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CHAPTER 5. RISK ASSESSMENT OVERVIEW

5.1 THIRA PROCESS

The SHMP risk assessment process began with development of the Threat Hazard Identification and Risk Assessment (THIRA). The THIRA serves as the foundational risk assessment method for identifying hazards, assessing their risks, and analyzing their consequences for all preparedness and planning efforts in the Commonwealth. The THIRA process took into account hazards that had been documented in various plans, including the 2010 SHMP. Using this information, the Commonwealth can undertake additional risk assessment methodologies, such as the SHMP risk assessment process, to conduct more concentrated assessments of certain THIRA-identified hazards for a specific planning purpose (such as hazard mitigation planning). The THIRA serves as the risk assessment and consequence analysis process for non-natural hazards. The SHMP risk assessment process incorporated an additional, focused risk assessment for natural hazards (see Appendix A).

5.1.1 Process Guidelines

FEMA issued guidelines in 2012 that required all state administrative agencies and urban areas (designated under the Urban Areas Security Initiative) receiving FEMA Preparedness Grant funding to complete and submit a THIRA to the FEMA regional federal preparedness coordinator. The process followed for the 2012 THIRA development was established in *Comprehensive Preparedness Guide (CPG) 201*, which aligns with the planning requirements of 44 CFR 201.4 in several areas and is therefore a logical beginning for updating this plan. The basic plan development steps for the THIRA are illustrated in Figure 5-1.

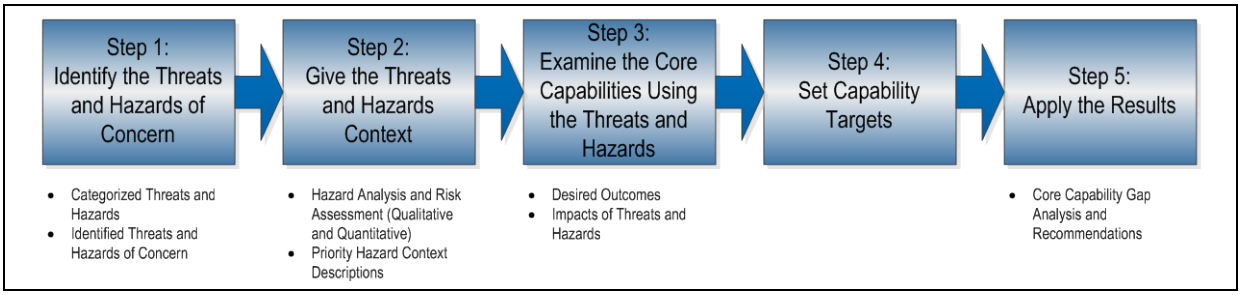

Figure 5-1. FEMA Risk Assessment Methodology

5.1.2 Identification of Hazards of Concern

To identify threats and hazards of concern for the THIRA, the SHMT reviewed the 2010 SHMP and Comprehensive Emergency Management Plan and interacted with the Commonwealth Fusion Center for hazard information. As a result of the document review and stakeholder comments, the THIRA planning process began with recognizing 21 natural hazards, six technological hazards, and 16 terrorism hazard scenarios. Of these, the following were determined to be relevant for the THIRA:

WHY THIS SECTION?

This section of the State Hazard Mitigation Plan meets the requirements of 44 CFR §201.4(c)(2)(i), which states the following:

To be effective the plan must include an overview of the type and location of all natural hazards that can affect the State, including information on previous occurrences of hazard events, as well as the probability of future hazard events, using maps where appropriate.

- Natural Hazards
  - Drought
  - Earthquake
  - Flood
  - Hurricane and Tropical Storm
  - Ice Jam
  - Ice Storm
  - Landslide
  - Pandemic (in THIRA)
  - Severe Nor'easter
  - Severe Winter Event
  - Thunderstorm
  - Tornado
  - Wind Storm
- Technological Events
  - Blackout
  - Bridge Failure
  - Commodity Shortage
  - Dam Failure
  - Nuclear Power Station Radiological Release
  - Transportation Accidents
- Terrorist Events
  - Active Shooter
  - Biological Weapon
  - Chemical Weapon
  - Cyber Attack – Data
  - Cyber Attack – Infrastructure
  - Explosive Device
  - Radiological Device

This list, developed during the kickoff meeting (see Section 2), represents the hazards of concern for the Commonwealth, including the natural hazards profiled in the 2013 SHMP update. The hazards of concern were verified during the review of local hazard mitigation plans as a part of the integration phase of this plan update. The SHMP accepts the assessment and consequence analysis completed under the THIRA for non-natural hazards. Mitigation actions associated with the non-natural hazards, in the form of enhancements to build capability to mitigate these hazards, are detailed under the THIRA, which is included in Annex 1.

5.2 NATURAL HAZARDS RISK ASSESSMENT

Building from the THIRA, the SHMP risk assessment adds further analysis for the natural hazards of concern, including a probabilistic and deterministic process as defined below and in Appendix A. This risk assessment provides a factual basis for the mitigation goals and actions proposed by the SHMP. Loss estimations based on historical losses can help to identify jurisdictions most vulnerable to impacts from hazards. Probabilistic and deterministic analysis assists in determining potential future losses, based on severity, extent, potential impact, and probability of occurrence. All this information assists at the state and local levels to form an overall strategy for the mitigation plan.

The hazard profile chapters of the plan examine the natural hazards that have the potential to impact the Commonwealth, identify counties and populations that are most vulnerable to each hazard, identify hazards of greatest concern based on the THIRA, and estimate potential losses from the hazards at the state and local levels. This statewide overview estimates potential losses by jurisdiction as well as for state facilities. The state risk assessment includes the following:

- An overview of the type and location of all natural hazards, including historical occurrences and probability of future occurrence
- An analysis of the vulnerability of state facilities to identified hazards
- An analysis of local jurisdictions' vulnerability to identified hazards
- An estimate of potential losses by jurisdiction and to state-owned facilities.
- An overview of the exposure of population, critical facilities, economy, etc. to each hazard.

The SHMT compiled data from multiple sources, including FEMA-approved regional and local hazard mitigation plans (current plans, as well as expired plans if they represent best available data); county level information from the U.S. Census; Indiana State University; various councils of

government and planning commissions; the University of Massachusetts; previous loss data; and other sources. Extensive GIS analysis and Hazus modeling was performed, integrating information from federal, state, and local sources. Each hazard profile contains updated maps, which were produced to illustrate areas at risk from natural hazards. Each hazard profile presents risks in addition to areas most vulnerable to the hazard. The following definitions apply for terms used in the risk assessment:

- Hazard—Natural (or human-caused) source or cause of harm or damage, demonstrated by actual (historical events) or potential (probabilistic) events.
- Risk—The potential for an unwanted outcome resulting from a hazard event, as determined by its likelihood and associated consequences and expressed, when possible, in dollar losses. Risk represents potential future losses, based on assessments of probability, severity, and vulnerability. In some instances, dollar losses are based on actual demonstrated impact, such as through the use of the Hazus model. In other cases, it is demonstrated through exposure analysis due to the inability to determine the extent to which a structure is impacted.
- Location—The area of potential or demonstrated impact within the region in which the analysis is being conducted. In some instances, the area of impact is within a geographically defined area, such as a floodplain. In other instances, such as for severe weather, there is no established geographic boundary associated with the hazard, as it can impact the entire Commonwealth.
- Probability—Probability is used as a synonym for likelihood, or the estimated potential for an incident to occur.
- Severity—The extent or magnitude upon which a hazard is ranked, demonstrated in various means, e.g., Richter Scale, Saffir-Simpson Hurricane Scale, Regional Snowfall Index, etc.
- Vulnerability—The degree or level of damage, e.g., building performance (functionality), damage, or the number of people injured.
- Consequence—The effect of a hazard occurrence. Consequence is demonstrated by impact on population, physical property (e.g., state facilities, local jurisdiction assets and general building stock, critical facilities), responders, operations, the environment, the economy, and public confidence in state governance. A consequence analysis meets the Emergency Management Accreditation Program standard for hazards identified in state plans.

5.3 HAZARD PROFILE REVIEW

A hazard is a phenomenon that has the potential to produce harm or other undesirable consequences to a person or thing. Hazard profiles in Sections 6 through 16 describe each natural hazard that affects the Commonwealth, the likely location of hazard impact, facilities at risk, the severity and extent of the impact, previous occurrences, and the probability of future hazard events. All hazard profiles were updated for the 2013 update with any available new information. Data from the 2010 plan were retained where it was appropriate and current. Further information on the hazard profile development process is provided in Section 1, Section 2, and Appendix A.

5.3.1 Information Sources

The 2013 hazard profiles are based on a wide range of information and data, including best available science and most current information on hazards, impacts, and the vulnerability of jurisdictions. The data collection for this plan was from February 1, 2010, through December 31, 2012.

State facilities data used in the risk assessment were provided by the Division of Capital Asset Management and Maintenance (DCAMM) (see Section 1 and Appendix A). The SHMT and SHMIC directed the revision of each hazard profile to include significant hazard events that occurred between

February 1, 2010, and December 31, 2012; added new hazard zone maps; and updated other information as necessary. Subject-matter experts from various disciplines provided relevant data, including updated studies and reports (e.g., coastal hazard data and updated earthquake and landslide data), and reviewed and updated the completed hazard profiles. This expert review ensured the accuracy and currency of information, validated the criteria used to assess vulnerability, and ensured conformity with federal requirements. Extensive GIS data from state, regional, and local sources were utilized. Data from various FEMA-approved local and multi-jurisdictional multi-hazard mitigation plans were incorporated with existing statewide data sets as applicable. The most up-to-date and accurate information available for this update was compiled from several federal sources. Appendix B lists many of the sources used. It is intended that Appendix B will be continually updated to maintain a list of resources available for local jurisdictions' use as they update their local plans. The following are key information sources used:

- Historical disaster records and documents, including, but not limited to, reports and spreadsheets maintained by MEMA as it relates to assistance made available following disasters
- Literature developed by state and national hazard experts containing best available science and most current knowledge of hazards
- Current hazard zone maps, including new Shake Maps, SLOSH models, and Q3 Flood Data
- Written and oral communication from state and national hazard experts
- State facilities inventory developed by DCAMM, with information provided by state agencies
- Federal Emergency Management Agency
- Hazard Research Laboratory, Department of Geography, University of South Carolina
- National Drought Mitigation Center, University of Nebraska-Lincoln
- National Oceanic and Atmospheric Administration (NOAA) and its agencies/programs (National Climatic Data Center and National Weather Service)
- U.S. Forest Service
- U.S. Department of Agriculture
- U.S. Geological Survey, U.S. Department of the Interior
- U.S. Army Corps of Engineers
- Office of the State Climatologist
- Other state offices, including Agriculture, Commerce/Economic Development, Health, Ecology, and Social and Health Services agencies.

5.3.2 Data Limitations

The following data limitations were identified and strategies developed to assist in future plan updates:

- Digital Flood Insurance Rate Maps are not available for all counties; however, the Commonwealth is currently working with FEMA to update maps and will continue throughout the 2013-2016 update cycle to be a technical partner in enhancing this project.
- The DCAMM facility database could not provide all of the necessary property attributes to determine potential dollar losses without making assumptions based, in part, on RS Means 2010 (see Appendix A). Enhancing these data is a continuing strategy for the 2013 plan.
- Hazard data for some hazards, such as landslides and wildland fires, were limited. The Commonwealth previously received a grant for a project to study landslide issues in the Commonwealth, as well as developing a statewide dataset for this hazard that will be

available to all local jurisdictions for use in future plan updates. This item is listed in the strategy portion of the plan as a 2013 new project.

- Limited information was available about state and local critical facilities. The Commonwealth is addressing this in a mitigation action presented in this plan (a new project for 2013) to enhance future state-level planning efforts and local planning efforts.

5.4 STATEWIDE HAZARD ASSESSMENT

To assess all natural hazards that have occurred or could occur in Massachusetts, a natural hazards risk matrix was developed. Information contained in this matrix was based on the THIRA, best available science, input from committee members, historical data concerning past hazard events, review of local plans, and input from various subject matter expertise. This process is similar to the process used for risk ranking by many local jurisdictions. Results are presented in Table 5-1. Similar information was displayed in the 2010 plan, but the table has been modified into a new format. This table also includes information with respect to the non-natural hazards as identified within the THIRA, which contains the full analysis for non-natural hazards. The assessment was based on the following categories and criteria:

- Frequency (for natural hazards only):
  - Very low: events that occur less often than once in 100 years (Less than 1% probability per year)
  - Low: events that occur from once in 50 years to once in 100 years (1% to 2% probability per year)
  - Medium: events that occur from once in 5 years to once in 50 years (2% to 20% probability per year)
  - High: events that occur more frequently than once in 5 years (Greater than 20% probability per year)
- Severity:
  - Minor: Limited and scattered property damage, limited damage to public infrastructure and essential services not interrupted, limited injuries or fatalities.
  - Serious: Scattered major property damage, some minor infrastructure damage, essential services are briefly interrupted, some injuries and/or fatalities.
  - Extensive: Widespread major property damage, major public infrastructure damage (up to several days for repairs), essential services are interrupted from several hours to several days, many injuries and/or fatalities.
  - Catastrophic: Property and public infrastructure destroyed, essential services stopped, numerous injuries and fatalities.

TABLE 5-1.
2013 HAZARD ASSESSMENT—HAZARDS OF GREATEST CONCERN

Hazard	Frequency[b]	Severity[a] Likely Level	Severity[a] Potential Worst-Case	Area of Impact	Area of Occurrence
Natural Hazards					
Flood (including Ice Jam)	High	Serious	Catastrophic	Regional	Statewide
Dam Failure	Very low	Extensive	Catastrophic	Local	Regional
Coastal Hazards	High	Serious	Extensive	Regional	Regional
Hurricane/ Tropical Storm	Medium	Serious	Catastrophic	Widespread	Statewide
Nor'easter	High	Minor	Extensive	Widespread	Statewide
Earthquake	Very low	Serious	Catastrophic	Regional	Statewide
Landslide	Low	Minor	Extensive	Local	Statewide
Snow & Blizzard (Severe Winter Weather)	High	Minor	Extensive	Widespread	Statewide
Ice Storm (Severe Winter Weather)	Medium	Minor	Extensive	Regional	Statewide
Wildland Fire	Medium	Minor	Extensive	Local	Regional
Major Urban Fires	Low	Minor	Serious	Isolated	Statewide
Thunderstorm (Severe Weather)	High	Minor	Extensive	Regional	Statewide
High Wind (Severe Weather)	High	Minor	Extensive	Regional	Statewide
Tornado (Severe Weather)	Medium	Serious	Extensive	Local	Statewide
Drought (Severe Weather)	Low	Minor	Serious	Widespread	Statewide
Extreme Temperature (Severe Weather)	Medium	Minor	Serious	Widespread	Statewide
Tsunami	Very low	Extensive	Catastrophic	Widespread	Regional
Non-Natural Hazards of Concern – Not profiled in SHMP but data are available in Annex 1					
Public Health Hazard (epidemic or pandemic)		Extensive	Catastrophic	Widespread	Widespread
Blackout		Minor	Extensive	Widespread	Widespread
Bridge Failure		Minor	Extensive	Local	Regional
Commodity Shortage		Serious	Extensive	Widespread	Widespread
Nuclear Power Station Radiological Release		Serious	Catastrophic	Widespread	Regional
Transportation Accident		Minor	Serious	Isolated	Statewide
Terrorist Related Risk - Not profiled in SHMP - Privileged data					
Active Shooter		Minor	Serious	Isolated	Statewide
Biological Weapon		Serious	Extensive	Local	Statewide
Chemical Weapon		Serious	Extensive	Local	Statewide
Cyber Attack - Data		Serious	Extensive	Widespread	Statewide
Cyber Attack – Infrastructure		Serious	Extensive	Widespread	Statewide
Explosive Device (improvised or vehicle-borne)		Serious	Catastrophic	Widespread	Statewide
Radiological Device		Extensive	Catastrophic	Local	Statewide

a. Two severity ratings were assigned for each hazard: A likely level used in the risk assessment, and a potential worst-case defined for consideration in developing the THIRA and mitigation goals and actions.
b. Frequency analysis is not included for non-natural hazards; the criteria are specific for natural hazard frequency and are not transferable. See Annex 1 for details on the non-hazards.

- Area of Impact (extent of impact on any locality for a particular event):

  - Isolated: a single whole or partial community impacted
  - Local: One community to several communities impacted
  - Regional: many communities to a county impacted
  - Widespread: multiple counties impacted
- Area of Occurrence (location and size of areas likely to experience this hazard in the future):
  - Isolated: Scattered areas around the Commonwealth can experience this hazard
  - Regional: Multiple communities and counties can experience this hazard
  - Statewide: The entire Commonwealth can experience this hazard

The completed risk assessment was reviewed and confirmed by the SHMIC during the February 6, 2013 meeting. Based on comparison of the 2010 and 2013 matrices, there were no changes in the perceived hazards of concern in the last three years. However, because of numerous enhancements in this risk assessment, there are minor differences between the Commonwealth's identified areas of impact and those identified in local plans (see Section 5.6.3). Information concerning areas of impact and notable variations in analysis are discussed in each hazard profile in this plan update.

5.4.1 Secondary Effects of Hazards

Some hazards can be a secondary effect of the occurrence of another hazard. For example, an earthquake can trigger fires, landslides, floods, ground liquefaction, or a tsunami; and an area experiencing drought is at greater risk of wildland fire. Table 5-2 shows connections among hazards, indicating that all hazards identified have at least one associated secondary risk.

5.5 STATEWIDE LOSS ESTIMATION APPROACH

5.5.1 State Facilities

The Commonwealth of Massachusetts owns and operates more than 6,000 properties and facilities. DCAMM provides state agencies with public-building design, construction, maintenance, and real estate services and manages an inventory of state property infrastructure and critical facilities. The vulnerability assessment in terms of type of facilities is outlined in detail in Section 5 and in Appendix A. There are more than 190 types of facilities in the DCAMM database that are included in this vulnerability assessment. The following list is just a short snapshot of some of the key critical facilities.

- Boat ramp
- Bridge
- Corrections
- Courthouse
- Dams/dam operations building
- Day care facility
- Docks/piers/marinas
- Electrical distribution/substation
- Fire station
- Fuel dispensing station
- Hospital / clinic
- Laboratory / research
- Library
- Marine & water transportation
- Military structure
- Miscellaneous
- Museum /monument
- Police station/barracks
- Pump house
- Residence/dormitory
- Salt/sand shed
- School
- Sewage treatment plant
- Telecommunications
- Water supply
- Office

TABLE 5-2.
SECONDARY HAZARD EFFECTS MATRIX

Primary Hazards	Structural Damage	Utility Outage	Chemical Release/ Spill	Commodity Shortages	Emergency Comm. Failure	Erosion	Structural Fire	Mold	Carbon Monoxide Poisoning	Disease	Flooding	Landslide	Dam Failure	Storm Surge	Tornado	Wildland fire	Hail	Tsunami
Coastal Erosion	X										X	X						
Coastal Flooding	X		X			X		X		X		X						
Inland Flooding	X	X	X			X		X		X		X	X					
Hurricane/ Tropical Storm	X	X	X	X	X	X		X	X	X	X	X	X	X	X			
Tornado/ Downburst	X	X	X					X										
Major Thunderstorm/ Lightning		X					X								X	X	X	
Earthquake	X	X	X	X	X		X		X	X	X	X	X					X
Winter Storms/Nor'easters	X	X		X		X	X		X		X			X				
Ice Storms	X	X		X	X		X		X									
Ice Jam	X										X		X					
Landslide	X					X												
Wildland fires	X						X											
Tsunami	X	X	X	X		X		X		X	X							
Major Urban Fire	X	X	X															
Drought				X												X		
Epidemic / Pandemic Disease				X														

The Commonwealth retained a consultant to perform the first statewide hazard analysis for state-owned property in 2002, using a previous version of this database. For the 2013 update, some of the DCAMM data were digitally enhanced with aerial photography. These data were then analyzed with FEMA's Hazus and ArcGIS software. This analysis used best available data as required by guidance. A more detailed description of the process is available in Appendix A. Some hazards, such as severe weather or severe winter storms, do not have a customary geographic boundary of impact, so statewide GIS layers were not available or were not compatible to this analysis; these are evaluated qualitatively.

Potential losses are shown in each hazard profile, as applicable. The DCAMM facility database was used to determine potential dollar losses. Where information was lacking, assumptions were made. All locations were geocoded using the ArcGIS Online North America Streets 10.0 online geocoding service. Upon initial inspection of the DCAMM Capital Asset Management Information System spreadsheet of facilities, 6,422 facilities were included; 5,398 facilities were matched via geocoding to the street, rooftop, or street name geocoding level. Out of the initial set of facilities, 916 facilities contained no address and 108 facilities would not match via coding with the address provided.

After the initial geocoding of the owned facilities data, these 1,024 facilities were sent back to DCAMM for review and to obtain additional information that would allow them to be located. Of the 1,024 facilities sent back for updating, 935 were able to be successfully located with the inclusion of additional data. This allowed for 6,333 state-owned facilities to be included in the overall analysis of state-owned

facilities, out of the 6,422 that were provided (98.6 percent). All 432 state-leased facilities were successfully geocoded, for a 100-percent return. The dataset utilized to run the 2013 state-owned and -leased facility risk analysis included information on a total of 6,765 facilities.

These data were used for a Hazus analysis to determine potential dollar losses or for an exposure analysis for hazards for which Hazus cannot be utilized. Additional information concerning the process utilized to manipulate the data into a useable format and to incorporate the information into a Hazus comprehensive data management system is contained in Appendix A.

5.5.2 Critical Facilities

All critical facilities, whether state or local, were used and obtained from MassGIS. Their data was more accurate in terms of location and more current than the default critical facility inventories in Hazus. The facility types used, in addition to those listed above, were police stations, fire stations, hospitals, emergency operation centers (state only) and schools (including pre-K through grade 12 and colleges).

5.5.3 Bridges

Included in the state impact is the potential for infrastructure failure, including bridges. Studies have shown that a bridge failure is most likely caused by an extreme event, the most prevalent type being flooding and scour. Table 5-3 lists the distribution of the Commonwealth's bridges by county.

TABLE 5-3.
BRIDGE COUNT BY COUNTY

	Number of Bridges				Area (square Miles)			
	All	Deficient[a]			All	Deficient[a]		
County	Bridges	SD	FO	Total	Bridges	SD	FO	Total
Barnstable	104	10	48	58	64,520	14,189	24,890	39,079
Berkshire	427	39	104	143	120,440	6,554	47,522	54,076
Bristol	384	51	138	189	339,293	113,296	107,948	221,244
Dukes	5	3	2	5	2,661	2,389	272	2,661
Essex	386	39	142	181	375,741	67,794	98,268	166,062
Franklin	289	56	60	116	120,528	35,708	26,781	62,489
Hampden	424	47	191	238	467,139	40,476	173,264	213,740
Hampshire	253	32	79	111	82,829	13,001	24,312	37,313
Middlesex	775	95	339	434	565,017	68,315	258,195	326,510
Nantucket	2	0	2	2	318	0	318	318
Norfolk	331	24	182	206	191,820	15,619	102,294	117,913
Plymouth	283	23	106	129	142,293	10,690	52,648	63,339
Suffolk	387	58	198	256	784,877	158,943	366,788	525,731
Worcester	986	114	390	504	488,107	47,576	214,614	262,190
Total	**5,038**	**593**	**1,981**	**2,574**	**3,745,746**	**594,711**	**1,498,114**	**2,092,825**

a. Deficiency codes: SD = Structurally Deficient/ FO = Functionally Obsolete
Source: http://www.fhwa.dot.gov/bridge/nbi/county09a.cfm#ma

Redundancy, the ability of a bridge system to sustain damage without collapse, has a significant role in the prevention of bridge failures. In a non-redundant bridge system, the failure of any one critical member may result in the collapse of all or a portion of the bridge system. In a redundant system, two or more components must fail before the bridge system collapses. There are three types of redundancy for bridges:

- *Internal Redundancy*—Internal redundancy relates to the fact that the failure of one element of a member will not result in the failure of other elements of the member. For example, riveted plate girders and multiple eye-bar truss members have internal redundancy. In a riveted plate girder, if a crack begins in one of the elements, it will not propagate directly into adjacent elements. Welded plate girders and rolled sections do not have internal redundancy.
- *Structural Redundancy*—Structural redundancy refers to the redundancy that exists as a result of continuity within the framing element. A statically indeterminate structure, such as a continuous beam, could be classified as being structurally redundant.
- *Load Path Redundancy*—Load path redundancy is related to the ability of the structure-carrying load following the loss of a single member. A bridge such as a two-girder superstructure is classified as non-redundant because it does not have any alternative load paths. The failure of a single girder in a two-girder bridge could result in failure of the entire bridge system. Another example is a single column pier.

Regularly scheduled inspections enable bridge owners to recognize the general condition of a bridge and help to detect any problems that could lead to a failure. Under the National Bridge Inspection Standards, bridges are to be inspected at regular intervals not to exceed 24 months. These schedules may vary if more rigorous requirements have been implemented at the state level.

Bridges rarely experience complete failure during non-extreme events, however when such failures do occur, the results can be catastrophic. Between 1854 and 2007, over 110 bridge failures have occurred in the United States (Cambridge, 2012). Failures occurring in Massachusetts include the following:

- Bussey Bridge, Boston, March 14, 1887—Iron Railroad Bridge collapsed due to poor construction. 30 people were killed with an additional 40 injured.
- Swing bridge in Boston-Charlestown, 1945—Ship impact with bridge while in half-open position resulted in partial collapse.
- Sullivan Square motorway bridge, Boston, 1952—Design error creating instability of scaffolding caused complete collapse.
- Tobin Bridge, September 10, 1973—An overloaded truck traveling northbound rammed into a support beam, knocking the southbound deck on the viaduct section onto the northbound deck, causing significant traffic issues. The collapse shut down the bridge for more than two months as workers repaired both decks of the collapsed viaduct section.
- High Bridge, May 28, 1999—Motorists bound for northern New England for the Memorial Day weekend experienced tire blowouts. The Massachusetts State Police shut down the bridge, and inspectors discovered that the upper deck had separated from the roadway by 8 inches because three of four rusted stringer beams supporting the upper deck had failed. (Source: http://www.bostonroads.com/crossings/zakim/)

5.5.4 Historic and Cultural Resources

The Commonwealth of Massachusetts has a rich cultural heritage and makes every effort possible to preserve that heritage. Cultural resources are an integral part of the Commonwealth's economic vitality, are essential to daily functions, and provide the continuity upon which society depends. Housed in libraries, museums, archives, city and town halls, public records repositories, museums, historical societies, cemeteries, places of worship, and historical properties, these resources represent irreplaceable

elements of the state culture. They exist in many forms: objects, records, manuscript collections, photographs, artistic works, artifacts, audio-visual collections, landscapes, and historic structures. Cultural assets serve as a reminder of the past and a driving force in present day society.

COSTEP-MA is working to protect the cultural heritage and to ensure that it is not ignored in the event of a local or regional disaster. Through its efforts in coordinating disaster mitigation, planning, preparedness, response, and recovery, COSTEP-MA has worked closely with cultural custodians, first responders, and emergency management professionals from all levels of government. Efforts to protect the Commonwealth's cultural heritage are carried out through coordinating community activities that promote cultural heritage, including educational opportunities, historic inventories, and plans essential to determining strategies for preservation. Cultural heritage resources are often valuable, vulnerable, rare, unique, and irreplaceable. They are essential to the functioning of society and to the recovery of municipalities following a disaster.

According to the COSTEP-MA website (www.mass.gov/mblc/constepma) many buildings, collections, and sites of historic and cultural significance are located in FEMA-designated flood zones. At least one quarter of Massachusetts communities have identified cultural resources that are located in flood zones.

In 2011, COSTEP-MA was awarded a hazard mitigation grant by FEMA and MEMA to conduct a three-year public awareness project on risk assessment and mitigation planning to cultural heritage collections and resources and essential government records in the Commonwealth. The project, called *Mitigation for Memory: Safeguarding Massachusetts Cultural History*, is designed to educate emergency management professionals, municipal planners and officials, regional planning agency directors, and cultural custodians. The project focuses on the importance of risk assessment and mitigation planning for cultural resources in hazard mitigation planning for the community. This grant-funded project brings together the representatives of these groups to identify the most efficient ways to integrate mitigation planning for cultural resources into the municipal plan. In addition, workshops will be conducted to train cultural heritage personnel in risk assessment and mitigation planning for their own institutions (on a micro level) as compared to the broader (macro level) of the municipal mitigation plan. The grant is being administered by the Massachusetts Board of Library Commissioners.

5.5.5 Economic Impact

This is a new element for the 2013 plan. Economic recovery after a disaster event is essential to a community's ability to rebound from the event. Resources for recovery following disasters are often limited, especially for small- and medium-sized businesses. Post-disaster business loans require a lengthy application process and often cause indebtedness to an extent greater than before the disaster occurred (Dalhamer and Tierney 1998; Runyan 2006). Given the challenges to post-disaster business recovery, it is important to understand how disasters impact businesses; how businesses recover; and how they might better prepare for extreme events.

Larger, older, and more financially stable businesses, often having previous disaster experience, are more likely than smaller businesses to engage in preparedness activities prior to a disaster event and to recover from such events (Chang and Falit-Baiamonte 2002; Dalhamer and Tierney 1998; Flynn 2007; Graham 2007; Runyan 2006; Tierney 1997; Yoshida & Deyle 2005). New businesses establishing themselves shortly after a disaster incident, when information concerning the event is still vivid in the minds of the communities, have a tendency to better prepare for such events.

Large businesses or chains often have redundant systems in place. Small, single-location businesses are more vulnerable because they lack such redundancy (Tierney, 1997). Small business owners who know about hazards of concern; have knowledge in business management, tax laws, and regulations; and have a business continuity plan are most likely to be able to recover from disaster incidents.

Small businesses typically have more difficulty managing the costs associated with rebuilding after a disaster. They are less able to meet the costs of engaging in structural mitigation and risk reduction, or

even the costs of seeking advice on how to begin the process of rebuilding the business. Even businesses that suffer no direct loss associated with a disaster, or minimal impact from which they quickly recover, continue to see impacts months afterward due to residents' lack of discretionary spending.

Economic losses at the local level impact jurisdictions in multiple ways, including loss of supplies, food, clothing, as well as economic impact supporting local governments through tax bases. Limited data were available in review of the local jurisdictional plans about hazard impacts on the economy.

5.5.6 History of Disaster Declarations

Declared Events and Related Costs

Table 5-4 provides an itemized list of state and federal disaster declarations for the Commonwealth. It includes a summary of assistance funding disbursed as a result of each past disaster declaration. The funding is distributed in the following categories:

- Public Assistance (PA) Project grants—Supplemental disaster assistance to states, local governments, and private non-profit organizations after declared disasters or emergencies.
- Hazard Mitigation Grant Program (HMGP) Project grants—To prevent future losses of lives and property due to disasters. Presidential declaration of a major disaster or emergency designated for hazard mitigation assistance.
- Individual Household Program (IHP; formerly named IFG)—Grants to individuals to provide funds for the serious needs and necessary expenses of disaster victims. NOTE: Individual assistance funding includes loans and grants under the FEMA Disaster Housing, state IFG Program and/or SBA Home and Business Loan Programs.
- Community Development Block Grant (CDBG) Project grants—Community development-type activities for long-term recovery needs (residential/commercial buildings) are covered.

TABLE 5-4.
HISTORY OF DISASTER DECLARATIONS

Disaster Name/ Disaster No.[a]	Date of Event	Declared Areas	Assistance Type[b]	Funds Disbursed		
				Federal	State	Total
Hurricane Bob/ FEMA-914-DR-MA	August 1991	Counties of Barnstable, Bristol, Dukes, Essex, Hampden, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk	PA	$28,166,029	$3,924,237	$32,090,266
			HMGP	$651,881		$651,881
Severe Coastal Storm/ FEMA –920-DR-MA	October 1991	Counties of Barnstable, Bristol, Dukes, Essex, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk	PA	$7,737,086	$983,661	$8,720,747
			IHP	$36,225,970	$581,924	$36,807,894
			HMGP	$626,406		$626,406
Winter Coastal Storm/ FEMA-975-DR-MA	December 1992	Counties of Barnstable, Dukes, Essex, Plymouth, Suffolk	PA	$11,929,598	$1,620,619	$13,550,217
			HMGP	$400,943		$400,943
Blizzard/ FEMA-3103-EM	March 1993	All 14 Counties	PA	$1,284,873	$183,649	$1,468,522
Microburst Storm/ state-declared	July 1994	Town of Greenfield	PA		$59,701	$59,701

TABLE 5-4.
HISTORY OF DISASTER DECLARATIONS

Disaster Name/ Disaster No.[a]	Date of Event	Declared Areas	Assistance Type[b]	Funds Disbursed		
				Federal	State	Total
Berkshire Tornado/ state-declared	May 1995	Towns of Egermont, Great Barrington, and Monterey; DEM and National Guard	PA		$871,633	$871,633
Russell Fire/ FEMA-2116-EM	September 1995	DEM and National Guard	PA	$79,665		$79,665
Russell Fire/ state-declared	September 1995	Towns of Russell, Blandford, Cummington, Huntington, Montgomery, and Southampton	PA		$100,000	$100,000
Blizzard/ FEMA-1090-EM	January 1996	All 14 Counties	PA	$16,177,860		$16,177,860
Windstorm/ state-declared	May 1996	Counties of Plymouth, Norfolk, and Bristol (inclusive of 27 communities)	PA		$774,388	$774,388
Franklin Co. Rainstorm	June 1996	Towns of Montague, Leverett, Shutesbury, Conway, Wendell, DEM, and National Guard			$2,267,236	$2,267,236
Severe Storms, Flood/ FEMA-1142-DR-MA	October 1996	Counties of Essex, Middlesex, Plymouth, Norfolk, and Suffolk	PA	$21.547.026	$3,430,009	$24,977,035
			IFG	$37,065,539	$478,072	$37,543,611
			HMGP	$12,262,500		$12,262,500
			CDBG FY 97	$4,259,911		$4,259,911
Heavy Rain, Flood/ FEMA-1224-DR-MA	June 1998	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, and Worcester	IFG	$20,034,025	$237.243	$20,034,025
			HMGP	$1,769,145		$1,769,145
			CDBG FY 98	$1,500,000		$1,500,000
Worcester Fire/ FEMA-3153-EM	December 1999	City of Worcester, State Fire Mobilization Communities, and various state agencies	PA	$2,733,435		
Tropical Storm Floyd/ state-declared	September 1999	Counties of Hampden, Hampshire, Franklin, Worcester (23 Communities)	PA		$1,690,539.91	$1,690,539.91
Rainstorm/ state-declared	June 25, 2000	Towns of Adams, Cheshire, New Ashford, North Adams, and Williamstown	PA		$316,210.61	$316,210.61
Rainstorm/ state-declared	July 2000	Town of Heath	PA		$180,000.00	$180,000.00
Severe Storms and Flooding/ FEMA-1364-DR-MA	March 2001	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester	IFG	$18,000,000	$213,039.00	$18,213,039.00
			HMGP	$1,562,356.00		$1,562,356.00

TABLE 5-4.
HISTORY OF DISASTER DECLARATIONS

Disaster Name/ Disaster No.[a]	Date of Event	Declared Areas	Assistance Type[b]	Funds Disbursed		
				Federal	State	Total
Snowstorm/ FEMA-3165-EM	March 2001	Counties of Berkshire, Essex, Franklin, Hampshire, Middlesex, Norfolk, and Worcester. The cost share is 75% federal and 25% local.	PA	$21,065,441.93		$21,065,441.93
Tropical Storm Allison/ state-declared	June 2001	Towns of Hampden, Leominster, Monson, Princeton, and Wilbraham	PA		$635,534.00	$635,534.00
Rainstorm/ state-declared	June/July 2001	Towns of Bellingham, Millis, and Walpole	PA		$254,968.02	$254,968.02
Terrorist Attack/ FEMA-1391	September 11, 2001	Massachusetts residents who requested crisis counseling services following September 11.	IFG	$1,500,000.00		$1,500,000.00
Snowstorm/ FEMA-3175-EM	February 2003	All 14 Counties. The cost share is 75% federal and 25% local	PA	$28,868,815.75		$28,868,815.75
Snowstorm/ FEMA-3191-EM	December 2003	Counties of Barnstable, Berkshire, Bristol, Essex, Franklin, Hampden, Hampshire, Middlesex, Norfolk, Plymouth, Suffolk, and Worcester	PA	$35,683,865.83		$35,683,865.83
Flooding/ FEMA-1512-DR	April 2004	Counties of Essex, Middlesex, Norfolk, Suffolk, and Worcester	IFG	$2,249,944.41	$62,457.61	$2,566,783.49
			HMGP	$243,225.00		$243,225.00
Snow/ FEMA-3201-EM	January 2005	All 14 Counties	PA	$49,945,087.29		$49,945,087.29
Hurricane Katrina/ FEMA-3252-EM	August 2005	All 14 Counties- 100% federally funded	PA	$5,855,580.73		$5,855,580.73
Severe Storms and Flooding/ FEMA-3264-EM	October 2005	Bristol County (Taunton Dam)	PA	$595,026.34	$56,819.60	$651,845.94
Severe Storms and Flooding/ FEMA-1614-DR-MA	October 2005	Counties of Berkshire, Franklin, Hampden, Hampshire, Worcester	PA	$6,731,194.23	$712, 674.43	$7,443,868.66
		Counties of Berkshire, Franklin, Hampden, Hampshire, Worcester, Middlesex, Plymouth, Bristol, Norfolk	IHP	$3,452,361.47	$146,281.79	$3,598,643.26
		All 14 Counties ($710,875 total as of 5/1/2009)	HMGP	$67,175.63		$67,175.63
Severe Storms and Flooding/ FEMA-1642-DR-MA	May 2006	Essex and Middlesex Counties	PA	$17,285,547.98	$5,530,431.10	$22,815,979.08
		Essex, Middlesex, Suffolk Counties	IHP	$18,355,115.63	$452,777.98	$18,807,893.61
		All 14 Counties ($2,321,506 total as of 5/1/2009)	HMGP	$240,510.00		$240,510.00
Severe Storms	April 2007		PA	$8,769,388.54	$2,805,305.76	$11,574,694.30

TABLE 5-4.
HISTORY OF DISASTER DECLARATIONS

Disaster Name/ Disaster No.[a]	Date of Event	Declared Areas	Assistance Type[b]	Funds Disbursed		
				Federal	State	Total
& Inland, Coastal Flooding/ FEMA-1701-DR-MA		All 14 Counties ($491,440 total as of 5/1/2009)	HMGP	TBD		TBD
Severe Winter Storm/ FEMA-3296-EM- MA	December 2008	Berkshire, Bristol, Essex, Franklin, Hampden, Hampshire, Middlesex, Suffolk, and Worcester.				
Severe Storms and Flooding FEMA-1813-DR-MA /	December 2008	Berkshire, Essex, Franklin, Hampden, Hampshire, Middlesex, and Worcester. ****Figure as of 9/8/2009	PA	$66,509,713.79	TBD	TBD
		All 14 Counties (6 month lock-in $7,200,000)	HMGP			
Severe Storms and Flooding/ FEMA-1895-DR-MA	March-April 2010	Bristol, Essex, Middlesex, Norfolk, Plymouth, Suffolk, Worcester	IHP	$58,954,565.86		
			PA	$25,876,403.39		
Severe Winter Storm and Snowstorm/ FEMA-1959-DR-MA	January 2011	Berkshire, Essex, Hampden, Hampshire, Middlesex, Norfolk, Suffolk	PA	$25,944,166.24		
Severe Storms and Tornadoes/ FEMA-1994-DR-MA	June 2011	Hampden, Worcester	IHP	$4,909,121.70		
			HA	$3,001,547.65		
			ON	$1,907,574.05		
Tropical Storm Irene/ FEMA-4028-DR-MA	August 2011	Barnstable, Berkshire, Bristol, Dukes, Franklin, Hampden, Hampshire, Norfolk, Plymouth	IHP	$5,551,834.20		
			HA	$5,296,447.24		
			ON	$255,386.96		
Severe Storm and Snowstorm/ FEMA-4051-DR-MA	October 2011	Berkshire, Franklin, Hampden, Hampshire, Middlesex, Worcester	PA	$71,796,736.97		
Hurricane Sandy/ FEMA-4097-DR-MA	October-November 2012	Barnstable, Bristol, Dukes, Nantucket, Plymouth, Suffolk		TBD	TBD	TBD

a. Disaster numbers are coded as follows: EM = Emergency Declaration; DR = Major Disaster Declaration; FM = Fire Management Assistance.
b. Assistance types are coded as follows: CDBG = Community Development Block Grant; HMGP = Hazard Mitigation Grant Program; IFG = Individual and Family Grant; IHP = Individual Household Program; PA = Public Assistance.

The following programs provide funding associated with disasters:

- **Special Appropriations**:
  - **Following State Disasters—**Following presidential disaster declarations, the Commonwealth may contribute half, or 12.5 percent, of the 25-percent local share of federal infrastructure support funds.
  - **Non-Federally Declared Disaster Assistance**—Although there is no separate state disaster relief fund in Massachusetts, the state legislature may enact special appropriations for communities sustaining damage following a natural disaster that are not large enough for a presidential disaster declaration. Since 1991, Massachusetts has issued 15 state disaster declarations and has provided in excess of $7 million in funding to aid communities affected by natural disasters.
- **State Revolving Fund—**This statewide loan program through the Executive Office of Environmental Affairs assists communities in funding local stormwater management projects that help to minimize or eliminate flooding in poor drainage areas.
- **State Land Acquisition & Conservation Program—**Through the Massachusetts Executive Office of Energy & Environmental Affairs, this annual multi-million dollar program purchases private property for open space, wetland protection, and floodplain preservation purposes. For instance, in 1998, the Commonwealth set a goal of protecting 200,000 acres of open space in the Commonwealth by 2010. In August 2001, less than three years later, the Commonwealth and its land protection partners had reached the halfway mark in achieving that goal (100,000 acres).
- **Major Flood Control Projects—**The Commonwealth provides 50 percent of the non-federal share on the costs of major flood control projects developed in conjunction with the U.S. Army Corps of Engineers. This program is managed by DCR.
- **Natural Resource Conservation Service PL 566 Flood Control Dams—**The Commonwealth funds the necessary engineering technical assistance and funding to operate and maintain the 25 PL 566 flood control dams located on state property.
- **National Flood Insurance Program Staff Funding—**The Commonwealth matches one staff position to FEMA's funding of National Flood Insurance Program staffing, translating to two full-time staff positions in the Flood Hazard Management Program within the DCR. These positions report directly to the federally funded NFIP manager and help implement the NFIP program in Massachusetts.

5.6 LOCAL HAZARD IDENTIFICATION AND RANKING

The 2013 risk assessment incorporates information from local hazard mitigation plans to help determine which jurisdictions are at greatest risk from the various hazards. This section describes the process of incorporating information from these plans. Descriptions of the type of analysis conducted by the local jurisdiction plans are included in plan review synopses provided in Appendix F.

5.6.1 Overview of Regional Planning Agencies

There are 13 planning regions in Massachusetts, established in 1963 under Chapter 40B of the Massachusetts General Laws. The commissions are regional advisory boards consisting of representatives from each member community. They work with partnering jurisdictions and organizations to complete mitigation plans and other planning efforts. Table 5-5 identifies the counties served by each commission. In some instances, the planning commissions cross over into other counties. In some instances, these various regions represent the geographic boundaries associated with the information captured below, and are often the agencies developing the respective hazard mitigation plan.

5.6.2 Local Jurisdiction Hazards of Concern

Review of the risk assessments in these plans shows the following:

- 83 percent of local plans list flood as a hazard of high frequency and impact.
- 94 percent of local plans list hurricanes and tropical storms as hazards of moderate or greater frequency and impact.
- 94 percent of local plans list snow and blizzard as hazards of moderate to high frequency and impact; most of these plans also list nor'easters and ice storms as hazards of moderate or greater frequency and impact.
- 67 percent of local plans list tornadoes as hazards of moderate or greater frequency and impact; most of these plans also list thunderstorms as hazards of moderate or greater frequency and impact.
- 89 percent of local plans list earthquakes as hazards of low or very low frequency and impact.
- Local plans that include an analysis of coastal hazards list coastal hazards as being of moderate or greater impact and frequency.

TABLE 5-5.
PLANNING COMMISSIONS BY COUNTY REPRESENTATION

	Barnstable	Berkshire	Bristol	Dukes	Essex	Franklin	Hampden	Hampshire	Middlesex	Nantucket	Norfolk	Plymouth	Suffolk	Worcester
Berkshire Regional Planning Commission		X												
Cape Cod Commission	X													
Central Massachusetts Regional Planning Commission														X
Franklin Regional Council of Governments						X								
Martha's Vineyard Commission				X										
Merrimack Valley Planning Commission					X									
Metropolitan Area Planning Council					X				X		X	X	X	X
Montachusett Regional Planning Commission									X					X
Nantucket Planning & Economic Development Commission										X				
Northern Middlesex Council of Governments									X					
Old Colony Planning Council			X								X	X		
Pioneer Valley Planning Commission							X	X						
Southeastern Regional Planning & Economic Development District			X								X	X		

Figure 5-2 identifies the most common hazards addressed in the local plans.

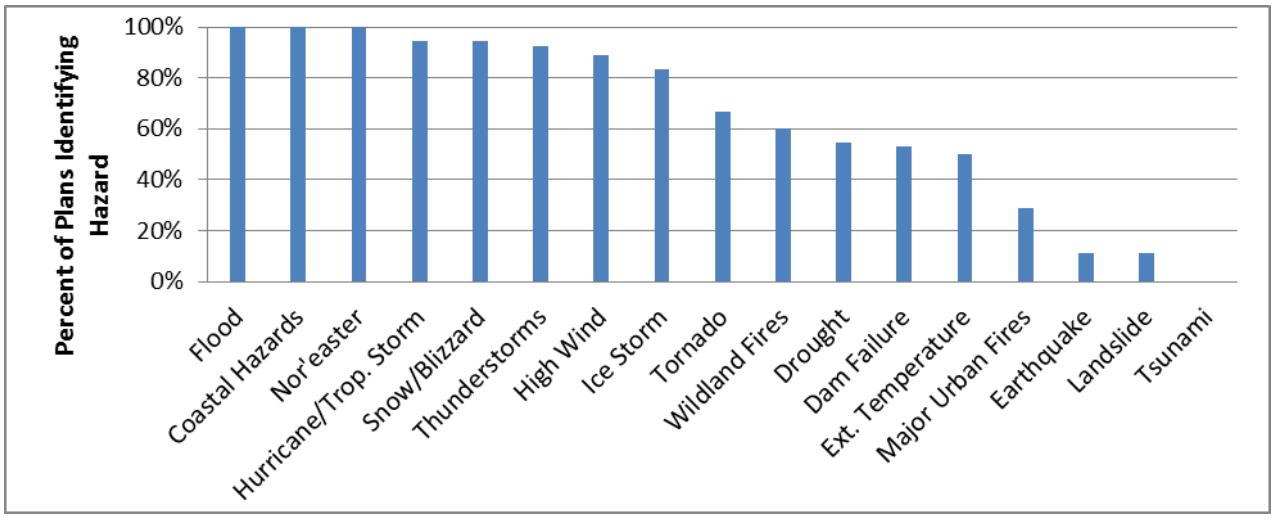

Figure 5-2. Hazards Identified in Local Plans

The top 10 hazards identified in the local plans are as follows:

- Flood: moderate risk or greater in 100% of plans
- Coastal Hazards: moderate risk or greater in 100% of plans
- Nor'easter: moderate risk or greater in 100% of plans
- Hurricane/Trop. Storm: moderate risk or greater in 94.4% of plans
- Snow/Blizzard: moderate risk or greater in 94.4% of plans
- Thunderstorms: moderate risk or greater in 92.3% of plans
- High Wind: moderate risk or greater in 88.9% of plans
- Ice Storm: moderate risk or greater in 83.3% of plans
- Tornado: moderate risk or greater in 66.7% of plans
- Wildland Fires: moderate risk or greater in 60.0% of plans

A review was conducted of risk assessments by each planning commission, and a limited number of local plans were incorporated. Where a regional plan was developed, its hazard ranking was used. Where multiple single jurisdiction plans were developed, the most commonly indicated rank was used. This subjective assessment represented the best available science. This is the same process previously followed for the 2010 plan update. Table 5-6 summarizes the findings of the review.

TABLE 5-6.
HAZARD FREQUENCY TOTALS, REGIONAL PLANNING COMMISSIONS

	Flood	Dam Failure	Coastal Hazards	High Wind	Hurricanes/ Tropical Storms	Thunderstorms	Tornado	Nor'easter	Snow and Blizzard	Ice Storm	Major Urban Fires	Wildland Fires	Drought	Extreme Temperatures	Earthquake	Landslide	Tsunami	**Hazard Rank Total**
Statewide	4	1	4	4	3	4	3	4	4	3	2	3	2	3	1	3	1	**49**
Berkshire	4	3			3	3	2		4	4		3	1		1			**28**
Cape Cod	4		4	3	3	3	2	3	3			2	2		2			**31**
Franklin County	3	1		4	3	4	3	4	4	4		3			2			**35**
MAPC (Average)	4	3		3	3	3	3	4	4	4	2	3	2	2	2	2		**44**
Merrimack Valley	4	3	4		3		2	4	4	4	3	3	3		2	2		**41**
Nantucket	4		4	2	2	3	3	4	4	3	2	3		2	2			**38**
Northern Middlesex	4	3		3	3	3	3	3	4	3			3	3	2			**37**
Old Colony	4	4	4	4	4	4	4	4	4			4			1	3	2	**46**
SRPEDD	4	3	3	3	3	3	3	3	3			3	3		2	2		**38**
Martha's Vineyard	3	1	4		3	3	1	4	2	1		2	3		1	1		**29**
PVPC Hampden County	4	2			3		3		4	4		2	2		2			**26**
PVPC Hampshire County	4	2			3		3		4	4		2	2		2			**26**
Montachusett Region	4	3			3	4	3		4	3	3	4	3		3	2		**39**
Central MA Regional Planning Commission	3	2			3	2	3	3	3	2	2	2	3	3	2	1	1	**35**

Hazard Coding: 1. Very Low | 2. Low | 3. Medium | 4. High | Not Ranked

5.6.3 County-by-County Hazard Ranking

Review of the plan demonstrates that the local jurisdictions assessed risk in various ways, as well as addressing different hazards of concern. Many used a methodology similar to that used for the state hazard-ranking (see Section 5.4). The Northeast Middlesex Council of Governments assessed hazards based on a scale of low, low-moderate, moderate, moderate-high, and high, with data from local Comprehensive Emergency Management Plans (NMCOG, 2012). Others used significantly different methods, establishing point systems and different groupings of hazards. To overcome these variations, risk assessment results from local plans were compared to the analysis using the criteria of high-medium-low and very-low at the county level (coordinating with the 4, 3, 2, 1-based analysis). The information represented at the county level was extracted during plan review.

Table 5-7 indicates whether the hazard is identified in each local plan, to what level the hazard is ranked (high, medium, low, very low), and whether the Commonwealth's analysis found the hazard to be of concern within the county as a result of the Commonwealth's assessment.

TABLE 5-7.
HAZARD RANKING COMPARISON

	Barnstable	Berkshire	Bristol	Dukes	Essex	Franklin	Hampden	Hampshire	Middlesex	Nantucket	Norfolk	Plymouth	Suffolk	Worcester
Flood														
State	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Local	H	H	H	M	H	M	H	H	H	H	H	H	H	M
Coastal Hazards														
State	Y	N	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	N
Local	H	N/R	M	H	H	N/R	N/R	N/R	N/R	H	N/R	H	N/R	N/R
High Wind														
State	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Local	M	N/R	M	N/R	N/R	H	N/R	N/R	M	L	M	H	M	N/R
Hurricane/ Tropical Storms														
State	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Local	M	M	M	M	M	M	M	M	M	L	M	H	M	M
Thunderstorms														
State	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Local	M	M	M	M	N/R	H	N/R	N/R	M	M	M	H	M	M
Tornado														
State	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y
Local	L	L	M	VL	L	M	M	M	M	M	M	H	M	M
Nor'easter														
State	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Local	M	N/R	M	H	H	H	N/R	N/R	M	H	H	H	M	M
Wildland Fires														
State	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Local	L	M	M	L	M	M	L	L	M	M	M	H	M	L
Earthquake														
State	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Local	L	VL	L	VL	L	L	L	L	L	L	VL	VL	L	L
Landslide														
State	N	Y	N	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
Local	N/R	N/R	L	VL	L	N/R	N/R	N/R	L	N/R	VL	M	L	VL

N/R = Not Ranked by Local Jurisdiction's Hazard Mitigation Plan; H= High Hazard Ranking, M = Medium Hazard Ranking, L = Low Hazard Ranking, VL = Very Low Hazard Ranking

If there is a level of risk determined, there is an indication of "Y" for yes. If there was no indication of risk associated, there is an indication of "N" for no. In some instances, the Commonwealth's risk assessment determined that a jurisdiction was vulnerable to the hazard, while the jurisdiction did not address the hazard or assessed "no risk" to the hazard. Based on limited response to some of the hazards, only the top 10 hazards of concern identified by the local jurisdictions are compared.

5.6.4 Review of Previous Disaster Events

Table 5-8 shows the distribution of federal and state disaster declarations by affected county. In some instances, the state emergency declaration did evolve into a federal declaration, so the incidents may be indicated twice within the table.

TABLE 5-8.
HISTORY OF FEDERAL DISASTER DECLARATIONS, 1953 – 2012

Disaster No. [a]	Disaster Type	Date	Incident Period	Barnstable	Berkshire	Bristol	Dukes	Essex	Franklin	Hampden	Hampshire	Middlesex	Nantucket	Norfolk	Plymouth	Suffolk	Worcester	**Total by Disaster**
EM-3350	Hurricane Sandy	10/28/12	10/27/12 - 11/8/12	X	X	X	X	X	X	X	X	X	X	X	X	X	X	**14**
EM-3343	Severe Storm	11/01/11	10/29/11 - 10/30/11		X			X	X	X	X	X		X			X	**8**
EM-3330	Hurricane Irene	08/26/11	8/26/11 - 9/5/11	X	X	X	X	X	X	X	X	X	X	X	X	X	X	**14**
EM-3315	Hurricane Earl	09/02/10	9/1/10 - 9/4/10	X		X	X	X				X	X	X	X	X	X	**10**
EM-3312	Water Main Break	05/03/10	5/1/10 - 5/5/10					X				X		X		X		**4**
EM-3296	Severe Winter Storm	12/13/08	12/11/08 - 12/18/08		X	X		X	X	X	X	X				X	X	**9**
EM-3264	Severe Storms and Flooding	10/19/05	10/7/05 - 10/22/05			X												**1**
EM-3252	Hurricane Katrina Evacuation	09/13/05	8/29/05 - 10/1/05	X	X	X	X	X	X	X	X	X	X	X	X	X	X	**14**
EM-3201	Snow	02/17/05	1/22/05 - 1/23/05	X	X	X	X	X	X	X	X	X	X	X	X	X	X	**14**
EM-3191	Snow	01/15/04	12/6/03 - 12/7/03	X	X	X		X	X	X	X	X		X	X	X	X	**12**
EM-3175	Snowstorm	03/11/03	2/17/03 - 2/18/03	X	X	X	X	X	X	X	X	X	X	X	X	X	X	**14**
EM-3165	Snowstorm	03/28/01	3/5/01 - 3/7/01		X			X	X		X	X		X			X	**7**
EM-3153	Fire	12/06/99	12/3/99 - 12/13/99					X				X		X	X	X	X	**6**
EM-3119	Extreme Weather/ Flooding	10/23/96	10/20/96 - 10/25/96															**0**
EM-3103	Blizzards, High Winds and Record Snowfall	03/16/93	3/13/93 - 3/17/93	X	X	X	X	X	X	X	X	X	X	X	X	X	X	**14**
EM-3059	Blizzard and Snowstorm	02/07/78	02/07/78													X		**1**

TABLE 5-8.
HISTORY OF FEDERAL DISASTER DECLARATIONS, 1953 – 2012

Disaster No. [a]	Disaster Type	Date	Incident Period	Barnstable	Berkshire	Bristol	Dukes	Essex	Franklin	Hampden	Hampshire	Middlesex	Nantucket	Norfolk	Plymouth	Suffolk	Worcester	**Total by Disaster**
FM-2116	Russell Fire	09/12/95	09/05/95															**0**
DR-4097	Hurricane Sandy	12/19/12	10/27/12 - 11/8/12	X		X	X						X		X	X		**6**
DR-4051	Severe Storm And Snowstorm	01/06/12	10/29/11 - 10/30/11		X				X	X	X	X					X	**6**
DR-4028	Tropical Storm Irene	09/03/11	8/27/11 - 8/29/11	X	X	X	X		X	X	X			X	X			**9**
DR-1994	Severe Storms and Tornadoes	06/15/11	06/01/11							X							X	**2**
DR-1959	Severe Winter Storm and Snowstorm	03/07/11	1/11/11 - 1/12/11		X			X		X	X	X		X		X		**7**
DR-1895	Severe Storm and Flooding	03/29/10	3/12/10 - 4/26/10			X		X				X		X	X	X	X	**7**
DR-1813	Severe Winter Storm and Flooding	01/05/09	12/11/08 - 12/18/08		X			X	X	X	X	X					X	**7**
DR-1701	Severe Storms, Inland & Coastal Flooding	05/16/07	4/15/07 - 4/25/07	X	X		X	X	X	X	X				X			**8**
DR-1642	Severe Storms and Flooding	05/25/06	5/12/06 - 5/23/06					X				X				X		**3**
DR-1614	Severe Storms and Flooding	11/10/05	10/7/05 - 10/16/05		X	X			X	X	X	X		X	X		X	**9**
DR-1512	Flooding	04/21/04	4/1/04 - 4/30/04					X				X		X		X	X	**5**
DR-1364	Severe Storms & Flooding	04/10/01	3/5/01 - 4/16/01			X		X				X		X	X	X	X	**7**
DR-1224	Heavy Rain And Flooding	06/23/98	6/13/98 - 7/6/98			X		X				X		X	X	X	X	**7**
DR-1142	Severe Storm/ Flooding	10/25/96	10/20/96 - 10/25/96					X				X		X	X	X		**5**
DR-1090	Blizzard	01/24/96	1/7/96 - 1/13/96	X	X	X	X	X	X	X	X	X	X	X	X	X	X	**14**
DR-975	Winter Coastal Storm	12/21/92	12/11/92 - 12/13/92	X			X	X				X	X	X	X	X	X	**9**
DR-920	Severe Coastal Storm	11/04/91	10/30/91 - 11/2/91	X			X	X					X	X	X	X		**7**
DR-914	Hurricane Bob	08/26/91	08/19/91	X		X	X	X		X		X	X	X	X	X	X	**11**

TABLE 5-8.
HISTORY OF FEDERAL DISASTER DECLARATIONS, 1953 – 2012

Disaster No. [a]	Disaster Type	Date	Incident Period	Barnstable	Berkshire	Bristol	Dukes	Essex	Franklin	Hampden	Hampshire	Middlesex	Nantucket	Norfolk	Plymouth	Suffolk	Worcester	**Total by Disaster**
DR-790	Severe Storms, Flooding	04/18/87	3/30/87 - 4/13/87		X			X	X	X	X	X		X			X	**8**
DR-751	Hurricane Gloria	10/28/85	09/27/85	X	X	X	X	X	X	X	X	X		X	X	X	X	**13**
DR-650	Urban Fire	12/03/81	12/03/81					X										**1**
DR-546	Coastal Storms, Flood, Ice, Snow	02/10/78	2/6/78 - 2/8/78	X		X	X	X					X	X	X	X		**8**
DR-405	Fire (City of Chelsea)	10/16/73	10/16/73													X		**1**
DR-357	Toxic Algae in Coastal Waters	09/28/72	09/28/72	X		X	X	X					X	X	X	X		**8**
DR-325	Severe Storms, Flooding	03/06/72	03/06/72					X						X	X	X		**4**
DR-43	Hurricane/ Floods	08/20/55	08/20/55															**0**
DR-22	Hurricanes	09/02/54	09/02/54															**0**
DR-7	Tornado	06/11/53	06/11/53															**0**
			Total	**18**	**19**	**21**	**17**	**33**	**18**	**20**	**19**	**28**	**14**	**29**	**25**	**29**	**25**	
			Major Disaster Declaration	**10**	**9**	**11**	**10**	**20**	**8**	**11**	**9**	**15**	**7**	**17**	**16**	**17**	**13**	**28**

a. Disaster numbers are coded as follows: EM = Emergency Declaration; DR = Major Disaster Declaration; FM = Fire Management Assistance. Some EM declarations may have become major federal declarations and are listed in both categories.

When determining the level of risk to which a jurisdiction is susceptible, consideration must also be given to events that do not rise to the level of a FEMA or state-declared disaster event. Review of National Climatic Data Center (NCDC) data for various hazards demonstrates a higher number of events that have occurred than those which rose to the level of a state- or federal-declared event. Review of the online Spatial Hazard Event and Losses Database demonstrates similar data.

Information in this section is obtained from sources including local plans, FEMA website, state disaster data, NOAA, NCDC, and reports and studies on the state's drought assessment, climate change, and various fire analyses. These data demonstrate that, while FEMA disaster declarations are customarily used to determine a jurisdiction's level of risk, most jurisdictions sustain damage much more frequently for incidents that are not recognized declared disasters, but nonetheless have significant impacts. The following are examples of costs associated with disasters not declared:

- The Commonwealth as a whole has never sustained a state or federal drought declaration, but the 2010 analysis recognized six counties for drought incidents. Analysis for this update found that jurisdictions in 10 counties (Barnstable, Bristol, Dukes, Essex, Middlesex, Nantucket, Norfolk, Plymouth, Suffolk, and Worcester Counties) sustained drought impacts since 2010.

- Four counties have sustained significant urban fires, but only two were state or federal declared disasters. Worcester County listed two major urban fires in its plan. Since 2010, one additional event occurred in the county, as well as three incidents in Berkshire, Eastern Hampden, and Western Norfolk. While several fires are designated by multiple counties, only one has risen to the level of a FEMA declaration for fire management assistance—the 1995 Russell Fire (FM-2116), and two for disaster declarations—the 1981 Urban Fire (DR-650), and the 1973 City of Chelsea Fire (DR-405).
- Main water supply lines (Massachusetts Water Resources Authority) were impacted in four counties, causing the need to boil water throughout the greater Boston area on May 1, 2010, which rose to the level of a state declaration.

Eight counties have sustained a disaster declaration for fish loss due to toxic algae blooms, which resulted in an "estimate of economic impact due directly to lost shellfish sales in Massachusetts and Maine as a result of imposed closures at approximately $20 million (based on historical state and NOAA National Marine Fisheries Service annual harvest data)" (Council on Environmental Quality, 2008). The NCDC database lists eight events in Berkshire County. Two rose to the level of state or federal declarations (DR-1895 and DR-4028); the remainder were events that caused flooding over roadways. In one case a public park was partially flooded and structures with basements experienced some minor flooding. Since 1953, there have been 45 federally declared disaster events: 16 emergency declarations; one fire management declaration; and 28 major disaster declarations. A breakdown of those events is as follows (the total is greater than 45 because disaster events may fall into more than one category):

- 20 primarily involved flooding
- 3 primarily involved tornadoes
- 12 were blizzards, major snowstorms or severe winter storms
- 11 were severe weather events
- 2 were major fires.

This information indicates that while some areas may not reach the level of a disaster declaration, they are, in fact, significantly impacted by hazard events, increasing their level of vulnerability. In general, there has been minimal change in hazard risk or any increased risk by a jurisdiction since completion of the 2010 plan, but additional events in the past three years have increased overall impact.

5.7 LOCAL PLAN LOSS ESTIMATION APPROACH

The previous section assessed and ranked the natural hazards that are most likely to occur in Massachusetts. This section provides additional information on how natural hazards may impact a particular jurisdiction.

5.7.1 Limitations of Local Plan Loss Estimates

Since each region or local community analyzed losses differently (if at all), it is not possible to represent the information comparatively across the Commonwealth. The Commonwealth has endeavored during the 2013 update, to demonstrate loss data in different ways to ensure that adequate information of varying types is available to help fulfill the requirement to the best level possible based on available data. This includes, where possible, loss estimations captured from within the local plans selected for integration within this portion of the plan.

Due to the number of plans in place, information from randomly selected plans was incorporated within this section. While a range of plans were reviewed, that range includes the largest City within the Commonwealth, Boston, down to some of its smallest cities so as to provide a well-rounded perspective. Selected plans show variety with respect to: the hazards identified, type of risk assessment completed, availability of dollar loss estimations, risk matrices (where available) to rank the hazards of concern, as well as review of the goals and mitigation actions identified.

Use of loss data from local hazard mitigation plans is restricted by three major factors: absence of loss data in the local plans, inconsistent methods for determining losses, and inconsistent designations of critical facilities. These limitations are described in the sections below.

WHY THIS SECTION?

This section of the State Hazard Mitigation Plan meets the requirements of 44 CFR §201.4(c)(2)(ii & iii), which state the following:

To be effective the plan must include:

- An overview and analysis of the State's vulnerability to the hazards described in this paragraph §201.4(c)(2), based on estimates provided in local risk assessments as well as the State risk assessment. The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events. State owned or operated critical facilities located in the identified hazard areas shall also be addressed.
- An overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment. The State shall estimate the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.

Absence of Local Loss Data

The SHMP is required to provide an overview and analysis of potential losses to identified structures based on estimates from local risk assessments (44 CFR 201.4.c.2.iii); however, the local plans lack the necessary detail and consistency for such an analysis to be performed. Few of the local plans include loss information because it is not a requirement under FEMA planning regulations (44 CFR 201.6.c.2.ii). Local plans are required to provide only a summary of each hazard and its impact on communities.

Variations in Methodology

For some jurisdictions that do provide dollar loss estimates, the methodology used is not appropriate for use in this SHMP. For example, one jurisdiction assumed 100-percent destruction for all hazards, which results in excessively high estimates of loss. Other jurisdictions used only the Hazus loss estimates for content value, yielding very low estimates of loss. Measures that can be used to estimate hazard loss levels include historical impact based on payouts, vulnerable populations, structures or critical facilities in hazard areas, and projected population growth. Other methods of analysis used for local hazard plans that were reviewed include the following:

- Loss estimate for all properties within the 100-year floodplain based on assessor's values
- Loss estimate for all properties within the 100-year floodplain based on a median home value from census data
- Qualitative estimates based on the number of critical facilities in a 100-year floodplain.
- Qualitative estimates based on the number of residential structures in a 100-year A or V flood zone.
- Qualitative estimates based on the number of critical facilities located in a SLOSH zone.
- Number of structures in 100-year, 500-year or SLOSH (compounded)
- Number of repetitive-loss properties
- Total value of NFIP flood claims paid

- Number of NFIP flood claims paid
- Number of NFIP policies in force
- Average building values per acre for flood/SLOSH
- Average building values per acre for winter weather
- Average building values per acre for wind.
- Average building values per acre for landslide.

Critical Facilities

Some jurisdictions had difficulties assessing the risk to critical facilities in hazard areas. Some local plans used only the standard five facility types identified in Hazus (emergency operations centers, fire and police stations, schools/colleges, and hospitals); others identified many additional structures:

- Access roads to all listed facilities
- Bridges
- City or town offices
- Communication facilities
- Correctional facilities
- Dams
- Daycare facilities with more than five children
- Electric power substations
- Emergency operations centers
- Emergency shelters
- Evacuation routes
- Flood gates
- Gas pipelines/storage sites
- Hospitals
- Municipal wells
- Nuclear sites
- Nursing homes/elderly housing/senior centers
- Police and fire stations
- Power plants
- Problem areas based on local knowledge
- Public works garages
- Schools and colleges
- Sewage pumping stations
- Transportation hubs
- Water and wastewater treatment plants
- Water pumping stations and tanks.

While all of these structures are valid for treatment as critical facilities, difficulties in assessing dollar losses for critical infrastructure at the local level arise due to the variation of data included. Similarly, as the plans are developed, no standard methodology is used for assessing values to the critical facilities. Depending solely on Hazus default data rather than enhanced local datasets has not been consistently reliable, even though for most jurisdictions it is the best available science and meets requirements.

5.7.2 Selected Approach for Local Loss Estimates

Description of Selected Loss Estimation Approach

Given the data and methodology limitations of loss estimates from current local hazard mitigation plans, an overall vulnerability analysis using information from local plans was not possible in the risk assessment of this plan. Therefore, the Commonwealth elected to incorporate a county-by-county breakdown of impact in its risk analysis. To address inconsistencies in defining critical facilities, the Commonwealth used the five Hazus-defined default facilities within its analysis; however, the analysis used state GIS data, which, when validated, proved to be more accurate than the Hazus default data. For purposes of this assessment, public infrastructure was defined to include: roads, bridges, trains, and airports. Essential services included: utilities, hospitals, schools, police and fire stations, and emergency operations centers.

During review of the local plans, hazard ranking data were captured so as to allow for analysis between the Commonwealth's assessment and that determined by the local jurisdictions. The results of the loss estimation are presented in the hazard profiles in Sections 6 through 16. Where Hazus was used, this analysis is based on the Level 1 Hazus-defined data. Analyses were performed using the best available data.

Future Benefits of Selected Loss Estimation Approach

MEMA is taking proactive measures to help local jurisdictions determine risk loss in dollar values in a more consistent manner. All risk analysis work performed for this update, including Hazus and GIS models, will be available to local jurisdictions for enhancements and use during future plan development. This will provide a more uniform methodology for determining loss estimations, so as to provide enhanced capabilities for future planning efforts in capturing information from local plans. In addition, MEMA and DCR will provide training in a systematic approach to risk assessments that includes dollar losses, so that future plan editions will include better data for use in statewide loss estimates.

MEMA and DCR will continue to support the enhancement of data to support the development of a more robust risk assessment. Projects such as the landslide data enhancement project currently underway will provide relevant information to enhance the ability for local jurisdictions to perform GIS risk analysis that provides loss information. MEMA and DCR will look to other avenues over the life cycle of this plan to enhance data for use by local jurisdictions. A new survey for use by local jurisdictions, developed at the beginning of the planning process, will serve two purposes: it will give local jurisdictions information and concepts to include in their plans; and, when returned to MEMA, it will help MEMA capture relevant information for use in future state plan updates. A sample of the survey is included in Appendix E.

5.7.3 Growth and Development

The SHMP assesses jurisdictions and the changes in development that may impact vulnerability by either increasing or decreasing risk. Statewide population growth estimates, projections, and land use data was used to determine if the vulnerability has changed or is expected to change. In Section 4, the plan demonstrates that land uses, development trends, transportation, economy, and population were assessed to obtain a statewide picture of changes to vulnerability. As suggested in the guidance, this information is presented using text, graphics, and maps. In addition, this plan incorporates the development trends provided in local mitigation plans.

The analysis shows that there has not been a significant change in population, land use, economy, or transportation within the past three years that impacts that state's vulnerability to hazards. Most of the state saw a historical change in development from the 1960s to the 1990s.

Damage and losses in most communities are generally associated with existing infrastructure and buildings rather than new growth. Building codes and land use regulations, described in Section 17, limit development in hazard areas or require construction to meet higher standards within hazard areas. This provides a reduction of risk in areas where new development is occurring. In addition, infrastructure improvements, such as the Accelerated Bridge Program, outlined in Section 4.7.3, also strengthen the Commonwealth's resilience by providing enhancements and improvements above existing conditions.

However, jurisdictions experiencing growth and development in the future may have an increase in vulnerability to and impact from some hazards. For example, increased areas of impervious surfaces associated with development do have the potential to increase urban flooding. Jurisdictions approving new development will use mitigation tools such as low-impact development standards, Wetlands Protection Act, and Storm water Management ordnances and by-laws to mitigate any possible increase to their risk. To continue with the analysis of development that could occur and what codes and regulations exist to mitigate new growth the SHMT with continue to partner with the SHMIC to analyze statewide growth and how it relates to risk. Section 17 outlines the states specific goals and actions to achieve this coordination.

The SHMT looked at changes in growth and development as summarized in local mitigation plans. An analysis was performed of the total number of housing units, estimated housing values, estimated housing unit growth from 2000 through 2011, total population, and estimated population change from 2000 through 2011. Table 5-9 and Table 5-10 present the results. Additional data are provided in Section 4.

TABLE 5-9.
U.S. CENSUS HOUSING UNIT STATISTICS BY COUNTY

	Number of Housing Units				Change In Housing Units			
County	2000	2009	2010	2011	2010-2011	2000-2011	Average Annual	Average Value
Barnstable	147,463	155,686	160,281	161,001	720	13,538	1,231	$193,101
Berkshire	66,354	68,539	68,508	68,497	-11	2,143	195	$160,020
Bristol	217,090	225,670	230,535	231,083	548	13,993	1,272	$127,761
Dukes	14,886	16,381	17,188	17,385	197	2,499	227	$135,570
Essex	287,423	299,508	306,754	307,559	805	20,136	1,831	$148,912
Franklin	31,960	33,362	33,758	33,806	48	1,846	168	$123,156
Hampden	185,982	191,380	192,175	192,197	22	6,215	565	$144,859
Hampshire	58,732	61,949	62,603	62,766	163	4,034	367	$140,233
Middlesex	577,269	598,481	612,004	614,036	2,032	36,767	3,342	$155,303
Nantucket	9,258	10,657	11,618	11,776	158	2,518	229	$293,002
Norfolk	255,449	266,793	270,359	271,502	1,143	16,053	1,459	$180,494
Plymouth	181,843	194,237	200,161	201,419	1,258	19,576	1,780	$134,366
Suffolk	292,633	305,127	315,522	317,327	1,805	24,694	2,245	$121,392
Worcester	298,729	320,551	326,788	328,586	1,798	29,857	2,714	$136,488

TABLE 5-10.
POPULATION GROWTH PROJECTIONS BY COUNTY

	Population			Population Change		2020 Projection	
	2000	2009	2011	2009-2011	2000-2011	Population	Change from 2011
Barnstable	222,230	221,151	215,769	-5,382	-6,461	299,035	39%
Berkshire	134,953	129,288	130,458	1,170	-4,495	118,452	-9%
Bristol	534,678	547,433	548,922	1,489	14,244	576,868	5%
Dukes	14,987	15,974	16,766	792	1,779	21,822	30%
Essex	723,419	742,582	748,930	6,348	25,511	787,032	5%
Franklin	71,535	74,778	71,599	-3,179	64	73,806	3%
Hampden	456,228	471,081	463,783	-7,298	7,555	453,115	-2%
Hampshire	152,251	156,044	157,822	1,778	5,571	163,233	3%
Middlesex	1,465,396	1,505,006	1,518,171	13,165	52,775	1,469,494	-3%
Nantucket	9,520	11,322	10,142	-1,180	622	14,426	42%
Norfolk	650,308	666,303	675,436	9,133	25,128	652,440	-3%
Plymouth	472,822	498,344	497,579	-765	24,757	517,664	4%
Suffolk	689,807	753,580	730,932	-22,648	41,125	776,811	6%
Worcester	750,963	803,701	801,227	-2,474	50,264	843,534	5%
State Total	**6,349,097**	**6,596,587**	**6,587,536**	**-9,051**	**238,439**	**6,767,732**	**3%**

Based on these estimates, it is not likely that the natural hazard risks statewide will increase rapidly during the next three years. However, in the jurisdictions experiencing growth, the hazards may be locally exacerbated. The local plans reviewed indicate minimal short-term changes in risk, and the state review found similar results. Based on particular land use or development patterns locally, while there have been some areas of growth, limited increases in natural hazard risks have occurred to date.

5.7.4 Disaster Financial Aid by Jurisdiction

Losses based on previous disaster events are also a good indicator of potential future damage. Since 1991, more than $650 million in federal and disaster assistance has been obligated to Massachusetts in the last 15 years. MEMA maintains an archive listing all declared disaster events and the financial aid received. Table 5-11 summarizes public assistance funding by jurisdiction for four recent disaster declarations. This funding stream includes state agencies, private non-profits, and other eligible applicants whose physical damage is in more than one county or cannot be geographically identified. Since 2010, the county with the highest amount of FEMA Public Assistance Recovery eligible work losses is Hampden County, with $87,909,754 in recorded losses. In the 2010 plan, Worcester County had the highest losses amount, totaling $22,769,578.

TABLE 5-11.
PA PROGRAM FUNDING FOR DISASTER RECOVERY
ASSOCIATED WITH DR-4051, DR-4028, DR-1994, AND DR-1959

	Type of Hazard				
County	Severe Storm and Snow Storm 2011 DR-4051	Hurricane Irene 2011 DR 4028	Severe Storm and Tornadoes 2011 DR 1994	Severe Winter Storm and Snow Storm 2011 DR 1959	**Total Losses**
Barnstable	0	$1,178,043	0	0	**$1,178,043**
Berkshire	$404,015	$5,374,753	0	$687,684	**$6,466,453**
Bristol	0	$1,979,451	0	0	**$1,979,451**
Dukes	0	$49,249	0	0	**$49,249**
Essex	0	0	0	$3,440,957	**$3,440,957**
Franklin	0	$9,367,903	0	0	**$9,367,903**
Hampden	$53,528,269	$1,856,512	$30,887,637	$1,637,335	**$87,909,754**
Hampshire	$3,008,378	$877,145	0	$636,070	**$4,521,595**
Middlesex	$4,514,832	0	0	$6,737,510	**$11,252,342**
Nantucket	0	0	0	0	**0**
Norfolk	0	0	0	$3,097,204	**$3,097,204**
Plymouth	0	$2,082,031	0	0	**$2,082,031**
Suffolk	0	0	0	$2,784,768	**$2,784,768**
Worcester	$6,778,798	0	$311,152	0	**$7,089,951**
State	$1,960,662	$1,024,263	$3,182,410	$6,798,306	**$12,965,642**

As of the writing of this 2013 update, Hurricane Sandy figures are still pending, and therefore not included in this analysis. As more informative data are developed, this information will be enhanced for the next planning cycle. With the exception of Hurricane Sandy, Nantucket was not declared for any disaster events for this update (2010-2012).

5.7.5 Summary

The risk assessments of the local plans were reviewed for specific local information that would improve the SHMP assessment of vulnerability, as well as determination of which jurisdictions were at greatest risk from the natural hazards addressed in the plan. Review of the local and statewide risk assessment provides the following general conclusions:

- Middlesex and Essex Counties have had the highest number of declared flood events. The 2012 Northern Middlesex Hazard Mitigation Plan identifies 53 flood events from 1950 through July 2010. Review since 2010 shows one additional flood event in Middlesex since that time related to a hurricane.
- According to a 1999 study of U.S. Army Corps of Engineers and FEMA data, of the nation's 3,043 counties, Worcester County has the greatest number of dams, 425. Many of these dams are over 100 years old. The age of a dam increases the level of risk with associated failures. Similarly, land use development trends change, and dam inundation since the dams' original construction can have much greater impact than previously. Development of dam inundation zones and safety plans are the responsibility of the dam owners. In many instances, data

concerning this information are not provided by the dam owners to jurisdictions for planning purposes.

- Historically, Farmington River-West Branch, Marsh Brook, Millers River, Quaboag River, and Westfield River-Middle Branch have had the greatest risk of ice jams.
- As indicated in the risk assessment and hazard profiles, each area of the coast is impacted differently by each type of coastal hazard and has varying vulnerability. The coastal zones are North Shore, Boston Harbor/Massachusetts Bay, South Shore, Cape Cod and Islands, and South Coast.
- Based on wind analysis, the coastal area is most frequently impacted by damage due to high wind events.
- The entire Commonwealth is vulnerable to hurricanes and tropical storms, dependent on the storm's track. The coastal areas are more susceptible to damage from these storms.
- The area at greatest risk for a tornado touchdown runs from central to northeastern Massachusetts.
- Higher snow accumulations are more prevalent at higher elevations in Western and Central Massachusetts, and along the coast where snowfall can be enhanced by additional ocean moisture.
- Ice storms occur more frequently in the higher elevations of Western and Central Massachusetts.
- The southeastern parts of Massachusetts—Plymouth County to the Southern coast of Bristol County, Cape Cod, and Martha's Vineyard—are more susceptible to wildland fires due to the availability of fuel, impact from offshore winds, and past events.
- Colder temperatures and weather variations are more common at higher elevations.
- Western Massachusetts may be more vulnerable than eastern Massachusetts to severe drought.
- Northeastern Massachusetts, especially along the Massachusetts coastline from the northern portion of Plymouth County through the Boston metropolitan area to the New Hampshire border, has greater vulnerability to potential earthquake activity than the rest of the Commonwealth.
- The Connecticut River Valley in western Massachusetts and the greater Boston area have the highest risk for landslide.
- All of the coastal areas of Massachusetts are exposed to the threat of tsunamis.

Many local plans used information from the SHMP's risk assessment or from the same sources. While the SHMP is an excellent source of information, it also has drawbacks, as jurisdictions are not necessarily reviewing the hazard profiles at jurisdiction-specific level, but rather statewide. It is hoped that with the inclusion of county-specific data in the 2013 updated risk assessment, more locally specific assessments will occur during the next updates of local plans.

Local plans used a variety of methodologies to assess their vulnerability to hazards, which makes it difficult to incorporate data from the local plans into the Commonwealth's risk assessment element. Many plans rated hazards through a three-tier, *high—medium or moderate—low* vulnerability system. Still, the hazards of greatest concern to local jurisdictions remain consistent with previous editions of the local plans and with the current SHMP.

The review of local plans does not indicate the need for any revisions to the 2013 SHMP risk assessment, as the hazards remain consistent between the last planning cycle and this planning cycle. The exception is

the inclusion by some local jurisdictions of technological hazards, as well as consideration of the potential impacts of climate change, coastal erosion, and sea level rise. It is anticipated that the number of plans that address these issues will increase during the next planning cycle.