TOWN OF RYE, LONG RANGE PLANNING COMMITTEE – 2016 MASTER PLAN UPDATE SCHEDULE

Draft Preparing for Climate Change Chapter

DRAFTING THE CHAPTER

Late January – Prepare chapter outline
Mid February – review and edit draft content
Early March – Finalize recommendations
Mid March – distribute draft chapter to municipal staff, boards, commissions

MUNICIPAL AND PUBLIC OUTREACH IN APRIL

- Present draft chapter to municipal staff, Planning Board, ZBA and Conservation Commission for review and comment
- **Convene public workshop for input on draft chapter**
- Revise draft chapter to incorporate input

EARLY MAY >>>> Convene a public workshop for input on chapter topics – land use, natural resources, transportation

Land Use, Natural Resources, Transportation Chapters

DRAFTING THE CHAPTERS

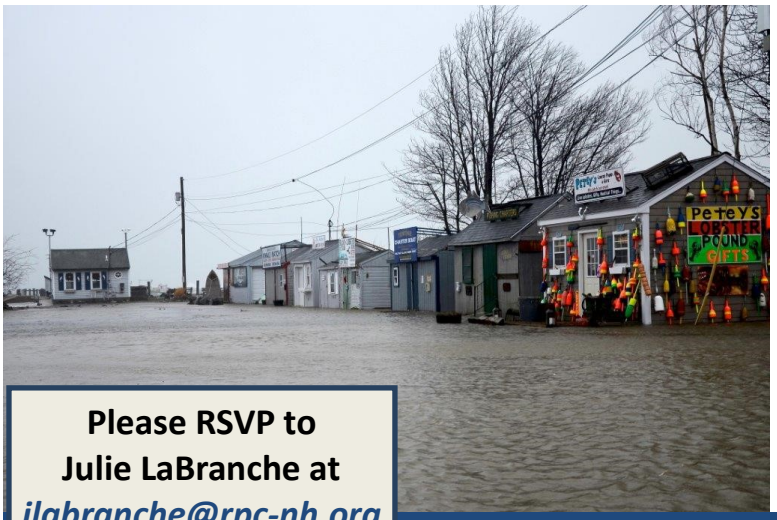
February to March – RPC reviews and makes suggested edits/updates to all 3 chapters, provides to LRP
When drafted, each chapter will be provided/presented to the planning board for review and comment
May – RPC and LRP edit, update and review new content for Land Use Chapter (2 meetings)
June – RPC and LRP edit, update and review new content for Natural Resources Chapter (2 meetings)
July – RPC and LRP edit, update and review new content for Transportation Chapter (2 meetings)
Early August – final edits to all 3 chapters; publish final draft chapters for public hearing

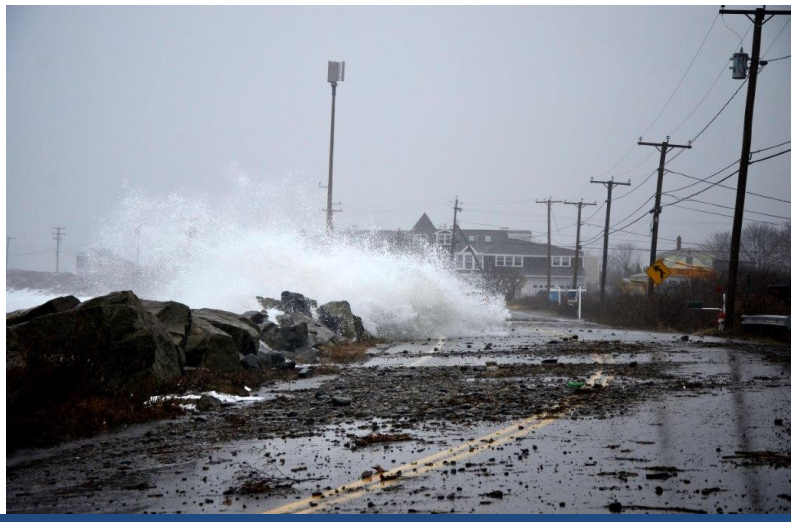
Finalize Preparing for Climate Change Chapter

FINALIZE THE CHAPTER

By Late August – finalize Chapter, adding any additional recommendations from the Land Use, Natural Resources and Transportation Chapters

EARLY SEPTEMBER >>>> Hold public hearing for adoption of updated master plan chapters





Please RSVP to Julie LaBranche at *jlabranche@rpc-nh.org* or (603) 778-0885.

MASTER PLAN - PUBLIC PARTICIPATION FORUM

Town of Rye

MASTER PLAN UPDATE

With technical assistance from the Rockingham Planning Commission, the Rye Planning Board is preparing a new Coastal Hazards and Adaptation Chapter for the Master Plan, and updating the existing Land Use, Natural Resources and Transportation Chapters.

CONTACTS

For more information about the Rye Master Plan Project, contact:

Kimberly Reed
Town of Rye, Planning & Zoning Administrator
kreed@town.rye.nh.us

Julie LaBranche
Rockingham Planning Commission
jlabranche@rpc-nh.org
(603) 778-0885

Thursday May 12, 2016

6:30-8:30 pm

Rye Junior High School

501 Washington Road

Share your ideas and opinions about how to prepare your town for coastal hazards.

Who Should Attend?

- ⇒ Residents, Businesses and Property Owners
- ⇒ Municipal Elected Officials and Department Heads
- ⇒ Land Use Boards and Conservation Commissions
- ⇒ Emergency Management Personnel

Meeting Agenda

- ⇒ Introduction to the Master Plan Project
- ⇒ Overview of ***draft*** Coastal Hazards and Adaptation Chapter
- ⇒ Public Input—breakout group discussions
- ⇒ Questions, Discussion
- ⇒ Review of Master Plan Update Timeline

TOWN OF RYE, N.H. SETTLED 1623 PARISH OF RYE 1726 INCORPORATED 1785

ROCKINGHAM PLANNING COMMISSION

NROC Northeast Regional Ocean Council

The Rye Master Plan project is funded by a grant from the Northeast Region Ocean Council.

Please RSVP to Julie LaBranche at *jlabranche@rpc-nh.org* or (603) 778-0885.
Walk-ins Welcome!

MASTER PLAN—
PUBLIC PARTICIPATION FORUM

Town of Rye
MASTER PLAN UPDATE

With technical assistance from the Rockingham Planning Commission, the Rye Planning Board is preparing a new Coastal Hazards and Adaptation Chapter for the Master Plan, and updating the existing Land Use, Natural Resources and Transportation Chapters.

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(603) 778-0885

Wednesday, June 22, 2016
6:30-8:30 pm
Rye Junior High School

Share your ideas and opinions as part of the Master Plan update Process.

Who Should Attend?

- ⇒ Residents, Businesses and Property Owners
- ⇒ Municipal Elected Officials and Department Heads
- ⇒ Land Use Boards and Conservation Commissions
- ⇒ Emergency Management Personnel

Meeting Agenda

- ⇒ Introduction to the Master Plan Project
- ⇒ **Review of coastal hazards in the Transportation, Land Use and Natural Resources Chapters**
- ⇒ Public Input—breakout group discussions
- ⇒ Questions, Discussion

The Rye Master Plan project is funded by a grant from the Northeast Region Ocean Council.

Chapter 3. Coastal Hazards and Climate Adaptation[1]

3.1 Introduction

Like other coastal municipalities in New Hampshire, Rye is confronted by a challenging set of concerns relating to coastal hazards and climate change that include exposure to storms, coastal erosion and flooding, damage to critical infrastructure, and impacts to key coastal resources. 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

Figure 1. Storm damage on Route 1A. [Photo Credit: Kimberly Reed (1/10/13)]

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.

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

3.2 Vision

Vision Statement

Proactive strategies are identified and implemented that address the impacts of coastal hazards, and ensure the community is better prepared to protect the security, health and safety of its citizens, provide for a stable and viable economic future, and create a more sustainable and climate resilient community.

The town's primary goals relating to coastal hazards and climate adaptation are to:

- 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.

Summary of Public Input – Issues and Concerns

The Planning Board sponsored two public informational workshops on May 12 and June22, 2016 to gain public input on the draft recommendations for this Chapter. Below is a summary of key issues and concerns raised most frequently during these workshops which are also reflected in the primary goals stated above.

Impacts and Flood Risk	Municipal Actions	Resource Protection & Public Safety	Regulations
Consider economic implications of impacts	Support future investment, transparency of funds	Keep saltmarshes healthy and functioning to protect life and property	Be proactive, address development in high risk areas
Sea-level rise and rising groundwater impacts to septic system function	Clarity about municipal roles and responsibilities	Protect drinking water	Manage stormwater and flooding from precipitation
Consider short, medium and long term timeframes for action	Improve communications systems for emergency response	Coordinate with the state on road improvements	Comprehensive action plan to address climate impacts and adaptation strategies
Need plans to adapt roads and its infrastructure	Consider expansion of public sewer services	Foster community coordination during emergencies	Consistency, better oversight, strengthen standards

3.3 Present and Future Coastal Hazards

A. Past and Present Coastal Hazards

A wide range of coastal storms have effected Rye in the past including extreme rainfall events, Nor'Easters, hurricanes, and tropical storms. Table 1 presents a summary of coastal storms that have produced widespread flooding and erosion along Rye's coastline from _____ to the present. Parts of town have sustained significant damage from these storms events, particularly the shale piles at Sawyers Beach and low-lying segments of Route 1A.

Table 1. 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

The severity of flood events depends upon several factors and different types of storm events. A 100-year/1% chance precipitation event is based on the volume of rainfall (in inches) within a 24-hour period. A 100-year/1% chance coastal storm event is based on storm surge elevation which is influenced by tide stage, wind (direction, speed and duration), and seasonal astronomical cycles

Today, extreme precipitation and coastal storm events are the most immediate risk and threat resulting in flooding and property damage, while sea-level rise poses a more long-term risk of increased daily tidal flooding.

The New Hampshire seacoast has experienced many significant storm events in the last 50 years including extreme precipitation, Nor' Easters, and storm surge. In recent years the New Hampshire seacoast has narrowly escaped two major storm events – Hurricane Irene and Super Storm Sandy. The likelihood of such storms reaching our area, with surges of 12 or more feet, has become an increasing concern as heavily developed coastal areas are at high risk of flood impacts (as documented in the Tides to Storms report, 2015).

Figure 2. Selectman Aldrich Mitchell inspecting damage to Route 1A following the Blizzard of '78. [Photo Credit: Selectwoman Priscilla Jenness]

B. Projected Future Conditions

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.

Figure 3 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.

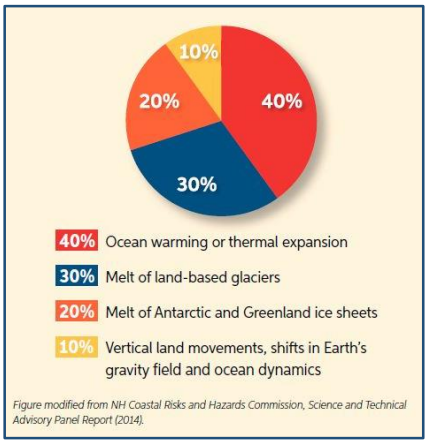


Figure 3. Percent contribution of factors that contribute to sea-level rise.

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 2.

[2] Paul Kirshen, Cameron Wake, 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.

Table 2. 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.

Note: Sea-level rise and storm surge are measured from Mean Higher High Water (the water elevation based on the average of the highest tides over a 19-year period). In Seacoast New Hampshire Mean Higher High Water is 4.4 feet. Storm surge is the area flooded by the current 100-year/1% chance storm event.

Storm Surge

Based on the FEMA Flood Insurance Rate Maps (2014, preliminary), the storm surge elevation associated with the 100-year or 1% chance storm event in Rye is _____ feet in the AE zone (tidal shoreline areas) and _____ feet in the VE zone (immediate coastal areas).

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 of Environmental Services, Alteration of Terrain Bureau for the design of stormwater management systems in permitting development projects. Figure 3 shows that the frequency of extreme precipitation events (greater 4 inches in a 24-hour period) has also increased significantly since 1990 compared with the period from 1950-1990.

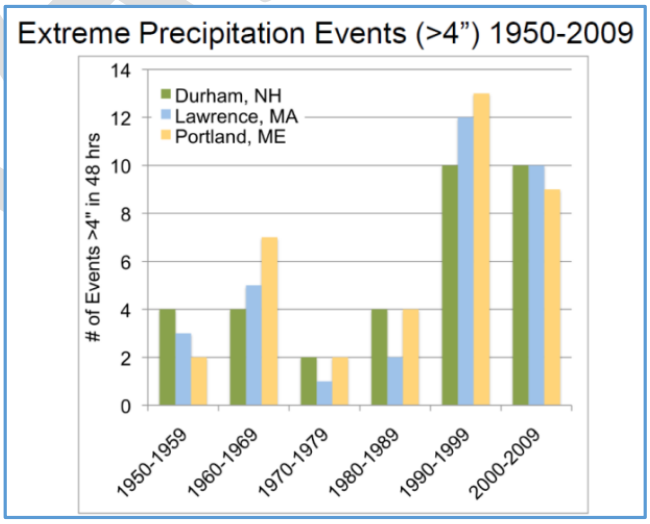


Figure 4. Total number of events with greater than four inches of precipitation in 48 hours per decade since 1950.[3]

[3] Paul Kirshen, Cameron Wake, 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.

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 3, rainfall for extreme events (50-year and 100-year storms) has increased 25 percent and 35 percent respectively in Rye.

Table 3. 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]

3.4 Future Impacts to Coastal Areas

The Rockingham Planning Commission (RPC) completed an assessment of impacts from sea-level rise and coastal storm surge flooding. The Tides to Storms Coastal Vulnerability Assessment (2015) evaluated flood impacts of six sea-level rise and storm surge scenarios at 2100 to identify the risk and sensitivity of roadways, infrastructure and natural resources to sea-level rise and storm related flooding. The Vulnerability Assessment data for Rye is reported below in section A. The Tides to Storms Vulnerability Assessment includes the following resources for Rye:

- A town Vulnerability Assessment Report detailing statistics and narrative descriptions of impacts to roads and their supporting infrastructure, critical facilities and services, and natural resources for each flood scenario.

[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 map set which displays where roads and their supporting infrastructure, critical facilities and services, and natural resources are impacted by each flood scenario.

These materials are available on the RPC website at http://www.rpc-nh.org/regional-community-planning/climate-change/resources.

A. Tides to Storms Coastal Vulnerability Assessment[5]

This section and Table 4 below summarizes impacts to road and transportation infrastructure, critical facilities, and natural resources from future sea-level rise and storm related flooding from the Tides to Storms Vulnerability Assessment. Most flooding is limited to the immediate coastal area where tidally influenced river systems and extensive saltmarsh are present. Refer to the Tides to Storms sea-level rise and storm surge maps in Figures 5 and 6 on the following page.

Table 4. 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.

Figure 5. Extent of flooding from sea-level rise.

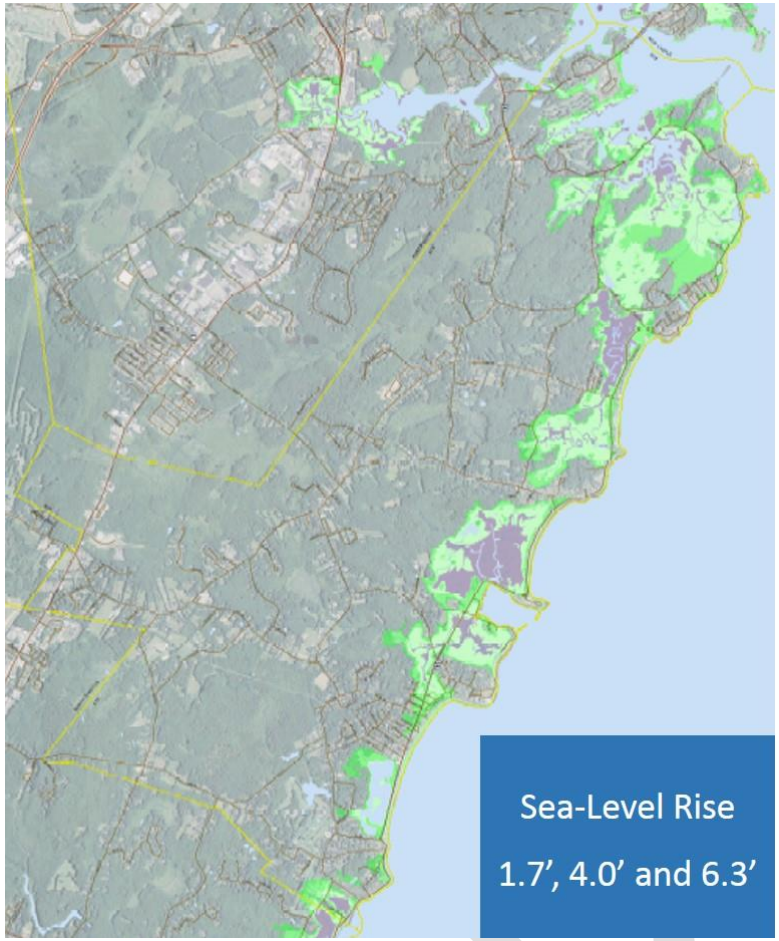
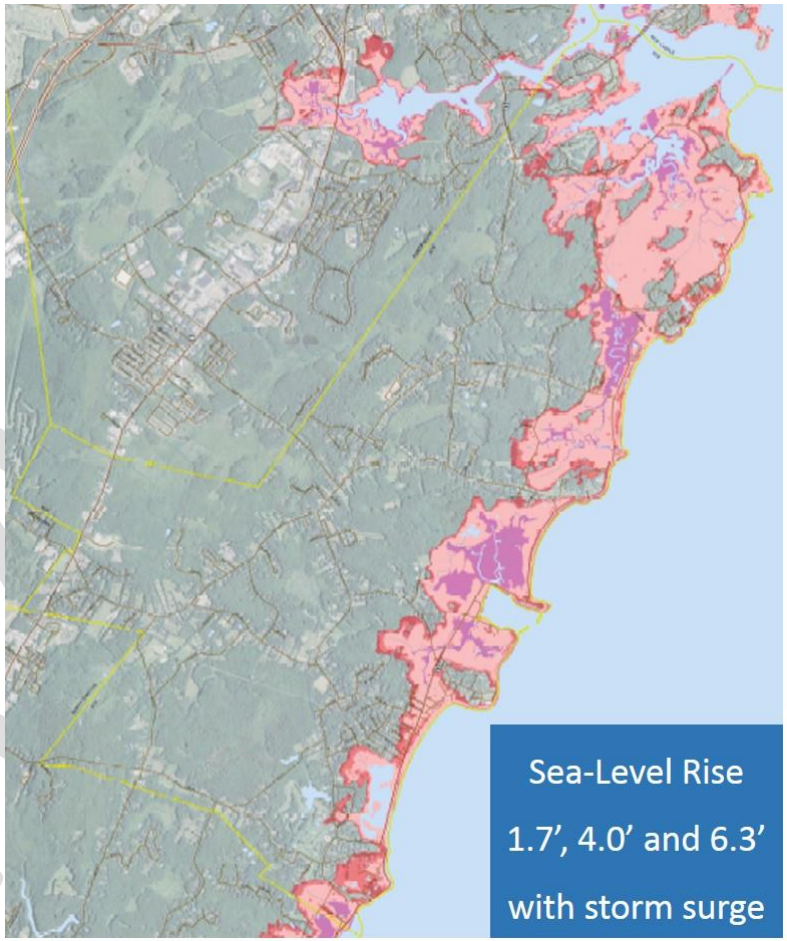


Figure 6. Extent of flooding from sea-level rise plus storm surge.



Source: Tides to Storms Vulnerability Assessment (2015)
Notes: Storm surge = 100-year /1% chance flood. Green and pink color schemes are arranged from lightest to darkest with increasing flood extent.

3.5 Other Climate-Related Impacts

A. Water Resources

The primary drinking water sources in Rye are private wells and areas serviced by the Aquarion Water Company. In 2008 (as revised in 2014 and 2015), the town adopted more stringent water quality standards in the form of an Aquifer and Wellhead Protection District to improve protection of the town's existing and future public drinking water supplies. 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). Emerging research from the University of New Hampshire indicates that groundwater levels and salt water intrusion could cause effects further inland than the immediate coast. For this reason, coastal municipalities are encouraged to collaborate on planning for future regional and municipal drinking water needs.

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.

Figure 7. 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 5, 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 5. 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.

3.6 Future Growth and Development

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. Referring back to Figure 5, the amount of precipitation associated with 50-year to 100-year or greater storms events has increased in the last 40 years resulting in more frequent flooding and failure of older infrastructure not designed to manage this increased runoff volume. Over the last several years, the Rye Planning Board and residents have been increasing concerned about flooding related to increased impervious cover. The Planning Board has discussed ways to reduce the risks and impacts of flooding as the town continues to grow particularly in the along the Route 1A corridor.

Studies show that impervious surface cover exceeding 10 percent of a watershed can negatively affect water quality and the health and diversity of aquatic species. Locally, pollutants discharged in stormwater runoff routinely result in degraded water quality particularly in the tidal creeks that have large contributing drainages areas that collect stormwater from upland areas.

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 contains pollutants that can degrade water quality. The changes in precipitation documented in the Northeast Regional Climate Center - Extreme Precipitation Atlas increases the volume of stormwater runoff generated from impervious surfaces during moderate to severe storm events. Stormwater runoff containing pollutants can be harmful when discharged into waterways, wetlands and saltmarshes. 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. The Parsons Creek Watershed Study (2015) has documented that pollutants from private septic systems are the major contributing source of pollution and water quality impairment in the waterway. Refer to the Tides to Storms Vulnerability Assessment maps, Figures 5 and6 in Section 3.4, to identify the low-lying areas at highest risk of flooding and groundwater inundation, particularly areas impacted by the 1.7 foot and 4.0 foot sea-level rise scenarios.

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 study 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 such as course sediments and rocks, trash and other types of debris.

Beach erosion could be a factor in the future, and one that would need specific management practices to address changes in beach stability. On such practice is beach nourishment which involves importing clean sand from another location (e.g. from a dredge site) and applying the sand to the beach surface to increase its elevation as sea levels rise.

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

Table 6 shows that upland areas impacted by flooding from 1.7 feet of sea-level rise is moderate, however impacts increase markedly with 4.0 feet and 6.3 of sea-level rise. Flooding from coastal storm surge is fairly widespread immediately adjacent to saltmarsh and tidally influenced areas. Further inland, Rye has enough increase in land elevation 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 6. 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.

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

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 7, 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.

Table 7. 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 8. 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.

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.

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]

3.7 Community Adaptation and Resilience

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.

FEMA Community Rating System Program
Currently, Rye is underway with preparation of an application to FEMA's Community Rating System program. This is a voluntary incentive based program designed to reduce property owner flood insurance premiums in exchange for actions that reduce risk and vulnerability throughout the community thus reducing the number of insurance claims and federal disaster relief needed.

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.

Figure 8. Storm flooding at Rye Harbor. [Photo Credit: Kimberly Reed (12/27/12)]

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.

The town is currently updating its Hazard Mitigation Plan. Information, data and maps from the Tides to Storms Vulnerability Assessment (RPC, 2015) will be incorporated as part of this plan update. ?Reference information/recommendations from 2016 HMP update???

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 and the town. 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*.

Incorporating new information about changes in weather, extreme events and long-term climate change can enhance emergency planning. Town officials recognize the need to provide cellular phone coverage town-wide to improve the effectiveness of emergency notifications. The town could reduce its risk and exposure by incorporating coastal hazards and risks assessments in municipal emergency management and hazard mitigation plans, and improving connections and efficiencies between these plans. Collaborating with private sector representatives to evaluate and identify necessary improvements to emergency communications systems preparedness can ensure 911 and other critical communications services remain operational during emergencies and disasters. Local officials recognize the need to update a regional comprehensive emergency evacuation plan for coastal flood and storm events that includes early notification to highest risk areas and properties.

3.8 Recommendations (2 pages)

Based on the Tides to Storms Vulnerability Assessment results and local knowledge of coastal hazards, the following are identified strategies and actions of local and regional significance that should be addressed in future policy, planning, regulatory and non-regulatory initiatives by the town and the community. These strategies and actions are organized under 7 primary Goals.

Goal 1. Protect municipal and state roads, bridges, culverts, and drainage lines.

R1.1 Coordinate with the NH Department of Transportation on anticipated improvements to state Route 1A and local roadways most vulnerable to flooding and leverage funding necessary for such improvements.

R1.2 Conduct drainage analyses to evaluate freshwater and tidal flooding impacts.

R1.3 Evaluate whether replacement of culverts is necessary in high flood risk areas to ensure proper drainage of stormwater and flood water.

R1.4 Keep drainage infrastructure maintained and clear of debris.

Goal 2. Sustain drinking water supplies, sources and infrastructure.

R2.1 Evaluate future drinking water and wastewater needs in the seacoast region both for municipalities and private service companies.

R2.2 Identify and prioritize actions to protect water quality and water quantity of local aquifers.

R2.3 Prepare an inventory of private wells, and map municipal service areas and those served by the Aquarion Water Company.

R2.4 Improve communication between the town and Jenness Beach District regarding drinking water services and supplies.

R2.5 Compile research about the future effects of rising groundwater levels on drinking water supplies.

Goal 3. Maintain function of wastewater services and infrastructure.

R3.1 Inventory and map the location of private septic systems.

R3.2 Consider expansion of wastewater services along Ocean Boulevard where needed and practical to replace existing private septic systems if or when they fail permanently due to rising seas and groundwater levels.

R3.3 Compile research about the future effects of rising groundwater levels on private septic systems.

Goal 4. Increase resilience of municipal infrastructure and facilities.

R4.1 Utilize the best available climate science and flood risk information for the siting and design of new, reconstructed, and rehabilitated municipal structures and facilities.

R4.2 Incorporate infrastructure assessments and improvements in the Capital Improvement Plan by dedicating funds for improvements to infrastructure and facilities.
The following departments will act as lead for:

- Stormwater Management - Public Works
- Roads and Transportation Infrastructure - Public Works
- Wastewater Services - Rye Sewer Department
- Drinking Water Services - Rye Water District, Acquarion
- Coordinate with Portsmouth on water service to Wentworth Road

R4.3 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).

R4.4 Apply for FEMA pre-disaster mitigation grant funds for infrastructure systems improvements, and other sources of funding to implement climate adaptation and planning strategies that reduce or eliminate flooding impacts.

R4.5 Be more proactive about acquiring funds to implement flood risk reduction projects.

R4.6 Evaluate federal and state funding options for shoreline management and protection projects.

R4.7 Encourage adoption of buffers and setbacks that better account for risk and vulnerability of municipal structures and facilities, and maintain ecosystem services (e.g. flood storage, storm surge protection).

R4.8 Incorporate solar energy installations for municipal buildings and facilities.

Goal 5. Implement sound land use and development standards and protect natural resources.

Land Use and Development

R5.1 Begin discussions with elected officials, planning board and zoning board of adjustment about long term options for management and regulation of land uses, development and natural resources in areas at high risk of flooding and erosion (e.g. land use development standards, building code, and zoning).

R5.2 Revise building codes to enable adaptive construction techniques and designs, considering increases in maximum building height standards to allow elevating structures above the base flood elevation.

R5.3 Revise zoning ordinances and regulations to incorporate flood-smart stormwater controls (e.g. reduce stormwater volume and impervious cover) and enforce implementation of low impact development standards.

R5.4 Track cumulative improvements to structures in the Special Flood Hazard Area designed on the FEMA Flood Insurance Rate Maps.

R5.5 Improve management of coastal shoreline protection structures and natural features (e.g. shale piles, sea walls, beaches, wetlands and marshes), and evaluate areas where construction of sea walls may be needed to protect infrastructure, property and natural resources.

R5.6 Amend existing floodplain ordinances for the town and Rye Beach Village District; this may require adjustment of maximum building height.

R5.7 Improve coordination between the town and the Rye Beach Village District including zoning administration and Building Departments.

R5.8 Revise building codes to enable adaptive construction techniques and designs.

R5.9 Consider adopting freeboard (+2-4 feet) and elevation of utilities above the BFE for all new construction and substantial improvements to residential and non-residential structures.

R5.10 Conduct outreach to property owners, land use boards, staff and elected officials about what freeboard would look like on the beach landscape.

R5.11 Adopt land development regulations aimed at minimizing impervious surfaces and stormwater flooding, and reducing or preventing non-point source pollution.

R5.12 Require development project approvals to include drainage maintenance plans for stormwater infrastructure and streams or open drainage ways on site.

R5.13 Provide recommendations and incentives for removal 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.

Natural and Recreational Resources

R5.14 Coordinate with the state, state agencies and coastal municipalities to manage coastal lands and resources to adapt to future conditions.

R5.15 Support efforts to prepare a comprehensive shoreline management plan that includes dune restoration and maintenance

R5.16 Enable the Conservation Commission to formally comment on development applications by defining their role with respect to the Planning Board's review and approval process.

R5.17 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.

R5.18 Engage in best practices for invasive species planning and removal and incorporate climate considerations in invasive species removal plans.

R5.19 Utilize existing state and federal grant programs for natural resource restoration.

R5.20 Develop natural resource restoration plans that explicitly consider future coastal risk and hazards, and the ecological services that they provide.

R5.21 Encourage adoption of buffers and setbacks that restore and maintain ecosystem services (e.g. flood storage, storm surge protection, habitat, recreation).

R5.22 Protect future marsh migration areas identified by marsh migration modeling.

R5.23 Improve designs for dams, culverts and bridges to maintain existing function and reconnect fragmented surface waters (wetlands, lakes, ponds, rivers and streams) and protect high quality habitat for aquatic organisms.

R5.24 Identify areas where erosion and shoreline instability exist, and prioritize areas for nature-based approaches (e.g. beach nourishment, dune restoration or marsh restoration).

R5.25 Incorporate in plans and implement strategies to prepare and adapt coastal recreational resources based on best available climate science.

R5.26 Assess existing and future recreational areas for their potential to provide storage for flood waters and stormwater runoff.

R5.27 Preserve open space and recreational areas that serve to minimize climate change impacts.

Goal 6. Increase preparedness across all municipal functions and services.

R6.1 Incorporate coastal hazards and risks assessments in municipal emergency management and hazard mitigation plans, and improve connections and efficiencies between these plans.

R6.2 Collaborate with private sector representatives to evaluate and identify necessary improvements to emergency communications systems preparedness to ensure 911 and other critical communications services remain operational during emergencies and disasters.

R6.3 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).

R6.4 Coordinate evacuation route planning with adjacent towns serviced by Route 1A. Incorporate early communication and notification protocols into regional evacuation route planning.

R6.5 Enhance communication infrastructure (e.g. cell towers/coverage) and planning before and during emergency events and incorporate new technologies.

R6.6 Update emergency preparedness plans, master plans and regulations for the Rye Water District and Rye Sewer District to address coastal hazards and adaptation.

R6.7 Conduct outreach to property owners, land use boards, staff and elected officials about the benefits of the National Flood Insurance Program.

R6.8 Implement the FEMA High Water Mark Initiative to illustrate future water levels associated with the 100-year storm surge and projected sea-level rise.

R6.9 Prepare a Response and Recovery Plan or Policy to guide rebuilding, redevelopment and reuse of lands and resources following a catastrophic event.

R6.10 Develop a Comprehensive Coastal Adaptation Implementation Plan.

- Include descriptions of actions, timeline, budget and assigned lead.
- Coordinate this Plan with state comprehensive shoreline management.

R6.12 Evaluate deficiencies and barriers in municipal regulations, plans and policies, and their implications for local and regional vulnerability.R6.11 Provide training to elected officials and land use boards and commissions about climate related hazards and impacts.

R6.13 Consider vulnerabilities of local tax base, state economic development plan, retention or replacement of economic resources, at risk populations and population migration.

R6.14 Adapt economic development planning approaches to respond to changing environmental conditions, leverage shifting opportunities, and promote resilience and sustainability planning as economic development strategies.

R6.15 Maintain and expand town partnerships with state and federal agencies to obtain grants, technical assistance, and coordinate land use, transportation and natural resource planning.

R6.16 Continue participation in the NH Coastal Adaptation Workgroup to facilitate, coordinate, provide technical information, and convene public outreach events about climate adaptation.

Goal 7. Support community preparedness and awareness of coastal hazards.

R7.1 Provide information to residents and businesses about alternative approaches, reducing risk and lowering insurance premiums through adaptation (e.g. the benefits of voluntarily elevating structures above the current base flood elevation).

R7.2 Conduct outreach to current and future affected property owners about potential flood risks to inform decisions about their property and investments.

R7.3 Provide an informational materials about flood risk reduction at public and community events.

R7.4 Schedule events at the library or other public venues featuring topics relating to coastal hazards and preparedness, and climate adaptation.

R7.5 Provide outreach and information to residents about how to clean up after a storm event (e.g. drainage ways, driveway culverts etc.)

R7.6 Encourage homeowners to obtain flood insurance through the National Flood Insurance Program, and in moderate- to low-risk areas, to purchase a Preferred Risk Policy.

R7.7 Encourage landowners to preserve the beneficial functions of natural features like wetlands and to restore and protect coastal dune habitat.

R7.8 Provide information through outreach to residents and businesses about the benefits of living shorelines.

R7.9 Implement the FEMA High Water Mark Initiative to illustrate past flood elevations and future water levels associated with the 100-year storm surge and projected sea-level rise.

R7.10 Partner with federal and state agencies as well as regional and local organizations to expand resources for education, outreach, and coordination.

R7.11 Encourage the incorporation of climate science and information about the risks and hazards associated with changing climatic conditions in public school curriculum.

R7.12 Engage youth and young adults through social media.

R7.13 Improve information available to property owners and prospective buyers about coastal hazards and vulnerabilities.

R7.14 Improve consumer protection disclosure of properties vulnerable to coastal flooding.