Chapter X. Coastal Hazards and Adaptation[1]

X.1 Introduction (1/2 page)

Like other coastal municipalities in New Hampshire, Rye is confronted by a challenging set of land use and hazard management concerns that include exposure to weather events, coastal erosion, and loss of key coastal habitats. Rye has experienced significant impacts during extreme and moderate coastal storm events, increases in extreme rainfall events, and localized flooding from more frequent seasonal highest tides both in immediate coastal areas and inland. These observed impacts may be exacerbated by changes in climate that may cause future increases in the frequency and intensity of storms and rates of sea-level rise. Flooding is compounded by increased stormwater runoff from development and impervious surfaces. Projected changes in climate and coastal conditions will present challenges to many sectors of municipal governance, asset and infrastructure management, sustainability of recreation and tourism, and protection of natural resources and coastal ecosystems. Adapting to changing conditions will play an important part in the town's strategic planning and actions in the future. Effective preparedness and proactive land use management can help the town reduce its future exposure and improve resilience to increased flood risks and thus minimize economic, social, and environmental impacts.

The Coastal Hazards and Adaptation Chapter addresses the following topics:

- Present and future coastal hazards
- Future impacts to coastal assets and resources
- Other climate related impacts
- Future growth demands
- Community adaptation and resilience
- Recommendations for future actions

Coastal hazards and adaptation strategies identified in this chapter will be expanded upon in the Transportation, Land Use and Natural Resources Chapters of the Master Plan.

X.2 Vision (1/2 page)

Vision Statement

To identify proactive strategies that address the impacts of coastal hazards, and ensure the community is better prepared to protect the security, health and safety of its citizens and provide for a stable and viable economic future.

- Protect important infrastructure.
- Ensure the safety of residents and businesses.
- Identify areas at high risk to coastal hazards including storm flooding and erosion.
- Manage development and use of land and resources in high risk areas.
- Adapt built landscapes and natural landscapes to changing conditions.

---

[1] Preparation of this Chapter was funded by a grant from the Northeast Region Ocean Council through the U.S. Fish & Wildlife Service.

X.3 Present and Future Coastal Hazards (1 page)

A. Past and Present Coastal Hazards (1 page with 2 photos)

Coastal Storms

A wide range of coastal storms have effected Rye in the past including extreme rainfall, N'Oreasters, hurricanes, and tropical storms. Below is a summary of significant coastal storms that have produced widespread flooding and erosion along Rye's coastline.

Table ___. History of significant coastal storm and flood events that have impacted Rye.

Event	Type	Rainfall/ Snow	Inland Flooding	Tidal Flooding	High Winds	Surge Height	Tide Stage
February 1972	Nor' Easter			✓	✓		
Blizzard of 1978	Nor' Easter	33" snow					
August 1991	Hurricane Bob						
October 1991 "Perfect Storm"	Nor' Easter			✓	✓	+3.5'	
October 1996	Tropical Storm	14" rain	✓	✓		500-yr	High
Mother's Day May 2006	100-year+	14" rain	✓				
Patriot's Day April 2007	Nor' Easter	6.5" rain	✓		✓		
Super Storm Sandy 2012	Tropical Storm	___" rain	✓	✓	✓		
King Tide 2014	extreme tide	None		✓			High
King Tide 2015	extreme tide			✓			High
King Tide 2016	extreme tide	None		✓			High

Photo Credit: Kimberly Reed (1/10/13)

Photo Credit: Kimberly Reed (12/27/12)

B. Projected Future Conditions (1.5 pages)

Studies published in the last five years, including the U.S. Global Change Research Project, 2014 National Climate Assessment, report updated trends and projections for several parameters influenced by changes in climate including sea levels, coastal storms, and precipitation. Information about New Hampshire trends and projections is summarized in sections 1-3 below.

1. Sea-Levels and Coastal Storm Surge[2]

Based on local tide gauge data, sea-level along the New Hampshire coastline has risen an average of 0.7 inches per decade since 1900. More recent reports show that the rate of sea-level rise has increased to approximately 1.3 inches per decade since 1983.

The figure at right shows the percent contribution of various factors that influence sea levels worldwide. Ocean warming and melting of land-based glaciers are the major drivers of sea-level rise.

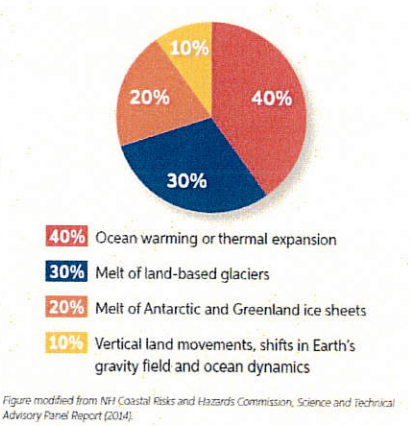


Figure modified from NH Coastal Risks and Hazards Commission, Science and Technical Advisory Panel Report (2014).

The possible sea-level rise increases at the year 2050 and 2100 published in the 2014 U.S. National Climate Assessment include a range of scenarios three of which are presented below in Table __.

Table ____. Sea-Level Rise Scenarios (in feet) provided by the National Climate Assessment using mean sea level in 1992 as a reference (Parris et al., 2012).

Time Period*	"Intermediate Low	"Intermediate High"	"Highest"
year 2050	0.6 ft.	1.3 ft.	2.0 ft.
year 2100	1.6 ft.	3.9 ft.	6.6 ft.

Among the scientific literature, there is insufficient basis to draw a specific conclusion whether storm surges will increase in the future however future storm surges will occur on top of higher sea levels. Considering changes in storm surge and high water levels due to sea-level rise alone, today's extreme surge events such as a 100-year storm will result in increased coastal flooding and expansion of the coastal floodplain over time.

2. Precipitation[3]

Recent studies show the mean annual precipitation in the Northeast has increased by approximately 5 inches or more than 10 %, from 1895 and 2011, and has experienced a greater than 50 % increase in annual precipitation from storms classified as extreme events (100-year/1% annual chance or greater event). In 2014, the Northeast Regional Climate Center (NRCC) Extreme Precipitation Atlas was published, improving the accuracy of rainfall data for a range of storm events applied to engineering and science research. The NRCC atlas is the new standard used by the NH Department

[2] Matt Huber, Kevin Knuuti, Mary Stampone, Sea-level Rise, Storm Surges, and Extreme Precipitation in Coastal New Hampshire: Analysis of Past and Projected Future Trends (2015), Prepared by Science and Technical Advisory Panel for the New Hampshire Coastal Risks and Hazards Commission.

[3] Ibid

of Environmental Services, Alteration of Terrain Bureau for the design of stormwater management systems in permitting development projects.

Prior to release of the NRCC 2014 atlas, engineers and researchers used National Weather Service Technical Paper 40 (TP-40) precipitation atlas based on data from the 1960's. Comparing rainfall data from the Technical Paper No. 40 (TP40) atlas (1961) and the NRCC Extreme Precipitation Atlas in Table ___, rainfall for extreme events (50-year and 100-year storms) has increased 25 percent and 35 percent respectively in Rye.

Table ___. Data for a range of 24-hour rainfall events (TP40, 1961 and NRCC, 2014).

	24-hour Rainfall Event					
Source	**1 year**	**2 year**	**10 year**	**25 year**	**50 year**	**100 year**
TP40*	2.6	3.1	4.4	5.2	5.8	6.5
NRCC	2.6	3.2	4.8	6.1	7.3	8.8

* TP40 was the previous standard used by the NH Department of Environmental Services, Alteration of Terrain Bureau.

Projected increases in annual precipitation are uncertain but could be as high as 20 % in the period 2071-2099 compared to 1970-1999. Most of the increases may occur in winter and spring with less increase in the fall and perhaps none in the summer. Extreme precipitation is also projected to increase with the occurrence of extreme rainfall events during summer and fall influenced by changes in tropical storm activity as the rainfall amounts produced by tropical storms is projected to increase. In general, total annual precipitation is expected to increase as is extreme precipitation.

3. Temperature

In the last century, annual and seasonal temperatures have warmed by almost 2°F and lake ice-out dates are occurring earlier. Regional climate assessments report expected changes in seasonal temperatures:

- Warmer winters with 20-50 fewer days per year below 32°F.
- Hotter summers with 3-7 additional days per year above 90°F (compared to about 10 days per year during the period 1970-1999).[4]

X.4 Future Impacts to Coastal Areas (2 pages)

The Rockingham Planning Commission completed an assessment of impacts from sea-level rise and coastal storm surge flooding. The Tides to Storms Coastal Vulnerability Assessment (2015) applied the three sea-level rise scenarios at 2100 reported in Table __ to evaluate the risk and sensitivity of roadways, infrastructure and natural resources to sea-level rise and storm related flooding. The assessment produced statistical data and mapping as part of a regional report and a customized assessment report for Rye. Assessment data for Rye is reported below in section A.

[4] 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. http://www.climatesolutionsne.org/

A. Tides to Storms Coastal Vulnerability Assessment[5]

This section and Table ___ below summarizes impacts to road and transportation infrastructure, critical facilities, and natural resources from future sea-level rise and storm related flooding. These types of flooding are limited to the immediate coastal area where tidally influenced river systems and extensive saltmarsh are present.

Table ____. Summary of Tides to Storms assessment data.

Sea-Level Rise (SLR) Scenarios	SLR 1.7 feet	SLR 4.0 feet	SLR 6.3 feet	SLR 1.7 feet + storm surge	SLR 4.0 feet + storm surge	SLR 6.3 feet + storm surge
Infrastructure (# of sites)	24	50	66	65	75	83
Critical Facilities (# of sites)	0	2	2	2	4	7
Roadways (miles)	0.2	4.5	9.5	9.9	14.2	17.1
Upland (acres)	567.7	945.8	1,223.7	1,200.6	1,465.9	1,690.6
Freshwater Wetlands (acres)	66.7	198.6	250.2	239.0	280.1	308.7
Tidal Wetlands (acres)	463.8	509.2	519.8	524.9	527.6	528.6
Conserved and Public Lands (acres)	309.0	436.2	501.0	495.7	544.3	588.3
100-year floodplain (acres)	1,227.6	1,603.9	1,707.9	1,721.7	1,786.4	1,808.1
500-year floodplain (acres)	1,228.6	1,609.1	1,763.7	1,777.1	1,842.3	1,864.1

Note: Storm surge refers to the 100-year floodplain as depicted on the FEMA Flood Insurance Rate Maps (2015, preliminary). Upland refers to land above mean higher high water (highest tidal extent). 500-year floodplain impacts were calculated using the full extent of the 500-year floodplain which includes areas within the 100-year floodplain.

Because most of the immediate coastal area is densely developed, flood impacts to buildings, infrastructure and roads are widespread. The nature and extent of these flood impacts are briefly summarized below.

- Roads and Transportation Infrastructure: impacts include state and municipal culverts, five bridges, Rye Harbor, and evacuation routes in Rye and connections to emergency routes in adjacent municipalities; and moderate flooding (less than 2 feet) can create isolated residential neighborhoods at Straws Point, Winslow Way and Fairhill.
- Critical Facilities: few critical facilities are impacted by projected sea-level rise and coastal storm surge flooding, with the exception of a sewage pump station.
- Natural Resources: the state and private property owners have conserved or hold easements on significant acreage within the coastal area, and considerable potential exists for inland tidal marsh migration and conversion of freshwater wetlands to tidal systems.

Refer to the Transportation, Land Use and Natural Resources Chapters for more detailed information about impacts from sea-level rise and storm related flooding.

[5] Tides to Storms Coastal Vulnerability Assessment (2015) prepared by Rockingham Planning Commission.

X.5 Other Climate-Related Impacts (2 pages)

A. Water Resources

Rising groundwater levels due to changes in sea level and saltwater intrusion may also impact water resources including local aquifers and drinking water sources (municipal, private and commercial supplies).

Rising groundwater levels and increased precipitation could compromise the function of individual septic systems and both private and municipal stormwater management infrastructure. These system failures may result in increased transfer of pollutants to groundwater, surface waters, wetlands and estuarine systems.

* Insert Map of areas serviced by Aquarion and town water/sewer, and areas served by private water and sewer

B. Economy

The economic vulnerability of municipalities can be evaluated by determining the exposure of its property tax base to coastal hazards. As shown in Table ___, the Tides to Storms project (RPC, 2015) analyzed the number of tax parcels in Rye affected by each of the six sea-level rise and storm surge scenarios evaluated and shows the aggregated assessed value of these parcels. For Rye, there is a 42 percent increase in the number of affected parcels and nearly a $167 million increase in assessed value from the 1.7 feet to the 4.0 feet sea-level rise scenarios. There is a 28 percent increase in the number of affected parcels and approximately a $140 million increase in assessed value from the 4.0 feet to the 6.3 feet sea-level rise scenarios

Table ___. Parcels and assessed value by sea-level rise and storm surge scenario.

Sea-Level Rise (SLR) Scenarios	Number of Parcels Affected by scenario	Aggregate Value of Affected Parcels	Percent Total Assessed Value (town)
1.7 feet SLR	462	$344,634,500	
4.0 feet SLR	656	$511,326,300	
6.3 feet SLR	842	$651,847,100	
1.7 feet SLR + storm surge	816	$644,606,700	
4.0 feet SLR + storm surge	981	$743,644,600	
6.3 feet SLR + storm surge	1094	$809,845,700	
Total Assessed Value (town)		$	

Note: Affected parcels were identified if they were found to be partially or fully located within the extent of the scenarios evaluated; however, the extent to which a parcel and any structure or development on the parcel will be impacted by flooding was not analyzed.

A significant portion of the economy in New Hampshire's state, regional and local economies may be vulnerable to changes in climate and coastal conditions such as extreme storms and sea-level rise. New Hampshire's coastal region is an important economic driver for the state and consistently ranks above the national average for job growth. The natural resources that draw residents, visitors and businesses to coastal New Hampshire are a cornerstone of our quality of life. Residents,

visitors and businesses depend on clean water for drinking, swimming, and boating; saltmarshes and eelgrass beds are critical habitat for commercial and recreational fisheries; beaches draw hundreds of thousands of visitors that boost the state economy and tax income; and forests and lands provide materials for heating, building and construction, and farm and food products.

X.6 Future Growth and Development (2 pages)

Planning for future growth and development should consider the implications of existing and projected future coastal hazard such as areas subject to flooding and erosion. Land use decisions will largely dictate where new development and redevelopment occurs and where it will not. Sustaining the services provided by natural features such as saltmarsh, freshwater wetlands and natural shoreline processes will be an important aspect of managing coastal high risk areas into the future.

A. Growth and Development

1. Population

As reported by the U.S. Census, the population of Rye is reported as 4,612 in 1990, 5,182 in 2000, and 5,298 in 2010. The town has grown by 14.6 percent from 1990 to 2010.

2. Land Use Changes and Regulations

Impervious Surfaces

From 1990 to 2010, impervious surfaces have increased from 7.2 percent (576 acres) to 15.5 percent (1,240 acres) of the total land area in Rye. Studies show that impervious surface cover exceeding 10 percent of a of watershed can negatively affect water quality and the health and diversity of aquatic species

Non-Point Source Pollution

In most cases, non-point source pollution is produced from a wide variety of activities and environmental conditions such as soils, groundwater table, land use and development patterns, and surface water hydrology. Runoff from impervious surfaces, lawns and landscaped areas carries with it pollutants that can degrade water quality. With increased precipitation projected for the future, the delivery of such pollutants could be magnified over time.

A component of development that could be impacted by rising seas and groundwater levels are private subsurface septic disposal systems. Municipalities have the option to adopt standards for the design and siting of subsurface septic disposal systems that are stricter than state standards. Based on the Tides to Storms vulnerability assess which shows the areas of town at highest risk for flooding, more stringent standards may be warranted in the future.

Parsons Creek Watershed Study

Rye has partnered with FB Environmental to prepare a watershed study for Parsons Creek, a 2.3 square mile watershed that drains to the Atlantic Ocean. The watershed is listed on the NH Department of Environmental Services Surface Water Assessment report as impaired for primary contact recreation and fishing due to high bacteria levels. The recent study of water quality in

Parsons Creek documented that pollutants from private septic systems are entering the waterway. Over time, rising sea levels and corresponding groundwater levels could further increase pollutant discharge and may impact a greater number of septic systems in the watershed. The project includes ways to reduce pollutants through strategic implementation of best management practices (e.g. rain gardens, tree box filters, and bioretention systems), improving the town's septic system records, and delivering outreach and education programs for homeowners and municipal staff that highlight ways to improve system maintenance and improve water quality.

Shoreline Stabilization

Particular stretches of Rye's coastline are highly susceptible to damage during storm events, including the "shale piles" at Sawyers Beach and Foss Beach where large volumes of materials are deposited on Route 1A and sometimes even further inland impacting both salt marshes and freshwater wetlands west of Route 1A. The transport of sediment and materials during storm events can impacts these wetland systems by introducing pollutants.

Beach erosion could be a factor in the future, and one that would need specific management practices, such as beach nourishment, to address changes in beach stability.

3. Land and Zoning Districts Impacted by Sea-level Rise and Storm Related Flooding[6]

Upland impacted by flooding from 1.7 feet of sea-level rise is low while impacts increase markedly with 4.0 feet and 6.3 of sea-level rise. Flooding from coastal storm surge is fairly widespread high. Rye has enough increase in land elevation moving from coastal and tidal areas to protect most existing developed areas and resources from low to moderate flood levels. The most heavily impacted areas are located directly adjacent to the coast, Route 1A and developed areas adjacent to inland tidal drainage systems.

Table ___. Acres of upland impacted by sea-level rise and storm surge.

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 of Upland	567.7	945.8	1,223.7	1,200.6	1,465.9	1,690.6
% Upland	7.0	11.7	15.2	14.9	18.2	20.9

Total Upland in Rye = 8,073.5 acres. Upland refers to land above mean higher high water (highest tidal extent) and excludes wetlands.

Open space and conservation lands located in Rye's coastal area today and in the future serve as buffers to the impacts of flooding and erosion, allowing salt marsh and freshwater wetlands systems to store flood waters and migrate inland as conditions change.

As reported in Table ___, the zoning districts most heavily impacted by flooding from sea-level rise and storm surge are open space and conservations lands, and medium density residential. Rye's coastal area is predominantly developed as moderate density single-family dwellings, with many areas served by municipal water and sewer services.

[6] Tides to Storms Coastal Vulnerability Assessment, 2015 prepared by Rockingham Planning Commission

Table ___. Zoning districts (acres) impacted by sea-level rise and storm surge.

Sea-Level Rise (SLR) Scenarios	SLR 1.7 feet	SLR 4.0 feet	SLR 6.3 feet	SLR 1.7 feet + storm surge	SLR 4.0 feet + storm surge	SLR 6.3 feet + storm surge
Zoning Districts / Land Use						
Commercial	1.7	1.7	1.9	1.9	1.9	1.9
Mixed Urban	4.3	11.9	20.2	19.0	24.9	28.7
Open Space/Conservation	308.0	415.3	437.5	434.1	447.1	455.9
Residential - High Density	47.0	100.9	141.2	142.3	171.3	195.4
Residential - Med Density	251.6	465.7	675.1	655.2	873.3	1,061.9

4. 100-year Floodplain and Flood Insurance

Approximately _____ parcels and ____ buildings are located within the current 100-year coastal floodplain. As of 2015, 309 property owners hold policies with the National Flood Insurance Program (NFIP) with an insured value of $79.1 million. Fifteen of these properties have experienced repetitive loss or damage (meaning properties that have had two or more claims of more than $1,000 paid by the NFIP within any 10-year period since 1978).

Table ___. Statistics of National Flood Insurance Program policies held in Rye.

# of Policies	Insurance $ In Force	Total # Paid Losses	Total $ Paid	Repetitive Loss Buildings	Repetitive Loss Payment $
309	$79,131,800	255	$1,709,579	15	$584,940

With expected increases in sea levels and extreme storm events, the 100-year and 500-year floodplains are likely to expand in size which will result in more parcels and buildings subject to flood impacts. Conducting outreach to currently and future affected property owners would be extremely helpful in informing them of potential risks and providing information they can use to make decisions about their property and investments.

Currently, Rye is underway with preparation of an application to FEMA's Community Rating System, a voluntary incentive based program designed to reduce property owner flood insurance premiums in exchange for actions that reduce risk and vulnerability within the community.

Floodplain Standards for Development

The town has adopted the Floodplain Development and Building Ordinance which contains the minimum floodplain management standards required by FEMA for eligibility in the National Flood Insurance Program. FEMA encourages municipalities to adopt more stringent standards such as requiring that buildings be elevated (1 foot or more) above the 100-year base flood elevation to reduce impacts from flooding and storm damage.

B. Municipal Services

* Describe demand, need and funding challenges for critical services, particularly during emergencies and storm events.

* Describe maintenance requirements for water and sewer infrastructure, and possible expansion of these systems in high risk flood areas where drinking water wells and septic systems might fail.

* Are additional long-range planning efforts needed to ensure critical services address coastal hazards?

C. Emissions and Energy Use

Climate change mitigation refers to the reduction of greenhouse gas (GHG) emissions through reduction in burning of fossil fuels, energy efficiency and conservation, use of renewable and alternative energy sources, and CO_2 and carbon capture and storage in living plants.

In recent years, the number of residential solar panel installations appears to be on the rise. This may be due to an increase in the number of solar energy companies operating in the seacoast and innovative financing mechanisms that allow for little or no up-front costs and incremental repayment following installation. ? Can the Rye Energy Committee provide more information?

Many factors influence transportation emissions including land development patterns, land cover conversion, individual preferences and behavior, convenience, and fuel pricing. Nationwide, the transportation sector contributes roughly 28 percent of the total greenhouse gas emissions each year. As of 2012, the transportation sector alone accounts for 43 percent of greenhouse gas emissions in New Hampshire, making it the largest single contributor at rates significantly higher than the national average.[7]

X.7 Community Adaptation and Resilience (2 pages)

A. Ways of Adapting and Being Resilient

Incorporating the latest flood trends and future projections into municipal planning and projects will minimize vulnerability and prove beneficial even if future hazards turn out to be less extreme than anticipated. ***Adapting*** to changing conditions means designing buildings and facilities that account for flooding or modifying uses of land that are compatible under a wide range of conditions. The process of adapting creates buildings and systems that are more ***resilient*** and better able to perform with fewer impacts.

> ***Adaptation*** – *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]*
>
> ***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]*

[7] NH Department of Environmental Services

1. Infrastructure and Building Guidelines

Increased precipitation and sea-level rise will produce more inland runoff and localized flooding in addition to coastal flooding. Experts recommend that for floodplain and coastal locations, where there is little tolerance for risk (e.g. costly to repair or serves a critical function), that the following guidelines be used in the siting and construction of infrastructure and facilities.[8]

- The range of sea-level rise scenarios from the Intermediate High to the Highest (Table ____) be applied as follows:
  Determine the time period over which the system is designed to serve (either in the range 2014 to 2050, or 2051 to 2100).
  Commit to manage to the Intermediate High condition, but be **prepared** to manage and adapt to the Highest condition if necessary.
  Be **aware** that the projected sea-level rise ranges may change and adjust if necessary.
- Development projects continue to use the present frequency distributions for storm surge heights and these be added to projected ranges for sea-level rise. The flood extent of the current 100-year storm surge will increase as sea level rises, and the 100-year floodplain will be flooded more frequently by smaller surges as sea level rises.
- At a minimum, infrastructure is designed using precipitation data from the current Northeast Regional Climate Center (Cornell) atlas and infrastructure be designed to manage a 15 % increase in extreme precipitation events after 2050. Infrastructure design should incorporate new precipitation data as it is published or updated.

B. Town Actions to Address Coastal Hazards

Preparing for Climate Change

In 2013, the Planning Department received assistance to implement the community based initiative *Preparing for Climate Change*. Partnering with the Rockingham Planning Commission, NH Sea Grant and UNH Cooperative Extension, a series of community workshops were held to introduce residents to climate change science and potential flood hazard information, and to gather public input about actions the town may consider to address coastal hazards.

Tides to Storms Vulnerability Assessment

In 2015, town staff participated in the *Tides to Storms Vulnerability Assessment* project with the Rockingham Planning Commission. Through a series of meetings, maps and statistical information about impacts to roadways, critical infrastructure and natural resources was evaluated. Staff provided their perspectives on critical issues facing the town and drafted recommendations to address current and future flood hazards which were included in a final report and map set for the town. Information from these maps and report are being incorporated into the 2016 update of the town's Natural Hazards Mitigation Plan and in this chapter.

[8] Matt Huber, Kevin Knuuti, Mary Stampone, Sea-level Rise, Storm Surges, and Extreme Precipitation in Coastal New Hampshire: Analysis of Past and Projected Future Trends (2015), Prepared by Science and Technical Advisory Panel for the New Hampshire Coastal Risks and Hazards Commission.

Not a lot of data or local information exists about what residents and businesses have done or are doing to accommodate and adapt to coastal hazards and climate change. However, many residents have installed generators to supply electricity in the event of power outages.

C. Planning for Public Safety

Municipal Response

This section will describe flood and storm related impacts within the community including how the town responds to storm and flood events, and describes community needs during such events.

1. Hazard Mitigation Plan

FEMA requires that municipalities maintain an updated and approved Hazard Mitigation Plan in order to qualify for federal disaster relief, grant funding, and participation in the National Flood Insurance Program. The Plan documents the town's exposure to past, current and future natural hazards, and recommends specific actions to reduce risk from these hazards. Rye's 2009 Hazard Mitigation Plan includes the following recommendations that address coastal hazards:

- Adopt controls on the release of water from Eel Pond, Burke Pond, Brown Pond, and Love Lane
- Update the 1998 Drainage Analysis Plan
- Review Building Code to insure adequate compliance with wind speed standards for construction
- Acquire grant funds to purchase or elevate repetitive loss properties

The town is currently in the process of updating its Hazard Mitigation Plan and will incorporate information from the Tides to Storms Coastal Vulnerability Assessment including maps, statistics of future impacts, and recommended adaptation strategies to reduce risk and vulnerability of municipal assets and resources.

2. Emergency Response Plan

The Emergency Response Plan is maintained by Rye's Emergency Management Director and Assistant Director. The Plan provides a comprehensive set of protocols that are activated in the event of an emergency, natural disaster or other situation that poses a threat to public safety.

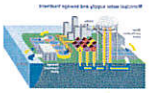
The Emergency Management webpage on the town's website also provides preparedness information including the publications *Storm Preparedness* and *How to Prepare for a Hurricane*.

D. Issues of Significance

Based on the Tides to Storms Vulnerability Assessment results and local knowledge of coastal hazards, the following are identified as issues of local and regional significance that should be addressed in future policy, planning, regulatory and non-regulatory initiatives by the town and the community.

Protect municipal and state roads, bridges, culverts, and drainage lines.

Sustain drinking water supplies, sources and infrastructure.



Maintain function of wastewater services and infrastructure.

Dedicate funds for infrastructure improvements.

Control flooding and protect natural resources with sound land use and development standards.

Increase preparedness and raise awareness of coastal hazards in the community.

X.8 Recommendations (2 pages)

Municipal Actions

Following are recommended actions to protect the community against impacts from coastal hazards including flooding from sea-level rise, storm surge and extreme precipitation:

RM1 Update comprehensive evacuation plans (e.g. maps of vulnerable areas, methods to deliver warnings and announcements and when most appropriate, outreach to affected property owners as needed).

RM2 Enhance emergency management plan to address coastal hazards and adaptation.

RM3 Update emergency preparedness plans, master plans and regulations for the Rye Water District and Rye Sewer District.

RM4 Incorporate infrastructure assessments and improvements in the Capital Improvement Plan. The following departments will act as lead for:

- Stormwater Management - Public Works
- Roads and Transportation Infrastructure - Public Works
- Wastewater Services - Rye Beach Sewer District
- Drinking Water Services - Rye Beach Water District

RM5 Revise building codes to enable adaptive construction techniques and designs.

RM6 Begin discussions with elected officials, planning board and zoning board of adjustment about long term land use and zoning options in high risk areas.

RM7 Track cumulative improvements to structures in the Special Flood Hazard Area designed on the FEMA Flood Insurance Rate Maps.

RM8 Prepare an inventory of private wells.

RM9 Revise land conservation priorities to incorporate criteria in the selection process to consider the value and benefits of protecting critical ecosystems and flood storage areas, and increasing land protection efforts in areas of high flood risk in the future.

Local, Regional and State Coordination

The following are recommended actions that require coordination to achieve consistency and efficiency at the local, regional and state levels.

RC1 Improve management of coastal shoreline protection structures and natural features (e.g. shale piles, sea walls, beaches, wetlands and marshes).

RC2 Evaluate funding options for shoreline management and protection projects.

RC3 Coordinate with the state, state agencies and coastal municipalities to manage coastal lands and resources to adapt to future conditions.

Community Preparedness and Awareness

Following are recommended actions to protect community preparedness and awareness of impacts from coastal hazards including flooding from sea-level rise, storm surge and extreme precipitation:

RPA1 Provide information to property owners and businesses about the benefits of (voluntarily) elevating structures above the current base flood elevation.

RPA 2 Conduct outreach to current and future affected property owners about potential flood risks to inform decisions about their property and investments.

RPA3 Provide an informational table or booth at public and community events.

RPA4 Schedule a twice-yearly "movie night" at the library or other public venue featuring topics relating to coastal hazards and preparedness and adaptation.

RPA5 Provide information through outreach to residents and businesses about alternative approaches, reducing risk and lowering insurance premiums with adaptation.

RPA6 Provide information through outreach to residents and businesses about the benefits of living shorelines.

RPA7 Implement the FEMA High Water Mark Initiative to illustrate future water levels associated with the 100-year storm surge and projected sea-level rise.

Note: An Executive Summary and Implementation Matrix will be prepared as a companion document to this chapter.

Note: The following expanded text will be added to the appropriate chapter updates.

Roads and Transportation Infrastructure

Mapping shows that state and municipal culverts and five bridges are affected by projected sea-level rise and coastal storm surge flooding in Rye. The majority of impacted culverts are state owned supporting Route 1A and Route 1B. Rye Harbor is also impacted by the 4.0 feet and 6.3 feet sea-level rise scenarios and all coastal storm surge scenarios. Many bridges, which by definition can also include large culverts, are located in areas susceptible to flooding under current seasonal high tide conditions and coastal storm surge. Even the lowest levels of projected sea-level rise may cause bridges and particularly their low-lying roadway approaches to flood. Another concern for both culverts and bridges is the introduction of tidal flood waters to freshwater drainage systems not designed to accommodate bi-directional tidal flow conditions.

Rye's local roads are more greatly affected by projected flooding than state roads at the 1.7 feet and 4.0 feet sea-level rise scenarios. The state and local road miles affected by the higher sea-level rise and three storm surge scenarios are nearly equal. At the 6.3 feet sea-level rise scenario and all three storm surge scenarios the majority of Route 1A in Rye is affected by flooding.

The municipal roads impacted, many of which connect to Route 1A, greatly affect the functionality of designated emergency evacuation routes in Rye and connections to emergency routes in adjacent municipalities. Rye recognizes the need for improved evacuation planning, particularly early notification to certain neighborhoods that may become isolated by flooding at early stages of a storm event, and installation of signage to mark evacuation routes in town. Even moderate roadway flooding can create isolated residential neighborhoods at Straws Point, Winslow Way and Fairhill.

Many of Rye's roadway improvement projects have required multi-jurisdictional approval (NH DES, USACE) whereby the town has opted to replace culverts "where is, as is" rather than upgrading or redesigning them to avoid a costly and lengthy approval process. Some upgrades to culverts and roads have been difficult due to the need for expansion on private land to accommodate a new design.

Critical Facilities

Rye has few critical facilities that are impacted by projected sea-level rise and coastal storm surge flooding. One sewage pump station and Jenness Beach State Park are affected by the 4.0 feet and 6.3 feet sea-level rise and the three coastal storm surge scenarios. Wallis Sands State Park is affected by the 4.0 feet plus storm surge scenario and 6.3 feet plus storm surge scenario. Rye Harbor State Park, Odiorne State Park and St. Andrews by the Sea are affected by the 6.3 feet SLR plus storm surge scenario.

Natural Resources

Natural resources provide important benefits to most everyone who lives, works or owns property in the coastal region. Natural coastal features such as forests, freshwater wetlands, salt marsh, sand beaches, and rocky shoreline provide protection against erosion and storm surge, and provide flood

storage for both tidal flooding and stormwater runoff. Maintaining these benefits is critical to the community economy, health, and safety. Yet, as our resource base is impacted by extreme precipitation, coastal flooding, sea-level rise and other climate impacts, the physical and biological character of our coastal lands is expected to change. Coastal natural resources like salt marshes and near shore ecosystems may be particularly affected due to their close proximity to various components of the build landscape such as roads, drainage infrastructure, buildings and utilities. Future decisions about how best to manage infrastructure and the built landscape may require trade-offs between public benefits and natural resource protection as both compete for space to adapt to changing conditions.

Combined the town, the state and private property owners have conserved or hold easements on significant acreage within Rye's coastal area. Retaining these lands in a natural undeveloped state helps to reduce the town's risk and vulnerability to projected sea-level rise and coastal storm flooding.

There is considerable potential in Rye for inland tidal marsh migration and conversion of freshwater wetlands to tidal systems. [Refer to the Tides to Storms report for a detailed description of project saltmarsh conditions from the Sea Level Affecting Marshes Model results from NH Fish & Game.] Significant acreage within the Coastal Conservation Plan priority lands and Wildlife Action Plan critical habitat areas may be affected by projected sea-level rise. Refer to the new Climate Change section of the Wildlife Action Plan for information about potential impacts to critical habitats and resources (http://www.wildlife.state.nh.us/wildlife/wap.html).

The town may consider revising its land conservation priorities to incorporate criteria in its selection process that takes into account the value and benefits of protecting critical ecosystems and flood storage areas, and increasing its efforts in areas projected to have high flood risk in the future.

Human Health (natural resources chapter)

Climate change affects human health and well-being in many ways, including impacts from increased extreme weather events, rising temperatures in both cold and warms months, wildfire, decreased air quality, threats to mental health, and illnesses transmitted by food, water, and disease-carriers such as mosquitoes and ticks. Increasing exposure to environmental pollutants and atmospheric emissions in recent decades has caused concern over its effect on public health, environmental ecosystems and climate worldwide.[9] Human health impacts are intensified with increasing levels of exposure which are likely to worsen with climate variability and change.[10]

Air pollution (ozone, pollen, mold, dust) and heat exposure have a range of mild to severe health effects and can aggravate chronic diseases, including cardiovascular and respiratory diseases, and respiratory conditions such as asthma.

---

[9] *Center for Disease Control and Prevention: Climate and Health*. (n.d.). Retrieved from http://www.cdc.gov/climateandhealth/effects/allergens.htm.

[10] Melillo, J., Richmond, T., & Yohe, G. (2013). *Climate Change Impacts in the United States: Human Health Chapter.* U.S. Global Change Research Project.

According to the Centers for Disease Control and Prevention, New Hampshire and specifically Rockingham County have one of the highest occurrences of Lyme Disease in the country and among the New England states. Climate change may increase the presence of ticks and Lyme disease with warmers winters which allow ticks to persist year round and increases in the population of its host species (mice, deer). Other diseases carried by insects may increase with increasing insect populations and increased geographic ranges of certain insect species.