

# Wareham Multi-Hazard Mitigation Plan

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*Virtually every type of weather has been and will be experienced within a coastal Massachusetts town. From freezing temperatures and blizzard conditions in the winter to heat and humidity in the summer, Wareham must plan for the worst. The old adage of “if you don’t like the weather, wait a minute” certainly applies.*

*In addition to potentially severe weather, Wareham’s unique peninsular geography and its position at the upper extent of Buzzards Bay exposes the Town to potential wave energy and storm surges capable of causing coastal erosion, flooding, and property damage to multiple sections of Town. In total, Wareham has approximately 57 miles of marine and estuarine shoreline.*

*Natural hazards of all kinds can result in injury, loss of life, damage to buildings and infrastructure, which can have significant adverse impacts on the Town’s economic, social and environmental resources. Through the development and implementation of this Mutli-Hazard Mitigation Plan, the Town of Wareham is proactively trying to prepare for and mitigate potential impacts from the various natural hazards.*



## 1.1 PURPOSE OF PLAN

The Federal Emergency Management Agency (FEMA) defines hazard mitigation as “any sustained action taken to reduce or eliminate the long-term risk to human life and property from (natural) hazards”, such as floods, hurricanes, winter storms, tornadoes, earthquakes, etc. Hazard mitigation may include both structural measures, such as flood control structures, and nonstructural measures, such as regulations and bylaws, to prevent flooding. Local planning and mitigation efforts allow communities to reduce or eliminate the loss of life and property damage resulting from natural hazards. The Town of Wareham produced this Multi-Hazard Mitigation Plan for the entire Town with the goal of providing sustained actions to reduce or eliminate risk to human life and property damage from a natural hazard event. Objectives of this plan are as follows:

- Describe the planning process;
- Identify relevant background information about the Town, including geography, climate, land use, and infrastructure;
- Identify natural hazard risks and areas in town most likely to be impacted;
- Complete a risk assessment to profile hazard events, inventory assets, and estimate potential losses;
- Identify existing disaster mitigation measures already in place;
- Develop proposed mitigation measures and a mitigation strategy based on the risk assessment; and
- Design a mechanism to keep the plan updated to reflect current conditions and establish a schedule for monitoring, evaluating, and updating the plan.

### What is a Hazard Mitigation Plan?

Natural hazard mitigation planning is the process of reducing or eliminating the loss of life and property damage resulting from natural hazards such as floods, earthquakes, and hurricanes through long-term strategies, including planning, policy changes, programs, projects, and other activities.

Preparation of this Multi-Hazard Mitigation Plan Update before a major disaster occurs will help the community prevent property damage and loss of life associated with natural hazards, save money by instituting mitigation measures to protect against natural hazards, allow funding through FEMA for post-disaster remediation, and expedite disaster recovery. The Plan will also help to reduce or eliminate repetitive flood losses.

## 1.2 THE PLANNING PROCESS

A1.a  
A1.e

Public participation is a central component of this planning process, providing critical information about the local occurrence of hazards while also serving as a means to build a base of support for hazard mitigation activities. Additionally, the most successful mitigation plans are developed after participation by a wide range of stakeholders who play a role in identifying and



implementing mitigation actions. During preparation of this Multi-Hazard Mitigation Plan, the planning process included the following:

- A public online survey to assess the community's experience with local natural hazards and its perception of the Town's risk to natural hazards;
- An opportunity for the public to comment on the plan during draft stages and prior to final approval;
- An opportunity for local and regional agencies and organizations, neighboring communities and private industries to be involved in the planning process; and
- A review and incorporation of existing plans, studies, reports and data.

A1.b

This Multi-Hazard Mitigation Plan (MHMP) is the first of its kind for the Town of Wareham. It was developed through substantial input from the Local Planning Team (LPT), which consisted of various Town officials and was able to provide critical local knowledge about the community to facilitate the development of this Plan.

A1.c

A1.d

The LPT was formed by the Town Planner, and included Chiefs of the Police and Fire Departments, the Conservation Agent, the Municipal Maintenance Department Director, department heads for the Water and Sewer Departments, and representatives from the Natural Resources, Emergency Management, and Health Departments. Additional input was sought and obtained from <include outside state, regional, etc. input>. The LPT met for 5 working meetings during the Plan development process. The 2020 MHMP was largely funded through FEMA's Pre-Disaster Mitigation Program. In addition to the LPT input, public participation in the hazard mitigation planning process is also important, both for plan development and for implementation of the plan. Residents, business owners, and other community members are an excellent source for information on the historic and potential impacts of natural hazard events and particular vulnerabilities the community may face from these hazards. Their participation in this planning process also builds understanding about the hazard mitigation process and potentially creates support for future mitigation actions. Although typically, public meetings would be hosted to gather this information and educate residents on hazard mitigation, due to the COVID-19 restrictions in place during the critical development stages of this report, the Town opted to host an online webinar presentation instead. The presentation was hosted live on May 20, 2020, and a recording of the webinar was also posted on the Town's website for residents to view when they were able.

A1.c

A2.a-c

A3.a-b

Copies of the announcements from this online webinar, as well as a master list of LPT members are provided in Appendix B. These materials provide a foundation for understanding the planning process and major decisions made along the way and can help provide crucial background information the next time the LPT meets to review and update the MHMP.

A public online survey was also administered to assess the community's experience with local natural hazards and their perception of the risk, and to reach a wider demographic that may not



be available to attend public meetings in person. The results of this online public survey are included in **Appendix B**.

The following steps were taken during the planning process:

- 1) Develop an LPT responsible for updating this Plan;
- 2) Define the potential natural hazards that could affect Wareham;
- 3) Determine high hazard locations and critical infrastructure potentially affected;
- 4) Conduct a vulnerability assessment of buildings and infrastructure;
- 5) Outline existing hazard mitigation measures and document progress on the previous Plan's actions;
- 6) Determine gaps in hazard mitigation preparedness;
- 7) Define proposed hazard mitigation measures to fill these gaps; and
- 8) Evaluate the feasibility of and prioritize mitigation measures.

The above steps will allow implementation of proposed mitigation measures with a goal of reducing damage and improving public safety during a natural disaster. To solicit public comment, the draft Plan was posted on the Town of Wareham's website, with a notification on the Town's homepage, a direct link to the plan, and directions for how to submit questions or comments. **A screenshot documenting the website posting is provided in Appendix B**. The draft Plan was also presented on May 20 2020 at a public meeting to gather additional public input. **Comments received during the meeting are included in Appendix B**. **Advertising for the public meeting included \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_, copies of which are included in Appendix B**. The draft plan was posted on the website for 2 weeks prior to finalization. **No additional comments were received during this time**.

A2.a

The draft Plan was also sent to Town Planners in Marion, Rochester, Middleborough, Carver, Plymouth and Bourne, as well as the Southeastern Regional Planning and Economic Development District (SRPEDD) for review and comment. **A copy of the email sent to these neighboring towns and regional planning body soliciting their feedback on the Plan is also provided in Appendix B**.

A4.a  
A4.b

During preparation of this Plan, several existing studies and documents related to Wareham and the surrounding area were reviewed. Preparation of this Plan borrowed from the following plans and documents where appropriate:

- Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2018);
- Wareham Master Plan Vision (2018);
- Wareham Climate Change Flood Vulnerability Assessment and Adaptation Planning (2020); and
- Local bylaws and regulations.

The 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan (SHMCAP) was developed through a collaborative process that involved numerous state agencies, a large cross-





section of stakeholders, members of the public, working groups, and a consulting team. This was the hazard plan's eighth revision from its initial preparation in 1986, but this version is unique in that it is the first-of-its-kind statewide plan that fully integrates a traditional hazard mitigation plan with a climate change adaptation plan.

The Wareham Master Plan Vision was created in 2018 to compile general mission statements, goals and recommendations that will ultimately be used to guide the development of a future Master Plan. The Master Plan Vision also includes a Future Land Use Map that depicts general patterns for the way Wareham should develop and conserve land in the future. The Master Plan Vision document covers land use, economic development, services and facilities, stewardship and service, transportation, housing, open space and recreation, and natural and cultural resources.

The Wareham Climate Change Flood Vulnerability Assessment and Adaptation Planning document describes a quantitative vulnerability assessment conducted by the Woods Hole Group. This project involved a climate change vulnerability assessment of municipal infrastructural, societal and environmental features to develop targeted strategies aimed at reducing risks from flooding, increased storm intensity, sea level rise and storm surge. A GIS database was developed for the Town, which can be used moving forward with resiliency planning. This report includes a range of climate change adaptation measures for individual assets through larger districts.

Various town departments and boards have implemented and updated bylaws and regulations as necessary to control development and ensure safe construction methods that adhere to current best management practices. The Wareham Planning Board is the primary town agency responsible for regulating development in the town, through the Zoning Bylaw. Feedback to the Planning Board was ensured through the participation of Town staff on the LPT. In addition, the SRPEDD, the regional planning agency for Wareham, works with all agencies that regulate development in its region, including the municipal entities and state agencies, such as Department of Conservation and Recreation and MassDOT. This regular involvement ensured that during the development of the Wareham Multi-Hazard Mitigation Plan, the operational policies and any mitigation strategies or identified hazards from these entities were incorporated.

Technical information from the plans, regulations and bylaws described above was incorporated into the Wareham Multi-Hazard Mitigation Plan in a number of ways, including:

- 1) Guide the planning process;
- 2) Help develop mitigation actions;
- 3) Provide recent data on various hazards and their impacts; and
- 4) Ensure that mitigation actions in this plan were consistent with current state and local activities and plans.





1.3 PLAN DESCRIPTION

A1.d  
A2.b

FEMA developed a “Local Mitigation Review Guide” (Guide) to ensure Local Hazard Mitigation Plans meet the requirements of the Stafford Act and Title 44 Code of Federal Regulations (CFR) 201.6. This Guide was used as a tool in developing this Plan. For ease of assessment, when the text addresses an element of the Guide, it is identified in a colored bullet in the margin.

1.4 PREVIOUS FEDERAL/STATE DISASTERS

The Town of Wareham has experienced 6 natural hazards that triggered federal or state disaster declarations since 2010 (FEMA 2019). These are listed in Table 1-1 below. The vast majority of these events involved flooding.

Table 1-1. Disaster declarations for the Town of Wareham since 2010.

Disaster Name	Type of Assistance	Declared Areas
<b>Severe Storm and Flooding (Mar 12–Apr 26, 2010)</b>	FEMA Public & Individual Assistance	Counties of Plymouth, Bristol, Essex, Middlesex, Norfolk, Suffolk, and Worcester
<b>Tropical Storm Irene (August 27-29, 2011)</b>	FEMA Public Assistance and Hazard Mitigation Grant Program	Counties of Plymouth, Barnstable, Berkshire, Bristol, Dukes, Franklin, Hampden, Hampshire, and Norfolk
<b>Hurricane Sandy (Oct 27 – Nov 8, 2012)</b>	FEMA Public Assistance and Hazard Mitigation Grant Program	Counties of Plymouth, Barnstable, Bristol, Dukes, Nantucket, and Suffolk
<b>Severe Winter Storm (February 8-10, 2013)</b>	FEMA Public Assistance and Hazard Mitigation Grant Program	All 14 MA Counties
<b>Severe Winter Storm (January 26-28, 2015)</b>	FEMA Public Assistance and Hazard Mitigation Grant Program	Counties of Plymouth, Barnstable, Bristol, Dukes, Essex, Middlesex, Nantucket, Norfolk, Suffolk and Worcester
<b>Severe Winter Storm (March 2-3, 2018)</b>	FEMA Public & Individual Assistance	Counties of Plymouth, Barnstable, Bristol, Nantucket, Norfolk and Essex



*One of the first steps in hazard mitigation planning is to identify and define the Town's assets. Without a detailed and accurate understanding of the infrastructural, societal and environmental resources present within the Town, it is impossible to develop a plan to protect them. The goal of this chapter is to provide a local profile, detailing the community's assets, the Town's geography and climate, an overview of the Town's environmental resources, the Town's land use and demographic patterns, the locations of major infrastructure and critical facilities, and historical locations throughout Town.*

*Although all community assets may be affected by natural hazards at times, some assets and infrastructure are more vulnerable because of their physical characteristics, location, or socioeconomic uses. This asset inventory will help support the vulnerability analysis conducted in Chapter 4, which will identify specific vulnerable assets within the Town of Wareham.*



B1.b

## 2.1 OVERVIEW

The Town of Wareham is known as the “Gateway to Cape Cod” and is located in Plymouth County, in southeastern Massachusetts. It was incorporated in 1739. As of the 2010 census, the population of Wareham was 21,822. This number swells to approximately 44,000 during the summer months with seasonal residents and visitors. The Town has a traditional New England government structure with a three-member Board of Selectmen, a Town Administrator and an open Town Meeting. Among the basic services provided to the residents are public safety, schools, sewer, recreational facilities, and public libraries.

In addition, residents and businesses within the Town of Wareham receive their fire protection and drinking water from one of two water providers depending on their geographic location: the Wareham Fire District and Onset Fire District. Districts are a special form of Town governance, in this case based on the geography that forms the District, and generally have their own taxing ability, similar to a Town. Districts need special legislation to form, as they originated from the need to provide a community fire suppression system and/or drinking water supply. Legislation was therefore granted for these settlements to source their own water for consumption and fire protection.

Most Fire Districts also have a Prudential Committee that oversees the financial matters of the Fire Departments, while Water Districts are typically managed by a Board of Water Commissioners. Depending on the makeup and history of the municipality, there may be one or more districts. For example, the Town of Barnstable has four water providers: Hyannis Water Department, West Barnstable Fire District, COMM Fire District and Cotuit Fire District. Wareham has two Districts, each with a Water Superintendent who serves as the head of the Water Department and a Fire Chief that serves as the head of the Fire Department. The District Water Superintendents and Fire Chiefs are typically included on municipal projects and matters that have a water element, which is the majority of them. For example, submitted building permits must be signed off by Town departments, such as Health and Conservation, but must also be circulated to the Water and Fire Districts. So, in some respects, the districts act as a municipal department, but they are technically their own entity.

The Town maintains a website at: <https://www.wareham.ma.us/>

## 2.2 GEOGRAPHY

The Town of Wareham is a coastal community located in southeastern Massachusetts at the head of Buzzards Bay where the Agawam and Wareham Rivers meet. With numerous estuaries and coves, the Town has approximately 57 miles of estuarine and marine coastline. These waterways are one of the Town’s greatest assets, which not only spurred early manufacturing and maritime industries, but provides multiple coastal outlets and harbors protecting commercial and recreational boaters, and beaches to draw summer vacationers.



Wareham is approximately 46 square miles in area. The Town is located approximately 35 miles east of Providence and 43 miles south of Boston. Wareham is bordered by Marion, Rochester, Middleborough, Carver, Plymouth and Bourne (from west to east in a clockwise direction).

### **2.3 CLIMATE**

Wareham averages 51 inches of rain per year, with an additional average annual snowfall of 35 inches. Average temperatures range from highs in the low 80's (Fahrenheit) during the summer months to lows in the low 20's during winter months. Wareham's location along Buzzards Bay generally keeps temperatures cooler in the summer and warmer in the winter relative to other nearby inland communities at the same latitude.

### **2.4 NATURAL ENVIRONMENT**

Wareham's natural environment and natural resources are important to the Town's identity and quality of life. In fact, one of the most important factors in why people move to and visit Wareham is its natural environment and coastal features. The Town has a varied landscape, with large stretches of open space, forested land, and upland, as well as coastal salt marshes, sandy beaches and protected harbors. These natural resources support the economy through tourism and recreation, in addition to a variety of other ecosystem services, such as clean air and water. The natural environment also increases resiliency and reduces hazard impacts, through flood attenuation as wetland areas absorb flood waters, through stormwater management as rainwater drains through the soil, and through erosion control as vegetation secures soil along coastal banks and dunes.

### **2.5 LAND USE**

Throughout much of the 20<sup>th</sup> century, Wareham's economy and landscape was shaped by two major industries: summer tourism and cranberry growing. The first summer communities appeared in Onset Village in the late 1800s, and similar residential neighborhoods began to flourish after World War II. Many of Wareham's neighborhoods are currently densely developed, particularly the in near-coastal areas. At the same time the Town was becoming a summer tourist destination, 37 cranberry farmers had established productive bogs in Wareham by 1900. Cranberry growing remains an important part of the Town's economy and cranberry growers own and manage over 30 percent of Wareham's 29,940 acres of land.

Figure 2-1 depicts the 2018 assessor's parcel dataset categorized by land use. The largest category by area is residential land use (including single-family homes, multi-unit properties, residential/agricultural, and residential/open space) for a total of 24% of Wareham's total area. The next largest categories by area are vacant, industrial and agricultural, comprising 18%, 17% and 17% of Wareham's area, respectively. This categorization reflects the classifications used in the 2018 Wareham Master Plan Vision.



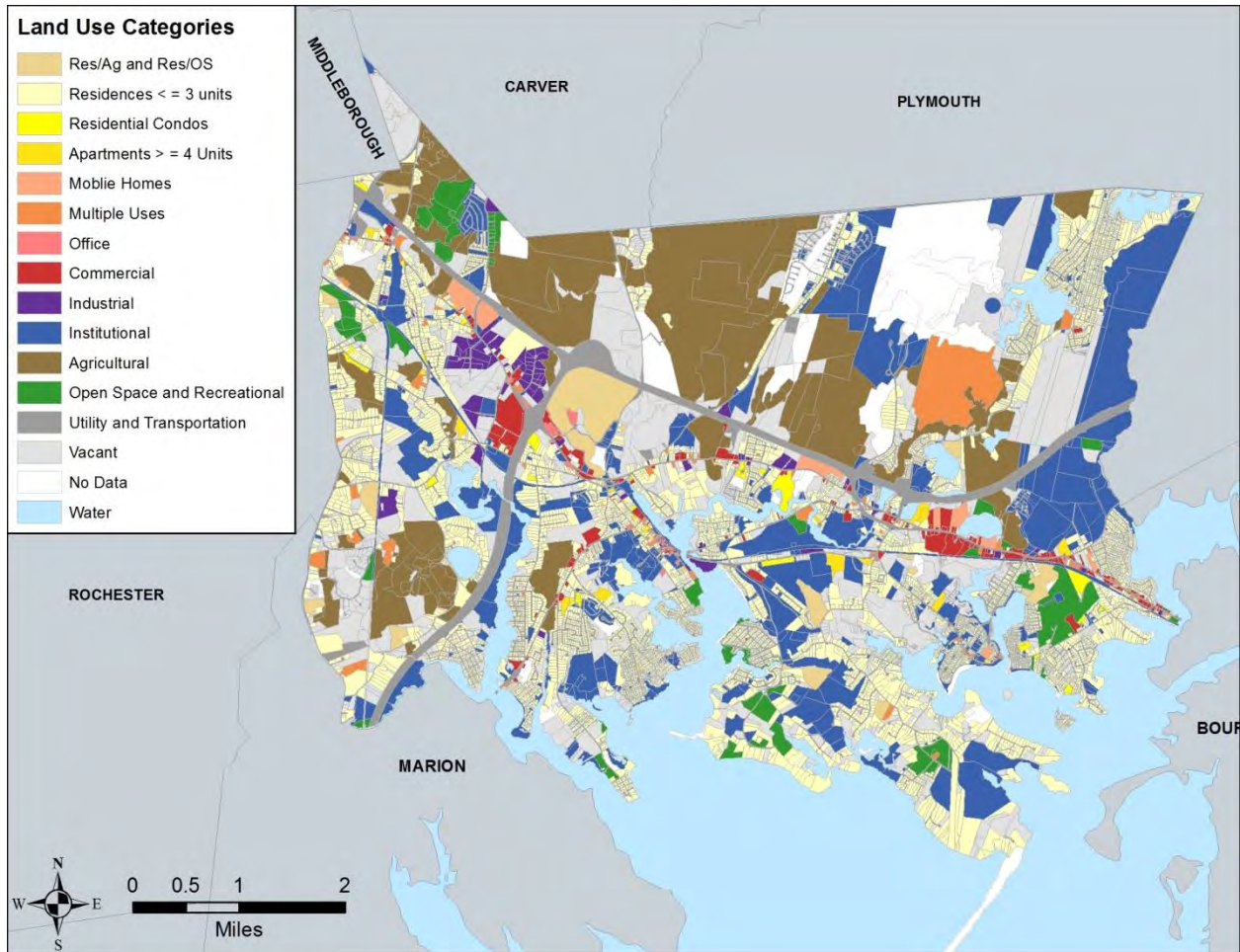


Figure 2-1. Town of Wareham land use categories (2018).

Table 2-1. Number of Parcels in Each Land Use Classification.

Land Use Type	Number of Parcels
Multiple Uses	208
Residences < = 3 units	9,898
Residential Condos	397
Apartments > = 4 Units	52
Mobile Homes	16
Office	71
Commercial	228
Industrial	117
Institutional	807
Res/Ag and Res/OS	17
Agriculture	122
Open Space and Recreation	87
Utility and Transportation	45



Vacant	2,498
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The 2018 Wareham Master Plan Vision also presented a Future Land Use Vision Map (Figure 2-2), that takes into account the various needs and goals of the Town. This future vision includes well-designed development within the context of Wareham’s small-town character, a variety of housing options, centralized commercial areas, and designed conservation and open space.

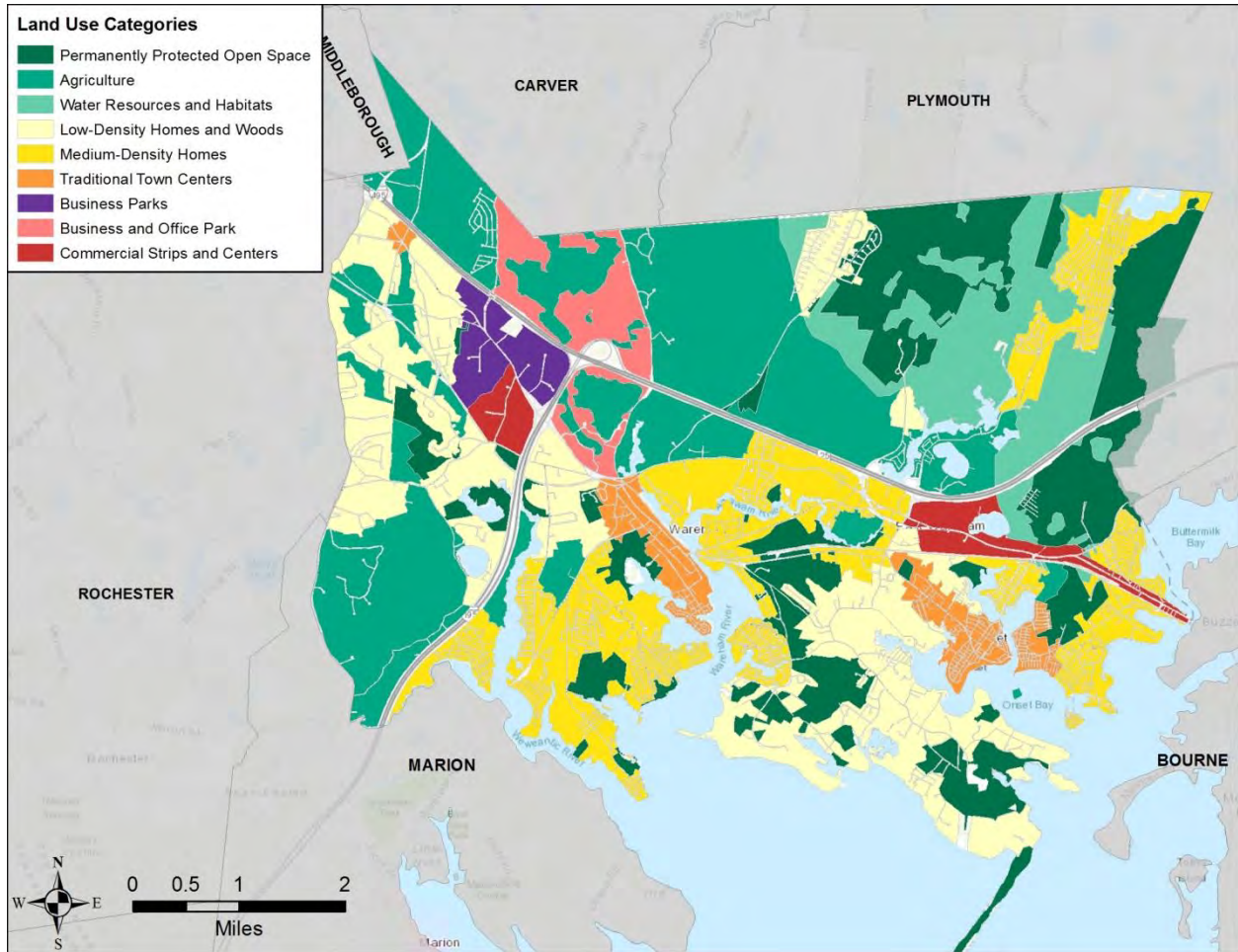


Figure 2-2. Town of Wareham Future Land Use Vision Map.

### 2.6 TRANSPORTATION

The Town of Wareham includes a number of major transportation corridors, including Routes 6, 25, 195 and 495. There are a series of bus routes through Wareham run by the Greater Attleboro Taunton Regional Transit Authority (GATRA), Wareham is also serviced seasonally by the MBTA train, with a station at Main Street, and another just over the border into Buzzards Bay.

### 2.7 CRITICAL FACILITIES

Critical facilities are those that are essential to the health and welfare of the Town and those that are especially important for response and recovery following hazard events. Critical facilities



include buildings and infrastructure such as emergency operations centers, critical municipal buildings, water and wastewater facilities, schools, churches, marinas, etc. The LPT developed a list of critical facilities, which is provided in [Appendix C](#). The critical facilities in Wareham are shown in Figure 2-3; the numbers correspond to the list in [Appendix C](#). Additional radio and emergency communication points were also included in the Wareham critical facilities list, but due to the sensitive nature of these assets, their locations are not included on the map in Figure 2-3. A portion of these critical facilities are located within high hazard areas, such as floodplains. However, due to the importance of these facilities, special care must be taken to ensure continued operation even during disaster events.

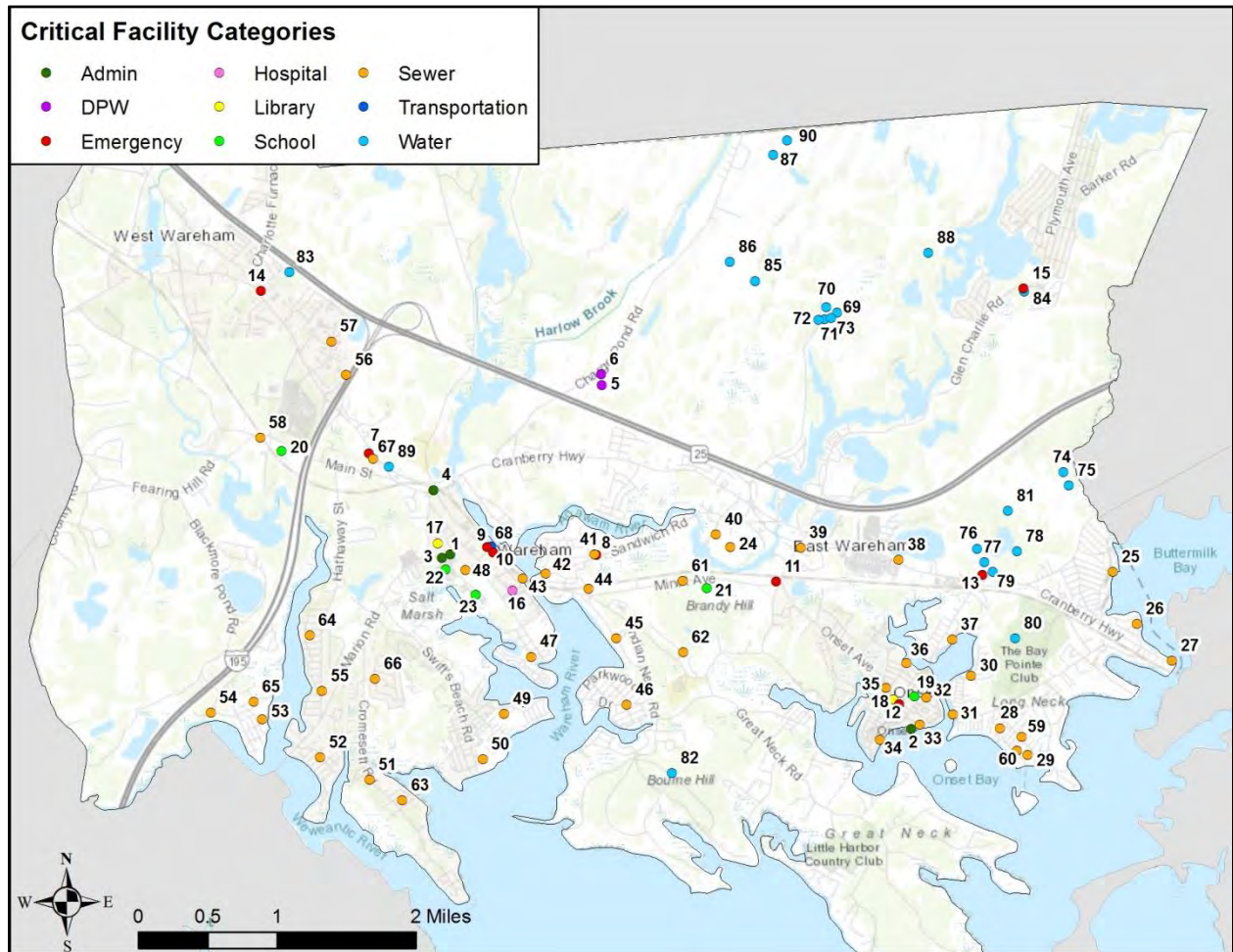


Figure 2-3. Wareham critical facilities map.

### 2.8 HISTORICAL PROPERTIES

The Wareham Historical Society owns and maintains five important historical structures. The buildings are located in the heart of Wareham’s historic center and include an extensive collection of artifacts and information about the Town’s past and some of its most illustrious citizens.





- 1) **Fearing Tavern Museum** – This Georgian Colonial house contains sections built in 1690, 1765, and 1820, and contains authentic 18th and 19th century furnishings, toys, tools, and decorative objects.
- 2) **Old Methodist Meeting House** - Built in 1835, and for a while was the only house of worship in Wareham.
- 3) **One-Room Schoolhouse** – Originally built in 1825, it served as a schoolhouse for eight grades of students for 100 years.
- 4) **Union Chapel** - Built around 1880 by the residents of the Great Neck neighborhood as a non-denominational place of worship for times when the weather made it difficult to travel to Wareham Center. The Wareham Historical Society has since moved the building to its present location next to the Schoolhouse and the Old Methodist Meeting House on Main Street.
- 5) **Captain John Kendrick Maritime Museum** - A gambrel roofed Cape style house built around 1745. The original paneling and other architectural features are intact, and inside are many items honoring the maritime history of Wareham.

## 2.9 REPETITIVE LOSS PROPERTIES

Repetitive Loss Properties are those for which two or more losses of at least \$1,000 each have been paid under the National Flood Insurance Program (NFIP) within any ten year period since 1978. As of 2019, the Town of Wareham has 19 Repetitive Loss Properties, two of which are Severe Repetitive Loss (SRL) properties. Twelve (12) are single-family residential, three (3) are multi-family residential, while four (4) are non-residential properties.



*Wareham is vulnerable to a wide range of natural hazards that can threaten the people, economy, infrastructure and natural resources of the Town. As suggested under FEMA planning guidance, the Town of Wareham reviewed the full range of natural hazards identified in the most recent Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2018), which included:*

- 1) Flooding
- 2) Coastal Erosion
- 3) Hurricanes and Tropical Storms
- 4) Severe Nor'easters
- 5) Severe Winter Weather (snow, blizzards, and ice storms)
- 6) Severe Weather (thunder-storms, wind, drought, extreme temperatures, and tornadoes)
- 7) Fire
- 8) Dam/Culvert Failure
- 9) Landslide
- 10) Earthquake
- 11) Tsunami
- 12) Invasive Species

*In addition to the hazards above, the Town of Wareham also included Culvert Failure and Water Quality as additional hazards. This chapter provides a description of each hazard, the location(s) within Wareham that are impacted by each hazard, previous occurrences of each hazard, the possible magnitude of each hazard, the probability of each hazard occurring in a given year, and some of the impacts that can happen in the event that hazard occurs.*



B1.a

FEMA defines a hazard as an act or phenomenon that has the potential to produce harm or other undesirable consequences to a person or thing. All natural disasters pose hazards to property, loss of human life, and have the ability to limit access to power, communication services, water, wastewater/collection/ treatment and transportation. Downed trees and limbs also limit emergency access and complicate cleanup efforts. Through the development of this Plan, Wareham is taking steps to protect its infrastructure from natural disasters as much as possible, such that essential utilities and services continue when most needed. Hazards associated with natural disasters typically encountered in Wareham include high winds, heavy rains, and coastal flooding and winter weather. Natural disasters occurring less frequently, such as tornadoes, earthquakes or brush/forest fires, pose less frequent but unique challenges.

The 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan identifies 14 natural hazards that could have an impact on communities in the Commonwealth of Massachusetts. These hazards are:

- |                                   |                                 |
|-----------------------------------|---------------------------------|
| 1) Inland Flooding                | 9) Average/Extreme Temperatures |
| 2) Coastal Flooding               | 10) Wildfire                    |
| 3) Coastal Erosion                | 11) Dam Failure                 |
| 4) Hurricanes and Tropical Storms | 12) Landslide                   |
| 5) Severe Winter Storm            | 13) Earthquake                  |
| 6) Other Severe Weather           | 14) Tsunami                     |
| 7) Drought                        | 15) Invasive Species            |
| 8) Tornadoes                      |                                 |

B1.b

As suggested under FEMA planning guidance (FEMA 2011), the Town of Wareham reviewed the full range of natural hazards identified in the 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan. Also, given some particularly problematic culverts in the Town, and the potential risk associated with their failure, culvert failure was also evaluated along with dam failure. The Local Planning Team (LPT) did not believe the topography in Wareham would be able to produce landslides, and as such, this hazard was not addressed directly in this plan. In addition to the 2018 State Plan, other resources consulted during the drafting of this plan included news articles and other media sources, and local knowledge from LPT members. All resources are referenced in the text of each hazard profile.

Hazards Addressed in Detail in the Wareham Multi-Hazard Mitigation Plan

- |                                |                        |  |
|--------------------------------|------------------------|--|
| 1. Flooding (Coastal & Inland) | 6. Tornado             | 11. Other Severe Weather<br><i>(Heavy Precipitation, Thunder/Lighting, Wind)</i> |
| 2. Coastal Erosion             | 7. Drought             | 12. Dam/Culvert Failure  |
| 3. Hurricane/ Tropical Storm   | 8. Extreme Temperature | 13. Water Quality  |
| 4. Severe Winter Weather       | 9. Earthquake          | 14. Tsunami  |
| 5. Wildfire                    | 10. Invasive Species   |  |



### 3.1 FLOODING (COASTAL & INLAND)

#### *Overview*

Flooding was one of the most prevalent natural hazards identified by the LPT in Wareham. Flooding can be caused by hurricanes, nor'easters, severe rainstorms, and thunderstorms. Sea-level rise also has the potential to exacerbate these flooding issues in the future.

The Town of Wareham is subject to two kinds of flooding: coastal flooding where wind, tides, waves and storm surge lead to flooding low lying coastal areas, and inland flooding where heavy precipitation overwhelms the capacity of natural and structured drainage systems to convey water away from roads and other areas of concern, causing it to overflow the system. Although the Town of Wareham experiences the majority of its flooding from coastal storm events, these two types of flooding are often related as inland flooding is prevented from draining by wind and tide driven coastal water. Both types of flooding can be caused by major storms, such as nor'easters and hurricanes. Nor'easters can occur at any time of the year but they are most common in winter. Hurricanes are most common in the summer and early fall. Due to Wareham's geographic position at the head of Buzzards Bay, the Town is somewhat protected from significant flooding impacts due to nor'easters, but is extremely vulnerable to the high storm surges that would result if a hurricane were to track up Buzzards Bay. Despite some geographical protection from nor'easters, these storms tend to cover a larger area than hurricanes and tend to last longer, resulting in storm conditions coinciding with at least one high tide – a combination that results in the most severe flooding. Large rain storms or snowfalls can also lead to inland flooding. See later sections for more specific details on these other natural hazards.

Most of the Town's rivers and waterways remain tidally influenced for their entire length such that inland flooding is closely tied to coastal flooding conditions. Much of this type of flooding is contained within existing wetland areas, reinforcing the need to protect and maintain these areas as a mitigation measure. High tides and coastal flooding can prevent water from draining out of the streams and stormwater conveyance systems. This can result in flooding that occurs well away from coastal areas.

Flooding due to storm run-off that overwhelms the carrying capacity of storm water infrastructure can be exacerbated by poor design or poor maintenance. Flooding from blocked drainage occurs in flat or depressional areas where runoff or rain collects, but cannot drain out. Drainage systems are made up of ditches, storm sewers, retention ponds and other infrastructure designed to transport storm water away from roadways and parking lots, to receiving streams, bays, and/or the ocean. Large storms can overwhelm these systems, and blocked or clogged drainage ditches and culverts can inhibit the flow of water, resulting in back-ups and ponding. Water will remain in an area until it infiltrates into the soil, evaporates, the blockage is cleared, or the water is actively pumped out.

Coastal flooding results from storm surge, which occurs when water is pushed onshore during powerful storms, such as hurricanes and nor'easters, can raise the water level by several feet. Storm surges are easily capable of inundating low-lying areas, and waves associated with coastal





storms can be highly destructive as they move inland, battering buildings, structures, and infrastructure in their path. However, the magnitude of flooding is strongly influenced by the tides; storm surge that occurs during a high tide will inundate a larger area than if the same surge occurs at low tide. A storm surge coinciding with a high tide event can devastate coastal features such as piers, floats, docks, and boats.



**Figure 3-1. Coastal flooding impacting Maco's Bait Shop during Hurricane Bob (1991).**

### *Hazard Location*

B1.c  
B2.a

Figure 3-2 shows the Effective 2014 FEMA Flood Insurance Rate Map (FIRM) for Wareham. These areas represent the risk of flooding from a 100-year storm. This map depicts the areas of Wareham in VE, AE, and A zones and within the 0.2% flood area (an area expected to be inundated during a 500-year storm event). The different FEMA flood zones are defined as follows:

- VE Zones, also known as the coastal high hazard areas, are defined by the 1% annual chance flood limits and wave effects 3 feet or greater. The hazard zone is mapped with base flood elevations (BFEs) that reflect the combined influence of stillwater flood elevations, primary frontal dunes, and wave effects 3 feet or greater.
- AE Zones, also within the 100-year flood limits, are defined with BFEs that reflect the combined influence of stillwater flood elevations and wave effects less than 3 feet. AO



Zones, representing coastal hazard areas that are mapped with flood depths instead of base flood elevations. Depths are mapped from 1 to 3 feet, in whole-foot increments.

- AO Zones, representing coastal hazard areas that are mapped with flood depths instead of base flood elevations. Depths are mapped from 1 to 3 feet, in whole-foot increments. These areas are generally located in areas of sheet flow and runoff from coastal flooding where a BFE cannot be established.
- A Zones are subject to inundation by the 1% annual chance flood event, but were determined using approximate methodologies. Because detailed hydraulic analyses have not been performed, no BFEs or flood depths are shown.

According to the 2016 Federal Emergency Management Agency (FEMA) Flood Insurance Study for Plymouth County, flooding in the Town of Wareham generally occurs along the Buzzards Bay coastline, usually as a result of the high tides and wave action associated with hurricanes and major storms. Approximately 35 percent of the Town's land area is located in FEMA Special Flood Hazard Areas (SFHA). Flooding in the Town of Wareham generally occurs along the Buzzards Bay coastline, usually as a result of the high tides and wave action associated with hurricanes and major storms.



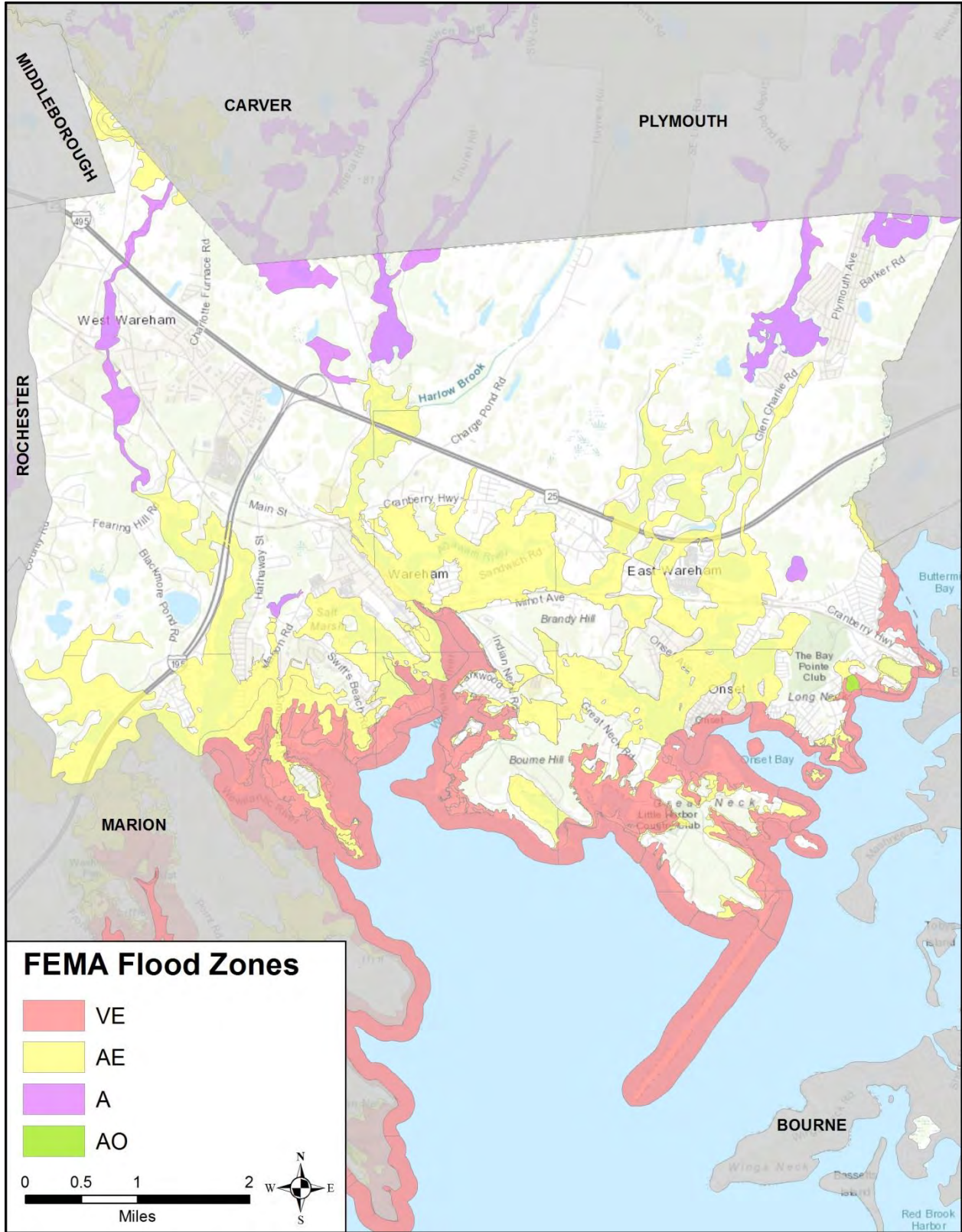


Figure 3-2. FEMA Special Flood Hazard Areas in Wareham (Effective 2016).





### *Previous Occurrences & Extent*

B1.c  
B2.a,c

Below is a list of major flooding events that have occurred in Wareham from between 2010 and 2019, from NOAA's NCEP Storm Events Database (NOAA 2019a), which lists a number of specific flooding incidents for Wareham:

July 13, 2011: A storm passed across southern New England producing heavy rain, thunderstorms and damaging winds. An underpass in Wareham was inundated with 2 feet of water. In addition, a vehicle became stuck in flood waters at the intersection of Cranberry Highway and Red Brook Road.

October 29-30, 2012: Coastal flooding associated with Hurricane Sandy required a person to be rescued from a house on East Boulevard. Pinehurst Beach was flooded. Sandwich Road from Narrows Road to Main Street was flooded and impassable. In Onset, Camp Street and North Boulevard were flooded. Inland, a microburst resulted in flash flooding, rendering Route 28 was flooded and impassable in front of the 99 Restaurant.

December 27, 2012: A low pressure coastal system brought a mixture of wintry precipitation and strong winds, resulting in minor coastal flooding.

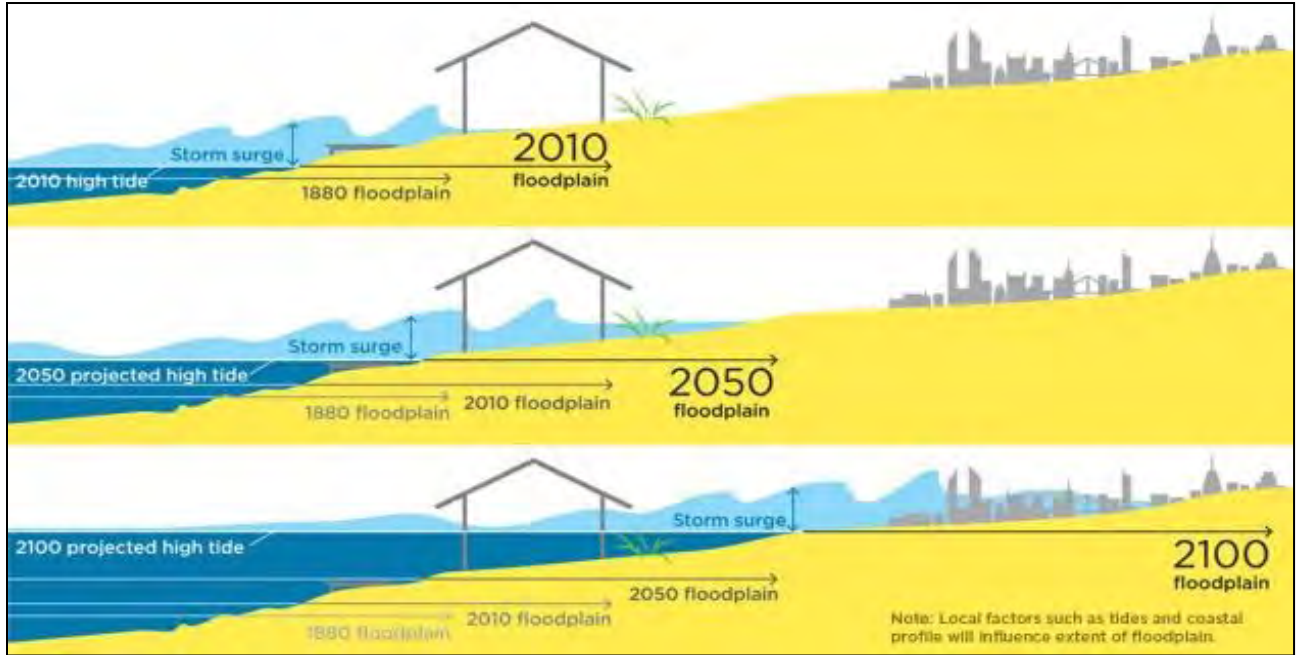
November 5, 2013: Heavy rain resulted in flooding of low lying and poorly drained areas. A foot of water flooded Route 28 near the Cranberry Plaza Shopping Center.

July 4, 2014: Torrential rainfall associated with Hurricane Arthur produced significant flash flooding in southeastern Massachusetts where rainfall totals of 4 to 8 inches were reported. Flooding resulting from this rainfall caused a vehicle to become stuck on Cranberry Highway.

May 30, 2016: Heavy rainfall in the morning and thunderstorms in the afternoon resulted in isolated flooding, including at the Main Street Bridge and along Cranberry Highway.

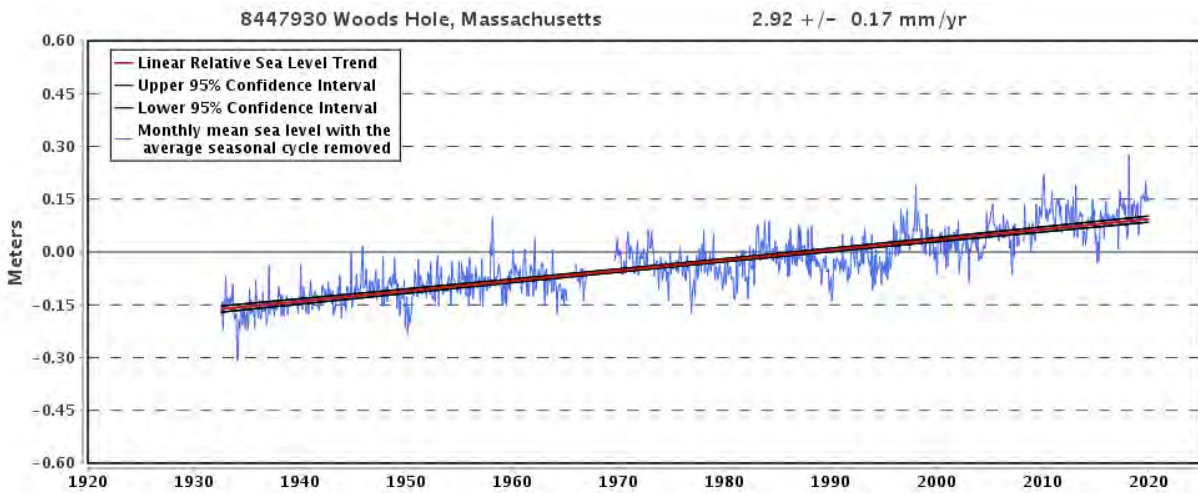
June 24, 2017: Remnants of Tropical Storm Cindy brought locally heavy downpours, causing a portion of Cranberry Highway to become impassible due to flooding.

The extent of flooding in the future, however, will impact a larger area of Wareham. Sea-level rise refers to the increase in mean sea level over time. Global mean sea level (MSL) has been rising since the end of the last ice age approximately 11,000 years ago. Recently, sea-level rise (SLR) rates have accelerated, with unprecedented rates along the northeastern U.S. since the late 19th century (Kemp et al., 2011). Global sea-level rise is driven by several factors, including thermal expansion of ocean water and freshwater inputs from melting glaciers. Because sea level sets a baseline for storm surge, sea-level rise will exacerbate already existing coastal flood issues. As local sea level rises, it allows coastal storm surge to extend farther inland. With the higher sea levels predicted in 2030, 2050 and 2070, areas much farther inland will be at risk of being flooded. Although sea-level rise plays a substantial role, local flooding also depends on tides, natural and artificial barriers, and the contours of the land along the coast (Figure 3-3).



**Figure 3-3. Sea-level rise magnifies the risks of storm surge and high tides (UCS 2015).**

The National Oceanic and Atmospheric Administration’s (NOAA) Center for Operational Oceanographic Products and Services maintains a series of tide gages along the coast of Massachusetts. Records from NOAA’s Woods Hole tide gage (station ID 8447930), indicate that our relative sea level has risen at a rate of 2.92 mm (+/- 0.17 mm) annually based on the monthly mean sea level between 1932 and 2019, resulting in a change of 0.96 feet (11.5 inches) in 87 years (Figure 3-4).



**Figure 3-4. Sea-level rise trend from Woods Hole, Massachusetts (NOAA, 2020a).**



Although the historical sea-level rise trend presented in Figure 3-4 is linear, this is not expected to continue. Global sea-level rise projections range from an additional 4.3 ft (under an intermediate sea level rise scenario) to 10.5 ft (under an extreme sea level rise scenario) by 2100.

The probability of inundation in present day, as well as in future outyears, along the entire Massachusetts coastline has been calculated through the Massachusetts Coast Flood Risk Model (MC-FRM), which was developed for the Massachusetts Department of Transportation (MassDOT) (Bosma, et al. 2019), and incorporated in the recent *Wareham Climate Change Flood Vulnerability Assessment and Adaptation Planning* (2020) project. The MC-FRM incorporates a full suite of processes that affect coastal water levels, including tides, waves, winds, storm surge, sea level rise, and wave set-up at a fine enough resolution to identify site-specific locations that may require adaptation alternatives. The MC-FRM provides fine-resolution data, and is also superior to a more rudimentary “bathtub” approach, since the latter does not account for critical physical processes that occur during a storm event, including waves and winds, nor can it determine the limited volume of water that may be able to enter certain areas, particularly those with narrow entry points.

The mean sea level in Wareham in the year 2000 was at an elevation of -0.30 feet (NAVD88). This starting elevation from 2000 can then be used to compare to projected relative mean sea-level elevations at future years under various scenarios. The data in Table 3-1 summarize the expected relative mean sea level elevations (relative to NAVD88) for various out-years under various sea-level rise scenarios. MassDOT chose to utilize the high sea level rise values as inputs to the MC-FRM; these values also correspond with the Massachusetts CZM recommendations for assessing sea-level rise. Note that the values in Table 3-1 are *elevations* of the projected mean sea level at various times relative to a vertical datum of NAVD88, not the *magnitude of change* in elevation. For comparison, the baseline (i.e., year 2000) mean sea level elevation, is -0.30 feet (NAVD88).

**Table 3-1. Relative mean sea level (feet, NAVD88).**

	2030	2050	2070	2100
Intermediate	0.7	1.4	2.3	4.0
Intermediate-High	0.8	1.7	2.9	5.0
High	1.2	2.5	4.3	7.8
Extreme	1.4	3.1	5.4	10.2

The results of the probabilistic flood risk maps developed as part of the *Wareham Climate Change Flood Vulnerability Assessment and Adaptation Planning* report are presented in Figures 3-5 and 3-6. The color-coded results in Figures 3-5 and 3-6 represent the percent chance of flooding in any given year due to the combined impact of sea-level rise and storm surge. For example, areas shaded light purple have a 5-10% chance of flooding. In other words, these areas will flood in a



10 to 20-year storm event. Similarly, areas shaded in yellow have a 0.2-0.5% chance of flooding (i.e., will flood in a 200 to 500-year storm event).

B2.b

**Probability**

Based on the frequency of past flooding occurrences described above, it is highly likely (near 100% probability in the next year) that flooding of some type will occur in Wareham.

B3.a

**Impact**

Below is a list of possible impacts for a flooding event in Wareham:

- **People:** People can be knocked down or washed off their feet while walking in floodwaters. Injury or death can result from people being trapped in their vehicles during a flood event. People can be displaced from their homes due to post-flood safety and health hazards. Also, intrusion of water into households can lead to health and respiratory issues caused by the development of mold and mildew issues.
- **Emergency Response:** Flooded roadways can inhibit emergency response access.
- **Infrastructure:** Flooding causes debris and sediment deposits on Town infrastructure and roads. Storm surges and associated waves can damage utility poles, roadways, water mains, sewer pipes and other Town infrastructure. Potential loss of potable drinking water in flooded areas due to the need to shut valves to protect the Town's drinking water supply.
- **Buildings:** Moving water associated with floods can damage buildings and other structures. Building foundations on or near the beach can be undermined by the velocity of floodwaters. Debris carried by flood waters can act as battering rams and damage buildings. Buildings can float off their foundations if not anchored properly. Basements can flood or can collapse due to external water pressure.
- **Economy:** Communication and infrastructure systems damaged during floods can disrupt economic activities and close businesses. Roadway disruptions due to flooding can reduce customer base. There can be economic losses associated with reduced value on coastal properties damaged by flooding.
- **Natural Systems:** Floods can deposit sediment and debris onto parks, beaches, marshes, and estuaries.
- **Transportation:** Floods can wash out bridges and culverts. Debris lodged in culverts can inhibit flow, causing additional flooding on the upstream side. There can be major disruptions to transit or ferry services.



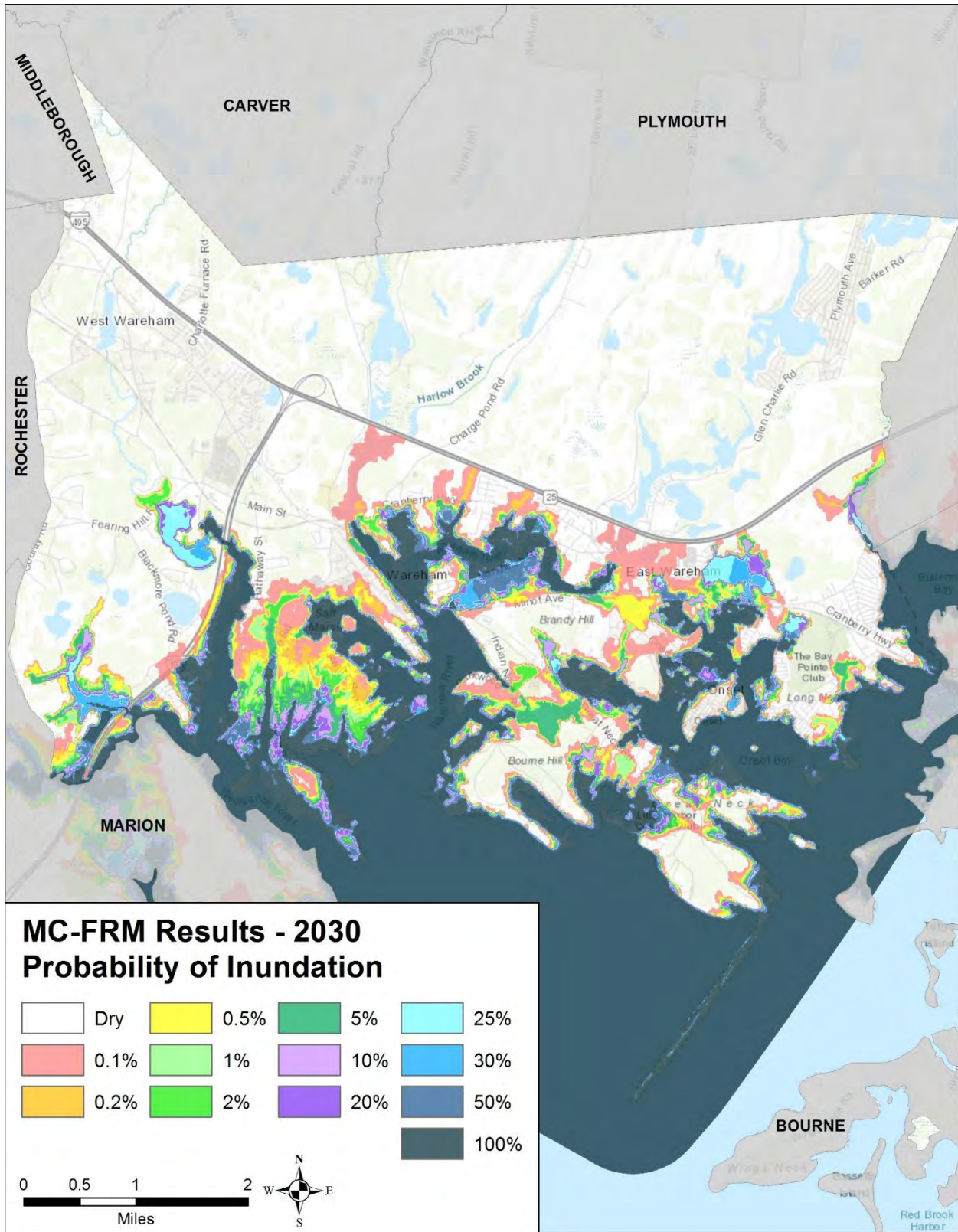


Figure 3-5. Probability of inundation in 2030 given assuming a high sea-level rise scenario (data from MC-FRM).

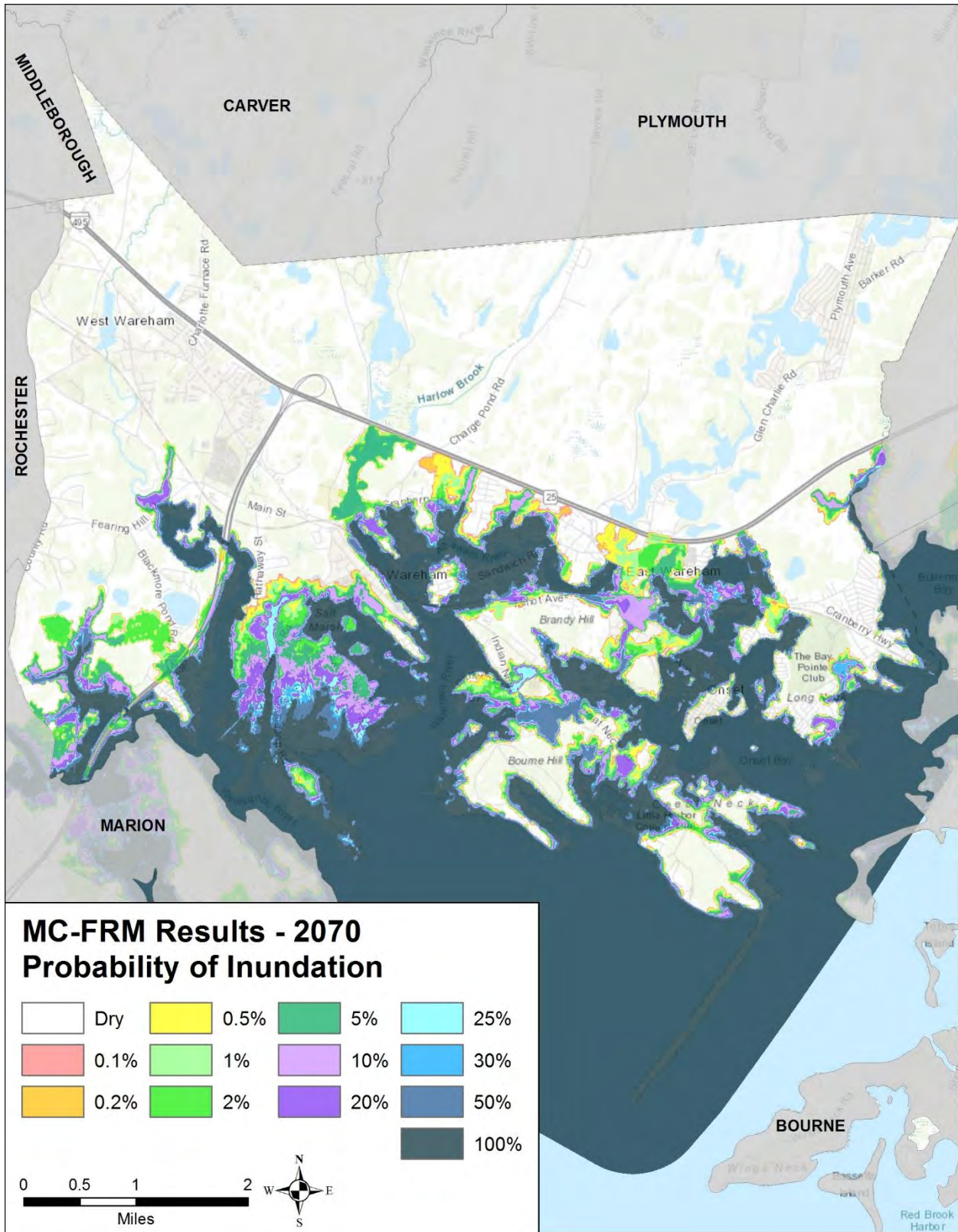


Figure 3-6. Probability of inundation in 2070 given assuming a high sea-level rise scenario (data from MC-FRM).





## 3.2 COASTAL EROSION

### Overview

Coastal shorelines—especially beaches, dunes and banks—change constantly in response to winds, waves, tides and other factors including seasonal variations, sea level rise and human alterations to the shoreline system. Every day, winds, waves and currents move sand, pebbles and other materials along the shore or out to sea. This dynamic and continuous process of erosion, sediment transport and accretion shapes the coastal shoreline. Shorelines change seasonally, tending to accrete gradually during the summer months when sediments are deposited by relatively low energy waves, and erode dramatically during the winter when sediments are moved offshore by high energy storm waves and currents, such as those generated by nor'easters.

B1.c  
B2.a

### Hazard Location

The Massachusetts Office of Coastal Zone Management (CZM) has documented the rate of change of all ocean-facing shorelines of Massachusetts through their Shoreline Change Project (Thieler, et al. 2013). Shorelines were delineated and evaluated to demonstrate trends from the mid-1800s to 2009. These data were then incorporated into MORIS, the Massachusetts Ocean Resource Information System, to provide better access to the shoreline change data and to allow the public to view the data using the online tool.

Figure 3-7 displays the long-term shoreline change data in Wareham from CZM's Shoreline Change Project. Long-term data ranges from 1895 to 2013 in Wareham. Rates shown in Figure 3-7 are in feet per year, where negative values indicate erosion and positive values indicate accretion. From these data, it is evident that the majority of the Town's coastline (95%) has been fairly stable over the long-term (1895 to 2013). Areas of more significant long-term erosion include Swifts Beach and the majority of Stony Point, while the Onset area and the northern end of Stony Point show a general accretionary trend in the long term. However, this erosion is often episodic, as a result of significant storm flooding and wave impacts, rather than continuous erosion.

The more recent rates of shoreline change, between 1978 and 2013, are shown in Figure 3-8. The erosion along Swifts Beach and Stony Point has decreased over the last couple decades. There are, however, isolated pockets of more significant erosion scattered across Town, including Long Beach, Great Neck, and Onset Bay, as indicated by the red and orange transects.



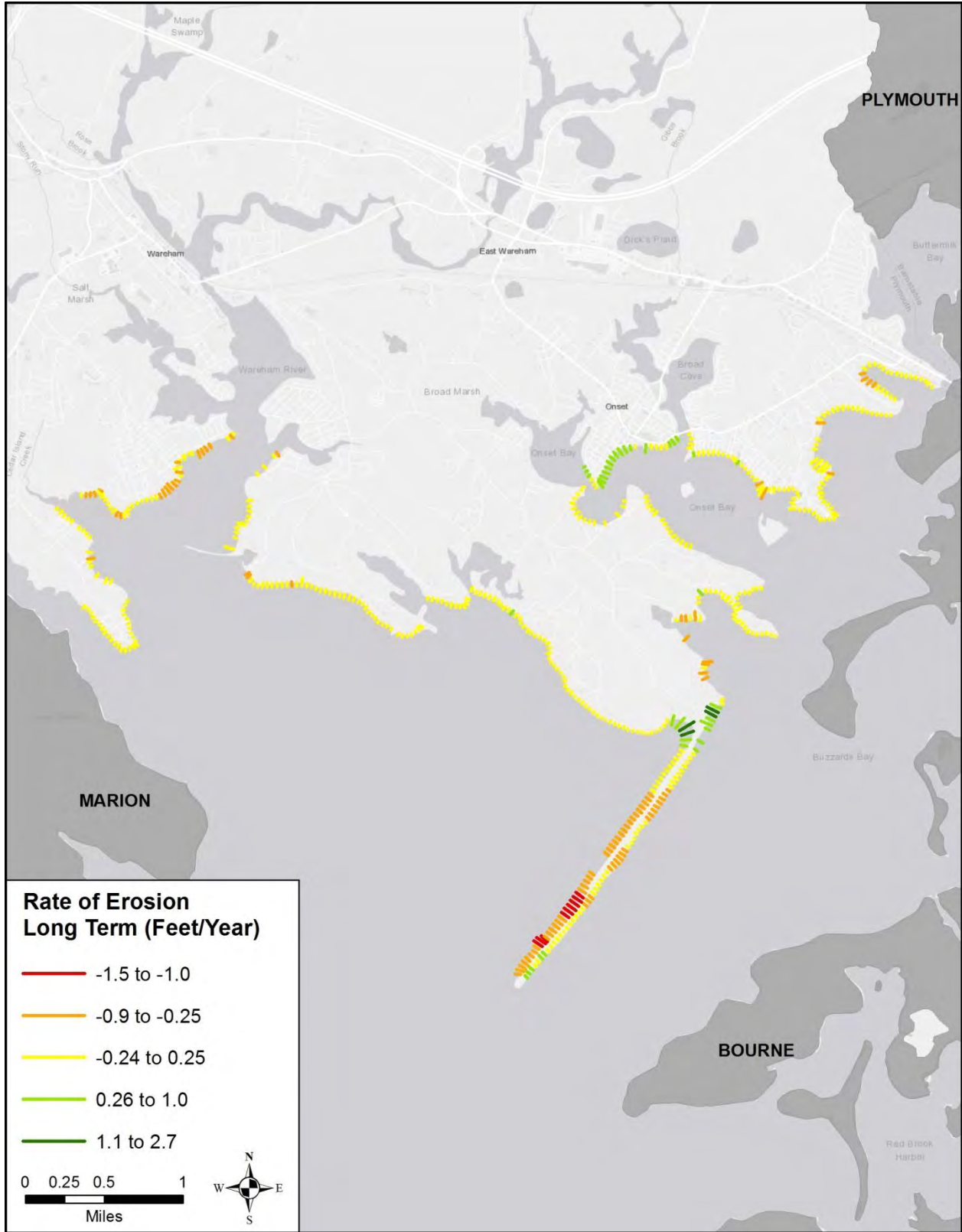


Figure 3-7. Long-term (1895 to 2013) rates of shoreline change (feet/year).

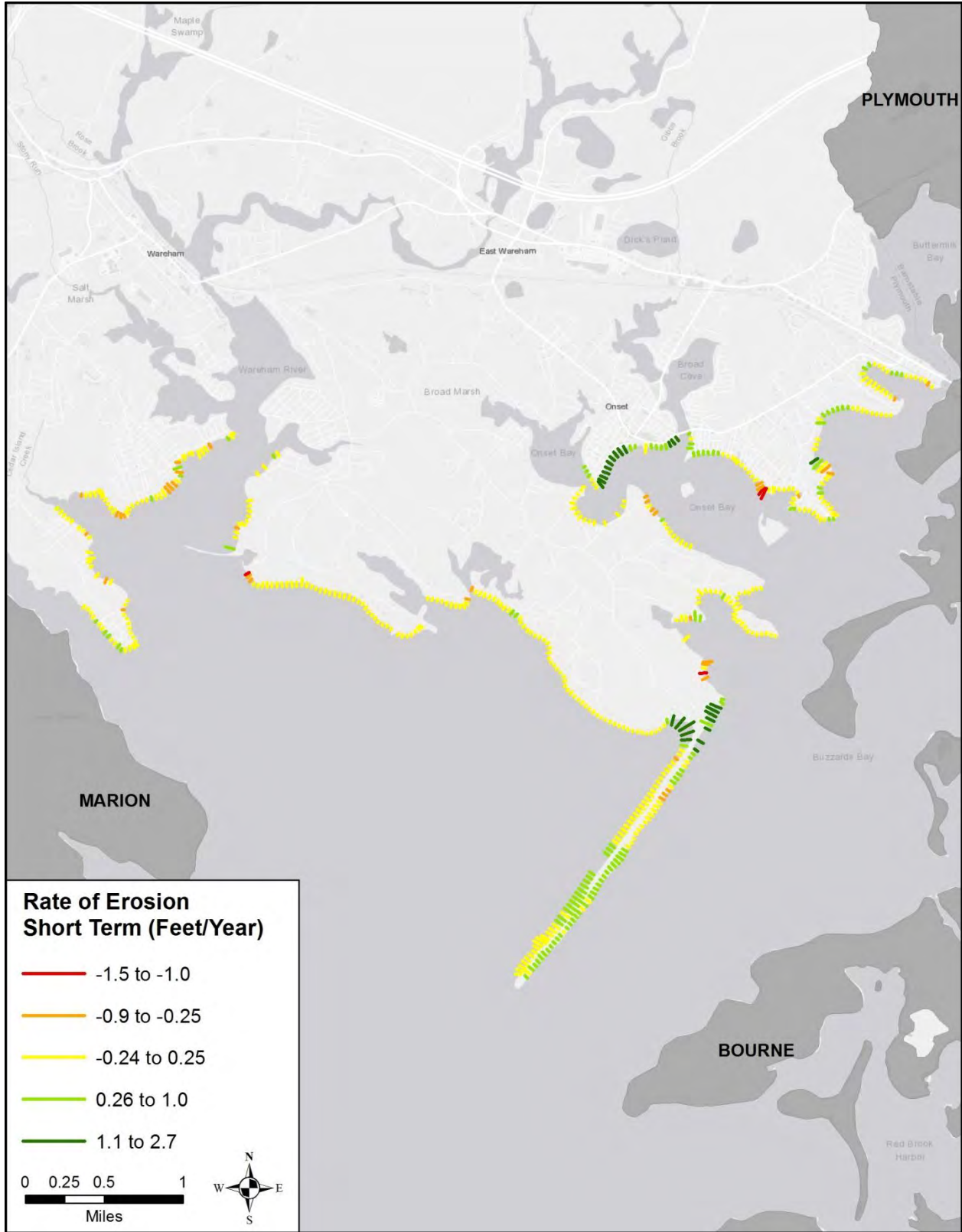


Figure 3-8. Short term (1978 - 2013) rates of shoreline change.



The Report of the Massachusetts Coastal Erosion Commission tabulated the average shoreline change rate, in feet/year, for all coastal communities (CEC 2015). The Coastal Erosion Commission calculated both short- and long-term average rates of change: the average short-term rate of change for the Wareham shoreline is 0.7 ft/yr, indicating minor accretion. The average long-term rate of change is -0.3 ft/yr, indicating minor erosion. These results are consistent with the data from CZM's Shoreline Change Project.

B1.c

B2.a,c

### *Previous Occurrences & Extent*

As shown in Figures 3-7 and 3-8, minor to moderate coastal erosion has occurred in Wareham in isolated locations. Most notably Stony Point, Swifts Beach, Onset Bay and Great Neck.

B2.b

### *Probability*

Based on the coastal erosion rates documented in the Massachusetts CZM Shoreline Change Project, it is highly likely (near 100% probability in the next year) that coastal erosion will occur in Wareham; although the magnitude of these events are likely to be largely minor to moderate.

B3.a

### *Impact*

Below is a list of possible impacts that could result from coastal erosion:

- **People:** Public safety is jeopardized when buildings and structures collapse due to coastal erosion.
- **Emergency Response:** Erosion can collapse or damage roadways, which would reduce the response time of emergency vehicles.
- **Infrastructure:** Erosion can expose septic systems, and break sewer pipes and water mains. Accreting sand can block outfall pipes, causing drainage issues and exacerbating flooding.
- **Buildings:** Erosion can undermine the foundations of buildings, making them more susceptible to settlement, lateral movement, or overturning. Buildings and debris from buildings that are damaged due to coastal erosion can be swept out to sea. Seawalls and other hard structures installed to reduce the effect of coastal erosion in one location can cause sediment losses at a downdrift area, affecting additional properties.
- **Economy:** Coastal erosion can adversely impact businesses if a business's building is damaged by erosion. Relocation costs would be an additional economic burden to anyone forced to move to avoid coastal erosion impacts.
- **Natural Systems:** If engineered structures are used to stabilize shorelines, the natural process of erosion is altered, changing the amount of sediment available and the erosion rates at adjacent areas. The Town's natural ecosystem attractions (i.e. beaches, dunes, salt marshes and estuaries) would also be threatened as sand sources that supply and sustain them are eliminated.
- **Transportation:** Roadways can become damaged through erosion.



### 3.3 HURRICANES & TROPICAL STORMS

#### Overview

A tropical cyclone is a rotating, organized system of clouds and thunderstorms that originates over tropical or subtropical waters. The hurricane season for the Atlantic Ocean extends from June 1st to November 30th, with the peak from mid-August to late October. However, deadly hurricanes can occur anytime during the hurricane season. Tropical cyclones are classified as follows (NHC 2016a), depending on their intensity:

- **Tropical Depression:** A tropical cyclone with maximum sustained winds of 38 mph (33 knots) or less.
- **Tropical Storm:** A tropical cyclone with maximum sustained winds of 39 to 73 mph (34 to 63 knots).
- **Hurricane:** A tropical cyclone with maximum sustained winds of 74 mph (64 knots) or higher. In the western North Pacific, hurricanes are called typhoons; similar storms in the Indian Ocean and South Pacific Ocean are called cyclones.
- **Major Hurricane:** A tropical cyclone with maximum sustained winds of 111 mph (96 knots) or higher, corresponding to a Category 3, 4 or 5 on the Saffir-Simpson Hurricane Wind Scale.

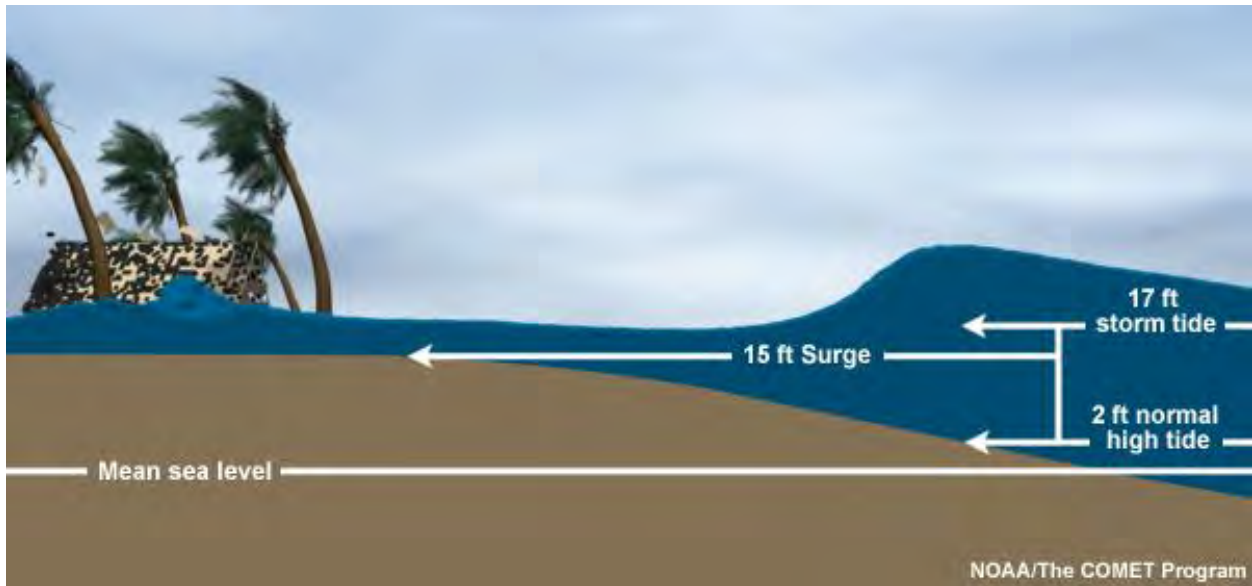
Hurricanes are typically fast-moving storms (typically lasting 6 to 12 hours) with high winds in excess of 74 miles per hour and torrential rains averaging 6 to 8 inches, but possibly dropping as much as 15 to 20 inches of rainfall during a single event

#### Hazard Location

The entire Town of Wareham is vulnerable to hurricanes and tropical storms. Coastal areas are extremely susceptible to damage due to a combination of wind and storm surge. However, even inland areas can be affected by the flooding, strong winds and heavy rains associated with these events. Storm surge occurs when water is pushed towards shore by storm generated winds. Storm surge combines with the water elevation, which can substantially increase water levels. In addition, wind generated waves are superimposed on the storm surge. This rise in water level can cause severe flooding in coastal areas, especially when a storm surge coincides with a high tide. Figure 3-9 depicts the components of storm surge.

The US Army Corps of Engineers (USACE) New England Division, in cooperation with FEMA, prepared Sea, Lake and Overland Surge from Hurricanes (SLOSH) inundation maps. SLOSH maps show the extent of potential flooding from worst-case combinations of hurricane direction, forward speed, landfall point, and high astronomical tide. However, the model considers only storm surge height and does not consider the effects of waves. When selecting model parameters, the USACE considered the highest wind speed for each category, the highest surge level, and the worst-case forward motion of the storm to develop a “worst case” scenario. The resulting inundation areas are grouped in Category 1, Category 2, Category 3, and Category 4. Figure 3-12 shows the SLOSH results for Wareham.





**Figure 3-9. Schematic image of a storm surge and storm tide affecting a shoreline (NHC 2016c).**

### ***Previous Occurrences & Extent***

A hurricane has not made landfall in Massachusetts for almost 30 years (Hurricane Bob in 1991), and it has been more than 60 years since a major hurricane (Category 3 or higher) has occurred. The most treacherous storms in the Town's history include Hurricanes Carol and Edna in 1954 and the Great New England Hurricane of 1938 (Figure 3-10). Though not as severe as the previous events, Hurricane Bob caused significant damage to a number of Wareham neighborhoods (Figure 3-11). Many of the areas that were hardest hit during Bob have continued to be developed and have been significantly built out since then. In a future storm of similar magnitude, a forced evacuation would be met with automobile congestion and difficulty for some residents in getting out of harm's way, particularly as many neighborhoods have a single point of entry and exit.

Smaller tropical storms and depressions have affected the area, generally inflicting minor damage, such as downed tree limbs, power outages, and limited damage to boating-related infrastructure. Table 3-2 provides a summary of historic hurricanes that have impacted the Massachusetts. However, due to the large diameter of many hurricanes and tropical storms, and the far reaching effects of storm surge, even storms that don't make landfall in New England can have significant hazard impacts on Massachusetts, and on Wareham. To illustrate the frequency of these storms, Figure 3-13 shows all hurricanes and tropical storms that have passed within 100 miles of Wareham, with the bold lines representing storms that occurred between 1950 and 2019. Note that although major hurricanes (H1 = Category 1, H2 = Category 2, etc.) occur approximately once every ten or twenty years in Massachusetts (Table 3-2), tropical storms (TS) tropical depressions (TD), and extra tropical storms (ET) (represented by the green, blue and gray lines in Figure 3-13) are relatively common, occurring every few years.



Figure 3-10. Impacts to the Narrows from the Hurricane of 1938 (left) and to a private home from Hurricane Edna in 1954 (right).



Figure 3-11. Impacts to the homes and roadways in the Swifts Beach area (left 2 photos) and to boats in Onset Harbor (right) during Hurricane Bob in 1991.



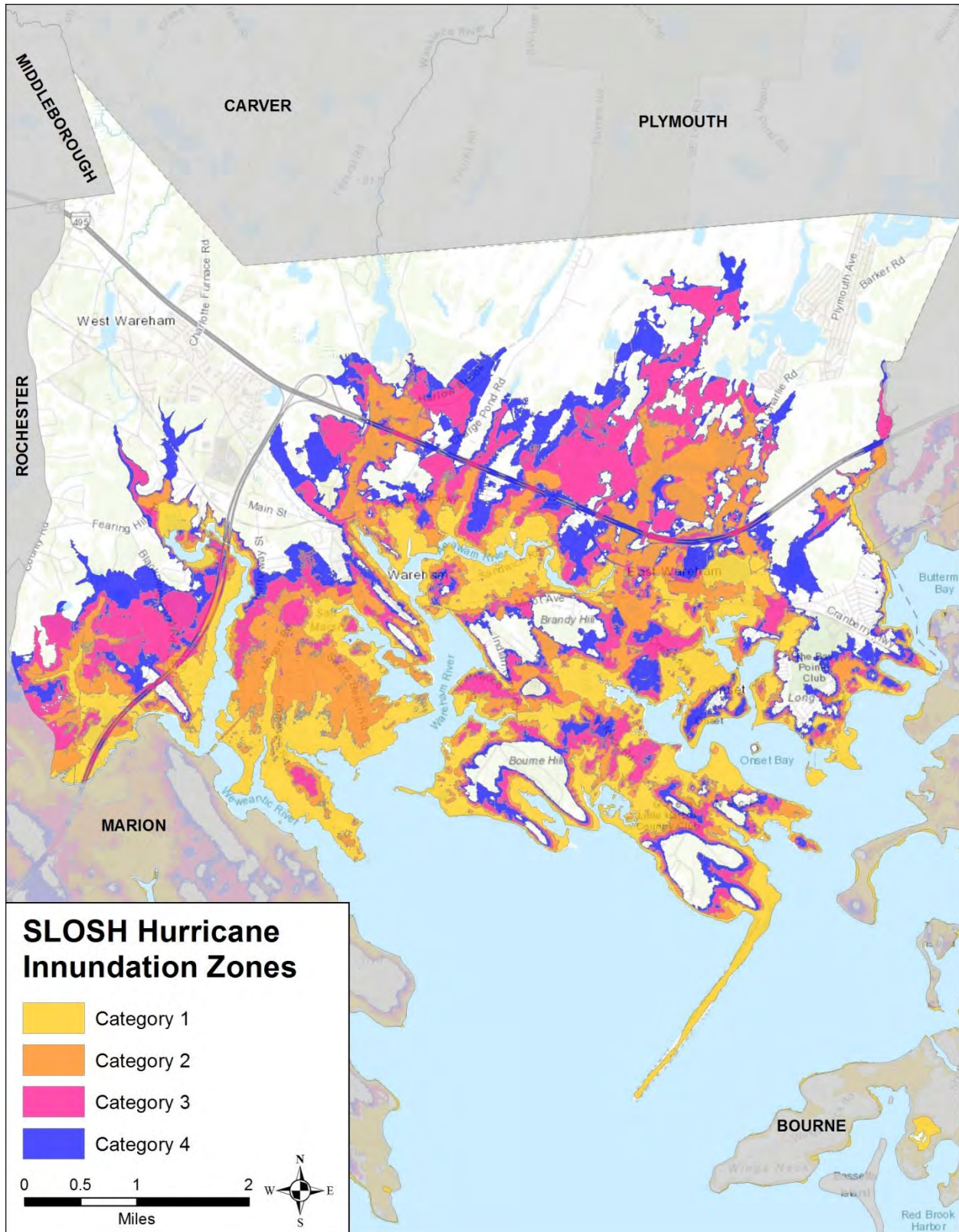
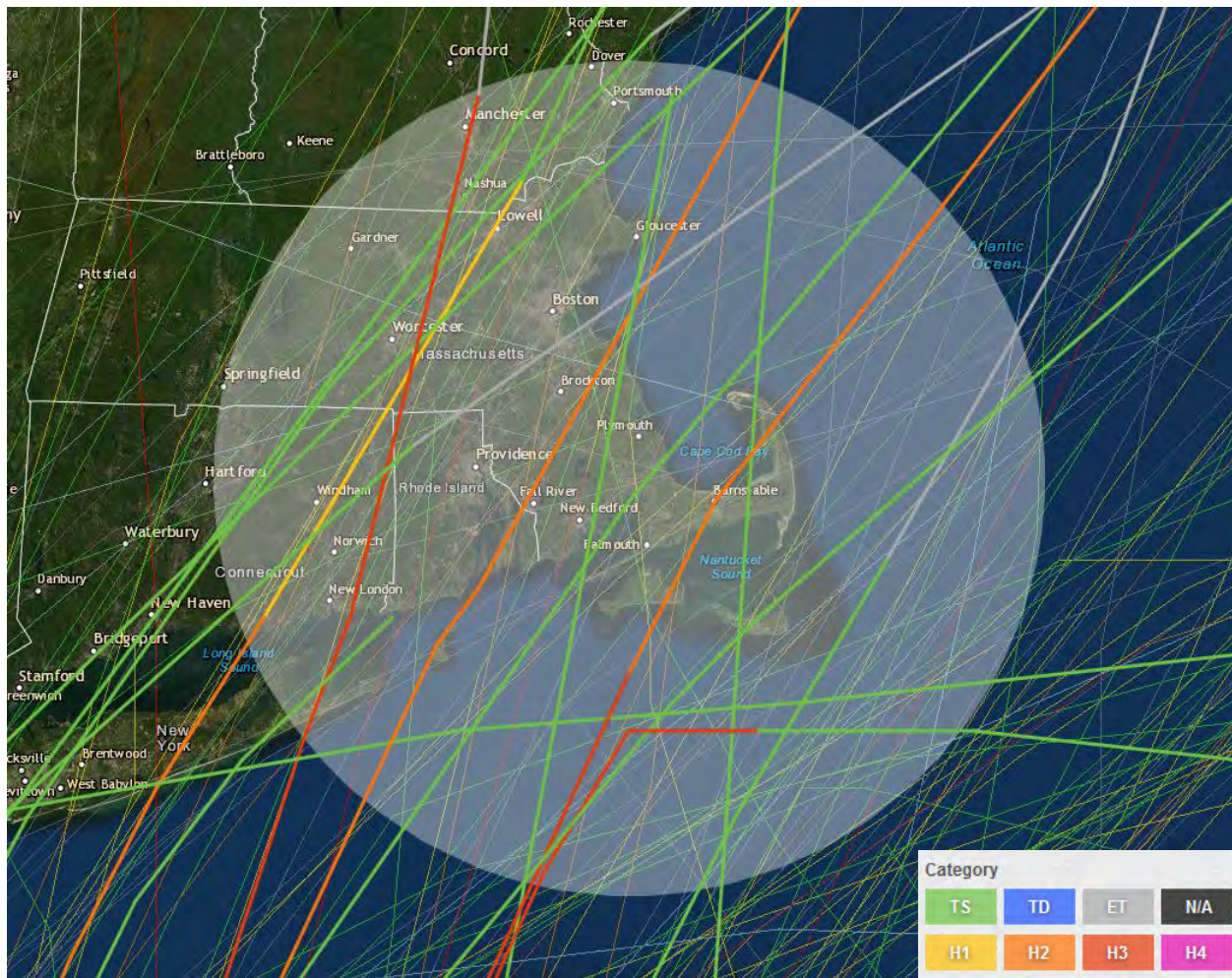


Figure 3-12. SLOSH Categories for Wareham.



**Table 3-2. Massachusetts hurricanes since 1938.**

Date	Name	Intensity (in MA)
August 19, 1991	Hurricane Bob	Category 2
September 27, 1985	Hurricane Gloria	Category 1
September 12, 1960	Hurricane Donna	Category 2
September 11, 1954	Hurricane Edna	Category 1
August 31, 1954	Hurricane Carol	Category 3
September 15, 1944	Great Atlantic Hurricane	Category 3
September 21, 1938	Great New England Hurricane	Category 3



**Figure 3-13. Hurricane and tropical storm tracks in the within 100 miles of Wareham (NOAA, 2020b). Bold lines represent storms between 1950 and 2019.**

The Saffir-Simpson Hurricane Wind Scale is often used to classify tropical cyclones. The Saffir-Simpson Scale, described in Table 3-3, outlines a rating system from 1 to 5 based on the hurricane’s sustained wind speed. This scale is then used to estimate potential property damage.



Hurricanes classified as a Category 3 or higher are considered major hurricanes due to their potential for devastating or catastrophic damage and loss of life.

Table 3-3. Saffir-Simpson Hurricane Wind Scale (NHC 2016b).

Category	Sustained Winds	Types of Damage Due to Hurricane Winds
1	75-95 mph 64-82 kt 119-153 km/h	<b>Very dangerous winds will produce some damage:</b> Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days
2	96-110 mph 83-95 kt 154-177 km/h	<b>Extremely dangerous winds will cause extensive damage:</b> Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3 (major)	111-129 mph 96-112 kt 178-208 km/h	<b>Devastating damage will occur:</b> Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4 (major)	130-156 mph 113-136 kt 209-251 km/h	<b>Catastrophic damage will occur:</b> Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5 (major)	157 mph or higher 137 kt or higher 252 km/h or higher	<b>Catastrophic damage will occur:</b> A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

**Probability**

B2.b

Based on the hurricane and tropical storm frequency documented in this section, it is likely (between 10 and 100% probability in the next year) that a hurricane or tropical storm will impact Wareham in the next year.

**Impact**

B3.a

Below is a list of possible impacts that could result from a hurricane or tropical storm:

- **People:** Public safety is jeopardized when buildings and structures collapse due to coastal erosion, downed trees land on buildings or cars, or emergency response is blocked by flooded roadways.
- **Emergency Response:** Heavy rains and flooding associated with hurricanes and tropical storms, as well as downed trees and branches caused by the high winds, can reduce the response time of emergency vehicles, or block access entirely.
- **Infrastructure:** High winds, heavy rains and coastal storm surge can cause widespread power outages, limit access to other utilities such as drinking water and communications, and limit transportation. A significant hurricane could also wellfields and wells, disrupting drinking water supply.
- **Buildings:** High coastal winds and storm surge can cause substantial damage to homes and businesses, and devastate coastal infrastructure such as marinas.
- **Economy:** Hurricanes and/or tropical storms can adversely impact businesses if a business's building is damaged by the storm, or if utilities or road access are affected.
- **Natural Systems:** Storm surge and wave action often associated with hurricanes and tropical storms can cause coastal erosion, potentially harming the Town's natural ecosystem attractions (i.e. beaches, dunes, barrier beaches, salt marshes and estuaries). Over time, coastal erosion can reduce the ability of coastal landforms to provide storm damage and flooding protection.
- **Transportation:** Roadways can become damaged through shoreline erosion or be made impassible due to flooding.



Figure 3-14. Wind-damaged home during Hurricane Edna (1954).





### 3.4 SEVERE WINTER WEATHER (SNOW/BLIZZARD/ICE STORM/NOR'EASTER)

#### *Overview*

Snow storms and blizzards are common events in New England. These storms are often high duration events with significant winds and heavy snowfall. The majority of blizzards and ice storms in the region cause more inconvenience than they do serious property damage, injuries, or deaths. Sleet and ice storms result when temperatures are appropriate for precipitation to fall as frozen or mostly frozen raindrops, or liquid rain that freezes upon contact with structures and objects on the ground. Travel is often limited and disruptions to power and other utility delivery are a high potential. Coastal flooding can occur during these events, especially with westerly winds. However, periodically, a storm will occur which is a true disaster, and necessitates intense large-scale emergency response. On average Wareham receives 35 inches of snow per year.

In addition to many of the same hazards posed by other natural disasters, winter storms have the added hazard associated with cold weather for prolonged periods of time. Unlike disasters occurring during the summer months such as hurricanes, power outages may result in extended periods of no heat. Prolonged contact with low temperatures can cause pipes to freeze and burst, damaging homes and businesses. Winter storms pose additional health problems with the added strain of exposure to freezing temperatures, especially for the elderly.

A nor'easter is a particular kind of cyclonic winter storm that moves along the east coast of North America, from south to north; once these storms reach New England, they often intensify. It is called a nor'easter because the winds associated with the storm blow from a northeasterly direction. Sustained wind speeds of 20 to 40 mph are common during a nor'easter, with gusting often reaching 50 to 60 mph. In some cases the wind speed may actually meet or exceed hurricane force. The storm radius of a nor'easter can be as much as 1,000 miles, and the storm is often accompanied with heavy rain and/or snow, depending on temperature. Most nor'easters bring both storm surge and high winds to the coast of Massachusetts, making the coastline particularly vulnerable to erosion and flooding.

B1.c  
B2.a

#### *Hazard Location*

The entire Town of Wareham is at risk from severe winter weather. The Northeast Regional Climate Center has compiled 30-year annual snow totals in New England and the eastern United States. Based on this data, between 1981 and 2010, the Wareham area averaged 20 to 40 inches of snowfall annually between 1981 and 2010 (Figure 3-15). Despite relatively low average annual snowfall, Plymouth County has still had 9 FEMA Declared Disasters between 1953 and 2017 (Figure 3-16).



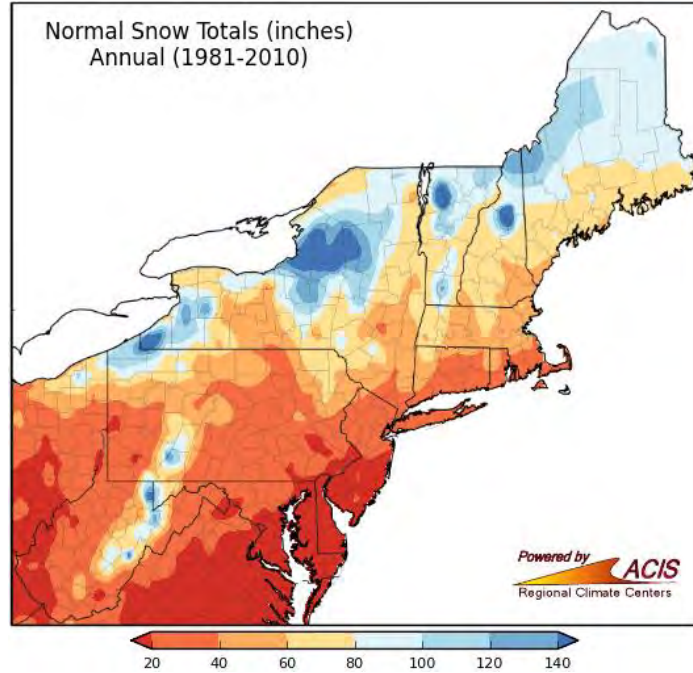


Figure 3-15. Annual average snow totals for New England between 1981 and 2010.

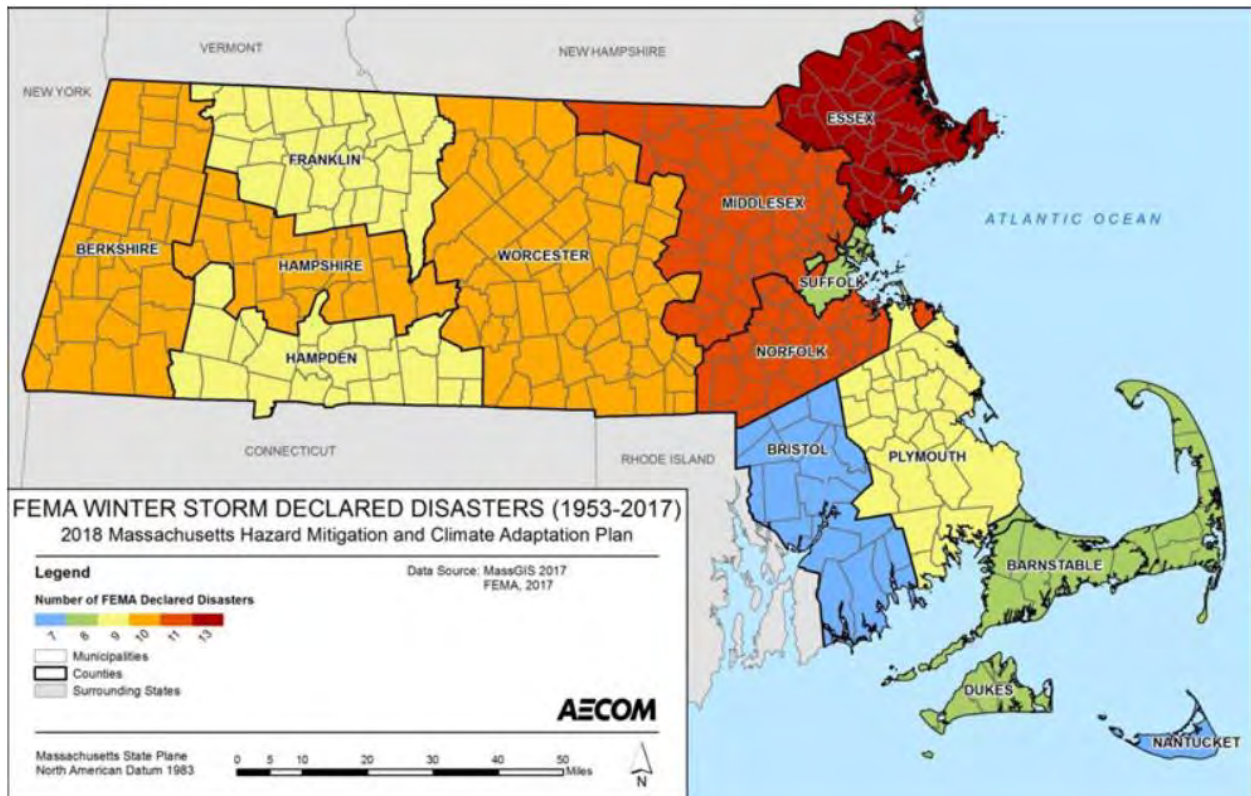


Figure 3-16. FEMA winter storm-related disasters by county (1953-2017) (from 2018 State Hazard Plan).

B1.c  
B2.a,c

### *Previous Occurrences & Extent*

Winter storms occur quite frequently, but due to preparation by the Town and its residents, typically amount to no more than a minor inconvenience. School delays and slow travel occur but crippling winter storms are a rarity. However, they do occur. The most severe winter storm to ever hit New England was the Blizzard of 1888, which occurred in March of that year. Snow accumulations reached 30 to 50 inches where precipitation was entirely snow. Boston received a mix of snow and rain creating up to nine inches of slush. The Blizzard of 1978 resulted in 24 to 38 inches of snow across New England, immobilizing the infrastructure and blocking major highways, and causing thousands of motorists to abandon their cars on the road. Two weeks were required to remove the snow. The Blizzard of 1978 resulted in a federal disaster declaration for many counties in Massachusetts. More recent blizzards and snowstorms occurred in March 1993, February 1996, March 2001, January 2005, February 2013 (Winter Storm Nemo) and January 2015 (Winter Storm Juno).

Winter Storm Juno, in January 2015 was a powerful nor'easter that impacted the northeast. A state of Emergency was declared in Massachusetts and travel bans were issued in preparation for the storm. The storm produced winds that gusted to 75 mph, a rain/snow mix that resulted in 15 to 18 inches of snowfall, coastal flooding that caused erosion in many areas across the state, and multi-day loss of electricity for many properties. This nor'easter resulted in a federal disaster declaration for many counties in Massachusetts, including Plymouth County (FEMA DR-4214). Table 3-4 below provides a list of major winter storms in New England from 2009 to 2019.

The Northeast Snowfall Impact Scale (NESIS) was developed by the National Weather Service to characterize and rank high-impact Northeast snowstorms. A "High-impact" snowstorm is one that produces large areas of 10 inch snowfall accumulations or greater. The NESIS has five categories: Notable, Significant, Major, Crippling, and Extreme (Table 3-5). This index differs from other meteorological indices, however, because it uses population information in addition to meteorological measurements; the NESIS gives a ranking to the societal impacts of a storm. NESIS values are a function of the area affected by the snowstorm, the amount of snow, and the number of people living in the path of the storm. The largest NESIS values result from storms producing heavy snowfall over large areas that include metropolitan centers. These values are then converted into one of the five NESIS categories (NOAA 2019b).

**Table 3-4. Major winter storms in New England (2009 to 2019).**

Date	NESIS	Cat	Description
Mar 1-3, 2009	1.59	1	Notable
Dec 18-21, 2009	3.99	2	Significant
Feb 4-7, 2010	4.38	3	Major
Feb 9-11, 2010	4.1	3	Major
Feb 23-28, 2010	5.46	3	Major
Dec 24-28, 2010	4.92	3	Major
Jan 9-13, 2011	5.31	3	Major
Jan 26-27, 2011	2.17	1	Notable
Feb 1-3, 2011	5.3	3	Major
Oct 29-30, 2011	1.75	1	Notable
Feb 7-10, 2013	4.35	3	Major
Mar 4-9, 2013	3.05	2	Significant
Dec 13-16, 2013	2.95	2	Significant
Dec 30, 2013 - Jan 3, 2014	3.31	2	Significant
Jan 20-24, 2014	1.26	1	Notable
Jan 29-Feb 4, 2014	4.08	3	Major
Feb 11-14, 2014	5.28	3	Major
Nov 26-28, 2014	1.56	1	Notable
Dec 9-14, 2014	1.49	1	Notable
Jan 25-28, 2015	2.62	2	Significant
Jan 29-Feb 3, 2015	5.42	3	Major
Feb 8-10, 2015	1.32	1	Notable
Jan 22-24, 2016	7.66	4	Crippling
Mar 12-15, 2017	5.03	3	Major
Jan 3-5, 2018	1.71	1	Notable
Mar 5-8, 2018	3.45	2	Significant
Mar 11-15, 2018	3.16	2	Significant
Mar 20-22, 2018	1.63	1	Notable

**Table 3-5. NOAA's Northeast Snowfall Impact Scale (NESIS).**

Category	NESIS Value	Description
1	1 – 2.499	Notable
2	2.5 – 3.99	Significant
3	4 – 5.99	Major
4	6 – 9.99	Crippling
5	10+	Extreme



B2.b

**Probability**

Based on the snow frequency of occurrence recorded from past events, it is highly likely (near 100% probability in the next year) that snow will occur in Wareham.

**Impact**

B3.a

Below is a list of possible impacts that could result from severe winter weather:

- **People:** Walking and driving can become extremely dangerous due to icy roads and sidewalks, snow accumulation, and low visibility. Poor driving conditions often require people to shelter in place, and loss of utility function can result in dangerous conditions during extreme cold temperatures associated with snow events. Injury is also possible from slipping on ice, overexertion from shoveling, and frostbite.
- **Emergency Response:** Snow, icy roads, and trees felled by storm conditions can reduce emergency vehicle response time.
- **Infrastructure:** Culverts and roads can be washed out during a heavy flow after a snowmelt. Ice and heavy snowfall can impact and cut off utilities, such as heating, power, and communication services, for several hours or days. Water pipes can burst due to extreme cold temperatures. Utility outages can result from nor'easters.
- **Buildings:** Buildings and roofs can experience structural failure as a result of heavy snow loads.
- **Economy:** Poor driving conditions and closed roads prohibit businesses from opening and people from going to work. Heavy snowfalls result in increased cost to the Town for plowing, snow removal, and treatment of roads. Utility outages and damaged buildings can result in loss of business function.
- **Natural Systems:** Snow and ice accumulation can negatively impact vegetation and natural habitat. Trees and tree limbs can be knocked down by the weight of accumulated snow, by high winds, or both. Beaches, coastlines and inlets can be reshaped by waves and storm surge associated with nor'easters.
- **Transportation:** Roadways can become extremely dangerous due to icy conditions, snow accumulation, and low visibility. Public transportation is also occasionally shutdown as a result of heavy snowfall.





### 3.5 WILDFIRE

#### Overview

Fire events can be broken into two major categories: urban fires and wildfires. Urban fires are the result of buildings and structures catching fire, with the potential for the fire to spread to neighboring properties. These events have a higher chance of spreading more rapidly in areas where residential and commercial buildings are clustered closely together. Urban fires tend to occur more frequently than wildfires, and often result from everyday activities such as cooking, smoking, or appliance malfunction.

A wildfire is an unplanned, unwanted fire burning in a natural area, such as a forest, scrubland, or grassy area. Wildfires and forest fires are naturally occurring events, and part of a normal, healthy ecosystem. Naturally occurring fires help keep forest floors free of excessive debris buildup, thin crowded trees, encourage growth of new vegetation, and recycle nutrients into the soil. Forest fires may occur at any time of year, however typically occur during hot, dry summer months, or during windy conditions during the spring and fall. Natural ignition most frequently occurs as the result of a lightning strike.

In Massachusetts, wildfires are typically caused by lightning or human activity (i.e. discarded cigarettes, unattended camp fires, downed power lines, etc.). The Bureau of Fire Control estimates that nearly 98% of fires in Massachusetts are started by human carelessness.

B1.c  
B2.a

#### Hazard Location

Wildfire has played a role in shaping the Plymouth County landscape for thousands of years. As a result, there are an abundance of fire-adapted ecosystems in the region. Wareham's forests are primarily composed of pitch pine, white pine, mixed conifer, oak, and oak mixed forests, which are considered by the State fire officials to be the forest types at highest risk for wildfires. The Wareham and Onset Fire Districts responds to very few wood, brush, and grass fires of varying sizes annually (typically less than 40 per year, and often with very little property damage).

B1.c  
B2.a,c

#### Previous Occurrences & Extent

Forest fires vary in size, however thanks to modern detection and firefighting equipment methods, fires are typically kept to a reasonably small area. The Bureau of Fire Control estimates that the average fire 100 years ago consumed approximately 34 acres, while today the average fire burns only 1.2 acres. However, large fires have occurred nearby in the past, such as the 1957 fire in Myles Standish State Forest which burned over 18,000 acres, stopping only when it reached the ocean. Fortunately, most fires are quickly identified and suppressed, or extinguish themselves naturally due to wet weather conditions. The majority of wildfires occur in the spring, before "green-up", or in late summer, following periods of drought.

Smaller fires are more common and are generally addressed quickly by the Wareham and Onset Fire Districts. The incidents classified by type. Between January 1, 2015 and December 31, 2019 the Wareham and Onset Fire Districts responded to 188 wildfire incidents. Below is a list of incident types and the number of each that occurred within that time frame:



- Natural vegetation fire (other): Wareham (98)
- Forest, woods or wildland fire: Wareham (15); Onset (11)
- Brush or brush/grass mixture fire: Wareham (35); Onset (16)
- Grass fire: Wareham (7); Onset (6)

Once a fire starts, location of the fire and the type of fuel consumed determines how severe the fire will be. There are four types of wildfires (Table 3-6). These fire types range from ground fires, which tend to travel relatively slowly and are easier to control, to canopy fires, in which flames can jump from tree to tree through the canopy relatively quickly. These are the most difficult to control and extinguish.

**Table 3-6. Wildfire types.**

Type	Location	Typical Fuel
Ground	At or below ground surface	Underground roots, buried leaves or other organic matter
Surface	Ground surface	Surface leaves, grass, low lying vegetation, underbrush
Ladder	Between the surface and canopy	Underbrush, downed logs, vines and small trees
Canopy	In the tree canopy	Tall trees, vines and branches

In the past, major fires in Wareham have been caused by storm events, such as happened to the Cornwell Department store on Main Street following Hurricane Carol in 1954 (Figure 3-17).



**Figure 3-17. Fire impacting a department store as secondary impact from Hurricane Carol.**

B2.b

**Probability**

The 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan identifies the Wareham area as susceptible to wildfires due to the availability of fuel, impacts from offshore

B3.a



winds, and increasing development within wooded areas. Therefore, it is possible (1 – 10% probability in the next year) that a wildfire will occur in Wareham.

### *Impact*

Below is a list of possible impacts that could result from wildfire:

- **People:** Death or injury can result if people are trapped by urban or wildfires. Smoke inhalation can cause health issues.
- **Infrastructure:** Utility services may be disrupted; a large fire in the wellfield could negatively impact the wellfield itself, while a large enough fire could adversely impact well water quality. Roads may become impassible and transportation may be disrupted.
- **Buildings:** Buildings and structures can be damaged or destroyed, either by the fire directly, or through ignition from flying sparks and embers.
- **Economy:** Indirect economic losses can result from lost tourism due to a major fire. Disrupted utilities may halt businesses and other economic activities.
- **Natural Systems:** Extensive areas of forests and other natural areas can be burned. Wildfires can strip slopes of vegetation, increasing the potential for runoff and erosion.

### 3.6 TORNADO

#### Overview

Tornadoes are a vortex of rapidly rotating air moving along the ground. Tornadoes typically occur during the spring, summer and fall months, usually during the afternoon. Tornadoes may occur in unusually severe thunderstorms, bringing hazards such as very high wind speeds (typically anywhere from 100 to 300 miles per hour) along a localized area, localized heavy rainfall and flooding, frequent lightning and damaging hail.

Tornadoes may be anywhere from less than 250 feet to over two miles in diameter. Typically, tornadoes dissipate after no more than a couple miles on the ground; however they have been known to stay on the ground for dozens of miles, causing substantial damage along the way. Although not common in the northeast, tornadoes have occurred in every state of the U.S. In Massachusetts, tornadoes occur most frequently in and around Worcester County, however they may occur wherever conditions are right. According to NOAA, Plymouth County is located in an area of very low probability of occurrence, with less than one tornado expected to occur every five years.

B1.c  
B2.a

#### Hazard Location

NOAA’s National Weather Service maintains a database of tornado information in the United States. The data include information on date, start and end location, number of injuries and fatalities, and categories of property loss values from each storm. There have been 181 tornadoes documented in Massachusetts since 1950 (Figure 3-18); of these, none have occurred in Wareham, and only 9 have occurred within all of Plymouth County (Table 3-7).

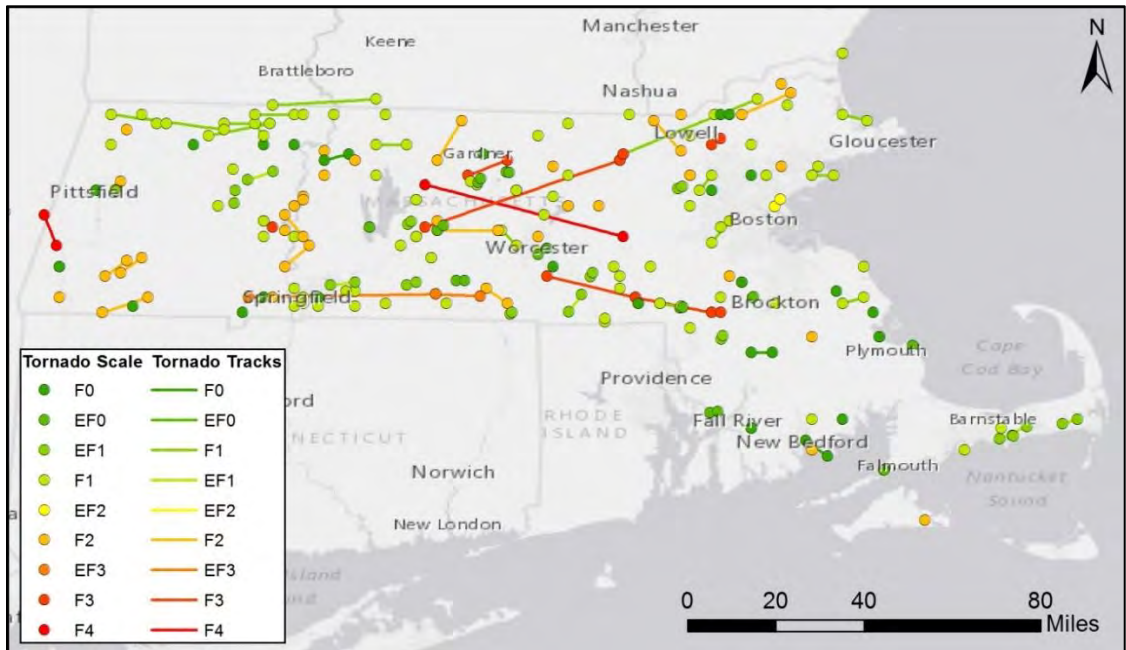


Figure 3-18. Massachusetts tornadoes between 1950 and 2019 (refer to Tables 3-8 and 3-9 for F and EF Scale descriptions).





Table 3-7. Plymouth County tornadoes between 1950 and 2019.

Date	Scale	Town	Death/Injury	Length/Width
9/7/1958	F0	Duxbury	1/1	0.1 mi / 33 yds
7/4/1964	F1	Pembroke/Duxbury/Marshfield	0/0	2.3 mi / 33 yds
6/9/1965	F0	Marion	0/0	0.1 mi / 33 yds
11/18/1967	F2	Halifax	0/0	0.1 mi / 17 yds
9/16/1986	F1	Scituate	0/0	0.1 mi / 50 yds
7/10/1989	F1	Brockton	0/1	0.1 mi / 23 yds
7/10/1989	F0	Hanover	0/0	0.1 mi / 23 yds
8/20/1997	F0	Plymouth	0/0	0.1 mi / 5 yds
7/24/2012	EF0	Plymouth	0/0	0.1 mi / 15 yds

B1.c  
B2.a,c

**Previous Occurrences & Extent**

Although no tornado has touched down directly in Wareham since at least 1950, as noted above, 9 tornadoes have occurred within Plymouth County during the same time period. Table 3-7 documents the characteristics of the 9 Plymouth County tornadoes; this table documents the F-scale (see description of the Fujita Tornado Damage Scale below) or EF-scale (see description of the Enhanced Fujita Scale below), number of injuries and fatalities, and the size of each tornado, as measured by the length and width of its track. Table 3-8 describes the Fujita Tornado Damage Scale developed by Dr. T. Theodore Fujita for winds, including tornadoes, which relates the degree of damage to the intensity of the wind, as well as the number of injuries and fatalities, and the value of any property loss associated with the event.

Recently, the National Weather Service has switch to using a revised rating system for tornadoes. The Enhanced Fujita Scale (EF-Scale) became operational in February 2007, and is similarly used to assign a tornado’s rating based on estimated wind speeds and related damage. The EF-Scale was revised from the original Fujita Scale to better reflect the results of tornado damage surveys so as to align wind speeds more closely with associated storm damage. The new scale has to do with how most structures are currently designed. A summary of the EF-Scale ratings is provided in Table 3-9.

B2.b

**Probability**

Although tornadoes have not been recorded in Wareham since NOAA’s records began in 1951, relatively small scale tornadoes do occur throughout Massachusetts on a regular basis. As such, it is possible (between 1 and 10% probability in the next year) that a tornado will occur in Wareham

**Table 3-8. Fujita tornado damage scale.**

Scale	Wind Estimate (mph)	Typical Damage
F0	< 73	Light damage: some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged
F1	73-112	Moderate damage: peels surface off roads; mobile homes pushed off foundations or overturned; moving autos blown off roads.
F2	113-157	Considerable damage: roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground
F3	158-206	Severe damage: roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.
F4	207-260	Devastating damage: well-constructed houses level; structures with weak foundations moved; cars thrown; large missiles generated.
F5	261-318	Incredible damage: strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 meters; trees debarked; incredible phenomena will occur.

**Table 3-9. Enhanced Fujita (EF) scale.**

Scale	3 Second Wind Gust (mph)
EF0	65-85
EF1	86-110
EF2	111-135
EF3	136-165
EF4	166-200
EF5	Over 200

**Impact**

B3.a

Below is a list of possible impacts that could result from tornadoes:

- **People:** Airborne debris can cause injury or death. Hazardous driving conditions can result from blocked roadways. Tornadoes can cause water contamination, which can affect drinking water quality and human health.
- **Infrastructure:** Tornadoes can damage power lines and other utility infrastructure, and can damage roads. Downed power lines can also cause electrical hazards.
- **Buildings:** Tornadoes that pass through highly developed areas can cause significant property damage, blowing off roofs, and in severe cases, leveling houses.
- **Economy:** Tornadoes can destroy farms and agricultural fields.
- **Natural Systems:** High winds associated with a tornado can break branches and snap or uproot trees. Wildlife can be killed or injured.



### 3.7 DROUGHT

#### Overview

Drought is an extended period of time where a region experiences a notable reduction in available water supply typically caused by a lack of precipitation. Drought can affect either surface water or groundwater sources. Though most droughts in Massachusetts last only a matter of months, it is possible for drought conditions to extend over a period of years due to reduced rainfall and snowfall accumulations contributing to lower groundwater and surface water levels.

B1.c  
B2.a

#### Hazard Location

The entire Town of Wareham is equally vulnerable to drought.

B1.c  
B2.a,c

#### Previous Occurrences & Extent

Significant periods of drought have occurred in Plymouth County, and Wareham specifically, in the past. The Massachusetts Department of Conservation and Recreation (DCR) compiles monthly water conditions reports, summarizing the rainfall and its diversion from average conditions for each of the 6 regions in the state (Cape Cod and Islands, Central, Connecticut River, Northeast, Southeast, and Western). Data for the Southeast region from a recent twelve (12) month period (DCR 2018) is summarized in Table 3-10.

**Table 3-10. Summary of the Southeast Region rainfall from DCR Hydrologic Conditions Reports (2019).**

Month-Year	Total Rainfall (inches)	Departure from normal (inches)
Jan 2019	6.04	2.12
Feb 2019	3.56	0.02
Mar 2019	3.34	-0.90
Apr 2019	6.98	3.05
May 2019	3.85	0.47
Jun 2019	4.50	1.13
Jul 2019	5.87	2.54
Aug 2019	3.19	-0.07
Sep 2019	1.92	-1.84
Oct 2019	6.01	1.62
Nov 2019	3.88	-0.47
Dec 2019	7.70	4.70
Total	56.84	+12.37



Although a significant drought is relatively uncommon in Wareham, and the total rainfall from the twelve (12) months in Table 3-10 is 12.37 inches above average, droughts do occur and have occurred in Wareham in the past. In fact, from July 2016 through May 2017, Wareham, as well as much of Massachusetts, was in a state of drought.

There are five levels of drought that have been developed to characterize the severity of the event:

- 1) Normal
- 2) Advisory
- 3) Watch
- 4) Warning
- 5) Emergency

These levels are based on the regional conditions and are designed to provide information about the current status of water resources. A drought advisory calls for a heightened level of vigilance and increased data collection as conditions begin to deviate from normal. During a drought watch, increased assessment would continue, in addition to proactive public education about water conservation. Water restrictions might become necessary during the watch or warning stage, depending on the capacity and condition of each water supply system. A drought warning is issued during a severe situation and the possibility of a drought emergency may be issued. Finally, a drought emergency often requires mandatory water restrictions and/or the use of emergency water supplies (EOEEA 2013). These categories and their associated characteristics are summarized in Table 3-11.

Based on the categories outlined in Table 3-11, the Massachusetts Executive Office of Energy and Environmental Affairs has compiled information about past drought declarations at a regional level. Drought declarations from 2015 to 2019 for the Southeast Region are detailed in Table 3-12. There was a relatively long drought from July 2016 to May 2017, ranging in severity from an Advisory to a Warning (Table 3-12).





**Table 3-11. Drought indices from the Massachusetts Drought Management Plan (EOEEA 2013).**

Drought Level	Precipitation	Groundwater	Streamflow	Reservoir
<b>Normal</b>	1 month below normal	2 consecutive months below normal**	1 month below normal**	Reservoir levels at or near normal for time of year
<b>Advisory</b>	2 month cumulative total below 65% of normal	3 consecutive months below normal**	At least 2 out of 3 consecutive months below normal**	Small index reservoirs below normal
<b>Watch</b>	1 of the following: 3 month cum. <65%; <u>or</u> 6 month cum. <70%; <u>or</u> 12 month cum. <70%	4-5 consecutive months below normal**	At least 4 out of 5 consecutive months below normal**	Medium index reservoirs below normal
<b>Warning</b>	1 of the following: 3 month cum. <65% and 6 month cum. <65%; <u>or</u> 6 month cum. <65% and 12 month cum. <65%; <u>or</u> 3 month cum. <65% and 12 month cum. <65%	6-7 consecutive months below normal**	At least 6 out of 7 consecutive months below normal**	Large index reservoirs below normal
<b>Emergency</b>	Same Warning <u>and</u> previous month was Warning or Emergency	>8 months below normal**	>7 months below normal**	Continuation of previous month's conditions

**Table 3-12. Drought dates and levels from Massachusetts DCR for the Southeast Region between 2015 and 2019.**

Year	Begin Date	End Date	Southeast Status
2016	7/1/2016	7/31/2016	Advisory
2016	8/1/2016	8/31/2016	Watch
2016-2017	9/1/2016	2/28/2017	Warning
2017	3/1/2017	3/31/2017	Watch
2017	4/1/2017	5/31/2017	Advisory



B2.b

**Probability**

Based on the data summarized above about past drought conditions in Wareham, the probability that a drought will occur in Wareham in the future is possible (between 1% and 10% probability in the next year, or at least one chance in the next 100 years).

B3.a

**Impact**

Below is a list of possible impacts that could result from tornadoes:

- **People:** Drought conditions can increase conflicts between water users. Water conservation actions may impact users' activities. Reduction in drinking water supply. Health related issues may arise due to dust inhalation.
- **Infrastructure:** Droughts can result in lower water levels in reservoirs. Drought can cause well water quality, and potentially quantity, to worsen. Drought can cause sanitary issues in the water distribution system, as well as increase water demand, which can result in a financial burden on rate payer since Wareham has a tiered water rate system. Drought can also result in private residential wells to dry up, increasing requests to be connected to the municipal water supply system.
- **Economy:** Farmers experience financial losses if a drought destroys their crops. Finances may need to be diverted to provide additional irrigation or drill new wells. Businesses that depend on farming may lose business. Food costs may increase.
- **Natural Systems:** Loss of fish habitat as streams, rivers, and ponds dry up. Lack of food and drinking water for wildlife. Wildlife may be forced to migrate to find adequate resources. Wildfires may become more common.



### 3.8 EXTREME TEMPERATURE

#### Overview

There is no defined cut-off for what defines extreme temperatures. Instead, extreme temperatures are considered relative to the usual weather in a region based on long-term climatic averages. According to the Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2018), extreme heat for this region is usually defined as a period of three or more consecutive days with temperatures above 90°F. However, more generally it can be thought of as a prolonged period of excessively hot weather, which is often accompanied by high humidity. Similarly, extreme cold is also relative to normal climatic lows in the region. Temperatures that drop well below normal, especially when accompanied by high winds can produce dangerous wind-chill factors. The wind-chill is the perceived decrease in air temperature felt by the body on exposed skin due to the flow of air.

Since extreme temperatures are defined relative to normal conditions, it is important to know the average temperatures for the region for a particular season. The average low winter temperature (Jan) for Massachusetts is 22°F, while the average high summer temperature (Jul) is 81°F.

B1.c  
B2.a

#### Hazard Location

The entire Town of Wareham is equally vulnerable to extreme temperature hazards.

B1.c  
B2.a,c

#### Previous Occurrences & Extent

NOAA's National Centers for Environmental Information houses a Storm Events Database (NOAA 2018), which includes accounts of Cold/Wind Chill, Extreme Cold/Wind Chill, Heat, and Excessive Heat. Querying the data for these types of events for the past 10 years returned five occurrences of extreme temperature:

- 1) July 6, 2010: Temperatures neared 100°F with a high percent of relative humidity. Heat index values ranged from 100 to 106 for most of Southern New England. Heat index values at the Plymouth Municipal Airport ranged between 100 and 104.
- 2) July 22, 2011: High temperatures and high humidity levels brought the heat index above 105 for several hours. Heat index values at the Plymouth Municipal Airport ranged between 105 and 108.
- 3) February 16, 2015: A winter storm brought significant snowfall, as well as frigid temperatures. The Automated Surface Observation Station at the Plymouth Municipal Airport recorded wind chill values as low as -28°F.
- 4) February 14, 2016: An arctic high pressure system brought strong northwest winds and extremely cold wind chills to southern New England. Wind chills as low as -36°F were reported in Plymouth.
- 5) July 3, 2018: An area of high pressure brought high temperatures and humidity to southern New England. The Automated Surface Observation Station at the Plymouth Municipal Airport reported a heat index of 107.



NOAA’s National Weather Service (NWS) has developed a Heat Index (NWS 2016a), which measures how hot it feels when relative humidity is considered along with the actual air temperature (Figure 3-19). Relative humidity is the amount of atmospheric moisture present relative to the amount that would be present if the air were fully saturated. For example, a 90°F day with 80% humidity would have a heat index of 113°F, and there is a dangerous likelihood of heat disorders with prolonged exposure or strenuous activity. The NWS issues alerts when the Heat Index is expected to exceed 105-110°F (depending on local climate) for at least 2 consecutive days. Wind chill temperature indicates how cold it feels outside, based on the rate of heat loss from exposed skin caused by the combination of wind and cold. Because wind draws heat from the body, reducing skin temperature, as well as internal body temperature, the wind actually makes it feel colder than the absolute temperature would indicate. Frostbite is the result of body tissue (i.e. skin) freezing. The most vulnerable parts of the body are the fingers, toes, ears and nose. The National Weather Service’s Wind chill Temperature Index (NWS 2016b) provides a useful method for calculating the dangers from extreme cold temperatures and winter winds, and the amount of time exposed skin will take to get frostbite (Figure 3-20). According to the chart in Figure 3-20, if it is 0°F with a 15 mph, the wind chill temperature would be -19°F and it would take exposed skin 30 minutes to get frostbite. The index calculates wind speed at an average height of 5 feet above the ground’s surface, the typical height of a person’s face, from the measured wind data collected from standard 33-foot high anemometers.

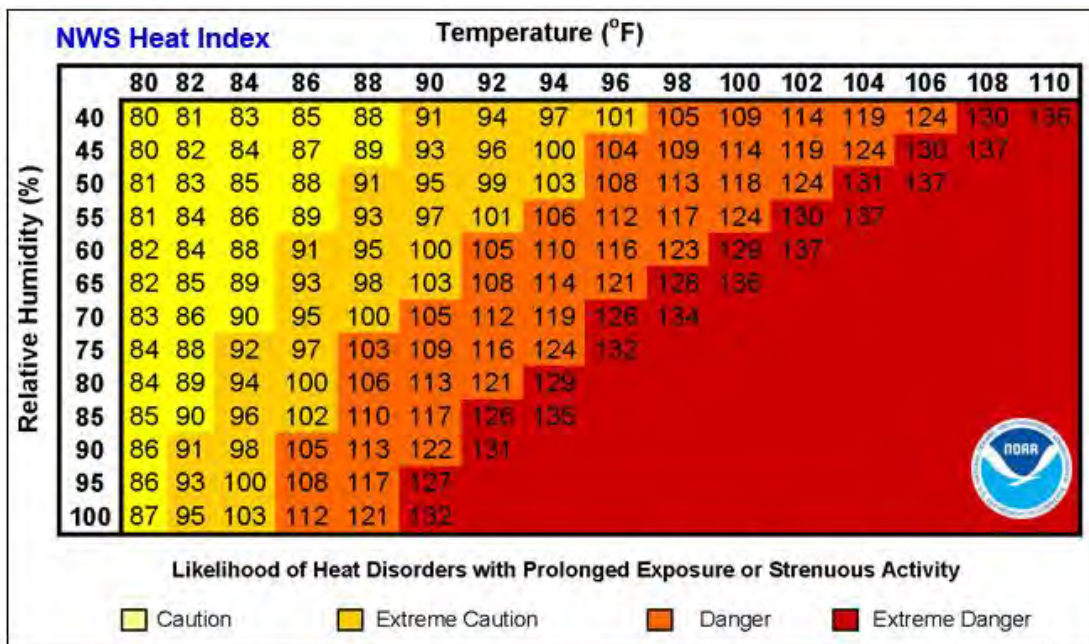


Figure 3-19. NWS’s Heat Index.



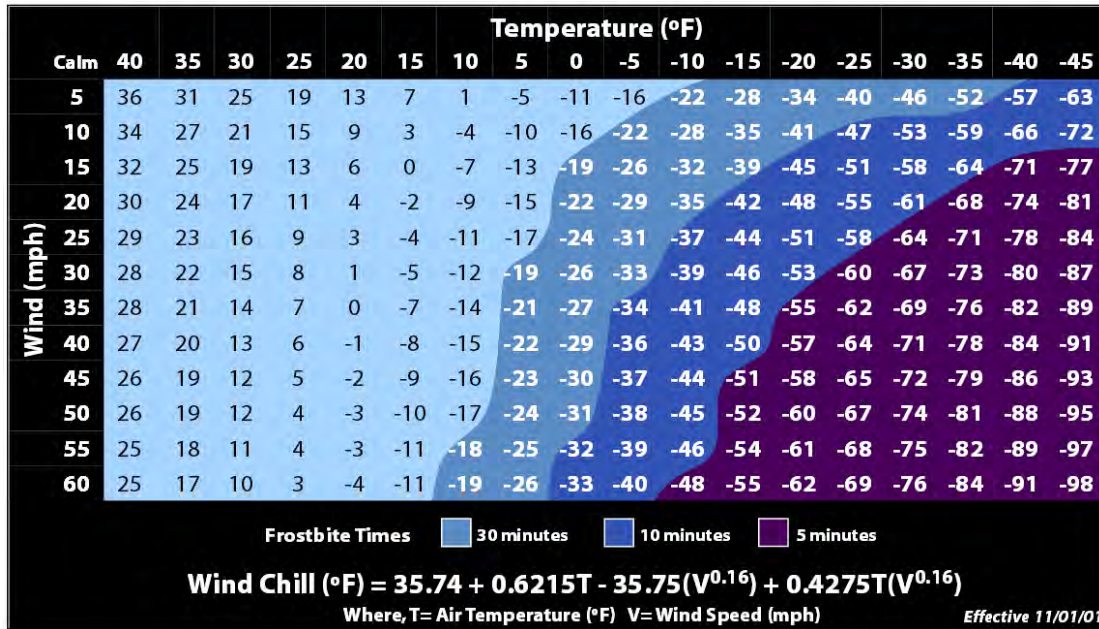


Figure 3-20. NOAA’s Wind Chill Chart.

B2.b

Probability

Based on the data summarized above about past extreme temperature conditions in Plymouth County, the probability that extreme temperatures will occur in Wareham in the future is likely (between 10% and 100% probability in the next year, or at least one chance in the next 10 years).

B3.a

Impact

Below is a list of possible impacts that could result from extreme hot or cold temperatures:

- **People:** Excessive heat poses serious health risks, including death.
- **Emergency Response:** Stress will be placed on the cooling systems of emergency vehicles in extreme heat.
- **Infrastructure:** Highways and roads can be damaged by excessive heat as asphalt softens. Both extreme heat and extreme cold can put significant strain on power utilities, as users’ energy needs increase to run air conditioners or heaters. Extreme heat can cause well water quality, and potentially quantity, to worsen. Extreme heat can cause sanitary issues in the water distribution system as the water in tanks and the groundwater heat up, as well as increase water demand, which can result in a financial burden on rate payer since Wareham has a tiered water rate system.
- **Economy:** Transported refrigerated goods experience a higher degree of spoilage during excessive heat conditions. Agriculture and livestock can be adversely impacted by extreme heat.
- **Natural Systems:** Extreme heat can reduce water levels in natural ponds and reservoirs, as well as increase surface water temperatures to dangerous levels. Both can have an adverse impact on fish and wildlife.



### 3.9 EARTHQUAKE

#### *Overview*

An earthquake is a sudden, intense shaking of the Earth's surface caused by the movement of large portions of the Earth's crust. These movements tend to occur along faults, which are fractures in the Earth's crust along which two plates of crust can move against each other. Earthquakes can occur suddenly at any time, with virtually no warning.

The depth at which an earthquake occurs is called a focal depth. A focal depth of less than 43.5 miles is considered to be a shallow earthquake; the majority of earthquakes fall into this category. Earthquakes originating at focal depths of 43.5 to 186 miles are considered intermediate. However, focal depths of earthquakes can reach depths of more than 435 miles. The epicenter of an earthquake is the location on the Earth's surface directly above the focal point of an earthquake.

New England is located in the middle of the North American tectonic plate; the western edge of this plate is along the west coast where it is pushing up against the Pacific Ocean Plate, and the eastern edge is in the middle of the Atlantic Ocean where it is spreading away from the European and African plates. Because New England is located a considerable distance from either edge of the North American plate, most earthquakes that occur here are due to the cracking of crustal rocks due to compression as the plate is slowly squeezed by the global movement of other plates.

B1.c  
B2.a

#### *Hazard Location*

Due to the configuration of the tectonic plates, the greatest threat from earthquakes in the United States occurs along the fault lines on the west coast. While earthquakes do occur in the eastern United States, they tend to be less frequent and less intense. Figure 3-21 shows earthquakes within 100 miles of the Town of Wareham since the 1970s as reported by USGS; this includes 90 earthquakes ranging in magnitude from 2.0 to 3.7.

B1.c  
B2.a,c

#### *Previous Occurrences & Extent*

Although there are no recorded earthquakes within Wareham itself, there have been 90 occurrences of earthquakes since 1970 within 100 miles of Wareham. The epicenter locations of these earthquakes are shown in Figure 3-21; the range in magnitude of each event is indicated by color. The Richter magnitude of these 90 events ranged from 2.0 to 3.7, which as described below, can often be felt, but only cause minor damage.

The Richter Scale (Table 3-13) is frequently used to measure the magnitude of earthquakes. It measures the maximum recorded amplitude of a seismic wave, which quantifies the ground motion and the energy released at the source of an earthquake.

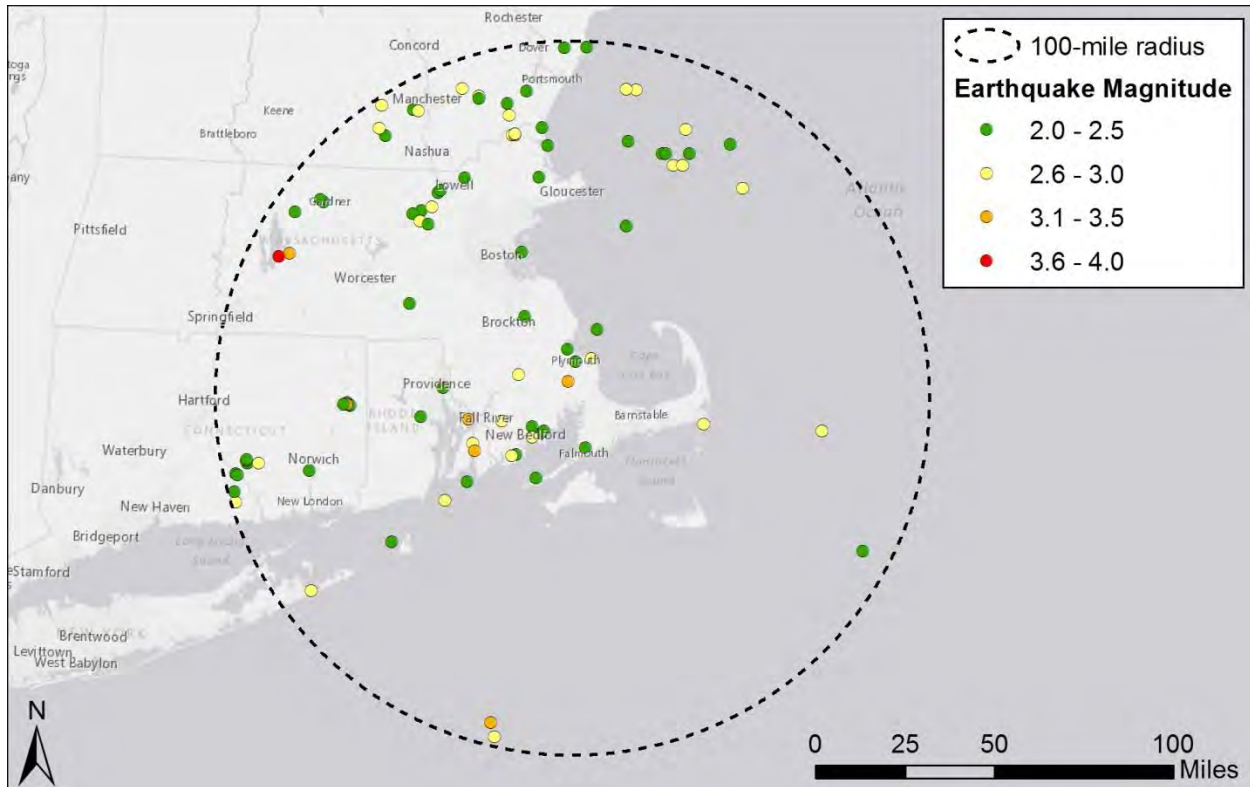


Figure 3-21. Earthquakes that have occurred within 100 miles of Wareham since 1970.

Table 3-13. Richter scale.

Richter Magnitude	Earthquake Effects
2.5 or less	Not felt or felt mildly near the epicenter; can be recorded by seismographs
2.5 to 5.4	Often felt, but only causes minor damage
5.5 to 6.0	Slight damage to buildings and other structures
6.1 to 6.9	May cause a lot of damage in very populated areas
7.0 to 7.9	Major earthquake; serious damage
8.0 or greater	Great earthquake; can totally destroy communities near the epicenter

B2.b

**Probability**

Given that earthquakes have occurred in Massachusetts and in Plymouth County specifically in recent years, it is possible (1-10% probability in the next year) that an earthquake could occur in Wareham.



B3.a

**Impact**

Below is a list of possible impacts that could result from an earthquake:

- **People:** Damage caused to buildings and other structures during an earthquake can lead to injury or loss of life.
- **Emergency Response:** Downed trees and power lines, as well as damaged roads caused by an earthquake can impede emergency vehicles.
- **Infrastructure:** Earthquakes can cause utility poles to fall and live wires to become exposed or to start fires. The shaking caused by an earthquake can also rupture gas lines and cause the release of flammable substances, and can break or separate sewer collection and water distribution pipes, resulting in loss of service.
- **Economy:** Earthquakes can damage foundations and buildings; most property damage is caused by the failure and collapse of structures during ground shaking. Concrete and masonry structures are brittle and thus more susceptible to damage and collapse.
- **Natural Systems:** Earthquakes can cause landslides and slope failure; this could have hazardous impacts on areas with steep slopes, such as coastal banks.





### 3.10 INVASIVE SPECIES

#### Overview

Invasive species are defined as non-native species that cause or are likely to cause harm to ecosystems, economies, and/or public health. Although invasive species can be any type of organism, including marine organisms, insects and birds, the 2018 Massachusetts State Hazard and Climate Adaptation Plan focuses specifically on invasive terrestrial plants, as these are the most studied and managed type of invasive species.

B1.c  
B2.a

#### Hazard Location

Although the entire Town of Wareham is potentially vulnerable to the introduction and establishment of invasive species, they pose the biggest threat to native or minimally managed ecosystems. In addition, the ability of invasive species to travel far distances (either via natural means or accidental human interference) allows these species to propagate rapidly over large geographic areas.

B1.c  
B2.a,c

#### Previous Occurrences & Extent

The Massachusetts Invasive Plant Advisory Group (MIPAG) recognizes 69 plant species as “Invasive”, “Likely Invasive”, or “Potentially Invasive.” In addition, the 2018 State Plan also lists a number of other invasive species, including gypsy moths (*Lymantria dispar*), the Dutch elm disease fungus (*Ophiostoma sp.*), European green crabs (*Carcinus maenus*), and Asian shore crab (*Hemigrapsis sanguineus*).

B2.b

#### Probability

There are known invasive species within the Town of Wareham, so it is 100% likely that invasive species occur in Town. However, the likelihood that a significant negative impact would occur due to the presence of these species is possible, but not as high.

B3.a

#### Impact

Below is a list of possible impacts that could result from invasive species:

- **People:** Those who rely on natural systems for their livelihood or well-being are more likely to experience negative repercussions from the expansion of invasive species.
- **Economy:** The agricultural sector is vulnerable to increased invasive species associated with increased temperatures. More pest pressure from insects, diseases, and weeds may harm crops and cause farms to increase pesticide use.
- **Natural Systems:** Biodiversity and ecosystem health may be impacted by invasive species. Aquatic invasive species pose a particular threat to water bodies. Impacts of aquatic invasive species include impairment of recreational uses, such as swimming, boating and fishing, degradation of water quality and wildlife habitat, declines in finfish and shellfish habitat, and diminished property values.



### 3.11 OTHER SEVERE WEATHER (HEAVY PRECIPITATION, HIGH WIND, THUNDER/LIGHTNING)

#### *Overview*

**Heavy Precipitation:** The Massachusetts State Hazard Mitigation and Climate Adaptation Plan notes that the Fourth National Climate Assessment published by the U.S. Global Change Research Program shows that heavy precipitation events have increased in both intensity and frequency over the past century across much of the country, with the largest increases occurring in the Northeast. Annual precipitation in Massachusetts is projected to increase by as much as 7.3 inches by the end of this century. Furthermore, increased precipitation will likely occur during more intense periods of precipitation coupled with more frequent episodic drought, causing more stormwater runoff and higher surface water levels.

**High Wind:** Major wind events in coastal Massachusetts are hurricanes and nor'easters. Tornadoes are extremely rare, although they do occur. Water spouts have been seen in Cape Cod Bay, in the Cape Cod Canal and in Buzzards Bay. Thunderstorms, especially in the summer months, do occur and can bring localized damage due to wind, especially to summer cottages of poorer construction and old or rotted tree limbs.

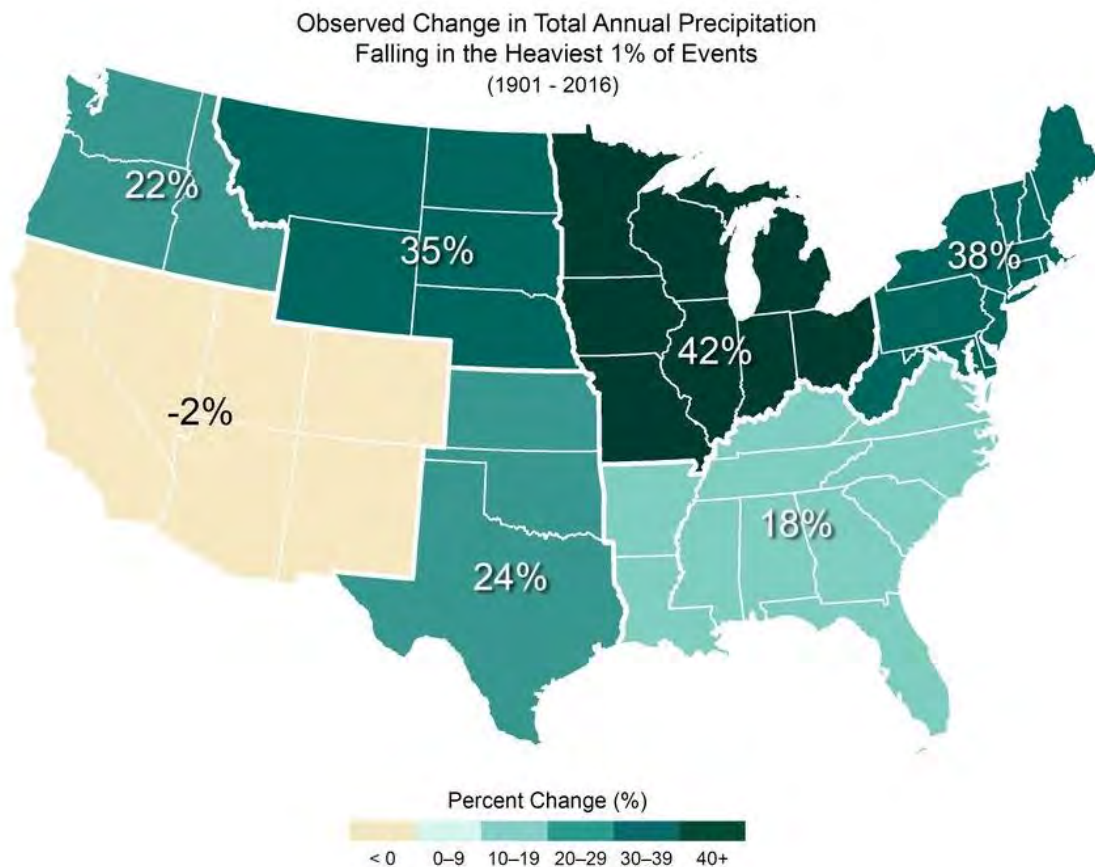
**Thunder and Lightning:** A thunderstorm is a storm that produces lightning and thunder and is usually accompanied by gusty winds, heavy rain, and sometimes hail. The National Weather Service defines a severe thunderstorm as one that produces a tornado, winds of at least 58 mph (50 knots or ~93 km/h), and/or hail at least 1 inch in diameter. Structural wind damage may imply the occurrence of a severe thunderstorm. A thunderstorm wind equal to or greater than 40 mph (35 knots or ~64 km/h) and/or hail of at least ½ inch is defined as approaching severe. Lightning is one of the most dangerous aspects of a thunderstorm, and it can strike up to 10 miles away from the main thunderstorm location; however, because lightning occurs during every thunderstorm, its presence does not indicate a “severe” thunderstorm.

Three basic ingredients are required for a thunderstorm to form: moisture, rising unstable air (air that keeps rising when given a nudge), and a lifting mechanism. The sun heats the surface of the earth, which warms the air above it. If this warm surface air is forced to rise—by hills or mountains, or areas where warm/cold or wet/dry air bump together—it will continue to rise as long as it weighs less and stays warmer than the air around it. As the air rises, it transfers heat from the surface of the earth to the upper levels of the atmosphere (the process of convection). The water vapor it contains begins to cool, releasing the heat; and it condenses into a cloud. The cloud eventually grows upward into areas where the temperature is below freezing. Some of the water vapor turns to ice, and some of it turns into water droplets. Both have electrical charges. Ice particles usually have positive charges, and rain droplets usually have negative charges. When the charges build up enough, they are discharged in a bolt of lightning, which causes the sound waves we hear as thunder.

B1.c  
B2.a

**Hazard Location**

**Heavy Precipitation:** Heavy precipitation can affect all portions of the Town of Wareham. Based on recent studies, New England has already experienced an increase in heavy precipitation events in the last 50 years. This is due to increased sea surface temperatures in the Atlantic Ocean that cause air moving north over the water to hold more moisture. As a result, when these warm fronts meet cold air systems from the north, an even greater amount of precipitation than normal can be anticipated to fall on Massachusetts. As shown in Figure 3-22, the percent change in the precipitation amount occurring as very heavy precipitation has increased by 38% in the northeast. This data compares a reference period from 1901-1960 with a more recent period: 1986-2016. The threshold used to define a heavy precipitation event is the top 1 percent of all days with precipitation.



**Figure 3-22. Observed changes in heavy precipitation (GlobalChange.gov, 2020).**

**High Wind:** In their effort to research potential sites for wind energy facilities, the Executive Office of Energy and Environmental Affairs (EOEEA) put considerable effort into measuring wind velocities in Massachusetts. These efforts produced four sets of data, representing mean wind speed at different elevations above the land’s surface: 30, 50, 70 and 100 meters. The mean wind speed, in miles per hour, at 30 meters above the land’s surface is shown for Wareham in Figure 3-23.

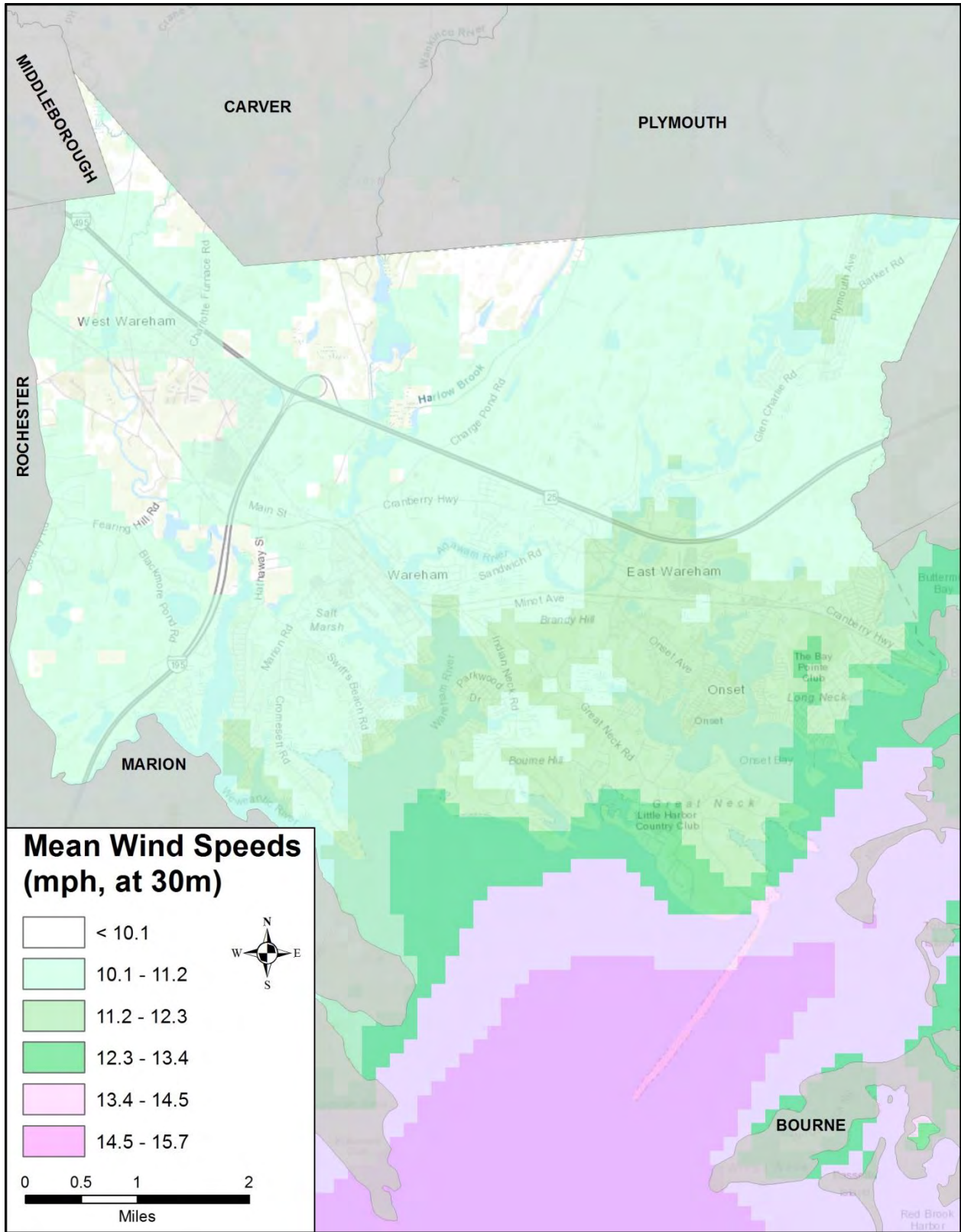
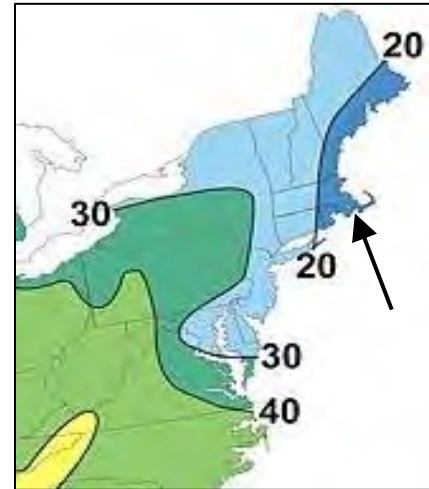


Figure 3-23. Mean wind speed (mph) at 30 meters above the surface.



**Thunder and Lightning:** The entire Town of Wareham is at risk from thunderstorms. NOAA has compiled data about the annual number of thunderstorms across the United States. Figure 3-24 shows the annual number of thunderstorms in the northeastern United States. The arrow shows that all of eastern Massachusetts, including Wareham, falls in the darker blue area, which receives, on average, 10-20 thunderstorms per year.



**Figure 3-24. Annual number of thunderstorms.**

B1.c  
B2.a,c

### **Previous Occurrences & Extent**

**Heavy Precipitation:** Because heavy rain is often associated with other major weather events (e.g., tropical storms, nor'easters, etc.) the list of heavy rain events from the NOAA NCDC Storm Events (NOAA 2019a) does not have many entries from the past 10 years:

- 1) July 4, 2014: Torrential rain produced significant flash flooding in southeast Massachusetts where storm totals of 4 to 8 inches were reported. In Wareham, a car was stuck in flood waters on Cranberry Highway.
- 2) September 18, 2018: Heavy downpours and damaging thunderstorms occurred throughout Massachusetts. Storm total rainfall amounts reached 2 to 5 inches across Plymouth County. Numerous roads were flooded and impassable.
- 3) July 12, 2019: A warm front moving northward across southern New England brought heavy rain and thunderstorms, causing significant flooding. Plymouth airport recorded 5.3 inches of rain in just 6 hours.

Given the tendency for heavy precipitation to occur during other weather events, it is likely that the frequency of these events is underestimated by this database.

**High Wind:** A summary of the high wind events from the NOAA NCDC Storm Events database (NOAA 2019a) from the last five years shows that high wind events are relatively common in Wareham (more than once per year):

- 1) March 17, 2015: An arctic cold front moving into southern New England brought rain and snow showers to the region, followed by strong, damaging winds. The event resulted in significant downed trees and power lines across the southern portion of Plymouth County.
- 2) April 4, 2015: A cold front moved across Southern New England creating strong gusty northwest winds. The Automated Surface Observation System at Plymouth Airport recorded sustained winds of 37 mph and gusts to 47 mph.
- 3) January 10, 2016: A strong low pressure system brought heavy rain, thunderstorms, and gusty winds to southern New England, resulting in scattered tree and power line damage across southern New England.



- 4) February 24-25, 2016: A low pressure system brought showers, thunderstorms, and strong winds.
- 5) September 5, 2016: The remnants of Hurricane Hermine, classified as a tropical system by the time it reached New England, resulted in moderate rainfall and high winds, although they were generally below tropical storm force. Because trees were still fully leaved and we had higher wind gusts, there was some wind damage. In Wareham, a tree was downed onto power lines on Main Street.
- 6) October 9, 2016: The remnants of Hurricane Matthew merged with a cold front off the coast and moved past Cape Cod during the night of October 9th-10th. This caused wind damage in parts of Eastern Massachusetts, including a tree down on Route 28 at Aunt Maryville Lane in Wareham.
- 7) December 18, 2016: A low pressure system brought strong gusty southwest winds to Southern New England, causing scattered tree and wire damage in Massachusetts, including a tree downed on Robinwood Road in Wareham.
- 8) March 14, 2017: A major winter storm moved up the east coast, producing significant snow amounts and high winds. It is estimated that winds gusted to 58 mph in southern Plymouth County during the storm.
- 9) April 6, 2017: A pair of coastal storm brought significant wind and rain to the area, resulting in a tree downed on Indian Neck Road in Wareham.
- 10) October 29-30, 2017: The remnants of Tropical Storm Phillipe generated strong to damaging winds in eastern Massachusetts. Wind gusts as high as 62 mph were recorded in Wareham.
- 11) December 25, 2017: A fast-moving low pressure system brought a several inches of snow to much of Southern New England, along with damaging west to northwest winds. A tree and wires were down on Hunter Avenue in Wareham.
- 12) January 12-13, 2018: A slow-moving cold front with strong southerly winds produced maximum wind gusts between 45 to 65 mph. The event resulted in a large tree down in Marion on Country Road near the Wareham line, as well as a tree down on wires on Rose Point Avenue in Wareham.
- 13) March 2-3, 2018: The storm brought heavy rain and strong winds to central and eastern Massachusetts. Wind gusts in Wareham were reported as high as 65 mph.
- 14) October 15-16, 2018: A cold front brought wind gusts of 40 to 60 mph to southeastern Massachusetts.
- 15) November 3, 2018: A low pressure brought heavy rain, severe thunderstorms, and strong to damaging westerly winds. Winds in the area were gusting to 50 to 60 mph.
- 16) December 21, 2018: A storm brought strong to damaging south winds and one to four inches of rain to Eastern Massachusetts. Phone and cable lines were reported down on Holly Street in Wareham.
- 17) January 24, 2019: A low pressure system brought high south winds and heavy rain to the area. Wind gusts as high as 64 mph were reported in Wareham.
- 18) January 30, 2019: A low pressure system brought a mix of snow and rain, as well as damaging west winds. A tree and wires were reported down on Sippican Road in Wareham.



The National Weather Service issues a variety of warnings related to wind hazards. They are:

- High Wind Watch: Issued when the following conditions are possible – sustained winds of 40 mph or higher for one hour or more, or wind gusts of 58 mph for one hour or more.
- High Wind Warning: Issued when the following conditions are occurring or imminent – sustained winds of 40 mph or higher for one hour or more, or wind gusts of 58 mph for one hour or more.
- Hurricane Watch: Issued when a tropical cyclone containing winds of 74 mph or higher poses a possible threat, generally within 48 hours.
- Hurricane Warning: Issued when sustained winds of 74 mph or higher associated with a tropical cyclone are expected in 36 hours or less.
- Wind Advisory: Issued when the following conditions are expected for 3 hours or longer – sustained winds of 31 to 39 mph and/or wind gusts of 46 to 57 mph.
- Extreme Wind Warning: Issued for surface winds of 115 mph or greater associated with non-convective, downslope, derecho (not associated with tornado), or sustained hurricane winds are expected to occur within one hour.
- Small Craft Advisory: Issued when one or all of the following conditions are expected to occur within 36 hours – sustained winds of 18 to 33 knots or frequent gusts (with a duration of 2 hours or more) between 18 to 33 knots or waves of 4 feet or higher.
- Gale Warning: Issued when one or both of the following conditions are expected to occur within 36 hours and is not directly associated with a tropical cyclone – sustained winds of 34 to 47 knots or frequent gusts (with a duration of 2 hours or more) between 34 to 47 knots.
- Storm Warning: Issued when one or both of the following conditions are expected to occur within 36 hours and is not directly associated with a tropical cyclone – sustained winds of 48 to 63 knots or frequent gusts (with a duration of 2 hours or more) between 48 to 63 knots.
- Hurricane Force Wind Warning: Issued when one or both of the following conditions are expected to occur within 36 hours and is not directly associated with a tropical cyclone – sustained winds of 64 knots or greater or frequent gusts (with a duration of 2 hours or more) between 64 knots or greater.

**Thunder and Lightning:** The NOAA NCDC Storm Events database lists 22 lightning and/or thunderstorm wind events were reported for Plymouth County within the last 5 years (NOAA 2019a). None of the recorded events were listed with Wareham as their specific location, but may simply mean that these events went unrecorded.

There are a variety of types of thunderstorms:

- Single-cell thunderstorms, which are small, brief, weak storms that can develop and then dissipate within an hour. They are typically produced by heating on a summer afternoon. Single-cell storms produce brief, heavy rain and lightning.



- Multi-cell storms form along the leading edge of rain-cooled air. Although individual cells that comprise the multi-cell storm can only last 30-60 minutes, the entire multi-cell storm system can persist for many hours. Multi-cell storms may produce hail, strong winds, brief tornadoes and flooding.
- A squall line is a group of storms arranged in line, often associated with “squalls” of heavy wind and rain. These storms tend to pass quickly and are less likely to produce tornadoes than supercells. A squall line can be hundreds of miles long, but tend to only be 10-20 miles wide.
- A supercell is a highly organized, long-lived storm fueled by an updraft that is tilting and rotating. These tilting and rotating updrafts can produce severe tornadoes.

B2.b

### **Probability**

Based on the data presented above, it is highly likely (near 100% probability in the next year) that other severe weather (heavy precipitation, high wind, and thunder/lightning) will occur in Wareham.

B3.a

### **Impact**

Below is a list of possible impacts that could result from other severe weather:

- **People:** Thunderstorms and high winds can result in power outages, leaving people without heat or other utilities. Lightning may cause injury or death to people who are outdoors during the onset of a thunderstorm, if they are unable to seek shelter.
- **Emergency Response:** Trees and power lines felled by high winds and/or lightning can impede emergency vehicles.
- **Infrastructure:** Lightning and high winds can result in downed power lines. High wind events can generate significant waves which can damage coastal infrastructure and moored/ docked vessels. Heavy rains associated with thunderstorms can result in flooded roads and overwhelm drainage systems.
- **Buildings:** Wind and wind-born debris can damage roofs, windows and other portions of houses and buildings. Heavy rains and flooding can damage properties. Lightning strikes can start fires, which can threaten buildings and structures.
- **Economy:** Power outages can force businesses to close temporarily.
- **Natural Systems:** Heavy winds can bring down trees and branches.

## **3.12 DAM AND CULVERT FAILURE**

### **Overview**

A dam is any artificial barrier and/or any controlling structure that can or does impound or divert water. There are 2,901 public and privately owned dams in Massachusetts. Forty-four (44) of these are located in Wareham (Figure 3-25).



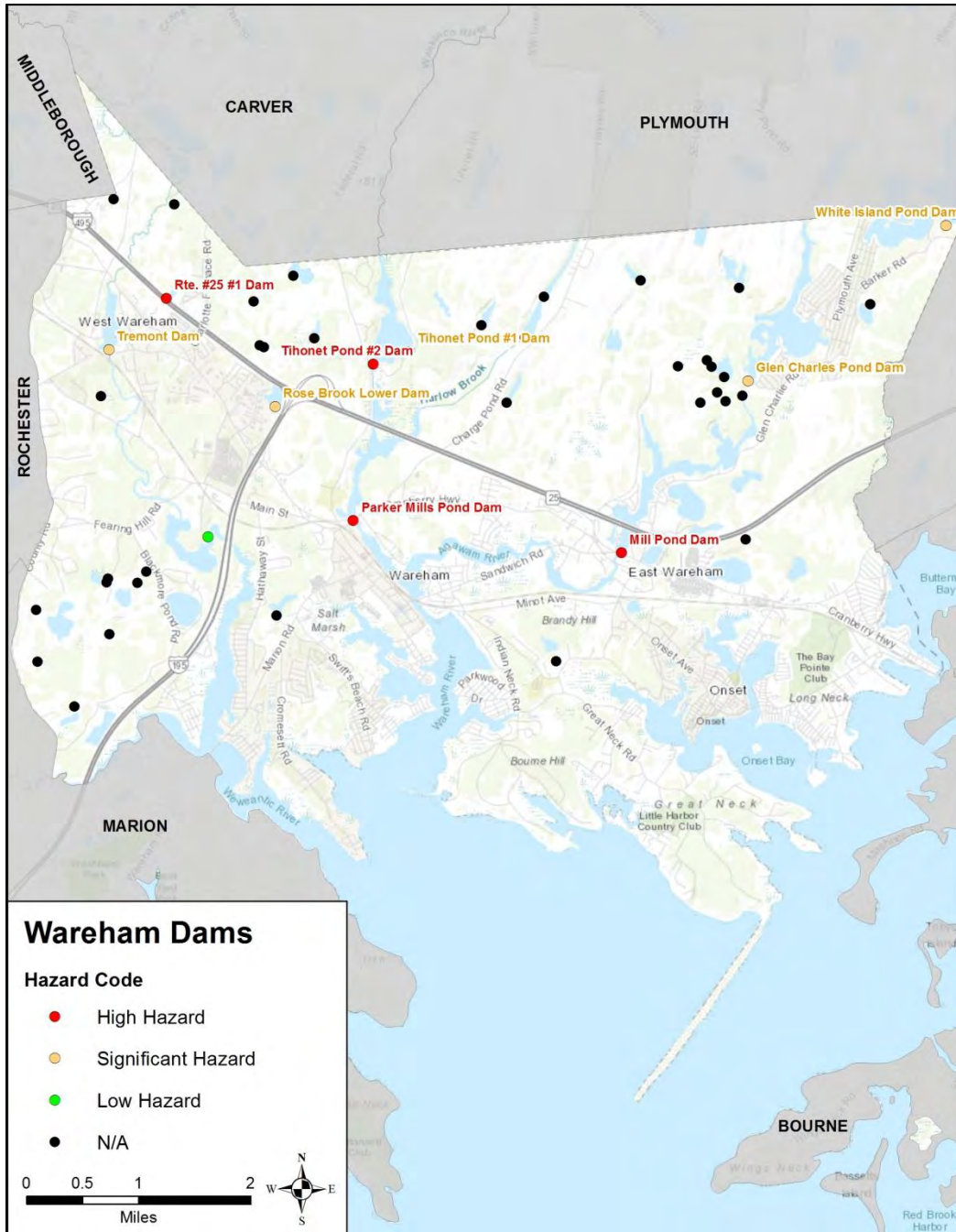


Figure 3-25. Locations of dams within Wareham.

Dam failure is any sudden, uncontrolled release of impounded water due to structural deficiencies in a dam. Dams can fail for a variety of reasons, including the dam being overtopped by floods that exceed its capacity, structural failure of the dam construction materials or the foundation supporting the dam, and inadequate maintenance and repair.

The hazards associated with a failing dam can also occur from culverts that act like dams during flooding events. A culvert is a structural opening under a roadway that allows water to pass from



one side of the road to the other. They are typically made of concrete, steel or aluminum, and their size is calculated based on the location-specific volume of water expected to pass through that location. The primary function of a culvert is to prevent flooding during normal and extreme weather conditions and to provide proper road drainage. Culverts can fail due to the pipe becoming occluded by debris or improper maintenance, the pipe caving in due to structural deficiencies, or from a buildup of flood waters exceeding the capacity of the culvert. While there are numerous culverts throughout the Town of Wareham, the Town’s Municipal Maintenance Department has identified four (4) culverts of particular concern (Figure 3-26).

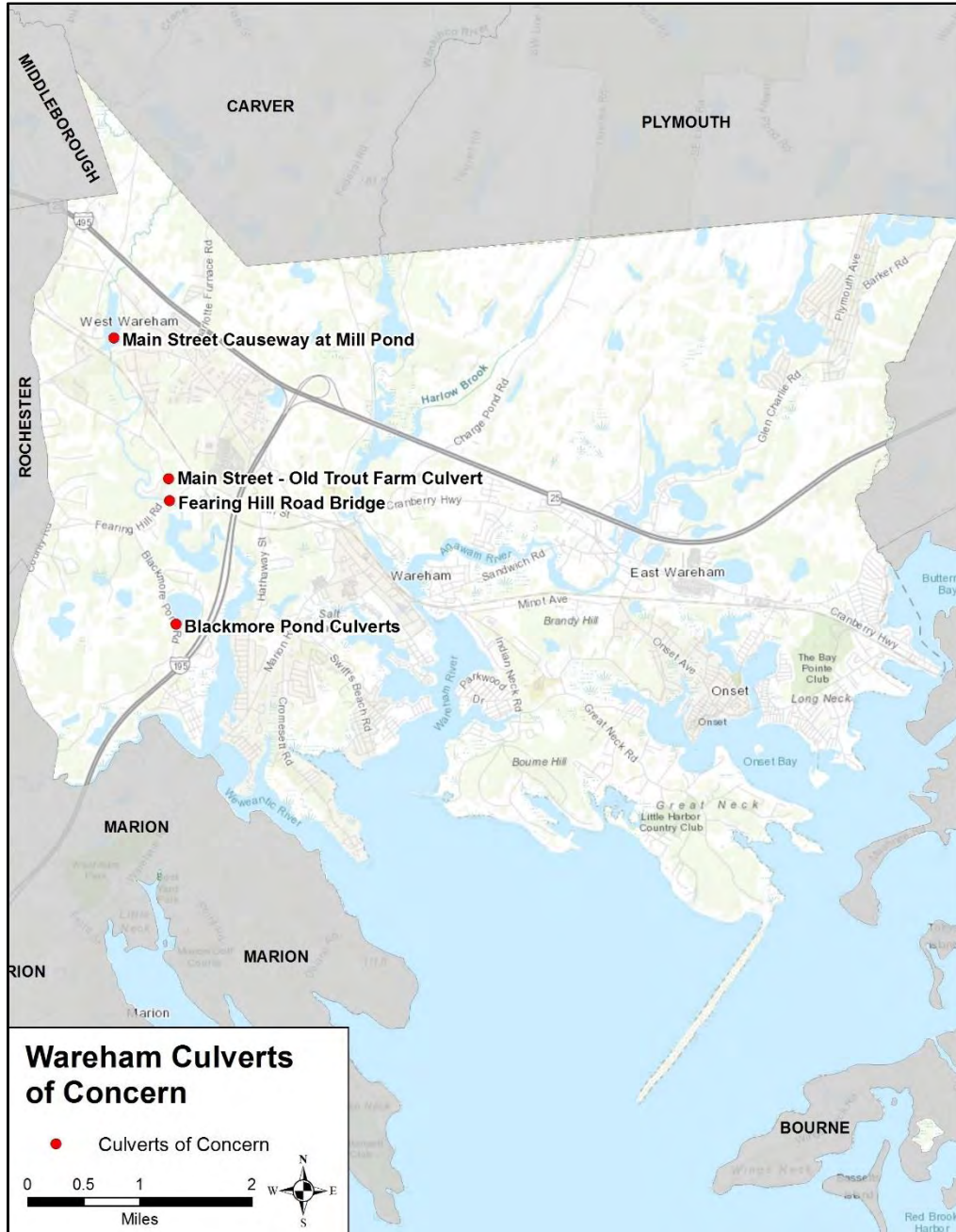


Figure 3-26. Locations of culverts of concern within Wareham.

B1.c  
B2.a

### *Hazard Location*

Hazards associated with dam failure are confined to the areas around existing dams. There are four (4) that are classified by the Office of Dam Safety as High Hazard dams located within Wareham: 1) the Route 25 #1 Dam and 2) the Mill Pond Dam (owned by the Massachusetts Department of Transportation), 3) the Parker Mills Dam (owned by the Town of Wareham), and 4) the Tihonet Pond #2 Dam (privately owned). In addition, 5 dams located in Wareham that are classified by the Office of Dam Safety as having the potential for Significant Hazard. Of the Significant Hazard dams, three (3) are privately owned (Glen Charles Pond Dam, Tihonet Pond #1 Dam, and Rose Brook Lower Dam), while the White Island Pond Dam is owned by the state Department of Fish and Wildlife, and the Tremont Dam is owned by the Town of Wareham. Of the remaining 35 dams in the Town of Wareham, the Office of Dam Safety has classified the privately owned Horseshoe Pond Dam as having a Low Hazard Potential, while the other 34 have not given a hazard code.

There are Emergency Action Plans for three of the four High Hazard dams (there is no Emergency Action Plan for the Tihonet Pond #2 Dam). These plans define departmental responsibilities in the event of an emergency and provide procedures for identifying unusual and unlikely conditions, which may result in a dam failure. Action plans are laid out for both Condition I (Potential dam failure situation rapidly developing) and Condition II (Urgent; dam failure is imminent or in progress) incidents. Information about each of the dams and the potential infrastructure at risk during a dam failure are described below:

- 1) **Route 25 #1 Dam:** This dam impounds water along a tributary to the Weweantic River to create an unnamed impoundment north of Rt 495 between Exits 1 and 2 for cranberry growing operations in the area. The dam was constructed in 1964, and consists of an earthen embankment, the concrete primary spillway, and the auxiliary spillway. It is approximately 650 feet long and approximately 16 feet high with a crest width of approximately 170 feet (the crest of the dam supports the embankments of Route 25/Interstate 495). Potential hazards downstream of the dam include Cranberry Highway (Rt 28), Gault Road, railroad tracks, Main Street, and Fearing Hill Road before the confluence with the Weweantic River just upstream of Horseshoe Pond. The dam is classified as a high hazard because “it appears that a failure of the dam at maximum pool will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highway(s) or railroad(s)” (Pare Corporation, 2016a).
- 2) **Mill Pond Dam:** This dam impounds water along the Agawam River to create Mill Pond. The Mill Pond Dam supports Route 28 West along the crest of the dam and is located approximately 500 feet upstream of Route 28 East. The dam is a 16.5-foot high, 285-foot long earthen fill embankment consisting of five major elements: a fish way, a primary spillway, a secondary spillway, an outlet pipe, and the earthen embankment. Although the original date of construction is unclear, evidence points to a construction date around 1850. Potential hazards downstream of the dam include the sewage treatment plant on the north side of the Agawam River, a residential development located along Linwood





Avenue shortly downstream of that facility, and parking lot and commercial building located between the dam and the downstream Route 28 East. As with the Route 25 #1 Dam, the Mill Pond Dam is classified as a high hazard because “it appears that a failure of the dam at maximum pool will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highway(s) or railroad(s)” (Pare Corporation, 2016b).

- 3) **Parker Mills Pond Dam:** The dam impounds water along the Wankinco River to create Parker Mills Pond. It is an approximately 415-foot long earthen structure with an approximately 100-foot long earthen dike located between the dam and the left abutment. The upstream side of the dam consists of a stacked cut stone block wall. The downstream side of the dam consists of a mortared stone masonry wall, the majority of which comprises the wall of a mill building location along the downstream side of the dam. It is assumed that the dam was originally built in the mid-1800s in conjunction with the mill building. The structure also includes a fish ladder that was originally constructed in 1952 and rebuilt in 1975. In addition to the downstream mill buildings, downstream features at risk also include a daycare center, as well as critical utility lines (e.g., gas, water, sewer, and electricity). As with the other two dams described above, the Parker Mills Dam is classified as a high hazard because “it appears that a failure of the dam at maximum pool will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highway(s) or railroad(s)” (Pare Corporation, 2013).

While all culverts could cause some damage if they failed, there are four (4) culverts of particular concern in Wareham (Figure 3-26):

1. **Blackmore Pond Culverts:** This location consists of two concrete rectangular culverts that run under Blackmore Pond Road and connect the cranberry bogs to the west with Blackmore Pond to the east. There is currently erosion along the side of the road at this culvert location that is exposing the base of the guardrail.
2. **Fearing Hill Road Bridge:** This bridge spans the Weweantic River (Figure 3-27). The Town is concerned about the lack of freeboard between the base of the bridge and the top of the water level elevations. The bridge is also aging and is undersized for the amount of flow in this location.
3. **Main Street at Old Trout Farm:** This is an aging rectangular culvert that the Town is concerned about due to its age, its condition, and ongoing erosion at the edge of the roadway above it (Figure 3-27).
4. **Main Street Causeway at Mill Pond:** There are two oval corrugated metal culverts running under the Main Street causeway, which connect the two halves of Tremont Mill Pond. One is approximately 12 feet wide and the other is approximately 6 feet wide. The Town is concerned about both the age and degraded condition of these culverts.





Figure 3-27. Fearing Hill Road Bridge (left) and Main Street culvert at Old Trout Farm (right).

B1.c  
B2.a,c

### *Previous Occurrences & Extent*

There have been no previous occurrences of dam or culvert failure in the Town of Wareham. But aging infrastructure, increased storm intensity and rising sea levels may produce such incidents in the future.

The Massachusetts Office of Dam Safety, within the Department of Conservation and Recreation, maintains a database of all the dams in Massachusetts, classified by their hazard potential. This database divides dams into three categories:

- 1) High Hazard Potential Dam: A dam location where failure will likely cause loss of life and serious damage to homes, industrial or commercial facilities, important public utilities, main highways or railroads.
- 2) Significant Hazard Potential Dam: A dam located where failure may cause loss of life and damage to homes, industrial or commercial facilities, secondary highways, or railroads, or cause interruption of use or service of relatively important facilities.
- 3) Low Hazard Potential Dam: A dam located where failure may cause minimal property damage to other, and loss of life is not expected.

B2.b

### *Probability*

As a dam failure has never occurred in the Town of Wareham, the probability of it occurring is low, but possible (1-10% probability in the next year). The 2018 Massachusetts Hazard Mitigation and Climate Adaptation Plan describes two primary types of dam failure: catastrophic failure, characterized by the sudden, rapid, and uncontrolled release of impounded water, and design failure, which occurs as a result of minor overflow events. Dam overtopping is caused by floods that exceed the capacity of the dam, and it can occur as a result of inadequate spillway design, settlement of the dam crest, blockage of spillways, and other factors. Overtopping accounts for 34 percent of all dam failures in the U.S. More extreme precipitation events could increase the



frequency of overtopping events. So, although climate change will not increase the probability of catastrophic failure, it may increase the probability of design failure.

B3.a

### Impact

Below is a list of possible impacts that could result from dam or culvert failure:

- **People:** Could become trapped or blocked by flooded roads resulting from overtopped dams.
- **Infrastructure:** Utilities may be disrupted due to damaged pipes or power lines near the dam or culvert.
- **Buildings:** May be damaged by flooding caused by a failed dam or blocked culvert.
- **Economy:** Businesses could experience economic losses due to flooded or blocked roads prohibiting employees and/or customers from accessing certain areas of Town.
- **Natural Systems:** Dam and culvert failures can result in bank erosion. Debris and other materials can be deposited in natural systems.

## 3.13 WATER QUALITY CONCERNS (ALGAL BLOOMS, RED TIDES)

### Overview

Nutrient pollution from poorly maintained septic systems and lawn fertilizers, among other sources, can fuel the growth of algae: tiny plants that can bloom rapidly in a body of water. This process of over-supplying nutrients (i.e., nitrogen and phosphorus) to an aquatic system is called eutrophication. An algal bloom is a rapid increase in the amount of algae. When this occurs, it affects the whole ecosystem. Its impacts range from benign (e.g., providing additional food for herbivorous organisms) to harmful (e.g., blocking sunlight from other photosynthetic organisms, depleting dissolved oxygen levels, or secreting toxins into the water). Algal blooms that result in adverse impacts to the aquatic ecosystem are called harmful algal blooms (HAB), and can lead to fish kills, fishery or shellfish closures, and disruption to residential water supplies.

A red tide refers to a particular type of marine algal bloom comprised of specific types of dinoflagellates, a particular type of unicellular plankton that contains a red pigment. Very dense blooms can discolor the water with a reddish tint, giving these occurrences their name “red tide”. The particular organism that is responsible for red tide blooms in the northeast is known as *Alexandrium fundyense*. Red tide blooms are natural phenomena that occur in marine waters along the Massachusetts coastline, although they are typically isolated in nature; red tide blooms over a large geographic area are unusual. These dinoflagellates secrete a harmful neurotoxin. Because certain species of shellfish feed on planktonic organisms, this toxin can accumulate in the shellfish tissue. Consuming contaminated shellfish can result in a serious illness called paralytic shellfish poisoning (PSP). The Massachusetts Division of Marine Fisheries monitors the red tide levels in our waters, and is responsible for announcing closures and openings of shellfish beds based on their data.

B1.c  
B2.a

### Hazard Location

There are 35 freshwater ponds and lakes in Wareham ranging in size from 154 acres (Glen Charlie Pond) to 3 acres (small unnamed pond). Of these, the major 22 named waterbodies are shown in Figure 3-28. Due to the factors causing algal blooms and eutrophication, freshwater ponds and lakes are some of the most likely areas to be adversely affected. Wareham also has a number of major rivers, including Wareham River, Agawam River, Harlow Brook, Wankinco River, Rose Brook, Weweantic River, and Sippican River. Eutrophication can also affect nearshore estuaries and shallow bays.

Because red tide is caused by a marine dinoflagellate, this hazard would be most likely to effect the estuarine and marine environments around Wareham.

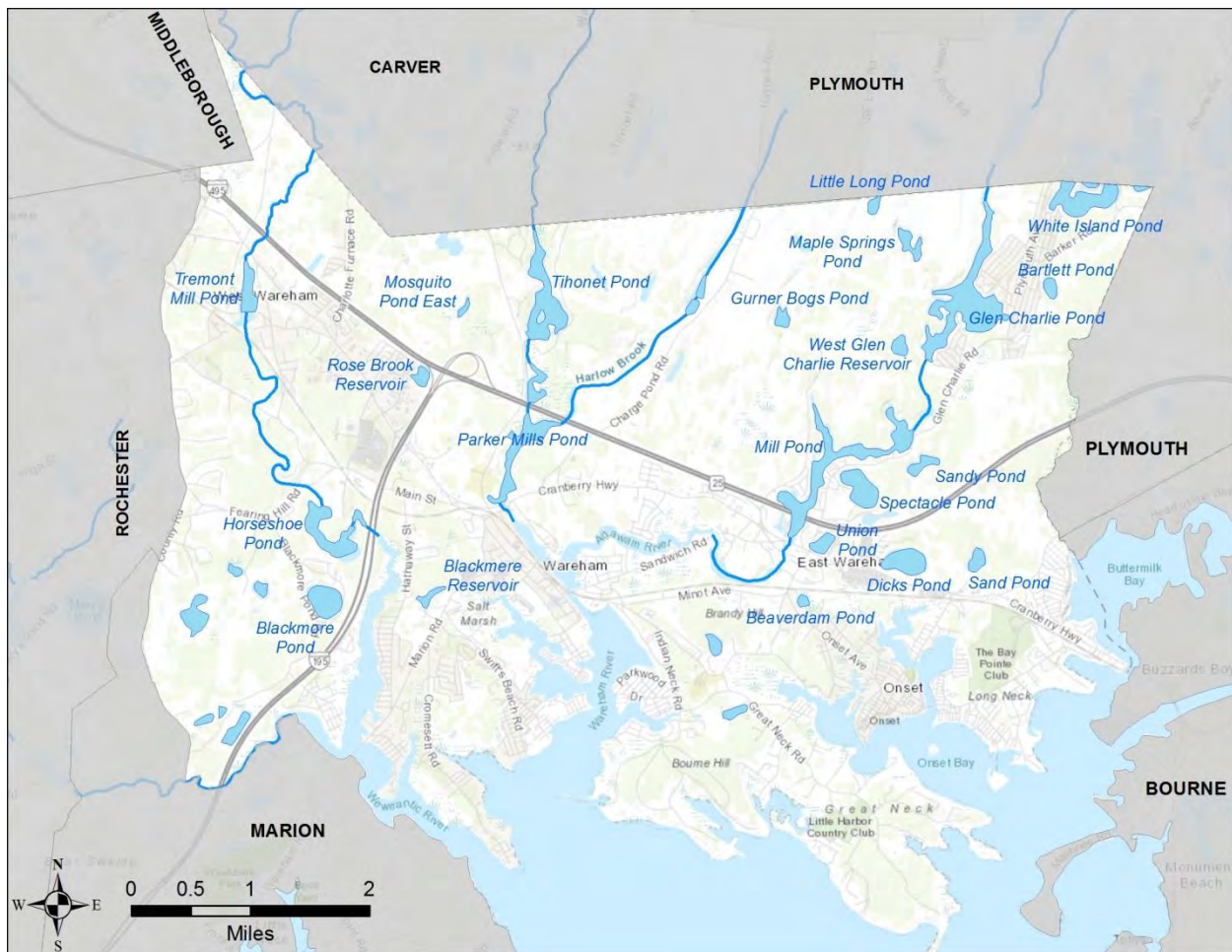


Figure 3-28. Freshwater ponds and lakes in Wareham.

B1.c  
B2.a,c

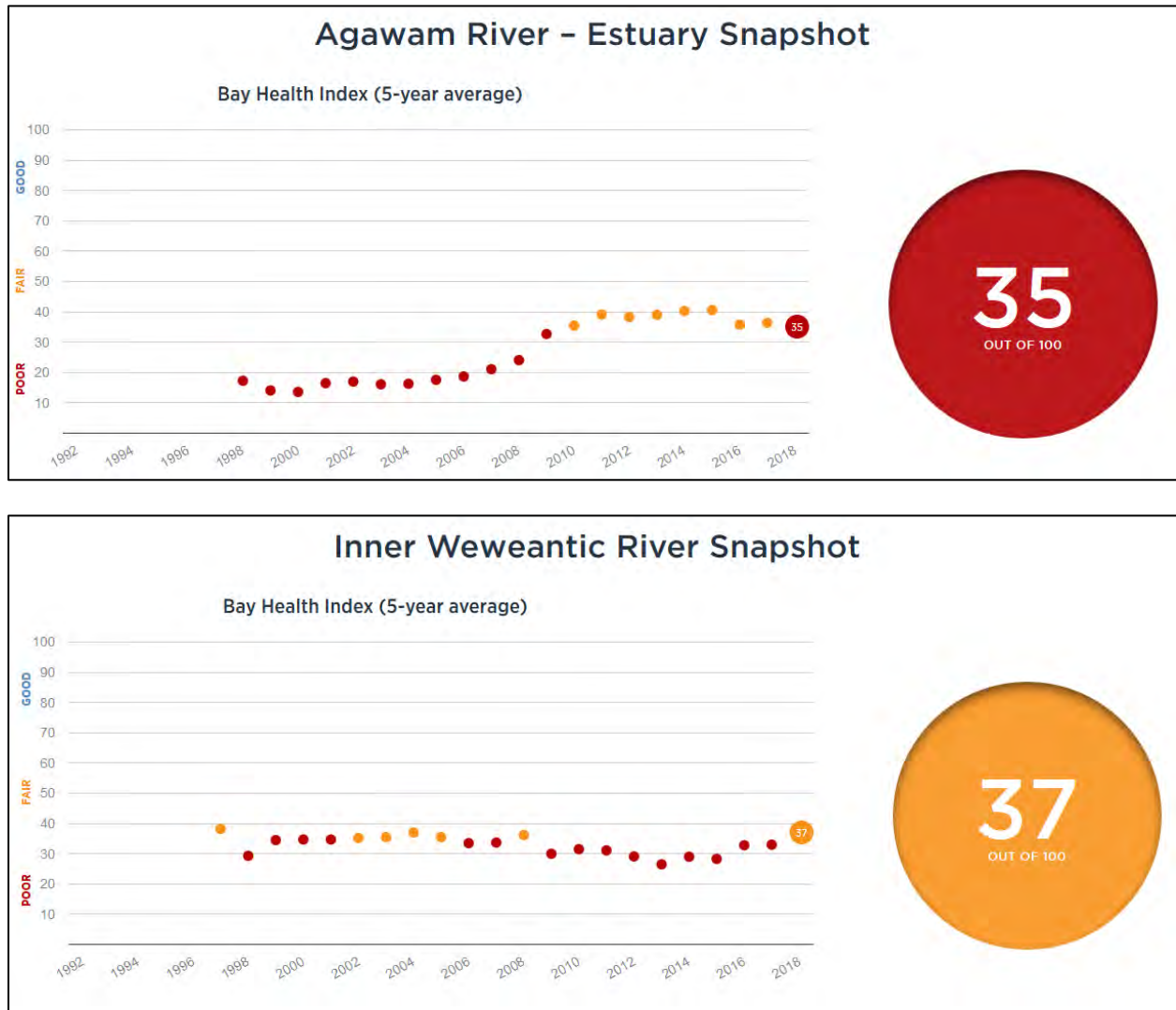
### Previous Occurrences & Extent

A 2010 report titled *The Wareham Nitrogen Consensus: An Action Plan* states that “nitrogen pollution is the greatest long-term threat both to Wareham’s waters and the larger Buzzards Bay ecosystem.” The Buzzards Bay Coalition has been monitoring water quality at 54 stations across





Wareham since the 1990s. This data show that the Agawam River (Figure 3-29, top), Wareham River and Weweantic River (Figure 3-29, bottom) rank among the most impaired in the Buzzards Bay watershed. These overall bay health indices are calculated based on measurements of total nitrogen, concentrations of algal pigments, water clarity and percent dissolved oxygen. Both the Wareham River and the Weweantic River are also listed by the USEPA and MassDEP as impaired for nutrients on the 303(d) list.



**Figure 3-29. Overall water quality summary from the Agawam River (top) and Inner Weweantic River (bottom) from the Buzzards Bay Coalition water quality monitoring program.**

The last time red tide was reported in Buzzards Bay, and Wareham specifically, was in 2005. The red tide bloom was first detected by the Massachusetts Division of Marine Fisheries (MarineFisheries) on April 27, 2005 in Nauset Estuary in Orleans. By May 27, the red tide bloom and associated shellfish closures extended to Massachusetts Bay, Cape Cod Bay and upper Buzzards Bay. On June 9, 2005, Governor Mitt Romney declared an economic disaster for the



state of Massachusetts, allowing the state to seek federal disaster aid for the impacts related to this red tide bloom. However, on June 24, the federal government decided the Red Tide outbreak and resulting PSP shellfish bed closures did not qualify for federal disaster relief. In July, Marine Fisheries began opening selected shellfish areas, as conditions improved, beginning with Buzzards Bay and a few areas around Cape Cod. The maximum extent of the PSP closures due to the red tide bloom in 2005 is shown in Figure 3-30.

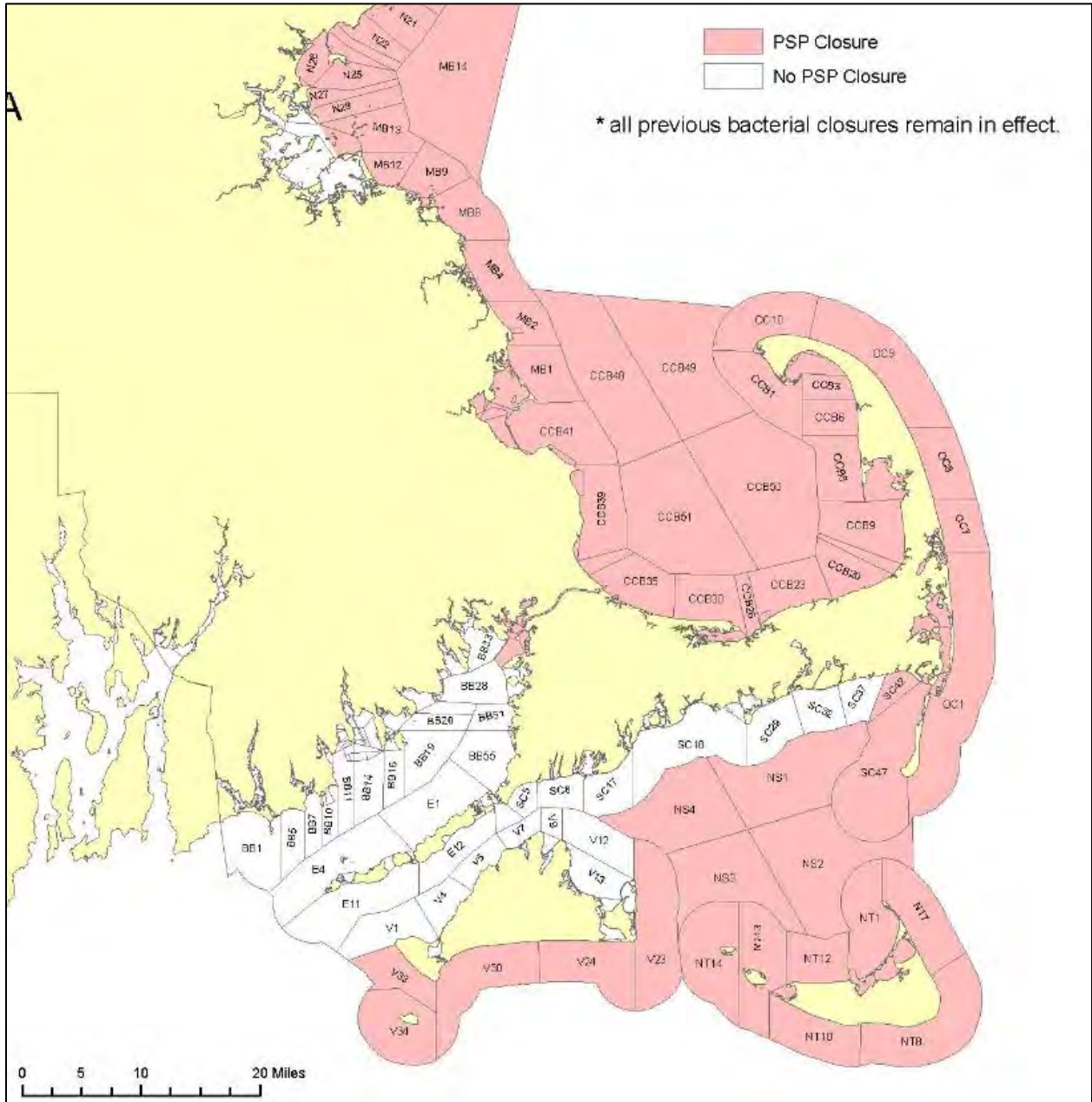


Figure 3-30. Maximum extent of PSP closures due to red tide in 2005 (BBNEP 2020).



B2.b

**Probability**

Based on past records, the likelihood of algal blooms and poor water quality in the Town's rivers and other waterbodies is likely (10 to 100% probability in the next year). Since it has been 15 years since a red tide occurrence in Wareham, the likelihood of a similar event occurring again is possible (1 to 10% probability in the next year).

B3.a

**Impact**

Below is a list of possible impacts that could result from water quality problems:

- **People:** Serious illness can result if people consume shellfish contaminated with the red tide neurotoxin: paralytic shellfish poisoning (PSP). Drinking water sources can be impacted if drinking water reservoirs are impacted by algal blooms.
- **Economy:** Businesses relying on the shellfishing industry can be negatively impacted during a red tide bloom as shellfishing areas are closed.
- **Natural Systems:** Freshwater and marine systems can be severely degraded due to algal blooms: algal blooms can shade out other photosynthetic organisms and oxygen depletion can result in fish kills.

**3.14 TSUNAMI****Overview**

A tsunami is a series of ocean waves generated by earthquakes, a sudden displacement of the ocean floor, underwater landslides or volcanic activity. In the deep ocean, a tsunami wave may only be a few inches high. However, as the wave nears shore, tsunamis generate a devastating onshore surge of water. Major tsunamis are produced by large (greater than 7 on the Richter scale), shallow focal depth (< 30km) earthquakes associated with continental plate movement. The waves associated with a tsunami move hundreds of miles per hour in the open ocean and can come ashore with wave heights of 100 feet or more. However, even waves that are 10 to 20 feet high can be extremely destructive.

B1.c  
B2.a**Hazard Location**

Although tsunamis most commonly occur in the Pacific Ocean, where dense oceanic plates slide under lighter continental plates, they can occur in the Atlantic Ocean as well.

B1.c  
B2.a,c**Previous Occurrences & Extent**

Although there are no records of a tsunami occurring in Wareham, there are six (6) reported tsunamis for the United States Atlantic coast and Gulf coast states in the last 200 years.

B2.b

**Probability**

There is no record of tsunamis ever occurring in Wareham, and only six occurrences along the Atlantic and Gulf coasts of the United States. Therefore, it is unlikely (less than a 1% probability over the next 100 years) that a tsunami will occur in Wareham.



B3.a

**Impact**

Below is a list of possible impacts that could result from a tsunami:

- **People:** The forces of a tsunami wave itself can injure people or lead to death. Floating debris can endanger human lives, and the effects of a tsunami may leave people within food or fuel.
- **Emergency Response:** Flooded roads and deposited debris may block emergency response.
- **Infrastructure:** Tsunami waves and floating debris can damage coastal infrastructure and piers. Ruptured utility pipes and storage containers can release oil and gas, resulting in fire hazards.
- **Buildings:** The force of the tsunami wave can destroy buildings, and floating debris can damage structures. Also, the scouring action of moving water can sweep away buildings.
- **Economy:** Utilities can be damaged and roadways blocked, which can adversely impact economic activities. Coastal systems impacted by tsunamis can also adversely impact the fishing and tourism industries.
- **Natural Systems:** Tsunamis can uproot trees and plants. Land animals can be killed by drowning and marine life can be killed by pollution if toxic chemicals are washed into the ocean.

**3.15 SUMMARY OF HAZARDS**

As suggested by the FEMA planning guidance, the Local Planning Team (LPT) reviewed the full range of natural hazards identified in the 2018 Massachusetts State Hazards and Climate Adaptation Plan and identified natural hazards that could impact Wareham in the future, or that have impacted the Town in the past (Chapter 3). The 14 individual hazards discussed in Chapter 3 are evaluated below in Table 3-14 based on the likelihood of occurrence, severity and area. Likelihoods for each hazard, as described in Chapter 3, are scored from 1 (unlikely) to 4 (highly likely). The severity of the hazard was scored on a scale of 1 to 4, with 1 being minor and 4 being catastrophic. Finally, whether the hazard was likely to have isolated impacts or a town-wide effect was scored as 1 or 2 respectively. For both severity and area, an “X” was used in Table 3-14 to indicate the most likely severity, while a “P” indicates the anticipated severity of a worst case scenario (i.e., a “potential” scenario). The value associated with the “X”, rather than the “P”, was used to calculate the estimated cumulative risk from that hazard. These determinations were made using local expertise from LPT members, data from the 2018 Massachusetts State Hazard and Climate Mitigation Plan and other resources.

The LPT selected only a subset of hazards from Table 3-14 to consider during the location-specific vulnerability analysis in Chapter 4. This selection was based on:

- **Area of influence:** If a hazard is expected to impact the entire Town equally, all properties and critical facilities are equally vulnerable to this hazard and no specific vulnerability



assessment is needed. Examples of this include severe winter weather, extreme temperature and earthquake.

- Lack of data: If spatial information about the likelihood of a hazard is not available, conducting a site-specific vulnerability assessment is not possible. Examples of this include thunderstorm, tornado and invasive species.
- Low estimated cumulative risk: If the estimated cumulative risk from a particular hazard is low, fully developing a vulnerability assessment to address it may be un-necessary. An example of this is the tsunami hazard.

The hazards that were selected for site-specific vulnerability assessments are indicated in Table 3-14 in bold font with asterisks. Additional detail as to what data will be used to evaluate these selected hazards in the vulnerability assessment is provided in Section 4.1.

**Table 3-14. Relative risk of hazards in Wareham.**

	Likelihood				Severity				Area		Estimated Cumulative Risk†
	Unlikely	Possible	Likely	Highly Likely	Minor	Serious	Extensive	Catastrophic	Isolated	Town Wide	
Score	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	
Severe Winter Storm				X		X		P		X	16
<b>Flooding (Inland &amp; Coastal)*</b>				X			X		X		12
<b>Hurricane &amp; Tropical Storm*</b>			X			X		P		X	12
Other Severe Weather				X		X		P	X	P	8
Extreme Temperature			X		X					X	6
Tornado			X			X		P	X		6
Coastal Erosion				X	X		P		X		4
Drought		X			X					X	4
Wildfires		X				X	P		X		4
Dam/Culvert Failure		X				X			X		4
Earthquake		X			X		P			X	4
Water Quality			X		X	P			X		3
Invasive Species		X			X				X	P	2
Tsunami	X				X			P	X		1

X indicates the believed value, while P indicates an extreme potential.

\*These **bolded** hazards were selected for specific vulnerability analyses in Chapter 4.

† This value is based on the formula Likelihood\*Severity\*Area. The Likelihood of the hazard is based on a scale of 1 to 4, with 1 being unlikely and 4 being highly likely. The Severity of the hazard was based on a scale from 1 to 4, with 1 being minor and 4 being catastrophic. Area was given a value of 1 for isolated and 2 for town-wide. The “P”s were not incorporated into the Estimated Cumulative Risk value.





*Risk analyses involve evaluating vulnerable assets, describing potential impacts, and estimating the loss from each hazard. Chapter 2 of the Wareham Multi-Hazard Mitigation Plan profiled the local assets and amenities, such as the natural resources, demographics, infrastructure and critical facilities, to document assets within the Town. Chapter 3 detailed the various natural hazards that have impacted or could impact the Town in the future. Chapter 4 combines the hazard descriptions and asset inventories to conduct an exposure analysis, that quantifies the number, type, and value of properties and critical facilities located in identified hazard areas.*

*This vulnerability assessment provides a foundation for the rest of the mitigation planning process, which is focused on identifying and prioritizing actions to reduce risks to hazards. In addition to informing the mitigation strategy, the vulnerability assessment also facilitates the establishment of emergency preparedness and response priorities, land use and comprehensive planning, and decision making by elected officials, city and county departments, businesses, and organizations in the community.*



#### 4.1 METHODOLOGY

This report includes three separate vulnerability assessments:

- 1) Vulnerability assessment of parcels and buildings;
- 2) Exposure assessment of critical facilities; and
- 3) Evaluation of evacuation routes

To estimate the total number of parcels, as well as both the value of the buildings on the property and the total property value (total property value is the sum of the value of the buildings, other structures, and the land itself within a given parcel), the planning team utilized the most current Assessor's Parcel dataset for the Town of Wareham (2019). The dataset provides information about parcel size, land use type, assessed value, and building characteristics.

This parcel dataset was first classified into various land use types based on the Massachusetts Property Type Classification Codes according to the Land Use classifications presented in Figure 2-1. The outcome of this classification was presented in Table 2-4 where the number of parcels and total acreage within each land use category were quantified. Table 4-1 details the parcels Land Use Codes that are encompassed by each land use type used in this report.

**Table 4-1. Wareham Land Use Classifications Based on Property Land Use Codes**

Land Use Type	Land Use Codes
Multiple Uses	01, 02, 03, 04, 05, 09, 013, 031
Residences <= 3 units	10
Residential Condos	102
Apartments >= 4 Units	11, 12
Mobile Homes	Moblie Homes
Office	34
Commercial	14, 30, 32, 33, 35, 37
Industrial	31, 40, 41, 45
Institutional	36, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99
Res/Ag and Res/OS	06, 07, 08, 017, 018, 071
Agriculture	037, 067, 073, 076, 27, 71
Open Space and Recreation	26, 28, 38, 60, 80, 81
Utility and Transportation	49, 42, 43, MUN_ROW, PUB_ROW, PRIV_ROW, ROW, PAPER ST, RAIL_ROW
Vacant	13, 20, 21, 22, 23, 39, 44, 72
Water	WATER
No Data	PARCEL, ISLAND, TAX, ISLE, FEE, 00, <Null>

To determine each parcel's vulnerability, a GIS analysis was conducted by overlaying extent maps for a subset of the hazards shown in Chapter 3 with the parcel data. Below is a list of the hazard types selected for this vulnerability analysis, and a description of the data used for the evaluation:

1. **Flooding:** FEMA Hazard Maps (Effective 2016) (see Figure 3-2).



2. **Sea-Level Rise:** MC-FRM Results produced by Woods Hole Group for MassDOT (see Figures 3-5 through 3-6)
3. **Hurricanes and Tropical Storms:** The extent of storm surge and flooding during a hurricane was estimated using the SLOSH model (Figure 3-12).

The Local Planning Team (LPT) decided not to quantitatively evaluate the vulnerability from remainder of the natural hazards listed in Table 3-14, for the following reasons:

1. **Coastal erosion:** Although rates of erosion are available from MassCZM the LPT chose not to perform a detailed vulnerability assessment for this hazard since 1) much of the Town's shoreline is estuarine and was not included in the MassCZM dataset and 2) most of the areas that were showed little to no change in the short term. Additionally, it is assumed that any waterfront parcel has a risk of erosion.
2. **Dam and Culvert Failure:** Although the locations of waterbodies within Wareham are known, location specific data for areas that would more likely to be impacted by a water quality issues in the future are not available. Therefore, a detailed vulnerability assessment could not be completed at this time.
3. **Water Quality:** Although the locations of potentially problematic dams and culverts are known, location specific data for areas that would be impacted by a failure of one of these structures is not available. Therefore, a detailed vulnerability assessment could not be completed at this time.
4. **Severe winter weather, Wildfire, Tornado, Drought, Extreme Temperature, Earthquake, Invasive Species, Other Severe Weather and Tsunami:** Location specific data within Wareham is not available for these hazards. Therefore, a detailed vulnerability assessment could not be completed at this time.

Once the parcels affected by each hazard type were identified, the number of parcels in each land use category was totaled, as well as the value of the buildings and total property value associated with each parcel. In this way, the percent of the Town's parcels and the percent of the Town's property value potentially affected by each hazard type was quantified. These parcel totals and property values also represent the potential impact from secondary issues associated with each hazard (e.g., mold, mildew and other water damage impacts associated with flood hazard events). These results are summarized in Tables 4-3 to 4-13. As an additional analysis, for the FEMA flood zone vulnerability assessment, the parcels within the land use category "Residences <= 3 units" were further divided based on neighborhood. This was done to provide further insight as to which areas of Town would have the most impacted residents in the event of a flood hazard event. The results of this neighborhood-level vulnerability assessment are presented in Tables 4-14 through 4-16.

To assess the vulnerabilities of Wareham's critical facilities, as discussed in Chapter 2, the planning team first developed a list of the critical facilities and structures. Each location was mapped in GIS (Figure 2-3). The same hazards that were mapped and applied to the parcel vulnerability assessment were again overlaid on the map of critical infrastructure (i.e. flooding, sea-level rise, and hurricanes). If a critical facility was located in a hazard area, that particular facility was considered to be exposed, and therefore vulnerable, to that particular hazard. For



the same reasons listed above in the description of the parcel vulnerability analysis, potential impacts from other hazards, such as earthquakes and tsunamis were not directly evaluated for critical facilities. Results from the vulnerability analysis for critical facilities are summarized in Table 4-2, at the bottom of each of the hazard table (Tables 4-3 to 4-13).

An evaluation of the Town's evacuation routes was conducted to determine whether any of the current evacuation pathways was susceptible to inundation due to flooding or sea-level rise. Although other hazards may impact these areas, the Local Planning Team determined that inundated roadways posed the largest threat to the safe and effective utilization of emergency evacuation routes. To address this, the extents of these hazard areas were overlain on the existing evacuation routes, and vulnerable areas were identified. Impacts to evacuation routes are shown in Figures 4-1 and 4-2.





## 4.2 RESULTS

Table 4-2. Critical Facility Vulnerability Assessment

ID	Name	Category	FEMA Flood Zone	Min Hurricane Category That Will Affect Facility	Storm Surge Inundation Risk 2030	Storm Surge Inundation Risk 2070	
1	Multi-Service Center	Admin					
2	Harbormaster Building		VE		≥20%	≥20%	
3	Town Hall						
4	WCTV Building						
5	Municipal Maintenance Salt Shed	Municipal Maintenance Department					
6	Municipal Maintenance Main Building						
7	Police Department Main Building	Emergency					
8	EMS		AE	1	1.0% to <20%	≥20%	
9	Wareham Fire District Headquarters/Admin (Main St)		AE	1	1.0% to <20%	≥20%	
10	Wareham Fire District Fire Department		AE	2		1.0% to <20%	
11	East Wareham Fire Station (Minot Ave)		AE	2		1.0% to <20%	
12	Onset Fire Department						
13	Proposed Fire District Building - 8 Sand Pond Rd				3		1.0% to <20%
14	Wareham Fire Dist. St#2 W. Wareham 2368 Cran. Hwy						
15	Wareham Fire Dist. St#3 283 Glen Charlie Road						
16	Tobey Hospital		Hospital				
17	Main Library	Library					
18	Spinney Memorial Library				3		



ID	Name	Category	FEMA Flood Zone	Min Hurricane Category That Will Affect Facility	Storm Surge Inundation Risk 2030	Storm Surge Inundation Risk 2070
19	Ethel E. Hammond School (Boys & Girls Club)	School		4		
20	John William Decas Elementary School					
21	Minot Forest School					
22	Wareham Middle School		3			
23	Wareham High School		3			
24	Water Pollution Control Facility	Sewer		4		
25	Salt Works Road		VE	2	1.0% to <20%	1.0% to <20%
26	Hill Street		VE	2		1.0% to <20%
27	Cohasset Narrows		VE	1	≥20%	≥20%
28	Greene Street (ejector)		AE	2	1.0% to <20%	≥20%
29	Woodbury Street (ejector)			2		1.0% to <20%
30	Onset Heights		AE	2	≥20%	≥20%
31	South Water		VE	1	≥20%	≥20%
32	East Boulevard (ejector)		AE	1	≥20%	≥20%
33	Onset Pier		VE	1	≥20%	≥20%
34	South Boulevard (ejector)		VE	2	≥20%	≥20%
35	Hynes Field		AE	1	≥20%	≥20%
36	North Boulevard		AE	1	≥20%	≥20%
37	Riverside		AE	1	≥20%	≥20%
38	Dick's Pond		AE	1	1.0% to <20%	≥20%
39	Depot Street			2		
40	Linwood Avenue		AE	2		1.0% to <20%
41	Apple Street		AE	1	1.0% to <20%	≥20%
42	Avenue A Street		AE	1	1.0% to <20%	≥20%
43	Narrows		AE	1	≥20%	≥20%
44	Indian Neck		AE	1	1.0% to <20%	≥20%
45	Oak Street			4		1.0% to <20%
46	Parkwood		AE	2	1.0% to <20%	1.0% to <20%
47	Pinehurst		AE	2	1.0% to <20%	≥20%
48	Kennedy Lane			2		1.0% to <20%
49	Smith Avenue		VE	1	≥20%	≥20%
50	Ruggle		VE	1	≥20%	≥20%
51	Cromesett		AE	1	1.0% to <20%	≥20%
52	Briarwood Beach		AE	1	≥20%	≥20%
53	Arnold		AE	1	≥20%	≥20%



ID	Name	Category	FEMA Flood Zone	Min Hurricane Category That Will Affect Facility	Storm Surge Inundation Risk 2030	Storm Surge Inundation Risk 2070	
54	French	Sewer		2		1.0% to <20%	
55	Hathaway		AE	2	1.0% to <20%	≥20%	
56	Industrial Park II						
57	Industrial Park I						
58	Springbourne						
59	Nanumett				4		
60	Bay Street (ejector)				1	1.0% to <20%	≥20%
61	Minot Avenue						
62	Peter Copper Drive						
63	Mattapoissett				3		1.0% to <20%
64	Thirteenth Street				2		1.0% to <20%
65	Leonard			AE	1	≥20%	≥20%
66	Pine Tree Estates			AE	2	1.0% to <20%	1.0% to <20%
67	Police Station						
68	Train Station	Transportation	AE	1	≥20%	≥20%	
69	Maple Springs Well 2	Water		3			
70	Maple Springs Well 3				3		
71	Maple Springs Well 4				3		
72	Maple Springs Corrosion Control Building				4		
73	Maple Springs Well 1				3		
74	Sand Pond Road - Well 3				2		
75	Sand Pond Road - Well 4				3		
76	Sand Pond Road - Well 6				4		
77	Sand Pond Road - Storage Building				4		
78	Sand Pond Road - Well 5				4		
79	District Water Building - 5 Sand Pond Road						
80	Water Tower (Onset Fire District)						
81	Sand Pond Road - Well 7				4		
82	Bourne Hill Water Tank (Wareham Fire District)						
83	West Wareham Water Tank (Wareham Fire District)						



ID	Name	Category	FEMA Flood Zone	Min Hurricane Category That Will Affect Facility	Storm Surge Inundation Risk 2030	Storm Surge Inundation Risk 2070
84	Glen Charlie Water Tank (Wareham Fire District)	Water				
85	Seawood Springs Well 6					
86	Seawood Springs Well 7					
87	Southline Well 8 Building Pump House					
88	Maple Park Well 9					
89	Wareham Fire District Office (2550 Main Street)					
90	Well 8					



**Table 4-3. Parcels and buildings vulnerable to flooding in the VE Zone.**

Land Use	Number of Parcels			Value of Buildings			Value of Total Property		
	Total	Total in Hazard	% in Hazard	Total Value	Total Value in Hazard	% Value in Hazard	Total Value	Total Value in Hazard	% Value in Hazard
Multiple Uses	208	5	2%	\$33,966,500	\$1,039,700	3%	\$48,607,300	\$2,319,100	5%
Residences <= 3 units	9,898	1375	14%	\$1,355,396,781	\$215,261,700	16%	\$2,554,310,021	\$571,333,100	22%
Residential Condos	397	9	2%	\$74,466,204	\$3,824,100	5%	\$75,333,004	\$3,830,500	5%
Apartments >= 4 units	52	3	6%	\$37,596,400	\$755,600	2%	\$47,678,700	\$1,629,200	3%
Mobile Homes	16	0	0%	\$498,000	\$-	0%	\$16,763,600	\$-	0%
Office	71	3	4%	\$36,569,800	\$1,037,100	3%	\$45,164,100	\$1,349,700	3%
Commercial	228	14	6%	\$141,037,700	\$3,760,400	3%	\$221,758,600	\$7,492,300	3%
Industrial	117	2	2%	\$61,116,300	\$602,800	1%	\$88,003,200	\$2,089,000	2%
Institutional	807	119	15%	\$147,063,500	\$2,212,100	2%	\$282,997,200	\$23,387,700	8%
Res/Ag and Res/OS	17	1	6%	\$1,971,400	\$330,400	17%	\$3,814,700	\$466,400	12%
Agriculture	122	0	0%	\$2,804,800	\$-	0%	\$7,242,100	\$-	0%
Open Space and Recreation	87	22	25%	\$3,641,600	\$1,950,600	54%	\$17,539,900	\$9,015,600	51%
Utility and Transportation	45	7	16%	\$1,799,100	\$-	0%	\$3,974,900	\$-	0%
Vacant	2,498	371	15%	\$36,129,600	\$235,700	1%	\$136,196,600	\$19,094,000	14%
<b>Total</b>	<b>14,563</b>	<b>1931</b>	<b>13%</b>	<b>\$1,934,057,685</b>	<b>\$231,010,200</b>	<b>12%</b>	<b>\$3,549,383,925</b>	<b>\$642,006,600</b>	<b>18%</b>

Critical facilities vulnerable to flooding in the VE flood zone include the Hill Street, Salt Works Road, South Water, Onset Pier, Cohasset Narrows, Smith Avenue, and Ruggles pump stations, as well as the Harbormaster Building and South Boulevard Ejector. These facilities are located around the Wareham River, Onset Bay, and Buttermilk Bay.



Table 4-4. Parcels and buildings vulnerable to flooding in the AE Zone.

Land Use	Number of Parcels			Value of Buildings			Value of Total Property		
	Total	Total in Hazard	% in Hazard	Total Value	Total Value in Hazard	% Value in Hazard	Total Value	Total Value in Hazard	% Value in Hazard
Multiple Uses	208	139	67%	\$33,966,500	\$17,921,100	53%	\$48,607,300	\$23,214,100	48%
Residences <= 3 units	9,898	2695	27%	\$1,355,396,781	\$337,669,328	25%	\$2,554,310,021	\$636,350,228	25%
Residential Condos	397	117	29%	\$74,466,204	\$20,243,956	27%	\$75,333,004	\$20,404,956	27%
Apartments >= 4 units	52	21	40%	\$37,596,400	\$19,930,400	53%	\$47,678,700	\$24,273,500	51%
Mobile Homes	16	7	44%	\$498,000	\$481,000	97%	\$16,763,600	\$7,518,800	45%
Office	71	32	45%	\$36,569,800	\$8,044,200	22%	\$45,164,100	\$10,340,200	23%
Commercial	228	77	34%	\$141,037,700	\$40,269,700	29%	\$221,758,600	\$68,705,900	31%
Industrial	117	16	14%	\$61,116,300	\$4,676,200	8%	\$88,003,200	\$8,563,900	10%
Institutional	807	235	29%	\$147,063,500	\$60,332,300	41%	\$282,997,200	\$127,461,700	45%
Res/Ag and Res/OS	17	10	59%	\$1,971,400	\$1,304,400	66%	\$3,814,700	\$2,203,400	58%
Agriculture	122	37	30%	\$2,804,800	\$2,594,400	92%	\$7,242,100	\$4,887,000	67%
Open Space and Recreation	87	22	25%	\$3,641,600	\$1,691,000	46%	\$17,539,900	\$8,112,500	46%
Utility and Transportation	45	11	24%	\$1,799,100	\$-	0%	\$3,974,900	\$570,700	14%
Vacant	2,498	742	30%	\$36,129,600	\$6,586,400	18%	\$136,196,600	\$33,876,300	5%
<b>Total</b>	<b>14,563</b>	<b>4161</b>	<b>29%</b>	<b>\$1,934,057,685</b>	<b>\$521,744,384</b>	<b>27%</b>	<b>\$3,549,383,925</b>	<b>\$976,483,184</b>	<b>28%</b>

Critical facilities vulnerable to flooding in the AE flood zone include the Briarwood Beach, Leonard, Arnold, Riverside, Narrows, Hynes Field, North Boulevard, Apple Street, Avenue A, Dick's Pond, Cromesett, Indian Neck, Onset Heights, Linwood, Parkwood, Pine Tree Estates, Hathaway, and Pinehurst pump stations, the East Boulevard and Greene Street ejectors, as well as the East Wareham Fire Station, Wareham Fire District Fire Department, Wareham Fire District Headquarters, EMS, and MBTA train station. Fire station and EMS facilities are located on Main Street, Sandwich Road, and Minot Avenue.



Table 4-5. Parcels and buildings vulnerable to flooding in Other Flood Zones (AO, AH, A).

Land Use	Number of Parcels			Value of Buildings			Value of Total Property		
	Total	Total in Hazard	% in Hazard	Total Value	Total Value in Hazard	% Value in Hazard	Total Value	Total Value in Hazard	% Value in Hazard
Multiple Uses	208	3	1%	\$33,966,500	\$357,500	1%	\$48,607,300	\$915,700	2%
Residences <= 3 units	9,898	178	2%	\$1,355,396,781	\$29,371,000	2%	\$2,554,310,021	\$55,322,100	2%
Residential Condos	397	0	0%	\$74,466,204	\$-	0%	\$75,333,004	\$-	0%
Apartments >= 4 units	52	1	2%	\$37,596,400	\$202,500	1%	\$47,678,700	\$296,400	1%
Mobile Homes	16	0	0%	\$498,000	\$-	0%	\$16,763,600	\$-	0%
Office	71	0	0%	\$36,569,800	\$-	0%	\$45,164,100	\$-	0%
Commercial	228	1	0%	\$141,037,700	\$258,800	0%	\$221,758,600	\$460,100	0%
Industrial	117	1	1%	\$61,116,300	\$183,300	0%	\$88,003,200	\$353,200	0%
Institutional	807	14	2%	\$147,063,500	\$484,000	0%	\$282,997,200	\$3,997,800	1%
Res/Ag and Res/OS	17	0	0%	\$1,971,400	\$-	0%	\$3,814,700	\$-	0%
Agriculture	122	10	8%	\$2,804,800	\$-	0%	\$7,242,100	\$139,100	2%
Open Space and Recreation	87	5	6%	\$3,641,600	\$-	0%	\$17,539,900	\$52,500	0%
Utility and Transportation	45	0	0%	\$1,799,100	\$-	0%	\$3,974,900	\$-	0%
Vacant	2,498	57	2%	\$36,129,600	\$1,756,700	5%	\$136,196,600	\$5,118,000	4%
<b>Total</b>	<b>14,563</b>	<b>270</b>	<b>2%</b>	<b>\$1,934,057,685</b>	<b>\$32,613,800</b>	<b>2%</b>	<b>\$3,549,383,925</b>	<b>\$66,654,900</b>	<b>2%</b>

There are no critical facilities vulnerable to flooding in the AO, AH, or A flood zones.

**Table 4-6. Parcels and buildings vulnerable to flooding during a minor storm event (20% or greater chance of inundation) in 2030.**

Land Use	Number of Parcels			Value of Buildings			Value of Total Property		
	Total	Total in Hazard	% in Hazard	Total Value	Total Value in Hazard	% Value in Hazard	Total Value	Total Value in Hazard	% Value in Hazard
Multiple Uses	208	127	61%	\$33,966,500	\$15,110,500	44%	\$48,607,300	\$18,498,800	38%
Residences <= 3 units	9,898	2141	22%	\$1,355,396,781	\$312,124,400	23%	\$2,554,310,021	\$774,255,800	30%
Residential Condos	397	87	22%	\$74,466,204	\$18,412,300	25%	\$75,333,004	\$18,474,800	25%
Apartments >= 4 units	52	11	21%	\$37,596,400	\$6,307,500	17%	\$47,678,700	\$8,374,700	18%
Mobile Homes	16	6	38%	\$498,000	\$481,000	97%	\$16,763,600	\$6,539,300	39%
Office	71	6	8%	\$36,569,800	\$2,247,400	6%	\$45,164,100	\$2,847,200	6%
Commercial	228	46	20%	\$141,037,700	\$24,081,300	17%	\$221,758,600	\$43,184,300	19%
Industrial	117	9	8%	\$61,116,300	\$1,746,200	3%	\$88,003,200	\$4,921,300	6%
Institutional	807	245	30%	\$147,063,500	\$57,447,300	39%	\$282,997,200	\$132,598,100	47%
Res/Ag and Res/OS	17	4	24%	\$1,971,400	\$577,900	29%	\$3,814,700	\$841,200	22%
Agriculture	122	8	7%	\$2,804,800	\$-	0%	\$7,242,100	\$248,900	3%
Open Space and Recreation	87	30	34%	\$3,641,600	\$3,554,800	98%	\$17,539,900	\$16,411,600	94%
Utility and Transportation	45	12	27%	\$1,799,100	\$-	0%	\$3,974,900	\$570,700	14%
Vacant	2,498	765	31%	\$36,129,600	\$4,658,500	13%	\$136,196,600	\$36,705,500	27%
<b>Total</b>	<b>14,563</b>	<b>3497</b>	<b>24%</b>	<b>\$1,934,057,685</b>	<b>\$446,749,100</b>	<b>23%</b>	<b>\$3,549,383,925</b>	<b>\$1,064,472,200</b>	<b>30%</b>

Critical facilities vulnerable to flooding during a minor storm event in 2030 include the Cohasset Narrows, Onset Heights, South Water, Onset Pier, Hynes Field, North Boulevard, Riverside, Narrows, Smith Avenue, Ruggles, Briarwood Beach, Arnold, and Leonard pump stations around Weweantic River, Wareham River, Onset Bay, and Buttermilk Bay, in addition to the South and East Boulevard ejectors, the MBTA train station, and Harbormaster Building.



**Table 4-7. Parcels and buildings vulnerable to flooding during a major storm event (1% to less than 20% chance of inundation) in 2030.**

Land Use	Number of Parcels			Value of Buildings			Value of Total Property		
	Total	Total in Hazard	% in Hazard	Total Value	Total Value in Hazard	% Value in Hazard	Total Value	Total Value in Hazard	% Value in Hazard
Multiple Uses	208	7	3%	\$33,966,500	\$1,990,900	6%	\$48,607,300	\$3,049,000	6%
Residences <= 3 units	9,898	1435	14%	\$1,355,396,781	\$177,791,516	13%	\$2,554,310,021	\$314,827,116	12%
Residential Condos	397	49	12%	\$74,466,204	\$8,076,356	11%	\$75,333,004	\$8,174,156	11%
Apartments >= 4 units	52	8	15%	\$37,596,400	\$2,522,700	7%	\$47,678,700	\$3,554,300	7%
Mobile Homes	16	0	0%	\$498,000	\$-	0%	\$16,763,600	\$-	0%
Office	71	8	11%	\$36,569,800	\$3,572,300	10%	\$45,164,100	\$4,944,000	11%
Commercial	228	30	13%	\$141,037,700	\$9,572,600	7%	\$221,758,600	\$15,504,400	7%
Industrial	117	4	3%	\$61,116,300	\$4,693,900	8%	\$88,003,200	\$6,315,300	7%
Institutional	807	96	12%	\$147,063,500	\$10,623,200	7%	\$282,997,200	\$17,718,000	6%
Res/Ag and Res/OS	17	3	18%	\$1,971,400	\$752,800	38%	\$3,814,700	\$1,001,600	26%
Agriculture	122	6	5%	\$2,804,800	\$-	0%	\$7,242,100	\$110,300	2%
Open Space and Recreation	87	11	13%	\$3,641,600	\$86,800	2%	\$17,539,900	\$735,700	4%
Utility and Transportation	45	3	7%	\$1,799,100	\$-	0%	\$3,974,900	\$7,000	0%
Vacant	2,498	191	8%	\$36,129,600	\$308,300	1%	\$136,196,600	\$8,448,100	6%
<b>Total</b>	<b>14,563</b>	<b>1851</b>	<b>13%</b>	<b>\$1,934,057,685</b>	<b>\$219,991,372</b>	<b>11%</b>	<b>\$3,549,383,925</b>	<b>\$384,388,972</b>	<b>11%</b>

Critical facilities vulnerable to flooding during a major storm event in 2030 include Salt Works Road, Dick's Pond, Apple Street, Avenue A, Indian Neck, Parkwood, Pinehurst, Cromesett, Hathaway, and Pine Tree Estates pump stations located around the Weweantic River, Wareham River, Dick's Pond, and Buttermilk Bay. Additional vulnerable facilities include the Greene Street and Bay Street ejectors, Wareham Fire District Headquarters on Main Street, and EMS.

**Table 4-8. Parcels and buildings vulnerable to flooding during a minor storm event (20% or greater chance of inundation) in 2070.**

Land Use	Number of Parcels			Value of Buildings			Value of Total Property		
	Total	Total in Hazard	% in Hazard	Total Value	Total Value in Hazard	% Value in Hazard	Total Value	Total Value in Hazard	% Value in Hazard
Multiple Uses	208	133	64%	\$33,966,500	\$16,863,400	50%	\$48,607,300	\$21,064,400	43%
Residences <= 3 units	9,898	3248	33%	\$1,355,396,781	\$447,661,258	33%	\$2,554,310,021	\$1,014,480,258	40%
Residential Condos	397	124	31%	\$74,466,204	\$24,995,056	34%	\$75,333,004	\$25,152,056	33%
Apartments >= 4 units	52	19	37%	\$37,596,400	\$8,830,200	23%	\$47,678,700	\$11,929,000	25%
Mobile Homes	16	6	38%	\$498,000	\$481,000	97%	\$16,763,600	\$6,539,300	39%
Office	71	13	18%	\$36,569,800	\$5,378,400	15%	\$45,164,100	\$7,217,800	16%
Commercial	228	72	32%	\$141,037,700	\$32,484,800	23%	\$221,758,600	\$56,746,700	26%
Industrial	117	12	10%	\$61,116,300	\$3,545,600	6%	\$88,003,200	\$7,394,600	8%
Institutional	807	297	37%	\$147,063,500	\$60,479,500	41%	\$282,997,200	\$142,036,700	50%
Res/Ag and Res/OS	17	7	41%	\$1,971,400	\$1,330,700	68%	\$3,814,700	\$1,842,800	48%
Agriculture	122	12	10%	\$2,804,800	\$-	0%	\$7,242,100	\$354,600	5%
Open Space and Recreation	87	39	45%	\$3,641,600	\$3,641,600	100%	\$17,539,900	\$17,110,300	98%
Utility and Transportation	45	13	29%	\$1,799,100	\$-	0%	\$3,974,900	\$577,700	15%
Vacant	2,498	920	37%	\$36,129,600	\$4,966,800	14%	\$136,196,600	\$42,537,400	31%
<b>Total</b>	<b>14,563</b>	<b>4915</b>	<b>34%</b>	<b>\$1,934,057,685</b>	<b>\$610,658,314</b>	<b>32%</b>	<b>\$3,549,383,925</b>	<b>\$1,354,983,614</b>	<b>38%</b>

Critical facilities vulnerable to flooding during a minor storm event in 2070 include all critical facilities vulnerable to flooding during a minor storm event in 2030, in addition to Dick's Pond, Apple Street, Avenue A, Indian Neck, Pinehurst, Cromesett, and Hathaway pump stations, the Greene Street and Bay Street ejectors, the Wareham Fire District Headquarters on Main Street, and EMS.

**Table 4-9. Parcels and buildings vulnerable to flooding during a major storm event (1% to less than 20% chance of inundation) in 2070.**

Land Use	Number of Parcels			Value of Buildings			Value of Total Property		
	Total	Total in Hazard	% in Hazard	Total Value	Total Value in Hazard	% Value in Hazard	Total Value	Total Value in Hazard	% Value in Hazard
Multiple Uses	208	17	8%	\$33,966,500	\$3,067,100	9%	\$48,607,300	\$5,093,000	10%
Residences <= 3 units	9,898	1866	19%	\$1,355,396,781	\$241,089,774	18%	\$2,554,310,021	\$413,010,674	16%
Residential Condos	397	59	15%	\$74,466,204	\$8,939,900	12%	\$75,333,004	\$9,073,600	12%
Apartments >= 4 units	52	13	25%	\$37,596,400	\$14,840,100	39%	\$47,678,700	\$17,813,100	37%
Mobile Homes	16	2	13%	\$498,000	\$-	0%	\$16,763,600	\$1,132,400	7%
Office	71	23	32%	\$36,569,800	\$4,049,500	11%	\$45,164,100	\$4,912,100	11%
Commercial	228	33	14%	\$141,037,700	\$19,618,500	14%	\$221,758,600	\$32,803,100	15%
Industrial	117	9	8%	\$61,116,300	\$4,470,900	7%	\$88,003,200	\$6,952,200	8%
Institutional	807	119	15%	\$147,063,500	\$26,345,000	18%	\$282,997,200	\$37,116,000	13%
Res/Ag and Res/OS	17	2	12%	\$1,971,400	\$5,100	0%	\$3,814,700	\$115,200	3%
Agriculture	122	25	20%	\$2,804,800	\$91,200	3%	\$7,242,100	\$496,000	7%
Open Space and Recreation	87	6	7%	\$3,641,600	\$-	0%	\$17,539,900	\$92,400	1%
Utility and Transportation	45	7	16%	\$1,799,100	\$-	0%	\$3,974,900	\$67,500	2%
Vacant	2,498	360	14%	\$36,129,600	\$2,813,200	8%	\$136,196,600	\$15,710,000	12%
<b>Total</b>	<b>14,563</b>	<b>2541</b>	<b>17%</b>	<b>\$1,934,057,685</b>	<b>\$325,330,274</b>	<b>17%</b>	<b>\$3,549,383,925</b>	<b>\$544,387,274</b>	<b>15%</b>

Critical facilities vulnerable to flooding during a major storm event in 2070 include the Salt Works Road, Hill Street, Linwood Avenue, Oak Street, Parkwood, Kennedy Lane, French, Mattapoisett, Thirteenth Street, and Pine Tree Estates pump stations as well as the Woodbury Street Ejector, Proposed Fire District Building on Sand Pond Road, East Wareham Fire Station and Wareham Fire District Fire Department.



Table 4-10. Parcels and buildings vulnerable to a category 1 hurricane (SLOSH 1).

Land Use	Number of Parcels			Value of Buildings			Value of Total Property		
	Total	Total in Hazard	% in Hazard	Total Value	Total Value in Hazard	% Value in Hazard	Total Value	Total Value in Hazard	% Value in Hazard
Multiple Uses	208	133	64%	\$33,966,500	\$16,761,200	49%	\$48,607,300	\$21,034,700	43%
Residences <= 3 units	9,898	2716	27%	\$1,355,396,781	\$384,477,800	28%	\$2,554,310,021	\$904,173,100	35%
Residential Condos	397	113	28%	\$74,466,204	\$23,501,156	32%	\$75,333,004	\$23,583,256	31%
Apartments >= 4 units	52	17	33%	\$37,596,400	\$8,205,100	22%	\$47,678,700	\$11,115,600	23%
Mobile Homes	16	6	38%	\$498,000	\$481,000	97%	\$16,763,600	\$6,539,300	39%
Office	71	11	15%	\$36,569,800	\$4,988,900	14%	\$45,164,100	\$6,371,200	14%
Commercial	228	63	28%	\$141,037,700	\$30,052,300	21%	\$221,758,600	\$52,782,400	24%
Industrial	117	10	9%	\$61,116,300	\$1,818,900	3%	\$88,003,200	\$5,168,500	6%
Institutional	807	279	35%	\$147,063,500	\$59,815,500	41%	\$282,997,200	\$138,641,800	49%
Res/Ag and Res/OS	17	7	41%	\$1,971,400	\$1,330,700	68%	\$3,814,700	\$1,842,800	48%
Agriculture	122	9	7%	\$2,804,800	\$-	0%	\$7,242,100	\$261,100	4%
Open Space and Recreation	87	36	41%	\$3,641,600	\$3,641,600	100%	\$17,539,900	\$16,997,100	97%
Utility and Transportation	45	12	27%	\$1,799,100	\$-	0%	\$3,974,900	\$570,700	14%
Vacant	2,498	883	35%	\$36,129,600	\$4,966,800	14%	\$136,196,600	\$40,620,500	30%
<b>Total</b>	<b>14,563</b>	<b>4295</b>	<b>29%</b>	<b>\$1,934,057,685</b>	<b>\$540,040,956</b>	<b>28%</b>	<b>\$3,549,383,925</b>	<b>\$1,229,702,056</b>	<b>35%</b>

Critical facilities vulnerable to flooding during a Category 1 hurricane include the Cohasset Narrows, South Water, Onset Pier, Hynes Field, North Boulevard, Riverside, Dick's Pond, Apple Street, Avenue A Street, Narrows Pump, Indian Neck, Smith Avenue, Ruggles, Cromesett, Briarwood Beach, Arnold, and Leonard pump stations as well as the Bay Street and East Boulevard ejectors, MBTA train station, and Wareham Fire District Headquarters and EMS, located on Main Street and Sandwich Road.





Table 4-11. Parcels and buildings vulnerable to a category 2 hurricane (SLOSH 2).

Land Use	Number of Parcels			Value of Buildings			Value of Total Property		
	Total	Total in Hazard	% in Hazard	Total Value	Total Value in Hazard	% Value in Hazard	Total Value	Total Value in Hazard	% Value in Hazard
Multiple Uses	208	152	73%	\$33,966,500	\$20,583,200	61%	\$48,607,300	\$28,109,600	58%
Residences <= 3 units	9,898	4952	50%	\$1,355,396,781	\$664,690,832	49%	\$2,554,310,021	\$1,390,847,532	54%
Residential Condos	397	194	49%	\$74,466,204	\$35,891,756	48%	\$75,333,004	\$36,181,956	48%
Apartments >= 4 units	52	28	54%	\$37,596,400	\$20,034,100	53%	\$47,678,700	\$25,294,100	53%
Mobile Homes	16	8	50%	\$498,000	\$481,000	97%	\$16,763,600	\$7,671,700	46%
Office	71	37	52%	\$36,569,800	\$9,585,500	26%	\$45,164,100	\$12,433,500	28%
Commercial	228	108	47%	\$141,037,700	\$53,884,100	38%	\$221,758,600	\$91,874,000	41%
Industrial	117	23	20%	\$61,116,300	\$8,531,700	14%	\$88,003,200	\$15,206,800	17%
Institutional	807	433	54%	\$147,063,500	\$85,575,700	58%	\$282,997,200	\$178,419,500	63%
Res/Ag and Res/OS	17	10	59%	\$1,971,400	\$1,508,500	77%	\$3,814,700	\$2,350,200	62%
Agriculture	122	36	30%	\$2,804,800	\$2,666,500	95%	\$7,242,100	\$5,427,200	75%
Open Space and Recreation	87	44	51%	\$3,641,600	\$3,641,600	100%	\$17,539,900	\$17,194,300	98%
Utility and Transportation	45	22	49%	\$1,799,100	\$1,398,500	78%	\$3,974,900	\$2,159,000	54%
Vacant	2,498	1267	51%	\$36,129,600	\$7,560,500	21%	\$136,196,600	\$56,755,500	42%
<b>Total</b>	<b>14,563</b>	<b>7314</b>	<b>50%</b>	<b>\$1,934,057,685</b>	<b>\$916,033,488</b>	<b>47%</b>	<b>\$3,549,383,925</b>	<b>\$1,869,924,888</b>	<b>53%</b>

Critical facilities vulnerable to flooding during a Category 2 hurricane include all critical facilities vulnerable to a Category 1 hurricane, in addition to the Salt Works Road, Hill Street, Onset Heights, Depot Street, Linwood Avenue, Parkwood, Pinehurst, Kennedy Lane, French, Hathaway, Thirteenth Street, and Pine Tree Estates pump stations; the Greene Street, Woodbury, and South Boulevard ejectors; and Sand Pond Road Well 3. Vulnerable emergency facilities include Wareham Fire District Fire Department and the East Wareham Fire station located on Main Street and Minot Avenue.



Table 4-12. Parcels and buildings vulnerable to a category 3 hurricane (SLOSH 3).

Land Use	Number of Parcels			Value of Buildings			Value of Total Property		
	Total	Total in Hazard	% in Hazard	Total Value	Total Value in Hazard	% Value in Hazard	Total Value	Total Value in Hazard	% Value in Hazard
Multiple Uses	208	163	78%	\$33,966,500	\$23,516,100	69%	\$48,607,300	\$32,276,400	66%
Residences <= 3 units	9,898	6147	62%	\$1,355,396,781	\$824,731,173	61%	\$2,554,310,021	\$1,668,530,573	65%
Residential Condos	397	253	64%	\$74,466,204	\$45,271,312	61%	\$75,333,004	\$45,569,212	60%
Apartments >= 4 units	52	38	73%	\$37,596,400	\$30,300,100	81%	\$47,678,700	\$38,029,900	80%
Mobile Homes	16	10	63%	\$498,000	\$481,000	97%	\$16,763,600	\$10,407,700	62%
Office	71	41	58%	\$36,569,800	\$11,180,100	31%	\$45,164,100	\$14,535,100	32%
Commercial	228	142	62%	\$141,037,700	\$63,563,700	45%	\$221,758,600	\$108,059,500	49%
Industrial	117	27	23%	\$61,116,300	\$9,341,900	15%	\$88,003,200	\$16,687,900	19%
Institutional	807	499	62%	\$147,063,500	\$93,068,700	63%	\$282,997,200	\$195,517,300	69%
Res/Ag and Res/OS	17	12	71%	\$1,971,400	\$1,634,800	83%	\$3,814,700	\$3,206,800	84%
Agriculture	122	67	55%	\$2,804,800	\$2,804,800	100%	\$7,242,100	\$6,255,200	86%
Open Space and Recreation	87	47	54%	\$3,641,600	\$3,641,600	100%	\$17,539,900	\$17,311,500	99%
Utility and Transportation	45	26	58%	\$1,799,100	\$1,446,700	80%	\$3,974,900	\$2,607,200	66%
Vacant	2,498	1549	62%	\$36,129,600	\$8,947,900	25%	\$136,196,600	\$66,747,300	49%
<b>Total</b>	<b>14,563</b>	<b>9021</b>	<b>62%</b>	<b>\$1,934,057,685</b>	<b>\$1,119,929,885</b>	<b>58%</b>	<b>\$3,549,383,925</b>	<b>\$2,225,741,585</b>	<b>63%</b>

Critical facilities vulnerable to flooding during a Category 3 hurricane include all critical facilities vulnerable to a Category 2 hurricane, as well as the Mattapoisett Pump Station, Sand Pond Road Well 4, Maple Springs Wells 1-4, Wareham Middle School, Wareham High School, Spinney Memorial Library, and the Proposed Fire District Building on Sand Pond Road.



Table 4-13. Parcels and buildings vulnerable to a category 4 hurricane (SLOSH 4).

Land Use	Number of Parcels			Value of Buildings			Value of Total Property		
	Total	Total in Hazard	% in Hazard	Total Value	Total Value in Hazard	% Value in Hazard	Total Value	Total Value in Hazard	% Value in Hazard
Multiple Uses	208	176	85%	\$33,966,500	\$27,293,800	80%	\$48,607,300	\$37,666,200	77%
Residences <= 3 units	9,898	7018	71%	\$1,355,396,781	\$943,910,373	70%	\$2,554,310,021	\$1,874,962,813	73%
Residential Condos	397	269	68%	\$74,466,204	\$47,508,112	64%	\$75,333,004	\$47,847,512	64%
Apartments >= 4 units	52	44	85%	\$37,596,400	\$35,243,200	94%	\$47,678,700	\$44,472,400	93%
Mobile Homes	16	10	63%	\$498,000	\$481,000	97%	\$16,763,600	\$10,407,700	62%
Office	71	45	63%	\$36,569,800	\$27,482,600	75%	\$45,164,100	\$33,884,800	75%
Commercial	228	166	73%	\$141,037,700	\$75,892,800	54%	\$221,758,600	\$125,633,400	57%
Industrial	117	31	26%	\$61,116,300	\$11,783,900	19%	\$88,003,200	\$20,763,600	24%
Institutional	807	584	72%	\$147,063,500	\$109,274,400	74%	\$282,997,200	\$220,000,000	78%
Res/Ag and Res/OS	17	14	82%	\$1,971,400	\$1,789,000	91%	\$3,814,700	\$3,537,100	93%
Agriculture	122	72	59%	\$2,804,800	\$2,804,800	100%	\$7,242,100	\$6,298,300	87%
Open Space and Recreation	87	47	54%	\$3,641,600	\$3,641,600	100%	\$17,539,900	\$17,311,500	99%
Utility and Transportation	45	29	64%	\$1,799,100	\$1,446,700	80%	\$3,974,900	\$3,070,400	77%
Vacant	2,498	1748	70%	\$36,129,600	\$26,401,800	73%	\$136,196,600	\$96,727,900	71%
<b>Total</b>	<b>14,563</b>	<b>10253</b>	<b>70%</b>	<b>\$1,934,057,685</b>	<b>\$1,314,954,085</b>	<b>68%</b>	<b>\$3,549,383,925</b>	<b>\$2,542,583,625</b>	<b>72%</b>

Critical facilities vulnerable to flooding during a Category 4 hurricane include all critical facilities vulnerable to a Category 3 hurricane, in addition to the Oak Street and Nanumett pump stations, Sand Pond Road Wells 5-7 and Storage Building, Maple Springs Corrosion Control Building, Water Pollution Control Facility, Ethel E. Hammond School (Boys & Girls Club), and Voter Home Depot and Town Hall.



Table 4-14. Residential (&lt;=3 units) parcels and buildings vulnerable to flooding in the VE Zone by neighborhood.

Neighborhood	Number of Parcels			Value of Buildings			Value of Total Property		
	Total	Total in Hazard	% in Hazard	Total Value	Total Value in Hazard	% Value in Hazard	Total Value	Total Value in Hazard	% Value in Hazard
Briarwood	139	106	76%	\$15,025,400	\$11,577,800	77%	\$31,342,200	\$25,495,100	81%
Central Transition	467	0	0%	\$59,723,300	\$-	0%	\$99,509,900	\$-	0%
Cromesett	294	106	36%	\$43,948,200	\$19,898,000	45%	\$84,748,400	\$44,396,000	52%
Downtown	267	0	0%	\$40,488,800	\$-	0%	\$62,384,840	\$-	0%
East Wareham Corridor	86	4	5%	\$12,115,100	\$551,400	5%	\$26,041,200	\$1,838,800	7%
Great Neck	494	197	40%	\$96,407,400	\$45,287,000	47%	\$230,070,200	\$139,358,900	61%
Indian Neck	72	34	47%	\$21,025,100	\$11,653,100	55%	\$63,527,400	\$39,302,900	62%
Indian Mound	483	52	11%	\$54,059,100	\$7,135,300	13%	\$102,207,300	\$21,570,000	21%
Interchange	102	0	0%	\$16,122,700	\$-	0%	\$30,201,900	\$-	0%
Jefferson Shores	73	45	62%	\$10,866,900	\$7,027,200	65%	\$25,510,400	\$18,319,500	72%
Maple Springs	119	0	0%	\$23,072,900	\$-	0%	\$34,572,200	\$-	0%
Minot Forest	251	43	17%	\$41,274,100	\$6,462,700	16%	\$73,858,600	\$16,678,600	23%
Narrows	159	0	0%	\$20,880,972	\$-	0%	\$33,879,472	\$-	0%
Onset	1,893	249	13%	\$244,857,600	\$42,922,400	18%	\$514,901,100	\$123,011,700	24%
Onset Well Fields	16	0	0%	\$1,936,900	\$-	0%	\$3,239,700	\$-	0%
Parkwood Beach	442	136	31%	\$56,533,400	\$18,269,200	32%	\$107,600,100	\$39,918,600	37%
Pinehurst Beach	305	59	19%	\$34,213,400	\$6,752,900	20%	\$67,014,200	\$14,909,300	22%
Rose Point	228	0	0%	\$25,039,900	\$-	0%	\$44,460,600	\$-	0%
Spectacle Pond	326	0	0%	\$35,150,000	\$-	0%	\$69,050,100	\$-	0%
Swifts Beach	1,239	344	28%	\$139,272,201	\$37,724,700	27%	\$257,188,401	\$86,533,700	34%
Tihonet	21	0	0%	\$7,017,000	\$-	0%	\$10,117,100	\$-	0%
West Wareham	1,006	0	0%	\$168,929,600	\$-	0%	\$269,255,000	\$-	0%
Weweantic	394	0	0%	\$57,350,000	\$-	0%	\$93,730,900	\$-	0%
White Island	1,022	0	0%	\$130,086,808	\$-	0%	\$219,898,808	\$-	0%
<b>Total</b>	<b>9,898</b>	<b>1375</b>	<b>14%</b>	<b>\$1,355,396,781</b>	<b>\$215,261,700</b>	<b>16%</b>	<b>\$2,554,310,021</b>	<b>\$571,333,100</b>	<b>22%</b>



Table 4-15. Residential (&lt;=3 units) parcels and buildings vulnerable to flooding in the AE Zone by neighborhood.

Neighborhood	Number of Parcels			Value of Buildings			Value of Total Property		
	Total	Total in Hazard	% in Hazard	Total Value	Total Value in Hazard	% Value in Hazard	Total Value	Total Value in Hazard	% Value in Hazard
Briarwood	139	33	24%	\$15,025,400	\$3,447,600	23%	\$31,342,200	\$5,847,100	19%
Central Transition	467	173	37%	\$59,723,300	\$22,845,800	38%	\$99,509,900	\$39,235,700	39%
Cromesett	294	137	47%	\$43,948,200	\$17,692,700	40%	\$84,748,400	\$29,907,100	35%
Downtown	267	21	8%	\$40,488,800	\$2,991,300	7%	\$62,384,840	\$4,447,000	7%
East Wareham Corridor	86	30	35%	\$12,115,100	\$5,296,900	44%	\$26,041,200	\$13,446,500	52%
Great Neck	494	150	30%	\$96,407,400	\$24,294,900	25%	\$230,070,200	\$45,249,100	20%
Indian Neck	72	23	32%	\$21,025,100	\$4,395,100	21%	\$63,527,400	\$13,613,900	21%
Indian Mound	483	0	0%	\$54,059,100	\$-	0%	\$102,207,300	\$-	0%
Interchange	102	7	7%	\$16,122,700	\$1,083,900	7%	\$30,201,900	\$1,718,600	6%
Jefferson Shores	73	0	0%	\$10,866,900	\$-	0%	\$25,510,400	\$-	0%
Maple Springs	119	0	0%	\$23,072,900	\$-	0%	\$34,572,200	\$-	0%
Minot Forest	251	78	31%	\$41,274,100	\$11,555,700	28%	\$73,858,600	\$20,288,000	27%
Narrows	159	96	60%	\$20,880,972	\$13,231,931	63%	\$33,879,472	\$21,576,831	64%
Onset	1,893	586	31%	\$244,857,600	\$67,804,200	28%	\$514,901,100	\$145,347,300	28%
Onset Well Fields	16	0	0%	\$1,936,900	\$-	0%	\$3,239,700	\$-	0%
Parkwood Beach	442	91	21%	\$56,533,400	\$12,345,100	22%	\$107,600,100	\$21,807,400	20%
Pinehurst Beach	305	178	58%	\$34,213,400	\$19,223,900	56%	\$67,014,200	\$38,782,500	58%
Rose Point	228	120	53%	\$25,039,900	\$13,293,200	53%	\$44,460,600	\$25,189,600	57%
Spectacle Pond	326	154	47%	\$35,150,000	\$17,516,500	50%	\$69,050,100	\$37,972,100	55%
Swifts Beach	1,239	615	50%	\$139,272,201	\$67,444,797	48%	\$257,188,401	\$116,637,897	45%
Tihonet	21	0	0%	\$7,017,000	\$-	0%	\$10,117,100	\$-	0%
West Wareham	1,006	50	5%	\$168,929,600	\$10,521,300	6%	\$269,255,000	\$16,575,400	6%
Weweantic	394	140	36%	\$57,350,000	\$20,621,200	36%	\$93,730,900	\$35,203,000	38%
White Island	1,022	13	1%	\$130,086,808	\$2,063,300	2%	\$219,898,808	\$3,505,200	2%
<b>Total</b>	<b>9,898</b>	<b>2695</b>	<b>27%</b>	<b>\$1,355,396,781</b>	<b>\$337,669,328</b>	<b>25%</b>	<b>\$2,554,310,021</b>	<b>\$636,350,228</b>	<b>25%</b>





**Table 4-16. Residential (<=3 units) parcels and buildings vulnerable to flooding in Other Flood Zones (AO, AH, A) by neighborhood.**

Neighborhood	Number of Parcels			Value of Buildings			Value of Total Property		
	Total	Total in Hazard	% in Hazard	Total Value	Total Value in Hazard	% Value in Hazard	Total Value	Total Value in Hazard	% Value in Hazard
Briarwood	139	0	0%	\$15,025,400	\$-	0%	\$31,342,200	\$-	0%
Central Transition	467	0	0%	\$59,723,300	\$-	0%	\$99,509,900	\$-	0%
Cromesett	294	0	0%	\$43,948,200	\$-	0%	\$84,748,400	\$-	0%
Downtown	267	0	0%	\$40,488,800	\$-	0%	\$62,384,840	\$-	0%
East Wareham Corridor	86	0	0%	\$12,115,100	\$-	0%	\$26,041,200	\$-	0%
Great Neck	494	0	0%	\$96,407,400	\$-	0%	\$230,070,200	\$-	0%
Indian Neck	72	0	0%	\$21,025,100	\$-	0%	\$63,527,400	\$-	0%
Indian Mound	483	0	0%	\$54,059,100	\$-	0%	\$102,207,300	\$-	0%
Interchange	102	0	0%	\$16,122,700	\$-	0%	\$30,201,900	\$-	0%
Jefferson Shores	73	0	0%	\$10,866,900	\$-	0%	\$25,510,400	\$-	0%
Maple Springs	119	3	3%	\$23,072,900	\$-	0%	\$34,572,200	\$545,100	2%
Minot Forest	251	0	0%	\$41,274,100	\$-	0%	\$73,858,600	\$-	0%
Narrows	159	0	0%	\$20,880,972	\$-	0%	\$33,879,472	\$-	0%
Onset	1,893	2	0%	\$244,857,600	\$537,400	0%	\$514,901,100	\$934,800	0%
Onset Well Fields	16	0	0%	\$1,936,900	\$-	0%	\$3,239,700	\$-	0%
Parkwood Beach	442	0	0%	\$56,533,400	\$-	0%	\$107,600,100	\$-	0%
Pinehurst Beach	305	0	0%	\$34,213,400	\$-	0%	\$67,014,200	\$-	0%
Rose Point	228	0	0%	\$25,039,900	\$-	0%	\$44,460,600	\$-	0%
Spectacle Pond	326	0	0%	\$35,150,000	\$-	0%	\$69,050,100	\$-	0%
Swifts Beach	1,239	0	0%	\$139,272,201	\$-	0%	\$257,188,401	\$-	0%
Tihonet	21	8	38%	\$7,017,000	\$3,112,800	44%	\$10,117,100	\$4,475,200	44%
West Wareham	1,006	43	4%	\$168,929,600	\$8,777,800	5%	\$269,255,000	\$13,873,000	5%
Weweantic	394	1	0%	\$57,350,000	\$101,300	0%	\$93,730,900	\$214,000	0%
White Island	1,022	121	12%	\$130,086,808	\$16,832,400	13%	\$219,898,808	\$35,280,000	16%
<b>Total</b>	<b>9,898</b>	<b>178</b>	<b>2%</b>	<b>\$1,355,396,781</b>	<b>\$29,371,000</b>	<b>2%</b>	<b>\$2,554,310,021</b>	<b>\$55,322,100</b>	<b>2%</b>



The results of the evacuate route evaluation identified that sections along Route 25 and Route 6 in East Wareham, as well as an approximately 1-mile long section of Route 195 near the Marion border, are vulnerable to flooding during a 100-year flood event (i.e., the evacuation routes overlap with FEMA's mapped 100-year floodplain) (Figure 4-1). Figure 4-1 also shows a few very small areas of overlap on Route 195, Route 6, and Route 495 where the evacuation route crosses the Weweantic River. It is possible that these bridges are high enough that while the land around and under the roadway would flood, the roadway itself would remain dry and passable. Additional site-specific elevation data would be required to assess this further.

Figure 4-2 provides a similar evaluation of the evacuation routes with respect to their potential for flooding during a hurricane event. An approximately 4.5 mile stretch of Route 6 between Main Street and Main Ave is vulnerable to flooding during a hurricane event (with much of this area being predicted to be impacted by a Category 1 or 2 storm), while an approximately 3.8-mile stretch of Route 25 is vulnerable to flooding during a hurricane event (with much of this area being predicted to be impacted by a Category 2 or 3 storm). Additionally, there is an approximately 2.7-mile stretch of Route 195 from the Weweantic River to the Marion Townline that is vulnerable to flooding during a Category 1 or 2 storm.

Given the large proportion of the Town vulnerable to flooding during a major event, and the likelihood that many sections of key evacuation routes could also be flooding during these events, it will likely be important to consider the need to evacuate low-lying areas of Town, and issue that directive to residents, well in advance of the arrival of a major storm.

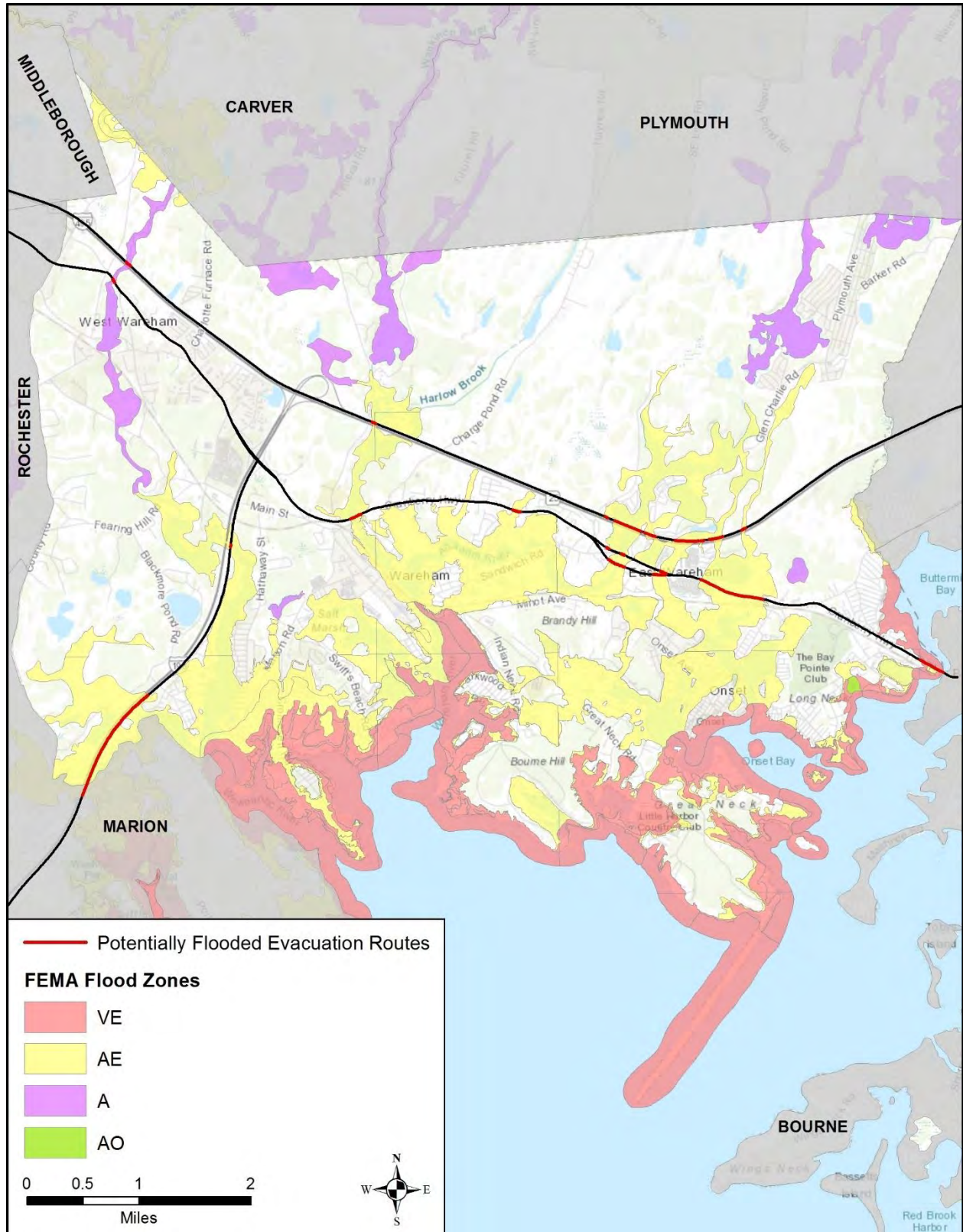


Figure 4-1. Potentially inundated evacuation routes due to the 100-year storm event.



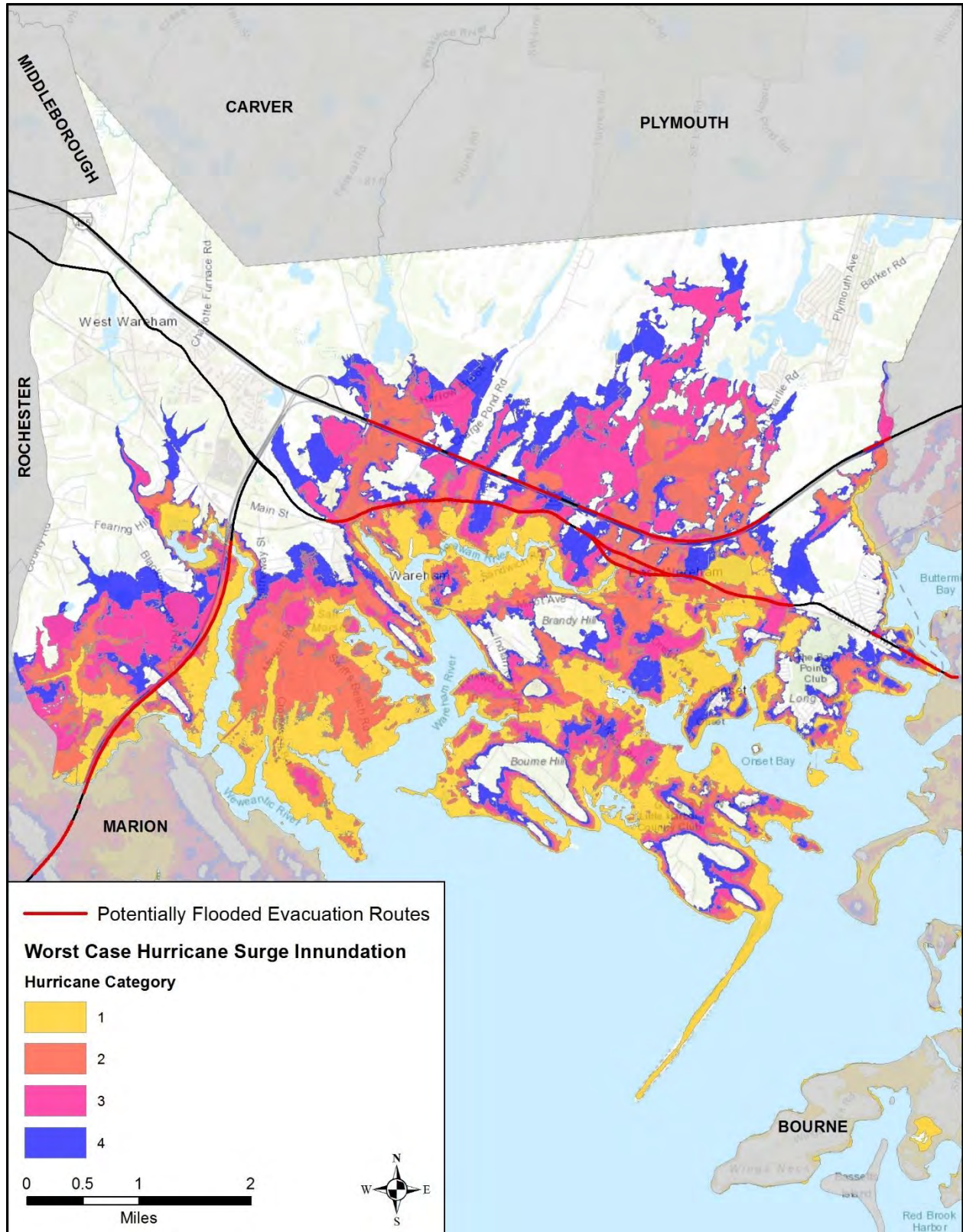


Figure 4-2. Potentially inundated evacuation routes due to hurricane storm surge.



B3.b

### 4.3 VULNERABLE PROPERTIES AND CRITICAL FACILITIES

Although the tables in Section 4.3 provide a detailed summary of the potential impacts from each type and magnitude of risk analyzed, this section will summarize the main risks identified from this analysis. The discussion below will focus on hazards that have the potential to harm the most properties or cost the most economic damage, critical facilities that are impacted by the most hazards, and vulnerabilities of the highest concern to the Town. This summary was also used to guide the development of mitigation actions.

Tables 4-3, 4-4, and 4-5 summarize the number of parcels that overlap with the VE, AE, or other types of flood zones, respectively. Although individual parcels may overlap with more than one flood zone, because the risk to each parcel was noted as the highest hazard flood type, the values in Tables 4-3, 4-4, and 4-5 are additive. For example, a single property can contain both a VE and an AE zone, but would only be listed in the VE zone risk table. Therefore, by summing the total values from those three tables, the total value of all structures and property at risk from flooding is approximately \$1.7 billion. Additionally, because flooding often causes more permanent damage to structures than to the land itself, it is worth noting that the total value of buildings within the SFHA in Wareham is approximately \$785 million. At a similar magnitude of financial impact, the surge inundation (i.e. flooding) that would result from a Category 2 hurricane would impact properties valuing approximately \$1.9 billion, with the structures and buildings on those properties valuing \$916 million (Table 4-11). Finally, although based on the mapping criteria alone, it appears that flooding will cause similar damage to hurricanes, this does not account for the Town-wide impacts that hurricanes can produce from heavy rains and high winds; these additional forces would likely make the financial impacts of a Category 2 hurricane much more substantial than would be expected with flooding alone.

Most of the critical facilities likely to be impacted by flooding are sewer pump stations (Table 4-2), located within both VE and AE flood zones. Other critical facilities within the SFHA include the East Wareham Fire Station, Wareham Fire District Fire Department, Wareham Fire District Headquarters, EMS, and MBTA train station, which are located in AE flood zones, and the Harbormaster Building, which is located in a VE flood zone.

It is also worth acknowledging the breakdown of land use types impacted by these hazards. The inundation projected from a Category 2 hurricane will impact primarily residential properties (4,952 parcels out of a total of 9,898 residential parcels with under 3 units in Wareham), which represents 50% of that land use category. However, although only 152 Multiple Use parcels are projected to be inundated, this number represents 73% of that land use category.

The MC-FRM results (see Section 3.1) were utilized to evaluate how climate change and sea level rise could affect the Town's vulnerability to flooding in the future. For the vulnerability assessment, two categories of vulnerability to flooding were selected: a probability of inundation from 1% to less than 20% (representing larger storm events) and a probability of inundation of 20% or greater (representing smaller, more frequent storm events). These results are based on a high sea level rise projection for 2030 and 2070. In 2030, 3,497 parcels have a 20% chance or





greater in any given year of experience some level of coastal flooding (Table 4-6), while an additional 1,851 parcels have between a 1% and 20% chance of inundation in a given year (Table 4-7). This means that during a 100-year flood event (i.e., the 1% chance event) in 2030, a total of 5,348 parcels are at risk of coastal inundation. These numbers increase to 4,915 and 2,541 parcels with a greater than 20% chance of inundation (Table 4-8) and between a 1% and 20% chance of inundation (Table 4-9), respectively, in 2070. This means that during a 100-year flood event (i.e., the 1% chance event) in 2070, a total of 7,456 parcels are at risk of coastal inundation.

B3.b

#### 4.4 VULNERABLE POPULATIONS

Wareham has several vulnerable populations, including residents of isolated coastal communities, areas with a high concentration of elderly residents, centers of tourism and visitor lodging, and mobile home parks.

##### *Isolated Coastal Communities*

As an oceanfront community, Wareham is an attractive place to live for both year-round and summer residents. For many, their enjoyment of the coastline is contingent on their proximity to the shore. However, due to the Town's topography, many of these coastal neighborhoods become "isolated" during a storm event or similar flood occurrence. During flood events, numerous roads can become submerged, leaving no means of access to particular neighborhoods. In addition, as sea-level rise progresses, some of these roads may start to become isolated on a daily basis, particularly around high tide. Coastal neighborhoods that will be isolated during a 1% chance storm event (i.e., 100-year storm event) and a 5% chance storm event (i.e., 20-year storm event) are shown in Figure 4-3 in yellow and red, respectively, and are listed in Table 4-18. Note, not all areas shown in yellow or red will actually flood. Some roads and neighborhoods may be dry, but inaccessible due to flooding of main connecting roadways.

##### *Concentrations of Elderly or Disabled People*

Wareham has two nursing homes (Tremont Rehab and Forestview Nursing Home) and one assisted living facility (All American Assisted Living). These locations will need special attention during emergencies or if evacuations become necessary. These locations are shown in Figure 4-3 in green and listed in Table 4-17. Nursing homes and assisted living facilities within Wareham are not located within or immediately adjacent to any FEMA Flood Zones

There are also three elderly housing communities and six age-restricted mobile home parks (55 and over) within Wareham. These locations are shown in Figure 4-3 in orange and purple, respectively, and listed in Table 4-17. Redwood Park and Agawam Village Elderly Housing Communities, as well as Onset Mobile Home Park (55 and over) are located within or immediately adjacent to AE FEMA Flood Zones. There are likely additional elderly and/or disabled residents residing in residential homes throughout Town. These residents may need additional help to exit buildings during an emergency.



### ***Visitor/Tourist Centers***

Wareham contains eight hotels, inns, and bed and breakfasts. These locations are shown in Figure 4-3 in pink and are listed in Table 4-17. These locations represent vulnerable populations as visitors to Wareham may not have the same support system, transportation ability, etc. in the event that a natural hazard occurs while they are in Wareham, and they may need additional assistance. Southwest at Little Harbor Hotel and Old Red Farm Inn are located within or immediately adjacent to VE FEMA Flood Zones and Briarwood Beach Motel, Atlantic Motel, and Silver Lake Motel are located within or immediately adjacent to AE FEMA Flood Zones.

### ***Mobile Home Parks***

Wareham also contains nine additional mobile home parks (in addition to the age-restricted location described above). These locations are shown in Figure 4-3 in blue and listed in Table 4-17. In some cases, residents of mobile home parks may have a lower income, limiting access to transportation and alternate lodging during an emergency. Additionally, some mobile home parks may be established within locations more vulnerable to flooding, and mobile homes may be more structurally vulnerable to severe weather. Residents of mobile homes may also have little to no yard surrounding each structure, limiting the impact the land can absorb. For instance, after a severe wind event, residents may not have adequate space to move downed trees and branches and other storm debris away from their home without blocking vital access routes for others. For these reasons, mobile home residents may require additional assistance during a natural hazard. Garden Homes East, Lakeside, Silver Lake, Waters Edge, and Redwing Mobile Home Parks are located within or immediately adjacent to AE FEMA Flood Zones.

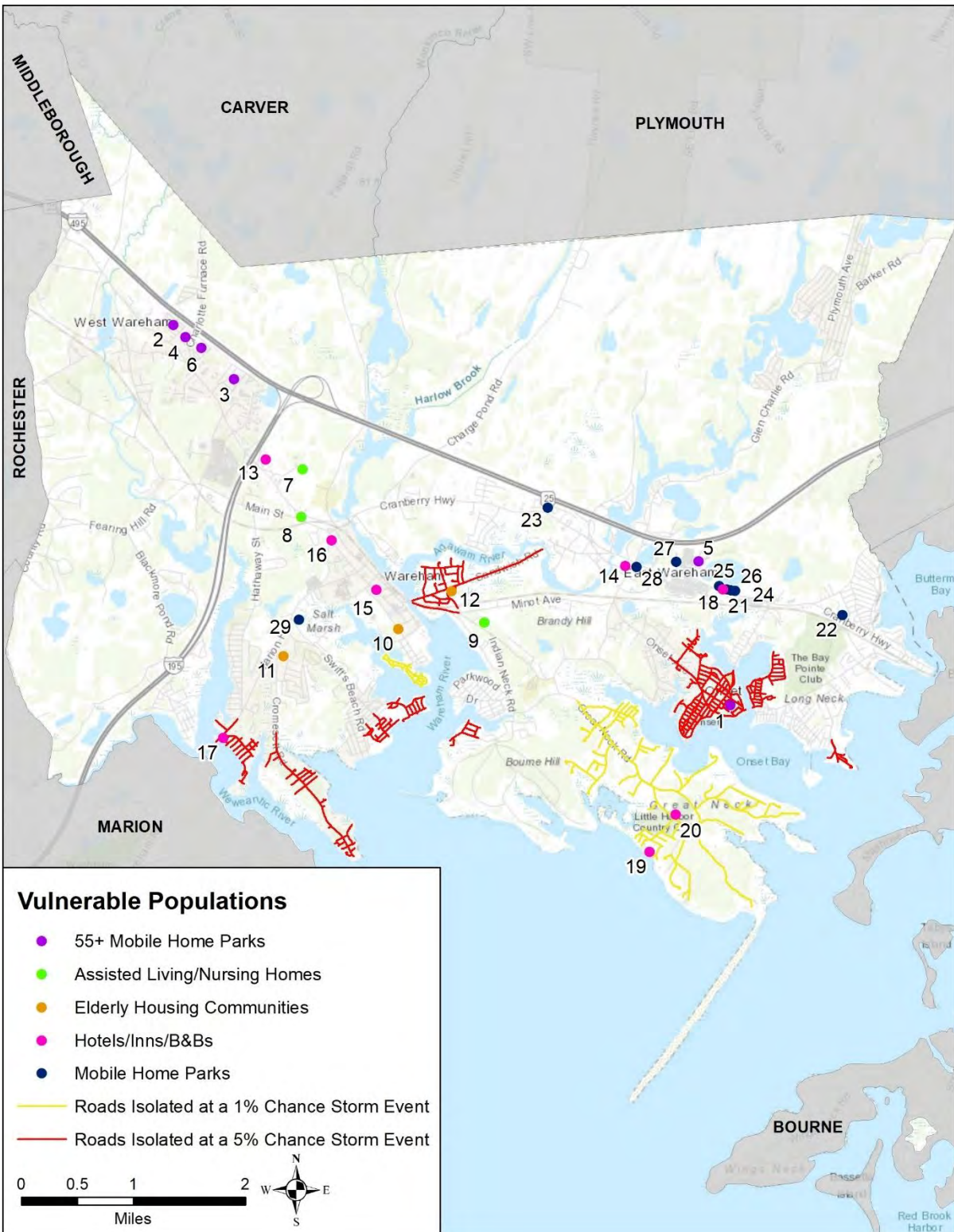


Figure 4-3. Locations of vulnerable populations in Wareham.



Table 4-17. List of vulnerable populations in Wareham.

#	Name	Address
<b>Elderly Communities</b>		
1	55+ Mobile Home Parks	Onset Mobile Home Park
2		Waban Avenue
3		Royal Crest
4		2340 Cranberry Highway
5		Great Hill
6		2400 Cranberry Highway
7	Assisted Living/ Nursing Home	Siesta Village
8		Siesta Drive
9		Mogan's
10	Elderly Housing Community	3012 Cranberry Highway
11		Holly Heights
12		Charlotte Furnace Road
13	All American Assisted Living	300 Rosebrook Way
14	Tremont Rehab	605 Main Street
15	Forestview Nursing Home	50 Indian Neck Road
16	Redwood Park	34 Church Avenue
17	Cromesett Woods	6 Cromesett Road
18	Agawam Village	57 Sandwich Road
<b>Hotels, Inns, and B&amp;Bs</b>		
13	TownePlace Suites by Marriott Wareham Buzzards Bay	50 Rosebrook Place
14	Atlantic Motel	7 Depot Street
15	Cranberry Gardens Inn	105 High Street
16	Mulberry Bed & Breakfast	257 High Street
17	Briarwood Beach Motel	388 Marion Road
18	Silver Lake Motel	Silver Lake Motel
19	Southwest At Little Harbor	5 Bayberry Road
20	Old Red Farm Inn	20 Stockton Short Cut Street
<b>Mobile Home Parks</b>		
21	Garden Homes East	3040 Cranberry Highway
22	Garden Homes South	3139 Cranberry Highway
23	Garden Homes North	2750 Cranberry Highway
24	Lakeside	3030 Cranberry Highway
25	Silver Lake	3024 Cranberry Highway
26	Waters Edge	3036 Cranberry Highway
27	Redwing	2900 Cranberry Highway
28	Depot Trailer Park	2 Depot Street
29	Ripley's Trailer Park	8 Swifts Beach Road



**Table 4-18. Roads isolated during 1% and 5% chance storm events.**

Road Name	From Street	To Street
<b>1% Chance Storm Event</b>		
Great Neck Road	Minot Avenue	Dead End
Pinehurst Drive	Nimrod Way	Pinehurst Drive
<b>5% Chance Storm Event</b>		
Alden Road	Edgewater Drive	Long Beach Road
Pilgrim Avenue	Shore Avenue	Worrall Avenue
Shore Avenue	Swifts Beach Road	Dead End
Cromesett Road	Marion Road	Dead End
Marion Road	High Street	Marion Townline
Sandwich Road	Narrows Road	11 <sup>th</sup> Avenue
Robinwood Road	Onset Avenue	Dead End
Onset Avenue	Shanley Way	Depot Street



*The first sections of this plan discuss the potential hazards that could occur in Wareham and some of the potential losses and vulnerabilities associated with each of these hazards. An important next step in hazard mitigation planning is to develop specific strategies and actions that will help mitigate or minimize the risk to these natural hazards. A mitigation action is a specific action, project, activity, or process taken to reduce or eliminate short- or long-term risks to people and property from hazards and their impacts. Implementing mitigation actions helps achieve the plan's mission and goals. These mitigation strategies are the heart of the mitigation plan. They describe how Wareham will accomplish their mitigation goals.*

*This chapter documents Wareham's mitigation goals and existing and ongoing mitigation actions, as well as its proposed mitigation actions. The purpose, responsibility, priority and timeline are detailed for each of the proposed mitigation actions.*



The central component of a hazard mitigation plan is the strategy for reducing the community's vulnerability to natural hazard events. Responding to the analysis of risk, vulnerabilities, potential impacts, and anticipated future development, the process for developing this strategy is one of setting goals, understanding what actions the community is already taking that contribute to mitigating the effects of natural hazards and assessing where more action is needed to complement or modify existing measures. The following sections include descriptions of the Town's mitigation goals, existing capabilities and ongoing mitigation actions, a status update on mitigation measures identified in previous plans, and descriptions of proposed new mitigation measures. All mitigation measures are evaluated by their benefits and potential costs to arrive at a prioritized list of action items.

### 5.1 MITIGATION GOALS AND OBJECTIVES

C3.a  
C3.b  
D3.a

During planning team meetings for this update of the plan, the Local Planning Team (LPT) developed a series of hazard mitigation goals. These goals are meant to reduce impacts and losses due to hazards associated with natural disasters, and to minimize the impacts of natural disasters on residents, businesses and infrastructure. The following five (5) goals were endorsed by the LPT for this Multi-Hazard Mitigation Plan:

1. Protect critical facilities and improve public safety by reducing, where possible, the potential adverse impacts caused by storms and other natural hazard events.
2. Maintain adequate access to public roads and public utilities, such as electricity, drinking water, and communications, during and after a natural disaster.
3. Provide residents with adequate access to emergency shelters equipped with sufficient provisions, climate control and emergency electricity during natural disaster events.
4. Encourage future development in areas that minimize risks to natural hazards, such as flooding.
5. Improve public education related to natural hazards, including informing the public about hazard-prone areas to minimize damage and losses where possible and what to expect during natural disasters.

C1.a  
C6

### 5.2 EXISTING CAPABILITES

Wareham has a unique set of capabilities, including Town plans, policies, staff, funding, and other resources available to accomplish mitigation actions and reduce short- and long-term vulnerability. These capabilities are summarized in this section.

#### *Town Plans and Policies*

Wareham has a series of planning documents that address natural hazards. These documents include measures associated with the Town's mitigation strategy and could be useful when implementing mitigation actions. Through the implementation of these plans, Wareham can guide and manage growth and development within the Town, with the goal of reducing hazard vulnerability. These plans include:



1. Master Plan Vision (2018): addresses topics such as covers land use, economic development, services and facilities, stewardship and service, transportation, housing, open space and recreation, and natural and cultural resources.
2. Wareham Climate Change Flood Vulnerability Assessment and Adaptation Planning (2020): quantitatively evaluates the present and future probability of inundation to municipal infrastructural, societal and environmental. This report includes a range of climate change adaptation measures for individual assets through larger districts
3. Water Pollution Control Facilities Emergency Response Plan (2016): provide the Town of Wareham’s Sewer Department with a standardized safety response to flooding emergencies or disasters that may directly affect the Town’s wastewater infrastructure.
4. Wareham Fire District and Water Department Emergency Response Plan (2019): This plan contains detailed procedures for the District to respond quickly and effectively to a variety of water supply emergencies.

Many of the existing Town policies and ordinances also provide an effective means of mitigating hazards. Wareham has Zoning, Subdivision and Floodplain ordinances.

### ***Town Staff***

The Town of Wareham has a very capable staff that includes an Emergency Manager, a Town Planner, Chief Building Official and a GIS Coordinator. The Town retains a part-time consultant to serve as a Chief Engineer, as needed. Together these staff allow the Town to effectively plan for and implement specific mitigation actions. In addition, the Town has a Local Planning Board and a Mitigation Planning Committee, which are instrumental in developing and coordinating mitigation actions.

### ***Financial Capabilities***

Financial capabilities are the resources that a Town has to fund mitigation actions. The costs to implement mitigation activities vary from relatively low cost to relatively high cost activities. Low cost actions include building assessment or outreach efforts, which require little to no costs other than staff time and existing operating budgets. Alternatively, higher cost actions, such as the acquisition of flood-prone properties, could require a substantial monetary commitment from local, state, and federal funding sources.

The Town of Wareham has the following potential sources of funding to implement hazard mitigation activities:

1. Capital improvements funding;
2. Authority to levy taxes for specific purposes (fire districts only);
3. Fees from water and sewer services; and
4. Incurring debt through general obligation bonds and/or special tax bonds.

The Town’s annual revenue from taxes can be used to fund some mitigation actions, but other larger actions may need additional outside funding, such as from state and federal grant programs.





D2.a

### Existing Mitigation Measures

The following are existing and ongoing mitigation measure performed by the Town of Wareham:

1. **Emergency Response Plans:** Both the Water Pollution Control Facility and the Water Department maintain comprehensive emergency plans. These plans address mitigation, preparedness, response and recovery from a variety of natural and man-made emergencies.
2. **Communications System:** The Town has an array of communications equipment that would assist public safety efforts during a natural hazard event. The Town continues to upgrade this system, which includes multiple radio and communications towers. Wareham also participates in the ALERTWareham system called RAVE Mobile Safety and powered by Smart911. The Town and the Districts are all moving toward a common microwave communication system.
3. **Emergency Power Generators:** Emergency power generators can be found in a number of Town buildings. These generators serve to protect government functionality during and immediately after a natural hazard event and also serve the operation of emergency shelters. Locations include: Police and Fire departments, Town Hall, Multi-Service Buildings, some of the schools, the Wareham Water District buildings and wellhouses, and many of the sewer pump stations.
4. **Massachusetts State Building Code:** The Massachusetts State Building Code contains many detailed regulations regarding wind loads, earthquake resistant design, flood-proofing, and snow loads.
5. **Public Information and Outreach:** The Town provides information to residents and business owners relating to a range of potential natural hazards. Many departments have an active social media presence through which important hazard mitigation information can be disseminated to the public.
6. **Municipal Maintenance Operations and Activities:** The Municipal Maintenance Department maintains the Town's storm drain system. Specific activities include street sweeping, catch basin cleaning and roadway treatments.
7. **Tree Trimming Program:** The electric and telephone utilities trim branches near the electric lines while the Town staff maintains trees in other areas. The Wareham Water District also has a tree trimming program to manage the trees around the power distribution system in the wellfields.
8. **Snow Disposal:** The Town conducts general snow removal operations with a combination of its own equipment and hired private plow contractors and has adequate space for snow storage as needed.
9. **Water Restrictions:** Even/odd lawn sprinkler restrictions are in effect from May 1<sup>st</sup> through September 30<sup>th</sup>. Additionally, during a state declared drought, a water ban can be placed on those connected to the District's public water system.
10. **Flood Plain District Zoning:** Zoning is intended to protect the public health and safety through the regulation of land use. The Wareham Zoning Bylaws include a Flood Plain Overlay District (Article 4). This zoning district limits certain development activities within designated FEMA flood zones.





11. **Wetlands Protection Bylaw:** The purpose of the Wareham Wetlands Protection By-Law (Division VI; Article I) is to protect the wetlands, water resources and adjoining land areas. The by-law reinforces the State Wetlands Protection Act.

C2.a

### *Participation in the National Flood Insurance Program (NFIP)*

Wareham currently participates in FEMA's National Flood Insurance Program (NFIP). Per FEMA's Local Multi-Hazard Mitigation Planning Guidance document, the NFIP has three basic aspects:

1. Floodplain identification and mapping – adopt flood maps depicting hazards;
2. Floodplain management – adopt and enforce floodplain management regulations; and
3. Flood insurance – require property owners to purchase insurance in exchange for floodplain management regulations that reduce future flood damages.

Flood Hazard Boundary Maps (FHBMs) were first established in 1979, with flood insurance rate maps (FIRMs) following in 1981. The most recent FEMA Flood Insurance Study became effective on July 16, 2014.

Loss statistics for January 1, 1978 through September 30, 2018 for the Town of Wareham include 882 total losses. 748 cases were closed with payment and 0 remain open, however, 134 cases were closed without payment. Of the 748 cases that did receive payment, the total payments amounted to \$11,724,393 (FEMA 2020).

As part of ongoing NFIP requirements, Wareham regulates new development within the Special Flood Hazard Area (SFHA). The Town follows NFIP regulations and guidelines for all new construction, as well as substantial improvements to existing structures, within the flood plain. Wareham also works with nearby communities to establish mutual aid agreements to address administration of the NFIP following a major storm.

## 5.3 PROPOSED MITIGATION

C4.a  
C5.a  
C5.b

### *Planning Process*

To identify, evaluate and prioritize specific mitigation actions and projects to reduce the effects of a natural disaster, the LPT used a prioritization method focusing on four key themes as follows, and as provided in [Appendix C:](#)

- **Benefits:** Determine whether the proposed mitigation measure will improve property protection, natural resource protection, technical capacity, public awareness, or post-hazard emergency response;
- **Feasibility:** Determine whether the proposed mitigation measure is feasible in terms of Town staffing, public and Town support, and whether it is technically feasible;
- **Economic:** Evaluate each mitigation measure in terms of estimated cost and potential funding sources; and



- **Regulatory:** Evaluate each mitigation measure for consistency with local, state and federal permitting/ regulatory requirements and goals.

Each proposed mitigation action presented in this section was given a score based on 13 subcategories within these four larger categories documented above (i.e. Benefits, Feasibility, Economic, Regulatory). For each of these subcategories, the proposed action was given a score of 3 if the action was thought to be a “good” fit with a particular category (likely to provide the benefit under consideration, required little additional training or funding, feasible, etc.), 2 if it was “average”, or 1 if it was “poor” (did not provide the benefit under consideration, difficult to permit, costly, etc.). For a detailed overview of how each action was scored, please see [Appendix C](#).

During the planning meetings where potential mitigation measures were discussed and prioritized, a few proposed actions were dismissed from the final Plan. These actions are documented in [Appendix C](#), along with an explanation for dismissal.

C4.a  
C4.b  
C4.c  
C5.c

**Proposed Mitigation Actions**

The final proposed mitigation actions developed during the planning process are summarized in this section. A total of 28 actions were developed. These actions address risks due to flooding, coastal erosion, hurricanes and tropical storms, severe weather, drought, water quality, dam and culvert failure and invasive species, as well as more general public outreach and multi-hazard mitigation actions. Specific actions range from public education to actions that involve the modifications of existing buildings or infrastructure to protect them from a hazard or removal from the hazard area, to actions developed to increase public education and awareness.

For each action identified below, a brief description is provided, as well as the responsible department(s), potential funding sources, priority, and anticipated timeline. To help tie the recommended actions to the Town’s hazard mitigation goals listed in Section 5.1, the numbers associated with the goal(s) each action addresses are also listed.

<b>Mitigation Action #1: Follow Vulnerability Assessment Recommendations for Harbor Master Building</b>	
HAZARD ADDRESSED	Flooding (Coastal & Inland)
PURPOSE	Mitigating flood impacts on the Harbor Master Building will preserve critical services provided by the Harbor Master, including emergency response. Short-term actions: wet flood proof structure; long-term actions: seek alternate location for critical harbormaster office functions.
RESPONSIBILITY	Department of Natural Resources
POTENTIAL FUNDING SOURCES	Short-term: Department Budget (Capital Budget); Long-term: FEMA Pre-Disaster Grant
PRIORITY	Medium
TIMELINE	Short-term; Long-term
GOAL(S) ADDRESSED	1, 2



<b>Mitigation Action #2: Develop Long-Term Plan for Critical Facilities at Future Risk to Coastal Flooding</b>	
HAZARD ADDRESSED	Flooding (Coastal & Inland)
PURPOSE	Evaluate the future flood risk sea level rise poses to critical facilities and develop a long-term plan to address flood risk to protect critical facilities and the public services they provide.
RESPONSIBILITY	Planning
POTENTIAL FUNDING SOURCES	MVP Action Grants; FEMA Pre-Disaster Grant
PRIORITY	Medium
TIMELINE	Long-term
GOAL(S) ADDRESSED	1, 2

<b>Mitigation Action #3: Improve or Develop Alternate Access to/from EMS</b>	
HAZARD ADDRESSED	Flooding (Coastal & Inland)
PURPOSE	Roads providing access to EMS are currently vulnerable to flooding. Improving or developing alternative access routes to EMS will ensure crucial services provided by EMS can continue during flooding events.
RESPONSIBILITY	EMS; Municipal Maintenance
POTENTIAL FUNDING SOURCES	Planning: Capital Budget; Design/Construction: Grant, Town Meeting; FEMA Pre-Disaster Grant
PRIORITY	Low
TIMELINE	Long-term
GOAL(S) ADDRESSED	1

<b>Mitigation Action #4: Implement Vulnerability Assessment Recommended Flood Protection Actions for Sewer Pump Stations</b>	
HAZARD ADDRESSED	Flooding (Coastal & Inland)
PURPOSE	Sewer pump stations are commonly located at low elevations, making them vulnerable to flooding and threatening the public services they provide. Properly dry floodproofing lower pump hatches at low-lying stations and/or elevating or protecting control panel and generator will preserve these services.
RESPONSIBILITY	Sewer
POTENTIAL FUNDING SOURCES	MVP Action Grants; CZM Resiliency Grants; FEMA Pre-Disaster Grant
PRIORITY	Medium
TIMELINE	Long-term
GOAL(S) ADDRESSED	1, 2



<b>Mitigation Action #5: Develop Emergency Evacuation and Response Plan for Road Flooding</b>	
HAZARD ADDRESSED	Flooding (Coastal & Inland)
PURPOSE	Coastal flooding presents a major threat to low-lying roadways, which can isolate neighborhoods and prohibit emergency access. Developing an emergency evacuation plan based on recent town wide Vulnerability Assessment results, which can show residents the best evacuation route depending on where they live and which points are likely to be flooded, will ensure a more organized and safe evacuation in the case of severe flooding.
RESPONSIBILITY	Emergency Management
POTENTIAL FUNDING SOURCES	Grants or Town Meeting Article; FEMA Pre-Disaster Grant
PRIORITY	Medium
TIMELINE	Short-term
GOAL(S) ADDRESSED	5

<b>Mitigation Action #6: Explore Interconnections Between Water Districts Distribution Systems</b>	
HAZARD ADDRESSED	Flooding (Coastal & Inland)
PURPOSE	In the case that one water distribution system is affected by a natural hazard, an interconnection between water distribution systems would provide redundancy and a backup water distribution system.
RESPONSIBILITY	Onset and Wareham Water Districts
POTENTIAL FUNDING SOURCES	Rate Payers; Grants (Water Management Action Grant - likely fund design only)
PRIORITY	Low
TIMELINE	Long-term
GOAL(S) ADDRESSED	1, 2

<b>Mitigation Action #7: Explore Interconnection Between Neighboring Towns Water/Sewer Systems</b>	
HAZARD ADDRESSED	Flooding (Coastal & Inland)
PURPOSE	In the case that one water/sewer system is affected by a natural hazard, an interconnection between neighboring towns would provide redundancy and a backup system.
RESPONSIBILITY	Board of Sewer
POTENTIAL FUNDING SOURCES	Grant; Town Meeting; State Revolving Fund (SRF)
PRIORITY	Low
TIMELINE	Long-term
GOAL(S) ADDRESSED	1, 2



<b>Mitigation Action #8: Explore Changing Local Policy Regarding Beach Nourishment</b>	
HAZARD ADDRESSED	Coastal Erosion
PURPOSE	Beach nourishment helps to address ongoing coastal erosion, provides a buffer to storm damage, and restore valuable coastal habitat.
RESPONSIBILITY	Conservation
POTENTIAL FUNDING SOURCES	Department Budget
PRIORITY	Low
TIMELINE	Long-term
GOAL(S) ADDRESSED	1, 2

<b>Mitigation Action 9: Develop Early Storm Warning System</b>	
HAZARD ADDRESSED	Hurricane/Tropical Storm; Tornadoes
PURPOSE	Developing an early warning system based on local weather data allows residents increased time to prepare and/or evacuate during severe weather events, including hurricanes, tropical storms, tornadoes, etc.
RESPONSIBILITY	Emergency Management
POTENTIAL FUNDING SOURCES	Grant or Town Meeting; FEMA Pre-Disaster Grant
PRIORITY	Medium
TIMELINE	Short-term
GOAL(S) ADDRESSED	5

<b>Mitigation Action 10: Improve Road Drainage at the Main Street - Toby Road Intersection</b>	
HAZARD ADDRESSED	Other Severe Weather (Heavy Precipitation, Thunder/Lighting, Wind)
PURPOSE	A number of key roadways in Town experience significant flooding during heavy rainfall events due to stormwater systems that are inadequately sized to handle the volume of precipitation produced by these large rain events. This results in impassible roadways, inaccessible parking lots and businesses, and stranded vehicles.
RESPONSIBILITY	Municipal Maintenance
POTENTIAL FUNDING SOURCES	Town Meeting; State Grant; Chapter 90
PRIORITY	Low
TIMELINE	Long-term
GOAL(S) ADDRESSED	1, 2





<b>Mitigation Action 11: Complete Wareham Water Drought Management Plan</b>	
HAZARD ADDRESSED	Drought
PURPOSE	Developing a drought management plan will provide a framework for conserving water and managing water use during water restrictions or shortages.
RESPONSIBILITY	Wareham Water District
POTENTIAL FUNDING SOURCES	Water Management Act
PRIORITY	Medium
TIMELINE	Long-term
GOAL(S) ADDRESSED	2

<b>Mitigation Action 12: Increase Water Quality Monitoring, Reporting, and Public Outreach</b>	
HAZARD ADDRESSED	Water Quality
PURPOSE	Water quality monitoring is necessary to evaluate the effect of anthropogenic eutrophication on fish/shellfish populations and residential water supply. Including public outreach in monitoring efforts will educate the public on both the importance of water quality and how to maintain it.
RESPONSIBILITY	Board of Health; Onset and Wareham Water Districts
POTENTIAL FUNDING SOURCES	Rate Payer; Grants
PRIORITY	Medium
TIMELINE	Long-term
GOAL(S) ADDRESSED	2, 5

<b>Mitigation Action 13: Identify and Create Large-Scale Medical Support</b>	
HAZARD ADDRESSED	Extreme Temperature
PURPOSE	In an extreme temperature event, large-scale medical support will be important in the case of health concerns. This will be especially important for vulnerable populations such as the elderly or those without homes.
RESPONSIBILITY	Emergency Management
POTENTIAL FUNDING SOURCES	Grant or Town Meeting
PRIORITY	Medium
TIMELINE	Short-term
GOAL(S) ADDRESSED	3



<b>Mitigation Action 14: Identify and Create Cooling/Warming Shelter(s) for Extreme Temperature Conditions</b>	
HAZARD ADDRESSED	Extreme Temperature
PURPOSE	Cooling/warming shelters will become vital during extreme temperature events. These centers will be especially important for vulnerable populations without adequate heating/cooling systems in their homes and those without homes. Minot Forest School is already under consideration.
RESPONSIBILITY	Emergency Management
POTENTIAL FUNDING SOURCES	Grant or Town Meeting; FEMA Pre-Disaster Grant
PRIORITY	Medium
TIMELINE	Ongoing
GOAL(S) ADDRESSED	3

<b>Mitigation Action 15: Complete Upcoming Scheduled Culvert Repairs</b>	
HAZARD ADDRESSED	Dam/Culvert Failure
PURPOSE	Maintaining culverts in good condition allows for effective water transport under the road, avoids debris build-up, and prevents flooding of or washing-out of roads.
RESPONSIBILITY	Municipal Maintenance
POTENTIAL FUNDING SOURCES	Chapter 90
PRIORITY	Medium
TIMELINE	Short-term
GOAL(S) ADDRESSED	1, 2

<b>Mitigation Action 16: Consider Dam Removal</b>	
HAZARD ADDRESSED	Dam/Culvert Failure
PURPOSE	Benefits of dam removal include restoration of aquatic ecosystems, decreased maintenance expense, and removal of the threat of dam failure. Candidates for dam removal include the Parker Mills Dam. The Horseshoe Pond Dam has just been removed by BBC. The agriculture industry, specifically the cranberry farmers, should be consulted regarding the impact of eliminating future dams.
RESPONSIBILITY	Conservation; Municipal Maintenance
POTENTIAL FUNDING SOURCES	Grant
PRIORITY	Low
TIMELINE	Ongoing
GOAL(S) ADDRESSED	1



<b>Mitigation Action 17: Identify Specialty Contractors for Invasive Plant Removal</b>	
HAZARD ADDRESSED	Invasive Species
PURPOSE	Removal of invasive plant species results allows re-establishment of native species. In addition, when invasive plant removal occurs along a stream or river, biodiversity of aquatic organisms increases.
RESPONSIBILITY	Conservation
POTENTIAL FUNDING SOURCES	Department Budget
PRIORITY	Low
TIMELINE	Long-term
GOAL(S) ADDRESSED	1

<b>Mitigation Action 18: Develop an Emergency Operations Center (EOC)</b>	
HAZARD ADDRESSED	Multi-Hazard/Non-Specific
PURPOSE	An Emergency Operations Center will improve the Town's capabilities and efficiency in responding to natural hazards. EOC will be developed following MEMA and FEMA guidelines.
RESPONSIBILITY	Emergency Management
POTENTIAL FUNDING SOURCES	Grant; Town Meeting; FEMA Pre-Disaster Grant
PRIORITY	High
TIMELINE	Short-term
GOAL(S) ADDRESSED	1

<b>Mitigation Action 19: Protect Main Street Fire Station Headquarters with Flood Wall</b>	
HAZARD ADDRESSED	Multi-Hazard/Non-Specific
PURPOSE	Constructing a flood wall around the Main Street Fire Station Headquarters will protect against a Category 3 hurricane, preserving use of the facility and services during major flood events.
RESPONSIBILITY	Wareham Fire Department
POTENTIAL FUNDING SOURCES	Grant; Town Meeting; FEMA Pre-Disaster Grant
PRIORITY	Medium
TIMELINE	Short-term/Long-term/Ongoing
GOAL(S) ADDRESSED	1



<b>Mitigation Action 20: Develop Disaster Response Plan for Business Districts</b>	
HAZARD ADDRESSED	Multi-Hazard/Non-Specific
PURPOSE	Developing a disaster response plan for business districts will provide a framework for an organized response in the case of a disaster, improving response time and decreasing losses.
RESPONSIBILITY	Planning
POTENTIAL FUNDING SOURCES	Grant
PRIORITY	Medium
TIMELINE	Long-term
GOAL(S) ADDRESSED	1

<b>Mitigation Action 21: Installation of Second Force Main from Narrows Pump Station to WPCF</b>	
HAZARD ADDRESSED	Multi-Hazard (Coastal Flooding/Severe Weather/Hurricane/Tornado)
PURPOSE	Provide redundant force main from Narrows Pump Station to the WPCF that is 100% subsurface. The existing force main is exposed under the Narrows Bridge and is subject to impact from floating debris during severe weather events.
RESPONSIBILITY	WPCF; Sewer
POTENTIAL FUNDING SOURCES	Town funding; Sewer Enterprise Fund; State Revolving Funds and grants such as the CZM Resiliency program; Retained Earnings
PRIORITY	Medium
TIMELINE	Construction to be completed within 5 years. Final design currently being worked on (as of April 2020).
GOAL(S) ADDRESSED	1, 2

<b>Mitigation Action 22: Installation of Second Force Main from Hynes Field Pump Station to WPCF</b>	
HAZARD ADDRESSED	Multi-Hazard (Coastal Flooding / Severe Weather / Hurricane / Tornado)
PURPOSE	Provide redundant force main from Hynes Pump Station to the WPCF. The existing force main is expected to have metal loss and operating under a reduced structural integrity.
RESPONSIBILITY	WPCF; Sewer
POTENTIAL FUNDING SOURCES	Town funding; Sewer Enterprise Fund; State Revolving Funds and grants such as the CZM Resiliency program; Retained Earnings
PRIORITY	Medium
TIMELINE	Construction to be completed within 5 - 10 years.
GOAL(S) ADDRESSED	1, 2



<b>Mitigation Action 23: Increase Discharge Capacity at WPCF</b>	
HAZARD ADDRESSED	Multi-Hazard (Coastal Flooding / Severe Weather)
PURPOSE	Provide additional discharge capacity for the WPCF due to expected increase in inflow and infiltration as well as development.
RESPONSIBILITY	WPCF; Sewer
POTENTIAL FUNDING SOURCES	Town funding; Sewer Enterprise Fund and State Revolving Funds; Retained Earnings; Grant
PRIORITY	Medium
TIMELINE	Construction to be completed within 5 - 10 years.
GOAL(S) ADDRESSED	1, 2, 4

<b>Mitigation Action 24: Reduction in Inflow and Infiltration for Subjected Gravity Mains</b>	
HAZARD ADDRESSED	Multi-Hazard (Coastal Flooding / Severe Weather)
PURPOSE	Provide ongoing projects to mitigate inflow and infiltration, primarily from developed areas at low elevations. These areas include Swifts Beach, Pinehurst, Onset and other areas.
RESPONSIBILITY	WPCF; Sewer
POTENTIAL FUNDING SOURCES	Town funding; Sewer Enterprise Fund and State Revolving Funds; Retained Earnings; Grant
PRIORITY	Medium
TIMELINE	Ongoing
GOAL(S) ADDRESSED	1, 2

<b>Mitigation Action 25: Upgrades at Priority Pump Stations (Hynes Field, Narrows, and Depot Street Stations)</b>	
HAZARD ADDRESSED	Multi-Hazard (Coastal Flooding / Severe Weather / Hurricane / Tornado)
PURPOSE	Provide upgrades to priority pump stations that include installation of bypass piping, flood proofing, structural improvements, rehabilitation of HVAC and mechanical systems and wet well improvements.
RESPONSIBILITY	WPCF; Sewer
POTENTIAL FUNDING SOURCES	Town funding; Sewer Enterprise Fund and State Revolving Funds; Retained Earnings; Grant
PRIORITY	Medium
TIMELINE	Designs for dry flood proofing and structural improvements completed, looking to complete construction within 5 years.
GOAL(S) ADDRESSED	1, 2





<b>Mitigation Action 26: Acquire Generator for Onset Fire Department</b>	
HAZARD ADDRESSED	Multi-Hazard/Non-Specific
PURPOSE	Providing a generator for the Onset Fire Department would ensure that emergency services provided could continue even in the event of a power-outage during a natural hazard.
RESPONSIBILITY	Onset Fire Department
POTENTIAL FUNDING SOURCES	Grants; District Meeting; FEMA Pre-Disaster Grant
PRIORITY	Medium
TIMELINE	Short-term
GOAL(S) ADDRESSED	1

<b>Mitigation Action 27: Installation of Additional Water Tank in Onset</b>	
HAZARD ADDRESSED	Multi-Hazard/Non-Specific
PURPOSE	Installation of an additional water tank for water storage provides increased water resources during a drought, ensuring access to essential drinking water.
RESPONSIBILITY	Onset Water District
POTENTIAL FUNDING SOURCES	Grant; Rates
PRIORITY	Low
TIMELINE	Long-term
GOAL(S) ADDRESSED	2

<b>Mitigation Action 28: Acquire Backup Generator for Maple Springs Water Purification Plant</b>	
HAZARD ADDRESSED	Multi-Hazard/Non-Specific
PURPOSE	Providing a secondary generator for the Maple Springs Water Purification Plant ensures access to drinking water if a power-outage occurs and the primary generator is nonfunctional. Out of all the drinking water items, this is one of the most important to run the filter plant.
RESPONSIBILITY	Water Department
POTENTIAL FUNDING SOURCES	Water Rate Payer; Surplus; FEMA Grant; SRF Loan
PRIORITY	High
TIMELINE	Short-term
GOAL(S) ADDRESSED	1, 2



*The Wareham Multi-Hazard Mitigation Plan is not meant to be a static document. As conditions change, new information becomes available, or mitigation actions progress or are completed over the life of the plan, adjustments and updates may be necessary to maintain its relevance. This chapter describes how the Plan will be tracked, updated and enhanced in the coming years. The plan must be fully reviewed and revised as necessary at least once every five years. Keeping the plan up-to-date also means continuing to provide opportunities for public involvement and comment on the plan and its implementation.*



As required by FEMA, this Plan must outline a maintenance process to ensure the Plan remains active and relevant to the current conditions of the Town. The process must identify the following items:

- Plan Monitoring, Evaluation and Updates – Method and schedule for monitoring, evaluating and updating the plan once every five years;
- Incorporation of Mitigation Strategies – Explanation of how local governments will incorporate mitigation strategies into existing mechanisms; and
- Continued Public Involvement – Requirements that public participation continue throughout the plan maintenance process.

This section details how Wareham will meet these Plan maintenance requirements.

### 6.1 PLAN MONITORING, EVALUATION AND UPDATES

A6

As required by FEMA, the written plan will be evaluated and updated at least once every five years by relevant Town departments, boards, and agencies. In the interim, select members of the LPT will conduct annual reviews of the progress of mitigation actions and update as necessary. If a major disaster occurs in the interim, the plan may be evaluated or updated if Town personnel feel that the plan failed in some way, or imminent changes are required to better respond to future disasters. As necessary, LPT members and/or departments may be added or removed from the LPT to obtain the most accurate and applicable information possible.

Evaluations and updates will take place in much the same way this updated plan was developed. The process will include meetings of the LPT, review of goals and objectives, updating the community profile, review and modification of potential hazards and hazard related data, review of existing hazard-prone areas and the addition of any new areas, updating existing and planned hazard mitigation measures, and an evaluation as to the effectiveness of the plan to date. The next update will begin in year 4 of this plan, to ensure that the subsequent update is ready within the required 5 year window.

### 6.2 INCORPORATION OF MITIGATION STRATEGIES

Mitigation strategies outlined in this Plan will be incorporated into existing plans, bylaws and regulations as feasible. During Plan updates, existing and proposed mitigation actions will be evaluated for effectiveness, level of completion, and continued appropriateness.

Upon approval of this plan, the LPT will provide all interested parties and implementing departments with a copy of the plan and will initiate a discussion regarding how the plan can be integrated into that department’s ongoing work. At a minimum, the plan will be reviewed and discussed with the following departments:

- Emergency Management
- Fire



- Police
- Municipal Maintenance Department
- Planning
- Conservation
- Water
- Sewer

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### 6.3 CONTINUED PUBLIC INVOLVEMENT

During the periodic five-year update process, the LPT will hold at least one public workshop or similar meeting to solicit feedback from the general public on the progress made to date. Concerned citizens will also be invited to review the revised Plan and submit any additional comments or recommendations for improving the Plan. All events will be publicly advertised in the local newspaper and/or similar method. Copies of the Plan will be provided in public places such as the Town Hall and/or the Library. The Plan will also be made available to the general public via the Town's website.

E1.a

### 6.4 PLAN ADOPTION

At the conclusion of planning efforts conducted by the Local Planning Team (LPT), the draft of the Wareham Multi-Hazard Mitigation Plan was reviewed by the Local Planning Team, stakeholders and the general public, and informally approved by all applicable Town departments, boards, and other agencies identified as members of the LPT. The plan was then submitted to the State Hazard Mitigation Officer (SHMO) of the Massachusetts Department of Resource Conservation, the Massachusetts Emergency Management Agency (MEMA) and the Federal Emergency Management Agency (FEMA) for review and approval. If approved by MEMA and FEMA, the plan will be brought before the Wareham Board of Selectmen for adoption, and the Plan will enter the five year "maintenance" phase. A draft of the certificate of adoption is provided on the following page. Proof of plan adoption will also be included at the front of this report.



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## Appendix A: Local Mitigation Plan Review Guide

1. Local Mitigation Plan Review Guide
2. CRS Scoring Checklist

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# Local Mitigation Plan Review Guide

October 1, 2011



**FEMA**

## SECTION 4: REGULATION CHECKLIST

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This section provides detailed guidance on how FEMA interprets the various requirements of the regulation for all Local Mitigation Plan reviews through a Regulatory Checklist. The guidance is limited only to the minimum requirements of *what* must be in a Local Mitigation Plan, and does not provide guidance on *how* the community should develop a plan. The Regulation Checklist includes the following Elements:

- 4.1 ELEMENT A: Planning Process
- 4.2 ELEMENT B: Hazard Identification and Risk Assessment
- 4.3 ELEMENT C: Mitigation Strategy
- 4.4 ELEMENT D: Plan Review, Evaluation, and Implementation
- 4.5 ELEMENT E: Plan Adoption
- 4.6 ELEMENT F: Additional State Requirements

Many requirements in the Checklist call for the plan to “document” or “describe” information. FEMA does not require specific formats for the plan or its content. Required information to “document” can be provided in the plan through a variety of formats, such as narrative, tables, lists, maps, etc. Examples provided in this *Guide* are samples of one or more approaches to meeting that particular requirement. Examples are not inclusive of all possible solutions to meet a requirement, and they are not necessarily considered “best practices” or exemplary. FEMA will recognize that there are many formats and types of documentation that may meet a particular requirement.

Terms from the regulation are defined in this *Guide*, where necessary. For example, many of the plan requirements ask for a “discussion” or “description.” FEMA considers the plan as the written record, or documentation, of the planning process. Therefore, many of these terms have the same meaning to document *what* was done. In addition, this *Guide* uses the terms “jurisdiction” and “community” interchangeably. For purposes of this *Guide*, these terms are equal to any local government developing a Local Mitigation Plan. This is defined at 44 CFR §201.2 as:

*“any county, municipality, city, town, township, public authority, school district, special district, intrastate district, council of governments (regardless of whether the council of governments is incorporated as a nonprofit corporation under State law), regional or interstate government entity, or agency or instrumentality of a local government; any Indian tribe or authorized tribal organization, or Alaska Native village or organization; and any rural community, unincorporated town or village, or other public entity.”*

Finally, an important distinction must be made between the words “shall” and “should” in the Mitigation Planning regulation at 44 CFR Part 201. The Regulation Checklist only includes the requirements where the regulation uses the words “shall” and “must,” and does not include the “should.” When the word “should” is used, the item is strongly recommended to be included in the plan, but its absence will not cause FEMA to disapprove the plan.

#### 4.1 ELEMENT A: PLANNING PROCESS

<b>Requirement §201.6(b)</b>	An open public involvement process is essential to the development of an effective plan. In order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process shall include:
<b>§201.6(b)(1)</b>	(1) An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval;
<b>§201.6(b)(2)</b>	(2) An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia and other private and non-profit interests to be involved in the planning process; and
<b>§201.6(b)(3)</b>	(3) Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.
<b>§201.6(c)(1)</b>	[The plan shall document] the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how the public was involved.
<b>§201.6(c)(4)(i)</b>	[The plan maintenance process shall include a] section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle.
<b>§201.6(c)(4)(iii)</b>	[The plan maintenance process shall include a] discussion on how the community will continue public participation in the plan maintenance process.

**Overall Intent.** The planning process is as important as the plan itself. Any successful planning activity, such as developing a comprehensive plan or local land use plan, involves a cross-section of stakeholders and the public to reach consensus on desired outcomes or to resolve a community problem. The result is a common set of community values and widespread support for directing financial, technical, and human resources to an agreed upon course of action, usually identified in a plan. The same is true for mitigation planning. An effective and open planning process helps ensure that citizens understand risks and vulnerability, and they can work with the jurisdiction to support policies, actions, and tools that over the long-term will lead to a reduction in future losses.

Leadership, staffing, and in-house knowledge in local government may fluctuate over time. Therefore, the description of the planning process serves as a permanent record that explains how decisions were reached and who involved. FEMA will accept the planning process as defined by the community, as long as the mitigation plan includes a narrative



description of the process used to develop the mitigation plan—a systematic account about how the mitigation plan evolved from the formation of a planning team, to how the public participated, to how each section of the plan was developed, to what plans or studies were incorporated into the plan, to how it will be implemented. Documentation of a current planning process is required for both new and updated plans.

<b>ELEMENT</b>	<b>REQUIREMENTS</b>
<p><b>A1. Does the Plan document the planning process, including how it was prepared and who was involved in the process for each jurisdiction?</b>  <b>44 CFR 201.6(c)(1)</b></p> <p><i><b>Intent:</b> To inform the public and other readers about the overall approach to the plan’s development and serve as a permanent record of how decisions were made and who was involved. This record also is useful for the next plan update.</i></p>	<p>a. Documentation of how the plan was prepared <b>must</b> include the schedule or timeframe and activities that made up the plan’s development as well as who was involved. Documentation typically is met with a narrative description, but may also include, for example, other documentation such as copies of meeting minutes, sign-in sheets, or newspaper articles.</p> <p><i><b>Document</b> means provide the factual evidence for how the jurisdictions developed the plan.</i></p> <p>b. The plan <b>must</b> list the jurisdiction(s) participating in the plan that seek approval.</p> <p>c. The plan <b>must</b> identify who represented each jurisdiction. The Plan <b>must</b> provide, at a minimum, the jurisdiction represented and the person’s position or title and agency within the jurisdiction.</p> <p>d. For each jurisdiction seeking plan approval, the plan <b>must</b> document how they were involved in the planning process. For example, the plan may document meetings attended, data provided, or stakeholder and public involvement activities offered. Jurisdictions that adopt the plan without documenting how they participated in the planning process will not be approved.</p> <p><i><b>Involved in the process</b> means engaged as participants and given the chance to provide input to affect the plan’s content. This is more than simply being invited (See “<b>opportunity to be involved in the planning process</b>” in A2 below) or only adopting the plan.</i></p> <p>e. Plan updates <b>must</b> include documentation of the current planning process undertaken to update the plan.</p>
<p><b>A2. Does the Plan document an opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, agencies that have the authority to regulate development as well as other interests to be involved in the planning process?</b> 44 CFR 201.6(b)(2)</p>	<p>a. The plan <b>must</b> identify all stakeholders involved or given an opportunity to be involved in the planning process. At a minimum, stakeholders <b>must</b> include:</p> <ol style="list-style-type: none"> <li>1) Local and regional agencies involved in hazard mitigation activities;</li> <li>2) Agencies that have the authority to regulate development; and</li> <li>3) Neighboring communities.</li> </ol> <p><i>An <b>opportunity to be involved in the planning process</b> means that the stakeholders are engaged or invited as participants and given the chance to provide input to affect the plan’s content.</i></p>

<b>ELEMENT</b>	<b>REQUIREMENTS</b>
<p><b><i>Intent:</i></b> To demonstrate a deliberative planning process that involves stakeholders with the data and expertise needed to develop the plan, with responsibility or authority to implement hazard mitigation activities, and who will be most affected by the plan's outcomes.</p>	<p>b. The Plan <b>must</b> provide the agency or organization represented and the person's position or title within the agency.</p> <p>c. The plan <b>must</b> identify how the stakeholders were invited to participate in the process.</p> <p>Examples of stakeholders include, but are not limited to:</p> <ul style="list-style-type: none"> <li>• Local and regional agencies involved in hazard mitigation include public works, zoning, emergency management, local floodplain administrators, special districts, and GIS departments.</li> <li>• Agencies that have the authority to regulate development include planning and community development departments, building officials, planning commissions, or other elected officials.</li> <li>• Neighboring communities include adjacent counties and municipalities, such as those that are affected by similar hazard events or may be partners in hazard mitigation and response activities.</li> <li>• Other interests may be defined by each jurisdiction and will vary with each one. These include, but are not limited to, business, academia, and other private and non-profit interests depending on the unique characteristics of the community.</li> </ul>
<p><b>A3. Does the Plan document how the public was involved in the planning process during the drafting stage?</b>  <b>44 CFR 201.6(b)(1) and 201.6(c)(1)</b></p> <p><b><i>Intent:</i></b> To ensure citizens understand what the community is doing on their behalf, and to provide a chance for input on community vulnerabilities and mitigation activities that will inform the plan's content. Public involvement is also an opportunity to educate the public about hazards and risks in the community, types of activities to mitigate those risks, and how these impact them.</p>	<p>a. The plan <b>must</b> document how the public was given the opportunity to be involved in the planning process and how their feedback was incorporated into the plan. Examples include, but are not limited to, sign-in sheets from open meetings, interactive websites with drafts for public review and comment, questionnaires or surveys, or booths at popular community events.</p> <p>b. The opportunity for participation <b>must</b> occur during the plan development, which is prior to the comment period on the final plan and prior to the plan approval / adoption.</p>

ELEMENT	REQUIREMENTS
<p><b>A4. Does the Plan document the review and incorporation of existing plans, studies, reports, and technical information? 44 CFR 201.6(b)(3)</b></p> <p><i><b>Intent:</b> To identify existing data and information, shared objectives, and past and ongoing activities that can help inform the mitigation plan. It also helps identify the existing capabilities and planning mechanisms to implement the mitigation strategy.</i></p>	<p>a. The plan <b>must</b> document <i>what</i> existing plans, studies, reports, and technical information were reviewed. Examples of the types of existing sources reviewed include, but are not limited to, the state hazard mitigation plan, local comprehensive plans, hazard specific reports, and flood insurance studies.</p> <p>b. The plan <b>must</b> document <i>how</i> relevant information was incorporated into the mitigation plan.</p> <p><i><b>Incorporate</b> means to reference or include information from other existing sources to form the content of the mitigation plan.</i></p>
<p><b>A5. Is there discussion on how the community(ies) will continue public participation in the plan maintenance process? 44 CFR 201.6(c)(4)(iii)</b></p> <p><i><b>Intent:</b> To identify how the public will continue to have an opportunity to participate in the plan’s maintenance and implementation over time.</i></p>	<p>a. The plan <b>must</b> describe how the jurisdiction(s) will continue to seek public participation after the plan has been approved and during the plan’s implementation, monitoring and evaluation.</p> <p><i><b>Participation</b> means engaged and given the chance to provide feedback. Examples include, but are not limited to, periodic presentations on the plan’s progress to elected officials, schools or other community groups, annual questionnaires or surveys, public meetings, postings on social media and interactive websites.</i></p>
<p><b>A6. Is there a description of the method and schedule for keeping the plan current (monitoring, evaluating and updating the mitigation plan within a 5-year cycle)? 44 CFR 201.6(c)(4)(i)</b></p> <p><i><b>Intent:</b> To establish a process for jurisdictions to track the progress of the plan’s implementation. This also serves as the basis of the next plan update.</i></p>	<p>a. The plan <b>must</b> identify how, when, and by whom the plan will be monitored. <i><b>Monitoring</b> means tracking the implementation of the plan over time. For example, monitoring may include a system for tracking the status of the identified hazard mitigation actions.</i></p> <p>b. The plan <b>must</b> identify how, when, and by whom the plan will be evaluated. <i><b>Evaluating</b> means assessing the effectiveness of the plan at achieving its stated purpose and goals.</i></p> <p>c. The plan <b>must</b> identify how, when, and by whom the plan will be updated. <i><b>Updating</b> means reviewing and revising the plan at least once every five years.</i></p> <p>d. The plan <b>must</b> include the title of the individual or name of the department/ agency responsible for leading each of these efforts.</p>

#### 4.2 ELEMENT B. HAZARD IDENTIFICATION AND RISK ASSESSMENT

<b>Requirement</b>	[The risk assessment shall include a] description of the type, location and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.
<b>§201.6(c)(2)(i)</b>	
<b>§201.6(c)(2)(ii)</b>	[The risk assessment shall include a] description of the jurisdiction’s vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description shall include an overall summary of each hazard and its impact on the community. All plans approved after October 1, 2008 must also address NFIP insured structures that have been repetitively damaged by floods. The plan should describe vulnerability in terms of:
<b>§201.6(c)(2)(ii)(A)</b>	(A) The types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas;
<b>§201.6(c)(2)(ii)(B)</b>	(B) An estimate of the potential dollar losses to vulnerable structures identified in ... this section and a description of the methodology used to prepare the estimate.
<b>§201.6(c)(2)(ii)(C)</b>	(C) Providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.
<b>§201.6(c)(2)(iii)</b>	For multi-jurisdictional plans, the risk assessment section must assess each jurisdiction’s risks where they vary from the risks facing the entire planning area.

***Overall Intent.*** The risk assessment provides the factual basis for activities proposed in the strategy that will reduce losses from identified hazards. A quality risk assessments makes a clear connection between the community’s vulnerability and the hazard mitigation actions. In other words, it provides sufficient information to enable the jurisdiction(s) to identify and prioritize appropriate hazard mitigation actions.

Local risk assessments do not need to be based on the most sophisticated technology, but do need to be accurate, current, and relevant. During a plan update, local jurisdictions assess current and expected future vulnerability to all hazards and integrate new hazard data such as recent hazard events and new flood studies. In the mitigation plan review, FEMA looks at the quality of the information in the risk assessment, not the quantity of information in the risk assessment.

The Mitigation Planning regulation includes several “optional” requirements for the vulnerability assessment. These are easily recognizable with the use of the term “should” in the requirement (See §201.6(c)(2)(ii)(A-C)). Although not required, these are strongly recommended to be included in the plan. However, their absence will not cause FEMA to disapprove the plan. These “optional” requirements were originally intended to meet the overall vulnerability assessment, and this analysis can assist with identifying mitigation actions.

<u>ELEMENT</u>	<u>REQUIREMENTS</u>
<p><b>B1. Does the Plan include a description of the type, location, and extent of all natural hazards that can affect each jurisdiction? 44 CFR 201.6(c)(2)(i) and 44 CFR 201.6(c)(2)(iii)</b></p> <p><i><b>Intent:</b> To understand the potential and chronic hazards affecting the planning area in order to identify which hazard risks are most significant and which jurisdictions or locations are most adversely affected.</i></p>	<p>a. The plan <b>must</b> include a description of the natural hazards that can affect the jurisdiction(s) in the planning area.</p> <p><i>A <b>natural hazard</b> is a source of harm or difficulty created by a meteorological, environmental, or geological event<sup>3</sup>. The plan <b>must</b> address natural hazards. Manmade or human-caused hazards may be included in the document, but these are not required and will not be reviewed to meet the requirements for natural hazards. In addition, FEMA will not require the removal of this extra information prior to plan approval.</i></p> <p>b. The plan <b>must</b> provide the rationale for the omission of any natural hazards that are commonly recognized to affect the jurisdiction(s) in the planning area.</p> <p>c. The description, or profile, <b>must</b> include information on location, extent, previous occurrences, and future probability for each hazard. Previous occurrences and future probability are addressed in sub-element B2.</p> <p>The information does not necessarily need to be described or presented separately for location, extent, previous occurrences, and future probability. For example, for some hazards, one map with explanatory text could provide information on location, extent, and future probability.</p> <p><i><b>Location</b> means the geographic areas in the planning area that are affected by the hazard. For many hazards, maps are the best way to illustrate location. However, location may be described in other formats. For example, if a geographically-specific location cannot be identified for a hazard, such as tornados, the plan may state that the entire planning area is equally at risk to that hazard.</i></p> <p><i><b>Extent</b> means the strength or magnitude of the hazard. For example, extent could be described in terms of the specific measurement of an occurrence on a scientific scale (for example, Enhanced Fujita Scale, Saffir-Simpson Hurricane Scale, Richter Scale, flood depth grids) and/or other hazard factors, such as duration and speed of onset. Extent is not the same as impacts, which are described in sub-element B3.</i></p>

<sup>3</sup> DHS Risk Lexicon, 2010 Edition. <http://www.dhs.gov/xlibrary/assets/dhs-risk-lexicon-2010.pdf>



<u>ELEMENT</u>	<u>REQUIREMENTS</u>
	<p>d. For participating jurisdictions in a multi-jurisdictional plan, the plan <b>must</b> describe any hazards that are unique and/or varied from those affecting the overall planning area.</p>
<p><b>B2. Does the Plan include information on previous occurrences of hazard events and on the probability of future hazard events for each jurisdiction? 44 CFR 201.6(c)(2)(i)</b></p> <p><i><b>Intent:</b> To understand potential impacts to the community based on information on the hazard events that have occurred in the past and the likelihood they will occur in the future.</i></p>	<p>a. The plan <b>must</b> include the history of previous hazard events for each of the identified hazards.</p> <p>b. The plan <b>must</b> include the probability of future events for each identified hazard.</p> <p><i><b>Probability</b> means the likelihood of the hazard occurring and may be defined in terms of general descriptors (for example, unlikely, likely, highly likely), historical frequencies, statistical probabilities (for example: 1% chance of occurrence in any given year), and/or hazard probability maps. If general descriptors are used, then they <b>must</b> be defined in the plan. For example, “highly likely” could be defined as equals near 100% chance of occurrence next year or happens every year.</i></p> <p>c. Plan updates <b>must</b> include hazard events that have occurred since the last plan was developed.</p>
<p><b>B3. Is there a description of each identified hazard’s impact on the community as well as an overall summary of the community’s vulnerability for each jurisdiction? 44 CFR 201.6(c)(2)(ii)</b></p> <p><i><b>Intent:</b> For each jurisdiction to consider their community as a whole and analyze the potential impacts of future hazard events and the vulnerabilities that could be reduced through hazard mitigation actions.</i></p>	<p>a. For each participating jurisdiction, the plan <b>must</b> describe the potential impacts of each of the identified hazards on the community.</p> <p><i><b>Impact</b> means the consequence or effect of the hazard on the community and its assets. Assets are determined by the community and include, for example, people, structures, facilities, systems, capabilities, and/or activities that have value to the community. For example, impacts could be described by referencing historical disaster impacts and/or an estimate of potential future losses (such as percent damage of total exposure).</i></p> <p>b. The plan <b>must</b> provide an overall summary of each jurisdiction’s vulnerability to the identified hazards. The overall summary of vulnerability identifies structures, systems, populations or other community assets as defined by the community that are susceptible to damage and loss from hazard events. A plan will meet this sub-element by addressing the requirements described in §201.6(c)(2)(ii)(A-C).</p> <p>Vulnerable assets and potential losses is more than a list of the total exposure of population, structures, and critical facilities in the planning area. An example of an overall summary is a list of key issues or problem statements that clearly describes the community’s greatest vulnerabilities and that will be addressed in the mitigation strategy.</p>

<u>ELEMENT</u>	<u>REQUIREMENTS</u>
<p><b>B4. Does the Plan address NFIP insured structures within each jurisdiction that have been repetitively damaged by floods? 44 CFR 201.6(c)(2)(ii)</b></p> <p><i><b>Intent:</b> To inform hazard mitigation actions for properties that have suffered repetitive damage due to flooding, particularly problem areas that may not be apparent on floodplain maps. Information on repetitive loss properties helps inform FEMA hazard mitigation assistance programs under the National Flood Insurance Act.</i></p>	<p>a. The plan <b>must</b> describe the types (residential, commercial, institutional, etc.) and estimate the numbers of repetitive loss properties located in identified flood hazard areas.</p> <p><i><b>Repetitive loss properties</b> are those for which two or more losses of at least \$1,000 each have been paid under the National Flood Insurance Program (NFIP) within any 10-year period since 1978.</i></p> <p><i><b>Severe repetitive loss properties</b> are residential properties that have at least four NFIP payments over \$5,000 each and the cumulative amount of such claims exceeds \$20,000, or at least two separate claims payments with the cumulative amount exceeding the market value of the building.</i></p> <p>Use of flood insurance claim and disaster assistance information is subject to The Privacy Act of 1974, as amended, which prohibits public release of the names of policy holders or recipients of financial assistance and the amount of the claim payment or assistance. However, maps showing general areas where claims have been paid can be made public. If a plan includes the names of policy holders or recipients of financial assistance and the amount of the claim payment or assistance, the plan cannot be approved until this Privacy Act covered information is removed from the plan.</p>

### 4.3 ELEMENT C. MITIGATION STRATEGY

<b>Requirement</b> <b>§201.6(c)(3)</b>	[The plan shall include the following:] A <i>mitigation strategy</i> that provides the jurisdiction’s blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs, and resources, and its ability to expand on and improve these existing tools.
<b>§201.6(c)(3)(i)</b>	[The hazard mitigation strategy shall include a] description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.
<b>§201.6(c)(3)(ii)</b>	[The hazard mitigation strategy shall include a] section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure. All plans approved by FEMA after October 1, 2008, must also address the jurisdiction’s participation in the NFIP, and continued compliance with NFIP requirements, as appropriate.
<b>§201.6(c)(3)(iii)</b>	[The hazard mitigation strategy shall include an] action plan, describing how the action identified in paragraph (c)(3)(ii) of this section will be prioritized, implemented, and administered by the local jurisdiction. Prioritization shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.
<b>§201.6(c)(3)(iv)</b>	For multi-jurisdictional plans, there must be identifiable action items specific to the jurisdiction requesting FEMA approval or credit of the plan.
<b>§201.6(c)(4)(ii)</b>	[The plan shall include a] process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvements, when appropriate.

***Overall Intent.*** The mitigation strategy serves as the long-term blueprint for reducing the potential losses identified in the risk assessment. The Stafford Act directs Local Mitigation Plans to describe hazard mitigation actions and establish a strategy to implement those actions.<sup>4</sup> Therefore, all other requirements for a Local Mitigation Plan lead to and support the mitigation strategy.

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<sup>4</sup> Section 322(b), Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), as amended, 42 U.S.C. 5165.

The mitigation strategy includes the development of goals and prioritized hazard mitigation actions. Goals are long-term policy statements and global visions that support the mitigation strategy. A critical step in the development of specific hazard mitigation actions and projects is assessing the community’s existing authorities, policies, programs, and resources and its capability to use or modify local tools to reduce losses and vulnerability from profiled hazards.

In the plan update, goals and actions are either reaffirmed or updated based on current conditions, including the completion of hazard mitigation initiatives, an updated or new risk assessment, or changes in State or local priorities.

<u>ELEMENT</u>	<u>REQUIREMENTS</u>
<p><b>C1. Does the plan document each jurisdiction’s existing authorities, policies, programs and resources, and its ability to expand on and improve these existing policies and programs? 44 CFR 201.6(c)(3)</b></p> <p><i><b>Intent:</b> To ensure that each jurisdiction evaluates its capabilities to accomplish hazard mitigation actions, through existing mechanisms. This is especially useful for multi-jurisdictional plans where local capability varies widely.</i></p>	<p>a. The plan <b>must</b> describe each jurisdiction’s existing authorities, policies, programs and resources available to accomplish hazard mitigation.</p> <p>Examples include, but are not limited to: staff involved in local planning activities, public works, and emergency management; funding through taxing authority, and annual budgets; or regulatory authorities for comprehensive planning, building codes, and ordinances.</p>
<p><b>C2. Does the Plan address each jurisdiction’s participation in the NFIP and continued compliance with NFIP requirements, as appropriate? 44 CFR 201.6(c)(3)(ii)</b></p> <p><i><b>Intent:</b> To demonstrate flood hazard mitigation efforts by the community through NFIP activities. Where FEMA is the official administering Federal agency of the NFIP, participation in the program is a basic community capability and resource for flood hazard mitigation activities.</i></p>	<p>a. The plan <b>must</b> describe each jurisdiction’s participation in the NFIP and describe their floodplain management program for continued compliance. Simply stating “The community will continue to comply with NFIP,” will <u>not</u> meet this requirement. The description could include, but is not limited to:</p> <ul style="list-style-type: none"> <li>• Adoption and enforcement of floodplain management requirements, including regulating new construction in Special Flood Hazard Areas (SFHAs);</li> <li>• Floodplain identification and mapping, including any local requests for map updates; or</li> <li>• Description of community assistance and monitoring activities.</li> </ul> <p>Jurisdictions that are currently not participating in the NFIP and where an FHBM or FIRM has been issued may meet this requirement by describing the reasons why the community does not participate.</p>

ELEMENT	REQUIREMENTS
<p><b>C3. Does the Plan include goals to reduce/avoid long-term vulnerabilities to the identified hazards? 44 CFR 201.6(c)(3)(i)</b></p> <p><i><b>Intent:</b> To guide the development and implementation of hazard mitigation actions for the community(ies). Goals are statements of the community's visions for the future.</i></p>	<p>a. The plan <b>must</b> include general hazard mitigation goals that represent what the jurisdiction(s) seeks to accomplish through mitigation plan implementation.</p> <p><i><b>Goals</b> are broad policy statements that explain what is to be achieved.</i></p> <p>b. The goals <b>must</b> be consistent with the hazards identified in the plan.</p>
<p><b>C4. Does the Plan identify and analyze a comprehensive range of specific mitigation actions and projects for each jurisdiction being considered to reduce the effects of hazards, with emphasis on new and existing buildings and infrastructure? 44 CFR 201.6(c)(3)(ii) and 44 CFR 201.6(c)(3)(iv)</b></p> <p><i><b>Intent:</b> To ensure the hazard mitigation actions are based on the identified hazard vulnerabilities, are within the capability of each jurisdiction, and reduce or avoid future losses. This is the heart of the mitigation plan, and is essential to leading communities to reduce their risk. Communities, not FEMA, "own" the hazard mitigation actions in the strategy.</i></p>	<p>a. The plan <b>must</b> include a mitigation strategy that 1) analyzes actions and/or projects that the jurisdiction considered to reduce the impacts of hazards identified in the risk assessment, and 2) identifies the actions and/or projects that the jurisdiction intends to implement.</p> <p><i><b>Mitigation actions and projects</b> means a hazard mitigation action, activity or process (for example, adopting a building code) or it can be a physical project (for example, elevating structures or retrofitting critical infrastructure) designed to reduce or eliminate the long term risks from hazards. This sub-element can be met with either actions or projects, or a combination of actions and projects.</i></p> <p>The mitigation plan may include non-mitigation actions, such as actions that are emergency response or operational preparedness in nature. These will not be accepted as hazard mitigation actions, but neither will FEMA require these to be removed from the plan prior to approval.</p> <p><i>A <b>comprehensive range</b> consists of different hazard mitigation alternatives that address the vulnerabilities to the hazards that the jurisdiction(s) determine are most important.</i></p> <p>b. Each jurisdiction participating in the plan <b>must</b> have mitigation actions specific to that jurisdiction that are based on the community's risk and vulnerabilities, as well as community priorities.</p> <p>c. The action plan <b>must</b> reduce risk to existing buildings and infrastructure as well as limit any risk to new development and redevelopment. <i><b>With emphasis on new and existing building and infrastructure</b> means that the action plan includes a consideration of actions that address the built environment.</i></p>



ELEMENT	REQUIREMENTS
<p><b>C5. Does the Plan contain an action plan that describes how the actions identified will be prioritized (including cost benefit review), implemented, and administered by each jurisdiction? 44 CFR 201.6(c)(3)(iii) and 44 CFR (c)(3)(iv)</b></p> <p><i><b>Intent:</b> To identify how the plan will directly lead to implementation of the hazard mitigation actions. As opportunities arise for actions or projects to be implemented, the responsible entity will be able to take action towards completion of the activities.</i></p>	<ul style="list-style-type: none"> <li>a. The plan <b>must</b> describe the criteria used for prioritizing implementation of the actions.</li> <li>b. The plan <b>must</b> demonstrate when prioritizing hazard mitigation actions that the local jurisdictions considered the benefits that would result from the hazard mitigation actions versus the cost of those actions. The requirement is met as long as the economic considerations are summarized in the plan as part of the community’s analysis. A complete benefic-cost analysis is not required. Qualitative benefits (<i>for example</i>, quality of life, natural and beneficial values, or other “benefits”) can also be included in how actions will be prioritized.</li> <li>c. The plan <b>must</b> identify the position, office, department, or agency responsible for implementing and administering the action (for each jurisdiction), and identify potential funding sources and expected timeframes for completion.</li> </ul>
<p><b>C6. Does the Plan describe a process by which local governments will integrate the requirements of the mitigation plan into other planning mechanisms, such as comprehensive or capital improvement plans, when appropriate? 44 CFR 201.6(c)(4)(ii)</b></p> <p><i><b>Intent:</b> To assist communities in capitalizing on all available mechanisms that they have at their disposal to accomplish hazard mitigation and reduce risk.</i></p>	<ul style="list-style-type: none"> <li>a. The plan <b>must</b> describe the community’s process to integrate the data, information, and hazard mitigation goals and actions into other planning mechanisms.</li> <li>b. The plan <b>must</b> identify the local planning mechanisms where hazard mitigation information and/or actions may be incorporated.</li> </ul> <p><i><b>Planning mechanisms</b> means governance structures that are used to manage local land use development and community decision-making, such as comprehensive plans, capital improvement plans, or other long-range plans.</i></p> <ul style="list-style-type: none"> <li>c. A multi-jurisdictional plan <b>must</b> describe each participating jurisdiction’s individual process for integrating hazard mitigation actions applicable to their community into other planning mechanisms.</li> <li>d. The updated plan <b>must</b> explain how the jurisdiction(s) incorporated the mitigation plan, when appropriate, into other planning mechanisms as a demonstration of progress in local hazard mitigation efforts.</li> <li>e. The updated plan <b>must</b> continue to describe how the mitigation strategy, including the goals and hazard mitigation actions will be incorporated into other planning mechanisms.</li> </ul>

#### 4.4 ELEMENT D. PLAN REVIEW, EVALUATION, AND IMPLEMENTATION *(Plan Updates Only)*

<b>Requirement §201.6(d)(3)</b>	A local jurisdiction must review and revise its plan to reflect changes in development, progress in local mitigation efforts, and changes in priorities, and resubmit if for approval within 5 years in order to continue to be eligible for mitigation project grant funding.
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**Overall Intent.** In order to continue to be an effective representation of the jurisdiction’s overall strategy for reducing its risks from natural hazards, the mitigation plan must reflect current conditions. This will require an assessment of the current development patterns and development pressures as well as an evaluation of any new hazard or risk information. The plan update is an opportunity for the jurisdiction to assess its previous goals and action plan, evaluate progress in implementing hazard mitigation actions, and adjust its actions to address the current realities.

Where conditions of growth and revisions in priorities may have changed very little in a community, much of the text in the updated plan may be unchanged. This is acceptable as long as it still fits the priorities of their community, and it reflects current conditions. The key for plan readers to recognize a good plan update is documentation of the community’s progress or changes in their hazard mitigation program, along with the community’s continued engagement in the mitigation planning process.

<u>ELEMENT</u>	<u>REQUIREMENTS</u>
<p><b>D1. Was the plan revised to reflect changes in development? 44 CFR 201.6(d)(3)</b></p> <p><b>Intent:</b> <i>To ensure that the mitigation strategy continues to address the risk and vulnerabilities to existing and potential development, and takes into consideration possible future conditions that can impact the vulnerability of the community.</i></p>	<p>a. The plan <b>must</b> describe changes in development that have occurred in hazard prone areas and increased or decreased the vulnerability of each jurisdiction since the last plan was approved. If no changes in development impacted the jurisdiction’s overall vulnerability, plan updates may validate the information in the previously approved plan.</p> <p><b>Changes in development</b> means recent development (<i>for example</i>, construction completed since the last plan was approved), potential development (<i>for example</i>, development planned or under consideration by the jurisdiction), or conditions that may affect the risks and vulnerabilities of the jurisdictions (<i>for example</i>, climate variability, declining populations or projected increases in population, or foreclosures). Not all development will affect a jurisdiction’s vulnerability.</p>

<u>ELEMENT</u>	<u>REQUIREMENTS</u>
<p><b>D2. Was the plan revised to reflect progress in local mitigation efforts? 44 CFR 201.6(d)(3)</b></p> <p><i><b>Intent:</b> To evaluate and demonstrate progress made in the past five years in achieving goals and implementing actions outlined in their mitigation strategy.</i></p>	<p>a. The plan <b>must</b> describe the status of hazard mitigation actions in the previous plan by identifying those that have been completed or not completed. For actions that have not been completed, the plan <b>must</b> either describe whether the action is no longer relevant or be included as part of the updated action plan.</p>
<p><b>D3. Was the plan revised to reflect changes in priorities? 44 CFR 201.6(d)(3)</b></p> <p><i><b>Intent:</b> To ensure the plan reflects current conditions, including financial, legal, and political realities as well as post-disaster conditions.</i></p>	<p>a. The plan <b>must</b> describe if and how any priorities changed since the plan was previously approved.</p> <p>If no changes in priorities are necessary, plan updates may validate the information in the previously approved plan.</p>

#### 4.5 ELEMENT E. PLAN ADOPTION

<b>Requirement §201.6(c)(5)</b>	[The plan shall include...] Documentation that the plan has been formally adopted by the governing body of the jurisdiction requesting approval of the plan (e.g., City Council, County commissioner, Tribal Council). For multi-jurisdictional plans, each jurisdiction requesting approval of the plan must document that it has been formally adopted.
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**Overall Intent.** Adoption by the local governing body demonstrates the jurisdiction’s commitment to fulfilling the hazard mitigation goals and actions outlined in the plan. Adoption legitimizes the plan and authorizes responsible agencies to execute their responsibilities. Updated plans also are adopted anew to demonstrate community recognition of the current planning process, changes that have occurred within the previous five years, and validate community priorities for hazard mitigation actions.

<u>ELEMENT</u>	<u>REQUIREMENTS</u>
<p><b>E1. Does the Plan include documentation that the plan has been formally adopted by the governing body of the jurisdiction requesting approval? 44 CFR 201.6(c)(5)</b></p> <p><i><b>Intent:</b> To demonstrate the jurisdiction’s commitment to fulfilling the hazard mitigation goals outlined in the plan, and to authorize responsible agencies to execute their responsibilities.</i></p>	<p>a. The plan <b>must</b> include documentation of plan adoption, usually a resolution by the governing body or other authority.</p> <p>If the local jurisdiction has not passed a formal resolution, or used some other documentation of adoption, the clerk or city attorney <b>must</b> provide written confirmation that the action meets their community’s legal requirements for official adoption and/or the highest elected official or their designee <b>must</b> submit written proof of the adoption. The signature of one of these officials is required with the explanation or other proof of adoption.</p> <p>Minutes of a council or other meeting during which the plan is adopted will be sufficient if local law allows meeting records to be submitted as documentation of adoption. The clerk of the governing body, or city attorney, <b>must</b> provide a copy of the law and a brief, written explanation such as, “in accordance with section ___ of the city code/ordinance, this constitutes formal adoption of the measure,” with an official signature.</p> <p>If adopted after FEMA review, adoption <b>must</b> take place within one calendar year of receipt of FEMA’s “Approval Pending Adoption.” See Section 5, <i>Plan Review Procedure</i> for more information on “Approvable Pending Adoption.”</p>

<u>ELEMENT</u>	<u>REQUIREMENTS</u>
<p><b>E2. For multi-jurisdictional plans, has each jurisdiction requesting approval of the plan documented formal plan adoption? 44 CFR 201.6(c)(5)</b></p> <p><i><b>Intent:</b> To demonstrate the jurisdiction’s commitment to fulfilling the hazard mitigation goals outlined in the plan, and to authorize responsible agencies to execute their responsibilities.</i></p>	<p>a. Each jurisdiction that is included in the plan <b>must</b> have its governing body adopt the plan prior to FEMA approval, even when a regional agency has the authority to prepare such plans.</p> <p>As with single jurisdictional plans, in order for FEMA to give approval to a multi-jurisdictional plan, at least one participating jurisdiction <b>must</b> formally adopt the plan within one calendar year of FEMA’s designation of the plan as “Approvable Pending Adoption.” See Section 5, <i>Plan Review Procedure</i> for more information on “Approvable Pending Adoption.”</p>



## APPENDIX A: LOCAL MITIGATION PLAN REVIEW TOOL

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The *Local Mitigation Plan Review Tool* demonstrates how the Local Mitigation Plan meets the regulation in 44 CFR §201.6 and offers States and FEMA Mitigation Planners an opportunity to provide feedback to the community.

- The Regulation Checklist provides a summary of FEMA’s evaluation of whether the Plan has addressed all requirements.
- The Plan Assessment identifies the plan’s strengths as well as documents areas for future improvement.
- The Multi-jurisdiction Summary Sheet is an optional worksheet that can be used to document how each jurisdiction met the requirements of the each Element of the Plan (Planning Process; Hazard Identification and Risk Assessment; Mitigation Strategy; Plan Review, Evaluation, and Implementation; and Plan Adoption).

The FEMA Mitigation Planner must reference this *Local Mitigation Plan Review Guide* when completing the *Local Mitigation Plan Review Tool*.

<b>Jurisdiction:</b> Town of Wareham, Massachusetts	<b>Title of Plan:</b> Wareham Multi-Hazard Mitigation Plan	<b>Date of Plan:</b> June 2020
<b>Local Point of Contact:</b> Kenneth Buckland	<b>Address:</b> Wareham Town Hall 54 Marion Road Wareham, MA 02571	
<b>Title:</b> Director of Planning and Community Development		
<b>Agency:</b> Planning Department		
<b>Phone Number:</b> 508.291.3100 x 6501	<b>E-Mail:</b> kbuckland@wareham.ma.us	

<b>State Reviewer:</b>	<b>Title:</b>	<b>Date:</b>

<b>FEMA Reviewer:</b>	<b>Title:</b>	<b>Date:</b>
<b>Date Received in FEMA Region (insert #)</b>		
<b>Plan Not Approved</b>		
<b>Plan Approvable Pending Adoption</b>		
<b>Plan Approved</b>		

**SECTION 1:  
REGULATION CHECKLIST**

**INSTRUCTIONS:** The Regulation Checklist must be completed by FEMA. The purpose of the Checklist is to identify the location of relevant or applicable content in the Plan by Element/sub-element and to determine if each requirement has been ‘Met’ or ‘Not Met.’ The ‘Required Revisions’ summary at the bottom of each Element must be completed by FEMA to provide a clear explanation of the revisions that are required for plan approval. Required revisions must be explained for each plan sub-element that is ‘Not Met.’ Sub-elements should be referenced in each summary by using the appropriate numbers (A1, B3, etc.), where applicable. Requirements for each Element and sub-element are described in detail in this *Plan Review Guide* in Section 4, Regulation Checklist.

<b>1. REGULATION CHECKLIST</b>		<b>Location in Plan</b> (section and/or page number)	<b>Met</b>	<b>Not Met</b>
<b>Regulation (44 CFR 201.6 Local Mitigation Plans)</b>				
<b>ELEMENT A. PLANNING PROCESS</b>				
A1. Does the Plan document the planning process, including how it was prepared and who was involved in the process for each jurisdiction? (Requirement §201.6(c)(1))	Sections 1.2 & 1.3 (pages 1-2 to 1-4, 1-6)			
A2. Does the Plan document an opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, agencies that have the authority to regulate development as well as other interests to be involved in the planning process? (Requirement §201.6(b)(2))	Sections 1.2 & 1.3 (pages 1-3 to 1-6)			
A3. Does the Plan document how the public was involved in the planning process during the drafting stage? (Requirement §201.6(b)(1))	Section 1.2 (pages 1-3 to 1-4)			
A4. Does the Plan describe the review and incorporation of existing plans, studies, reports, and technical information? (Requirement §201.6(b)(3))	Section 1.2 (pages 1-4 to 1-5)			
A5. Is there discussion of how the community(ies) will continue public participation in the plan maintenance process? (Requirement §201.6(c)(4)(iii))	Section 6.3 (page 6-3)			
A6. Is there a description of the method and schedule for keeping the plan current (monitoring, evaluating and updating the mitigation plan within a 5-year cycle)? (Requirement §201.6(c)(4)(i))	Section 6.1 (page 6-2)			
<b><u>ELEMENT A: REQUIRED REVISIONS</u></b>				

<b>1. REGULATION CHECKLIST</b>		<b>Location in Plan</b> (section and/or page number)	<b>Met</b>	<b>Not Met</b>
<b>Regulation (44 CFR 201.6 Local Mitigation Plans)</b>				
<b>ELEMENT B. HAZARD IDENTIFICATION AND RISK ASSESSMENT</b>				
B1. Does the Plan include a description of the type, location, and extent of all natural hazards that can affect each jurisdiction(s)? (Requirement §201.6(c)(2)(i))	Section 3 (throughout)			
B2. Does the Plan include information on previous occurrences of hazard events and on the probability of future hazard events for each jurisdiction? (Requirement §201.6(c)(2)(i))	Section 3 (throughout)			
B3. Is there a description of each identified hazard's impact on the community as well as an overall summary of the community's vulnerability for each jurisdiction? (Requirement §201.6(c)(2)(ii))	Section 3 (throughout); Sections 4.3 & 4.4 (pages 4-26 to 4-31)			
B4. Does the Plan address NFIP insured structures within the jurisdiction that have been repetitively damaged by floods? (Requirement §201.6(c)(2)(ii))	Section 2.9 (p2-7)			
<b><u>ELEMENT B: REQUIRED REVISIONS</u></b>				
<b>ELEMENT C. MITIGATION STRATEGY</b>				
C1. Does the plan document each jurisdiction's existing authorities, policies, programs and resources and its ability to expand on and improve these existing policies and programs? (Requirement §201.6(c)(3))	Section 5.2 (pages 5-2 to 5-3)			
C2. Does the Plan address each jurisdiction's participation in the NFIP and continued compliance with NFIP requirements, as appropriate? (Requirement §201.6(c)(3)(ii))	Section 5.2 (page 5-5)			
C3. Does the Plan include goals to reduce/avoid long-term vulnerabilities to the identified hazards? (Requirement §201.6(c)(3)(i))	Section 5.1 (page 5-2)			
C4. Does the Plan identify and analyze a comprehensive range of specific mitigation actions and projects for each jurisdiction being considered to reduce the effects of hazards, with emphasis on new and existing buildings and infrastructure? (Requirement §201.6(c)(3)(ii))	Section 5.3 (pages 5-5 to 5-15)			
C5. Does the Plan contain an action plan that describes how the actions identified will be prioritized (including cost benefit review), implemented, and administered by each jurisdiction? (Requirement §201.6(c)(3)(iv)); (Requirement §201.6(c)(3)(iii))	Section 5.3 (pages 5-5 to 5-15)			
C6. Does the Plan describe a process by which local governments will integrate the requirements of the mitigation plan into other planning mechanisms, such as comprehensive or capital improvement plans, when appropriate? (Requirement §201.6(c)(4)(ii))	Section 5.2 (page 5-2 to 5-3)			
<b><u>ELEMENT C: REQUIRED REVISIONS</u></b>				

<b>1. REGULATION CHECKLIST</b>		<b>Location in Plan</b> (section and/or page number)	<b>Met</b>	<b>Not Met</b>
<b>Regulation</b> (44 CFR 201.6 Local Mitigation Plans)				
<b>ELEMENT D. PLAN REVIEW, EVALUATION, AND IMPLEMENTATION</b> (applicable to plan updates only)				
D1. Was the plan revised to reflect changes in development? (Requirement §201.6(d)(3))	N/A			
D2. Was the plan revised to reflect progress in local mitigation efforts? (Requirement §201.6(d)(3))	N/A			
D3. Was the plan revised to reflect changes in priorities? (Requirement §201.6(d)(3))	N/A			
<b><u>ELEMENT D: REQUIRED REVISIONS</u></b>				
<b>ELEMENT E. PLAN ADOPTION</b>				
E1. Does the Plan include documentation that the plan has been formally adopted by the governing body of the jurisdiction requesting approval? (Requirement §201.6(c)(5))	Section 6.4 (page 6-3)			
E2. For multi-jurisdictional plans, has each jurisdiction requesting approval of the plan documented formal plan adoption? (Requirement §201.6(c)(5))	N/A			
<b><u>ELEMENT E: REQUIRED REVISIONS</u></b>				
<b>ELEMENT F. ADDITIONAL STATE REQUIREMENTS (OPTIONAL FOR STATE REVIEWERS ONLY; NOT TO BE COMPLETED BY FEMA)</b>				
F1.				
F2.				
<b><u>ELEMENT F: REQUIRED REVISIONS</u></b>				



## Appendix B: Planning Process and Public Outreach

1. Local Hazard Mitigation Planning Committee Member List
2. Online Public Survey Results
3. Meeting Agendas
4. Copy of Announcements for Public Webinar
5. Screenshot of Town Homepage with Link to Draft Report
6. Email Sent to Neighboring Towns
7. Comment Response Document

DRAFT



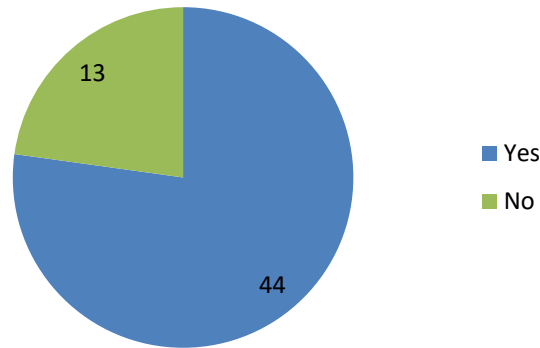
## Local Planning Team Members:

Ken Buckland –	Planning and Community Development
John Gerard –	Police Department
Andrew Reid –	Wareham Water District
David Pichette –	Conservation Department
Garry Buckminster -	Harbormaster
Guy Campinha –	Sewer Department
John Kelley –	Wareham Fire Department
John Walcek –	Police Department
Matthew Rowley –	Wareham Fire Department
Patrick Haskell –	Wareham Fire Department
Patrick MacDonald –	Emergency Management Department
Raymond Goodwin –	Onset Fire Department
Robert Ethier –	Health Department
Richard Sniger –	Onset Fire Department
David Morris -	Inspectional Services/ Building Commissioner
<b>Kenneth Fontes -</b>	<b>??</b>
Sean Osborne –	Onset Water District

# Wareham Natural Hazard Mitigation Public Opinion Survey

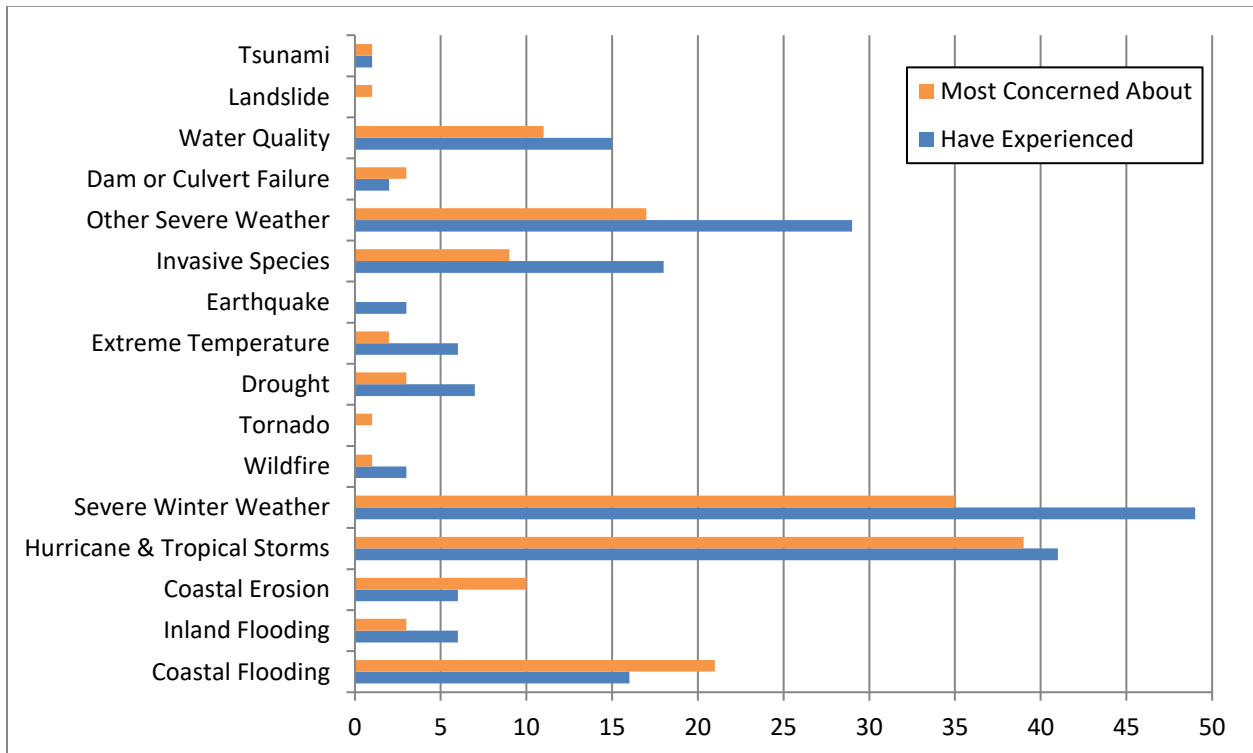
(Total responses: 57)

1. Have you experienced a weather-related disaster while living, working or visiting Wareham?



2. Which of the following natural hazards have you experienced while in Wareham?

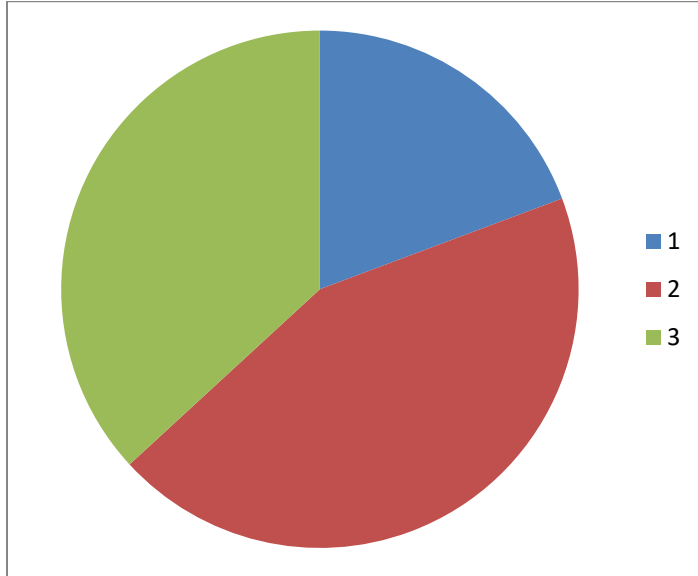
3. In your opinion, which of the following natural hazards are you most concerned about?



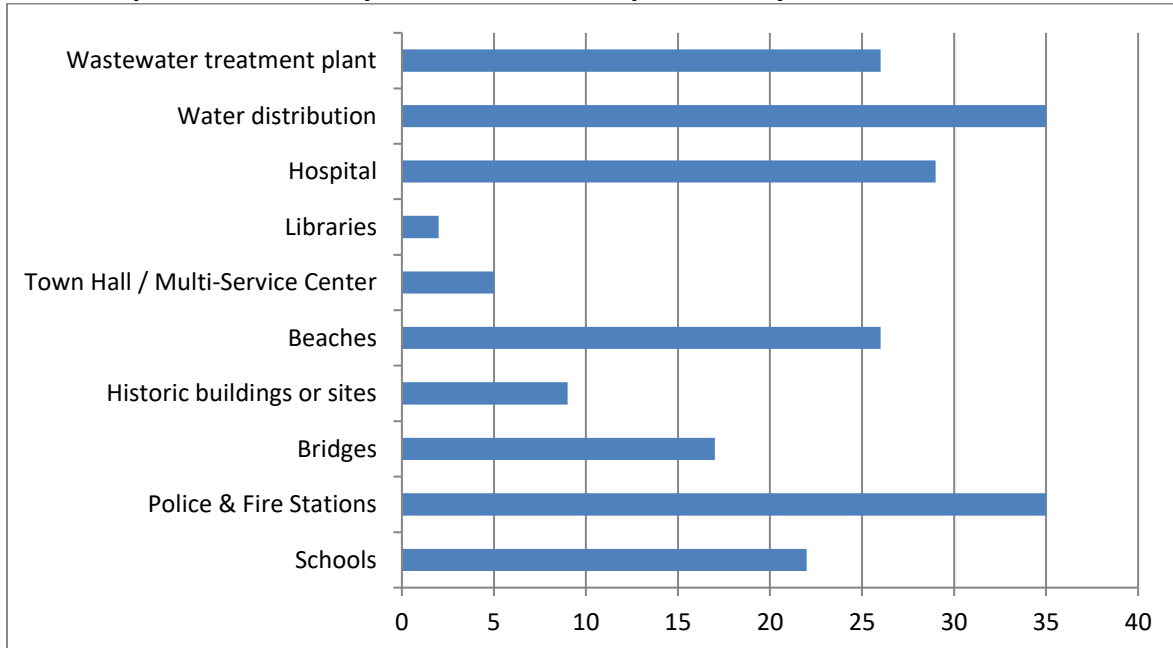
**4. How concerned are you about the possibility of any natural hazards impacting Wareham?**

Responses: Extremely Concerned/Somewhat concerned/Not Concerned

1= Not Concerned, 2=Mildly Concerned, 3=Extremely Concerned

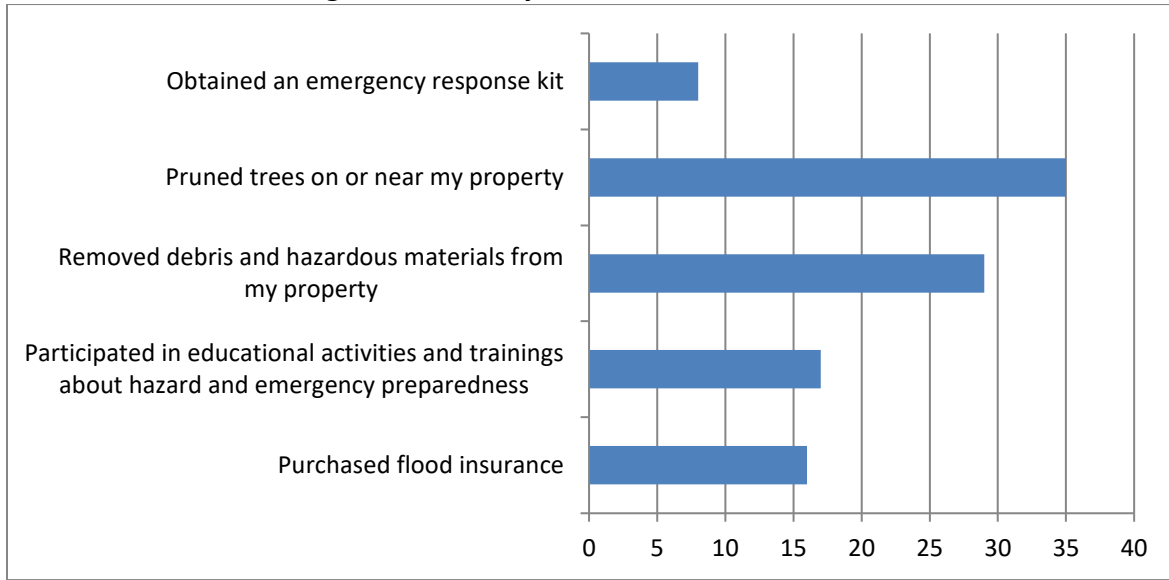


**5. What specific community assets are most important to you?**



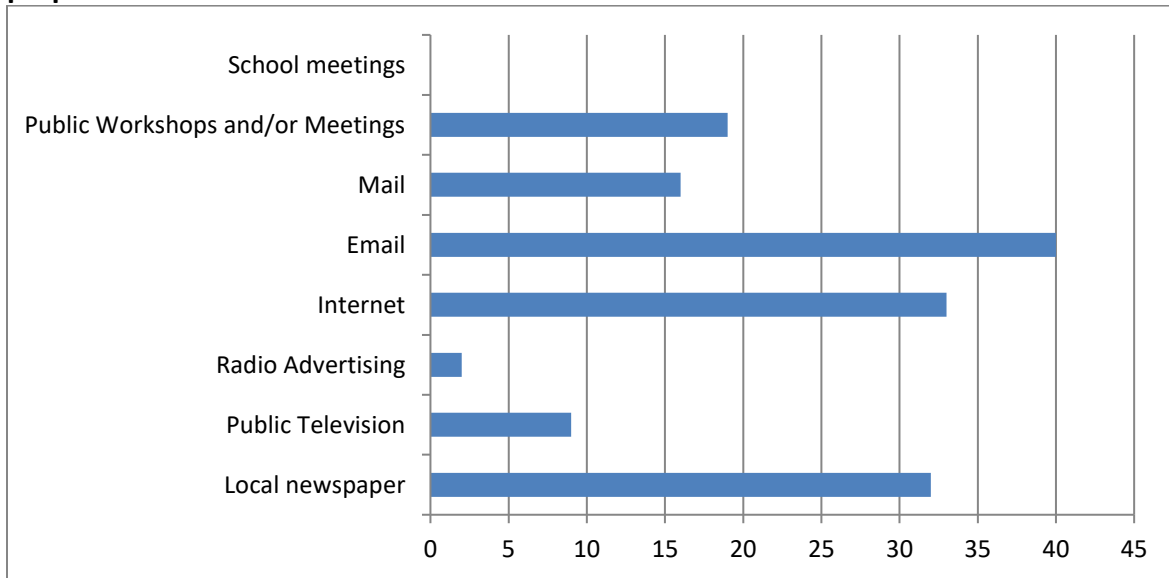
Specific assets mentioned: Sewer lines and roads collapsing in Swift's Beach

**6. Which of the following actions have you taken to be more hazard resistant?**



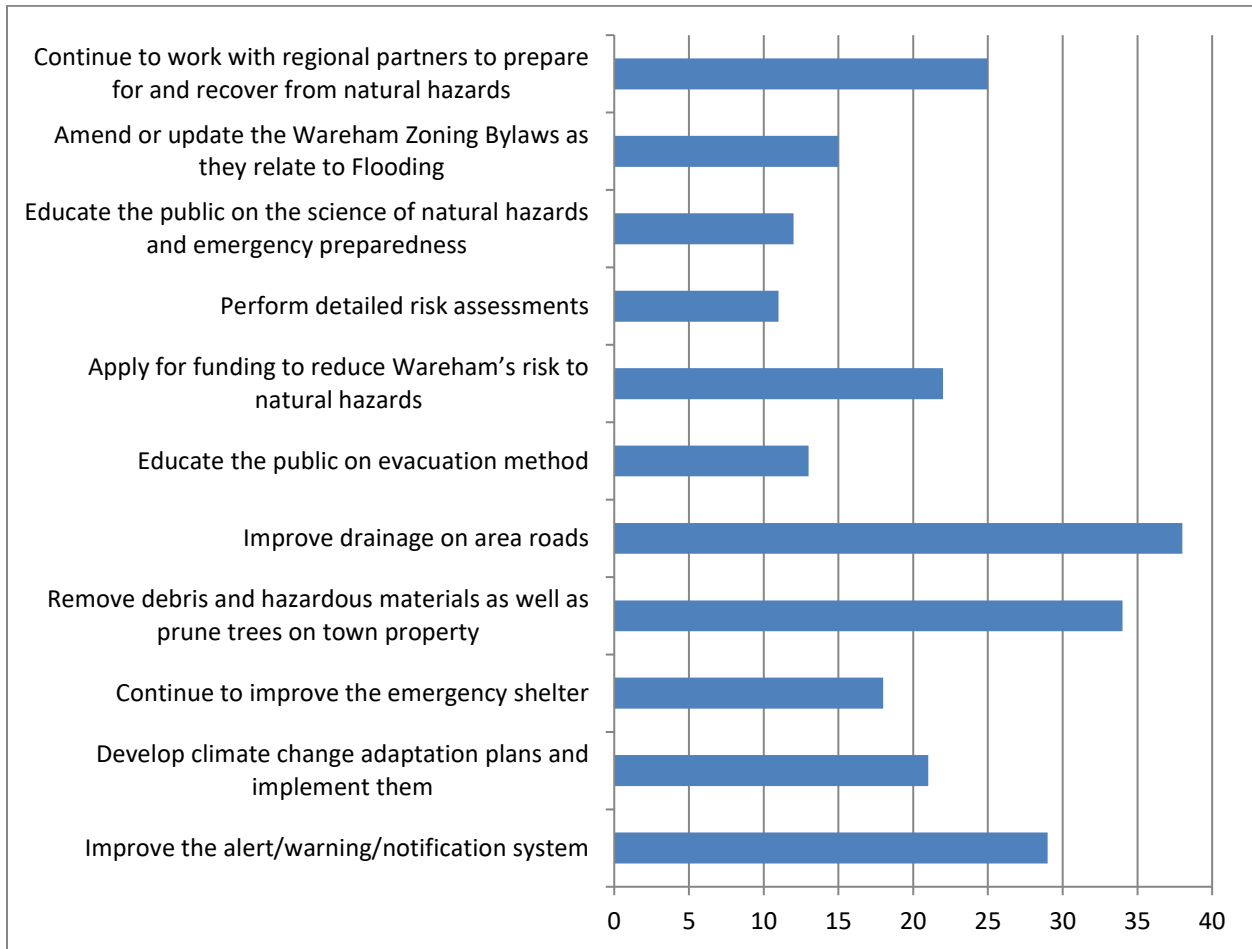
Other actions mentioned: maintained seawall (2); standby natural gas generator (2); install sump pump; built a watertight underground lair; maintain an emergency food & water supply; conserve water; nothing

**7. What is the most effective way to engage you in hazard planning and emergency preparedness activities?**



Other responses: I wish WCTV streamed all the community meetings in real time online like a webinar so people could participate and ask questions.

**8. What steps can your local government take to reduce its risk from natural hazards and protect the buildings and people of Wareham?**



**Other responses:**

- Allow people on waterfronts to bring in additional sand to prevent erosion (right now Con Com does not allow it – too much red tape)
- Add/replace sand on our shallow beaches
- Obtain a variance from the federal gov to allow homeowners to raise their property a few feet without meeting the current height minimum above mean high water so that the structure would be over than the current requirements, but above the near-term predicted flood heights.
- The wild growth of the Brush/Grass on Great Neck Road (across from Crooked River Road) needs to be taken care of every year. It's in the "Marshy" side of the road and grows so tall, you cannot see around the corner if you're on Great Neck Road headed toward Onset Ave.
- Fix roads/drains in Swift's Beach are, which have already collapsed.



**9. Please tell us about yourself.**

- a. Year-round resident - 50
- b. Part-time resident - 5
- c. I own a home in Wareham - 50
- f. I am a business owner in Wareham -2



**Town of Wareham  
Multi-Hazard Mitigation Plan  
Kick-off Meeting**

**Location: Wareham Library**

**Time 12:00 PM**

**November 14, 2019**

**Agenda Items:**

**1. Welcome and Introductions**

**2. Overview of the MHMP Process**

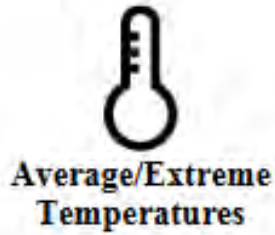
- a. What is a Multi-Hazard Mitigation Plan and why should Wareham have one?
- b. Review Scope of Work
- c. Review State Hazard List (see page 2)
- d. Discussion of Public Outreach Strategy
- e. Timeline/Schedule for MHMP Completion – June 30, 2020

**3. Data Requirements/Review**

- a. No previous MHMP Plan → new plan rather than an update
- b. Wareham Data:
  - Current assessor's parcel database – ArcGIS format
  - Recent records/photos (storms, flooding, major repairs, wildfire incidents, etc.)
  - Any newly available hazard related data?
- c. State issued climate change projections/modeling
- d. Relevant Town plans/reports:
  - Wareham Master Plan Vision (2018) ✓
  - Water Department Emergency Response Plan (Draft -2019) ✓
  - Water Pollution Control Facilities Emergency Response Plan (2016) ✓
  - Others?

From the Massachusetts State Hazard Mitigation and Climate Adaptation Plan (September 2018):

## Natural Hazards Assessed



+ Climate Change



**Town of Wareham  
Multi-Hazard Mitigation Plan  
Working Meeting #1**

**Location: Wareham Library**

**Time 12:00 PM**

**December 12, 2019**

**Agenda Items:**

- 1. Review outstanding tasks from previous meeting**
- 2. Present Online Public Survey**
  - a. Overview of final questions
  - b. Town will host on website?
- 3. Hazard Selection**
  - a. Discuss/approve data to be used
  - b. Additional data sources to consider?
- 4. Critical Infrastructure List**
  - a. Additional facilities to add?
  - b. Any to be removed?
- 5. Town Capabilities Assessment**
  - a. FEMA's Capabilities Assessment Questionnaire will help identify and document Town capabilities

### 3. Hazard Selection

	Natural Hazard*	Data Sources	Map Overlay for Vulnerability Analysis?
1	Flooding (Inland and Coastal)	FEMA; WHG Model Results (Present Day)	Yes
	<i>*1a. CC Impact on Flooding: Sea-Level Rise</i>	WHG Model Results (2030, 2070)	Yes
2	Coastal Erosion	CZM Shoreline Change Project	Yes?
3	Hurricane/Tropical Storm	SLOSH; Storm Tracks and Records	Yes
4	Severe Winter Storm (Snow/Blizzard/Ice Storm/Nor'easter)	Storm Records	
5	Wildfires	Fire Dept. Records	
6	Tornado	National Weather Service tornado database	
7	Drought	DCR precipitation database and drought conditions	
8	Extreme Temperature	NOAA's Storm Events Database accounts of Cold/Wind Chill, Extreme Cold/Wind Chill, Heat, and Excessive Heat	
9	Earthquake	USGS earthquake database	
10	Invasive Species	State invasive species lists; Local databases?	
11	Other Severe Weather (Heavy Precipitation, High Wind, Thunder/Lightning)	Rain data and statistics from local weather station; Records from NOAA's Storm Events Database	
12	Dam & Culvert Failure	State Dam database; Town data/map of culvert locations?	
13	Water Quality (Algal blooms, red tides)	Health department records?	
14	Landslide	NA	
15	Tsunami	NA	

*\*All hazard chapters will have a discussion about how climate change could affect this hazard in the future.*



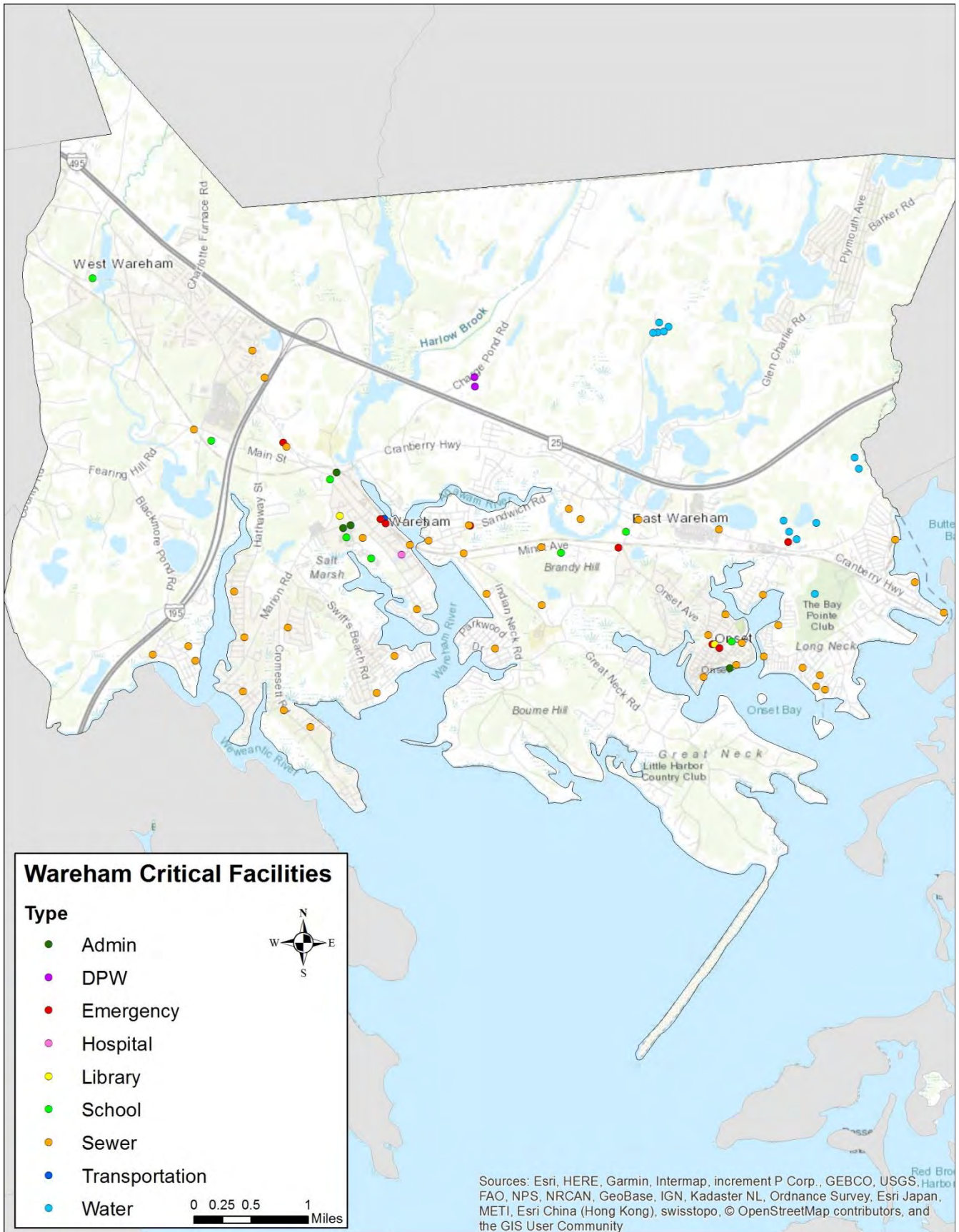
## 4. Wareham MHMP Critical Facilities - DRAFT (12/12/19)

<b>Id</b>	<b>Type</b>	<b>Label</b>	<b>Notes</b>
1	Admin	Multi-Service Center	
2	Admin	Harbormaster Building	
3	Admin	Town Hall	
4	Admin	WCTV Building	
5	DPW	Municipal Maintenance Salt Shed	
6	DPW	Municipal Maintenance Main Building	
7	Emergency	Police Department Main Building	
8	Emergency	Police Department Onset Substation	
9	Emergency	EMS	
10	Emergency	Wareham Fire District Headquarters	
11	Emergency	Wareham Fire District Fire Department	
12	Emergency	East Wareham Firestation	
13	Emergency	Onset Fire Department	
14	Emergency	Proposed Fire District Building	
15	Hospital	Tobey Hospital	
16	Library	Main Library	
17	Library	Spinney Memorial Library	
18	School	E. Wareham Elementary School (vacant)	
19	School	Ethel E. Hammond School (Boys & Girls Club)	
20	School	Everett School	
21	School	West Wareham School	
22	School	John William Decas Elementary School	
23	School	Minot Forest School	
24	School	Wareham Middle School	
25	School	Wareham High School	
26	Sewer	Water Pollution Control Facility	
27	Sewer	Salt Works Road Pump Station	
28	Sewer	Hill Street Pump Station	
29	Sewer	Cohasset Narrows Pump Station	
30	Sewer	Greene Street Ejector	
31	Sewer	Woodbury Street Ejector	
32	Sewer	Onset Heights Pump Station	
33	Sewer	South Water Pump Station	
34	Sewer	East Boulevard Ejector	
35	Sewer	Onset Pier Pump Station	
36	Sewer	South Boulevard Ejector	
37	Sewer	Hynes Field Pump Station	
38	Sewer	North Boulevard Pump Station	
39	Sewer	Riverside Pump Station	
40	Sewer	Dick's Pond Pump Station	
41	Sewer	Depot Street Pump Station	
42	Sewer	Linwood Avenue Pump Station	
43	Sewer	Apple Street Pump Station	
44	Sewer	Avenue A Street Pump Station	
45	Sewer	Narrows Pump Station	
46	Sewer	Indian Neck Pump Station	

4. Wareham MHMP Critical Facilities - DRAFT (12/12/19)

Id	Type	Label	Notes
47	Sewer	Oak Street Pump Station	
48	Sewer	Parkwood Pump Station	
49	Sewer	Pinehurst Pump Station	
50	Sewer	Kennedy Lane Pump Station	
51	Sewer	Smith Avenue Pump Station	
52	Sewer	Ruggles Pump Station	
53	Sewer	Cromesett Pump Station	
54	Sewer	Briarwood Beach Pump Station	
55	Sewer	Arnold Pump Station	
56	Sewer	French Pump Station	
57	Sewer	Hathaway Pump Station	
58	Sewer	Industrial Park II Pump Station	
59	Sewer	Industrial Park I Pump Station	
60	Sewer	Springbourne Pump Station	
61	Sewer	Nanumett Pump Station	
62	Sewer	Bay Street Ejector	
63	Sewer	Minot Avenue Pump Station	
64	Sewer	Peter Copper Drive Pump Station	
65	Sewer	Mattapoisett Pump Station	
66	Sewer	Thirteenth Street Pump Station	
67	Sewer	Leonard Pump Station	
68	Sewer	Pine Tree Estates Pump Station	
69	Sewer	Police Station Pump Station	
70	Transportation	MBTA Station	
71	Water	Maple Springs Well 2	
72	Water	Maple Springs Well 3	
73	Water	Maple Springs Well 4	
74	Water	Maple Springs Corrosion Control Building	
75	Water	Maple Springs Well 1	
76	Water	Sand Pond Road - Well 3	
77	Water	Sand Pond Road - Well 4	
78	Water	Sand Pond Road - Well 6	
79	Water	Sand Pond Road - Storage Building	
80	Water	Sand Pond Road - Well 5	
81	Water	District Water Building	
82	Water	Water Tower (Onset Fire District)	

*\*\*Not currently included: Housing Authority, Historical, Grocery/Pharmacy/Retail, Gas Stations, HAZMAT sites, etc.*





**Town of Wareham  
Multi-Hazard Mitigation Plan  
Working Meeting #2**

**Location: Wareham Library**

**Time 12:00 PM**

**January 16, 2020**

**Agenda Items:**

- 1. Review outstanding tasks from previous meeting**
- 2. Review Public Outreach Efforts**
  - a. Results of online public survey
- 3. Review of Hazard Profiles**
  - a. Review hazard maps
  - b. Data gaps
    - Local invasive species concerns?
    - Record of local water quality incidents?
    - Culvert locations of concern?
  - c. Review hazard screening/ranking process
- 4. Review/Finalize Critical Facilities List**
  - a. Additional facilities to add? (HAZMAT sites?)
  - b. Any to be removed? (Police Dept. Onset Substation?)
- 5. If time allows:**
  - a. Develop Hazard Mitigation Plan goals

**Next Meeting: March 19, 2020**

**Table XX. Relative risk of hazards in Wareham.**

	Likelihood				Severity				Area		Estimated Cumulative Risk†
	Unlikely	Possible	Likely	Highly Likely	Minor	Serious	Extensive	Catastrophic	Isolated	Town Wide	
Score	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	
Severe Winter Storm				X		X		P		X	16
<b>Flooding (Inland &amp; Coastal)*</b>				X			X		X		12
<b>Hurricane &amp; Tropical Storm*</b>			X			X		P		X	12
Other Severe Weather				X		X			X	P	8
Extreme Temperature			X		X					X	6
Coastal Erosion				X	X		P		X		4
Drought		X			X					X	4
Wildfires		X				X	P		X		4
Dam/Culvert Failure		X				X			X		4
Earthquake		X			X		P			X	4
Water Quality			X		X	P			X		3
Invasive Species		X			X				X	P	2
Tornado		X			X				X		2
Tsunami	X				X			P	X		1

X indicates the believed value, while P indicates an extreme potential.

\*These **bolded** hazards were selected for specific vulnerability analyses in Chapter 4.

† This value is based on the formula Likelihood\*Severity\*Area. The Likelihood of the hazard is based on a scale of 1 to 4, with 1 being unlikely and 4 being highly likely. The Severity of the hazard was based on a scale from 1 to 4, with 1 being minor and 4 being catastrophic. Area was given a value of 1 for isolated and 2 for town wide. The “P”s were not incorporated into the Estimated Cumulative Risk value.



## Develop Hazard Mitigation Plan Goals

### **Example Hazard Plan Goals (from other Towns):**

1. Protect life, safety and property by reducing, where possible, the potential adverse impacts caused by storms and other natural hazard events.
2. Safeguard the Town's most vulnerable populations, critical facilities, and buildings through the implementation of cost effective and technically feasible hazard mitigation projects and adaptation measures.
3. Ensure that critical infrastructure sites are protected from natural hazards.
4. Protect existing residential and business areas from flooding.
5. Maintain accessibility for emergency responders, in both the Town's roads and waterways, during and after natural hazard events.
6. Provide residents with adequate access to emergency shelters equipped with sufficient provisions, climate control and emergency electricity during natural disaster events.
7. Maintain adequate access to public utilities such as electricity, drinking water, and communications during and after a natural disaster.
8. Maintain an adequate Level of Service (LOS) on all roadways during and after natural disasters, particularly on major roadways.
9. Encourage future development in areas that are not prone to natural hazards;
10. Reduce or eliminate damage to buildings and infrastructure from natural hazards.
11. Improve communications between private citizens, businesses, utility companies, and town, regional, state, and federal agencies before, during and after a natural disaster.
12. Educate the public on hazard-prone areas to minimize damage and losses where possible.
13. Develop public education outlets and materials to inform residents about what to expect during natural disasters, particularly regarding natural disasters such as hurricanes.



**Town of Wareham  
Multi-Hazard Mitigation Plan  
Working Meeting #3**

**Location: ~~Wareham Library~~ Conference Call      Time 12:00 PM      March 19, 2020**

**Agenda Items:**

**1. Review Public Outreach Efforts**

- a. Results of online public survey

**2. Review of Vulnerability Assessment Results**

We will discuss the results of the vulnerability assessment of the critical facilities and Town parcels related to the specific hazards previously discussed (FEMA Flood Zones, SLOSH Hurricane impacts, and Inundation Probabilities in 2030 and 2070 based on MC-FRM). These results will help develop targeted hazard mitigation actions.

**3. Data Gaps**

- a. **Section 4.4: Vulnerable populations** – what do we want to include?
- b. **Section 5.2: Existing Capabilities**
  - Town wide CEMP? Generators? Snow disposal?
  - Check other bullets for accuracy
  - Additional existing mitigation measures?

**4. Develop Draft Mitigation Actions**

**Next Meeting(s):**

- Public Outreach Presentation: March 23 @ 6pm
- Working Meeting #4: April 16 @ 12pm



**Town of Wareham  
Multi-Hazard Mitigation Plan  
Working Meeting #4**

**Location: Conference Call**

**Time 12:00 PM**

**April 16, 2020**

**Agenda Items:**

- 1. Review Draft Mitigation Actions**
- 2. Review Initial Prioritization for Mitigation Actions**
- 3. Discuss Additional Details for Each Mitigation Action Retained:** See example below.
- 4. Schedule Final Meetings/Events/Tasks:**
  - a. Last working meeting:** We need to schedule a final meeting in mid- to late-May. This will be a review/discussion of a full Draft of the MHMP.
  - b. Public outreach:** Webinar?
  - c. Distribution of plan to neighboring Towns/regional agencies?**
  - d. Final submittal to MEMA/FEMA:** by June 30, 2020

Template for mitigation action information:

<b>Mitigation Action #1: &lt;Name of Action&gt;</b>	
HAZARD ADDRESSED	Flooding/Fire/Erosion/etc
PURPOSE	<Description of action and purpose>
RESPONSIBILITY	<Responsible Department(s)>
POTENTIAL FUNDING SOURCES	Capital Improvements/Utility Fee/Town Meeting/Community Preservation Act (CPA)/Grants/Donations
PRIORITY	High/Medium/Low
TIMELINE	Short-term/Long-term/Ongoing
GOAL(S) ADDRESSED	1-5



**Town of Wareham  
Multi-Hazard Mitigation Plan  
Working Meeting #5**

**Location: Conference Call**

**Time 12:00 PM**

**May 20, 2020**

**Agenda Items:**

- 1. Compliance with FEMA/MEMA Hazard Plan Guidance**
- 2. Review Final Draft**
  - a. Local Planning Team Comments?
    - i. Can submit until additional comments until June 5
  - b. We will solicit comments in response to Draft MHMP on website
  - c. We will solicit comments from neighboring Towns, SRPEDD, Others?
- 3. Next Steps**
  - a. Post Draft Plan Online for Comments
  - b. Virtual Public Presentation – Tonight: May 20, 2020
  - c. Plan Submittal to MEMA/FEMA – by June 30, 2020
  - d. Plan Adoption by Board of Selectmen – after FEMA approval



### Contact Info

**Phone:**

(508) 291-3100

**Address:**

Town Hall

54 Marion Rd

Wareham, MA 02571

United States

See map: [Google Maps](#)

[Home](#)



## Wareham Multi-Hazard Mitigation Plan

**Event Date:** Wednesday, May 20, 2020 - 5:30pm

Wareham Multi-Hazard Mitigation Plan

Wed, May 20, 2020 5:30 PM

This online meeting will present the plan for responding to local natural disasters, which was funded by the federal and state agencies, FEMA and MEMA. Note that by the federal and state guidelines, the plan does not deal with COVID-19 or pandemics.

Please join the meeting from your computer, tablet or smartphone by clicking on the following link:  
<https://global.gotomeeting.com/join/163117221>

You can also dial in using your phone.

United States: +1 (571) 317-3112

Access Code: 163-117-221

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<https://global.gotomeeting.com/install/163117221>



Grief doesn't respect social distancing. Fortunately, we respect both.



## Town of Wareham to discuss disaster preparedness

May 12, 2020



**Event Date:**

Wednesday, May 20, 2020 - 5:30pm

The Town of Wareham will host a public presentation on the town's plan for responding to local and natural disasters on Wednesday, May 20 at 5:30 p.m.

The Wareham Multi-Hazard Mitigation Plan meeting will be held remotely. Participants can join online via the following link: <https://global.gotomeeting.com/join/163117221>.

Participants can also join by phone by calling 1 (571) 317-3112. The access code for the meeting is 163-117-221.

Presenters will discuss the town's plan for responding to local and natural disasters, funded by federal and state agencies FEMA and MEMA.

The plans are not related to coronavirus or pandemics.

**Event Date:**

Wednesday, May 20, 2020 - 5:30pm

**Event Location:**

Remote

**Contact Name:**

Kenneth Buckland

**Contact Phone:**

(571) 317-3112



## Appendix C: Critical Facilities and Vulnerability

1. Critical Facilities List
2. Mitigation Actions Prioritization
3. Removed Mitigation Actions

DRAFT

<b>Id</b>	<b>Name</b>
1	Multi-Service Center
2	Harbormaster Building
3	Town Hall
4	WCTV Building
5	Municipal Maintenance Salt Shed
6	Municipal Maintenance Main Building
7	Police Department Main Building
8	EMS
9	Wareham Fire District Headquarters/Admin (Main St)
10	Wareham Fire District Fire Department
11	East Wareham Firestation (Minot Ave)
12	Onset Fire Department
13	Proposed Fire District Building - 8 Sand Pond Rd
14	Wareham Fire Dist. St#2 W. Wareham 2368 Cran. Hwy
15	Wareham Fire Dist. St#3 283 Glen Charlie Road
16	Tobey Hospital
17	Main Library
18	Spinney Memorial Library
19	Ethel E. Hammond School (Boys & Girls Club)
20	John William Decas Elementary School
21	Minot Forest School
22	Wareham Middle School
23	Wareham High School
24	Water Pollution Control Facility
25	Salt Works Road
26	Hill Street
27	Cohasset Narrows
28	Greene Street (ejector)
29	Woodbury Street (ejector)
30	Onset Heights
31	South Water
32	East Boulevard (ejector)
33	Onset Pier
34	South Boulevard (ejector)
35	Hynes Field
36	North Boulevard
37	Riverside
38	Dick's Pond
39	Depot Street
40	Linwood Avenue
41	Apple Street
42	Avenue A Street
43	Narrows
44	Indian Neck
45	Oak Street
46	Parkwood
47	Pinehurst
48	Kennedy Lane
49	Smith Avenue
50	Ruggle
51	Cromesett
52	Briarwood Beach
53	Arnold
54	French
55	Hathaway
56	Industrial Park II
57	Industrial Park I
58	Springbourne
59	Nanumett
60	Bay Street (ejector)

<b>Id</b>	<b>Name</b>
61	Minot Avenue
62	Peter Copper Drive
63	Mattapoisett
64	Thirteenth Street
65	Leonard
66	Pine Tree Estates
67	Police Station
68	Train Station
69	Maple Springs Well 2
70	Maple Springs Well 3
71	Maple Springs Well 4
72	Maple Springs Corrosion Control Building
73	Maple Springs Well 1
74	Sand Pond Road - Well 3
75	Sand Pond Road - Well 4
76	Sand Pond Road - Well 6
77	Sand Pond Road - Storage Building
78	Sand Pond Road - Well 5
79	District Water Building - 5 Sand Pond Road
80	Water Tower (Onset Fire District)
81	Sand Pond Road - Well 7
82	Bourne Hill Water Tank (Wareham Fire District)
83	West Wareham Water Tank (Wareham Fire District)
84	Glen Charlie Water Tank (Wareham Fire District)
85	Seawood Springs Well 6
86	Seawood Springs Well 7
87	Southline Well 8 Building Pump House
88	Maple Park Well 9
89	Wareham Fire District Office (2550 Main Street)
90	Well 8

3=Best/Most Benefit/Least Cost/Easy or no permitting; 2=Some benefit/Moderate Cost/Some potential permitting complications; 1=Little to no benefit/Expensive/Complicated permitting required

	Hazard Type and Potential Mitigation Actions	Benefits					Feasibility				Economic		Regulatory		Total Score
		Protects Properties and Structures	Protects Natural Resources	Technical/Capacity Improvement (Training, Evaluations, Regulations, etc)	Improves Public Awareness	Improves Emergency Response or Public Protection After an Emergency	Appropriate Staffing Available	Technically Feasible	Public Support	Town/Political Support	Cost	Funding Available / Attainable	Permitting/Regulatory Feasibility	Consistent with Local, State, & Federal Goals	
<b>Flooding (Coastal &amp; Inland)</b>															
1	Follow VA recommendations for Harbor Master Building: Short term: wet flood proof structure; Long term: seek alternate location for critical harbormaster office functions	3	1	1	2	2	3	3	2	2	2	3	3	3	30
2	Develop a long-term plan for critical facilities at increased risk to coastal flooding in the future due to SLR	3	1	2	2	3	2	2	2	3	3	3	3	3	32
3	Improve or develop an alternate access to/from EMS given flood vulnerability of roadways	2	1	1	1	3	2	3	3	3	1	3	2	3	28
4	Implement VA recommendations for general flood protection action for sewer pump stations (properly dry floodproof lower pump hatches at low-lying stations, elevate or protect control panel and generator at vulnerable stations)	3	1	1	1	2	3	3	3	3	2	3	3	3	31
5	Develop a comprehensive emergency evacuation and response plan for road flooding based on recent town wide VA results (show the best evacuation route depending on where you live and which points are likely to be flooded)	1	1	2	3	3	2	3	3	3	3	3	2	3	32
6	Explore interconnections between the two water districts distribution systems – to provide redundancy	2	1	1	2	2	2	3	2	3	2	2	3	2	27
7	Interconnection with neighboring Towns for water/sewer	2	2	1	2	1	2	3	2	3	2	2	3	3	28
<b>Coastal Erosion</b>															
8	Explore a change in local policy regarding beach nourishment in Wareham	2	2	2	2	1	3	3	2	1	3	2	2	3	28
<b>Hurricane/Tropical Storm</b>															
9	Develop a local early warning system for hurricane/tropical storm/tornado (based on local weather data/conditions)	1	1	1	3	3	2	2	3	3	2	3	3	3	30
<b>Other Severe Weather (Heavy Precipitation, Thunder/Lighting, Wind)</b>															
10	Improve road drainage at the Main Street - Toby Road intersection by the RR (regularly floods during heavy rain)	3	1	1	2	3	2	2	3	3	1	2	2	3	28
<b>Drought</b>															
11	Complete Wareham Water Drought Management Plan	1	2	2	2	2	3	3	3	3	3	2	3	3	32
<b>Water Quality</b>															
12	Ramp up monitoring/reporting/public outreach	1	2	2	2	2	3	3	3	3	3	2	3	3	32
<b>Extreme Temperature</b>															
13	Identify and create locations for large-scale medical support in case of health concerns	1	1	1	2	3	3	3	3	3	1	2	3	3	29
14	Identify and create locations for cooling/warming shelter(s) during extreme temperature conditions ( <i>Additional detail: Minot Forest School is already under consideration</i> )	1	1	1	2	3	3	3	3	3	1	3	3	3	30
<b>Dam / Culvert Failure</b>															
15	Complete upcoming scheduled culvert repairs	3	3	1	2	2	2	3	2	3	2	2	2	3	30
16	Consider removal of dams, such as the Parker Mills Dam ( <i>Additional detail: Horseshoe Pond dam has just been removed by BBC; the agriculture industry, specifically the cranberry farmers, should be consulted regarding the impact of eliminating the dams</i> )	1	3	1	2	1	2	3	2	2	1	2	2	3	25
<b>Invasive Species</b>															
17	Identify specialty contractors that can treat/remove invasive plant species	1	3	1	1	1	3	3	2	2	3	2	2	3	27
<b>Multi-Hazard / Non-specific</b>															
18	Develop an Emergency Operations Center (EOC) following MEMA and FEMA guidelines	2	2	3	2	3	2	3	3	3	1	3	3	3	33
19	Protect Main Street Fire Station Headquarters with flood wall to protect against Category 3 hurricane	3	1	1	1	3	3	2	3	3	1	3	3	3	30
20	Develop disaster response plan for business districts	2	1	2	2	3	2	3	2	3	3	2	3	3	31
21	Installation of Second Force Main from Narrows Pump Station to WPCF	3	2	2	1	2	3	3	2	2	2	3	2	3	30
22	Installation of Second Force Main from Hynes Field Pump Station to WPCF	3	2	2	1	2	3	3	2	2	2	3	2	3	30
23	Increase Discharge Capacity at WPCF	3	2	2	1	2	3	3	2	2	2	3	2	3	30
24	Reduction in Inflow and Infiltration for Subjected Gravity Mains	3	2	2	1	2	3	3	2	2	2	3	2	3	30
25	Upgrades at Priority Pump Stations (Hynes Field, Narrows and Depot Street Stations) ( <i>Additional Detail: This upgrades include more than flood improvements; also mechanical improvements</i> )	3	2	2	1	2	3	3	2	2	2	3	2	3	30
26	Acquire generator for the Onset Fire Department	2	2	1	1	3	3	3	3	2	3	3	3	3	32
27	Installation of additional water tank for water storage in Onset for use during drought	1	2	1	2	2	2	3	2	2	3	2	3	3	28
28	Acquire a back up generator for the Maple Springs Water Purification Plant ( <i>Additional Detail: Out of all the drinking water items, this is one of the most important to run the filter plant.</i> )	2	2	2	1	3	3	3	3	3	3	2	3	3	33

Low	<=28
Med	29-32
High	>=33



**Proposed Mitigation Actions Dismissed from the Final Plan**

Mitigation Action	Reason Removed
Relocate Main Street Fire Station Headquarters	Not Realistic
Explore alternative options for water department treatment stations and wells in the case of salt water intrusion	Wells are located far enough inland that this will not be a concern for many years
Consider changing regulations on water use	Not necessary; current regulations are adequate
Reach out to Makepeace to discuss potential future forest management practices	Makepeace is a private landowner and we are limited in what we can enforce regarding forest management on their lands
Coordinate with DCR on their wildland management program, which includes 600 acres of MassWildlife property in Wareham (program will take place over the next 10 years)	Program is already in place. The state has already done a bunch of clearing, beginning ~1.5 year ago. Once clearing is complete - they're going to do controlled burns to reintroduce native fire-dependent species
Coordinate with private property manager of Onset Mobile Home Park to incentivize drainage improvements – in the past, the property required pumping by Onset Fire District whenever there is a heavy rain	The Onset Mobile Home Park has recently installed a pump system to alleviate flooding in the park, which discharges into the bay.