acres beyond FP)	74% (0.07 acres beyond FP)	85% (0.07 acres beyond FP)	67% (0.07 acres beyond FP)	55% (0.07 acres beyond FP)

Floodplain assessment based on Preliminary Flood Insurance Rate Maps (FIRMs) released by FEMA in 2014 (not adopted).

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.

- The following areas are most susceptible to sea-level rise and storm related flooding:
  - River Road waterfront commercial/industrial area
  - Fox Point Marina has high flood risk
  - Residential parcels and structures along the west and southwest shorelines
  - Evaluate the flood risk on Shattuck Way at the Route 16 intersection; identify implications as a designated evacuation route
  - Fabyan Point has future residential development potential and high flood risk
  - Performance of more than half of the culverts assessed is moderate to poor

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

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

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

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

- 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.

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

RECOMMENDATIONS

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

REGULATORY

R1 - Elevate Structures 1-2 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 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 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.
- Adopt a cluster/open space/conservation subdivision ordinance.

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 - 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 Newington's Natural Hazards Mitigation Plan for additional recommendations for outreach and engagement activities.

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

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 Approa*ch – 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 I – MAP SET

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

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

APPENDIX II – 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, intermediate high and highest projected sea-levels at the year 2100.

FIGURE 14: Sea-Level and Storm Surge Scenarios in NEWINGTON

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	--	--	--	1.7ft + storm surge	4.0ft + storm surge	6.3ft + 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]

Storm Surge: *Storm surge is the rise of water level accompanying intense coastal storm events such a tropical storm, hurricane or Nor'easter, whose height is the difference between the observed level of the sea surface and the level that would have occurred in the absence of the storm event.*[2] Storm surge is mapped using the 100-year/1% chance flood events from the Preliminary Flood Insurance Rate Maps (FIRMs) released by FEMA in 2014. The preliminary FIRM's account for the limit of moderate wave action in coastal

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

areas, however this assessment does not take into account additional flooding and impacts related to more severe wave action, wind action, erosion and other dynamic coastal processes.

Sea-Level Rise Scenarios

Figures 15 and 16 below document how the scenarios used in this report relate to 2011 by Wake et al (see reference in Figure 15) and are similar to a more recent report issued by the NH Coastal Risks and Hazards Commission's Science and Technical Advisory Panel in 2014

Figure 15: 2014 Sea Level Rise Scenarios (based on greenhouse gas emissions)

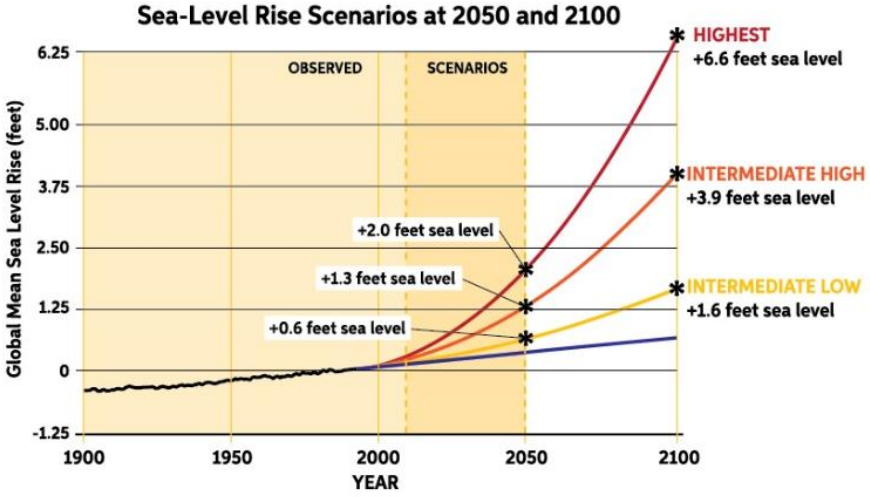
	Lower Emissions (B1)		Higher Emissions (A1fi)	
	2050	2100	2050	2100
Current Elevation of MHHW [a,b]	4.43	4.43	4.43	4.43
100-Year Flood Height	7.78	7.78	7.78	7.78
Subsidence	0.012	0.016	0.012	0.016
Eustatic SLR	1.0	2.5	1.7	6.3
Total Stillwater Elevation [a,c]	**13.2**	**14.7**	**13.9**	**18.5**

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 16: 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.

The sea-level rise projections used in this study are based on an earlier study completed in 2011 by Wake et al (see reference in Figure 14) and are similar to a more recent report issued by the NH Coastal Risks and Hazards Commission's Science and Technical Advisory Panel Report (2014) as depicted in Figure 14. As shown in the graphics above, 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.

Assets and Resources Evaluated

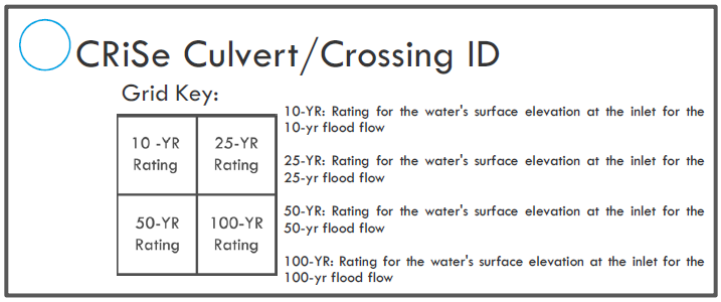
Figure 17 lists the three major categories and a detailed list of the assets and resources evaluated as part of the Climate Risk in the Seacoast vulnerability assessment. The assets and resources evaluated are listed in subsequent tables in this report only if they are affected by one or more of the sea-level rise and/or coastal storm surge scenarios.

FIGURE 17: Assets and Resources Evaluated for the Vulnerability Assessment

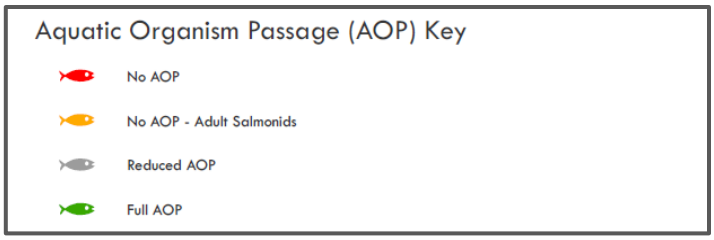
Category	Assets and Resources
State and Municipal Infrastructure	Municipal Culverts Federal and State Historic Register Properties Other Assets: graveyards, water access, transmission lines
Municipal Critical Facilities	Municipal Critical Facilities
Transportation Assets & Roadways	State and Local Roadways 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.

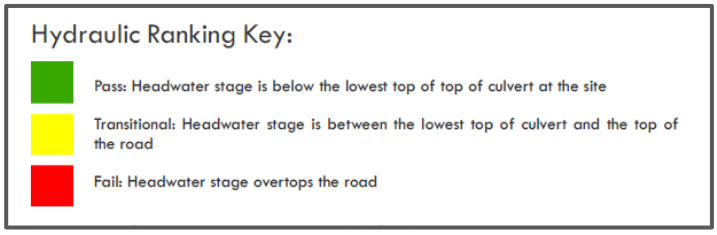


The AOP rating is labeled by color; Red, Orange, Gray, and Green. Ratings of Red and Orange mean that there is estimated to be little to no AOP at that crossing, with Red being no AOP for all species and Orange meaning no AOP for all species except for adult Salmonids. A rating of Gray means that there 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 18). 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[3] method was used; and for watersheds larger than one square mile, flows were calculated using the Regression Equations[4] 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 18: 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 in Figures 19 and 20 on pages 24 and 25.

[3] 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.

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

Vulnerability Assessment: Planning to Reduce Risk and Impacts

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

What is a Vulnerability Assessment?

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

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

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.

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 can a 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

Assessment results can be incorporated into existing practices, plans, policies and regulations.

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

Extent of Flooding from Sea Level Rise and Storm Surge

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

Figure 19: Sea Level Rise Scenarios 1.7 feet, 4.0 feet, and 6.3 feet

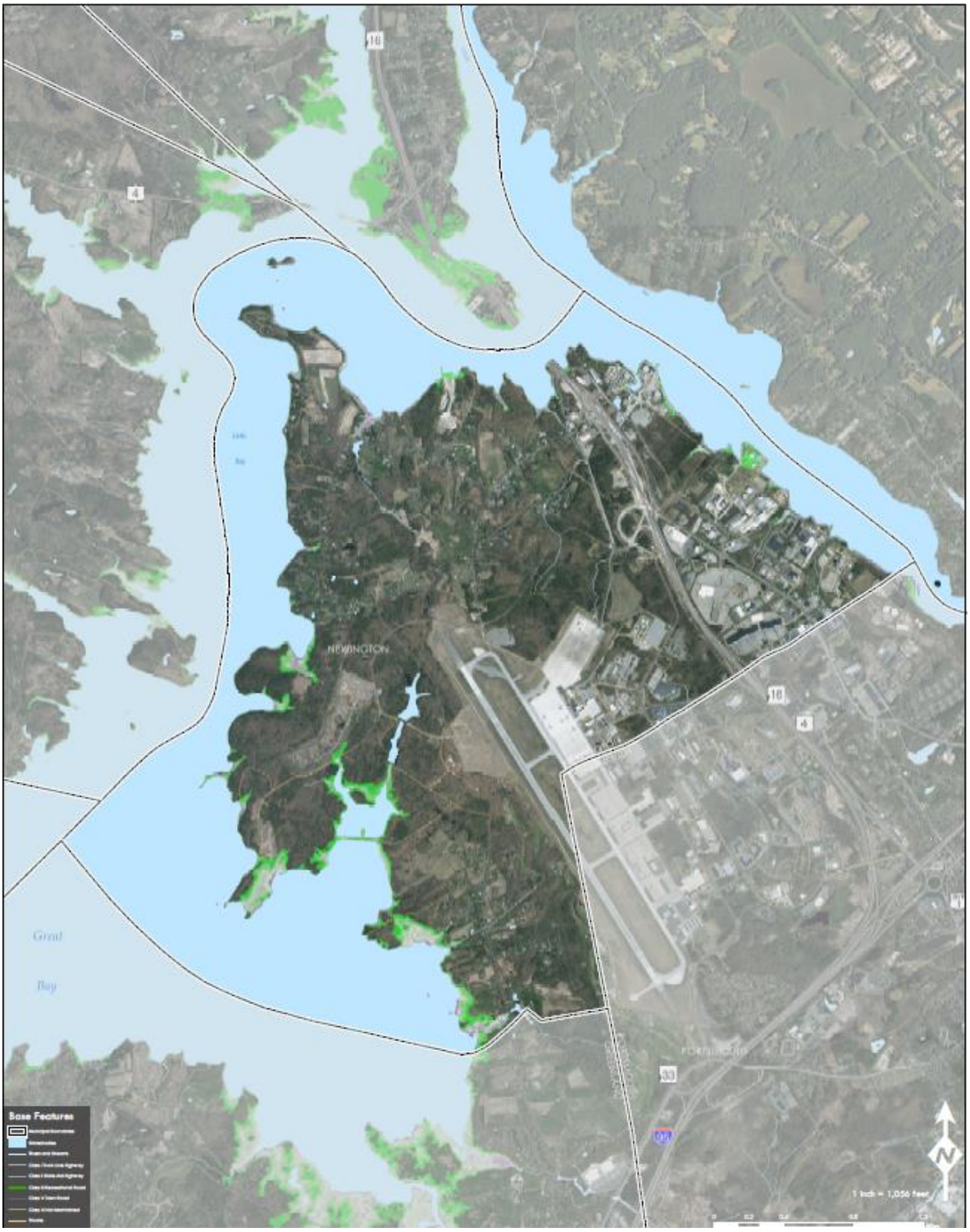


Figure 20: Sea Level Rise Scenarios 1.7 feet, 4.0 feet, and 6.3 feet + storm surge

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