

Hazard Mitigation Plan - 2020 UPDATE

Chelmsford, Massachusetts



FEMA

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 December 1, 2020

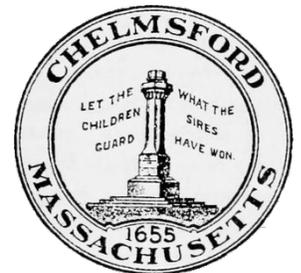


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EXECUTIVE SUMMARY

A natural hazard is defined as “an event or physical condition that has the potential to cause fatalities, injuries, property damage, infrastructure damage, agricultural losses, damage to the environment, interruption of business, or other types of harm or loss¹. The Town of Chelmsford is susceptible to many types of natural hazards including floods, severe thunderstorms, winter storms, earthquakes, hurricanes, and climate change. The economic cost of these disasters can be staggering. In addition, disasters can bring social and emotional devastation to our communities. This Hazard Mitigation Plan Update outlines actions that can be taken now to reduce the impact of natural disasters when and if they occur later. Mitigation breaks the costly cycle of recurrent damage and increasing reconstruction costs.

This document builds upon the Hazard Mitigation Plan for the Northern Middlesex Region, prepared by the Northern Middlesex Council of Governments (NMCOG), most recently updated in 2015, and further assesses vulnerability and develops plans to prepare for current and future hazards unique to Chelmsford. This update was completed in concert with the Town’s designation as a Municipal Vulnerability Preparedness (MVP) community through receipt of an MVP Planning Grant from the Executive Office of Energy and Environmental Affairs (EEA). The MVP Program, administered by the EEA, provides funding to municipalities to assess vulnerability, prepare for climate change impacts, build community resilience, and implement future actions.

The Hazard Mitigation Plan Update for Chelmsford contains goals and objectives for developing the Plan, provides an assessment and inventory of natural hazard risks, as well as a vulnerability analysis based on the geographic location of critical infrastructure and facilities, and delineates an existing protection matrix for the town. Through the Community Resiliency Building (CRB) process facilitated by Beals and Thomas, Inc., a list of hazard mitigation actions and projects has been developed for future implementation. This plan also considers the current and potential impacts of climate change and includes courses of actions to lessen impacts and improve safety for the community.

This document has been prepared in accordance with the federal Disaster Mitigation Act (DMA) of 2000. This update will maintain the Town’s eligibility for certain types of federal funds to implement mitigation initiatives under the Pre-Disaster Mitigation (PDM), Flood Mitigation Assistance (FMA), and Hazard Mitigation Grant (HMGP) programs. The update has a strong emphasis on integrating local, regional and state planning initiatives.

The Town’s vulnerability to natural hazards can be viewed as having three components²:

- Exposure to a hazard – for example, a community located in proximity to a natural hazard, such as a geological fault line, is more likely to be impacted by an earthquake;

¹ MEMA and DCR PowerPoint presentation, 2010.

² Cutter, S.L., Burton, C.G. & Emrich, C.T. Disaster Resilience Indicators for Benchmarking Baseline Conditions, Journal of Homeland Security and Emergency Management, 2010

- Sensitivity or the ability to mitigate a threat – a community that has not permitted development in the floodplain is less sensitive to flooding than a community that has not protected low-lying lands; and
- Capacity to adapt – a community with the resources to plan for, prevent, limit, and recover from a natural disaster event is less vulnerable than one that has little capacity to respond.

Vulnerability can vary from community to community. For example, communities that are close to hazard-prone areas, such as riverine floodplains, are vulnerable to flooding depending on the magnitude, intensity, and frequency of an event. Vulnerability is also greatest where buildings are poorly constructed or maintained, or where critical infrastructure, such as bridges, roads and water, and sewer lines, is susceptible to damage. Social vulnerability may occur in areas with high poverty, minority status, gender inequality, an aging population or a high percentage of individuals with a disability. These factors tend to affect access to governmental and social service resources both before and after a disaster.

This plan will continue to reduce the town's vulnerability to natural disasters by effectively identifying appropriate projects for the limited amount of funding that is made available in the future. Development of a mitigation plan before disaster strikes will result in the most efficient and effective means of reducing the loss of life and property. Mitigation assists in minimizing or preventing damage to structures, infrastructure, and other resources. The nature of this plan helps to ensure that mitigation initiatives, measures, and strategies are coordinated across municipal boundaries. Ultimately, such integration of the plan will also improve the ability of the community to implement post-disaster recovery projects in a cooperative and coordinated manner. Implementing the mitigation measures identified in the plan will also help reduce short-term and long-term recovery and reconstruction costs.

Many tools have been analyzed within the planning process for their applicability in mitigating natural hazards, including the following:

- Land use planning and regulation of development in hazard-prone areas, such as prohibiting construction in a floodplain;
- Enforcement of building codes and environmental regulations;
- Public safety measures, such as routine and ongoing maintenance of roadways, culverts and dams;
- Acquisition or relocation of properties, e.g. purchasing repetitive flood loss properties;
- Retrofitting of structures and careful design of new construction, such as elevating buildings; and
- Comprehensive emergency planning, preparedness and recovery.

PREFACE

Congress enacted the Disaster Mitigation Act of 2000 (DMA 2000) on October 10, 2000. Also known as the Stafford Act Amendments, the bill was signed into law by President Clinton on October 30, 2000, creating Public Law 106-390. The law established a national program for regional mitigation, and streamlined the federal administration of disaster relief. Specific rules on the implementation of DMA 2000 were published in the Federal Register in February 2002 and required that all communities maintain a Multiple Hazards Mitigation Plan in order to qualify for future federal disaster mitigation grants following a Presidential disaster declaration.

According to federal regulations, every five years regional and local jurisdictions must review and revise their plan to reflect changes in development, progress in mitigation efforts, and changes in priorities. The updated plan must be resubmitted to the Massachusetts Emergency Management Agency (MEMA) and the Federal Emergency Management Agency (FEMA) for review and approval in order to continue to be eligible for mitigation project grant funding. Plan updates must demonstrate that progress has been made in the last five years through a comprehensive review of the previous plan.

Due to the pending expiration of the 2015 Update to the Hazard Mitigation Plan for the Northern Middlesex Region prepared by the Northern Middlesex Council of Governments, the Town of Chelmsford received a Municipal Vulnerability Preparedness (MVP) Planning Grant from the Executive Office of Energy and Environmental Affairs (EEA) to commence a local update of the Hazard Mitigation Plan alongside completion of the MVP Certification process. The MVP program provides a framework for cities and towns in Massachusetts to assess potential hazards to the community, including climate change, and develop action-oriented resiliency plans to address those hazards.

Hazard mitigation plans emphasize measures that can be taken to reduce or prevent future disaster damages caused by natural hazards. Mitigation, in the context of natural hazard planning, refers to any action that permanently reduces or eliminates long-term risks to human life and property. In 2017, FEMA performed a cost-benefit analysis based on a sampling of hazard mitigation grants and determined that society saves an average of six dollars for every dollar spent through federal mitigation grants, and an average of four dollars for every dollar spent exceeding certain building codes³.

A variety of mitigation actions are available to reduce the risk of losses from natural hazards. These activities, which can be implemented at the local and state levels, include hazard mitigation planning, the adoption and enforcement of development codes and standards, the use of control structures such as floodwalls and culverts, and the protection of wetlands, floodplain, and open space.

³ National Institute of Building Sciences, Natural Hazard Mitigation Saves: 2017 Interim Report.

Many of the strategies identified in hazard mitigation planning are implemented through land use planning tools and development regulations that can prevent or limit development in hazard-prone areas. Where development has already occurred in hazard-prone areas, buildings can be retrofitted or modified to increase the chances of surviving a known hazard. Enforcement of the state building code is critical in order to effectively minimize natural hazard losses. For example, studies have shown that inadequate code enforcement resulted in significant losses from Hurricane Andrew in 1992.

In addition to addressing natural hazard mitigation, this updated hazard mitigation plan includes an overview of non-natural hazards and assesses the interrelationship of climate change and hazard mitigation.

1.0 PLANNING PROCESS AND PUBLIC PARTICIPATION

The Town of Chelmsford received a Municipal Vulnerability Preparedness Planning Grant from the Massachusetts Executive Office of Energy and Environmental Affairs to evaluate climate hazards facing the Town, discuss municipal strengths and vulnerabilities, and identify opportunities to improve the Town's overall resiliency. These goals were accomplished by following the Community Resiliency Building (CRB) framework, a public-input process developed by The Nature Conservancy, which leverages the local knowledge and experience of community members to develop a Town-specific list of priorities to respond to climate-related hazards. This process was further expanded into an update of the 2015 Hazard Mitigation Plan for the Northern Middlesex Region prepared by the Northern Middlesex Council of Governments (NMCOG), which itself built upon an initial Hazard Mitigation Plan created in 2006.

Using the Chelmsford-specific data from the 2015 Regional Hazard Mitigation Plan Update, as well as updated information from the Massachusetts Emergency Management Agency (MEMA), the Federal Emergency Management Agency (FEMA), the Massachusetts Department of Conservation and Recreation (DCR), the U.S. Census Bureau, the American Community Survey (ACS), the National Oceanic and Atmospheric Administration (NOAA) and several other agencies, a mitigation plan update for Chelmsford has been created. The plan identifies actions completed from the regional plan, and assesses new goals and actions based on the completion of the Community Resilience Building (CRB) framework. Use of specific data regarding natural hazard events, non-natural hazards, demographics, climate-changing hazards, and critical infrastructure has been incorporated into the document. Updated information regarding development patterns, population and density, and assessed property values by class have also been included. Recently developed plans, open space and recreation plans, economic development plans, housing production plans, and emergency management plans have been consulted to complete the updates. The intent of this plan is to reflect on existing conditions and provide an updated plan to address concerns of the community that consist of a variety of hazards that are currently or may in the future impact the Town of Chelmsford.

The process for developing the updated document included the following steps:

- Update the identification of natural hazards for the town;
- Update all demographics, land use, economic and other data, as needed;
- Re-evaluate and update the Existing Protection Matrix for the community;
- Review and update the risk assessment/vulnerability section of the Plan, by identifying critical infrastructure and repetitive flood loss structures, and estimating potential losses;
- Review the action plan from the 2015 hazard mitigation plan for the region to identify those measures that were implemented, and to determine whether the remaining measures are still relevant and should be carried into the updated plan;
- Develop and prioritize mitigation strategies and create an action plan for Chelmsford based on current and future conditions.

Once comments on the plan have been incorporated and the draft plan is approved by MEMA and FEMA, final approval will be sought from the Chelmsford Board of Selectmen, and plan maintenance will be initiated.

1.1 MVP Core Team

Upon award of the MVP Planning Grant, the Town contracted with Beals and Thomas, Inc. as an MVP certified provider to complete the CRB process. The following individuals from the Town of Chelmsford and Beals and Thomas, Inc. comprised the primary MVP Core Team:

- Evan Belansky, Chelmsford Director of Community Development, Core Team Member
- John P. Gelcich, AICP Beals and Thomas, Inc., Lead Facilitator
- Eric J. Las, PE, Beals and Thomas, Inc., Facilitator
- Mary Kate Schneeweis, Beals and Thomas, Inc., Facilitator
- Nicholas P. Santangelo, EIT, Beals and Thomas, Inc., Facilitator

The MVP Core Team corresponded by telephone and email over the course of the CRB and HMP update processes, to discuss the goals and outcomes of the project.

1.2 Kick-Off Meeting

In preparation for completion of the CRB process and HMP update, the MVP Core Team held a kick-off meeting in Chelmsford on October 24, 2019. The following individuals attended the kick-off meeting:

- Evan Belansky, Chelmsford Director of Community Development
- Katie Guertin, Chelmsford Conservation Commission
- Steve Jahnle, Chelmsford Public Works
- Steve Maffetone, Chelmsford Emergency Management
- Todd Melanson, Environmental Compliance Manager, Chelmsford Water District
- Christina Papadopoulos, Chelmsford Engineering
- Gary Persichetti, Chelmsford Public Works
- Gary Ryan, Chelmsford Fire Department
- James Spinney, Chelmsford Police Department

Attendees preliminarily discussed the top hazards facing Chelmsford and whether they had changed since 2015. Particular emphasis was placed on flooding of the Merrimack River, as well as localized flooding due to snowmelt and rain. Infrastructural concerns resulting from flooding included undersized culverts, as well as capacity issues with the existing sewer system.

Geographic areas of concern included the Williamsburg condominium complex, Stony Brook at Jordan Street and the crossing of the rail line, and Jones Pond. Additional hazards identified including road closures and loss of utility service resulting from downed trees during storms. Lastly, attendees preliminary identified stakeholders to attend the CRB workshops.

Sign-in sheet and minutes from this meeting are enclosed in Appendix B.

1.3 Community Resilience Building Workshops

The central objectives of the CRB workshops were to: define top local natural and climate-related hazards of concern, identify existing and future strengths and vulnerabilities, develop prioritized actions for the community, identify immediate opportunities to collaboratively advance actions to increase resilience.

The Town chose to conduct the CRB process over the course of two four-hour workshops. The Town invited a total of 60 individuals to participate as stakeholders in the CRB process. These stakeholders included a variety of community members with interest in resiliency efforts, including representatives of municipal and state government, non-profits, and other interest groups. More specifically, a representative of NMCOG, the Regional Planning Agency that prepared the 2015 Hazard Mitigation Plan for the Northern Middlesex Region, participated in the workshops to provide knowledge on regional hazards shared with neighboring communities. Please refer to Table 1 for a list of invited stakeholders, with asterisks denoting those who attended the workshop(s). Refer to Appendix B for presentations and handouts provided to workshop participants.

Table 1: Final MVP Stakeholder List

| Contact | Title | Organization | Workshop #1 | Workshop #2 |
|------------------------|---|--|-------------|-------------|
| Emily Antul | Clerk | Chelmsford Board of Selectmen | | * |
| Nancy Araway | | Chelmsford Planning Board | | |
| Gail Beaudoin | | Chelmsford Housing Authority | | |
| Evan Belansky | Community Development Director | Chelmsford Department of Community Planning | * | * |
| Kathleen Canavan | Public Facilities Director | Chelmsford Public Facilities | | |
| Douglas Chandler | | Middlesex Canal Commission | | |
| Paul Cohen | Town Manager | Chelmsford Town Manager | * | * |
| Albert Glenn Diggs | | Chelmsford Board of Selectmen | | |
| George Dixon | | Chelmsford Board of Selectmen | | |
| Mike Donoghue | Deputy Fire Chief | Chelmsford Fire Department - Operations | * | * |
| Larry Ferreira | Superintendent of Streets | Chelmsford Highway Division | | |
| Katie Guertin | | Chelmsford Conservation Commission | * | |
| Bruce J. Harper | Superintendent | North Chelmsford Water District | | |
| David Hedison | Executive Director | Chelmsford Housing Authority | | |
| Hank Houle | | Chelmsford Planning Board | | |
| Steve Jahnle | Assistant Director | Chelmsford Public Works | * | * |
| Kathy Kelley | President | Chelmsford Business Association | | |
| James Kelsey | | Chelmsford Bicycle and Pedestrian Advisory Committee | | |
| Dennis King | | Chelmsford School Committee | | |
| Glen Kohl | | Chelmsford Planning Board | | |
| Jay Lang | Superintendent | Chelmsford School Administration | * | * |
| Kenneth M. Lefebvre | Chair | Chelmsford Board of Selectmen | | |
| Scott Ludwig | Civil Engineer | Chelmsford Engineering | | |
| Ted Lutter | IT Director | Chelmsford Information Technology | | |
| Steve Maffetone | | Chelmsford Emergency Management | * | * |
| Lisa Marrone | Director of Business Development | Chelmsford Business Development | * | * |
| Michael McCall | Assistant Town Manager | Chelmsford Assistant Town Manager | * | * |
| Danielle McFadden | President/CEO | Greater Lowell Chamber of Commerce | | |
| David McLachlan | | Chelmsford Conservation Commission | * | * |
| Todd Melanson | Environmental Compliance Manager | Chelmsford Water District | | * |
| Katharine Messer | Conservation Agent / Planner | Chelmsford Conservation Agent | * | |
| Leonard Olenchak Jr | | Chelmsford Council on Aging | | |
| Christina Papadapoulas | Town Engineer | Chelmsford Engineering | * | * |
| Nick Parlee | Energy Manager, Recycling and Solid Waste Manager | Chelmsford Energy Manager | | |
| Henry Parlee Jr | | Chelmsford Planning Board | | |
| Gary Persichetti | Director of Public Works | Chelmsford Public Works | * | * |
| Debbie Phillips | Transportation Coordinator | Chelmsford School Administration | | |
| Linda Prescott | | Chelmsford Historical Commission | | |
| Mike Raisbeck | | Chelmsford Planning Board | | |
| Brian Reidy | Director | Chelmsford Board of Appeals | | |

| | | | | |
|------------------------|----------------------------|---|---|---|
| Annmarie Roark | Chair | Chelmsford Board of Health | | |
| Susan Rosa | Health Director | Chelmsford Board of Health | * | |
| Gary Ryan | Fire Chief | Chelmsford Fire Department | * | * |
| Shaun Shanahan | Building Commissioner | Chelmsford Building Department | * | * |
| Tim Shanahan | | Chelmsford Planning Board | | |
| Debra Siriani | Human Services Director | Chelmsford Senior Center/CoA | * | |
| Anne Smith | Chair | Chelmsford Commission on Disabilities | | |
| John Sousa | Finance Director/Treasurer | Chelmsford Finance Director | * | |
| James Spinney | Police Chief | Chelmsford Police Department | * | * |
| Paul Stedman | Operations Engineer | Massachusetts Department of Transportation District 4 | | |
| Donald Van Dyne | | Chelmsford Planning Board | | |
| Mike Vosnakis | Sewer Superintendent | Chelmsford Sewer Division | | |
| Dale Williams | President | Chelmsford Land Conservation Trust | | |
| Pat Wojtas | Vice Chair | Chelmsford Board of Selectmen | * | * |
| Beverly Woods | Director | NMCOG - Director | * | * |
| | | Chelmsford TV | | |
| | | East Chelmsford Water District | | |
| | | The Trustees of Reservations, Leominster Office | | |
| | | Chelmsford Community Exchange (Food Pantry) | | |
| | | MA Department of Conservation and Recreation, Central Regional Office | | |

1.3.1 Hazard Identification and Assessment Process

The first CRB workshop, which focused on identifying the top hazards facing Chelmsford, as well as related strengths and vulnerabilities, was hosted on February 7, 2019. Facilitators presented demographic data specific to Chelmsford from the 2017 ACS. In addition, stakeholders were given a presentation and handout summarizing climate change data specific to the Merrimack Basin from the Massachusetts Climate Change Projections, published December 2017. As a large group, stakeholders discussed the top hazards facing Chelmsford, reaching agreement on the top five natural and non-natural hazards as outlined herein. Stakeholders then divided into small groups to discuss and identify features that could be considered strengths and/or vulnerabilities unique to the community with respect to the identified hazards.

After discussion, Workshop #1 stakeholders identified the top hazards facing the Town of Chelmsford as the following:

- Flooding
- Severe storms
- Wind
- Extreme temperature
- Pollution

As a community bounded to the north by the Merrimack River and to the east by the Concord River, Chelmsford faces risks associated with flooding. According to a GIS analysis of the latest FEMA data, approximately 13% of the town's total area is mapped in the 100-year floodplain under current conditions. Some areas of denser residential development are located in or adjacent to the floodplain. With the volume of rainfall projected to increase as a result of climate change, the strain that flooding places on existing drainage infrastructure is expected to increase.

Wind was identified as a hazard posing a concern to infrastructure, resulting in risks such as downed overhead wires, as well as impediments to public and emergency response access from fallen trees across roadways. These interruptions in service pose challenges to effective communication of hazards to the public, emergency response, and evacuation.

In addition to flooding and wind, hazards presented by severe storms, such as ice and snow, were considered separately. Severe storms were also noted as contributors to erosion. For instance, Tropical Storm Irene in August 2011 resulted in the erosion of a portion of the southern bank of the Merrimack River, such that the Town applied to the FEMA Hazard Mitigation Grant Program to conduct a bank stabilization project.

The Massachusetts Climate Change Projections predict that the Merrimack Basin will experience 11 to 33 more days with temperatures above 90°F by the 2050s as compared to the present day. These extreme temperatures were identified as having the potential to adversely affect the quality of water resources in the Town. Drought was also discussed as a cause of increased risk of wildfires as a result of dry trees and brush. This hazard can be exacerbated by heat islands in areas of dense development.

Pollution as a non-natural hazard was tied closely to flooding and severe storms, particularly in the vicinity of major transportation corridors such as Route 3, Route 495, and railroads. Potential land and water pollutants of concern included anthropogenic sources such as the storage and transport of hazardous materials, as well as pests, cultural eutrophication, and bacterial loading.

1.3.2 Development of Hazard Mitigation Strategies

The second CRB workshop was hosted on March 20, 2019. Facilitators presented a summary of findings from the first workshop and outlined the goals of the second workshop. This presentation included an overview of nature-based solutions for stakeholders' consideration when identifying actions. Stakeholders divided into small groups to develop actions that will enhance the strengths and mitigate the vulnerabilities identified during the previous workshop.

The small groups prioritized these actions and identified a timeframe for completion. Then, as a large group, stakeholders collectively discussed the high priority actions, and identified the top three priority actions for the Town, as outlined in Section 8.0.

1.4 Public Listening Session

A public listening session was held at the Board of Selectmen meeting on May 20, 2019 to review the results of the CRB process. The meeting was televised, and a recording of the meeting was subsequently posted online. At this meeting, members of the MVP Core Team provided an overview of the MVP and HMP update process, and presented the top actions identified at the CRB workshops. The Draft MVP Summary of Findings Report was then made available for public comment for a period of three weeks, through June 17, 2019. During this period, announcements requesting input on the report were posted on the Town's website and social media pages. A sample announcement soliciting public comment is enclosed in Appendix B. Public comments were incorporated into the Draft HMP Update and the Final Summary of Findings Report.

Refer to Appendix E for the agenda for the applicable Board of Selectmen meeting, the presentation given at the listening session, and written comments received during and after the listening session

1.5 Updating the Existing Protection Matrix

The existing protection matrix is a summary of measures, programs, and projects that have been implemented locally to mitigate natural hazards. The matrix is essentially a listing of the items already in place which work toward solving hazard problems or preventing future losses, as outlined in FEMA's Local Multi-Hazard Mitigation Planning Guidance. In order to update the matrix, the MVP Core Team reviewed the protection matrix from the 2015 HMP with the Town's Emergency Management Coordinator to examine the adequacy of each community's programs, policies, and bylaws, and to determine what has been accomplished since the previous plan was approved. The information gathered from these interviews is detailed in the updated existing protection matrix.

1.6 Other Local and Regional Planning Initiatives

As previously mentioned, recently developed local plans, such as the Master Plan, Open Space and Recreation Plan, Affordable Housing Plan, and Comprehensive Emergency Management Plan were consulted in formulating this document. Within these documents hazard mitigation has been included and considered in terms of planning and initiatives.

In 2010 NMCOG assisted the Town of Chelmsford in preparing its Master Plan, which included discussion of hazard mitigation issues and references to the 2006 Hazard Mitigation Plan.

The Chelmsford Open Space Plan, updated in 2017, provides an inventory of public and private lands with natural resource interest, and identifies needs for management of existing open space property, as well as future acquisition of additional open space. To protect inventoried areas from natural and non-natural hazards the plan identified goals such as maintenance of wildlife corridors between open spaces, providing public education on stormwater and pollution, and identification of invasive species populations.

In 2011, NMCOG completed the Regional Strategic Plan (RSP) for Greater Lowell. The RSP assisted NMCOG and its member communities in planning for future development initiatives and for the preservation of open space and natural resources. The RSP focuses on smart growth and sustainable development principles that promote compact development in those areas with available infrastructure and fosters the protection and preservation of the region's most vulnerable and valuable environmental and cultural resources. Several of the goals outlined in the Strategic Plan are beneficial in mitigating natural hazards and addressing climate change, including the following:

- Use land efficiently and protect sensitive resource areas by directing growth to priority development areas and locations with adequate infrastructure;
- Support the transformation of key underutilized lands, such as brownfields, to productive uses that complement the community and enhance existing neighborhoods;
- Minimize the environmental impact of future development by encouraging mixed-use and compact development patterns, and by promoting the use of low impact development techniques;
- Care for the natural environment by protecting and restoring natural systems, conserving habitat, improving water quality, and reducing air pollution, thereby ensuring that all residents, regardless of social and economic status, live in a healthy environment;
- Promote the use of innovative, environmentally sensitive development practices, including design, materials, construction, and on-going maintenance;
- Encourage the use of low impact development techniques and other best management practices (BMPs) for managing stormwater;
- Preserve, protect and enhance the region's remaining agricultural lands;
- Preserve significant historic, visual and cultural resources, including public views, landmarks, archaeological sites, historic and cultural landscapes and areas of special character; and
- Promote the production and use of alternative energy.

The 2020-2040 Northern Middlesex Regional Transportation Plan, prepared by NMCOG, is currently available in draft form. The plan identifies transportation infrastructure improvement projects to increase safety and accessibility for vehicles and pedestrians, while protecting critical infrastructure from hazards exacerbated by climate change. For instance, one of the goals of the plan is to mitigate the impacts of the transportation system on the environment by reducing the number of vehicle miles travelled, addressing floodway and stormwater management concerns, reducing the risk of pollution from operation and maintenance activities, and improving access to public transportation.

Projects that benefit hazard mitigation are also incorporated within the region's Comprehensive Economic Development Strategy (CEDS) prepared by NMCOG in partnership with the Economic Development Administration (EDA) of the U.S. Department of Commerce. Some of these projects are listed in the document's Priority Projects list.

2.0 PLAN PURPOSE

The process utilized by the Municipal Vulnerability Preparedness (MVP) Core Team focused on identifying strengths and vulnerabilities to future disasters and formulating mitigation strategies to avoid or minimize losses and enhance strengths. The Plan contains data and information that can be utilized to increase public awareness and promote improved mitigation planning at the local, regional, and state levels of government. Developing a mitigation plan before disaster strikes will result in the most efficient and effective means for reducing the loss of life and property.

The Federal Emergency Management Agency (FEMA), within the Department of Homeland Security, is responsible for leading the country's efforts to prepare for, prevent, respond to, and recover from disasters. FEMA has made hazard mitigation a primary goal in its efforts to reduce the long-term effects of natural hazards. FEMA provides guidance to state, regional and local governments in developing their hazard mitigation plans, reviews and approves the plans, and administers several hazard mitigation grant programs to fund mitigation activities.

Several state and federal grant programs and related regulations, mandate that local governments develop and maintain natural hazard mitigation plans. The Federal Disaster Mitigation Act of 2000 requires that all communities have such plans in place in order to be eligible for future federal post-disaster mitigation funds under FEMA's Hazard Mitigation Grant Program (HMGP), Pre-Disaster Mitigation (PDM) grant program, and the Flood Mitigation Assistance (FMA) program. In addition, Chelmsford is seeking designation as an MVP community from the Massachusetts Executive Office of Energy and Environmental Affairs (EEA). This plan is intended to assist the town in complying with these requirements. Although the mitigation plan itself is designed for the town of Chelmsford, the mitigation planning process is also directed at ensuring that proposals for mitigation projects and initiatives are coordinated among surrounding communities.

Hazard Mitigation Plans must be updated and resubmitted to FEMA for approval every five years. In addition, towns are required to submit an annual progress report to EEA to maintain designation as an MVP community. The HMP updates must demonstrate that progress has been made in fulfilling the commitments made in the previous plan. This requires a review and update of each section of the plan and a discussion of the progress made over the past five-year period to meet the requirements for FEMA. This document represents the first version of the plan that is specific to the town of Chelmsford and it describes occurrences of hazards included in the previous regional plan, as well as new occurrences of hazard events and changes in the town and in some cases the region's vulnerability to such hazards. The goals contained in the prior plan have been reviewed and either reaffirmed or revised to reflect new information and priorities.

3.0 **TOWN PROFILE**

The Town of Chelmsford is one of nine towns within Massachusetts’ Northern Middlesex County, which is tied together by the Merrimack River and located in the northeastern section of the state. It shares a boundary with the City of Lowell, the county seat. Chelmsford is approximately forty-five minutes from the City of Boston, the City of Worcester, and the City of Manchester, New Hampshire. Chelmsford has a land area of approximately 23.2 square miles according to the US Census Bureau.

There are 134 public safety personnel in Chelmsford, including 53 uniformed police officers and 64 fire fighters.⁴

3.1 **Population and Housing**

Chelmsford is one of the early suburbanizing communities in the region, with residential growth beginning in the 1960s. According to the American Community Survey, the town had a population of 35,067 in 2017, which represented an increase of 3.74% since the 2010 U.S. Census. Almost fifteen percent (15%) of the town’s population is 65 years of age or older and approximately four percent (4%) of the town’s residents live below the poverty level.

Table 2: 2010 and 2017 Population in Chelmsford

| Year | Total Populations | Percent Change |
|------|-------------------|----------------|
| 2010 | 33,802 | |
| 2017 | 35,067 | 5.09% |

Source: 2010 U.S. Census, 2017 American Community Survey

There are approximately 6,078 students enrolled in school through grade 12. The public-school system includes five elementary schools, two middle schools, and one high school.

The total number of housing units in Chelmsford increased from 13,807 units in 2010 to 14,147 units in 2017, an increase of 340 units, or 2.46%. Approximately 97% of these units were occupied, with the average owner-occupied unit sheltering approximately 2.71 people and the average renter-occupied unit sheltering 1.74 people. Housing density increased to a total of 609.78 housing units per square mile. This is the second highest population density of the nine communities in Northern Middlesex County, behind the City of Lowell at 2,861 housing units per square mile. Table 3 below, provides population density and housing density data for the community.

⁴ The Town of Chelmsford, 2019

Table 3: Housing and Population Density in Chelmsford

| Population | Housing Units | Land Area (Sq. Mi.) | Population Density (Per Sq. Mi.) | Housing Unit Density (Per Sq. Mi.) |
|------------|---------------|------------------------|--|--|
| 35,067 | 14,147 | 23.2 | 1,511.51 | 609.78 |

Source: 2017 American Community Survey

3.2 Land Use Characteristics

The most recent land use data for the state of Massachusetts was compiled by MassGIS using aerial photogrammetric data from 2016. As shown in Table 4 below, land use pattern have changed dramatically since 1971.

Table 4: Land Use Characteristics

| Land Use | Acres | | | | | Percentage Change (1971-2016) |
|--------------------|-----------|-----------|-----------|-----------|-----------|-------------------------------------|
| | 1971 | 1985 | 1991 | 2005 | 2016 | |
| Commercial | 158.39 | 216.55 | 376.89 | 410.70 | 454.74 | 187.10 |
| Industrial | 310.07 | 503.97 | 637.32 | 560.91 | 535.04 | 72.55 |
| Residential | 3,249.10 | 3,914.34 | 6,866.71 | 7,162.52 | 8,061.15 | 148.10 |
| Developed | 3,717.56 | 4,634.86 | 7,880.92 | 9,286.53 | 13,507.18 | 263.33 |
| Undeveloped | 11,110.09 | 10,192.79 | 6,946.73 | 5,463.36 | 1,265.12 | -88.61 |
| Total | 14,827.65 | 14,827.65 | 14,827.65 | 14,749.89 | 14,772.43 | N/A |

Source: McConnell Land Use Data, University of Massachusetts (1971-2005), MassGIS (2016)

The rate of development increased between the periods of 2005 to 2016 over the period of 1991 to 2005. Land consumption will likely continue at an alarming rate for as long as large lot zoning remains the norm in the suburbs. According to 2016 land use data, the largest category of developed land use in the town was residential at fifty-four percent. This included all residential dwelling types, from large lot, single-family homes to multi-family apartments and condominiums.

Undeveloped land includes land that is vacant and developable, as well as land that may be classified as undevelopable due to various development constraints, such as wetlands.

Seven percent of land in Chelmsford is in commercial and industrial use, including 455 acres of land in commercial use, and 535 acres in industrial use. This type of development is generally focused at major highways interchanges, such as Route 3 and Route 4, Route 4 and Route 129, and Route 110 and Interstate 495.

The trend toward urbanization/suburbanization of the region has implications for natural hazard planning. As more land is developed, additional impervious surface is created, potentially increasing the flood risk and decreasing the area available for flood storage. As population and housing density increases, the potential for property damage and economic loss as a result of a natural disaster also increases.

3.3 Open Space/Conservation Land

According to the 2017 Open Space and Recreation Plan, there are currently 3,636 acres, a total of 30% of open space and vacant land and 1,283 acres, a total of 10% of protected open space within the Town of Chelmsford, as shown in Table 5. These lands range from large tracts of state-owned land located across multiple communities, to small tracts held by private land trusts and municipalities.

Table 5: Protected Open Space

| State | Municipality | Land Trusts | Total Acreage | | | Agricultural Preservation Restriction (APR) | Other | Total |
|-------|--------------|-------------|--------------------------|--------------|---|---|----------|-------|
| | | | Conservation Restriction | Water Supply | | | | |
| 56.15 | 1,077.78 | 79.25 | 66.09 | 4.00 | 0 | 0 | 1,283.27 | |

Source: Town of Chelmsford Open Space and Recreation Plan 2017

3.4 Water Resources and Water Quality

The region possesses an abundance of water resources, including rivers, streams, brooks, lakes, ponds, reservoirs, marshes and wetlands. The entire region falls within the drainage basin of the Merrimack River, the second largest in New England. Chelmsford has an extensive hydrological system that includes groundwater, wetlands and surface water. The Merrimack River forms a portion of Chelmsford’s northern border, and the Concord River runs 2/3 of a mile along its eastern border. Surface water accounts for 2.3% (328 acres) of the town’s area. The town also contains wetlands and floodplain that accounts for more than 13% of the town’s total land area. The Town falls within two sub-watersheds of Merrimack River basin: the Merrimack and the Sudbury, Assabet and Concord (SuAsCo). Eleven named streams run through Town including Beaver Brook, Stony Brook, Crooked Spring Brook, Scotty Hollow Brook, Farley Brook, Putnam Brook, Black Brook, Hales Brook, Cold Spring Brook and River Meadow Brook. There are two Coldwater Fisheries Resources (CFR) in Chelmsford, both in the Merrimack River watershed in the northern portion of town.

Abundant, high quality water sources are essential to the region’s long-term growth and economic vitality. According to the Massachusetts 2014 Integrated List of Waters, six rivers (River Meadow Brook, the Concord River, Black Brook, Deep Brook, Stony Brook, and the Merrimack River) and two lakes (Newfield Pond and Heart Pond) located in Chelmsford are listed as impaired for a variety of pollutants, including nutrients, pathogens, and low dissolved oxygen. Of these impaired waterbodies, a Total Maximum Daily Load (TMDL) has been established only for Heart Pond. Ongoing efforts by environmental groups, such as the Merrimack River Watershed Council, the Nashua River Watershed Association, and the Northern Middlesex Stormwater Collaborative focus on water quality addressing problems through a watershed or regional approach.

Wetlands are protected from development by the state Wetlands Protection Act and the Chelmsford Wetlands Bylaw and Regulations. Freshwater wetlands support high biodiversity, including unique plant communities and many animal species that are dependent on wetlands for various lifecycle needs. Wetlands also capture heavy rains and prevent flooding downstream, absorb greenhouse gases from the atmosphere, and store and purify groundwater. Despite federal, state and local regulations, wetland destruction, habitat fragmentation, unsustainable water withdrawals, pollution, invasive species and climate change threaten the quantity and quality of the region’s wetland resources.

Public drinking water supply in the region comes from the Merrimack River and Concord River, as well as groundwater wells. Ninety-five percent of Chelmsford is served by a public drinking water supply distributed by three independent water districts: the Chelmsford Water District, the North Chelmsford Water District, and the East Chelmsford Water District. Nearly 100% of the Town is served by sewer, which is treated at the Greater Lowell Wastewater Treatment Facility.

It is essential that the region protect both the quantity and quality of its water supply through effective land use controls and health regulations. Toward this end, Chelmsford has adopted the Aquifer Protection District as a zoning overlay consistent with MassDEP drinking water source protection requirements. These regulations prohibit high-risk commercial and industrial uses within the protection district. The following table provides an overview of the towns primary water supply lands (Zone A and Zone II), as mapped by MassDEP and summarized in Table 6 below. Zone A is an area delineated 400 feet from a surface water supply (200 feet from tributaries). Zone II is a wellhead protection area that has been determined by hydro-geologic modeling and approved by MassDEP. In cases where hydro-geologic modeling studies have not been performed and there is no approved Zone II, an Interim Wellhead Protection Area (IWPA) is established based on MassDEP well pumping rates or default values. Certain land uses may be either prohibited or restricted in both approved (Zone II) and interim (IWPA) wellhead protection areas.

Table 6: Municipal Drinking Water Supplies – Primary Protection Zones

| Zone I (acres) | Zone II (acres) | Zone I and Zone II protected area (acres) | % Permanently Protected | |
|----------------|-----------------|---|----------------------------|---------|
| | | | Zone I | Zone II |
| 208.54 | 4,715.05 | 4,715.05 | 180.65 | 506.10 |

Source: Massachusetts Department of Environmental Protection, GIS analysis

Under the Sustainable Water Management Initiative (SWMI), EEA developed a framework to promote sustainable use of the Commonwealth’s water resources. This framework included methods for calculating the safe yield of basins, seasonal streamflow criteria for subbasins, and subbasin baselines against which additional requests for water withdrawal could be compared. In particular, the seasonal streamflow criteria included the determination of biological conditions for fluvial fish, as well as groundwater withdrawal levels. Elements of this framework were subsequently incorporated into the 2014 updates to the Water Management Act

Chelmsford has 13 subbasins, and have been assigned groundwater withdrawal categories (GWC) based on the ratio of the 2000-2004 groundwater withdrawal volume to the unimpacted median monthly flow for August, as described in Table 7 below.

Table 7: Subbasin Groundwater Withdrawal Categories

| MWI Subbasins | Category | Groundwater Withdrawal % |
|---------------------------|----------|--------------------------|
| 13069 | 1 | >0-3% |
| 12044 | 2 | >3-10% |
| 13034, 12039 | 3 | >10-25% |
| 12045, 12043 | 4 | >25-55% |
| 13044,13045, 13035, 12042 | 5 | >55% |
| 13092, 13089, 13073 | No Data | No Data |

Sustainable Water Management Initiative Interactive Map created by the Executive Office of Energy and Environmental Affairs, http://maps.env.state.ma.us/flexviewers/SWMI_Viewer/index.html

Of these 13 subbasins, three (Subbasins 13035, 12042, and 12043) in the northeastern and northwestern portion of the Town are classified as having greater than 25% August net groundwater depletion (NGD), calculated based upon the median August flow data compared to water withdrawals and returns in the basin.

Much of the Town’s area has been assessed at Category 5, indicating that the habitat for riverine fish has undergone 65% or greater alteration to its range.

3.5 The Regional Economy

The economic conditions in the Greater Lowell region were negatively impacted by the national recession, which began in December 2007. The region experienced 1,984 layoffs from July 1, 2009 to June 30, 2013. These layoffs directly impacted the town of Chelmsford with a total of 321 employees in 8 businesses out of work.

Additionally, the housing crisis, which initially impacted this region in 2008, continued to negatively impact the economy through 738 foreclosure petitions, 577 foreclosure auctions and 200 bank-owned/REO properties between April 2008 and March 2010. During 2011, the region experienced 561 foreclosure petitions, 955 auctions and 428 foreclosure deeds.

The City of Lowell has generally accounted for 40% of the foreclosure petitions, 45-50% of the auctions and 41-48% of the foreclosure deeds in the region. These statistics illustrate that the Greater Lowell region is still slowly recovering from the national recession. According to the Warren Group, foreclosure petitions statewide fell to the lowest monthly level in June 2013 since they started compiling foreclosure statistics in 2006. A total of 245 foreclosure petitions were recorded in June, which represented an 84% decrease from the 1,548 foreclosure petitions filed in June 2012. From January to June 2013 2,943 foreclosure petitions were filed statewide, which represented a decrease of 69% from the same time period in 2012.

During the recession in the early 2000s, this region's computer manufacturing and information technology industries were significantly impacted. During the most recent recession, layoffs occurred in high tech manufacturing, information technology and retail industries, but the impact on these industries wasn't as severe and the economic downturn has affected every industry. Due to the diverse and high-tech nature of the Massachusetts economy, industries in this region have been able to recover more readily than industries in other parts of the country.

Recent statistics show that the Commonwealth of Massachusetts has done better than most states in creating new jobs as we continue to emerge from the national recession. According to the ACS, the unemployment rate in Chelmsford has fallen consistently from its peak at 7.0% in 2012, down to 4.2% in 2017. In 2018, the Middlesex 3 Coalition presented an Economic and Employment Outlook panel that identified the education level of the workforce, international immigration into Massachusetts, and the region's research and development as factors in the economic growth. However, housing costs and the aging population were identified as pending concerns regarding the economy and businesses ability to retain a labor force.

3.6 Historic and Cultural Resources

Incorporated in 1655, Chelmsford's early European settlers made a living through agriculture and lumber, which developed around the current Town Center. The construction of the Middlesex Canal and railroad in the early to mid-nineteenth century led to the establishment of mills and other industrial uses in the Town, primarily in North Chelmsford. As industrial jobs left the region after the Great Depression, the Town continued to grow as a residential community in the 1960s.

The preservation of historic and cultural resources must be carefully considered in order to protect the character of the town. Many colonial era residences, mill structures, and village greens are already protected to some extent through the establishment of historic districts, however, additional consideration should be given to protecting such resources from potential natural hazards. Historic inventories and plans are essential in guiding historic preservation initiatives, and such plans should consider hazard mitigation. Effective preservation of these resources requires active stewardship and support of the overall community.

Table 8 provides a listing of the National Register Historic Districts for the town, while Table 9 lists historic properties with preservation restrictions. The Town of Chelmsford Historic & Cultural Preservation Plan notes that several additional properties or districts, such as North Chelmsford, South Chelmsford, and Varney Playground are eligible for designation in the National Register.

Table 8: Historic Districts in Chelmsford Listed in the National Register of Historic Places

| Historic Name | Location | Date Listed | # of Properties |
|---|---|-------------|-----------------|
| Chelmsford Center | Intersection of Billerica, Littleton, Boston and North Rds, Westford and Chelmsford Sts and the NY/NH and Hartford Railroad | 2/20/1980 | 42 |
| Middlesex Canal | (Regional Historic District) | 8/21/1972 | 6 |
| Middlesex Canal Historic & Archaeological District | (Billerica/Boston (Charlestown)/ Chelmsford/ Lowell/Medford/ Somerville/Wilmington/ Winchester/ Woburn) Running SE from Chelmsford-Lowell border at southern edge of Rt. 3S ramp to SE corner of 100 Equador Rd | 11/19/2009 | 4 |

Source: Town of Chelmsford Historic & Cultural Preservation Plan, 2013

Table 9: Preservation Restrictions on Historic Properties in Chelmsford

| Property | Location | Date Enacted | Holder of Restriction |
|---------------------------------|----------------------|--------------|-----------------------|
| Chelmsford Old Town Hall | 1 North Road | 4/24/1985 | MHC |
| First Parish Church | 2 Westford Street | In Progress | Town of Chelmsford |
| J.P. Emerson House | 11 North Road | 11/21/1978 | Town of Chelmsford |
| Forefathers' Cemetery | Westford Street | 7/2/2003 | MHC |
| Richardson Barn | 66 Graniteville Road | 11/30/2009 | Town of Chelmsford |

Source: Town of Chelmsford Historic & Cultural Preservation Plan, 2013

COSTEP-MA promotes proactive steps to reduce losses from natural hazards, especially flooding or water damage following fires, through cooperative, team-building activities in communities and through educational activities within the cultural heritage and emergency management communities. COSTEP-MA promotes education and cooperation in communities to enhance the protection of cultural resources from natural disasters.

3.7 Demographic Data and Projections

In considering exposure to natural hazards it is important to assess population and development trends. As more land is developed, additional impervious surface is created, increasing the flood risk and decreasing available flood storage area.

Population, household and employment projections for each municipality in Massachusetts were updated in 2017 and 2018 by the Massachusetts Department of Transportation (MassDOT). Note that these projections are derived from the 2010 Census Bureau reports; the population of Chelmsford has exceeded the projected number for 2020 of 34,750 residents according to the 2017 ACS.

The data summarized in Table 10 below reflects previous and anticipated population, employment, and household trends over the next three decades. The town’s population is expected to increase from 2010 until 2020, then fall between 2020 and 2040. This reflects the aging population of the Town. Similarly, the growth of households is expected to slow between 2020 and 2040, with an increase of approximately 5% over these twenty years. Growth in the number of employed persons is projected to increase dramatically until 2020, consistent with recovery from the national recession of 2008, then slowly decrease until 2040.

Table 10: Previous and Projected Population, Employment, and Households

| | 2000 | 2010 | 2020 | 2030 | 2040 |
|---------------------------|--------|--------|--------|--------|--------|
| Population | 33,858 | 33,802 | 34,394 | 34,037 | 33,548 |
| Number of Employed | 22,801 | 19,603 | 24,005 | 23,813 | 23,806 |
| Households | 12,812 | 13,313 | 14,394 | 14,962 | 15,063 |

Source: MassDOT

3.8 Assessed Valuations

The Massachusetts Department of Revenue (DOR) requires communities to value all property each year and conduct a complete recertification every third year. Both a recertification and an interim year adjustment (the two years in between the triennial recertification) include a detailed analysis of the appropriate sales data as a basis for adjusting the property values. The goal is to keep the values as close as possible to 100% of market value and avoid an excessive swing in the assessments in one year. Table 11 below contains the Assessed Values for all property classes in Chelmsford over the last five years.

Table 11: Assessed Values by Class between 2017 and 2019

| Year | Residential | Open Space | Commercial | Industrial | Personal Property | Total |
|-------------|-----------------|------------|---------------|---------------|-------------------|-----------------|
| 2015 | \$3,751,821,126 | \$0 | \$381,934,290 | \$358,288,100 | \$160,390,410 | \$4,652,433,926 |
| 2016 | \$4,014,794,476 | \$0 | \$416,205,740 | \$373,485,500 | \$171,567,290 | \$4,976,053,006 |
| 2017 | \$4,275,711,081 | \$0 | \$423,505,335 | \$382,908,200 | \$169,535,300 | \$5,251,659,916 |
| 2018 | \$4,454,472,335 | \$0 | \$443,653,085 | \$395,021,500 | \$161,682,430 | \$5,454,829,350 |
| 2019 | \$4,808,623,510 | \$0 | \$461,100,110 | \$410,397,000 | \$177,329,470 | \$5,857,450,090 |

Source: Massachusetts Department of Revenue, Division of Local Services

4.0 HAZARD IDENTIFICATION

In the context of this plan, a “hazard” is defined as an extreme natural event that poses a risk to people, infrastructure, or resources. Hazard identification details the geographic extent, the significance, and the probability of a natural hazard affecting the region. Federal regulations for hazard mitigation plans include a requirement for a risk assessment, in order to provide communities with information needed to prioritize mitigation strategies. Hazard mitigation is commonly defined as any sustained action that permanently reduces or eliminates long-term risk to people, property, and resources. It is important to note that one category of hazard can be caused by several different types of events. For example, flooding can be the result of a hurricane, a nor’easter, a thunderstorm or a winter storm.

In an urbanized area, such as the Northern Middlesex region, natural hazards can result in disaster. Hazard mitigation planning is a process directed at reducing the impact that natural disasters may have on the built environment and the lives of area residents. As the region grows and population increases, the risk of disaster caused by natural hazards becomes greater. It is impossible to predict exactly when and where such a disaster might occur; however, careful planning can help minimize the losses that may result. Hazards can be exacerbated by human behavior and practices, such as building in a floodplain, along steep slopes, or on a fault line.

The Massachusetts Emergency Management Agency (MEMA) is the state agency responsible for coordinating federal, state, local, voluntary, and private resources during emergencies and disasters in the Commonwealth of Massachusetts. MEMA provides leadership in developing plans for effective response to all hazards, disasters or threats; trains emergency personnel; provides information to the public; and assists individuals, families, businesses, and communities to mitigate against, prepare for, respond to, and recover from emergencies caused by both nature and humans.

In addition to hazard mitigation at the state level, each municipality in Massachusetts has a Comprehensive Emergency Management Plan (CEMP) in place. The CEMP combines the four phases of emergency management: mitigation, preparedness, response and recovery.

4.1 Natural Hazards Inventory

Natural hazards that are likely to occur in Chelmsford and the broader Northern Middlesex region are summarized in this section of the report. These include flood-related hazards, wind-related hazards, winter-related hazards, fire-related hazards, and geologic hazards. In addition, some information is provided regarding non-natural hazards such as pandemics, chemical and hazardous materials, transportation accidents, nuclear incidents, infrastructure failure, terrorism, and commodity shortages. This section provides a summary of these hazards and assesses the potential for occurrence based on historic records and information available from local, state and national sources.

4.1.1 Flood-Related Hazards

Floods are the most common hazard to affect New England. Most floods are caused by spring rains, thunderstorms, hurricanes, or rapid snowmelt. Inland floods are most likely to occur in spring due to increased rains and snowmelt. In addition, there are several low-lying areas that have the potential to flood. Two types of flooding typically affect the Northern Middlesex region: riverine flooding and urban flooding.

Riverine flooding consists of the overbank flooding of rivers and streams, typically resulting from either extremely rapid snowmelt or a large-scale weather event that generates an unusual amount of precipitation.

In areas of urban flooding, heavy rainfall collects and flows quickly across impervious surfaces. During periods of urban flooding, roadway flooding is common, and basements may fill with water.

Flash floods usually result from an intense storm, typically a thunderstorm that drops a large amount of rainfall over a short period of time. Flash flood waters move very quickly and often happen unexpectedly. Floodwaters can be extremely dangerous, as the force of six inches of rapidly moving water can knock people off their feet. Flash floods can also destroy buildings and obliterate bridges.

Flooding poses a danger to life and property. According to the National Climatic Data Center, eighty-two (82) flood events were reported in Middlesex County from January 1, 2010 to March 31, 2019. The reported flood events resulted in \$36.58 million worth of property damages, with Chelmsford center incurring \$35,000 of property damage in a March 30, 2014 flood alone.

Since 1985, there have been fourteen federal Disaster Declarations for flood events in Middlesex County, most of which were the result of severe weather. Table 12 below summarizes the details of each declaration.

Table 12: Flood-related Disaster Declarations (1985-present)

| Disaster # | Disaster Type | Declaration Date | Incident Period |
|------------|--|------------------|---------------------|
| DR-4214 | Severe Winter Storm, Snowstorm, and Flooding | 4/13/2015 | 1/26/2015-1/28/2015 |
| DR-4110 | Severe Winter Storm, Snowstorm, and Flooding | 4/19/2013 | 2/8/2013-2/9/2013 |
| DR-1895 | Severe Storm and Flooding | 3/29/10 | 3/12/10-4/26/10 |
| DR-1813 | Severe Winter Storm and Flooding | 1/05/09 | 12/11/08-12/18/08 |
| DR-1642 | Severe Storms and Flooding | 5/25/06 | 5/12/06-5/23/06 |
| DR-1614 | Severe Storms and Flooding | 11/10/05 | 10/7/05-10/16/05 |
| DR-1512 | Flooding | 4/21/04 | 4/1/04-4/30/04 |
| DR-1364 | Severe Storms and Flooding | 4/10/01 | 3/5/01-4/16/01 |
| DR-1224 | Heavy Rain and Flooding | 6/23/98 | 6/13/98-7/6/98 |
| DR-1142 | Severe Storms/Flooding | 10/25/96 | 10/20/96-10/25/96 |
| DR-975 | Winter Coastal Storm | 12/21/92 | 12/11/92-12/13/92 |
| DR-914 | Hurricane Bob | 8/26/91 | 8/19/91 |
| DR-790 | Severe Storms, Flooding | 4/18/87 | 3/30/87-4/13/87 |
| DR-751 | Hurricane Gloria | 10/28/85 | 9/27/85 |

Source: FEMA

Flood Prone Areas

Flood zones in Chelmsford are located adjacent to the rivers, streams, and wetlands within Town.

While the Merrimack River is generally prone to minor flooding, on May 15, 2006 rainfall raised the river to more than 8 feet (2.4 m) above flood stage, forcing evacuations and damaging property. Reports of total rainfall vary, but most areas appear to have received around a foot of rain, with some areas receiving as much as 17 inches. According to the Boston Globe, around 1,500 people evacuated their homes to escape the flood. This flood also prompted the City of Lowell, Massachusetts to install a modern (albeit temporary) flood control gate comprised of square steel beams at the site of the historic Francis Gate, a 19th and 20th century wooden flood gate. When lowered, the Francis Gate seals the city's canal system off from its source on the Merrimack. The Mother's Day 2006 flood caused \$25 million in damage to infrastructure in the City of Lowell alone, and approximately 400 homes in the City were damaged from the floodwaters.

During this flood, a half mile of Tyngsborough Road in Chelmsford was closed. At 81 Tyngsborough Road, the Mobile gas station was forced to close after flood waters caused the station's tanks to leak gasoline. Workers were forced to cap the tanks to prevent further environmental damage. East of Tyngsborough Road residents of Sleeper and Butterfield Streets were evacuated by boat. Gas service to several homes on Dunshire Drive were also shut off. The gauging station on the Merrimack River recorded at 59.7 feet, approximately 10 feet over flood stage.

The most significant flood in the recorded history of the Merrimack River was in March 1936, when rain, melting snow, and ice swelled the Merrimack in Lowell to 68.4 feet (20.8 m), 10 feet (3 m) higher than the 2006 flood. In addition to the 1936 flood, the 1852 flood, the Mother's Day Flood of 2006, the New England Hurricane of 1938, and April 2007 flood are among the River's most serious flood events in Lowell. Most recently, from March 14 through 21, 2010, a major rain event caused all seven gauged mainstream rivers in Middlesex County to rise above flood stage.



Flooding at the Lawrence Mills in Lowell in 2007

Stony Brook is a tributary of the Merrimack River located in the north end of town. It has a 100-year flood plain that extends back from its confluence with the Merrimack River and under Route 3. River Meadow Brook runs south to north, draining much of the eastern third of the town, and has several tributaries that flow into it from the west. There is flood plain throughout large portions of River Meadow Brook's watershed, much of it extending upstream from where it crosses under Interstate 495. In 2002, the River Meadow Brook floodplain elevation was increased from 106 feet to 108 feet through the FEMA amendment process.

According to the Town's 2017 Open Space and Recreation Plan Update, several other areas have reportedly been observed to flood regularly during storm events or after an extended period of heavy rain:

- Littleton Road, west of Chelmsford Center
- Turnpike Road at River Meadow Brook
- Portions of Southwell Park near the Williamsburg Condominium complex and the Merrimack River
- High Street at Beaver Brook
- Warren Avenue at River Meadow Brook;
- Butterfield and Sleeper Streets•
- Crooked Spring Road and Meadowbrook Road
- Meadowbrook Road at Stony Brook

The Town has reported recurrent flooding problems along Tyngsborough Road (Route 3A) in North Chelmsford when the Merrimack River is at flood stage. In 2006, Dunshire Avenue also flooded. During past years, this flooding has been severe enough to require closure of the roadway along with Butterfield and Sleeper Streets for days at a time. In 2010, Route 110 was closed from Chelmsford Center to Hunt Road due to flooding of an adjacent brook that washed out 15 feet of roadway. The Town also has concerns that access to the sewer pump station located on Wotton Street could become blocked during a severe flooding event.

Floodplains and Repetitive Loss Structures

The Federal Emergency Management Agency (FEMA) produces Flood Insurance Rate Maps, commonly known as FIRMs, to support the National Flood Insurance Program (NFIP). The FIRMs depict Special Flood Hazard Areas (SFHA), the areas subject to inundation from the 1% annual chance flood (also known as the Base Flood or the 100-Year Flood). The SFHA determines where flood insurance is required as a condition of a federally insured loan through the NFIP mandatory purchase requirement. This requirement is intended to shift flood damage and recovery costs away from the general taxpayer and on to those who live in floodplains. The risk zones and flood elevations shown on the FIRMs within the SFHA are used to determine flood insurance rates. The SFHA also determines where NFIP floodplain management requirements must be enforced by communities that participate in the program. These include land use and building code standards. In addition to the NFIP, the FIRMs are also used within FEMA's Individual and Public Disaster Assistance programs and FEMA's Mitigation Grant Programs, in emergency management, and they are also used to identify areas where certain State Building Code and Wetland Protection regulations must be enforced.

Massachusetts State Building Code covers the entire state, applies to both public and private construction, and is administered through the local building inspectors with state oversight. Section 3107 of the State Building Code contains most of the construction requirements related to buildings or structures.

In 2014, new FEMA floodplain maps were released for Chelmsford, with Letters of Map Revision and Letters of Map Amendment subsequently incorporated. The latest FIRM maps indicate a net increase of approximately 250 acres now determined to be in the floodplain from the 1979 maps.

Table 13: Floodplain Area

| Acres of floodplain as shown on 1979 FIRM maps | Acres of floodplain as shown on 2010 FIRM maps | Acres of floodplain as shown on 2014 FIRM Maps* | Difference in acres (1979-2014 FIRM maps) | % Change 1979-2014 | Total Land Area in Acres | % Land Area in Flood Plain (according to the 2014 FIRM maps) |
|--|--|---|---|--------------------|--------------------------|--|
| 1,947.67 | 2,076.28 | 2,198.17 | 250.50 | 12.87% | 14,749.89 | 14.90% |

*includes areas mapped in the 100 and 500-year floodplain

Source: GIS Analysis of the FEMA FIRM maps

It is important to note that the term "100-year flood" is misleading. It is not a flood that will occur only once every 100 years. Rather, it is a flood that has a one percent chance of being equaled or exceeded each year. Thus, the 100-year flood could occur more than once in a relatively short period of time. The 100-year flood, which is the standard used by most federal and state agencies, is used by the NFIP as the standard for floodplain management and to determine the need for flood insurance. For instance, a structure located within a SFHA shown on an NFIP map has a 26-percent chance of suffering flood damage during the term of a 30-year mortgage.

Chelmsford has seven (7) repetitive flood loss properties located within its boundaries. Table 14 displays the number of repetitive losses and the money paid out by FEMA in insurance claims under the NFIP as of February 2019. Since 1979, the National Flood Insurance Program paid out \$344,702 for twenty-two (22) claims. The most vulnerable locations in town for flooding are along the Merrimack River.

Table 14: Repetitive Flood Loss Properties under the NFIP (as of February 2019)

| Number of Repetitive Flood Loss Properties | Number of Losses | Single-Family Residential Properties | 2-4 Family Residential | Other Residential Properties | Non – Residential Properties | Total Paid |
|--|------------------|--------------------------------------|------------------------|------------------------------|------------------------------|------------|
| 7 | 22 | 7 | 0 | 0 | 0 | 344,702.28 |

Source: Massachusetts Department of Conservation and Recreation

Of these repetitive loss properties, two have been identified as Severe Repetitive Loss properties impacted by riverine flooding. A Severe Repetitive Loss property is a residential property that is covered under an NFIP flood insurance policy and:

- That has at least four NFIP claim payments (including building and contents) over \$5,000 each, and the cumulative amount of such claims exceeds \$20,000; or
- For which at least two separate claim payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building.

In addition to threatening building structures, flood events pose risks to critical infrastructure, such as dams and bridges. The ability of these structures to withstand flood events depends in part on the current maintenance and repair status. Dam failure during a flood event can pose a serious threat to downstream properties by releasing a surge of water that was stored behind the dam prior to its failure.

The floodplain boundaries provide a reasonable approximation of where the risk is greatest within each community.

Town Programs to Address Stormwater, Flooding and Drainage Issues

The town currently maintains drainage swales, retention and detention basins, culverts and ponds within its jurisdiction. The town has a dredging permit for this purpose and regularly sweeps streets, empties catch basins, cleans inlet screens, and cleans blocked culverts as a flood prevention measure

In addition to these maintenance practices, the Town has several regulatory controls to address flooding. Initially adopted in 1997, Chelmsford’s Floodplain Overlay District is similar to that of other communities across the Commonwealth. It includes all areas within the 100-year floodplain and floodways, as shown in the FIRM. All development in the district, including structural and non-structural activities, whether permitted by right or special permit, must be in compliance with M.G.L. c.131, §40.

The Zoning Board of Appeals can grant a special permit for new construction in the floodplain, as long as the applicant demonstrates that a proposed project conforms to the State Building Code and provides an engineer's certification that it will not increase the flood levels during the 100-year flood.

The Town enacted a local wetlands bylaw in 1996, and the bylaw was updated in 2009 to strengthen areas of jurisdiction and setbacks. The purpose of Chapter 187 is to "protect the wetlands, water resources, flood prone areas, and adjoining uplands...by controlling activities deemed by the Conservation Commission as likely to have a significant or cumulative effect on Resource Area values, including but not limited to the following: public or private water supply, groundwater supply, flood control, erosion and sedimentation control, storm damage prevention, water quality, prevention and control of water pollution, fisheries, fresh water shellfisheries, wildlife habitat, rare species habitat, agriculture, aquaculture, recreation and aesthetic values deemed important to the community". The local wetlands bylaw includes a 50-foot no build zone, a 30-foot no impervious surface restriction, and a 25-foot no-disturbance zone

National Flood Insurance Program

The National Flood Insurance Program (NFIP) is a federal program administered by FEMA. The NFIP provides subsidized flood insurance within communities that agree to adopt corrective and preventative floodplain management regulations that will reduce future flood damages. Congress created the NFIP in 1968, with the passing of the National Flood Insurance Act. The Act was passed to benefit homeowners whose insurance does not cover flood damage. In general, flood insurance from private companies is either not available or extremely expensive.

NFIP flood insurance is available anywhere within a participating community, regardless of the flood zone in which a property is located. Federal law requires that flood insurance be purchased as a condition of federally insured financing used for the purchase of buildings in the Special Flood Hazard Area (SFHA).

Chelmsford participates in the NFIP, along with the rest of the communities in Northern Middlesex County. To join the program, the Town adopted a resolution of intent to participate and cooperate with FEMA. Each community agreed to "*maintain in force...adequate land use and control measures consistent with the NFIP criteria*" and to:

- Assist the Administrator in the delineation of the floodplain;
- Provide information concerning present uses and occupancy of the floodplain;
- Maintain for public inspection and furnish upon request, for the determination of applicable flood insurance risk premium rates within all areas having special flood hazards, elevation and floodproofing records on new construction;
- Cooperate with agencies and firms which undertake to study, survey, map, and identify floodplain areas, and cooperate with neighboring communities with respect to the management of adjoining floodplain areas in order to prevent aggravation of existing hazards; and
- Notify the Administrator whenever the boundaries of the community have been modified by annexation or the community has otherwise assumed or no longer has authority to adopt and enforce floodplain management regulations for a particular area.

Table 15 summarizes the NFIP policy data for Chelmsford:

Table 15: National Flood Insurance Policies as of April 30, 2019

| Total Policies | Insurance in Force | Number of Closed Paid Losses |
|----------------|--------------------|------------------------------|
| 289 | \$70,962,400 | 59 |

Source: Massachusetts Department of Conservation and Recreation

National Flood Insurance Program Compliance Although the NFIP is a federal program, its successful implementation and management depends on the participation of a variety of partners, including local communities, MEMA, DCR and FEMA. FEMA, MEMA and DCR support local communities by providing technical assistance, monitoring, and enforcing compliance with the requirements of the NFIP.

Communities must enforce the ordinances or bylaws that they adopt. This means that all development in a community’s SFHA as mapped by FEMA must be reviewed and permitted. The local permitting process ensures that all construction and development is adequately designed, located, constructed and anchored to minimize flood damage and is fully compliant with the local bylaw or ordinance. Communities can grant exceptions, called variances, to the NFIP requirements under limited circumstances.

Chelmsford has adopted Article XV Floodplain District under Chapter 196 Zoning as a local floodplain management bylaw, which is enforced according to FEMA requirements. The Town conducts inspections during the construction process to detect violations and remedies such violations prior to completion of the project.

The Town periodically reviews its floodplain bylaw/ordinance and makes necessary revisions as needed. Chelmsford works to identify potential and actual violations of the bylaw/ordinance and takes necessary steps to avert them or enforce compliance. In addition, municipal staff takes advantage of training opportunities offered by MEMA and FEMA, as a means of staying up to date with changes in the NFIP program and requirements. Most recently, Chelmsford assisted with the revision of the FIRM maps, and helped residents understand the changes that were made and how such changes impacted their properties.

Chelmsford has a designated floodplain manager who is responsible for ensuring the community's compliance with NFIP. This person is responsible for understanding NFIP regulations, reviewing permit applications, conducting inspections (or designating a staff member to perform inspections), taking enforcement actions against non-compliant projects, monitoring and participating in the variance process, and maintaining the community's floodplain records.

Community Rating System

The Community Rating System (CRS) is part of the NFIP. The CRS program encourages communities to reduce their flood risk by engaging in floodplain management activities. CRS provides discounts on flood insurance for communities that establish floodplain management programs that go beyond the minimum requirements of the NFIP. Depending on the level of activities that communities undertake in four areas – public information, mapping and regulatory activities, flood damage reduction, and flood preparedness - communities are categorized into 1 to 10 CRS classes. A Class 1 rating provides the largest flood insurance premium reduction, while a community with a Class 10 rating receives no insurance premium reduction. Although communities are not required to participate in CRS to receive approval of a hazard mitigation plan, FEMA encourages jurisdictions to integrate the CRS planning steps in their multi-hazard mitigation plans.

Bridges

Bridges in Massachusetts are rated in accordance with standards set by the American Association of State Highway and Transportation Officials (AASHTO). AASHTO standards rate bridges on a scale of 1 to 100, with one being the least compliant with the ideal and 100 being the most compliant. Bridges with an AASHTO rating lower than 50 are considered in need of improvement and are placed on a state bridge repair list. In some cases, a bridge may have an AASHTO rating greater than 50 but is considered deficient due to a specific key structural problem with a particular component. A bridge may also be considered functionally obsolete, meaning that the roadway carried by the bridge does not meet current design standards for things such as roadway width. For the purpose of flood related hazards, the designation of structurally deficient is the most critical. Based on a review of MassDOT GIS data, there are no bridges in Chelmsford which are currently classified as structurally deficient and located over waterways.

Dams

A dam is an artificial barrier that has the ability to impound water, wastewater, or any liquid for the purpose of storage or control. Dam failure can be defined as a catastrophic failure characterized by the sudden, rapid, and uncontrolled release of impounded water. Dams can fail for several reasons:

- Overtopping caused by floods that exceed the capacity of the dam;
- Deliberate acts of sabotage;
- Structural failure of materials used in dam construction;
- Movement and/or failure of the foundation supporting the dam;
- Settlement and cracking of concrete or embankment dams;
- Piping and internal erosion of soil in embankment dams; or
- Inadequate maintenance and upkeep.

Dam failures potentially represent the worst of flood events. When a dam fails, huge volumes of water are often released, causing widespread destruction and potential loss of life. Floods due to dam failures have occurred in New England in the past. On May 16, 1874, in Williamsburg, Massachusetts, a landslide destroyed a 43-foot dam on Mill Creek, a tributary of the Connecticut River, resulting in the deaths of 144 people.



Pawtucket Dam on the Merrimack River in Lowell

Dams are classified by the Massachusetts Department of Conservation and Recreation, Office of Dam Safety, according to their “hazard potential”. Dams are classified as High Hazard (Class I), Significant Hazard (Class II), and Low Hazard (Class III). Each level of classification has an associated hazard potential. Class I dams are located in areas where “failure or mis-operation will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highway(s) or railroad(s)”. Class II dams are located in areas “where failure or mis-operation may cause loss of life and damage home(s), industrial or commercial facilities, secondary highway(s) or railroad(s) or cause interruption of use or service of relatively important facilities”. Class III dams are located in areas “where failure or mis-operation may cause minimal property damage to others”. Loss of life is not expected from the failure of Low Hazard dams.

In accordance with MGL Chapter 235, Section 45, and 302 CMR 10.05, dam owners must add their dam(s) to the public record by completing a Dam Registration form provided by the Office of Dam Safety, which in turn issues a Dam Registration Certificate to the dam owner. The dam owner must record the certificate at the applicable Registry of Deeds as an attachment to the record deed and provide the Office with a copy of the recorded certificate. When land ownership is transferred, a revised form must be submitted to the Office to initiate an updated registration certificate.

It is important to note that a dam’s hazard classification is not an assessment of its potential for failure. For example, a Class I – High Hazard Dam does not have a higher potential for failure than a Class III – Low Hazard Dam. The hazard classification identifies the potential damage that would be caused if failure did occur. However, because of the greater risk posed by higher hazard dams, the state requires more frequent inspections of such dams. The higher the hazard classification the more frequently dam inspections must be performed. Owners of dams are required by 302 CMR 10.07 to hire a qualified engineer to inspect high hazard dams every two years. Significant dams must be inspected every five years, while low hazard dams must be inspected every ten years.

The current Dam Safety Regulations (302 CMR 10.00-10.16), dated February 10, 2017, identify the responsibilities of dam owners to register, inspect, develop emergency action plans for high hazard dams, and maintain dams in good operating condition. In 2013, new dam safety legislation, “An Act Further Regulating Dam Safety, Repair and Removal (H4557)” was signed into law, with the intent of encouraging the removal or repair of unsafe dams by creating financing opportunities at the municipal and state level, and increasing fines for owners of hazardous dams. Furthermore, the legislature established the Dam and Seawall Repair or Removal Fund, which offers grants and funds to repair or remove dams, seawalls, and other coastal infrastructure that are unsafe or impaired.

There are seven dams located within the Town of Chelmsford reported by the Office of Dam Safety.. None are classified as high hazard dams. The hazard classification for each dam is provided in Table 16 below. Additionally, the Town is aware of a second dam on Stony Brook that is not reported by the Office of Dam Safety.

Table 16: Hazard Classification of Chelmsford Dams

| Dam Name | Impoundment Name | Hazard Class** | Downstream Population |
|---------------------------------------|---------------------|--------------------|-----------------------|
| Stony Brook Dam*** | Stony Brook | Significant | 500 |
| Crooked Spring Dam | Crooked Spring Pond | Non-jurisdictional | NA |
| Lowell Sportsman's Club Dam*** | Scotty Hollow Brook | Non-jurisdictional | NA |
| Swains Pond Dam | Swains Pond | Non-jurisdictional | 200 |
| Heart Pond Dam | Heart Pond | Non-jurisdictional | 50 |
| Russell Mill Pond Dam*** | Russell Mill Pond | Significant | 300 |
| Freeman Lake Dam | Freeman Lake | Significant | 200 |

Source: Massachusetts of Conservation and Recreation, Office of Dam Safety

**Non-jurisdictional dams are not regulated by Office of Dam Safety

*** These dams are not owned or operated by the Town of Chelmsford

4.1.2 Wind Related Hazards

As wind speed increases, the pressure against an object increases at a disproportionate rate. For example, a 25-mile per hour wind causes about 1.6 pounds of pressure per square inch. When the wind speed increases to 75 miles per hour, the force on that object increases to 450 pounds per square inch. At a wind speed of 125 miles per hour, the force increases to 1,250 pounds per square inch. High winds can cause considerable damage to structures, infrastructure and trees. Winds sustained at 31 to 39 mph for at least one hour, or any gusts of 46 to 57 mph, cause the National Weather Service to issue a Wind Advisory. While winds 58 mph or higher would lead to the issuance of a High Wind Warning. Local communities in the Northern Middlesex region do not monitor or record wind speed data, and no other local source for this information has been identified. There are no airports or National Weather Service stations located within the region.

Effects from high winds can include downed trees and/or power lines and damage to roofs, windows, etc. High winds can cause scattered power outages, and are also a hazard for the boating, shipping, and aviation industry sectors. The region is susceptible to high wind from several types of weather events: before and after frontal systems, hurricanes and tropical storms, severe thunderstorms, and Nor'easters. The State Building Code has incorporated engineering standards for wind loads. Calculating wind load is important in the design of the wind force-resisting systems (including structural members, components, and cladding) to ensure against shear, sliding, overturning, and uplift actions.

Two major wind-related hazards that occur in the region include hurricanes and tornadoes. (Nor'easters are discussed under winter-related hazards). The entire region is at equal risk for wind-related hazards. Though these are not frequent events on an annual or seasonal basis, the chance of occurrence and the extent of damage associated with each are of concern to disaster mitigation planners. Unlike flooding, where historical river flow records allow the potential extent of flooding to be delineated with some accuracy within each community, delineating the exact area where a hurricane or tornado will strike is not possible. A brief description of hurricanes and tornadoes, along with the general risks associated with each follows.

Hurricanes A hurricane is a type of tropical cyclone; an organized rotating weather system that develops in the tropics. Tropical cyclones are classified as follows:

Tropical depression: An organized system of persistent clouds and thunderstorms with a low-level circulation and maximum sustained winds of 39 mph or less.

Tropical storm: An organized system of strong thunderstorms with a well-defined circulation and maximum sustained winds of 39-73 mph.

Hurricane: An intense tropical weather system with a well-defined circulation and maximum sustained winds of 74 mph or higher.

The typical hurricane moves at an average speed of approximately twelve (12) miles per hour. While in the lower latitudes, hurricanes tend to move from east to west. However, when a storm drifts further north, the westerly flow at the mid-latitudes tends to cause the storm to curve toward the north and east. When this occurs, the storm may accelerate its forward speed. This explains why some of the strongest hurricanes have reached New England.

Tropical depressions and tropical storms, while generally less dangerous than hurricanes, can be deadly. The winds of tropical depressions and tropical storms are usually not the greatest threat. Heavy rains, flooding and severe weather associated with tropical storms and depressions can cause significant problems in the region. Serious power outages can be associated with hurricanes and other tropical storms. After Hurricane Gloria in 1985, some area residents were without power for five days. When the remnants of Hurricane Irene passed through the region as a tropical storm in late August 2011, much of the region was without power for 3 to 5 days.

Hurricanes can occur along the East Coast of the United States anytime in the period between June and November. However, from 1851-2019, there are no records of a storm with hurricane intensity making landfall in New England during the months of June or July. August, September, and the first half of October have the most frequent hurricane occurrences for New England. This is due to the fact that it takes a while for the waters south of Long Island to warm up enough to sustain storms this far north. In addition, as fall approaches, the upper level jet stream contains more dips, which means that the steering winds may flow from the Great Lakes southward to the Gulf states and then back northward up the eastern seaboard. This pattern is conducive for capturing a tropical system over the Bahamas and accelerating it northward.

Hurricane intensity and the potential property damage posed by a hurricane are rated from 1 to 5, according to the Saffir-Simpson Hurricane Scale. Hurricanes reaching Category 3 and higher are considered major hurricanes, given the potential for loss of life and property damage. The wind intensity and potential damage for each category is summarized as follows⁵:

Category 1 – Winds 74 to 95 miles per hour (mph). Damage potential to unanchored mobile homes, trees, shrubbery, and poorly constructed signs.

Category 2 – Winds 96 to 110 mph. Damage to roofing material, doors, and windows. Considerable damage to mobile homes and poorly constructed signs. Significant damage to trees and shrubs, with some trees blown down.

Category 3 – Winds 111 to 130 mph. Small residences and buildings may experience some structural damage. Minor curtain wall failure is possible. Destruction of mobile homes and poorly constructed signs. Foliage is blown off trees and trees may be blown down.

Category 4 – Winds 131 to 155 mph. Small residences may experience complete roof structure failures. Mobile homes completely destroyed. All signs, trees, and shrubs blown down. Doors and windows extensively damaged.

Category 5 – Winds greater than 155 mph. Many residences and industrial buildings experience complete roof failure. Complete building failures possible. Small utility buildings are blown over or away. All signs, trees, and shrubs blown down. Mobile homes completely destroyed. Windows and doors severely and extensively damaged.

⁵ References to coastal surges are not included as there is no coast line within the Northern Middlesex region.

Hurricane force winds can destroy buildings and mobile homes. According to NOAA, the strongest sustained 1-minute wind speed and wind gust ever recorded in Massachusetts from a hurricane was at the Blue Hill Observatory in Milton, MA, during the Great New England Hurricane in 1938. A sustained wind of 121 mph with a peak gust to 186 mph was recorded. In hurricane conditions, debris such as signs, roofing materials, siding and lawn furniture can become missiles. Hurricanes can also spawn tornadoes that generally occur in thunderstorms embedded in rain bands well away from the center of the hurricane. Tornadoes can also occur near the eye wall.

A hurricane watch is issued when a hurricane or hurricane conditions pose a threat to an area within the next thirty-six (36) hours. A hurricane warning is issued when hurricane winds of 74 mph or higher are expected in the next twenty-four (24) hours. If a hurricane's path is erratic or unusual, the warning may be issued only a few hours before the beginning of hurricane conditions.

While there have been relatively few direct hits from hurricanes in New England, peripheral effects from offshore hurricanes and tropical storms that track inland are not uncommon. Since records have been kept for hurricanes, Massachusetts has experienced forty-seven (47) wind-related occurrences associated with hurricanes. Of those, seven (7) have had a direct impact and forty (40) have had an indirect impact. Each community in the Northern Middlesex region is at equal risk of being impacted by a hurricane. Table 18 below provides a summary of hurricanes that have affected New England since 1938.

The most recent hurricane to significantly affect the Northern Middlesex region was Hurricane Irene in August 28, 2011, which became a tropical storm as it passed over the region. The Commonwealth of Massachusetts and federal government issued a Pre-Landfall Emergency Declaration on August 26, 2011 and local states of emergency were declared on August 27, 2011. The local emergency managers were in constant communication with National Grid, MEMA and FEMA. Local DPW crews supported power restoration efforts and the LEPCs participated in MEMA's daily conference calls from August 26th through September 1st. In the Northern Middlesex region, local communities communicated with residents through reverse 911 phone calls, emails and web postings.

Table 17: New England Hurricanes and Tropical Cyclones (1938-2019)

| Date | Storm/ Event | Description | Fatalities | Injuries | Property Damage |
|-------------------|--------------------------------|--|------------|----------|---|
| 09/21/1938 | New England Hurricane | Highest sustained winds-121 mph, Forward motion in excess of 50 mph. 17 inches of rain; extensive flooding. | 564 | 1700+ | 9,000 homes and businesses destroyed, 15,000 damaged. |
| 09/15/1944 | Great Atlantic Hurricane | Forward motion in excess of 40 mph. | 390 | NA | \$925 million |
| 09/12/1950 | Hurricane Dog | Center passed offshore Cape Cod. 4.42 inches of rain in 24 hours. | 0 | 0 | \$2 million |
| 09/07/1953 | Hurricane Carol | Moved through the Bay of Fundy with only minor damage. | 0 | 0 | |
| 08/31/1954 | Hurricane Carol | First of three devastating hurricanes of 1954. Forward motion in excess of 50 mph. Category 3. Extensive flooding and damage. | 60 | NA | \$438 million |
| 09/11/1954 | Hurricane Edna | Over 7 inches of rainfall. Extensive flooding. | 29 | NA | \$40.5 million |
| 10/15/1954 | Hurricane Hazel | Forward motion over 50 mph. | 600 | NA | \$350 million |
| 08/00/1955 | Hurricane Connie | Extensive flooding with 4-6 inches of rainfall | 43 | NA | \$40 million |
| 08/18/1955 | Tropical Storm Diane | 20 inches of rainfall caused devastating floods | 184 | NA | \$832 million |
| 08/29/1958 | Hurricane Daisy | New England felt only periphery gales. | 0 | 0 | NA |
| 09/12/1960 | Hurricane Donna | Category 2. Forward motion of 39 mph. | 133 | NA | \$387 million |
| 09/21- 25/1961 | Hurricane Esther | Did unusual loop-de-loop southeast of Cape Cod. 7-8 inches of rainfall. Forward motion slowed approaching New England. | 0 | NA | NA |
| 10/10/1961 | Hurricane Frances | Category 3 storm, 110 mph winds. Some wind damage in New England | NA | NA | NA |
| 08/29/1962 | Hurricane Alma | Minor damage only. | NA | NA | NA |
| 10/06- 07/1962 | Hurricane Daisy | 14.25 inches of rainfall over 48 hours in Wakefield, MA. Significant flooding occurred throughout New England. Set record for 24-hour precipitation which remained unbroken until Hurricane Bob in 1991. | 24 | NA | NA |

| | | | | | |
|------------------|---------------------------|--|---------------------------|----|---------------|
| 10/29/1963 | Hurricane Ginny | Famous snow hurricane in Maine with up 18 inches falling in the Maine mountains. | 0 | 0 | \$300,000 |
| 09/14/1964 | Hurricane Dora | Moderate rainfall. | 3 | NA | \$200 million |
| 09/24/1964 | Hurricane Gladys | Moderate to heavy precipitation. | 2 | NA | \$6.7 million |
| 06/13/1966 | Hurricane Alma | Minor damage. | 5 | NA | \$1.5 million |
| 09/09/1969 | Hurricane Gerda | Center passes directly over Nantucket with gusts to 140 mph. | NA | NA | NA |
| 08/28/1971 | Tropical Storm Doria | Wind gusts to 80 mph. Heavy rains, flooding. | 3 | NA | NA |
| 09/14/1971 | Tropical Storm Heidi | Moderate rainfall, little damage. | 0 | 0 | NA |
| 09/03-04/1972 | Tropical Storm Carrie | Hurricane force wind gusts. Heavy rainfall | 1 | NA | \$1.2 million |
| 07/27/1975 | Hurricane Blanche | Most heavy weather remained offshore | 0 | NA | NA |
| 08/09-10/1976 | Hurricane Belle | Category 1. Forward motion 32 mph. Heavy rainfall causes some flooding. | 3 | 3 | NA |
| 09/06/1979 | Tropical Storm David | Minor effects | 1,100 (Virgin Islands) | NA | \$60 million |
| 09/25/1985 | Tropical Storm Henri | Minor effects | 0 | 0 | NA |
| 09/27/1985 | Hurricane Gloria | Category 2. Forward motion of 72 mph. Gusts to 80 mph. | NA | 3 | \$ 1 billion |
| 08/07/1988 | Tropical Storm Alberto | Winds of 50 mph. | 31 | NA | \$500 million |
| 08/19/1991 | Hurricane Bob | Category 2. Forward motion of 51 mph. Wind speeds of up to 60 mph. Set new 24- hour precipitation record. Major flooding and power outages | 18 | NA | \$1.5 billion |
| 10/30-11/01/1991 | Unnamed "Halloween" storm | Huge storm surge caused extensive damage along the coast | 12 | NA | \$210 million |
| 07/13/1996 | Hurricane Bertha | Forward motion of 48 mph. Very heavy rainfall and strong gusty winds. Spawned one tornado in Massachusetts | 12 | NA | \$275 million |
| 09/02/1996 | Hurricane Edouard | Left 40,000 residents without power, 3 inches of rain fell | 0 | 0 | \$3.5 million |

| | | | | | |
|---------------|----------------------|--|-----|----|---------------------|
| 07/25/1997 | Tropical Storm Danny | Dropped 3-5 inches of rain | 0 | 0 | |
| 09/16-17/1999 | Tropical Storm Floyd | Forward motion of 56 mph. No significant damage in Massachusetts. | 0 | 0 | \$4.5 billion |
| 09/03/10 | Hurricane Earl | Tropical Storm passed 98 miles east of New England with winds of 40+ mph producing high surf, heavy rain and coastal flooding | 1 | 0 | NA |
| 08/28/11 | Hurricane Irene | Hurricane Irene, became a tropical storm as it moved inland over New York, Connecticut, Massachusetts, New Hampshire and Maine | 42 | NA | 7-10 Billion (est.) |
| 10/30/12 | Hurricane Sandy | Major impacts caused by flooding of roads and bridges in Massachusetts; widespread power outages | 160 | NA | \$50 billion |
| 9/19/17 | Tropical Storm Jose | Peak of 6.4 inches of rainfall | 1 | NA | \$2.84 million |

Source: National Climatic Data Center, NOAA, U.S. Dept. of Commerce

Since there are no coastal areas within the region, the risk of storm surge associated with a hurricane is not a factor. However, inland flooding resulting from intense rain is a serious threat and is often responsible for more deaths than wind. In the past 30 years, inland flooding has been responsible for more than half the deaths associated with tropical cyclones in the United States. There is no direct correlation between wind speed and rain intensity. Less intense hurricanes can deliver the highest amount of rainfall, especially if a storm stalls over an area. Flooding events in Chelmsford tend to be most severe along the Merrimack River.

Though heavy rains associated with hurricanes probably present the highest recurrent risk in the Northern Middlesex region, high winds are also a risk. Blowing objects carried by the wind pose a threat to people stranded outside in a hurricane. Hurricanes can also spin off small, localized tornadoes outside the center of the storm. Though typically weaker than other tornadoes, those associated with hurricanes still pose an additional threat outside the primary track of the hurricane. Downed trees and tree limbs, blocked roads, and downed telephone and power lines can disrupt transportation routes and communication channels.

It is impossible to predict where these things might occur during a hurricane event; therefore, the entire town is considered to be vulnerable. Given the likelihood of high winds, residents in the mobile home park on Route 110 are particularly vulnerable. The Town appropriates capital funds each year to have a certified arborist remove any hazardous tree limbs in order to protect property and prevent injuries.

Since 1954, there have been five hurricane-related Presidential Disaster Declarations affecting the region, as shown in Table 18 below.

Table 18: Hurricane-related Presidential Disaster Declarations in Middlesex County (1954-2019)

| Disaster Number | Date | Storm/Incident |
|-----------------|------------|----------------------|
| 4028 | 09/03/2011 | Tropical Storm Irene |
| 914 | 08/26/1991 | Hurricane Bob |
| 751 | 10/28/1985 | Hurricane Gloria |
| 43 | 8/20/1855 | Unnamed hurricane |
| 22 | 09/02/1954 | Unnamed hurricane |

Source: FEMA

The National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center provides a searchable database that allows one to query hurricane records dating back to as early as 1842. Query results show historical storm tracks by storm intensity within a specified radius of a site. Query results for this region for hurricanes of Category 1 or above, passing within a 75-mile radius, show nine Category 1-5 hurricanes, as depicted in Map 1 on the following page. These include five unnamed storms for the years 1858, 1869, 1894, 1896, and 1944, as well as Hurricane Carol (1954), Hurricane Donna (1960), Hurricane Gloria (1985), and Hurricane Bob (1991). The map that follows shows the tracks of these storms. As noted above, however, a hurricane’s wind intensity alone does not speak to the threat posed by intense rains that can cause serious inland flooding. Less intense hurricanes or tropical storms can carry higher rainfall amounts independent of wind speed.

Map 1: Typical Historical Cyclone Tracks over Massachusetts

Historical Hurricane Tracks

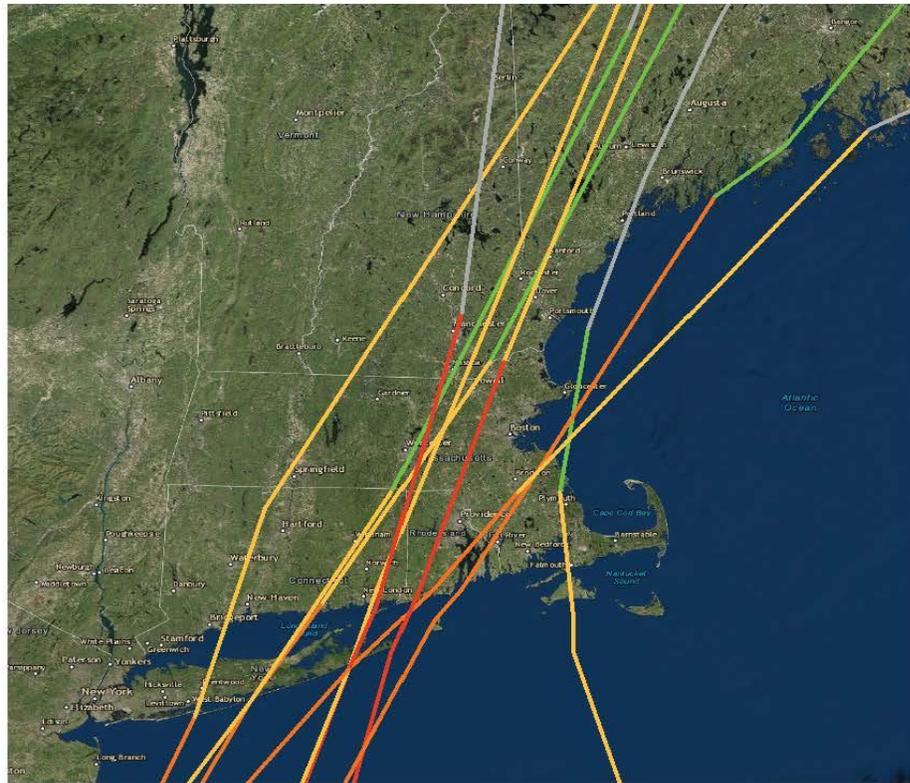
National Oceanic and Atmospheric Administration

Summary of Search

Location: 42.60263078536242,-71.39190673828126
Buffer: 120675 Meters (65 Nautical Miles)

Search Refined By

Categories : H5,H4,H3,H2,H1



Source: NOAA

The 2015 Update to the Hazard Mitigation Plan for the Northern Middlesex Region estimated the number of people affected by a possible hurricane, as well as those that may lack access to transportation, based upon Chelmsford's Comprehensive Emergency Management Plan.

Table 19: Estimated Population Impacted by a Possible Hurricane in Chelmsford

| Maximum Population Affected | Maximum Number of People Without Transportation |
|-----------------------------|---|
| 20,000 | 2,000 |

Source: Hazard Mitigation Plan for the Northern Middlesex Region 2015 Update

Tornadoes

According to the American Meteorological Society’s Glossary of Meteorology, a tornado is “a violently rotating column of air, pendant from a cumuliform cloud or underneath a cumuliform cloud, and often (but not always) visible as a funnel cloud”. The most deadly and destructive tornado forms from a super cell, which is a rotating thunderstorm with a well-defined circulation called a mesocyclone.

Tornadoes can appear from any direction, but most move from southwest to northeast, or west to east. Tornadoes can last from several seconds to more than an hour. Most last less than ten minutes, and over 80% of strikes occur between noon and midnight. “Tornado season” is generally from March through August, although a tornado may occur any time of the year. Some ingredients for tornado formation include:

- Very strong winds in the mid and upper levels of the atmosphere;
- Clockwise turning of the wind with height (i.e., from southeast at the surface to west aloft);
- Increasing wind speed in the lowest 10,000 feet of the atmosphere (i.e., 20 mph at the surface and 50 mph at 7,000 feet);
- Very warm, moist air near the ground with unusually cooler air aloft; and
- A forcing mechanism, such as a cold front or leftover weather boundary from prior shower or thunderstorm activity.

The most devastating tornado to occur in New England was the Worcester tornado of July 9, 1953, which killed ninety-six people and injured over thirteen hundred. The last significant tornado to strike New England occurred on June 1, 2011, pummeling sections of Springfield and West Springfield. This event included seven confirmed tornadoes, the worst of which was a category F3. The storm killed three, injured hundreds and left over 48,000 people without electricity. As a result, President Obama declared Springfield and the surrounding region a Federal Disaster Area. Governor Patrick also activated National Guard troops to assist with rescue and recovery efforts. Most recently, a tornado touched down in Concord, Massachusetts in 2016, causing downed trees and power lines along its half-mile trail.

On average, seven tornadoes per year touch down somewhere in New England. Those at risk include people in automobiles, anyone not in a secure structure, and those residing in mobile homes. Since 1951, there have been 166 tornadoes in Massachusetts, which resulted in 109 fatalities and 1,562 injuries.

Within the Northern Middlesex region, there have been eight tornadoes since 1955. As shown in Table 21 below, the most recent tornado impacting the region occurred in September 1974 and was classified as an F3. The oldest record of a tornado in the region is from July 24, 1857, when a powerful tornado swept through Tewksbury, MA. The town was sparsely populated at the time, and there were no injuries or fatalities. The tornado tore up fields and orchards, and destroyed barns and sheds, as it headed south to Wilmington. In July 1890, a tornado touched down for three minutes in North Billerica, destroying the roofs on some buildings and damaging trees. On July 21, 1972 an F2 tornado sliced a 7.6-mile-long, 35-yard path from Tyngsborough, along the Merrimack River, into North Chelmsford and over Robin Hill into South Chelmsford. There have been no tornadoes reported in the Northern Middlesex region since 1974. Each community in the region is at equal risk of being impacted by a tornado.

Table 20: Tornadoes in the Northern Middlesex Region

| Date | Category | Injuries/Fatalities |
|----------|----------|---------------------|
| 10/24/55 | F1 | 0 |
| 8/21/57 | F2 | 1 injury |
| 7/11/58 | F2 | 0 |
| 7/18/63 | F1 | 0 |
| 10/3/70 | F3 | 1 fatality |
| 7/1/71 | F1 | 1 injury |
| 7/21/72 | F2 | 4 injuries |
| 9/29/74 | F3 | 1 injury |

Source: www.tornadohistoryproject.com

As outlined in the Commonwealth’s 2018 State Hazard Mitigation and Climate Adaptation, the Reported Tornado Occurrences (1950-2016) map shows tornado risk based on the historic past occurrence of tornadoes. The density per square mile indicated the probable number of tornado touchdowns for each square mile cell within the contoured zone that can be expected over a similar timeframe (fifty years). The analysis shows that the area of the state at greatest risk runs from central to northeastern Massachusetts and includes the Northern Middlesex region.

The National Weather Service (NWS) issues tornado forecasts through each local NWS office. In predicting severe weather, meteorologists look for the development of instability, lift and wind shear for tornadic thunderstorms. Real-time weather observations from satellites, weather stations, weather balloons, and radar become highly important as a storm approaches.

A tornado watch defines an area where tornadoes and other types of severe weather are possible in the next several hours. A tornado warning means that a tornado has been spotted, or that Doppler radar indicates a thunderstorm with circulation that can spawn a tornado.

Tornado damage severity is measured by the Fujita Tornado Scale, in which wind speed is not measured directly but rather estimated from the amount of damage. As of February 01, 2007, the National Weather Service began rating tornados using the Enhanced Fujita-scale (EF- scale). It is considerably more complicated than the original F-scale, and it allows surveyors to create more precise assessments of tornado severity. Table 21 illustrates the EF-scale and the damage indicators. It uses three-second gusts estimated at the point of damage as judged by eight levels of damage to the 28 indicators listed in Table 22. These estimates vary with height and exposure.

Table 21: The Enhanced F-Scale

| F Number | Fastest ¼-mile (mph) | 3-second gust (mph) ¹ | Derived | | Operational EF Scale | |
|----------|----------------------|----------------------------------|-----------|---------------------|----------------------|----------------------|
| | | | EF Number | 3-second gust (mph) | EF Number | 3-second gusts (mph) |
| 0 | 40-72 | 45-78 | 0 | 65-85 | 0 | 65-85 |
| 1 | 73-112 | 79-117 | 1 | 86-109 | 1 | 86-110 |
| 2 | 113-157 | 118-161 | 2 | 110-137 | 2 | 111-135 |
| 3 | 158-207 | 162-209 | 3 | 138-167 | 3 | 136-165 |
| 4 | 208-260 | 210-261 | 4 | 168-199 | 4 | 166-200 |
| 5 | 261-318 | 262-317 | 5 | 200-234 | 5 | Over -200 |

Source: www.noaa.gov

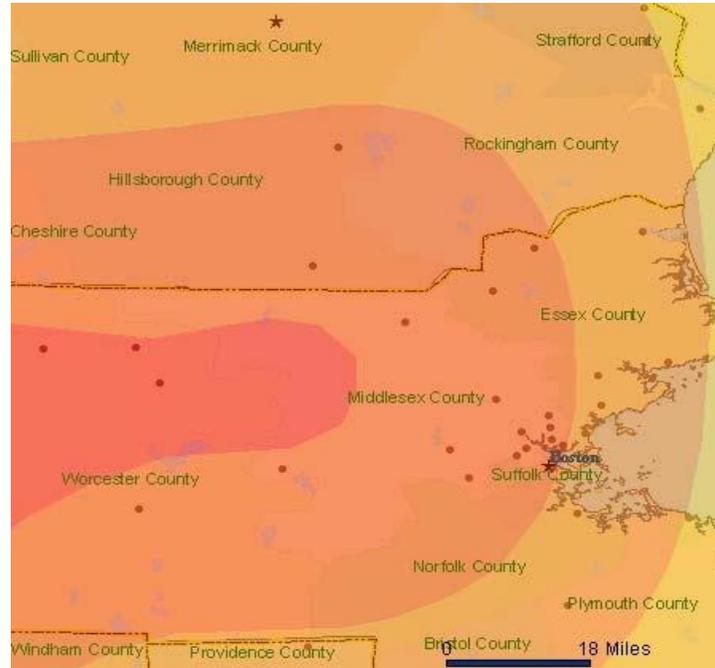
Table 22: Enhanced F-Scale Damage Indicators

| Number | Damage Indicator | Abbreviation |
|--------|--|--------------|
| 1 | Small barns, frames outbuildings | SBO |
| 2 | One or two-family residences | FR12 |
| 3 | Single-wide mobile home | MHSW |
| 4 | Double-wide mobile home | MHDW |
| 5 | Apt, Condo, townhouse (3 stories or less) | ACT |
| 6 | Motel | M |
| 7 | Masonry Apt. or motel | MAM |
| 8 | Small retail building (fast food) | SRB |
| 9 | Small professional (Doctor office, Bank) | SPB |
| 10 | Strip Mall | SM |
| 11 | Large shopping mall | LSM |
| 12 | Large, isolated (big box) retail building | LIRB |
| 13 | Automobile showroom | ARS |
| 14 | Automobile service building | ASB |
| 15 | School – 1-story elementary (interior or exterior halls) | ES |
| 16 | School – jr. or sr. high school | JHSH |
| 17 | Low-rise (1-4 story) building | LRB |
| 18 | Mid-rise (5-20) building | MRB |
| 19 | High-rise (over 20 stories) | HRB |
| 20 | Institutional bldg. (hospital, govt. or university) | IB |
| 21 | Metal building system | MBS |
| 22 | Service station canopy | SSC |
| 23 | Warehouse (tilt-up walls or heavy timber) | WHB |
| 24 | Transmission line tower | TLT |
| 25 | Free-standing tower | FST |
| 26 | Free standing pole (light, flag, luminary) | FSP |
| 27 | Tree - hardwood | TH |
| 28 | Tree - softwood | TS |

Source: www.noaa.gov

The Disaster Center evaluated tornado statistics from 1950-1995 by state. When compared with other states across the country, Massachusetts ranked 35th in frequency, 16th in the number of tornado-related deaths, 21st in the number of injuries, and 12th for the cost of tornado-related damages. In terms of tornado frequency per square mile, Massachusetts ranked 14th in overall frequency, and first in terms of fatalities, injuries, and cost per area. Map 2 on the following page shows tornado density for Middlesex County.

Map 2: Tornado Density for Middlesex County



Source: NOAA

Severe Thunderstorms

The National Weather Service considers a thunderstorm to be severe if it produces hail at least $\frac{3}{4}$ inch in diameter, has winds of 58 mph or higher, or has the potential to produce a tornado. Lightning accompanies all thunderstorms and can cause death, injury and property damage. Straight-line winds can exceed 100 mph and are responsible for most thunderstorm wind damage. A downburst, a small area of rapidly descending air beneath a thunderstorm, can reach speeds equal to that of a strong tornado.

Three basic ingredients are required for a thunderstorm to form: moisture, rising unstable air (air that keeps rising when given a nudge), and a lifting mechanism to provide the impetus. The sun heats the surface of the earth, which warms the air above it. When this warm surface air begins to rise, such as in areas with hills or mountains, or areas where warm/cold or wet/dry air bump together, it will continue to rise as long as it weighs less and stays warmer than the air around it. As the air rises, it transfers heat from the surface of the earth to the upper levels of the atmosphere (a process known as convection). The water vapor in the air begins to cool, releases heat and condenses into a cloud. The cloud eventually expands upward into areas where the temperature is below freezing. Some of the water vapor turns to ice, and some of it turns into water droplets. Both ice particles and water droplets have electrical charges.

Ice particles usually have positive charges, and rain droplets usually have negative charges. When the charges build up they are eventually discharged in a bolt of lightning, which causes the sound waves we hear as thunder.

An average thunderstorm is 15 miles in diameter and lasts an average of 30 minutes. Severe thunderstorms can be much larger and last much longer. Southern New England typically experiences about 10-15 days per year in which there are severe thunderstorms. It is not unusual for the region to experience a few severe thunderstorms over the course of the spring and summer. The greatest hazard caused by this type of storm is flash flooding. In addition, hail can cause substantial damage to property and crops. Large hailstones can fall faster than 100 mph, and can be very costly in terms of economic losses.



A thunderstorm in Westford

Every thunderstorm has an updraft (rising air) and a downdraft (sinking air, usually with the rain). However, sometimes, there are extremely strong downdrafts, known as downbursts, which can cause tremendous straight-line wind damage at the ground, similar to that of a tornado. A small (< 2.5 mile path) downburst is known as a “microburst” and a larger downburst is called a “macroburst.” An organized, fast-moving line of embedded microburst that travels across large portions of a state is known as a “derecho” and this can occasionally occur in Massachusetts. The strongest downburst ever recorded was 175 mph, near Morehead City, North Carolina. Winds exceeding 100 mph have been measured in Massachusetts from downbursts.

One hazard specifically associated with thunderstorms is lightning. Fatalities, although rare, can occur from lightning. In the United States, 99 percent of fatalities have occurred outside of a large substantial building or fully enclosed metal-topped vehicle. For the United States, approximately 72 people were killed by lightning per year from 1959 to 2016 or 4,114 total fatalities, and Massachusetts accounted for 32 of those incidents.

There have been several damaging thunderstorms in Massachusetts. In June of 1998, a very slow moving and complex storm system moved through southeast New England. The combination of its slow movement and presence of tropical moisture across the region produced rainfall of 6 to 12 inches over much of eastern Massachusetts. This led to widespread urban, small stream, and river flooding. As a result, the counties of Suffolk, Essex, Middlesex, Norfolk and Bristol received a Presidential Disaster Declaration for the Individual Household Program (Individual Assistance) on June 23, 1998. Each community in the Northern Middlesex region is at equal risk of being impacted by a severe thunderstorm and it is not possible to predict where damage from such a storm might occur.

On May 22, 2006 a severe thunderstorm toppled trees in Tyngsborough, Chelmsford and Lowell and left 5,000 residents without power. Wind gusts reached 45 mph. Since 2015, approximately seven thunderstorms have resulted in a total \$104,000 worth of property damage in Chelmsford.

4.1.3 Winter Related Hazards

Severe winter storms can produce a wide variety of hazardous weather conditions, including heavy snow, freezing rain, sleet, and extreme wind and cold. A severe winter storm is one that results in four or more inches of snow over a twelve-hour period, or six or more inches over a twenty-four-hour period. The leading cause of death during winter storms is from an automobile or other transportation accidents. Exhaustion or heart attacks caused by overexertion are the second most likely cause of winter storm-related deaths. Chelmsford, like the rest of the region, is at risk for winter storms.

The National Weather Service issues outlooks, watches, warnings and advisories for all winter weather hazards. These statements are defined as follows:

- Outlook:** Winter storm conditions are possible in the next 2-5 days
- Watch:** Winter storm conditions are possible in the next 36-48 hours
- Warning:** Life-threatening severe winter conditions have begun or will begin
- Advisory:** Winter weather conditions are expected to cause significant inconveniences and may be hazardous.

The most severe winter storm to ever strike New England was the Blizzard of 1888. The storm that occurred from March 11-14, 1888, deposited up to 50 inches of snow. The Blizzard of 1978 dumped 24-36 inches of snow on the eastern part of the state and paralyzed the area for several days.

Since 1983, the most significant winter snowfall in the region occurred during the winter of 1995, when snowfall measurements in the City of Lowell reached 126.5 inches. Snowfall totals in Chelmsford were similar, however the Town does not maintain its own records.

The winter of 2010-2011 produced some of the largest snowfall totals in the region's and state's history, and included two blizzards, both occurring in January 2011. According to the National Weather Service, Boston received 80.1 inches of snow that winter, while the Northern Middlesex region received 79.6 inches. The snowstorm left 640,000 Massachusetts homes and residents without power, according to MEMA. Table 23 outlines the number of power outages by community as a result of the early season snowstorm, which left 79,296 customers, or 67% of the region, in the dark.

Table 23: Power Outages in the Region During the October 2011 Snowstorm (10/30/11)

| Customers without power | % of Customers without power |
|-------------------------|------------------------------|
| 13,898 out of 15,372 | 90.41 |

Source: National Grid

The most recent blizzard to hit Middlesex County occurred in January of 2015, with a total snowfall of 17.9 inches recorded in Lowell. The storm resulted in a Presidential Disaster Declaration, and federal funding was made available to reimburse towns’ costs for plowing, emergency response, and property damage.

Table 24 below details the annual snowfall totals for the City of Lowell, from 1990-2017.

Table 24: Annual Snowfall Totals for Lowell, MA – 1990-2017

| Year | Snowfall Total (inches) |
|----------------|-------------------------|
| 1990 | 45.90 |
| 1991 | 45.83 |
| 1992 | 37.13 |
| 1993 | 41.04 |
| 1996 | 55.78 |
| 1997 | 36.62 |
| 1998 | 44.57 |
| 2000 | 51.26 |
| 2001 | 40.56 |
| 2002 | 46.93 |
| 2005 | 60.76 |
| 2007 | 45.59 |
| 2008 | 64.56 |
| 2009 | 57.36 |
| 2010 | 57.57 |
| 2012 | 48.56 |
| 2013 | 50.19 |
| 2014 | 52.41 |
| 2015 | 41.85 |
| 2016 | 35.47 |
| 2017 | 43.89 |
| 2018 | 57.32 |
| Average | 59.4 |

Source: NOAA National Centers for Environmental Information.

Since 2005, there have been several disaster declarations for Middlesex County related to winter weather, as well as specific “snow emergency” declarations. Each community in the Northern Middlesex region is at equal risk of being impacted by a severe winter storm. As an example, the Lowell Sun published the following snowfall totals for the February 9, 2013 snowstorm. Every community in the region received significant snow ranging from 19 inches in Chelmsford to 28 inches in Tyngsborough. Temperature, wind direction, and banding of precipitation impact where the highest snowfall totals occur, but these factors are unpredictable, as shown in the case of the snowfall from the February 9, 2013 storm where each community received the following:

- Billerica-23.8 inches
- Chelmsford-19 inches
- Dracut-24.9 inches
- Dunstable-25 inches
- Lowell-20 inches
- Tewksbury-27 inches
- Tyngsborough-28 inches
- Westford-24 inches

A summary of the winter weather related disaster declarations for Middlesex County is provided in Table 25 below.

Table 25: Winter Weather Related Federal Disaster and Emergency Declarations for Middlesex County 2005-2019

| Disaster Name (Date of Event) | Disaster Number (Type of Assistance) | Declared Areas |
|---|---|---|
| Severe Winter Storm and Snowstorm (March 13-14, 2018) | FEMA DR 4379 | Worcester, Middlesex, Norfolk, Essex, and Suffolk |
| Severe Winter Storm, Snowstorm, and Flooding (January 26-28, 2015) | FEMA DR 4214 | Worcester, Essex, Middlesex, Norfolk, Plymouth, Bristol, Barnstable, Dukes, Nantucket, and Suffolk |
| Severe Winter Storm, Snowstorm and Flooding (February 8-9, 2013) | FEMA DR 4110 | All 14 counties |
| Severe Storm and Snowstorm (October 29-30, 2011) | FEMA DR 4051 | Counties of Berkshire, Franklin, Hampden, Hampshire, Middlesex, and Worcester. |
| Severe Storm (Jan. 11-12, 2011) | FEMA DR 1959 (Public) | Counties of Berkshire, Essex, Hampshire, Hampden, Hampshire, Middlesex, Norfolk and Worcester |
| Severe Winter Storm and Flooding (December 11 – 18, 2009) | FEMA-1813 (Public and individual) | Counties of Berkshire, Essex, Franklin, Hampden, Hampshire, Middlesex, and Worcester |
| Severe Winter Storm (Dec. 11–18, 2008) | FEMA 3296 (Public) | Counties of Berkshire, Essex, Franklin, Hampden, Hampshire, Middlesex, Bristol, Suffolk and Worcester |
| Severe Winter Storm (January 22- 23, 2005) | FEMA 3201 (Public) | All 14 Counties |

Source: www.fema.gov

Nor'easters

Nor'easters occur in New England more frequently than hurricanes and typically have a longer duration than hurricanes. A nor'easter is a large New England storm formed from a weather system traveling from South to North, passing along or near the seacoast. The nor'easter derives its name from the northeasterly direction of its counterclockwise cyclonic winds. It is not unusual for the sustained winds of a nor'easter to meet or exceed hurricane force. The duration of a nor'easter may outlast a hurricane event by many hours or even days. High winds associated with a nor'easter can last from 12 hours to 3 days, while the duration of a hurricane ranges from 6 to 12 hours.

Nor'easters pose a threat to infrastructure, including critical facilities. During the height of a storm, blizzard conditions present a hazard to driving or any other outdoor activity. A blizzard is defined as a storm with winds in excess of 35 mph, with falling and blowing snow reducing visibility to less than ¼ mile for at least three hours. Heavy snow disrupts transportation and may impede the passage of emergency vehicles. Heavy snow may also bring down power lines and trees, and lead to roof collapses. The Blizzard of 1978 dumped 24-48 inches of snow on eastern Massachusetts, paralyzing the region for several days.

The region experienced a significant nor'easter on March 5-7, 2001, that resulted in a Presidential Disaster Declaration on April 10, 2001. Two feet of snow fell over a three-day period (March 5-7). Wind gusts to 64 miles per hour were reported in some areas. The combination of heavy wet snow and high winds resulted in broken tree limbs that blocked roadways and downed power lines. More than 16,000 people in the Merrimack Valley were left without power on March 6, 2001. The late season snow set the stage for flooding. Two subsequent rainstorms, on March 20-22 and 29-30, 2001 resulted in the flooding of more than 10,000 residences and businesses in northeastern Massachusetts. Most of the damage due to flooding occurred along smaller tributary streams and rivers.

Most recently, the region experienced a series of significant Nor'easters in March 2018. The most extreme of these events occurred on March 13-14, 2018 and resulted in a total of 20.6 inches of snowfall recorded in Lowell. MEMA reported 352,380 power outages primarily in Essex, Middlesex, and Worcester counties. As a result of the March 13-14 storm, a Presidential disaster declaration was approved on July 19, 2018.



The October 2011 snowstorm downed trees and power lines in Chelmsford

Recovery during the aftermath of a snowstorm poses its own challenges. Prolonged curtailment of all forms of transportation can have significant adverse impacts for people stranded at home, preventing the delivery of critical services such as home heating fuel supplies or the ability to get to a local food store. Extended power outages, the cost of snow removal, repairing damages, and the loss of business can have severe economic impacts on local communities. Each community in the region is at equal risk of being impacted by a Nor'easter, and the impact of such a storm is widespread and consistent across the region. The elderly and infirmed are populations of concern during these events. Chelmsford residents residing in the mobile home park located on Route 110 are also vulnerable due to the weight of snow and the possibility of roof collapses.

While the Fujita and Saffir-Simpson Scales characterize tornadoes and hurricanes respectively, there is no widely used scale to classify snowstorms. NOAA's National Climatic Data Center is now producing the Regional Snowfall Index (RSI) for significant snowstorms that impact the eastern two thirds of the U.S. The RSI differs from these other indices because it includes population. RSI is based on the spatial extent of the storm, the amount of snowfall, and the juxtaposition of these elements with population. Including population information ties the index to societal impacts. Currently, the index uses population based on the 2000 Census. The RSI is an evolution of the Northeast Snowfall Impact Scale (NESIS), which NCDC began producing operationally in 2005. While NESIS was developed for storms that had a major impact in the Northeast, it includes the impact of snow on other regions as well. It can be thought of as a quasi-national index that is calibrated to Northeast snowstorms. By contrast, the RSI is a regional index; a separate index is produced for each of the six NCDC climate regions in the eastern two-thirds of the nation. The RSI is important because of the need to place snowstorms and their societal impacts into a historical perspective on a regional scale.

Table 26: Regional Snowfall Index Values

| Category | RSI Value | Description |
|----------|-----------|-------------|
| 1 | 1–3 | Notable |
| 2 | 3–6 | Significant |
| 3 | 6–10 | Major |
| 4 | 10–18 | Crippling |
| 5 | 18.0+ | Extreme |

<http://www.ncdc.noaa.gov/snow-and-ice/rsi/societal-impacts>

Table 27 shows the RSI values of winter storms for the Northeast area. Fifteen storms were rated as “Crippling” or “Extreme” through the winter of 2018-2019.

Table 27: Regional Snowfall Index and Societal Impacts for the Northeast

| Start Date | End Date | Category | RSI | Area of Snow | Population |
|------------|------------|----------|--------|--------------|------------|
| 2/22/1969 | 2/28/1969 | 5 | 34.026 | 174,950 | 58,912,750 |
| 2/4/1978 | 2/8/1978 | 5 | 18.422 | 174,950 | 58,912,680 |
| 3/12/1993 | 3/15/1993 | 5 | 22.117 | 174,949 | 58,912,681 |
| 1/6/1996 | 1/9/1996 | 5 | 21.708 | 162,312 | 58,450,268 |
| 2/26/1900 | 3/3/1900 | 4 | 15.654 | 143,092 | 29,473,924 |
| 3/3/1902 | 3/6/1902 | 4 | 12.193 | 140,027 | 28,479,887 |
| 2/27/1947 | 3/4/1947 | 4 | 10.63 | 174,834 | 58,911,466 |
| 11/22/1950 | 11/30/1950 | 4 | 14.531 | 149,339 | 57,671,970 |
| 1/28/1966 | 2/1/1966 | 4 | 12.281 | 174,940 | 58,902,827 |
| 12/25/1969 | 12/29/1969 | 4 | 10.137 | 174,949 | 58,912,747 |
| 2/26/1971 | 3/6/1971 | 4 | 10.178 | 174,940 | 58,908,221 |
| 2/14/2003 | 2/18/2003 | 4 | 14.671 | 163,081 | 58,771,975 |
| 2/21/2010 | 3/1/2010 | 4 | 17.827 | 174,950 | 58,912,816 |
| 1/22/2016 | 1/24/2016 | 4 | 17.758 | 92,140 | 52,963,122 |
| 3/12/2017 | 3/15/2017 | 4 | 10.658 | 176,160 | 60,603,632 |
| 2/12/1914 | 2/15/1914 | 3 | 9.875 | 174,200 | 58,903,411 |
| 12/10/1915 | 12/15/1915 | 3 | 6.133 | 173,960 | 58,896,221 |
| 2/4/1920 | 2/7/1920 | 3 | 6.028 | 174,594 | 58,908,334 |
| 1/28/1925 | 1/31/1925 | 3 | 7.383 | 174,142 | 58,904,199 |
| 12/25/1947 | 12/27/1947 | 3 | 8.108 | 174,325 | 58,906,173 |
| 2/12/1958 | 2/18/1958 | 3 | 7.866 | 174,729 | 58,910,377 |
| 3/18/1958 | 3/23/1958 | 3 | 7.144 | 174,729 | 58,910,374 |
| 2/29/1960 | 3/5/1960 | 3 | 6.899 | 174,296 | 58,905,710 |
| 2/1/1961 | 2/5/1961 | 3 | 8.276 | 152,539 | 58,535,284 |
| 2/10/1983 | 2/13/1983 | 3 | 7.86 | 141,411 | 55,366,925 |
| 12/4/2003 | 12/8/2003 | 3 | 9.398 | 174,950 | 58,912,724 |
| 2/11/2007 | 2/16/2007 | 3 | 6.891 | 174,949 | 58,912,781 |
| 2/4/2010 | 2/8/2010 | 3 | 9.062 | 90,382 | 50,257,627 |
| 2/8/2013 | 2/10/2013 | 3 | 9.212 | 172,576 | 58,579,289 |
| 1/25/2015 | 1/28/2015 | 3 | 6.158 | 177,785 | 60,992,661 |
| 2/13/1902 | 2/19/1902 | 2 | 3.274 | 167,713 | 58,826,793 |
| 2/14/1903 | 2/18/1903 | 2 | 3.906 | 173,277 | 58,891,210 |
| 2/4/1907 | 2/6/1907 | 2 | 3.803 | 173,633 | 58,898,494 |
| 12/23/1909 | 12/27/1909 | 2 | 4.391 | 173,258 | 58,894,772 |
| 1/12/1910 | 1/15/1910 | 2 | 3.287 | 141,238 | 57,793,029 |
| 2/10/1910 | 2/13/1910 | 2 | 3.297 | 173,249 | 58,894,184 |

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|------------|------------|---|-------|---------|------------|
| 3/2/1916 | 3/9/1916 | 2 | 4.44 | 174,200 | 58,903,443 |
| 3/2/1917 | 3/6/1917 | 2 | 4.661 | 173,691 | 58,820,367 |
| 12/12/1917 | 12/15/1917 | 2 | 4.354 | 172,941 | 58,890,720 |
| 2/18/1921 | 2/22/1921 | 2 | 3.91 | 163,706 | 58,587,848 |
| 1/26/1922 | 1/30/1922 | 2 | 3.756 | 102,682 | 53,135,150 |
| 2/3/1926 | 2/5/1926 | 2 | 4.379 | 173,614 | 58,847,801 |
| 2/16/1927 | 2/21/1927 | 2 | 3.209 | 172,605 | 58,889,211 |
| 1/21/1935 | 1/25/1935 | 2 | 4.301 | 174,008 | 58,902,811 |
| 1/18/1936 | 1/21/1936 | 2 | 3.988 | 173,595 | 58,805,481 |
| 11/23/1938 | 11/25/1938 | 2 | 3.525 | 174,834 | 58,911,490 |
| 2/13/1940 | 2/15/1940 | 2 | 4.094 | 154,250 | 58,562,128 |
| 3/7/1941 | 3/10/1941 | 2 | 4.451 | 174,834 | 58,911,560 |
| 2/15/1946 | 2/21/1946 | 2 | 3.732 | 173,085 | 58,632,305 |
| 2/20/1947 | 2/24/1947 | 2 | 4.948 | 174,834 | 58,911,534 |
| 2/17/1952 | 2/18/1952 | 2 | 3.313 | 166,935 | 53,866,427 |
| 3/14/1956 | 3/17/1956 | 2 | 3.14 | 174,748 | 58,910,585 |
| 3/12/1959 | 3/14/1959 | 2 | 3.848 | 172,432 | 58,488,470 |
| 12/10/1960 | 12/13/1960 | 2 | 4.205 | 174,440 | 58,907,325 |
| 1/18/1961 | 1/21/1961 | 2 | 3.905 | 173,028 | 58,859,231 |
| 1/9/1964 | 1/14/1964 | 2 | 5.819 | 171,692 | 58,878,525 |
| 1/21/1966 | 1/24/1966 | 2 | 3.906 | 168,213 | 58,791,555 |
| 2/23/1966 | 2/26/1966 | 2 | 3.578 | 174,940 | 58,912,068 |
| 12/22/1966 | 12/26/1966 | 2 | 3.567 | 174,950 | 58,912,785 |
| 2/6/1967 | 2/8/1967 | 2 | 3.175 | 170,183 | 58,809,600 |
| 2/8/1969 | 2/10/1969 | 2 | 4.397 | 173,575 | 58,690,661 |
| 11/23/1971 | 11/27/1971 | 2 | 3.085 | 170,971 | 57,675,388 |
| 2/16/1972 | 2/20/1972 | 2 | 5.123 | 174,950 | 58,912,688 |
| 1/17/1978 | 1/21/1978 | 2 | 5.372 | 174,950 | 58,912,754 |
| 4/4/1982 | 4/8/1982 | 2 | 3.464 | 174,421 | 58,769,410 |
| 1/21/1987 | 1/24/1987 | 2 | 4.772 | 174,950 | 58,912,764 |
| 2/9/1988 | 2/14/1988 | 2 | 3.034 | 174,950 | 58,912,735 |
| 12/9/1992 | 12/13/1992 | 2 | 4.673 | 161,582 | 58,500,685 |
| 2/28/1994 | 3/4/1994 | 2 | 4.184 | 174,950 | 58,912,691 |
| 2/2/1995 | 2/6/1995 | 2 | 4.331 | 174,950 | 58,912,666 |
| 12/18/1995 | 12/22/1995 | 2 | 3.372 | 174,940 | 58,912,026 |
| 3/3/1996 | 3/9/1996 | 2 | 3.085 | 174,940 | 58,899,945 |
| 3/31/1997 | 4/1/1997 | 2 | 4.669 | 172,979 | 58,882,868 |
| 12/28/2000 | 1/1/2001 | 2 | 3.228 | 168,395 | 54,141,847 |
| 12/23/2002 | 12/26/2002 | 2 | 3.631 | 170,318 | 58,592,271 |

| | | | | | |
|------------|------------|---|-------|---------|------------|
| 1/22/2005 | 1/24/2005 | 2 | 3.772 | 172,989 | 58,891,510 |
| 2/28/2005 | 3/2/2005 | 2 | 3.005 | 174,949 | 58,912,741 |
| 2/10/2006 | 2/14/2006 | 2 | 4.946 | 174,950 | 58,912,730 |
| 3/16/2007 | 3/18/2007 | 2 | 3.151 | 173,883 | 58,758,178 |
| 12/28/2009 | 1/4/2010 | 2 | 3.735 | 174,383 | 58,858,437 |
| 2/8/2010 | 2/11/2010 | 2 | 3.061 | 146,360 | 58,156,565 |
| 12/24/2010 | 12/28/2010 | 2 | 3.238 | 174,950 | 58,912,655 |
| 1/9/2011 | 1/13/2011 | 2 | 3.377 | 174,940 | 58,907,580 |
| 2/11/2014 | 2/14/2014 | 2 | 4.398 | 176,679 | 59,114,214 |
| 3/11/2018 | 3/15/2018 | 2 | 4.335 | 171,105 | 57,502,057 |
| 3/15/1900 | 3/16/1900 | 1 | 2.195 | 167,406 | 58,823,250 |
| 2/1/1901 | 2/6/1901 | 1 | 1.813 | 166,800 | 58,567,510 |
| 12/11/1902 | 12/14/1902 | 1 | 1.645 | 151,722 | 57,101,980 |
| 1/27/1904 | 1/30/1904 | 1 | 1.187 | 141,286 | 57,763,280 |
| 3/12/1906 | 3/17/1906 | 1 | 1.759 | 174,287 | 58,905,710 |
| 3/17/1906 | 3/20/1906 | 1 | 2.562 | 174,594 | 58,908,880 |
| 1/29/1908 | 2/2/1908 | 1 | 1.948 | 173,576 | 58,897,938 |
| 2/3/1908 | 2/7/1908 | 1 | 1.977 | 173,316 | 58,894,571 |
| 2/16/1908 | 2/20/1908 | 1 | 1.638 | 170,538 | 58,866,094 |
| 1/10/1909 | 1/15/1909 | 1 | 1.076 | 170,520 | 58,426,429 |
| 1/27/1909 | 1/31/1909 | 1 | 1.231 | 171,625 | 58,834,736 |
| 3/2/1909 | 3/5/1909 | 1 | 1.617 | 171,183 | 58,874,770 |
| 2/16/1910 | 2/18/1910 | 1 | 1.292 | 161,236 | 50,813,830 |
| 1/29/1915 | 2/3/1915 | 1 | 1.686 | 174,161 | 58,902,970 |
| 3/2/1915 | 3/8/1915 | 1 | 1.444 | 108,093 | 50,980,710 |
| 4/3/1915 | 4/5/1915 | 1 | 2.158 | 119,682 | 51,166,922 |
| 12/6/1917 | 12/9/1917 | 1 | 1.247 | 170,424 | 58,692,200 |
| 1/12/1918 | 1/16/1918 | 1 | 2.114 | 170,856 | 58,287,560 |
| 1/21/1918 | 1/23/1918 | 1 | 1.078 | 164,801 | 58,794,700 |
| 1/25/1918 | 1/29/1918 | 1 | 1.261 | 171,673 | 58,886,325 |
| 2/3/1923 | 2/7/1923 | 1 | 1.016 | 140,209 | 57,380,761 |
| 2/17/1924 | 2/21/1924 | 1 | 2.952 | 173,278 | 58,897,029 |
| 4/1/1924 | 4/4/1924 | 1 | 2.88 | 173,537 | 58,899,540 |
| 12/31/1924 | 1/3/1925 | 1 | 1.962 | 119,336 | 53,381,377 |
| 1/7/1926 | 1/10/1926 | 1 | 2.068 | 169,991 | 58,862,492 |
| 2/20/1929 | 2/22/1929 | 1 | 2.186 | 174,834 | 58,911,540 |
| 12/19/1929 | 12/24/1929 | 1 | 1.481 | 174,143 | 58,904,209 |
| 3/4/1931 | 3/12/1931 | 1 | 1.662 | 164,859 | 52,446,314 |
| 12/16/1932 | 12/18/1932 | 1 | 1.282 | 122,143 | 54,890,980 |

| | | | | | |
|------------|------------|---|-------|---------|------------|
| 12/26/1933 | 12/27/1933 | 1 | 2.848 | 174,478 | 58,907,690 |
| 2/23/1934 | 2/27/1934 | 1 | 2.73 | 174,719 | 58,910,390 |
| 2/10/1936 | 2/15/1936 | 1 | 1.5 | 168,261 | 58,818,876 |
| 2/28/1942 | 3/4/1942 | 1 | 1.782 | 168,472 | 57,033,415 |
| 3/28/1942 | 3/31/1942 | 1 | 2.4 | 169,798 | 58,860,294 |
| 1/25/1943 | 1/29/1943 | 1 | 2.647 | 154,730 | 58,476,132 |
| 2/8/1944 | 2/13/1944 | 1 | 1.972 | 173,893 | 58,855,980 |
| 12/8/1944 | 12/13/1944 | 1 | 2.155 | 174,421 | 58,818,348 |
| 1/13/1945 | 1/17/1945 | 1 | 2.548 | 174,373 | 58,868,569 |
| 12/17/1945 | 12/20/1945 | 1 | 2.729 | 163,235 | 58,759,660 |
| 1/23/1948 | 1/25/1948 | 1 | 2.661 | 171,269 | 58,873,780 |
| 1/29/1949 | 2/1/1949 | 1 | 1.439 | 174,950 | 58,912,679 |
| 2/11/1950 | 2/17/1950 | 1 | 2.456 | 166,262 | 52,892,032 |
| 12/13/1951 | 12/16/1951 | 1 | 2.149 | 174,940 | 58,912,706 |
| 3/3/1956 | 3/9/1956 | 1 | 1.151 | 155,605 | 40,701,725 |
| 3/18/1956 | 3/20/1956 | 1 | 2.774 | 172,057 | 58,780,618 |
| 12/3/1957 | 12/5/1957 | 1 | 1.175 | 123,190 | 56,371,800 |
| 2/12/1960 | 2/15/1960 | 1 | 1.896 | 174,440 | 58,907,321 |
| 2/13/1962 | 2/16/1962 | 1 | 2.157 | 155,576 | 58,605,785 |
| 2/28/1962 | 3/7/1962 | 1 | 1.731 | 142,497 | 57,612,182 |
| 3/5/1962 | 3/9/1962 | 1 | 1.793 | 142,487 | 57,611,005 |
| 12/21/1963 | 12/24/1963 | 1 | 1.684 | 174,950 | 58,912,752 |
| 2/18/1964 | 2/21/1964 | 1 | 2.396 | 174,950 | 58,912,707 |
| 3/20/1967 | 3/23/1967 | 1 | 1.305 | 169,097 | 58,847,740 |
| 2/25/1969 | 3/4/1969 | 1 | 1.221 | 162,735 | 57,803,468 |
| 12/31/1970 | 1/2/1971 | 1 | 1.732 | 171,115 | 58,872,394 |
| 12/15/1973 | 12/18/1973 | 1 | 1.622 | 174,901 | 58,902,390 |
| 1/8/1974 | 1/12/1974 | 1 | 2.625 | 174,335 | 58,841,600 |
| 1/7/1977 | 1/11/1977 | 1 | 1.956 | 174,940 | 58,911,001 |
| 3/21/1977 | 3/25/1977 | 1 | 2.074 | 163,033 | 51,465,264 |
| 1/11/1978 | 1/15/1978 | 1 | 2.085 | 174,950 | 58,912,751 |
| 1/14/1978 | 1/19/1978 | 1 | 2.746 | 174,950 | 58,912,695 |
| 2/6/1979 | 2/9/1979 | 1 | 1.391 | 154,634 | 58,587,372 |
| 2/17/1979 | 2/20/1979 | 1 | 2.869 | 135,587 | 54,931,701 |
| 1/12/1982 | 1/15/1982 | 1 | 1.999 | 174,949 | 58,912,680 |
| 1/20/1982 | 1/24/1982 | 1 | 1.129 | 174,949 | 58,912,669 |
| 2/24/1984 | 3/1/1984 | 1 | 2.217 | 168,722 | 56,968,639 |
| 1/29/1985 | 2/3/1985 | 1 | 1.915 | 174,950 | 58,912,744 |
| 3/1/1985 | 3/5/1985 | 1 | 1.058 | 156,835 | 49,963,540 |

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|------------|------------|---|-------|---------|------------|
| 1/1/1987 | 1/3/1987 | 1 | 2.622 | 173,729 | 58,728,733 |
| 1/8/1987 | 1/12/1987 | 1 | 1.589 | 170,740 | 58,083,020 |
| 2/22/1987 | 2/24/1987 | 1 | 1.471 | 139,681 | 57,622,073 |
| 11/10/1987 | 11/12/1987 | 1 | 1.076 | 169,088 | 58,715,870 |
| 12/13/1987 | 12/17/1987 | 1 | 1.024 | 164,052 | 52,297,704 |
| 1/5/1988 | 1/9/1988 | 1 | 1.632 | 174,834 | 58,911,500 |
| 1/22/1988 | 1/27/1988 | 1 | 2.142 | 174,940 | 58,912,450 |
| 12/27/1990 | 12/29/1990 | 1 | 1.644 | 174,344 | 58,906,350 |
| 2/14/1993 | 2/18/1993 | 1 | 2.074 | 174,930 | 58,908,030 |
| 2/20/1993 | 2/24/1993 | 1 | 2.176 | 174,949 | 58,912,726 |
| 1/1/1994 | 1/5/1994 | 1 | 2.729 | 173,825 | 58,738,855 |
| 1/4/1994 | 1/9/1994 | 1 | 2.481 | 173,652 | 58,703,048 |
| 1/16/1994 | 1/18/1994 | 1 | 2.803 | 174,940 | 58,912,438 |
| 2/22/1994 | 2/25/1994 | 1 | 1.79 | 173,604 | 58,699,443 |
| 2/1/1996 | 2/4/1996 | 1 | 1.329 | 128,889 | 54,699,600 |
| 4/9/1996 | 4/11/1996 | 1 | 1.638 | 174,758 | 58,882,332 |
| 1/8/1997 | 1/12/1997 | 1 | 1.52 | 174,949 | 58,912,671 |
| 1/13/1999 | 1/16/1999 | 1 | 2.392 | 172,922 | 58,598,684 |
| 3/12/1999 | 3/16/1999 | 1 | 1.815 | 165,157 | 56,251,871 |
| 1/24/2000 | 2/1/2000 | 1 | 1.366 | 174,036 | 58,757,576 |
| 1/24/2000 | 1/27/2000 | 1 | 2.483 | 174,940 | 58,910,447 |
| 2/16/2000 | 2/20/2000 | 1 | 1.309 | 172,979 | 58,891,980 |
| 1/1/2003 | 1/4/2003 | 1 | 2.444 | 167,617 | 57,344,653 |
| 4/3/2007 | 4/6/2007 | 1 | 1.08 | 161,476 | 47,541,472 |
| 11/30/2007 | 12/4/2007 | 1 | 1.294 | 169,895 | 57,377,950 |
| 12/14/2007 | 12/17/2007 | 1 | 1.726 | 166,377 | 54,824,473 |
| 12/18/2008 | 12/22/2008 | 1 | 2.645 | 174,930 | 58,911,304 |
| 12/21/2008 | 12/23/2008 | 1 | 2.96 | 174,921 | 58,910,684 |
| 2/22/2009 | 2/24/2009 | 1 | 1.429 | 169,443 | 56,989,600 |
| 2/26/2009 | 3/3/2009 | 1 | 1.474 | 171,125 | 58,315,320 |
| 12/7/2009 | 12/11/2009 | 1 | 1.702 | 169,750 | 57,511,523 |
| 12/18/2009 | 12/21/2009 | 1 | 2.836 | 130,657 | 56,388,060 |
| 2/12/2010 | 2/19/2010 | 1 | 1.085 | 174,690 | 58,873,066 |
| 1/26/2011 | 1/27/2011 | 1 | 2.643 | 174,690 | 58,910,064 |
| 2/1/2011 | 2/4/2011 | 1 | 1.779 | 170,298 | 56,938,590 |
| 2/24/2011 | 2/27/2011 | 1 | 1.736 | 155,855 | 43,474,028 |
| 10/25/2011 | 10/31/2011 | 1 | 1.849 | 157,709 | 55,844,726 |
| 12/24/2012 | 12/28/2012 | 1 | 2.004 | 174,200 | 58,845,960 |
| 12/28/2012 | 12/31/2012 | 1 | 1.095 | 173,479 | 58,679,218 |

| | | | | | |
|------------|------------|---|-------|---------|------------|
| 3/3/2013 | 3/9/2013 | 1 | 1.308 | 157,056 | 58,614,413 |
| 3/17/2013 | 3/20/2013 | 1 | 1.621 | 173,441 | 58,544,700 |
| 12/13/2013 | 12/16/2013 | 1 | 2.678 | 174,507 | 58,818,190 |
| 12/30/2013 | 1/3/2014 | 1 | 2.766 | 170,587 | 59,042,162 |
| 1/20/2014 | 1/22/2014 | 1 | 1.294 | 169,039 | 59,023,320 |
| 11/26/2014 | 11/28/2014 | 1 | 1.756 | 173,671 | 60,326,804 |
| 12/9/2014 | 12/14/2014 | 1 | 1.881 | 162,706 | 51,280,184 |
| 1/29/2015 | 2/3/2015 | 1 | 2.606 | 175,690 | 60,670,793 |
| 2/8/2015 | 2/10/2015 | 1 | 1.897 | 136,000 | 44,457,219 |
| 2/14/2015 | 2/16/2015 | 1 | 1.14 | 176,958 | 60,987,376 |
| 11/17/2016 | 11/22/2016 | 1 | 2.154 | 150,944 | 48,054,817 |
| 2/9/2017 | 2/10/2017 | 1 | 2.154 | 175,084 | 60,655,477 |
| 1/3/2018 | 1/5/2018 | 1 | 2.548 | 172,240 | 60,240,318 |
| 3/1/2018 | 3/3/2018 | 1 | 2.185 | 151,415 | 52,939,672 |
| 3/5/2018 | 3/8/2018 | 1 | 2.096 | 175,853 | 60,907,768 |
| 3/20/2018 | 3/22/2018 | 1 | 1.598 | 104,912 | 54,227,211 |
| 11/14/2018 | 11/16/2018 | 1 | 2.016 | 173,883 | 60,958,725 |
| 1/18/2019 | 1/21/2019 | 1 | 2.831 | 172,076 | 59,153,084 |

Source: <http://www.ncdc.noaa.gov/snow-and-ice/rsi/societal-impacts>

Ice Storms

Ice storms occur when a mass of warm moist air collides with a mass of cold Arctic air. As the less dense warm air rises moisture may precipitate as rain. The rain falls through the colder, denser air and comes in contact with cold surfaces where ice forms. Ice may continue to form until the ice is several inches thick.

Ice storms may strain tree branches, power lines and even transmission towers to the breaking point and often create treacherous conditions for highway travel and aviation. The weight of formed ice (especially with a following wind) may cause power and phone lines to snap and the towers that support them to collapse under the load, and may break tree limbs. Debris impacted roads make emergency access, repair and cleanup extremely difficult.

The most recent ice storm in New England and the region occurred in December 2008. The storm resulted in one fatality and left over one million people without power, some for as long as two weeks. Damage from the storm was measured in millions of dollars in property damage, lost business and clean-up costs. For example, The Town of Westford alone spent \$650,000 in responding to this storm, according to Town Manager Jodi Ross. Many of the expenses incurred were related to debris cleanup. Given the magnitude of damage, the storm resulted in a Presidential Disaster Declaration.

Ice storms equally as severe have been recorded in New England since 1929. The U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory estimates a 40 – 90 year return period for an event with a uniform ice thickness of between .75 and 1.25 inches. In other words, on average, a one-inch ice storm is likely every fifty years. Middlesex County has experienced 22 ice storms since 1971.⁶ Each community in the region is at equal risk of being impacted by an ice storm and impacts are consistent across the region, with the exception of Lowell, where tree damage and power outages are often lessened due to the community's urban nature and the fact that utilities within the downtown are located underground.



Utility company responds to the aftermath of the December 2008 ice storm in Westford, MA

Ice Jams

Ice jams occur when warm temperatures and heavy rain cause rapid snow melting. The melting snow combined with the heavy rain, causes frozen rivers to swell, breaking the ice layer into large chunks that float downstream and pile up near narrow passages or near obstructions, such as bridges and dams. Historically, there have been hundreds of ice jams in New England. Within the Northern Middlesex region, ice jams have been recorded on the Merrimack River in Lowell and on the Nashua River in the Town of Pepperell. According to the U.S. Army Cold Regions Research Lab's database,⁷ an ice jam occurred along the Merrimack River on January 10, 1967, the Nashua River on March 19, 1968 and January 24, 1999, and along the Nashoba Brook on March 18, 1972 and on February 17, 2008. The major hazard associated with an ice jam is flooding.

⁶ NCDC Database

⁷<https://www.erdc.usace.army.mil/Locations/CRREL/>

Given that sizable rivers traverse every community in the region, each municipality is at equal risk of being impacted by an ice jam, however, based on historical occurrences, the probability of such an event occurring is relatively low.

4.1.4 Fire-Related Hazards

Fire poses a danger to developed and urbanized areas of the town, as well as to forested areas. A wildland fire can be defined as any non-structure fire that occurs in the wildland. Three distinct types of wildland fire have been defined and include wildfire (naturally occurring or human caused), and prescribed fire. Many of these are highly destructive and can be very uncontrollable. They occur in forested, semi-forested or less developed area.

Drought

Drought is a normal recurrent feature of climate, occurring in virtually all climatic zones. Drought originates from a deficiency in precipitation over an extended period, typically two winter seasons or more, and should be considered relative to the long-term average condition based on precipitation and evapo-transpiration. The first evidence of drought is usually seen in rainfall records. Within a short period of time, soil moisture can begin to decrease. The effects on stream and river flow, or water levels in lakes and reservoirs, may not be noticed for several weeks or months. Water levels in wells may not be impacted for a year or more after the drought begins.

Massachusetts is often considered to be a water-rich state, receiving an average of 45 inches of precipitation each year. The region can experience extended periods of dry weather, from single season events to multi-year events, such as occurred in the mid-1960s. Historically, droughts in Massachusetts have started with dry winters, rather than summers.

A serious drought occurred in Massachusetts during the spring and summer of 1999. Cumulative deficits in precipitation reached 8 to 12 inches below normal over a one-year period. Stream flows routinely fell below the 25th percentile of historical flows for the month. Ground water levels were also below normal throughout the summer over nearly the entire state. During this period, the Massachusetts Emergency Management Agency developed the Massachusetts Drought Management Plan. The Plan includes ground water, surface water, reservoir, precipitation data, and stream flow conditions, as well as a report on fire danger and agricultural conditions. The latest approved Drought Management Plan is dated September 2013; however, we understand that an update to the plan is in progress. This update will be evaluated and incorporated into the Hazard Mitigation Plan upon publication.

The current Massachusetts Drought Management Plan has four different levels of drought: Advisory, Watch, Warning, and Emergency. The difference between these levels can be identified based on the severity of a variety of factors, including precipitation, crop moisture, the Keetch-Byram Drought Index, groundwater, streamflow, and reservoir level. These drought levels are proposed to be revised as part of the pending update to the Drought Management Plan.

During the summer of 2002, one-third of the nation, including New England, experienced drought conditions. Massachusetts has experienced multi-year drought episodes in 1879-1873, 1908-1912, 1929-1932, 1939-1944, 1961-1969 and 1980-1983. According to the Department of Conservation and Recreation, Drought Advisories and Watches for Middlesex County have occurred in 2001, 2007, and 2010. The most recent drought in the state began on July 1, 2016 and extended through April 30, 2017, reaching the Warning level at its peak.

The Drought Management Plan provides specific action items to be implemented during a drought watch, drought warning and drought emergency. A drought emergency is one in which state-mandated water restrictions or use of emergency water supplies is necessary. Each community in the region is at equal risk of being impacted by a drought emergency. Communities within the Northern Middlesex region have imposed outdoor watering restrictions during times of drought.

In addition to the state Drought Management Plan, the three water districts in Chelmsford all operate and adhere to Summer Water Management Plans. These are state-mandated protocols attached to the districts' Water Management Act permits, and have required actions, such public notification.

Wildfires

A wildfire is an uncontrolled fire that spreads due to the presence of vegetative fuel. These fires often begin unnoticed and spread quickly. In this area of the country, wildfire season generally begins in March and ends in late November. Human beings start four out of every five wildfires through arson or carelessness; lightning strikes account for the remainder. If heavy rain follows a major wildfire, other natural disasters can occur, including landslides and floods. Once groundcover is burned away, there is little left to hold soil in place on steep slopes. Water supplies can also be affected. The loss of ground cover materials and the chemical transformation of burned soils can make some watersheds more susceptible to erosion.

A surface fire is the most common type of wildfire, burning slowly along the floor of a forest, destroying or damaging trees. Lightning typically starts a ground fire and burns on or below the forest floor; such fires are difficult to detect and extinguish. Crown fires spread quickly along the tops of trees and are driven by wind. Crown fires are seen when high-intensity surface fire spreads or “ladders” upward through the lower foliage to the canopy.

Chelmsford is located in Massachusetts Fire Control District 6. The Chelmsford Fire Department has provided information on the number of brush and wildfires reported in the town.

Table 28: Brush Fires / Wildfires in Chelmsford

| Time Period | Number of Events |
|-------------|------------------|
| 2002-2010 | 325 |
| 2010-2019 | 266 |

Source: Chelmsford Fire Department

Input received from the region’s communities indicates that there are no specific geographic patterns related to brush fire incidents, although brush fires along major highways were noted to be frequently caused by careless disposal of cigarette materials by passing motorists. The area surrounding the Thanksgiving Forest in Chelmsford is vulnerable, as it is one of the most heavily forested areas of the town. The Chelmsford Fire Department identified the following open space and forested parcels as areas of potential risk:

Private Areas

- Sportsman Club, Swain Road - 51.50 acres
- Kent Farm, Elm Street - 31 acres
- Visnewski Land, Concord Road -17.25 acres
- Bridge Street Realty Trust - 13.72 acres
- Hennessy Misty Meadow - 41.16 acres
- Chelmsford Swim & Tennis, Robin Hill Rd - 17.30 acres
- Russell Mill Swim & Tennis, Mill Road - 10.60 acres

Water District Properties inclusive of pump station sites

- Center Water District - 255.41 acres
- North Water District - 53.75 acres
- East Water District - 32.93 acres

Conservation Commission properties

- Crooked Spring Reservation - 37.44 acres
- Lime Quarry - 64.37 acres
- Wright Reservation - 57.17 acres
- Bill Edge Deep Brook Reservation - 15.67 acres
- Red Wing Farm - 12.56 acres
- Cranberry Bog (Chelmsford portion) - 180 acres
- Thanksgiving Forest - 45.67 acres
- Greenwood Wildlife Reserve - Concord Rd 13.20 acres
- Russell Mill, 105 Mill Rd - 132 acres
- Town of Chelmsford Landfill - 16.76 acres

There is no specific data available detailing the greatest number of acres burned during a wildfire. The collective memory of the current Fire Department Command Staff places the amount in the 2-3 acre range.

The early detection of forest fires is critical to preventing a large wildfire. The sooner suspicious smoke is located, and units are dispatched for investigation the less likely there will be needless damage to homes and property. Early detection is achieved by trained DCR observers who staff the statewide network of operating fire towers. From their high vantage points, observers utilize alidade tables, binoculars, and topographic maps to triangulate the precise location of any fire. This information is then given to local community fire departments for prompt response. There is a fire tower on Robbin Hill in Chelmsford that is manned by DCR staff during periods of high fire danger.

Wildland/Urban Interface

Wildland/urban interface areas exist wherever homes and businesses are built among trees and other combustible vegetation. In particular, Chelmsford residences bordering on forests, such as Thanksgiving Forest and the Cranberry Bog, are located within this interface. The wildland/urban interface problem stems from two different sources of fire and their impact on the community. Fire can move from forest, brush or pastureland into the community or from the community into adjacent wild areas. In temperate areas vegetative decay is a slow process, and logs, leaves and evergreen needles pile up on the forest floor. This accumulation of fuel increases the probability of large fires that are difficult to control. Ignitions are more frequent in the wildland/urban interface because of the increased presence of people - carelessness, recreation, damaged power lines, and industrial activity are potential ignition sources.

Interface fire can move rapidly through agricultural landscapes. Drought conditions, high winds, and accumulation of fine fuels, such as grass or stubble, set the stage for interface fires far away from any forests. In addition to building and equipment loss, crops, feed, soil, livestock and farm infrastructure are also at risk.

Typically, wildland/urban interface fires do tremendous damage, resulting in large economic losses and severe social impacts. The impact to residents can include the loss of, or damage to, homes and irreplaceable items, and even death or serious injury. Financial costs include building and infrastructure loss or damage, and business interruptions, as well as suppression and evacuation costs.

Wildland fires produce firebrands that are lofted into the air and travel great distances, often igniting spot fires ahead of the main fire. Firebrands that land on a combustible roof will usually start a fire that will consume a building, if not suppressed in time. The reality of firebrand-caused ignitions is that buildings located in relatively urban settings, some distance inside the community interface boundary, are still vulnerable to wildland fires. Additionally, direct flame contact or radiant heat can ignite vulnerable buildings. Ignitions can result from both vegetation-to-structure spread and structure-to-structure spread.

Urban Fire

The probability of an urban fire increases with population density. This is due to human error and carelessness, which are primary factors contributing to urban fires. The elderly (age 65 and older) tend to be more vulnerable to fires than any other age group. They also experience the highest number of deaths per fire. The second most vulnerable age group is those age 14 years and younger. Many homes destroyed by urban fires are often older homes in the community. Fire can spread faster in areas with high concentrations of housing, compared to less densely developed suburban and rural areas. The potential secondary effects of an urban fire include utility failures and hazardous material releases. While Chelmsford is not currently at high risk for urban fire, future development may necessitate reevaluation of this risk.

4.1.5 Geological Hazards

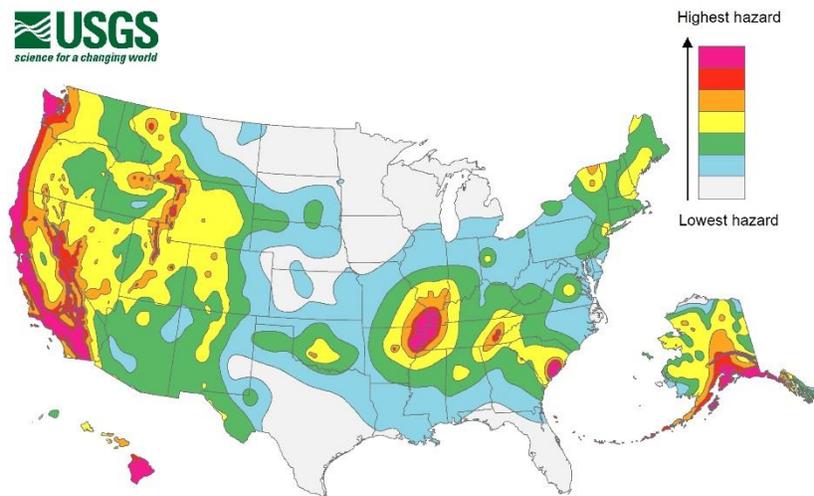
Earthquakes

Earthquakes in the Northeast are not associated with specific known faults, as they are in California. In New England, the immediate cause of most earthquakes is the sudden release of stress along a fault or fracture in the earth's crust. Much of the research on earthquakes in the northeast has involved attempts to identify pre-existing faults and other geological features that may be susceptible to such stress, but this has proven to be quite difficult.

Unlike the situation in the western part of the country where many plate boundary earthquakes occur, it is unclear whether faults mapped at the earth's surface in the northeast are the same faults along which earthquakes are occurring.

It is impossible to predict the time and location of future earthquakes in New England. The USGS has produced a series of earthquake hazard maps for the United States. These maps show the amount of earthquake generated ground shaking that is predicted to have a specific chance of being exceeded over a certain period of time. Ground shaking caused by earthquakes is often expressed as a percentage of the force of gravity. Due to the difficulty of identifying specific seismically active geological features in the Northeast, the level of seismic hazard is based primarily on past seismic activity. These maps generally show that there is a 1 in 10 chance that in any given fifty-year period a potentially damaging earthquake will occur. Map 3 on the following page shows the earthquake risk for each region of the United States.

Map 3: Seismic Risk Map of the U.S.



Source: USGS

New England experiences 30-40 earthquakes each year, although most are not felt. According to the Northeast States Emergency Consortium (NESEC), there were 408 felt earthquakes in Massachusetts between 1668 and 2016, with damaging earthquakes occurring in 1727 and 1755. Recorded earthquakes range in magnitude up to 5.8. Potential earthquake losses total \$4.4 billion annually in the United States, with the Northeast ranking third in the nation for annualized losses, according to FEMA.

The \$4.4 billion estimate includes only losses to buildings and business interruption. It does not include damage and losses to critical facilities, transportation infrastructure and services, utilities, or indirect economic losses.⁸

The Northern Middlesex region is considered to be at moderate risk of experiencing an earthquake. Moderate risk means that there is a relatively long period of time between strong earthquakes. Since 1985, there has been a small earthquake approximately every 2 ½ years within a few miles of Littleton and Westford, Massachusetts. It is not clear why some localities experience such clustering of earthquakes, but one possibility suggested by Prof. John Ebel of Weston Observatory of Boston College is that these spatial clusters are sites where strong earthquakes were centered in the prehistoric past. These spatial clusters may indicate locations where there is an increased likelihood of future earthquake activity.

The area's vulnerability to a devastating earthquake is based primarily on two elements: the density of the population in the region, and the age of the region's buildings and lack of earthquake proof design. Additionally, seismic waves travel further in the eastern U.S. than in other parts of the country

Earthquake magnitude is measured on two scales, the Richter Scale and the Mercalli Scale. The Richter Scale (expressed as "mb") is an open-ended logarithmic scale that measures the amount of energy released by an earthquake. An earthquake registering 1.5mb on the Richter Scale represents that point at which some disturbance may be felt. At 4.5mb slight damage may be caused. An 8.5mb is considered a devastating earthquake. The Mercalli Scale is measured on a Scale of I to XII and expresses more directly the damaged caused by an earthquake. A Scale I earthquake on the Mercalli Scale would barely be felt, whereas a Scale XII quake would result in complete destruction of all buildings. The intensity of the quake is evaluated according to observations at specific locations.

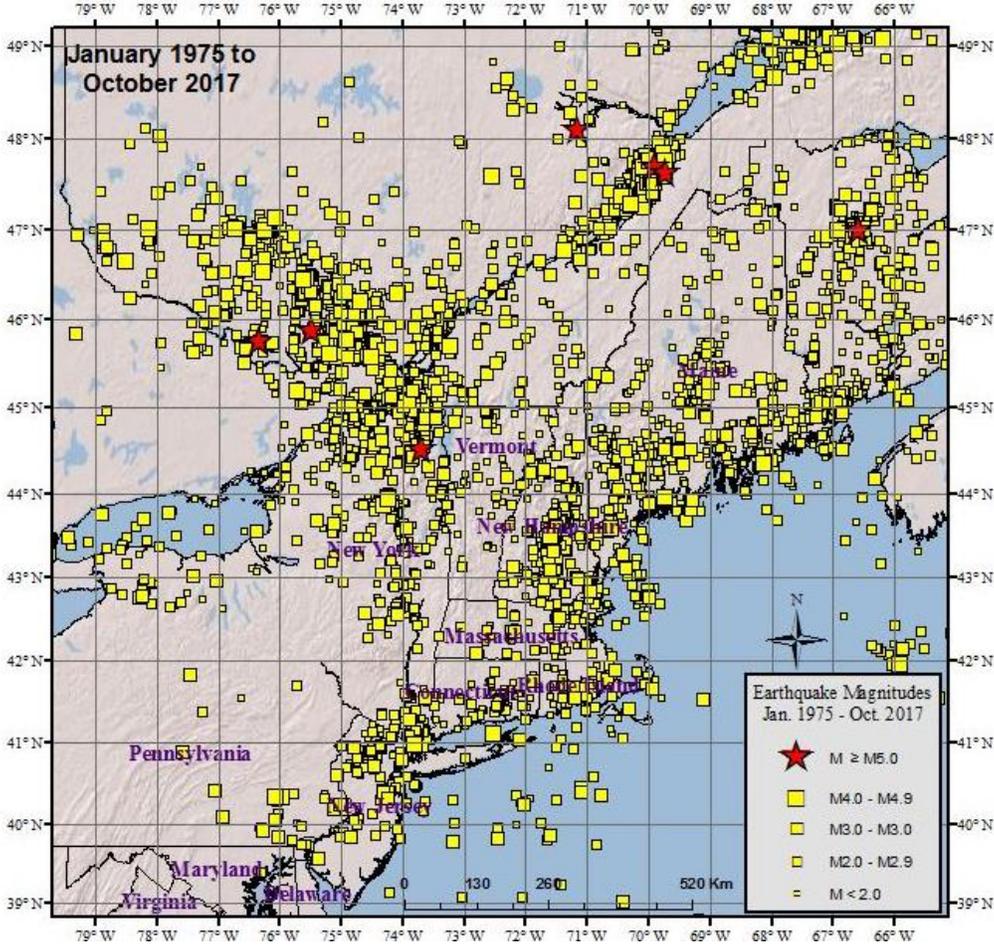
Ground movement during an earthquake is seldom the direct cause of injury or death. Collapsing walls, falling objects and flying glass cause most casualties. Buildings with foundations resting on unconsolidated landfill, old waterways, or other unstable soils are most at risk. Buildings, trailers, and manufactured homes not tied to a reinforced foundation anchored to the ground are also at risk, since they can be shaken off their mountings during an earthquake. In the eastern part of the U.S. a magnitude 5.5 earthquake can be felt as far as 300 miles from where it occurred and can cause damage out to 25 miles from the epicenter.

⁸ www.nesec.org

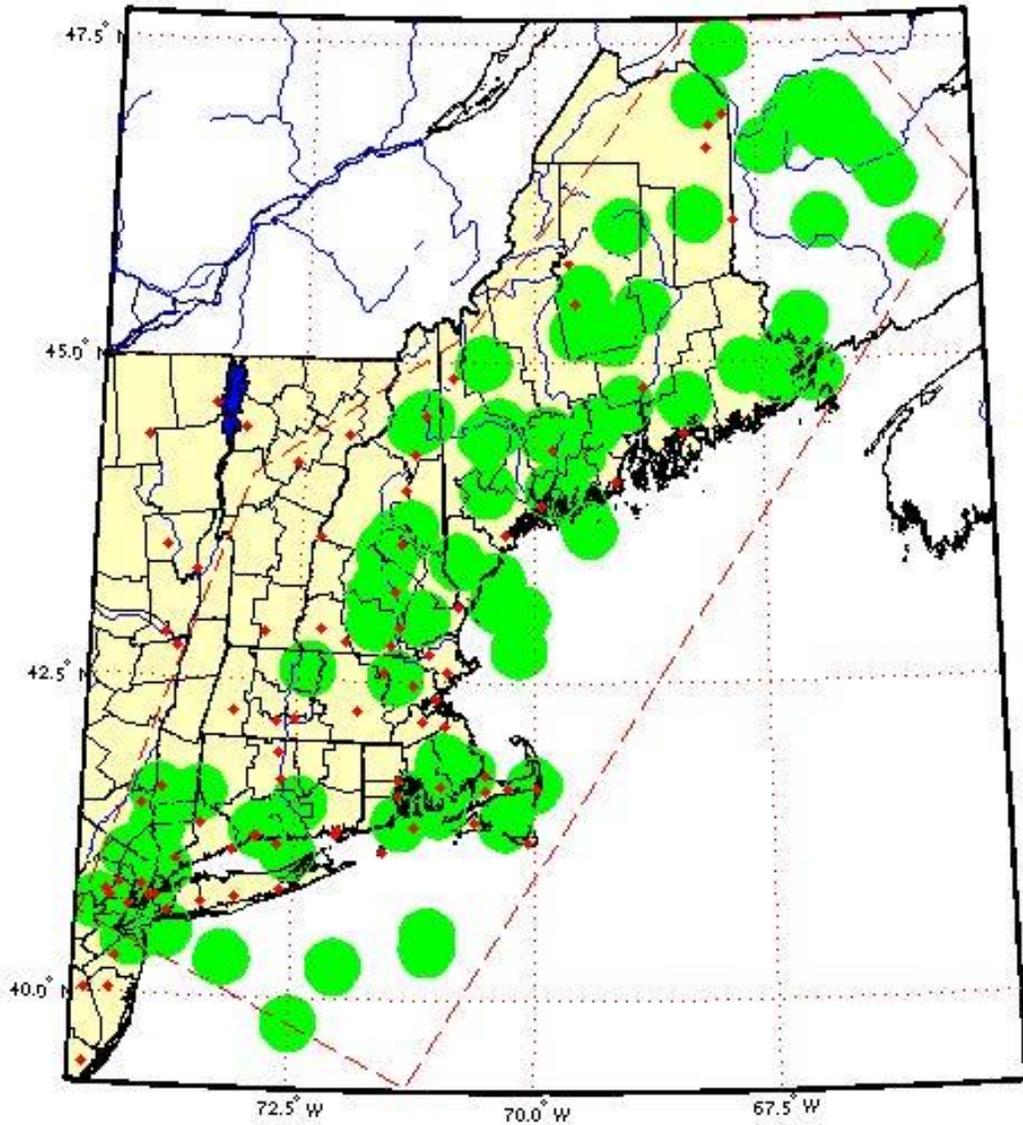
Based on past records, the maximum experienced earthquake intensities on the Mercalli Scale in Northern Middlesex County have been in the range of VI (where there is damage to objects indoors, the tremor is felt by all people indoors and outdoors, movement is unsteady, moderately heavy furniture moves, and pictures fall off walls) to VII (where there is damage to architecture, the tremors are frightening, it is difficult to stand, cracks occur in chimneys and plaster, bricks may fall, and stream banks may cave in).

Map 4 below shows earthquake activity in the northeast from 1975 to 2017. Map 5 on the following page shows the results of an earthquake probability analysis conducted by the Weston Observatory at Boston College. The study examined earthquake activity of magnitude greater than 2.7. According to the analysis, there is a 66% chance that the next earthquake of magnitude greater than 2.7 will occur in the green areas shown on Map 5 on the following page. Map 6 shows the seismic activity in Massachusetts since 1973.

**Map 4: Map of Earthquakes of the Northeastern US and Southeastern Canada
1975 to 2017**

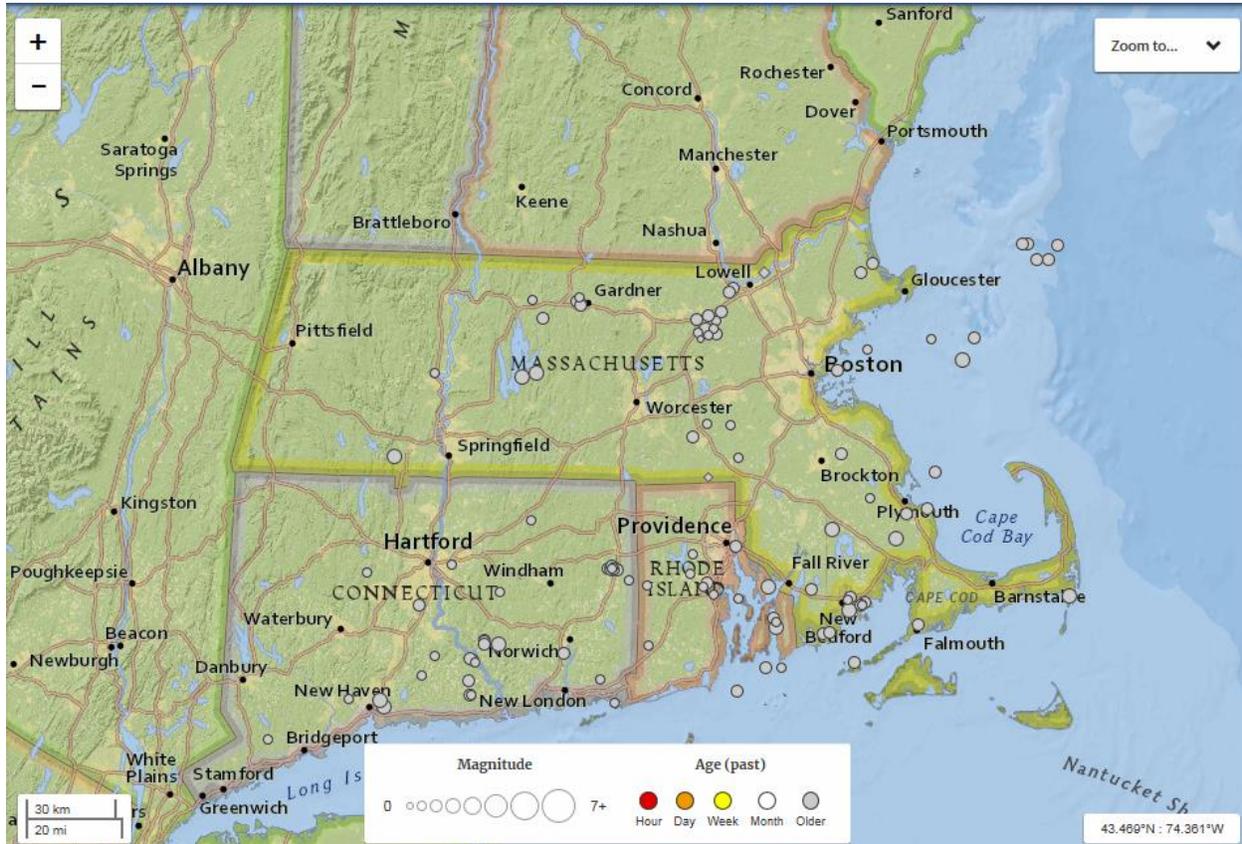


Map 5: New England Earthquake Probability



Source: Weston Observatory, Boston College

Map 6: Seismicity in Massachusetts, 1973 to present



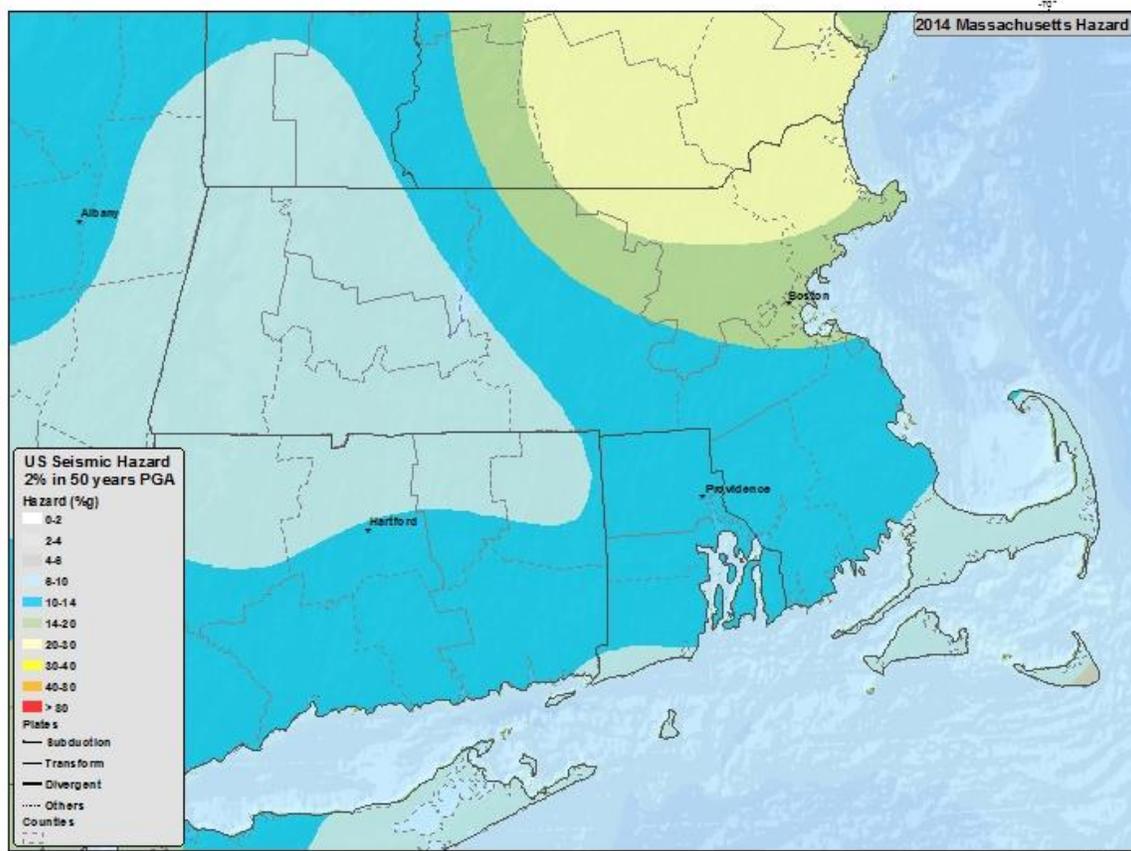
Source: www.earthquake.usgs.gov

The 2015 Update to the Hazard Mitigation Plan for the Northern Middlesex Region estimated the number of people affected by a possible earthquake, as well as those that may lack access to transportation, based upon Chelmsford’s Comprehensive Emergency Management Plan. This essentially includes the entire population of the Town.

Table 29: Persons at Risk to Earthquakes

| Maximum Population Affected | Maximum Number of People without Transportation (est.) |
|-----------------------------|--|
| 35,067 | 1,157 |

Map 7: Seismic Hazard in Massachusetts



Source: <http://earthquake.usgs.gov/earthquakes/states/massachusetts/hazards.php>

Failure to design structures with earthquakes in mind will also affect the potential damage caused by an earthquake. Map 7 on the previous page shows seismic hazard for the state of Massachusetts. Regulations that require buildings and structures to meet some minimum seismic criteria were only put in place over the past three decades. For example, the Commonwealth of Massachusetts began requiring new or rehabilitated bridges to meet minimum seismic criteria in 1991. Therefore, many bridges in the region have an elevated risk of failure during a significant earthquake. A review of MassDOT data indicates that 31 of the 54 bridges and culverts in Chelmsford (57%) were built or rebuilt prior to state seismic requirements.

Little is understood about the occurrence of earthquakes in this area, as mentioned previously. Overall, the region is at a moderate risk for earthquakes, and the greatest damage is likely to occur where structures were designed prior to seismic standards being incorporated into the state building code.

In the Town of Chelmsford, concentrations of older buildings can be found in the North Chelmsford and Vinal Square neighborhoods and in the area around the Town Center. Older buildings can also be found throughout other areas of town, for example the Old Chelmsford Garrison House, located off Route 110, dates back to 1691. In addition, many older structures in the region, such as schools, hospitals and fire stations, are built of un-reinforced masonry (i.e., “red brick”) and are particularly vulnerable to damage or collapse in the event of an earthquake.

Landslides

A landslide is the downward movement of a slope and its materials under the force of gravity. Human activity such as construction and mining, and natural factors such as topography, geology and precipitation influence landslides. Landslides often develop when water rapidly accumulates in the ground, such as during periods of heavy rainfall or rapid snowmelt. Other factors contributing to a landslide include earthquakes, and erosion by rivers and streams. Landslides commonly occur with other major natural disasters, such as earthquakes and floods that exacerbate relief and reconstruction efforts.

Nationally, landslides constitute a major geologic hazard, as they are widespread, occur in every state, cause an estimated 25 fatalities annually, and result in \$1-2 billion in property damage each year. Landslides are common throughout New England, but are generally limited to mountainous or hilly terrain. The Northern Middlesex region is not considered to be at risk for this type of natural hazard.

4.1.6 Other Natural Hazards

Extreme Temperatures

A heat wave is a period of three consecutive days during which the air temperature reaches or exceeds 90 degrees Fahrenheit on each day. Temperatures that hover ten degrees or more above the average high for the region and last for several weeks are defined as extreme heat. Humid or muggy conditions, which add to the discomfort of high temperatures, occur when a dome of high-pressure traps hazy, damp air near the surface.

Heat kills by pushing the human body beyond its limits. Most heat disorders occur because the victim has been overexposed to heat or has over-exercised for his or her age and physical condition. The most severe heat-induced illnesses are heat exhaustion and heat stroke. If left untreated, heat exhaustion can progress to heat stroke and possible death. Young children, the elderly and those with existing illnesses are more likely to become victims. Other conditions that can cause heat-related illness include stagnant atmospheric conditions and poor air quality.

Statistics from the Centers for Disease Control and Prevention indicate that an average of approximately 618 deaths in the United States per year are attributable to exposure to excessive heat, with the largest number (1,050) occurring in 1999. In 1980, high summer temperatures in Central and Southern States caused an estimated 1,700 excess deaths directly attributable to the heat. In July 1995, a heat wave in the mid-west caused 670 deaths, 375 in the Chicago area alone. High cooling demands also increase the risk of utility black outs as transmission systems are stretched to their limits. The combination of a loss of air conditioning due to a black out, along with a heat wave could have catastrophic results for the region.

The hottest temperature ever recorded in the region was 105 degrees measured in Dunstable and Pepperell during August 1948.⁹ In recent years, temperatures over 100 degrees were recorded in the region in July 1995, June 2008, July 2011, July 2013, September 2015, and July and August 2016. Extreme heat is of particular concern in areas where the built environment contributes to the phenomenon of urban heat-island effect. Heat islands develop when built surfaces replace a large portion of natural land, keeping nighttime air temperatures high, relative to temperatures in less urbanized areas. According to meteorologists, a heat island is a well- defined area where temperatures are higher than the surrounding region, sometimes as much as 15° F higher.

Extreme cold events are days where the mean daily temperature (average of the high and low recorded temperatures over a 24-hour period) falls below 32° F. Prolonged exposure to extreme cold temperatures can lead to serious health problems such as hypothermia, cold stress, frostbite, or freezing of the exposed extremities such as fingers, toes, noses and earlobes. Infants, seniors, people who are homeless, and those living in a home without adequate heat are most susceptible to such conditions. As the temperature drops and wind speed increases, heat can leave the body more rapidly. This phenomenon is known as the wind-chill effect, which can exacerbate an extreme cold event. The coldest temperature ever recorded in the region was -29 degrees, as recorded in Dunstable and Pepperell in January 1957.¹⁰

The entire region is at risk for extreme cold and heat. The record high and low temperatures for Chelmsford is shown in Table 30 below.

⁹ www.intellicast.com

¹⁰ Ibid

Table 30: Record High and Low Temperatures

| Record High Temperature (degrees F) | Month and Year Recorded | Record Low Temperature (degrees F) | Month and Year Recorded |
|-------------------------------------|-------------------------|------------------------------------|-------------------------|
| 103 | August 1948 | -17 | January 1994 |

Source: www.intellicast.com

Invasive Species

Invasive species are those non-indigenous species that have a high likelihood of spreading beyond their area of introduction and establishing themselves without cultivation. Invasive species can outcompete natural species in the same community and are highly adaptable. The anticipated impacts of a changing climate are expected to exacerbate their spread.

EEA established the Massachusetts Invasive Plant Advisory Group (MIPAG) to develop strategies for invasive species management at the state level. MIPAG has identified 69 plant species as invasive to Massachusetts. Some of those impacting Chelmsford include Japanese knotweed (*Reynoutria japonica*) and oriental bittersweet (*Celastrus orbiculatus*). In addition to invasive plant species, a number of insects, such as the emerald ash borer (*Agrilus planipennis*) and the Asian Longhorned beetle (*Anoplophora glabripennis*) threaten local forests.

Massachusetts maintains multiple laws and regulations intended to control invasive species, including a list of prohibited plants provided by the Department of Agricultural Resources (DAR), the Wetlands Protection Act (310 CMR 10.00), and others outlined in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan.

4.1.7 Climate Change

Scientific assessments indicate that climate change is expected to alter the frequency or severity of weather-related natural hazards, increasing the vulnerability to such hazards. These assessments suggest that the potential effects of climate change on weather-related events could be significant. For example, increasing temperatures may impact communities by altering the frequency or severity of hurricanes, tornadoes, and severe thunderstorms. There is growing evidence that the warming surface temperatures in the sea have increased the destructive potential of Atlantic tropical storms since 1970.

Massachusetts' climate is already changing – ambient temperature has increased by approximately 1.8°F since 1970 and sea surface temperature has increased by 2.3°F between 1970 and 2002. These warming trends have also been associated with more frequent days with temperatures above 90°F, reduced snowpack, and earlier snow melt and spring peak flows.¹¹

The Massachusetts Climate Change Projections predict that the Merrimack Basin will experience a 3.25°F to 6.70°F increase in average temperature by 2050, and a 4.02°F to 11.78°F increase by 2090. Days with temperatures above 90°F are predicted to increase from 7.43 days annually presently, to 10.5 to 33.34 days annually by 2050, and 14.93 to 73.79 days annually by 2090. Sea temperatures are expected to increase by 8°F.¹²

As a result of increased temperature, New England is expected to experience changes in the amount, frequency and timing of precipitation. Since 1900, precipitation recorded at the U.S. Historical Climatology Network weather stations located across the northeast has increased by 5 to 10 percent. By the end of the century, annual precipitation is expected to increase by up to 7.57 inches, with the potential for a decrease by up to 1.39 inches in the summer.¹³

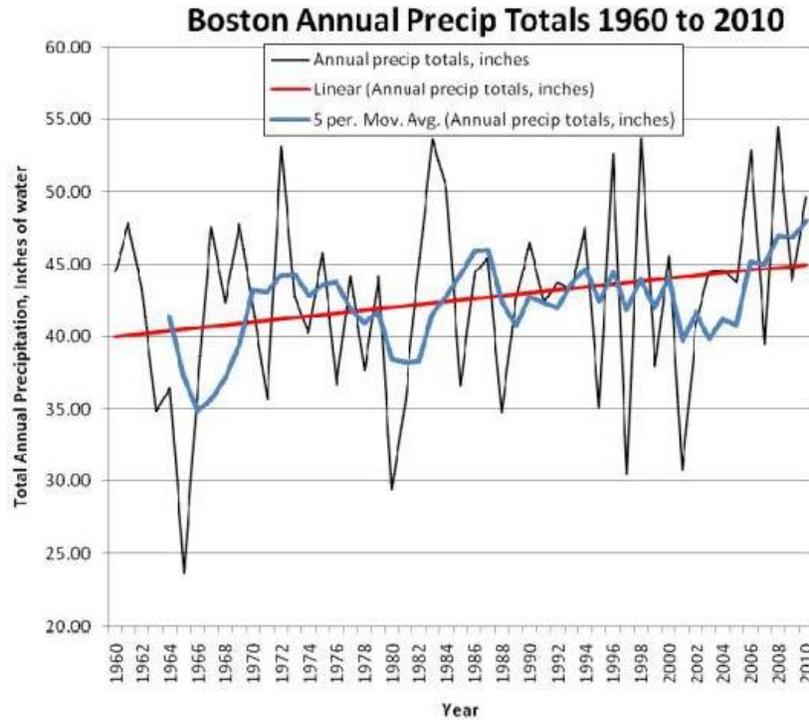
More specifically, winter precipitation (generally in the form of rain) is expected to increase by up to 2.41 inches by 2050 and 3.79 inches by 2090, while the number of snow events is expected to decrease. The shift toward more rainy and icy winters would have serious implications in terms of possible damaging ice storms, similar to the storm that severely impacted the region in December 2008. In addition, more winter rain is expected to cause more high-flow and flooding events during the winter, earlier peak flows in the spring, and extended low-flow periods in the summer months. Such hydrologic changes would impact water resources, including an increase in flooding, pollutant laden overflows from stormwater and wastewater systems during high periods of flow, and increased stress on surface and groundwater drinking sources during periods of low flow or drought. Figure 1 below shows the annual precipitation totals for Boston over the past four decades.

¹¹ Frumhoff, P.C., J.J. McCarthy, J.M. Melillo, S.C. Moser and D.J. Wuebbles, 2006. Climate Change in the U.S. Northeast: A Report of the Northeast Climate Change Impacts Assessments, Union of Concerned Scientists, Cambridge, MA

¹² Massachusetts Climate Adaptation Report, Executive Office of Energy and Environmental Affairs and the Adaptation Advisory Committee, September 2011

¹³Ibid.

Figure 1: Boston Annual Precipitation Totals 1960-2010



Source: National Weather Service

Higher temperatures will have a negative effect on air quality and human health. Increased rates of respiratory illness, worsening of allergies and asthma, increased vector borne diseases, and degraded water quality are expected. Floods caused by high intensity precipitation will also impact the region and the state. Should these events occur with greater frequency as many climate experts predict, future damage may be severe and cumulative, straining local and state resources. Extreme weather events can disrupt power, limit access to safe and nutritious food, damage property, and impact health care services.

Climate change is also expected to impact the state and local economy. Among the sectors most likely to be affected are agriculture, forestry, fisheries, manufacturing and service industries, tourism, recreation and health care. Establishing redundant supply routes and sources, developing renewable energy sources, and protecting facilities and sites which are vulnerable to flooding, will help minimize the potential economic impact to businesses. With these higher temperatures, electricity demand in Massachusetts could increase by 40% in 2030 most of the increase would occur during the summer months, requiring significant investment in peak load capacity and energy efficiency measures.¹⁴

¹⁴ Ibid.

Given the known natural hazard risks and the projected impacts of climate change, there are several reasons to integrate hazard mitigation and climate change adaptation. First, the decisions and choices made today will shape the future of our communities and impact their ability to be resilient. Second, given significant time is required to develop adaptive strategies and implementation capacity, acting now will allow the time needed for communities to work toward achieving long-term adaptation goals. Third, proactive planning is far less costly than reacting and responding to a disaster created by a hazard that has been exacerbated by the effects of climate change.

By creating an engaged community and taking a proactive approach to reducing the region's vulnerability, the region will be better positioned to deal with the increased threats posed by climate change. Some solutions that address climate change can also be viewed as hazard mitigation strategies in that they achieve reductions in greenhouse gas emissions that contribute to global warming and exacerbate the severity and impacts of natural hazards.

Developing effective and efficient initiatives to address climate change will require communication, coordination, and collaboration among government bodies, the private sector, non-profit organizations, academic institutions and other stakeholders. Neither adaptation nor mitigation alone can address the impacts of climate change but taken together the two programs can reduce the risks of climate change and result in more resilient communities.

The Region's Vulnerability to Climate Change

The most significant vulnerability to structures in the region is that they were designed and constructed based on historic weather conditions. This puts infrastructure at an increased risk of future damage from increased precipitation and flooding. It is expected that increased frequency of extreme weather events will raise the risk of damage to transportation systems, energy-related facilities, communications systems, and water supply and wastewater management systems. Improving siting and design of new structures to include consideration of the impacts of climate change will minimize the region's vulnerability and allow communities to be more resilient. The Insurance Institute for Business & Home Safety (IBHS) has released a new report which provides an analysis of residential building codes in the 18 hurricane-prone coastal states along the Gulf of Mexico and the Atlantic Coast. Massachusetts rated fourth with a score of 87 out of 100.¹⁵

¹⁵ Rating the States: An Assessment of Residential Building Codes and Enforcement Systems for Life Safety and Property Protection in Hurricane Prone Regions", IBHS, 2012.

Municipalities and the State should adjust traditional maintenance and inspection schedules for roadways, bridges and drainage structures to take into account the impacts of climate change. Short-term measures for publicly owned water and wastewater treatment facilities could include flood-proofing by increasing the elevation of structures, installing water-tight doors and windows, replacing wet/dry well pumps with submersible pumps, increasing emergency back-up provisions to keep key equipment operational, and relocating vulnerable equipment.

There are similar vulnerabilities across ecosystems based on projected temperature changes, increased storm intensity, precipitation changes, drought, and sea level rise. Different organisms have different rates of response to climate change. It is expected that climate change will cause changes in species composition and forest structure. Climate change, in conjunction with other stressors, will alter forest function and its ability to provide wildlife habitat, and could reduce the ability of forests to provide ecological services such as air and water cleansing. In addition, the negative impacts of invasive species may increase, as native forests are increasingly stressed. In general, adaptive strategies for natural resources and habitats include land and water protection, land and water resource management, regulation changes and increased monitoring.

Higher summer temperatures, less summer precipitation, and an increase in drought frequency will impact water quality and quantity. Intermittent streams will cease flowing earlier in the season and some cold-water habitat will be replaced with warm water habitat. The predicted changes in precipitation patterns will also increase stormwater discharge. Hydrologic changes from increased flooding will lead to increased erosion, stream scouring and sedimentation. Overbank floods that once spilled across the floodplain can become confined within the channel and disconnect the waterway from the floodplain. Adaptation strategies should integrate the protection of rivers, streams, lakes, floodplain, and wetlands with land use, watershed and floodplain management.

The entire region is vulnerable to impacts of climate change. The area's most at risk include those located in the floodplain, near wetlands and along waterways. In order to help protect existing structures and minimize or prevent exposure, sound land use decisions should be promoted through technical support to local communities on effective land use standards, model bylaws and permitting processes. Hazard mitigation, evacuation and emergency response plans should be evaluated and updated to reflect changing climate conditions and new development patterns.

Climate Change Planning and Adaptation at the State Level

Massachusetts is actively working to reduce greenhouse gas emissions and address climate change adaptation. The Global Warming Solutions Act, passed by the Massachusetts Legislature and signed by Governor Deval Patrick in 2008, directed the Secretary of Energy and Environmental Affairs to convene an advisory committee charged with developing a report that analyzed strategies for adapting to the predicted impacts of climate change. The Massachusetts Climate Change Adaptation Report was published in September 2011. The report provides an overview of the observed and predicted changes to Massachusetts' climate and the anticipated impacts, outlines key findings, sets guiding principles, and identifies key adaptation strategies that could help increase resilience and preparedness.

Governor Charlie Baker issued Executive Order No. 569: Establishing an Integrated Climate Change Strategy for the Commonwealth in September 2016. This order established timelines for the state to review and update its emission standards, and created the Municipal Vulnerability Preparedness Program, under which this HMP Update is being conducted.

Furthermore, the 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan is the first plan in the nation to integrate climate adaptation into its hazard mitigation plan. The plan addresses how climate change intensifies existing natural hazards, as well as outlines an adaptation strategy.

4.2 Non-Natural Hazards

In the interest of holistically addressing mitigation and its interrelationship with emergency management overall, this Hazard Mitigation Plan Update provides an overview of several hazards that are non-natural and pose a threat to the state, the region, and individual municipalities. Strategies will not be provided for addressing these hazards at the regional and local levels. MEMA and Chelmsford maintain a Comprehensive Emergency Management Plan (CEMP), as well as other documents that outline the specific response and mitigation associated with non-natural disasters, crime, and other emergencies.

According to the National Preparedness Report published by the Department of Homeland Security (DHS) in March 2012, the Nation's preparedness capabilities have improved considerably since 9/11. Areas of overall strength include:

- **Planning:** All hazards planning considers routine emergencies and catastrophic events, integrating local perspectives;
- **Operational Coordination:** The National Incident Management System (NIMS) provides a common doctrine for incident management;
- **Intelligence and information sharing:** A national network of fusion centers and Joint Terrorism Task Forces (JTTFs) brings together federal, state and local law enforcement, intelligence community, and other public safety officials and private sector partners;
- **Environmental Response/Health and Safety:** A diverse set of federal, state and local assets have the capabilities to address a wide range of routine and large-scale hazardous material and chemical, biological, radiological, nuclear, and explosive incidents;
- **Mass Search and Rescue Operations:** Federal, state and local resources comprise a comprehensive rescue network;
- **Operational communication:** Government partners have established communication capabilities tested through exercises and real events; and
- **Public Health and Medical Services:** A wide range of partners provide a responsive public health and medical network.

4.2.1 Public Health Emergencies and Hazards

A community or region may face serious illness due to a communicable disease which threatens to overwhelm the public health system. Infectious disease emergencies are extremely rare - while the Massachusetts Department of Public Health (MDPH) receives 10,000 case reports of infectious disease annually, only a small fraction is considered public health infectious disease emergencies. Health care providers, local boards of health, and the MDPH handle most infectious diseases routinely. However, when an infectious disease spreads undetected or undeterred through a community, especially an easily communicable disease with high morbidity and mortality, it is considered an emergency. The longer this type of disease goes unrecognized and untreated, the more severe the impact will be on human health and mortality.

Worldwide travel and the re-emergence of infectious diseases in more virulent forms may increase the rate of public health infectious disease emergencies in the future. The Massachusetts Department of Public Health is the primary agency responsible for the study, planning, isolation/quarantine and actions, surveillance, and reporting for all public health emergencies.

Any cluster or outbreak of any unusual disease or illness must be reported to the local board of health (or to MDPH if the local board of health is not available). The H1N1 flu (also referred to as the swine flu) caused by a new virus first recognized in April of 2009 and was the most recent public health emergency. The H1N1 flu quickly spread to many parts of the world and was identified as a pandemic, or global outbreak impacting Massachusetts. More recently, the novel coronavirus COVID-19 was recognized as a pandemic by the World Health Organization on March 11, 2020, with approaching 6.7 million cases in the US and 126,000 in Massachusetts as of the writing of this report. Governor Charlie Baker issued an emergency order on March 23, 2020, closing schools, in-person operations for non-essential businesses, and limiting the size of gatherings. In addition to the ongoing public health impacts from the pandemic, the stay-at-home order has resulted in large-scale disruption of the economy and municipal services.

Bioterrorism is the intentional use of (or threat to use) biological agents including but not limited to: anthrax, botulism, brucellosis, cholera, pandemic influenza, plague, ricin, smallpox, tularemia, and viral hemorrhagic fevers.

4.2.2 Transportation Accidents

Transportation accidents can occur in any community. Automobile accidents occur with great frequency. MassDOT has reported the Town of Chelmsford to have a 2% decrease in accidents between 2015 and 2016, from 742 crashes down to 727 crashes. Between 1990 and 2016 the town has reported a total of 23,601 crashes. NMCOG has an ongoing safety program aimed at identifying, reducing and mitigating motor vehicle crashes within the region.

Railroad accidents occur less frequently and are isolated to areas where active lines exist. Aircraft accidents occur with the least frequency but have the potential to affect the region, given current flight paths and patterns for local and regional airports.

4.2.3 Nuclear Event

As described in the joint Nuclear Regulatory Commission and Federal Emergency Management Agency publication “Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants” (NUREG-0654 REMA-REP-1 Rev.1), a radioactive plume released from a nuclear power plant consists of gaseous and/or particulate material. Three dominant modes of exposure have been identified from atmospheric releases: external whole-body irradiation, inhalation, and ingestion. External whole-body irradiation is direct exposure from gamma radiation in or from the plume. Internal exposure occurs primarily through the inhalation of airborne radioactive material in the plume or from breathing re-suspended material deposited from a passing plume. Ingestion is exposure to radiation following the consumption of contaminated food or water by mouth.

Exposure to radiation is measured on a dose equivalent basis. Dose equivalent (or effective dose) combines the amount of radiation absorbed and the medical effects of that type of radiation. For beta and gamma radiation, the dose equivalent is the same as the absorbed dose. By contrast, the dose equivalent is larger than the absorbed dose for alpha and neutron radiation, because these types of radiation are more damaging to the human body. Units for dose equivalent are the roentgen equivalent man (rem) and sievert (Sv), and biological dose equivalents are commonly measured in 1/1000th of a rem (known as a millirem or mrem).¹⁶ Linear no-threshold (LNT) dose-response relationship is used to describe the relationship between radiation dose and the occurrence of cancer. This dose-response model suggests that any increase in dose, no matter how small, results in an incremental increase in risk. The U.S. Nuclear Regulatory Commission (NRC) accepts the LNT hypothesis as a conservative model for estimating radiation risk. The greater the dose received the greater the potential for biological effect. However, it is impossible to predict precisely how an individual will respond to a particular dose, as effects will vary from one person to another.

The average annual whole-body dose equivalent from all-natural sources of radiation in the U.S. is estimated to be approximately 360 millirems. This dose results from exposure to cosmic and terrestrial radiation sources and radiation from internally deposited radio nuclides.

Additionally, the use of x-rays and radioactive materials in medicine and dentistry add to overall population doses.

Radiation effects can be classified in two categories, early or delayed, but these categories are not mutually exclusive. Early acute effects of radiation exposure generally occur within 90 days from exposure, and may include fatalities, symptoms of acute radiation syndrome, or clinically detectable changes in blood and chromosomes. However, emergency protective actions can be taken to prevent or minimize these effects. Delayed effects of radiation exposure (i.e., biological effects that can only be observed on a statistical basis) could occur in some members of a population that has been exposed to radioactive materials. The effects may include fatalities or disabilities of anatomical or genetic origin.

The Nuclear Regulatory Commission (NRC) and the Environment Protection Agency (EPA) utilize the emergency planning zone (EPZ) concept. EPZs are designated areas for which plans are prepared to ensure that prompt and effective actions can be taken to protect the public in the event of an incident at a nuclear power plant.

¹⁶18 <http://www.nrc.gov/about-nrc/radiation/health-effects/measuring-radiation.html>

The EPZ for Seabrook Nuclear Power Station, located in Seabrook, New Hampshire and operated by NextEra Energy, impacts Massachusetts. In addition, two decommissioned nuclear power plants, Pilgrim Nuclear Power Station located in Plymouth, Massachusetts and the Vermont Yankee Nuclear Power Station (Vermont Yankee) located in Vernon, Vermont, both formerly operated by Entergy Nuclear Northeast, are also located in the region.

Within the Northern Middlesex region, the University of Massachusetts Lowell (UML) operates a small nuclear reactor that is utilized for educational purposes. The UML Nuclear Reactor is water cooled and operates at a maximum power level of one megawatt. It is used primarily for training and research in the fields of nuclear science, radiochemistry and engineering. The reactor is housed in a containment building which is part of the UML Radiation Laboratory.

Radiation sources at the University of Massachusetts Lowell (UML) are regulated by the U.S. Nuclear Regulatory Commission (NRC) and the Commonwealth of Massachusetts Department of Public Health (DPH). Through these agencies, the University has been granted three broad scope licenses to manage its campus radiation safety program. As part of the requirements of the broad scope licenses, the University is required to appoint a Radiation Safety Committee (RSC) and a Radiation Safety Officer (RSO) to develop and manage the university radiation safety program. This program is subject to periodic audits by the NRC and DPH to verify regulatory compliance and to ensure the safety of university personnel and members of the public.

4.2.4 Infrastructure Failure

Infrastructure failure includes technological emergencies that result in an interruption or loss of a utility service, power source, life support system, information system or equipment needed to keep the businesses in operation. Examples include:

- Utilities such as electric power, gas, water, hydraulics, compressed air, municipal sewer systems, water treatment plants, and wastewater treatment plants;
- Security and alarm systems, elevators, lighting, life support systems, heating, ventilation and air conditioning systems, and electrical distribution systems;
- Manufacturing equipment and pollution control equipment;
- Communication systems, both data and voice computer networks; and
- Transportation systems including air, highway, railroad and waterways.

Technological emergencies have the potential to occur in every community. Communities with limited infrastructure are more vulnerable to experiencing an incident because of the lack of redundant systems. Communities should consider mitigation measures such as installing emergency generators, burying cable, installing back-up systems, and undertaking vegetation management and pruning to help reduce risks.

The New York Blackout of 2003, the December 2008 Ice Storm, the October 2011 snowstorm, Hurricane Irene in 2011, and Winter Storm Nemo in 2013 resulted in widespread power outages of up to five days in duration. These outages significantly impacted the delivery of services, the regional economy, and the quality of life for the region's residents.

4.2.5 Commodity Shortages

Commodities are goods that are in demand in an emergency, such as food, fuel and medicine. For example, petroleum shortages in Massachusetts may be caused by natural disasters in the Commonwealth itself or in those parts of the world which supply petroleum. The shortage may be created by geopolitical events such as revolutions, embargoes, or war, or by economic factors that drive up prices or reduce available supply.

Petroleum Shortages

Massachusetts is particularly vulnerable to petroleum shortages during the winter months due to a combination of high demand for home heating oil and severe weather that may impact regional distribution mechanisms. Massachusetts and New England in general are logistically isolated from major U.S. refineries and pipelines, and depend on imports, chiefly by water, from domestic and foreign sources.

Historically, there have been several events that have impacted the price and availability of petroleum. The Arab Oil Embargo in 1973 led to increased fuel prices and rationing throughout the United States. In 1979, the Iranian Revolution caused a steep decline in that country's oil exports, which in turn caused a spike in fuel prices in the United States. Severe weather in January and February of 2000 not only increased demand in Massachusetts, but limited supply as weather conditions slowed the docking and unloading of barges and tankers. In 2005, Hurricane Katrina shut down refineries and oil rigs in the Gulf of Mexico, leading to price spikes in Massachusetts due to limited supplies. In the summer of 2008, oil prices skyrocketed to almost \$150 per barrel, creating concern that residents would have difficulty affording the oil needed to heat their homes in winter.

The Regional Strategic Plan for Greater Lowell calls for policies that will result in reducing fossil fuel use in buildings, power generation, and transportation. The use of renewable energy sources would help to reduce greenhouse gas emissions, manage energy costs, and reduce reliance on fossil fuels, thereby creating a sustainable energy future for the region. Increased reliance on local solar, wind and geothermal energy sources would provide a buffer against the fluctuations in supply and prices of traditional fossil fuel markets.

Natural Gas Shortages

Natural gas shortages may be caused by a natural disaster, disruptions to pipelines and other facilities which transport natural gas, geopolitical events such as revolutions, embargoes or war, or by economic factors that drive up prices or reduce available supply. New England receives 80% of its natural gas supply from the Gulf Coast, western Canada, and eastern Canada via interstate pipelines. Liquefied natural gas (LNG) is also imported through the Distrigas facility in Everett. LNG presently meets 20 to 25% of New England's demand, spiking to 30% in winter months. Concern for natural gas supply reliability is almost exclusively confined to the winter months when demand for natural gas for space heating increases. During the three winter months, interstate pipelines feeding Massachusetts operate at over 90% of capacity.¹⁷ Nearly half of all homes in Massachusetts are heated with natural gas.

Severe winter weather can cause increased demand for natural gas for heating and electric power generation, along with delays of over-the road transportation of LNG to satellite facilities. Hurricanes in the Gulf of Mexico may shut down or damage natural gas infrastructure in that area. Intensely cold weather in January 1981, combined with disruptions in the supply of liquefied natural gas created by storm off the coast of Algeria which disrupted tanker shipments, caused the Governor to declare an energy emergency in Massachusetts. Schools heated by natural gas were closed, non-residential buildings were ordered to lower thermostats to 55 degrees, and residential customers were urged to lower their thermostats by ten degrees.

Electricity Shortage

Electricity shortage may be caused by a sudden increase in demand due to weather conditions, a shortfall in generating capacity, or by power issues in neighboring regions that decrease available electricity reserves. An electricity shortage is distinguished from a power failure in that the electric transmission infrastructure has suffered little or no damage.

¹⁷2010 State Hazard Mitigation Plan, Massachusetts Emergency Agency, p. 95.

All areas are vulnerable to electricity shortages. Shorter-duration heat waves (2-3 days) may cause demand surges, generator stresses/outages, and transmission problems. A prolonged heat wave may lead to electricity supply problems, rolling blackouts, and health and safety risks if priority users cannot be supplied with power. Electricity problems in neighboring power pools may deplete available electricity reserves, leading to supply problems if conditions in New England deteriorate.

Disruptions in the supply of natural gas or petroleum may impact generating capacity in the region. Disruptions to generation plants or key transmission lines due to natural disasters, mechanical failure, or deliberate action may reduce the supply of electricity. Most electricity in Massachusetts is produced by gas- or oil-fired power plants, with coal-fired plants accounting for about 25% of net electricity production. National Grid is the delivery company for the region.

4.2.6 Food Contamination / Foodborne Illnesses

Foodborne illnesses are caused by more than two hundred different pathogens, including viruses, bacteria, parasites, toxins, chemical contaminants, and metals. Symptoms of foodborne illness range from mild stomach upset to life-threatening neurological conditions, liver and kidney syndromes, or even death. All communities are vulnerable to foodborne illness. According to the Centers for Disease Control (CDC), there are approximately 76 million cases per year of illness from foodborne agents, including about 325,000 hospitalizations and 5,000 deaths.¹⁸ Most cases of foodborne illness are natural or accidental in nature, but deliberate contamination of food for financial gain or as an act of terrorism is possible.

In addition to illnesses and deaths, food contamination can cause significant economic impact to the food industry through the effects of recalls and decreased consumer confidence. Changes in demographics and consumption patterns have increased susceptibility to food-borne pathogens and contamination. Approximately 25% of the population is in a high-risk category from foodborne illness (e.g. young, elderly, pregnant, immune compromised). Furthermore, people are increasingly consuming ready-to-eat and prepared foods, and these “convenience foods” are at higher risk of cross-contamination from other foods and/or from food workers. Consumers are also eating a greater variety of foods year-round, particularly those consumed raw or with minimal processing, which are often associated with foodborne illness. In addition, a greater proportion of foods are imported now than in the past, some of which come from countries with less well-developed food safety systems.

¹⁸ Ibid.

In September 2011, Colorado's state health department reported to CDC an outbreak of listeriosis. From August to October, the outbreak reached 28 states, and 146 cases of invasive listeriosis were confirmed and reported to public health officials. Ultimately, thirty patients died. The outbreak made national headlines as the deadliest outbreak of foodborne illness since 1924. Most recently, in December 2018, Massachusetts reported one case of *E. coli* to the CDC in association with contaminated red leaf lettuce, green leaf lettuce, and cauliflower grown in California. The outbreak infected a total of sixty-two people in 16 states nationwide.

4.2.7 Water Contamination / Waterborne Illnesses

Water supplies in the region may be contaminated by pathogens, such as *E. coli* or *Giardia*, or by chemicals from stormwater runoff or point sources such as industrial sources or storm sewers. Infants, young children, the elderly, pregnant women, and the immune compromised are particularly vulnerable to water contamination and waterborne illness. There is also an economic impact if public water supplies are unusable for extended periods, as businesses which rely on these supplies must remain closed and bottled water is substantially more expensive per gallon than tap water.

When water supply contamination is suspected, boil water orders are issued by MassDEP to local public water suppliers, who in turn issue advisories to their consumers advising them that they should boil their tap water for drinking and other human-consumption uses like cooking, hand washing, brushing teeth, etc. Boil water orders are preventative measures issued to protect public health from waterborne infectious agents that could be or are known to be present in drinking water. When a boil order is issued by MassDEP to the local public water supplier (PWS), the PWS must take appropriate corrective action, notify/advise its customers, continue to monitor its water supply, and notify customers when it has remedied the problem and the boil water order is lifted.

4.2.8 Chemical / Hazardous Materials

Chemical agents are poisonous vapors, aerosols, liquids, and solids that have a toxic effect on people, animals, or plants. Such agents can be released by accident, by bombs or sprayed from aircraft, boats, and vehicles. They can have an immediate effect (a few seconds to a few minutes) or a delayed effect (2 to 48 hours). While potentially lethal, chemical agents are difficult to deliver in lethal concentrations. Outdoors, the agents often dissipate rapidly. Chemical agents also are difficult to produce. A chemical attack could come without warning. Symptoms of a chemical release include difficulty breathing, eye irritation, a loss of coordination, nausea, or burning sensation in the nose, throat, and lungs. The presence of many dead insects or birds may also indicate a chemical agent release.

Chemicals are found throughout our communities. They are used to purify drinking water, increase crop production, and simplify household chores. But chemicals can be hazardous to humans or the environment if used or released improperly. Hazards can occur during production, storage, transportation, use, or disposal processes. Hazardous materials come in the form of explosives, flammable and combustible substances, poisons, and radioactive materials. These substances are most often released as a result of transportation accidents or because of chemical accidents at industrial plants. A hazardous material spill or release can pose a risk to life, health or property. An incident can result in the evacuation of a few people, a section of a facility or an entire neighborhood.

There are a number of Federal laws that regulate hazardous materials, including: the Superfund Amendments and Reauthorization Act of 1986 (SARA), the Resource Conservation and Recovery Act of 1976 (RCRA), the Hazardous Materials Transportation Act (HMTA), the Occupational Safety and Health Act (OSHA), the Toxic Substances Control Act (TSCA) and the Clean Air Act. Title III of SARA regulates the packaging, labeling, handling, storage and transportation of hazardous materials. The law requires facilities to furnish information about the quantities and health effects of materials used at the facility, and to promptly notify local and State officials whenever a significant release of hazardous materials occurs.

Communities with a large industrial base may be more likely to experience a hazardous material release due to the number of facilities that use such materials in their manufacturing processes. Communities with major highways or rail corridors may also be at a greater risk due to the number of trucks or trains transporting hazardous materials.

4.2.9 Terrorism

Terrorism is the use of force or violence against persons or property in violation of the criminal laws of the United States for purposes of intimidation, coercion or ransom. Terrorists bypass established institutions (such as courts), using violence against citizens to force changes in society or to force governments to change policies in support of their cause. Terrorists might use weapons of mass destruction, such as toxic or poisonous chemicals, disease causing organisms, dangerous radiation, explosive, incendiary or poison gas bombs, grenades, rockets or missiles, mines or similar devices. Terrorists may also use traditional weapons such as automatic guns or grenades in armed attacks on targets.

The terrorist attacks of September 11, 2001 had a profound impact on the nation, the state and the region. A series of four suicide attacks were carried out by nineteen terrorists from the Islamist militant group al-Qaeda.

The attacks involved the hijacking of four passenger jets. Two of the planes were flown into the towers of the World Trade Center in New York City, a third plane hit the Pentagon just outside Washington, D.C., and the fourth plane crashed in a field in Pennsylvania. The two passenger jets that struck the World Trade Center, American Airlines Flight 11 and United Airlines Flight 175, originated from Logan Airport in Boston. Following this attack, a presidential disaster declaration was made that provided \$1.5 million in FEMA Individual Household Program funds for Massachusetts residents who requested crisis counseling.

Depending on the severity and type of a terrorist attack, many things can impact a community or the region overall:

- There could be casualties;
- Significant damage to buildings and the community's infrastructure;
- Health and mental health resources in the affected communities could be strained to the limit or overwhelmed;
- There could be heavy involvement of law enforcement at local, state and federal levels, due to the event's criminal nature;
- Evacuation may be necessary;
- Workplaces and schools may be closed;
- There may be restrictions on domestic and international travel;
- Cleanup could take months; and
- Public fear could continue for a prolonged period.

High-risk targets for acts of terrorism include military and civilian government facilities, and high-profile landmarks. Terrorists might also target large public gatherings, water and food supplies, utilities, public transportation facilities and corporate centers.

Since 1995, MEMA has conducted multiple anti-terrorism programs, training thousands of local, state, and federal public safety officials, hospital emergency room personnel, and emergency management personnel, through classes in Anti-Terrorism, Incident Command, and Hazmat Awareness, including chemical-biological threats. To ensure adequate preparedness, MEMA has conducted hundreds of exercises in conjunction with local communities and other state and federal agencies.

The MEMA Planning Department works closely with communities to ensure that the all hazards Comprehensive Emergency Management Plans (CEMP) are current. These local plans include a Terrorism Annex, which helps local officials focus on specific potential terrorist threats to their particular community.

The Massachusetts Statewide Anti-Terrorism Unified Response Network (SATURN) is an information sharing and first responder network created to enhance the existing public security delivery system. SATURN brings together fire, emergency management, and police personnel from each municipality, and provides a process for receiving and exchanging information during a terrorist threat.

The Commonwealth maintains a fusion center which is defined by the Global Justice Information Sharing Initiative as: “a collaborative effort of two or more agencies that provide resources, expertise, and/or information to the center with the goal of maximizing the ability to detect, prevent, apprehend and respond to criminal and terrorist activity.” The Commonwealth Fusion Center (CFC) operates around the clock and provides terrorist-related intelligence and public safety and security information to state, local and federal public safety interests. The CFC also serves as a clearinghouse for information and information requests between the state’s public and private safety and security entities, as well as DHS.

4.2.10 Other Non-Natural Hazards

As recommended by FEMA, Massachusetts completed a Threat Hazard and Risk Assessment (THIRA) in 2017 to identify threats and hazards of concerns, provide context, develop actions and outcomes for response, and estimate resources required to meet those outcomes. In addition to natural hazards, the THIRA also assesses cyberattacks, hazmat releases, and complex coordinated attacks as technological and human-caused hazards.

5.0 CRITICAL FACILITIES AND SPECIFIC AREAS OF COMMUNITY CONCERN

In association with completion of the CRB process, a map depicting select critical facilities relative to the 100- and 500-year floodplain was prepared and provided to stakeholders. These facilities are vital to the delivery of key government services and may significantly impact the public during a time of emergency or while recovering from an emergency. The primary sources of information relative to critical facilities were MassGIS, the Emergency Manager, and the Town Engineer. During CRB workshops, stakeholders reviewed and updated the maps with additional critical facilities and areas of concern.

Some of the critical facilities identified include the following:

- emergency operations center
- city or town offices
- water and wastewater treatment plants
- water pumping stations and tanks
- municipal wells
- sewage pumping stations
- police and fire stations
- schools and colleges
- hospitals
- daycare facilities with greater than 5 children
- electric power substations
- public works garages
- nursing homes/elderly housing/senior centers
- correctional facilities
- emergency shelters
- dams
- power plants
- access roads to all listed facilities
- evacuation routes
- bridges
- communication facilities
- gas pipelines/storage sites
- flood gates
- transportation hubs
- problem areas based on local knowledge

Refer to Appendix C for the base map provided to workshop participants, and Appendix D for the participatory mapping completed during the workshop.

5.1 Critical Care Facilities

The list of critical care facilities includes emergency operation centers, health care facilities and shelters. It has been updated based on input received from the Town during the development of this Plan. This information is shown in Table 31.

Table 31: Emergency Operations, Health Care Facilities and Shelters

| Facility Type | Common Name | Street Address | Health Facility Type | Average Daily Patient Capacity | Capacity | Feeding Capability | Emergency Generator Available |
|------------------------------------|---|----------------------|----------------------|--------------------------------|----------|--------------------|-------------------------------|
| Emergency Operations Center | Police Headquarters (Primary) | North Road | | | | No | Yes |
| | Town Offices (Secondary) | 50 Billerica Road | | | | No | Yes (7-days fuel) |
| Health Facilities | Harvard Pilgrim Health Plan | 228 Billerica Road | General | 50 | | No | No |
| | Lowell General Hospital Surgical Center | 10 Research Place | | | | | |
| | Chelmsford Walk-in | Parkhurst Road | General | 25 | | No | No |
| | Palm Manor Nursing | Parkhurst Road | Level III | 85 | | No | No |
| | Sunny Acres Nursing | 254 Billerica Road | Levels I-IV | 75 | | No | No |
| Shelters | McCarthy Middle School | 250 North Road | | | 400 | Yes | Yes |
| | Chelmsford High School | 200 Richardson Road | | | 800 | Yes | Yes |
| | Parker Jr. High School | 75 Graniteville Road | | | 200 | Yes | Yes |
| | Byam School | 25 Maple Road | | | 200 | Yes | Yes |
| | South Row School | 250 Boston Road | | | 150 | Yes | Yes |
| | Town Hall | One North Road | | | 150 | Yes | No |
| | Town Offices | 50 Billerica Road | | | 200 | No | Yes |

| | | | | |
|--|------------------|-----|-----|-----|
| Senior Citizen Center | 75 Groton Road | 500 | Yes | Yes |
| St. John's Church | Middlesex Street | 250 | Yes | No |
| St. Mary's Church | North Road | 250 | Yes | No |
| North Chelmsford Congregational Church | Princeton Street | 150 | Yes | No |
| Central Congregational Church | Worthen Street | 200 | Yes | No |

5.2 Areas with Limited Access or Specific Areas of Concern of the Community

Over the course of the CRB workshop process, stakeholders identified geographic areas of concern including the Williamsburg condominium complexes located off Route 3A in the northern area town, the mobile home park located to the south of Route 110, and assisted living facilities located throughout the Town.

In particular, access to the Williamsburg complexes is limited by two at-grade railroad crossings which carry an active freight line. The complex has an estimated population of 2,500 residents, and much of the area lies within the floodplain of the Merrimack River. Freight trains that use the rail line on a regular basis are often 100 or more cars in length. During normal train travel, emergency vehicle access to the Williamsburg area can be blocked for critical periods of time. Complete stoppage of a train along the line for extensive periods of time is possible during extreme weather events, or as a result of damage to the rail line. There is a secondary gravel access road to this area, but the roadway has fallen into disrepair. In addition, the bank of the Merrimack River in this area is eroding. Bank stabilization is needed to protect nearby homes that are in the floodplain.

Stakeholders also expressed the need to better understand the locations of vulnerable populations, such as those utilizing group homes and the elderly, for the purposes of emergency response. Multiple strategies to improve municipal outreach and communication to these groups were identified, such as the hiring of a Town social worker, establishment of dedicated Town social media accounts, and voluntary enrollment in the Reverse 911 program.

6.0 EXISTING PROTECTION MATRIX

The existing protection matrix is a summary of current measures, programs, projects and activities already in place that are related to hazard mitigation. Compiling such an inventory allows gaps and deficiencies to be identified. In preparing the region’s 2006 Pre-Disaster Mitigation Plan, a detailed questionnaire was developed and distributed to each local community. As part of the plan update process, the MVP Core Team reviewed the protection matrix from the 2015 HMP with the Town’s Emergency Management Coordinator to examine the adequacy of the Town’s programs, policies, and bylaws, and to determine what has been accomplished since the previous plan was approved. The updated existing protection matrix reflects current conditions and incorporates new measures that have been put in place over the last five years, as shown in Table 32. The table has been prepared using the format suggested in FEMA guidelines.

Table 32: Existing Protection Matrix for the Town of Chelmsford

| Type of Existing Protection | Description | Area Covered | Effectiveness or Enforcement | Improvements or Changes Needed |
|---|--|---|--|--|
| Community participates in the National Flood Insurance Program. | NFIP provides flood insurance to property owners in exchange for community compliance with floodplain management. | FEMA Zones A and AZ (100-year floodplain) | Moderately effective | Improved zoning enforcement needed. |
| Town has floodplain zoning in place | The Town adopted DCR’s model floodplain bylaw in April 2004. | Covers Zones A and AZ (100-year floodplain) | Effective | None. |
| Stormwater and erosion control measures | The Planning Board requires adherence to DEP’s Stormwater policy town wide. The town also has a Stormwater management plan as required under its MS4 Permit. | Town-wide | Regulations should be reviewed; although a major revision is not needed. | Improved coordination is needed between the Planning Board, Conservation Commission, and ZBA (as 40B permit granting authority). Implementation of a Low Impact Development (LID) bylaw should be evaluated. |
| The Town has a wetlands protection and aquifer protection bylaw and district. | The Conservation Commission has a general (non-zoning) wetlands bylaw; the zoning bylaw includes a section regarding the Aquifer Protection District. | Town-wide | Both wetland and aquifer protection bylaws are effective. | No improvements needed. |

| | | | | |
|---|---|--|---|---|
| The Town has impervious surface limitations. | The Aquifer Protection District limits impervious surface to 2,500 square feet, or 15%. | Within the Aquifer Protection District | Routine review is warranted. | Better enforcement would be beneficial. |
| Open Space Plan includes measures aimed at natural hazard mitigation. | Identifies improvements to open space properties and protection of resource areas; includes a seven-year action plan. | Town-wide | Open Space Plan is updated every 7 years. | OSRP has been approved by the State. Implementation will be ongoing. |
| Master Plan addresses Natural Hazard Mitigation | The town's 2010 Master Plan contains recommendations relative to natural hazard mitigation. | Town-wide | The town has an established Master Plan Implementation Committee charged with implementing the recommendations contained within the Plan. | The Implementation Committee should continue to its work to implement the plan recommendations; progress will be reported to town meeting on an annual basis. |
| The Town has local stormwater regulations in place. | Zoning and subdivision regulations require limiting the rate of runoff to pre-development rates. Culverts are sized for 10-year storms, detention basins for 25-year storms with damage avoidance for the 100-year event. | Town-wide | Stormwater controls are generally effective; Town relies on closed stormwater systems. Best management practices required for new commercial developments and subdivisions. | Town should evaluate and consider Low Impact Development (LID); improved coordination between the Planning Board, Conservation Commission, and ZBA. |
| A response plan is in place for dams located within Town. | There is emergency plans in place for the Freeman Lake and Heart Pond Dams. | Area in vicinity of dams | Plans adequately assess potential damage and provide response measures. | Response plans should be routinely reviewed and updated. |
| Town performs limited maintenance of drainage infrastructure. | The Town clears several small streams, swales, etc. each year. | Town-wide | In general, stormwater systems are maintained only when there is a failure/emergency. | A plan for routine maintenance should be established. |
| Town has program to sweep streets, clean out catch basins, and clear blocked culverts | Town sweeps streets and cleans each catch basin yearly. Culverts are cleaned as needed. | Town-wide | Marginally effective. More frequent maintenance is necessary to protect resource areas and meet DEP standards. | Financial constraints limit more frequent maintenance. |

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|---|--|-----------|---------------------|------------------------|
| Green Community Designation | The Town has been designated by the Department of Energy Resources as a Green Community. Hence, the community works toward improving energy efficiency and reducing greenhouse gas emissions, which benefits climate change. | Town-wide | Effective | None. Ongoing program. |
| Enforcement of State Building Code | The town's building inspector enforces the state building code, including those sections that relate to the NFIP requirements. | Town-wide | Effective | None. |
| Town has active program to address tree hazards | Street trees are monitored, cut and pruned as needed. Town relies on abutters to report problem locations. | Town-wide | Generally effective | None |

7.0 VULNERABILITY / RISK ASSESSMENT

7.1 Overview of Natural Hazards Vulnerability

Previous sections of this report describe the natural hazards that have occurred or are most likely to occur in the region. Since 1991, there have been twenty-six Presidential disaster declarations that included Middlesex County, as summarized in Table 33 below. Since 2015, there have been two Presidential disaster declarations in Middlesex County, both of which were the result of severe winter storms, with one also consisting of flooding. The Hazard Identification analysis is outlined in Section 4.0 of this document.

Table 33: Disaster Declarations for Middlesex County (1991-2018)

| Disaster Name (Date of Event) | Disaster Number (Type of Assistance) | Declared Areas |
|--|---|--|
| Hurricane Bob (August 1991) | FEMA -914-DR-MA (PA); FEMA-914-DR-MA (HMGP) | Counties of Barnstable, Bristol, Dukes, Essex, Hampden, Middlesex, Plymouth, Nantucket, Norfolk, and Suffolk |
| Severe Coastal Storm (October 1991) | FEMA-920-DR-MA (PA); FEMA-920-DR-MA IMA); FEMA-920-DR-MA (HMGP) | Counties of Barnstable, Bristol, Dukes, Essex, Middlesex, Plymouth, Nantucket, Norfolk, and Suffolk |
| Blizzard (March 1993) | FEMA-3103-EM (PA) | All 14 Massachusetts counties |
| Blizzard (January 1996) | FEMA-1090-EM (PA) | All 14 Massachusetts counties |
| Severe Storms/Flood (October 1996) | FEMA – 1142 –DR-MA (PA); FEMA -1142 – DR- MA (IFG); FEMA-1142-DR- MA (HMGP); and FY 1997 CDBG | Counties of Essex, Middlesex, Plymouth, Norfolk, and Suffolk |
| Heavy Rain/Flood (June 1998) | FEMA-1224-DR-MA (IFG); FEMA-1224-DR-MA (HMGP); 1998 CDBG | Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth and Worcester |
| Severe Storms and Flooding | FEMA-1364-DR-MA (IFG); FEMA-1364-DR-MA (HMGP) | Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, and Worcester |
| Snowstorm (March 2001) | FEMA-3164-DR-MA (IFG) | Counties of Berkshire, Essex, Franklin, Hampshire, Middlesex, Norfolk, and Worcester |
| Terrorist Attack (September 11, 2001) | FEMA-1391 (IFG) | Massachusetts residents who requested crisis counseling services following September 11 th . |
| Snowstorm (February 2003) | FEMA-3175-EM (PA) | All 14 Massachusetts counties. |
| Snowstorm (December 2003) | FEMA-3191-EM (PA) | Counties of Barnstable, Berkshire, Bristol, Essex, Franklin, Hampden, Hampshire, Middlesex, Norfolk, Plymouth, Suffolk, and Worcester |
| Flooding (April 2004) | FEMA-1512-DR (IFG); FEMA-1512-DR (HMGP) | Counties of Essex, Middlesex, Norfolk, Suffolk and Worcester |
| Severe Winter Storm (January 2005) | FEMA-3201-EM (PA) | All 14 Massachusetts counties. |
| Hurricane Katrina (August 2005) | FEMA- 3252-EM (PA) | All 14 Massachusetts counties. |

| | | |
|---|---|---|
| Severe Storms and Flooding (October 2005) | FEMA-1614-DR (IHP); FEMA -1614-DR-MA (HMGP) | Counties of Berkshire, Bristol, Franklin, Hampden, Hampshire, Middlesex, Norfolk, Plymouth and Worcester (HMGP funds were available to all 14 Massachusetts counties) |
| Severe Storms and Flooding (May 2006) | FEMA-1642- DR-MA (PA) | Essex and Middlesex Counties |
| | FEMA-1642-DR-MA (IHP) | Essex, Middlesex and Suffolk |
| | FEMA-1642-DR-MA (HMGP) | All 14 Massachusetts counties |
| Severe Storms and Flooding (April 2007) | FEMA-1701-DR-MA (PA); FEMA-1701-DR-MA (HGMP) | All 14 Massachusetts counties |
| Severe Winter Storm (December 2008) | FEMA-3296-EM-MA (Public) | Counties of Berkshire, Bristol, Essex, Franklin, Hampden, Hampshire, Middlesex, Suffolk and Worcester |
| Severe Storms and Flooding (December 2008) | FEMA-1813-DR-MA (PA); FEMA-1813-DR-MA (HMGP) | Counties of Berkshire, Essex, Franklin, Hampden, Hampshire, Middlesex, and Worcester. (HGMP funds were made available to all 14 counties. |
| Severe Storm and Flooding (March-April 2010) | FEMA-1895-DR-MA (PA); FEMA-1895-DR-MA (IHP) | Counties of Essex, Suffolk, Plymouth, Middlesex, Norfolk, and Worcester |
| Severe Storm and Snowstorm (January 2011) | FEMA-1959-DR-MA (PA); FEMA-1959-DR-MA (HGMP) | Counties of Berkshire, Essex, Hampden, Hampshire, Middlesex, Norfolk, and Suffolk. (HGMP funds were made available in all 14 Massachusetts counties) |
| Severe Storm/snowstorm (October 2011) | FEMA – 4051-DR-MA (PA); FEMA-4051-DR-MA (HMGP) | Counties of Berkshire, Franklin, Hampden, Hampshire, Middlesex, and Worcester. (HMGP funds are available in all 14 counties) |
| Severe Winter Storm, snowstorm and flooding (April 2013) | FEMA-4110-DR-MA | All 14 Massachusetts counties |
| Massachusetts Explosion (April 2013) | FEMA-3362-EM-MA | Boston Marathon Bombing |
| Severe Winter Storm, Snowstorm, and Flooding (January 2015) | FEMA-4214-DR-MA | Worcester, Essex, Middlesex, Norfolk, Plymouth, Bristol, Barnstable, Dukes, Nantucket, and Suffolk |
| Severe Winter Storm and Snowstorm (March 2018) | FEMA-4379-DR-MA | Worcester, Middlesex, Norfolk, Essex, and Suffolk |

Key:

PA-Public Assistance Project Grants: Supplemental disaster assistance to states, local governments, certain private non-profit organizations resulting from declared major disasters or emergencies.

HMGP – Hazard Mitigation Grant Program: Project grants to prevent future loss of life or property due to disaster. A presidential declaration of a major disaster or emergency is needed to designate HMGP assistance.

IHP – Individual Household Program: Formerly named IFG, this program provides grants and loans to individual disaster victims to address serious needs and necessary expenses, under the FEMA Disaster Housing, State IFG Program, and/or SBA Home and Business Loan Programs.

CDBG – Community Development Block Grant: Project grants for community development –type activities to assist with long- term recovery needs related to both residential and commercial buildings.

Source: FEMA

7.2 Potential Flood Damage as a Measure of Vulnerability

All jurisdictions within the region have hazard-prone areas. Clearly, the most common hazard is flooding. Estimates of the potential losses from flooding were calculated as one means of measuring the region's vulnerability. Methodologies to measure the geographic impact of flood events are well developed, and mitigation practices to reduce flood impacts are well understood.

Flood Hazard Identification

Flood hazard identification is the first phase of flood-hazard assessment. Identification is the process of estimating the geographic extent of the floodplain, the intensity of flooding that can be expected in specific locations, and the probability of occurrence of flood events.

The methodology employed in assessing the hazard presented by flooding involved mapping the 100-year flood plain in Chelmsford. Flood Insurance Rate Map (FIRM) data was obtained from FEMA showing the 100-year floodplain (Zones A, A1-30, and AE). Town-wide building information based upon 2011/2012 aerial photographs and updated through 2017 was then obtained by MassGIS. The structures were then overlain onto the 100-year floodplain map, and all buildings in the 100-year floodplain were identified. Given the level of accuracy of the 100-year flood plain data, it was decided that if any part of a building lie outside the 100-year flood plain, that structure would not be included in the calculation.

Beals and Thomas, Inc. estimated the value of buildings within the 100-year flood plain using assessed value data from the tax assessor records. Note that only the building value, and not the land value or total property value, was identified. After visually being checked for accuracy, assessors' parcels with buildings in the floodplain were selected and parcel files were merged with assessor's data from MassGIS. The building count will be far higher than the parcel count, due to the inclusion of condominiums. Buildings were grouped together by land use category: residential (all types), commercial, industrial and institutional.

The final output shows the total value of buildings within the 100-year flood plain for each community. Given the limitations of funding and methodology, there was no attempt made to estimate the probable amount of damage from the 100-year storm event. Hence, the value of each building is the upper limit of potential damage and would not be exceeded, except in an exceedingly rare catastrophic storm event far exceeding a 100-year storm. Table 34 below summarizes by community the value of properties located in the 100-year floodplain by land use code.

Table 34: Assessed Value of Buildings in the 100 Year Floodplain by Use Code

| Number of Structures | Residential | Commercial | Industrial | Governmental /Institutional | Total Value |
|----------------------|-------------|------------|------------|-----------------------------|-------------|
| 407 | 22,732,300 | 15,945,900 | 1,166,700 | 4,663,000 | 44,804,900 |

¹Includes 118 Condo units, the Williamsburg Condominium Complex

Source: Local assessor records, FIRM maps,

While the Table 34 above provides an estimate of the building values, the figures do not include the estimated cost of replacing building contents. According to HAZUS, the value of building contents depends on the type of building. The contents of residential buildings have a replacement cost of approximately 50% of the building value. Commercial building contents cost approximately 100% of the building value to replace and industrial building contents cost about 125%. For purposes of this analysis, the commercial rate was applied to governmental and institutional buildings. The estimated costs of contents replacement for structures located in the 100-year floodplain by community can be found in Table 36 below. As can be seen from the Tables 35 and 36, replacement costs for building contents total over \$33 million, while building value exceeds \$44 million. Therefore, the estimated value of property and contents located within the 100-year floodplain exceeds \$78 million for the Town of Chelmsford.

Table 35: Estimated Contents Replacement Cost for Buildings in the 100-Year Floodplain

| Residential Contents Value | Commercial Contents Value | Industrial Contents Value | Governmental/ Institutional Contents Value | Total Contents Value |
|----------------------------|---------------------------|---------------------------|--|----------------------|
| 11,366,150 | 15,945,900 | 1,458,375 | 4,663,000 | 33,433,425 |

Source: Local assessor records, FIRM maps, contents value calculations utilize HAZUS methodology.

It is important to note that loss of property does not reflect the entire cost of a region-wide flood event where there may be rescue and evacuation costs, infrastructure repair/replacement, cleanup costs, personnel costs, and economic costs related to business closures and damage. Utilizing GIS and stakeholder input, select critical infrastructure and vulnerable populations located within the 100-year flood plain were identified. This information is shown below in Table 36 below and displayed on the maps located in Appendix C and D. Specific geographic locations subject to flooding have been discussed in previous chapters of this document.

Table 36: Critical Infrastructure in the 100 -Year Floodplain

| Infrastructure/Structures Located in the 100-year Flood Plain |
|---|
| Water supply wells, water storage tank, drinking water pumping station, bridges, dams |

7.3 Vulnerability to Other Natural Hazards

The vulnerability to natural hazards for the overall region is the same from community to community for the following hazards: earthquake, tornado, winter storms (snowstorm, blizzard, ice storm), drought, landslide, and hurricane.

7.4 Vulnerability to Future Natural Hazards

Based on the identification and profile of the natural hazards that have occurred throughout the region over time, a vulnerability table has been developed. The matrix, adapted from the 2010 Massachusetts Hazard Mitigation Plan developed by MEMA, was used to categorize each hazard based on frequency, severity, extent of impact, and area of occurrence. Historical data was utilized, as well as the best available scientific assessments, published literature and input from subject area experts. The criteria were formulated based on the hazard identification profile and assessment performed for the region. The probability of drought was updated from the 2015 HMP Update to reflect data from the State Hazard Mitigation and Climate Adaptation Plan citing an 8% chance of a Watch-level drought occurring in any given month.

Table 37 lists the hazards to which Chelmsford is vulnerable, describes the expected frequency of occurrence, and the potential severity of the damage resulting from each individual hazard.

Table 37: Potential Vulnerability to Future Natural Hazards

| Hazard | Frequency | | | Severity | | | Extent of Impact | | | Probability Of Occurrence | | |
|----------------------------|-----------|--------|------|----------|--------|------|------------------|--------|------|---------------------------|--------|------|
| | Low | Medium | High | Low | Medium | High | Low | Medium | High | Low | Medium | High |
| Flood | | | X | | X | | | | X | | | X |
| Hurricane | X | | | | X | | | | X | | X | |
| Wildfire | | X | X | | | | | X | | | X | |
| Urban Fire | | X | X | | | | | X | | | X | |
| Earthquake | | X | X | | | | | | X | | | X |
| Tornado | X | | | X | | | | | X | X | | |
| Drought | X | | | | X | | | X | | | X | |
| Nor'easter | | | X | | X | | | | X | | | X |
| Snowstorm/Blizzard | | | X | | X | | | X | | | | X |
| Severe Thunderstorm | | X | | X | | | | X | | | X | |
| Landslide | X | | X | | | | X | | | | X | |
| Ice Storm | | X | | | X | | | | X | | | X |
| Ice Jam | X | | | X | | | X | | | X | | |

Hazards can be interrelated and the impacts of one hazard can create the occurrence of another. For example, an earthquake might trigger fires or landslides, and the impacts of climate change are known to increase the frequency and severity of storm events. Table 38 below graphically outlines the potential secondary effects of each natural hazard.

Table 38: Secondary Impacts from Primary Natural Hazards

| Primary Hazard | Secondary Impacts | | | | | | | | | | | | | |
|---------------------------|-------------------|----------------|------------------|--------------------|----------------------------------|---------|-----------------|---------|----------|-----------|-------------|---------|------|----------|
| | Structural damage | Utility outage | Chemical release | Commodity shortage | Emergency communications failure | Erosion | Structural fire | Disease | Flooding | Landslide | Dam failure | Tornado | Hail | Wildfire |
| Flood | X | X | X | | | X | | X | | X | X | | | |
| Dam Failure | X | X | X | | | X | | X | X | | | | | |
| Hurricane | X | X | X | X | X | X | | X | X | | | X | | |
| Tornado | X | X | X | | | | | | | | | | X | |
| Thunderstorm | | X | | | | | X | | | | X | X | X | |
| Nor'easter | X | X | | X | | X | X | | X | | | | | |
| Snowstorm/Blizzard | X | X | | X | | | X | | | | | | | |
| Ice Storm | X | X | X | X | X | | X | | | | | | | |
| Ice Jam | X | | | | | | | | X | | X | | | |
| Drought | | | | X | | | | | | | | | | X |
| Wildfire | X | | X | | | | X | | | | | | | |
| Earthquake | X | X | X | X | X | | X | | | X | X | | | |
| Landslides | X | | | | | X | | | | | | | | |

Source: Derived from the 2010 Massachusetts State Mitigation Plan, MEMA

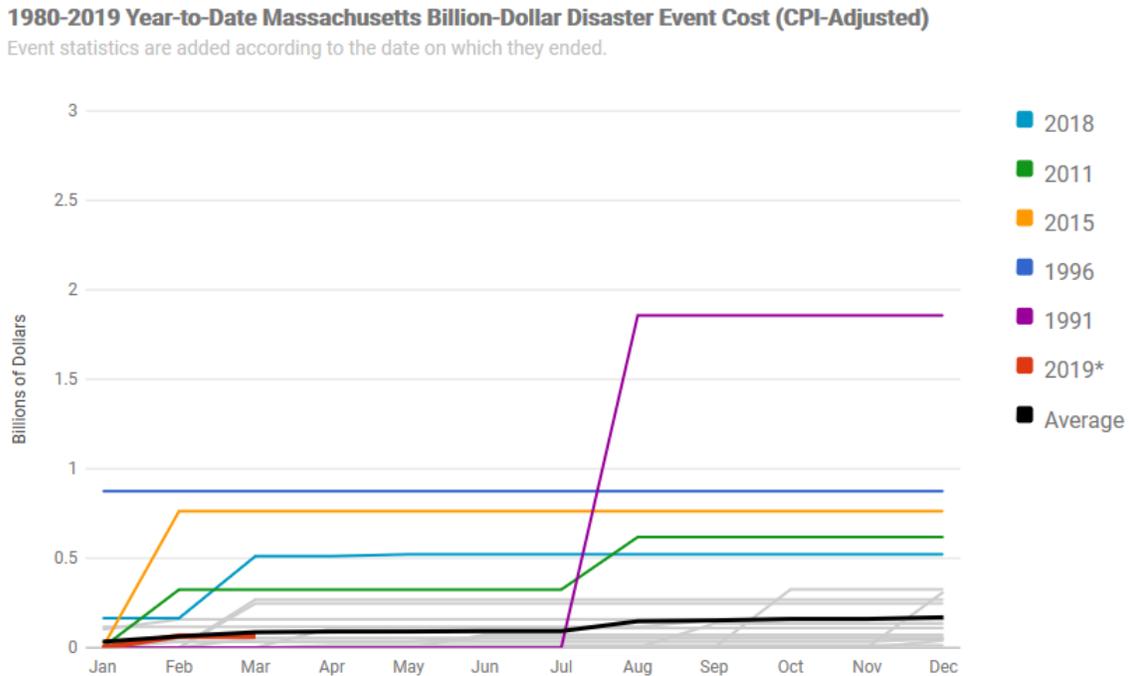
7.5 Impacts of New Growth on Vulnerability

The U.S. Census data shows that the town’s population increased over 5.09% between 2010 and 2017. Based on demographic projections summarized in Section 3.7, growth is expected to slow in coming decades. This suggests that there will be minimal changes in risk in the region overall. The losses that have been seen over the last several years have occurred in existing structures. New construction has not been significantly impacted given the regulatory requirements in place within the Northern Middlesex communities.

To provide a sense of the development activity in the town the Chelmsford has issued 11,360 building permits between January 2010 and June of 2019.

To better understand the monetary implications of natural disaster to properties, Table 39 below outlines the average residential property value for 2017. For each disaster event, damage and associated financial losses are assessed by state and local officials. The costliest disasters to strike the region since completion of the 2006 Plan were the 2007 flood, the ice storm of 2008, the October 2011 snowstorm, the 2015 blizzard, and the March 2018 Nor’easters.

Figure 2 :1980-2019 Year-to-Date Massachusetts Billion Dollar Disaster Event Cost (CPI-Adjusted)



Statistics valid as of April 9, 2019.
*Cost statistics not included for Midwest Flooding (March 2019)

Table 39: Average Residential Property Values, 2017

| Number of Housing Units, 2017 | Average Residential Property Value |
|-------------------------------|------------------------------------|
| 14,147 | \$368,500 |

Source: U.S. Census Bureau, American Community Survey

7.6 Natural Hazard Risk Assessment

A risk assessment was performed for Chelmsford, taking into consideration the historic occurrence of natural hazard events, and utilizing data available through the municipality, MEMA, and other sources. The vulnerability and risk assessment have been based on: the frequency of disasters, the potential extent of the impact from each hazard and the probability of the event occurring. The 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan was consulted for this analysis. Ratings were applied to each hazard based on frequency, severity, extent of impact, and probability as follows:

- Low – 1 point
- Medium – 2 points
- High – 3 points

The criteria for each category were weighted as follows:

- Frequency (weight factor = 2) is based on the record of previous occurrences.
 - Low: 0-1 event has occurred over the past 100 years
 - Medium: 2-3 events have occurred over the past 100 years
 - High: 4 or more events have occurred over the past 100 years
- Severity (weight factor = 5) is based on the percentage of population and property likely to be affected by the hazard under an average occurrence of the event.
 - Low: less than 1% affected
 - Medium: 1-10% affected
 - High: greater than 10% affected
- Extent of Impact (weight factor = 7) is the highest percentage of population and property that could be impacted under the worst-case scenario.
 - Low: less than 5% affected
 - Medium: 5-25% affected
 - High: greater than 25% affected
- Probability (weight factor = 7) is the likelihood of future occurrence within a specified time period.
 - Low: one incident likely within 75 to 100 years
 - Medium: one incident likely within 26 to 74 years
 - High: one incident likely within the next 25 years.

Using the methodology outlined above an assessment of hazard risk was performed based on frequency, severity, extent of impact and the probability of a future event. With the exception of flooding, urban fire and dam failure, all of the region's communities are equally at risk for the remaining hazards.

Tables 40: Hazard Risk Assessment

| Hazard | Frequency- (Weight factor=2) | Severity- (Weight factor=5) | Extent of Impact – (Weight factor=10) | Probability- (weight factor=7) | Total Score |
|-------------------------------------|------------------------------------|-----------------------------------|--|--------------------------------------|-------------|
| Flood | 3x2=6 | 2x5=10 | 3x10=30 | 3x7=21 | 67 |
| Wildfire | 3x2=6 | 1x5=5 | 3x10=30 | 3x7=21 | 62 |
| Urban Fire | 2x2=4 | 1x5=5 | 2x10=20 | 2x7=14 | 43 |
| Earthquake | 3x2=6 | 3x5=15 | 3x10=30 | 2x7=14 | 65 |
| Tornado | 1x2=2 | 2x5=10 | 3x10=30 | 1x7=7 | 49 |
| Dam Failure | 1x2=2 | 1x5=5 | 1x10=10 | 1x7=7 | 24 |
| Drought | 2x2=4 | 3x5=15 | 3x10=30 | 2x7=14 | 63 |
| Nor'easter/ Severe Storm | 3x2=6 | 3x5=15 | 3x10=30 | 3x7=21 | 72 |
| Hurricane | 3x3=9 | 3x5=15 | 3x10=30 | 3x7=21 | 75 |
| Snowstorm/ Blizzard | 3x2=6 | 3x5=15 | 3x10=30 | 3x7=21 | 72 |
| Landslide | 1x2=2 | 1x5=5 | 1x10=10 | 1x7=7 | 24 |
| Ice Storm | 3x2=6 | 3x5=15 | 3x10=30 | 3x7=21 | 72 |
| Ice Jam | 1x2=2 | 1x5=5 | 1x10=10 | 1x7=7 | 24 |

Based on this analysis, Chelmsford is at a high risk for flooding, drought, wildfire, earthquake, nor'easters, hurricanes, ice storms, snowstorms and blizzards. The town is at a moderate risk for urban fire and at low risk for ice jams, dam failure, and tornadoes.

8.0 ACTION PLAN AND STRATEGIES

The following categorizes mitigation actions that will serve to minimize risks or reduce losses from natural hazards. The actions have been organized into the following categories, as recommended in the FEMA Local Multi-Hazard Mitigation Planning Guide (7/1/08) and the Multi-Jurisdictional Mitigation Planning Guide, (August 2006):

- Prevention: Prevention actions are intended to address future development and guide development away from natural hazards. Many of the hazards that impact the region can be reduced by addressing them upfront through code enforcement and regulatory measures. Prevention activities include planning, zoning, building ordinances, subdivision regulations, and requirements to bury utilities;
- Property Protection: Property protection actions address individual buildings and reduce risk through modification. Activities include acquisition, building relocation, building elevation, retrofitting, barriers, flood-proofing, utility relocation or flood-proofing, and insurance;
- Public Education and Awareness: Public educations and awareness actions will inform and remind the public about natural hazards and actions that can be taken to avoid potential damage and injury resulting from a hazard. Activities include providing informational mailings or workshops, community outreach, real estate disclosure of hazards, environmental education, and technical assistance provided on disaster management issues;
- Natural Resource Protection: Natural resource protection reduces the intensity of hazard effects and improves the quality of the environment. Activities include preservation or restoration of natural systems, open space preservation, state and local floodplain and wetland regulations, stormwater management, watershed protection measures and best management practices, and soil erosion and sediment control;
- Structural Projects: Structural projects are actions that control the hazard and directly protect people and property. Such activities include construction and maintenance of berms, dams, floodwalls, channel improvements, drainage improvements, and detention/retention basins; and
- Emergency Services Protection: Emergency services protection actions are aimed at protecting emergency services before, during and immediately after an occurrence. Activities include hazard recognition, emergency warning systems, emergency response training, evacuation planning, protection of critical facilities, protection of public facilities, and health and safety maintenance.

These actions will be coordinated with other regional and community priorities, as well as with mitigation goals of state and federal agencies. Such coordination will improve access to technical assistance; provide broader support for implementation; and reduce duplication of effort. The actions have been further categorized by timeframe into on-going, immediate, short-term projects and long-term measures.

8.1 Mitigation Goals

In updating the Action Plan, the regional Multiple Hazard Community Planning Team (MHCPT) reviewed the hazard identification and analysis, the regional vulnerability assessment, and the existing protection matrix and measures. The goals in the 2006 Plan were reviewed and affirmed. In addition, a new goal was added to address the impacts of climate change. The following goals were considered in the development of the Action Plan Update:

- Increase coordination between the Federal, State, regional and local levels of government;
- Discourage future development in hazard prone areas, such as flood plains;
- Protect and preserve irreplaceable cultural and historic resources located in hazard prone areas;
- Ensure that critical infrastructure is protected from natural hazards;
- Develop programs and measures that protect residences and other structures from natural hazards;
- Protect electric power delivery infrastructure from natural hazards;
- Provide alternative drinking water supplies for local communities in the event of contamination or disruption from a natural hazard;
- Increase awareness and support for natural hazard mitigation among municipalities, private organizations, businesses, and area residents through outreach and education;
- Implement a broad range of mitigation measures that protect the region's vulnerable population and infrastructure;
- Protect critical public facilities and services from damage due to natural hazards;
- Develop a mitigation strategy that considers area businesses and protects the economic vitality of the region;

- Update and maintain the Plan as resources permit;
- Increase the number of communities participating in the Community Rating System;
- Provide communities with information concerning hazard mitigation funding opportunities, and assist the communities in the identification and development of specific mitigation projects;
- Increase each community’s capacity for responding to a natural hazard event by promoting the adequate provision of emergency service capabilities; and
- Implement adaptation strategies and modify local emergency plans to protect critical infrastructure and property from the impacts of climate change.

8.2 Mitigation Progress Since 2015

Since completion of the last Plan, Chelmsford made significant progress in implementing additional measures to mitigate natural hazards. The following table lists measures that have been implemented since 2015.

In addition, the Town of Chelmsford has taken steps to implement findings from the 2015 Hazard Mitigation Plan into the following policy, programmatic areas, and plans: the 2020-2040 Northern Middlesex Regional Transportation Plan and the region’s Comprehensive Economic Development Strategy, efforts in stormwater management such as completion of reports on the maintenance of drainage and stormwater structures, DPW capital planning, and ongoing safety and emergency management efforts such as the Town shelter plan.

Table 41: Mitigation Progress

| 2015 Priorities | Current Status | 2020 Actions | 2015 Priority/ Timeframe | 2020 Priority/ Timeframe |
|--|---|---|-----------------------------|----------------------------------|
| Elevate, flood- proof and maintain the alternate access roadway for the Williamsburg Condominium complex and stabilize riverbank. | There has been no progress made on this priority except that part of the riverbank was stabilized through the Merrimack Riverbank Stabilization Project. | Hire a consultant to prepare an alternative access study for the Williamsburg condominium complexes | Short-term | High, Short Term |
| Work with DCR Office of Dam Safety to ensure that the inspections of all dams are current. | There is only one dam under jurisdiction under DCR: Freeman Lake. DCR inspects per updated Emergency Action Plan. | Assess local bridges, culverts, and dams | Short-term | Complete |
| Address flooding and bank erosion in the vicinity of Williamsburg Condos and along Tyngsborough Road in North Chelmsford. | Merrimack Riverbank Stabilization Project has been complete. | Conduct Merrimack Riverbank stabilization project at Williamsburg | Short-term | Complete |
| Address the Meadowbrook Road culvert and associated flooding. | Repaired canal crossing as it was structurally deficient. | Assess local bridges, culverts, and dams | Short-term | Complete |
| Install emergency vehicle pre-emption at signalized intersections. | Completed 100% of intersections. | | Long-term | Complete |
| Install a generator at the new fire station. | Complete, date of install was with new Fire Station. | Create an inventory of facilities with generators and a prioritized list of facilities that require generators or have undersized generators | Short-term | Complete |
| Strengthen enforcement of the town's floodplain zoning bylaw. | Increased encouragement for groundwater recharge where an increase in impervious area is being proposed within the Aquifer Protection Zone II. | Planning Board, Conservation Commission and Building inspector. Since the completion of the 2006 Plan, the town has improved its process for enforcement of the floodplain bylaw. | Annual | Moderate, Short/Long Term |
| Increase enforcement of impervious surface limitations within the Aquifer Protection District. | (Same as above) Increased encouragement for groundwater recharge where an increase in impervious area is being proposed within the Aquifer Protection Zone II (same as above). | Action is ongoing as projects move through the Engineering and Community Development Divisions. | Short-term | Moderate, Short/Long Term |
| Propose a Low Impact Development bylaw for consideration of local officials and town meeting | Applied for grant through MVP that included LID as part of a stormwater bylaw operation | Establish LID bylaw incorporating or requiring strategies such as green roofs, porous pavement, cistern irrigation, and drought-tolerant plants | Short-term | Moderate, Short/Long Term |
| Update the response plan for the Freeman Lake and Heart Pond dams. | Hart Pond is declassified but has an O&M plan. Boat ramp is still being considered. | Construct a boat ramp at Hart Pond for emergency response and evacuation | Annual | High, Long Term |
| Perform maintenance on drainage/ stormwater structures. | Weston and Sampson is completing report, working on ongoing projects and compilation of 5, 10, 20 year capital plan. | Assess local bridges, culverts, and dams; Coordinate with state regarding maintenance of state-owned drainage infrastructure | Annual | High, Short Term |
| Conduct outreach program to encourage the purchase of flood insurance by private property owners. | Community Development Department provided guidance and education to property owners in 2014 when FEMA FIRMs became available. Further outreach will be conducted when they are updated again. | Outreach planned for new map updates. | Short-term | Moderate, Long-Term |
| Conduct a study to examine measures to mitigate flooding along Tyngsborough Road. | Merrimack Riverbank Stabilization Project has been complete and it is anticipated that this project would mitigate areas of concern in that area. | Coordinate with state regarding maintenance of state-owned drainage infrastructure | Short-term | Moderate, Long-Term |
| Improve dam maintenance at the School Street Dam on Stony Brook where stones have been dislodged. | Dam Owner at the behest of the town. | Assess local bridges, culverts, and dams | Short-term | High, Short Term |
| Continue to work with NMCOG in studying the establishment of a Regional Emergency Communications Center . | NMCOG has developed a regional emergency communications center but the Town has opted not to participate at this time via town meeting. | | Short-term | Complete |
| Increase public awareness of the dangers of extreme | Info is posted on web page, code reds are | Hire a Town social worker and enhance volunteer-based | Short-term | Complete |

| | | | | |
|--|---|---|------------|--|
| temperatures and outline locations where vulnerable populations (elderly, homeless and those with health issues) can have access to air conditioning or shelter from the cold | sent out with warming, cooling and regional shelters, and communication via the Senior Center from the Town Emergency Manager. | programs for vulnerable populations (Complete) Maintain and create new heating/cooling shelters | | |
| Establish an emergency shelter to care for pets during a natural disaster. | In the Town Shelter Plan, the Senior Center garage and the animal control area near PD is going to be used and all the material is purchased. | Establish pet-friendly emergency shelters | Short-term | Complete |
| Revise Planning Board, Conservation Commission, and Board of Health regulations to improve floodplain management | No current action. Current management in place. | Current management is sufficient and is guided by the Town Bylaw adopted in the early 80s | Short-term | Complete |
| Study the Community Rating System to determine appropriateness for Chelmsford | Review of criteria completed and presented to Town. | Coordination with Town departments to determine staffing and budget implications and feasibility for adoption under current financial conditions | Short-term | Short-term |
| Enhance the knowledge of local officials, builders, developers, citizens and other stakeholders on how to read and interpret the FIRM. | Regulatory implications of floodplain are discussed in public meetings upon submission of development projects to Planning Board or Conservation Commission | Information captured in town GIS system and utilized regularly. Post FIRM tutorials produced by FEMA on various municipal webpages: https://www.fema.gov/flood-maps/tutorials#gis | Short-term | Short-term |
| Distribute educational information to residents and businesses on protecting life and property from severe winter storm events | Emergency Manager completes annual report, and updates the town website annually. | | Complete | |
| Ensure that administrators of schools, businesses, medical facilities, and mobile home park have a shelter plan in the event of a hurricane or tornado warning | Town shelter plan written to establish shelters in several municipal buildings- confidential but shared internally. Communicated through code red and pre warning system. Also, there are pre emergency meetings. | | Complete | |
| Inspect public buildings to evaluate the capacity to withstand snow loads and prevent roof collapse. Develop plans to clear roofs of excessive snow accumulations to prevent collapse. | The DPW Director has calculations and plan in place with a structural engineer who completed an assessment based on roof construction. | | Complete | |
| Identify locations for snow storage farms for utilization in severe winters with heavy snowfall | Three areas have been identified: Mill Road soccer fields and parking lot, salt shed at Swaine Road and the little league parking lot on Chelmsford Street. | | Complete | |
| Evaluate public buildings and critical facilities for the potential to withstand high winds | Building Inspector and DPW Director will have to address this in the future. | As projects arise, these issues are addressed through work with structural engineering and re-engineering for retrofits. | Long-term | Ongoing evaluations as projects arise |
| Assess bridges and roadways to ascertain their capability to support fire apparatus and develop alternative routing plans where deficiencies are noted | Town owed bridges undergo yearly assessments from DOT and there are posted weight limits. Fire Department proceeds with route planning given this information as they are able to reroute apparatus as needed. | | Complete | |
| Develop an inventory of public buildings that do not currently meet seismic standards | Building Inspector and DPW Director will have to address this in the future. | As projects arise, these issues are addressed through work with structural engineering and re-engineering for retrofits to bring buildings up to new standards. | Long-term | Ongoing evaluations as projects arise |
| Provide information to homeowners on how to protect their property from brush fire or wildfire during times of drought | Fire Department post burning and no burning days and provides information via burn permit and Facebook and the Town Website. More information could be provided for preventative planning. Online software for burn permits now available | Ongoing outreach and education as needed and as situations arise. Monitoring and enforcement activities in place and ongoing by Fire Prevention personnel and Police Department bike patrol. | Long-term | Ongoing evaluations as opportunities arise |

8.3 The Action Plan

The Action Plan outlines action items for Chelmsford in Table 42 on the following page. The priorities were established through a consensus-building process that consisted of workshops with various boards, districts, and departments as outlined in Section 1.3 as well as extensive research into ideas presented by the Hazard Mitigation Plan for the Region and inclusion of hazards presented by climate change. The following factors were considered in establishing the timeframe/priority for each action:

- The cost of the measure vs. the mitigation benefits;
- The availability of funding;
- The lead time required for design and implementation;
- Political feasibility and acceptability;
- The need for institutional and interagency agreements;
- Consistency with local and regional plans and priorities; and
- Whether the measure has been through a public process, needs Town Meeting action, or action by a permitting agency.

The Core Team conducted a Benefit-Cost Review of the actions identified by stakeholders based on the principles outlined in Using Benefit-Cost Review in Mitigation Planning prepared by FEMA. The Core Team utilized Method A: Simple Listing Technique. Priorities were expressed through timeframe designations in accordance with the CRB process. Projects that are defined as “ongoing” are currently underway, and will be addressed continuously over the plan’s effective period. Costs were generally estimated based on Core Team knowledge of similar project prices in the following categories:

- Very high (over \$1 million)
- High (\$500,000 - \$1 million)
- Medium (\$100,000 - \$500,000)
- Low (\$50,000 - \$100,000)
- Very low (under \$50,000)

8.4 High Priority Actions

Table 42a: High Priority Action Plan

| Action Description | Lead Department | Priority Level | Cost | Possible Funding Sources | Hazards Being Addressed | Implementation Schedule |
|--|---|----------------|-----------|--|---|-------------------------|
| Infrastructural | | | | | | |
| Improve communication regarding hazards, such as enrollment of vulnerable populations in the Reverse 911 program | Police Department, Fire Department | High | Low | MVP Action Grant | All | Ongoing |
| Create landscaping and maintain trees along roadways | Department of Public Works | High | Low | MVP Action Grant | Severe Storms, Flooding, Pollution | Ongoing |
| Continue existing Hardy Tree Program | Department of Public Works | High | Medium | Town of Chelmsford | Severe Storm | Ongoing |
| Hire a consultant to prepare an alternative access study for the Williamsburg condominium complexes | Community Development, with support from Williamsburg Condominium Associations | High | Very low | Town of Chelmsford | Severe Storm, Flooding | 7/1/2020 - 6/30/2024 |
| Conduct Merrimack Riverbank stabilization project at Williamsburg | Department of Public Works, with support from Army Corps of Engineers | High | Very high | FEMA Hazard Mitigation Grant Program | Severe Storm, Flooding | Complete |
| Establish dedicated funding for invasive species removal and public education | Conservation Commission | High | Medium | MVP Action Grant | Wind, Extreme Temperatures | Ongoing |
| Create an inventory of facilities with generators and a prioritized list of facilities that require generators or have undersized generators | Department of Public Works | High | Low | Town of Chelmsford | All | Ongoing |
| Install generator at Adams Library | Department of Public Works, Adams Library | High | Medium | Town of Chelmsford | All | 7/1/2022 - 6/30/2025 |
| Assess local bridges, culverts, and dams | Department of Public Works | High | Medium | MVP Action Grant | Flooding | Ongoing |
| Implement roadside low-impact development in an effort to mitigate flash flooding | Department of Public Works | High | Medium | MVP Action Grant | Flooding | Ongoing |
| Societal | | | | | | |
| Maintain voluntary database for tracking elderly community in case of emergency situations | Senior Center/Council on Aging, with support from Police Department and Fire Department | High | Very low | Town of Chelmsford | All | Ongoing |
| Streamline communication during extreme storm events | Emergency Management, with support from Police Department and Fire Department | High | Low | Town of Chelmsford | All | Ongoing |
| Enhance volunteer-based programs for vulnerable populations | Town Manager | High | Medium | Town of Chelmsford | All | Ongoing |
| Maintain and create new heating/cooling shelters | Emergency Management | High | High | Emergency Management Performance Grant | All | Ongoing |
| Create an inventory of facilities with generators and a prioritized list of facilities that require generators or have undersized generators | Department of Public Works | High | Low | Town of Chelmsford | Severe Storms, Flooding, Wind, Extreme Temperatures | Ongoing |
| Establish Twitter or other social media accounts with Town official support and dedicated management | Town Manager | High | Very Low | Town of Chelmsford | All | Complete |
| Environmental | | | | | | |
| Hire a consultant to review existing local regulations and create a new comprehensive Stormwater Management Bylaw | Community Development | High | Medium | MVP Action Grant | All | 7/1/2020 - 6/30/2024 |
| Construct a boat ramp at Hart Pond for emergency response and evacuation | Police Department, Fire Department, with support from Conservation Commission | High | High | Town of Chelmsford | Extreme Temperature, Pollution | 7/1/2022 - 6/30/2025 |

8.5 Moderate Priority Actions

Table 42b: Moderate Priority Action Plan

| Action Description | Lead Department | Priority Level | Cost | Possible Funding Sources | Hazards Being Addressed | Implementation Schedule |
|---|--|----------------|-----------|--|---|-------------------------|
| Infrastructural | | | | | | |
| Conduct stream and waterway maintenance | Conservation Commission | Moderate | High | Local Acquisitions for Natural Diversity Grant Program | Severe Storm, Flooding, Pollution | Ongoing |
| Evaluate existing culverts in the Farms Neighborhood in particular | Department of Public Works | Moderate | Low | MVP Action Grant | Severe Storms, Flooding, Pollution | Ongoing |
| Improve access and use of public transportation | Department of Public Works, with support from MBTA | Moderate | High | TBD | Severe Storms, Flooding, Pollution | Ongoing |
| Inspect existing stormwater infrastructure | Department of Public Works | Moderate | Medium | Town of Chelmsford | Flooding | Ongoing |
| Install additional electric vehicle charging stations | Department of Public Works | Moderate | Medium | Town of Chelmsford | Severe Storms, Flooding, Pollution | Ongoing |
| Hire a Consultant to create an Evacuation Routes Plan and associated planning study | Emergency Management | Moderate | Medium | Emergency Management Performance Grant | Severe Storms, Flooding, Pollution | 7/1/2022 -6/30/2025 |
| Increase Emergency Shelters | Emergency Management | Moderate | High | Emergency Management Performance Grant | Severe Storms, Flooding, Wind, Extreme Temperatures | Ongoing |
| Repair gas leaks and understand major users | Utility Companies | Moderate | Very High | TBD | Flooding, Extreme Temperature | Ongoing |
| Facilitate coordination between Williamsburg condominium associations for emergency flood management | Emergency Management, Police Department, Fire Department | Moderate | Low | Town of Chelmsford | Extreme Storms, Flooding | Ongoing |
| Secure additional funding for existing Hardy Tree Program | Department of Public Works | Moderate | Low | Town of Chelmsford | Wind, Extreme Temperatures | Ongoing |
| Construct additional landscaped islands in areas such as Center Village and Vinal Square | Department of Public Works | Moderate | Medium | MVP Action Grant | Wind, Extreme Temperatures | Ongoing |
| Conduct flood mitigation response training | Police Department, Fire Department | Moderate | Medium | Emergency Management Performance Grant | All | Ongoing |
| Incorporate LID/low water use appliances | Department of Public Works | Moderate | Medium | Town of Chelmsford | All | 7/1/2020 - 6/30/2024 |
| Establish LID bylaw incorporating or requiring strategies such as green roofs, porous pavement, cistern irrigation, and drought-tolerant plants | Community Development | Moderate | Medium | MVP Action Grant | Extreme Temperatures | 7/1/2020 - 6/30/2024 |
| Maintain emergency action plans for medical facilities | Emergency Management, Board of Health | Moderate | Low | Emergency Management Performance Grant | All | Ongoing |
| Install back-up power at pump stations | Department of Public Works | Moderate | High | TBD | All | Ongoing |
| Societal | | | | | | |
| Maintain first responder action plan | Police Department, Fire Department, Emergency Management | Moderate | Low | Town of Chelmsford | All | Ongoing |
| Communicate with public regarding expectations for pets in emergencies | Emergency Management | Moderate | Low | Town of Chelmsford | All | Ongoing |
| Purchase camera, repeaters, towers, etc. in support of the town microwave project | Department of Public Works | Moderate | Very High | TBD | All | Ongoing |
| Streamline communication during extreme events | Police Department, Fire Department, Emergency Management | Moderate | Low | Town of Chelmsford | All | Ongoing |

| | | | | | | |
|--|--|----------|----------|--|---|----------------------|
| Utilize existing message boards throughout Town to spread information | Department of Public Works, Emergency Management | Moderate | Very Low | Town of Chelmsford | All | Ongoing |
| Purchase additional sign boards for posting during emergencies | Department of Public Works Emergency Management | Moderate | Medium | Emergency Management Performance Grant | All | Complete |
| Improved abutter education regarding stormwater management (e.g. lawn fertilizer, pet waste) | Conservation Commission | Moderate | Low | MVP Action Grant | Flooding, Extreme Temperatures | Ongoing |
| Improve Board of Health reporting and public education | Board of Health | Moderate | Low | Town of Chelmsford | Flooding, Extreme Temperatures | Ongoing |
| Conduct chemical application for invasive species management | Conservation Commission | Moderate | High | Town of Chelmsford | Flooding, Extreme Temperatures | 7/1/2022 - 6/30/2025 |
| Install water aerator at Town beaches | Conservation Commission | Moderate | Medium | Town of Chelmsford | Flooding, Extreme Temperatures | 7/1/2022 - 6/30/2025 |
| Environmental | | | | | | |
| Incorporate hazard mitigation into design criteria of local regulations | Community Development | Moderate | Medium | MVP Action Grant | All | 7/1/2020 - 6/30/2024 |
| Utilize dogs or swans to harass and deter geese from Freeman Lake | Conservation Commission | Moderate | Low | Town of Chelmsford | Extreme Temperature, Pollution | Ongoing |
| Establish an awareness/education program related to dog licenses regarding pests | Board of Health, Town Clerk | Moderate | Low | Town of Chelmsford | Severe Storms, Flooding, Extreme Temperature | Ongoing |
| Develop a stormwater management bylaw that requires post-construction monitoring and maintenance agreements for private property | Community Development | Moderate | Medium | MVP Action Grant | All | 7/1/2020 - 6/30/2024 |
| Coordinate with state regarding maintenance of state-owned drainage infrastructure | Department of Public Works, MassDOT | Moderate | Very Low | TBD | All | Ongoing |
| Support open space stewardship | Conservation Commission | Moderate | Low | Conservation Partnership Grant Program | Severe Storms, Flooding, Wind, Extreme Temperatures | Ongoing |
| Coordinate with state regarding maintenance of brush along state highways | Department of Public Works, MassDOT | Moderate | Very Low | TBD | Severe Storms, Flooding, Wind, Extreme Temperatures | Ongoing |
| Improve forest management operations | Conservation Commission | Moderate | Medium | Habitat Management Grant Program | Severe Storms, Flooding, Wind, Extreme Temperatures | Ongoing |
| Conserve existing open space | Conservation Commission | Moderate | Low | Massachusetts Land and Water Conservation Fund Grant Program | Severe Storms, Flooding, Wind, Extreme Temperatures | Ongoing |
| Improve public awareness and education regarding shifting habitat | Conservation Commission | Moderate | Low | Habitat Management Grant Program | Severe Storms, Flooding, Wind, Extreme Temperatures | 7/1/2022 - 6/30/2025 |
| Establish Smart Growth bylaw to reduce suburban sprawl | Community Development | Moderate | Medium | MVP Action Grant | Severe Storms, Flooding, Wind, Extreme Temperatures | 7/1/2022 - 6/30/2025 |
| Develop an invasive species mitigation program | Conservation Commission | Moderate | Medium | MVP Action Grant | Severe Storms, Flooding, Wind, Extreme Temperatures | Ongoing |
| Increase public awareness of existing brush disposal programs | Department of Public Works | Moderate | Very Low | Town of Chelmsford | Severe Storms, Wind | Ongoing |

8.6 Lower Priority Actions

Table 42c: Lower Priority Action Plan

| Action Description | Lead Department | Priority Level | Cost | Possible Funding Sources | Hazards Being Addressed | Implementation Schedule |
|--|--|----------------|-----------|--|---|-------------------------|
| Infrastructural | | | | | | |
| Move utilities underground | Department of Public Works, Utility Companies | Lower | Very high | TBD | Severe Storms, Flooding, Wind, Extreme Temperatures | 7/1/2025 - 6/30/2050 |
| Facilitate the creation of additional walk-in clinics | Board of Health | Lower | High | Town of Chelmsford | All | Ongoing |
| Improve education and signage related to evacuation routes | Emergency Management | Lower | Low | Emergency Management Performance Grant | All | 7/1/2022 - 6/30/2025 |
| Societal | | | | | | |
| Establish staffing for 24-hour emergency shelter | Emergency Management | Lower | High | Emergency Management Performance Grant | All | Ongoing |
| Establish pet-friendly emergency shelters | Emergency Management | Lower | Medium | Emergency Management Performance Grant | All | Complete |
| Improve geese management | Conservation Commission | Lower | Low | Town of Chelmsford | Extreme Temperatures, Flooding | Ongoing |
| Provide multiple language options for communication during emergency response situations | Emergency Management, Police Department, Fire Department | Lower | Low | Emergency Management Performance Grant | All | Ongoing |
| Increase frequency of religious leader meetings and create educational programming | Town Manager | Lower | Very Low | TBD | All | Ongoing |
| Encourage use of generators for private development | Community Development | Lower | Low | Town of Chelmsford | Severe Storm, Wind | 7/1/2022 - 6/30/2025 |
| Environmental | | | | | | |
| Develop management plans for individual wildlife habitat areas | Conservation Commission | Lower | Medium | Habitat Management Grant Program | Severe Storms, Flooding, Wind, Extreme Temperatures | 7/1/2022 - 6/30/2025 |
| Support composting to reduce landfill use | Department of Public Works | Lower | Low | Town of Chelmsford | Severe Storms, Wind | Ongoing |
| Establish municipal brush disposal facility | Department of Public Works | Lower | Medium | Town of Chelmsford | Severe Storms, Wind | 7/1/2025 - 6/30/2050 |
| Improve access to and maintenance of Town-owned open space | Conservation Commission | Lower | Medium | Massachusetts Land and Water Conservation Fund Grant Program | Extreme Temperatures, Severe Storms | Ongoing |
| Create a tree clearing bylaw to prevent new or greater heat islands | Community Development | Lower | Medium | MVP Action Grant | Extreme Temperatures, Severe Storms | 7/1/2020 - 6/30/2024 |

9.0 PLAN ADOPTION AND MAINTENANCE

Under 44 CFR Part 201 mitigation plans must be sent to the State Hazard Mitigation Officer (SHMO) for initial review and coordination. The State then forwards the plan to FEMA for formal review and approval. The final draft is submitted to the State and FEMA prior to seeking formal adoption of the plan by the local community. FEMA reviewers document their evaluation of the Plan using the Plan Review criteria.

Mitigation plans are approved when they receive a “satisfactory” for all requirements outlined under 44 CFR Section 201.6. Once a final plan is submitted, the FEMA Regional Office generally completes the review within 45 days. In the event that the plan is not approved, the FEMA Regional Office will provide comments on the areas that need improvement. FEMA will then complete review of the re-submittal within 45 days of receipt.

Once FEMA determines that the Plan is “approvable pending adoption”, the local adoption process is initiated. The adoption of the Hazard Mitigation Plan update provides continued written guidance for all local governments within the region, and signifies that the plan’s recommendations have been considered and approved in accordance with state and federal requirements. A draft Certificate of Adoption is provided in Appendix F for completion by the Board of Selectmen upon approval from FEMA and MEMA.

The Disaster Mitigation Act of 2000 stipulates that regions and municipalities must not only develop a Regional Mitigation Plan, but also take steps to ensure that the plan is implemented, maintained and updated as needed. The following steps will be taken to maintain the plan in each community, assuming that funding is provided:

- Chelmsford will monitor this plan by a combination of an annual meeting with the local team and by responsible department staff following up on specific projects. This will be coordinated with the annual update required by Chelmsford’s designation as an MVP-certified community. An annual review of the plan by the hazard mitigation team will be conducted at one of the monthly interdepartmental meetings. At that time, the hazard mitigation team will review the hazard mitigation measures that have been implemented to date and determine if these measures have impacted the overall hazard. This review may include site visits to appropriate locations where measures have been implemented. Mitigation measures that have not been implemented will be reviewed to determine if they will still minimize natural hazards or if they are no longer a viable option. Additionally, the hazard mitigation team will determine if there are new options that should be included in an update of the plan. The Emergency Manager will be responsible for overseeing and coordinating the update process, if needed.

- The public will have opportunities to submit feedback and solicit comments from the municipality regarding the Plan and mitigation projects. Residents and businesses will be notified when hazard mitigation issues are brought to the Board of Selectmen. Notification by each municipality will occur through the Lowell Sun, the local newspapers, the municipal website, the City Clerk or Town Clerk bulletin board, and local cable television community bulletin boards, and social media feeds, such as Facebook and Twitter.
- As a facilitator, NMCOG will meet with members of the regional Multiple Hazard Community Planning Team, local emergency managers, city/town planners, public works departments, city/town engineers, Conservation Commissions and Chief Administrative Officers on an annual basis to discuss each community's progress in implementing the local and regional mitigation plans;
- Should the Town or region experience a significant disaster, the Hazard Mitigation Plan will be updated and revised to reflect the technical information gleaned from the event and to outline the mitigation needs that have stemmed from the disaster. Appropriate mitigation strategies will then be added to an amended Plan document; In addition, should Federal or State regulations and requirements change, the plan will be updated accordingly. In order for communities to qualify for mitigation funding, it is necessary that the Regional and local plans be amended to incorporate new mitigation projects as they are identified by the local communities;
- The ongoing monitoring and updates of this Plan will include public participation utilizing the media, the community bulletin board on the local cable channels, the municipal website, and the NMCOG website to facilitate the public's involvement;
- Evaluation of the hazard mitigation plan in its entirety will be done on a 5-year basis in accordance with the Disaster Mitigation Act of 2000 or any significant natural hazard disaster. Any new problems that arise will be reviewed by the hazard mitigation team and incorporated into the hazard mitigation plan. The evaluation will include a review of the goals and objectives and a determination will be as to whether each still addresses current and expected conditions. Local fiscal issues, administrative challenges or major regulation changes will be discussed during the evaluation process. The plan will be updated with possible new mitigation measures and plans of action as determined from the review. This allows for updates to be made as each municipality or the region grows and changes. Within the municipalities, the Emergency Managers will oversee the hazard mitigation team's involvement in the review and updating process; and

- The Town of Chelmsford intends to update this plan five years from the date of approval, as resources allow. The next update will be completed in 2025. The update will focus on the successes and failures of the current plan as documented through surveys, meetings and reports from the local communities. Any new information, such as new or changing hazard conditions or vulnerability assessments, will be incorporated into the update. The Plan revision will follow the same planning and outreach process that was utilized to develop this plan.

The latest guidance available from FEMA and MEMA will be consulted to ensure that the process meets all state and federal requirements. Members of the community will be invited to provide input into the plan revisions and stakeholders will be kept apprised of the revision process. Residents and businesses will be notified when hazard mitigation issues are brought to the Board of Selectmen. Such public involvement opportunities will be noticed in the Lowell Sun and posted in the Town Clerk office. All public meetings will conform with the Massachusetts Open Meeting Law. The official update process will commence 18 months prior to this plan's expiration date.

10.0 PLAN IMPLEMENTATION

The implementation of the Hazard Mitigation Plan will take place at the State, Regional and local levels of government. Local governments play a pivotal role in hazard mitigation, particularly in floodplain management. The municipal Planning Board, Conservation Commission, and Board of Health have legal responsibilities to implement local floodplain bylaws, floodplain guidelines incorporated into the Wetlands Protection Act, the Rivers Protection Act and Title 5 of the State Environmental Code (wastewater disposal). The Building Department enforces the National Flood Insurance Program (NFIP) construction standards incorporated into the Massachusetts State Building Code. Local public works and highway departments are responsible for local roadways, and municipal drainage, sewer and stormwater management systems. Each municipality has an emergency manager who is responsible for local preparedness, mitigation response and recovery for natural and manmade hazards. Table 43 below provides a summary of local boards and departments and their corresponding roles in implementing the action items contained in the Regional and Local Mitigation Plans.

The incorporation of the hazard mitigation actions outlined in this plan update within other local and regional planning documents and procedures is highly encouraged. Such documents include community master plans, capital improvement plans, Open Space and Recreation Plans, stormwater plans and regulations, emergency management plans, zoning bylaws, subdivision regulations, and local wetland bylaws and ordinances. Elected officials should be directly involved in the implementation of the updated Plan, as they set policy and can provide direction in establishing timeframes, assigning implementation responsibility, and providing implementation funding.

Table 43: Role of Local Boards, Departments and Committees in Plan Implementation

| Department, Board or Committee | Function | Effect on Loss Reduction |
|--|--|--|
| Building Department/Inspector | The building inspector enforces the Massachusetts State Building Code that incorporates NFIP construction standards. The building inspector also enforces locally adopted bylaws. The state building code also contains sections on wind, snow, structural loads and seismic retrofitting. | Insures that NFIP standards and other mitigation standards are uniformly applied throughout the region |
| Public Works Department and/or City/Town Engineer | The Public Works Department and/or engineer are primarily responsible for municipal drainage and stormwater management issues, taking the lead in insuring compliance with EPA Phase II Stormwater Regulations. | Ongoing maintenance and upgrading of local stormwater systems is crucial to reducing and managing flood risks. |

| | | |
|--|---|--|
| Conservation Commission | <p>The Conservation Commission is responsible for implementing the Rivers Protection Act of 1996 (MGL Chapter 258, 310 CMR 10.58), and the Wetlands Protection Act (MGL Chapter 131, Section 40, 310 CMR 10.00). The Conservation Commission reviews, approves or denies applications for projects in the 100-year floodplain, in the floodplain of a small water body not covered by a FEMA study, within 100 feet of any wetland or 200 feet of any river or stream</p> | <p>These regulations contain performance standards which address flood control and storm damage prevention.</p> |
| Planning Board and Community Development Department | <p>The Planning Board has authority under MGL Chapter 41, and implements local subdivision regulations. The Planning Board ensures that new development incorporates state and federal stormwater management “best management practices”. The Planning Board is responsible for maintaining local floodplain bylaws and ordinances.</p> | <p>The Community Development Department coordinates the hazard mitigation planning process and the implementation of hazard mitigation plans.</p> |
| Board of Health | <p>The Board of Health implements the State Environmental Code, Title 5, and 310 CMR 15: Minimum Requirements for the Subsurface Disposal of Sanitary Sewage.</p> | <p>Title 5 protects public health and mitigates losses due to adverse effects of improper sewage treatment in high hazard areas. The Board is also involved in issues related to water quality and infectious diseases following a disaster.</p> |
| Board of Selectmen | <p>The Town of Chelmsford is governed by a Board of Selectmen.</p> | <p>The Board of Selectmen must adopt the Hazard Mitigation Plan Update. In addition, their approval is necessary for hazard mitigation grant applications and potential projects.</p> |
| Emergency Management Department | <p>The emergency manager is responsible for local response and recovery, as well as mutual aid.</p> | <p>Emergency managers play a primary role in the development of the Comprehensive Emergency Management Plan (CEMP), as well as in other plans required by MEMA and FEMA.</p> |

11.0 FUNDING SOURCES

Appropriate action is needed to ensure that financial resources are available to implement hazard mitigation projects. Such projects need to be included in capital improvement programs at the state and local levels. Federal funding programs are available to qualifying municipalities. The availability of current federal funding sources changes regularly and is dependent upon Congress' ongoing budget appropriations process. In 2003, the federal government established two comprehensive websites that track available funding from all the federal agencies at www.fedgrants.gov or www.grants.gov. In addition, it may also be helpful to check current federal appropriations from Congress through the Federal Register at www.thomas.loc.

The following table provides a summary of FEMA programs which fund hazard mitigation projects and activities. These programs are the primary source of federal hazard mitigation funding in Massachusetts:

Table 44: FEMA Hazard Mitigation Funding Programs

| Program | Type of Assistance | Availability | Managing Agency | Funding Source |
|---|---|---|-------------------------------------|---|
| National Flood Insurance Program (NFIP) | Flood Insurance | Any time (pre- and post- disaster) | DCR Flood Hazard Management Program | Property Owner, Federal Emergency Management Agency |
| Severe Repetitive Loss (SRL) (Part of the NFIP) | Grants to state emergency management offices to reduce damage to insured severe RLPs | Varies | MEMA | Up to 90% FEMA/ 10% state government |
| Repetitive Flood Claims Program (RFC) (Part of the NFIP) | Grants to states and municipalities to reduce damage to insured RLPs | Any time | FEMA | 100% FEMA |
| Community Rating System (CRS) (Part of the NFIP) | Disaster Insurance Discounts | Any time (pre and post disaster) | DCR Flood Hazard Management Program | Property Owner, Federal Emergency Management Agency |
| Flood Mitigation Assistance (FMA) Program | Cost share grants for pre-disaster planning and projects | Annual pre-disaster grant program | DCR & MEMA | 75% FEMA/25% local government or organization |
| Hazard Mitigation Grant Program (HMGP) | Post-disaster Cost-Share Grants | Post disaster program | DCR & MEMA | 75% FEMA/25% local government or organization |
| Pre-Disaster Mitigation Program | National, competitive grant program for multiple hazard mitigation projects and "all hazards" | Annual, pre-disaster mitigation program | DCR & MEMA | 75% FEMA/25% local government or organization |

| | | | | |
|---|---|----------------|------|-------------------------------|
| Small Business Administration (SBA) Mitigation Loans | Pre- and Post- disaster loans to qualified businesses | Ongoing | MEMA | Small Business Administration |
| Public Assistance Program | Post-disaster aid to state and local governments | Post- Disaster | MEMA | FEMA |

The Federal Emergency Management Agency (FEMA), which is part of the Department of Homeland Security, administers the National Flood Insurance Program, the Community Rating System, the Flood Mitigation Assistance Program (FMA), the Hazard Mitigation Grant Program (HMGP) and the Pre-Disaster Mitigation Program (PDM). All of these programs are administered in coordination with DCR and MEMA. FEMA also prepares and revises flood insurance studies and maps as well as information on past and current acquisition, relocation and retrofitting programs. The Mitigation Division provides expertise in other natural and technological hazards, including hurricanes, earthquakes and hazardous materials, to state and local government agencies.

Immediately following a Presidential declaration, FEMA’s Response and Recovery Division works closely with state agencies, especially MEMA, in assisting in the short-term and long-term recovery effort. FEMA assists disaster-affected communities through emergency funding programs, such as Infrastructure Support and Human Services. In coordination with its Mitigation Division, Response and Recovery distributes information on hazard mitigation methods and acquisition/relocation initiatives as well as coordinating HMGP grants for mitigation projects to protect eligible damaged public and private nonprofit facilities through the Public Assistance Program. In addition to these programs, FEMA also provides disaster recovery and hazard mitigation training at its Emergency Management Institute in Emmitsburg, Maryland.

For the latest information on these funding programs, go to FEMA’s website at www.fema.gov. More detailed information regarding the mitigation funding options is provided in the following sections.

National Flood Insurance Program (NFIP)

The National Flood Insurance Program (NFIP), established by Congress in 1968, provides flood insurance to property owners in participating communities. This program is a direct agreement between the federal government and the local community that flood insurance will be made available to residents in exchange for community compliance with minimum floodplain management requirements. Since homeowners’ insurance does not cover flooding, a community’s participation in the NFIP is vital to protecting property in the floodplain, as well as ensuring that federally backed mortgages and loans can be used to finance property within the floodplain.

Pursuant to the Flood Disaster Protection Act of 1973, any federal financial assistance related to new construction or substantial improvements (greater than 50% of a structure’s market value) of existing structures located in the 100-year floodplain is contingent on the purchase of flood insurance. Such federal assistance includes not only direct aid from agencies, but also from federally insured institutions. Thus, in order for property owners to be eligible for purchasing flood insurance, their respective community must be participating in the NFIP and in compliance with the NFIP.

Communities participating in the NFIP must:

- Adopt the Flood Insurance Rate Maps as an overlay regulatory district;
- Require that all new construction or substantial improvement to existing structures in the flood hazard area will be elevated; and
- Require design techniques to minimize flood damage for structures being built in high hazard areas, such as floodways or velocity zones.

The NFIP standards are contained in the Massachusetts State Building Code (Section 3107), which is implemented at the local level by municipal building inspectors. In Massachusetts, 344 out of 351, or 98%, of Massachusetts municipalities participate in the NFIP.

Severe Repetitive Loss Program (SRL)

The Severe Repetitive Loss Program was authorized by the Bunning-Beruter-Blumaneauer Flood Insurance Reform Act of 2004 with amended the National Flood Insurance Act of 1968 to provide funding to reduce or eliminate the long-term risk of flood damage to severe repetitive loss structures.

MEMA must apply for these funds but may work with other state agencies or local governments. Priority is given to programs that will have the greatest cost-benefit ratio in keeping with the purpose of the program. Grants may be used for acquisition, demolition and relocation but cannot be used for maintenance or repair.

Funds are allocated to the state based on the percentage of validated SRL properties and may be up to 90 percent federal and 10 percent local.

Repetitive Flood Claims Program (RFC)

The Repetitive Flood Claims Program was authorized by the Bunning-Beruter-Blumaneauer Flood Insurance Reform Act of 2004 with amended the National Flood Insurance Act of 1968 to provide funding to reduce risk of flood damage to repetitive loss structures.

The program is 100 percent federal funded and the applicant must demonstrate that the proposed activities cannot be funded under the Flood Assistance Program. (See below.)

Community Rating System (CRS)

A voluntary initiative of the NFIP, the Community Rating Systems (CRS) encourages communities to undertake activities that exceed the minimum NFIP floodplain management standards. Communities participating in CRS can reduce flood insurance premiums paid by policyholders in that community by performing such activities as: maintaining records of floodplain development, publicizing the flood hazard, improving flood data, and maintaining open space. Communities can gain additional credit under CRS by developing a flood mitigation plan.

Flood Hazard Mitigation Program (FMA)

Authorized by the National Flood Insurance Reform Act of 1994, the Flood Mitigation Assistance (FMA) program makes cost-share grants available for flood mitigation planning and projects, such as property acquisition, relocation of residents living in floodplains, and retrofitting of existing structures within a floodplain. Flood hazard mitigation plans, approved by the state and FEMA, are a pre-requisite for receiving FMA project grants. Communities contribute a minimum of 25% of the cost for the planning and project grants with an FMA match of up to 75%.

Hazard Mitigation Grant Program (HMGP)

Established pursuant to Section 404 of the Stafford Disaster Relief and Emergency Relief Act (PL 100-707), this program provides matching grants (75% Federal, 25% Local) for FEMA- approved hazard mitigation projects following a federally declared disaster. These grants are provided on a competitive basis to state, local and tribal governments as well as non-profit organizations. The grants are specifically directed toward reducing future hazard losses, and can be used for projects protecting property and other resources against the damaging effects of floods, hurricanes, earthquakes, high winds, and other natural hazards. HMGP in Massachusetts encourages non-structural hazard mitigation measures, such as:

- The acquisition of damaged structures and deeding the land to a community for open space or recreational use;
- Relocating damaged or flood prone structures out of a high hazard area; and
- Retrofitting properties to resist the damaging effects of natural disasters. Retrofitting can include wet- or dry-flood proofing, elevation of the structure above flood level, elevation of utilities, or proper anchoring of the structure.

Proposals for funding are submitted for review by Massachusetts' Interagency Hazard Mitigation Committee with final approval given by the Commissioner of the DCR, the Director of MEMA and FEMA's Region I office.

Pre-Disaster Mitigation Program

The Pre-Disaster Mitigation Program (PDM) was authorized by §203 of the Robert T. Stafford Disaster Assistance and Emergency Relief Act (Stafford Act), 42 USC, as amended by §102 of the Disaster Mitigation Act of 2000. Funding for the program is provided through the National Regional Mitigation Fund to assist States and local governments (to include Indian Tribal governments) in implementing cost-effective hazard mitigation activities that complement a comprehensive mitigation program. All applicants must be participating in the National Flood Insurance Program (NFIP) if they have been identified through the NFIP as having a Special Flood Hazard Area (a Flood Hazard Boundary Map (FHBM) or Flood Insurance Rate Map (FIRM) has been issued). In addition, the community must not be suspended or on probation from the NFIP.

44 CFR Part 201, Hazard Mitigation Planning, establishes criteria for State and local hazard mitigation planning authorized by §322 of the Stafford Act, as amended by §104 of the DMA. The development of State and local multi-hazard mitigation plans is key to maintaining eligibility for future PDM funding.

Small Business Administration (SBA) Mitigation Loans

The SBA's Regional Mitigation Loan Program was developed in support of FEMA's Regional Mitigation program. Businesses proposing mitigation measures to protect against flooding must be located in a Special Flood Hazard Area (SFHA). Businesses may consult FIRM maps to find out if the business is located in a SFHA. For information pertaining to hazard identification mapping and floodplain management, contact the local community floodplain administrator or the State floodplain manager. To apply for a regional mitigation loan, a business must submit a complete Regional Mitigation Small Business Loan Application within the 30-day application period announced by the SBA. SBA will publish a Notice of Availability of Regional Mitigation Loans in the Federal Register announcing the availability of Regional mitigation loans each fiscal year. The Federal Register notice will designate a 30-day application period with a specific opening date and filing deadline, as well as the locations for obtaining and filing loan applications. In addition, SBA will coordinate with FEMA, and will issue press releases to the local media to inform potential loan applicants where to obtain loan applications.

Public Assistance

The Federal Emergency Management Agency's Public Assistance Program is triggered for counties declared major disaster areas by the President. Communities and public agencies in designated counties are eligible for partial reimbursement (75%) of expenses for emergency services and removal of debris, and partial funding (75%) for repair and replacement of public facilities that were damaged by the declared disaster. Massachusetts funds an additional 12.5% of these projects. Eligible applicants for Public Assistance include:

- State government agencies/departments;
- Local governments (county, city, town, village, district, etc.); and
- Certain private non-profit organizations.

Typical federal/state aid can include:

- Reimbursable payment of 87.5% of the approved costs for emergency protective measures deployed in anticipation of the storm;
- Reimbursable payment of 87.5% of the approved costs for emergency services and debris removal;
- Payment of 75% of the costs for the permanent repair or replacement of damaged public property; and
- Funding for repair/construction of damaged highways other than those on the Federal Aid System.

MVP Action Grants

Upon completion of the CRB process, the Town will become designated by EEA as an MVP Certified community. This designation will make the Town eligible for MVP Action Grant funds to implement resiliency planning and improvement projects identified through the CRB process. The MVP Certified designation is also considered in awarding other state grant programs.

Special Appropriations Following State Disasters

Although there is no separate state disaster relief fund in Massachusetts, the state legislature will enact special appropriations for those communities sustaining damages following a natural disaster that are not large enough for a presidential, disaster declaration. Since 1995, there have been 15 state disaster declarations and has provided over \$7,177,251 in funding to aid communities affected by natural disasters

State Revolving Fund

This statewide loan program through the Executive Office of Energy and Environmental Affairs “...offers affordable loan options to cities and towns to improve water supply infrastructure and drinking water safety; and to help them to comply with federal and state water quality requirements that deal with wastewater treatment plants and collection systems, while addressing issues such as watershed management priorities, stormwater management, and green infrastructure. Additionally, the SRF supplies financial assistance to address communities with septic system problems” (Massachusetts Department of Environmental Protection).

Massachusetts Land and Water Conservation Fund

Land and Water Conservation Funds provide 50 percent of the total project cost to purchase land for conservation or recreation purposes. The program is administered by DCR, and funds are eligible to municipalities with an updated Recreation and Open Space Plan.

Major Flood Control Projects

The state provides 50% 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.

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Appendices

Appendix A
Local Mitigation Plan Review Tool

LOCAL MITIGATION PLAN REVIEW TOOL - APA

Town of Chelmsford, MA

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

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

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

| | | |
|---|--|------------------------------------|
| Jurisdiction: Town of Chelmsford, MA | Title of Plan: Draft Hazard Mitigation Plan 2020 Update | Date of Plan: June 30, 2020 |
| Single or Multi-jurisdiction plan? Single jurisdiction | New Plan or Plan Update? <u>Update</u> | |
| Local Point of Contact: Melissa Joyce Title: Sustainability Manager Agency: Department of Public Works E-Mail: mjoyce@chelmsfordma.gov Regional Point of Contact: N/A | Address: 9 Alpha Road Chelmsford, MA 01824 Phone Number: 978.250.5203 | |

| | | |
|--|--|--|
| State Reviewer: Jeffrey Zukowski | Title: Hazard Mitigation Planner | Date: 8/1/2020; 11/3/20; 11/12/20; |
|--|--|--|

| | | |
|---|---|--|
| FEMA Reviewer: Sean Loughlin Brigitte Ndikum-Nyada | Title: Community Planner Community Planner | Date: 8/3/2020 – 8/6/2020 8/10/20–8/12/20; 11/3/20; 11/12/20; |
| Date Received in FEMA Region I | 8/1/2020; 11/3/20; 11/12/20; | |
| Plan Not Approved | 8/12/2020; 11/10/20 | |
| Plan Approvable Pending Adoption | 11/12/2020 | |
| Plan Adopted | | |
| Plan Approved | | |

**SECTION 1:
REGULATION CHECKLIST**

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

| 1. REGULATION CHECKLIST | | Location in Plan (section and/or page number) | Met | Not Met |
|---|--|--|------------|--------------------|
| Regulation (44 CFR 201.6 Local Mitigation Plans) | | | | |
| ELEMENT A. PLANNING PROCESS | | | | |
| A1. Does the Plan document the planning process, including how it was prepared and who was involved in the process for each jurisdiction? (Requirement §201.6(c)(1)) | Section 1: Planning Process and Public Participation | X | | |
| A2. Does the Plan document an opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, agencies that have the authority to regulate development as well as other interests to be involved in the planning process? (Requirement §201.6(b)(2)) | Section 1.3: Community Resilience Building Workshops | X | | |
| A3. Does the Plan document how the public was involved in the planning process during the drafting stage? (Requirement §201.6(b)(1)) | Section 1.4: Public Listening Session | X | | |
| A4. Does the Plan describe the review and incorporation of existing plans, studies, reports, and technical information? (Requirement §201.6(b)(3)) | Section 1.6: Other Local and Regional Planning Initiatives | X | | |
| A5. Is there discussion of how the community(ies) will continue public participation in the plan maintenance process? (Requirement §201.6(c)(4)(iii)) | Section 9.0: Plan Adoption and Maintenance | X | | |
| A6. Is there a description of the method and schedule for keeping the plan current (monitoring, evaluating and updating the mitigation plan within a 5-year cycle)? (Requirement §201.6(c)(4)(i)) | Section 9.0: Plan Adoption and Maintenance | X | | |
| ELEMENT A: REQUIRED REVISIONS | | | | |
| | | | | |

| 1. REGULATION CHECKLIST | | Location in Plan (section and/or page number) | Met | Not Met |
|--|--|--|------------|--------------------|
| Regulation (44 CFR 201.6 Local Mitigation Plans) | | | | |
| ELEMENT B. HAZARD IDENTIFICATION AND RISK ASSESSMENT | | | | |
| B1. Does the Plan include a description of the type, location, and extent of all-natural hazards that can affect each jurisdiction(s)? (Requirement §201.6(c)(2)(i)) | Section 4.0: Hazard Identification | X | | |
| B2. Does the Plan include information on previous occurrences of hazard events and on the probability of future hazard events for each jurisdiction? (Requirement §201.6(c)(2)(i)) | Section 4.0: Hazard Identification, and Section: 7.0: Vulnerability/Risk Assessment | X | | |
| B3. Is there a description of each identified hazard’s impact on the community as well as an overall summary of the community’s vulnerability for each jurisdiction? (Requirement §201.6(c)(2)(ii)) | Section 4.0: Hazard Identification, and Section: 7.0: Vulnerability/Risk Assessment | X | | |
| B4. Does the Plan address NFIP insured structures within the jurisdiction that have been repetitively damaged by floods? (Requirement §201.6(c)(2)(ii)) | Section 4.1.1: Flood-Related Hazards | X | | |
| <u>ELEMENT B: REQUIRED REVISIONS</u> | | | | |
| ELEMENT C. MITIGATION STRATEGY | | | | |
| C1. Does the plan document each jurisdiction’s existing authorities, policies, programs and resources and its ability to expand on and improve these existing policies and programs? (Requirement §201.6(c)(3)) | Section 6.0: Existing Protection Matrix | X | | |
| C2. Does the Plan address each jurisdiction’s participation in the NFIP and continued compliance with NFIP requirements, as appropriate? (Requirement §201.6(c)(3)(ii)) | Section 4.1.1: Flood-Related Hazards pg. 27-31 | X | | |
| C3. Does the Plan include goals to reduce/avoid long-term vulnerabilities to the identified hazards? (Requirement §201.6(c)(3)(i)) | Section 8.0: Action Plan & Strategies – pg. 14 | X | | |
| C4. Does the Plan identify and analyze a comprehensive range of specific mitigation actions and projects for each jurisdiction being considered to reduce the effects of hazards, with emphasis on new and existing buildings and infrastructure? (Requirement §201.6(c)(3)(ii)) | Section 8.0: Action Plan and Strategies | X | | |
| C5. Does the Plan contain an action plan that describes how the actions identified will be prioritized (including cost benefit review), implemented, and administered by each jurisdiction? (Requirement §201.6(c)(3)(iv)); (Requirement §201.6(c)(3)(iii)) | Section 8.0: Action Plan and Strategies | X | | |
| C6. Does the Plan describe a process by which local governments will integrate the requirements of the mitigation plan into other planning mechanisms, such as comprehensive or capital improvement plans, when appropriate? (Requirement §201.6(c)(4)(ii)) | Sect 1.6: Other Local & Reg Planning Initiatives; Section 8.2: MIT Progress Since 2015; Sect 10: Plan Implement & pg. 13 | X | | |
| <u>ELEMENT C: REQUIRED REVISIONS</u> | | | | |

| 1. REGULATION CHECKLIST | | Location in Plan (section and/or page number) | Met | Not Met |
|---|---|--|------------|--------------------|
| Regulation (44 CFR 201.6 Local Mitigation Plans) | | | | |
| ELEMENT D. PLAN REVIEW, EVALUATION, AND IMPLEMENTATION (applicable to plan updates only) | | | | |
| D1. Was the plan revised to reflect changes in development? (Requirement §201.6(d)(3)) | Sect 3.0: Town Profile; Sect 7.5: Impacts of New Growth on Vulnerability | X | | |
| D2. Was the plan revised to reflect progress in local mitigation efforts? (Requirement §201.6(d)(3)) | Section 8.2: Mitigation Progress Since 2015 pg. 109 | | | |
| D3. Was the plan revised to reflect changes in priorities? (Requirement §201.6(d)(3)) | Section 8.1: Mitigation Goals; Section 8.3: The Action Plan | X | | |
| <u>ELEMENT D: REQUIRED REVISIONS</u> | | | | |
| ELEMENT E. PLAN ADOPTION | | | | |
| E1. Does the Plan include documentation that the plan has been formally adopted by the governing body of the jurisdiction requesting approval? (Requirement §201.6(c)(5)) | Appendix F: Draft Certificate of Adoption | X | | |
| E2. For multi-jurisdictional plans, has each jurisdiction requesting approval of the plan documented formal plan adoption? (Requirement §201.6(c)(5)) | N/A | | | |
| <u>ELEMENT E: REQUIRED REVISIONS</u> | | | | |
| ELEMENT F. ADDITIONAL STATE REQUIREMENTS (OPTIONAL FOR STATE REVIEWERS ONLY; NOT TO BE COMPLETED BY FEMA) | | | | |
| F1. | | | | |
| F2. | | | | |
| <u>ELEMENT F: REQUIRED REVISIONS</u> | | | | |

**SECTION 2:
PLAN ASSESSMENT**

A. Plan Strengths and Opportunities for Improvement

This section provides a discussion of the strengths of the plan document and identifies areas where these could be improved beyond minimum requirements.

Revision required prior to plan adoption:

D2.a - The plan **must** describe the status of hazard mitigation actions in the previous plan by identifying those that have been completed or not completed. For actions that have not been completed, the plan **must** either describe whether the action is no longer relevant or be included as part of the updated action plan. There are several actions from the previous approved HMP, listed as **“blank”** and “no current action, or No action” Describe or expand on what this mean.

Table 41: Mitigation Progress

| 2015 Priorities | Current Status | 2020 Actions | 2015 Priority/ Timeframe | 2020 Priority/ Timeframe |
|--|--|--|-------------------------------------|-------------------------------------|
| Study the Community Rating System to determine appropriateness for Chelmsford | Civil engineer is in process.??? | | Short-term | |
| Enhance the knowledge of local officials, builders, developers, citizens and other stakeholders on how to read and interpret the FIRM. | No action. | Information captured in town GIS system and utilized regularly. | Short-term | |
| Evaluate public buildings and critical facilities for the potential to withstand high winds | Building Inspector and DPW Director will have to address this in the future. | As projects arise, these issues are addressed through work with structural engineering and re-engineering for retrofits. | Long-term | |
| Develop an inventory of public buildings that do not currently meet seismic standards | Building Inspector and DPW Director will have to address this in the future. | As projects arise, these issues are addressed through work with structural engineering and re-engineering for retrofits. | Long-term | |
| Provide information to homeowners on how to protect their property from brush fire or wildfire during times of drought | Fire Department post burning and no burning days and provides information via burn permit and Facebook and the Town Website. More information could be provided for preventative planning. | Ongoing outreach and education as needed and as situations arise. Monitoring and enforcement activities in place and ongoing by Fire Prevention personnel and Police Department bike patrol. | Long-term | |

Recommended Corrections:

- Section 9, paragraph four, bullet four: Please change the word Tow to Town. This is an apparent typo.
- The page numbering is off after Section 8.2 and should be updated.
- Section 8.3 Action Plan, paragraph one states the “following page” contains Table 44, however, Table 44 is not found on the following page. This should be updated.

Element A: Planning Process

Strengths:

- A range of studies reports, and plans were reviewed and incorporated, resulting in a plan that is comprehensive and current.
- The public listening session held at a Board of Selectmen meeting was televised and a recording of the meeting was posted online. Also, the draft MVP Summary of Findings Report was available for public comment for a period of three weeks.

Opportunities for Improvement:

- Table 1, MVP Stakeholder invitee list, is primarily Chelmsford officials. While the plan notes that the NMCOG was invited to provide knowledge on regional hazards shared with neighboring communities, invites to the actual bordering jurisdictions would have been optimal.

Element B: Hazard Identification and Risk Assessment

Strengths:

- The plan identifies many hazards that are not natural hazards. This provides greater visibility to the many hazards that could impact the community.
- The plan identifies public health emergencies within the plan. This is excellent considering the corona virus pandemic that is underway.
- The continuum from the 2015 NMCOG Multi-jurisdiction HMP to Chelmsford's 2020 single jurisdiction's HMP is commendable.

Opportunities for Improvement:

- Use more maps and other graphics to visually highlight the key ideas in the risk assessment.
- Consider the 0.2% (500-year) risk of flood when assessing the risk to development.
- Identify dams in upstream areas that may pose a risk to neighborhoods and assets within Chelmsford. Be specific and mention whether a dam breach has occurred in the Town of Chelmsford.

Element C: Mitigation Strategy

Strengths:

- The community's mitigation goals are unique and customized to the community. The plan clearly states that all of the goals are affirmed from the previous plan, plus one new goal added related to climate change. Great mitigation strategy-goal to protect the economic vitality of the region.
- The plan includes a variety of different types of mitigation actions (local plans and regulations, structure and infrastructure projects, natural system protections, and education and awareness programs).
- The plan identifies a range of potential resources for implementing the mitigation strategy, increasing opportunities for success.
- The plan is integrated with other community planning efforts, including but not limited to the CEDS, CEMP, Master Plan, Open Space & Recreation Plan, Affordable Housing Plan and Regional Transportation Plan.
- The update of Hazard Mitigation Plan happened concurrently with the MA MVP program, integrating these two important initiatives.
- The plan incorporates the Community Resilience Building (CRB) Guidebook, developed by the Nature Conservancy, as part of the planning process.
- **COSTEP-MA** adds value to the community's capability. Kudos
- **NFIP**- The plan provides a good discussion of continued compliance in the NFIP program. Encouraged to join the CRS program.

Opportunities for Improvement:

- Table 41, Mitigation Progress Matrix and Sections 8.4, 8.5 and 8.6 contain Short Term, Long Term and Ongoing timeframes for completion. An opportunity for improvement is to provide more concise definitions for these timeframes and, where applicable, include more details about why action(s) could not be completed (funding, staffing, etc.).
- Expand the discussion on National Flood Insurance (NFIP) as well as identify key NFIP related data such as the effective flood map data, last community FEMA visit/contacts, important map changes or variances, and any recently updated/adopted flood ordinance. <https://www.mass.gov/guides/floodplain-management> Massachusetts 2020 Model Floodplain Bylaws. <https://msc.fema.gov/portal>

Element D: Plan Update, Evaluation, and Implementation (*Plan Updates Only*)

Strengths:

- Plan evaluation will entail reviewing the plan annually. Residents will be informed when hazard mitigation issues are brought forth to the Board of Selectmen.

Opportunities for Improvement:

- Consider adding a section on planned and/or potential future development, if applicable.
- Describe general land use changes in neighboring jurisdictions, if applicable, that may affect the community's risk.
- Including a discussion of lessons learned about implementing mitigation actions would strengthen the plan, as would a short narrative on some "success stories" about their implementation.

B. Resources for Implementing Your Approved Plan

Refer to the [Massachusetts Integrated State Hazard Mitigation and Climate Action Plan](#), [Resilient MA Climate Clearinghouse](#), and State's [Climate Action Page](#) to learn about hazards relevant to Massachusetts and the State's efforts and action plan.

Technical Assistance:

FEMA

- [FEMA Climate Change](#): Provides resources that address climate change.
- [FEMA Library](#): FEMA publications can be downloaded from the library website. These resources may be especially useful in public information and outreach programs. Topics include building and construction techniques, NFIP policies, and integrating historic preservation and cultural resource protection with mitigation.
- [FEMA RiskMAP](#): Technical assistance is available through RiskMAP to assist communities in identifying, selecting, and implementing activities to support mitigation planning and risk reduction. Attend RiskMAP discovery meetings that may be scheduled in the state, especially any in neighboring communities with shared watersheds boundaries.

Other Federal

- [EPA Resilience and Adaptation in New England \(RAINE\)](#): A collection of vulnerability, resilience and adaptation reports, plans, and webpages at the state, regional, and community levels. Communities can use the RAINE database to learn from nearby communities about building resiliency and adapting to climate change.
- [EPA Soak Up the Rain](#): Soak Up the Rain is a public outreach campaign focused on stormwater quality and flooding. The website contains helpful resources for public outreach and easy implementation projects for individuals and communities.
- [NOAA C-CAP Land Cover Atlas](#): This interactive mapping tool allows communities to see their land uses, how they have changed over time, and what impact those changes may be having on resilience.
- [NOAA Sea Grant](#): Sea Grant's mission is to provide integrated research, communication, education, extension and legal programs to coastal communities that lead to the responsible use of the nation's ocean, coastal and Great Lakes resources through informed personal, policy and management decisions. Examples of the resources available help communities plan, adapt, and recovery are the Community Resilience Map of Projects and the National Sea Grant Resilience Toolkit
- [NOAA Sea Level Rise Viewer](#) and [Union for Concerned Scientists Inundation Mapper](#): These interactive mapping tools help coastal communities understand how their hazard risks may be changing. The "Preparing for Impacts" section of the inundation mapper addresses policy responses to protect communities.
- [NOAA U.S. Climate Resilience Toolkit](#): This resource provides scientific tools, information, and expertise to help manage climate-related risks and improve resilience to extreme events. The "[Steps to Resilience](#)" tool may be especially helpful in mitigation planning and implementation.

State

- [Massachusetts Emergency Management Agency](#): The Massachusetts State Hazard Mitigation Officer (SHMO) and State Mitigation Planner(s) can provide guidance regarding grants, technical assistance, available publications, and training opportunities.

- Massachusetts Departments of [Conservation and Recreation](#) and [Environmental Protection](#) can provide technical assistance and resources to communities seeking to implement their hazard mitigation plans.
- [MA Mapping Portal](#): Interactive mapping tool with downloadable data.
- <https://www.mass.gov/guides/floodplain-management> Massachusetts 2020 Model Floodplain Bylaws. <https://msc.fema.gov/portal>

Not for Profit

- [Kresge Foundation Online Library](#): Reports and documents on increasing urban resilience, among other topics.
- [Naturally Resilient Communities](#): A collaboration of organizations put together this guide to nature-based solutions and case studies so that communities can learn which nature-based solutions can work for them.
- [Rockefeller Foundation Resilient Cities](#): Helping cities, organizations, and communities better prepare for, respond to, and transform from disruption.

Funding Sources:

- [Massachusetts Coastal Resilience Grant Program](#): Funding for coastal communities to address coastal flooding, erosion, and sea level rise.
- [Massachusetts Municipal Vulnerability Preparedness](#) program: Provides support for communities to plan for climate change and resilience and implement priority projects.
- [Massachusetts Water Quality Grants](#): Clean water grants that can be used for river restoration or other kinds of hazard mitigation implementation projects.
- [Grants.gov](#): Lists of grant opportunities from federal agencies (HUD, DOT/FHWA, EPA, etc.) to support rural development, sustainable communities and smart growth, climate change and adaptation, historic preservation, risk analyses, wildfire mitigation, conservation, Federal Highways pilot projects, etc.
- [FEMA Hazard Mitigation Assistance](#) (HMA): FEMA’s Hazard Mitigation Assistance provides funding for projects under the Hazard Mitigation Grant Program (HMGP), Pre-Disaster Mitigation (PDM), and Flood Mitigation Assistance (FMA). States, federally recognized tribes, local governments, and some not for profit organizations are eligible applicants.
- [GrantWatch](#): The website posts current foundation, local, state, and federal grants on one website, making it easy to consider a variety of sources for grants, guidance, and partnerships. Grants listed include The Partnership for Resilient Communities, the Institute for Sustainable Communities, the Rockefeller Foundation Resilience, The Nature Conservancy, The Kresge Climate-Resilient Initiative, the Threshold Foundation’s Thriving Resilient Communities funding, the RAND Corporation, and ICLEI Local Governments for Sustainability.
- USDA [Natural Resource Conservation Service](#) (NRCS) and [Rural Development Grants](#): NRCS provides conservation technical assistance, financial assistance, and conservation innovation grants. USDA Rural Development operates over fifty financial assistance programs for a variety of rural applications.

Appendix B **Workshop Materials**

Sign-In Sheet from October 25, 2018 Kick-Off Meeting

Minutes from October 25, 2018 Kick-Off Meeting

Agendas for February 7, 2019 and March 20, 2019 Workshops

Introductory Presentations for February 7, 2019 and March 20, 2019 Workshops

Announcement Soliciting Public Input, June 6, 2019

SIGN IN

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Chelmsford.us

□ How many sessions?

□ Late Jan - Feb + Late Feb - March

□ What are top hazards - have they changed since 2015?

□ When considering mitigation - think "wish list"

- Flooding of River - Williamsburg

- Localized flooding

- Winter melt + rain = problems w/ flooding

- Sewer plants can't keep up w/ rain + flooding

- Low point by boat ramp Williamsburg

- Stony Brook / Jordan Road

- crosser along Rail line

- Undersized culverts

- Trees - roads closed after storms

- No tree/forestry division

- Nat'l grid had 5 yr tree plan

- move to 4 yr plan

- Jones pond - no emerg. access

- Boat ramp is not managed

- Cyanotoxins in water system

Stakeholders

Memorial River Assoc.

Health Dept

Williamsburg Board of Directors

Dam owner @ School St

MassDOT DY

Nat'l Grid

MEETING DATE: February 7, 2019

MEETING TIME: 9:00 AM to 1:00 PM

MEETING LOCATION: Room 204, Chelmsford Town Hall
 50 Billerica Road, Chelmsford, MA

REFERENCE: Municipal Vulnerability Preparedness
 Stakeholder Workshop #1
Chelmsford, Massachusetts
 B+T Project No. 3055.00

PREPARED BY: Beals and Thomas, Inc.

COPIES TO: Attendees

AGENDA ITEMS:

| <u>Time</u> | <u>Activity</u> | |
|-------------------------|---|-------------------------------|
| 8:45 – 9:15 AM | Sign-in / Priority Exercise | |
| 9:15 – 9:25 AM | Welcome, Workshop Overview, and Introductions | Evan Belansky |
| 9:25 – 9:40 AM | MVP Overview | John Gelcich |
| 9:40 – 10:00 AM | Science and Resources | Nick Santangelo |
| 10:00 – 10:30 AM | Large Team Exercise | Stakeholders and Facilitators |
| 10:30 – 12:00 PM | Small Team Exercises | Stakeholders and Facilitators |
| 12:00 – 12:15 PM | Break and Lunch | |
| 12:15 – 12:35 PM | Small Group Report Outs | Small Group Representative |
| 12:35 – 12:55 PM | Summary Discussion | Eric Las |
| 12:55 – 1:00 PM | Workshop #1 Conclusion and Introduction to Workshop #2 | John Gelcich |

MKS/jpg/305500AG001

MEETING DATE: March 20, 2019

MEETING TIME: 9:00 AM to 1:00 PM

MEETING LOCATION: Room 204, Chelmsford Town Hall
50 Billerica Road, Chelmsford, MA

REFERENCE: Municipal Vulnerability Preparedness
Stakeholder Workshop #2
Chelmsford, Massachusetts
B+T Project No. 3055.00

PREPARED BY: Beals and Thomas, Inc.

COPIES TO: Attendees

AGENDA ITEMS:

| <u>Time</u> | <u>Activity</u> | |
|-------------------------|---|---------------------------------------|
| 8:45 – 9:15 AM | Sign-in and Breakfast | |
| 9:15 – 9:20 AM | Welcome and Introductions | Evan Belansky |
| 9:20 – 9:35 AM | Workshop #1 Recap and Workshop #2 Overview | John Gelcich, Mary Kate Schneeweis |
| 9:35 – 11:35 AM | Small Team Exercises | Stakeholders and Facilitators |
| 11:35 – 12:05 PM | Break and Lunch | |
| 12:05 – 12:20 PM | Small Group Report Outs | Small Group Representative |
| 12:20 – 12:55 PM | Large Group Discussion | Stakeholders and Facilitators |
| 12:55 – 1:00 PM | Wrap-Up and Next Steps | John Gelcich |

MKS/jpg/305500AG002



Community Resilience Building Workshop 1

Presented by:



BEALS + THOMAS



February 7, 2019



Merrimack River, 2005

Welcome and Introduction



BEALS + THOMAS

Team Members

Town of Chelmsford Coordinator

- Evan Belansky, Community Development Director

Beals and Thomas (B+T) Facilitators

- Eric Las, PE
- John Gelcich, AICP
- Mary Kate Schneeweis
- Nick Santangelo, EIT

Roundtable Stakeholder Introductions



www.CommunityResilienceBuilding.org

Municipal Vulnerability Preparedness (MVP) Program Overview



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Executive Order 569

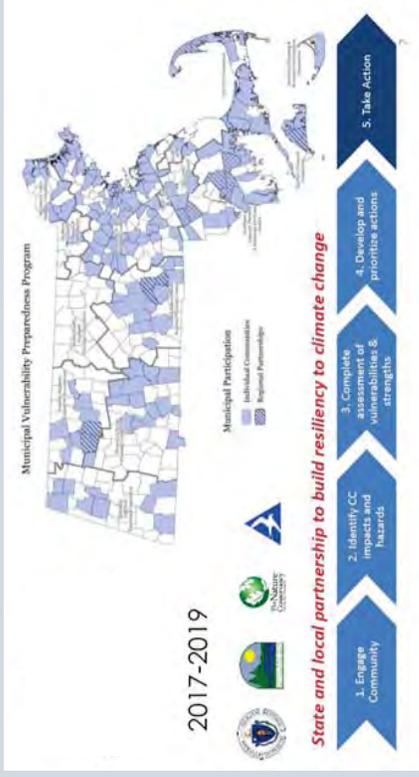
Issued by Governor Baker in September 2016

- Tasked Executive Office of Energy and Environmental Affairs (EEA) with creating two frameworks to assess vulnerabilities and adaptation strategies related to climate change

- MVP Office
- Resilient MA website
- State Hazard Mitigation and Climate Adaptation Plan



State's Vision for MVP Program



Chelmsford MVP Designation Schedule

- Receipt of planning grant: June 2018
- Core team established approach: Late 2018
- Workshop #1: February 2019
- Workshop #2: March 2019
- Public listening session: Spring 2019
- Final report: June 2019



Mitigation Planning Benefits

A process for communities to identify policies, activities and tools to implement mitigation actions

- Increases awareness of vulnerabilities
- Promotes safety and welfare of communities and citizens
- Cultivates community commitment to mitigation

Lack of hazard awareness and mitigation plan could lead to unnecessary losses to infrastructure and critical facilities and potential human casualties



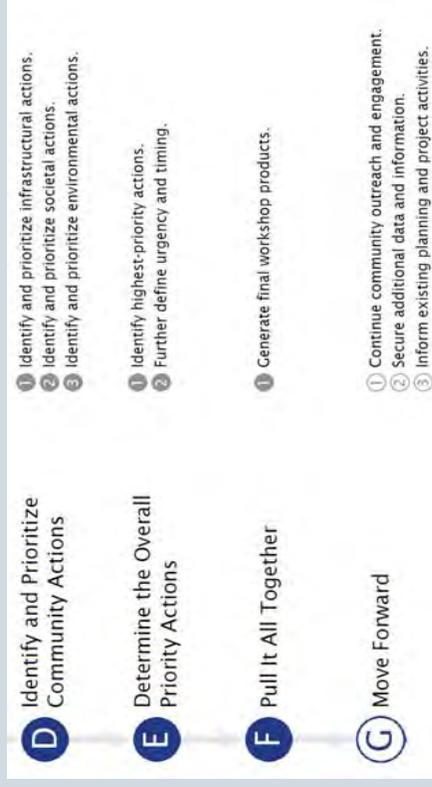
BEALS + THOMAS

MVP Process



BEALS + THOMAS

MVP Process



BEALS + THOMAS

Hazard Mitigation Plan Update

Required for municipalities to receive FEMA funding for on-emergency disaster assistance

- Updates required every 5 years
- Effective regional plan prepared by Northern Middlesex Council of Governments in 2015
- Additional EEA funds for communities with expiring hazard mitigation plans who are undertaking MVP process
- Similar public input process to MVP program
 - Submission of MVP final report to Massachusetts Emergency Management Agency June 2019



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Workshop Objectives

Workshop 1

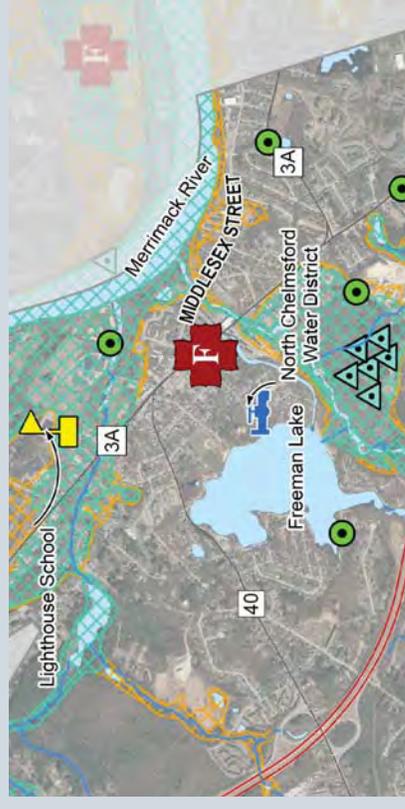
- Define extreme weather and natural and climate-related hazards
- Identify existing and future vulnerabilities and strengths

Workshop 2

- Develop and prioritize actions for the community and broader stakeholder networks
- Identify opportunities for the community to advance actions to reduce risks and build resilience.



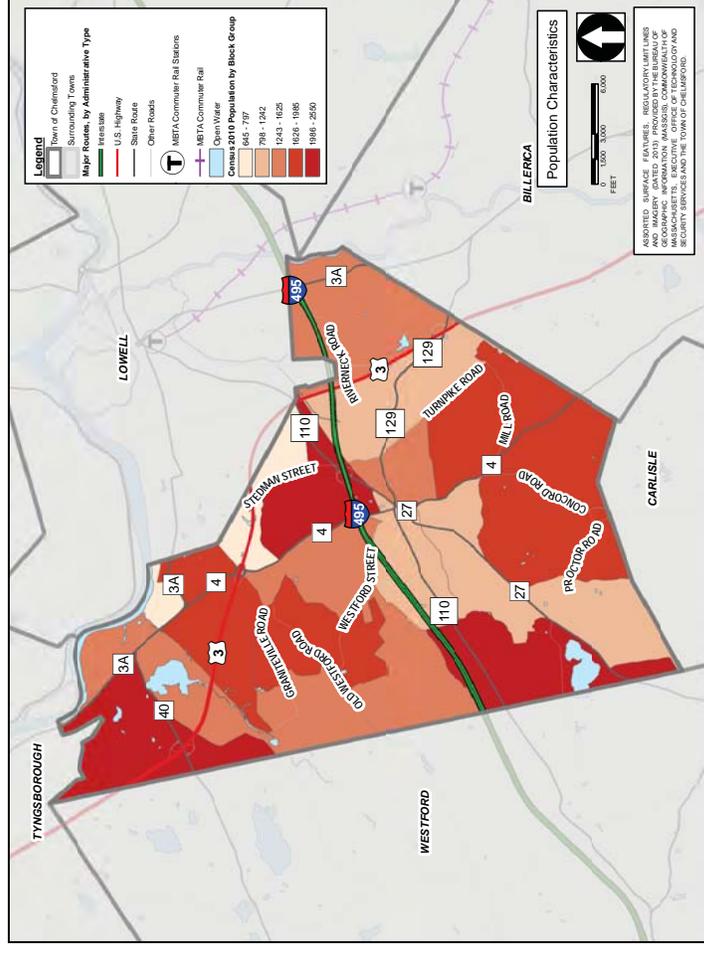
Science and Resources



Chelmsford Demographics

- Total Population: 35,067
- Potential Vulnerable Populations:
 - Age 65+: 18%
 - Persons with disabilities: 10.3%
 - Speak language other than English at home: 13.8%
 - Below poverty line: 2.3%

Source: American Community Survey, 2017



Hazard Mitigation Plan Update

Recommendations to address natural hazards

- Identified as high hazards:
 - Severe storm events (e.g. Nor'easter, hurricanes, ice storms, snow storms, blizzards)
 - Flooding
 - Wildfires
 - Earthquakes

Prioritized mitigation based on anticipated area of hazard impact, expected benefit, and cost



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Severe Storms

Hurricanes – heavy rain, high wind

- 41 hurricanes in New England since 1938
 - 2011 Hurricane Irene most recent

Winter Storms – heavy snow, freezing rain, extreme wind, extreme cold

- Severe winter storm: 6 inches or more of snow in 24 hours
 - Regional record for winter snowfall: 126.5 inches in 1995



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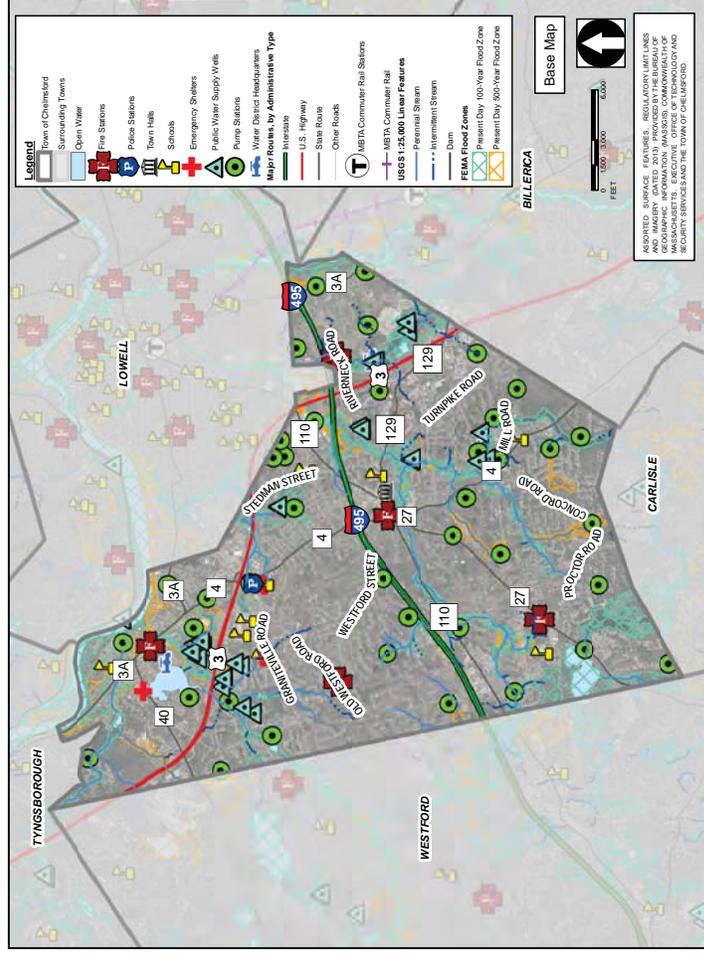
Vulnerability to Flooding

- Tributary to two sub-watersheds
 - Merrimack
 - SuAsCo
- 11 named streams run through the Town
- 2.3% of Town's total area is comprised of Surface Water
 - 7 dams retain water
- 9.3% of Town's total area is mapped as Floodplain

Source: Hazard Mitigation Plan for the Northern Middlesex Region



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Massachusetts Climate Change Projections (Merrimack Basin)

Temperature

- Increased average temperatures and number of days with maximum temperature above 90°F
 - Annually – 11 to 33 more days with temperatures above 90°F by 2050s
- Decrease in number of days with minimum temperature below 32°F
 - Winter – 3 to 12 fewer days with temperatures below 32°F by 2050s

Precipitation

- Increase in number of days with greater than 1" precipitation and total precipitation
 - Seasonally – approximately 1 more day with precipitation greater than 1" by 2050s

Drought

- Increase in consecutive dry days
 - Summer – potential increase of 2 more days with less than 1mm of precipitation



Workshop Exercises



Summary of Workshop 1 Exercises

- Develop and prioritize list of **Hazards**
- Identify community **Strengths** and **Vulnerabilities**
 - Infrastructural
 - Societal
 - Environmental
- Begin thinking about opportunities for mitigation and solutions to addressing vulnerabilities



Definitions

Hazard – cause of negative impacts to community

Risk – potential result from hazard

Vulnerability – feature (societal, environmental, or infrastructural) that is susceptible to risk

Action – addresses vulnerability



Hazards vs. Vulnerabilities

Hazards

- Flooding →
- Drought →
- Wind →
- Wildfire →

Vulnerabilities

- Residences in flood zone
- Water supply
- Overhead power lines
- Dry vegetation



10-Minute Break

When you return, please sit at the table that corresponds to your nametag color



Risk Matrix Columns 1-4

List top **hazards** for community in top row

For each sector (infrastructure, societal, environmental)

- Identify **vulnerabilities** and **strengths**
 - Determine location
 - List on Risk Matrix
 - Mark on Base Map
 - Identify ownership of issue or place.
 - Identify if feature/asset is a strength and/or vulnerability



Small Groups: Complete Risk Matrix

The image shows a screenshot of a spreadsheet titled "Community Resilience Building Risk Matrix". The spreadsheet has several columns and rows. A red box highlights the first four columns, which correspond to the "Risk Matrix Columns 1-4" mentioned in the adjacent slide. The columns are labeled "Hazard", "Location (Infrastructure)", "Societal", and "Environmental". The rows are labeled "Infrastructure", "Societal", and "Environmental". The spreadsheet is used for identifying and assessing risks to the community.



Lunch Break

Please help yourself to the lunch provided.

We will conduct the Report Outs after everyone has had a chance to get food.



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Report Out

Identify team spokesperson

Report findings to the whole group

- 3-5 minute summary
- What Risks were identified?
- What were the top priority Hazards identified?
- Were there any other items of discussion worth noting?

Begin thinking about potential action items that may address the hazards and vulnerabilities identified by your team and the other teams.



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Next Steps

Workshop 2: Identify and Prioritize community actions based on Strengths and Vulnerabilities from Workshop 1

- Infrastructural
- Societal
- Environmental



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Community Resilience Building Workshop 2

Presented by:



March 20, 2019



Welcome and Introduction



BEALS + THOMAS

Workshop #1 Recap

- Conducted initial priority exercise
- Reviewed Background on climate change data
- Reached Agreement on hazards facing Chelmsford
- Discussed vulnerabilities and strengths
- Completed first part of risk matrix



Workshop Objectives

Workshop 1

- Define extreme weather and natural and climate-related hazards
- Identify existing and future vulnerabilities and strengths

Workshop 2

- Develop and prioritize actions for the community and broader stakeholder networks
- Identify opportunities for the community to advance actions to reduce risks and build resilience



BEALS + THOMAS

Definitions

Hazard – cause of negative impacts to community

Risk – potential result from hazard

Vulnerability – feature (societal, environmental, or infrastructural) that is susceptible to risk

Action – addresses vulnerability



Summary of Findings from Workshop #1

Top Hazards

- Severe Storms
- Flooding
- Extreme Temperature
- Wind
- Pollution



Summary of Findings from Workshop #1

Strengths

- Stormwater management systems/MS4
- Communication within Town
- Emergency shelters

Vulnerabilities

- At-risk populations (e.g. elderly, Williamsburg)
- Utilities
- Roadway infrastructure



Workshop Exercises



Small Group Exercise

- Revisit top hazards
- Revisit vulnerabilities and strengths
- Determine actions
 - Identify the actions needed to reduce the vulnerability or reinforce the strength represented by each feature/asset.
- Prioritize
 - Priority (high, medium, low)
 - Timeframe (ongoing, short-term, long-term)



Examples of Ecological Restoration

Dam Removal



If Possible: Use Nature Based Solutions

Use or mimic natural systems to address hazards

- Ecological Restoration
- Green Infrastructure
- Low-Impact Development (LID)

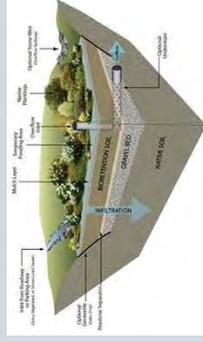


Examples of Green Infrastructure/LID

Stormwater Management with Green Roofs



Stormwater Management with Bioretention Areas and Rain Gardens



Small Group Report Out

- Small group spokesperson
 - 3-5 minute summary to present completed matrices



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Lunch Break

- Please help yourself to the lunch provided.
- Review final risk matrices and mark your top three priorities

Large Group Discussion

- Identify top 3-5 priority actions
- Further refine timeframe(s)



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Next Steps

- Town and B+T to compile results of workshop into summary report
- Listening session to be scheduled to gather public input
 - Present list of priority actions and how to implement
- Submit final report to EEA to receive MVP designation



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WHAT CAN WE HELP YOU FIND?

[News Flash Home](#)

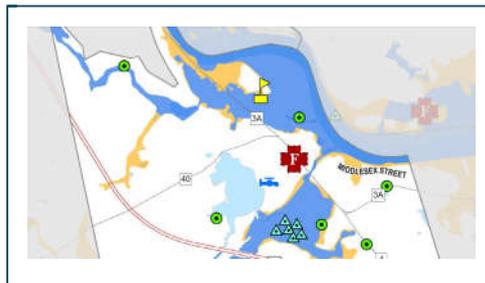
The original item was published from 6/4/2019 10:56:00 AM to 6/20/2019 12:00:06 AM.

Community Development

Posted on: May 15, 2019

[ARCHIVED] Municipal Vulnerability Preparedness

Yo
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. Submit comments by June 17th.

The Town of Chelmsford invites the public to comment on the final draft Community Resiliency Building Plan. This

Tools

[RSS](#)

[Notify Me](#)

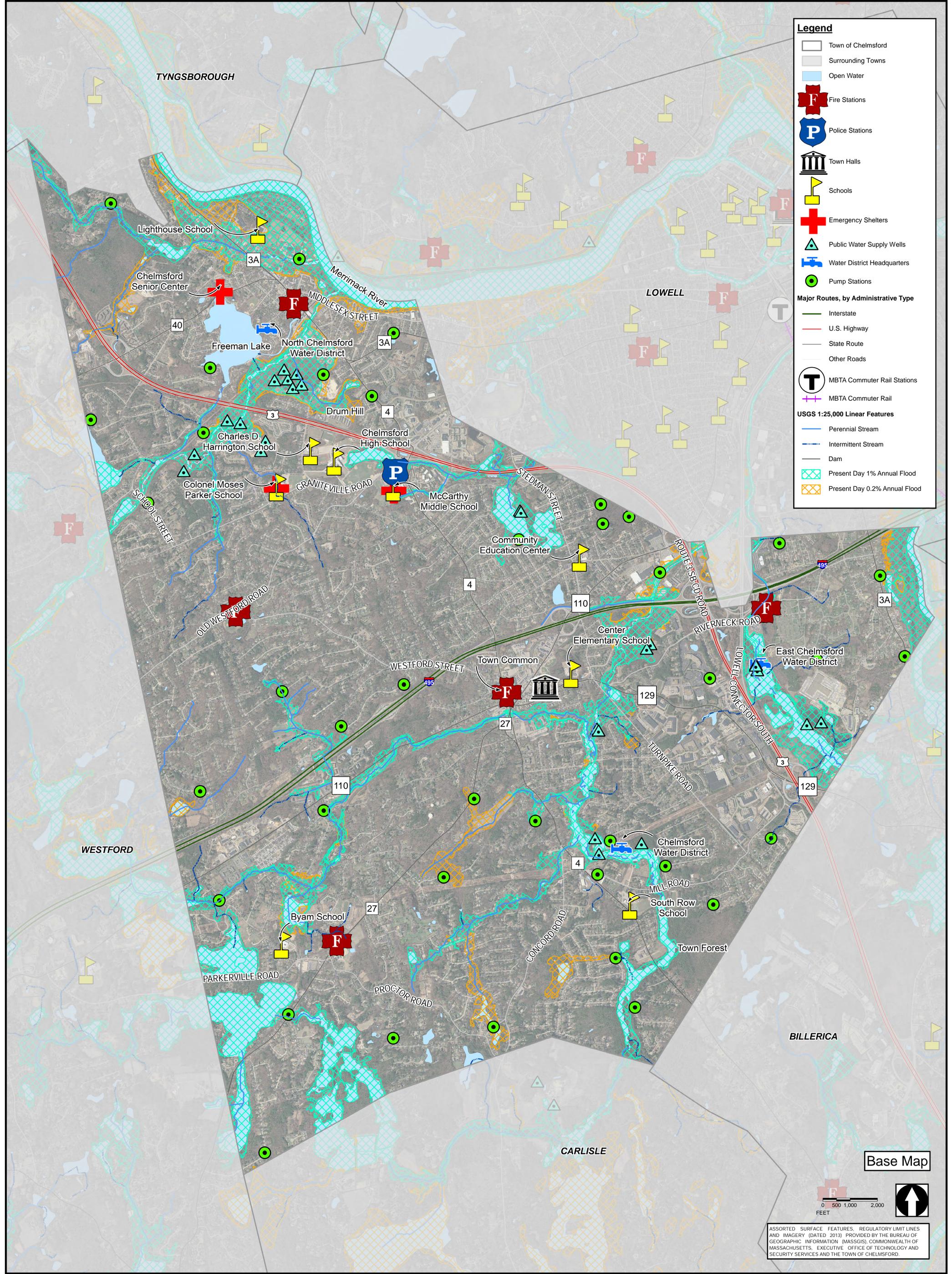
Categories

- [All Categories](#)
- [1 - Home Page Newsflash](#)
- [3 - Town Clerk](#)
- [4 - Public Works](#)
- [Fire Department](#)
- [Select Board](#)
- [Stormwater](#)

process, made possible by a Municipal Vulnerability Preparedness (MVP) Planning Grant from the Executive Office of Energy and Environmental Affairs, leverages local knowledge and the experience of community stakeholders to guide future resiliency planning and improvement projects. The Plan presents the top climate-related hazards facing Chelmsford as identified by stakeholders, as well as prioritized actions to respond to these hazards. Submit comments to Evan Belansky at ebelansky@townofchelmsford.us by June 17th.

[Additional Info...](#)

Appendix C
Base Map



Legend

- Town of Chelmsford
- Surrounding Towns
- Open Water
- Fire Stations
- Police Stations
- Town Halls
- Schools
- Emergency Shelters
- Public Water Supply Wells
- Water District Headquarters
- Pump Stations

Major Routes, by Administrative Type

- Interstate
- U.S. Highway
- State Route
- Other Roads

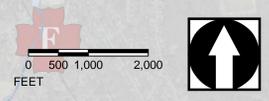
MBTA Commuter Rail Stations

- MBTA Commuter Rail Stations
- MBTA Commuter Rail

USGS 1:25,000 Linear Features

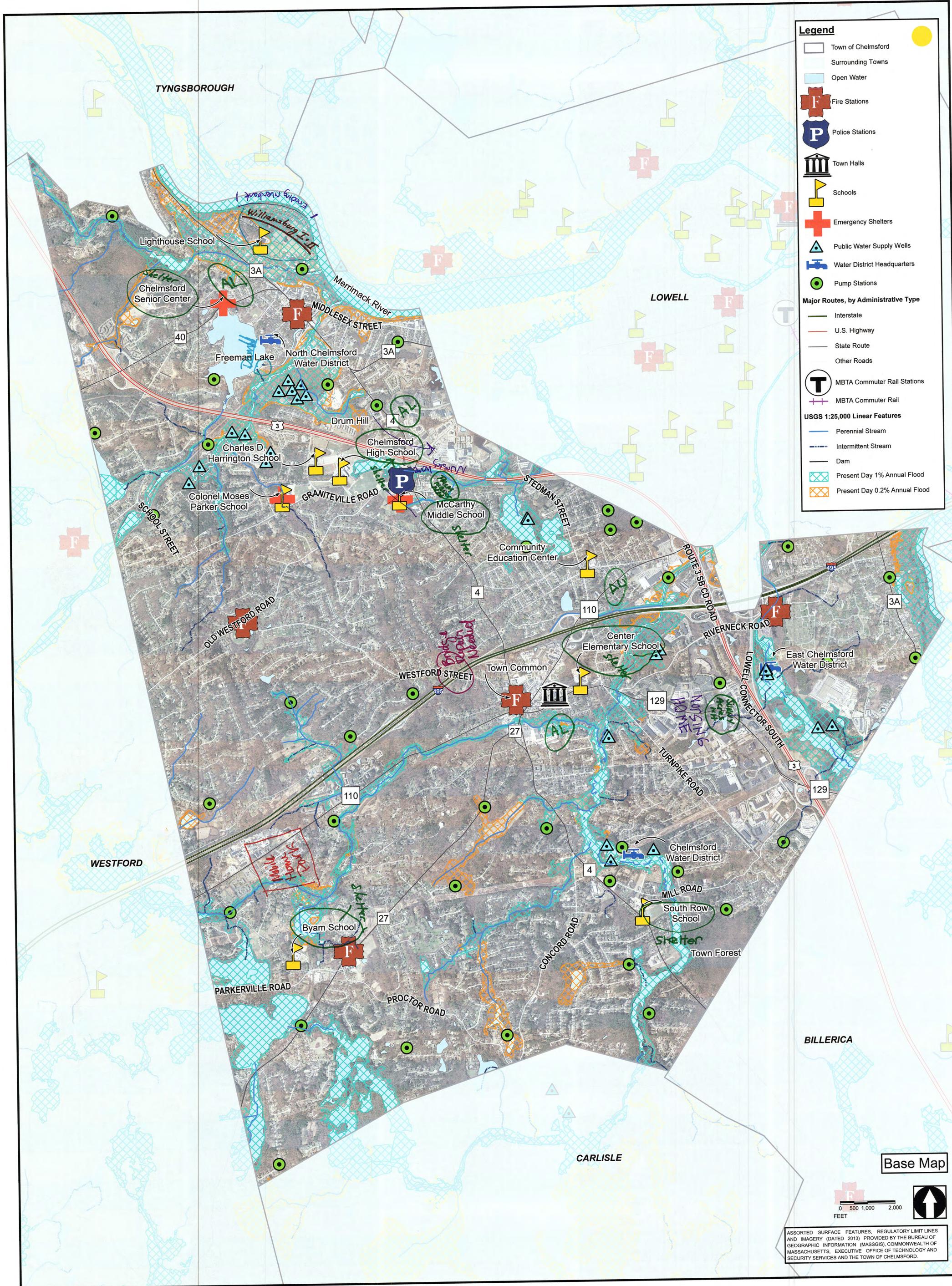
- Perennial Stream
- Intermittent Stream
- Dam
- Present Day 1% Annual Flood
- Present Day 0.2% Annual Flood

Base Map



ASSORTED SURFACE FEATURES, REGULATORY LIMIT LINES AND IMAGERY (DATED 2013) PROVIDED BY THE BUREAU OF GEOGRAPHIC INFORMATION (MASSGIS), COMMONWEALTH OF MASSACHUSETTS, EXECUTIVE OFFICE OF TECHNOLOGY AND SECURITY SERVICES AND THE TOWN OF CHELMSFORD.

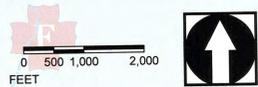
Appendix D
Participatory Mapping



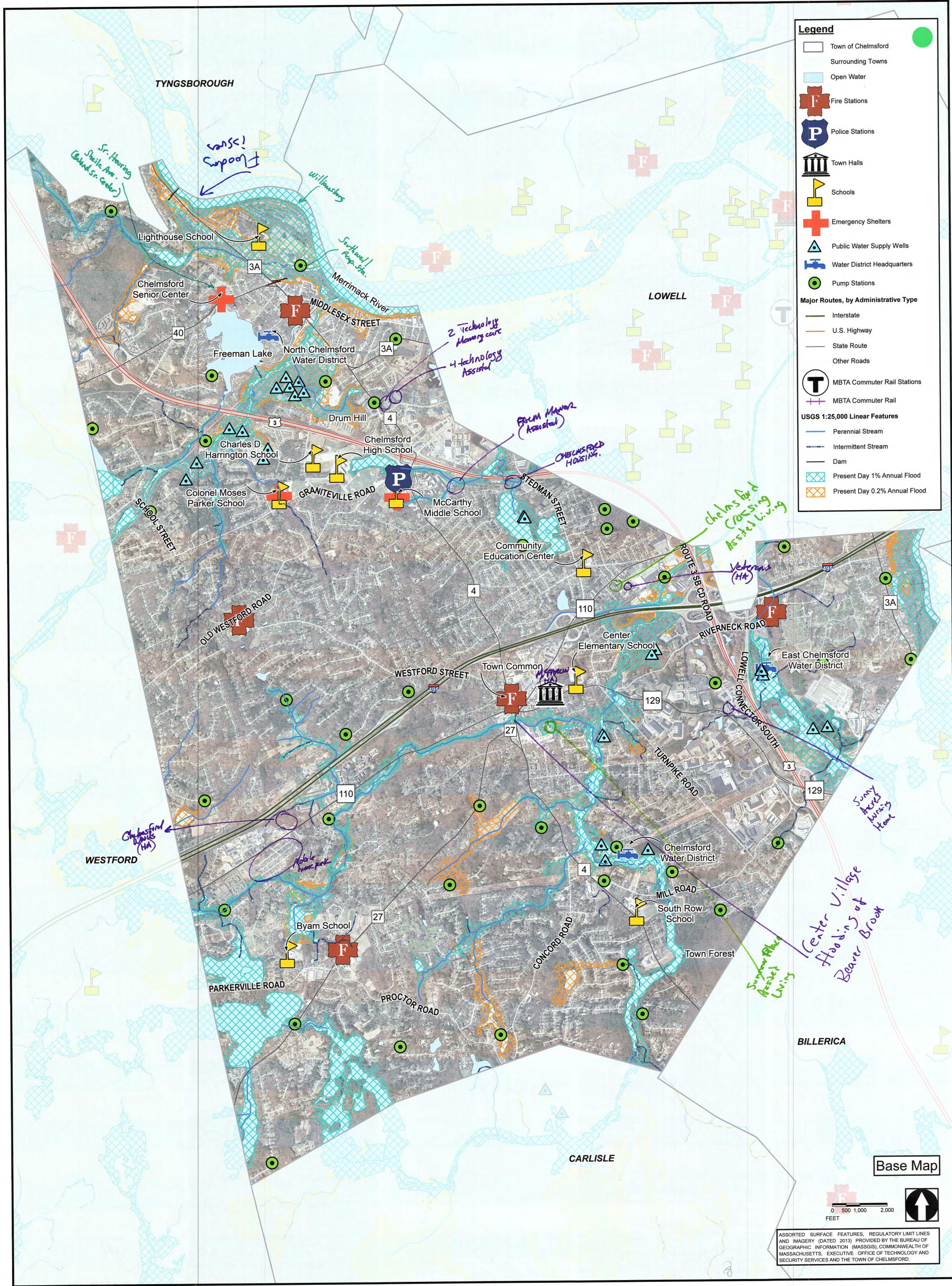
Legend

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Base Map



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Legend

- Town of Chelmsford
- Surrounding Towns
- Open Water
- F Fire Stations
- P Police Stations
- ⌚ Town Halls
- 🚩 Schools
- + Emergency Shelters
- ⚙️ Public Water Supply Wells
- 🚒 Water District Headquarters
- ⦿ Pump Stations

Major Routes, by Administrative Type

- Interstate
- U.S. Highway
- State Route
- Other Roads

USGS 1:25,000 Linear Features

- Perennial Stream
- Intermittent Stream
- Dam

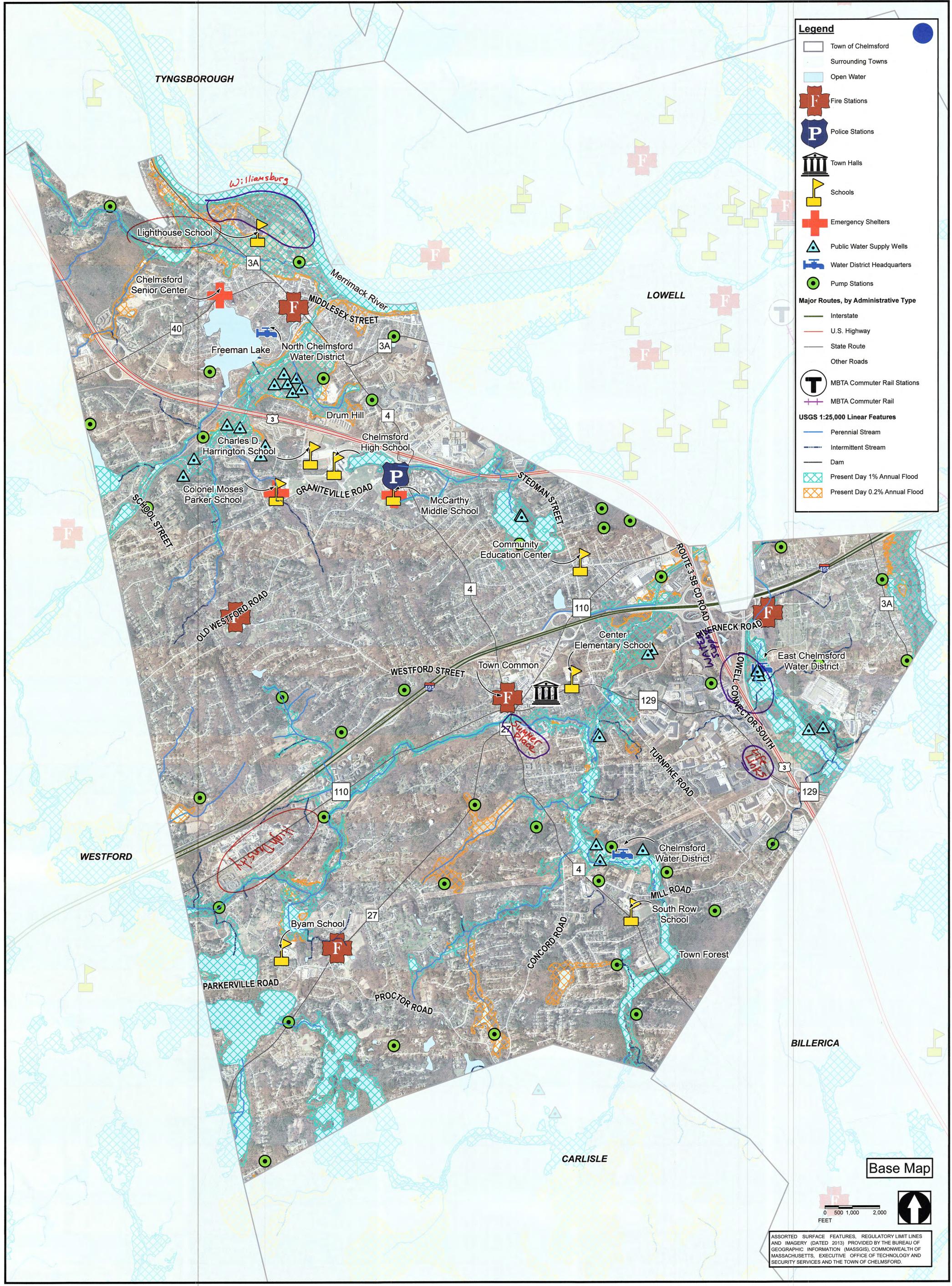
Flood Risk Indicators

- Present Day 1% Annual Flood
- Present Day 0.2% Annual Flood

Base Map

0 500 1,000 2,000
FEET

ASSORTED SURFACE FEATURES, REGULATORY LIMIT LINES AND IMAGERY (DATED 2013) PROVIDED BY THE BUREAU OF GEOGRAPHIC INFORMATION (MASSGIS), COMMONWEALTH OF MASSACHUSETTS, EXECUTIVE OFFICE OF TECHNOLOGY AND SECURITY SERVICES AND THE TOWN OF CHELMSFORD.



Legend

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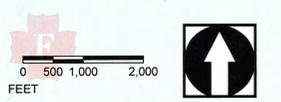
MBTA Commuter Rail Stations

- MBTA Commuter Rail Stations
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USGS 1:25,000 Linear Features

- Perennial Stream
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Base Map



ASSORTED SURFACE FEATURES, REGULATORY LIMIT LINES AND IMAGERY (DATED 2013) PROVIDED BY THE BUREAU OF GEOGRAPHIC INFORMATION (MASSGIS), COMMONWEALTH OF MASSACHUSETTS, EXECUTIVE OFFICE OF TECHNOLOGY AND SECURITY SERVICES AND THE TOWN OF CHELMSFORD.

Appendix E
Public Listening Session Information

Agenda for May 20, 2019 Board of Selectmen Meeting
Summary of Findings Presentation for Listening Session
Public Comments Received



BOARD OF SELECTMEN MEETING AGENDA
 May 20, 2019
 Town Offices, 50 Billerica Road
 Chelmsford, MA 01824
 Dennis Ready Meeting Room 204

1. 7:00 PM CALL TO ORDER - NOTIFICATION OF LIVE BROADCAST

2. PUBLIC SERVICE ANNOUNCEMENTS

- Regina Jackson, Veterans Agent: Memorial Day 2019 Proclamation and Parade Information
- John Osborn, Parade Committee: July 4th Parade
- Proclamation: LGBTQ Pride Month, June 2019

Documents:

[MEMORIAL DAY 2019.PDF](#)
[PROCLAMATION LGBT PRIDE MONTH 2019.PDF](#)

3. OPEN SESSION

4. COMMITTEE VACANCIES

Documents:

[COMMITTEE VACANCIES AS OF 05-20-19.PDF](#)

5. PUBLIC HEARINGS

- All Alcoholic Beverages Restaurant License: Spicy Touch, Inc. DBA Bawarchi Biryani, 313 Littleton Rd., Units 10-12

Documents:

[SPICY TOUCH.PDF](#)

6. LICENSES

- Common Victualer and Entertainment License: Trailside Ice Cream Parlor LLC, 59-61 Central Square, Unit 5
- Change of Hours on All Alcoholic Beverages License: Sterling Golf Management, Inc. DBA Chelmsford Country Club, 66 Park Rd.
- Special License to Sell Wine at an Agricultural Event: House Bear Brewing LLC, Chelmsford Town Common Farmers Market - 6/15/19 to 9/14/19
- One Day Expansion of Entertainment License: Center Brickhouse Pizza, 1 Central Sq., 7/3/19

Documents:

[TRAILSIDE ICE CREAM.PDF](#)
[STERLING GOLF.PDF](#)
[HOUSE BEAR BREWING.PDF](#)
[BRICKHOUSE ENTERTAINMENT EXPANSION.PDF](#)

7. REPORTS AND PRESENTATIONS

- Chelmsford Water District Presentation
- 8:00 PM: MVP Grant Public Listening Session Presentation

Documents:

[MVP PRESENTATION.PDF](#)
[MVP SUMMARY OF FINDINGS REPORT DRAFT 2019-05-15.PDF](#)

8. TOWN MANAGER BID AWARDS

- School Parking Lots Expansion at Center School and Harrington School
- Town Offices Cleaning Services
- Natural Gas
- Golf Course 9th Hole Reconstruction

Documents:

[BID RESULTS SHEET -- PARKING LOT EXPANSION CENTER AND HARRINGTON 4.24.19.PDF](#)
[CLEANING BID -- BID RESULTS.PDF](#)
[NATURAL GAS SUPPLY.PDF](#)
[GOLF COURSE 9TH HOLE RECONSTRUCTION.PDF](#)

9. TOWN MANAGER REPORTS

- Age Friendly Community Certification
- June 12th Listening Session Regarding Town Traffic Issues
- Change in Town Offices Weekday Schedule of Hours of Operation
- BOS Meeting Schedule Milestones

Documents:

[AARP NAFC WELCOME LETTER 368 CHELMSFORD MA 5-10-19 UNSIGNED.PDF](#)
[ENROLLMENT CERTIFICATE 368 CHELMSFORD MA 5-10-19 UNSIGNED.PDF](#)
[TOWN OFFICES WEEKDAY HOURS OF OPERATION.PDF](#)
[BOARD OF SELECTMEN MEETING SCHEDULE MILESTONES 2019-2020.PDF](#)

10. TOWN MANAGER APPOINTMENTS

- Council on Aging, Associate Member: Ami Ogrady, unexpired 3-year term exp. 6/30/2020
- Council on Aging, Associate Member: Jennifer Hardy, unexpired 3-year term exp. 6/30/2020

Documents:

[TOC1184 AMI OGRADY.PDF](#)
[TOC1186 JENNIFER HARDY.PDF](#)

11. BOARD OF SELECTMEN AND TOWN MANAGER FY20 GOALS

Documents:

FISCAL YEAR 2020 GOALS FOR THE BOARD OF SELECTMEN AND TOWN MANAGER.PDF

12. MEETING MINUTES

- BOS Regular Session Minutes 04-08-19
- BOS Regular Session Minutes 04-22-19
- BOS Executive Session Minutes 05-06-19

Documents:

BOS MINUTES 04-08-19.PDF
BOS MINUTES 04-22-19.PDF

13. SELECTMEN LIAISON REPORTS & REFERRALS

14. PRESS QUESTIONS

15. EXECUTIVE SESSION

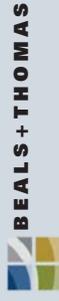
- Strategy with Respect to Pending Litigation from the Police Superior Officers (Sergeants) Union

NEXT REGULAR MEETING DATE: **June 3, 2019**

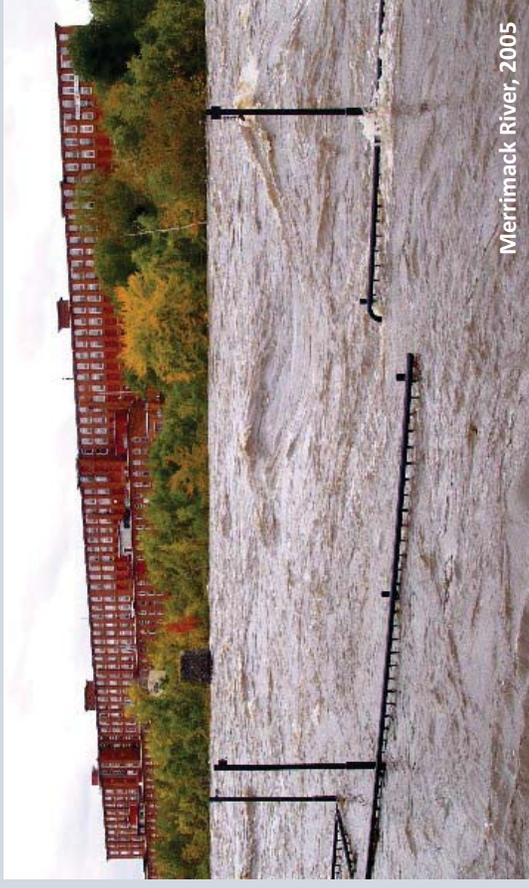


Community Resilience Building: Public Listening Session

Presented by:



May 20, 2019



Merrimack River, 2005

Welcome and Introduction



BEALS + THOMAS

Team Members

Town of Chelmsford Core Team

◦ Evan Belansky, Community Development Director

Beals and Thomas, Inc. (B+T) Facilitators

◦ Eric Las, PE



The Nature
Conservancy
Protecting nature. Restoring life.



www.CommunityResilienceBuilding.org

Municipal Vulnerability Preparedness (MVP) Program



BEALS + THOMAS



BEALS + THOMAS

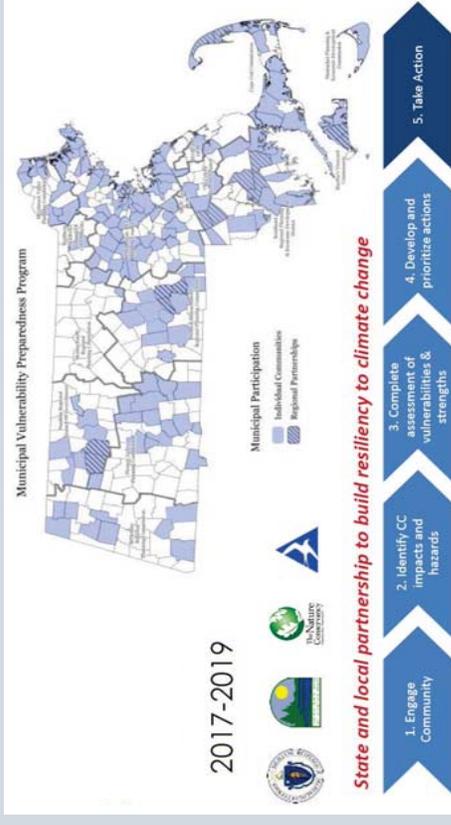
Executive Order 569

Issued by Governor Baker September 2016

- Tasked Executive Office of Energy and Environmental Affairs (EEA) with creating two frameworks to assess vulnerabilities and adaptation strategies related to climate change
 - MVP Office
 - Resilient MA website
 - State Hazard Mitigation and Climate Adaptation Plan



State's Vision for MVP Program



MVP Timeline

- Receipt of Planning Grant: June 2018
- Core Team Established Approach: Late 2019
- Workshop #1: February 2019
- Workshop #2: March 2019
- Public Listening Session: May 2019
- Final Report: June 2019



Listening Session Purpose

Present results of Community Resilience Building workshops to broader public

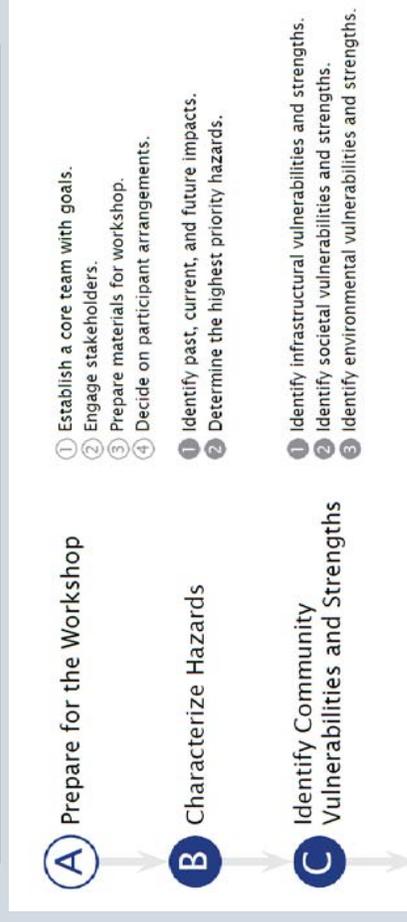
Provide forum for interested members to provide input

Make draft of Summary of Findings report available for written public comment prior to submission to the state



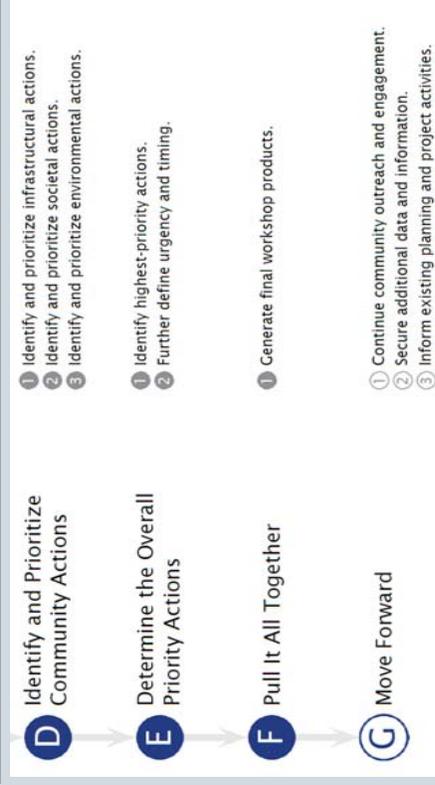
BEALS + THOMAS

MVP Process



BEALS + THOMAS

MVP Process



BEALS + THOMAS

Hazard Mitigation Plan Update

Regional plan prepared by NMCOG in 2015

Recommendations to address natural hazards

- Identified as high hazards:
 - Severe storm events (e.g. Nor'easter, hurricanes, ice storms, snow storms, blizzards)
 - Flooding
 - Wildfires
 - Earthquakes

Prioritized mitigation based on anticipated area of hazard impact, expected benefit, and cost



BEALS + THOMAS

Workshop Objectives

Workshop 1

- Define extreme weather and natural and climate-related hazards
- Identify existing and future vulnerabilities and strengths

Workshop 2

- Develop and prioritize actions for the community and broader stakeholder networks
- Identify opportunities for the community to advance actions to reduce risks and build resilience.



Invited Stakeholders

Chelmsford Town Manager
Chelmsford Board of Selectmen
Chelmsford Police Department
Chelmsford Fire Department
Chelmsford Engineering
Chelmsford Public Works
Chelmsford Energy Manager
Chelmsford Public Facilities
Chelmsford Highway Division
Chelmsford Sewer Division
Chelmsford Building Department
Chelmsford Board of Health
Chelmsford Emergency Management
Chelmsford Department of Community Planning
Chelmsford Conservation Agent
Chelmsford Conservation Commission
Chelmsford Information Technology
Chelmsford Land Conservation Trust
Chelmsford Senior Center
Chelmsford Council on Aging
Chelmsford School Administration

Chelmsford School Committee
Chelmsford Water District
North Chelmsford Water District
East Chelmsford Water District
Massachusetts Department of Transportation District 4
Chelmsford TV
The Trustees of Reservations
Chelmsford Community Exchange (Food Pantry)
Chelmsford Planning Board
Chelmsford Business Association
MA Department of Conservation and Recreation
Chelmsford Housing Authority
Chelmsford Board of Appeals
Historical Commission
Chelmsford Bicycle and Pedestrian Advisory Committee
Chelmsford Commission on Disabilities
Middlesex Canal Commission
Greater Lowell Chamber of Commerce
NMCODG - Director
Chelmsford Finance Director



Definitions

Hazard – cause of negative impacts to community

Risk – potential result from hazard

Vulnerability – feature (societal, environmental, or infrastructural) that is susceptible to risk

Action – addresses vulnerability



Highest Ranked Hazards

Severe Storms

Flooding

Extreme Temperature

Wind

Pollution



Top Priorities to Improve Resiliency

1. Install generator at Adams Library
2. Assess local bridges, culverts, and dams, inspect existing stormwater infrastructure, and implement roadside low-impact development in an effort to mitigate flash flooding
3. Create an inventory of facilities with generators and a prioritized list of facilities that require generators or have undersized generators



Additional High Priority Actions

- Improve communication regarding hazards, such as enrollment of vulnerable populations in the Reverse 911 program
- Create landscaping and maintain trees along roadways
- Continue existing Hardy Tree Program
- Hire a consultant to prepare an alternative access study for the Williamsburg condominium complexes
- Conduct Merrimack River bank stabilization project at Williamsburg
- Establish dedicated funding for invasive species removal and public education



Additional High Priority Actions

- Maintain voluntary database for tracking elderly community members in case of emergency situations
- Streamline communication during extreme storm events
- Hire a Town social worker and enhance volunteer-based programs for vulnerable populations
- Create and maintain new heating/cooling centers
- Establish Twitter or other social media accounts with Town official support and dedicated management
- Hire a consultant to review existing local regulations and create a new comprehensive Stormwater Management Bylaw
- Construct a boat ramp at Hart Pond for emergency response and evacuation



Draft Summary of Findings Report

<https://www.townofchelmsford.us/DocumentCenter/View/9998/MVP-Summary-of-Findings-Report-DRAFT-2019-05-15-2>

Submit comments to EBelansky@TownofChelmsford.US by June 17, 2019.



Next Steps

- Incorporate feedback from listening session into final report
- Prepare updated Hazard Mitigation Plan
- Submit final MVP Summary of Findings report to state for designation as MVP community
- Submit HMP update to MEMA and FEMA for review and comment
- Incorporate MEMA/FEMA comments on HMP
- Final HMP approval from Board of Selectmen
- Prepare and submit MVP Action Grant application for Summer 2019 grant announcement



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MVP Action Grants

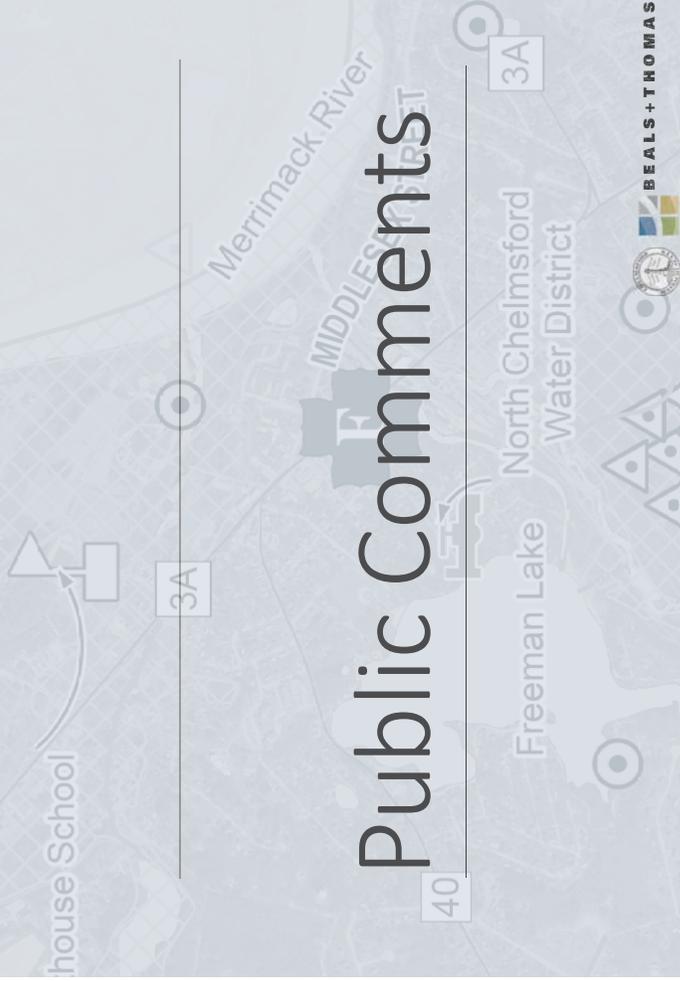
Project categories include:

- Detailed vulnerability/risk assessments
- Local bylaw and ordinance improvements
- Engineering and construction retrofits
- Ecological restoration projects
- Nature-based solutions to reduce vulnerability



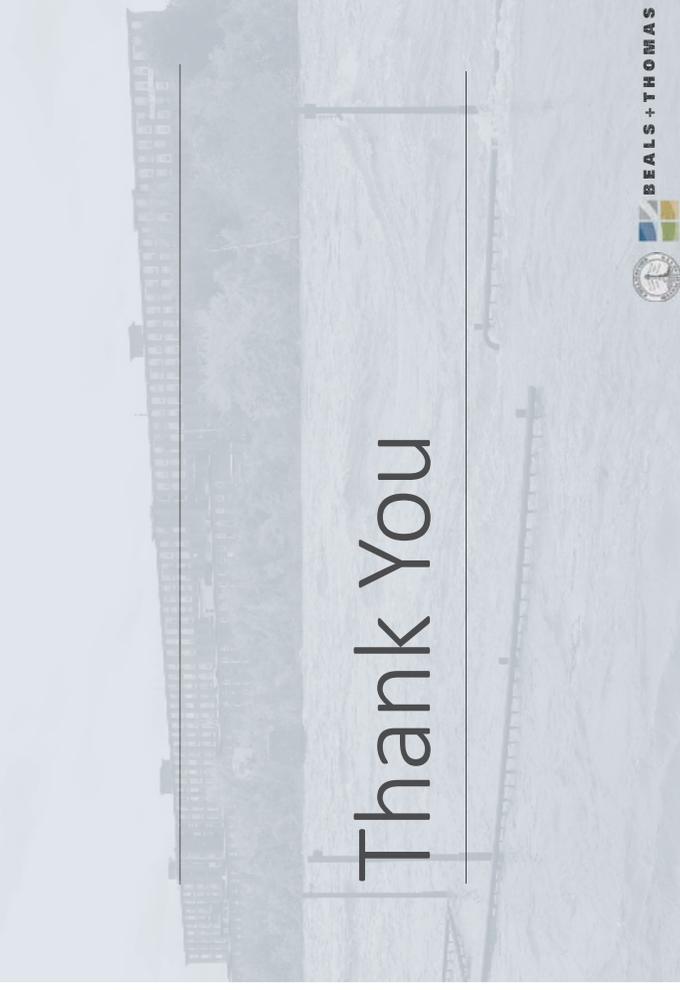
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Public Comments

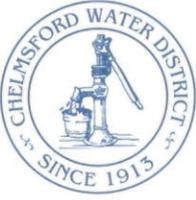


BEALS + THOMAS

Thank You



BEALS + THOMAS



Chelmsford Water District

20 Watershed Lane • Chelmsford MA 01824-4884 • www.chelmsfordwater.com

June 13, 2019

Evan Belansky
Community Development Director
Town of Chelmsford
50 Billerica Rd
Chelmsford Ma 01824

Mr. Belansky,

I have finished the statement listing the facts and reasons supporting the Chelmsford Water District's list of water priorities to be included in the Municipal Vulnerability Preparedness report. Should you need any further information or any clarification of the information submitted please feel free to contact me.

Sincerely,

Todd A. Melanson

Environmental Compliance Manager

Chelmsford Water District

978-256-2381

tmelanson@chelmsfordwater.com

Water Priorities for the Municipal Vulnerability Preparedness program:

The Chelmsford Water District in regards to planning for and accommodating operations to climate change face similar dangers and issues facing the Town of Chelmsford in the amounts of precipitation. In regards to flooding, the District's water resources and water production facilities all exist within the flood plain and are therefore susceptible to infrastructure dangers. In addition to the dangers posed by flooding too much precipitation can and does affect the water quality and overall chemistry of the watershed. These changes with an influx or overabundance of water make treating water, to the standards of drinking water, difficult since it can introduce new contaminants into the water resources or increase the quantities of existing contaminants.

In the case of drought, the District has already experienced the affects and repercussions of drought as recently as 2016. The stress on the system causes well sites to need expedited source maintenance and cleaning due to the decreased water quality. The risk from fire during these times of drought exasperates fire risk situations and the associated demands on a water system. The required and mandated actions associated with drought can cause fiscal issues for the District as well. The economic planning of the Town of Chelmsford is reliant upon the continued access year-round to safe and sufficient quantities of drinking water and fire protection.

An aspect unique to a water utility is the required legal adherence to the Water Management Act (WMA) and the formal inclusion of the Sustainable Water Management Initiative (SWMI) into the WMA. This put further regulatory stresses on the District and its abilities to adjust to climate changes associated with water. The two watersheds and the associated sub-basins that the District withdraws water from are categorized as depleted and both basins being stressed in terms of biological and groundwater withdrawal categories with at least one sub-basin containing a cold-water Fishery Resource within it. These factors can possibly put further regulatory restrictions on withdrawals due to factors centered on climate change.

Given these factors of infrastructure placement and the associated effects of climate change, there are a few priorities the District would like outlined for the MVP program report.

1. A large part of the answer for the District in cases of precipitation focuses on redundancies of sources, to protect from contamination and to balance the load of withdrawal. Therefore, the Chelmsford Water District would like to include water priority resources for wellhead protection through land purchases for wellhead protection or new sources.
2. The Chelmsford Water District would add to the stormwater section a local recharge program but it needs to have measurable quantities that could be associated with the SWMI process in terms of mitigation credits.
3. Monitoring of stormwater should also include the monitoring of stormwater quality, since its ability to transport and spread potential contaminants into wellhead protection areas. A program that highlighted the proper funneling of stormwater into areas without this risk and monitoring of the water quality contained in the stormwater should be considered.
4. Through the use of road treatment materials in our region salt concentrations have increased. Looking for an alternative to road salt and brine solutions would be a water priority as well. The increasing amounts of salt in the surface and groundwater resources of our region have been noted. Salinity Syndrome is highlighted in at least one major academic study/report.

In short, the Chelmsford Water District wants to highlight the need for redundancy in its water resources, further protection of its water resources and the need for local aquifer recharge as its main priorities to be included with the Chelmsford MVP report.

Appendix F
Draft Certificate of Adoption

Chelmsford, Massachusetts

RESOLUTION NO. _

A RESOLUTION OF THE TOWN OF CHELMSFORD, MA ADOPTING THE HAZARD MITIGATION PLAN 2020 UPDATE

WHEREAS the Town of Chelmsford, Board of Selectman recognizes the threat that natural hazards pose to people and property within Chelmsford; and

WHEREAS the Town of Chelmsford has prepared a multi-hazard mitigation plan, hereby known as the Hazard Mitigation Plan 2020 Update in accordance with the Disaster Mitigation Act of 2000; and

WHEREAS the Hazard Mitigation Plan 2020 Update dated _____ identifies mitigation goals and actions to reduce or eliminate long- term risk to people and property in Chelmsford from the impacts of future hazards and disasters; and

WHEREAS adoption by the Town of Chelmsford Board of Selectman demonstrates their commitment to the hazard mitigation and achieving the goals outlined in the Hazard Mitigation Plan 2020 Update dated _____.

NOW THEREFORE, BE IT RESOLVED BY THE CHELMSFORD, MASSACHUSETTS THAT:

Section 1. In accordance with _____, the Town of Chelmsford, Board of Selectman adopts the Hazard Mitigation Plan 2020 Update dated _____.

ADOPTED by a vote of _____ in favor and __ against, and __ abstaining, this _____ day of

_____, _____.

By: _____ (print name)

ATTEST:

By: _____ (print name)

APPROVED AS TO FORM:

By: _____ (print name)