Barnstable County
Cape Cod, Massachusetts

Multi-Hazard Mitigation Plan
March 19, 2010

Coordinated and written by the Cape Cod Commission

Prepared for the Federal Emergency Management Agency to comply with the DMA Act of 2000

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Local Multi-Hazard Mitigation Plan Updates (status)

Chatham *(Draft attached for MEMA review)*

Eastham *(Draft attached for MEMA review)*

Dennis* (*Draft attached for MEMA review)*

Provincetown *(Draft attached for MEMA review)*

Truro* (*Draft attached for MEMA review)*

Barnstable *(Draft under development; not submitted)*

Brewster (*Draft under development; not submitted*)

Bourne *(Draft under development; not submitted)*

Harwich *(Draft under development; not submitted)*

Mashpee *(Draft under development; not submitted)*

Orleans *(Draft under development; not submitted)*

Sandwich *(Draft under development; not submitted)*

Wellfleet *(Draft under development; not submitted)*

* Indicates new plan

Section 1 Introduction

1.1 Introduction and Plan Update Process

In 2004, the Cape Cod Commission developed a multi-jurisdictional, Pre-Disaster Mitigation (PDM) plan for Barnstable County, Massachusetts, and assisted the 15 local governments of Cape Cod in their development of local PDM plans. This work was done in order to satisfy federal requirements that such plans be completed by November 1, 2004 [under the Federal Emergency Management Agency's Disaster Management Act of 2000 (DMA 2000)]. These plans were prepared to address natural hazards to which Cape Cod, Massachusetts, is vulnerable, and are required to be updated every five years to maintain certification.

The purpose of the multi-jurisdictional plan update, now referred to as the Multi-Hazard Mitigation (MHM) Plan, is to identify new and on-going hazards that are common to the communities of Barnstable County, to understand specific locations where the region is vulnerable to these hazards, and to assess the mitigation strategy developed in the 2004 plan to reduce the risks associated with these hazards and recommend new strategies where necessary. Local jurisdictions must review and revise their plans to reflect changes in development, progress in local mitigation efforts, and changes in priorities, and re-submit the plan for approval within five (5) years in order to continue to be eligible for mitigation project grant funding.

The Barnstable County Regional Multi-Hazard Mitigation Plan (hereinafter referred to as the Regional MHM Plan) is organized into six (6) main sections and is accompanied by (5) Local Multi-Hazard Mitigation Plans (Local MHM Plan). Each Local MHM Plan includes the original goals that support hazard mitigation, a local hazard inventory and risk assessment, a vulnerability analysis based on the location of local critical facilities and infrastructure (using GIS mapping) and an updated existing protection matrix. Local MHM Plan Updates have been provided for: Truro, Provincetown, Chatham, Eastham, Brewster and Dennis. Both Truro and Dennis have developed MHM Plans for the first time.

Where priority shifts in certain hazards, risks and vulnerabilities have been identified in the Local and Regional MHM Plans, due to better or new information, the goals and corresponding mitigation actions and strategies have been updated to reflect that. The Local MHM Plans also show where there has been progress implementing mitigation actions and projects. These plan elements were undertaken so that each town could re-visit the heart of its 2004 Local PDM Plan and demonstrate progress, or a shift in priorities, on the list of hazard mitigation actions and projects from the 2004 Local PDM Plan.

This section, **Section 1**, serves as an introduction, explaining the purpose and benefits of natural hazard mitigation in general and the Regional MHM Plan in particular. It also describes the planning process used to update the county and local plans.

Section 2 of this plan is the hazard identification and risk assessment. This section provides an overview of the recent disaster history affecting Barnstable County and a discussion and ranking of the types of hazards to which Cape Cod is susceptible, including climate change. The eight (8) natural hazards identified were flood, shoreline change, wildfire, wind, snow and ice accumulation, drought, tornado, and earthquake. In addition to these natural hazards, sea-level rise and increased precipitation, two projected local impacts of climate change, were considered as a factor that threatens to increase the risks and

vulnerabilities associated with flooding and shoreline change. Adaptation strategies were discussed for their potential to mitigate these impacts.

Section 3 presents the region's updated vulnerability assessment and analysis of risk. A profile of Barnstable County highlights the region's existing development patterns and presents the best available population data and distribution, as well as seasonal population fluctuations. The section identifies such things as the location of regional critical facilities and infrastructure (using GIS mapping) and analyzes their locations as related to spatial hazard zones (e.g., FIRM, SLOSH, and wildfire hazard areas). It concludes with a summary of the region's vulnerability.

Section 4 of this plan identifies existing regional programs, projects, and activities that relate to hazard mitigation. A table of existing protection measures identifies current policies and programs that support hazard mitigation and notes ongoing or planned hazard mitigation programs, projects, and activities of the county. By identifying what already exists in Barnstable County, this section brings to light the gaps in existing protections, which ultimately led to development of needed action items.

Section 5 lays out what is the key to hazard mitigation – having a strategy. Implementation of the 2004 planning strategy is discussed in terms of progress with mitigation goals and the success of implementing and administering the comprehensive range of action items and projects. Did implementation fully achieves the goal of the 2004 PDM Plan; to reduce the loss of or damage to life, property, infrastructure, and natural, cultural, and economic resources from natural disasters? A revised strategy, including updated action items and projects is presented.

Section 6 of this plan outlines how this plan was initially adopted, updated, and how it will be reviewed and updated in the future. The plan and its associated project list should be reviewed and updated periodically to account for projects that are undertaken and completed, to consider the impact of future disasters and new needs that are identified, and to reflect changing regional and local priorities. A review of the plan and its project list should occur on an annual basis with a complete revision of the plan every five years.

In an attempt to get an accurate picture of Cape Cod as a whole, the Regional MHM Plan provides summaries of the information provided in, and draws comparisons between, Local MHM Plans when appropriate. Importantly, this plan goes out of its way to point out what could not yet be accomplished, particularly in the area of climate change adaptation. This is valuable information that led to many of the action items that Barnstable County needs to undertake. For example education, particularly as it relates to climate change adaptation in our region, is identified herein as an important part of the hazard mitigation strategy that should be undertaken.

1.2 Purpose and Benefits of Multi-Hazard Mitigation Plans

The best way to deal with natural hazards is to recognize that they occur and to take advance action that will minimize the impacts.

The work undertaken during the creation of the 2004 Regional PDM Plan, the implementation work that followed and that will continue upon revision of the Plan, is for the purpose of achieving the following overall goal:

To reduce the loss of or damage to life, property, infrastructure, and natural, cultural, and economic resources from natural disasters.

Creating, adopting, and implementing the Regional and Local MHM Plans will:

- **Make certain funding sources available** to implement the mitigation initiatives that would not otherwise be available if the plan was not in place, including Hazard Mitigation Grant Program funds for post-disaster projects and Multi-Disaster Mitigation Competitive Grant Program funds for projects annually. Hazard Mitigation Grant Program (HMGP) funds are currently available and will remain so for project implementation after the next federally declared disaster in Massachusetts.

- **Support effective pre- and post-disaster decision making efforts.** Mitigation is directly related to disaster recovery. This plan emphasizes actions to be taken now to reduce or prevent future disaster damages. If the actions identified in these plans are implemented, the damage that is left in the aftermath of future events will be minimized, thereby easing recovery and reducing the cost of repairs and reconstruction. Additionally, mitigation planning improves the region's ability to implement post-disaster recovery by establishing improved emergency response within and between communities, reducing social, emotional, and economic disruption following a disaster event, reducing damage to public and private facilities, and identifying projects ready for funding.

- **Ease the receipt of post-disaster state and federal funding** because the list of mitigation initiatives is already identified.

- **Reduce vulnerability to disasters** by focusing limited financial resources to specifically identified needs.

- **Connect hazard mitigation planning to community planning** where possible.

- **Enhance and preserve natural resource systems,** thus providing benefits that will be felt regardless of the occurrence of a disaster.

- **Provide a framework for addressing climate change,** by considering projected climate change impacts on existing hazards in our region under the risk and vulnerability assessment. As better climate change data becomes available, such as LiDAR data to better estimate sea-level rise impacts, the MHM Plan's risk and vulnerability assessment is an appropriate place for this information to reside.

1.3 Hazards, Risks and Vulnerability - Defined

In the context of natural disasters, ***hazard mitigation*** is commonly defined as any sustained action that permanently reduces or eliminates long-term risk to people, property, and resources from natural hazards and their effects.

In the context of this Plan ***hazard*** refers to an extreme natural event that poses a risk to people, infrastructure, or resources. ***Risk*** can be defined as "hazard; danger; peril; exposure to loss, injury, or destruction" or "the possibility of suffering harm or loss." Barnstable County's hazard risk assessment determines which areas of the county may be affected by a natural hazard, how likely it is that a given hazard may occur, and how intense that hazard might be. This Plan extends the meaning of ***hazard*** to include projected climate change impacts, such as sea-level rise, increased intensity of coastal storms and hurricanes, and increased precipitation in the form of heavy downpours. While the science broadly supports climate change as a man made hazard, the impacts that are projected to affect our region will occur in the form of extreme natural hazards, therefore, the plan has attempted to include climate change as an event that poses risk to people, infrastructure and resources in our region. As new and better data becomes available, it will be included in the plan update overtime to better determine vulnerability.

Vulnerability can be defined as "susceptibility to injury or attack." Vulnerability indicates what is likely to be damaged by the identified hazards and how severe the damage might be. For example, if an area is determined to be at risk of flooding, vulnerability estimates could include residential property losses, impacts to the tax base, and damages to public infrastructure. A vulnerability assessment is often communicated in terms of the potential number of lives that could be harmed or lost and the value of property in the high-risk areas.

1.4 Hazard Mitigation Planning

Hazard mitigation planning is the process that analyzes a community's risk and vulnerability to natural hazards, develops a plan for coordinating available resources, and develops an implementation strategy to eliminate those risks.

Geographic information systems, or GIS, is a powerful tool for developing a risk and vulnerability assessment in map form. GIS has been an essential component in developing Barnstable County's hazard mitigation planning framework since 2002, and has continued to be valuable in expanding the scope of the analysis in the MHM Plan update. Improved data-layers (such as SLOSH and land use, as it pertains to wildfire risks) have allowed for better quantification of risks and potentially vulnerable areas.

In the past decade alone, FEMA and the United States Congress have witnessed large increases in disaster response and recovery costs. As a result, they have provided funds to communities, counties, and states to reduce impacts for natural hazards through hazard mitigation planning. Changes in federal laws have resulted in mitigation planning requirements. Each state and county must have a mitigation plan that identifies steps to reduce the impacts from hazards; if they do not have approved plans in place and a disaster occurs, they will not be able to apply for certain FEMA discretionary grant funding through the Hazard Mitigation Grant Program and the Pre-Disaster Mitigation Competitive Grant Program. Therefore, it is imperative that Barnstable County and the 15 towns of Cape Cod each undergo a hazard mitigation planning effort.

1.5 Preparedness, Mitigation and Response Activities

Often, questions arise about the difference between disaster preparedness/hazard mitigation and emergency response. Both are important but do constitute different phases of the disaster cycle. Planning for a coordinated and effective response must occur during the preparedness phase of the disaster cycle,

but the actual response activities occur after the impact of a natural hazard. Therefore, emergency response mitigation is one of the six categories of mitigation actions that this Regional MHM Plan employs in its overall mitigation strategy, which includes prevention, property protection, natural resource protection, public education/information, structural projects, and emergency services/response. Barnstable County's MHM Plan addresses needed mitigation action in each of these six categories.

The ongoing work of the Barnstable County Regional Emergency Planning Committee (BCREPC), which is actively undergoing the certification process to become the Cape's Local Emergency Planning Committee (LEPC), is inherently considered ongoing hazard mitigation activity on Cape Cod. Ultimately, the BCREPC has expanded beyond its original mandate of hazard materials incident response to be able to prepare for emergency response for myriad situations, including natural disasters. The BCREPC has been instrumental in supporting the mission of this Regional MHM Plan and will likely be key to its implementation.

1.6 Documentation of the Planning Process

The Barnstable County Pre-Disaster Mitigation Plan (Regional PDM Plan) was certified by FEMA in March of 2004. The Regional PDM Plan has served as an umbrella that covers regional hazard mitigation planning issues on Cape Cod. Under this umbrella plan, nine local plans were prepared by teams of municipal officials in the towns of Bourne, Chatham, Eastham, Harwich, Mashpee, Orleans, Provincetown, Sandwich, and Wellfleet. For the 2009 Multi-Hazard Mitigation (FEMA's new designation for this hazard mitigation planning process) Plan Update, the Cape Cod Commission assembled a Regional Multi-Hazard Planning Team (RMHPT), which included representatives from each of the Cape's 15 towns that were in various stages of hazard mitigation planning. Through this group, Commission staff facilitated a comprehensive update of the 2004 Regional PDM Plan, resulting in this 2010 Regional MHM Plan. Currently, 5 Cape Cod Towns are pursuing re-certification for their local MHM Plans alongside re-certification of the County's plan, and 2 of those towns are preparing MHM Plans for the first time; Dennis and Truro. The remaining towns are in various stages of completion in their local MHM Plan Updates and anticipate submitting plans to FEMA for re-certification by summer, 2010. Commission staff will continue to work with these towns to help them meet their re-certification goals.

Regional Multi-Hazard Mitigation Planning Team Members
Representatives from the Regional MHMPT (below) met on a monthly basis, and as needed beginning in June 2009 through February 2010.

Town Representatives
Barnstable - Jo Anne Miller Buntich, Director of Growth Management
Bourne – Coreen Moore, Town Planner
Brewster - Sue Leven, Town Planner; Elizabeth Taylor, Planning Board
Chatham – Paul Lagg, GIS Coordinator
Dennis - Dan Fortier, Town Planner; Terence Hayes, Health Director
Eastham – Sarah Raposa, Town Planner; Amy Usowski, Conservation Agent
Falmouth – Sarah Brooks, Natural Resources
Harwich – David Spitz, Town Planner; Lee Culver, Emergency Management
Provincetown – Brian Carlson, Conservation Agent
Sandwich – Greg Smith, Town Planner; Mark Galkowski, Natural Resource Officer
Truro – Charleen Greenhalgh, Town Administrator
Wellfleet – Rex Peterson, Assistant Town Administrator
Yarmouth – Terry Sylvia, Town Planner; Robert Kelleher, Deputy Chief/EMT

Regional Representatives
Barnstable County's AmeriCorps Cape Cod – Mary Lawrence, Program Coordinator
Barnstable County Department of Health & Environment – Sean O'Brien, Senior Environmental Specialist
Barnstable County Regional Emergency Planning Committee – Sean O'Brien, Coordinator
Cape Cod National Seashore – Nicole Taylor; Bob Grant
Cape Cod Commission – Gary Prahm, GIS Analyst
Provincetown Center for Coastal Studies – Graham Giese, Coastal Geologist
Massachusetts Emergency Management Agency – Sarah White, State Hazard Mitigation Planner
Massachusetts Office of Coastal Zone Management – Daniella Hirshfield
New England Regional Climate Center – Dr. Art DeGaetano, Director
USGS/WHOI – Rob Theiler, Research Geologist
Waquoit Bay National Estuarine Research Reserve - Chris Weidman, Research Coordinator

Process Facilitators
Cape Cod Commission - Ryan Christenberry, Planner
Adaptation Network – Dr. Lynne Carter, Director
Waquoit Bay National Estuarine Research Reserve – Tonna-Marie Rogers, Coastal Training Program Coordinator

Regional Multi-Hazard Mitigation Planning Team Meeting Schedule

June 2, 2009 9:00 – 11:00 Cape Cod Commission
Kick-off Meeting; Discussion of Plan Update Requirements and Climate Adaptation

July 7, 2009 9:00 – 11:00 Cape Cod Commission
Hazards & Vulnerability, Critical Facilities, RVAM Maps

August 4, 2009 9:00 – 11:00 Cape Cod Commission
Risk Assessment; Estimating Potential Losses, Rep Loss Properties & Development Trends

September 1, 2009 9:00 – 11:00 Cape Cod Commission
Attend Local MHM Meetings; Update Goals & Mitigation Strategies

October 6, 2009 9:00 – 11:00 Cape Cod Commission
Implementation; NFIP

November 3, 2009 9:00 – 11:00 Cape Cod Commission
Complete Strategy Development; Review Draft Local Plan Updates

November 17, 2009* 9:00 – 11:00 Cape Cod Commission
Review Regional Draft Plan; Discuss Updated Mitigation Action Items & Climate Change Adaptation; Complete Strategy Development

January & February, 2010
FEMA, MEMA & Public to review Draft Local and Regional Plans
Develop Final Plans to address comments to Draft Plans
Present Draft Regional Plan to County Commissioners and Cape Cod Commissioners

* Regional representatives only

The following Commission staff members were involved in the preparation this plan:
Project Manager: Ryan Christenberry, Planner
GIS Analysis: Gary Prahm, GIS Analyst

A special thanks to Tonna-Marie Surgeon-Rogers, Waquoit Bay Coastal Training Program Coordinator, and Dr. Lynne Carter, Director of the Adaptation Network, as well as Associate Director, Southern Climate Impacts Planning Program (SCIPP) at LSU, who generously contributed their time and expertise to the development of this Plan.

The regional planning meetings coordinated by the Cape Cod Commission followed the outline in *Local Multi-Hazard Mitigation Planning Guidance*, issued by FEMA (July, 2008). At each team meeting, goals and homework assignments were established to help the Local MHM Planning teams make progress toward updating their Local MHM Plan. There were two towns that had not previously developed a PDM Plan in 2004. By breaking the process down into achievable goals and tasks, the planning process was able

to bring local planning teams that were new to the process up to speed, while keeping those planning teams that were preparing updates moving forward in a timely manner.

Because the role of the Cape Cod Commission regarding the Local MHM Plan Updates was one of *encouraging* and *aiding* their creation, the Commission's project manager did the following: educated municipalities on the basics of hazard mitigation; led participants through the planning steps; provided towns with resources to make the job of creating such a plan easier; provided technical assistance to the towns by attending local meetings and hearings when asked and by reviewing and commenting on draft local plans; and, created a forum for town planners to discuss and focus on hazard mitigation planning.

The 2004 PDM planning structure established a process whereby the regional and local plans would be developed on a parallel track. The 2010 regional and local plan updates continued this process. While the Commission was aiding municipalities with their local plan updates, it was also updating the regional plan. Ultimately, the results of this planning process were coordinated updates to regional and local hazard mitigation goals, hazard identification, risk and vulnerability assessment, and mitigation strategies.

The plan update process borrowed from the initial planning process by generating "homework assignments" for the local team leaders. The process worked in such a way that, at the end of the planning process, if a town had kept on a course parallel to the regional team they would have generated all of the information needed for a local MHM plan update. The "homework assignments" (attached hereto as Appendix E) include materials for updating the Hazard Identification Matrix, Critical Facilities spreadsheets, Descriptive Location Chart, and Existing Protection Measures matrix.

GIS Mapping Work

Regional work for this MHM effort initially began through the FEMA funded *Project Impact Cape Cod* initiative in 2000 to 2003, followed by the PDM Plan development process in 2004. The underlying goal of Project Impact was to empower towns/regions to protect themselves by undertaking hazard mitigation actions that in the long run would reduce the loss of life, damage to natural and cultural environments, and damage costs caused by natural disasters.

Project Impact Cape Cod produced Risk and Vulnerability Assessment Maps (RVAM) for each Cape Cod town. These RVAMs were used as the basis for the vulnerability assessment that each local multi-hazard community planning team (LMHCPT) undertook in the PDM planning process. Many of the towns updated and added critical facilities and infrastructure or other local resources to their Project Impact RVAM to better address the requirements of DMA 2000 and PDM best practices. These RVAMs are appended to each local annex herein and have been updated to reflect additional changes since the 2004 plan. The RVAM showing *regional* critical facilities and infrastructure was also updated.

To support the State Hazard Mitigation Plan, the Department of Conservation and Recreation and MEMA contracted with Dewberry and Davis to produce Significant Hazard Maps showing myriad hazards and the likelihood of their effect on Massachusetts. These maps were referred to during the regional PDM planning process to underscore the risks that Cape Cod faces. As part of the MHM Plan Update process, the Commission's GIS Department updated many of the following maps (see Appendix A) where new information was available, and as noted.

Map 1: Shoreline Change Susceptibility (Long-term Change; mid 1800's – 1944); Historical Tornado Activity; Historical Earthquake Activity, Cape Cod, MA
Map 2: Historical Hurricane Data and Flood Hazard Areas; Historical Annual Snowfall and Flood Hazard Areas, Cape Cod, MA
Map 3: Wildfire Hazard Areas, Cape Cod, MA
Map 4: Regional Policy Plan's Cape Cod Significant Natural Resource Areas MAP (2009)
Map 5: Regional Policy Plan's Cape Cod Water Resources Classification Map 1 (2009)
Map 6: Regional Policy Plan's Cape Cod Water Resources Classification Map II (2009
Map 7: Regional Risk and Vulnerability Assessment Map, Cape Cod, MA (2009)

Maps generated by the Commission's GIS Staff for use by each town's planning team, which are appended to the Local MHM Plans, are:

- Regional Hazard Risk (Map I), Cape Cod, MA (combining landslide susceptibility; long-term shoreline change susceptibility; historical tornado activity; historical earthquake activity).
- Regional Hazard Risk (Map II), Cape Cod, MA (combining flood hazard areas, historical hurricane activity, historical average annual snowfall).
- Regional Hazard Risk (Map III), Wildfire Hazard Areas
- Local Risk and Vulnerability Assessment Map with SLOSH zones

Section 2 – Hazard Identification and Assessment

2.1 Hazard Identification and Ranking

The hazard ranking matrix in Table 1, Hazard Ranking for Cape Cod, Massachusetts, is the basis for the county's determination of the most likely and most damaging natural hazards to which Cape Cod is vulnerable. This matrix was compiled based on the best judgment and knowledge of the members of the Regional MHCPT. Note that one hazard can be the result of numerous events. For example, flooding is a natural hazard that can be caused by a hurricane, winter storm, or nor'easter. Therefore, it is the potential impact of the damaging hazard—the flooding—and not the event—a hurricane or a nor'easter—that this matrix ranks. Climate change is an event to which Cape Cod has become vulnerable. The projected impacts of climate change are covered through existing events and hazards, such as hurricanes and intensification of coastal erosion. However, heavy downpours, a more recent phenomenon expected to worsen over time has been included as a hazard associated with climate change, as it can occur in any season, independent of a Nor'easter or hurricane.

Using the rating system and the definition of ranges from the *Local Multi-Hazard Mitigation Planning Guidance* (July, 2008), by MEMA/DCR, the Regional MHCPT ranked hazards from most likely and damaging to least likely and damaging. Generally, Cape Cod is subject to the following types of events:

- Hurricanes — which can cause hazards such as flooding and storm surge, shoreline change (episodic erosion), wind, tornadoes, and heavy downpours
- Sea level rise — which can cause shoreline change, long-term coastal erosion, and flooding
- Winter storms / Nor'easters — which can cause wind, snow and ice accumulation, shoreline change (episodic erosion), and flooding
- Drought — which can contribute to the risk of wildfires
- Tornadoes and Waterspouts
- Earthquakes
- Climate change

TABLE 1: Hazard Ranking for Cape Cod, Massachusetts				
Natural Hazard:	**Location†** **Rate:** **1=small** **2=medium** **3= large**	**Frequency of Occurrence††** *Rate:* **0=unlikely** **1=possible 2=likely** **3=highly likely**	**Magnitude / Severity†††** **Rate:** **1=limited** **2=significant** **3=critical** **4=catastrophic**	**Hazard Ranking**
Flood	2	3	4	**9**
Shoreline change (long term, sea level rise, or storm-induced)	2	3	4	**9**
Heavy downpours	3	2	2	**7**
Wildfire	2	2	4	**8**
Snow and Ice Accumulation	3	3	2	**8**
Wind	3	3	2	**8**
Tornado	1	2	3	**6**
Drought	3	1	1	**5**
Earthquake	2	1	2	**5**

† **Location**

1=small (isolated to a specific town during one event)
2=medium (occurring in multiple towns across county during one event)
3= large (affecting a significant portion of Barnstable County during one event)

†† ***Frequency of Occurrence***

0=unlikely (less than 1% probability in the next 100 years)
1=possible (between 1 and 10% probability in the next year; or at least one chance in next 100 years)
2=likely (between 10 and 100% probability in the next year; or at least one chance in next 10 years)
3=highly likely (near 100% probability in the next year)

††† ***Magnitude/Severity***

1=limited (injuries and/or illnesses are treatable with first aid; minor "quality of life" loss; shutdown of critical facilities and services for 24 hours or less; property severely damaged < 10%)
2=significant (injuries and/or illnesses do not result in permanent disability; shutdown of several critical facilities for more than one week; property severely damaged <25% and >10%)
3=critical (injuries and/or illnesses result in permanent disability; complete shutdown of critical facilities for at least two weeks; property severely damaged <50%, >25%)
4=catastrophic (multiple deaths; complete shutdown of facilities for 30 days or more; property severely damaged >50%)

Hurricanes[1]

Of all the natural threats that might affect Cape Cod, hurricanes have the potential to cause the most property damage and loss of life if adequate planning and preparation is not undertaken.
Although hurricanes can produce tremendous damage they can, unlike other threats, be tracked for several days before impacting a community—giving residents and visitors time to prepare and evacuate if necessary. We cannot, however, plan to move or remove infrastructure when a hurricane is predicted.

The Atlantic hurricane season runs from June 1st through November 30th. Based on the number and intensity of storms, mid-August through mid-October is defined as the peak period. However, hurricanes or other severe storms can occur at any time. During the months of June and July, hurricanes tend to form in the Caribbean and the Gulf of Mexico. By mid-August, as the waters of the tropical Atlantic warm, the focus turns to the Eastern Atlantic in the vicinity of the Cape Verde Islands off the African coast. The tropical waves intensify as they move westward, become tropical depressions, then tropical storms and finally hurricanes. Most of these storms turn northward around the peripheries of the semi-permanent Bermuda and Azores high-pressure areas, but in some cases can affect the Atlantic and Gulf Coast states. By early October, the waters over the Atlantic begin to cool and the focus for storm development shifts back to the Caribbean and the Gulf of Mexico. Climate change threatens to alter this cooling effect through warming ocean water temperatures. While it is impossible to pinpoint the exact impact this phenomenon will have on our region, both the intensity and frequency of hurricanes is expected to rise.

What are the Real Hazards During a Hurricane?[2]

It is difficult to visualize the total devastation that a hurricane can cause. Few of our citizens have experienced the massive damage from the Hurricane of 1938. Hurricane Bob, while destructive in its own right, was only a relatively weak Category 2 storm that struck on a low-tide cycle. It can get much worse. Below are some of the main hazards that may occur during a hurricane event.

Wind

Strong surface winds can cause a barrage of flying debris. Hurricanes are categorized by sustained winds of 74 mph to 200 mph, which can cause tremendous debris problems. Southern New England has been affected by 41 tropical cyclones between 1900—2002. Twelve of these storms have caused significant landfall damage. Each of these storms brought high winds resulting in heavy precipitation and coastal flooding. The angle at which the majority of these storms made landfall was approximately 60 to 90 degrees—a storm track generally perpendicular to the coastline, worsening the storm surge in north-south orientated bays and inlets. As a result, much of the Nantucket Sound shoreline was adversely affected. Major storms of the last 100 years have behaved in a relatively consistent manner: each storm bringing the Cape high winds and heavy precipitation resulting in varying levels of coastal flooding. The time frame for their arrival (August/September) coincides with the zenith of Cape Cod's tourist season. The potential damage that could be inflicted by a significant storm event on the surrounding environment will most likely be complicated by the burden of additional populations located in and around potential hazard areas.

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[1] See Map 1: Historical Hurricane Data and Flood Hazard Areas, Cape Cod, MA.

[2] Text about the hazards related to hurricanes comes directly from the Cape Cod Emergency Preparedness Handbook: A Guide to Natural Disasters, a handbook written and coordinated by the Cape Cod Commission, 2004. The full contents of this handbook is accessible at www.capecodcommmission.org/projectimpact/handbook.htm.

Tornadoes & Waterspouts

Tornadoes may form in the rain bands of a hurricane and cause significant damage. They can also form over water (waterspouts) with little or no warning. Tornadoes are commonly found in the right front quadrant of an approaching storm. Although these tornadoes are not as intense as those that form in the Midwest tornado belt they can still inflict tremendous damage with little or no warning. There were four reports of tornadoes on Cape Cod as Hurricane Bob came ashore.

Heavy Downpours

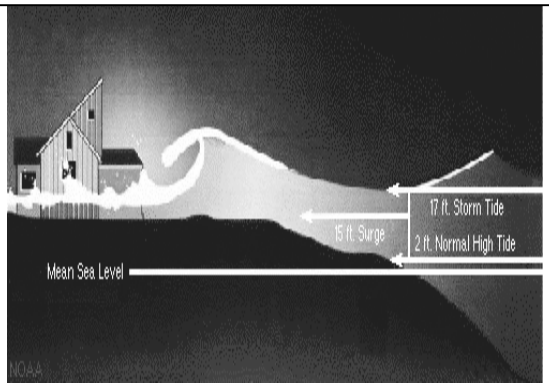
Torrential rains are associated with slow moving or stationary tropical weather systems. In addition to flooding residences and businesses, heavy rain can overcome the Cape's storm drain systems and cause severe flooding or structural failure of roads or culverts. Climate change projections suggest an increase in frequency and occurrence of heavy rainstorms over the next 30 years. While these heavy rains can have a disastrous effect on agricultural interests by drowning crops and increasing the probability of disease and pest infestations in surviving crops, coastal flooding and storm surge inundation are of primary concern to Cape Cod.

Coastal flooding is the main risk faced by Cape Cod's residents and visitors during a serious weather event such as a hurricane or winter storm. It doesn't take a major event for flooding to result in many areas—many of our storm drain systems are overcome during small rain events, which flood roadways and personal property.

Storm Surge

Rapidly rising storm surge is the hurricane's main threat to life. Storm surge is a dome of water that moves ashore to the right of the hurricane eyewall. It can be the primary risk to life if adequate evacuations are not done. In the case of Cape Cod Bay, storm surge will actually affect the shoreline, and particularly Wellfleet Harbor, shortly *after* the storm has passed. Residents and visitors should be aware to remain well above surge elevations until all threats have passed. Damage amounts depend on the hurricane's intensity, size and its direction of movement. Storm surge causes salt water flooding that can render evacuation routes impassable, cripple communications, cause sewers and storm water basins to back up, and contaminate drinking water supplies. Storm surge flooding can wash out roads and leave streets filled with sand and debris, rendering them impassible long after surge waters have receded.

Storm Surge Model, courtesy FEMA



The Southeastern Massachusetts Hurricane Evacuation Study was conducted in December 1994 by the U.S. Army Corps of Engineers, New England Division, in conjunction with the Federal Emergency Management Agency, for the Massachusetts Emergency Management Agency. This study produced two atlases that identify hurricane evacuation zones and SLOSH (Sea, Lake, and Overland Surges from Hurricanes) zones. The SLOSH is a computer model by the National Weather Service designed to forecast surges that could occur from wind and pressure forces of hurricanes. The model is applied to the Cape to estimate potential flooding from hurricanes that may make landfall in New England. Surge limits shown on the community maps represent potential flooding that may occur from critical combinations of

hurricane track direction, forward speed, landfall location, and high astronomical tide. The 2010 Barnstable County MHM Plan and corresponding Local MHM Plans utilize the most recent (2004) SLOSH data.

History of Hurricanes in New England

Two of the worst hurricanes to affect Cape Cod and the Islands were the Great New England Hurricane of 1938, which caused severe damage to the Upper Cape, and the Great Atlantic Hurricane of 1944, which heavily damaged the Middle and Lower Cape. The 1938 Hurricane struck on September 21 at a high tide that coincided with the highest astronomical tide of the year, pushing a storm surge of 12 to 15 feet across the south coast and up the many bays and inlets. The destructive power of the storm surge was felt throughout the coastal community. Sections of Falmouth and New Bedford were submerged under as much as 8 feet of water. Winds of over 120 miles per hour blew across the coastal regions. Extensive damage occurred to roofs, trees, and crops. Widespread power outages occurred, which in some areas lasted several weeks. In Connecticut, downed power lines resulted in catastrophic fires to sections of New London and Mystic. Parts of interior Connecticut and Massachusetts not only bore the brunt of high winds, but also experienced severe river flooding as rain from the hurricane combined with heavy rains earlier that week and produced rainfall totals of up to 17 inches. This resulted in some of the worst river flooding ever experienced in parts of Connecticut and Massachusetts. This powerful storm caused 564 deaths and over 1,700 injuries. Nearly 9,000 homes and businesses were destroyed with over 15,000 damaged. Damage to the fishing fleets in southern New England was catastrophic, with a total of 2,605 vessels destroyed and 3,369 damaged.

It is not uncommon for New England to be impacted more than once in a given season. The Cape has been impacted by two or more tropical storms or hurricanes in one season a total of 11 times. The most notable season was 1954, when southeastern Massachusetts faced Hurricanes Carol, Edna, and Hazel. Carol and Edna each rated as Category 3 storms.

Winter Storms[3]

In contrast to a hurricane, winter storms that affect Cape Cod tend to concentrate their effects on the north shore, where the normal tidal range is 8 feet (and up to 14 feet in some places). The geography on the north side often gains elevation more quickly as distance from the shore increases. A main thoroughfare and evacuation route, Route 6A, crosses tidal creeks and marshes in many locations and is subject to inundation during storms. The result is that isolated residential areas may be free of flooding but may still be entirely isolated in terms of evacuation and emergency services. These impacts are projected to worsen over time as climate change related impacts, such as flooding, storm surge and sea-level rise, are expected to intensify.

A winter storm can range from moderate snow to blizzard conditions. A severe winter storm deposits four or more inches of snow during a 12-hour period or six inches of snow during a 24-hour period. A blizzard is a snowstorm with sustained winds of 40 miles per hour (mph) or more or gusting up to at least 50 mph with heavy falling or blowing snow, persisting for one hour or more, temperatures of 10 degrees Fahrenheit or colder, and potentially life-threatening traveling conditions.

[3] See Map 2: Historical Annual Snowfall and Flood Hazard Areas, Cape Cod, MA.

A nor'easter is a large weather system traveling from south to north, passing along, or near the seacoast. As the storm approaches New England and intensifies, the resulting counterclockwise cyclonic winds impact the coast and inland areas from a northeasterly direction. The sustained winds may meet or exceed hurricane force. New England generally experiences at least one or two nor'easters each year with varying degrees of severity. These storms have the potential to inflict more damage than many hurricanes because the high storm surge and high winds can last anywhere from 12 hours to 3 days, while the duration of hurricanes ranges generally from 6 to 12 hours.

New England has a long history of severe winter storms, blizzards, and nor'easters. The most severe winter storm to ever hit New England was the Blizzard of 1888, which occurred March 11-14. Snow depths measured from 30 to 50 inches where precipitation was entirely snow. Boston received a mix of snow and rain creating up to nine inches of slush. The Blizzard of 1978 dumped 24-38 inches of snow on New England, immobilizing the infrastructure and blocking major interstates. Thousands of motorists abandoned their cars on the highway. Two weeks were required to remove the snow. More recent blizzards and snowstorms occurred in March 1993, February 1996, March 2001 and January 2005. These events killed scores of people, caused millions of dollars in damage, and left thousands of people without power for days.

Most winter storms bring to the Cape both storm surge and high winds, making our coastline particularly vulnerable to damage. Because the coastline is highly developed, infrastructure is at significant risk. If a storm should coincide with a high tide, an additional layer of vulnerability and associated risk is added. Infrastructure and critical facilities may be impacted by these events, with associated power outages and transportation disruptions (i.e., snow and/or debris-impacted roads, as well as hazards to navigation and aviation).

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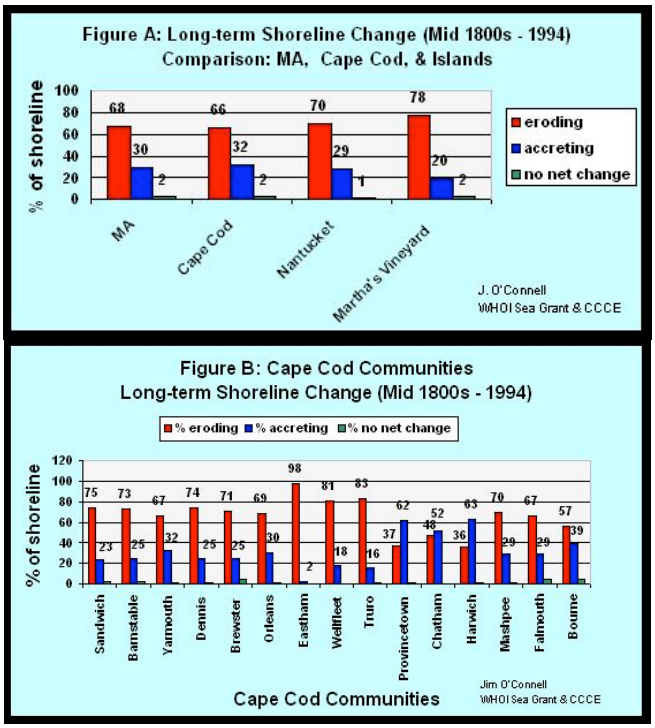
Shoreline Change[4]

Cape Cod's shore is, for the most part, eroding.[5] Of the 586 miles of Cape Cod's tidal shore, a shoreline change analysis of 238 miles of its outer shore, including the landward side of major barrier beaches was completed in 2002.[6]

As shown on Figure A below, that study revealed that approximately 66% (157 miles) of Cape Cod's shore shows long-term erosion, 32% (76 miles) exhibits long-term accretion, while 2% (5 miles) shows no long-term net change. These percents of the linear length of shoreline changes closely match the state-wide averages as shown on Figure A. Twelve of the Cape's 15 communities exhibit a long-term erosion trend, while three show long-term accretion (Figure B). It is important to note, however, that both erosion and accretion occur along a community's shoreline and site-specific shoreline change data need to be analyzed for planning purposes.

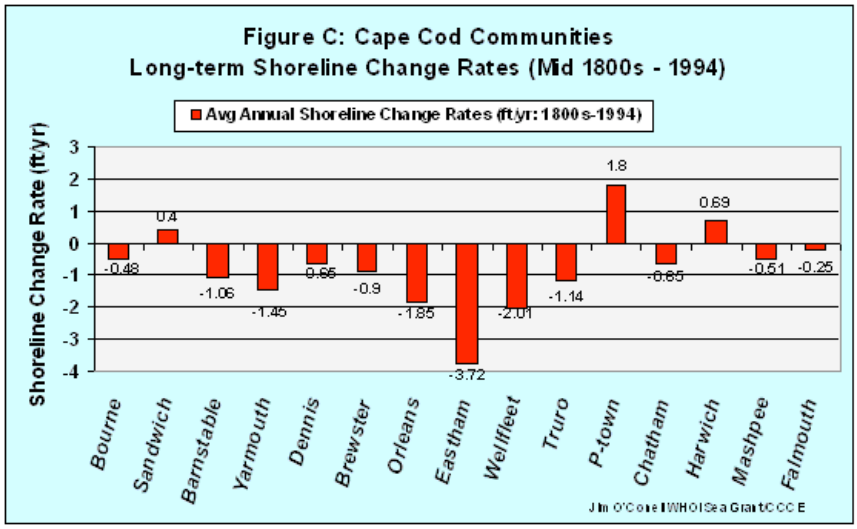


[4] The information provided here on shoreline change was originally written and provided by James F. O'Connell, formerly the Coastal Processes and Hazard Specialist of both the Barnstable County Cooperative Extension office and the Woods Hole Oceanographic Institution Sea Grant program. Mr. O'Connell also developed a map representing his findings as presented in this section. See Map 3: Shoreline Change Susceptibility, Cape Cod, MA, (Long term change; mid 1800s – 1944). Using the most recent available data, an update to this section was provided by Graham Giese, Coastal Geologist for the Provincetown Center for Coastal Studies.

[5] O'Connell, J.F., 2003, New Shoreline Change Data Reveal Massachusetts Is Eroding, WHOI Sea Grant and Cape Cod Cooperative Extension, Marine Extension Bulletin, March, 2003.

[6] O'Connell, J.F., Thieler, E.R., and Schupp, C, 2002, New Shoreline Change Data and Analysis for the Massachusetts Shore, with Emphasis on Cape Cod and the Islands: Mid 1800s-1994, Environment Cape Cod, Vol. 5, No. 1. See also Thieler, E.R., O'Connell, J.F., and Schupp, C., 2002, The Massachusetts Shoreline Change Project: 1800s – 1994, Technical Report, U.S.G.S. Administrative Report, Woods Hole, MA.

Figure C shows the long-term average annual shoreline change rate for each of the 15 Cape Cod communities.



Note that communities that exhibit the highest erosion rates and linear length of eroding shore are primarily those that include shorelines facing the open ocean, such as Truro, Wellfleet, and Eastham. (Chatham also has a highly erosive shore but much of the shore was not included in the data analysis due to complex barrier beach migration and breaching.) Communities that exhibit the lowest shoreline change and erosion rates are those that generally are sheltered from significant storm waves, such as the Buzzards Bay and eastern Nantucket Sound areas. Significant accretion areas are generally at the ends of barrier beaches, the updrift side of jetties and groins, and downdrift of significant sediment sources.

The causes of shoreline change, particularly erosion, are both natural and human-induced. The primary natural causes of erosion in Massachusetts are relative sea-level rise, which is presently approximately one vertical foot every 100 years, and coastal storms. The most important cause of human-induced erosion is interruption of sediment sources and longshore sediment transport. Examples include the armoring of sediment source coastal bluffs (banks) with revetments, seawalls, and bulkheads, and interruption of longshore sediment transport by the construction of jetties and groins.

Natural coastal erosion is an important geologic process. Without erosion, flooding, storms, relative sea-level rise, and unimpeded longshore sediment transport, the beaches, dunes, barrier beaches, and biologically important bays and estuaries with their associated tidal flats would not exist today. Due to extensive armoring of sediment source coastal banks, beaches and dunes in areas of Cape Cod are slowly diminishing in size and volume. In fact, due to human activity in some areas of Cape Cod, beaches no longer exist at high tide due to a lack of sediment supply coupled with continuing relative sea-level rise. The rate of sea-level rise is predicted to accelerate in the near future, and could possibly triple over the next century.[7]

Beaches, dunes, and barrier beaches are part of the environmental, ecological, and economic vitality of Cape Cod and its communities. They also provide storm damage reduction and flood control to landward

[7] IPCC, 2007, Fourth Assessment – Climate Change 2007: A Report of the Intergovernmental Panel on Climate Change, IPCC, Geneva, Switzerland.

resources and the developed environment. Thus, it is critical to the future existence of beaches, dunes, and barrier beaches to allow coastal banks and dunes to continue to erode and to provide necessary source sediment and uninterrupted transport.

As part of the MHM planning work, a commitment to develop a better understanding of regional sediment transport and its implications for sediment management will be coordinated by several county agencies and regional interest groups. Through this type of comprehensive shoreline planning and foresight (including identifying and mapping highly erosive areas and identifying and protecting important sediment sources and pathways) Cape Cod beaches, dunes, and barrier beaches may survive for future generations.

Wildfire[8]

It is possible that raging wildfires, like those we associate with California and the "West," could happen on Cape Cod. Western forests differ from most eastern forests because they contain mostly evergreen trees that have a lot of resin in their needles. This resin burns readily, creating an explosive flame that rages up the crown, where it jumps easily from tree to tree. However, because of the Cape's extensive pitch pine, we are vulnerable to these types of burns, particularly when the Cape faces drought conditions.

Western and eastern forests differ in another important respect: precipitation. Many western forests are extremely dry. They receive most of their precipitation in hit-or-miss summer rainstorms or in winter snowfall. Because of the dry climate, the West is plagued by "dry lightning"—electrical storms without rain that often spark fires. While the Cape does not tend to have huge, rampant fires like the West, there have been serious wildfires here in the past and it is likely they will occur again.

Table 2: Historic Long-term Drought Event Details for Cape Cod and Islands, MA	
Occurrences between 1919-2002:	
# of Distinct Warnings	7
# of Distinct Emergencies	4
Total # of Months in Emergency	31
# of Months in Emergency per 100 Years	37
# of Emergencies per 100 Years	5
# of Warnings per 100 Years	8

The Cape is not unfamiliar with wildfires. In the past many wildfires have begun and spread quickly throughout large tracts of pitch pine forest and large salt marsh areas in which *Phragmites* is prolific. *Phragmites* is an invasive plant that has taken over many of the Cape's salt marshes in which the natural tidal system has been disrupted and saltwater flow has been restricted or limited. Even the salt hay itself would be quick to burn and is considered susceptible to wildfire. Cape residents and visitors must take extra precautions and be diligent to prevent fires from starting in or threatening these areas. While wildfires can be started in these areas naturally, such as by a lightening strike, more often they are started as a result of human carelessness or intervention.

Wildfire season begins in March in coastal and southern New England, gradually extending to central, western, and northern areas, and usually ends in late November. The majority of wildfires usually occur in April and May, when home owners are cleaning up (burning brush) from the winter months, and when the majority of vegetation is void of any appreciable moisture, making it highly flammable. Once "green-up" takes place in late May to early June (a period of ample spring rain), the fire danger usually is reduced somewhat.

[8] See Map 4: Wildfire Hazard Areas, Cape Cod, MA.

Drought Activity Affecting Cape Cod

While drought conditions certainly add to the Cape's susceptibility to wildfires, drought conditions in our region have not prevailed since the 2004 PDM Plan. We've experienced more normal to extremely moist periods of precipitation since 2003[9]. This trend is expected to continue under current climate change projections. Table 2 details the Cape and Islands historic long-term drought details based on the precipitation data from the Massachusetts Department of Conservation and Recreation precipitation database.

Table 3: Normal Precipitation Amounts for Cape Cod, MA (Inches)

Month (2008 - 2009)	Normal	Actual
AUG ('08)	3.88	2.97
SEP	3.55	7.50
OCT	3.66	2.12
NOV	4.33	4.59
DEC	4.15	6.90
JAN ('09)	3.87	4.48
FEB	3.50	2.08
MAR	4.18	3.83
APR	4.11	5.80
MAY	3.65	2.91
JUN	3.11	3.30
JUL	2.78	6.56
CUMULATIVE		**53.04**

Despite climate change projections for an increase in precipitation of 5% to 8% in our region by mid-century[10], it is important for the purposes of disaster preparedness to recall that between 1999 and 2001, Cape Cod experienced rainfall deficits and below-normal groundwater levels that resulted in a long period of drought conditions throughout the state. Table 3 shows *normal* and *actual* precipitation amounts for the Cape Cod region. The drought watch level is based on thresholds contained in the state's Drought Management Plan that was developed by the Executive Office of Environmental Affairs and MEMA.

A drought advisory was initially issued for the entire state in December 2001 following significantly below-normal levels of precipitation the previous fall. The entire state was raised to a drought watch in early March 2002. In February, 2008 the statewide average precipitation was 8.7 inches, about 270% above normal, making it the wettest February on record. Other key areas of concern, such as ground water levels, stream flow and water supply were determined normal and by March 2008, the drought advisory was lifted. For this reason, the RMHPT changed the cumulative hazard ranking for drought for our region from a 6 to a 5 on the Hazard ID Ranking matrix (see Table 1) reflecting a rate of occurrence that is possible, rather than likely.

Tornado[11]

A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud with whirling winds of up to 300 miles per hour. These events are spawned by thunderstorms and occasionally by hurricanes, and may occur singularly or in groups. Tornadoes can occur at anytime of the year, although they are rare outside of the warm season. "Tornado season" is marked from March through August with August being the month of greatest tornado frequency, although tornadoes may occur at any time of the year. Most tornadoes are likely to occur during the mid-afternoon and evening hours, however, they can occur at any time, often with little or no warning. Water-based tornadoes—*called waterspouts*—can and have formed over the water bodies surrounding the Cape.

[9] National Oceanic and Atmospheric Administration National Climatic Data Center, Annual Climate Drought.
[10] Hayhoe et al., 2006. Past and future changes in climate and hydrological indicators in the U.S. Northeast.
[11] See Map 5: Historical Tornado Activity, Cape Cod and Massachusetts.

Most vortices remain suspended in the atmosphere, but when they do touch down they become a destructive force. Tornadoes move at an average speed of 30 miles per hour and generally move from the southwest to northeast. Their direction of travel can be erratic. These short-lived storms are the most violent of all atmospheric phenomena and the most destructive over a small area.

Tornadoes in New England

On average the United States experiences 100,000 thunderstorms each year. Approximately 1,000 tornadoes develop from these storms. Damage from tornadoes is caused as a result of high wind velocity and wind blown debris. Over 80% of tornadoes strike between noon and midnight. Normally, a tornado will stay on the ground for no more than 20 minutes. Injuries and deaths most often occur when buildings collapse. The tornadoes experienced in recent history in New England have been generated by severe summer storms. Fortunately for us on Cape Cod, we are not susceptible to the major tornadoes of the Midwest and Great Plains states, but we are vulnerable and have experienced deadly tornadoes.

The most devastating tornado ever to occur in New England was the Worcester Tornado of July 9, 1953. The tornado hit Worcester at 5:08 p.m. Within one minute more than 90 people were dead and over 1,300 injured. Damage estimates were placed in excess of $52 million. Another damaging tornado occurred in Windsor Locks, Connecticut, at about 3:00 p.m. on October 3, 1979. This twister lasted only about 60 seconds, but killed three people, injured over 300, destroyed 40 homes and caused $300 million in property damage.

The most recent killer tornado to strike New England occurred on May 29, 1995, in Great Barrington, Massachusetts. This tornado had winds in excess of 200 miles per hour, killed three people, injured 23, and caused an estimated $25 million in damage.

Earthquakes[12]

The Massachusetts State Hazard Mitigation Plan, October 2004, contains an extensive and detailed discussion of New England's vulnerability to earthquakes, how earthquakes happen, and how to measure severity of an earthquake. That information is not duplicated here. Map 6 (attached hereto in Appendix A) provides information about and a history of earthquakes in the Northeast and locates the epicenter of three earthquakes that have been recorded on Cape Cod, including Harwich in 1847, Falmouth in 1961, and Chatham in 1976.

Climate Change in Barnstable County, Massachusetts

The Intergovernmental Panel on Climate Change (IPCC, 2007) has projected that global and US temperatures could rise between 2 and 10°F by the end of the century (depending on what choices are made around energy use and emissions). Many of the changes that have already been observed, for instance increased air and water temperatures, reduced snow cover, retreating glaciers, increased frequency and intensity of heavy downpours, and rising sea levels are expected to continue while new ones will likely emerge, such as increased intensity of hurricanes. Trends will continue for generations—even if mitigation is extremely successful. These expected changes would result in some impacts that are valued as positive, such as longer growing seasons, and some as negative. For our region, these negative impacts will include increases in storm surge, wind, rainfall in the form of heavy downpours, intensified coastal erosion and sea-level rise.

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[12] See Map 6: Historical Earthquake Activity, Cape Cod and Massachusetts.

The projected negative impacts from climate change will be a continual theme throughout this Multi-Hazard Mitigation Plan. Climate change mitigation and adaptation planning is a logical extension of hazard mitigation planning, as many of the hazards to which our region is vulnerable to are expected to become more sever as a result of climate change. This planning effort is an attempt to be forward looking with respect to hazard mitigation actions to help reduce local vulnerabilities and increase regional resilience, and therefore must consider climate change impacts.

The northeast U.S. has already experienced an increase in annual average temperature of 2°F and the winters are warming at twice that rate[13]. Figure 1 shows what summers could feel like in Massachusetts over the next century[14]. The yellow arrows track the results under a lower emissions scenario and the red arrows track the possible results under a higher emissions scenario. Projecting future climate impacts beyond 2040 is hugely dependent on the choices that are made today in terms of greenhouse gas emissions. If we chose as a society to greatly reduce our emissions then the impacts will more likely be nearer the lower end of the ranges described.

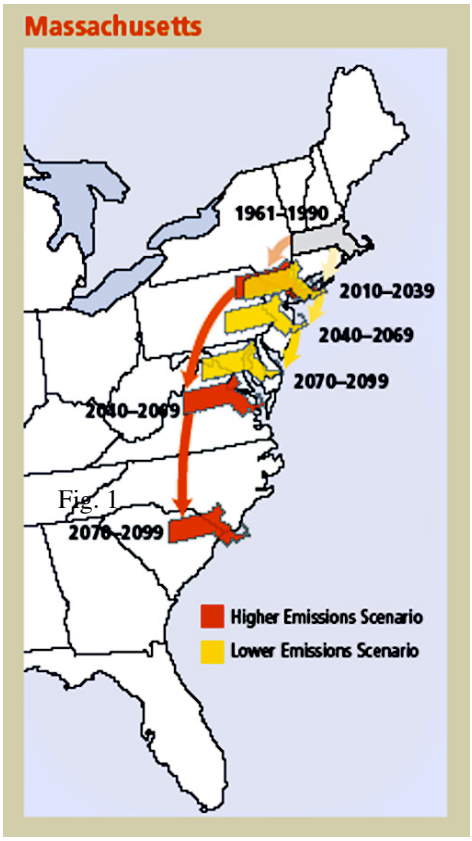


Fig. 1

A high emissions scenario projection for this region also includes the following (from CCSP, 2009):

- shorter winters with fewer cold days and more precipitation
- increases in days over 100°F for many regional cities
- increases in short-term summer droughts
- longer hot summer conditions

[13] *Global Climate Change Impacts on the United States,* Climate Change Science Program, 2009.
[14] *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions*, a report of the Northeast Climate Impacts Assessment (NECIA), 2007.

Section 3 – Regional Vulnerability and Risk Assessment / Analysis

3.1 Profile of Barnstable County

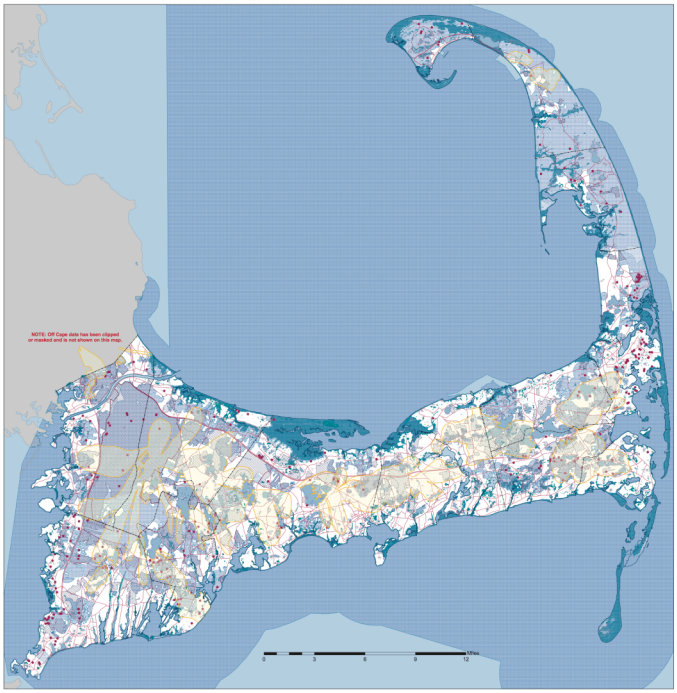
Cape Cod is approximately 412.42 square miles (236,930.17 acres) and is surrounded by the waters of the Cape Cod Canal, Cape Cod Bay, Atlantic Ocean, Nantucket Sound, and Vineyard Sound. Effectively, Cape Cod is an island.

Of the Cape's 412.42 square miles:

- 396 square miles (253,440 acres) are upland
- 198.29 square miles (126,908.67 acres) are in an identified wildfire risk area
- 71.96 square miles (46,056.41 acres) are in a Flood Insurance Rate Map (FIRM) zone
- 72.22 square miles (46,231.75) are in a zone of potential sea, lake, and overland surges by hurricanes (SLOSH[15])

Sensitive Environmental Areas

Barnstable County's Regional Policy Plan is a planning document that, for planning purposes only, has identified and mapped several types of resource areas. Sensitive environmental areas of Cape Cod are shown on the Cape Cod Significant Natural Resource Area (SNRA) map dated July 3, 2009 (attached hereto in Appendix A: Maps, Map 7: SNRA Map). This SNRA map includes the location of wellhead protection areas, designated potential public water supply areas, rare species habitat, priority natural communities, wetlands, critical upland areas, unfragmented forest habitat, and land within 350 feet of vernal pools and 300 feet of ponds.



Land Use and Build Out

As of 2003, approximately 44% of the land (263,800 acres) on the Cape was developed. Another 39% (of which 13% is wetlands or water bodies) was permanently protected, leaving approximately 17% available

[15] The SLOSH (Sea, Lake, and Overland Surges from Hurricanes) zones are generated from a computer model designed by the National Weather Service, and generated by the Army Corps of Engineers, to forecast surges that could occur from wind and pressure forces of hurricanes. The model is applied to the Cape to estimate potential flooding from hurricanes that may make landfall in New England. Surge limits shown on the SLOSH maps represent potential flooding that may occur from critical combinations of hurricane track direction, forward speed, landfall locations, and high astronomical tide.

for development. However, not all of this land is "buildable," because of the presence of wetland, unsuitable topography, or other constraints, but it is still subject to fragmentation.

In 2000, the Cape Cod Commission, working in partnership with the Massachusetts Executive Office of Environmental Affairs, conducted a "build-out" analysis for all 15 Cape towns. This analysis examined local zoning and other growth-related regulations currently in place, and made projections about future growth based on the amount of remaining developable land. The analysis revealed that, with no additional growth management or land-protection efforts, the Cape could add 37,000 houses and at least 50,000 people at build-out. Moreover, at current growth rates, build-out will likely be reached within 30 years.

Water Supplies

Cape Cod has a sole source aquifer, is totally surrounded by coastal waters, and has more than 400 freshwater ponds and lakes. These resources provide myriad potential for flooding. Groundwater contamination by chemicals is a gravely serious problem for Cape Cod's aquifer. Federal and state agencies have made great strides with a major groundwater clean-up program at the Massachusetts Military Reservation, where plumes of contamination tainted four public water supply wells and threatened additional pristine groundwater supplies, ponds, wetlands and nearby marine waters. Similar instances of smaller-scale contamination are a concern for public water supply wells and private wells throughout Cape Cod. Cape Codders must also be vigilant about preventing chemical contamination of groundwater from hazardous wastes and materials.

See Appendix A, Map 5: Regional Policy Plan's Cape Cod Water Resources Classification Map 1, which shows the location of public supply wells, small volume wells, potential public water supply areas, wellhead protection areas, freshwater recharge areas, as well as other planning classifications.

Increases in Precipitation

Compared to the rest of the US, the northeast region is already experiencing the highest increases in heavy precipitation, a projected climate change impact, as well as increases in number of days with heavy precipitation. These impacts are represented in Figure 2 and Figure 3 on the following page. Projections for the future are based on two different emission scenarios, discussed previously, and include an increasing amount of heavy versus light precipitation (Fig. 4) continuing the observed trend. For the northeast region an increase of 20-30% in winter precipitation is also projected. It is important to note that Massachusetts has already experienced a nearly 30% increase in total precipitation since records were begun in 1895 (NERA, 2001) (Fig. 4). Based on these projects, it is likely that local flooding will continue to become a greater problem in our region.

Figure 2 - Percent Change in Heavy Precipitation[16]

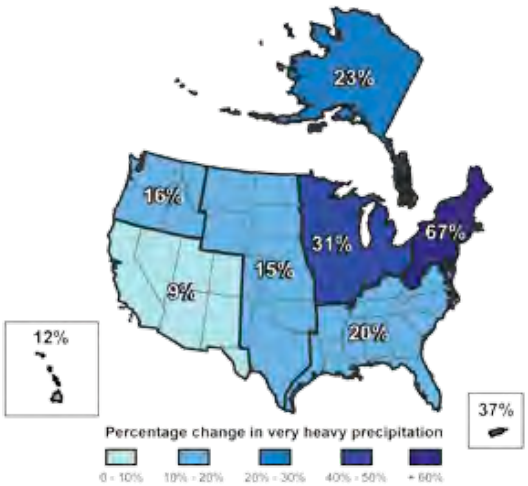


Figure 3 - Annual Increase in Precipitation Days[17]

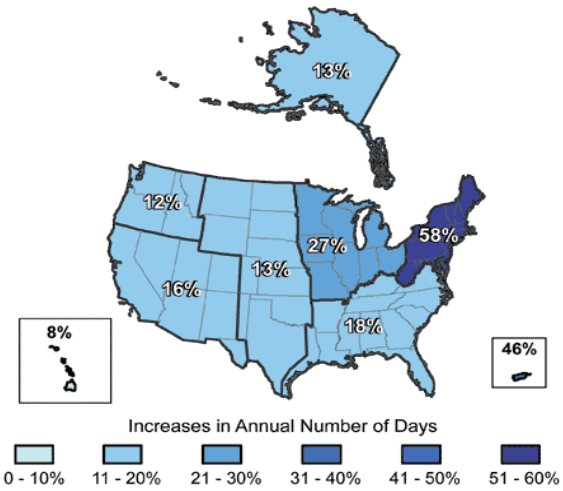
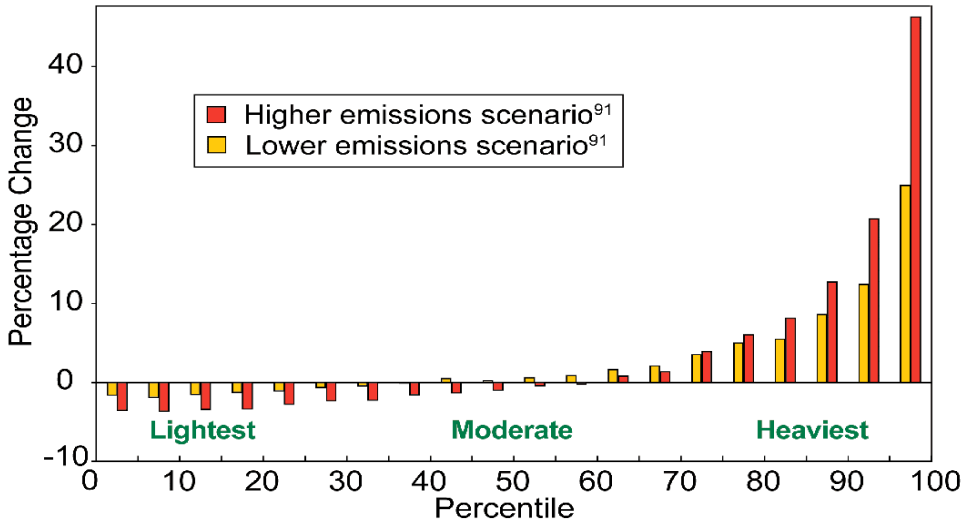


Figure 4 - Projected Change in Precipitation Intensity[18]



[16] Fig 2: Increases in Amounts of Very Heavy Precipitation (1958 to 2007)
The map shows the percentage increases in very heavy precipitation (defined as the heaviest 1 percent of all events) from 1958 to 2007 for each region, compared to a baseline period of 1961 to 1990. The clearest trends toward more very heavy precipitation are evident at the national scale, and in the Northeast and Midwest. (CCSP, 2009, pg. 32)

[17] Fig. 3: Increases in Very Heavy Precipitation Days, 1958-2007
The map shows the percentage increases in the average number of days with very heavy precipitation (defined as the heaviest 1 percent of all events) from 1958 to 2007 for each region. There are clear trends toward more days with very heavy precipitation for the nation as a whole, and particularly in the Northeast and Midwest. (CCSP, 2009, pg. 44)

[18] Fig 4. Projected Change in Precipitation Intensity
The figure shows projected changes from the 1990s average to the 2090s average in the amount of precipitation falling in light, moderate, and heavy events in North America. Projected changes are displayed in 5 percent increments from the lightest drizzles to the heaviest downpours. As shown here, the lightest precipitation is projected to decrease, while the heaviest will increase, continuing the observed trend. The higher emission scenario yields larger changes. Projections are based on the models used in the IPCC 2007 Fourth Assessment Report. (CCSP, 2009, pg. 32)

Regional Transportation Network

Automobile access to Cape Cod occurs through two major vehicle crossings of the Cape Cod Canal via the Bourne and Sagamore bridges. These four-lane bridges carry over 130,000 vehicles per day during peak season and are owned and maintained by the Army Corps of Engineers. The Canal area connecting roadway system, consisting of Routes 25 (connecting to I-495 and I-195), Route 6, Route 6A, Route 3, and Route 3A, is owned and maintained by the Commonwealth of Massachusetts. Additional travel to the Cape is accomplished by a railroad bridge over the Canal (currently used only for minor freight and excursion passenger service), by ferries to Provincetown, and by regularly scheduled passenger flights to Barnstable Municipal Airport and Provincetown Municipal Airport. Pedestrian and bicycle access is also provided across the Canal on the vehicular bridges. Many bus lines also have regularly scheduled service to the Cape. It is also possible to fly a private plane or sail a private boat to Cape Cod including use of four general aviation airports and many public and private marinas. An additional aspect of the Cape's transportation system is that most ferry service to the islands of Nantucket and Martha's Vineyard have ports on Cape Cod, and consequently the majority of traffic to these islands uses the Canal crossings and the Cape's roadway system. (These transportation facilities are sited on the Regional Risk and Vulnerability Assessment Map.)

The 15 towns of Cape Cod are arranged for the most part in a linear configuration. The miles of roadways by town and type are shown here in Table 4.

At issue for any hazard mitigation or emergency response plan is the fact that many Cape Cod roads face severe traffic congestion, especially during the summer months when the threat of tropical storms is high. Projections of traffic volumes indicate that congestion will worsen; based on 2003 forecasts of traffic at build-out in 2025, current summer traffic volumes could become the winter traffic volumes in several decades. Consequently, congested roadways may slow evacuation and response activities if not properly planned and managed.

Table 4: Miles of Roadway on Cape Cod, Massachusetts

Town Name	Centerline Miles of Public Roads	Centerline Miles of Private Roads	Total
Barnstable	381	66	447
Bourne	151	39	190
Brewster	78	90	168
Chatham	70	43	113
Dennis	143	65	208
Eastham	62	41	103
Falmouth	237	110	347
Harwich	140	12	152
Mashpee	122	9	131
Orleans	62	33	95
Provincetown	29	0	29
Sandwich	181	25	206
Truro	49	10	59
Wellfleet	69	2	71
Yarmouth	167	83	250
Barnstable County (Total)	**1,938**	**630**	**2,568**

Congestion reporting on the Cape is undertaken by local radio stations and the Boston Smart Traveler system in real time. Additionally, construction updates are provided by Barnstable County on a transportation-dedicated web site. Implementation of an Intelligent Transportation System (ITS) is in process on the Cape, which was identified as an initiative in the 2004 PDM Plan as beginning with the Canal area and the Cape Cod National Seashore area. The

expansion of the ITS is planned over time to include all regions of the Cape and nearby off-Cape locations and would be used in the event of an emergency to inform the traveling public. This MHM Plan's mitigation strategy (see Section 5.0) references this ITS and promotes its development for use in hazard mitigation planning and response activities.

Population

The year-round population of Barnstable County, according to the most recent census at the time of this plan update (2000) was 222,230 persons; of that total 51,265 persons (23.07%) are older than 65 years of age. More recent estimates from the U.S. Census Bureau and Cape Cod Commission staff analysis show that Cape population reached 229,545 persons in 2003 and that growth levels in five Cape towns ranked in the state's top 25 of its 351 cities and towns. This more recent estimate indicates Cape-wide growth of 7,315 persons or 3.3 percent since the U.S. Census counted 222,230 residents in 2000. The four Upper Cape towns of Bourne, Falmouth, Mashpee, and Sandwich, plus neighboring Barnstable, together accounted for 5,129 or 70 percent of the new residents since 2000. It is expected that the 2010 US Census will reflect a continuation of these trends.

	U.S. Census Bureau – Resident Population Estimates				U.S. Census Count
Town	**July 2003**	**July 2002**	**July 2001**	**July 2000**	**April 2000**
Barnstable	48,907	48,701	48,300	47,995	47,821
Bourne	19,523	19,313	19,066	18,820	18,721
Brewster	10,401	10,331	10,239	10,139	10,094
Chatham	6,849	6,786	6,732	6,657	6,625
Dennis	16,226	16,143	16,072	16,020	15,973
Eastham	5,632	5,600	5,556	5,483	5,453
Falmouth	33,823	33,522	33,166	32,815	32,660
Harwich	12,859	12,761	12,556	12,440	12,386
Mashpee	14,200	13,939	13,500	13,078	12,946
Orleans	6,491	6,450	6,407	6,365	6,341
Provincetown	3,472	3,474	3,472	3,444	3,431
Sandwich	20,960	20,726	20,487	20,240	20,136
Truro	2,169	2,145	2,120	2,097	2,087
Wellfleet	2,841	2,815	2,786	2,761	2,749
Yarmouth	25,192	25,156	25,006	24,888	24,807
Barnstable County:	**229,545**	**227,862**	**225,465**	**223,242**	**222,230**
Massachusetts:	**6,433,422**	**6,421,800**	**6,399,869**	**6,362,076**	**6,349,097**

Data source:
U.S. Census 2000; U.S. Census Bureau Population Estimates, 2000–2003, issued June 24, 2004.

From 1980 to 1990 the population of Barnstable County grew by 38,680 persons, a growth rate of 26%. The population of Massachusetts as a whole grew only 5% during the same period. This trend continued from 1990 to 2000, when the population grew by 35,625, a growth rate of 19.1%, while the population of

Massachusetts grew by only 5.5%. This makes Barnstable County's growth rate the third highest in the state, behind only Nantucket and Martha's Vineyard.

Total population figures for Cape Cod do not convey the actual number of persons present on the Cape at a given time. This is due in large part to the influx of summer and vacation tourists and summer homeowners and renters, who are difficult to track and quantify. Even estimated summertime population varies depending on the weather and the time of the season. Predictably, holiday weekends bring a large influx of tourists and visitors to Cape Cod. Housing unit and household occupancy/vacancy data can be used to estimate summertime population. According to the 2000 Census, the number of housing units on the Cape has more than doubled since 1970, from 65,676 to 147,083. The number of occupied households was based on occupancy on April 1, by residents and owners or renters. "Vacant" units may be for rent, sale, rented, or sold but not occupied, or be for seasonal, recreational, or occasional use, for migrant workers, or may be vacant for other reasons. The total number of vacant households in Barnstable County on April 1 was determined to be 52,261. Assuming an average of 4 persons per household during the summer, an estimated additional 209,044 persons are on Cape Cod during the summer vacation season. Therefore, summertime population in 2000 was estimated to be 431,274, considered an underestimate because it does not include hotel, motel, or other types of room rentals. Cape Cod summertime population is often estimated at 500,000 persons.

Cultural Resources

Cape Cod's cultural resources include historic structures, museums, archival collections, and archaeological sites. These resources are significant not only to the region's history, but also to its economic vitality as a tourist destination. The Cape has thousands of properties listed on the National Register of Historic Places, dozens of local historic districts, and numerous archaeologically sensitive areas. The region also has many non-profit and town-owned historical organizations and museums with valuable archival collections.

Both historic structures and archival collections are subject to loss due to fire, flood, or other natural disasters. Archaeological resources may be uncovered during heavy winds or coastal erosion due to severe storms. Appropriate initial treatment and prompt response measures can help prevent total loss of these resources in the event of a natural disaster or fire.

The Cape Cod Commission has mapped Local Historic Districts and National Register properties. Many historic properties in the region go unrecognized, however, because they have not been formally inventoried. Efforts to identify historic structures and districts within hazard areas will need to look beyond existing maps. A map of the region's historic artifact collections would be useful in developing recommendations for their protection.

Relative Sea-Level Rise

Another climate change related issue that is very likely to become an even larger problem for the Cape Cod region over time is relative sea-level rise. Sea-level rise is already occurring at various rates around the US coastal region (Fig. 6). The projections for the rates of sea-level rise are a bit uncertain at this time (see Fig. 7), however, projections for this region include an increase that is more than the global average (CCSP, 2009, pg. 107).

Figure 6[19] - Relative Sea-Level Changes on U.S. Coastlines

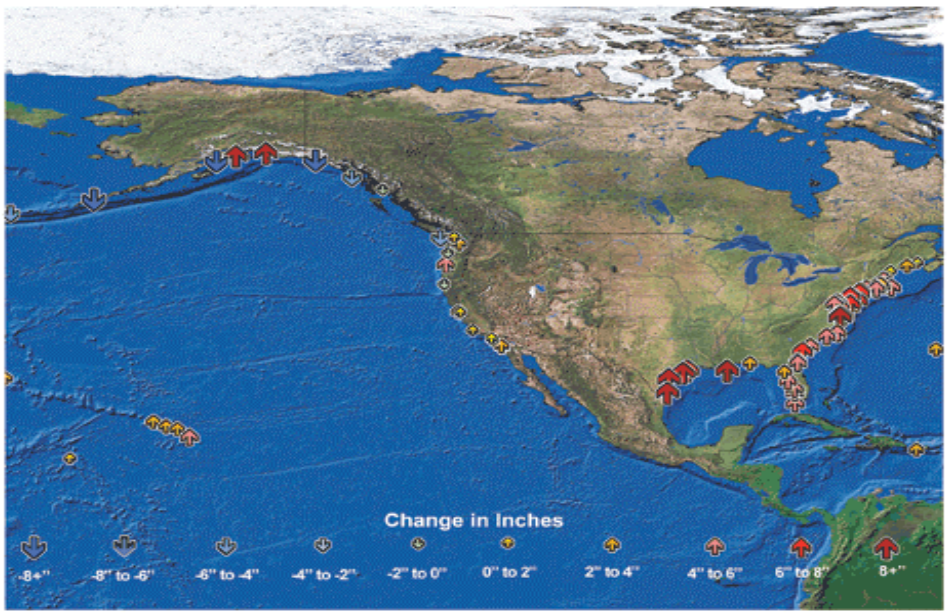
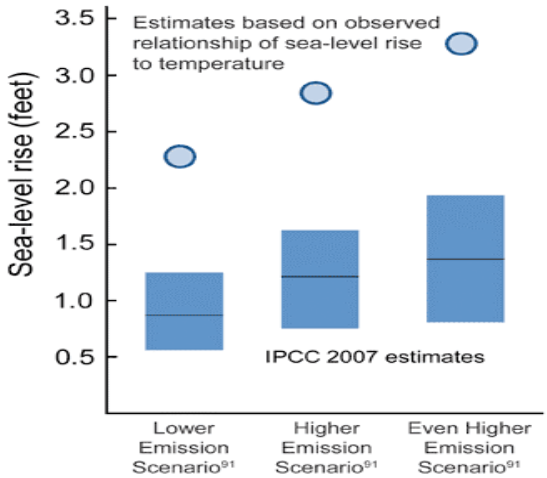


Figure 7[20] - Projected Sea-Level Rise



Sea-level rise combined with the possibility for stronger storms (see Figs. 8 and 9) including greater winds, increasing storm surge, and greater amounts of precipitation (described previously) could lead to increases in inundation, flooding, and erosion in the coastal areas. The projections include the now once-in-a-century flood in Boston to change its frequency to become every two to three years by mid-century. This could result in shoreline change in some areas and become more and more problematic especially for populated areas, recreational areas, and infrastructure. All of these potential changes could result in impacts that would include increases in

[19] Fig 6: Relative Sea-Level Changes on U.S. Coastlines
Observed changes in relative sea level from 1958 to 2008 for locations on the U.S. coast. Some areas along the Atlantic and Gulf coasts saw increases greater than 8 inches over the past 50 years. (CCSP, 2009, pg 37)

[20] Fig 7. Projected Sea-Level Rise
Estimates of sea-level rise by the end of the century for three emissions scenarios. Intergovernmental Panel on Climate Change 2007 projections (range shown as bars) exclude changes in ice sheet flow. (CCSP, 2009, pg. 150)

potential regional hazards with resulting economic ramifications for the region and specific local areas.

In order to better project impacts from sea-level rise for our region, a coastal mapping analysis utilizing LIDAR (Light Detection and Ranging) data will be important. The state and other federal institutions have begun collecting LIDAR data. Until this dataset is comprehensive and available, impacts for relative sea-level rise are varied and unpredictable. At present, SLOSH data is our best tool for determining coastal inundation as a result of storm events.

3.2 Risk and Vulnerability Assessment and Analysis

Risk and Vulnerability Assessment Mapping

Table 5: Barnstable County RVAM Inventory

Town	Critical Facility or Infrastructure	Type
Barnstable	Barnstable County Fire & Rescue Training Academy	D
	American Red Cross	A
	Barnstable County Complex	B,D
	Cape Cod Hospital	C
	Barnstable Municipal Court	D
	Cape Cod Community College	G,I
	Cape Cod Hospital Extended Care	H
	MSPCA Animal Shelter	K
	Humane Society of the US	K
Bourne	Sagamore Bridge	bridge
	Bourne Bridge	bridge
Brewster	Brewster Medical Association	C
	Animal Rescue League of Boston	K
Chatham	US Coast Guard Station	B
	Chatham Airport	D
Eastham	Nauset Regional High School	A,G
Falmouth	Falmouth Hospital	A,C
Harwich	Long Pond (Fontaine) Medical Center	C
	Cranberry Pointe Rehab & Skilled Care Center	C,H,I
Orleans	Nauset Regional Middle School	A,G
Provincetown	Coast Guard Station	B
Sandwich	MMR Barracks/Otis	A
	MMR Barracks/ Otis (designated as emergency animal shelter)	K
	Falmouth Hospital Urgent Care	C
	Sandwich Terminal LLC/ Northeast Petroleum	F
	Mirant Energy/ESCO Terminal	F
	Canal Station Power Plant	F
	Cape Cod Ice	F
	Coca Cola Bottling Plant	F
	Cape Cod YMCA Lorusso Center	I
Yarmouth	NSTAR	D
	Keyspan	F
	Massachusetts State Police Troop D-2	A

As discussed earlier, each Cape community has developed a Risk and Vulnerability Assessment Map (RVAM). There is also a RVAM for regional facilities and infrastructure (attached hereto in Appendix A, Map 10 - Regional RVAM).

Each RVAM does the following:

- identifies critical facilities and infrastructure in the following categories (types):

A: Emergency facilities/shelters
B: Public safety facilities
C: Hospitals and acute care facilities
D: Town government facilities
E: Wastewater infrastructure
F: Hazardous materials facilities[21]
G: Schools
H: Nursing homes/elderly housing
I: Group day care facilities
J: Senior/youth/recreation centers
K: Designated emergency animal shelters/hospitals
L: Marinas/boat yards

- identifies public transportation facilities;
- identifies public water supply wells;
- identifies FEMA-designated FIRM zones;
- identifies designated evacuation routes according to local Comprehensive Emergency Management Plans;
- identifies critical facilities or infrastructure that intersect a SLOSH zone;
- identifies points where a designated evacuation route intersects with a SLOSH zone; and,
- identifies structurally deficient bridges (as defined by Massachusetts Highway Department).

[21] Note that the hazardous materials facilities identified on each RVAM are by no means a complete listing. The BCREPC's incident planning provides towns with an accurate and comprehensive list of hazardous materials facilities.

Table 5 lists the 34 critical facilities or infrastructure that were determined to be of regional importance. Also, analysis of the regional RVAM identified the following:

- 2 airports
- 6 ferry terminals
- 6 bus, 4 rail stations

As part of its prior PDM and current MHM planning work, the Cape Cod Commission has converted the SLOSH maps to a GIS compatible format for the 15 towns of Barnstable County. The SLOSH zones are shown on the regional RVAM and are available for use on the local RVAMs, which presently show the extent of the FIRM (Flood Insurance Rate Map) zones.

For the purposes of natural hazard mitigation planning it is reasonable to assume that the SLOSH zones are actually a better indicator of the potential for flooding during a storm event because the boundaries of the SLOSH zones generally extend beyond those of the FIRM zone. Since this MHM Plan is intended to identify potential risk, planning for the greater of the two areas seemed reasonable and in the vein of "plan for the worst, but hope for the best."

Table 6 below tallies the number of facilities that have the potential for flooding in either of these zones. Table 7 breaks down the updated SLOSH zone acreage by town.

TABLE 6: Critical Facilities and Infrastructure (CF) within SLOSH or FIRM Zones

FACILITY TYPE	TOWN	# of CFs SLOSH**	# of CFs FIRM***	TOTAL # of CFs	Regional CFs in SLOSH	Total # of Regional CFs
Library	All Towns*	13	x	32	x	x
CF	Barnstable	17	15	89	3	11
CF	Bourne	19	17	42	2	2
CF	Brewster	1	3	27	0	2
CF	Chatham	8	8	33	0	2
CF	Dennis	18^	16	44	0	0
CF	Eastham	1	3	13	0	1
CF	Falmouth	25	28	79	0	2
CF	Harwich	8	8	35	0	2
CF	Mashpee	6	6	26	0	0
CF	Orleans	10	7	26	0	1
CF	Provincetown	16	8	27	2	2
CF	Sandwich	9	5	45	2	10
CF	Truro	1	1	9	0	0
CF	Wellfleet	11	6	22	0	0
CF	Yarmouth	22	13	49	1	3

Notes:
*Most libraries are not included in town counts of CF.
**Based on "SLOSH = Yes" in attribute table of local RVAM.
***Based on query where parcel layer intersects FIRM layer of local RVAM.
"x" indicates not queried.
^ Dennis MHM included10 local beaches as CF's.

Table 7: SLOSH Acreage by Town

Town	SLOSH Acres*	SLOSH Sq. Miles	Town Total Acres	Town Total Sq. Miles
Barnstable	7,474.78	11.68	40,200.39	62.81
Bourne	4,482.33	7.00	26,493.11	41.40
Brewster	833.10	1.30	16,207.83	25.32
Chatham	1,761.91	2.75	10,746.16	16.79
Dennis	4,134.92	6.46	13,672.45	21.36
Eastham	1,596.66	2.49	9,185.81	14.35
Falmouth	5,510.72	8.61	29,419.70	45.97
Harwich	2,216.95	3.46	14,430.50	22.55
Mashpee	1,734.96	2.71	16,574.85	25.90
Orleans	1,766.13	2.76	9,260.15	14.47
Provincetown	2,652.07	4.14	6,444.61	10.07
Sandwich	2,969.26	4.65	28,083.81	43.88
Truro	1,733.83	2.71	13,863.97	21.66
Wellfleet	2,660.40	4.16	13,015.77	20.34
Yarmouth	4,703.73	7.35	16,200.59	25.31
Total	**46,231.75**	**72.23**	**263,788.70**	**412.18**

Note: Acreages of land in SLOSH zones in this table are obtained using 2004 digital GIS data of the Army Corps of Engineers SLOSH model. The areas of each town's SLOSH zone are noticeably smaller than the areas reported in the "Natural Hazards Pre-Disaster Mitigation Plan 2004" by the Cape Cod Commission. The areas in that report were based upon paper Atlas maps (published in 1994) of the first SLOSH computer models. The computer model runs that provided the areas shown here utilized more accurate, larger scale shoreline data and topographic GIS data with finer elevation intervals. This sharpened the precision of the borders of the new SLOSH zones which also reduced their total area. Close examination of the data also revealed some parts of towns are missing from the analysis. For example, Barnstable's current data does not include several large marshy islands in Barnstable Harbor (uninhabitable) and the entire island of Oyster Harbors was missing from the current model.

Wildfire Hazard

The Cape Cod Commission created maps that show the areas vulnerable to wildfire (see Appendix A, Map 4: Wildfire Hazard Areas). The parameters used include the Wildfire Risk category of unfragmented forest habitat greater than 40 acres and salt marsh areas greater than 3 acres. The map also identifies wildland/urban interface areas that include areas adjacent to residential and commercial development, electrical transmission lines and rail right-of-ways, and major transportation infrastructure that may represent an elevated risk. The regional critical facilities were identified in relation to the wildfire risk area and it was determined that seven are located in wildfire hazard areas.

Recognizing the fact that Barnstable County is prone to wildfire, the Cape Cod Cooperative Extension developed an initiative in the Fiscal Year 2004 budget to fund the development of forest fire protection and preparedness plans (see also the Existing Regional Protection Measures, Section 4.0). Tasks included taking an inventory of public lands for their potential hazard for forest fire, mapping vulnerable areas and surrounding development, compiling related meteorological data, developing management plans and educational materials, developing model land management regulations, and providing mini-grants to towns to create management plans.

In the first year of this effort the Cooperative Extension's initiative funded plans for the following parcels:

- Barnstable: West Barnstable Conservation Area (1,200+ acres)
- Bourne: Nightengale Pond Estates (Buzzards Bay, off Scenic Highway) (184+ acres)
- Brewster: Punkhorn Parklands (West Brewster, Run Hill Road) (1,000+ acres)
- Chatham: Goose Pond Area (100+ acres)
- Eastham: Wiley Park (1400 Herringbrook Road) (44 acres)
- Falmouth: Bebe Woods Conservation Area (397.65 acres)
- Harwich: Thompson's Field (Route 39 and Chatham Road) (57+ acres)
- Orleans: Orleans Watershed (500+ acres)
- Sandwich: Maple Swamp Conservation Land (SWD Well field) (800+ acres)

Tidally Restricted Salt Marshes

In December 2001, the Cape Cod Commission completed the *Cape Cod Atlas of Tidally Restricted Salt Marshes*. This atlas presented the findings of a study undertaken to identify salt marsh systems impaired by the restriction of tidal flow along the coast of Cape Cod, Massachusetts. The scope of the work was limited to sites where salt marshes have been impacted by transportation-related facilities such as roads, railroads, causeways, and footpaths, as well as cranberry bog infrastructure. The atlas was designed to help the region identify and target funds to those projects that best address specific community or regional salt marsh restoration goals.

In a similar study and atlas, the Buzzards Bay National Estuary Program previously identified 74 tidally restricted sites in the Town of Bourne, which are located in the Buzzards Bay Watershed.[22] The Cape Cod Atlas identifies 114 sites. Therefore, in total there are 188 tidally restricted locations in Barnstable County. Typically, this means that there are 188 sites at which culverts are not properly sized to accommodate natural tidal flow, or such infrastructure is broken, collapsed, or otherwise unable to function properly.

The locations of these tidal restrictions are important to hazard mitigation planning because they indicate where flooding can occur during a storm event. The tidal restrictions constrain the natural flow of tidal waters; as a result, these locations are subject to flooding when tidal waters "back up" on one side of the culvert, overflowing channel banks. All of these locations should be considered for infrastructure resizing and/or repair/replacement to eliminate their potential for causing flooding.[23] There are of course salt marsh and other wetland impacts (either positive or negative) that will result from such work that must be factored into the permitting and construction of these infrastructure improvement projects. As progress is made to repair these identified structures, or as the *Atlas* undergoes an update, progress made should be identified as part of the MHM planning work.

[22] See Atlas of Tidally Restricted Salt Marshes, Buzzards Bay Massachusetts, by the Buzzards Bay Project National Estuary Program, 2000.

[23] In 2003, C*ape Cod Project Impact* funded the replacement of a tidally restrictive culvert under Foster Road in Sandwich, Massachusetts. This culvert was determined to be non-functioning, which, in addition to the implications on maintaining healthy upstream salt marsh, had direct implications for floodwaters to remain over portions of the road for an unacceptably long period of time. This site was identified in the *Cape Cod Atlas of Tidally Restricted Salt Marshes* as site SA-8.

Dam Hazards

Massachusetts Department of Conservation and Recreation (MDCR) maintains an inventory of dams across the state. The 2004 Massachusetts State Hazard Mitigation Plan includes a map of these dam locations and their ranking. The ranking is an indicator of the severity of downstream damage that could occur if the dam failed, such as potential to cause loss of life or damage. This ranking is not an assessment of the dam's current condition or integrity. Based on the hazard ranking provided by MDCR (see Table 8), 10 dams are ranked as significant hazards and one as a high hazard on Cape Cod. It is important to realize that even dams that are now considered safe and which, theoretically, pose little threat under normal circumstances can fail/breach and pose a hazard to life and property during an extreme weather event or earthquake.

The Mashpee MHCPT has identified the Santuit Pond dam as a potential hazard for the Town of Barnstable should this dam fail.

TABLE 8: Dam Hazards in Barnstable County

MDCR's Dam Hazard Ranking	Location	*Dam Name*	River	Owner
High	Mashpee	Mashpee Pond Dam (Route 130)	Mashpee River	Town of Mashpee
Significant	Bourne	Foundry Pond Dam		Privately owned
Significant	Eastham	Herring Pond Dam (Great Pond)		Town of Eastham
Significant	Mashpee	Quashnet River (Rt. 28)	Quashnet River	Town of Mashpee
Significant	Mashpee	Santuit Pond Dam	Santuit River	Town of Mashpee
Significant	Sandwich	Upper Shawme Lake Dam		Town of Sandwich
Significant	Sandwich	Shawme Lake Dam	Mill Creek - spring fed	Town of Sandwich
Significant	Truro	Pilgrim Lake Dam	spring fed	Town of Truro
Significant	Yarmouth	Old Winslow Gray Rd. Dam	Plashes Brook	Town of Yarmouth
Significant	Yarmouth	Crane Brook Bog Dam	Mill Creek	Unknown
Significant	Yarmouth	Baxter Grist Mill Dam	Mill Creek	Town of Yarmouth

MDCR defines dam hazard rankings as follows: *Significant hazard* = dams that are located where failure or mis-operation may cause loss of life and damage to homes, industrial or commercial facilities, secondary highways, or railroads, or cause interruption of use or service of relatively important facilities. *High hazard* = dams that are located where failure or mis-operation will likely cause loss of life and serious damage to homes, industrial or commercial facilities, important public utilities, main highways, or railroads.

Program Statistics as Flooding Indicators

Statistics on repetitive loss properties and claims made under the National Flood Insurance Program (NFIP) record past and multiple occurrences of damage and should be considered indicators of where

flooding is likely to occur and cause damage again. Such information was obviously valuable for comparison in this MHM planning process.

The data in Tables 9, 10, and 11 were provided by the Massachusetts Emergency Management Agency/MDCR. The local RVAMs each show the general location of the repetitive loss properties across Cape Cod.

Table 9: Cape Cod Communities – Repetitive Flood Losses (as of March 2009)

	(as of Dec. '02)	*(March, '09)*
Barnstable	17	17
Bourne	14	6
Brewster	0	0
Chatham	5	6
Dennis	16	18
Eastham	7	7
Falmouth	24	34
Harwich	3	2
Mashpee	0	1
Orleans	5	6
Provincetown	7	7
Sandwich	15	15
Truro	0	0
Wellfleet	0	0
Yarmouth	13	15
Barnstable County total	**125**	**134**

The Town of Falmouth has both the highest number of repetitive loss properties (34), and an increase of 10 additional repetitive loss properties since the data was reported in 2002, and the highest number of losses claimed under the NFIP (619). Fortunately, it also has the highest number of NFIP policies in force (2,150); indicating that the risk of flooding is known and the residents are insuring themselves against loss with federal flood insurance. Brewster has the lowest incidence with no repetitive loss properties, and only 15 NFIP claims on 94 policies in force.

TABLE 11: NFIP Loss Statistics, Cape Cod, Massachusetts: 1978 (start of NFIP) – April 30, 2009

Town	Total Loss Claims	Closed Losses	Open Losses	CWOP* Losses	Total Payments
Barnstable	272	198	1	78	2,893,815.62
Bourne	460	377	0	83	5,435,069.19
Brewster	15	9	0	6	33,894.27
Chatham	129	98	0	34	2,508,901.93
Dennis	222	148	0	74	1,427,839.87
Eastham	64	51	0	13	388,704.45
Falmouth	619	472	0	147	9,091,548.94
Harwich**	40	26	0	14	330,024.53
Mashpee	57	31	0	26	186,258.77
Orleans	47	36	0	11	631,910.35
Provincetown	167	104	0	63	1,293,769.57
Sandwich	129	94	0	35	1,096,722.24
Truro	25	9	0	16	79,359.70
Wellfleet	31	18	0	13	135,130.25

TABLE 11: NFIP Loss Statistics, Cape Cod, Massachusetts: 1978 (start of NFIP) – April 30, 2009					
Yarmouth	217	119	0	98	879,940.13
* CWOP= Closed without payment ***Harwich experienced no change from 2002 Loss Statistics*					

Regional Vulnerability Summary

Based on the above profile of Barnstable County, its population, resources, and infrastructure, the following is a summary of regional vulnerability to natural hazards:

- Summertime population is *estimated* at 500,000 persons; because this is an estimate, an accurate number of the people that may be vulnerable to a hazard event are unknown.
- 46,231.75 acres (72.22 square miles) are located in the SLOSH zone.
- There are 85 locations at which a locally designated evacuation route intersects with a SLOSH zone.
- There are 179 critical facilities located in a SLOSH zone.
- LIDAR data is critical for determining the impacts of projected sea-level rise in our region.
- There are 7 critical facilities located in a wildfire risk area.
- Cape Cod is accessible by vehicle by two four-lane bridges that are often seriously congested, and/or in repair.
- There are 148 repetitive loss properties on Cape Cod (as of March 2009), 23 more than in December 2002.
- There were 188 tidal restrictions identified in Barnstable County (as of December 2001).
- There is one high-hazard dam and ten significant-hazard dams in the County.

Section 4 – Existing Regional Hazard Mitigation Programs, Projects & Activities

This is the second hazard mitigation *plan* written for Barnstable County. However, hazard mitigation *actions* have been undertaken on Cape Cod prior to the development of the first hazard mitigation plan. Table 12 below lists several natural hazard mitigation projects funded jointly or in part by the Massachusetts Emergency Management Agency, the Massachusetts Department of Conservation and Recreation, or the Federal Emergency Management Agency and undertaken on Cape Cod in the recent past. By identifying what already exists or has been done in Barnstable County, this section brings to light the gaps in existing protections that ultimately informed the development of the County's hazard mitigation strategy.

TABLE 12: Mitigation Grant Funding Received by Barnstable County (1991 – 2009)

Town	Grant (year granted)	Project Title	Scope of Work	Total Project Cost ($)	Federal Funding Amount ($)	Local Funding Amount ($)
Brewster	HMGP 1224-08 (1998)	Breakwater Beach Drainage Improvements	Extension of corrugated metal drainage pipe towards Cape Cod Bay, restoration of sand over pipe, emplacement of pre-cast concrete.	7,200	5,400	1,800
Cape Cod Commission	PDM 02-02 (2002)	Regional Natural Hazard Plan	Community outreach and training; regional/local risk assessment and GIS mapping; development of regional/local mitigation strategy.	53,333	40,000	13,333
Chatham	HMGP 914-07 (1991)	Retrofitting – Home Protection	Retrofitting homes to protect against flood damage.	279,840	200,000	66,660
Falmouth	HMGP 914-06 (1991)	Acquisition and Demolition	Purchase of three beachfront lots and clearing of properties to restore locations to open space.	31,013	21,925	7,307
Falmouth	FEMA Section 1362 (ended)	Acquisition and Demolition	Purchase of 1.1 acres for 360 feet of beachfront property now protected as open space	400,000	300,000	100,000
Northeast States Emergency Consortium	HMGP 1364-14	Remote Wind Sensing for Hurricane Safety	Installation of remote ultrasonic wind sensor on top of the Buzzards Bay Vertical Lift Railroad Bridge over Cape Cod Canal in Bourne, MA.	9,950	7,463	2,487
Orleans	HMGP 920-05 (1992)	Retrofitting – Home Protection	Retrofitting homes to protect against flood damage.	20,780	14,691	4,896
Sandwich	FMA 00-02 (2000)	Flood Mitigation Plan	Develop a comprehensive flood mitigation plan for the town.	10,160	6,111	2,560
Yarmouth	HMGP 914-08 (1991)	Sea Gull Beach dune restoration	Design, permitting, and construction of a primary dune.	6,291	4,448	1,482

Regional Existing Protection Measures, Summary Matrix

Table 13, Regional Existing Protection Measures, Cape Cod, Massachusetts, presented on the following pages identifies existing regional programs, projects, and activities that relate to hazard mitigation. The following six mitigation technique categories are used to classify hazard mitigation activities: 1) Prevention; 2) Property Protection; 3) Natural Resource Protection; 4) Structural Projects; 5) Emergency Services; and 6) Public Information & Awareness. Each Local MHM Plan appended hereto includes a review of the existing protection measures and projects that are in place or have occurred locally. Many of these protection measures have been developed as a result of the 2004 PDM Plan.

Table 13: Regional Existing Protection Measures, Cape Cod, Massachusetts

Existing Protection Measure	Mitigation Technique Addressed	Area Covered	Description	Effectiveness and/or Enforcement
Barnstable County Regional Emergency Planning Committee (BCREPC)	5	14 Cape towns and the Town of Nantucket (Town of Falmouth does not participate in the REPC, but has own LEPC)	The BCREPC is the primary implementation group of the hazard mitigation actions presented in the 2004 PDM Plan. The BCREPC was formed at the request of the Barnstable County Fire Chiefs Association through the Barnstable County Department of Health & Environment to bring communities on Cape Cod and Nantucket into compliance with the Superfund Amendments and Reauthorization Act of 1988 also known as SARA title III. EPCRA, a regulation under SARA Title III, requires municipalities to establish Local Emergency Planning Committees (LEPC) and Local Emergency Response Plans to address the release of a hazardous material. BCREPC is charged with preparing for intentional and nonintentional hazardous materials emergencies through the development of a hazardous materials response plan, exercising of this response plan, training of first responders and the community to respond to these emergencies and by inventorying and locating reportable amounts of hazardous materials used by industry and other agencies with in its jurisdiction. The BCREPC also coordinates preliminary emergency response efforts by communicating shelter and evacuation plans in advance of severe weather related events. The BCREPC, along with the Cape Cod Commission and the Barnstable County AmeriCorps program work to coordinate ongoing hazard mitigation planning efforts throughout the region.	Voluntary coaliti of regional organizations, county personnel and local departments or boards. The BCREPC is recognized by the Massachusetts Emergency Management Agency. The BREPC participated in th development of t 2010 MHM plan.
Barnstable County's AmeriCorps Cape Cod	1 2 3 4 5 6 (with primary	15 Cape Towns	AmeriCorps Cape Cod is a residential program addressing the regional environmental and disaster preparedness needs of Cape Cod. The program engages 26 trained, dedicated individuals. AmeriCorps members are trained annually in multiple American Red Cross Disaster Services Training Programs, including Disaster Services, Mass Care, Shelter Operations, Family Services, First Aid and CPR. Members are available 24	Members are supervised by sta of the AmeriCorp Cape Cod progra within the County's Resour Development Office. Member

Table 13: Regional Existing Protection Measures, Cape Cod, Massachusetts

Existing Protection Measure	Mitigation Technique Addressed	Area Covered	Description	Effectiveness and/or Enforcement
	focus on 1, 3, 5, and 6)		hours a day to respond to unexpected and emergency situations on an as-needed basis to situations occurring within the County. Community organizations have the opportunity to submit proposals for AmeriCorps assistance on an ongoing basis. In the past members have served as participants in simulations for emergency response teams, taught community disaster education programs, and inventoried emergency shelter kits. Also, members address projects in the realm of natural resources needs for mitigation of disasters such as assisting with the maintenance of herring runs, dune stabilization efforts, dead and down debris removal on conservation lands.	participation is mandatory. The program is grant funded and vulnerable to gra availability.
Cape Cod Cooperative Extension's Wildfire Assessment and Preparedness Program	3 6	Barnstable County	The County actively participates and budgets for ongoing maintenance of forest fire protection and preparedness plans. Tasks include maintaining an inventory of public lands for their potential hazard for forest fire, mapping vulnerable areas and surrounding development, compiling related meteorological data, maintaining management plans and educational materials, developing model land management regulations, and providing mini-grants to towns to create management plans.	Participation is voluntary. All towns did not participate in the first year (FY04). Funding is subjec to County's budg process. Permanent fundir sources should be identified to ensu the program's continuation.
Cape Cod Cooperative Extension & Cape Cod Commission – Technical Assistance Staff	6	Barnstable County	The County employs two coastal processes and hazard mitigation specialists through the Cape Cod Cooperative Extension and the Cape Cod Commission. This staff has the expertise to provide technical assistance to towns, specifically related to shoreline change impacts, shoreline hazard mitigation, and coastal geology.	Existing County employees.
Regional Policy Plan	1	Barnstable County	Provides goals and policies to provide both guidelines for evaluating Developments of Regional Impact (DRI) and a framework for the development and implementation of Local Comprehensive Plans (LCPs). The 2009 RPP includes a Coastal Hazard Mitigation goal (CR2) with minimum performance standards that restrict, and/or severely limit development in the coastal zone.	Enforced by the Cape Cod Commission with support by towns 2009 RPP recommends that towns develop an adopt hazard mitigation plans - 12 of 15 towns ar in the process of developing MHM Plans for

Table 13: Regional Existing Protection Measures, Cape Cod, Massachusetts

Existing Protection Measure	Mitigation Technique Addressed	Area Covered	Description	Effectiveness and/or Enforcement
				certification in 2010.
District of Critical Planning Concern (DCPC)	1	Barnstable County DCPC boundaries delineated by identifying the resources and issues of concern needing special land use protections.	Management of critical resources – areas can be designated a DCPC and afforded heightened and targeted levels of protection through the creation of implementing regulations. Hazard districts could be created as the underlying reason for a specific DCPC. Six DCPCs presently exist: • Barnstable Growth Management DCPC, Barnstable • Bournedale DCPC, Bourne • Quivett Neck/Crowe's Pasture, Dennis • Black Beach/Great Sippewissett Marsh, Falmouth • Six Ponds, Harwich • Three Ponds, Sandwich	Enforced by the Cape Cod Commission and towns—local implementing regulations are created for the DCPC to regulate use and development of tl area within.
Regional Intelligent Transportation System (ITS)	5 6	Southeastern Massachusetts (ultimately linking to regional control centers statewide)	A regional ITS architecture development process for southeastern Massachusetts is under way. ITS systems are defined as the application of advanced sensor, computer, computer technologies, and management strategies in integrated and interrelated systems to deliver transportation services. The architecture is a specific, tailored framework for ensuring integrated communication. The Cape Cod Commission transportation staff is pivotal in the development of this ITS system. Between 2003 and now, EOT/MHD (now MassDOT) has initiated "511" for traffic information, the statewide technical architecture is being updated this year and next so ITS equipment is compatible in communication/ emergency situations. Commission staff are working to get more cameras & real time traffic info available in the Canal area (beginning with the bridges).	Progress is slow due to limited funding.
Cape Cod Emergency Traffic Plan	5	Major highway approaches (Route 6, Route 28) to Cape Cod Canal bridges	The Plan and its coordinating committee are organized by MEMA Region 1 in concert with the Massachusetts State Police and many other agencies to facilitate the egress of a high volume of traffic from Cape Cod in the event of a hurricane. As traffic levels build before the hurricane arrives, direct access to and from off-Cape locations will be restricted at the bridges in order to allow vehicles to continue north from the bridges unimpeded. At higher traffic levels, and as bridge flows warrant (e.g., lower demand at Bourne Bridge than at Sagamore Bridge), traffic on Route 6 destined for Routes 25 & 495 would be diverted through the Massachusetts Military Reservation	Plan in place. Effectiveness to b determined durin major weather event.

Table 13: Regional Existing Protection Measures, Cape Cod, Massachusetts

Existing Protection Measure	Mitigation Technique Addressed	Area Covered	Description	Effectiveness and/or Enforcement
			(MMR). When sustained winds reach 80 mph, the bridges will be closed and the motorists will have the option of going to designated emergency parking areas in the MMR and to be shuttled to shelter in the MMR.	
Barnstable County Hazard Mitigation Working Group	1 5 6	All 15 towns of Barnstable County	Formation of the Barnstable County Hazard Mitigation Working Group is a recommendation of the 2010 MHM Plan. The working group is comprised of representatives from the BCREPC, the CCC and AmeriCorps. The goal of this working group is to better coordinate implementation of the regional hazard mitigation strategy. Most of the action items from the 2004 PDM Plan have been implemented, or are "ongoing" within various county agencies and departments. The status of these efforts across county agencies is often unclear and educational initiatives and grant pursuits could use better coordination. The working group will meet bi-annually to better communicate educational initiatives, grant opportunities, and general implementation strategy progress.	Not utilized yet. Effectiveness to b determined.
Model Bylaw for Effectively Managing Coastal Floodplain Development	1 2 3 4 5 6	Barnstable County; National	The Cape Cod Commission and the Cape Cod Cooperative Extension, in partnership with the WHOI Sea Grant Program, developed a model coastal floodplain bylaw to comprehensively restrict or severely limit development with the coastal zone. The CCC will be introducing the bylaw to towns to encourage local adoption.	One town on Martha's Vineyar has adopted elements of the bylaw. Effectiveness to b determined; will b measured by widespread local adoption.

Section 5 – Natural Hazard Mitigation Strategy

This section, which has been separated into the following sections, outlines Barnstable County's overall strategy to reduce Cape Cod's vulnerability to the effects of natural hazards:

- **Mitigation Objectives** – These are designed to directly support Barnstable County's hazard mitigation goal stated earlier (pg. 6). If all objectives are met, the goal will be met.

- **Mitigation Actions** – These are specific measures to be undertaken in order to achieve the identified objectives. These actions should guide future funding decisions for both pre- and post-disaster mitigation projects throughout Barnstable County.

Barnstable County's hazard mitigation strategy is an evolving plan that will change over time as circumstances warrant, as new studies are conducted, and as technology for understanding, predicting, and locating risk improves. This strategy will be updated over time so that it will meet the needs of the Cape should it confront a natural hazard. Part of what this strategy does is to identify gaps in data, planning, and policies that should be addressed and completed over time.

5.1 Available Mitigation Techniques

In considering the appropriate mitigation techniques for Barnstable County to undertake, the Regional MHM Team reviewed the hazard identification and analysis, the regional vulnerability assessment, and the existing protection measures. An assessment of these earlier planning steps was the foundation for generating mitigation actions to reduce Cape Cod's vulnerability to natural hazards. Six categories of available mitigation techniques were assessed as they relate to the hazards faced by the Cape. The appropriateness of the techniques is presented below in Table 14. These categories remain unchanged in their priority and relevance since the 2004 PDM Plan. While climate change has been discussed throughout this plan, it is essential to have better data about future climate change impacts locally to both accurately identify local hazard areas and to assess risk and vulnerability in those areas.

Table 14: Appropriate Mitigation Technique to Mitigate Natural Hazards, Cape Cod

Mitigation Technique	Possible Hazard							
	Flood	Wildfire	Shoreline Change	Snow & Ice	Wind	Earthquake	Tornado	Drought
Prevention	√	√	√	√				√
Property Protection	√	√	√	√	√		√	
Natural Resource Protection	√	√	√	√				√
Structural Projects	√		√					
Emergency Services	√	√		√	√	√	√	
Public Information & Awareness	√	√	√	√	√	√	√	√

5.2 Barnstable County's Mitigation Objectives

As previously stated the overall goal of the 2004 PDM Plan was to:

> *Reduce the loss of or damage to life, property, infrastructure, and natural, cultural, and economic resources from natural disasters.*

This goal and the corresponding list of objectives remain unchanged for the 2010 MHM Plan Update. If the following 14 objectives are met, this goal will be achieved. While progress has been made relevant to these objectives through implementation of the 2004 PDM Plan, the objectives remain unchanged since they are still relevant in supporting the county's overall mitigation strategy.

1. Increase coordination between the State, the County and the local governments of Cape Cod in pre-disaster planning and continuous hazard mitigation implementation.

2. Assist local governments with the preparation of a Local Multi-Hazard Mitigation Plan to ensure that all 15 towns on Cape Cod qualify for available pre- and post- disaster mitigation grant funding.

3. Increase awareness and support for hazard mitigation among regional agencies, municipalities, private organizations, businesses, and the general public of Cape Cod through a multi-faceted education program. Promote educational opportunities to introduce residents and visitors to the risks of natural hazards, including climate change, and the various appropriate mitigation and adaptation strategies that can be taken.

4. Implement a broad range of programs and projects that promote Cape Cod's mitigation strategy and therefore safeguard the most vulnerable regional populations, critical facilities and infrastructure, and the natural, cultural, and economic resources, and reduce financial losses.

5. Utilize risk assessment, mitigation, and loss estimation modeling technology and software in future hazard mitigation planning work and in future updates of the Barnstable County MHM Plan, as relevant and available.

6. Protect critical public facilities and services from hazard damage.

7. Make efficient use of grant funds for hazard mitigation by protecting critical public facilities and services from hazard damage; prioritizing hazard mitigation activities by utilizing cost-benefit analysis; purchasing property in hazard-prone locations; and preserving natural, cultural, and historic resources in hazard-prone areas.

8. Identify and implement a mitigation strategy to protect the economic vitality of businesses.

9. Utilize existing funding and seek new funding sources to expand the scope of this MHM plan beyond natural hazards to include climate change and adaptation planning, and to make hazard mitigation projects and activities a priority of the region and Barnstable County government.

10. Continually analyze and improve this plan's effectiveness in terms of implementing the mitigation strategy in this plan.

11. Increase the number of Cape Cod towns participating in the Community Rating System.

12. Continue funding and participating in active hazard mitigation programs and initiatives.

13. Assist towns in the identification and development of specific mitigation projects.

14. Increase each town's capacity for dealing with natural hazard events by promoting the adequate provision of emergency services and response capabilities.

5.3 Mitigation Actions and Projects

As part of the MHM Plan Update, the Regional MHCPT reviewed the 2004 PDM Plan Action Items. The Actions Items were organized into five categories: General, Continuation or Development of Programs and Initiatives, Call for Conferences or to Convene Groups, Educational Activities, and Infrastructure Projects. For the purpose of the MHM Plan Update, the 2004 Actions Items were condensed into the following table and a status column was added. For consistency, 'completed' or 'ongoing' action items are noted in the Existing Protections Measures Matrix (EPM Matrix) is referenced (see Table 13).

2004 PDM Action Items – Status

Number	Action	Status
Action Item # 1 (general)	Implement, continue, and expand the regional hazard mitigation work begun under the PDM Planning Grant (a MEMA grant to the Cape Cod Commission, FY2003).	**Complete. See EPM Matrix**
Objectives	All	
Implementation	Barnstable County Commissioners; Cape Cod Commission; Resource Development Office; Department of Health & Environment	
Funding	County Budget; grant funding	

Action Item # 2 (general)	Establish a County Ordinance to encourage ongoing hazard mitigation planning and commit to the implementation of this Regional Plan's Mitigation Strategy	**"Ordinance" revised to "Resolution". Cont'd as 2010 MHM Action**
Objectives	4, 9, 14	
Implementation	Barnstable County Commissioners	
Funding	not required	

Action Item # 3 (general)	Identify Opportunities for the County to continue to serve as liaison between FEMA, MEMA and municipalities	**Ongoing through REPC, CCC & RDO. See EPM Matrix**
Objectives	1	
Implementation	Barnstable County Commissioners to designate; MEMA; DCR; FEMA	
Funding	allocated staff time	

Action Item # 4 (general)	Identify and seek public and private sector funding for residents, businesses, and municipalities that will allow the implementation of sound hazard mitigation measures across Cape Cod.	**Ongoing through REPC, CCC & RDO. See EPM Matrix**
Objectives	2, 4, 9	
Implementation	Barnstable County Resource Development Office (RDO)	
Funding	FEMA Hazard Mitigation Grant Program	

Action Item # 5 (general)	Encourage municipalities to develop, adopt, and implement Local PDM Plans.	**Ongoing through CCC. See EPM Matrix**
Objectives	2, 14	
Implementation	Cape Cod Commission; MEMA; DCR	
Funding	Grant funding; county budget	

Action Item # 6 (general)	Incorporate natural hazard mitigation priorities and best planning practices into Barnstable County's regional planning work.	**Complete. See 2009 RPP and EPM Matrix**
Objectives	4, 12	
Implementation	Cape Cod Commission	
Funding	none	

Action Item # 7 (general)	Coordinate County mitigation planning with that occurring on state and federally owned land/facilities located in Barnstable County.	**Ongoing through REPC & CCC. See EPM Matrix**
Objectives	1, 4	
Implementation	Barnstable County Commissioners to designate	
Funding	County budget	

Action Item # 8 (general)	Conduct a needs assessment of privately-owned facilities that have regional importance (for example, hospitals, airports, and day care centers).	**"Needs Assessment" revised to "Survey". Cont'd as 2010 MHM Action**
Objectives	4, 6, 7, 8	
Implementation	Barnstable County Commissioners to designate	
Funding	Private; County staff support; grant funding	

Action Item # 9 (general)	Conduct the following mitigation activities to prepare and protect Cape Cod's cultural resources from the damaging effects of natural hazards: Identify key cultural resources for protection in hazard areas; establish actions to reduce risk; coordinate with emergency response personnel.	**Revised; "Develop a Critical Cultural Resource Inventory". Cont'd as 2010 MHM Action**
Objectives	4, 6, 7, 8	
Implementation	Regional Coordination needed; Barnstable County Commissioners to designate; Cape & Islands Historical Association	
Funding	Grant funding; MA Board of Library Commissioners	

Action Item # 10 (general)	Utilize FEMA's HAZUS-MH for hurricane's and/or other available modeling software to test and improve the mitigation strategy presented in this Regional PDM Plan (based on available funding).	**Revised; seek MOU from MMA for addt'l scenarios. Cont'd as 2010 MHM Action**
Objectives	5, 10	
Implementation	Barnstable County Commissioners to designate	
Funding	County budget; grant funding	

Action Item # 11 (general)	Evaluate and take steps to ensure the reliable provision of electricity to the Cape: focus under-grounding transmission lines.	**Revised to include "smart grid technologies". Cont'd as 2010 MHM Action**
Objectives	4, 6, 8	
Implementation	Barnstable County Commissioners to designate; NSTAR	
Funding	Grant funding; private sector	

Action Item # 12	Ensure that any problems being caused by the Cape Cod Canal and its jetties are	**Revised to Regional,**

(general)	mitigated. Study possible alternatives for mitigation that may include removal, replacement, modification or other remedies.	**high priority "sediment management plan". Cont'd as 2010 MHM Action**
Objectives	4	
Implementation	Army Corps of Engineers; Town of Sandwich; Barnstable County Commissioners to designate	
Funding	Grant funding; Army Corps of Engineers	

Action Item # 13 (programs & initiatives)	Continue to fund, implement and expand the County's Wildfire Assessment Program.	**Ongoing through CCCExt. See EPM Matrix**
Objectives	4, 7, 12	
Implementation	Cape Cod Cooperative Extension; Barnstable County Commissioners	
Funding	County budget; grant funding	

Action Item # 14 (programs & initiatives)	Affect the ongoing development of the Cape's Intelligent Transportation System (ITS) so that hazard mitigation needs are factored into the design/architecture of the system.	**Ongoing through CC Regional Transportation Authority. See EPM Matrix.**
Objectives	1, 12	
Implementation	Cape Cod Commission; Dept. of Health & Environment; Regional Emergency Planning Committee; Mass Highway; State Police	
Funding	County budget; grant funding	

Action Item # 15 (programs & initiatives)	Continue to plan for coordinated evacuation and sheltering on Cape Cod in the event of an emergency.	**Ongoing through REPC. See EPM Matrix**
Objectives	4, 6, 7, 14	
Implementation	Dept of Health & Environment; Regional Emergency Planning Committee; County Commissioners to designate; Army Corps of Engineers; MEMA; Red Cross; State Police; others	
Funding	County staff time; grant funding	

Action Item # 16 (conferences)	Organize and hold an annual conference on managing emergencies on Cape Cod, including; educating the public about the link between hazard mitigation and emergency response.	**Ongoing through REPC. Update "Emergency Response Guidebook" as 2010 MHM Action.**
Objectives	1, 3, 14	
Implementation	Dept of Health & Environment; Regional Emergy Planning Committee; County Commissioners to designate	
Funding	Grant funding	

Action Item # 17 (conferences)	Organize and hold a workshop on the Community Rating System (CRS) for town planners, floodplain managers, emergency managers, and others intended to encourage their application and participation in the program.	**Ongoing through CCC. See EPM Matrix**
Objectives	3, 11	
Implementation	County Commissioners to designate; Resource Development Office	
Funding	Grant funding	

Action Item # 18	Develop a multifaceted regional hazard mitigation education program to: raise	**Ongoing through**

(education)	awareness; assist local governments; reduce regional duplication of effort. Program may include: distribution of hazard mitigation materials; seasonal visitor evacuation education; promote *Firewise Communities Program*; update *Emergency Preparedness Handbook*; provide better access to hazard mitigation information on-line.	**REPC, RDO/AmeriCorps and CCC. See EPM Matrix.**
Objectives	3, 4, 12, 14	
Implementation	Barnstable County Resource Development Office/AmeriCorps of Cape Cod; County Commissioners to designate	
Funding	Grant funding; public service donation from private sector	

Action Item # 19 (infrastructure)	Seek funding to develop and administer mini-grants (Planning Assistance Grants) to municipalities to identify, prioritize, and engineer mitigation infrastructure projects.	**Ongoing through CCC. See EPM Matrix**
Objectives	7, 13	
Implementation	Barnstable County Commissioners; FEMA; MEMA; MDCR	
Funding	Grant Funding	

Action Item # 20 (infrastructure)	Seek funding to remediate tidally restrictive infrastructure on Cape Cod, which affect the retention time of floodwaters or impound stormwater.	**Ongoing through CCC, MA Wetlands Restoration Program, et al.**
Objectives	4, 6, 7	
Implementation	Cape Cod Commission; Massachusetts Wetlands Restoration Program; municipal conservation and public works staff; private land owners	
Funding		

Action Item # 21 (infrastructure)	Route 6 and Coles Neck Road, Wellfleet—drainage study and redesign to eliminate roadway flooding.	
Objectives	4, 6, 7	
Implementation	Mass Highway	
Funding	TIP; grant funding	

Action Item # 22 (infrastructure)	Route 6 and Oliver's Tennis Courts, Wellfleet—drainage study and redesign to eliminate roadway flooding.	
Objectives	4, 6, 7	
Implementation	Mass Highway	
Funding	TIP; grant funding	

Action Item # 23 (infrastructure)	Route 6 and Black Fish Creek, Wellfleet—drainage study and redesign to eliminate roadway flooding.	
Objectives	4, 6, 7	
Implementation	Mass Highway	
Funding	TIP; grant funding	

2010 MHM Action Items

The Regional MHCPT was in agreement that a shorter, more manageable list of Action Items was necessary, and recommended the following 6 Action Items for the 2010 MHM Plan Update. In addition, they recommended establishing a Hazard Mitigation Planning Working Group to consist of Barnstable County's AmeriCorps Coordinator, Regional Emergency Planning Committee Coordinator, and the Cape Cod Commission Hazard Planner to meet bi-annually and oversee the implementation of action items.

Number	Action

Action Item # 1	Formally adopt a County resolution to encourage and support ongoing hazard mitigation planning.
Objectives	4, 9, 14
Implementation	Barnstable County Commissioners
Funding	Not required
Priority	High / Spring of 2010

Action Item # 2	Conduct a needs assessment of privately owned facilities that have regional importance (i.e hospitals, airports, day care centers)
Objectives	4, 6, 7, 8
Implementation	Barnstable County Commissioners to designate
Funding	Private; county staff support; grant funding
Priority	High

Action Item # 3	Establish the Hazard Mitigation Planning Working Group to facilitate and monitor implementation of the 2010 MHM Plan.
Objectives	1, 3, 4, 13, 14
Implementation	Barnstable County Commissioners to designate; CCC, REPC, AmeriCorps
Funding	County staff support
Priority	High

Action Item # 4	Support the development of Regional and Local Climate Adaptation Plans as an extension of the MHM Plan
Objectives	3, 4, 5, 6, 9
Implementation	Barnstable County Commissioners to designate; Cape Cod Commission, AmeriCorps, REPC, CC Coop Ext.
Funding	County staff support; grant funding
Priority	Medium

Action Item # 5	Conduct the following activities to prepare and protect Cape Cod's cultural resources from the damaging effects of natural hazards: • Identify key cultural resources for protection in hazard areas (museums, libraries, archival collections, significant public or institutional structures, concentrations of historic structure/districts) • Establish actions to reduce risk to these resources; educate cultural resource owners on how to lessen risk, secure funds for these projects. • Coordinate cultural resource information with emergency response personnel; develop an emergency response plan for prompt treatment of damaged resources.
Objectives	4, 6, 7, 8
Implementation	Regional Coordination needed; Barnstable County Commissioners to designate; CCC; AmeriCorps
Funding	Grant funding
Priority	Medium

Action Item # 6	Conduct a Regional Sediment Management Study and develop a general guidance document to inform local sediment management planning and best practice management efforts.
Objectives	1, 4, 6, 8, 13
Implementation	Barnstable County Commissioners to designate; Cape Cod Commission, AmeriCorps, REPC, CC Coop Ext.
Funding	County staff support; private sector; grant funding
Priority	Medium

5.4 Prioritization and Implementation of Action Items

The Regional MHCPT discussed each suggested action item and worked to determine its feasibility. A priority structure was then determined using the STAPLEE criteria (Appendix C) as suggested in the Local Multi-Hazard Mitigation Planning Guidance. STAPLEE (Social, Technical, Administrative, Political, Legal, Economic, and Environmental) is a general set of criteria used to make decisions regarding community initiatives. Using these criteria, the team determined the overall feasibility of the 6 action items above.

The use of STAPLEE ranks all action items against each other, without regard to impact on reducing the Cape's vulnerability to natural hazards. Consideration had to be given to actions intended to address the greatest hazard risks as well. Therefore, the team weighted the ranking of the STAPLEE criteria by adding in the hazard ranking values assigned to the hazards the Cape faces. If an action item addressed multiple hazards it was given the value of 10, or one number higher than the highest hazard ranking assigned. This hazard-weighted STAPLEE mitigation strategy resulted in three levels of feasibility, rated as follows:

- High (31-29 points) = 15 actions
- Medium (28-26 points) = 6 actions
- Low (25-23 points) = 2 actions

STAPLEE generally correlates feasibility with priority. Utilization of this method to prioritize which activity should be undertaken will allow the County to review both the costs and the benefits of the activity consistent with the mitigation goals and prioritize them based on cost effectiveness. It is the County's intention to implement first those that are determined to have the highest benefit/cost ratio and cost effectiveness.

Although all of the identified mitigation techniques will likely reduce costs by avoiding losses, many projects are costly to implement. Barnstable County will continue to seek outside funding assistance for projects in both the pre- and post-disaster environment. Similarly, it is the role of the County to help the towns find the resources to conduct "local" mitigation projects. The County will continue to identify potential funding sources and pass this information on to the town officials.

Setion 6 – Plan Adoption, Implementation, Monitoring and Maintenance

6.1 Regional MHM Plan Review and Adoption

The Draft Regional MHM Plan was presented to the Barnstable County Commissioners on February 3, 2010. This meeting was videotaped, broadcast on the local cable channel, and made available through the County Commissioner's website.

The Draft Regional MHM Plan was also posted on the Cape Cod Commission's web site for a public comment period from February 5 to February 19, 2010. General public comment was received during this period. Notice of this comment period posted prominently in various places on the web site. At this time, the Draft Plan was also submitted to MEMA for review and comment.

The Draft Regional MHM Plan was presented at a public meeting of the Cape Cod Commission's Planning Committee on April 26, 2010. This meeting is noticed in advance and is a regular standing committee meeting of the Commission.

On February 19, 2010 the Draft Regional MHM plan was submitted to FEMA for 'approval pending local adoption'.

On (__date__), the Barnstable County Commissioners voted to adopt the Barnstable County Multi-Hazard Mitigation Plan.

6.2 Implementation

This Regional MHM Plan is to be implemented as identified in the Mitigation Strategy (Section 5.0) and as delegated by the Barnstable County Commissioners.

6.3 Monitoring and Updating the Regional PDM Plan

The Disaster Mitigation Act of 2000 stipulates that localities must not only develop Hazard Mitigation Plans but also take steps to ensure that these plans get implemented and updated as needed. It is therefore necessary for Barnstable County to include procedures for maintaining and updating this plan.

Because the Cape Cod Commission has been charged with preparing this regional plan for Barnstable County, the Commission staff planner, tasked with hazard mitigation planning, will be responsible for monitoring its implementation and coordinating the required updates. Procedures will be as follows:

1. The Commission will convene the Regional MHCPT annually to check on the status of implementation.
2. The Commission will take information from these annual meetings and compile an annual progress report on hazard mitigation Cape-wide.

3. The Commission intends to update this plan five years from its adoption, as resources allow. The next update will be due in the fall of 2014.

The update process should focus on evaluating the successes and failures of this plan, which would be done in two ways. First, the information gathered annually from each town would describe how each municipality has performed in terms of implementation. Second, any new information such as new or changing hazard conditions or improved vulnerability assessment will provide the basis for altering and refining elements of the plan.

5. Should Cape Cod experience a disaster, the Regional MHM Plan shall be evaluated and updated to reflect findings from that experience. These findings will be evaluated against the inventory, assessments, and action items of this plan. The Barnstable County Commissioners, through the Cape Cod Commission, the Regional MHCPT and the Hazard Mitigation Planning Working Group shall update the plan to accommodate the changes deemed necessary by these findings.

6. Should federal or state hazard mitigation planning regulations and requirements change, the Commission will update this plan to reflect such changes, as appropriate.

7. The ongoing monitoring and updates of this plan will include a public participation program using the media and the Commission's web site to facilitate public involvement. Additionally, the Cape Cod Commission's regularly scheduled meetings, which are televised public meetings, can be utilized as necessary.

- Document End -

Appendix A: MHM Planning Maps

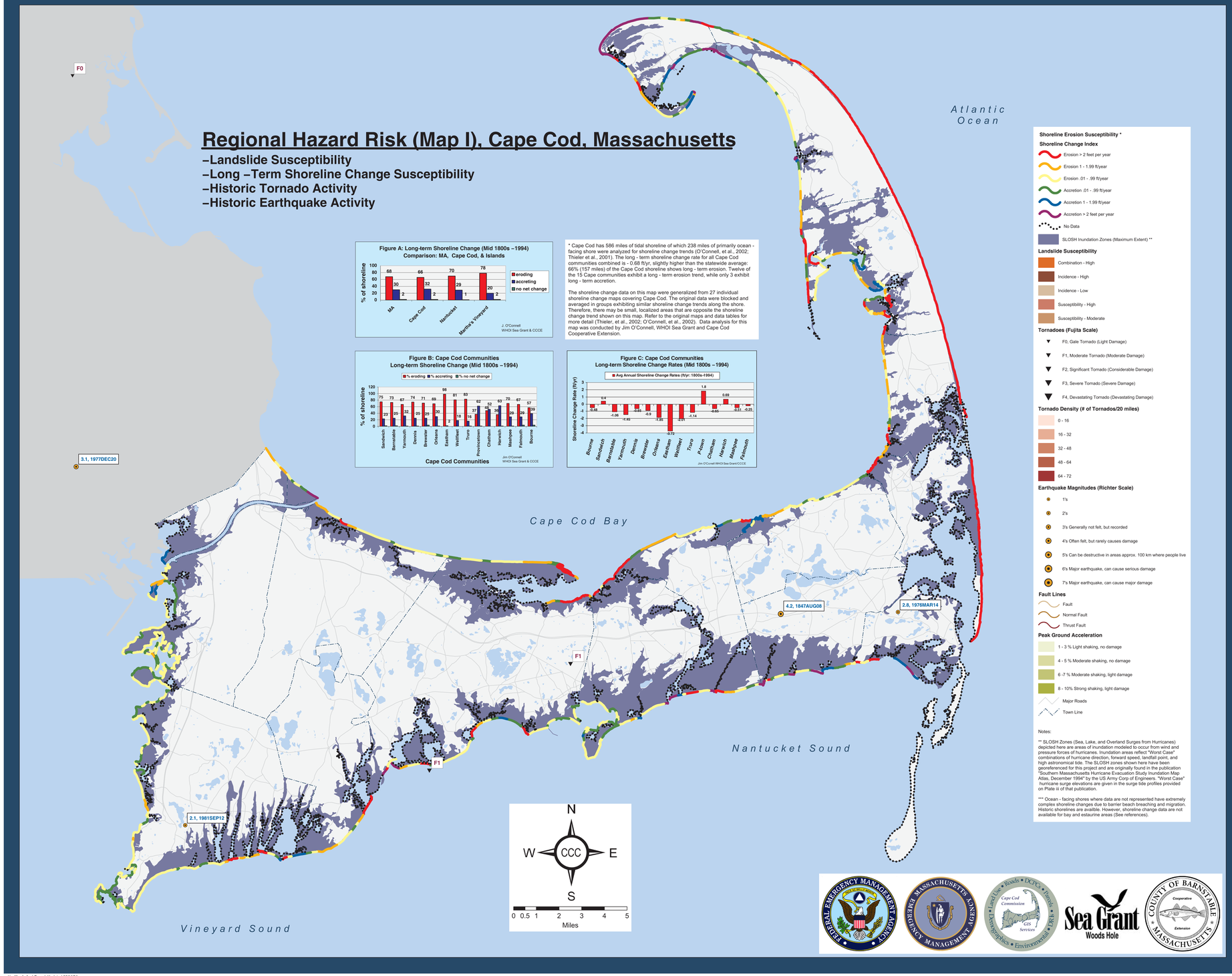
Map 1:	Shoreline Change Susceptibility (Long-term Change; Mid 1800s – 1944); Historical Tornado Activity; Historical Earthquake Activity, Cape Cod, MA
Map 2:	Historical Hurricane Data and Flood Hazard Areas; Historical Annual Snowfall and Flood Hazard Areas, Cape Cod, MA
Map 3:	Wildfire Hazard Areas, Cape Cod, MA
Map 4:	Regional Policy Plan's Cape Cod Significant Natural Resource Areas Map (2009)
Map 5:	Regional Policy Plan's Cape Cod Water Resources Classification Map I (2009)
Map 6:	Regional Policy Plan's Cape Cod Water Resources Classification Map II (2009)
Map 7:	Regional Risk and Vulnerability Assessment Map with SLOSH, Cape Cod, MA

Appendix C: Acronym's Defined

FEMA – Federal Emergency Management Agency
PDM – Pre-Disaster Mitigation (hazard mitigation planning process, as defined by FEMA in 2004)
MHM – Multi-Hazard Mitigation (hazard mitigation planning process as defined by FEMA in 2009)
GIS – Geographic Information Systems
BCREPC – Barnstable County Regional Emergency Planning Committee
LEPC – Local Emergency Planning Committee
RMHPT – Regional Multi-Hazard Planning Team
LMHPT – Local Multi-Hazard Planning Team
HMGP – Hazard Mitigation Grant Program
SLOSH – Sea, Lake and Overland Surges from Hurricane
RVAM – Risk and Vulnerability Assessment Map

Regional Hazard Risk (Map I), Cape Cod, Massachusetts

–Landslide Susceptibility
–Long –Term Shoreline Change Susceptibility
–Historic Tornado Activity
–Historic Earthquake Activity



* Cape Cod has 586 miles of tidal shoreline of which 238 miles of primarily ocean - facing shore were analyzed for shoreline change trends (O'Connell, et al., 2002; Thieler et al., 2001). The long - term shoreline change rate for all Cape Cod communities combined is - 0.68 ft/yr, slightly higher than the statewide average: 66% (157 miles) of the Cape Cod shoreline shows long - term erosion. Twelve of the 15 Cape communities exhibit a long - term erosion trend, while only 3 exhibit long - term accretion.

The shoreline change data on this map were generalized from 27 individual shoreline change maps covering Cape Cod. The original data were blocked and averaged in groups exhibiting similar shoreline change trends along the shore. Therefore, there may be small, localized areas that are opposite the shoreline change trend shown on this map. Refer to the original maps and data tables for more detail (Thieler, et al., 2002; O'Connell, et al., 2002). Data analysis for this map was conducted by Jim O'Connell, WHOI Sea Grant and Cape Cod Cooperative Extension.

Shoreline Erosion Susceptibility *

Shoreline Change Index

- Erosion > 2 feet per year
- Erosion 1 - 1.99 ft/year
- Erosion .01 - .99 ft/year
- Accretion .01 - .99 ft/year
- Accretion 1 - 1.99 ft/year
- Accretion > 2 feet per year
- No Data
- SLOSH Inundation Zones (Maximum Extent) **

Landslide Susceptibility

- Combination - High
- Incidence - High
- Incidence - Low
- Susceptibility - High
- Susceptibility - Moderate

Tornadoes (Fujita Scale)

- F0, Gale Tornado (Light Damage)
- F1, Moderate Tornado (Moderate Damage)
- F2, Significant Tornado (Considerable Damage)
- F3, Severe Tornado (Severe Damage)
- F4, Devastating Tornado (Devastating Damage)

Tornado Density (# of Tornados/20 miles)

- 0 - 16
- 16 - 32
- 32 - 48
- 48 - 64
- 64 - 72

Earthquake Magnitudes (Richter Scale)

- 1's
- 2's
- 3's Generally not felt, but recorded
- 4's Often felt, but rarely causes damage
- 5's Can be destructive in areas approx. 100 km where people live
- 6's Major earthquake, can cause serious damage
- 7's Major earthquake, can cause major damage

Fault Lines

- Fault
- Normal Fault
- Thrust Fault

Peak Ground Acceleration

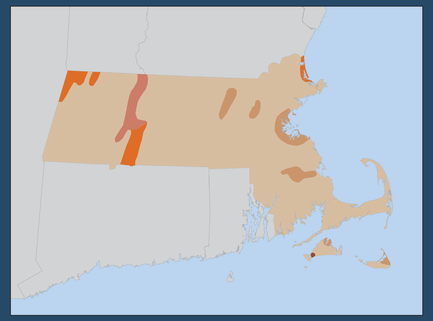
- 1 - 3 % Light shaking, no damage
- 4 - 5 % Moderate shaking, no damage
- 6 -7 % Moderate shaking, light damage
- 8 - 10% Strong shaking, light damage
- Major Roads
- Town Line

Notes:

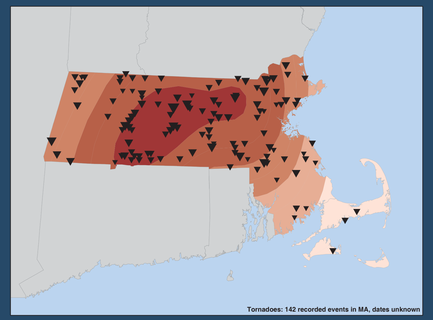
** SLOSH Zones (Sea, Lake, and Overland Surges from Hurricanes) depicted here are areas of inundation modeled to occur from wind and pressure forces of hurricanes. Inundation areas reflect "Worst Case" combinations of hurricane direction, forward speed, landfall point, and high astronomical tide. The SLOSH zones shown here have been georeferenced for this project and are originally found in the publication "Southern Massachusetts Hurricane Evacuation Study Inundation Map Atlas, December 1994" by the US Army Corp of Engineers. "Worst Case" hurricane surge elevations are given in the surge tide profiles provided on Plate iii of that publication.

*** Ocean - facing shores where data are not represented have extremely complex shoreline changes due to barrier beach breaching and migration. Historic shorelines are available. However, shoreline change data are not available for bay and estaurine areas (See references).

Landslide Susceptibility

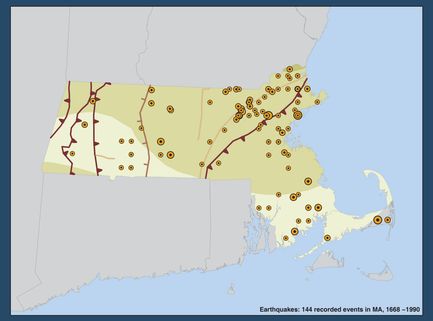


Historic Tornado Activity



Tornadoes: 142 recorded events in MA, dates unknown

Historic Earthquake Activity



Earthquakes: 144 recorded events in MA, 1668 –1990

NOTE and CAUTION: The shoreline change data on this map were generalized from 27 individual shoreline change maps covering Cape Cod. The shoreline change data span approximately 150 years (mid1800s to 1994), with an uncertainty range of +/- 0.4 feet per year. The original data were blocked and averaged in groups exhibiting similar shoreline change trends along the shore. Therefore, there may be small, localized areas that are opposite the shoreline change trend shown. Furthermore, caution should be used when interpreting any shoreline change data as recent trends in shoreline movement may have changed as a result of natural causes, or importantly, human activities, such as seawall/revetment, jetty or groin construction. It is important to analyze the short-term shoreline change data that were used to calculate the long-term rates of change to identify recent changes in shoreline movement that may be more applicable for planning purposes. For case examples, see O'Connell, et al, 2002 & 2003, and Thieler, et al, 2002 listed in the references below. Data tables and maps can be viewed at www.state.ma.us/czm/czm.htm.

Data Sources:

Northeast States Emergency Consortium (NESEC) www.nesec.org, MassGIS Executive Office of Environmental Affairs, "Coastal Erosion on Cape Cod: Some Questions and Answers" (http://woodshole.er.usgs.gov/staffpages/boldale/capecod/), Federal Emergency Management Agency (FEMA), and the Cape Cod Commission's Geographic Information System Department.

References

IPCC, 1995, Second Assessment - Climate Change 1995: A Report of the Intergovernmental Panel on Climate Change, IPCC, Geneva, Switzerland.

O'Connell, J.F., 2003, New Shoreline Change Data Reveal Massachusetts is Eroding, WHOI Sea Grant and Cape Cod Cooperative Extension, Marine Extension Bulletin, March, 2003.

O'Connell, J.F., Thieler, E.R., and Schupp, C. 2002, New Shoreline Change Data and Analysis for the Massachusetts Shore, with Emphasis on Cape Cod and the Islands: Mid1800s - 1994. Environment Cape Cod, Vol. 5, No. 1.

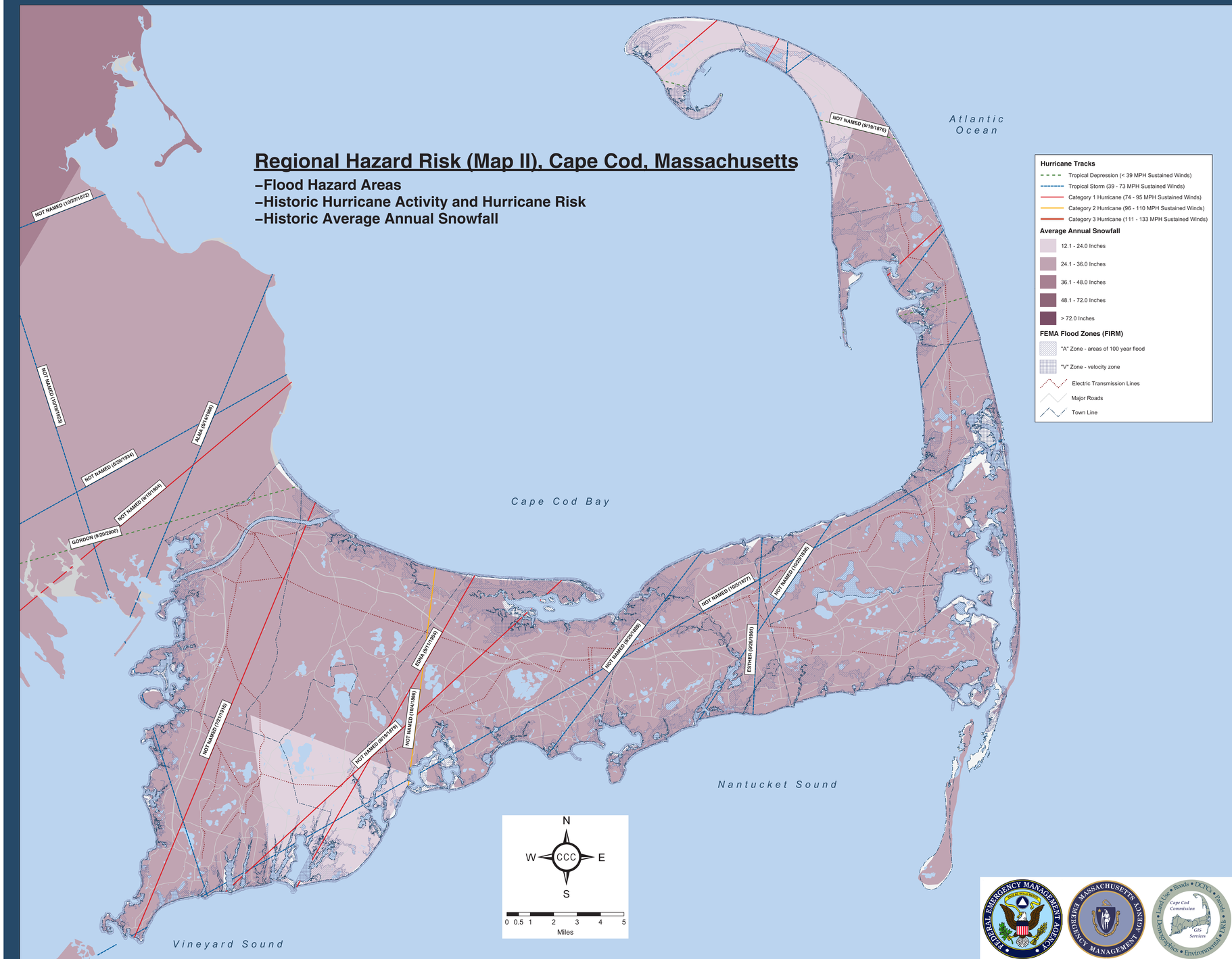
Thieler, E.R., O'Connell, J.F., and Schupp, C., 2002, The Massachusetts Shoreline Change Project: 1800s - 1994, Technical Report, U.S.G.S. Administrative Report, Woods Hole, MA.

Funding for the Cape Cod Pre-disaster Mitigation Planning grant was provided to the Cape Cod Commission by the Federal Emergency Management Agency under the DMA 200 Initiative through the Massachusetts Emergency Management Agency. This map was produced through the Cape Cod Commission's Geographic Information System Department for the Pre-disaster Mitigation Project. January, 2004, based on data analysis, graphs and text provided by Jim O'Connell, Woods Hole Oceanographic Institution Sea Grant Program and Cape Cod Cooperative Extension. A description of the shoreline change data base analyzed for this project can be found in Thieler, O'Connell and Schupp (2002) - see references above. Comments and corrections are welcome at the Cape Cod Commission office or contact gis@capecodcommission.org. This map is illustrative and all depicted boundaries are approximate.

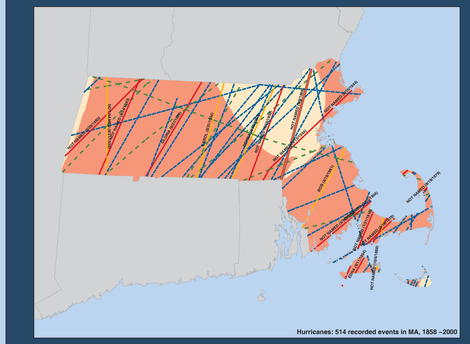
HazMap1_ArchE.mxd, Updated 06/14/04

Regional Hazard Risk (Map II), Cape Cod, Massachusetts

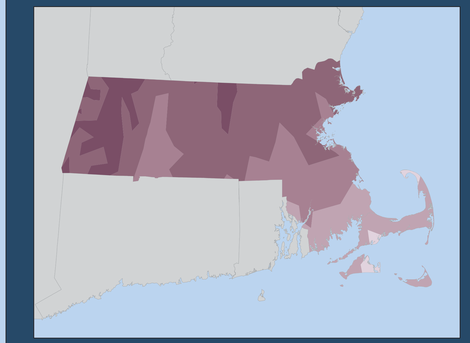
–Flood Hazard Areas
–Historic Hurricane Activity and Hurricane Risk
–Historic Average Annual Snowfall



Hurricane Tracks and Hurricane Risk



Average Annual Snowfall



Data Sources:

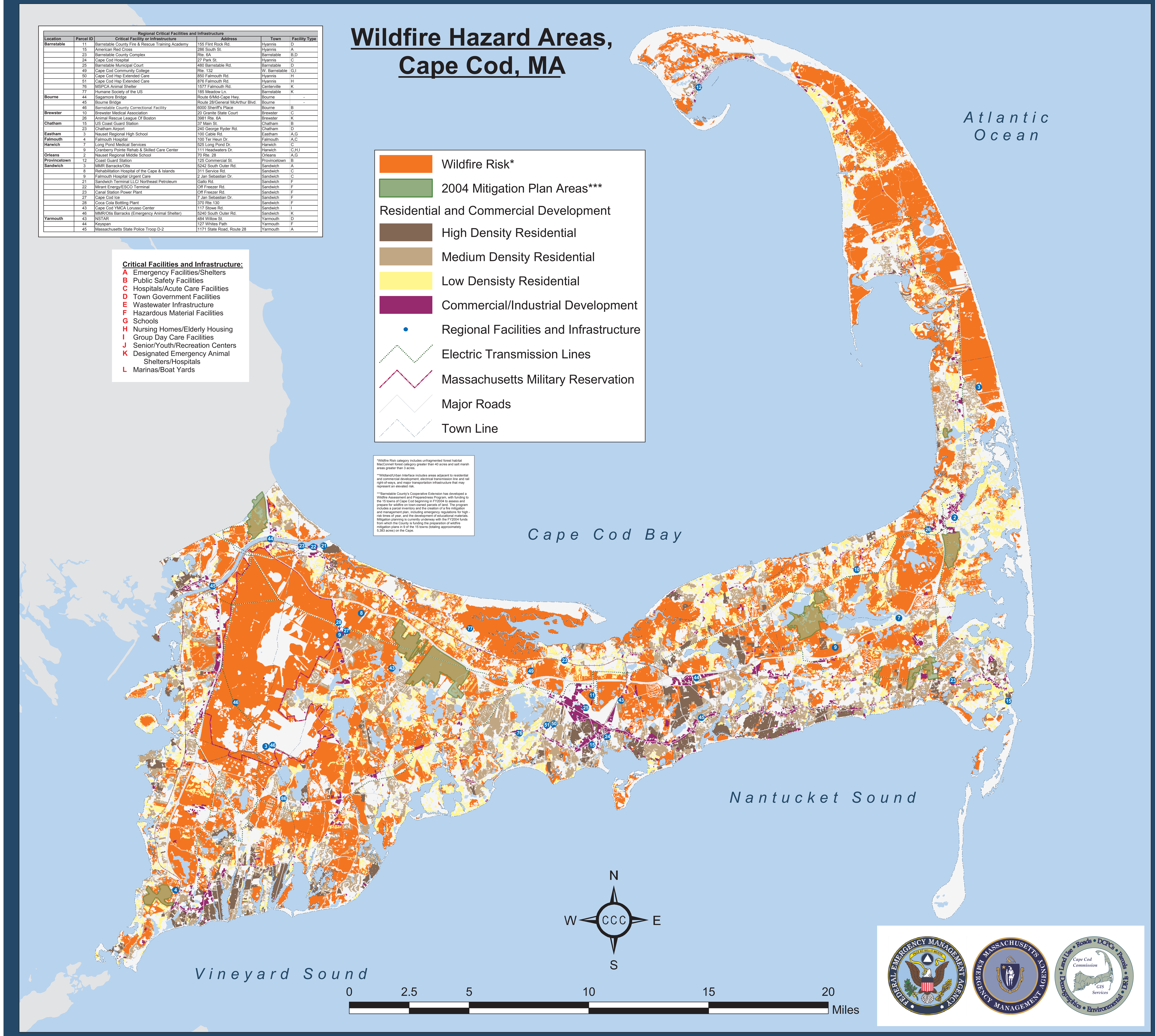
Northeast States Emergency Consortium (NESEC) www.nesec.org, MassGIS Executive Office of Environmental Affairs, Greg's Weather Center (http://hometown.aol.com/hurctrack/HurcTrack.index.html), The United States Hurricane Page (http://www.geocities.com/hurricanene/), and the Cape Cod Commission's Geographic Information System Department.

Funding for the Cape Cod Pre-Disaster Mitigation Planning grant was provided to the Cape Cod Commission by the Massachusetts Emergency Management Agency. Funding for statewide PDM planning was originally provided by the Federal Emergency Management Agency - Region I under the DMA 2000 Initiative.

This map was produced by the Cape Cod Commissions Geographic Information System Department for the Pre-Disaster Mitigation Project May 30, 2003. Comments and corrections are welcome at the Cape Cod Commission office or contact gis@capecodcommission.org. This map is illustrative and all depicted boundaries are approximate.

HazMap2_ArchE.mxd, Updated 06/14/2004

Wildfire Hazard Areas, Cape Cod, MA



Regional Critical Facilities and Infrastructure

Location	Parcel ID	Critical Facility or Infrastructure	Address	Town	Facility Type
Barnstable	11	Barnstable County Fire & Rescue Training Academy	155 Flint Rock Rd.	Hyannis	D
	15	American Red Cross	286 South St.	Hyannis	A
	23	Barnstable County Complex	Rte. 6A	Barnstable	B,D
	24	Cape Cod Hospital	27 Park St.	Hyannis	C
	25	Barnstable Municipal Court	480 Barnstable Rd.	Barnstable	D
	49	Cape Cod Community College	Rte. 132	W. Barnstable	G,I
	50	Cape Cod Hsp Extended Care	850 Falmouth Rd.	Hyannis	H
	51	Cape Cod Hsp Extended Care	876 Falmouth Rd.	Hyannis	H
	76	MSPCA Animal Shelter	1577 Falmouth Rd.	Centerville	K
	77	Humane Society of the US	185 Meadow Ln.	Barnstable	K
Bourne	44	Sagamore Bridge	Route 6/Mid-Cape Hwy.	Bourne	-
	45	Bourne Bridge	Route 28/General McArthur Blvd.	Bourne	-
	46	Barnstable County Correctional Facility	6000 Sheriff's Place	Bourne	B
Brewster	10	Brewster Medical Association	20 Granite State Court	Brewster	C
	26	Animal Rescue League Of Boston	3981 Rte. 6A	Brewster	K
Chatham	15	US Coast Guard Station	37 Main St.	Chatham	B
	23	Chatham Airport	240 George Ryder Rd.	Chatham	D
Eastham	3	Nauset Regional High School	100 Cable Rd.	Eastham	A,G
Falmouth	4	Falmouth Hospital	100 Ter Heun Dr.	Falmouth	A,C
Harwich	7	Long Pond Medical Services	525 Long Pond Dr.	Harwich	C
	9	Cranberry Pointe Rehab & Skilled Care Center	111 Headwaters Dr.	Harwich	C,H,I
Orleans	2	Nauset Regional Middle School	70 Rte. 28	Orleans	A,G
Provincetown	12	Coast Guard Station	125 Commercial St.	Provincetown	B
Sandwich	3	MMR Barracks/Otis	5242 South Outer Rd.	Sandwich	A
	8	Rehabilitation Hospital of the Cape & Islands	311 Service Rd.	Sandwich	C
	9	Falmouth Hospital Urgent Care	2 Jan Sebastian Dr.	Sandwich	C
	21	Sandwich Terminal LLC/ Northeast Petroleum	Gallo Rd.	Sandwich	F
	22	Mirant Energy/ESCO Terminal	Off Freezer Rd.	Sandwich	F
	23	Canal Station Power Plant	Off Freezer Rd.	Sandwich	F
	27	Cape Cod Ice	7 Jan Sebastian Dr.	Sandwich	F
	28	Coca Cola Bottling Plant	370 Rte.130	Sandwich	F
	43	Cape Cod YMCA Lorusso Center	117 Stowe Rd.	Sandwich	I
	46	MMR/Otis Barracks (Emergency Animal Shelter)	5240 South Outer Rd.	Sandwich	K
Yarmouth	43	NSTAR	484 Willow St.	Yarmouth	D
	44	Keyspan	127 Whites Path	Yarmouth	F
	45	Massachusetts State Police Troop D-2	1171 State Road, Route 28	Yarmouth	A

*Wildfire Risk category includes unfragmented forest habitat MacConnell forest category greater than 40 acres and salt marsh areas greater than 3 acres.

**Wildland/Urban Interface includes areas adjacent to residential and commercial development, electrical transmission line and rail right-of-ways, and major transportation infrastructure that may represent an elevated risk.

***Barnstable County's Cooperative Extension has developed a Wildfire Assessment and Preparedness Program, with funding to the 15 towns of Cape Cod beginning in FY2004 to assess and prepare for wildfire on town-owned parcels of land. The program includes a parcel inventory and the creation of a fire mitigation and management plan, including emergency regulations for high - risk times of year, and the development of educational materials. Mitigation planning is currently underway with the FY2004 funds from which the County is funding the preparation of wildfire mitigation plans in 9 of the 15 towns (totaling approximately 5,383 acres) on the Cape.

What is a Fire Hazard?

There are many types and causes of fires. Wildfires, arson, accidental fires and others all pose a unique danger to communities and individuals. America's fire death rate is one of the highest per capita in the industrialized world. Fire kills over 4,000 and injures more than 23,000 people each year. Firefighters pay a high price for this terrible fire record as well; approximately 100 firefighters die in the line of duty each year. Direct property losses due to fire exceed $8.5 billion a year. Most of these deaths and losses can be prevented! However, America's fire losses today represent a dramatic improvement from nearly 30 years ago. In 1971, this Nation lost more than 12,000 citizens and 250 firefighters to fire. This is clear evidence that mitigation and fire prevention efforts are successful.

History of Fire in New England:

Since 1985, approximately 9,000 homes have been lost to urban/wild land interface fires across the United States. The towns of Seabrook and Hampton, NH have recently experienced wildfires as well as neighboring Salisbury, MA. A Seabrook fire in 1996 was started as a controlled burn. However, due to the density of the Phragmites vegetation, the fire burned so hot, it melted the vinyl siding off a nearby house. A fire in Salisbury, MA on April 8, 1999 is indicative of the danger that Phragmites posses. This fire began in the Phragmites and within 20 minutes had consumed seven acres of the marsh. The fire then jumped a road, burned down a vacant home and threatened three other occupied dwellings. Fire fighters responding from 4 communities saved these dwellings.

Pine forests in the spring can be explosive fuel.
Pitch Pine and Scrub Oak found on the Cape burns readily an can create and explosive fire.

What is the Risk of Fire in New England?

The risk of fire is difficult to predict based on location. Some areas and structures that are surrounded by dry vegetation that has not been suitably cleared are at high risk. In addition, homes and buildings without functioning smoke detectors are at higher risk for fires that cause injury and increased damage. However, fire danger is generally universal and can occur to any home, business or community at practically any time.

When Are Wildfires Most Likely?

Wildfire season usually begins in March in coastal and southern sections, gradually extending to central, western and northern areas. The wildfire season usually ends in late November. The majority of wildfires usually occur in April and May, when home owners are cleaning up from the winter months, and when the majority of vegetation is void of any appreciable moisture making them highly flammable. Once "green-up" takes place in late May to early June, the fire danger usually is reduced somewhat.

Raging Wildfires - Could They Happen Here?

Could it happen here in the Northeast? The answer is yes and no. Western forests differ from eastern forests because they contain mostly evergreen trees that have a lot of resin in their needles. This resin burns readily, creating an almost explosive flame that rages up the crown, where it jumps easily from tree to tree.

The Northeast has many more leafy trees that generally have no resins and therefore don't burn as easily. However, there are areas here that have many evergreens-the spruce and fir in the northern regions and the "pine barrens" found on sandy sites like the Ossipee region of New Hampshire and on Cape Cod. When the Northeast has droughts, these are the areas where extensive fires tend to occur.

Western and eastern forests differ in one more important respect-precipitation. Many western forests are extremely dry. They receive most of their precipitation in hit-or-miss summer rain -storms or in winter snowfall. And because of the dry climate, the West is plagued by "dry lightning" -electrical storms without rain that often spark fires.

While the Northeast doesn't tend to have huge, rampant fires like the West, that doesn't mean there isn't any wildfire danger here. There are thousands of "fire starts" here each season, most caused by humans. Because of higher population densities and good detection by state and local authorities, fires are usually discovered quickly. They rarely burn more than a few acres. However, with more and more people living in rural wooded areas, the risk of property loss and injuries or deaths has increased. Whenever the Northeast has extremely dry conditions, there is the potential for devastating fires. In 1947, fires ripped through southern Maine and left thousands of acres charred and dozens of people homeless.

Data Sources:

MacConnell landuse: (digital) 2005.

Northeast States Emergency Consortium (NESEC) www.nesec.org, MassGIS Executive Office of Environmental Affairs, Federal Emergency Management Agency (FEMA), Cape Cod Brush Breakers Pictorial History (http://www.capecodfd.com/PAGES%20Special/Breakers00.htm), USDA Forest Service (http://www.fs.fed.us/na/durham/), and the Cape Cod Commission's Geographic Information System Department. Additional appreciation to Jeffrey Stanovich, Forest Fire Patrolman, Plymouth County, MA for his thoughtful input.

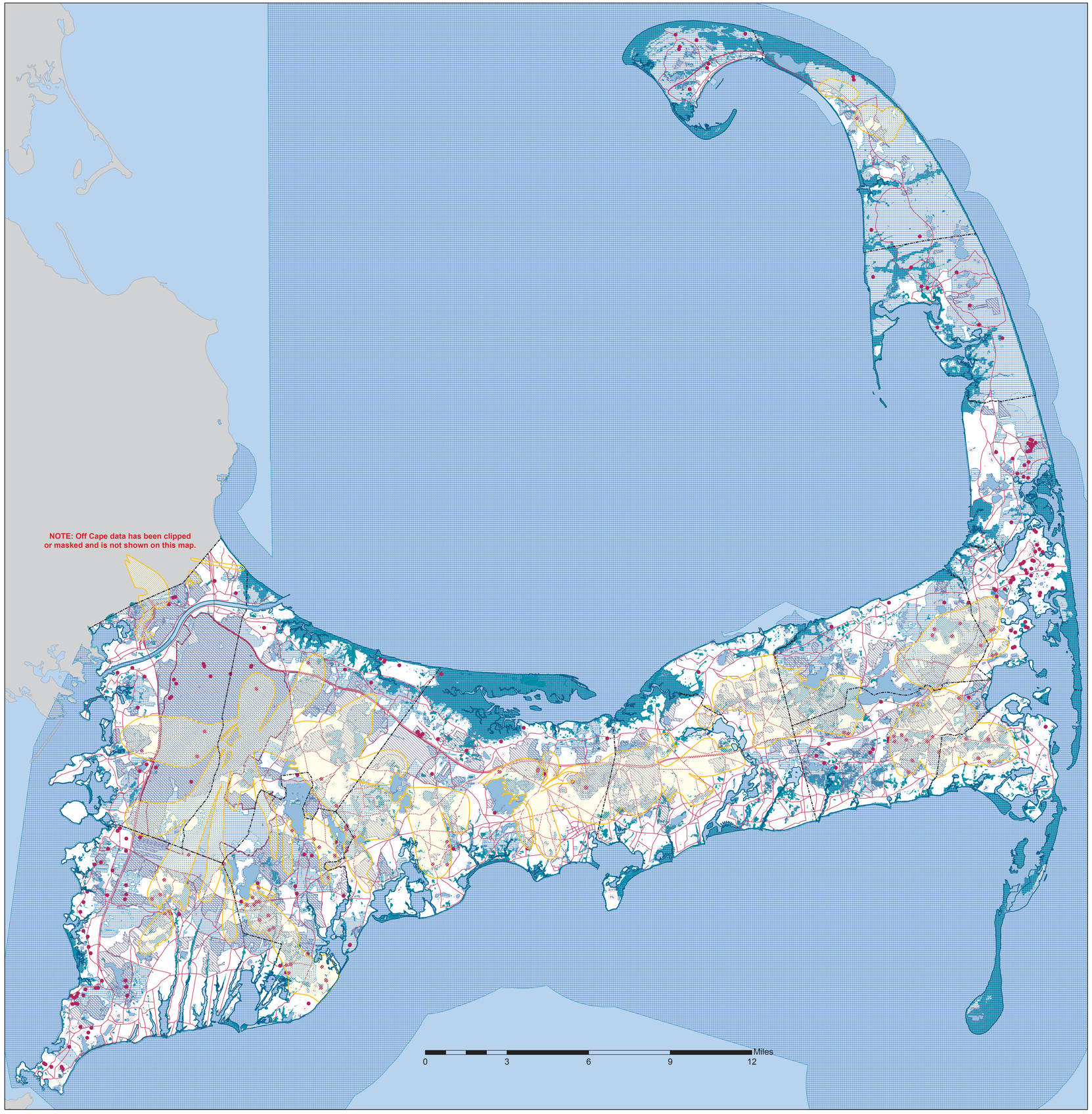
Funding for the Cape Cod Pre-Disaster Mitigation Planning grant was provided to the Cape Cod Commission by the Massachusetts Emergency Management Agency. Funding for statewide PDM planning was originally provided by the Federal Emergency Management Agency - Region I under the DMA 2000 Initiative.

This map was produced by the Cape Cod Commissions Geographic Information System Department for the Pre-Disaster Mitigation Project May 30, 2003 and updated with 2005 land use data for the Cape Cod Multi Hazard Mitigation project in 2009.

Comments and corrections are welcome at the Cape Cod Commission office. This map is illustrative and all depicted boundaries are approximate.

FireCC_RCF.mxd, Updated 08/18/2004

Cape Cod Significant Natural Resource Areas



Regional Policy Plan (Effective January 16, 2009)
Amended -- Effective July 3, 2009
Cape Cod Significant Natural Resource Areas

- Current DEP Zone II (April 2009)
- Major Roads
- 350 foot buffer of Certified Vernal Pool
- Water Body
- 300 foot buffer from pond shore
- Mass. Military Reservation
- Potential Public Water Supply Area (PLAAP)
- Priority and Estimated Habitats (NHESP 2008)
- DEP Wetland Area

Data Sources:

Habitat Information: Mass. NHESP Vernal Pools, February 2009, Priority and Estimated Habitats for Rare Species, October 2008. Identified Wellhead Protection Areas: (Zones of Contribution) 1:25,000, DEP April 2009.

Potential Public Water Supply Tracts: From the "Priority Land Acquisition Assessment Project" (PLAAP), November 2008, CCC Water Resources Office. This was the follow-up investigation of USGS's "Water Resources Investigations Report" of 1994. Also Lower Cape data from the Lower Cape Water Quality Task Force, 2001.

Wetlands: 1:12,000, April 2007 DEP Wetlands Conservancy Program.

Non - digital data was automated by the Cape Cod Commission GIS staff using the ARC/INFO GIS software.

This Map was produced by the Cape Cod Commission's Geographic Information System Department for the Regional Policy Plan update, effective January 16, 2009, with any amendments listed below:
Data amendments effective July 3, 2009 including Certified Vernal Pools, DEP Zone II, and PLAAP.

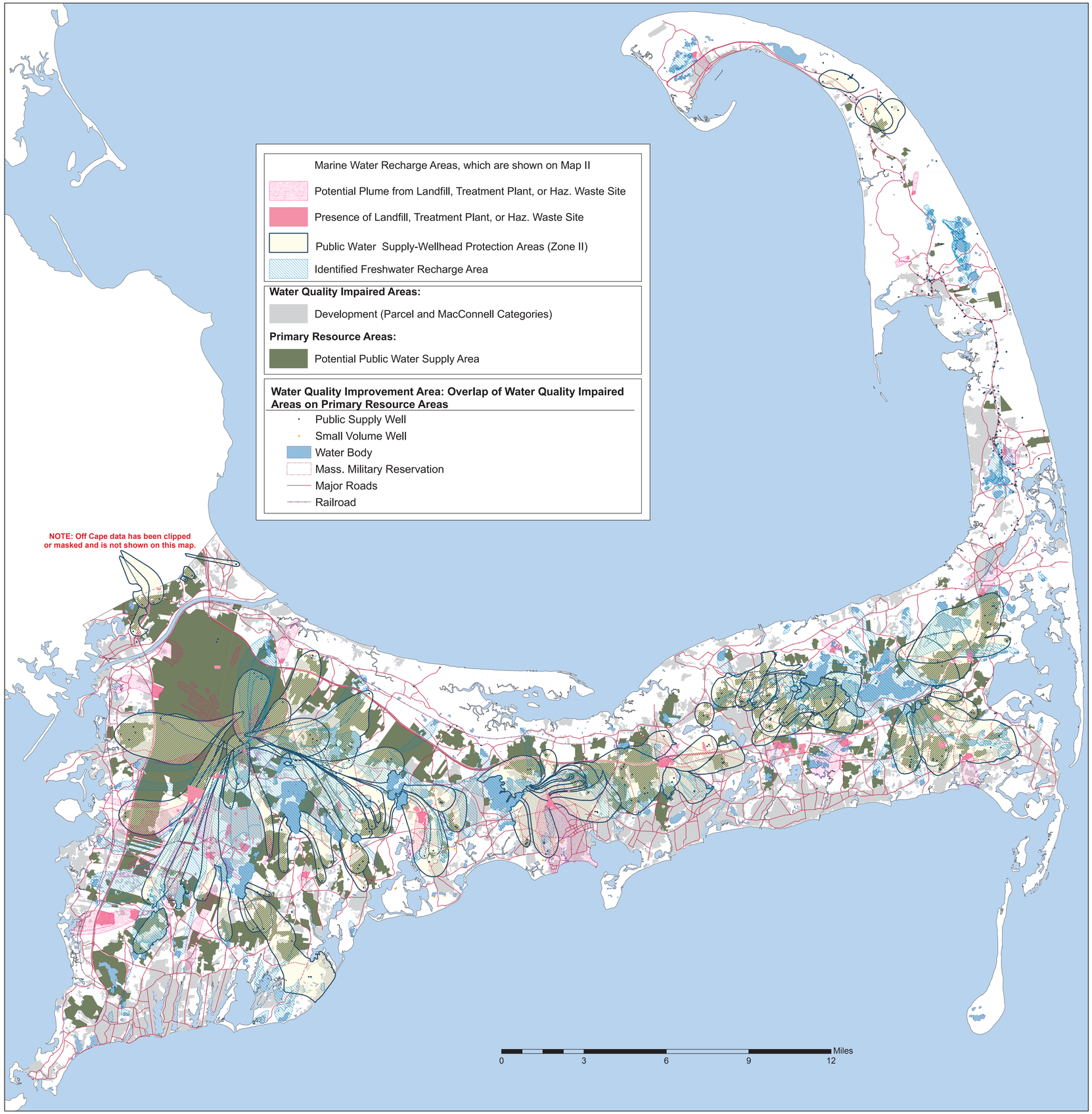
The Cape Cod Commision is a division of Barnstable County. Corrections are welcome at the Cape Cod Commission office or contact gis@capecodcommission.org.

This map is illustrative and all depicted boundaries are approximate. It is intended for planning purposes only - - not site specific purposes.

N

Land Use • Roads • DCPCs • Parcels • DRIs • Environmental • Demographics
Cape Cod Commission
GIS Services

Cape Cod Water Resources Classification Map I



Regional Policy Plan (Effective January 16, 2009)
Amended -- Effective July 3, 2009
Cape Cod Water Resources
Classification Map I

Explanation and Data Sources:

Water Quality Impaired Areas: include "development" such as unsewered residential lots less than 20,000 square feet, marinas, landfills, septage and wastewater treatment plant discharge sites; commercial and industrial areas. (determined from digital parcel and assessors' data and MacConnell land use.)

Identified Wellhead Protection Areas: (Zones of Contribution) 1:25,000, Department of Environmental Protection and MassGIS 2008, CCC Water Resources staff, and various private consulting firms.

Freshwater Recharge Area: Areas shown are those identified TO DATE by USGS (see reports 2004-5014 and 2004-5181) MEP, and CCC Water Resources Staff, 2008.

Potential Public Water Supply Tracts: From the "Priority Land Acquisition Assessment Project" (PLAAP), June 1999, updated 2008 and 2009. Lower Cape data from the Lower Cape Water Quality Task Force, 2001.

Small Volume Wells: include registered and unregistered water supplies which are likely to serve 25 or more persons per day for more than 60 days per year. (CCC Small Volume Well Inventory and Prioritization Project, DEP FY92 604(b) grant. 1996

MacConnell land use: (digital) 1999, source of the categories: medium and high density residential, multi-family residential, commercial, industrial, transportation, waste disposal, and marina; from aerial photo interpretation (1:25,000 scale). Digitized by the Resource Mapping - Land Information Systems Dept. of Forestry and Wildlife Management, U Mass, Amherst in cooperation with the EOEA MassGIS project and the Cape Cod Commission.

Non - digital data was automated by the Cape Cod Commission GIS staff using the ARC/INFO GIS software.

This Map was produced by the Cape Cod Commission's Geographic Information System Department for the Regional Policy Plan update, effective January 16, 2009, with any amendments listed below: Data amendments effective July 3, 2009 including DEP Zone II, DEP Public Supply Wells, and the Cape Cod Commission PLAAP.

The Cape Cod Commision is a division of Barnstable County. Corrections are welcome at the Cape Cod Commission office or contact gis@capecodcommission.org.

This map is illustrative and all depicted boundaries are approximate. It is intended for planning purposes only - - not site specific purposes.

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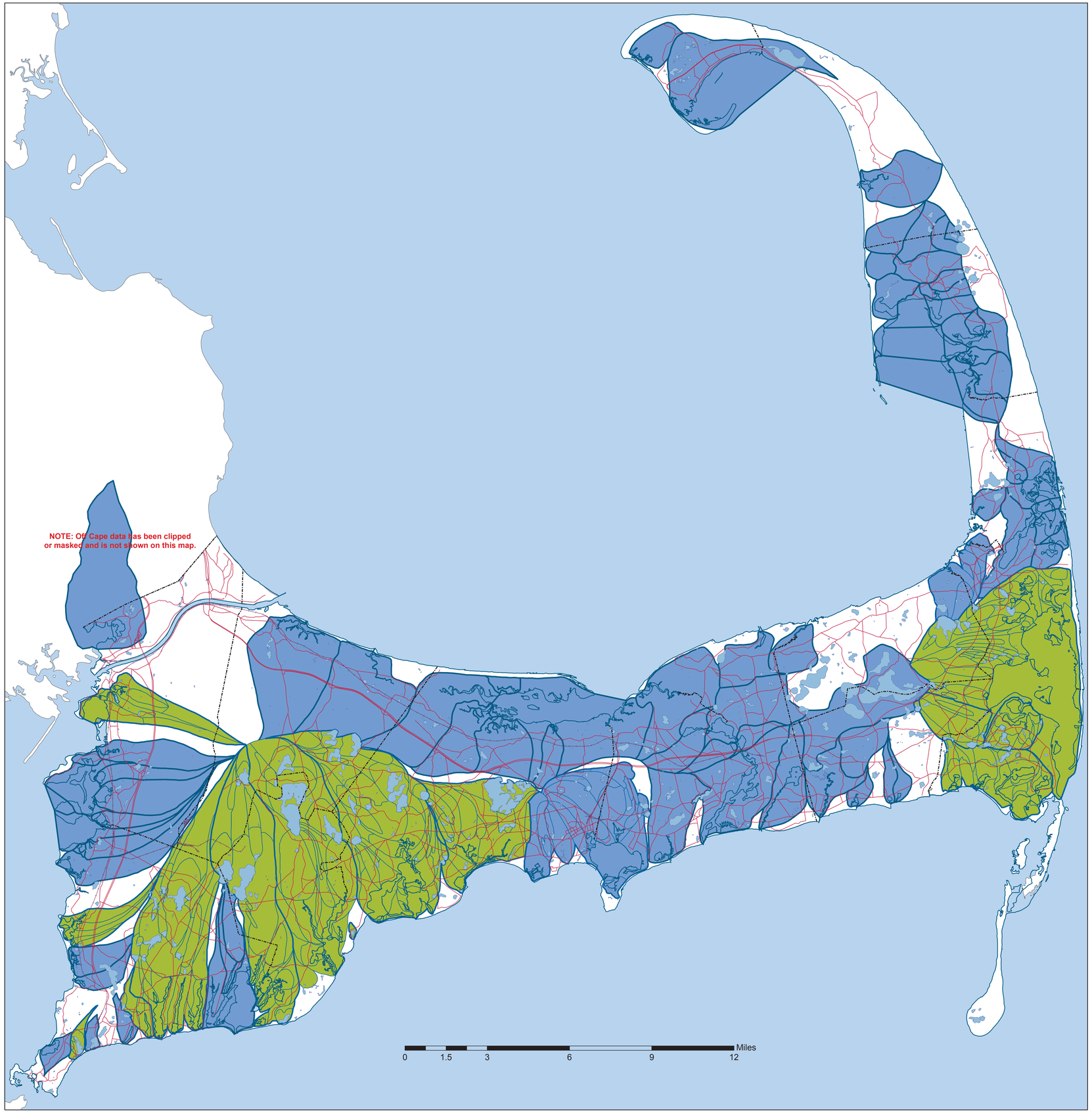
Land Use • Roads • DCPCs • Parcels • DRIs • Environmental • Demographics
Cape Cod Commission
GIS Services

Cape Cod Water Resources Classification Map II



Regional Policy Plan (Effective January 16, 2009)
Amended -- Effective July 3, 2009
Cape Cod Water Resources
Classification Map II

Marine Water Recharge Areas

- Preliminary Estuaries to be refined under Mass. Estuaries Project
- Final US EPA TMDL approved

Explanation and Data Sources:

Marine Water Recharge Areas: Watersheds and sub watershed delineations were obtained from Massachusetts Estuary Project (MEP) Technical reports, "Chapter 3, Delineation of Watersheds" for each seperate watershed. http://www.oceanscience.net/estuaries

MEP Watersheds were based upon Groundwater Modeling by the USGS Scientific Investigation Reports 2004-5014 and 2004-5181.

Preliminary Marine Water Recharge Areas: Delineated by Cape Cod Commission Water Resources Staff, 1998 for the Cape Cod Coastal Embayment Project. (Technical Memorandum: Nitrogen Sensitivity and Prioritization of Cape Cod Embayments, August 1996.)

Final State Nutrient TMDLs:
http://www.mass.gov/dep/water/resources/tmdls.htm#cape

Final EPA TMDLs:
http://www.epa.gov/region1/eco/tmdl/approved.html#ma/

Non - digital data was automated by the Cape Cod Commission GIS staff using the ARC/INFO GIS software.

This Map was produced by the Cape Cod Commission's Geographic Information System Department for the Regional Policy Plan update, effective January 16, 2009, with any amendments listed below:

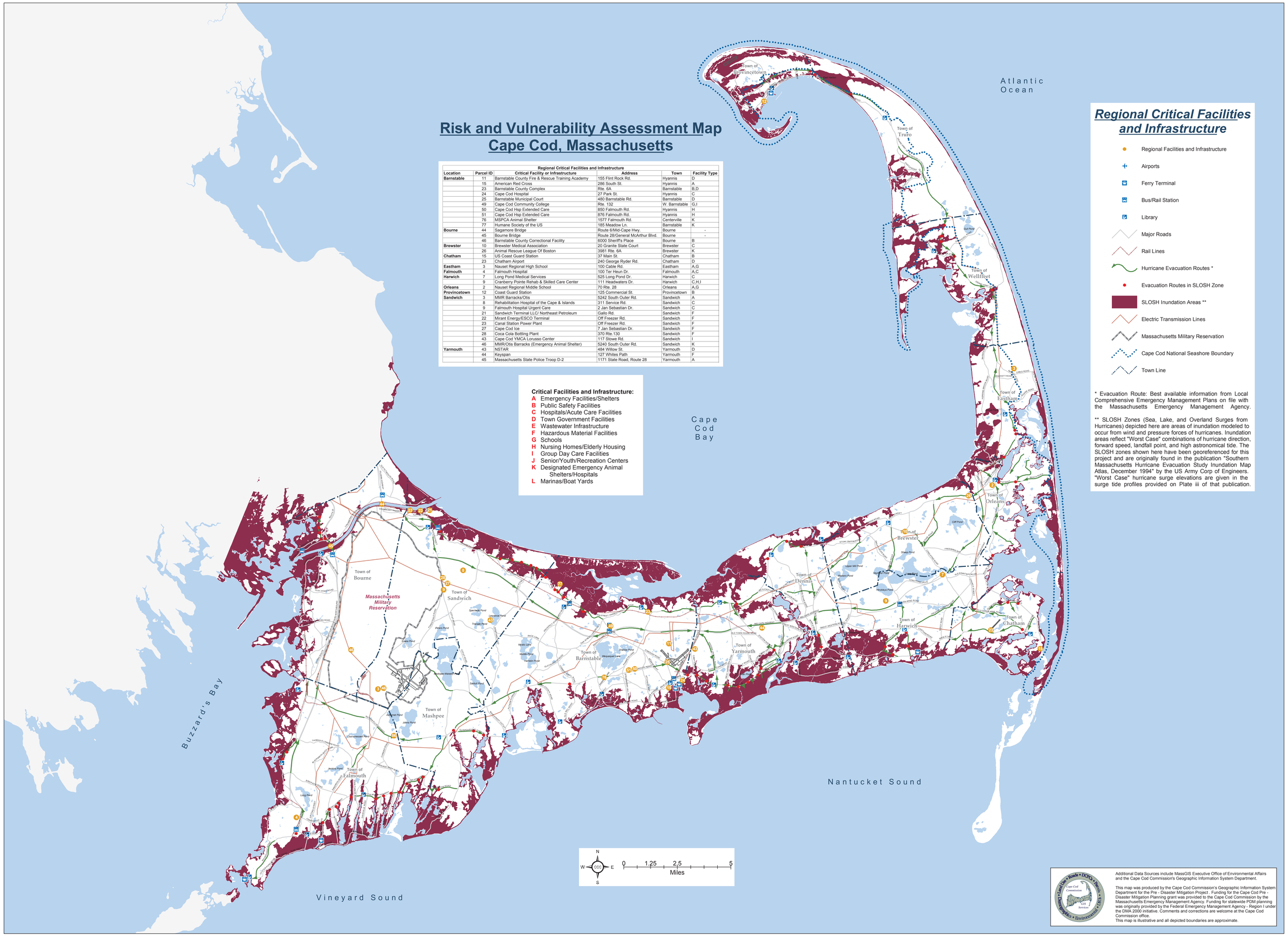
The Cape Cod Commision is a division of Barnstable County. Corrections are welcome at the Cape Cod Commission office or contact gis@capecodcommission.org.

This map is illustrative and all depicted boundaries are approximate. It is intended for planning purposes only - - not site specific purposes.

N

Land Use • Roads • DCPCs • Parcels • DRIs • Environmental • Demographics
Cape Cod Commission
GIS Services

Risk and Vulnerability Assessment Map
Cape Cod, Massachusetts



Regional Critical Facilities and Infrastructure					
Location	**Parcel ID**	**Critical Facility or Infrastructure**	**Address**	**Town**	**Facility Type**
Barnstable	11	Barnstable County Fire & Rescue Training Academy	155 Flint Rock Rd.	Hyannis	D
	15	American Red Cross	286 South St.	Hyannis	A
	23	Barnstable County Complex	Rte. 6A	Barnstable	B,D
	24	Cape Cod Hospital	27 Park St.	Hyannis	C
	25	Barnstable Municipal Court	480 Barnstable Rd.	Barnstable	D
	49	Cape Cod Community College	Rte. 132	W. Barnstable	G,I
	50	Cape Cod Hsp Extended Care	850 Falmouth Rd.	Hyannis	H
	51	Cape Cod Hsp Extended Care	876 Falmouth Rd.	Hyannis	H
	76	MSPCA Animal Shelter	1577 Falmouth Rd.	Centerville	K
	77	Humane Society of the US	185 Meadow Ln.	Barnstable	K
Bourne	44	Sagamore Bridge	Route 6/Mid-Cape Hwy.	Bourne	-
	45	Bourne Bridge	Route 28/General McArthur Blvd.	Bourne	-
	46	Barnstable County Correctional Facility	6000 Sheriff's Place	Bourne	B
Brewster	10	Brewster Medical Association	20 Granite State Court	Brewster	C
	26	Animal Rescue League Of Boston	3981 Rte. 6A	Brewster	K
Chatham	15	US Coast Guard Station	37 Main St.	Chatham	B
	23	Chatham Airport	240 George Ryder Rd.	Chatham	D
Eastham	3	Nauset Regional High School	100 Cable Rd.	Eastham	A,G
Falmouth	4	Falmouth Hospital	100 Ter Heun Dr.	Falmouth	A,C
Harwich	7	Long Pond Medical Services	525 Long Pond Dr.	Harwich	C
	9	Cranberry Pointe Rehab & Skilled Care Center	111 Headwaters Dr.	Harwich	C,H,I
Orleans	2	Nauset Regional Middle School	70 Rte. 28	Orleans	A,G
Provincetown	12	Coast Guard Station	125 Commercial St.	Provincetown	B
Sandwich	3	MMR Barracks/Otis	5242 South Outer Rd.	Sandwich	A
	8	Rehabilitation Hospital of the Cape & Islands	311 Service Rd.	Sandwich	C
	9	Falmouth Hospital Urgent Care	2 Jan Sebastian Dr.	Sandwich	C
	21	Sandwich Terminal LLC/ Northeast Petroleum	Gallo Rd.	Sandwich	F
	22	Mirant Energy/ESCO Terminal	Off Freezer Rd.	Sandwich	F
	23	Canal Station Power Plant	Off Freezer Rd.	Sandwich	F
	27	Cape Cod Ice	7 Jan Sebastian Dr.	Sandwich	F
	28	Coca Cola Bottling Plant	370 Rte.130	Sandwich	F
	43	Cape Cod YMCA Lorusso Center	117 Stowe Rd.	Sandwich	I
	46	MMR/Otis Barracks (Emergency Animal Shelter)	5240 South Outer Rd.	Sandwich	K
Yarmouth	43	NSTAR	484 Willow St.	Yarmouth	D
	44	Keyspan	127 Whites Path	Yarmouth	F
	45	Massachusetts State Police Troop D-2	1171 State Road, Route 28	Yarmouth	A

Critical Facilities and Infrastructure:

- **A** Emergency Facilities/Shelters
- **B** Public Safety Facilities
- **C** Hospitals/Acute Care Facilities
- **D** Town Government Facilities
- **E** Wastewater Infrastructure
- **F** Hazardous Material Facilities
- **G** Schools
- **H** Nursing Homes/Elderly Housing
- **I** Group Day Care Facilities
- **J** Senior/Youth/Recreation Centers
- **K** Designated Emergency Animal Shelters/Hospitals
- **L** Marinas/Boat Yards

Regional Critical Facilities and Infrastructure

- Regional Facilities and Infrastructure
- Airports
- Ferry Terminal
- Bus/Rail Station
- Library
- Major Roads
- Rail Lines
- Hurricane Evacuation Routes *
- Evacuation Routes in SLOSH Zone
- SLOSH Inundation Areas **
- Electric Transmission Lines
- Massachusetts Military Reservation
- Cape Cod National Seashore Boundary
- Town Line

* Evacuation Route: Best available information from Local Comprehensive Emergency Management Plans on file with the Massachusetts Emergency Management Agency.

** SLOSH Zones (Sea, Lake, and Overland Surges from Hurricanes) depicted here are areas of inundation modeled to occur from wind and pressure forces of hurricanes. Inundation areas reflect "Worst Case" combinations of hurricane direction, forward speed, landfall point, and high astronomical tide. The SLOSH zones shown here have been georeferenced for this project and are originally found in the publication "Southern Massachusetts Hurricane Evacuation Study Inundation Map Atlas, December 1994" by the US Army Corp of Engineers. "Worst Case" hurricane surge elevations are given in the surge tide profiles provided on Plate iii of that publication.

Additional Data Sources include MassGIS Executive Office of Environmental Affairs and the Cape Cod Commission's Geographic Information System Department.

This map was produced by the Cape Cod Commission's Geographic Information System Department for the Pre - Disaster Mitigation Project . Funding for the Cape Cod Pre - Disaster Mitigation Planning grant was provided to the Cape Cod Commission by the Massachusetts Emergency Management Agency. Funding for statewide PDM planning was originally provided by the Federal Emergency Management Agency - Region I under the DMA 2000 initiative. Comments and corrections are welcome at the Cape Cod Commission office.
This map is illustrative and all depicted boundaries are approximate.

RegionalMHM09.mxd, Updated 01/07/10

Appendix B: STAPLEE

Key: 1 = not acceptable, no; 2 = somewhat acceptable, maybe; 3 = desirable, yes. Actions	Action	Hazard Rank	S Social Acceptable	T Technically Feasible	A Administratively Possible	P Politically Acceptable	L Legal	E Economically Sound	E Environmentally Sound	Priority Score
Formally adopt a County resolution to encourage and support ongoing hazard mitigation planning.	# 1	10	3	3	3	3	3	3	3	31
Conduct a needs assessment of privately owned facilities that have regional importance (i.e hospitals, airports, day care centers)	# 2	9	2	3	3	2	3	3	2	27
Establish the Hazard Mitigation Planning Working Group to facilitate and monitor implementation of the 2010 MHM Plan.	# 3	10	3	3	3	3	3	3	3	31
Support the development of Regional and Local Climate Adaptation Plans as an extension of the MHM Plan	# 4	9	2	3	2	2	3	3	3	27
Conduct necessary activities to prepare and protect Cape Cod's cultural resources from the damaging effects of natural hazards:	# 5	10	3	2	2	3	3	3	2	28
Conduct a Sediment Mangement Study to Inform Local Sediment Mangement Planning	# 6	9	2	3	3	2	2	2	3	26

High Priority (31 - 29 points) = 2 actions
Medium Priority (28 - 26 points) = 3 actions
Low Priority (25 - 23 points) = 1 action

Appendix C: Acronym's Defined

FEMA – Federal Emergency Management Agency
PDM – Pre-Disaster Mitigation (hazard mitigation planning process, as defined by FEMA in 2004)
MHM – Multi-Hazard Mitigation (hazard mitigation planning process, as defined by FEMA in 2009)
GIS – Geographic Information Systems
BCREPC – Barnstable County Regional Emergency Planning Committee
LEPC – Local Emergency Planning Committee
RMHPT – Regional Multi-Hazard Planning Team
LMHPT – Local Multi-Hazard Planning Team
HMGP – Hazard Mitigation Grant Program
SLOSH – Sea, Lake and Overland Surges from Hurricanes
RVAM – Risk and Vulnerability Assessment Map
LIDAR – Light Imaging Detection and Radar
FIRM – Flood Insurance Rate Map
MEMA – Massachusetts Emergency Management Agency
CRS – Community Rating System

Appendix D: Local MHM Plan "Homework Assignments"

Hazard Identification & Ranking Matrix

DIRECTIONS:
This ranking matrix is intended to be a planning tool for hazard assessment purposes to help a town determine its most likely and most damaging natural hazard. Users should apply their best judgement and solicit information and knowledge from various sources (historical data and town employees) to consider as comprehensively as possible the locations at risk of damage. Note that one hazard can be the result of numerous events. For example, flooding is a natural hazard that can be caused by a hurricane, a coastal storm, a winter storm, or a nor'easter. Therefore, it is the damaging hazard, and not the event that caused it, that the Hazard Identification Matrix is intended to track.

Later in the mitigation planning process the Local Team will take the next step, which is to document where damage is anticipated to occur and what the specific impacts may be. This is done by listing specific areas of local concern including, but not limited to, known trouble spots and areas suffering chronic damage. (Teams can use the **Descriptive Location Chart** as a guide to document this information.)

Rating System
When rating location, frequency, and magnitude/severity, consider all locations where damage may occur collectively. Each natural hazard should have only one associated number. Therefore, towns will conclude this exercise with a ranking of flood, wind, fire, geologic, and any others you identify as most likely and damaging to least likely and damaging. The **hazard ranking** is determined by adding the rating scores for location, frequency, and magnitude/severity.

Location

1=small	(isolated to a specific parcel, building, intersection, or neighborhood)
2=medium	(occurring in multiple locations across town during one event)
3= large	(affecting a significant portion of town during one event)

Frequency of Occurrence

0=unlikely	(less than 1% probability in the next 100 years)
1=possible	(between 1 – 10% probability in the next year; or at least one chance in next 100 years)
2=likely	(between 10-100% probability in the next year; or at least one chance in next 10 years)
3=highly likely	(Near 100% probability in the next year)

Magnitude/Severity

1=limited	(injuries and/or illnesses are treatable with first aid; minor "quality of life" loss; shutdown of critical facilities and services for 24 hours or less; property severely damaged < 10%)
2=significant	(injuries and/or illnesses do not result in permanent disability; shutdown of several critical facilities for more than one week; property severely damaged <25% and >10%)
3=critical	(injuries and/or illnesses result in permanent disability; complete shutdown of critical facilities for at least two weeks; property severely damaged <50%, >25%)
4=catastrophic	(multiple deaths; complete shutdown of facilities for 30 days or more; property severely damaged >50%)

Natural Hazard:	*Location* *RATE:* *1=small* *2=medium* *3= large*	*Frequency of Occurrence* *RATE:* *0=unlikely* *1=possible 2=likely* *3=highly likely*	*Magnitude / Severity* *RATE:* *1=limited* *2=significant* *3=critical* *4=catastrophic*	*Hazard Ranking*
Flood				
Wind				
Fire				
Snow and Ice Accumulation				
Shoreline Change (long term change or storm induced)				
Tornado				
Earthquake				
Others?				

DESCRIPTIVE LOCATION CHART

Natural Hazard:	***Cause and Effect*** ***➪ First, identify the event that may cause a particular type of damage.*** • ***Second, what is the EFFECT of that event***	***Descriptive Location*** • *For each EFFECT - List specific areas of local concern, known trouble spots, areas suffering chronic damage, other (be as specific as possible – will lead to specific project identification)*
Flood	***(Flooding is caused by either inundation or failed infrastructure)*** ➪ **natural inundation** in the floodplain (can be caused by coastal storms; winter storms; nor'easters; hurricanes) • coastal flooding • episodic erosion • river flooding • pond flooding • dam failure • infrastructure failure (dikes, stormdrains, roadways) ➪ **infrastructure failure** (can be caused by coastal storms; winter storms; northeasters; hurricanes; ice/snow melt) • dam failure • stormdrain failure • dike failure	Coastal flooding • x intersection • y neighborhood • z street • undeveloped areas/parcels that are at risk and would be at greater risk of damage if built upon Episodic erosion • x beach Pond flooding • east bank of x's pond River flooding • X river at intersection with y road Failed infrastructure (Town is aware that the following culverts, dikes, dams are undersized or in disrepair and is afraid they may fail during the next event) • x intersection • y intersection

Natural Hazard:	***Cause and Effect*** ***➪ First, identify the event that may cause a particular type of damage.*** • ***Second, what is the EFFECT of that event***	***Descriptive Location*** • *For each EFFECT - List specific areas of local concern, known trouble spots, areas suffering chronic damage, other (be as specific as possible – will lead to specific project identification)*

Wind	➪ hurricanes
	• effect - roofs blowing off
	
	➪ nor'easters
	• effect – roofs blowing off
	
	➪ tornadoes
	• effect – roofs blowing off
		• **Roof Damage** - a concern in following locations:
		  • geographically high, exposed spots in town
		  • xyz building(s) in the xx neighborhood

Fire	➪ drought • wildfire ➪ lightning strikes • wildfire	• **Wildfire** – a concern in following locations: • provide list
Geologic	➪ earthquakes ➪ landslides • loss of land ➪ sink holes • loss of land	• any in your town?

Natural Hazard:	***Cause and Effect*** ➪ ***First, identify the event that may cause a particular type of damage.*** • ***Second, what is the EFFECT of that event***	***Descriptive Location*** • *For each EFFECT - List specific areas of local concern, known trouble spots, areas suffering chronic damage, other (be as specific as possible – will lead to specific project identification)*

Other	➪ snow and ice accumulation
	• street flooding from melt
	• impassable roads from accumulation
	• roof cave-in
	
	➪ chronic erosion
	• eroding shoreline/ acreage losses
	
	➪ sea level rise
	• eroding shoreline/ acreage losses
		• Eroding shorelines – loss of property in the following locations:
		  • x beach
		  • y beach
		  • z neighborhood in coastal zone (give streets if possible)

EXISTING PROTECTION MEASURES , TOWN OF _____				
Type of Existing Protection **[Examples below]**	**Description**	**Area Covered**	**Effectiveness and/or Enforcement**	**Improvements or Changes Needed**
Floodplain District Zoning Bylaw	requires elevation of new or improved structures in floodplain; prohibits hazardous materials in Floodplain	100-year floodplain as shown on Flood Insurance Rate Map dated July 15, 1983	enforced by zoning official; variances rarely granted; additional flood areas not included in district	include newly identified flood areas in zoning district; encourage lower development density in the district
Participation in the Community Rating System (Chatham, Orleans, Harwich only)				
Participation in the Barnstable County Cooperative Extension's Wildfire Assessment & Preparedness Program (ask your fire chief if your town made an application)				
Elevation or acquisition of flood-prone homes (indicate number that were repetitive loss structures)				
Participation in the NFIP (all 15 Cape towns are members)				
Has your town purchased any repetitive loss properties?				
Has your town purchased any property in the floodplain and taken it out of development?				
OTHERS				

Appendix E: Cape Cod Hazard Occurances

Hazard	Location	Occurance	Characteristics
Hurricanes		10/4/1869	(category)
Not Named	n/a	10/27/1872	H2
Not Named	n/a	9/19/1876	TS
Not Named	n/a	10/5/1877	TD
Not Named	n/a	8/19/1879	TS
Not Named	n/a	10/23/1880	H1
Not Named	n/a	9/26/1888	TS
Not Named	n/a	9/25/1889	TS
Not Named	n/a	9/16/1908	TS
Not Named	n/a	9/16/1908	H1
Not Named	n/a	7/22/1920	H1
Not Named	n/a	10/20/1927	H1
Not Named	n/a	9/18/1936	TS
Not Named	n/a	6/21/1938	TS
Not Named	n/a	6/21/1938	TS
Not Named	n/a	10/26/1942	TS
Not Named	n/a	10/22/1948	TS
Not Named	n/a	2/5/1956	TS
Not Named	n/a	2/5/1956	TS
Not Named	n/a	9/12/1958	TS
EDNA	n/a	7/12/1963	H1
CINDY	n/a	9/27/1965	TS
ESTHER	n/a	6/15/1970	TS
ALMA	n/a	10/10/2000	TS
JOSEPHINE	n/a	9/21/2004	TS
GORDON	n/a	10/4/1869	TD
Not Named	n/a	10/27/1872	H2
Earthquakes	(Lat/Long)		(magnitude)
Brewster	41.7/-70.09	8/8/1847	4.2
South Chatham	41.7/-70.0	3/14/1976	2.8
Falmouth	41.57/-70.609	9/12/1981	2.1
Tornadoes			
n/a	Barnstable	8/10/1972	n/a
n/a	Barnstable	8/23/1981	n/a
Other Storm Events			
Thunderstorm/Wind	n/a	6/30/1957	
Thunderstorm/Wind	n/a	8/4/1957	
Thunderstorm/Wind	n/a	8/25/1957	
Thunderstorm/Wind	n/a	8/29/1961	
Tornado	n/a	8/9/1968	
Thunderstorm/Wind	n/a	7/15/1973	
Thunderstorm/Wind	n/a	7/12/1976	
Tornado	n/a	8/22/1977	
Hail	n/a	5/28/1986	
Thunderstorm/Wind	n/a	9/16/1986	
Thunderstorm/Wind	n/a	9/16/1986	
Thunderstorm/Wind	n/a	7/10/1989	
Thunderstorm/Wind	n/a	5/21/1996	

Appendix E: Cape Cod Hazard Occurances

Thunderstorm/Wind	n/a	7/9/1996	
Thunderstorm/Wind	n/a	7/9/1996	
Hail	n/a	7/3/1997	
Hail	n/a	7/18/1997	
Hail	n/a	7/18/1997	
Thunderstorm/Wind	n/a	6/26/1998	
Hail	n/a	6/26/1998	
Hail	n/a	6/30/1998	
Hail	n/a	6/30/1998	
Thunderstorm/Wind	n/a	7/20/1998	
Hail	n/a	7/6/1999	
Thunderstorm/Wind	n/a	7/6/1999	
Hail	n/a	5/8/2000	
Hail	n/a	5/10/2000	
Thunderstorm/Wind	n/a	9/15/2000	
Thunderstorm/Wind	n/a	7/11/2001	
Hail	n/a	7/11/2001	

This information is excerpted from the National Climatic Data Center (NCDC) Weather Events Database containing data about extreme weather and climate events from the following sources:
1) All Weather Events from 1993 - 1995, as entered into Storm Data. (Except 6/93 - 7/93, which is missing)
2) All Weather Events from 1996 - Current, as entered into Storm Data. (Including Latitude/Longitude)
3) Plus additional data from the Storm Prediction Center; Including
Tornadoes 1950-1992, Thunderstorm Winds 1955-1992, Hail 1955-1992
The Storm Events Database is updated when the data becomes available to NCDC.
The data is updated on a monthly basis and is usually 90-120 days behind the current month.
To access additional information about the events listed here, use the following link:http://www4.ncdc.noaa.gov/