8 NATURAL HAZARDS

Overview

In Barrington, the hurricanes of 1938 and 1954 are still remembered for their destructive force, more than a half century later. More recent events will not soon be forgotten either: Hurricane Bob (1991), Hurricane Irene (2011), and Hurricane Sandy (2012). Hurricanes are not the only hazards—blizzards and heavy rainstorms have resulted in power outages, flooding and other impacts—most notably the rains of March 2010 that flooded basements throughout town., and the blizzard of 2013 (Nemo), which left many without power for as long as a week.

With almost 20 miles of coastline, Barrington will continue to be threatened by hurricanes and nor'easters that hit New England. The risk will only grow, due to the projected rise in sea levels already affecting coastal communities.

The Natural Hazards element identifies potential natural hazards that could affect the community, including hurricanes, blizzards and impacts of rising sea levels; determines Barrington's vulnerability to these hazards; and establishes actions designed to mitigate the risks from natural hazards. The element draws from the Town's 2010 Multi-Hazard Mitigation Plan, as well as input from the public and Town departments, to identify critical issues and steps that help reduce impacts of hazards on the community.

Existing Conditions

Community Context

Barrington has 19.6 miles of coastline, occupying two peninsulas bound by Narragansett Bay to the west and the Palmer and Warren Rivers to the east. The Barrington River separates the two peninsulas, and the Central Bridge and the Barrington River Bridge connect the two land masses. The western portion of Barrington, which includes the Village Center business district, is physically connected to the City of East Providence. The eastern portion of Barrington, which includes the Hampden Meadows neighborhood,

Downed power lines and damaged trees in the Hampden Meadows area resulting from Hurricane Irene (Aug. 2011)

is connected to the Town of Swansea, Massachusetts. No location in Barrington is more than two miles from coastal waters.

Barrington is classified as a medium-density developed community, with significant areas of wetland, public open space, and recreation land. Based on data from the Land Use element, Barrington is mostly residential, which comprises 55 percent (2,844 acres) of total land area within town. Commercial land comprises just two percent (119 acres), institutions (including government, schools and churches) comprise three percent (148 acres) and transportation and utilities makes up 0.6 percent (31 acres) of the land. Wetlands, forest, agricultural areas, vacant/transitional areas, parks and other open space make up most of the remainder of the landscape (38 percent, or 1,970 acres).

Natural Hazards: Threats

The most prevalent natural hazard facing the Town of Barrington is flooding. Flooding may occur quickly or over a period of days and can result from a number of natural hazards. Storm surge[1] from hurricanes and winter storms often results in coastal flooding and erosion. Many neighborhoods along the coast are also located in FEMA-designated Special Flood Hazard Areas (100-year Flood Zone or Velocity Zone), where heavy rains, snowmelt, ice jams, and dam failures can contribute to flooding. Because of Barrington's low, coastal location, relatively flat topography, and large areas of inland water and wetlands, flooding is a pervasive problem throughout many areas.

High winds associated with a variety of seasonal storms, including hurricanes and winter storms, are also a frequent natural hazard in Barrington, particularly along the coastal areas. Wildfires, earthquakes, and hailstorms are considered to be low-risk natural hazards for Barrington, although all have the potential to occur.

Hurricanes

The New England District of the U.S. Army Corps of Engineers, using data from the National Hurricane Center, developed maps depicting the worst case scenario for coastal inundation from storm surge for Category 1 through 4 hurricanes striking the coast of Rhode Island (see **Map NH-1**). Hurricane

Table 1. Significant Hurricanes in Rhode Island

Date	Name	Category	Property Damage	Deaths
September 21, 1938	N/A	3	$100,000,000	262
September 14, 1944	N/A	3	$2,000,000	0
August 31, 1954	Carol	2	$200,000,000	19
August 17-20, 1955	Diane	Trop. Storm	$175,000,000	0
September 12, 1960	Donna	2	$2,400,000	0
September 27, 1985	Gloria	2	$19,800,000	2
August 19, 1991	Bob	2	$115,000,000	0
August 27, 2011	Irene	Trop. Storm	$9,300,000	**0**
October 29, 2012	Sandy	Trop. Storm	$41,600,000	**0**

Sources: Rhode Island State Hazard Mitigation Plan, 2005; Town of Barrington Natural Hazards Mitigation Plan, 2004; National Weather Service Forecast Office, Boston, MA, http://www.erh.noaa.gov/box/hurricane/tropicalCycloneReview.shtm.

[1] The National Oceanic Atmospheric Administration describes storm surge as "the abnormal rise in water level, over and above the regular astronomical tide, caused by a severe storm such as a tropical cyclone or nor'easter. Large waves also raise coastal water levels and ride on top of the storm surge to cause extreme damage. Coastal inundation is the flooding of normally dry, low-lying coastal land, primarily caused by severe weather events along the coasts, estuaries, and adjoining rivers." Source: http://www.stormsurge.noaa.gov/

surge values were developed using the SLOSH (Sea Lake and Overland Surge from Hurricanes) model, which estimates storm surge heights through hypothetical measures of pressure, size, forward speed, track, and winds.

According to the National Hurricane Center, approximately six Atlantic tropical storms mature into hurricanes in an average year. The RI State Hazard Mitigation Plan indicates that Rhode Island is particularly vulnerable to hurricanes due to its geographic location and features such as Narragansett Bay, which can act as a funnel for hurricane surges. The State plan indicates that in any given year, the probability of a hurricane reaching Rhode Island is six percent. **Table 1** (previous page) lists significant hurricanes starting with the Hurricane of 1938.

Barrington's coastal location and low elevation makes it particularly susceptible to hurricane-related hazards, and the town's small size means that the majority of properties are vulnerable to hurricane impacts to some degree. It is evident that under this worst case model, even Category 1 and Category 2 hurricanes could produce storm surges that inundate large areas of town, particularly in Hampden Meadows. Hurricanes have the potential to cause coastal erosion, particularly along Barrington's southern and western shores.

Severe Rainstorms and Floods

Barrington is a low-lying community virtually surrounded by water and containing approximately 6.9 square miles of inland water. As a result, several areas of town can be flooded by heavy rains or storm activity. FEMA has designated flood zones for Rhode Island according to varying levels of flood risk. Each zone reflects the potential severity or type of flooding in the area. High risk areas in Barrington are designated as Zone AE and Zone VE.

Zone AE, or the 100-year Flood Zone, identifies areas with a one percent or greater chance of flooding in any given year and where the base flood elevation has been determined. Zone VE identifies the Velocity Zone, which are coastal areas with a one percent or greater chance of

Table 2. Severe Rainfall and Floods in Bristol County, Rhode Island, 1993-2010

Date	Type	Rainfall (inches)	Notes
January 10, 1997	Coastal Flood	N/A	2-4 foot tidal surge in Narragansett Bay. Palmer River flooded some Barrington streets.
March 28, 2005	Flood	3-4	Flooding in poor drainage areas; significant street flooding.
June 7, 2006	Flood	2-4	Some street flooding.
October 28, 2006	Coastal Flood	2-4	Significant coastal flooding; some street flooding.
March 2, 2007	Flood	2-3	Urban, small stream; some street flooding.
February 13, 2008	Flood	2-4	Flooding in streams and poor drainage areas; some minor river flooding; minor wind damage from strong northeast winds, especially along the coast.
March 8, 2008	Coastal Flood	2-3	Minor coastal flooding due to high tide, rough seas, and storm surge.
December 12, 2008	Flood	3-5	Small stream and some street flooding.
March 2010	Flood	8	Upland Way/Maple Avenue/Middle Highway intersection flooded. Widespread basement flooding.

Sources: National Climatic Data Center, http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms, Rhode Island Department of Transportation, http://www.dot.state.ri.us/Flooded_streets_March2010.asp#Closures

Table 3. National Flood Insurance Policies and Claims—Bristol County (as of 7/31/13)

Municipality	Number of Policies In-Force	Coverage Total $	Annual Premium	Number of Claims*	Claim Total Value*	Average Claim Value $
Barrington	1,058	$293,975,100	$1,445,523	421	$1,546,326	$3,673
Bristol	619	$138,955,500	$877,963	189	$1,397,949	$7,397
Warren	464	$86,213,400	$587,957	132	$1,217,785	$9,226

*From Jan. 1, 1978 to July 31, 2013

Source: FEMA BureauNet / Rhode Island State Hazard Mitigation Plan

flooding with additional hazards associated with storm-induced waves, or velocity action.

The Flood Insurance Rate Maps (FIRMs) for Barrington and the rest of Bristol County were made effective July 7, 2014. Current flood zone mapping for Barrington shows the Velocity Zone occurring along much of the western and southern coast, where the town is proximate to Narragansett Bay and the Warren River (see **Map NH-2**). Areas of undeveloped coastal wetland can be found along Rumstick Point, between Nayatt Point and Town Beach, and along Mussachuck Creek. These areas may help minimize the effects of localized flooding.

The 100-year Flood Zone extends inland from the Velocity Zone in most areas, and includes freshwater wetlands such as Brickyard Pond and Echo Lake, and the estuarine wetlands associated with the Barrington River, 100-Acre Cove, and the Palmer River.

Barrington regularly experiences storms and heavy rains that result in localized flooding. Several of the most significant recent floods to occur in Bristol County are highlighted in **Table 2** (previous page). In March 2010 storms and periods of heavy rain resulted in significant flooding in the state and resulted in a Presidential Major Disaster Declaration for Rhode Island, including Bristol County. Barrington experienced substantial flooding in some areas. As it has done several times in the past, the RI Department of Transportation (RIDOT) closed the intersection of Middle Highway and Maple Avenue for several days due to flooding from Volpe Pond and associated wetlands. This area has been identified on the currently available FIRM as a minimal flood hazard because it is located well outside 100-year Flood Zone, and even outside the 500-year Flood Zone, or the 0.2 percent chance annual floodplain.

While it is difficult to predict flood events, FEMA has determined that properties in Zone AE and Zone VE have a 26 percent chance of flooding over the life of a 30-year mortgage.

Flooding from dam failure represents another possible threat to localized areas of town. Barrington has three dams, all located on the west side of town: the Echo Lake Dam and the Rhode Island Country Club Dam are three-foot earthen dams that control flow from Echo Lake and Mussachuck Creek, while a third, privately owned dam controls flow from Annawamscutt Brook to Allin's Cove. This dam is located adjacent to an elderly housing complex, and the headwater is lower than the lowest level of the complex. All three dams are located in the 100-year Flood Zone (Zone AE).

Inventoried dams in Rhode Island are classified by size and hazard rating. The size classification provides a relative description of small, medium, or large, based on the storage capacity and height of the impounded water.

The hazard classification relates to the probable consequences of failure or misoperation of the dam. The Rhode Island Country Club Dam and the Echo Lake Dam were classified as low hazard dams in the 2009 Annual Dam Safety Report from the Rhode Island Department of Environmental Management. Failure or misoperation of low hazard dams is determined to result in no probable loss of human life and low economic losses.

Winter Storms

Winter storms are a regular occurrence in Barrington, with snowfall ranging from a few inches to blizzard conditions, including sustained winds or frequent gusts up to 35 mph or greater, and considerable falling snow, broken tree limbs, loss of power, and reduced visibility to less than a quarter mile. Barrington has experienced several notable blizzards and winter storms over the years (see **Table 4**). The Blizzard of 1978 is perhaps the most significant and memorable snowstorm to hit Rhode Island, resulting in a virtual shut-down of commerce and transportation across the state for several days, 21 deaths, and millions of dollars of damages. More recently, the powerful winter storm Nemo of February 2013 produced significant snowfall and heavy winds, resulting in power outages that left areas of Barrington without power for as long as a week. Across the state, more than 150 people were hospitalized.

Low-Risk Hazards

Low-risk hazards include droughts, earthquakes, tornadoes, wildfires and hailstorms.

- *Droughts.* According to the RI Drought Management Plan, there have been just six major historical drought events since 1930, most with statewide impacts.

- *Earthquakes.* There are no significant geologic fault lines in Rhode Island or New England, and the U.S. Geological Survey's (USGS) Earthquake Hazards Program identifies all of Rhode Island as occurring in a low seismic risk area (<2%g peak acceleration). Historically, earthquakes originating in other states have been felt in various parts of Rhode Island. Should an earthquake strike or its effects be felt in Barrington, old masonry structures that do not meet current earthquake codes such as Town Hall and the Public Library/Senior Center could potentially be at risk of damage or collapse.

- *Tornadoes.* Tornadoes are a rare occurrence in Rhode Island, but a risk does exist, particularly during hurricane season (June through October). Between 1953 and 2004 Rhode Island had almost no tornadoes, but on July 23, 2008 an F1 scale tornado began just off of Rumstick Point in Barrington and then moved to land in Warren. The tornado's path was 3.0 miles long and

Table 4. Significant Snowstorms—Bristol County, 2003-2014

Date	Snowfall (inches)	Notes
February 17, 2003	12 to 24	Numerous traffic accidents throughout RI.
March 6, 2003	6 to 10	Numerous traffic accidents throughout RI.
December 5, 2003	10 to 20	15 inches in Barrington; transportation disrupted.
January 22, 2005	21	Coastal flooding; transportation disrupted.
February 12, 2006	9 to 14	
December 13, 2007	12	Transportation disrupted; Providence shut down.
December 19, 2008	10 to 11	
December 19, 2009	18 to 21	Transportation difficult; schools closed.
December 26, 2010	6 to 10	
January 26, 2011	9 to 10	
February 8, 2013	24 to 30	Gusts of 74+ mph; 170 people hospitalized in RI; widespread power outages

Source: National Climatic Data Center, http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

40 yards wide, with winds reaching speeds of 65-75 mph. The majority of damage was to trees, some of which fell onto power lines and houses, and was estimated at $45,000. No injuries were reported.

- *Wildfires*. Based on 2011 land use figures, approximately 38 percent of Barrington is forested (1,969 acres), and approximately one percent is brush/transitional (45 acres). Wooded areas are generally surrounded by development. Larger forested tracts are located in the vicinity of Brickyard Pond, Haines State Park, and the former Vitullo Farm on the western side of town; the Hampden Meadows Greenbelt area on the eastern side; the South Road Area at Washington Road; and Nockum Hill near the Massachusetts line.

  Many of these wooded areas are dominated by forested wetland, but given the proper conditions, these areas could be at risk for wildfire. As an example, a 2008 fire in Warren caused spread across the marshes at Jacob's Point, threatening homes and destroying much of the Audubon Society's boardwalk to the river. The area is across the Warren River from Barrington's Rumstick Point. In Barrington, significant wildfires have not been known to occur, although occasional brush fires have occurred in the wooded parts of town.

- *Hailstorms*. Hail is a showery precipitation in the form of irregular pellets or balls of ice more than 5 millimeters in diameter. Hail often is associated with severe thunderstorms, and occurs primarily during summer months in Rhode Island. While significant hailstorms are infrequent in Barrington, there is potential for a hailstorm of any magnitude to strike in town. Hailstorms have been a relatively infrequent occurrence in Barrington – the National Climatic Data Center lists three hailstorms occurring in Barrington between 1950 and 2014.

Future Development

Barrington has limited vacant land available for future development. The Housing & Neighborhoods element calls for development of two key remaining areas to fulfill current land use needs such as affordable and senior housing: the Zion Bible Institute along Middle Highway and the Sowams Nursery land on the east side of Sowams Road in Hampden Meadows.

The Zion Bible Institute property is in a low-risk area for natural hazards, situated outside of hurricane surge inundation zones. Areas designated for redevelopment and re-use of historic structures are outside flood zones.

The Sowams Nursery site is partially located within the 100-year Flood Zone (areas nearest the Palmer River), but the master plan approved for this area does not call for structures to be placed within this zone. The property also spans surge inundation areas associated with all four classes of hurricanes (Categories 1 -4). Portions of the site proposed for residential structures are subject to storm surge from a Category 2 or larger hurricane, which potentially represents a higher risk for these properties.

The Town is in the process of building a park at the "Police Cove" site, located north of County Road fronting on the Barrington River. The site is at risk for flooding, as it is largely located within the 100-year Flood Zone and subject to storm surge from a Category 1 hurricane. Plans for the park, scheduled for completion in spring/summer of 2015, call for a reduction of impervious surface and additional storm water management features that will help the site better handle any future flooding.

The Town is considering sites for a new senior center, currently in the lower level of the Public Library building at 281 County Road. However, a decision on either moving forward with the project or, if so, the location has not yet been determined.

Table 5. Estimated Number of Structures In flood zones

Use	Residential		Commercial		Marina		Institutional		Public School/ Municipal	
Zone	AE	VE	AE	VE	AE	VE	AE	VE	AE	VE
Structures	1,068	29	28	1	4	-	2	-	1	-

Source: Town of Barrington GIS data

Existing, Ongoing Mitigation Measures

Building Codes

The Town's building official is responsible for ensuring new structures meet building code requirements. Before a building permit is issued for construction in the AE or VE zone, an elevation certificate that verifies a proposed structure meets the minimum elevation requirements must be submitted to the building official. Other building code requirements include:

- Structures are required to be able to withstand 110-mile-per-hour winds, or a Category 2 hurricane.
- Bridges must be built to withstand seismic forces based on the bridge's classification and site-specific geophysical conditions.
- Residential and commercial structures must be designed and built to resist the effects of earthquake motions based on site-specific elements such as soil profile and ground motion.

Regulations and Ordinances

The Town has enacted regulatory restrictions designed to reduce the potential impacts of flooding to property by limiting development in and around wetlands and flood-prone areas.

Article XXIII of the Zoning Ordinance regulates development within areas of special flood hazard. The floodplain ordinance was last amended on June 2, 2014, representing adoption of the official Flood Insurance Rate Maps effective July 7, 2014. Article XXIII establishes Special Flood Hazard Areas – areas designated AE or VE on the FIRM panels – as a floodplain overlay district. Within the overlay district, all proposed construction or other development requires a permit – not just projects where building permits are required.

Development projects "include any filling, grading, excavation, mining, drilling, storage of materials, temporary stream crossings." Construction or other development within the overlay district not covered by a building permit would be subject to approval by CRMC or RIDEM, as applicable; the building official is to have an opportunity to comment and must keep a copy of the permit on file.

In 1994 the Town adopted a Wetlands Overlay District Zoning Ordinance that requires a special use permit from the Zoning Board for proposed activities within the 100-foot wetland setback. The ordinance also prohibits any reduction in flood storage capacity, and the storage of materials or equipment which could cause damage under flood conditions. In addition, the ordinance requires any construction activity in the Velocity Zone to take place above the mean high tide line.

National Flood Insurance Program

Barrington is a member of the National Flood Insurance Program, a federal program created by Congress in 1968 that makes flood insurance available to communities that enact minimum floodplain management regulations.

Table 5 provides an estimated count of the number of structures (excluding accessory buildings) within flood zones in Barrington, based on the flood maps in effect as of July 2014. There are approximately 14 repetitive loss properties in town, of which two have

been mitigated, according to the RI Emergency Management Agency. Repetitive flood loss properties are properties that are currently insured through the NFIP for which two or more losses of at least $1,000 each have been paid within any 10-year period since 1978.

The Town in 2014 applied for a FEMA Hazard Mitigation Grant on behalf of seven property owners who were seeking assistance to elevate their houses out of the flood zone (review was ongoing as of fall 2014). The private property owner is required to provide the minimum 25 percent match. Similar grant opportunities are likely to become available in the future.

Protection and Restoration of Coastline

Barrington has worked with the State and conservation organizations such as the Barrington Land Conservation Trust and Save the Bay to restore degraded wetlands in critical areas, which helps reduce the risk of damages from flooding events.

In 2006 a significant wetland restoration project was completed that restored approximately 11 acres of degraded coastal wetlands at the mouth of Allin's Cove. This project was also critical for halting erosion of the shoreline along Byway Road, which had the potential to undermine the structural integrity of the road. Efforts to address erosion along the Byway Road shoreline are ongoing. The installation in 2013 of sand-filled coir envelopes (see **Figure 1**) provided a base for establishing vegetation needed to stabilize the slope. This area is susceptible to damage from wave action, such that the area requires periodic monitoring and repair.

The Town has worked on shoreline projects in other coastal areas as well. At Latham Park and Barrington Beach, the Town completed projects intended to restore coastal protection features, reduce potential structural flood damage, stabilize shorelines, and enhance public access.

Improvements at Town Beach have taken place in two phases. In 2011, the Town built a new

Figure 1. Shoreline protection project—Byway Road

Save the Bay worked with the Town and volunteers to install coir envelopes to stabilize and re-vegetate an eroded embankment on Allin's Cove near the end of Byway Road.

Figure 2. Erosion reduction and water quality improvements —Town Beach

In 2014, Save the Bay working with volunteers planted beach grass within a 10-foot-wide section in front of the Town Beach parking lot. The planting area was created through the removal of pavement as part of a beach drainage improvement project. Pulling the parking area farther away from the Bay provided more room for high tides and for the addition of beach grass needed to create protective dunes.

beach house with restrooms and office space, replacing a 1950s cinderblock restroom building that was located within the VE zone. The new building was built on piles and set back away from the shoreline to meet floodplain elevation requirements.

The second phase consisted of site improvements were completed in 2014, including the removal of excess asphalt, allowing the shifting of the parking lot away from the water by 10 to 12 feet. New bioretention swales were built to capture and treat storm-water from adjacent streets, with the added effect of reducing beach erosion. About 20 parking spaces at the west end of the parking lot were eliminated to allow for additional asphalt removal within an area most vulnerable to impacts from storms and flooding. Beach grass has been planted (see **Figure 2**) within the new beach created with the asphalt removal, in an effort to establish new vegetation and, over time, protective dunes.

The Latham Park project was completed in summer 2014. It included repairs to the existing revetment protecting the shoreline along Bullock Cove, with additional public access provided to the water (see **Figure 3**, next page). Reconfiguration of the parking lot shifted pavement away from the water's edge, allowing for additional plantings, storm-water retention and a new public walkway with benches in the park adjacent to the revetment.

Other recent/ongoing projects include:

- *Walker Farm marsh restoration.* In 2005, restoration of the Walker Farm marsh was completed, increasing the size of the marsh to 15 acres and addressing problems on the site from historic alterations, including roads and dam structures. This property separates Route 103/114 from the Barrington River and 100-Acre Cove, and is vital for storing flood waters.

- *Mussachuck Creek*. In 2007 restoration work was completed along Mussachuck Creek, restoring the tidal flow and aquatic system after sand buildup restricted the inlet.
- *The former "Vitullo Farm" site on Wampanoag Trail*. The reconstruction of the gravel driveway and parking area near Wampanoag Trail included providing additional area needed to allow for the expansion of a coastal wetland.
- *RISD marsh*. Save the Bay has been working with RISD to improve the health of coastal marsh areas at Tillinghast Estate off Nayatt Road by improving drainage of the site.

Acquisition of Freshwater/Inland Wetlands

To reduce the potential impacts to structures and property due to flooding associated with hurricanes and heavy rains, Barrington has worked to protect and acquire wetlands, which serve as a natural buffer and storage area for flood waters. The most recent major acquisitions of property containing significant wetland areas took place in the early 2000s. These sites are: the "Brickyard Wetlands," a 10-acre site between the Bayside YMCA and the Barrington Shopping Center; and the 21.5-acre Vitullo Farm on Wampanoag Trail, which contains wetland features within the center of the site.

Bridge Projects

The State is in the process of replacing the Central Bridge, which carries Massasoit Avenue across the Barrington River. The bridge, in response to concerns of the Town about boat clearance in the future with rising sea levels, was re-engineered to add two feet to the height. Other bridge projects in Barrington are the planned replacement of the East Bay Bike Path bridges that cross the Barrington and Warren rivers. The project in 2014 was in the design phase; construction could start as early as 2016. The land to either side of both bridges is within the AE flood zone.

Location of Emergency Centers, Town Facilities

In 2000 a Public Safety Complex housing both the Police and Fire Departments was built on Federal Road, an area outside of the 100-year Flood Zone and beyond the surge inundation areas for Category 1 and 2 hurricanes. This

Figure 3. Shoreline stabilization project—Latham Park

In 2014, a contractor working for the Town rebuilt the revetment at Latham Park, which needed repair due to erosion problems. The project included stabilization of the land behind the revetment, new plantings, improved access to the shore, a rebuilt parking lot with additional drainage, and site amenities including bike racks and benches. Funding came from a RIDEM park development grant and the Town's capital budget.

action allowed the Police Department to move from the previous location at 95 County Road, located in the 100-year Flood Zone on the west side of the Barrington River.

Barrington's other operating facilities, including Town Hall and the Department of Public Works, are located outside of the 100-year Flood Zone and surge inundation areas for Category 1 and 2 hurricanes. Although Barrington only has one hurricane-approved shelter, Primrose Hill Elementary School, the Town has signed agreements with the City of East Providence, and the Towns of Seekonk and Rehoboth, Massachusetts, that allows Barrington residents to use the hurricane shelters in those communities in the event of a Category 3 or 4 hurricane.

Posted Evacuation Routes

Barrington has evacuation route signs posted throughout town indicating the best route to follow in the event of flooding (routes are shown on Map NH-1). Extensive sections of several major routes—including County Road , Sowams Road and New Meadow Road—are within the 100-year and the 500-year floodplain.

Issues and Opportunities

Barrington's Vulnerability to Impacts of Climate Change / Sea Level Rise

With an extensive coastline, Barrington is among the most susceptible communities in the state to impacts from projected rises in sea level—which has the potential over time to add more properties to flood zones. The long-term forecast of greater frequency and intensity of storms means buildings in low-lying areas along the shore, in particular houses within the Velocity and Coastal A zones—could be subjected to greater risk of flood and wind damage in the future.

According to the Rhode Island Coastal Resources Management Council (CRMC), potential effects include[3]:

- Increased extent of flood damage and greater vulnerability to storm surges in lower elevations;
- Greater risk to infrastructure—roads, sewers, stormwater facilities, utilities—in areas more prone to flooding;
- Saltwater intrusion into aquifers contaminating water supplies;
- Higher water tables resulting in subsurface issues such as wet basements;
- A significant increase in incidence of extreme high tide levels;
- More coastal lands becoming susceptible to erosion due to increased intensity and frequency of storms;
- A net loss of coastal marshes that become inundated at a greater rate, resulting in a loss of salt march vegetation and an alteration of habitat types.

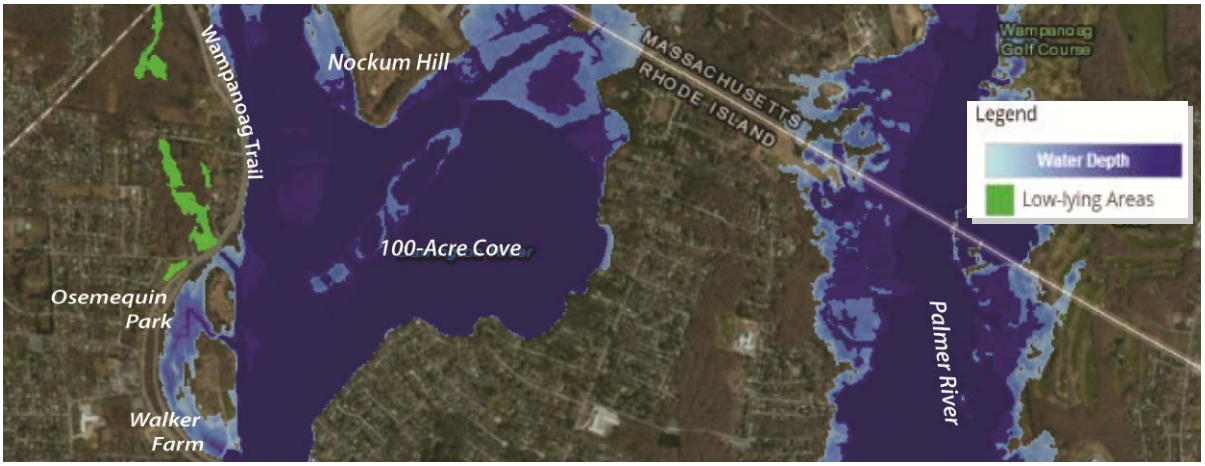
Figures 4A and **4B** on the next pages illustrate the potential impacts of sea level rise (SLR) in Hundred Acre Cove area and the Brickyard Pond/Nayatt area, based on modeling by the National Oceanic and Atmospheric Administration.[4] These images show current conditions (mean high water) compared to SLR increases of two feet and five feet—the range of sea level rise projected by CRMC for Rhode Island by 2100. The higher the rise in water, the greater the impact, including the loss of marshes, blocked roadways and water reaching into developed areas.

As Figures 4A and 4B show, long-term impacts resulting from an increase in SLR could be significant, especially if it approaches five feet.

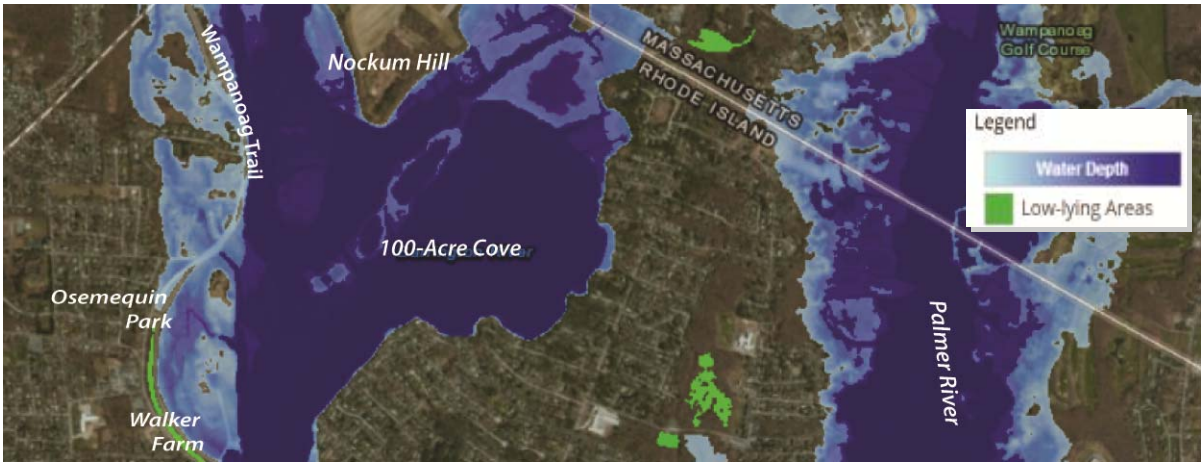
[3] Coastal Resources Management Program (as amended) - Section 145 - Climate Change and Sea Level Rise (Adopted: May 14, 2013; effective date: June 13, 2013)
[4] http://www.csc.noaa.gov/slr/viewer/

Figure 4A: Sea Level Rise/Coastal Flooding Impacts: Hundred Acre Cove/Palmer River

Current mean high water



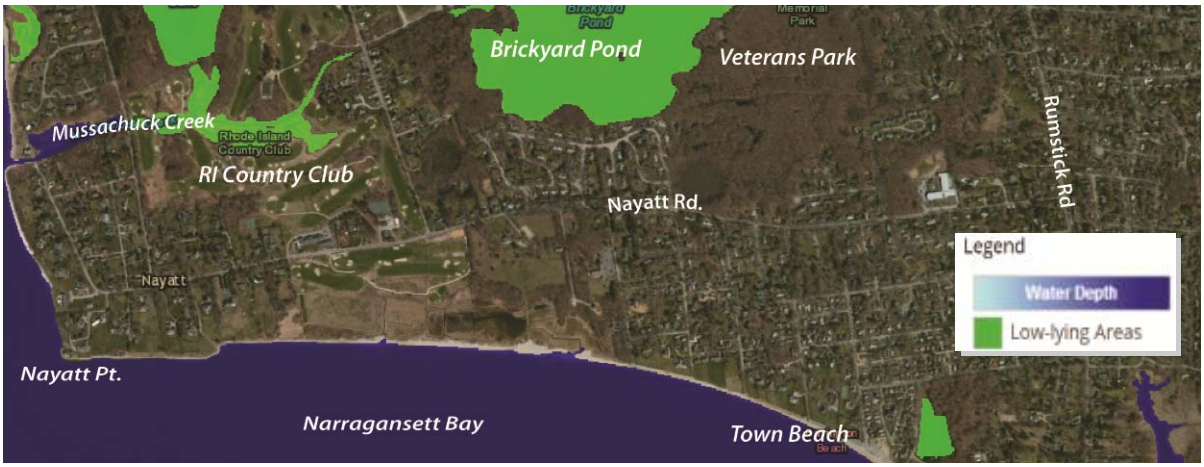
2-foot sea level rise



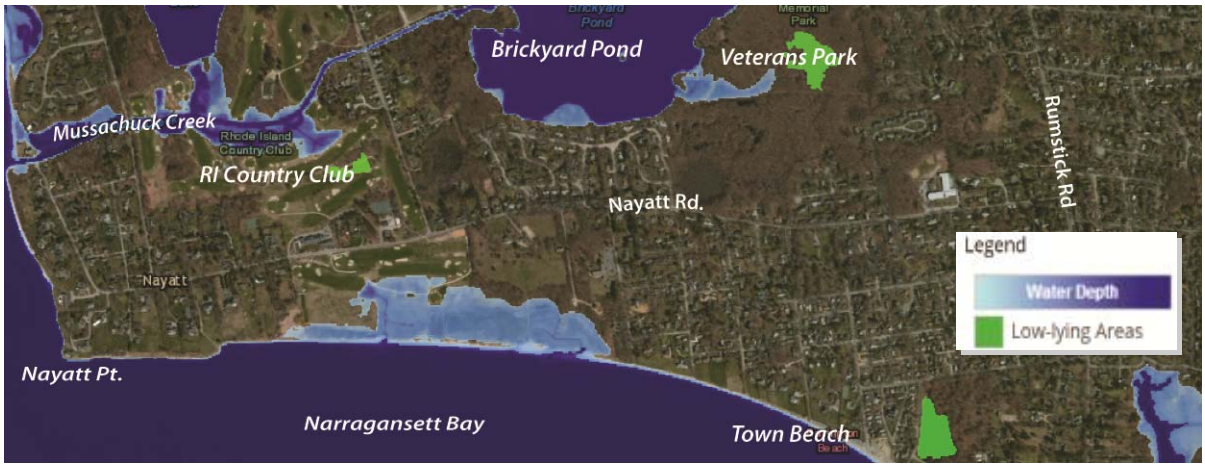
5-foot sea level rise

Source: National Oceanic and Atmospheric Administration. http://www.csc.noaa.gov/slr/viewer/

Figure 4B: Sea Level Rise/Coastal Flooding Impacts: Brickyard Pond/Nayatt Area



Current mean high water



2-foot sea level rise

5-foot sea level rise

Source: National Oceanic and Atmospheric Administration: http://www.csc.noaa.gov/slr/viewer/

The effects, some alarming and none favorable, could include:

- Inundation of coastal marshes (Palmer River, Hundred Acre Cove, Allin's Cove, along Narragansett Bay) that serve as wildlife habitat areas as well as provide protective buffers against storm surge for inland areas;
- The complete inundation of "Crab Island" and the "Great Tongue" in 100-Acre Cove;
- The loss of Walker Farm (including a boat ramp, community gardens and a yard waste storage area) and most of Osemequin Park, should the SLR rise by 4 or more feet;
- Regular flooding at high tide of the Wampanoag Trail, County Road near the High School and Prince's Pond, and sections of New Meadow Road and Sowams Road (in particular nearest the Barrington and Palmer Rivers);
- The potential loss of Town Beach as a recreational asset should SLR exceed four feet;
- Waters from Narragansett Bay reaching into the coastal marshes at RI Country Club and portions of RISD's Tillinghast Estate;
- Inundation of residential lots near the shoreline, including those at the end of residential streets near the Palmer River and the Warren River;
- Water from Echo Lake, Brickyard Pond and Mussachuck Creek affecting adjacent neighborhoods and the RI Country Club;
- Waters extending from Bullock Cove into low-lying areas of Latham Park, and from Allin's Cove into low-lying areas in the Alfred Drown and Bay Spring neighborhoods;
- Worsening flooding of RI 114/103 on the Warren side of the Warren River Bridge;
- Water from the Barrington and Warren Rivers covering sections of Mathewson Road and Tyler Point, impacting boat facilities and other uses close to the Barrington and Warren Rivers, and a critical roadway for residents in the Mathewson Road area.

While five feet of SLR may not occur, and if it does it would not take place for decades, the Town (and the State in the case of roads such as Rte. 114/103) will need to plan for long-term capital investments to protect critical infrastructure — such as roads, storm-water facilities, sewers, and pump stations — and work to limit new development within areas identified as vulnerable to rising sea levels. The issue underscores the need to continue protection of open space parcels within low-lying and critical habitat areas and the rigorous enforcement of floodplain regulations.

Vulnerability—Critical Assets

Vulnerability is defined as the exposure or susceptibility of the Town to the effects of the identified hazards. The vulnerability assessment process helps identify vulnerable points in the community's infrastructure and population and examines structures, including residential and commercial structures; infrastructure, including bridges, roads, and utilities; natural resources and areas subject to environmental vulnerability, such as beaches prone to erosion; and populations, such as children and the elderly.

Table 6 on the next page provides a summary of critical assets susceptible to storm surge and flooding. (See also **Appendix V** for a comprehensive list of critical assets such as transportation systems, emergency centers, utility infrastructure, special population centers such as nursing homes and schools, and natural resources, such as beaches and coastal parks.)

Due to its coastal location and the potential for the occurrence of various seasonal storms, Barrington's critical assets are more vulnerable to flooding than any other hazard. Hurricane storm surge has perhaps the greatest potential

Table 5. Critical Facilities Located in Areas Susceptible to Storm Surge and Flood Zones

Asset Type	Hurricane Category - Storm Surge				Flood Zone	
	1	2	3	4	AE	VE
Dams (Allin's Cove, Mussachuck Creek, Echo Lake)	2	3	3	3	2	1
Public Safety Building (Police/Fire Station/EMS)				1		
Public School (High School)		3	5	5	1	
Private School		1	2	3		
State Facility (East Bay Center)			1	1		
Post Office			1	1		
Elderly Housing / Assisted Living		2	2	2		
Marina	3	4	4	4	4	
Park & Ride Lots	2	2	2	2	2	

Source: Town Planning Department, FIRM Maps (2014)

to impact the Town, as surge from even a low level hurricane could flood large sections of Town in a short period of time.

Fast moving, widespread flooding has the ability to halt transportation, damage residential and commercial property, and impair important infrastructure such as sewer pump stations. If roads were to become impassable, Barrington's population, including Special Needs populations, could also experience difficulty evacuating and/or conducting daily activities until flood waters recede. The Town's Public Safety Complex could experience flooding from high caliber hurricanes, but other emergency centers/operating facilities such as Town Hall and the Department of Public Works are located well beyond the storm surge area identified for any hurricane.

Barrington's critical assets are also at risk from flooding due to other natural hazards besides hurricanes. Winter storms and heavy rains can flood assets located within the 100-year Flood Zone and the Velocity Zone, schools (the high school and three private schools), coastal homes, roads, park and ride lots, and utility infrastructure. The East Bay Center, a State-owned facility on County Road, is in the AE zone, as are the Atria Bay Spring assisted living facility and Barrington Cove Apartments on Bay Spring Avenue. Both park and ride lots serving the bus routes on RI 114 are in the AE zone and susceptible to storm surge during the weakest of hurricanes.

Strong winds and winter storms can also present a major obstacle to transportation and impair road functions, with the potential to damage structures, impair electric utilities, and block roads and evacuation routes. Above-ground utilities like transmission and distribution lines can be impaired by strong winds and heavy snow and ice associated with winter storms. Power outages can have secondary effects on the Town's ability to manage emergencies and keep residents safe and warm. Winter storms also regularly contribute to coastal erosion, which then in turn contributes to flooding by reducing the buffer of land between coastal waters and Barrington's developed areas.

Although Barrington faces impacts from other potential natural hazards, including earthquakes, wildfire, and hailstorms, the risk from these hazards is currently quite low, and mitigation efforts are better spent on addressing higher risk flood and wind-related hazards.

High Mitigation Cost: Houses in Flood Zones

Flood risk remains a significant issue for residents throughout town. As cited previously, Barrington has more than 1,000 structures within the AE and VE zones—almost all privately owned homes. Elevation of a structure above the base flood elevation—for example on piles (velocity zone) or on a new, higher foundation with flood vents—is one mitigation measure available to property owners.

Elevation projects, however, are a financial burden for most people, typically costing more than $100,000. Property owners who are unable to elevate their home are not only at risk of incurring flood damage to their property, they also are facing escalating flood insurance premiums.

On occasion, FEMA provides opportunities to homeowners to apply for financial assistance to offset some of the cost of an elevation project. One example is the Hazard Mitigation Grant program, which, when available, can provide assistance to property owners in municipalities with an approved Hazard Mitigation Plan.

Limited Adaptation Opportunities

The changing shoreline has already created erosion, flooding and water quality problems that Barrington will need to confront in the short-term as well as long-term. The potential impacts are widespread, with more than 1,000 structures in flood zones. And with the community approaching build-out, there are limited options to make changes to the built environment that would significantly reduce the risk. However, a starting point is Save the Bay's Coastal Adaptation Project, which included an assessment of Barrington.

Save the Bay has worked with the Town on the retrofit of the Town Beach parking lot and Water Way, and the installation of sand-filled coir envelopes to protect a sewer line at Byway Road. Additional projects (with owner noted) recommended by Save the Bay include:

Figure 5. Adaptation Opportunity: Mathewson Road—Utilities

Utility poles along sections of Mathewson Road are under water at high tide. Adaptation activities recommended by Save the Bay include relocation of the poles and additional protection of Mathewson Road. (Credit: Save the Bay)

Figure 6. Adaptation Opportunity: "Vitullo Farm" - Wetland Expansion

This photograph depicts conditions at a "moon tide" at the former "Vittulo Farm" off Wampanoag Trail (now Town-owned open space where a community garden has been established). Plans for improving parking at the site call for providing additional space to allow for expansion of a wetland to the north and west. (Credit: Save the Bay)

- Latham Park (Town) — Allow low-lying, flood-prone area within the lower-middle portion of the park to become salt marsh over time; enhance buffer; reconstruct revetment to protect Shore Drive. (As mentioned previously, the Town has completed reconstruction of the parking lot, which was shifted inland with a new buffer strip near the water. The northerly portion of the existing revetment was also repaired.)
- Haines Park, Bullock Cove (State) — Remove a section of pavement in the parking lot adjacent to shoreline (just north of Cove Haven Marina) to provide room for stormwater infiltration.
- Mathewson Road (Town) – Relocate utility poles that now are underwater at high tide for most of the length of this road (see **Figure 5,** previous page). The road will require protection as well, as the street is vulnerable to sea level rise and flooding.
- The former "Vitullo Farm" (Barrington Community Garden), Wampanoag Trail (Town). The site contains marsh to the south of a gravel parking lot and driveway off the Trail (see **Figure 6**). Reconfiguration of the parking and driveway could allow room for the expansion of a wetland to the north and west.
- Barrington Town Beach (Town) – Remove section of parking to allow area for beach migration and filter stormwater runoff from parking area and side roads (This project has been completed, though there may be an opportunity for additional pavement removal and installation of stormwater measures within adjacent Town rights of way such as at the end of Lorraine Street).
- Woodbine Avenue (Town) — East side of Bullock Cove. There is an opportunity to carve back pavement, creating an infiltration area and move an outlet more inland.
- Prince's Pond (Town) – Install larger culvert that can accommodate larger tidal flows and that has a natural bottom.
- Sowams Road (State) – Stabilize bank to protect road where it is in close proximity to the Palmer River (just north of County Road).

- Walker Farm (Town) – Allow salt marsh to become established north of boat ramp; stop mowing marsh; relocate benches inland to allow for erosion.
- Arvin Avenue (Town) – Create dead end from either side of Arvin and remove section of road to allow area for marsh retreat.
- Bourne Lane (Town/Private) — Potential site for stormwater infiltration along edge of road prior to entering marsh
- Belvedere Avenue (Town) – Remove pavement at end of road; infiltrate stormwater and allow marsh an area to retreat inland.
- Tillinghast Salt Marsh (RISD) — Create new creeks to allow impounded water to drain off marsh area; plant beach grass to encourage dune establishment at southern end of footpath. (Project in progress.)
- Juniper Street and Virginia Road (Town) — Remove pavement at end of road; infiltrate stormwater. (This is to be completed as part of abatement related to the Central Bridge replacement project.)

Floodplain Management / Community Rating System

An effective floodplain management program is needed if Barrington hopes to reduce future flood damage. Such a program can also produce financial benefits to property owners.

FEMA's Community Rating System (CRS), established through the National Flood Insurance Program, provides incentives in the form of discounts on flood insurance premiums ranging from 5 to 45 percent. The program rewards communities that undertake floodplain management practices exceeding minimum standards.

The CRS Coordinator's Manual provides a range of potential public information and floodplain management activities a community could implement to achieve a score needed to qualify for premium reductions (see **Figure 7**).

Figure 7: Community Ratings System—Example Activities

Examples of activities that result in a higher CRS score include:

Public Information

- Maintain elevation certificates for new construction in the floodplain (required) (Barrington already requires this)
- Require real estate agents to advise potential purchasers of flood-prone property of potential flood hazard.
- Provide technical advice to interested property owners and lessees on how to protect their property from flooding.

Mapping and Regulations

- Complete regulatory administrative tasks, including staff training as Certified Floodplain Managers.
- Prohibit new buildings on fill or compensatory storage where filling is allowed.
- Reflect in future conditions mapping sea level rise and climate change
- Add building elevation data and natural floodplain functions to GIS mapping.
- Implement low-impact development regulations that reduce runoff "to the maximum extent possible."

Flood Damage Reduction

- Relocate structures out of the floodplain. Extra credit is available for removing "critical facilities", and for removing buildings from the VE or Coastal AE zone.
- Protect buildings through flood-proofing
- Complete a flood hazard mitigation plan in accordance with FEMA requirements
- Conduct periodic inspections and maintenance of stormwater system to maintain flood carrying capacity

Flood Preparedness

- Timely identification of impending flood threats, dissemination of warnings to floodplain occupants, and coordination of flood response
- Provide a flood response plan with preparations for possible dam failure.

Source: RI Emergency Management Agency

A minimum score of 500 would result in a CRS rating of "9" and a 5 percent flood insurance premium reduction. The highest rating—achieved by only four communities in the United States—is a score of "1", providing a 45 percent premium discount.

An issue for the Town relates to personnel who would implement floodplain activities required to effectively reduce risk and improve the CRS program score. Options for administering a CRS program include hiring a qualified consultant or designating someone on staff to be trained as a certified floodplain manager.

Drought Preparedness

Drought is a relatively low risk hazard in Barrington. Most of Barrington has access to public water from the Bristol County Water Authority, with water from the Scituate Reservoir delivered through the cross-bay pipeline.

With the majority of water users in Barrington reliant on public water, the community's vulnerability to drought is directly related to the availability of water provided by the Bristol County Water Authority—either from the Scituate Reservoir or from a secondary source. (Water supply is discussed in more detail in the Community Services and Facilities element). Bristol County Water can address drought impacts through enactment of water restrictions when necessary.

The area potentially most vulnerable to impacts of drought is the George Street area, which is 100 percent reliant on well water. There are just 11 houses in the area currently; however, Four-Town Farm is a heavy user of water, requiring it for irrigation on approximately 60 acres of farmland in town. Mitigation of drought impact in the George Street area and the few other areas in town that rely on well water will require additional public outreach about the need for water conservation, focusing on the small number of affected property owners.

Data Availability

A data gap exists within the parcel and the building data available from the Town's GIS database. Currently nearly 400 parcels in the parcel dataset are lacking use classification information (i.e., residential property, commercial property, etc.). This information may be critical during an emergency. An additional data gap exists in the building dataset, as it does not contain any actual information about the primary use of the building (commercial, residential, school, etc.). Although this information can be obtained in a round-about method through the parcel data on which a building sits, adding a basic description of the primary use of the building to the building dataset would streamline the vulnerability assessment in future versions of the report.

Streamlining the GIS data for parcels and buildings will improve the Town's ability to prepare for, respond to, and recover from natural disasters. The Town's GIS mapping software also provides an opportunity to expand on its capabilities to integrate into natural hazard planning and response, such as utilization of software specifically designed for assessment of vulnerabilities and mitigation of threats. This could improve the Town's planning, operations, and public information efforts related to hazards.

Public Awareness

Information about natural hazards—such as storm surge maps, evacuation routes and floodplain maps—are readily available through the Town's website, barrington.ri.gov. A more concerted effort is needed, however, to reach more people about potential long-term risk (such as owning and insuring structures in flood-prone areas) and immediate risk (hurricanes, blizzards, nor'easters, etc.).

A communications strategy would also help the disseminate information of benefit to property owners, such as:

- Announcements of the availability of grant opportunities, such as Hazard Mitigation Grants, that potentially benefit individual property owners;
- Educational/technical assistance events on protecting property from flood damage;
- Invitations for public input on updates to the Town's Hazard Mitigation Plan.

The role of public outreach on natural hazards could fall to a Town floodplain manager.

Goals, Objectives, Policies and Actions

Goal 1: Reduce current and future risk of natural hazards and sea level rise to the built environment.

Objective 1.1: By 2018 complete a town-wide assessment of the potential impacts to structures and infrastructure resulting from projected sea-level rise.

Policy 1.1.1: Plan for effects of projected sea level rise in the site selection and planning of parks, buildings and other public projects.

Policy 1.1.2: Reduce impact of development within the floodplain and other vulnerable areas.

Actions

A. Complete an assessment of potential impacts, including physical and financial, of projected sea-level rise on publicly and privately owned buildings and sites, as well as streets, storm-water, sewer systems and other utilities.
B. Include in the six-year capital improvement program critical projects required to mitigate threats to infrastructure and properties.
C. Consider amending the Zoning Ordinance and subdivision regulations to require design standards that exceed FEMA's requirements.
D. Provide support for property owners to help take advantage of funding opportunities, such as FEMA Hazard Mitigation Grants, that assist with covering the cost of mitigating risk such as elevating properties out of flood zones.
E. Publish illustrated design guidelines to provide ideas for designing building elevations that are compatible with the surrounding neighborhood. Include best practices to mitigate impacts of elevations that require relief from the height limit. (See also Housing & Neighborhoods Goal ___.)
F. Adopt low-impact development standards to reduce the amount of impervious coverage, such as reduced street widths and a maximum impervious lot coverage percentage.
G. Provide measures to improve stormwater retention in the planning and design of park improvements and construction of schools and other new public buildings.
H. Amend stormwater management system regulations to enhance infiltration and expand stormwater retention areas.
I. Evaluate the condition of and impacts of dams within Barrington.

Goal 2: Preserve and enhance the capacity of the natural environment to improve Barrington's resilience against impacts of natural hazards.

Policy 2.1.1: Identify and protect critical open space areas that are vulnerable to natural hazards and sea level rise.

Policy 2.1.2: Plan for and implement projects that allow natural systems to adapt over time to changes in sea level rise and the climate.

Actions

A. Prioritize and implement coastal adaptation projects, working with Save the Bay, the State and other stakeholders, to reduce flood risk and the potential damage to vul-

nerable infrastructure, allow the expansion of wetlands and other purposes.

B. Identify tree species that will be most resilient to climate change and use these species in public projects. Consider requiring these species in new subdivisions and land development projects.

C. Assess streams and dams and prioritize projects needed to maintain/improve water flow.

D. Develop plan to allow restoration of natural areas at Walker Farm.

E. Implement a tree management program to reduce risk to property due to winds, heavy snow/ice or other natural hazard impacts.

F. Work with the local land trust and other stakeholders to identify low-lying vulnerable land that could be designated as permanently protected open space. (See also Open Space and Recreation Goal ___.)

Goal 3: Participate in FEMA's Community Ratings System to reduce risk and the cost of flood insurance within Barrington.

Objective 3.2: Achieve a Community Rating System score of "7" or better by 2020 (with "1" being the top score).

Policy 3.2.1: Participate in the Community Rating System and provide resources necessary to run an effective program that reduces future risk and results in a CRS score of 7 or better.

Policy 3.2.2: Maintain a FEMA-approved Hazard Mitigation Plan that is based on the latest data and proposes strategies on natural hazards and climate change.

Actions

A. Complete steps required to enroll in the National Flood Insurance Program Community Rating System, with a minimum starting CRS score of "9".

B. Engage a consultant or provide staff training for a certified floodplain manager to coordinate implementation of CRS activities and implementation of the Town's Hazard Mitigation Plan.

C. Complete the required Hazard Mitigation Plan five-year update that addresses effects of climate change and includes activities that would achieve a CRS goal of "7" by 2020. (The current plan expires in November 2015.)

D. Update the plan as necessary to address impacts of new significant natural hazard events such as severe flooding, wind damage and storm surge.

E. Establish an administrative team to meet quarterly to review progress on implementation of the Hazard Mitigation Plan and activities resulting in CRS credit.

Goal 4: Improve the community's awareness of threats to minimize risk to the public due to natural hazards.

Policy 4.1.1: Inform the public on the concept of community resilience and the risk of impacts from natural hazards, with an emphasis on stream and coastal flooding, including storm surge, and winter storms.

Actions

A. Use informational signs at areas of historic flooding showing the 1938 surge elevations along the bay and rivers and update as necessary based on March 2010 flooding. These signs could be as simple as a painted blue ring around a telephone pole or a plaque indicating where floodwaters have reached previously. It is especially important to include inland areas where the risk is less obvious.

B. Outreach to community members through orchestrated public forums, radio, television, and the Town website are useful for

disseminating preparedness information for emergency situations, especially during hurricane season immediately before an event.

C. Establish a process to directly contact special populations such as those who are particularly vulnerable, due to location or age and infirmity, should be established to ensure their understanding of procedures immediately before and after an event.

E. Expand the "Emergency Information" section of the Town's website to provide information on minimizing risk to private property and on general preparedness.

F. Publicize spaces (shelters, etc.) available to the public in times of power outages, loss of heat and other secondary impacts resulting from natural hazards.

G. Work with the State and FEMA to make brochures and other information available on the website, in the library, and at other destinations.

A. Improve Geographic Information Systems (GIS) capabilities to support assessment and planning activities.

E. Work with the Bristol County Water Authority to assist with public outreach about water restrictions in effect during drought conditions.

F. Develop a list of property owners not on public water for communications on responding to drought conditions as they relate to users of well water.