Truro

2017 Hazard Mitigation Plan

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Introduction

The purpose of hazard mitigation is to reduce loss from future natural disasters. Storms and other natural disasters can cause loss of life, damage to buildings and infrastructure and have devastating consequences to a community's economic, social and environmental well-being. One step to reducing loss in a community is to have a plan for the future. To accomplish this task, most communities develop a local Hazard Mitigation Plan, also known as a single jurisdiction Hazard Mitigation Plan. It is drafted and reviewed by town officials and residents and then approved by the Massachusetts Emergency Management Agency (MEMA) and the Federal Emergency Management Agency (FEMA).

The purpose of the Truro Hazard Mitigation Plan is to reduce damages resulting from natural hazards by implementing sustained actions to reduce or eliminate long-term risk to human life and property from hazards. The Truro Hazard Mitigation Plan is also about building a successful, long-term outreach strategy to educate residents about natural hazards that could affect the town, to prepare them in case a storm impacts the town, and to create a resilient town that can recover after a storm event. Over a year and a half, Town staff and the residents of Truro worked diligently to meet FEMA requirements for updating their single jurisdiction hazard plan while maintaining the character and individuality of Truro.

A1, A1b

It is important to note that if and when the 2017 Truro Hazard Mitigation Plan Update is approved by FEMA and adopted by the Board of Selectmen, the town becomes eligible to receive funding from FEMA's Hazard Mitigation Assistance (HMA) program, which includes the following programs:

- **Hazard Mitigation Grant Program (HMGP):** assists in implementing long-term, "forward thinking" hazard mitigation measures following a major disaster
- **Pre-Disaster Mitigation (PDM):** provides funds for hazard mitigation planning and projects on an annual basis
- **Flood Mitigation Assistance (FMA):** provides funds for projects to reduce or eliminate risk of flood damage to buildings that are insured under the National Flood Insurance Program (NFIP) on an annual basis.

Review Tool Description:

FEMA developed a "Local Mitigation Review Guide" to help Federal and State officials assess Local Hazard Mitigation Plans in a fair and consistent manner and to ensure approved local plans meet the requirements of the Stafford Act and Title 44 Code of Federal Regulations (CFR) 201.6. The "Local Mitigation Review Guide" was used as guidance in updating the Truro Hazard Mitigation Plan. When text in the Truro Hazard Mitigation Plan meets an element identified in the Review Guide, it is called out in a colored box in the margin.

The Planning Process

CHAPTER ONE

Municipal plans require expertise from a core team of Town officials and input from stakeholders, the public and neighboring communities. When community-wide plans have the support from a diverse cross-section of stakeholders, residents and Town officials, the final plan becomes a "living" document that is useful for the community on a long-term basis. A hazard plan, in particular, is considered successful if it educates residents about the risk and vulnerability related to natural hazards and builds support for policies, actions and tools that reduce future losses from natural hazards. **Chapter 1 is a narrative on the hazard planning team and the outreach process used to develop the 2017 Truro Hazard Mitigation Plan.**

Planning Team

Members and Responsibilities

The Planning Team is an interdisciplinary group of town staff members with expertise to develop the plan and the authority and expertise to implement its action items. Several staff members from the Cape Cod Commission provided technical support to the Planning Team. ***Table 1.1*** lists the names, titles and affiliations of the Truro Hazard Planning Team.

Name	Title	Affiliation
Russell Braun	Building Commissioner	Building Department
Tim Collins (joined 10/8/16)	Chief	Fire Department
Jay Norton (left 9/1/16)	Director	Department of Public Works
Jarrod Cabrol (joined 9/1/16)	Director	Department of Public Works
Pat Pajaron	Health and Conservation Agent	Health and Conservation Department
Kyle Takakjian	Chief	Police Department
Cally Harper	Planner	Cape Cod Commission
Gary Prahm	GIS Analyst	Cape Cod Commission

Table 1.1 | Truro Hazard Planning Team

Planning Team

This core group was responsible for developing and reviewing drafts of the Hazard Plan, creating the mitigation strategies and submitting the plan for adoption by the Federal Emergency Management Agency (FEMA) and the Truro Board of Selectmen. ***Table 1.2*** outlines the responsibilities of each member of the Planning Team.

Building Department	Developed critical facilities list; provided data on weather impacts; assisted with vulnerability assessment; reviewed/developed mitigation actions; reviewed drafts of the plan; assisted with public outreach strategy
Police	Developed critical facilities list; provided data on weather impacts; assisted with vulnerability assessment; reviewed/developed mitigation actions; reviewed drafts of the plan; assisted with public outreach strategy
Fire	Developed critical facilities list; provided data on weather impacts; assisted with vulnerability assessment; reviewed/developed mitigation actions; reviewed drafts of the plan; assisted with public outreach strategy
Public Works	Developed critical facilities list; provided data on weather impacts; assisted with vulnerability assessment; reviewed/developed mitigation actions; reviewed drafts of the plan; assisted with public outreach strategy
Health and Conservation	Developed critical facilities list; provided data on weather impacts; assisted with vulnerability assessment; reviewed/developed mitigation actions; reviewed drafts of the plan; assisted with public outreach strategy
Planner, Cape Cod Commission	Facilitated group meetings with the Planning Team; coordinated the development of the hazard plan
GIS Analyst, Cape Cod Commission	Prepared maps for the town hazard plan; used GIS software to conduct a risk assessment for the town

Table 1.2 | Planning Team Responsibilities

Meeting Schedule and Involvement

The Planning Team worked collaboratively in large and small group meetings. The Planning Team met every three weeks from September 2015 to December 2015 to develop sections of the hazard plan.

Below is a list of dates and topics covered at each of these large group meetings.

- **September 1, 2015:** local kick-off meeting; overview of hazard planning process
- **October 8, 2015:** develop a public outreach process and assigned specific responsibilities to planning team members
- **October 15, 2015:** identification of critical facilities, definition of a hazard profiles, discussion of draft hazard maps and discussion of the relevance and future probability of natural hazards in town
- **October 22, 2015:** review of critical facilities, reviewed mitigation goals and objectives.
- **December 1, 2015:** review and develop new mitigation action;

The sign-in sheets for these team meetings are located in ***Appendix 1.***

There were several instances where the expertise of only a few team members was required for a specific task in the Truro Hazard Mitigation Plan. Therefore, small group meetings were also held from January 2016 to October 2016 with the Fire Chief and Police Chief.

Outreach Strategy

A1a, d

A3a, b

With the Public

The public was engaged at two different times during the planning process: during plan development and just prior to submission of the draft plan for MEMA/FEMA review.

During Plan Development

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The Planning Team developed an online survey to gather data on the significance/relevance of the natural hazards identified in the Massachusetts State Hazard Plan to Truro, the impact of those significant natural hazards, and preparedness efforts in Truro. The survey also gathered data on how residents would like to be engaged in the future. The survey was launched on September 19, 2016 and the public was given at least three weeks to fill out the survey. A link to the survey was available to residents and to the people who work in Truro via the main page of the Town Website and posted to Truro Office of Emergency Management and Police Department Facebook page. The Planning team received 51 respondents to the public survey. For a copy of the survey, see “Public Survey on Hazard Mitigation” in

Appendix 1. Documentation for the launch of the survey can be found in the "Survey Documentation" section of ***Appendix 1***.

The Planning Team incorporated these comments in the plan in the following ways:

- The public was asked to identify specific hazards they experienced or are most concerned about while living or working in Truro. They were presented with the 11 hazards identified in the Massachusetts State Hazard Plan and could select as many of these hazards as they wanted. These selections were used to determine whether or not a hazard is significant to the town (***see Column 3, Table 2.2***).
- The public was asked to identify steps that the local government could take to reduce risk from natural hazards and protect the buildings and people of Truro. They were presented with a list of mitigation actions to reduce risk and loss and given the opportunity to suggest additional actions. These actions were incorporated into the Mitigation Actions of the hazard plan. For example, several survey respondents expressed concern about evacuation plans for Truro, so the Planning Team met on February 2, 2016 to discuss specific mitigation actions on evacuation and sheltering in place.

With Stakeholders

A31

A stakeholder is someone who may be affected by or have an interest in the Truro Hazard Mitigation Plan and its implications, but did not participate in weekly Planning Team meetings. Stakeholders for hazard planning efforts can be public officials, agency heads, members of neighborhood/civic organizations, business associations or staff from academic institutions.

Stakeholders were actively engaged in updating the Truro Hazard Mitigation Plan. The stakeholder process involved three important steps:

1. Stakeholders were identified by the Planning Team
2. The Planning Team designed a strategy to engage and gather input from stakeholders
3. Stakeholders provided input during the planning process and just prior to plan approval

Outreach Strategy

Identification of Stakeholders

Members of the Planning Team identified stakeholders and staff at the Cape Cod Commission assisted in identifying stakeholders at the County, State and Federal levels.

Stakeholders included employees and volunteers from many different organizations and groups in Truro and across Cape Cod, including:

- Conservation Commission
- CERT Team
- Cape Cod National Seashore

A2c

Stakeholder Participation

Stakeholders were engaged twice during the planning process – once during plan development and again just prior to submission of the draft plan to MEMA and FEMA.

A2c

During plan development, stakeholders were invited to complete an online survey (to view the survey, see "Public Survey on Hazard Mitigation" in ***Appendix 1***). Stakeholder input from the survey resulted in the following:

A3d

- Provided data on whether or not specific hazards were significant to the town (***See Table 2.1***)
- Identified problem areas in town and specific projects that they wanted to see implemented (i.e. creation of an evacuation plan) and those actions were incorporated into the Mitigation Actions of the Hazard Plan

Prior to Submission to MEMA/FEMA

The Truro Hazard Mitigation Plan was presented at the Board of Selectmen's meeting on January 24, 2017. During this meeting, the public had the opportunity to provide comments.

Below is a list of comments received during and just after the Board of Selectmen's meeting:

- Selectman Weinstein expressed disappointment that issues related to Entergy's Pilgrim Nuclear Power Station in Plymouth. MA was not described in the plan. It was explained that those issues are described and addressed in other county and town plans.
- Board members noted a number of typographical errors, which were forwarded and incorporated into this final draft.

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A2b
A2c

With Neighboring Communities

Neighboring communities were given the opportunity to participate in the planning process during two meetings – at the Barnstable County Regional Emergency Planning Committee monthly meeting.

Barnstable County Regional Emergency Planning Committee (BCREPC)

The Planning Team gathered input from Towns across Cape Cod during the March 2, 2016 meeting of the Barnstable County Regional Emergency Planning Committee. During the meeting, Cally Harper, Planner at the Cape Cod Commission, informed the committee that several towns on Cape Cod, including Truro, are updating their Hazard Plans and asked committee members to comment on the history and impact of specific hazards on Cape Cod and their level of concern for future hazard events. The presentation and survey were given in 1 meeting and documentation for these activities are located in the "BCREPC Presentation" and "BCREPC survey results" section in ***Appendix 1***.

The process for incorporating input from the BCREPC meeting into the hazard plan was as follows:

1. The Planner from the Cape Cod Commission reviewed the impact and probability ranking and the comments from the BCREPC meeting
2. Those rankings and comments were incorporated into the plan and used to determine whether or not a hazard is significant to the town (***see Column 3, Table 2.2***).

Continuing Outreach Efforts During Plan Maintenance

A5a

Once the 2017 Truro Hazard Mitigation Plan is approved by MEMA and FEMA, it will be forwarded to the Truro Board of Selectmen for adoption. Once adopted, the plan enters into the "Maintenance Period" and will be active for five years. During this maintenance period, FEMA requires the Planning Team to continue engaging with the public.

A5a

The following is a list of engagement activities that the Planning Team will complete during this five-year maintenance period:

- **Online surveys** to gather data on whether or not Truro residents are prepared for nor'easters, hurricanes and severe winter weather. This survey was posted on the Town website and on the Police Department's Facebook page.
- **Presentations** to school and community groups about the science of hazards and/or how to prepare for specific weather events.

Incorporation with Other Town Plans and Report

Technical Information Used in the Plan

A4a

The 2017 Truro Hazard Mitigation Plan was drafted using existing plans, studies, reports and technical information from local, county, state and federal agencies. Technical data used to formulate the Hazard Profile is cited under each Hazard Profile and is not explicitly cited in the list below.

Below is a list of the resources from Federal, State and Local agencies that were used and incorporated into the 2017 Truro Hazard Mitigation Plan:

- **Technical Information from Federal Agencies:**
  - Local Mitigation Planning Handbook (2013) prepared by FEMA
  - How-To Guide: Getting Started – Building Support for Mitigation Planning (FEMA 386-1, 2002) prepared by FEMA
  - How-To Guide: Understanding Your Risks – Identifying Hazards and Estimating Losses (FEMA 386-2, 2001) prepared by FEMA
  - How-To Guide: Developing the Mitigation Plan (FEMA 386-3, 2003) prepared by FEMA
  - How-To Guide: Bringing the Plan to Life – Implementing the Hazard Mitigation Plan (FEMA 386-1, 2002) prepared by FEMA
  - Mitigation Ideas: A Resource for Reducing Risk to Natural Hazards (2013) prepared by FEMA
  - Hazard Mitigation Assistance Guidance (2015) prepared by FEMA
  - National Flood Insurance Program Community Rating System Coordinator's Manual (FIA-15/2013 prepared by FEMA
  - National Flood Insurance Program Floodplain Management Requirements: Study Guide and Desk Reference for Local Officials (FEMA 480, February 2005) prepared by FEMA
  - Risk Management Series Design Guide for Improving Critical Facility Safety from Flooding and High Winds (FEMA 543, January 2007) prepared by FEMA
  - Mitigation Assessment Team Report Hurricane Ike in Texas and Louisiana : Building Performance Observations, Recommendations, and Technical Guidance (FEMA P-757, April 2009) prepared by FEMA
  - Recommended Residential Construction for Coastal Areas: Building Strong and Safe Foundations (FEMA P-550, 2nd Edition, December 2009) prepared by FEMA

Incorporation with Other Town Plans and Report

- Wind Retrofit Guide for Residential Buildings (FEMA P-804, December 2010) prepared by FEMA
- Home Builder's Guide to Coastal Construction Technical Fact Sheets Series (FEMA P-499, December 2010) prepared by FEMA
- Coastal Construction Manual: Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas Volume I and II (4th edition, FEMA P-55, August 2011) prepared by FEMA
- Highways in the Coastal Environment: Assessing Extreme Events (2014) prepared by the U.S. Department of Transportation and the Federal Highway Administration
- National Climate Assessment (2014)

- **Technical Information from State Agencies:**
  - Massachusetts State Hazard Mitigation Plan (2013) prepared by Tetra Tech on behalf of the Massachusetts Emergency Management Agency and the Department of Conservation and Recreation
  - Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas: A Guide for Planners, Designers, and Municipal Officials (2003) prepared by Franklin, Hampden, Hampshire Conservation Districts
  - Massachusetts Climate Change Adaptation Report (2011) prepared by Executive Office of Energy and Environmental Affairs and the Adaptation Advisory Committee
  - Sea Level Rise: Understanding and Applying Trends and Future Scenarios for Analysis and Planning (2013) prepared by the Massachusetts Office of Coastal Zone Management
  - Massachusetts Coastal Erosion Commission Report (draft released in 2015) prepared by Coastal Erosion Commission
  - Commonwealth of Massachusetts All Hazards Disaster Debris Management Plan (2010) prepared by the Massachusetts Emergency Management Agency
  - Massachusetts Homeowner's Handbook to Prepare for Coastal Hazards (2014) prepared by Barnstable County, Woods Hole Sea Grant and MIT Sea Grant
- **Technical Information from County Agencies:**
  - Barnstable County Multi-Hazard Mitigation Plan (2010) prepared by the Cape Cod Commission
  - Barnstable County Wildfire Preparedness Plan (2012) prepared by Barnstable County and the Cape Cod Cooperative Extension

- **Technical Information from Truro:**
  - Truro Local Comprehensive Plan (2005) prepared by the town of Truro
  - Town of Truro Zoning Bylaws
  - Beach Management Plan for Town of Truro Beaches (2013)

A4b

How Technical Information was incorporated

The technical information listed above was incorporated into the 2017 Truro Hazard Mitigation Plan in the following ways:

- Federal documents, especially all FEMA documents, were used to:
  - guide the activities of the planning process
  - provide technical guidance on successful mitigation practices in coastal communities
  - help the Planning Team develop mitigation actions
  - provide current data on climate change and adaptation strategies
- **State and County documents were used to:**
  - provide current data on hazard events affecting Massachusetts and Barnstable County especially climate change, sea level rise and coastal erosion
  - guide the Planning Team on current state mitigation actions and plans; these documents were used as reference for the Planning Team
- Truro specific documents were used to:
  - ensure that mitigation actions in the 2017 Hazard Plan were consistent with current activities and plans already in place in Truro
  - provide technical data for the hazard profiles, risk assessment and mitigation actions

Integrating the Hazard Plan into other Town Plans

C6

The Mitigation Goals and Objectives identified in the 2017 Truro Hazard Mitigation Plan will be incorporated into the objectives and policies of the Truro Local Comprehensive Plan (LCP).

- **Truro Local Comprehensive Plan:** The Truro LCP describes goals, policies and actions on land use, growth management, natural resources, open space and recreation, historic preservation and community character, economic development, affordable housing, and community facilities and services. Mitigation Goals, Objectives and Actions will be incorporated in the Natural Resources and Open Space and Recreation sections of the LCP. Below are a few examples of Mitigation Goals that will be integrated in the update of the Truro LCP:

- Reduce the potential for loss of life, property, infrastructure, and environmental, cultural and economic resources in Truro from natural disasters.
- Mitigate repetitive damage caused by natural hazard events.
- Ensure that mitigation measures are sensitive to the natural features, historic resources, and community character of Truro.

C6

New FEMA guidance requires that the 2017 Truro Hazard Mitigation Plan Update describe how the plan was integrated with other plans over the last five years. Because this is a new requirement, Truro does not have a process in place to collect such information. Going forward, Truro will keep a running list of the new and updated town plans on its website and the Director of Planning and Development will be responsible for ensuring that town planning efforts are consistent with the 2017 Truro Hazard Mitigation Plan.

Contents of Chapter 1 Appendix

Contents in the Chapter 1 Appendix include:

- Team Meeting Sign-In Sheet
- Public Survey and Results
- Survey Documentation
- BCREPC Presentation
- BCREPC Meeting Minutes
- BCREPC Survey Results

Contents of Chapter 1 Appendix

Natural Hazards

CHAPTER TWO

Truro is vulnerable to a wide range of natural hazards that threaten life and property. Current FEMA regulations and guidance under the Disaster Mitigation Act of 2000 require, at a minimum, an evaluation of a full range of natural hazards identified in the most recent Massachusetts State Hazard Plan. An evaluation of human-caused hazards (i.e. nuclear explosions, technological hazards, terrorism, etc.) is encouraged but not required for plan approval. Truro has included an assessment of natural hazards only in the 2017 Truro Hazard Mitigation Plan. **Chapter 2 provides a detailed description of the natural hazards that could impact Truro in the future or have impacted Truro in the past.**

Hazard Identification

State Hazards

The 2013 Massachusetts State Hazard Plan identifies 11 natural hazards that could have an impact or have a history of impacting communities in the Commonwealth of Massachusetts. These hazards are listed below:

- Shoreline Change and Erosion
- Dam Failure
- Earthquake
- Fire (urban and wildland)
- Flood
- Hurricane and Tropical Storms
- Landslide
- Nor'easters
- Severe Weather (includes high winds, thunderstorms, extreme temperatures, tornadoes and drought)
- Severe Winter Weather (includes snow, blizzards and ice storms)
- Tsunami

Selection of Hazards that affect Truro

As suggested under FEMA planning guidance, the Planning Team reviewed the full range of natural hazards identified in the 2013 Massachusetts State Hazard Plan and identified natural hazards that could impact Truro in the future or that have impacted Truro in the past (***Table 2.1***). This determination was made using local expertise from Planning Team members, input from the Barnstable County Regional Emergency Planning Committee, data from the 2013 Massachusetts State Hazard Plan and other resources. All resources are referenced in the text of each hazard profile.

B1a,b

B1a,b

Table 2.1 | List of relevant natural hazards for Truro

Type of Natural Hazard	According to weather data, is there a history of this hazard happening in Truro?	What resources were used to make that determination?	According to the Planning Team, could this hazard happen in Truro?	Why was this determination made?
Shoreline Change and Erosion	Yes	▪ 2013 Massachusetts Hazard Mitigation Plan ▪ 2015 Coastal Erosion Commission Draft Report ▪ Massachusetts Coastal Zone Management Storm Coasts application ▪ Local knowledge from Town Staff	Yes	There is a history of erosion and shoreline change in Truro
Dam (Culvert) Failure	Yes	▪ 2013 Massachusetts Hazard Mitigation Plan ▪ Local knowledge from Town Staff	Yes	There are aging culverts in Truro
Earthquake	No	▪ 2013 Massachusetts Hazard Mitigation Plan ▪ Local knowledge from Town Staff	Yes	There is a no history of earthquakes in Truro but there is a history of earthquakes in Massachusetts
Fire (Urban and Wildland)	Yes	▪ 2013 Massachusetts Hazard Mitigation Plan ▪ Local knowledge from Town Staff ▪ Barnstable County Wildfire Preparedness Plan	Yes	Fire-adapted vegetation puts the town at risk for wildfire and there is a history of urban and wildland fires in Truro.
Flood	Yes	▪ 2013 Massachusetts Hazard Mitigation Plan ▪ FEMA 480 ▪ Local knowledge from Town Staff ▪ Newspaper articles	Yes	There is a history of flooding in Truro
Hurricane and Tropical Storms	Yes	▪ 2013 Massachusetts Hazard Mitigation Plan ▪ National Hurricane Center ▪ Local knowledge from Town Staff	Yes	There is a history of hurricanes and tropical storms in Truro
Landslide	No	▪ 2013 Massachusetts Hazard Mitigation Plan ▪ Local knowledge from Town Staff	Yes	Loose soils and likelihood of flooding pose a risk for landslides

Hazard Identification

Table 2.1 | List of relevant natural hazards for Truro (cont.)

Type of Natural Hazard	According to weather data, is there a history of this hazard happening in Truro?	What resources were used to make that determination?	According to the Planning Team, could this hazard happen in Truro?	Why was this determination made?
Nor'easters	Yes	▪ 2013 Massachusetts Hazard Mitigation Plan ▪ Local knowledge from Town Staff	Yes	There is a strong history of nor'easters in Truro
High Winds	Yes	▪ 2013 Massachusetts Hazard Mitigation Plan ▪ Local knowledge from Town Staff	Yes	There is a history of high winds in Truro
Thunderstorms	Yes	▪ 2013 Massachusetts Hazard Mitigation Plan ▪ Local knowledge from Town Staff	Yes	There is a history of thunderstorms in Truro
Extreme Temperatures	Yes	▪ 2013 Massachusetts Hazard Mitigation Plan ▪ Local knowledge from Town Staff	Yes	There is a history of extreme cold and hot temperatures in Truro
Tornadoes	No	▪ 2013 Massachusetts Hazard Mitigation Plan ▪ Local knowledge from Town Staff	Yes	There is no history of tornadoes in Truro, but there have been tornado warnings in Barnstable County
Drought	Yes	▪ 2013 Massachusetts Hazard Mitigation Plan ▪ Local knowledge from Town Staff	Yes	There is a history of drought in Barnstable County
Severe Winter Weather	Yes	▪ 2013 Massachusetts Hazard Mitigation Plan ▪ Local knowledge from Town Staff	Yes	There is a history of severe winter weather in Truro
Tsunami	No	▪ 2013 Massachusetts Hazard Mitigation Plan ▪ Local knowledge from Town Staff	Unknown	The probability of a damaging tsunami impacting Massachusetts is unknown
Sea Level Rise	Yes	▪ 2013 Massachusetts Hazard Mitigation Plan ▪ Local knowledge from Town Staff ▪ Cape Cod Commission Sea Level Rise Viewer	Yes	There is a history of sea level rise in Truro

Hazard Profiles

Shoreline Change and Erosion

Overview

Coastal shorelines — especially beaches, dunes and banks — change constantly in response to wind, waves, tides and other factors including seasonal variation, sea level rise and human alterations to the shoreline system.[1] Every day, wind, waves and currents move sand, pebbles and other materials along the shore or out to sea. This dynamic and continuous process of erosion, transport and accretion shape 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, such as those generated by nor'easters.

Hazard Location

B1c

Through the Shoreline Change Project at the Massachusetts Office of Coastal Zone Management (CZM), the ocean-facing shorelines of Massachusetts were delineated and statistically analyzed to demonstrate trends from the mid-1800s to 2009. An update of the Shoreline Change Project was completed in 2001 using 1994 National Oceanic and Atmospheric Administration (NOAA) aerial photographs of the Massachusetts shoreline. CZM established an agreement with the U.S. Geological Survey (USGS), the Woods Hole Oceanographic Institution Sea Grant Program, and Cape Cod Cooperative Extension to produce the 1994 shoreline and calculate shoreline change rates. CZM then incorporated the shorelines and shore-perpendicular transects with shoreline change rates into MORIS, the Massachusetts Ocean Resource Information System, to provide better access to the shoreline change data and encourage the public to browse the data using this online mapping tool. To launch the MORIS tool, use the following link: http://www.mass.gov/eea/agencies/czm/program-areas/mapping-and-data-management/moris/

Using the data from the Shoreline Change Project, the Planning Team concluded that the entire coastline of the planning area is vulnerable to shoreline change. ***Figure 2.1*** is a series of three maps of the planning area showing how the shoreline has changed from the mid-1800s to 2009 and two aerial images of the coast as of September 2016 (images taken by AirShark).

1 Report of the Massachusetts Coastal Erosion Commission, December 2015

Hazard Profiles

Figure 2.1a | Historic shoreline change along the coast of Truro. Map was created using data from the Massachusetts Ocean Resource Information System

Figure 2.1b | Historic shoreline change along the coast of Truro. Map was created using data from the Massachusetts Ocean Resource Information System

Hazard Profiles

Figure 2.1c | Historic shoreline change along the coast of Truro. Map was created using data from the Massachusetts Ocean Resource Information System.

Figure 2.1d | Aerial image of the overwash at Ballston Beach on the eastern coast of Truro. Images were taken in August using a UAV, operated by AirShark.

Hazard Profiles

Figure 2.1e | Image of the "slump" along the Truro coastline near Coast Guard Beach. Portions of the bluff slumped down, falling onto the beach below. Images were taken in August 2016.

B1c

B2a,c

Previous Occurrences and Extent

Coastal erosion is measured as the horizontal displacement of a shoreline over a specific period of time, measured in units of feet or meters per year.[2] Shoreline change can be monitored over short-term and long-term time scales. Monitoring shoreline change on a relatively short period of record does not always reflect actual conditions and can misrepresent long-term erosion rates. However, long-term patterns of coastal erosion are difficult to detect because of substantial, rapid changes in coastlines over days or weeks from storms and natural tidal processes.

The Report of the Massachusetts Coastal Erosion Commission[1] states the average shoreline change rates for Truro, where positive values indicate accretion and negative values indicate erosion, is the following:

- **Entire Town:**
  - Short-Term Rate: -2.4 ± 2.7 ft/year
  - Long-Term Rate: -0.9 ± 1.4 ft/year
- **Cape Cod Bay Shoreline:**
  - Short-Term Rate: *-1.6 ± 2.3 ft/year
  - Long-Term Rate: 0.1 ± 1.3 ft/year
- **Atlantic Coast:**
  - Short-Term Rate: *-3.0 ± 2.8 ft/year
  - Long-Term Rate: *-1.6 ± 0.9 ft/year

For the values listed above, negative values indicate erosion and positive values indicate accretion. An asterisk indicats top 20 short and long term erosion rates in MA. It is important to note this data represents averages for shoreline change throughout Truro, and that within the town there might be areas with greater or lesser erosion and accretion rates.

Impact

B3a

While erosion is a natural process, it causes damage to coastal property and related infrastructure — particularly when development is sited close to the shoreline in unstable or low-lying areas. Below is a list of possible damages that could result from shoreline change[1]:

- **People:** public safety is jeopardized when buildings collapse or water supplies are contaminated; erosion can cause roadways to collapse which would reduce the response time of emergency vehicles
- **Infrastructure:** erosion can expose septic systems and sewer pipes risking contamination of shellfish beds and other resources; accreting sand can block storm water pipes, causing urban drainage issues in town

2 Massachusetts State Hazard Plan, Coastal Erosion and Shoreline Change, 2013

- **Buildings:** erosion reduces the embedment of foundations in the soil, causing shallow foundations to collapse and making buildings on foundations more susceptible to settlement, lateral movement or overturning; once a building moves or is overturned, construction materials and other debris can be swept out to sea; seawalls and other hard structures open downdrift property owners to similar or greater losses
- **Economy:** if businesses are affected by coastal erosion, there could be loss of business function; damage to inventory; relocation costs; wage loss
- **Natural Systems:** where engineered structures are used to stabilize shorelines, the natural process of erosion is altered, changing the amount of sediment available and erosion rates at adjacent areas; the town's natural ecosystem attractions — beaches, dunes, barrier beaches, salt marshes and estuaries — would also be threatened and could slowly disappear as sand sources that supply and sustain them are eliminated; under conditions of reduced sediment supply, the ability of coastal landforms to provide storm damage and flooding protection would be diminished, increasing the vulnerability of infrastructure and development.
- **Transportation:** roadways and parking lots can become damaged due to shoreline recession.

Probability

B2b

The Planning Team determined that it is **HIGH LIKELY** that a shoreline change will impact the planning area. High probability was defined based on the frequency of occurrence:

- **Unlikely:** less than a 1% probability over the next 100 years
- **Possible:** 1-10% probability in the next year or at least one chance in the next 100 years
- **Likely:** 10-100% probability in the next year or at least one chance in the next 10 years
- **Highly Likely:** near 100% probability in the next year

Data from the Shoreline Change Project, local knowledge and the Report of the Massachusetts Coastal Erosion Commission were used to make this probability determination.

Culvert Failure and Dams

Overview

A dam is an artificial barrier that has the ability to impound water, wastewater or any liquid-borne material for the purpose of storage or control of water.[13] Dam failure is a catastrophic type of failure characterized by a sudden, rapid and uncontrolled release of impounded water.[13]

There are also several culverts in Truro that could act like dams during flooding events. Therefore the Planning Team decided to profile culvert failure in the Truro Hazard Mitigation Plan. The text below focuses on the definition of culverts and how they fail.

A culvert is a structural opening under a roadway that allows water to pass from one side of a roadway to the other.[3,4] Water flowing under the road typically comes from two sources – streams and road runoff – and these water resources require different types of culverts[5]:

- stream crossing culvert is located where the roadway crosses over a stream channel and the culvert allows water to pass downstream
- runoff management culvert is a strategically placed culvert to manage roadway runoff along, under and away from the roadway. Typically, these culverts are used to transport upland runoff that accumulated in ditches to the lower side of the roadway for disposal.

Culverts are typically made of concrete, steel or aluminum and can have various cross-sectional shapes (i.e. oval, circular, arched or rectangular).[4] The size of the culvert opening is calculated using location-specific data on the amount of precipitation, snow accumulation and the probability of hurricanes impacting the area. The primary function of a culvert is to prevent flooding during normal and extreme weather conditions and provide proper road and highway drainage. Culverts can fail and when failure occurs, it can be catastrophic. There are several reasons why culverts fail, including but not limited to[5]:

- buildup of flood waters on the upstream side of the culvert that exceed the capacity of the culvert. (video of a culvert failure in Maine, see: https://www.youtube.com/watch?v=NTbhyHNA1Vc)
- the pipe inside the culvert becomes occluded
- the pipe inside the culvert loses its structural integrity and begins to cave in

3 Massachusetts Highway Department: Project Development and Design Guide 2006

4 http://water.epa.gov/polwaste/nps/urban/upload/2003_07_24_NPS_unpavedroads_ch3.pdf

5 Failing culverts: Structural problems and economic considerations, Tenbusch, Inc, June 2013, www.tenbusch.com/underground_equipment/files/FailingCulvertsStructuralAndEconomicConsiderations.pdf

- culvert and road are washed out during a heavy rain event or from snowmelt runoff
- the soil/material around the culvert pipe begins to move. Without support from such material, the culvert will buckle or sag and the culvert will collapse.

B1c

Hazard Location

There are 7 culverts in Truro (***Figure 2.2a, b***).

B1c, B2a,c

Previous Occurrences and Extent

Truro has not experienced catastrophic culvert failure but it has occurred in other areas of New England. The following description of the extent of culvert failure is taken from events that occurred in the state of Vermont during Tropical Storm Irene.[6] In August of 2011, Tropical Storm Irene brought heavy precipitation to New England and eastern New York. During Irene, the state of Vermont incurred damages to state and local infrastructure:

- over 200 state road segments and 200 state-owned bridges were damaged
- 2,000 local road segments, 277 locally-owned bridges and nearly 1,000 locally-owned culverts were damaged

The extent of the culvert and bridge damage in Vermont was:

- large river and stream bank failures delivered a tremendous amount of woody debris downstream and plugged bridges, causing streams to overtop the bridge and wash out the bridge approach
- culverts became plugged with debris and redirected a large volume of water over areas of towns. In Rochester, NH water was redirected onto cemetery grounds – unearthing caskets and scattering human remains throughout the downtown area

The culverts in Truro have not experienced catastrophic failure but it is important to note that Truro has several aging culverts. Some of these older culverts are in the town of Truro but are owned by other agencies such as the National Park Service and Massachusetts Department of Transportation.

Figure 2.2b and c are close-up photographs of the two culverts that are associated with East Harbor. One culvert is owned by the National Park Service (***Figure 2.2***b) and the other culvert and associated outfall pipe are owned by Truro (***Figure 2.2***c). Recently the Town of Truro hired Woods Hole Group to do an alternatives analysis to determine how to repair the aging culvert system.

6 Gillespie et al., 2014, Flood effects on road-stream crossing infrastructure: economic and ecological benefits of stream simulation designs, Fisheries, volume 39 (2), page 62 - 76

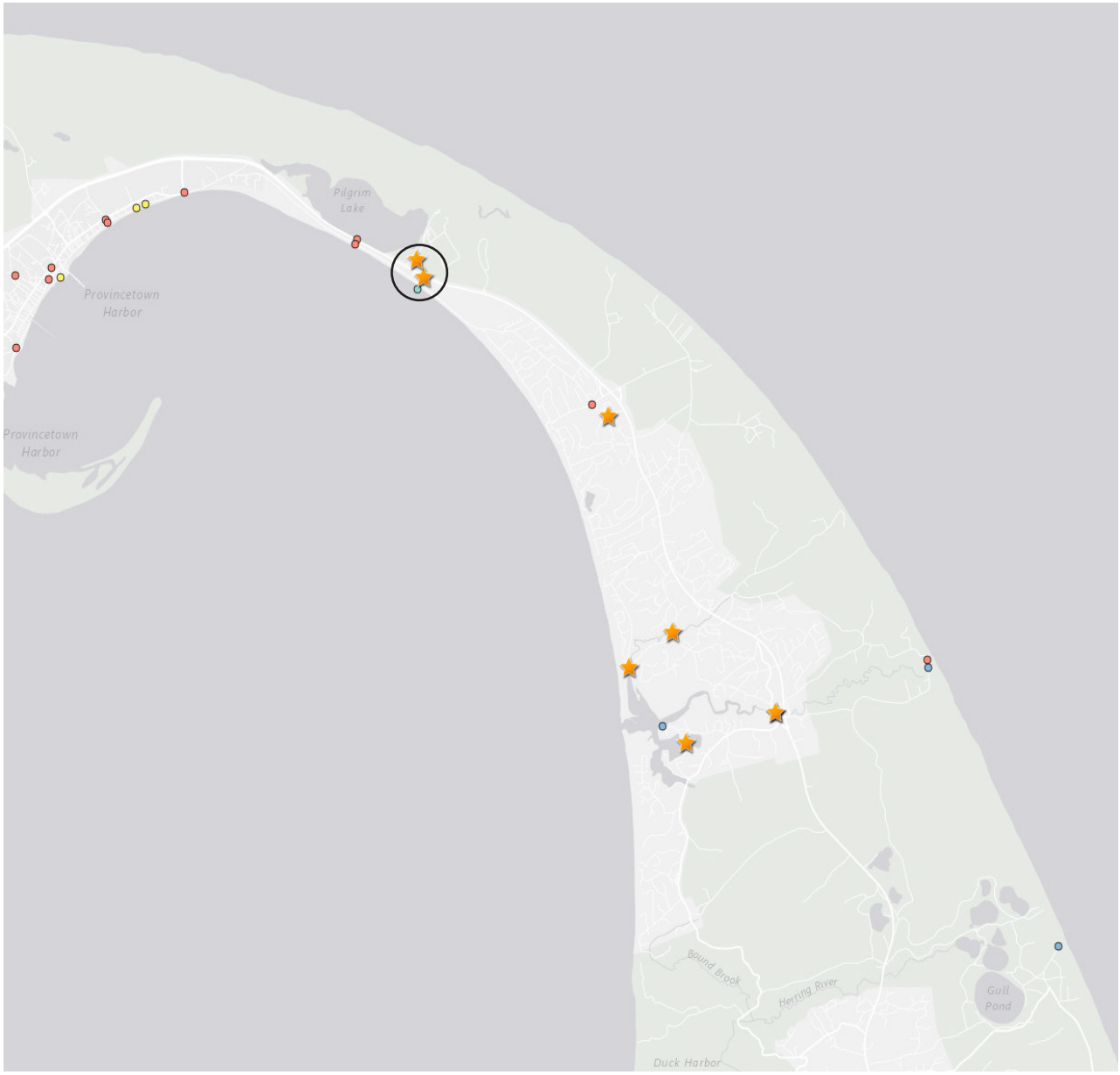


Figure 2.2a | Map of culverts in Truro. Culverts are identified as orange stars on the map. The black circle surrounds two culverts that are associated with East Harbor shown in Figure 2.2 b and c..

Hazard Profiles

Figure 2.2b | High Head Road Culvert owned by the National Park Service. Built in 1956. These photographs were taken during an extreme high tide. Note that the water level is close to the road level.

Figure 2.2c | The outfall pipe of the East Harbor culvert, owned by the Town of Truro..

B3a

Impact

Below is a list of additional possible impacts from culvert failure:

- **People:** community isolation from impassable roads, often leaving residents without power and water
- **Infrastructure:** power outages from disruption of underground utilities; no water due to disruption of pipes near the failed culvert; the high cost of relief and recovery may adversely affect investment in infrastructure or other development activities
- **Economy:** impacted traffic flow and impassable roads may prevent people from returning to work and tourists from visiting the area; expensive infrastructure repairs, residents will bear the extra cost of circumventing damaged roads
- **Natural Systems:** bank erosion, debris in natural systems
- **Transportation:** impaired traffic flow and impassable roads

B2b

Probability

The Planning Team determined that it is **POSSIBLE** that a culvert failure will impact the planning area. This determination was defined based on the frequency of occurrence:

- **Unlikely:** less than a 1% probability over the next 100 years
- **Possible:** 1-10% probability in the next year or at least one chance in the next 100 years
- **Likely:** 10-100% probability in the next year or at least one chance in the next 10 years
- **Highly Likely:** near 100% probability in the next year

The age of the culverts, dams and dikes was used to make this probability determination.

Earthquake

Overview

An earthquake is movement or trembling of the ground produced by a sudden displacement of rock in the Earth's crust. Scientists have formulated several theories to explain the causes of earthquakes but the theory of plate tectonics is commonly used to explain much of the earthquake activity in the world.[7]

The theory of plate tectonics postulates that, at one point, the earth was covered by a single crust, or plate, with no oceans. Over time, this plate started to split and drift into separate plates of land or ocean crusts. Now the earth's surface looks much like a spherical jigsaw puzzle; all the plates fit together. The plates over the earth are in constant slow motion. They generally move in one of three ways—they collide, spread or slide. Any one of these plate movements can cause an earthquake. Maps of earthquake activity throughout the world show that earthquakes most frequently occur at the boundaries of plates.

Plate movement or other forces create tremendous stress on rocks that make up the earth's outer shell. When rock is strained beyond its limit, it will fracture, and the rock mass on either side will move. This fracture is called a fault. Not all faults will cause earthquakes, but if there is a sudden rupture, energy is released that creates the motions associated with an earthquake. Once the sudden rupture occurs, the earth begins to shake. This shaking is caused by a series of waves known as seismic waves moving from the center of the earthquake outward to surrounding areas. Two scales are frequently used to measure earthquakes:

- **THE MODIFIED MERCALLI INTENSITY SCALE** measures the intensity or impact of an earthquake on people and the built environment. It measures the impact of an earthquake by sending out trained observers to look at the damage done to the built environment and the earth (landslides, etc.) and at the reaction of people to the event (***Table 2.2***).
- **THE RICHTER SCALE** measures the maximum recorded amplitude of a seismic wave. This measurement quantifies the ground motion and the energy released at the source of an earthquake, which is referred to as its magnitude.
  - **Richter Magnitude of 3.5 -5.4:** often felt but rarely causes damage
  - **Richter Magnitude of 5.5 - 6.0:** slight damage to well-designed buildings, major damage to poorly constructed buildings
  - **Richter Magnitude of 6.1 – 6.9:** destructive

7 Earthquake Causes and Characteristics, FEMA Emergency Management Institute Training Guide, https://training.fema.gov/emiweb/is/is8a/is8a-unit3.pdf

- **Richter Magnitude of 7.0 – 7.9 :** major earthquake, causes serious damage over large areas
- **Richter Magnitude of 8.0 or higher:** named Great Earthquakes, cause serious damage over extremely large areas

Both the Modified Mercalli Intensity Scale and Richter Scale are used to describe earthquakes because they utilize different data sets; the Richter Scale describes an earthquake's magnitude while the Modified Mercalli Intensity Scale describes the earthquake's impact on people and structures.

B1c

Hazard Location

The greatest earthquake threat in the United States is along tectonic plate boundaries and seismic fault lines in the central and western states. The eastern United States does experience earthquakes, but they are less frequent and less intense than the ones in the central and western U.S. ***Figure 2.3*** shows relative seismic risk for the United States.

B1c, B2a,c

Previous Occurrences and Extent

Between 1627 and 2008, there were 366 earthquakes recorded in Massachusetts.[13] Generally, most earthquakes that occur in the Northeast region of the United States tend to be small in magnitude and cause little damage, however; 104 earthquakes between 1924 and 2012 have measured at a magnitude of 4.5 or greater on the Richter scale. Due to the geologic composition and rock structure in the Northeast seismic shaking for many of these larger earthquakes were felt throughout all of New England.

Level	Description
I	Not felt except by a very few under especially favorable circumstances.
II	Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
III	Felt quite noticeably indoors, especially on upper of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration like passing of truck. Duration estimated.
IV	During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Felt by nearly everyone, many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.
VI	Felt by all, many frightened and run indoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.
VII	Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.
VIII	Damage slight in specially designed structures; considerable in ordinary substantial buildings, with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motor cars disturbed.
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rail bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.
XI	Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
XII	Damage total. Practically all works of construction are damaged greatly or destroyed. Waves seen of ground surface. Lines of sight and level are distorted. Objects are thrown into the air.

Table 2.2 | Modified Mercalli Scale, from Earthquake Causes and Characteristics, Chapter 3 of Emergency Management Institute Training Guide

Hazard Profiles

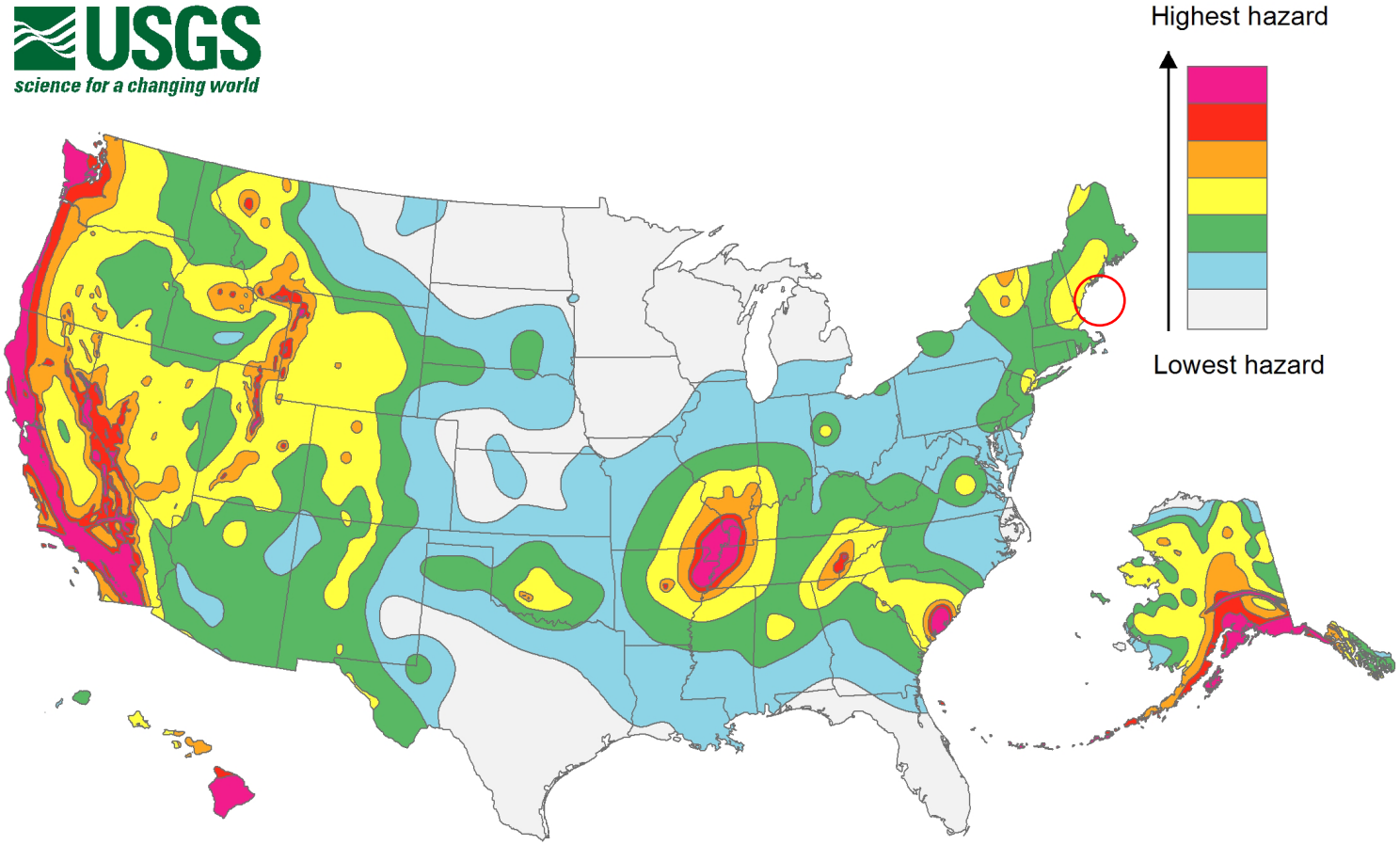


Figure 2.3 | 2014 Simplified earthquake hazard risk map for the United States. A circle was used to identify the planning area on the map.

B2c

Below is a list of earthquakes that affected eastern Massachusetts[13]:

- **August 8, 1847:** no data available on extent of hazard
- **November 27, 1852:** no data available on extent of hazard
- **December 10, 1854:** no data available on extent of hazard
- **September 21, 1876:** no data available on extent of hazard
- **May 12, 1880:** no data available on extent of hazard
- **January 21, 1903:** no data available on extent of hazard
- **April 24, 1903:** no data available on extent of hazard
- **October 15, 1907:** no data available on extent of hazard
- **January 7, 1925:** earthquake occurred off of Cape Ann and the reported felt area extended from Providence, RI to Kennebunk, ME
- **April 24, 1925:** no data available on extent of hazard
- **January 28, 1940:** no data available on extent of hazard
- **October 16, 1963:** Intensity VI, caused plaster to fall in a house, a wall cracked, stones fell from a building foundation, dishes were broken, windows cracked
- **October 30, 1963:** no data available on extent of hazard
- **October 24, 1965:** slight damage to homes on Nantucket, house timbers creaked, doors, windows and dishes rattled
- **December 30, 2012:** Magnitude 1.2 earthquake about 7 miles south of Gardner, MA. No extent data available.
- **April 2012:** a collection of 12 or more earthquakes occurred off of the New England coast about 250 miles east of Boston. The largest of these earthquakes measured a magnitude of 4.4 on the Richter Scale. This collection of earthquakes was of particular concern because of the major earthquake on the continental shelf further north in 1929 that produced a deadly and damaging tsunami in Nova Scotia

There have been no earthquake declared disasters for Massachusetts. No data is available on the history of earthquakes in Truro.

B3a

Impact

Earthquakes can affect hundreds of thousands of square miles, cause damage to property, result in loss of life and injury and disrupt the social and economic functioning of the affected area. Most property damage and earthquake related deaths are caused by the failure and collapse of structures during ground shaking. .

Earthquakes can also cause large and sometimes disastrous landslides. Sand dunes, like the ones located in the National Seashore in Truro, are vulnerable to slope failure during an earthquake. This process, called sand liquefaction, occurs when water-saturated sands, silts or gravelly soils are shaken so violently that the individual grains lose contact with one another and move freely, turning the ground into a liquid.[13]

B2b

Probability

Earthquakes cannot be predicted and may occur at any time of the day and any time of the year.[13] The Planning Team determined that it is **POSSIBLE** that an earthquake will impact Truro. Probabilities were defined based on the frequency of occurrence:

- **Unlikely:** less than a 1% probability over the next 100 years
- **Possible:** 1-10% probability in the next year or at least one chance in the next 100 years
- **Likely:** 10-100% probability in the next year or at least one chance in the next 10 years
- **Highly Likely:** near 100% probability in the next year

The Planning Team used data collected from the 2013 Massachusetts State Hazard Plan and historical earthquake data in Massachusetts to make this probability determination.

Fire: Urban and Wildland

Overview

This portion of the Truro Hazard Mitigation Plan assesses two types of fire events: urban fires and wildfires.

Urban fires occur when buildings and structures catch fire and there is potential for the fire to spread to adjoining structures. Urban fires are more common in areas where single family homes, multi-family homes and businesses are clustered closely together, thereby increasing the possibility of rapid spread to nearby structures. Urban fires occur more frequently than wildfires and often result from everyday activities such as cooking, smoking and appliance malfunction.

Wildfires are defined as any non-structural fire that occurs in a vegetative wildland including grass, shrub, leaf litter or forested area.[13] Wildfires often begin undetected and spread quickly when brush, trees and

homes are ignited. In Massachusetts, wildfires are typically caused by lightning, human activity (i.e. smoking, unattended camp fires) or prescribed burns (intentional, controlled burns that are started under the supervision of experienced fire personnel)[13].

In 2012, the Cape Cod Cooperative Extension and many other regional partners developed the Barnstable County Wildfire Preparedness Plan. As stated in this document, Cape Cod is vulnerable to wildfires for several reasons:

- The region has a long history of wildfires. As a result, most of Cape Cod has fire-adapted ecosystems and therefore they are prone to burning. Also pitch pine barrens are the dominant vegetative community on Cape Cod. These ecosystems contain several highly flammable plant species that are adapted to survive or regenerate post fire.
- Many residents of Barnstable County live in the Wildland Urban Interface (WUI). This zone is defined as the line, area or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuel. Development in the WUI is dangerous because wildfires can move to surrounding developments and place homes and other buildings at risk for ignition.

Hazard Location

B1c

A team of fire professionals developed the Barnstable County Wildfire Preparedness Plan and conducted a town-wide risk assessment for wildfire in Truro. This team identified three sites in Truro that are at risk to wildland fires (***Figure 2.4***).

Previous Occurrences and Extent

B1c, B2a,c

The following is a list of notable wildland fires that occurred in Barnstable County since 1887:

- **1887:** A large forest fire burned over 25,000 acres from the Pocasset section of Bourne to Sandwich. This fire destroyed approximately 600 cords of stacked wood at the Sandwich Glass Company as well as several stands of oak and pine. The Sandwich Glass Company was forced to purchase and burn coal in its furnaces at a substantial financial cost. This, along with a labor union strike, ultimately contributed to the demise of the Sandwich Glass Company, one of the Cape's largest industrial businesses between 1825 and 1894. (www.capecodfd.com)
- **May 30, 1923:** A fire began in the woods of Pocasset village and burned through the day. It was under control by nightfall, only to flare up again and again for 7 days. An area of approximately

Hazard Profiles

BARNSTABLE COUNTY WILDFIRE PREPAREDNESS PLAN
Community Wildfire Protection Plan

Town of Truro

TOWN OF TRURO WILDFIRE RISK MAP

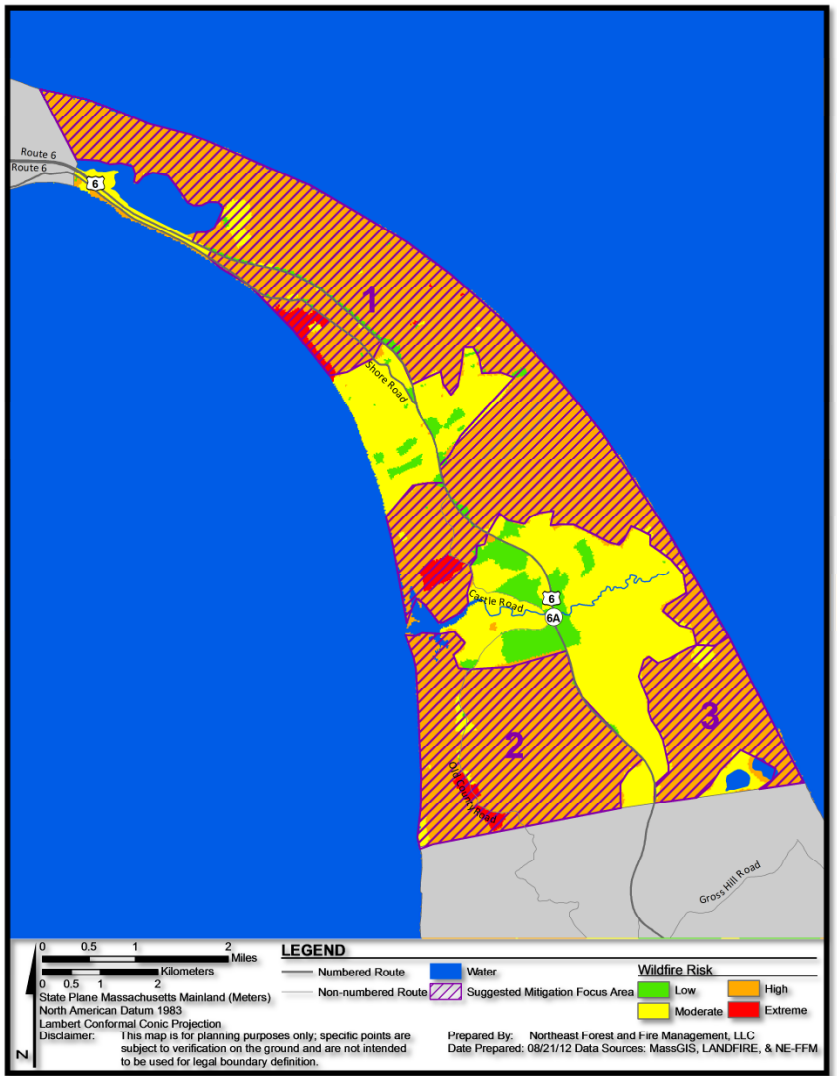


Figure 2.4 | Town of Truro Wildfire Risk map from the Barnstable County Wildfire Preparedness Plan

25,000 acres, between Pocasset village, Sagamore, Sandwich, East Sandwich, and South Sandwich was left blackened. (www.capecodfd.com)

- **April 19, 20, 21, 1927:** 2,500 acres burned in Truro. (Barnstable Patriot, April 28, 1927)
- **1938:** 5,000-acre wildfire kills three Sandwich firefighters on Route 130 (http://www.mashpeema.gov/Pages/MashpeeMA_Fire/MashpeeWildlife.pdf)
- **April 1946:** Slash piles started by German prisoners of war at Camp Edwards blaze out of control and consume 50,000 acres (http://www.mashpeema.gov/Pages/MashpeeMA_Fire/MashpeeWildlife.pdf)
- **June 1949:** 75 acres or more of brush and woodland burned after a fire started at the Truro Town Dump. Firefighters from Truro, Provincetown, Wellfleet, Brewster and Orleans helped bring it under control. (Provincetown Banner, June 16, 1949)
- **June 5, 2016:** A 3-Alarm brush fire destroys over 12 acres behind the Coca Cola plant on Route 130. Mutual aid is brought in from Plymouth and Barnstable Counties to assist in extinguishing.
- **May 10, 2016:** A 2-Alarm brush fire on Crestview Drive in East Truro destroys over 5 acres of Town of Truro open space property.

Impact

B3a

Destruction caused by urban fires and wildfires depends on the following factors:

- size of the fire
- landscape
- amount of fuel (i.e. vegetation and structures) in the path of the fire
- direction and intensity of the wind
- response time of fire personnel
- number of firefighters able to respond to the fire
- access to the fire once it starts

Below is a list of possible damages from urban and wildland fires.

- **People:** death or injury to people and animals, smoke can cause health issues for people, even for those far away from the fire
- **Infrastructure:** gas, power and communications may be disrupted, flying embers can set fire to buildings more than one mile away from the initial fire
- **Buildings:** structures can be damaged or destroyed, a large number of buildings can be burned
- **Economy:** indirect economic losses in reduced tourism; as communication and infrastructure systems are damaged and disrupted, economic

activities come to a standstill, often resulting in dislocation and dysfunction of normal business activities; when roadways are disrupted, it impacts the customer base for small businesses and leads to slow recovery times for these businesses; the high cost of relief and recovery may adversely affect investment in infrastructure or other development activities

- **Natural Systems:** extensive acreage can be burned, damaging watersheds and critical natural areas, flash flooding and landslides can result from fire damage to the surrounding landscape; wildfires strip slopes of vegetation exposing them to greater runoff and erosion; this will weaken soils and cause failure on slopes, wildfires can affect the land for many years, including causing changes to the soil and therefore increasing the risk of future flooding, contamination of reservoirs, change the permeability of the ground. When fires burn hot and for long periods of time, the soil will bake and become impermeable. When this happens, runoff and the risk of flooding increases
- **Transportation:** transportation may be temporarily disrupted

Probability

B2b

The Planning Team determined that it is **LIKELY** that an urban fire will impact Truro and **LIKELY** that a wildfire will impact the planning area. Probabilities were defined based on the frequency of occurrence:

- **Unlikely:** less than a 1% probability over the next 100 years
- **Possible:** 1-10% probability in the next year or at least one chance in the next 100 years
- **Likely:** 10-100% probability in the next year or at least one chance in the next 10 years
- **Highly Likely:** near 100% probability in the next year

The Planning Team used data collected from the 2013 Massachusetts State Hazard Plan, the 2012 Barnstable County Wildfire Preparedness Plan and local knowledge of the town to make this probability determination.

Flood

Overview

There are several types of flood hazards that frequently impact Truro:

- **Flash flooding** occurs when a severe storm like a nor'easter or tropical storm causes a large amount of rain in a short period of time.[8]
- **Coastal flooding** occurs when persistent high wind and changes in air pressure during a hurricane or nor'easter push water towards the shore. This action causes storm surge which raises the level of the water by several feet. Waves can be highly destructive as they move inland, battering structures in its path (***Figure 2.9***). The magnitude of a flood varies with the tides; storm surge that occurs during high tide will flood larger areas than if the same surge occurred at low tide.[9]
- **Urban drainage** occurs in flat areas where runoff or rain collects and cannot drain out. Drainage systems are made up of ditches, storm sewers, retention ponds and other infrastructure that store runoff and carries it into a receiving stream, lake, or ocean. When most of these systems were built, they were designed to handle the amount of water expected during a 10-year storm event. Larger storms overload the system and result in back-ups. When this system is blocked, water forms temporary ponds. This water will remain in an area until it infiltrates into the soil, evaporates, the blockage is cleared or the water is actively pumped out.[9]

Hazard Location

B1c

Flooding in Truro is also the direct result of coastal storms, nor'easters, heavy rains, tropical storms, and hurricanes. ***Figure 2.5*** shows the 2014 FEMA Flood Insurance Rate Map (FIRM) for Truro. This map depicts areas of Truro in V and A zones and the 2% annual flood areas.

Previous Occurrences and Extent

Below is a list of rain, flooding and coastal flooding events experienced in Truro and in Barnstable County from 1950 - 2015. Data was collected from NOAA's National Climatic Data Center:

- **February 24, 1998:** The second powerful nor'easter to affect the region in less than a week brought a deluge of rain to southeastern Massachusetts, gale force winds along the coast, and coastal flooding to Chatham on Cape Cod and to Martha's Vineyard and Nantucket. Coastal flooding occurred on Martha's Vineyard where Beach Road was closed from Edgartown to Oak Bluffs. Waves were reported splashing over the top of houses in the Eastville

8 National Flood Insurance Program, Floodplain Management Requirements, FEMA 480

Hazard Profiles

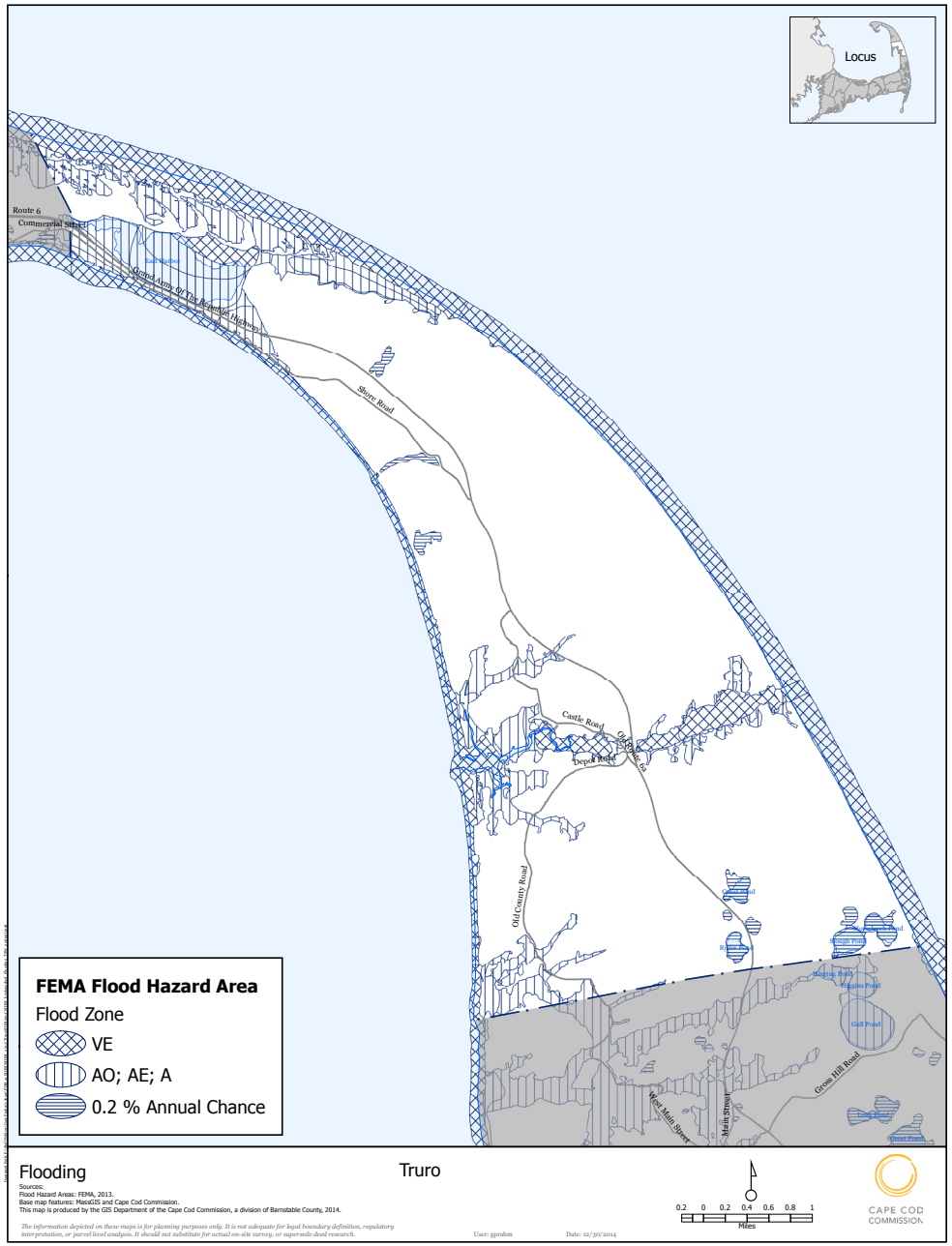


Figure 2.5 | FEMA flood hazard area map

section of Oak Bluffs. Beach erosion occurred on Nantucket, where there was a loss of about 20 feet of dunes on the east side of the Island. Up to 12 to 15 feet was lost along Sconset Bluff. There were a few reports of coastal flooding at Chatham on Cape Cod. Dozens of basements were flooded and coastal roads had to be closed as the aftermath of the heavy rain

- **March 5, 2001:** A major winter storm impacted the Bay State with near blizzard conditions, high winds, and coastal flooding. The slow-moving storm, which tracked south of New England, dumped over two feet of snow across the interior, knocked out power to about 80,000 customers, and shut down businesses and schools for several days. There were also many reports of downed trees and wires during the height of the storm, along with reports of lightning and thunder. High tides during the storm ran 2 to 3 feet above normal, resulting in widespread coastal flooding along the entire east facing coastline, including Cape Cod and the islands. The strong surf slammed sea walls and flooded beachfront homes and roadways
- **January 23, 2005:** Blizzard conditions caused major power outages for an extended amount of time. Vulnerable populations were caused to evacuate to local shelters. Snow fall totals up to 3 feet in some areas. Wind gusts up to 65 MPH at times. Power lines and trees down all over roads and travel was extremely dangerous. Coastal flooding caused major damages to homes along the vulnerable areas.
- **April 16, 2007:** An unusually strong and slow moving coastal storm for mid-April tracked to western Long Island Sound on April 16th before weakening slowly and drifting offshore. This storm brought a variety of impacts in southern New England, including heavy snow to the higher elevations of western Massachusetts, damaging winds in excess of 60 mph, widespread river and stream flooding, and significant coastal flooding through several high tide cycles. Minor to moderate coastal flooding occurred along the coastline of Massachusetts through several high tide cycles, due to the combination of strong onshore winds, high seas, and astronomically high tides. A small stream in Harwich came out of its banks and closed a nearby roadway.
- **September 3, 2010:** Tropical Storm Earl made its closest pass to Southern New England the morning of September 4th, passing 98 miles to the southeast of Nantucket Island. The Automated Surface Observing System at Nantucket Memorial Airport (ACK) recorded the only tropical storm force wind in Southern New England, measured shortly after midnight on the 4th at 36 knots (41 mph). High surf induced by Earl resulted in minor coastal flooding in Newport, RI and Nantucket, MA. Meanwhile, a couple of locations on Cape Cod experienced minor freshwater flooding due to three to five inches of heavy rainfall. Also on Cape Cod, several trees were downed by the persistent sustained winds.

Hazard Profiles

A foot of water flooded Orleans Road in Chatham and the intersection of Route 137 and Pleasant Bay Road in Harwich.

- **October 30, 2011:** A rare and historic October Nor'easter brought very heavy snow to portions of southern New England on Saturday October 29. A state of emergency was declared by Governor Patrick on October 29th and he declared an end to the state of emergency on November 6th. This storm also brought damaging winds to Cape Cod and the islands with wind gusts up to 70 mph occurring early Sunday morning October 30 as well as minor to moderate coastal flooding to east coastal Massachusetts during the high tide early Sunday morning. Moderate coastal flooding occurred with splashover a small seawall that resulted in the flooding of Old Main Street in Sandwich with 18 to 24 inches of water. This made the road impassable. Astronomically high tides contributed to the coastal flooding.
- **July 18, 2012:** Lightning struck a home on Coast Guard Road in Truro, which started a fire. Some minor flash flooding.
- **September 13, 2013:** A cold front moved through an unstable atmosphere across southern New England, triggering showers and thunderstorms across much of Massachusetts and Rhode Island. There was enough shear and instability for some of these storms to become severe, producing damaging winds. In addition, because of the very moist atmosphere and heavy rain over the previous two days, flash flooding also occurred in several locations. A basement was flooded on Chris Drive. Five to six inches of water flooded the police station parking lot.
- **January 27, 2015:** Blizzard conditions for more than 12 hours recorded Cape wide. Snow totals reaching 30+ in. Coastal flooding and high winds caused widespread moderate damages. Ballston Beach was inundated with ocean water which affected South Pamet Road.
- **July 1, 2015:** A strong upper level disturbance and cold air aloft moved into southern New England resulting in showers and thunderstorms. Plenty of moisture throughout the atmosphere led to heavy rain and some minor street flooding. Main Street was flooded and closed for 20 minutes.
- **August 11, 2015:** A warm front moving north through southern New England brought showers and thunderstorms to much of the area. Because of a copious amount of moisture in the atmosphere, some of these showers and storms produced heavy rain which in turn produced street flooding, most of it minor. In Chatham, several roads experienced street flooding, closing the roads. These included: Orleans Road at Frost Fish Road, Stepping Stones at

Heritage Lane, Commerce Park South, Main Street near the Chatham Motel, and Route 28 near Stoney Hill Road.

B3a

Impact

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

- **People:** people can be knocked down or washed off their feet while walking in floodwaters; injury and death for people who become trapped in their cars during a flood event; often people place themselves in harm's way by ignoring warning signs of water depth on roadways; people can be displaced from their homes because of post-flood safety and health hazards; mold, mildew and bacteria can cause health issues; flooding can cause drinking water to become contaminated.
- **Infrastructure:** flooding can leave large amount of debris and sediment on and around town infrastructure; floods can damage gas lines, utility poles, water infrastructure, wastewater treatment plants; cause sewage spills.
- **Buildings:** moving water can damage the walls of buildings; building foundations on the beach can be undermined by the velocity of floodwaters; floodwaters pick up anything that floats, including logs, lumber, propane tanks and vehicles – when this happens, these objects can act as battering rams and damage buildings; buildings can float off of their foundations if not anchored properly
- **Economy:** as communication and infrastructure systems are damaged and disrupted, economic activities come to a standstill, often resulting in dislocation and dysfunction of normal business activities; roadways disruptions affect the customer base and slow recovery times for small businesses; the high cost of relief and recovery may adversely affect investment in infrastructure or other development activities; there can be losses associated with decreased land value in floodplains
- **Natural Systems:** During flood events, storm water systems cannot handle the high water volume and oftentimes, untreated sewage can enter into the environment, floods can transfer sediment and debris into parks, beaches, estuaries, rivers, etc.

- **Transportation:** floods can wash out bridges and culverts, debris in floodwaters can occlude culverts so much that the culvert acts like a dam; roadways can be washed away in a flood event; there can be major disruptions to transit, train or ferry services

B2b

Probability

The Planning Team determined that it is **HIGHLY LIKELY** flooding will impact the planning area. High probability was defined based on the frequency of occurrence:

- **Unlikely:** less than a 1% probability over the next 100 years
- **Possible:** 1-10% probability in the next year or at least one chance in the next 100 years
- **Likely:** 10-100% probability in the next year or at least one chance in the next 10 years
- **Highly Likely:** near 100% probability in the next year

The Planning Team used the history of hurricanes, tropical storms, nor'easters in Truro to make this probability designation.

Hurricanes and Tropical Storms

Overview

A tropical cyclone is a rotating, organized system of clouds and thunderstorms that originates over tropical or subtropical waters.[9] In the Atlantic Basin, the hurricane season "officially" runs from June 1 to November 30; peak activity is in early to mid-September.[10]

There are four types of tropical cyclones that can occur in the Atlantic Basin:

- **Tropical Depression:** a tropical cyclone with maximum sustained winds of 38 mph or less
- **Tropical Storm:** a tropical cyclone with maximum sustained winds of 39 to 73 mph
- **Hurricane:** a tropical cyclone with maximum sustained winds of 74 mph or higher
- **Major Hurricane:** a tropical cyclone with maximum sustained winds of 111 winds or higher, corresponding to a Category 3, 4, or 5 on the Saffir-Simpson Hurricane Wind Scale

There are two data sets used to classify tropical cyclones:

9 National Hurricane Center Outreach and Education, http://www.nhc.noaa.gov/climo/
10 National Hurricane Center Outreach and Education http://www.srh.noaa.gov/jetstream/tropics/tc_basins.htm

1. **Saffir-Simpson Hurricane Wind Scale** is a 1 to 5 rating based on a hurricane's sustained wind speed[11]. This scale estimates potential property damage (***Table 2.3***). Hurricanes reaching Category 3 and higher are considered major hurricanes because of their potential for significant loss of life and damage. Category 1 and 2 storms are still dangerous, however, and require preventative measures.
2. **Amount and location of storm surge**. Storm surge is simply water that is pushed toward the shore by the force of the winds swirling around the storm.[12] This advancing surge combines with the normal tides to create the hurricane storm tide, which can increase average water levels 15 feet (4.5 m) or more. In addition, wind-driven waves are superimposed on the storm tide. This rise in water level can cause severe flooding in coastal areas, particularly when the storm tide coincides with the normal high tides.

The US Army Corps of Engineers New England Division, in cooperation with FEMA, prepared Sea, Lake and Overland Surge from Hurricanes (SLOSH) inundation maps.[13] SLOSH mapping represents potential flooding from worst-case combinations of hurricane direction, forward speed, landfall point, and high astronomical tide. It does not include riverine flooding caused by hurricane surge or inland freshwater flooding. The model, developed by the National Weather Service to forecast surges that occur from wind and pressure forces of hurricanes, considers only storm surge height and does not consider the effects of waves. The mapping was developed for New England coastal communities using the computer model, Long Island Sound bathymetry, and New England coastline topography. The resulting inundation areas are grouped into Category 1 and 2, Category 3, and Category 4. The hurricane category refers to the Saffir-Simpson Hurricane Intensity Scale. The Army Corps of Engineers considered the highest wind speed for each category, the highest surge level, combined with worst-case forward motion and developed a model to depict areas that would be inundated under those combined conditions.

Hazard Location

B1c

The entire planning area is vulnerable to tropical cyclones. Coastal areas are extremely susceptible to damage because of wind and storm surge. Inland areas can also be affected by flooding, strong wind and heavy rain associated with tropical cyclones. ***Figure 2.7*** shows the predicted storm surge in the planning area for the Category 1-4 storms.

11 http://www.nhc.noaa.gov/aboutsshws.php

12 National Weather Service Jetstream – Online School for Weather, Tropical Weather, Tropical Hazards www.srh.noaa.gov/jetstream/tropics/tc_hazards.htm

13 Massachusetts State Hazard Mitigation Plan, 2013

Hazard Profiles

Category	Sustained Winds	Types of Damage Due to Hurricane Winds
1	74-95 mph 64-82 kt 119-153 km/h	Very dangerous winds will produce some damage: 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	Extremely dangerous winds will cause extensive damage: 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	Devastating damage will occur: 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	Catastrophic damage will occur: 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	Catastrophic damage will occur: 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.

Table 2.3 | Saffir-Simpson Hurricane Wind Scale (National Hurricane Center)

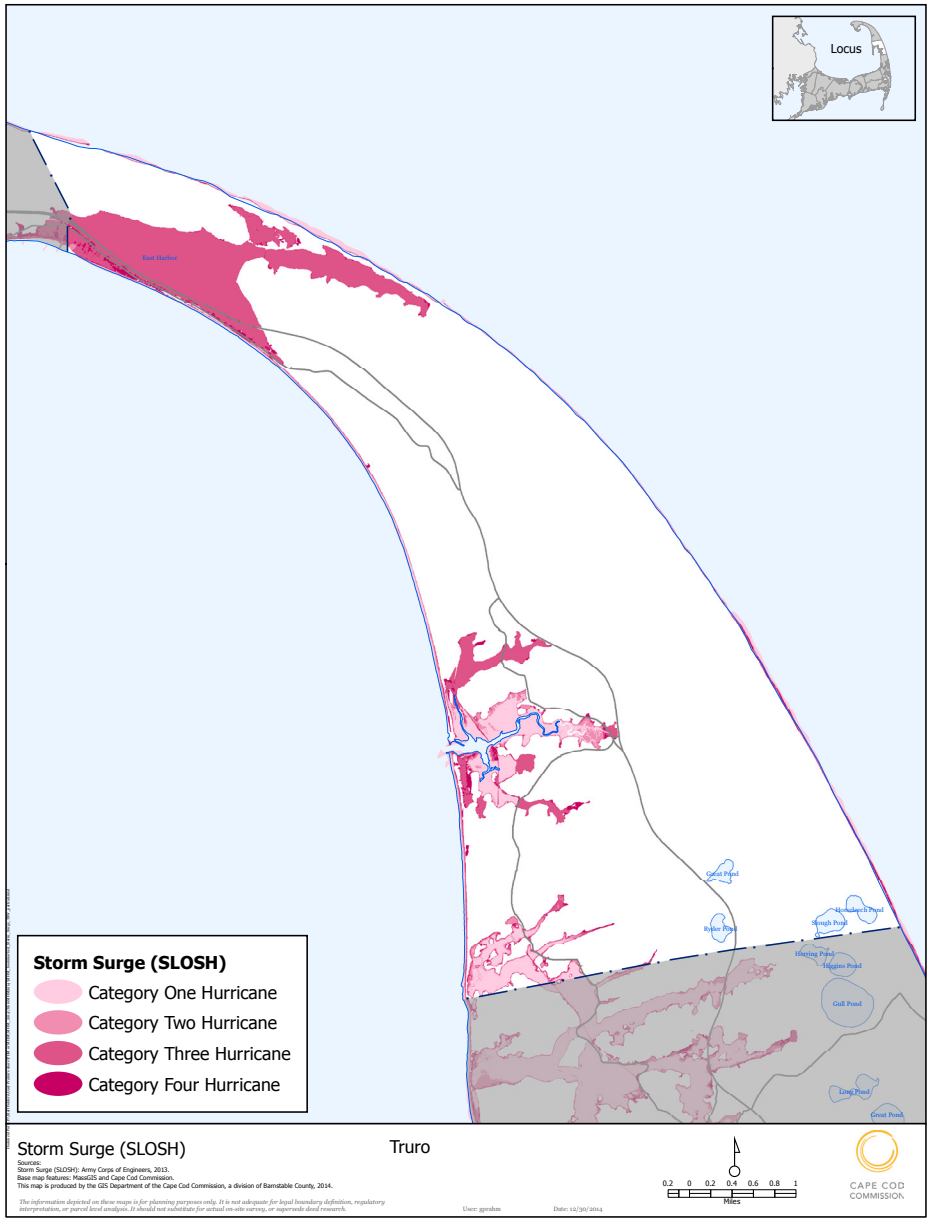


Figure 2.7 | SLOSH map for Truro

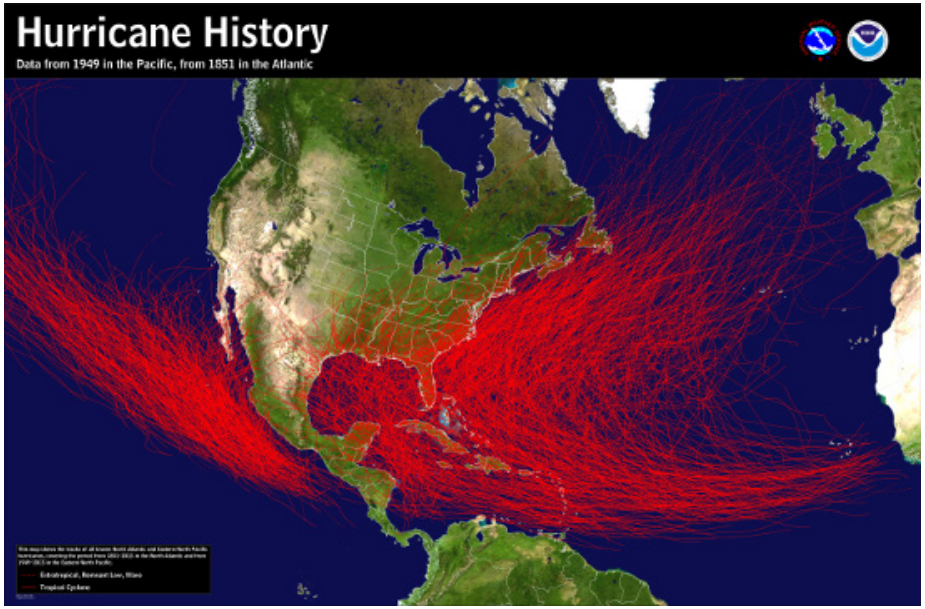
B1c, B2a,c

Previous Occurrences and Extent

The National Hurricane Center created maps showing the tracks of all known North Atlantic hurricanes and major hurricanes between the years 1851 and 2013 (***Figure 2.8***). These maps indicate that there is a strong history of hurricanes affecting the Atlantic Coast of the United States, including Barnstable County.

The Moris tool and data from NOAA was used to plot hurricane tracks making landfall in New England between 1851 and 2008 (***Figure 2.9***).

Data collected from the FEMA disaster declaration website, the 2013 MA State Hazard Plan, and local experts (including the Planning Team and the Barnstable County Emergency Planning Committee) was also used to document the previous occurrences of tropical cyclones that affected Cape Cod. ***Table 2.4*** describes the major disaster declarations and most memorable cyclones to affect Barnstable County and thus, the planning area.



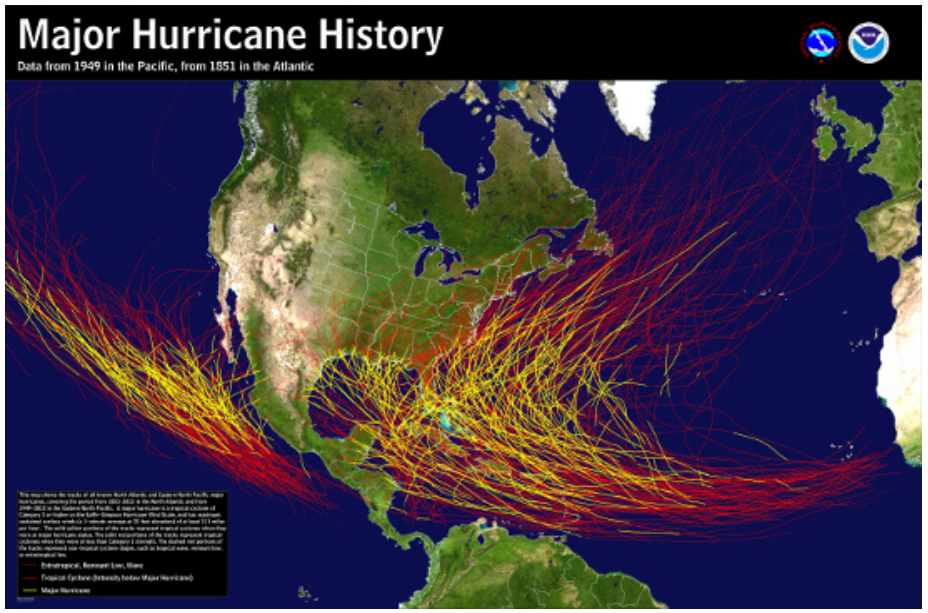


Figure 2.8 | Hurricanes and major hurricanes in the Atlantic Basin (above) and in Barnstable County from 1851-2013, National Hurricane Center (right).

Hazard Profiles

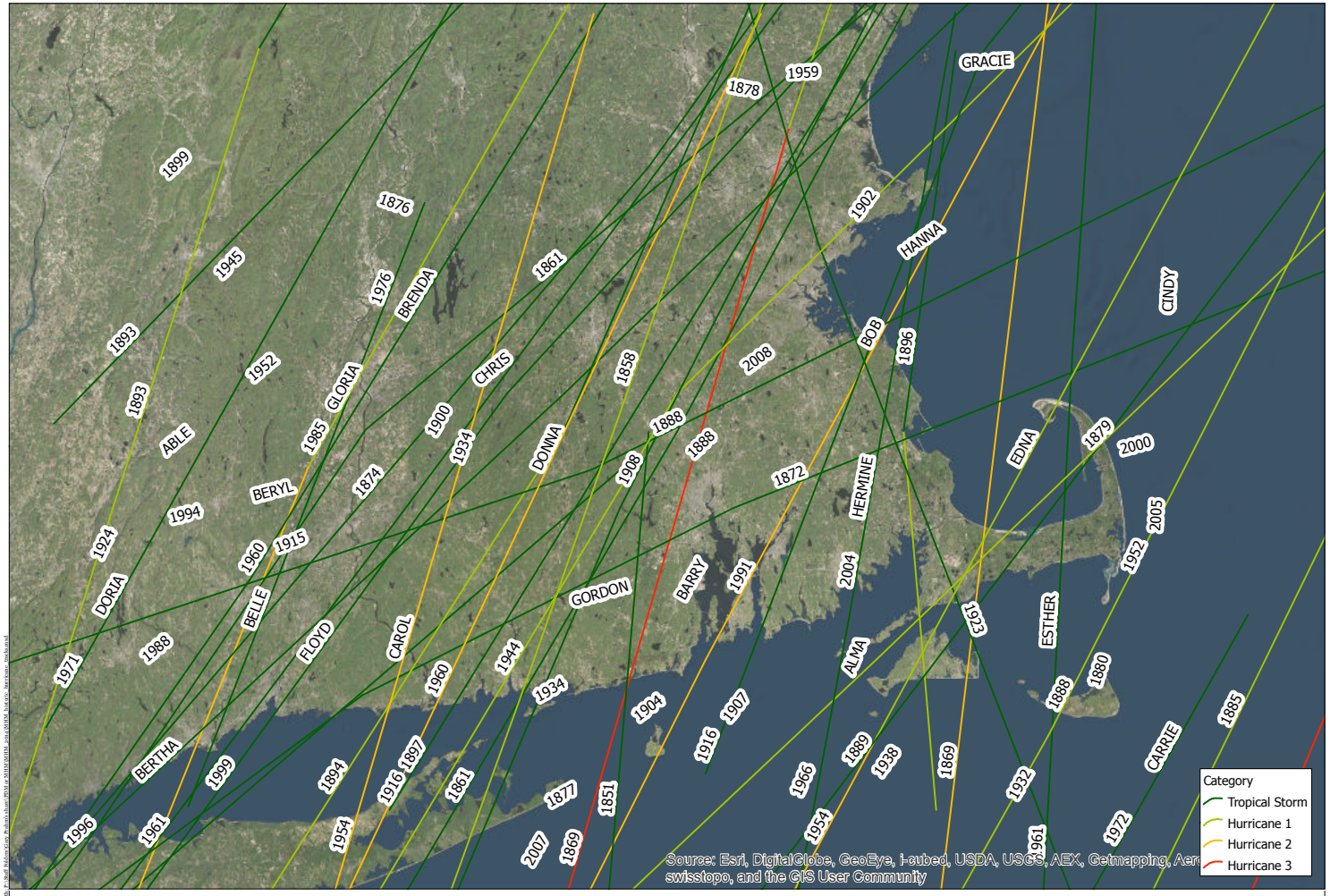


Figure 2.9 | Hurricanes Making Landfall in New England, 1851-2008

Major Disaster Declarations and Most Memorable Tropical Cyclones for Barnstable County from 1954 - 2012

Number	Storm Name	Safrir-Simpson Classification	Landfall	Incident period	Declaration Date	Comments	References
	Tropical Storm Arthur	TS		July 4, 2014			Barnstable County Regional Emergency Planning Committee
EM-3350	Tropical Storm Sandy	TS	yes	October 27 to November 8, 2012	October 28, 2012	Barnstable County was designated for Category B Public Assistance	FEMA Disaster Declaration website
DR-4097	Tropical Storm Sandy	TS	yes	October 27 to November 8, 2012	December 19, 2012	HMGP Assistance was provided for Barnstable County	FEMA Disaster Declaration website
EM-3330	Tropical Storm Irene	Category 2		August 26 |to September 5, 2011	August 26, 2011	Barnstable County was designated for Category B Public Assistance	FEMA Disaster Declaration website
DR-4028	Tropical Storm Irene	Category 2		August 27 to August 29, 2011	September 3, 2011	HMGP Assistance was provided for Barnstable County	FEMA Disaster Declaration website
EM-3315	Hurricane Earl	Category 4		September 1 to September 4, 2010	September 2, 2010		FEMA Disaster Declaration website
DR-914	Hurricane Bob	Category 3	yes	August 19, 1991	August 26, 1991		FEMA Disaster Declaration website
DR-751	Hurricane Gloria	Category 4		September 27, 1985	October 28, 1985		FEMA Disaster Declaration website
	Hurricane Donna	Category 5	yes	September 12 to September 13, 1960	not declared		FEMA Disaster Declaration website
	Hurricane Carol	Category 2-3		August 31, 1954	not declared		Barnstable County Regional Emergency Planning Committee
	Hurricane Edna	Category 3	yes	September 11, 1954	not declared		Barnstable County Regional Emergency Planning Committee
	1938 Hurricane	Category 3	yes	September 1938	not declared		Barnstable County Regional Emergency Planning Committee
	1944 Hurricane	Category 4	yes	September 1944	not declared		Barnstable County Regional Emergency Planning Committee

Table 2.4 | History and extent of tropical storms and hurricanes for Barnstable County

B3a

Impact

The National Hurricane Center describes the types of damages that a community could experience during a Category 1-5 storm.[14]

CATEGORY 1: 74-95 mph 1 minute sustained winds

- **Impact to People/Pets/Livestock:**
  - Could result in injury or death from flying or falling debris.
- **Impact to Frame Homes:**
  - Some poorly constructed frame homes can experience major damage, involving loss of the roof covering, damage to gable ends, removal of porch coverings and awnings.
  - Unprotected windows may break if struck by flying debris.
  - Masonry chimneys can be toppled.
  - Well-constructed frame homes could have damage to roof shingles, vinyl siding, soffit panels and gutters.
  - Failure of aluminum, screened-in, swimming pool enclosures can occur.
- **Impact to Apartments, Shopping Centers, and Industrial Buildings**
  - Some apartment building and shopping center roof coverings could be partially removed.
  - Industrial buildings can lose roofing and siding especially from windward corners, rakes and eaves.
  - Failures to overhead doors and unprotected windows will be common.
- **Impacts to Signage, Fences and Canopies:**
  - There will be occasional damage to commercial signage, fences and canopies.
- **Impacts to Trees:**
  - Large branches will snap.
  - Shallow-rooted trees will be toppled.
- **Impacts to Power and Water Infrastructure:**
  - Extensive damage to power lines and poles will likely result in power outages that could last a few to several days.

CATEGORY 2: 96-110 mph 1 minute sustained wind

- **Impact to People/Pets/Livestock:**
  - There is substantial risk of injury or death due to flying or falling debris.
- **Impact to Frame Homes:**

14 National Hurricane Center Outreach and Education, Saffir-Simpson Hurricane Wind Scale Extended Table, http://www.nhc.noaa.gov/aboutsshws.php

- Poorly constructed frame homes have a high chance of having their roof structures removed especially if they are not anchored properly.
- Unprotected windows will have a high probability of being broken by flying debris.
- Well-constructed frame homes could sustain major roof and siding damage.
- Failure of aluminum, screened-in, swimming pool enclosures will be common.

- **Impact to Apartments, Shopping Centers, and Industrial Buildings**
  - There will be a substantial percentage of roof and siding damage to apartment buildings and industrial buildings.
  - Unreinforced masonry walls can collapse.
- **Impacts to Signage, Fences and Canopies:**
  - Commercial signage, fences, and canopies will be damaged and often destroyed.
  - Impacts to Trees:
  - Many shallow-rooted trees will be snapped or uprooted.
  - Roads will be blocked by toppled trees.
- **Impacts to Power and Water Infrastructure:**
  - Near total power loss is expected with outages that could last from several days to weeks.
  - Potable water could become scarce as filtration systems begin to fail.

CATEGORY 3: 111-129 mph 1-minutes sustained wind

- **Impact to People/Pets/Livestock:**
  - There is high risk of injury or death due to flying and falling debris.
- **Impact to Frame Homes:**
  - Poorly constructed frame homes can be destroyed by the removal of the roof and exterior walls.
  - Unprotected windows will be broken by flying debris.
  - Well-built frame homes can experience major damage involving the removal of roof decking and gable ends.
- **Impact to Apartments, Shopping Centers, and Industrial Buildings**
  - There will be a high percentage of roof coverings and siding damage to apartment and industrial buildings.
  - Isolated structural damage to wood or steel framing can occur.
  - Complete failure of older metal buildings is possible.

- Older unreinforced masonry buildings can collapse.

- **Impacts to Signage, Fences and Canopies:**
  - Most commercial signage, fences, and canopies will be destroyed.
- **Impacts to Trees:**
  - Many trees will snap or become uprooted.
  - Numerous roads will be blocked.
- **Impacts to Power and Water Infrastructure:**
  - Electricity and water will be unavailable for several days to a few weeks after the storm passes

CATEGORY 4: 130-156 mph 1-minute sustained wind

- **Impact to People/Pets/Livestock:**
  - There is a very high risk of injury or death due to flying and falling debris.
- **Impact to Frame Homes:**
  - Poorly constructed homes can sustain complete collapse of all walls as well as the loss of the roof structure.
  - Well-built homes also can sustain severe damage with loss of most of the roof structure and/or some exterior walls.
  - Extensive damage to roof coverings, windows, and doors will occur. Large amounts of wind-borne debris will be lofted into the air.
  - Wind-borne debris will break most unprotected windows and penetrate some protected windows.
- **Impact to Apartments, Shopping Centers, and Industrial Buildings:**
  - There will be a high percentage of structural damage to the top floors of apartment buildings.
  - Steel frames in older industrial buildings can collapse.
  - There will be a high percentage of collapse to older unreinforced masonry buildings.
- **Impacts to Signage, Fences and Canopies:**
  - Nearly all commercial signage, fences, and canopies will be destroyed.
- **Impacts to Trees:**
  - Most trees will snap or become uprooted.
  - Power poles will be downed.
  - Numerous roads will be blocked.
  - Fallen trees and power poles will isolate residential areas.

- **Impacts to Power and Water Infrastructure:**
  - Power outages will last for weeks to possibly months.
  - Long term shortages will increase human suffering.
  - Most of the area will be uninhabitable for weeks to months.

CATEGORY 5: 157 mph or higher 1-minute sustained wind

- **Impact to People/Pets/Livestock:**
  - There is a very high risk of injury or death due to flying and falling debris even if indoors in mobile or framed homes.
- **Impact to Frame Homes:**
  - A high percentage of frame homes will be destroyed, with total roof failure and wall collapse.
  - Extensive damage to roof covers, windows, and doors will occur.
  - Large amounts of wind-borne debris will be lofted into the air.
  - Wind-borne debris damage will occur to nearly all unprotected windows and many protected windows.
- **Impact to Apartments, Shopping Centers, and Industrial Buildings:**
  - Significant damage to wood roof commercial buildings will occur due to loss of roof sheathing.
  - Complete collapse of many older metal buildings can occur.
  - Most unreinforced masonry walls will fail, which can lead to building collapse.
  - A high percentage of industrial buildings and low-rise apartment buildings will be destroyed.
- **Impacts to Signage, Fences and Canopies:**
  - Nearly all commercial signage, fences, and canopies will be destroyed.
- **Impacts to Trees:**
  - All trees will snap or become uprooted.
  - All power poles will be downed.
  - Fallen trees and power poles will isolate residential areas.
- **Impacts to Power and Water Infrastructure:**
  - Power outages will last for weeks to possibly months.
  - Long term shortages will increase human suffering.
  - Most of the area will be uninhabitable for weeks to months.

B2b

Probability

The Planning Team determined that it is **HIGHLY LIKELY** that a hurricane or tropical storm will impact the planning area. High probability was defined based on the frequency of occurrence:

- **Unlikely:** less than a 1% probability over the next 100 years
- **Possible:** 1-10% probability in the next year or at least one chance in the next 100 years
- **Likely:** 10-100% probability in the next year or at least one chance in the next 10 years
- **Highly Likely:** near 100% probability in the next year

The Planning Team used the history of tropical cyclones in Barnstable County and local knowledge to make this probability designation.

Landslides

Overview

A landslide is a general term used to describe the downslope movement of soil, rock and organic materials under the effect of gravity.[15]

Below is a list of the most common causes of landslides in Massachusetts[13]:

- **Water saturation** on a slope occurs after intense rainfall, snow melt, changes in level of groundwater and water level changes along coasts and banks. Water from a rain event adds weight to the slope and reduces the strength of slope materials.
- **Undercutting of slopes by flooding and wave action** occurs when streams and waves erode the base of slopes, causing them to over-steepen and eventually collapse. Areas where this type of failure occurs includes Cape Cod, Nantucket and Martha's Vineyard.[13]
- **Construction related failures** occur during construction activities such as cut and fill construction for highways and roads and when vegetation on a slope is removed during the

15 The Landslide Handbook – A Guide to Understanding Landslides USGS Circular 1325, 2008

construction of buildings. These activities can increase slope angle and decrease lateral support which can sometimes lead to landslide.[16]

B1c

Hazard Location

Landslides occur in every state in the U.S., but the majority of Massachusetts has a low incidence of landslides. In Truro, the risk of flooding and loose soils could result in a landslide in the planning area.

B1c, B2a,c

Previous Occurrences and Extent

There have been no federally declared landslide disasters in Massachusetts from 1954 to 2012. To date, there have been no significant landslides in Truro.

Based on reports from the USGS website, the extent of a landslide is quantified as the estimated amount of material in cubic yards that was deposited from a higher elevation. There is no history of a landslide in Truro, therefore there is no data on the worst conditions experienced in Truro from a landslide.

B3a

Impact

Below is a list of possible impacts that could result from a landslide.

- **People:** people, cars and homes can become buried, delays in emergency services, isolated residents
- **Infrastructure:** damaged power lines
- **Buildings:** unstable foundations of structures, damage and destruction to buildings because of the movement of sediment and flooding
- **Economy:** isolated businesses
- **Natural Systems:** downed trees, decreased water quality
- **Transportation:** road closures, damage to road segments and/or culverts, transportation delays because of blocked access to roadways

Probability

B2b

The Planning Team determined that it is **POSSIBLE** that a landslide will impact the planning area. Probability was defined based on the frequency of occurrence:

- **Unlikely:** less than a 1% probability over the next 100 years
- **Possible:** 1-10% probability in the next year or at least one chance in the next 100 years
- **Likely:** 10-100% probability in the next year or at least one chance in the next 10 years
- **Highly Likely:** near 100% probability in the next year

16 Landslide Loss Reduction: A Guide for State and Local Government Planning, FEMA-182, 1989

The Planning Team used the history of flooding and the presence of loose soils to make this probability determination.

Nor'easters

Overview

A nor'easter is a cyclonic storm that forms outside of the tropics and moves along the east coast of North America.[17] It is called a nor'easter because the winds over coastal areas blow from a northeasterly direction. These storms usually develop between Georgia and New Jersey within 100 miles of the coastline and then move north or northeastward. Once these storms reach New England, they usually become more intense. These storms can occur at any time of year but are most frequent between September and April. The years with the most nor'easters tend to coincide with El Niño events.[18]

The east coast of North America provides an ideal breeding ground for nor'easters.[17] During the winter, the polar jet stream transports cold Arctic air southeast across Canada, the United States and the Atlantic Ocean. In addition, warm air from the Gulf of Mexico and the Atlantic moves northward, keeping the coastal waters relatively mild during the winter. This difference in temperature between the warm air over the water and cold Arctic air over the land is the area where nor'easters are born.

Nor'easters bring heavy rain and snow, gale force winds, rough seas, coastal flooding and can cause beach erosion. Sustained wind speeds of 20-40 mph are common during a nor'easter with short-term wind speeds gusting up to 50-60 mph.[13] Wind gusts associated with these storms can exceed hurricane force in intensity. Nor'easters are notorious for producing heavy snow, rain, and oversized waves that crash onto Atlantic beaches, often causing beach erosion and structural damage. Nor'easters may also sit stationary for several days, affecting multiple tide cycles and producing extended periods of heavy precipitation. The level of damage in a strong hurricane is often more severe than a nor'easter, but historically Massachusetts has suffered more damage from nor'easters because of the greater frequency of these coastal storms (one or two per year).

Traditionally, nor'easters are not given names like hurricanes and tropical storms. This changed recently as a result of The Weather Channel adopting a naming protocol in 2012 that gained popularity in defining storm systems. Nor'easters do not have their own categorization scheme; instead aspects of a nor'easter are categorized. For example, the Beaufort Scale is used to categorize the wind speed of a nor'easter (small craft

17 NOAA: Know the dangers of nor'easters, http://www.noaa.gov/features/03_protecting/noreasters.html

advisory, gale warning, storm warning, hurricane force wind warning) and the Regional Snowfall Index is used to categorize snowfall during a nor'easter.

B1c

Hazard Location

Coastal areas of Truro are susceptible to damages from wind, snow and surge during a nor'easter. However, it is also important to note that nor'easters can also bring heavy snow and flooding to the entire planning area.

B1c, B2a,c

Previous Occurrences and Extent

Since nor'easters are not categorized like Hurricanes and Tropical Storms, it is difficult to track their history. Also, it is important to note that hurricanes and tropical storms can transform into nor'easters,[18] making it especially difficult to track the history of nor'easters in a particular area.

The following is a list of some of the nor'easters that affected Barnstable County, but it is not a complete list because of the reasons mentioned above[13]:

- **February 1978:** this blizzard/nor'easter produced 8-12 inches of snow as well as ice and flooding and 92 mph winds in Chatham. It damaged buildings and infrastructure across Barnstable County including battering the bathhouse and parking lot at Coast Guard Beach in Eastham; waves flooded and flattened dunes on barrier beaches in Chatham, Eastham and Orleans; Monomoy Island off of Chatham split in several places; homes were destroyed; the Outer Cape was an island for a few hours when a 16-foot storm tide flooded Route 6 at Fort Hill with three feet of water; Bridge Road flooded in Eastham.[18] This event resulted in a federal disaster declaration (FEMA DR-546).
- **October-November 1991:** This large nor'easter was an unusual event because it moved south and strengthened when it joined with Hurricane Grace – producing what some would call the "Perfect Storm." Winds measured over 80 mph with waves over 30 feet high in some parts of the coastline. This event resulted in a federal disaster declaration (FEMA DR-920).
- **December 1992:** A strong nor'easter affected the Commonwealth from December 11 to 13, 1992. Impacts included deep and intense snowfall, freezing rain, heavy rainfall near the coast, coastal flooding and damaging winds. The weight of the snow taxed snow removal equipment in many communities and caused roof damage. Precipitation totals for this storm were extraordinary. Much of southern New England received up to 5 inches of liquid equivalent precipitation during a 2 to 3 day period, with locally close to 8 inches recorded in parts of southeast Massachusetts. Along coastal sections of Massachusetts, much of the precipitation fell as rain or rain/snow mix. This

18 "Storm of the Century" by Susan Milton, Cape Cod Times, reported in the February 3, 2008 issue

caused considerable ponding and localized flooding in poorly drained areas. The greatest damage from this storm was due to coastal flooding. Most east-facing shoreline communities from Chatham to Truro and Plymouth to the North Shore, as well as Nantucket Island, experienced some level of coastal flood damage. As much as 20 feet of dune was lost in Truro. Many coastal roads closed and docks and cottages were damaged.

- **March 1994:** A strong nor'easter passed to the southeast of Cape Cod, resulting in heavy snow and drifting snow. Over southeast Massachusetts, between three and six inches of snow fell before it changed to rain. Wind gusts of up to 40 and 60 mph resulted from this event and created snow drifts of up to three feet. Buildings were damaged, businesses and schools were closed, and road travel was disrupted.
- **January 22-23, 2005:** A major winter storm brought heavy snow, high winds, and coastal flooding to southern New England. In Massachusetts, blizzard conditions were reported on Nantucket. Near-blizzard conditions were reported in areas and brought between one and three feet of snow and produced wind gusts of up to 65 mph. The highest snowfall totals were reported in eastern Massachusetts (between two and three feet). Minor to moderate coastal flooding was observed around high tide in eastern Massachusetts coast. Roads were inundated and evacuations occurred.
- **April 2007:** an intense coastal storm brought rain and coastal/inland flooding to eastern Massachusetts. The storm was primarily a rain event due to warmer temperatures. For this Patriot's Day Storm, the surge peaked on a high tide on April 16, 2007 and the time period of one foot surge lasted more than four high tides (~47 hours). Major coastal flooding and storm damage resulted not only from the severity of the storm but also due to the timing of the Perigean spring tides. The 2007 nor'easter hit during highest predicted tide of the month which was also the top 0.2% of the year. This 2007 storm breached the barrier beaches at both Pleasant Bay on the Lower Cape and Katama Bay on Martha's Vineyard. While some breaches will close by themselves in a short amount of time, both of these 2007 breaches became new inlets for the bays.[19] This event resulted in a federal disaster declaration (FEMA DR-1701). Counties included in this disaster received over $8 million in public assistance from FEMA.
- **January 2015:** Winter storm Juno was a powerful nor'easter that impacted the northeast and New England.[19] Governor Baker declared a state of Emergency and issued travel bans in preparation for this storm; all shelters in Barnstable County were opened; transit and ferry services were

19 http://capeandislands.org/post/blizzard-2015-delivers-high-wind-more-snow-forecast

canceled; winds gusted to 75 mph; rain/snow mix transitioning to 15-18 inches of snow; thundersnow occurred in various regions across Cape Cod; storm surge and coastal flooding caused erosion in many areas on Cape Cod; Pilgrim Nuclear Power Station shutdown in response to degrading off-site electrical grid conditions; overwash at Ballston Beach in Truro; significant damage to coastal areas in Cape Cod National Seashore. This event resulted in a Federal Disaster Declaration (FEMA DR-4214).

Impact

B3a

Below is a list of possible impacts that could occur in Truro during a nor'easter:

- **People:** longer response time for emergency personnel; see also impact on people in the Flood Hazard Profile
- **Infrastructure:** damages to water infrastructure; utility outages
- **Buildings:** wind damage to buildings, see also damages to buildings in the Flood Hazard Profile
- **Economy:** loss of business function; damage to inventory; relocation costs; wage loss
- **Natural Systems:** snow and ice accumulation can negatively impact vegetation and natural habitat, downed trees and fallen branches; coastal landscape can be reshaped by storm surge
- **Transportation:** roadways can become impassable from storm surge and debris; culverts damaged from storm surge

Probability

B2b

The Planning Team determined that it is **HIGHLY LIKELY** that a nor'easter will impact the planning area. High probability was defined based on the frequency of occurrence:

- **Unlikely:** less than a 1% probability over the next 100 years
- **Possible:** 1-10% probability in the next year or at least one chance in the next 100 years
- **Likely:** 10-100% probability in the next year or at least one chance in the next 10 years
- **Highly Likely:** near 100% probability in the next year

The Planning Team used the history of nor'easters impacting Truro to make this probability designation.

High Winds

Overview

Wind is air in motion relative to the ground surface.[13] High winds can occur as an isolated event or it can accompany other weather events such as:

- before and after frontal systems
- hurricanes and tropical storms
- severe thunder and lightning storms
- tornadoes
- nor'easters

The National Weather Service issues warnings and advisories for high wind events as follows[13]:

- **Wind Advisory:** for non-tropical events over land, sustained winds of 31-39 mph for at least one hour or any gusts up to 46-57 mph
- **High Wind Warning:** for non-tropical events over land, sustained winds of 40-73 mph or any gusts 58+ mph
- **Small Craft Advisory:** for non-tropical events over water, sustained winds of 29-38 mph.
- **Gale Warning:** for non-tropical events over water, sustained winds of 39-54 mph
- **Storm Warning:** for non-tropical events over water, sustained winds of 55-73 mph
- **Hurricane Force Wind Warning:** for non-tropical events over water, sustained winds of 74+ mph
- **Tropical Storm Warning:** for tropical systems, any inland or coastal area with expected sustained winds from 39-73 mph
- **Hurricane Warning:** for tropical systems, any inland or coastal area with expected sustained winds of 74+ mph.

Hazard Location

B1c

FEMA compiled 40 years of tornado history and 100 years of hurricane history to generate a map of the frequency and strength of windstorms in the United States (***Figure 2.10***).

The map shows that Truro is located in Wind Zone II with maximum wind speeds of 160 mph. Since this map includes hurricane and tornado winds, it does not capture wind advisories, high wind warnings, small craft advisories, and gale warnings; it generalizes data at the local level.

The planning team decided that the entire planning area is vulnerable to high winds, especially the coastline of Truro.

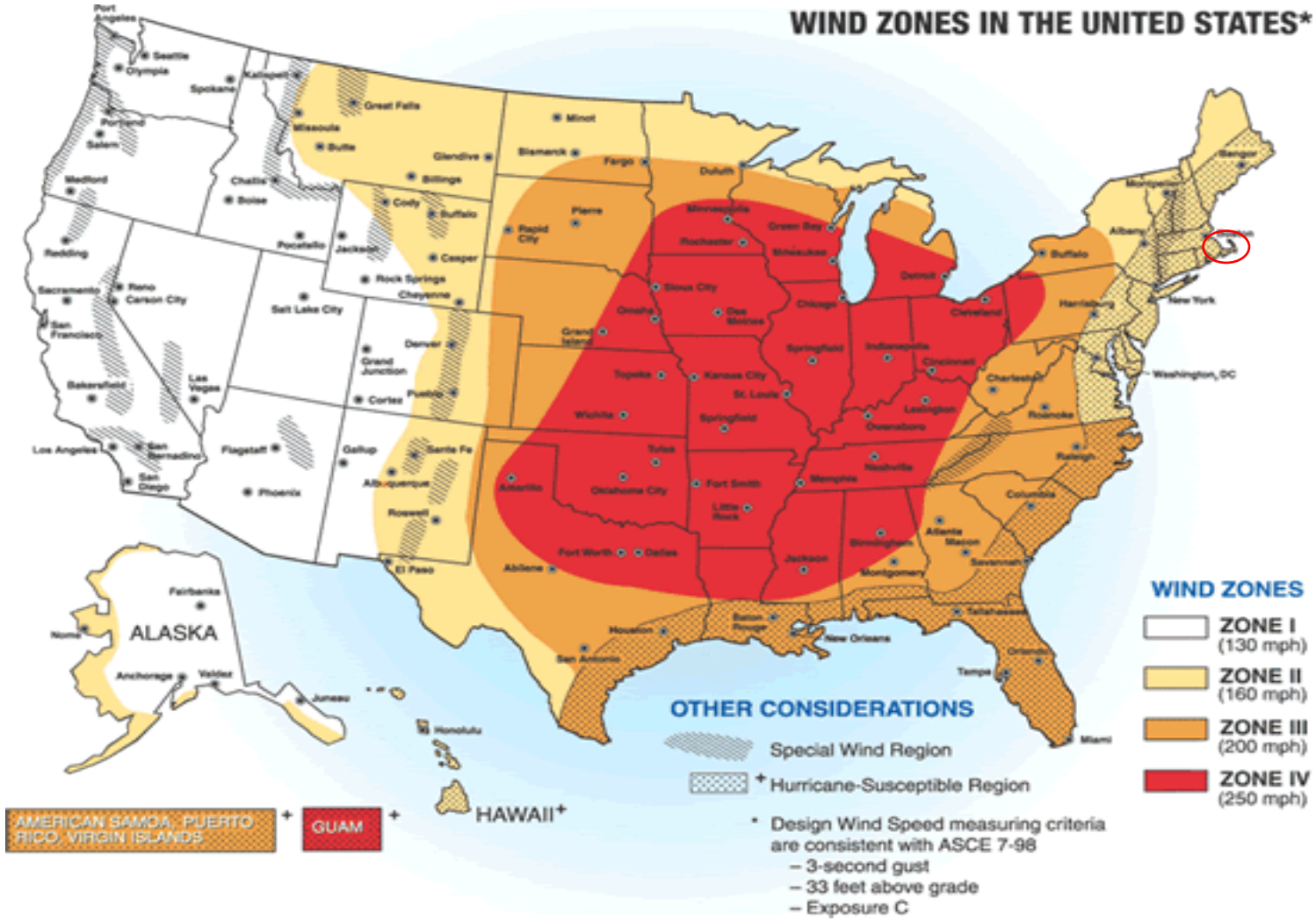


Figure 2.10 | Map of frequency and strength of windstorms in the United States. Planning area is highlighted with a red circle. Map is from the 2013 Massachusetts State Hazard Plan.

B1c, B2a,c

Previous Occurrences and Extent

According to the NOAA National Climatic Data Center (NCDC), Barnstable County experienced the following wind events between January 1, 1950 and July 21, 2015:

- **71 days of High Wind**
- **28 days of Thunderstorm Wind**

B2c

However, specific information on the extent of these NCDC wind events in Truro is not available.

B3a

Impact

The following damages can result from high wind events.

- **People:** power outages can affect vulnerable populations especially if outages occur during the winter months
- **Infrastructure:** downed power lines, power outages (wind gusts of only 40 to 45 mph have caused scattered power outages from downed trees and wires), high wind events can generate rough seas which can cause damage to coastal infrastructure
- **Buildings:** damage to roofs, windows
- **Economy:** loss of power can cause businesses to close temporarily until power is restored
- **Natural Systems:** downed trees and branches

B2b

Probability

The Planning Team determined that it is **HIGHLY LIKELY** that a high wind events will impact the planning area. High probability was defined based on the frequency of occurrence:

- **Unlikely:** less than a 1% probability over the next 100 years
- **Possible:** 1-10% probability in the next year or at least one chance in the next 100 years
- **Likely:** 10-100% probability in the next year or at least one chance in the next 10 years
- **Highly Likely:** near 100% probability in the next year

The Planning Team used Truro's history of high wind, hurricanes/tropical storms, and nor'easters as well as the town's proximity to the ocean to make this probability determination.

Thunderstorms

Overview

A thunderstorm is a storm that produces lightning and thunder and is usually accompanied by gusty winds, heavy rain and sometimes hail.[13] The National weather service considers a thunderstorm to be severe if it produces any of the following: hail at least one inch in diameter, winds of 58+ mph or a tornado.

Three basic "ingredients" are required for the formation of a thunderstorm: moisture that forms clouds and rain, unstable air that rises rapidly and lift caused by cold or warm fronts, sea breezes or heat from the sun. The following is a description of the formation of thunderstorms.[20] The rising air in a thunderstorm cloud causes various types of frozen precipitation to form within the cloud (i.e. small ice crystals, snow and ice pellets, and water pellets). The smaller ice crystals are carried upward toward the top of the clouds by the rising air while the denser ice pellets are either suspended by the rising air or start falling towards the ground. Collisions occur between the ice crystals and the pellets and these collisions serve as the charging mechanism for the thunderstorm. The small ice crystals become positively charged while the pellets become negatively charged. As a result, the top of the cloud becomes positively charged and the middle to lower part of the cloud becomes negatively charged. When the charge difference between the ground and the cloud becomes large, a charge starts moving toward the ground and a powerful discharge occurs between the cloud and the ground (***Figure 2.11***).

This discharge is seen as a bright, visible flash of lightning. The channel of air through which lightening passes can be heated to 50,000°F. The rapid heating and cooling of the air near this lightning channel causes a shock wave that results in the sound of thunder. Compared to hurricanes and winter storms, thunderstorms affect a relatively small area. The typical thunderstorm is 15 miles in diameter and lasts on average for 30 minutes.[21]

Hazard Location

B1c

According to a map presented in the Massachusetts State Hazard Plan, Barnstable County experiences about approximately 20 thunderstorm days per year (see ***Figure 2.12***).

Previous Occurrences and Extent

B1c, B2a,c

Using local knowledge, the Planning Team concluded that at least 1-2 thunderstorms occur every year in Truro. However, data on these storm events are not consistently recorded at the local level. The thunderstorm profile relies on data from the NOAA National Climatic Data Center (NCDC) but this website does not have searchable data at the town level

The following is a list of historical thunderstorms that occurred on Cape Cod; although it is not a complete list:

- **August 19, 2008:** A cold front moved through Southern New England producing showers and thunderstorms that became severe as they moved

20 Thunderstorms, Tornadoes, Lightning: Nature's Most Violent Storms, A Preparedness Guide, US Department of Commerce, NOAA, and the National Weather Service.

through the Commonwealth. Large hail and damaging winds affected Cape Cod. Trees were downed by thunderstorm winds.

- **August 4, 2015:** A line of thunderstorms developed across Long Island, NY and raced towards RI and southeastern MA. These storms caused significant wind damage knocking down a significant number of trees.

B3a

Impact

Below is a list of impacts that could occur during a Thunderstorm:

- **People:** power outages can affect vulnerable populations especially if outages occur during the winter months, injury or death can occur because people are often caught outdoors during a thunderstorm and do not have enough time to run inside, people can become stuck if area flooding occurs
- **Infrastructure:** downed power lines and power outages, heavy rain associated with a thunderstorm can overwhelm drainage systems, causing area flooding and property destruction
- **Buildings:** damage to roofs and windows, heavy rain associated with a thunderstorm can overwhelm drainage systems, causing area flooding and property destruction, lightning strikes can cause buildings to catch on fire
- **Economy:** loss of power can cause businesses to close temporarily until power is restored; lightning strikes are possible during thunderstorm events which can cause economic loss to businesses
- **Natural Systems:** downed trees and branches

Figure 2.11 | Schematic of how lightning develops. From Thunderstorms, Tornadoes and Lightning: Nature's Most Violent Storms

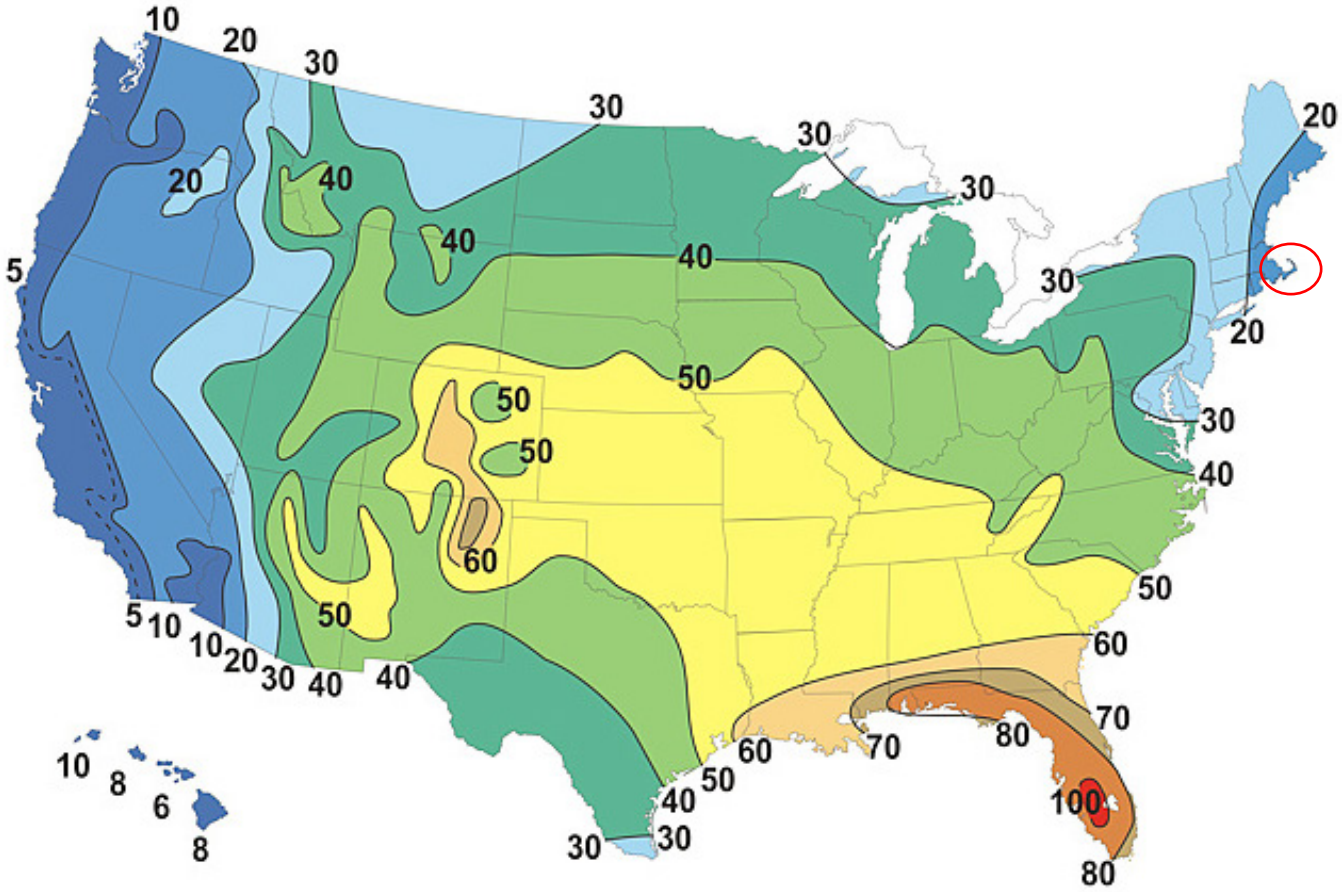


Figure 2.12 | Map of the average number of thunderstorms per year in the United States. Planning area is highlighted with a red circle. Map is from the 2013 Massachusetts State Hazard Plan

B2b

Probability

The Planning Team determined that it is **LIKELY** that thunderstorms will impact the planning area. High probability was defined based on the frequency of occurrence:

- **Unlikely:** less than a 1% probability over the next 100 years
- **Possible:** 1-10% probability in the next year or at least one chance in the next 100 years
- **Likely:** 10-100% probability in the next year or at least one chance in the next 10 years
- **Highly Likely:** near 100% probability in the next year

The Planning Team used Truro's history of thunderstorms and the town's proximity to the ocean to make this probability determination.

Extreme Temperatures

Overview

Extreme temperatures are defined as temperatures that are far outside the normal ranges for the season in a specific area. Extreme cold events occur when temperatures drop well below normal in an area. Extreme cold temperatures are generally characterized in temperate zones by the ambient air temperature dropping to approximately 0°F or below. Excessive summer temperatures are often identified as the number of days with maximum temperatures greater than or equal to 90°F and greater than or equal to 100°F.

Hazard Location

B1c

The entire planning area is vulnerable to extreme temperatures.

Previous Occurrences and Extent

B1c, B2a,c

According to NOAA's National Climatic Data Center (NCDC), the following extreme heat and extreme cold events were reported for Barnstable County between January 1, 1950 and July 31, 2015:

- **August 22, 2011:** Extreme heat event. A strong upper level ridge brought very hot temperatures to Southern New England and increased humidity levels such that heat index values rose above 105

degrees for a period of a few hours. The Automated Weather Observation System at Coast Guard Air Station Cape Cod (KFMH) near Falmouth, recorded heat indexes of 105 over a three hour period. The Automated Weather Observation System at Provincetown Municipal Airport (KPVC) also recorded heat indexes of 105 during this time frame.

B3a

Impact

Below is a list of possible impacts that could occur during extreme temperature events[13]:

- **People:** children and elderly are particularly at risk to health problems associated with extreme temperature; heat-induced illness such as sunburn, heat cramps, heat exhaustion and heat stroke; cold-induced illness such as frost bite and hypothermia; air quality can be affected during extreme heat events which can cause health hazards; residents can be displaced if warming/cooling centers are opened during extreme temperature events
- **Infrastructure:** power failure; salt water freezes in bays/harbors and can damage coastal infrastructure; extreme temperatures can cause school closings
- **Buildings:** in extreme cold temperature, urban fire risk increases as people often use space heaters, generators and candles to stay warm
- **Economy:** extreme cold temperatures can inhibit fishing operations and the transport of goods and services
- **Natural Systems:** saltwater freezing can occur in coastal bays and harbors
- **Transportation:** icy roads make travel difficult

Probability

B2b

The Planning Team determined that it is **POSSIBLE** that extreme temperatures will impact the planning area. Probability was defined based on the frequency of occurrence:

- **Unlikely:** less than a 1% probability over the next 100 years
- **Possible:** 1-10% probability in the next year or at least one chance in the next 100 years
- **Likely:** 10-100% probability in the next year or at least one chance in the next 10 years
- **Highly Likely:** near 100% probability in the next year

The Planning Team used Truro's history of extreme temperatures in town to make this probability determination.

Tornadoes

Overview

A tornado is a violently rotating column of air extending from a thunderstorm cloud to the ground.[21] Tornadoes are not always visible as funnel clouds because they are nearly translucent until they pick up dust and debris. The average tornado moves from southwest to northeast, but they can move in any direction and can suddenly change direction. The average speed of a tornado is 30 mph, but they can be stationary or move as fast as 70 mph. The strongest tornadoes have rotating winds of more than 200 mph.

Tornadoes can form from a variety of sources:

- accompany tropical storms and hurricanes as they move onto land
- form from individual cells within severe thunderstorms squall lines
- form from an isolated super-cell thunderstorm
- spawn from tropical cyclones or even their remnants that are passing through
- form when air converges and spins upward

B1c

Hazard Location

The entire planning area is vulnerable to tornadoes, especially the coastline. Compared to the rest Massachusetts, Barnstable County has a very low tornado density, defined as the number of tornadoes per 20 square miles[13] (***Figure 2.13)***.

Previous Occurrences and Extent

B1c, B2a,c

According to the NOAA National Climatic Data Center, Barnstable County experienced the following tornado and waterspouts events between January 1, 1950 and July 21, 2015:

- **August 9, 1968:** F1 tornado was reported for Barnstable County. Many trees felled, destructive wind and hail, fruit and vegetable crops damaged, utility lines damaged, power outages, roof was lifted from a fruit stand (account taken from NCDC Storm data for August 1968)
- **August 22, 1977:** F1 tornado was reported for Barnstable County, a small tornado touched down in Yarmouth and destroyed an art gallery and signs on the street. It also picked up two buildings and two people were inside the building. Also, it spawned very large thunderstorms across Cape Cod.
- **August 20, 1997:** Showers developed during the afternoon in southeastern Massachusetts and these went on to produce three waterspouts, at least one confirmed weak tornado (F0) and numerous funnel clouds. The first waterspout occurred just east of the Sagamore Bridge, over Cape Cod Bay,

at 1:30 p.m. Another waterspout was reported just west of Bourne, over Buzzards Bay, at 3:20 p.m. Throughout the afternoon, there were numerous reports of funnel clouds, some of which appeared in newspaper photos and documented via amateur radio operators' videos. Many of the funnels came as far a half-way down before retreating up into the cloud. There were no reports of damage or injury as a result of these events.

According to the NOAA National Climatic Data Center (NCDC), there were no specific reports of tornadoes in Truro from 1950 to the July 31, 2015.

B3a

Impact

Below is the Fujita Tornado Damage Scale developed in 1971 by T. Theodore Fujita[21]:

- **Scale F0, <73 mph winds, light damage:** some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
- **Scale F1, 73- 112 mph winds, moderate damage:** Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.
- **Scale F2, 113- 157 mph winds, 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.
- **Scale F3, 158- 206 mph winds, 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.
- **Scale F4, 207-260 mph winds, devastating damage:** Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.
- **Scale F5, 261-318 mph winds, 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.

B2b

Probability

The Planning Team determined that it is **POSSIBLE** that a tornado will impact the planning area. Probability was defined based on the frequency of occurrence:

- **Unlikely:** less than a 1% probability over the next 100 years
- **Possible:** 1-10% probability in the next year or at least one chance in the next 100 years

21 NOAA's National Weather Service, Storm Prediction Center: http://www.spc.noaa.gov/faq/tornado/f-scale.html

Hazard Profiles

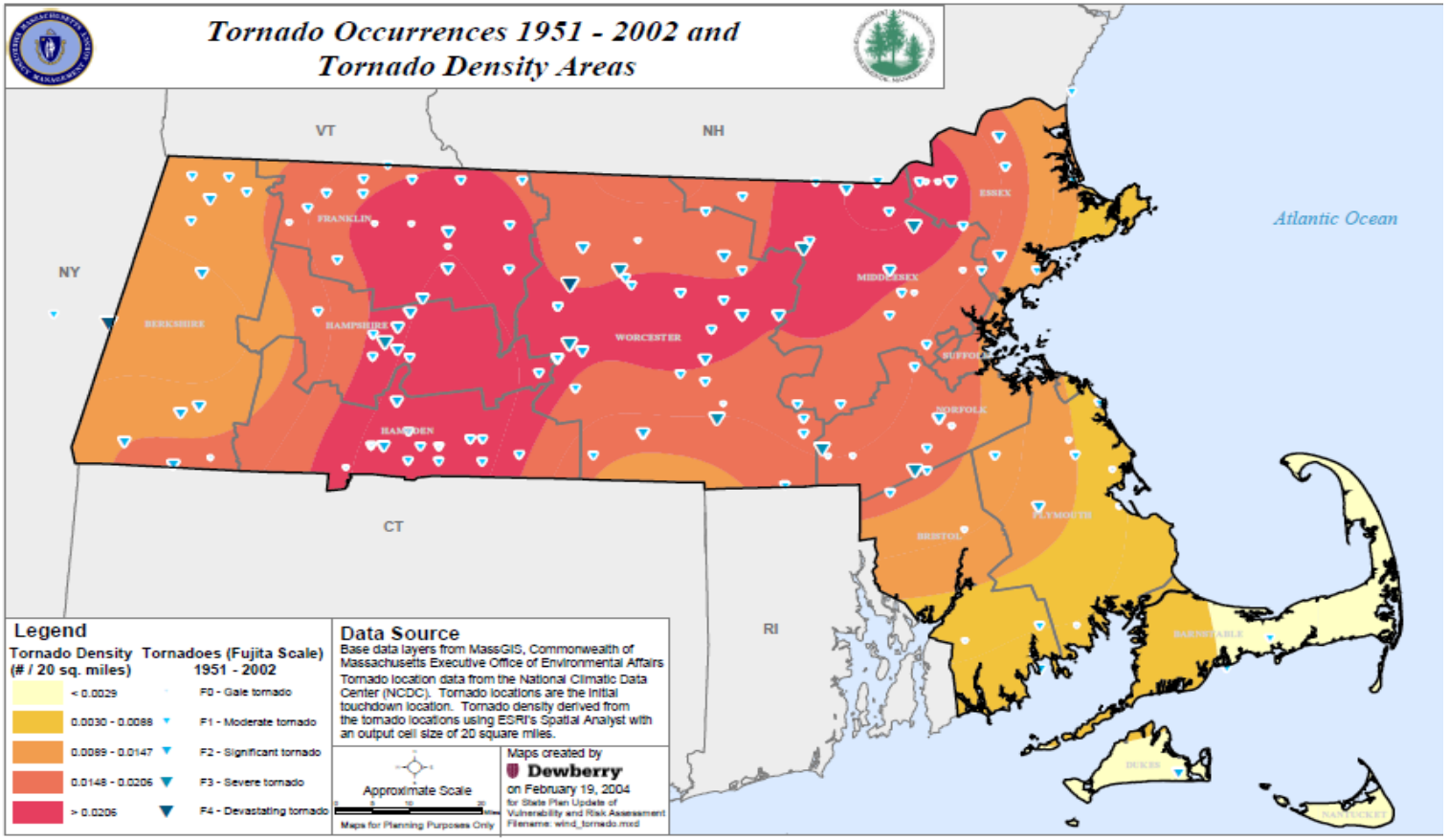


Figure 2.13 | Tornado occurrence and density for Massachusetts. Map is from the 2013 Massachusetts State Hazard Plan

- **Likely:** 10-100% probability in the next year or at least one chance in the next 10 years
- **Highly Likely:** near 100% probability in the next year

The Planning Team used Truro's propensity for tropical weather and Cape Cod's history of tornadoes to make this probability determination.

Drought

Overview

Drought is a period characterized by long durations of below normal precipitation.[13] Drought conditions occur in virtually all climatic zones yet its characteristics vary significantly from one region to another, since it is relative to the normal precipitation in that region.

B1c

Hazard Location

The entire planning area could be affected by drought. ***Figure 2.14*** shows how Barnstable County compares to the rest of the Commonwealth of Massachusetts for the number of months in a drought emergency per 100 years.

B1c, B2a,c

Previous Occurrences and Extent

According to the Massachusetts Drought Management Plan, a determination of drought level is based on seven indices:

- **Standardized Precipitation Index (SPI)** reflects soil moisture and precipitation conditions; calculated monthly using Massachusetts Rainfall Database at DCR, Office of Water Resources. SPI values are calculated for "look-back" periods of 1 month, 3 months, 6 months, and 12 months.
- **Crop Moisture Index (CMI)** reflects short-term soil moisture conditions as used for agriculture; available from the National Climate Data Center.
- **Keetch-Byram Drought Index (KBDI)** is designed specifically for fire potential assessment. The KBDI attempts to measure the amount of precipitation necessary to return the soil to full field capacity.
- **Precipitation Index** is a comparison of measured precipitation amounts (in inches) to historic normal precipitation. Cumulative amounts for 3-, 6-, and 12-month periods are factored into the drought determination.
- **Groundwater Level Index** is based on the number of consecutive months groundwater levels are below normal (lowest 25% of period of record for the respective months). The U.S. Geological Survey (USGS) monitors groundwater levels in a network of monitoring wells throughout Massachusetts.
- **Streamflows Index** is based on the number of consecutive months that streamflow levels are below normal (lowest 25% of period of record

Hazard Profiles

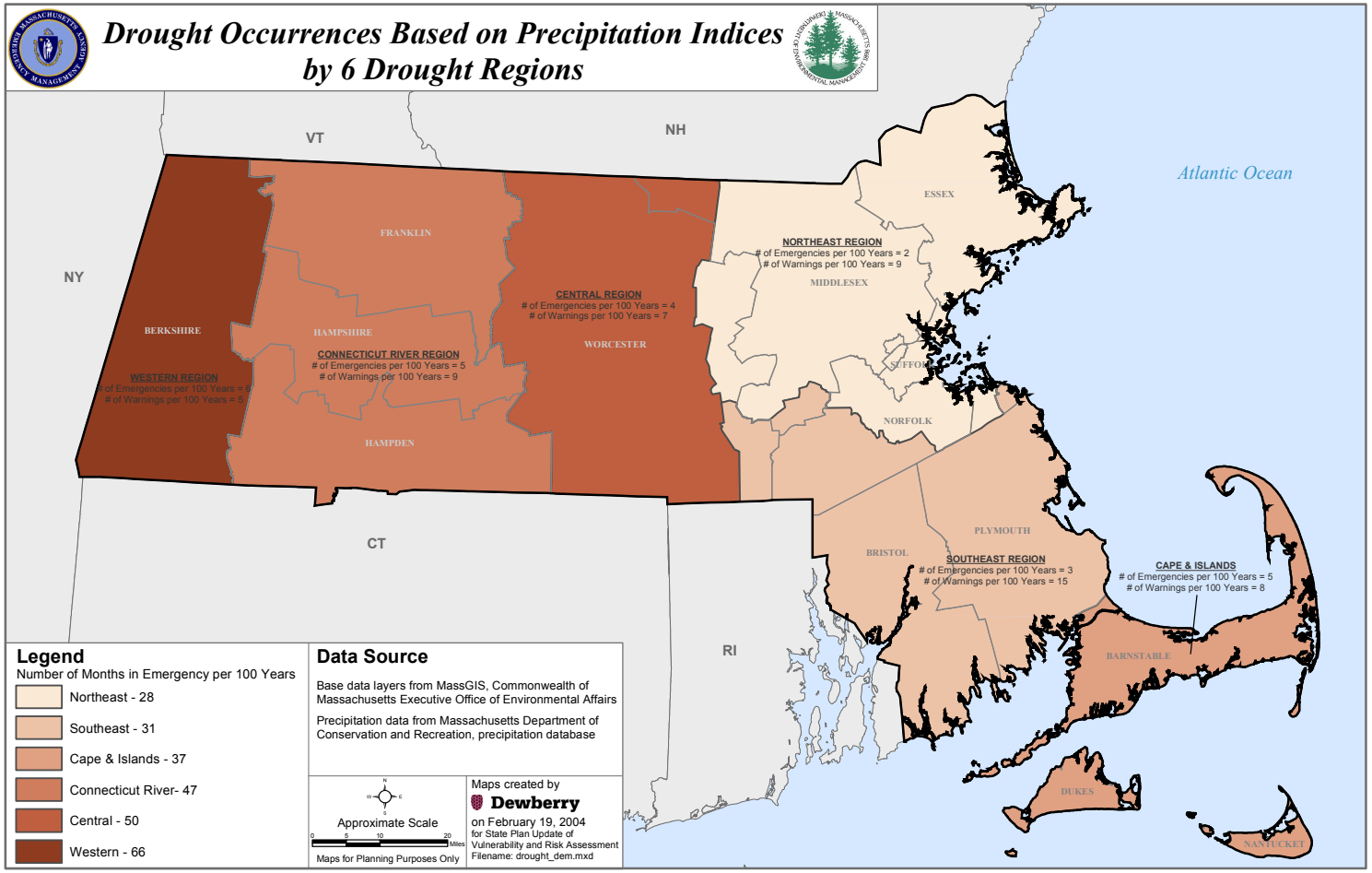


Figure 2.14 | Number of drought emergencies per 100 years for Massachusetts. Map is from the 2013 Massachusetts State Hazard Plan

for the respective months). The USGS monitors streamflow in a network of gages throughout Massachusetts.

- **Reservoir Index** is based on the water levels of small, medium and large index reservoirs across the state. The reservoir level relative to normal conditions for each month of the year will be considered. As part of its monthly conditions report, DCR, Office of Water Resources maintains a list of index water supply reservoirs and the percentage at which they are at capacity as well as non-water supply index reservoir levels, as available.

Using these indices, the Massachusetts Drought Management Plan uses five levels to characterize drought severity. (See ***Table 2.5***)

These drought levels are intended to provide information on the current status of water resources in distinct regions of Massachusetts (Western, Central, Connecticut River Valley, Northeast, Southeast and Cape and Islands). The levels provide a basic framework from which to take actions to assess, communicate, and respond to drought conditions. They begin with a normal situation where data are routinely collected and distributed, move to heightened vigilance with increased data collection during an advisory, to increased assessment and proactive education during a watch.

The following list of dates and drought levels/descriptions for Barnstable County was compiled from data in the Massachusetts State Hazard Mitigation Plan, US Drought Monitor website and the Department of Conservation and Recreation Drought Management website:

- **1991:** drought conditions in Barnstable County but no data is available on the Drought Level as described above. The observation well located in the vicinity of the Barnstable Airport set a record monthly low for two months. Local and state officials were concerned with water table levels primarily because of the impacts of low pond levels (i.e. Mary Dunn Pond) on wildlife and vegetation.
- **2001:** Drought Advisory in December
- **2002:** Drought Advisories and Watches from February to December
- **2012:** January to May of 2012 was the driest start to any year on record for the Commonwealth of Massachusetts, with only 6 inches of total precipitation. Most areas in southern New England were running 6-8 inches below normal. In April 2012, most of the Commonwealth was again under drought conditions that lasted until May 2012. Rivers and streams were most affected as most ran at record low levels during the spring run-off season. The main impact of the meteorological drought was periods of very high fire danger. In addition, small pond levels were reduced. While

Hazard Profiles

Drought Level	Standardized Precipitation Index	Crop Moisture Index*	Keetch-Byram Drought Index*	Precipitation	Groundwater	Streamflow	Reservoir***
Normal	3-month > -1.5 **or** 6-month > -1.0 **or** 12-month > -1.0	0.0 to -1.0 slightly dry	< 200	1 month below normal	2 consecutive months below normal**	1 month below normal**	Reservoir levels at or near normal for the time of year
Advisory	3-month = -1.5 to -2.0 **or** 6-month = -1.0 to -1.5 **or** 12-month = -1.0 to –1.5	-1.0 to -1.9 abnormally dry	200-400	2 month cumulative below 65% of normal	3 consecutive months below normal**	At least 2 out of 3 consecutive months below normal**	Small index Reservoirs below normal
Watch	3-month < -2.0 **or** 6-month = -1.5 to -3.0 **or** 12-month = -1.5 to -2.0	-2.0 to –2.9 excessively dry	400-600	1 of the following criteria met: 3 month cum. < 65% **or** 6 month cum. < 70% **or** 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
Warning	6-month < -3.0 **or** 12-month = -2.0 to -2.5	< -2.9 severely dry	600-800	1 of the following criteria met: 3 month cum. < 65% and 6 month cum. <65%, **or** 6 month cum. <65% and 12 month cum. <65%, **or** 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
Emergency	12-month < -2.5	<-2.9 severely dry	600-800	Same criteria as Warning and previous month was Warning or Emergency	>8 months below normal**	>7 months below normal**	Continuation of previous month's conditions

* The Crop Moisture Index is subject to frequent change. The drought level for this indicator is determined based on the repeated or extended occurrence at a given level.

** Below normal for groundwater and streamflow are defined as being within the lowest 25th percentile of the period of record.

*** Water suppliers should be consulted to determine if below normal reservoir conditions are due to operational issues.

Table 2.5 | Drought Indices as defined in the 2013 Massachusetts Drought Management Plan

soil moisture was well below normal, this drought occurred prior to the beginning of the growing season. Thus, no agricultural impacts were realized.

- **2014:** Drought Advisory in October

There is no data on the extent of drought for Truro specifically; all drought levels are reported at the County level.

B3a

Impact

The following is a list of impacts that are possible with drought[13]:

- **People:** migration from a community, increased conflicts between water users, reduction in drinking water, food shortages
- **Infrastructure:** reduced water levels, soil erosion
- **Buildings:** soil erosion could cause damage to foundations and buildings
- **Economy:** reduced crop yield, increased prices for food
- **Natural Systems:** increased fire hazard, damage to water quality, damage to wildlife and fish habitat, degradation of landscape quality, loss of biodiversity, soil erosion, loss of wetlands

B2b

Probability

The Planning Team determined that it is **POSSIBLE** that a drought will impact the planning area. Probability was defined based on the frequency of occurrence:

- **Unlikely:** less than a 1% probability over the next 100 years
- **Possible:** 1-10% probability in the next year or at least one chance in the next 100 years
- **Likely:** 10-100% probability in the next year or at least one chance in the next 10 years
- **Highly Likely:** near 100% probability in the next year

The Planning Team used Barnstable County's history of drought to make this probability designation.

Severe Winter Weather: Snow, Blizzards and Ice Storms

Overview

A winter storm occurs when there is significant precipitation during periods of low temperatures.[22] Winter storms typically occur from early autumn to late spring and can include any of the following events[13,23]:

- **Blizzards:** defined as winter storms with sustained or frequent wind gusts to 35 miles per hour or more, accompanied by falling or blowing snow that reduces visibility to or below one-quarter mile. Severe blizzards are defined as winter storms with temperatures near or below 10°F, winds exceeding 45 miles per hour and visibility near zero miles[13]
- **Blowing snow:** wind-driven snow that reduces visibility. Blowing snow may be falling snow and/or snow on the ground that is picked up by the wind
- **Snow squalls:** brief, intense snow showers accompanied by strong gusty winds. Snow accumulation may be significant
- **Snow showers:** snow falling at varying intensities for brief periods of time, some accumulation is possible
- **Snow flurries:** light snow falling for short durations with little to no accumulation
- **Ice pellets and sleet:** composed of frozen or mostly frozen raindrops or refrozen partially melted snowflakes. These pellets of ice usually bounce after hitting the ground or other hard surfaces. A Winter Storm Warning is issued for sleet or a combination of sleet and snow based on total accumulation which is locally defined by area.
- **Icing:** occurs when liquid rain falls and freezes on contact with structures and objects on the ground, causing a coating of ice on a solid object or surface
- **Coastal flooding:** winds generated from intense winter storms can cause widespread tidal flooding and severe beach erosion along coastal areas
- **Ice jams and floes:** long cold spells can cause rivers and lakes to freeze. A rise in the water level or a thaw breaks the ice into large chunks which become jammed at man-made and natural obstructions. Ice jams act as a dam, resulting as severe flooding
- **Snow melt:** sudden thaw of a heavy snow pack, often leads to flooding

There are many ways for winter storms to form; all have three key components: cold air, moisture and lift. (***Figure 2.15***).

22 How to Prepare for a Winter Storm, www.ready.gov/prepare

23 Winter Storms, The Deceptive Killers, A Preparedness Guide, U.S. Department of Commerce, NOAA, National Weather Service, American Red Cross, June 2008

There are many ways for winter storms to form; however, all three have key components.

COLD AIR: For snow and ice to form, the temperature must be below freezing in the clouds and near the ground.

MOISTURE: Water evaporating from bodies of water, such as a large lake or the ocean, is an excellent source of moisture.

LIFT: Lift causes moisture to rise and form clouds and precipitation. An example of lift is warm air colliding with cold air and being forced to rise. Another example of lift is air flowing up a mountainside.

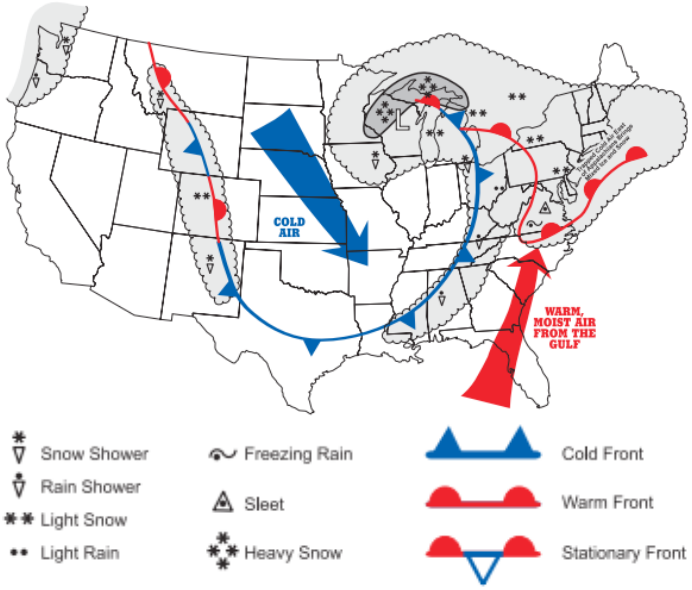


Figure 2.15 | How winter storms form[24]

Hazard Location

B1c

The entire planning area is at risk for snow, blizzards and ice storms. During these events, the coastline of Truro experiences higher snow accumulations and higher winds than other areas of town.

Previous Occurrences and Extent

B1c, B2a,c

Snow and other forms of winter precipitation occur frequently in Truro. The Northeast Regional Climate Center compiled normal 30-year average annual snow totals in New England and in the eastern U.S (***Figure 2.16)***. These maps show normal snow totals for Truro to be within 14-40 inches per year from 1971-2000 and from 1981-2010.[13]

Table 2.6 is a list of federally-declared disasters from winter storm events in Barnstable County. The Blizzard of 1978 crippled most of the Commonwealth of Massachusetts, including Barnstable County. This event included blizzard conditions, extreme snowfall, high winds and devastating coastal flooding. As stated in the Massachusetts Hazard Mitigation Plan, the worst conditions in this storm event were snowfall rates of at least 3 inches per hour, 1-3 feet of snowfall, zero visibility, wind peaked at 93 mph in Chatham, major coastal flooding occurred over multiple high tide cycle

Hazard Profiles

Major Disaster Declarations for Winter Storms in Barnstable County from 1954 - 2015

Number	Disaster Type	Incident period	Declaration Date
DR-546	coastal storms, flood, ice, snow	February 6 - 8, 1978	February 10, 1978
DR-975	winter coastal storm	December 11 - 13, 1992	December 21, 1992
EM-3103	blizzards, high winds and record snowfall	March 13-17, 1993	March 16, 1993
DR-1090	blizzard	January 7-13, 1996	January 24, 1996
EM-3175	snowstorm	February 17 - 18, 2003	February 11, 2003
EM-3191	snow	December 6 - 7, 2003	January 15, 2004
EM-3201	snow	January 22-23, 2005	February 17, 2005
DR-1701	severe storms, inland and coastal flooding	April 15 - 25, 2007	May 16, 2007
DR-4110	severe winter storm, snowstorm, flooding	February 8-10, 2013	April 19, 2013
DR-4214	severe winter storm, snowstorm, flooding	January 26 - 29, 2015	April 13, 2015

Table 2.6 | Major Disaster Declarations for Barnstable County for Winter Storms. Data is from the FEMA Disaster Declaration website and from the 2013 Massachusetts State Hazard Plan

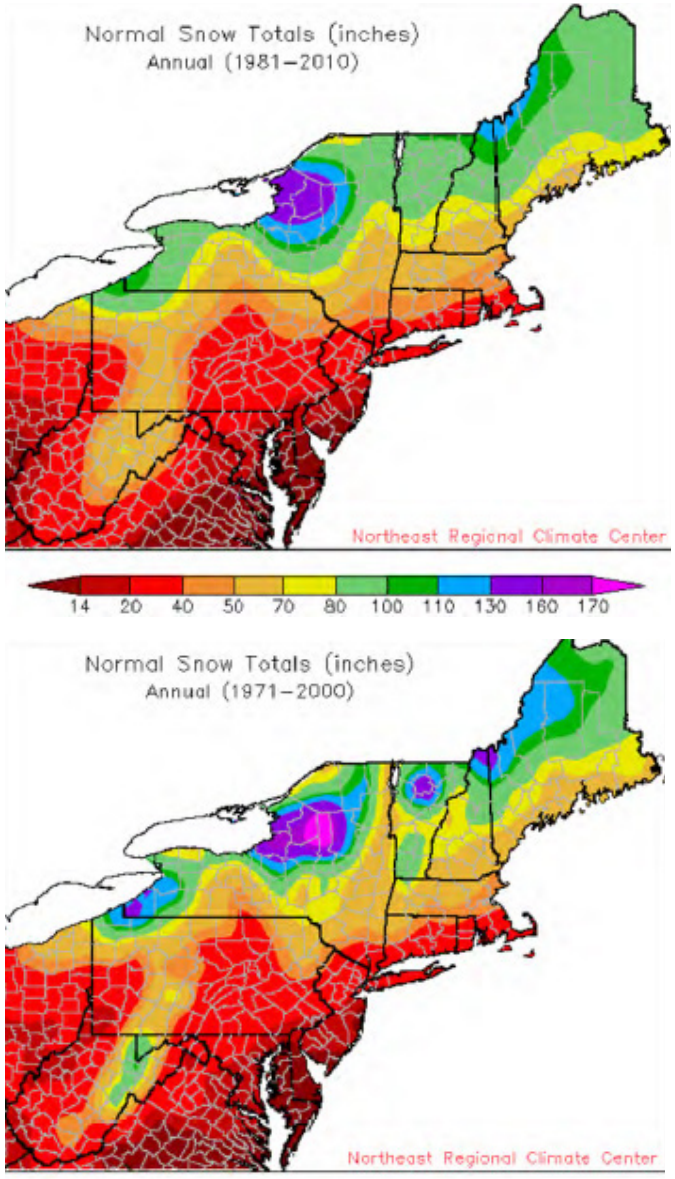


Figure 2.16 | Annual Snow Totals in inches from 1971-2000 (top) and 1981-2010 (bottom). Maps are from the 2013 Massachusetts State Hazard Plan

Impact

B3a

Below is a list of impacts likely to occur during a winter storm event[13.24]:

- **People:** walking and driving can become extremely hazardous due to icy conditions, snow accumulation, low visibility and extreme cold which causes people to shelter in place without utilities or other services until driving is safe or utilities are restored; injury from slipping and falling, overexertion during shoveling, frostbite; death from hypothermia, carbon monoxide poisoning (when gas powered furnaces and alternative heating sources are used inappropriately indoors during power outages); people become isolated in their homes
- **Infrastructure:** ice and heavy snowfall can knock out heating, power, and communication services for several hours or days; pipes and water mains may break due to extremely cold temperatures; large sections of ice can cause damage to floating docks
- **Buildings and Property:** structural failure of buildings due to heavy snow loads; roof failure; structural damage to buildings because of high wind; damage to fishing vessels, recreational boats and kayaks because of ice floes and coastal flooding
- **Economy:** as people are immobilized by the storm, they are unable to go to work, leading to economic

losses; excessive costs to the town and residents because of increased plowing, snow removal, salting and sanding

- **Transportation:** roadways can become extremely hazardous due to icy conditions, snow accumulation, low visibility and extreme cold; car accidents can occur if people attempt to travel in unsafe conditions; Transit and airport facilities will close temporarily because of severe winter weather; snow storms halt the transport of supplies, goods and services because of unsafe roadways

It is important to note that not all winter storms affecting Truro were declared federal disasters. Therefore, Truro likely experienced more severe winter weather than documented above.

B2b

Probability

The Planning Team determined that it is **HIGHLY LIKELY** that a winter storm (snow and blizzard) will impact the planning area. High probability was defined based on the frequency of occurrence:

- **Unlikely:** less than a 1% probability over the next 100 years
- **Possible:** 1-10% probability in the next year or at least one chance in the next 100 years
- **Likely:** 10-100% probability in the next year or at least one chance in the next 10 years
- **Highly Likely:** near 100% probability in the next year

The Planning Team used Truro's history of snow storms and blizzards to make this probability designation.

Tsunami

Overview

A tsunami is a series of traveling ocean waves of extremely long wavelength usually caused by displacement of the ocean flood, seismic or volcanic activity or underwater landslides. Tsunamis generate a devastating onshore surge of water.[13] 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.

Hazard Location

B1c

All of the coastal communities of Massachusetts are exposed to the threat of tsunamis, but at the present time, it is unknown what the probability is of a damaging tsunami along the Massachusetts coast.[13]

B1c, B2a,c

Previous Occurrences and Extent

According to the NOAA National Climatic Data Center, Barnstable County did not experience any tsunamis between January 1, 1950 and July 31, 2015.

The US Atlantic coast and Gulf Coast states have experienced six tsunamis in the last 200 years – only a total of six tsunamis have been reported[13]:

- Three tsunamis were generated in the Caribbean. Tsunamis are more likely to occur at convergent margins and there is a convergent plate in the Caribbean Sea. Thus, this area has a higher probability of generating earthquakes that could produce a tsunami.
- Two tsunamis were related to a magnitude 7+ earthquake along the Atlantic coast.
- One tsunami was reported off the mid-Atlantic states and may be associated with an underwater landslide.
- There is no data on the extent of these tsunamis for Barnstable County or Truro.

Impact

B3a

Below is a list of potential impacts of a tsunami:

- **People:** hydraulic forces of the tsunami injure people or lead to death, floating debris can endanger human lives, people and businesses will be without fuel, food or employment
- **Infrastructure:** floating debris can batter infrastructure, breakwaters and piers collapse, scouring actions sweep away infrastructure, oil fires often result because the waves carry away oil tanks therefore damaging infrastructure
- **Buildings:** hydraulic forces of the tsunami will destroy buildings, floating debris can batter inland structures, scouring actions sweep away buildings, oil fires often result because the waves carry away oil tanks therefore damaging buildings
- **Economy:** public utilities will be damaged and therefore the economy will suffer, especially for the fishing industry, disruption of coastal systems will have far-reaching economic effects
- **Natural Systems:** trees and plants are uprooted; animal habitats such as nesting sites for birds are destroyed. Land animals are killed by drowning and sea animals are killed by pollution if dangerous chemicals are washed away into the sea, thus poisoning marine life.
- **Transportation:** roads, bridges and culverts buckle or are swept away

B2b

Probability

The Planning Team determined that it is **unknown** and **UNLIKELY** that a tsunami will impact the planning area. Probability was defined based on the frequency of occurrence:

- **Unlikely:** less than a 1% probability over the next 100 years
- **Possible:** 1-10% probability in the next year or at least one chance in the next 100 years
- **Likely:** 10-100% probability in the next year or at least one chance in the next 10 years
- **Highly Likely:** near 100% probability in the next year

The Planning Team used the low frequency of tsunamis in Barnstable County to make this probability designation

Sea Level Rise

Overview

Sea level rise refers to the increase in mean sea level over time.[24] Relative sea level rise is a combination of eustatic and isostatic contributions:

- **Eustatic contributions to sea level rise** are global-scale changes and include thermal expansion of seawater as it warms and the addition of water volume from melting land-based glacial ice sheets.
- **Isostatic contributions to sea level rise** are more localized changes in land surface elevations, such as subsidence or sinking.

Sea level has been rising around the globe for thousands of years since the end of the last Ice Age. For a little over a century, tidal gauges and satellites have been measuring changes in sea level. Tide gauge stations measure the height of water referenced to a horizontal control point, or benchmark, and gauges are used to track and predict tide levels and longer term sea level. Long-term data sets from tide stations have been used to understand local and global sea level trends. The National Oceanic and Atmospheric Administration's (NOAA) Center for Operational Oceanographic Products and Services maintains several tide gauge stations across coastal Massachusetts, including long-term stations at Boston, Woods Hole and Nantucket. The sea level data recorded by NOAA and other tide gauges produce trends in relation to fixed reference levels on land, and therefore the data from these stations includes variation in local land elevations.

There is high confidence that the warming atmosphere associated with global climate change is expected to

24 Sea level rise: understanding and applying trends and future scenarios for analysis and planning, Massachusetts Office of Coastal Zone Management, December 2013

accelerate both the thermal expansion of seawater and the melting of glaciers and ice sheets and will lead to increasing rates of sea level rise.[26]

B1c

Hazard Location

The entire coast of Truro is vulnerable to sea level rise (***Figure 2.17a and b***).

In 2014, the Cape Cod Commission developed a bathtub model to visualize Cape Cod's vulnerability to sea level rise (see Sea Level Rise Viewer at www.capecodcommission.org/blackbox). The Sea Level Rise data was derived from classified Digital Elevation Model (DEM) data collected through Light Detection and Ranging (LiDAR) in 2011 by the USGS. The elevation data is accurate to 18 cm at a 95% confidence level with a 1 meter resolution. This elevation data was adjusted to Mean Higher High Water (MHHW) using the NOAA VDatum Software. The Sea Level Rise is shown as a simple representation of a change in elevation, commonly referred to as a "bathtub" model. No account has been made for the effects of velocity and resulting erosion caused by wave action.

Previous Occurrences and Extent

B1c, B2a,c

Mean sea level trends from the Boston, Woods Hole and Nantucket long-term stations are listed below[26]:

- **Boston, MA tide gauge station:**
  - 0.11 ± 07 inches per year, measured over the period of 1921-2012
  - Century rate at the Boston tide gauge: 0.92 feet per 100 years
- **Woods Hole, MA tide gauge station:**
  - 0.11 ± 07 inches per year, measured over the period of 1932-2012
  - Century rate at the Woods Hole tide gauge: 0.92 feet 100 years
- **Nantucket, MA tide gauge station:**
  - 0.14 ± 0.017 inches per year, measured over the period of 1965-2012
  - Century rate at the Nantucket tide gauge: 1.15 feet per 100 years

Impact

B3a

As relative sea level rises, high water elevations will move landward, areas of coastal shorelines will retreat, and low-lying areas will be increasingly exposed to erosion, tidal inundation, and coastal storm flooding. Developed parts of the coast are especially vulnerable because of the presence of infrastructure, homes and businesses

Hazard Profiles

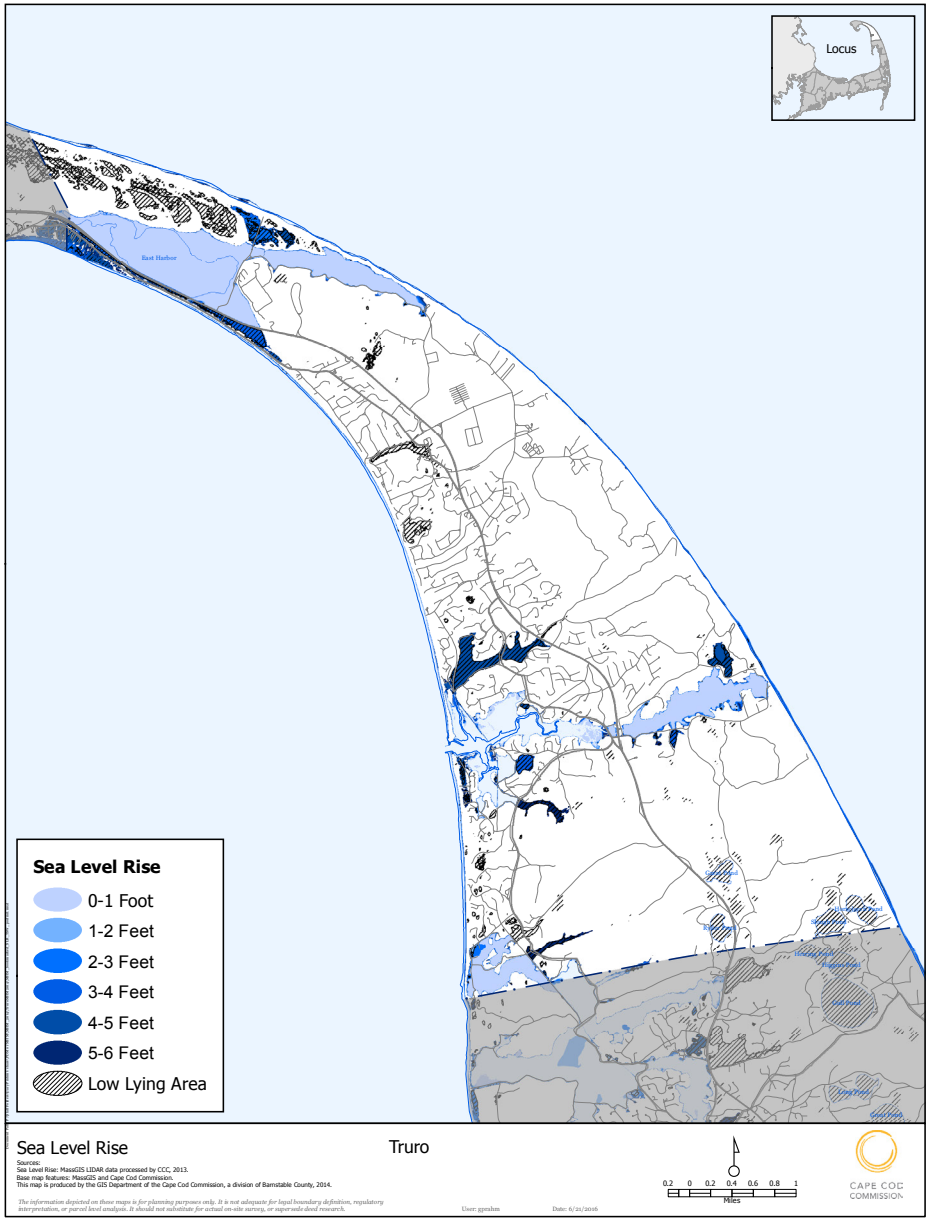


Figure 2.17a | Sea level rise maps for Truro

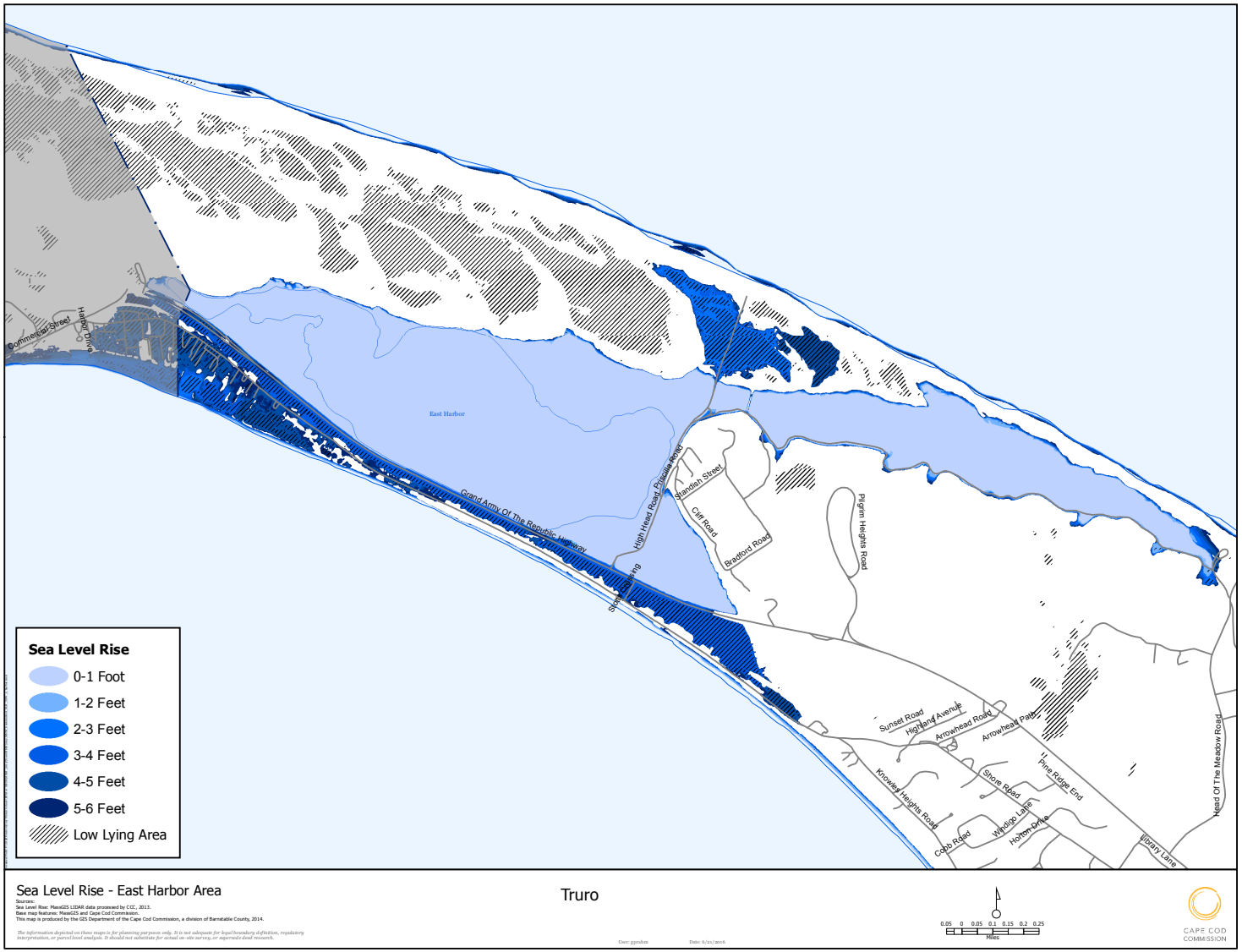


Figure 2.17a | Sea level rise map of East Harbor in the north part of Truro.

that can be damaged or destroyed by coastal storms. In addition, development often impedes the ability of natural coastal systems to buffer inland areas from storm damage, further exacerbating the problem. Many coastal habitats are also vulnerable to rising sea levels, including salt marshes, beaches and dune systems, and floodplains, because they are generally at or within a few feet of existing sea elevations. These areas provide significant environmental benefits, including habitat value, filtering of pollutants for improved water quality, protection of inland areas from flooding and storm surge, and extensive recreational opportunities.[26]

B2b

Probability

The Planning Team determined that it is **HIGHLY LIKELY** that sea level rise will impact the planning area. Probability was defined based on the frequency of occurrence:

- **Unlikely:** less than a 1% probability over the next 100 years
- **Possible:** 1-10% probability in the next year or at least one chance in the next 100 years
- **Likely:** 10-100% probability in the next year or at least one chance in the next 10 years
- **Highly Likely:** near 100% probability in the next year

The Planning Team used the history of sea level rise in Massachusetts to make this probability designation.

Climate Change

Climate is defined as average temperature and precipitation and it also includes the type, frequency, and intensity of weather events. Both globally and at the local scale, climate change has the potential to alter the prevalence and severity of extremes such as storms, including those which may bring precipitation, high winds, and tornado events. While predicting changes of storm events under a changing climate is difficult, understanding vulnerabilities to potential changes is a critical part of estimating future climate change impacts on human health, society, and the environment.[25]

The following changes in hazard frequency and intensity are expected to occur with changes in climate[13]:

Coastal Erosion: Climatic trends can change a beach from naturally accreting to eroding due to increased episodic erosion events caused by waves from an above-average number of storms and high tides, or the long-term effects of fluctuations in sea or lake level. The coastal zone is being severely impacted by erosion and flooding due in part to climate change and sea-level rise.

25 United States Environmental Protection Agency, 2006

It is likely that the impact will increase in the future as sea levels continue to rise at the current rate or rises at an accelerated rate.

Earthquakes: The impacts of global climate change on earthquake probability are unknown. Some scientists feel that melting glaciers could induce tectonic activity. As ice melts and water runs off, tremendous amounts of weight are shifted on the earth's crust. As newly freed crust returns to its original, pre-glacier shape, it could cause seismic plates to slip and stimulate volcanic activity according to research into prehistoric earthquakes and volcanic activity. NASA and USGS scientists found that retreating glaciers in southern Alaska might be opening the way for future earthquakes.

Fire: Climate change has the potential to affect multiple elements of the wildfire system: fire behavior, ignitions, fire management and vegetation fuels. Hot dry spells create the highest fire risk. Increased temperatures may intensify wildfire danger by warming and drying out vegetation. When climate alters fuel loads and fuel moisture, forest susceptibility to wildfires changes. Climate change also may increase winds that spread fires. Faster fires are harder to contain, and thus are more likely to expand into residential neighborhoods.

Flooding: While it is not known if the number of storms will increase in the future as the result of climate changes, it is anticipated that the intensity of tropical and extra-tropical storms may increase as the storm intensity is a function of sea surface temperature, which continue to rise. Thus, we may experience more intense storms with greater rainfall in the future.

Tropical Cyclones: Although there is still some level of uncertainty, research indicates the warming climate may double the frequency of Category 4 and 5 hurricanes by the end of the century, and decrease the frequency of less severe hurricane events.

Nor'easters and Winter Storms: Weather extremes are likely to become more frequent and cause more damage under a changing climate. Although no specific storm is directly linked to climate change, an increasing number of events could become more common. New England is expected to experience changes in the amount, frequency, and timing of precipitation. Along with rising temperatures, it is expected that annual precipitation will increase by 14%, with a slight decrease in summer totals and a 30% increase in winter totals. Winter precipitation is predicted to be in the form of rain rather than snow. This change in precipitation will have significant effects on the amount of snow cover, winter recreation, spring snowmelt and peak stream flows, water supply, aquifer recharge, and water quality. Snow is also predicted to fall later in the winter and cease falling earlier in the spring.

Severe Weather (wind, extreme temperature, thunderstorms, tornadoes, drought): Climate change presents a significant challenge for risk management associated with severe weather. The frequency of severe

weather events has increased steadily over the last century. The number of weather related disasters during the 1990s was four times that of the 1950s, and cost 14 times as much in economic losses. Historical data show that the probability for severe weather events increases in a warmer climate. With a warmer climate, droughts could become more frequent, more severe, and longer-lasting.

Hazards Selected for Risk Assessment

After profiling the hazards in the 2013 Massachusetts Hazard Mitigation Plan and assigning a probability to each hazard, the Planning Team reached out to members of the public and stakeholders through an online survey. In the survey, the public was asked if they had experienced any of the hazards identified in the 2013 Massachusetts State Hazard Plan (Question 2 and 3 of the online survey – see "Public Survey on Hazard Mitigation" in ***Appendix 1***). Public and stakeholder input was then used to determine if specific hazards were significant to Truro (see Column 2 of ***Table 2.7***)

Table 2.7 documents the evaluation process used for determining which of the 11 Massachusetts State hazards are considered significant enough to warrant further evaluation in the risk assessment. A hazard was further evaluated for a risk assessment if the following criteria were met:

- the Planning Team determined that the probability of the hazard was highly likely
- the public and stakeholders have experienced the hazard in the past

Using the process described above, the following hazards were selected for risk assessment in Chapter 4:

- Shoreline Change and Erosion
- Flood
- Hurricanes and Tropical Storms
- Nor'easters
- High Winds
- Severe Winter Weather
- Sea Level Rise

	COLUMN 1	COLUMN 2	COLUMN 3
Type of Natural Hazard	**What is the future probability of the hazard as determined by the Planning Team?**	**Did the public/stakeholders/ neighboring communities experience the hazard in the past?**	**Was the hazard further evaluated in the risk assessment in Chapter 4?**
Shoreline Change and Erosion	HIGHLY LIKELY	Yes	Yes
Dam (Culvert) Failure	POSSIBLE	No	No
Earthquake	POSSIBLE	No (<1% said yes)	No
Urban Fire	LIKELY	Yes	No
Wildfire	LIKELY	Yes	No
Flood	HIGHLY LIKELY	Yes	Yes
Hurricane and Tropical Storms	HIGHLY LIKELY	Yes	Yes
Landslide	POSSIBLE	No (<1% said yes)	No
Nor'easters	HIGHLY LIKELY	Yes	Yes
High Winds	HIGHLY LIKELY	Yes	Yes
Thunderstorms	LIKELY	Yes	No
Extreme Temperatures	POSSIBLE	Yes	No
Tornadoes	POSSIBLE	Yes	No
Drought	POSSIBLE	Yes	No
Severe Winter Weather	HIGHLY LIKELY	Yes	Yes
Tsunami	UNLIKELY	No (<1% said yes)	No
Sea Level Rise	HIGHLY LIKELY	Yes	Yes

Table 2.7 | List of Hazards selected for a risk assessment

Asset Inventory

CHAPTER THREE

Chapter 2 profiled natural hazards that have affected Truro in the past or could affect the town in the future. The next step in the hazard planning process is to determine the types of assets and people that are located in Truro. Once this asset inventory in complete, the Planning Team can determine which of these assets and populations are vulnerable to the impacts of natural hazards. **Chapter 3 is an inventory of the people and natural and built environments in Truro.**

People

Population: Year-round and Seasonal

Truro is part of Barnstable County and is the least populated of the county's 15 towns. The total population in Truro is 2,003 residents according to the 2010-2014 U.S. Census American Community Survey estimate. The median household income for this population is $60,432 and the average household income is $75,969. There is no estimate of Truro's seasonal population because it is difficult to determine, but the Truro Local Comprehensive Plan (2005) estimates that their population multiplies ten times with visitors and the return of non-resident taxpayers.

Base Map of Truro

Located on Cape Cod, Truro is located 106 miles from Boston and it occupies 22 square miles of the Outer Cape land, with 67% of its area included in the Cape Cod National Seashore. Truro is bound on the northwest by Provincetown and on the south by Wellfleet. It is bordered by Cape Cod Bay on the west and by the Atlantic Ocean on the east. Parts of Truro are quite hilly, similar to the rolling hills of central Massachusetts, while other portions such as in the Beach Point area are very flat.

Figure 3.1 is a base map for the Town of Truro; it is a map showing the geographic area of Truro and includes features such as roads, rivers, and beaches. The base map acts as a frame of reference for the reader and reviewer of the Truro Hazard Mitigation Plan.

Housing

Truro has 3,277 total housing units. ***Table 3.1*** is a list of the type and number of housing units in Truro.

UNITS IN STRUCTURE	Estimate
1-unit, detached	2,980
1-unit, attached	30
2 units	44
3 or 4 units	70
5 to 9 units	28
10 to 19 units	50
20 or more units	35
Mobile home	40
Boat, RV, van, etc.	0
Total Housing Units	3,277

Table 3.1 | Number and type of housing units in Truro, U.S. Census American Community Survey (estimate), 2013

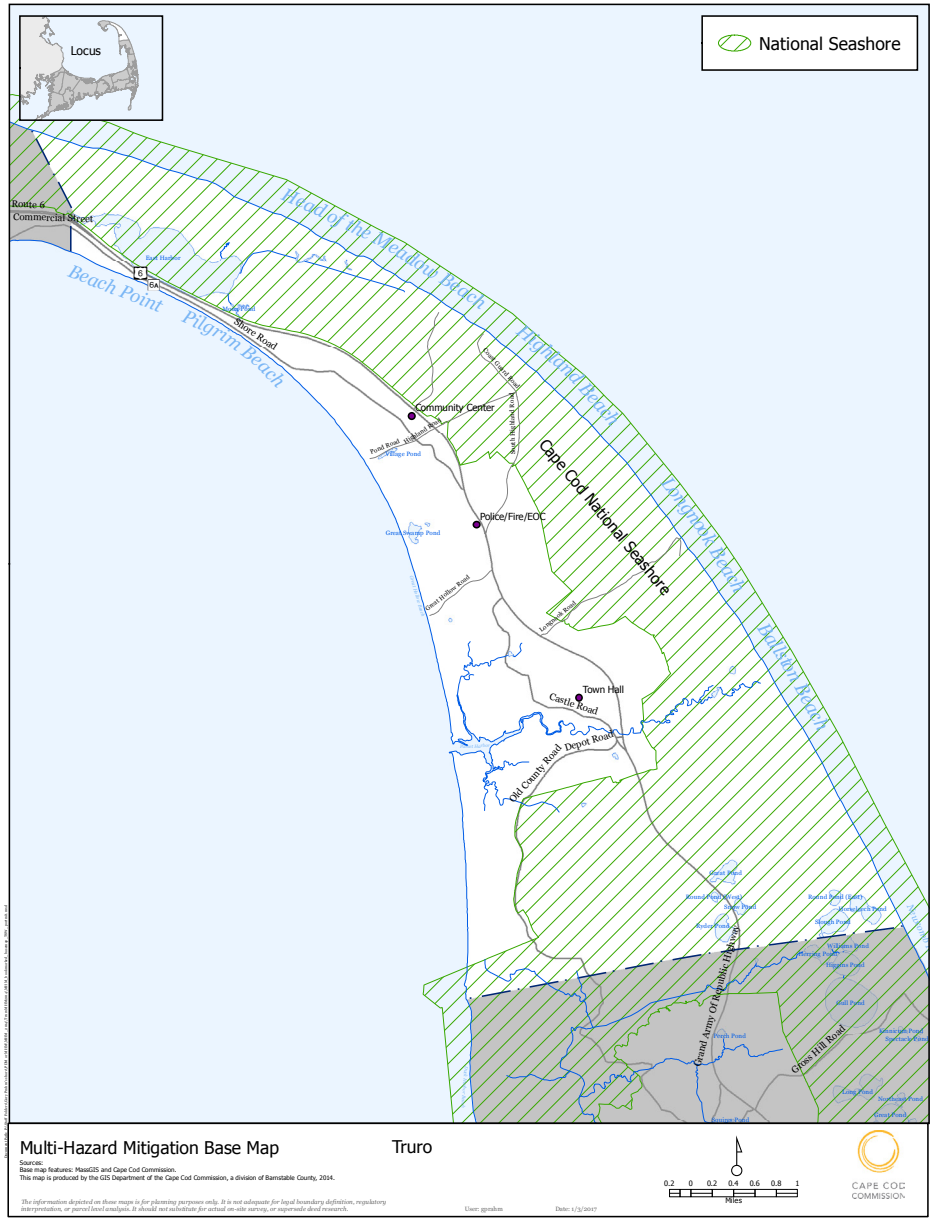


Figure 3.1 | Base map of Truro

Businesses and Employment

During the 1700s, Truro was whaling town. In the early 1800s, Pamet Harbor was the center of a booming fishing industry, with more than 60 sailboats bringing fish from Grand Banks and other fishing spots. By the1870s, local fishermen installed netting called weirs in the on-shore waters of Cape Cod. Two cold storage plants processed fish for transport by railroad to off-Cape markets. The railroad, which reached Truro and Provincetown in 1873, brought vacationers to Truro from the big cities. Today, Truro's economic health depends primarily on summer visitors and second home owners, along with a rapidly growing population of retirees. Residents and visitors are attracted to Truro, not for its shopping since it lacks a town center, but for its unique beauty and physical characteristics.

Beginning in the 1920s, an extraordinary number of eminent authors, artists, composers and photographers lived or sojourned in Truro. They include Edward Hopper, Walker Evans, Elliott Carter, Eugene O'Neill, Edna St. Vincent Millay, John Dos Passos, Edmund Wilson, Mary McCarthy, E. J. Kahn Jr., William Gibson, Alan Dugan, Annie Dillard and Robert Pinsky. They came for the quiet, rural atmosphere and open space—very different from the bustling, noisy, partying Provincetown art colony.

This diverse history is reflected in the types of industries and employment numbers in the town of Truro (*Table 3.2*).

Industry	Number	Values (1,000)
Utilities	1	Q
Accommodation and food services	30	16,750
Administrative, support, waste management, remediation services	10	D
Arts, entertainment, and recreation	4	D
Educational services	1	D
Finance and insurance	2	N
Health care and social assistance	1	D
Information	1	N
Professional, scientific, and technical services	3	D
Real estate and rental and leasing	4	1,124
Retail trade	13	9,622
Wholesale trade	2	D
Other services (except public administration)	6	

Table 3.2 | Estimated Number and Value of Truro Businesses, 2012 Economic Census of the U.S., Economic Census of Island Areas, and Nonemployer Statistics data files released on a flow basis from March 2014 through June 2016. D=Withheld to avoid disclosing data for individual companies, N=Data not available or not comparable

Natural Environment

Truro is a community of many unique environments; from ocean bluffs to bay side beaches and marshes to interior woodlands and fresh water wetlands. Changes in both demographics and the real estate market provide special challenges to Truro and its unique environment. The Town of Truro, like other coastal communities, continues to feel the pressure of development. This was heightened decades ago when approximately 70% of the town's area became part of the Cape Cod National Seashore (see ***Figure 3.1***). The remaining land outside the Seashore became under more intense building pressure. While there is now extensive acreage within the National Seashore, not all of that land is "Permanently Protected Open Space." There are private in-holdings that are subject to "tear-downs" and expansion that could potentially damage the visual landscape and natural environment of this theoretically protected area. Building projects on private in-holdings in the Seashore warrant very close attention, since the Seashore is limited in its ability to enforce its own regulations related to expanded residences.

The Town of Truro and the Cape Cod National Seashore provide access to the following beaches:

- Ocean Side:
  - Head-of-the-Meadow (Town and National Seashore)
  - Coast Guard Beach
  - Longnook Beach
  - Ballston Beach
- Cape Cod Bay Beaches (with public landings and access)
  - Beach Point
  - Noons Beach
  - Cold Storage Beach
  - Great Hollow Beach
  - Corn Hill Beach
  - Fisher Beach
  - Ryder Beach

The Pamet River flows through the town from east to west. The river and its wetlands have been described as the "ecological heart" of Truro and were the center of Native American activities in this area. Draining from the ocean dunes at Ballston Beach to Pamet Harbor, this watershed covers a quarter of Truro and contains a significant concentration of biological diversity. Views of its freshwater wetlands can be seen from the Ballston Beach end of North and South Pamet Roads, while its bay side salt marshes can be seen from the Pamet Harbor area. Some marsh areas have returned to a tidal condition with breaks in old man-made dikes, and the National Park Service may consider opening a clapper valve under Route 6 to restore tidal flushing to the upper

Natural Environment

Pamet wetlands. The Pamet River Harbor is an important asset to the Town of Truro, It is the most productive shellfish habitat area in town and it is used for recreational fishing, commercial fishing, recreational boating, viewing scenery, artist paintings, sunbathing and swimming. Starting about 1860, when Wilder Dyke was built and the Upper Pamet was separated from the Lower with a clapper valve, flushing of the tidal area in Pamet Harbor was diminished by the accumulation of silt which reduced its utility for boating and as a fishing port. Pamet Harbor was dredged in 1918, and about that time the North and South jetties were installed. The harbor was redredged in 1965, 1968, and 1996, the result of recurrent silting and impeded navigation. Maintenance dredging was performed in 1998, and has continued on an annual basis since the year 2000. Given how critical and significant the Pamet River system is to Truro, the Planning Team selected this site as the site for a UAV study (***Figure 3.2)***

Figure 3.2a | Aerial image of Ballston Beach, looking east on the Pamet River System (photo credit: AirShark)

Natural Environment

Figure 3.2b | Aerial image of the Pamet River System, looking east, between Ballston Beach and Route 6 (photo credit: AirShark)

Figure 3.2c | Aerial image of the Pamet River System at its intersection wtih Route 6 (photo credit: AirShark)

Natural Environment

Figure 3.2d | Aerial image of the Pamet River System east of Route 6 (photo credit: AirShark)

Figure 3.2e | Aerial image of the Pamet River System near Pamet Harbor (photo credit: AirShark)

Natural Environment

Figure 3.2f | Aerial image of the entrance to Pamet Harbor (photo credit: AirShark)

Drinking Water Supply

The Town of Truro's water supply comes from the Pamet Lens (shared by Provincetown) and the Chequessett Lens (shared by Wellfleet). There are two drinking water delivery systems serving our end of the Cape: private wells; and the Provincetown water system. The Provincetown Water system which also serves Beach Point and other North Truro areas including the school and Police station, originates within the Pamet lens. The remaining households and businesses in Truro depend on private, smaller-volume wells. Because of the naturally poor water quality of the Pilgrim lens which underlies Provincetown, Provincetown was granted permission through state legislation in 1908 and again in 1952 to develop water supply wells in the Pamet lens. All of Provincetown and parts of North Truro rely on the public wells in Truro for their drinking water

Cultural and Historic Resources

The following historic properties in Truro are already listed in the National Register or are formally Determined Eligible by the Keeper of the National Register:

- Cobb Memorial Library (Town)
- Dune Shacks Historic District (Determined Eligible 1989)
- Dune Shacks Historic District (NPS)
- First Congregational Parish Historic District (Town)
- Jedediah Higgins House
- Highland House
- Highland Light Station
- Lighthouses of Massachusetts Thematic Group Nomination
- Old North Burial Ground (Town)
- Union Hall (Town Hall)

According to the Truro Historic Properties Survey in 2011, the following historic properties in Truro are currently in process for National Register listing (nomination proponent shown in parentheses):

- Charles W. Snow Farmstead/Truro Center for the Arts at Castle Hill (Town)
- The Highlands Historic District (NPS)
- Mid-Twentieth Century Modern Residential Architecture on Outer Cape Cod, 1929 – 1979, Multiple Property Documentation (NPS)
- Pine Grove Cemetery (Town)

Below is a list of historical context for the cultural and historic resources in Truro:

- **Native Patterns and Colonial Explorations (Pre-history to 1650):** Prior to the first colonial

explorations in the seventeenth century, Truro was the site of several native settlements, represented by the Corn Hill Area.

- **Colonial Settlements (1650-1790):** Modest resources survive from the early permanent colonial settlements of the late seventeenth through the eighteenth centuries, including the ca. 1719 Richard Paine House at 1 Higgins Hollow Road and the ca. 1727-1730 Rich-Cobb House at 84 Prince Valley Road, as well as clusters of houses in the Longnook/ Higgins Hollow and Pamets areas.
- **Maritime Boom Years (1790-1860):** Many houses and institutional buildings survive from Truro's early to mid-nineteenth-century maritime boom, such as the Hughes McKinnon House at 21 Whitmanville Road (ca. 1790-1800), the John Francis/Ruth Hopkins House on Atwood Road (ca. 1830-1850), and the former North Truro Primary-Grammar School at 52 Shore Road (ca. 1852). The Depot Road and Pond Village/North Truro areas also developed during this period.
- **Transition from Maritime Industry to Tourism (1860-1890):** A few well-preserved examples of residential architecture from the town's late nineteenth-century shift from maritime industry to tourism remain extant, including the ambitious ca. 1880-1890 Captain Atkins Hughes House at 11 Hughes Road and the modest J.E. Roger Barber House at 18 Pond Road, built ca. 1875-1890. The Pond Village Cold Storage Fish House Buildings are a rare reminder of the evolution of Truro's fishing industry, before it largely disappeared to be replaced by the twentieth-century tourism boom.
- **Tourism Boom Years (1890-1960), including cottage colonies and artist/writer communities:** The Beach Point, Corn Hill, Sladeville, and Young's Camps/Prince of Whales Cottages are all associated with Truro's development into a resort town that began with small vacation complexes and cottage colonies. By the 1930s, many artists and writers arrived to live and work amid the town's dramatic natural landscapes. Some built new houses, like the Edward Hopper House at 31 Stephens Way (ca. 1930); while others moved into historic houses, like Henry Varnum Poor who bought the ca. 1830 Perez Bangs House on Phats Valley Road.
- **Consolidation of Truro as Summer Destination (1960 to Today):** Truro's Mid-Twentieth Century Modern resources that are in the process of being surveyed and evaluated illustrate this phase of the Town's development, including the Serge Chermayeff House and Studio on Black Pond Road and the Charles Jencks House on Slough Pond Road.

Repetitive Loss Properties

B4a

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. The Town of Truro has no Repetitive Loss Properties.

Critical Facilities

Table 3.3 is a list of the Critical Facilities in Truro.

Type of Critical Facility			
Essential Facilities	Assets that are essential to the health and welfare of the whole population and important following hazard events. The potential consequence of losing these assets is so great that they were carefully inventoried. The building, contents and function/ services provided to the community are significant. Source: FEMA How-to Guide 2/ FEMA 386-2	Truro Town Hall	Truro Public Safety Facility
		Truro DPW	DPW Gas and Diesel Station
		Truro Community Center	Truro Central School
		Truro Public Library	Pamet Harbor
		Pamet Harbor Pier	Pamet Harbor Boat Ramp
		Harbormaster's Office	Truro Transfer Station
Transportation Systems	Critical assets in all 5 modes of transportation (air, road, transit, rail, sea). Source: FEMA How-to Guide 2/ FEMA 386-2	Route 6	Ballston Beach Overwash Fan
		Route 6A	Fisher Beach Parking Lot
		Old Colony Road	Ryder Beach Parking Lot
		Depot Road	High Head Road Culvert
		Great Hollow Beach Parking Lot	East Harbor Culvert
		Head of the Meadow Parking Lot	East Harbor Outfall Pipe
		Head of the Meadow Parking Lot (CCNS)	Route 6 Culverts near S. and N. Pamet Roads
		Corn Hill Beach Parking Lot	Route 6 Culvert near Long Nook Road
		Cold Storage Beach Parking Lot	Wilder Dike Culvert Tidal Restriction
		Long Nook Beach Parking Lot	Mill Pond Culvert
		Pamet Harbor Parking Lot	Eagle Creek Culvert
		Pamet Harbor Jetties - North and South	Culvert near Corn Hill Rd (Little Pamet)
		Ballston Beach Parking Lot	Culvert on Castle Road (Little Pamet)
Lifeline Utilities	Includes wastewater, water, oil, natural gas, electric power, and communication systems	Well fields for Provincetown and Truro	Pump House and Filtration System (CCNS)
		Knowles Heights Pump House	Coast Guard Rescue Communications Tower
		Eversource Transformer Station	South Hollow Pump House and Well Field
		FAA Radar Facility	CellTower (not town owned)

Table 3.3 | List of Critical Facilities in Truro

New Developments in Truro

Below is a list of new developments in Truro:

- **Department of Public Works Garage:** this project is still in the early stages and the feasibility study is ongoing. There are several sites being proposed including near the Public Safety Facility on Route 6, the Transfer Station on Route 6 and the State Highway Barn on Route 6
- **Affordable Housing:** this project is being proposed on the site of the current DPW Building
- **Affordable Housing:** this project is being proposed on the corner of Route 6 and Highland

The Planning Team mapped these new developments and determined if they are located in the floodplain according the most recent FIRMs, vulnerable to storm surge using SLOSH models or vulnerable to sea level rise using the Cape Cod Commission's sea level rise viewer. (***Table 3.4***). The exposure assessment shows that the following assets are not vulnerable to flooding, storm surge and sea level rise.

Name of New Development	Special Flood Hazard Area	SLOSH zone	Sea Level Rise
Proposed Site #1: DPW Garage near the Public Facility Building	no	no	no
Proposed Site #2: DPW Garage at the Transfer Station	no	no	no
Proposed Site #3: DPW Garage at the State Highway Barn	no	no	no
Proposed Affordable Housing at the current DPW site	no	no	no
Proposed Affordable Housing at Route 6 and Highland Road	no	no	no

Table 3.3| Exposure Assessment of New Developments in Truro

New Developments in Truro

Vulnerability Assessment

CHAPTER FOUR

Chapter 2 of the Truro Hazard Mitigation Plan profiled natural hazards that could impact the town in the future or have impacted Truro in the past. Chapter 3 inventoried the assets that could be damaged during a hazard event, such as buildings, infrastructure and critical facilities. Chapter 4 ties together the hazard profiles and asset inventories to estimate the potential losses that Truro could experience during a natural hazard event. **Essentially, Chapter 4 answers the question: How will assets in Truro be affected by hazard events?**

Methodology: Vulnerability Assessments

There are four vulnerability assessments included in the 2017 Truro Hazard Mitigation Plan:

- **Vulnerability Assessment of Parcels and Buildings**: this assessment was completed by the Town of Truro and the Cape Cod Commission (i.e. the Planning Team) using data from the Town Assessor's office.
- **Exposure Assessment of Critical Facilities**: the Planning Team used Geographic Information System (GIS) analysis to identify whether critical facilities could be exposed to flooding, surge, sea level rise and coastal erosion.
- **Aerial Photography of the Truro coastline:** an unmanned aerial vehicle (AUV) acquired high resolution video footage and still images of the beach from the Cape Cod Canal to Town Neck Beach. These high resolution images show shoreline change and coastal resources as of September 2016 and can be used as a baseline for any future damage to the area. Also, the UAV was flown at high tide, which is the part of the tide cycle when heavy precipitation and storm surge could have the most impact.
- **Hazus:** this assessment tool was used to look at the impact of high winds in Truro

The methods of both assessments are provided in the remaining part of this section.

Methods: Vulnerability Assessment of Parcels and Buildings:

1. To estimate the total number of parcels and value of buildings located in Truro, the Planning Team used Town Assessing data from 2011. This 2011 data set contains information about parcels such as use codes, building characteristics and assessed value. The 2011 parcel data is also linked to geometry data for specific parcels on the ground. The 2011 data was used because it is the most current data set that contains both the parcel and the geometry data. This large data set was grouped into categories using Massachusetts Property Type Classification Codes. Parcel numbers and building values were totaled for each category.[1] It is important to note that the category titles were not selected by members of the Planning Team; instead category names are based on the State's Classification Code. Below is a list of examples of asset types in each category.
    - **Agriculture**: agricultural land/farms, greenhouses, farm buildings
    - **Banks**: bank buildings

1 Property type classification codes, non-arm's length codes and sales report spreadsheet specifications, prepared by the Bureau of Local Assessment, revised March 2015, http://www.mass.gov/dor/docs/dls/bla/classificationcodebook.pdf

- **Entertainment and Recreation**: includes eating and drinking establishments, indoor recreation, recreational land
- **General Services**: includes warehouses and distributional facilities, post office, housing authority, municipal property
- **Medical Office/Clinics**: includes medical office buildings
- **Multi-Family Dwelling**: includes condos, 2-3 family homes, multiple houses on a single property, 4-8 unit homes and 8+ units
- **Non-Profit/Municipal**: government or town owned properties, public parking lots, libraries, museums, fraternal offices
- **Parking**: commercial parking lots
- **Personal/Repair Services**: includes buses and funeral homes
- **Retail Trade**: includes hardware stores, shopping malls, supermarkets, small retail
- **Single Family Dwelling**: single family homes
- **Temporary Lodging**: includes motels, inns, resorts
- **Theaters**: includes theaters and stadiums
- **Vacant**: includes developable land, undevelopable land, residential open land, underwater land or marshes not under public ownership
- **Wholesale Trade**: includes tanks holding fuel and oil products for retail distribution, bottled gas and propane tanks, lumber yards

2. Next, the Planning Team used GIS to overlay maps of hazard areas onto parcel and value data. Only a subset of natural hazards were identified for further vulnerability assessment (see ***Table 2.6*** for rationale). Below is a list of hazards selected for the vulnerability assessment and a description of the available data used for the assessment.
    - **Flooding**: FEMA flood hazard maps, adopted by Truro in 2014
    - **Hurricanes and Tropical Storms**: The storm surge that occurs during tropical cyclones is assessed using the SLOSH (Sea, Lake, and Overland Surges from Hurricanes) model. Currently, there is no model available for the impact of wind from tropical cyclones. ***Figure 2.7*** in Chapter 2 shows a SLOSH map for the Town of Truro.
    - **Sea Level Rise**: Bathtub model developed by the Cape Cod Commission was used to model the impacts of sea level rise on Truro. ***Figure 2.17*** in Chapter 2 shows a Sea Level Rise map for the Town of Truro.

Methodology: Vulnerability Assessments

- **Coastal Erosion/Shoreline Change**: The Planning Team used GIS to identify which properties had a physical connection to saltwater. Properties that share a boundary with saltwater was identified as "coastal property." Parcel and building values were identified. The Planning Team recognizes that this method is not perfect.
- **Nor'easters**: Data is not available. A detailed vulnerability assessment could not be completed at this time.
- **High Winds**: Data is not available for this particular type of assessment. A more detailed vulnerability assessment was conducted using Hazus
- **Severe Winter Weather**: Data is not available. A detailed vulnerability assessment could not be completed at this time.

It is important to note that SLOSH and Sea Level Rise models are course models to illustrate vulnerability to storm surge and sea level rise using the best available data. Both of these models have their strengths and their weaknesses:

- **Sea, Lake and Overland Surges from Hurricanes (SLOSH) model**: SLOSH is a computerized numerical model developed by the National Weather Service (NWS) to estimate storm surge heights resulting from historical, hypothetical, or predicted hurricanes by taking into account the atmospheric pressure, size, forward speed, and track data[2]. These parameters are used to create a model of the wind field which drives the storm surge. The SLOSH model consists of a set of physics equations which are applied to a specific locale's shoreline, incorporating the unique bay and river configurations, water depths, bridges, roads, levees and other physical features. However, the SLOSH model does not explicitly model the impacts of waves on top of the surge nor does it account for normal river flow or rain flooding. Future advancements in the SLOSH model will allow for the resolution of some of these limitations.[2]
- **Cape Cod Commission's Sea Level Rise model**: Sea Level Rise data was derived from classified Digital Elevation Model (DEM) data collected through Light Detection and Ranging (LiDAR) in 2011 by the United States Geological Society (USGS). The elevation data is accurate to 18 cm at a 95% confidence level with a 1 meter resolution. This elevation data was adjusted to Mean Higher High Water (MHHW) using the NOAA VDatum Software. The Sea Level Rise is shown as a simple representation of a change in elevation, commonly referred

2 http://www.nhc.noaa.gov/surge/slosh.php

to as a "Bathtub" model. No account has been made for the effects of velocity and resulting erosion caused by wave action.

Methods: Exposure Assessment of Critical Facilities:

For this exposure assessment, the Team compiled a list of critical facilities list and mapped them in GIS. Sea level rise, flooding, storm surge maps were overlaid on the map of critical facilities. If a critical facility was located in a hazard area, the Planning Team determined that it was exposed and therefore vulnerable. To assess exposure to coastal shoreline change, the Planning Team determined if the parcel boundary of the critical facility was adjacent to salt water. As mentioned in the previous section, maps for nor'easters, severe winter weather and are not available and therefore their impact on critical facilities was not determined.

Methods: Aerial Photography:

The small UAV captured video and oblique images of the coastline and video. Any identifiable people were digitized out during editing of the raw dataset. AirShark, a certified commercial operator, flew the UAV with a certified FAA pilot and visual observer. The small UAV was flown at 200-400 feet above ground and operations had the required authorizations from the FAA, State and Local entities before the flight. Personnel had signs, radios and safety vests during the flight. The flight was conducted in 1-2 hours during the day on July 17, 2016

Methods: Hazus:

Hazus is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of Hazus is to provide a methodology and software application to develop multi-hazard losses at a regional scale.

The information provided by the model will assist state and local officials in evaluating, planning for, and mitigating the effects of hurricane winds. The Hurricane Model provides practitioners and policy makers with a tool to help reduce wind damage, reduce disaster payments, and make wise use of the nation's emergency management resources. The methodology deals with important aspects of the built environment, and a wide range of different types of losses. Extensive national databases are embedded within Hazus, containing information such as demographic aspects of the population in a study region, square footage for different occupancies of buildings, and numbers and locations of bridges. Using this information, users can carry out general loss estimates for a region or town.

Methodology: Vulnerability Assessments

Uncertainties are inherent in any loss estimation methodology. They arise in part from incomplete scientific knowledge concerning hurricanes and their effects upon buildings and facilities. They also result from the approximations and simplifications that are necessary for comprehensive analyses. Incomplete or inaccurate inventories of the built environment, demographics and economic parameters add to the uncertainty. The hurricane loss estimation methodology is based on sound scientific and engineering principals and experimental and experience data. The methodology has been tested against the judgment of experts and, to the extent possible, against records from several past hurricanes. However, limited and incomplete data about actual hurricane damage precludes complete calibration of the methodology.

The planning team used Hazus to examine debris generation and the impact of wind on the residential homes in Truro. To examine the impact of wind, the parameters of a Category 3 hurricane was simulated in Hazus. This simulation allowed the planning team to take a closer look at the impact of wind speed on building type; specifically what types of damage could be prevented with different building construction. Parameters of a hurricane were input into a model based on the history of storms to affect the area (***Figure 4.1***). The eye of this simulated hurricane passed to the west of the Town of Truro, which will create maximum wind scenarios for the town. The majority of buildings in Truro are constructed from wood or concrete and the wind damage from this modeled hurricane is shown as a set of functions (shown in "Simulated Hurricane" in the Results section of this chapter).

Storm Track Data Review

This page allows you to review the validated hurricane track data for this scenario.
Select the "Back" button to make any changes.

	Latitude (Degrees)	Longitude (Degrees)	Translation Speed (miles/hr)	Time (Hours)	Radius to Max Winds (miles)	Wind Speed (mph @ 10m)	Central Pressure (mBar)
	40.97	-70.63	15.00	0.00	21.00	120.00	954.00
	41.43	-70.63	15.00	0.00	21.00	120.00	954.00
	41.98	-70.58	15.00	0.00	21.00	120.00	954.00
	42.27	-70.44	15.00	0.00	21.00	120.00	954.00

Methodology: Vulnerability Assessments

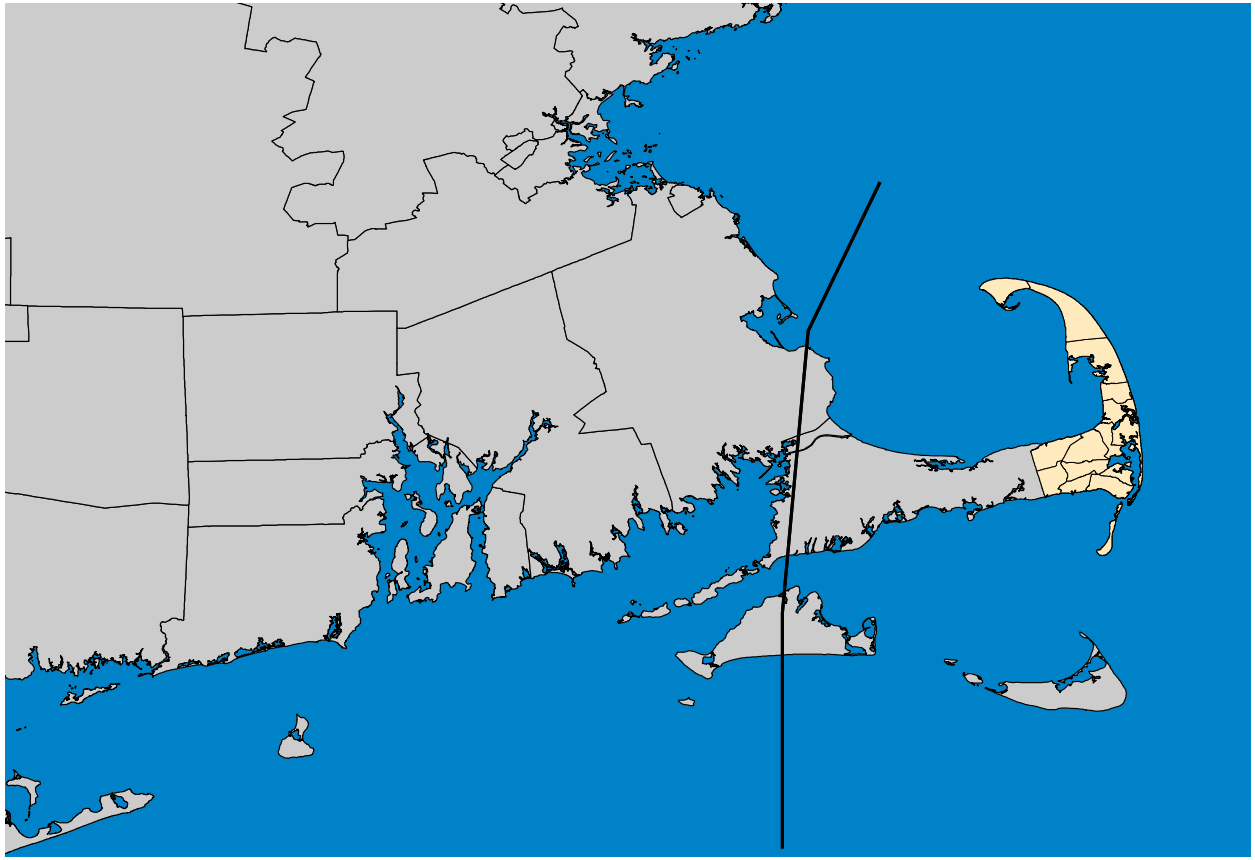


Figure 4.1 | Simulated Category 3 hurricane for Truro with storm track parameters shown in the image on the left and map of the hurricane shown above. Note: this is not an actual hurricane, it was created in Hazus to model a worst case scenario for a Category 3 storm impacting Truro

Results of the Vulnerability Assessment

Parcels and Buildings in Hazard Areas

Parcels and Buildings Vulnerable to Flooding

Flooding (A Zone)

Type of Structure	Number of Parcels			Value of Buildings		
	# in town	# in Hazard area	% in Hazard Area	$ in town	$ in Hazard area	% in Hazard Area
Agriculture	5	2	40%	$0	$0	0%
Banks	1	0	0%	$1,260,900	$0	0%
Church/Non-Profit Offices	104	39	38%	$1,391,800	$0	0%
Emergency Response	1	0	0%	$2,067,800	$0	0%
Entertainment and Recreation	7	1	14%	$1,253,200	$139,600	11%
General Services	48	13	27%	$16,392,300	$4,240,700	26%
Heavy Industrial	3	0	0%	$0	$0	0%
Medical Office/Clinic	1	0	0%	$1,823,900	$0	0%
Metals/Minerals Processing	1	0	0%	$201,500	$0	0%
Multi-family Dwelling	245	49	20%	$176,922,100	$70,812,000	40%
Professional/Tech. Services	10	0	0%	$433,500	$0	0%
Retail Trade	11	4	36%	$2,331,900	$650,400	28%
Schools	3	0	0%	$4,087,900	$0	0%
Single Family Dwelling	2047	304	15%	$512,631,000	$66,526,200	13%
Temporary Lodging	38	22	58%	$18,416,400	$11,355,400	62%
Vacant	788	177	22%	$5,556,200	$408,500	7%
Wholesale Trade	7	0	0%	$1,782,600	$0	0%
COLUMN TOTALS	3,320	611		$746,553,000	$154,132,800	

Table 4.1 | The proportion of buildings and value of buildings located in a A zone.
Table generated using 2015 Truro Assessing Data

Flooding (V Zone)

Type of Structure	Number of Parcels			Value of Buildings		
	# in town	# in Hazard area	% in Hazard Area	$ in town	$ in Hazard area	% in Hazard Area
Agriculture	5	0	0%	$0	$0	0%
Banks	1	0	0%	$1,260,900	$0	0%
Church/Non-Profit Offices	104	13	13%	$1,391,800	$0	0%
Emergency Response	1	0	0%	$2,067,800	$0	0%
Entertainment and Recreation	7	1	14%	$1,253,200	$139,600	11%
General Services	48	6	13%	$16,392,300	$1,956,800	12%
Heavy Industrial	3	0	0%	$0	$0	0%
Medical Office/Clinic	1	0	0%	$1,823,900	$0	0%
Metals/Minerals Processing	1	0	0%	$201,500	$0	0%
Multi-family Dwelling	245	50	20%	$176,922,100	$75,782,800	43%
Professional/Tech. Services	10	0	0%	$433,500	$0	0%
Retail Trade	11	0	0%	$2,331,900	$0	0%
Schools	3	0	0%	$4,087,900	$0	0%
Single Family Dwelling	2047	217	11%	$512,631,000	$62,247,000	12%
Temporary Lodging	38	16	42%	$18,416,400	$8,126,100	44%
Vacant	788	103	13%	$5,556,200	$3,715,400	67%
Wholesale Trade	7	0	0%	$1,782,600	$0	0%
COLUMN TOTALS	3,320	406		$746,553,000	$151,967,700	

Table 4.2 | The proportion of buildings and value of buildings located in a V zone. Table generated using 2015 Truro Assessing Data

Results of the Vulnerability Assessment

Parcels and Buildings Vulnerable to Sea Level Rise

Sea Level Rise (1 foot)

Type of Structure	Number of Parcels			Value of Buildings		
	# in town	# in Hazard area	% in Hazard Area	$ in town	$ in Hazard area	% in Hazard Area
Agriculture	5	3	60%	$0	$0	0%
Banks	1	0	0%	$1,260,900	$0	0%
Church/Non-Profit Offices	104	45	43%	$1,391,800	$0	0%
Emergency Response	1	0	0%	$2,067,800	$0	0%
Entertainment and Recreation	7	3	43%	$1,253,200	$630,800	50%
General Services	48	13	27%	$16,392,300	$3,290,800	20%
Heavy Industrial	3	0	0%	$0	$0	0%
Medical Office/Clinic	1	0	0%	$1,823,900	$0	0%
Metals/Minerals Processing	1	1	100%	$201,500	$201,500	100%
Multi-family Dwelling	245	65	27%	$176,922,100	$75,481,600	43%
Professional/Tech. Services	10	0	0%	$433,500	$0	0%
Retail Trade	11	2	18%	$2,331,900	$354,200	15%
Schools	3	0	0%	$4,087,900	$0	0%
Single Family Dwelling	2047	338	17%	$512,631,000	$90,999,900	18%
Temporary Lodging	38	17	45%	$18,416,400	$9,718,900	53%
Vacant	788	227	29%	$5,556,200	$3,854,300	69%
Wholesale Trade	7	0	0%	$1,782,600	$0	0%
COLUMN TOTALS	3,320	714		$746,553,000	$184,532,000	

Table 4.3 | The proportion of buildings and value of buildings exposed to 1 foot of sea level rise.
Table generated using 2015 Truro Assessing Data

Sea Level Rise (2 feet)						
	Number of Parcels			Value of Buildings		
Type of Structure	# in town	# in Hazard area	% in Hazard Area	$ in town	$ in Hazard area	% in Hazard Area
Agriculture	5	3	60%	$0	$0	0%
Banks	1	0	0%	$1,260,900	$0	0%
Church/Non-Profit Offices	104	49	47%	$1,391,800	$54,100	4%
Emergency Response	1	0	0%	$2,067,800	$0	0%
Entertainment and Recreation	7	3	43%	$1,253,200	$630,800	50%
General Services	48	15	31%	$16,392,300	$4,998,500	30%
Heavy Industrial	3	0	0%	$0	$0	0%
Medical Office/Clinic	1	0	0%	$1,823,900	$0	0%
Metals/Minerals Processing	1	1	100%	$201,500	$201,500	100%
Multi-family Dwelling	245	75	31%	$176,922,100	$85,931,200	49%
Professional/Tech. Services	10	0	0%	$433,500	$0	0%
Retail Trade	11	2	18%	$2,331,900	$354,200	15%
Schools	3	0	0%	$4,087,900	$0	0%
Single Family Dwelling	2047	407	20%	$512,631,000	$108,377,100	21%
Temporary Lodging	38	22	58%	$18,416,400	$13,179,800	72%
Vacant	788	243	31%	$5,556,200	$3,854,300	69%
Wholesale Trade	7	0	0%	$1,782,600	$0	0%
COLUMN TOTALS	3,320	820		$746,553,000	$217,581,500	

Table 4.4 | The proportion of buildings and value of buildings exposed to 2 feet of sea level rise. Table generated using 2015 Truro Assessing Data

Results of the Vulnerability Assessment

Sea Level Rise (3 feet)

Type of Structure	Number of Parcels			Value of Buildings		
	# in town	# in Hazard area	% in Hazard Area	$ in town	$ in Hazard area	% in Hazard Area
Agriculture	5	3	60%	$0	$0	0%
Banks	1	0	0%	$1,260,900	$0	0%
Church/Non-Profit Offices	104	49	47%	$1,391,800	$54,100	4%
Emergency Response	1	0	0%	$2,067,800	$0	0%
Entertainment and Recreation	7	3	43%	$1,253,200	$630,800	50%
General Services	48	16	33%	$16,392,300	$5,411,800	33%
Heavy Industrial	3	0	0%	$0	$0	0%
Medical Office/Clinic	1	0	0%	$1,823,900	$0	0%
Metals/Minerals Processing	1	1	100%	$201,500	$201,500	100%
Multi-family Dwelling	245	84	34%	$176,922,100	$97,991,300	55%
Professional/Tech. Services	10	0	0%	$433,500	$0	0%
Retail Trade	11	2	18%	$2,331,900	$354,200	15%
Schools	3	0	0%	$4,087,900	$0	0%
Single Family Dwelling	2047	450	22%	$512,631,000	$118,948,000	23%
Temporary Lodging	38	25	66%	$18,416,400	$14,328,500	78%
Vacant	788	256	32%	$5,556,200	$3,985,900	72%
Wholesale Trade	7	0	0%	$1,782,600	$0	0%
COLUMN TOTALS	3,320	889		$746,553,000	$241,906,100	

Table 4.5 | The proportion of buildings and value of buildings exposed to 3 feet of sea level rise.
Table generated using 2015 Truro Assessing Data

Sea Level Rise (4 feet)

Type of Structure	Number of Parcels			Value of Buildings		
	# in town	# in Hazard area	% in Hazard Area	$ in town	$ in Hazard area	% in Hazard Area
Agriculture	5	3	60%	$0	$0	0%
Banks	1	0	0%	$1,260,900	$0	0%
Church/Non-Profit Offices	104	51	49%	$1,391,800	$219,100	16%
Emergency Response	1	0	0%	$2,067,800	$0	0%
Entertainment and Recreation	7	3	43%	$1,253,200	$630,800	50%
General Services	48	16	33%	$16,392,300	$5,411,800	33%
Heavy Industrial	3	0	0%	$0	$0	0%
Medical Office/Clinic	1	0	0%	$1,823,900	$0	0%
Metals/Minerals Processing	1	1	100%	$201,500	$201,500	100%
Multi-family Dwelling	245	92	38%	$176,922,100	$100,451,900	57%
Professional/Tech. Services	10	0	0%	$433,500	$0	0%
Retail Trade	11	2	18%	$2,331,900	$354,200	15%
Schools	3	0	0%	$4,087,900	$0	0%
Single Family Dwelling	2047	495	24%	$512,631,000	$126,877,800	25%
Temporary Lodging	38	26	68%	$18,416,400	$14,666,000	80%
Vacant	788	278	35%	$5,556,200	$3,985,900	72%
Wholesale Trade	7	0	0%	$1,782,600	$0	0%
COLUMN TOTALS	3,320	967		$746,553,000	$252,799,000	

Table 4.6 | The proportion of buildings and value of buildings exposed to 4 feet of sea level rise. Table generated using 2015 Truro Assessing Data

Results of the Vulnerability Assessment

Sea Level Rise (5 feet)

Type of Structure	Number of Parcels			Value of Buildings		
	# in town	# in Hazard area	% in Hazard Area	$ in town	$ in Hazard area	% in Hazard Area
Agriculture	5	3	60%	$0	$0	0%
Banks	1	0	0%	$1,260,900	$0	0%
Church/Non-Profit Offices	104	53	51%	$1,391,800	$698,100	50%
Emergency Response	1	0	0%	$2,067,800	$0	0%
Entertainment and Recreation	7	3	43%	$1,253,200	$630,800	50%
General Services	48	19	40%	$16,392,300	$5,864,000	36%
Heavy Industrial	3	0	0%	$0	$0	0%
Medical Office/Clinic	1	0	0%	$1,823,900	$0	0%
Metals/Minerals Processing	1	1	100%	$201,500	$201,500	100%
Multi-family Dwelling	245	102	42%	$176,922,100	$103,641,000	59%
Professional/Tech. Services	10	0	0%	$433,500	$0	0%
Retail Trade	11	3	27%	$2,331,900	$593,000	25%
Schools	3	0	0%	$4,087,900	$0	0%
Single Family Dwelling	2047	523	26%	$512,631,000	$132,449,300	26%
Temporary Lodging	38	28	74%	$18,416,400	$15,515,500	84%
Vacant	788	288	37%	$5,556,200	$3,985,900	72%
Wholesale Trade	7	1	14%	$1,782,600	$82,600	5%
COLUMN TOTALS	3,320	1,024		$746,553,000	$263,661,700	

Table 4.7 | The proportion of buildings and value of buildings exposed to 5 feet of sea level rise.
Table generated using 2015 Truro Assessing Data

Sea Level Rise (6 feet)

Type of Structure	Number of Parcels			Value of Buildings		
	# in town	# in Hazard area	% in Hazard Area	$ in town	$ in Hazard area	% in Hazard Area
Agriculture	5	3	60%	$0	$0	0%
Banks	1	0	0%	$1,260,900	$0	0%
Church/Non-Profit Offices	104	53	51%	$1,391,800	$698,100	50%
Emergency Response	1	0	0%	$2,067,800	$0	0%
Entertainment and Recreation	7	3	43%	$1,253,200	$630,800	50%
General Services	48	20	42%	$16,392,300	$6,336,000	39%
Heavy Industrial	3	0	0%	$0	$0	0%
Medical Office/Clinic	1	0	0%	$1,823,900	$0	0%
Metals/Minerals Processing	1	1	100%	$201,500	$201,500	100%
Multi-family Dwelling	245	106	43%	$176,922,100	$110,640,000	63%
Professional/Tech. Services	10	0	0%	$433,500	$0	0%
Retail Trade	11	3	27%	$2,331,900	$593,000	25%
Schools	3	0	0%	$4,087,900	$0	0%
Single Family Dwelling	2047	549	27%	$512,631,000	$139,680,700	27%
Temporary Lodging	38	28	74%	$18,416,400	$15,515,500	84%
Vacant	788	303	38%	$5,556,200	$3,985,900	72%
Wholesale Trade	7	1	14%	$1,782,600	$82,600	5%
COLUMN TOTALS	3,320	1,070		$746,553,000	$278,364,100	

Table 4.8 | The proportion of buildings and value of buildings exposed to 6 feet of sea level rise. Table generated using 2015 Truro Assessing Data

Results of the Vulnerability Assessment

Parcels and Buildings Vulnerable to Storm Surge During Hurricanes

SLOSH (Category 1 Storm)						
	Number of Parcels			Value of Buildings		
Type of Structure	# in town	# in Hazard area	% in Hazard Area	$ in town	$ in Hazard area	% in Hazard Area
Agriculture	5	0	0%	$0	$0	0%
Banks	1	0	0%	$1,260,900	$0	0%
Church/Non-Profit Offices	104	27	26%	$1,391,800	$0	0%
Emergency Response	1	0	0%	$2,067,800	$0	0%
Entertainment and Recreation	7	1	14%	$1,253,200	$139,600	11%
General Services	48	5	10%	$16,392,300	$2,066,400	13%
Heavy Industrial	3	0	0%	$0	$0	0%
Medical Office/Clinic	1	0	0%	$1,823,900	$0	0%
Metals/Minerals Processing	1	0	0%	$201,500	$0	0%
Multi-family Dwelling	245	25	10%	$176,922,100	$41,368,800	23%
Professional/Tech. Services	10	0	0%	$433,500	$0	0%
Retail Trade	11	0	0%	$2,331,900	$0	0%
Schools	3	0	0%	$4,087,900	$0	0%
Single Family Dwelling	2047	156	8%	$512,631,000	$44,724,300	9%
Temporary Lodging	38	9	24%	$18,416,400	$4,208,800	23%
Vacant	788	110	14%	$5,556,200	$3,544,500	64%
Wholesale Trade	7	0	0%	$1,782,600	$0	0%
COLUMN TOTALS	3,320	333		$746,553,000	$96,052,400	

Table 4.9 | The proportion of buildings and value of buildings located in a SLOSH category 1 zone.
Table generated using 2015 Truro Assessing Data

SLOSH (Category 2 Storm)						
	Number of Parcels			Value of Buildings		
Type of Structure	# in town	# in Hazard area	% in Hazard Area	$ in town	$ in Hazard area	% in Hazard Area
Agriculture	5	0	0%	$0	$0	0%
Banks	1	0	0%	$1,260,900	$0	0%
Church/Non-Profit Offices	104	29	28%	$1,391,800	$0	0%
Emergency Response	1	0	0%	$2,067,800	$0	0%
Entertainment and Recreation	7	1	14%	$1,253,200	$139,600	11%
General Services	48	5	10%	$16,392,300	$2,066,400	13%
Heavy Industrial	3	0	0%	$0	$0	0%
Medical Office/Clinic	1	0	0%	$1,823,900	$0	0%
Metals/Minerals Processing	1	0	0%	$201,500	$0	0%
Multi-family Dwelling	245	40	16%	$176,922,100	$57,571,200	33%
Professional/Tech. Services	10	0	0%	$433,500	$0	0%
Retail Trade	11	0	0%	$2,331,900	$0	0%
Schools	3	0	0%	$4,087,900	$0	0%
Single Family Dwelling	2047	235	11%	$512,631,000	$69,227,600	14%
Temporary Lodging	38	15	39%	$18,416,400	$9,658,500	52%
Vacant	788	130	16%	$5,556,200	$3,544,500	64%
Wholesale Trade	7	0	0%	$1,782,600	$0	0%
COLUMN TOTALS	3,320	455		$746,553,000	$142,207,800	

Table 4.10 | The proportion of buildings and value of buildings located in a SLOSH category 2 zone. Table generated using 2015 Truro Assessing Data

Results of the Vulnerability Assessment

SLOSH (Category 3 Storm)

Type of Structure	Number of Parcels			Value of Buildings		
	# in town	# in Hazard area	% in Hazard Area	$ in town	$ in Hazard area	% in Hazard Area
Agriculture	5	2	40%	$0	$0	0%
Banks	1	0	0%	$1,260,900	$0	0%
Church/Non-Profit Offices	104	35	34%	$1,391,800	$0	0%
Emergency Response	1	0	0%	$2,067,800	$0	0%
Entertainment and Recreation	7	1	14%	$1,253,200	$139,600	11%
General Services	48	15	31%	$16,392,300	$5,172,300	32%
Heavy Industrial	3	0	0%	$0	$0	0%
Medical Office/Clinic	1	0	0%	$1,823,900	$0	0%
Metals/Minerals Processing	1	0	0%	$201,500	$0	0%
Multi-family Dwelling	245	64	26%	$176,922,100	$91,228,100	52%
Professional/Tech. Services	10	0	0%	$433,500	$0	0%
Retail Trade	11	3	27%	$2,331,900	$593,000	25%
Schools	3	0	0%	$4,087,900	$0	0%
Single Family Dwelling	2047	363	18%	$512,631,000	$96,883,200	19%
Temporary Lodging	38	27	71%	$18,416,400	$15,272,500	83%
Vacant	788	201	26%	$5,556,200	$3,544,500	64%
Wholesale Trade	7	0	0%	$1,782,600	$0	0%
COLUMN TOTALS	3,320	711		$746,553,000	$212,833,200	

Table 4.11 | The proportion of buildings and value of buildings located in a SLOSH category 3 zone.
Table generated using 2015 Truro Assessing Data

SLOSH (Category 4 Storm)

Type of Structure	Number of Parcels			Value of Buildings		
	# in town	# in Hazard area	% in Hazard Area	$ in town	$ in Hazard area	% in Hazard Area
Agriculture	5	2	40%	$0	$0	0%
Banks	1	0	0%	$1,260,900	$0	0%
Church/Non-Profit Offices	104	30	29%	$1,391,800	$0	0%
Emergency Response	1	0	0%	$2,067,800	$0	0%
Entertainment and Recreation	7	1	14%	$1,253,200	$139,600	11%
General Services	48	15	31%	$16,392,300	$5,172,300	32%
Heavy Industrial	3	0	0%	$0	$0	0%
Medical Office/Clinic	1	0	0%	$1,823,900	$0	0%
Metals/Minerals Processing	1	0	0%	$201,500	$0	0%
Multi-family Dwelling	245	66	27%	$176,922,100	$91,245,500	52%
Professional/Tech. Services	10	0	0%	$433,500	$0	0%
Retail Trade	11	4	36%	$2,331,900	$650,400	28%
Schools	3	0	0%	$4,087,900	$0	0%
Single Family Dwelling	2047	391	19%	$512,631,000	$104,973,100	20%
Temporary Lodging	38	27	71%	$18,416,400	$14,910,700	81%
Vacant	788	185	23%	$5,556,200	$3,544,500	64%
Wholesale Trade	7	0	0%	$1,782,600	$0	0%
COLUMN TOTALS	3,320	721		$746,553,000	$220,636,100	

Table 4.12 | The proportion of buildings and value of buildings located in a SLOSH category 4 zone. Table generated using 2015 Truro Assessing Data

Results of the Vulnerability Assessment

Parcels and Buildings Vulnerable to Shoreline Change

Coastal Properties		
	# of Parcels in Hazard area	**$ of Buildings in Hazard area**
Coastal	389	$155,148,000
Not Coastal	2929	$590,630,300
COLUMN TOTAL	3,318	745,778,300

Table 4.13 | The proportion of buildings and value of buildings on parcels that share a physical boundary with sea water. If a parcel shares a physical boundary with sea water, it is assumed to be vulnerable to shoreline change and erosion.
Table generated using 2015 Truro Assessing Data

Results of the Vulnerability Assessment

Results of the Vulnerability Assessment

Exposure Assessment of Critical Facilities by the Planning Team

Name of Critical Facility	SLOSH Cat 1	SLOSH Cat 2	SLOSH Cat 3	SLOSH Cat 4	Sea Level Rise 1 foot	Sea Level Rise 2 feet	Sea Level Rise 3 feet	Sea Level Rise 4 feet	Sea Level Rise 5 feet	Sea Level Rise 6 feet	Special Flood Hazard Area (AE)	Special Flood Hazard Area (VE)	COASTAL (boundary with salt water)
Public Safety Facility	N	N	N	N	N	N	N	N	N	N	N	N	N
Town Hall	N	N	N	N	N	N	N	N	N	N	N	N	N
Truro Community Center	N	N	N	N	N	N	N	N	N	N	N	N	N
Department of Public Works	N	N	N	N	N	N	N	N	N	N	N	N	N
Truro Transfer Station	N	N	N	N	N	N	N	N	N	N	N	N	N
Fuel Station for gas and diesel	N	N	N	N	N	N	N	N	N	N	N	N	N
Truro Central School	N	N	N	N	N	N	N	N	N	N	N	N	N
Truro Public Library	N	N	N	N	N	N	N	N	N	N	N	N	N
Pamet Harbor	N	N	N	N	Y, coast	Y, coast	Y, coast	Y, coast	Y, coast	Y, coast	No	Y	Y
Pamet Harbor Pier	Y	N	N	N	Y, coast	Y, coast	Y, coast	Y, coast	Y, coast	Y, coast	N	Y	Y
Pamet Harbor Boat Ramp	Y	Y	Y	Y	Y, coast	Y, coast	Y, coast	Y, coast	Y, coast	Y, coast	N	Y	Y
Pamet Harbor Jetties North	Y	Y	Y	Y	Y, coast	Y, coast	Y, coast	Y, coast	Y, coast	Y, coast	N	Y	N
Pamet Harbor Jetties South	Y	Y	Y	Y	Y, coast	Y, coast	Y, coast	Y, coast	Y, coast	Y, coast	N	Y	N
Harbormasters Office	N	N	Y	Y	N	N	N	N	Y, coast	Y, coast	N	Y	Y
Well field for Provincetown and Truro	N	N	N	N	N	N	N	N	N	N	N	N	N
Knowles Heights Pump House	N	N	N	N	N	N	N	N	N	N	N	N	N
South Hollow Pump House and well field	N	N	N	N	N	N	N	N	N	N	N	N	N
Pump House and Filtration System	N	N	N	N	N	N	N	N	N	N	N	N	N

Results of the Vulnerability Assessment

Name of Critical Facility	SLOSH Cat 1	SLOSH Cat 2	SLOSH Cat 3	SLOSH Cat 4	Sea Level Rise 1 foot	Sea Level Rise 2 feet	Sea Level Rise 3 feet	Sea Level Rise 4 feet	Sea Level Rise 5 feet	Sea Level Rise 6 feet	Special Flood Hazard Area (AE)	Special Flood Hazard Area (VE)	COASTAL (boundary with salt water)
Route 6A	N	N	Partial	Partial	N	N	Partial	Partial	Partial	Partial	Partial	Partial	N
Route 6	N	N	Partial	Partial	N	N	N	Partial	Partial	Partial	Partial	N	N
Old County/Rd Depot/ Rd Route 6A	Partial	Partial	Partial	Partial	Partial	Partial	Partial	Partial	Partial	Partial	Partial	N	Partial
Highhead Road Culvert	N	N	Y	Y	Y, coast	Y, coast	Y, coast	Y, coast	Y, coast	Y, coast	Y	No	Y
Culvert at East Harbor	N	N	N	Y	N	N	N	Y, coast	Y, coast	Y, coast	Y	N	N
East Harbor outfall pipe	Y	Y	Y	Y	Y, coast	Y, coast	Y, coast	Y, coast	Y, coast	Y, coast	N	Y	N
culvert near Corn Hill Road, Little Pamet	N	N	N	Y	N	N	N	N	N	Y, coast	Y	N	Y
Route 6 culvert near Long Nook Road	N	N	Y	Y	Y, depression	Y, depression	Y, depression	Y, depression	Y, depression	Y, depression	Y	N	N
Culvert on Castle Hill Road, Little Pamet	N	N	Y	Y	N	N	Y, depression	Y, coast	Y, coast	Y, coast	Y	N	N
Culvert under Route 6 near South Pamet Road	N	N	N	N	Y, coast	Y, coast	Y, coast	Y, coast	Y, coast	Y, coast	Y	N	N
Wilder Dike Culvert Tidal Restriction	Y	Y	Y	Y	N	N	N	N	N	N	Y	N	N
Mill Pond Culvert	N	N	Y	Y	N	N	N	N	Y, coast	Y, coast	Y	N	N
Eagle Creek culvert	N	N	N	Y	N	N	N	N	N	Y, coast	Y	N	N

Table 4.14 | Exposure Assessment for Critical Facilities. In the Sea Level Rise section of the table, "Y coast" represents facilities that are inundated by water from the coast, "Y depression" represents facilities that are inundated because they are in low-lying areas. Asterisks indicate that the Planning Team would like to provide additional commentary on the exposure of the asset - See Additional Comments on Asset Exposure Section

Results of the Vulnerability Assessment

Name of Critical Facility	SLOSH Cat 1	SLOSH Cat 2	SLOSH Cat 3	SLOSH Cat 4	Sea Level Rise 1 foot	Sea Level Rise 2 feet	Sea Level Rise 3 feet	Sea Level Rise 4 feet	Sea Level Rise 5 feet	Sea Level Rise 6 feet	Special Flood Hazard Area (AE)	Special Flood Hazard Area (VE)	COASTAL (boundary with salt water)
Great Hollow Beach Parking Lot	N	N	N	N	N	N	N	N	N	N	N	N	N
Cold Storage Beach Parking Lot	N	N	N	N	N	N	N	N	N	N	N	N	N
Great Hollow Beach Parking Lot	N	N	N	N	N	N	N	N	N	N	N	Y	Y
Corn Hill Beach Parking Lot	N	N	Y	Y	N	N	N	Y, coast	Y, coast	Y, coast	Y	N	Y
Pamet Harbor Parking Lot	N	N	Y	Y	N	N	N	N	N	Y, coast	Y	N	Y
Ballston Beach Parking Lot	N	N	N	N	Y, coast	Y, coast	Y, coast	Y, coast	Y, coast	Y, coast	Y	N	Y
Ballston Beach overwash fan over parking lot	N	N	N	N	Y, coast	Y, coast	Y, coast	Y, coast	Y, coast	Y, coast	Y	N	N
Long Nook Beach Parking Lot	N	N	N	N	N	N	N	N	N	N	N	N	N
Head of the Meadow Parking Lot	N	N	N	N	N	N	N	N	N	N	N	N	N
CCNS Head of the Meadow Parking Lot	N	N	Y	Y	N	N	N	Y, coast	Y, coast	Y, coast	Y	N	Y
Fisher Beach Parking Lot	N	N	Y	Y	N	N	Y, depression	Y, depression	Y, depression	Y, depression	N	Y	N
Ryder Beach Parking Lot	N	N	Y	Y	N	N	Y, coast	Y, coast	Y, coast	Y, coast	Y	N	N

Results of the Vulnerability Assessment

Name of Critical Facility	SLOSH Cat 1	SLOSH Cat 2	SLOSH Cat 3	SLOSH Cat 4	Sea Level Rise 1 foot	Sea Level Rise 2 feet	Sea Level Rise 3 feet	Sea Level Rise 4 feet	Sea Level Rise 5 feet	Sea Level Rise 6 feet	Special Flood Hazard Area (AE)	Special Flood Hazard Area (VE)	COASTAL (boundary with salt water)
Coast Guard Rescue 21 Communications Tower	N	N	N	N	N	N	N	N	N	N	N	N	Y
Eversource Transformer Station	N	N	N	N	N	N	N	N	N	N	N	N	N
Cell Tower	N	N	N	N	N	N	N	N	N	N	N	N	N
FAA Radar Facility	N	N	N	N	N	N	N	N	N	N	N	N	Y

Results of the Vulnerability Assessment

Results: Hazus Simulations for High Winds

General Description of the Region:

According to the data in Hazus, the geographical size of the region (the Town of Truro) contains 21.76 square miles and contains 1 census track. There are an estimated 2,000 buildings in Truro with a total building replacement value (excluding contents) of $739 million (2010 dollars). Approximately 97% of the buildings and 92% of the building value are associated with residential housing.

General Building Stock Damage:

Hazus estimates that in a 100-year event about 48 buildings will be at least moderately damaged. This is over 2% of the total number of buildings in the region. Hazus estimates that 1 building will be completely destroyed. For an explanation of these damage states, see Hazus Technical Manual, Chapter 6.

Debris Generation:

Hazus estimates the amount of debris that will be generated by the hurricane. The model breaks the debris into four general categories: a) Brick/ Wood, b) Reinforced Concrete/Steel, c) Eligible Tree Debris, and d) Other Tree Debris. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 9,205 tons of debris will be generated. Of the total amount, 6,315 tons (69%) is Other Tree Debris. Of the remaining 2,890 tons, Brick/Wood comprises 29% of the total, Reinforced Concrete/Steel comprises of 0% of the total, with the remainder being Eligible Tree Debris. If the building debris tonnage is converted to an estimated number of truckloads, it will require 34 truckloads (@25 tons/ truck) to remove the building debris generated by the hurricane. The number of Eligible Tree Debris truckloads will depend on how the 2,037 tons of Eligible Tree Debris are collected and processed. The volume of tree debris generally ranges from about 4 cubic yards per ton for chipped or compacted tree debris to about 10 cubic yards per ton for bulkier, uncompacted debris.

Simulated Hurricane Assessment

According to the data in Hazus, the majority of buildings in Truro are constructed with wood and concrete. With help from a student and faculty member at Massachusetts Maritime Academy, the team compared two types of 2-story wooden single family homes and two types of concrete single family homes and analyzed their performance during high wind events.

Wooden Buildings:

- **Building Type #1:** has the following characteristics: gable roof shape (a roof that slopes up from all four sides of the building), 6d nails for roof-deck attachment, toe-nailed roof-wall connections, no shutters, "trees terrain" meaning the building is in a wooded area
- **Building Type #2:** has the following characteristics: hip roof shape (a ridged roof that slopes up from only two sides of a building), 8d nails for roof-deck attachment, strapped roof-wall connections, shutters, "trees terrain" meaning the building is in a wooded area

Figure 4.2 shows the functions curves for both building types.

The assessment was repeated except the terrain surrounding the home was changed from "tree terrain" to "open." The open terrain characteristic can be used as a proxy for homes that are in coastal environments with few surrounding trees. ***Figure 4.3*** shows the functions curves for both building types in "open" terrain.

Concrete Buildings:

The team performed a similar assessment for concrete buildings in Truro.

- **Building Type #3:** has the following characteristics: single ply membrane roof, high window area, no shutters, "trees terrain" meaning the building is in a wooded area
- **Building Type #4:** has the following characteristics: built up roof, high window area, shutters, "trees terrain" meaning the building is in a wooded area

Figure 4.3 shows the functions curves for both concrete building types. The assessment was repeated except the terrain surrounding the home was changed from "tree terrain" to "open." The open terrain characteristic can be used a proxy for homes that are in coastal environments with few surrounding trees. ***Figure 4.4*** shows the functions curves for the weaker and stronger building construction in "open" terrain.

Results of the Vulnerability Assessment

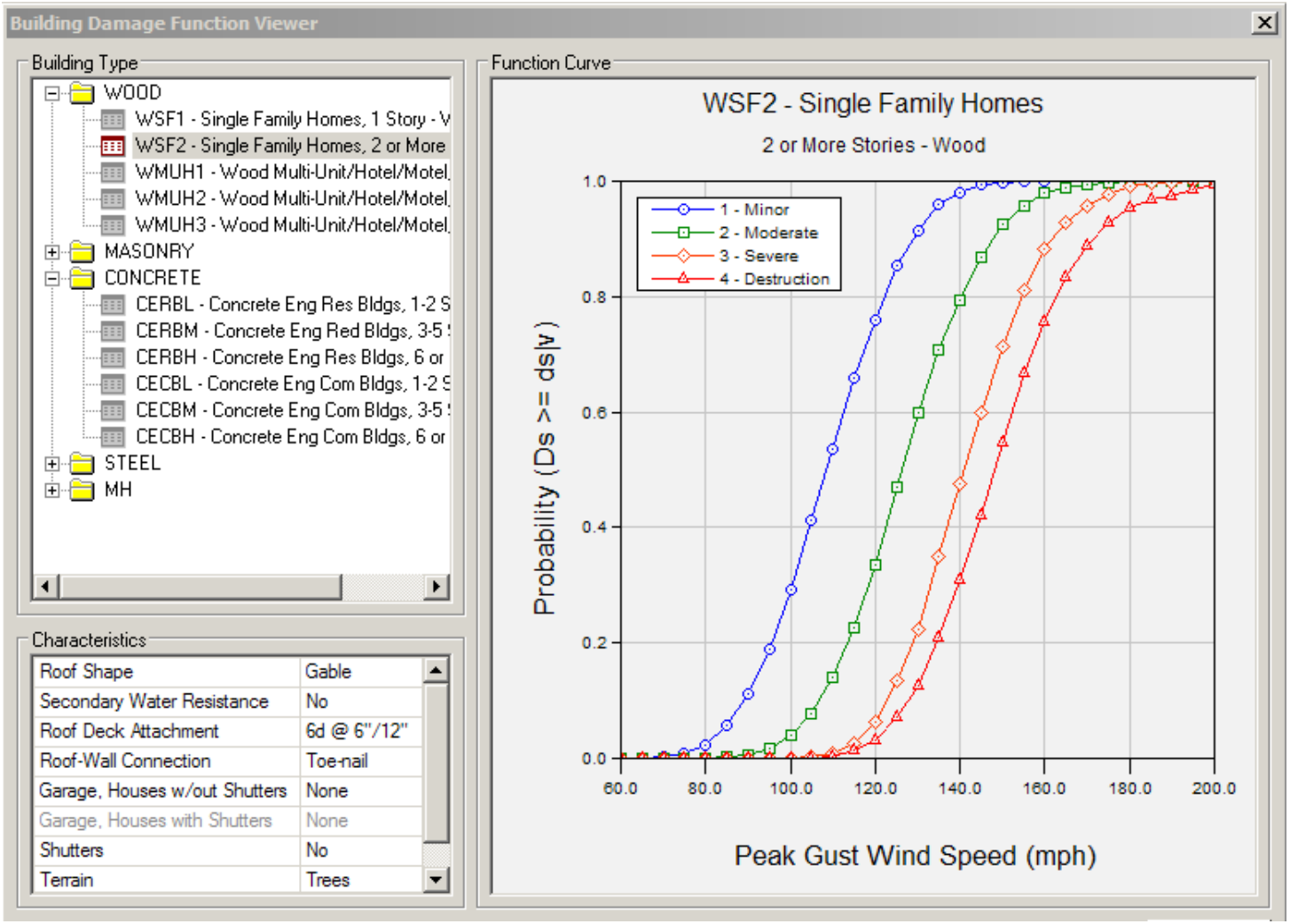


Figure 4.2a | Impact of wind speed on a wooden single family home with a gable roof, 6d nails, toe nail roof wall connection and no shutters in tree terrain (Building Type #1)

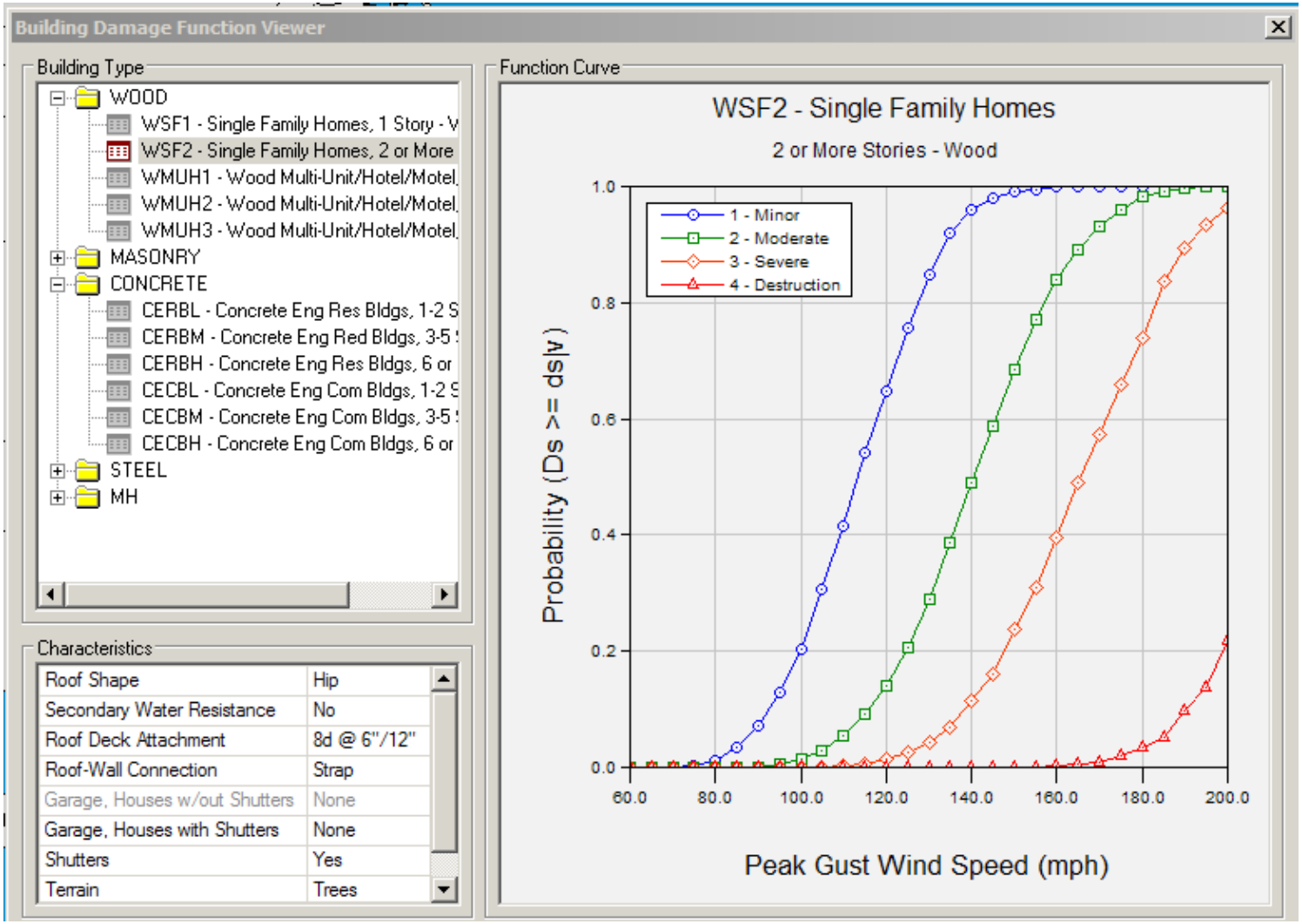


Figure 4.2b | Impact of wind speed on a wooden single family home with a hip roof shape, 8d nails, strap roof-wall connection and shutters in tree terrain. (Building Type #2)

Results of the Vulnerability Assessment

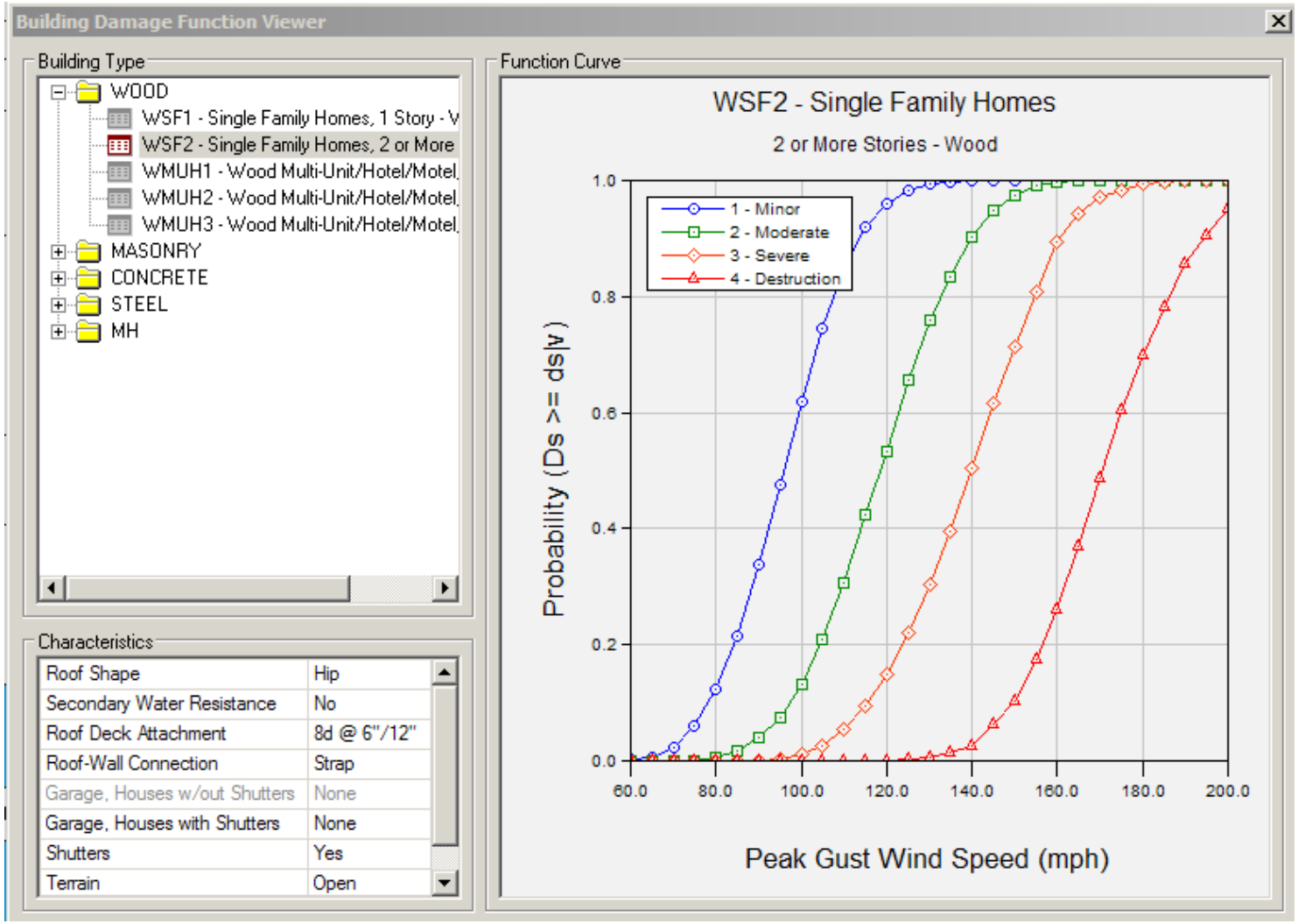


Figure 4.3a | Impact of wind speed on a wooden single family home with a gable roof, 6d nails, toe nail roof wall connection and no shutters in open terrain. (Building Type #1)

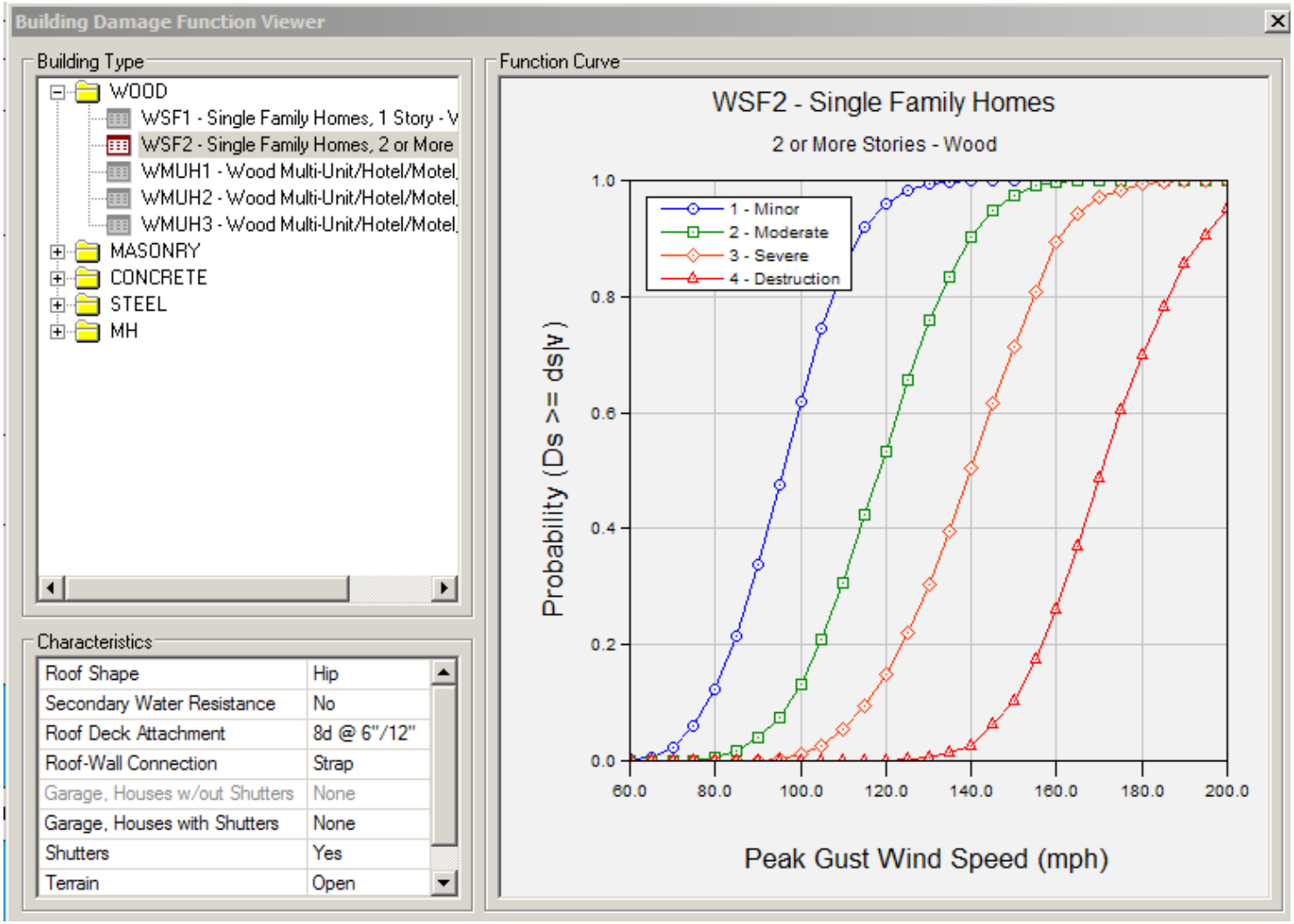


Figure 4.3b | Impact of wind speed on a wooden single family home with a hip roof shape, 8d nails, strap roof-wall connection and shutters in open terrain. (Building Type #2)

Results of the Vulnerability Assessment

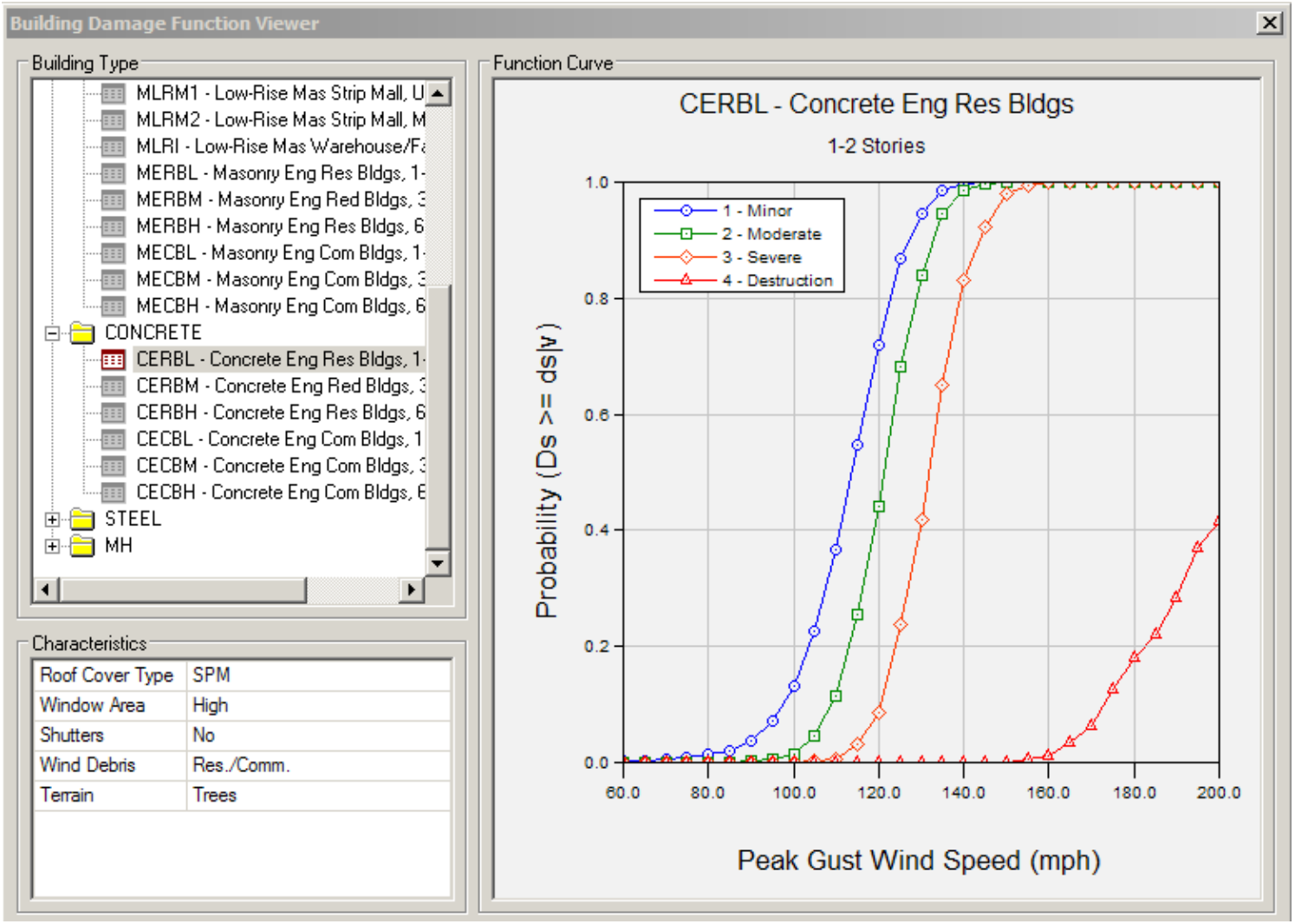


Figure 4.4a | Impact of wind speed on a concrete single family home with single ply membrane, high window area, no shutters in tree terrain. (Building Type #3)

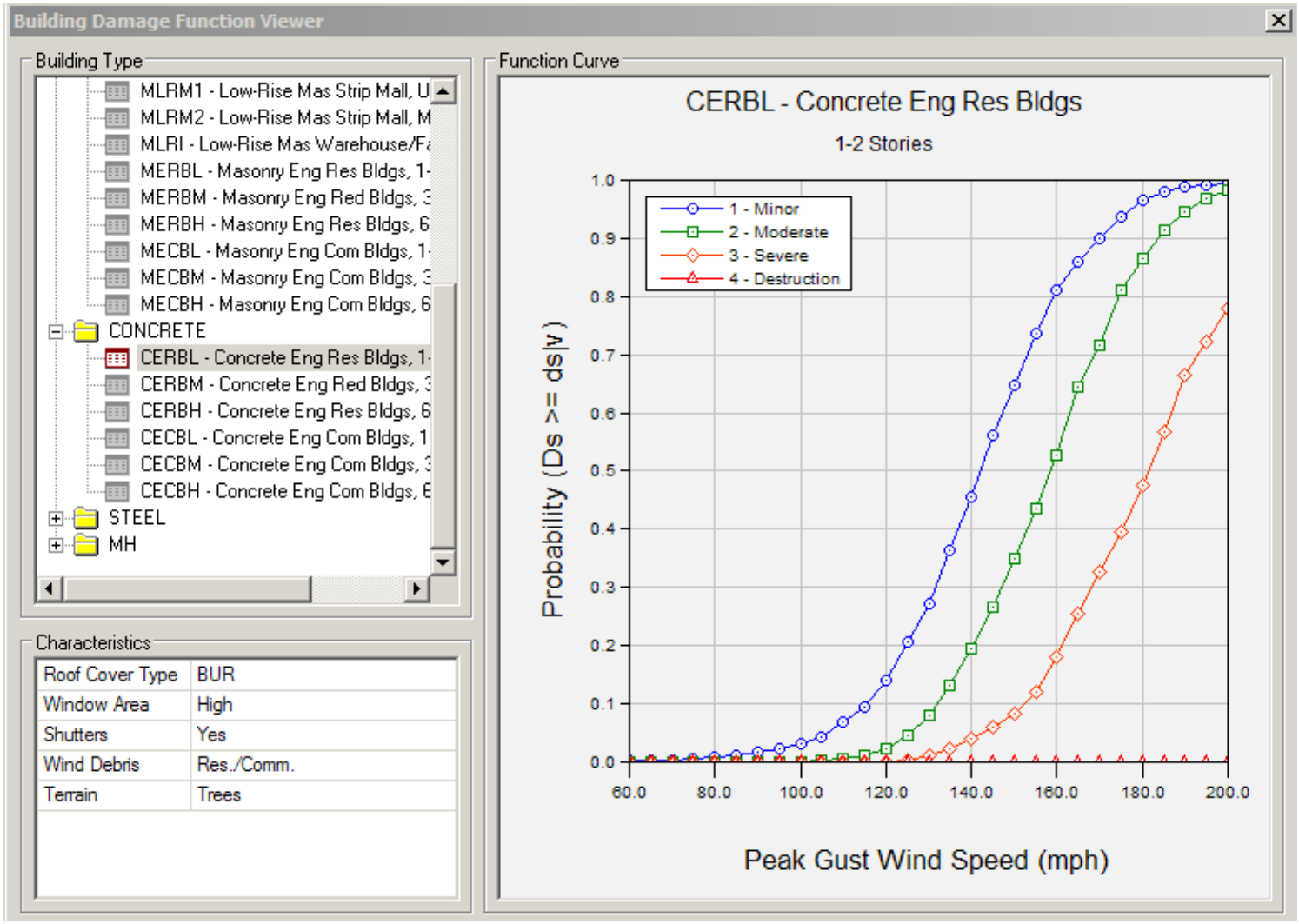


Figure 4.4b | Impact of wind speed on a concrete single family home with a built up roof, high window area, shutters in tree terrain (Building Type #4)

Results of the Vulnerability Assessment

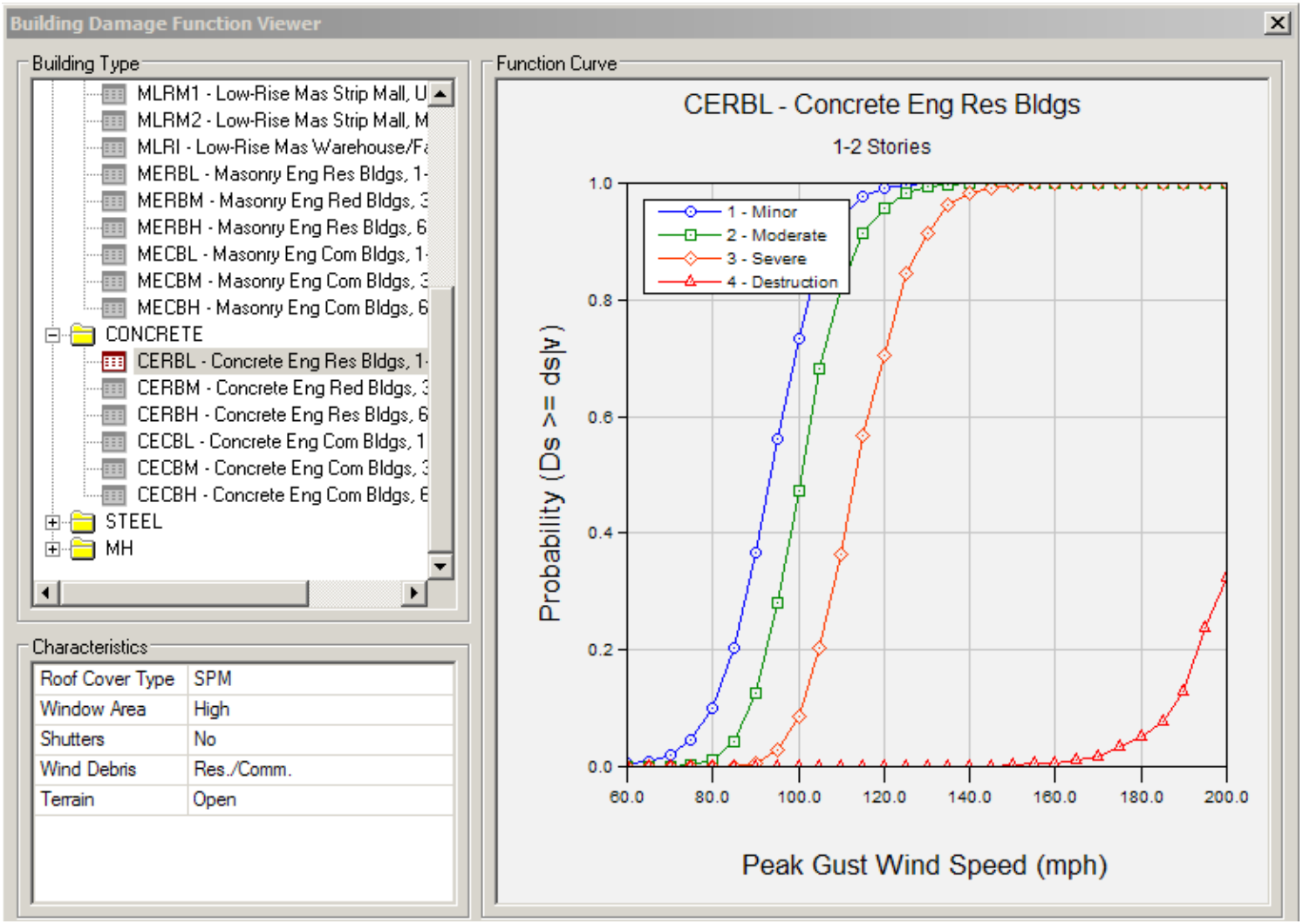


Figure 4.5a | Impact of wind speed on a concrete single family home with single ply membrane, high window area, no shutters in open terrain. (Building Type #3)

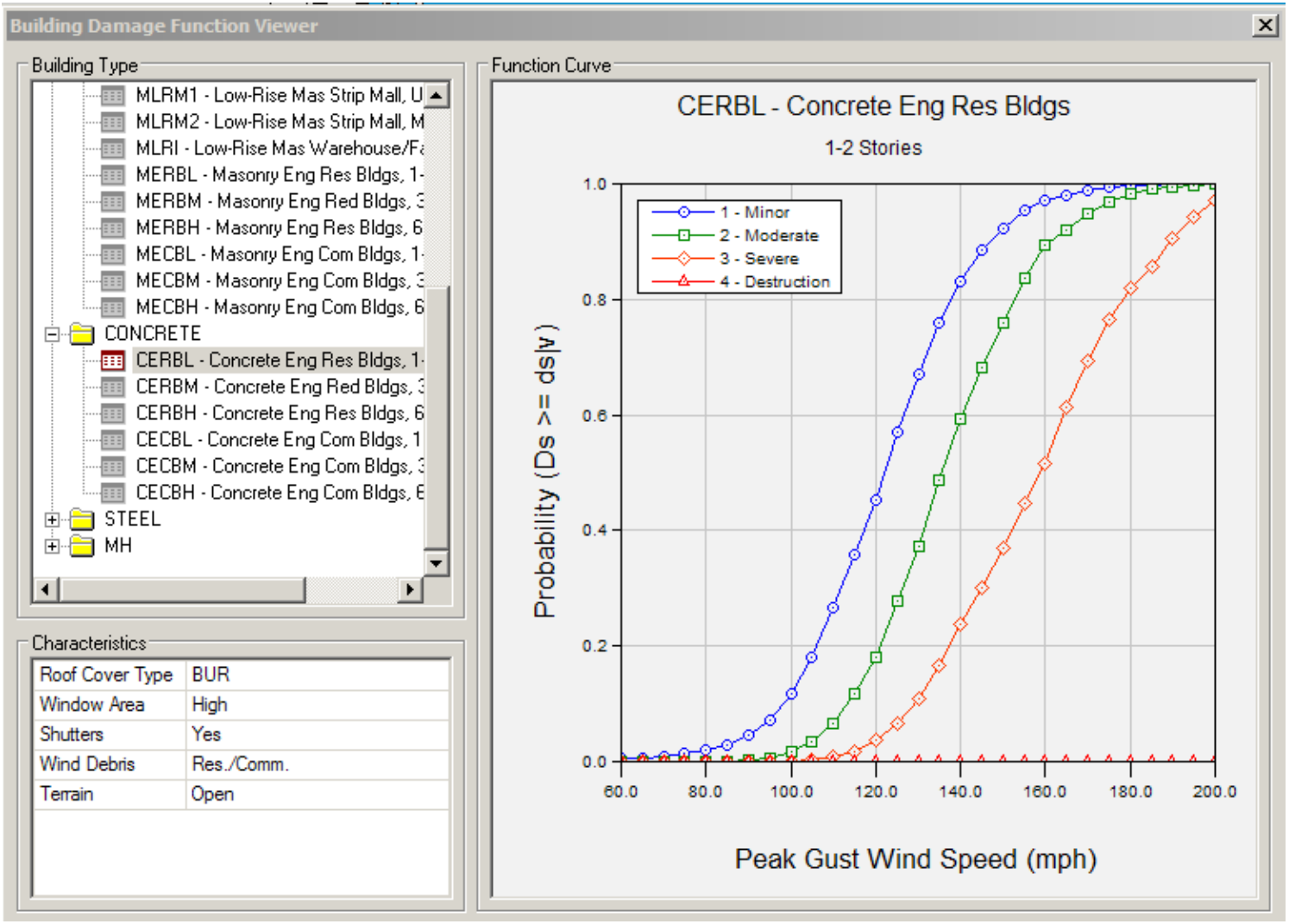


Figure 4.5b | Impact of wind speed on a concrete single family home with a built up roof, high window area, shutters in open terrain (Building Type #4)

Conclusion: Hazus Simulations

These curves show that properly constructed homes are able to withstand much higher winds than other types of homes. According to the data in Hazus, wooden homes with shutters, 8d nails, a hip roof shape can perform better at higher wind speeds than homes with a gable roof, 6d tails, toe nail roof wall construction and no shutters. Concrete homes with built up roof and shutters can withstand much higher wind speeds than concrete homes with a single ply membrane and no shutters. The town can factor these findings into their discussions of zoning and building codes in the future.

B3b

Vulnerable Populations

Below is a description of segments of the population who are vulnerable to the impacts of natural hazard events[3]:

Coastal Erosion: Coastal erosion is not generally considered an imminent threat to public safety because shoreline changes are gradual over many years. However, drastic changes to the shoreline may occur in a single storm event which can threaten homes and public safety.

Culvert Failure: All populations in a culvert failure inundation zone would be exposed to the risk of culvert failure. The potential for loss of life is affected by the capacity and number of evacuation routes available to populations living in areas of potential inundation[2].

Earthquake: The entire population of Massachusetts is potentially exposed to direct and indirect impacts from earthquakes. The degree of exposure is dependent on many factors, including the age and construction type of dwelling structures, soil types in which homes are constructed, proximity to fault locations, etc. Further, the time of day also exposes different sectors of the community to the hazard.[2]

Wildland and Urban Fire: As demonstrated by historical urban and wildfire events, potential losses include human health and life of residents and responders. The most vulnerable populations include the elderly, children, and disabled as well as emergency responders and those within a short distance of the interface between the built environment and the wildland environment.[2]

Flooding: The impact of flooding on life, health, and safety is dependent upon several factors including the severity of the event and whether or not adequate warning time is provided to residents. Exposure includes the population living in or near floodplain areas that could be impacted should a flood event occur. Additionally, exposure should not be limited to only those who reside in a defined hazard zone, but everyone who may be affected by a hazard event (e.g., risk while traveling in flooded areas, or compromised access to

3 2013 Massachusetts State Hazard Plan

emergency services during an event). The degree of such impacts will vary and is not strictly measurable.[2] Of the population exposed, the most vulnerable include the economically disadvantaged and population over the age of 65. Those over the age of 65 are vulnerable because they are more likely to seek or need medical attention, which may not be available due to isolation during a flood event. They also may have more difficulty evacuating.[2]

Hurricanes and Tropical Storms: The impact of a hurricane or tropical storm on life, health and safety is dependent upon several factors including the severity of the event and whether or not residents received adequate warning time. It is assumed that the entire population of Barnstable County is exposed to this hazard. Residents may be displaced or require temporary to long-term sheltering. In addition, downed trees, damaged buildings, and debris carried by high winds can lead to injury or loss of life. Socially vulnerable populations are most susceptible, based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing.[2] Of the population exposed, the most vulnerable include the economically disadvantaged and population over the age of 65. Those over the age of 65 are vulnerable because they are more likely to seek or need medical attention, which may not be available due to isolation during a flood event. They also may have more difficulty evacuating.[2]

Landslides: It is difficult to determine demographics of populations vulnerable to landslides.[2]

Nor'easters: The impact of a nor'easter on life, health and safety is dependent upon several factors including the severity of the event and whether or not residents received adequate warning time. It is assumed that the entire Commonwealth's population is exposed to this hazard (wind and rain/snow). Of the population exposed, the most vulnerable include the economically disadvantaged and population over the age of 65. Those over the age of 65 are vulnerable because they are more likely to seek or need medical attention, which may not be available due to isolation during a flood event. They also may have more difficulty evacuating.[2]

Severe Weather (wind, thunderstorms, tornadoes, extreme temperatures, drought): For the purposes of this plan, the entire population of the Truro is exposed to severe weather events. Residents may be displaced or require temporary to long-term sheltering due to severe weather events. In addition, downed trees, damaged buildings and debris carried by high winds can lead to injury or loss of life. Socially vulnerable populations are most susceptible, based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. In general, vulnerable populations include the elderly, low income or linguistically isolated populations, people with life-threatening illnesses, and residents living in areas that are isolated from major

Vulnerable Populations

roads. Power outages can be life threatening to those dependent on electricity for life support. Isolation of these populations is a significant concern. These populations face isolation and exposure during severe weather events and could suffer more secondary effects of the hazard.[2]

Severe Winter Weather (snow, blizzards and ice): According to NOAA's National Severe Storms Laboratory, winter weather indirectly and deceptively kills hundreds of people in the U.S. every year, primarily from automobile accidents, overexertion and exposure. Winter storms are often accompanied by strong winds, creating blizzard conditions with blinding wind-driven snow, drifting snow and extreme cold temperatures with dangerous wind chills. These storms are considered deceptive killers because most deaths and other impacts or losses are indirectly related to the storm. Injuries and fatalities may occur due to traffic accidents on icy roads, heart attacks while shoveling snow or hypothermia from prolonged exposure to cold.[2]

Heavy snow can immobilize a region and paralyze a town, shutting down its transportation network, stopping the flow of supplies, and disrupting medical and emergency services. The elderly are considered most susceptible due to their increased risk of injury and death from falls and overexertion and/or hypothermia from attempts to clear snow and ice, or related to power failures. In addition, severe winter weather events can reduce the ability of these populations to access emergency services. Residents with low incomes may not have access to housing or their housing may be less able to withstand cold temperatures (e.g., homes with poor insulation and heating supply).[2]

Tsunami: It is difficult to determine demographics of populations vulnerable to tsunamis.[2]

Figure 4.6 | Aerial image of the deteriorating and vulnerable characteristics of East Harbor Culvert. From the Final Report: East Harbor Culvert Evaluation (Woods Hole Group, 2015)

Summary of Vulnerable Infrastructure

Below is a description of infrastructure that is vulnerable in Truro to the impacts of natural hazards:

- Route 6 near East Harbor
- Shore Road/Route 6A near East Harbor
- High Head Road Culvert
- East Harbor Culvert and outfall Pipe (see ***Figure 4.6***)
- Intersection of Highland, Pond and Shore Roads
- Shore Road Culvert
- Castle Road Culvert
- Cornhill Road Culvert
- Pamet Harbor Parking Lot
- Mill Pond Road Culvert
- Truro Center Road Culvert
- Ballston Beach Parking Lot
- Connection between North and South Pamet Road

Results: Vulnerability Assessment

Mitigation Strategy

CHAPTER FIVE

Chapter 2 profiled specific hazards that could affect Truro and Chapter 4 assessed the losses that could result from those hazard events. The next step in the hazard planning process is to identify actions to reduce risk and loss of life and to develop way to implement these actions. This so-called “Mitigation Strategy” determines broad goals and objectives and outlines specific actions for the next five years. **Chapter 5 outlines a mitigation strategy for the Town of Truro for the next five years.**

C3a,b

Mitigation Goals

Mitigation goals are broad guidelines that articulate Truro's desire to protect people and structures, reduce the cost of disaster response and recovery, and minimize disruption to the community following a disaster.[1]

Mitigation Goals for the 2017 Truro Hazard Mitigation Plan are:

1. Reduce the potential for loss of life, property, infrastructure, and environmental, cultural and economic resources in Truro from natural hazards.
2. Mitigate financial losses incurred by municipal, residential, industrial, agricultural and commercial establishments due to natural hazards.
3. Reduce the damage to public infrastructure resulting from natural hazards including but not limited to critical facilities, roadways and culverts and water facilities.
4. Competitively position the Town to seek and apply for funding opportunities to implement the actions identified in the Truro Hazard Mitigation Plan.
5. Ensure that mitigation measures are sensitive to the natural features, historic resources, and community character of Truro.
6. Communicate local hazard mitigation planning activities with Barnstable County, neighboring towns and the Massachusetts Emergency Management Agency.
7. Increase public awareness of existing hazards and encourage hazard mitigation planning as part of the overall municipal planning process.

Mitigation Actions

Mitigation actions are any action, process or project designed to reduce or eliminate long term risk from natural hazards. These mitigation actions are developed by the Planning Team and they must be consistent with the vulnerability and risk assessment performed in Chapter 4 and with the priorities of the Town of Truro.

Below is a description of how the Planning Team developed the Mitigation Action section of the 2017 Truro Hazard Mitigation Plan Update:

1. **A Progress Determination on Mitigation Actions in 2011**: the Team assigned a status to each mitigation action identified in the 2011 Hazard Mitigation Plan and explained why the action was completed, an existing capability, in progress, deferred or deleted (See ***Table 5.1***).
2. **Future Mitigation Actions for the 2017 Hazard Mitigation Plan Update**: the list contains:

1 FEMA How-to Guide 3: Developing the Mitigation Plan: Identifying mitigation actions and implementation strategies, FEMA 386-3, April 2003

- new mitigation actions based on the Vulnerability and Risk Assessment in Chapter 4
- "In Progress" actions identified in ***Table 5.1*** were carried forward into the Future Mitigation Action List

3. **Capability Assessment**: the Team reviewed and revised the Capability Assessment from the 2011 Hazard Mitigation Plan. Also, any action designated as an "existing capability" in ***Table 5.1*** was carried over to the Capability Assessment. (***Table 5.2***)

Progress Determination on Mitigation Actions since 2011

Before identifying new Mitigation Actions for the 2017 Hazard Plan, the Planning Team discussed the status of the mitigation actions identified in 2011 Hazard Mitigation Plan. One of the following status determinations was given to each mitigation action identified from the 2011 plan:

- **Complete:** The project was implemented and completed in 2011 – 2017.
- **Existing Capability:** The project was implemented and completed in 2011 – 2017, and it will continue to be implemented on an annual basis in the future. These action items are also identified in the capability assessment (***Table 5.2***).
- **In Progress:** The project was started in the 2011 – 2017 timeframe and it is still in progress.
- **Deferred:** The project is important, but it was deferred because there was no funding available or it is not feasible to complete the project.
- **Deleted:** The project is no longer relevant to the community.

In 2011 the Planning Team identified Mitigation Actions; and during the plan update, the Planning Team assessed the Town's progress on all of these actions (***Table 5.1***).

Progress Determination on 2011 Mitigation Actions

Table 5.1 | Progress Determination on 2002 Mitigation Actions

Hazard(s) to Mitigate	Action Item Number and Description	Responsible Department	Status	Explanation of Status
All Hazards	1. Assign staff to conduct in-depth risk assessments, including a Quantification of Potential Losses, to apply for mitigation funding and to track the results.	Assistant Town Manager, DPW Director, Health/ Conservation Agent, Building Commissioner, Emergency Management Director"	In Progress	In 2011, the town assessed how vulnerable the Public Safety Building was to lightning strikes and the appropriate mitigation actions were implemented. In 2013, the bluff was damaged at Ballston Beach during storm events and the Town is currently working with DER and the Army Corps of Engineers to identify an appropriate mitigation strategy. This action was carried forward to Mitigation Action #15
All Hazards	2. Monitor the Town's emergency response services to identify needs or shortfalls in terms of protocol, personnel, equipment or resources.	Emergency Management Director, Police Chief, Fire Chief, Health/ Conservation Agent"	In Progress	Several positions were filled at the Truro Police and Fire Departments. Currently, there is a need for better communication systems and the Fire Department needs a water tender to replace the existing one that is 27 years old. This action was carried forward to Mitigation Action #14
All Hazards	3. Continue regional and sub-regional meetings and planning efforts. Coordination with other Outer Cape towns and the County can avoid duplication of services and equipment and a coordinated overall effort."	Emergency Management Director, Police Chief, Fire Chief, Assistant Town Manager, Health & Conservation Agent"	Existing Capability	Town Staff continue to meet with the Barnstable County Regional Emergency Planning Committee on a monthly basis.

Progress Determination on 2011 Mitigation Actions

Hazard(s) to Mitigate	Action Item Number and Description	Responsible Department	Status	Explanation of Status
Flooding, Erosion and Sea Level Rise	4. Revise the Town's Flood Plain Zoning to incorporate cumulative substantial damage or improvement requirements. Truro's Zoning by-laws do not include a definition of "substantial improvement." The by-law should require buildings to be brought into compliance with flood protection standards earlier in their life cycle. The Town should maintain permit history so when cumulative repairs and improvements equal 50% of the building value, the building must be brought up to current codes for floodplain development."	Assistant Town Manager, Building Commissioner, Planning Board, Conservation Commission"	Existing Capability	Substantial damage or improvement requirements are included in the State Building Code, but it is not cumulative.
Flooding	5. Identify developed areas and roadways subject to repeated flooding.	DPW Director, Conservation Agent, Building Commissioner, Assistant Town Manager"	Existing Capability	The town of Truro in collaboration with the Cape Cod Commission identifies transportation infrastructure that is vulnerable to flooding, sea level rise and erosion. This work is part of the Unified Planning and Work Program.
All Hazards	6. Develop protocols for relocation of vulnerable equipment and for provision of emergency utilities for emergency centers. Retrofit critical Town facilities located in the SLOSH and FIRM zones. Existing emergency response plans do not address relocation of computer and other electronic equipment in Town facilities, such as Provincetown Pump Houses. In addition, none of these facilities has undergone retrofitting to improve their ability to withstand high winds or flooding.	Assistant Town Manager, DPW Director, Town of Provincetown	Existing Capability	A generator was purchased and installed for the Public Safety Facility. Generators were also purchased for Town Hall, library, community center, and elementary school. The town of Truro contributed money to the town of Provincetown for their wind shutters and a container for their emergency supplies for the shelter. Back up for the Town Hall server is provided through Barnstable County.

Progress Determination on 2011 Mitigation Actions

Hazard(s) to Mitigate	Action Item Number and Description	Responsible Department	Status	Explanation of Status
All Hazards	7. Preserve, enhance and restore natural mitigation measures within the floodplain, wetlands, beaches and dunes.	Building Commissioner, Conservation Agent, Conservation Commission, ZBA, Assistant Town Manager"	In Progress	Currently, the town is working on the Pamet River Restoration project with the Provincetown Center for Coastal Studies and other agencies. This action was carried forward to Mitigation Actions #18, 21, 23, 24, 25
Flooding and High Wind	8. Develop early notification program and protocol for areas subject to flooding and difficult to evacuate. A program for early notification and public education should be targeted toward areas that repeatedly flood and have limited vehicle access."	Emergency Management Director, Police, Fire.	Existing Capability	Barnstable County Regional Emergency Planning Committee works on region wide plans for emergency responses to natural hazards. The CERT team in Truro has protocols in place before a storm (i.e. contact buses, motels, hotels) and they reach out to residents who sign up for the early notification system. Also, there are educational brochures related to natural hazards at Town Hall.
Wildfire, Wind and Winter Hazards	9. Work with the CCNS in developing a plan and protocol for clearing and maintenance of fire roads. Analyze the fire road network and determine the critical roads.	Fire Chief, DPW Director, Assistant Town Manager and CCNS	Existing Capability	The town works with the Cape Cod National Seashore on controlled burns. The town and the CCNS have protocols in place for Fire Roads in town.
Flooding	10. Develop policies that would provide for incentives for building above the floodplain. Develop policies that would allow for a waver of application fees, provided construction is 1 or more feet above base flood elevations.	Building Commissioner, Assistant Town Manager, Town Administrator, Selectmen"	Delete	The team decided to delete this action item because the State Building Code includes policies for building in a floodplain.
Wind	11. Augment the enforcement of the State Building Code and related Town By-laws by encouraging wind resistant design techniques for new residential construction during the Town's permitting process.	Building Commissioner	Complete	Wind design is in the Building Code and the town enforces the Building Code.

Progress Determination on 2011 Mitigation Actions

Hazard(s) to Mitigate	Action Item Number and Description	Responsible Department	Status	Explanation of Status
Flooding and Erosion	12. Review Subdivision Rules and Regulations regarding road construction requirements and development within areas prone to flooding or subject to erosion. Review General By-laws regarding requirements to retain all drainage on site. Subdivision Rules and Regulations should be reviewed and updated to include more detailed requirements for road drainage design and to facilitate review of drainage design and calculations by an engineer. Enforcement of existing requirements for property owners to retain runoff on their own property should be stepped up.	"Assistant Town Manager, Building Commissioner, DPW Director, Planning Board"	Existing Capability	At site plan review, drainage is reviewed.
All Hazards	13. Educate Town staff, boards and committees about the importance of hazard mitigation and the techniques and programs available. Hazard mitigation and emergency response are not seen as high planning priorities. They should be included in all long range planning efforts.	"Assistant Town Manager, Health & Conservation Agent, Harbormaster"	Existing Capability	Town Staff and boards learn about the importance of hazard mitigation and the new programs that are available during the update of their hazard mitigation plan.
All Hazards	14. Develop educational materials, displays and events to inform residents about hazards that threaten the Town and mitigation measures they can take to lessen the impact and be better prepared. Materials could be available at various locations such as the Library, Building Department and Community Center. Other outlets might include local newspapers and public access television.	Local MHMP Team, Police, Fire	Existing Capability	Educational material is available at Town Hall. Additional pamphlets are distributed by several county departments including the Cape Cod Cooperative Extension and the Barnstable County Regional Emergency Planning Committee. These pamphlets are also available online.

Progress Determination on 2011 Mitigation Actions

Hazard(s) to Mitigate	Action Item Number and Description	Responsible Department	Status	Explanation of Status
All Hazards	15. Make the local MHMP and other emergency planning and emergency response documents easily accessible to the public. Accessibility to these documents could be improved by posting them on the Town website and by establishing a special area at the Library for written materials.	Local MHMP Team	Existing Capability	Educational material can be accessed through the town website and on social media. Also the Truro Police Department shares information about sheltering on their website.
Flooding	16. Participate in the Community Rating System Program. Participation and certification in the Community Rating System would provide flood insurance policy owners a decrease in their rates.	Assistant Town Manager, Building Commissioner	In Progress	This action was carried over to Mitigation Action #16
All Hazards	17. Continue education programs and materials specific to specialized situations and groups, i.e., campgrounds, boat owners, etc. Specialized information needs to be disseminated to campgrounds, hotels/motels, seasonal rentals and boat owners about preparing for and responding to a disaster.	Local MHMP Team	Existing Capability	The town created materials for special hazard situations such as sharks in the nearby coastal waters and beach fires. These are available on the town website or at Town Hall.
Flooding	18. Work with Mass Highway to control flooding on Route 6 and with the CCNS to provide alternate routes for evacuation and emergency vehicles. Flooding even during routine rainstorms can make area of Route 6 hazardous. In the event of a hurricane or other disaster, alternate routes should be available. A plan should also be developed to control access to these alternative routes."	Police Chief, Fire Chief, DPW Director, Emergency Management Director."	In Progress	Currently, the town is working with Woods Hole Group to mitigate the East Harbor culvert under Route 6. Funds were already appropriated at Town Meeting to repair its outfall pipe in Cape Cod Bay. This action was carried over to Mitigation Action #12

Progress Determination on 2011 Mitigation Actions

Hazard(s) to Mitigate	Action Item Number and Description	Responsible Department	Status	Explanation of Status
All Hazards	19. On an annual basis, contact all owners of FEMA-identified repetitive loss properties and inform them of the assistance available through the federal Flood Mitigation Assistance (FMA) program, in addition to other flood protection measures. Eligible property owners should be contacted every year to promote the availability of the FMA funding through MEMA and to determine their interest in applying for funding.	Assistant Town Manager, Building Commissioner, Assessor	Existing Capability	The town of Truro does have any repetitive loss properties. However, the Fire Department receives loss reports and causes of the loss. The Fair Plan notifies the town that a claim has been filed and investigation took place.
Flooding	20. Identify existing facilities eligible for upgrading through grant programs and new mitigation measures that would qualify for grant funding. Assign responsibility for identifying and applying for grant funding. Currently, there is no organized effort to apply for grant funding. This action item would call for identifying what needs to be done, and then assigning responsibility for seeking the funding to appropriate Town staff and committees.	Assistant Town Manager, Local MHMP Team	Existing Capability	The town recently received a grant from CZM to work with the Provincetown Center for Coastal Studies on inundation pathway mapping. The town also has a history of collaborating with State and Federal agencies to protect infrastructure and conduct an alternatives analysis (i.e. East Harbor, Pamet River and Noon's Landing)

Mitigation Actions for the 2017 Hazard Plan

This section of the plan is the most dynamic because it is heavily influenced by factors such as grant funding and staff capability. The Mitigation Actions section will be routinely updated to ensure that it remains consistent with current Town priorities. The mitigation actions are in no particular order.

The Planning Team carried over the 2011 Mitigation Actions that were identified as "In Progress" and developed new Mitigation Actions based on the Vulnerability and Risk Assessments in Chapter 4 (***See Future Action List***). The mitigation actions described in the future action list are in no particular order.

C4a,b,c C5b,c C6a

The Planning Team developed a "Team Score" to prioritize the Mitigation Actions where high scores represent high priority projects. Several variables factored into the Team Score:

C5a

Life Safety/Social:

- How effective is the action at protecting lives and preventing injuries?
- If the action is to improve structures/infrastructure, will it also protect lives and prevent injury?
- Will the action affect one segment of the population more than another?
- Will the action disrupt the community in any way? (i.e. impact emergency service routes, break up neighborhoods)

Property Protection:

- Will the action eliminate or reduce damage to structures and infrastructure? If so, how?
- What are the secondary impacts of the mitigation action?
- Does it solve a problem or a symptom of the problem?

Technical/Legal/Environmental/ Administrative:

- Is the mitigation action technically feasible based on Truro's current capabilities?
- Is the action a long or short-term solution?
- What are the benefits of the project? What are the costs?
- Does the action support Truro's Mitigation Goals and Objectives?
- Does Truro have the authority to implement the action? If not, who does?
- Is the action consistent with town values and other planning projects?
- What are the environmental impacts of the action?
- Does it comply with environmental regulations?

Political/Local Champion:

- Is there political support to implement and maintain the action?
- Does the public support the mitigation action?
- Is there a strong advocate for the action?

The Priority designations for 2017 Mitigation Actions (high, medium, low) were based on the Team Score:

- **Team Score 4:** High Priority; town will begin or complete these projects within three years.
- **Team Score 2 and 3:** Medium Priority; town will begin or complete these projects within four years.
- **Team Score 1:** Low Priority; town will begin or complete these projects within five years.

The following is a list of projects recommended by the Planning Team. The list identifies Responsibility, Funding and a Time Frame for the recommended mitigation projects. The actions will begin as soon as the plan is approved and the community is eligible for funding, unless otherwise stated, and will be completed in the amount of time as noted in the "Duration" section.

Mitigation Actions for the 2017 Hazard Plan

All Hazards

Mitigation Action #1

Create a Storm Operations Manual that identifies the roles and responsibilities of specific town departments, provides checklists for departments, outlines alternative scenarios in the case of an emergency and guidelines for debris management

Project Type:
Planning

Responsible Dept:
Police, Fire, DPW

Funding Source(s):
Town Staff Budget, <$50,000

Timeframe:
Duration: 2 years

Consistency With Mitigation Goals:
Reduce the potential for loss of life, property, infrastructure, and environmental, cultural and economic resources in Truro from natural hazards

Consistency With Other Town Plans:
Truro Local Comprehensive Plan (2005)

Team Score: 4/4 **Priority:** HIGH

All Hazards

Mitigation Action #2

Improve Truro's emergency notification system and purchase variable message boards

Project Type:
Planning

Responsible Dept:
Police, Fire

Funding Source(s):
Town Staff Budget, <$100,000

Timeframe:
Duration: 3 years

Consistency With Mitigation Goals:
Reduce the potential for loss of life, property, infrastructure, and environmental, cultural and economic resources in Truro from natural hazards

Consistency With Other Town Plans:
Truro Local Comprehensive Plan (2005)

Team Score: 4/4 **Priority:** HIGH

All Hazards

Mitigation Action #3

Develop educational materials, displays and events to inform residents about natural hazards that threaten the town and mitigation measures they can take to lessen the impact and be better prepared

Project Type:
Outreach

Responsible Dept:
Health and Conservation, Building

Funding Source(s):
Town Staff Budget, <$50,000

Timeframe:
Duration: 1 year, annual thereafter

Consistency With Mitigation Goals:
Increase public awareness of existing hazards and encourage hazard mitigation planning as part of the overall municipal planning process.

Consistency With Other Town Plans:
Truro Local Comprehensive Plan (2005)

Team Score: 4/4 **Priority:** HIGH

All Hazards

Mitigation Action #4

Work with Provincetown to improve logistics at the Provincetown shelter

Project Type:
Mitigation Project

Responsible Dept:
Emergency Management

Funding Source(s):
Town Staff Budget, <$50,000

Timeframe:
Duration: 2 years

Consistency With Mitigation Goals:
Reduce the potential for loss of life, property, infrastructure, and environmental, cultural and economic resources in Truro from natural hazards

Consistency With Other Town Plans:
Truro Local Comprehensive Plan (2005)

Team Score: 3/4 **Priority:** MEDIUM

Mitigation Actions for the 2017 Hazard Plan

All Hazards

Mitigation Action #5

Create a weather monitoring station and reporting system to gather accurate data on the location, history, extent and impact of natural hazards in Truro

Project Type:
Mitigation Project

Responsible Dept:
DPW, Police, Fire

Funding Source(s):
FEMA HMA grants (25% appropriation from Town Meeting), < $50,000

Timeframe:
Duration: 3 years

Consistency With Mitigation Goals:
Reduce the potential for loss of life, property, infrastructure, and environmental, cultural and economic resources in Truro from natural hazards

Consistency With Other Town Plans:
Truro Local Comprehensive Plan (2005)

Team Score: 1/4 **Priority:** LOW

All Hazards

Mitigation Action #6

Gather data on the seasonal and tourist populations in Truro. It is important to have an accurate estimate of the number of people visiting Truro to ensure that they are informed, prepared and safe in the event of a storm.

Project Type:
Planning

Responsible Dept:
Planning, Recreation Department

Funding Source(s):
Town Staff Budget, <$50,000

Timeframe:
Duration: 3 years

Consistency With Mitigation Goals:
Reduce the potential for loss of life, property, infrastructure, and environmental, cultural and economic resources in Truro from natural hazards

Consistency With Other Town Plans:
Truro Local Comprehensive Plan (2005)

Team Score: 2/4 **Priority:** MEDIUM

All Hazards

Mitigation Action #7

Obtain inspection kits for Building Department staff and others to conduct post-disaster inspections of buildings

Project Type:
Mitigation Project

Responsible Dept:
Building

Funding Source(s):
Town Staff Budget, Public Safety Grant from Target <$100,000

Timeframe:
Duration: 3 years

Consistency With Mitigation Goals:
Reduce the potential for loss of life, property, infrastructure, and environmental, cultural and economic resources in Truro from natural hazards

Consistency With Other Town Plans:
Truro Local Comprehensive Plan (2005)

Team Score: 3/4 **Priority:** MEDIUM

All Hazards

Mitigation Action #8

Pre-plan a rapid assessment of post-storm structural damages and formalize an emergency response network with local and State Building Inspectors

Project Type:
Planning

Responsible Dept:
Building

Funding Source(s):
Town Staff Budget, <$50,000

Timeframe:
Duration: 3 years

Consistency With Mitigation Goals:
Reduce the potential for loss of life, property, infrastructure, and environmental, cultural and economic resources in Truro from natural hazards

Consistency With Other Town Plans:
Truro Local Comprehensive Plan (2005)

Team Score: 2/4 **Priority:** MEDIUM

Mitigation Actions for the 2017 Hazard Plan

All Hazards

Mitigation Action #9

Improve emergency response communications in Truro (i.e. obtain a town radio band and vehicle repeater system for town departments)

Project Type:
Mitigation Project

Responsible Dept:
Police, Fire, DPW

Funding Source(s):
Town Staff Budget, Public Safety Grant from Target <$100,000

Timeframe:
Duration: 4 years

Consistency With Mitigation Goals:
Reduce the potential for loss of life, property, infrastructure, and environmental, cultural and economic resources in Truro from natural hazards

Consistency With Other Town Plans:
Truro Local Comprehensive Plan (2005)

Team Score: 3/4 **Priority:** MEDIUM

All Hazards

Mitigation Action #10

Continue to coordinate with the Local Emergency Planning Committee, Barnstable County Regional Emergency Planning Committee, Cape Cod National Seashore, Massachusetts Department of Transportation

Project Type:
Outreach

Responsible Dept:
Police, Fire

Funding Source(s):
Town Staff Budget, <$50,000

Timeframe:
Duration: 1 year, annual thereafter

Consistency With Mitigation Goals:
Communicate local hazard mitigation planning activities with Barnstable County, neighboring towns and the Massachusetts Emergency Management Agency.

Consistency With Other Town Plans:
Truro Local Comprehensive Plan (2005)

Team Score: 4/4 **Priority:** HIGH

All Hazards

Mitigation Action #11

Continue to monitor assets that are vulnerable to the effects of climate change

Project Type:
Planning

Responsible Dept:
DPW

Funding Source(s):
Town Staff Budget, collaboration with the Cape Cod Commission through the Unified Planning and Work Program, <$50,000

Timeframe:
Duration: 1 year, annual thereafter

Consistency With Mitigation Goals:
Reduce the damage to public infrastructure resulting from natural hazards including but not limited to critical facilities, roadways and culverts and water facilities.

Consistency With Other Town Plans:
Truro Local Comprehensive Plan (2005)

Team Score: 3/4 **Priority:** MEDIUM

All Hazards

Mitigation Action #12

Monitor the Town's emergency response services to identify needs or shortfalls in terms of protocol, personnel, equipment or resources (from 2011 Plan)

Project Type:
Planning

Responsible Dept:
Police, Fire, DPW

Funding Source(s):
Town Staff Budget, <$50,000

Timeframe:
Duration: 3 years

Consistency With Mitigation Goals:
Reduce the potential for loss of life, property, infrastructure, and environmental, cultural and economic resources in Truro from natural hazards

Consistency With Other Town Plans:
Truro Local Comprehensive Plan (2005)

Team Score: 4/4 **Priority:** HIGH

Mitigation Actions for the 2017 Hazard Plan

All Hazards

Mitigation Action #13

Assign staff to conduct in-depth risk assessments, including a Quantification of Potential Losses, to apply for mitigation funding and to track the results (from 2011 Plan)

Project Type:
Planning

Responsible Dept:
Police, Fire, DPW

Funding Source(s):
Town Staff Budget, <$50,001

Timeframe:
Duration: 4 years

Consistency With Mitigation Goals:
Reduce the potential for loss of life, property, infrastructure, and environmental, cultural and economic resources in Truro from natural hazards

Consistency With Other Town Plans:
Truro Local Comprehensive Plan (2005)

Team Score: 4/4 **Priority:** HIGH

Flooding

Mitigation Action #14

Improve Truro's class in the Community Rating System (CRS) to at least a Class 9

Project Type:
Planning

Responsible Dept:
Planning

Funding Source(s):
Town Staff Budget, <$50,000

Timeframe:
Duration: 3 years

Consistency With Mitigation Goals:
Reduce the potential for loss of life, property, infrastructure, and environmental, cultural and economic resources in Truro from natural hazards

Consistency With Other Town Plans:
Truro Local Comprehensive Plan (2005)

Team Score: 4/4 **Priority:** HIGH

Flooding

Mitigation Action #15

Educate the public about MEMA's "Know Your Zone," Campaign and sheltering in place

Project Type:
Outreach

Responsible Dept:
Police, Fire

Funding Source(s):
Town Staff Budget, <$50,000

Timeframe:
Duration: 1 year

Consistency With Mitigation Goals:
Increase public awareness of existing hazards and encourage hazard mitigation planning as part of the overall municipal planning process.

Consistency With Other Town Plans:
Truro Local Comprehensive Plan (2005)

Team Score: 3/4 **Priority:** MEDIUM

Flooding, Hurricanes, Tropical Storms, Severe Winter Weather, Nor'easters, Sea Level Rise

Mitigation Action #16

Continue work on the coastal and ecological restoration of the Pamet River System to reduce the overwash and flooding at Ballston beach parking lot

Project Type:
Mitigation Project

Responsible Dept:
Health and Conservation, DPW

Funding Source(s):
FEMA HMA grants (25% appropriation from Town Meeting), CZM grants, DER Priority Project, $100,000+

Timeframe:
Duration: 3 years

Consistency With Mitigation Goals:
Reduce the damage to public infrastructure resulting from natural hazards including but not limited to critical facilities, roadways and culverts and water facilities.

Consistency With Other Town Plans:
Truro Local Comprehensive Plan (2005)

Team Score: 4/4 **Priority:** HIGH

Mitigation Actions for the 2017 Hazard Plan

Flooding, Hurricanes, Tropical Storms, Severe Winter Weather, Nor'easters, Sea Level Rise

Mitigation Action #17

Model and conduct a benefit cost analysis for repairing the undersized culvert at Eagle Neck Creek and Mill Pond. To date, the permitting is complete, but more modeling and cost analysis is required for proper design

Project Type:
Mitigation Project

Responsible Dept:
Health and Conservation, DPW

Funding Source(s):
Town Staff Budget, CZM grants, DER Priority Project, $100,000+

Timeframe:
Duration: 3 years

Consistency With Mitigation Goals:
Reduce the potential for loss of life, property, infrastructure, and environmental, cultural and economic resources in Truro from natural hazards

Consistency With Other Town Plans:
Truro Local Comprehensive Plan (2005)

Team Score: 3/4 **Priority:** MEDIUM

Flooding, Hurricanes, Tropical Storms, Severe Winter Weather, Nor'easters, Sea Level Rise

Mitigation Action #18

Repair the drainage pipe at the East Harbor culvert on the Cape Cod Bay side. Conduct a stakeholder engagement process with local, regional and state partners about the degradation of the East Harbor culvert

Project Type:
Outreach, Mitigation

Responsible Dept:
Health and Conservation, DPW

Funding Source(s):
Town Staff Budget, CZM grants, $100,000 +

Timeframe:
Duration: 3 years

Consistency With Mitigation Goals:
Reduce the damage to public infrastructure resulting from natural hazards including but not limited to critical facilities, roadways and culverts and water facilities; Increase public awareness of existing hazards and encourage hazard mitigation planning as part of the overall municipal planning process.

Consistency With Other Town Plans:
Truro Local Comprehensive Plan (2005)

Team Score: 4/4 **Priority:** HIGH

Flooding, Hurricanes, Tropical Storms, Severe Winter Weather, Nor'easters, Sea Level Rise

Mitigation Action #19

Conduct an assessment of local infrastructure and critical facilities that are subject to damage from flooding or storm surge. Develop, prioritize and seek funding for a list of needed infrastructure improvement projects

Project Type:
Mitigation Project

Responsible Dept:
Health and Conservation, DPW

Funding Source(s):
Town Staff Budget, CZM grants, $100,000+

Timeframe:
Duration: 3 years

Consistency With Mitigation Goals:
Reduce the damage to public infrastructure resulting from natural hazards including but not limited to critical facilities, roadways and culverts and water facilities.

Consistency With Other Town Plans:
Truro Local Comprehensive Plan (2005)

Team Score: 4/4 **Priority:** HIGH

Flooding, Hurricanes, Tropical Storms, Severe Winter Weather, Nor'easters, Sea Level Rise, Shoreline change

Mitigation Action #20

Prepare design plans for a dune restoration project at Noons Landing on Beach Point. The project would provide storm damage protection for vulnerable infrastructure including Shore Road, and utilities within the road. The Dune restoration project would improve the natural function of the Coastal Dune and Barrier Beach, while maintaining public access to the shore line.

Project Type:
Mitigation

Responsible Dept:
Health and Conservation, DPW

Funding Source(s):
Town Staff Budget, CZM grants, $100,000 +

Timeframe:
Duration: 3 years

Consistency With Mitigation Goals:
Reduce the damage to public infrastructure resulting from natural hazards including but not limited to critical facilities, roadways and culverts and water facilities.

Consistency With Other Town Plans:
Truro Local Comprehensive Plan (2005)

Team Score: 4/4 **Priority:** HIGH

Mitigation Actions for the 2017 Hazard Plan

Flooding, Hurricanes, Tropical Storms, Severe Winter Weather, Nor'easters, Sea Level Rise

Mitigation Action #21

Draft a barrier beach management plan to assess and monitor beach conditions (see *), evaluate all vulnerable shoreline areas for possible mitigation projects, identify low-lying flooding pathways under current and future storm conditions and incorporate mapping data onto a town website

Project Type:
Planning

Responsible Dept:
Health and Conservation, DPW

Funding Source(s):
FEMA HMA grants (25% appropriation from Town Meeting), CZM grants, $100,000+

Timeframe:

Duration: 3 years

Consistency With Mitigation Goals:

Reduce the potential for loss of life, property, infrastructure, and environmental, cultural and economic resources in Truro from natural hazards

Consistency With Other Town Plans:

Truro Local Comprehensive Plan (2005)

Team Score: 4/4

Priority: HIGH

* A Barrier Beach Management plan would include an evaluation of existing flood hazard issues on Beach Point in North Truro and identify viable shoreline protection strategies. The evaluation will also include an assessment of local regulations and bylaws relative to development, redevelopment and re-construction in high hazard flood areas; development of recommended regulatory adjustments to link into the goals established in the 2005 Local Comprehensive Plan and dovetail with the local multi-hazard mitigation plan, and development of public outreach materials to communicate the vulnerability assessment results.

A6c

Participation in NFIP

B4a

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.

The Town of Truro has no Repetitive Loss Properties.

C2a

Continued compliance with NFIP

To be approved by the Federal Emergency Management Agency (FEMA), the Truro Hazard Mitigation Plan must describe the Town's participation in the National Flood Insurance Program (NFIP). The NFIP is based on a mutual agreement between the Federal government and the Town of Truro.[1] Federally backed flood insurance is available in Truro as long as the Town agrees to regulate development in their mapped floodplain.[2] To remain compliant with the NFIP, Truro is committed to the following activities:

- Issue or deny floodplain development/ building permits.
- Inspect all developments to ensure compliance with local ordinance.
- Maintain records of floodplain development.
- Assist with floodplain identification and mapping as well as any revision of floodplain maps, including local requests for map updates.
- Help residents obtain information on flood hazards, floodplain map data, flood insurance and proper construction practices.

Capability Assessment

C1

During the development of the 2017 Truro Hazard Mitigation plan, members of the Planning Team reviewed the capabilities of each town department (Table 5.2).

The following Table reflects the Town's current ability to implement capabilities, but cannot expand at this time; however, the Community will revisit the capabilities during the evaluation and maintenance process to discuss the Town's ability to expand and improve.

1 National Flood Insurance Program (NFIP) Floodplain Management Requirements: A study guide and desk reference for local officials, FEMA 480, February 2005

Capabilities Assessment

Natural Hazard	Explanation of Capability	Responsible Department
All Hazards	Educational Materials: The town distributes educational materials from local, county and State level organizations such as the Barnstable County Regional Emergency Planning Committee (BCREPC) and the Cape Cod Cooperative Extension (CCCE). Materials include but are not limited to: CCCE's "Questions and Answers on Purchasing Coastal Real Estate in MA" and "Homeowner's Handbook to Prepare for Coastal Hazards."	**Conservation, Harbormaster**
All Hazards	Mutual Aid: Truro opted-in to the Public Works Mutual Aid Agreement through MEMA. By opting in, Truro can send and/or request assets from any other community within the Commonwealth that has also opted into the agreement. This agreement can be used for everyday use and/or be activated for any public safety incident/event. Truro also has mutual aid agreements with neighboring communities.	**Police and Fire Departments, DPW**
All Hazards	Emergency Planning: Town staff determine supplies, equipment and communications needs and prioritize purchases so that Truro is prepared for any needed emergency response to any natural hazard event. The Emergency Manager attends the monthly Barnstable County Regional Emergency Planning Committee meetings.	**Police, Fire**
All Hazards	Eversource: In 2012, an Act Relative to Emergency Response of Public Utility Companies was signed into law, requiring a more robust response to emergencies from power companies. Additionally, Eversource has MOUs with private companies to provide accommodations during all but the summer seasons.	**Police Department, DPW, Town Manager to designate**
All Hazards	Generators: An inventory of town owned generators is continually reviewed and monitored by town staff.	**Police and Fire Departments, DPW**
All Hazards	Shelter: Equipment inventories and needs for the Provincetown shelter are assessed during monthly meetings of the Local Regional Emergency Planning Committee (Provincetown and Truro)	**Police and Fire Departments, DPW**
All Hazards	Grant Funding: Town Departments have pro-actively applied for grant funding for mitigation projects.	**Town Manager**
Wind	State Building Code: State Building Code regulates construction for specific wind loads.	**Building**
Shoreline Change	The town has partnered with agencies to nourish, vegetate and monitor dunes in Truro.	**Conservation**

Table 5.2 | Capability Assessment

Natural Hazard	Explanation of Capability	Responsible Department
Fire	Fire Code: Town observes State, Federal and local fire codes. New sprinkler system laws are continually enforced. The Fire Department seeks input from the Building Commissioner on where to place sprinklers in local businesses. The plans are reviewed jointly.	**Fire Department, Building Commissioner**
Flooding	Education: The Truro Police collaborate with other Departments to send out press releases about the locations of regional shelter and natural hazards.	**Police Department**
Flooding	Coastal Infrastructure: Department of Public Works and Conservation assess infrastructure that is vulnerable to flooding and storm surge in collaboration with regional, State and Federal partners	**DPW, Conservation**
Flooding	State Building Code: Substantial monitoring and compliance activities are performed under administration of the State Building Code. Inspection and certification of lowest floor elevation is required by State Building Code. Elevation certificates are required by State Building Code. Applicants are required to submit plans that include the Special Flood Hazard Area and proposed elevations of the proposed structures.	**Building Commissioner**
Flooding	Flood Insurance Rate Map (FIRM): voters amended the Truro Zoning Bylaw to make it consistent with the newly updated Flood Insurance Rate Maps (FIRMs) for Barnstable County.	**Town Manager**
Flooding	Truro Zoning Bylaw: This bylaw is consistent with NFIP regulations and the State Building Code. The town reviews the bylaw to ensure it is a protective as possible and reflects current floodplain science and policy.	**Planning, Conservation, Building**
Flooding	Conservation Commission: the Conservation Commission reviews the local regulations on an annual basis and regulates development within and adjacent to wetland resource areas	**Conservation Commission**
Flooding, Sea Level Rise, Severe Winter Storms, Nor'easters, Shoreline Change, Hurricanes/Tropical Storms	Stormwater: Clean out the storm water catchments and other infrastructure on a regular basis.	**DPW**
Hurricanes, Tropical Storms, Severe Winter Storms, Nor'easters, Wind	Education: The Harbormaster works directly with boat owners to educate them on appropriate actions to take during a storm event. These interactions usually occur in person at the Harbormaster's office.	**Harbormaster**

D3

An Assessment of the Changes in Priorities from 2011 to 2017

The Mitigation Actions described in the 2011 Truro Hazard Mitigation Plan were prioritized based on their feasibility using the STAPLEE method. The Mitigation Actions in the 2017 Hazard Mitigation Plan were prioritized as high, medium, low based on the Team Score.

Below is a list of activities that remain a priority for the Town of Truro in 2017:

- Truro remains dedicated to public outreach on emergency preparedness, communication with residents and visitors before, during and after a hazard event, and communicating with the public about the impact of natural hazards.
- Truro remains committed to assessing local infrastructure for damage to coastal hazards such as storm surge, flooding and shoreline change
- Truro remains committed to their participation in the National Flood Insurance Program and the Community Rating System
- The town is dedicated to managing their local beaches

Below is a list of activities that are slightly different from the 2011 Hazard Mitigation Plan:

- Inspection kits and plans for post-storm rapid assessment of buildings were added to the 2017 plan
- Continuing work on the Pamet River System to reduce overwash and flooding of the Ballston Beach Parking Lot and repair the East Harbor Culvert were specifically called out in the 2011 plan.
- The plan specifically calls out monitoring assets vulnerable to climate change.

Changes in Priority from 2011 to 2017

Plan Evaluation and Maintenance

CHAPTER SIX

Once the 2017 Truro Hazard Mitigation Plan is adopted by the Board of Selectmen, the plan enters into a five-year "maintenance" phase. **Chapter 6 describes how the Truro Hazard Mitigation Plan will be evaluated, updated and enhanced over the next five years.**

Plan Maintenance

A6d

Who is involved?

Each department identified in the Truro Hazard Mitigation Plan is responsible for implementing specific mitigation actions as prescribed in the Mitigation Action section of the plan (Chapter 5). Every proposed action listed in the Mitigation Action section is assigned to a specific "lead" department as a way to assign responsibility and accountability and increase the likelihood of subsequent implementation.

The Town Manager, Rae Ann Palmer , will be responsible for ensuring that the plan is monitored, evaluated and updated throughout the next five years.

How will the plan be maintained?

Below is a list of the activities describing how the plan will be maintained and updated over the next five years:

A6a

- Plan Monitoring:
  - Members of the Planning Team will meet annually to discuss the implementation status of each Mitigation Action identified in Chapter 5. During these meetings, the Planning Team will also describe and document any new hazard data that can be incorporated in the Hazard Profile section of the plan; specifically new hazard locations, extent and impacts.
  - After the annual meeting, members of the Planning Team will present to the Board of Selectmen on the implementation status of the Mitigation Actions identified in Chapter 5. This presentation will occur once per year and will include an evaluation of the appropriateness of Mitigation Actions. If an amendment, change or update is needed, the Board of Selectmen can vote to adopt the change and amend the Truro Hazard Mitigation Plan.
- Plan Evaluation:

A6b

  - A subset of the Planning Team (Police, Fire, DPW, Health and Conservation) will meet annually to evaluate the stated purpose and goals of the Truro Hazard Mitigation Plan. During this annual meeting, this smaller group will ensure that the plan continues to serve its purpose through the following activities:
    - Review the Mitigation Goals in the 2017 Truro Hazard Mitigation Plan
    - Discuss any recent activities to reduce the loss of life and property in Truro such as grants received/applied for and any completed Mitigation Actions
    - Distribute an online survey to gauge the public's awareness of the risks posed by natural hazards

- Discuss ongoing or recent planning efforts that are consistent with the Mitigation Goals and Actions of the 2017 Truro Hazard Mitigation Plan.

A6c

- Plan Update:
  - The Truro Hazard Mitigation Plan will be reviewed and updated every five years to ensure that there is no lapse in plan coverage. The Hazard Plan update process must begin one to one and half years before the plan is set to expire.

When will the plan be maintained?

A start date and time period were assigned to each Mitigation Action in Chapter 5 to assess whether actions are being implemented in a timely fashion. Also, the Planning Team will also reconvene annually to discuss progress on the Mitigation Actions.

Following a disaster declaration, the Truro Hazard Mitigation Plan will be revised as necessary to reflect lessons learned or to address specific issues and circumstances arising from the event. It will be the responsibility of the Planning Team to reconvene the Local Emergency Planning Committee and to ensure the appropriate stakeholders are invited to participate in the plan revision and update process following declared disaster events.

Plan Adoption

CHAPTER SEVEN

Once the draft of the Truro Hazard Mitigation Plan is reviewed by the Planning Team, stakeholders and the general public, the plan is reviewed by the Massachusetts Emergency Management Agency (MEMA) and the Federal Emergency Management Agency (FEMA). If approved by MEMA and FEMA, the Truro Board of Selectmen can officially adopt the plan. If and when the plan is approved, it enters into the five year "maintenance" phase. **Chapter 7 describes the timeline for plan adoption and includes documentation for plan adoption by the Truro Board of Selectmen.**

Timeline for Plan Adoption

The timeline for Plan Adoption is as follows:

- **January 2017:** After approval by the Board of Selectmen, the Planning Team submitted the Truro Hazard Mitigation Plan to the Massachusetts Emergency Management Agency (MEMA) in January 2017. MEMA reviewed the plan and returned it to the Town of Truro with required edits. The updated Truro Hazard Mitigation Plan was then submitted to the Federal Emergency Management Agency (FEMA) for final review. Minutes of the January 24, 2017 vote are included in the Chapter 7 Appendix.
- **May 2017:** FEMA issued an Approved Pending Adoption status and the Truro Board of Selectmen officially adopted the Truro Hazard Mitigation Plan during its meeting on May 23, 2017.

E1a

Plan Adoption

The Certificate of Adoption signed by the Truro Board of Selectmen is shown in ***Figure 7.1***.

Certificate of Adoption
Truro, Massachusetts
Board of Selectmen
A Resolution Adopting the 2017 Truro Hazard Mitigation Plan

WHEREAS, the Town of Truro established a Committee to prepare the Hazard Mitigation plan; and

WHEREAS, the Town of Truro participated in the development of the Truro 2017 Hazard Mitigation Plan; and

WHEREAS, the Truro 2017 Hazard Mitigation Plan contains several potential future projects to mitigate potential impacts from natural hazards in the Town of Truro, and

WHEREAS, a duly-noticed public meeting was held by the Truro Board of Selectmen in January 2017 for the public and municipality to review prior to consideration of this resolution; and

WHEREAS, the Town of Truro authorizes responsible departments and/or agencies to execute their responsibilities demonstrated in the plan, and

NOW, THEREFORE BE IT RESOLVED that the Town of Truro Board of Selectmen, formally approves and adopts the Truro 2017 Hazard Mitigation Plan, in accordance with M.G.L. c. 40.

ADOPTED AND SIGNED this May 23, 2017

Paul Wisotzky, Chair

Maureen Burgess, Vice-Chair

Robert Weinstein, Clerk

Jay Coburn

Jan Worthington

Figure 7.1 | Draft Certificate of Adoption signed by the Truro Board of Selectmen

Appendix

Local Mitigation Plan Review Guide

October 1, 2011

FEMA

4.1 ELEMENT A: PLANNING PROCESS

Requirement §201.6(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:
§201.6(b)(1)	(1) An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval;
§201.6(b)(2)	(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
§201.6(b)(3)	(3) Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.
§201.6(c)(1)	[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.
§201.6(c)(4)(i)	[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.
§201.6(c)(4)(iii)	[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.

ELEMENT	REQUIREMENTS
A1. Does the Plan document the planning process, including how it was prepared and who was involved in the process for each jurisdiction? ***44 CFR 201.6(c)(1)*** ***Intent****: 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.*	a. Documentation of how the plan was prepared **must** 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. ***Document*** *means provide the factual evidence for how the jurisdictions developed the plan.* b. The plan **must** list the jurisdiction(s) participating in the plan that seek approval. c. The plan **must** identify who represented each jurisdiction. The Plan **must** provide, at a minimum, the jurisdiction represented and the person's position or title and agency within the jurisdiction. d. For each jurisdiction seeking plan approval, the plan **must** 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. ***Involved in the process*** *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* "***opportunity to be involved in the planning process***" in A2 below) or only adopting the plan. e. Plan updates **must** include documentation of the current planning process undertaken to update the plan.
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? ***44 CFR 201.6(b)(2)***	a. The plan **must** identify all stakeholders involved or given an opportunity to be involved in the planning process. At a minimum, stakeholders **must** include: 1) Local and regional agencies involved in hazard mitigation activities; 2) Agencies that have the authority to regulate development; and 3) Neighboring communities. *An* ***opportunity to be involved in the planning process*** *means that the stakeholders are engaged or invited as participants and given the chance to provide input to affect the plan's content.*

Introduction: Local Mitigation Plan Review Guide, FEMA

ELEMENT	REQUIREMENTS
***Intent**: 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.*	b. The Plan **must** provide the agency or organization represented and the person's position or title within the agency. c. The plan **must** identify how the stakeholders were invited to participate in the process. Examples of stakeholders include, but are not limited to: • Local and regional agencies involved in hazard mitigation include public works, zoning, emergency management, local floodplain administrators, special districts, and GIS departments. • Agencies that have the authority to regulate development include planning and community development departments, building officials, planning commissions, or other elected officials. • 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. • 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.
A3. Does the Plan document how the public was involved in the planning process during the drafting stage? ***44 CFR 201.6(b)(1) and 201.6(c)(1)*** ***Intent**: 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.*	a. The plan **must** 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. b. The opportunity for participation **must** occur during the plan development, which is prior to the comment period on the final plan and prior to the plan approval / adoption.

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.

ELEMENT	REQUIREMENTS
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)*** ***Intent**: 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.*	a. The plan **must** include a description of the natural hazards that can affect the jurisdiction(s) in the planning area. *A **natural hazard** is a source of harm or difficulty created by a meteorological, environmental, or geological event*[3]. The plan **must** 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. b. The plan **must** provide the rationale for the omission of any natural hazards that are commonly recognized to affect the jurisdiction(s) in the planning area. c. The description, or profile, **must** include information on location, extent, previous occurrences, and future probability for each hazard. Previous occurrences and future probability are addressed in sub-element B2. 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. ***Location** 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. ***Extent** 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.

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

ELEMENT	REQUIREMENTS
	d. For participating jurisdictions in a multi-jurisdictional plan, the plan **must** describe any hazards that are unique and/or varied from those affecting the overall planning area.
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)*** ***Intent****: 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.*	a. The plan **must** include the history of previous hazard events for each of the identified hazards. b. The plan **must** include the probability of future events for each identified hazard. ***Probability*** *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 **must** 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. c. Plan updates **must** include hazard events that have occurred since the last plan was developed.
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)*** ***Intent****: 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.*	a. For each participating jurisdiction, the plan **must** describe the potential impacts of each of the identified hazards on the community. ***Impact*** *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). b. The plan **must** 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). 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.

ELEMENT	REQUIREMENTS
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)*** ***Intent****: 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.*	a. The plan **must** describe the types (residential, commercial, institutional, etc.) and estimate the numbers of repetitive loss properties located in identified flood hazard areas. ***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 10-year period since 1978.* ***Severe repetitive loss properties*** *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.* 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.

Introduction: Local Mitigation Plan Review Guide, FEMA

4.3 ELEMENT C. MITIGATION STRATEGY

Requirement §201.6(c)(3)	[The plan shall include the following:] A *mitigation strategy* 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.
§201.6(c)(3)(i)	[The hazard mitigation strategy shall include a] description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.
§201.6(c)(3)(ii)	[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.
§201.6(c)(3)(iii)	[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.
§201.6(c)(3)(iv)	For multi-jurisdictional plans, there must be identifiable action items specific to the jurisdiction requesting FEMA approval or credit of the plan.
§201.6(c)(4)(ii)	[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.[4] Therefore, all other requirements for a Local Mitigation Plan lead to and support the mitigation strategy.

[4] 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.

ELEMENT	REQUIREMENTS
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)* ***Intent**: 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.*	a. The plan **must** describe each jurisdiction's existing authorities, policies, programs and resources available to accomplish hazard mitigation. 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.
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)* ***Intent:** 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.*	a. The plan **must** 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 not meet this requirement. The description could include, but is not limited to: • Adoption and enforcement of floodplain management requirements, including regulating new construction in Special Flood Hazard Areas (SFHAs); • Floodplain identification and mapping, including any local requests for map updates; or • Description of community assistance and monitoring activities. 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.

ELEMENT	REQUIREMENTS
C3. Does the Plan include goals to reduce/avoid long-term vulnerabilities to the identified hazards? *44 CFR 201.6(c)(3)(i)* ***Intent**: 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.*	a. The plan **must** include general hazard mitigation goals that represent what the jurisdiction(s) seeks to accomplish through mitigation plan implementation. ***Goals** are broad policy statements that explain what is to be achieved.* b. The goals **must** be consistent with the hazards identified in the plan.
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)* ***Intent**: 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.*	a. The plan **must** 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. ***Mitigation actions and projects** 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. 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. *A **comprehensive range** consists of different hazard mitigation alternatives that address the vulnerabilities to the hazards that the jurisdiction(s) determine are most important.* b. Each jurisdiction participating in the plan **must** have mitigation actions specific to that jurisdiction that are based on the community's risk and vulnerabilities, as well as community priorities. c. The action plan **must** reduce risk to existing buildings and infrastructure as well as limit any risk to new development and redevelopment. ***With emphasis on new and existing building and infrastructure** means that the action plan includes a consideration of actions that address the built environment.*

ELEMENT	REQUIREMENTS
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)* ***Intent**: 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.*	a. The plan **must** describe the criteria used for prioritizing implementation of the actions. b. The plan **must** 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 (*for example*, quality of life, natural and beneficial values, or other "benefits") can also be included in how actions will be prioritized. c. The plan **must** 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.
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)* ***Intent**: To assist communities in capitalizing on all available mechanisms that they have at their disposal to accomplish hazard mitigation and reduce risk.*	a. The plan **must** describe the community's process to integrate the data, information, and hazard mitigation goals and actions into other planning mechanisms. b. The plan **must** identify the local planning mechanisms where hazard mitigation information and/or actions may be incorporated. ***Planning mechanisms** 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.* c. A multi-jurisdictional plan **must** describe each participating jurisdiction's individual process for integrating hazard mitigation actions applicable to their community into other planning mechanisms. d. The updated plan **must** 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. e. The updated plan **must** continue to describe how the mitigation strategy, including the goals and hazard mitigation actions will be incorporated into other planning mechanisms.

Introduction: Local Mitigation Plan Review Guide, FEMA

Requirement §201.6(d)(3)	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.

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.

ELEMENT	REQUIREMENTS
D1. Was the plan revised to reflect changes in development? *44 CFR 201.6(d)(3)* ***Intent**: 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.*	a. The plan **must** 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. ***Changes in development*** means recent development (*for example*, construction completed since the last plan was approved), potential development (*for example*, development planned or under consideration by the jurisdiction), or conditions that may affect the risks and vulnerabilities of the jurisdictions (*for example*, climate variability, declining populations or projected increases in population, or foreclosures). Not all development will affect a jurisdiction's vulnerability.

ELEMENT	REQUIREMENTS
D2. Was the plan revised to reflect progress in local mitigation efforts? *44 CFR 201.6(d)(3)* ***Intent**: To evaluate and demonstrate progress made in the past five years in achieving goals and implementing actions outlined in their mitigation strategy.*	a. The plan **must** 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 **must** either describe whether the action is no longer relevant or be included as part of the updated action plan.
D3. Was the plan revised to reflect changes in priorities? *44 CFR 201.6(d)(3)* ***Intent**: To ensure the plan reflects current conditions, including financial, legal, and political realities as well as post-disaster conditions.*	a. The plan **must** describe if and how any priorities changed since the plan was previously approved. If no changes in priorities are necessary, plan updates may validate the information in the previously approved plan.

4.5 ELEMENT E. PLAN ADOPTION

Requirement §201.6(c)(5)	[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.

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.

ELEMENT	REQUIREMENTS
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)*** ***Intent****: 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.*	a. The plan **must** include documentation of plan adoption, usually a resolution by the governing body or other authority. If the local jurisdiction has not passed a formal resolution, or used some other documentation of adoption, the clerk or city attorney **must** provide written confirmation that the action meets their community's legal requirements for official adoption and/or the highest elected official or their designee **must** submit written proof of the adoption. The signature of one of these officials is required with the explanation or other proof of adoption. 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, **must** 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. If adopted after FEMA review, adoption **must** take place within one calendar year of receipt of FEMA's "Approval Pending Adoption." See Section 5, *Plan Review Procedure* for more information on "Approvable Pending Adoption."

ELEMENT	REQUIREMENTS
E2. For multi-jurisdictional plans, has each jurisdiction requesting approval of the plan documented formal plan adoption? ***44 CFR 201.6(c)(5)*** ***Intent****: 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.*	a. Each jurisdiction that is included in the plan **must** have its governing body adopt the plan prior to FEMA approval, even when a regional agency has the authority to prepare such plans. As with single jurisdictional plans, in order for FEMA to give approval to a multi-jurisdictional plan, at least one participating jurisdiction **must** formally adopt the plan within one calendar year of FEMA's designation of the plan as "Approvable Pending Adoption." See Section 5, *Plan Review Procedure* for more information on "Approvable Pending Adoption."

Chapter 1: Team Meeting Sign-In Sheet

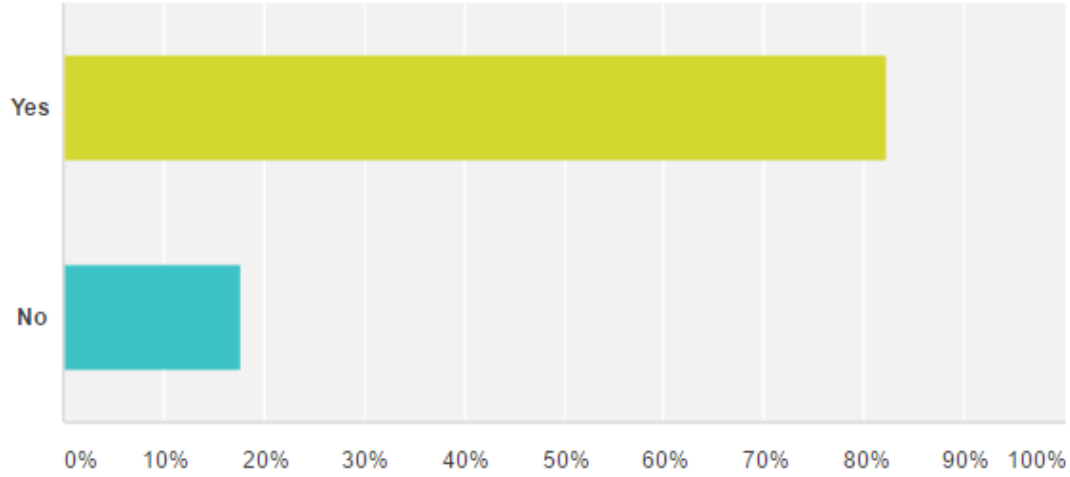
	September 1, 2015	October 8, 2015	October 15, 2015	October 22, 2015	December 1, 2015
Russell Braun					RB
Tim Collins		TC	TC	TC	TC
Jarrod Cabral / Jay Norton	JC	JC	JC	JC	JC
Pat Pajaron	PP	PP	PP	PP	PP.
Kyle Takakjian	KT	KT	KT	KT	KT
Cally Harper	CH	CH	CH	CH	CH

A: absent from the meeting

E. Beebe
1/6/17

Have you experienced a weather-related event or disaster while living, working or visiting Truro?

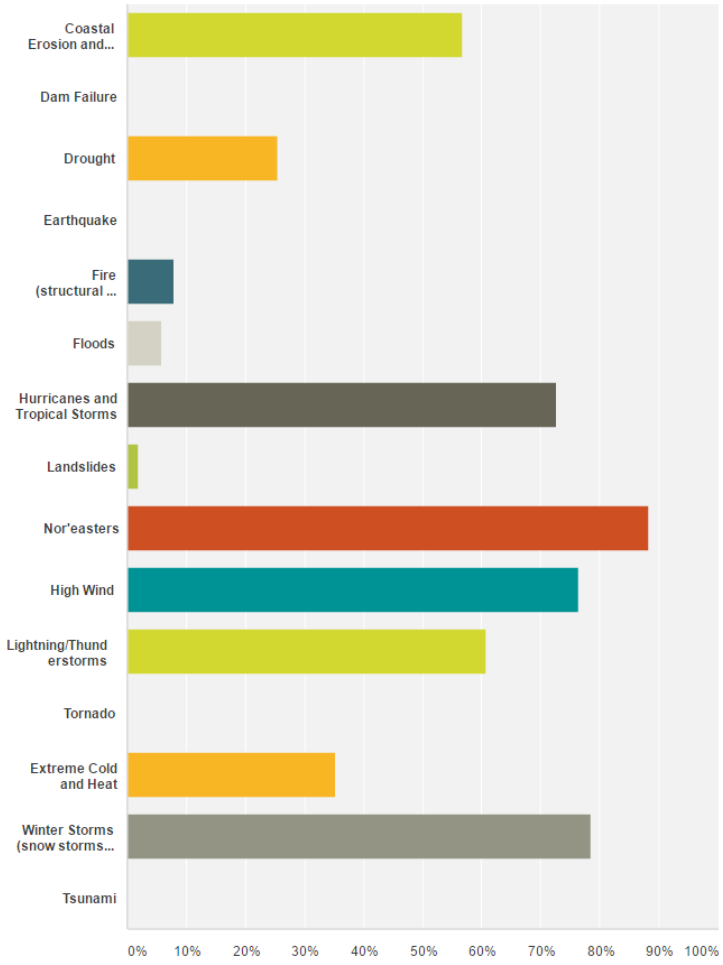
Answered: 51 Skipped: 0

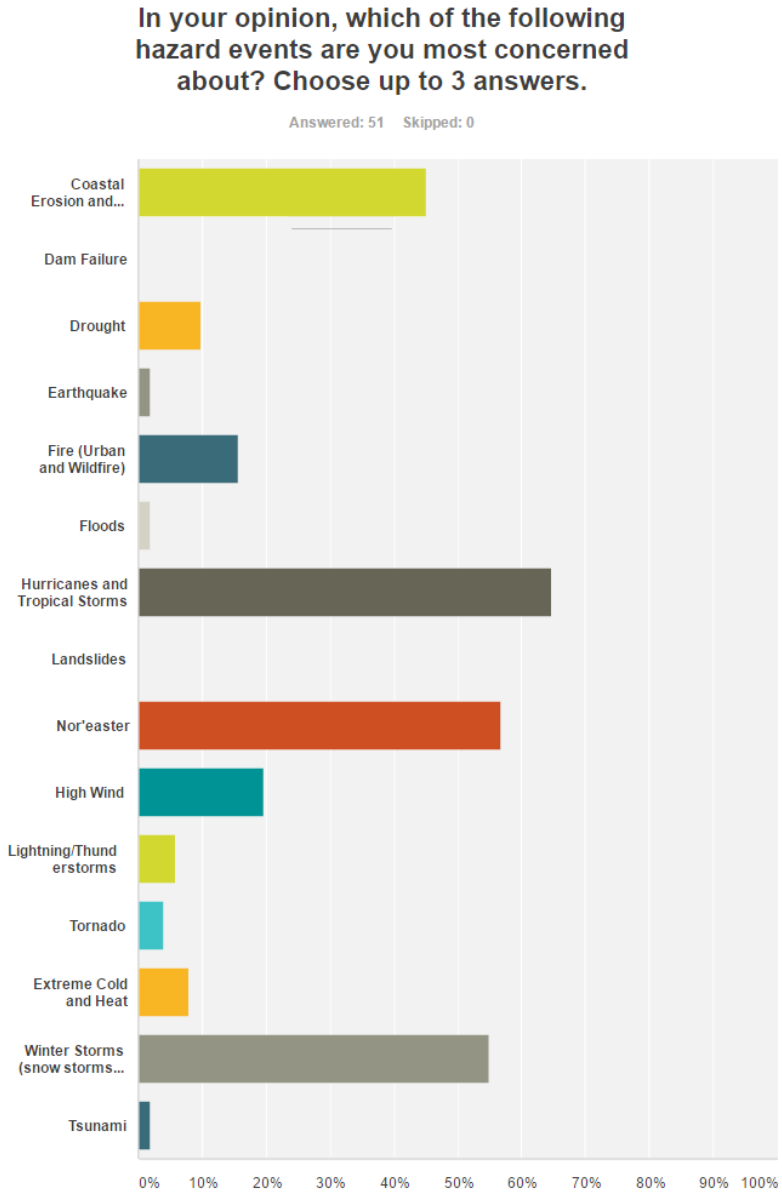


Chapter 1: Public Survey and Results

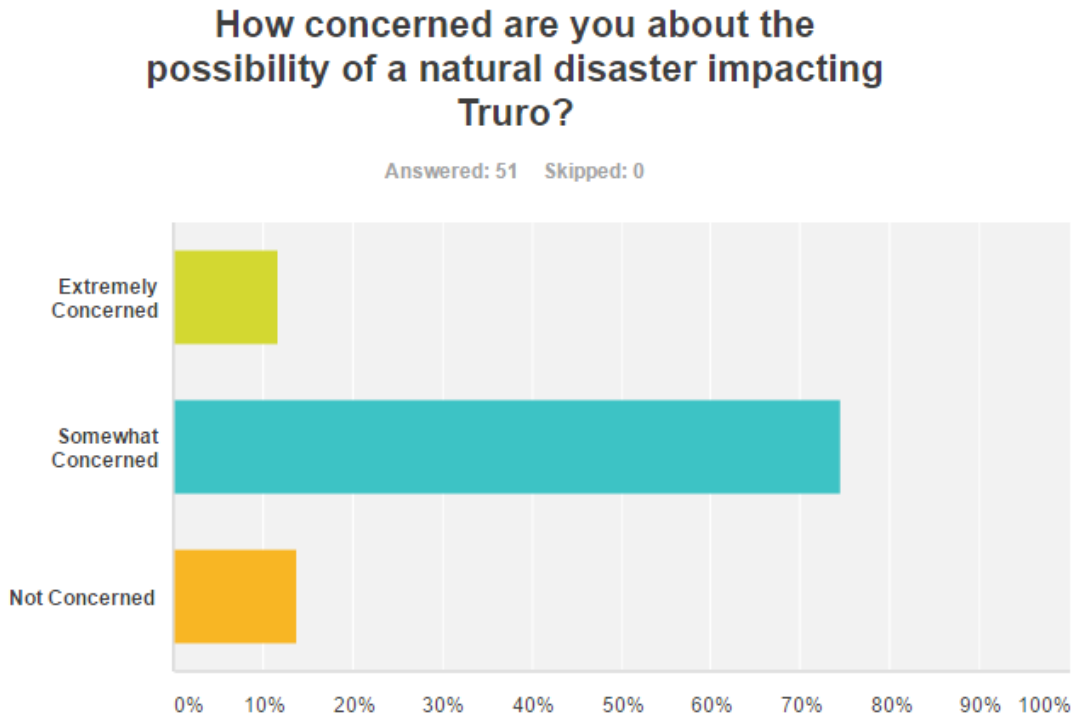
Which of the following events have you experienced while in Truro? You can select more than 1 answer. The hazard types listed below were taken directly from the State Hazard Plan for the Commonwealth of Massachusetts drafted in 2013.

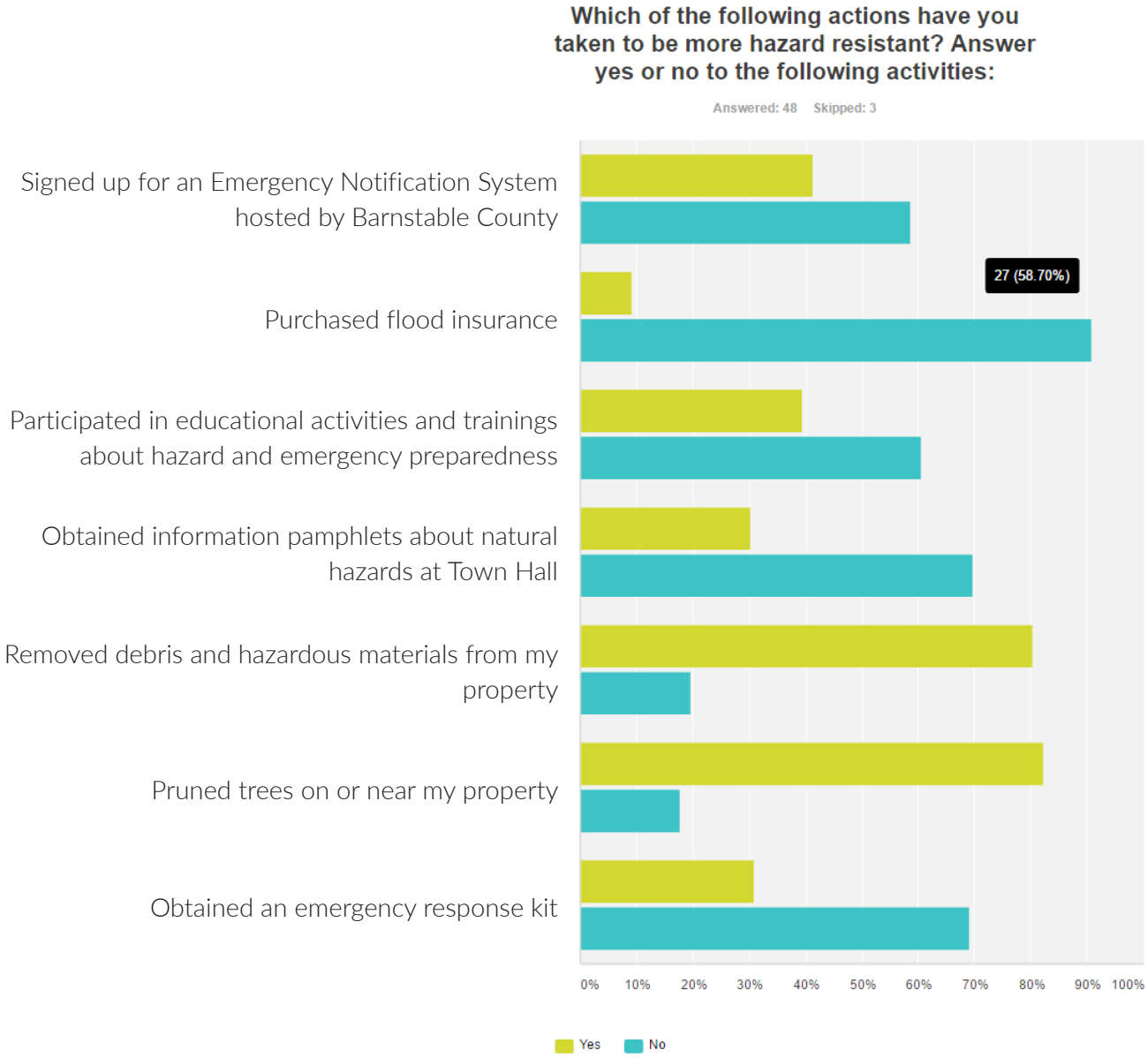
Answered: 51 Skipped: 0



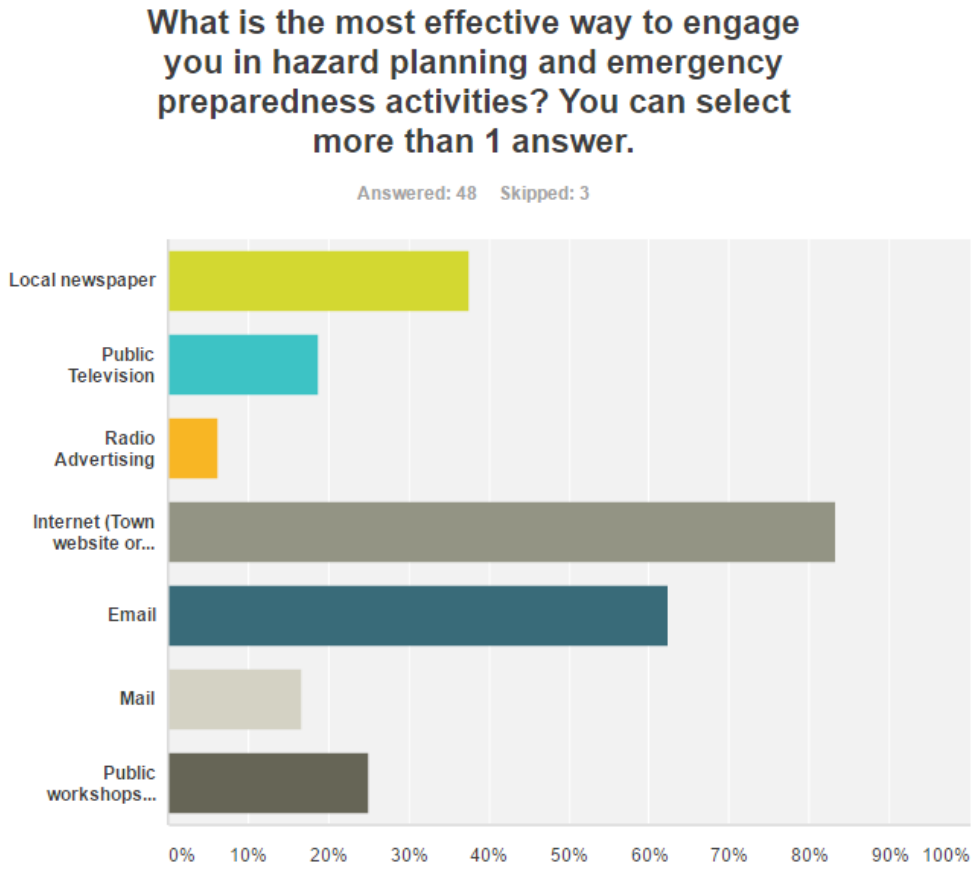

In your opinion, which of the following hazard events are you most concerned about? Choose up to 3 answers.
Answered: 51 Skipped: 0
Coastal Erosion and...
Dam Failure
Drought
Earthquake
Fire (Urban and Wildfire)
Floods
Hurricanes and Tropical Storms
Landslides
Nor'easter
High Wind
Lightning/Thunderstorms
Tornado
Extreme Cold and Heat
Winter Storms (snow storms...
Tsunami
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Chapter 1: Public Survey and Results



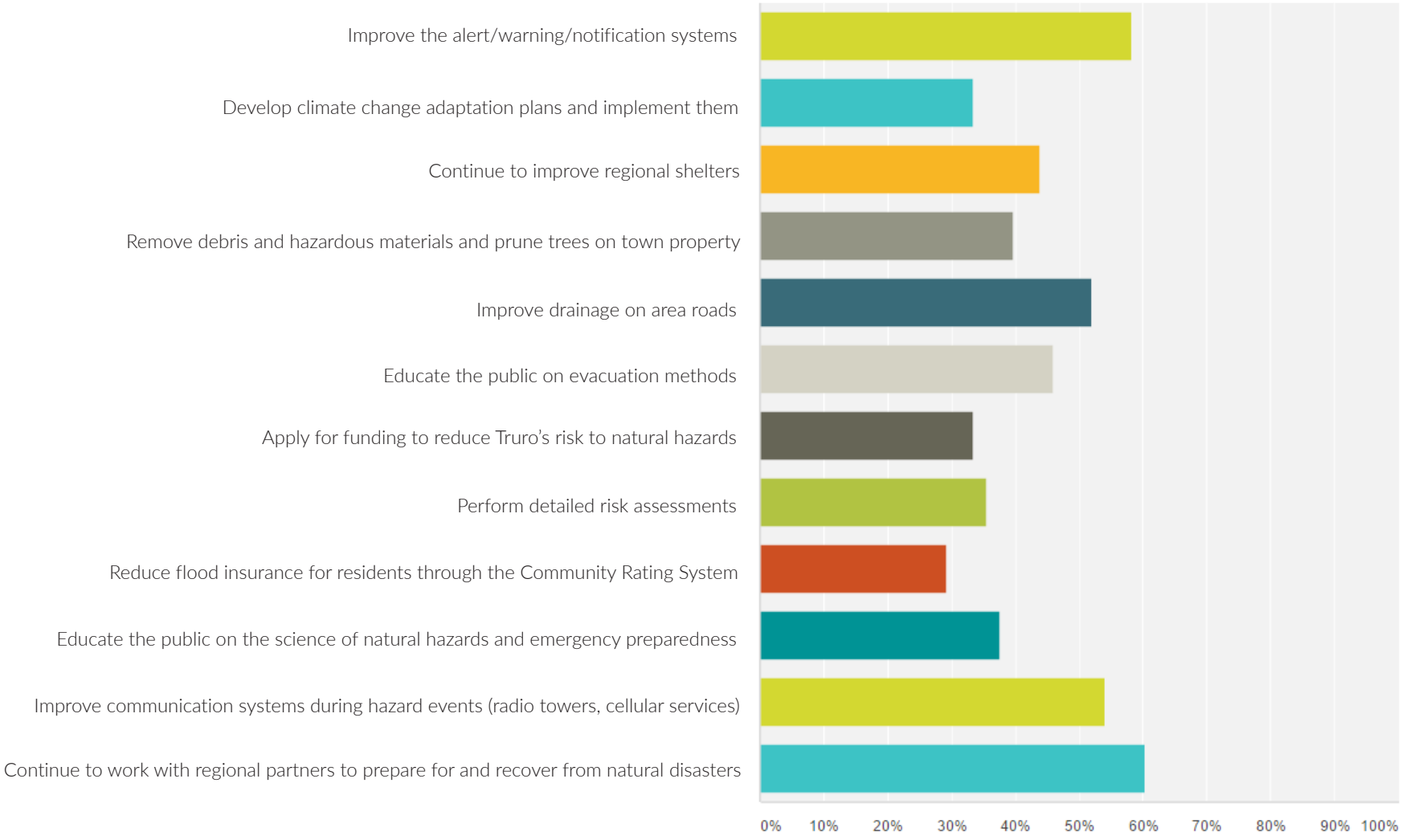

Which of the following actions have you taken to be more hazard resistant? Answer yes or no to the following activities:
Answered: 48 Skipped: 3
Signed up for an Emergency Notification System hosted by Barnstable County
Purchased flood insurance
27 (58.70%)
Participated in educational activities and trainings about hazard and emergency preparedness
Obtained information pamphlets about natural hazards at Town Hall
Removed debris and hazardous materials from my property
Pruned trees on or near my property
Obtained an emergency response kit
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Yes
No

Chapter 1: Public Survey and Results

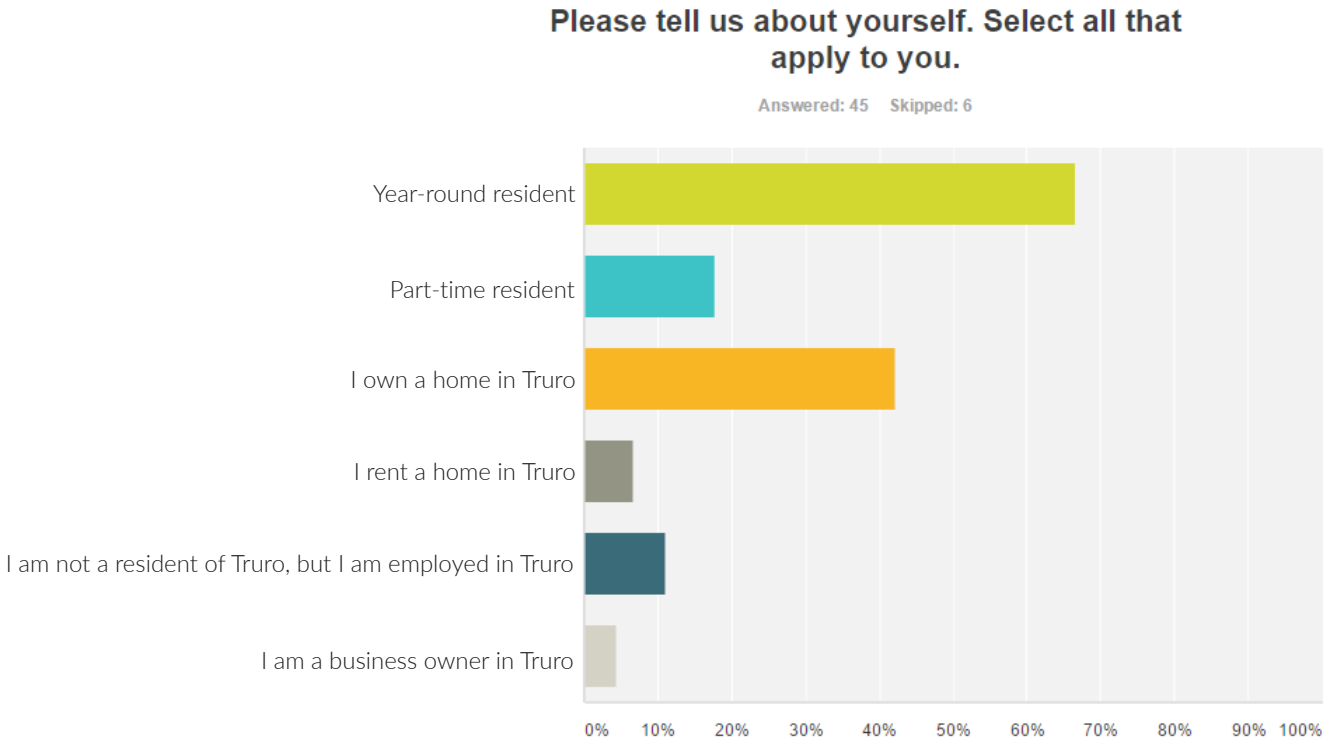


What steps can your local government take to reduce risk from natural hazards and protect the buildings and people of Truro? Please select more than 1 answer.

Answered: 48 Skipped: 3



Chapter 1: Public Survey and Results

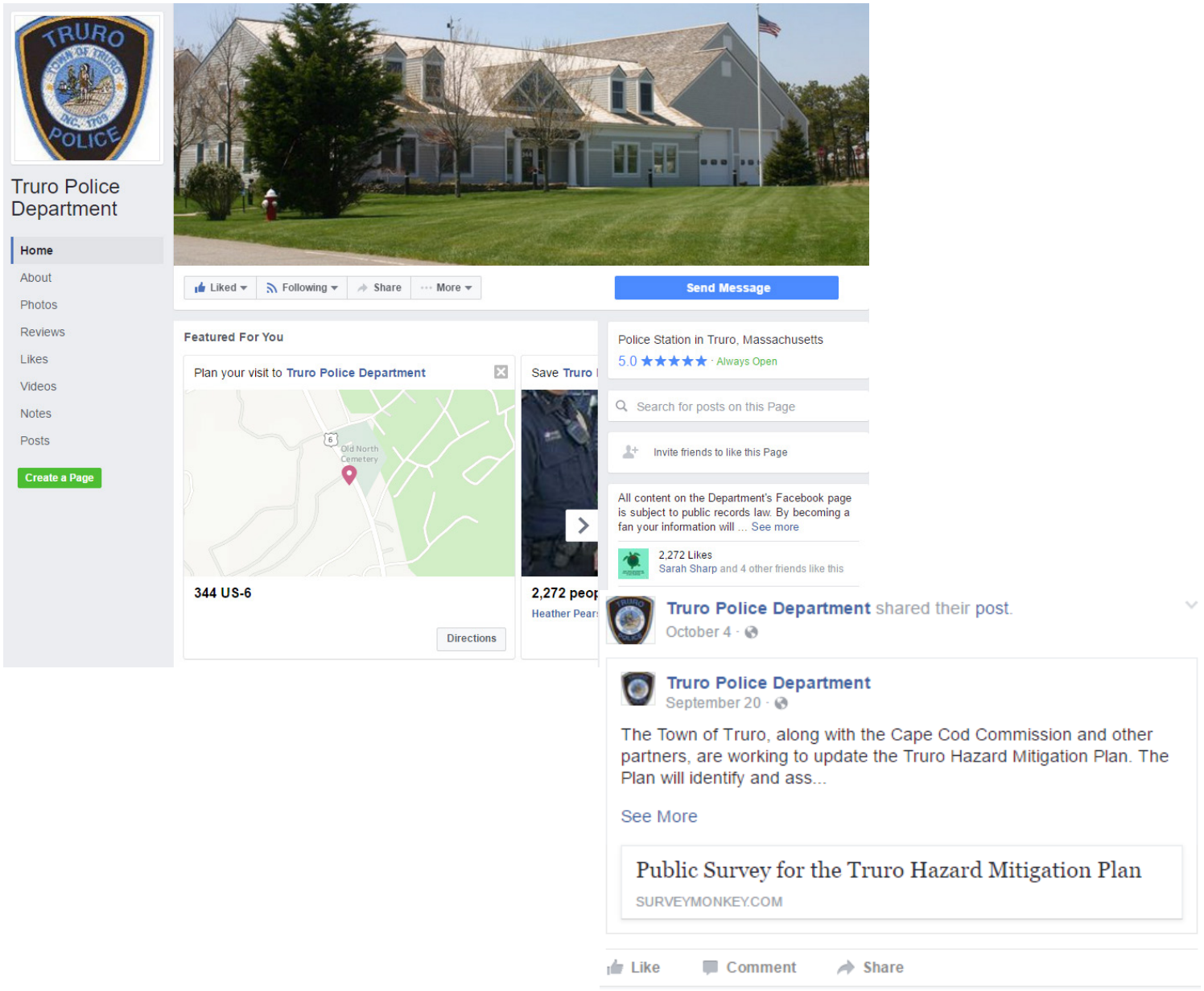


If you are interested in the hazard planning process, please provide your name, email and/or alternate contact information.

Answered: 15 Skipped: 36

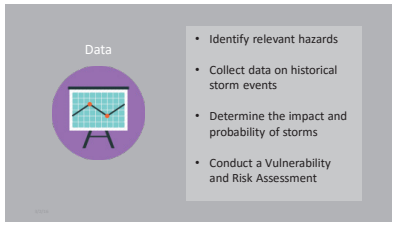
Answer Choices		Responses	
Name	Responses	100.00%	15
Email	Responses	100.00%	15
Alternate Contact Information	Responses	40.00%	6

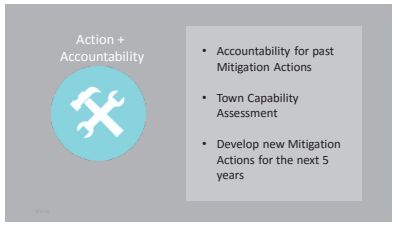
Chapter 1: Survey Documentation



Chapter 1: BCREPC Presentation

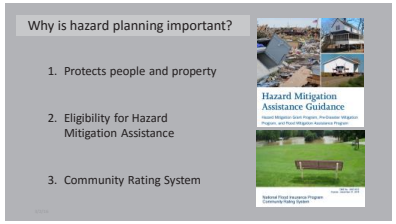
March 2, 2016

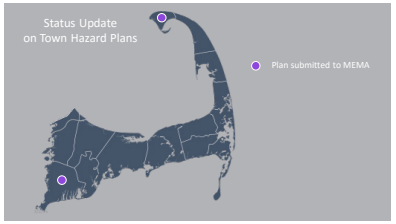


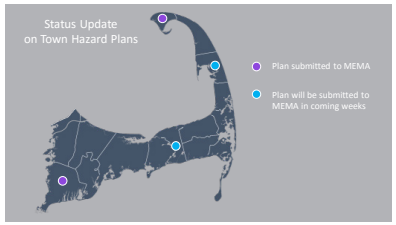


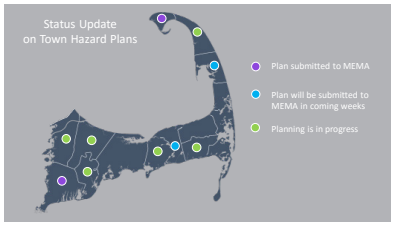
Chapter 1: BCREPC Presentation

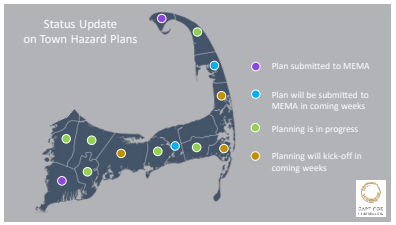
March 2, 2016











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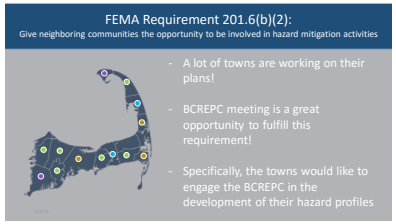
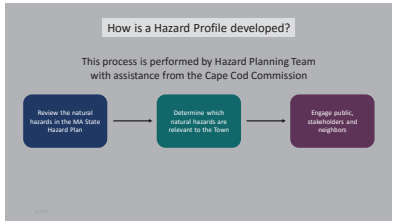
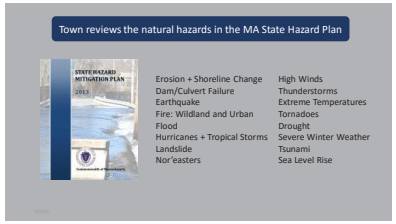
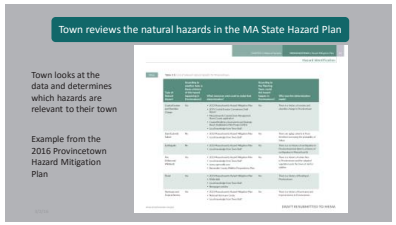
Chapter 1: BCREPC Presentation

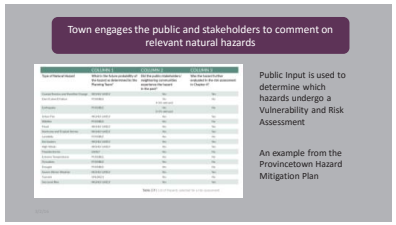
March 2, 2016





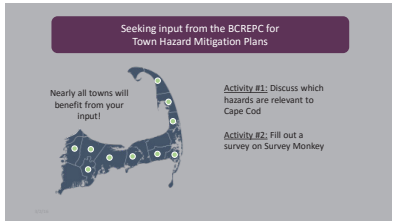


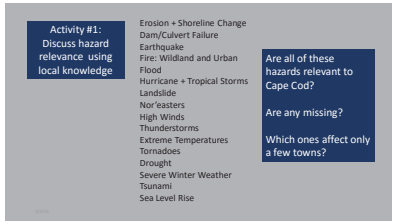


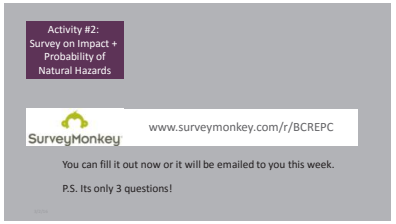


Chapter 1: BCREPC Presentation

March 2, 2016







BARNSTABLE COUNTY
REGIONAL EMERGENCY PLANNING
COMMITTEE
SUPERIOR COURT HOUSE
POST OFFICE BOX 427
BARNSTABLE, MA 02630

Phone: (508) 375-6618
FAX: (508) 362-2603
Email: bcrepc@barnstablecounty.org

MEETING NOTES

The Barnstable County Regional Emergency Planning Committee
Held a meeting on Wednesday, March 2, 2016 at **2:00 p.m.** in the
Innovation Room in the OpenCape Building at the Barnstable County Complex
3195 Main Street, Barnstable, MA 02630

I. Welcome/Introductions

The meeting was called to order at 1405 by co-chair Chief Ron Fisette. Introductions were made around the room:

Tim Lynch, Massachusetts Maritime Academy, Cally Harper, Cape Cod Commission, Lance Lambros, Office of Senator Vinny deMacedo, Hilary Greene, American Red Cross, Kent Farrenkopf, Eastham Fire Department, Jerry McDermott, Eversource, Philip Simonian, Yarmouth Fire Department, Kevin Morley, PIO BCREPC, Sean O'Brien, BCREPC, Debra Rogers, Falmouth Community Television, Dan Howard, ARES, Jeff Tavares, Falmouth Fire Department, Michael Walker, Incident Management Team, Diana Gaumond, Cape Cod Medical Reserve Corps, Roy Jones, Cape Cod Regional Transit Authority, Chrystal LaPine Health and Medical Coordinating Coalition, Bill Ciocca, National Grid, Dee Yeater, Visiting Nurse Association, Amy Henderson, AmeriCorps Cape Cod, Chloe Schaefer, Cape Cod Commission, Deirdre Arvidson, Barnstable County Department of Health and Environment, Amy Alati, Barnstable County Department of Health and Environment, Brian Dale, Cape Cod Regional Transit Authority, Ed Kulhawik, Eastham Police Department, Jeff Rossi, AmeriCorps Cape Cod, Paul Hoy, American Red Cross, Jake Garringer, AmeriCorps Cape Cod, Michael Clark, Barnstable Police Department, Brian Gallant, Sandwich Office of Emergency Management, Ron Fisette, Wellfleet Police Department, Chad Absten, Falmouth Fire Department, Laura Marin, Provincetown Health Department, Rachel Potts, Massachusetts Emergency Management Agency, Joseph Gordon, Barnstable County Sheriff's Office, Phil Burt, BCREPC, Eric Trudeau, National Park Service, Charles Noyes, Bourne Emergency Management Director.

II. Minutes: February 3, 2016

A motion was made by Brian Gallant to accept the minutes; the motion was seconded by Roy Jones and approved unanimously.

III. Status Reports from REPC Subcommittees and Programs:

- **Executive Committee**

  Sean O'Brien said there would be a meeting on March 14 to discuss expansion of the executive committee from 5 to 9 members

- **HAZMAT/Tier 2 Update**

  Amy Alati reported it was the best year ever but most complicated. She praised the filers using the Tier 2 Manager software. 418 facilities reported in Barnstable County this year. BCREPC covers Nantucket County as well – 27 facilities reported on the island.

  There were 67 office visits from public and private facility representatives in the month of February. Compliance protects the facilities by ensuring fire departments on Cape Cod and Nantucket receive the HAZMAT database and the facility emergency response plans.

  Oyster Harbor Marine and Cape Cod Oil were exemplary said Amy. They were assiduous in their willingness to do the right thing.

- **Health Agents Coalition**

  No report but Amy mentioned a program around opioid abuse. She has copies of the presentation

- **Incident Management Team**

  Mike Walker reported on the MACC standup and the call-out for a search operation in Harwich. The team continues to seek more training opportunities.

- **Sheltering Task Group**

  Phil Burt said there were no shelter operations this winter. The committee is looking for grant funding for equipment and supplies and scheduling walk-throughs during the summer months.

- **American Red Cross**

  Paul Hoy introduced himself as the Disaster Program Manager on an interim basis. He reported the ARC is looking for a full-time replacement

Chapter 1: BCREPC Meeting Notes, 03/02/16

for Ellen Rossano who left the ARC due to health reasons. In terms of volunteers the ARC is trying to increase shelter manager capacity by 25%. The ARC is also adding supplies, in addition to shelter equipment and is also working on a mobile capacity, each of which would shelter 100 people. ARC is also increasing by 100 % the capacity of the Nantucket shelter with material for 100 people. Hilary Greene updated to committee on the Heroes Breakfast.

- **MEMA**

  Rachel Potts reported there were no updates

- **OpenCape Liaison Task Group**

  Sean O'Brien said the Task Group would be looking at dash/body cams and 700 MHz He would have a report at the next meeting.

- **Citizens Corps Council**

  Amy Alati reported that the final edits were being made to the senior emergency reference magnetic card, which is to be printed by the Barnstable County Sheriff's Office. It will educate the senior population about planning for emergencies. Public seminars and education events will be held as well.

- **ARES**

  Dan Howard reported that issues with antennas are being addressed at the Old Jail.

- **Barnstable County Sheriff's Office**

  Joe Gordon reported that the S39 vehicle responded to Harwich for a search and rescue operation. He said that agencies shouldn't hesitate to ask for that vehicle as a command post. He reported that a new CERT class was starting at the Massachusetts Maritime Academy.

- **Public Information Officer**

  Kevin Morley reported the shelter video project is making good progress. He reported that he is engaging Cape Cod Community Access TV stations in the production of Regional Shelter System videos

IV. **Introduction: Verizon Government Affairs**
Ellen Cummings, Regional Director

Sean introduced Ellen. She has been working with Cape for six years wireline and wireless. She is very happy to make connection with public safety, She will stay around after meeting to meet with public municipal officials to hand out information sheet on reporting on problems.

Sean praised Ellen and Verizon for their responsiveness.

V. **Presentation: Engaging Neighboring Communities in Hazard Planning**
Cally Harper, PhD. Planner II
Cape Cod Commission

Cally Harper reported her primary role is helping towns update hazard mitigation plans. She reviewed elements of hazard mitigation plan. She presented a status update on hazard mitigation plans for Cape towns. She reported that the majority of towns do not have an active plan. She reviewed the process of developing a hazard profile. She also sought input from the BCREPC for Town Hazard Mitigation Plans. She sought discussion of the relevant hazards on Cape Cod. She asked the meeting members to fill out a survey on Survey Monkey.
www.surveymonkey.com/r/bcrepc

VI. News - Open Announcements - Information

Hillary Greene announced a fundraiser for Frank O'Laughlin on March 11.

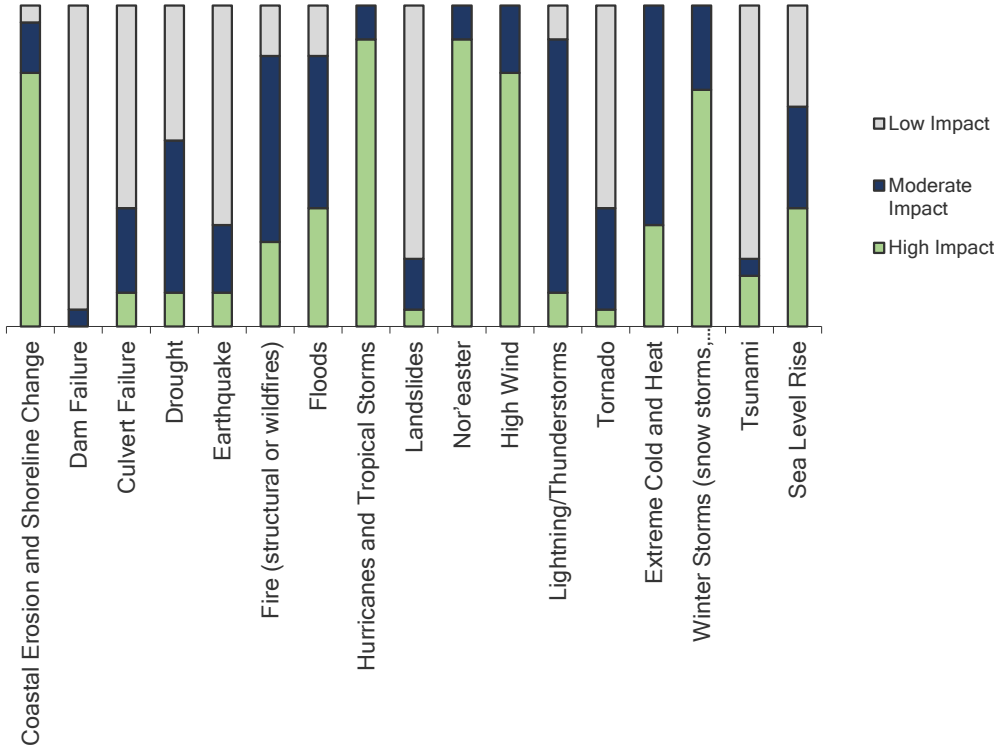
VII. Public Comments

None

VIII. Adjourn

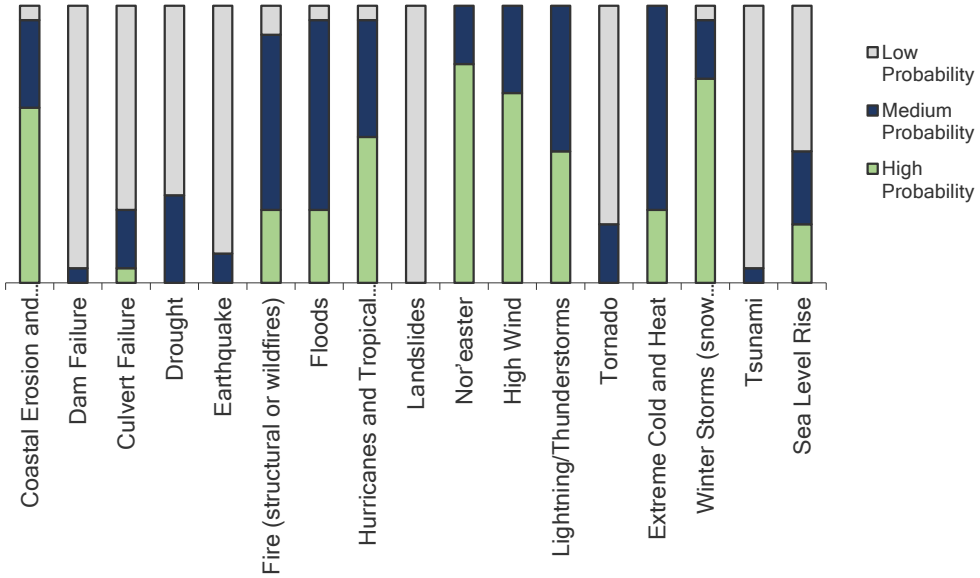
A motion for adjournment was made by Joe Gordon; seconded by Brian Gallant. The meeting was adjourned at 1445

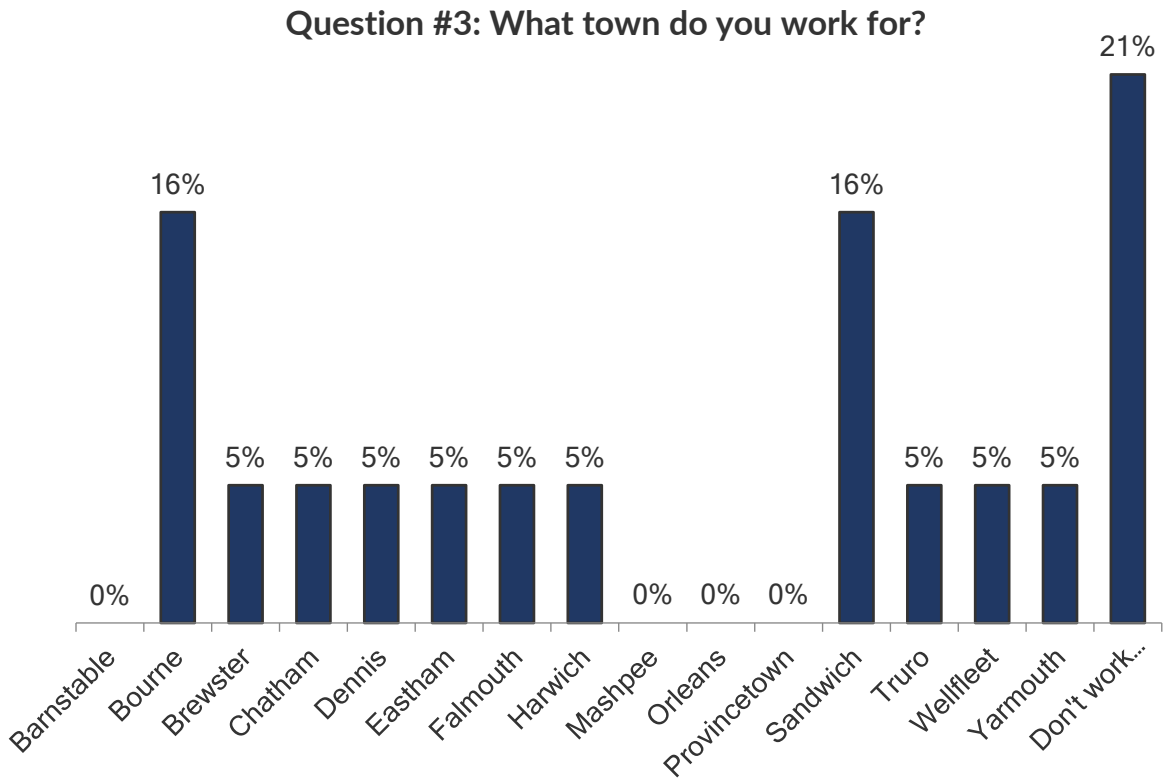
Question 1: For each hazard listed below, please identify if it will have a "low," "moderate" or "high" impact on Cape Cod. The towns would like you to use your local knowledge of Cape Cod. According to FEMA, impact is defined as the damage or consequence



Chapter 1: BCREPC Survey Results

Question #2: For each hazard listed below, please assign a probability score of "low," "medium" or "high". According to FEMA, probability measures how often an event is likely to occur. Low probability means the event will occur at least once in the next




Question #3: What town do you work for?
0%
16%
5%
5%
5%
5%
5%
5%
0%
0%
0%
16%
5%
5%
5%
21%
Barnstable
Bourne
Brewster
Chatham
Dennis
Eastham
Falmouth
Harwich
Mashpee
Orleans
Provincetown
Sandwich
Truro
Wellfleet
Yarmouth
Don't work...

Chapter 7: Truro Board of Selectmen Minutes, 01/24/2017 – Hazard Plan Vote

Truro Board of Selectmen Meeting
Selectmen's Chambers Town Hall
Tuesday, January 24, 2017

Members Present: Chair Paul Wisotzky; Maureen Burgess, Jay Coburn, Robert Weinstein, Janet Worthington
Present: Town Manager Rae Ann Palmer

Chair Paul Wisotzky opened the meeting at 5:00 p.m.

PUBLIC COMMENT
Chis Lucy said he was seeking to raise awareness and support for the Planning Board's work on a bylaw for accessory dwelling units with an Affordable component.

Scott Landry of 24 Shore Rd. wanted to know that the summer parking situation near the winery on Shore Rd. would be on the agenda for the Feb. 14, 2017 Selectmen's meeting and was assured that it is.

BOARD OF SELECTMEN ACTION
Lower Cape Community Access Television (LCCAT) Presentation
Teresa Martin, Executive Director of the Lower Cape Community Access Television, and Larry Greeley, LCCAT Board Chair, gave a PowerPoint presentation and short video, updating LCCAT features. They explained the structure of the organization, a media access center for the public, five towns and Nauset Regional High School. The studio and production facility is located at Nauset Regional. There are workshops and private coaching available. Public Service Announcement (PSA) Days are available for non-profit organizations. In addition, LCCAT has been developing more local news, features and community productions such as *Peak Time* with Jack Peak of Truro. The video portion of their presentation outlined offerings and accomplishments during the past year. Their goals are to increase offerings and give access to diverse voices. Funding for LCCAT comes in part from Comcast.

Bylaw for Two-thirds Vote
Town Moderator Monica Kraft presented Town Counsel's wording for a bylaw for two-thirds votes at Town Meeting. The issue came up at the last Town Meeting, she said. Certain Town Meeting votes have to be counted by statute. A two-thirds call can be declared without a count unless the two-thirds majority is questioned. For its time saving purpose, this procedure can be approved at each Town Meeting, or it can be achieved by acceptance of a two-thirds vote bylaw, Ms. Kraft said.

Jay Coburn moved to approve that staff prepare a bylaw for the two-thirds vote bylaw Article for inclusion in the 2017 Town Meeting Warrant. Maureen Burgess seconded, and the motion carried 5-0.

Discussion on Electronic Voting
Monica Kraft, Town Moderator, remained to discuss electronic voting, another time saver for Town Meetings. Assistant Town Manager Kelly Clark joined her for the discussion which had originated through a citizen's request. Ms. Clark explained the procedure for using the devices. They could be rented or purchased, she said. There are companies that are available for one-time trial usage. Kelly Clark named some of the communities in the state that are now using e-voting. Monica Kraft said she had been in contact with communities who now use e-voting. Ms. Kraft recommended forming a committee first, the way Eastham, the nearest town that uses electronic voting devices, had done before approving their use.

Town Manager Rae Ann Palmer said she had discussed sharing electronic device purchase with Provincetown and Wellfleet. Kelly Clark discussed some of the cost options that companies had offered. She explained allowances that are made for those with impairments that prevent use of the electronic devices. Selectmen discussed their interest in the e-devices, the privacy the system affords the voters, sharing with the other towns and formation of a committee before introducing the devices at Town Meeting. Board members discussed whether forming a committee on e-voting possibilities was feasible before Town Meeting 2017.

Robert Daglio of 3 Hooker's Way came forward to discuss the advantages of privacy in voting and to ask about the number or voters who attend Town Meeting. Further consideration will be given to the use of electronic voting devices for this year's Town Meeting at the next Board of Selectmen's meeting on February 14, 2017. Kelly Clark and Rae Ann Palmer will gather more information on purchasing vs. renting options.

Approval of Hazard Mitigation Plan
Health Agent Patricia Pajaron, Fire Chief Tim Collins and Kelly Harper, formerly of the Cape Cod Commission, who helped develop the plan, appeared to present the 2017 *Hazard Mitigation Plan*. Health Agent Pajaron gave background information on the new plan which includes an asset inventory and a vulnerability list as well as the mitigation plans for hazard events. The draft plan will go to MEMA if the Selectmen approve the plan, Ms. Pajaron said. Ms. Harper explained that the plan protects homeowners, helps the town get into the community rating system for flood insurance, and makes Truro eligible for FEMA money. Robert Weinstein noted the omission of the hazard of a possible nuclear power plant equipment failure. Jay Coburn and Ms. Pajaron said that is not something that the Town of Truro can mitigate, and it is addressed in the *Emergency Management Plan*. Ms. Harper explained how the hazardous situations had been chosen.

Jay Coburn moved to approve, with some corrections, the 2017 *Hazard Mitigation Plan* and forward it to MEMA. Robert Weinstein seconded, and the motion carried 5-0.

Opening the Warrant for the 2017 Annual Town Meeting
Rae Ann Palmer said it was time to open the Warrant for Town Meeting. Any petitioned money Articles need to be submitted by February 10, 2017 and any other Articles need to be submitted prior to March 14, 2017, the date that the Warrant closes. Non-binding ballot initiatives have their own set of deadlines, but if they are to be printed in the Warrant need to be submitted prior to March 14, 2017.

Chapter 7: Truro Board of Selectmen Minutes, 01/24/2017 – Hazard Plan Vote

Paul Wisotzky, Chair

Maureen Burgess

Jay Coburn, Clerk

Janet Worthington, Vice-chair

Robert Weinstein

Public Records Materials of 1/24/17

1. LCCAT Presentation materials
2. 2017 *Hazard Mitigation Plan*
3. Fiscal Year 2017 *Goals and Objectives*
4. *Policy #59 for Public Comment, Selectmen Reports and Comments*
5. Application papers of Gary Palmer for Water Resources Oversight Committee

Truro Hazard Mitigation Plan, 2017

Prepared by the Cape Cod Commission
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