TOWN OF BOXBOROUGH, MA
HAZARD MITIGATION PLAN UPDATE
APRIL 2024

Town of Boxborough
29 Middle Road
Boxborough, MA 01719

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https://www.boxborough-ma.gov

Prepared by:

JAMIE CAPLAN CONSULTING LLC
Emergency Management Services

351 Pleasant Street, Suite B # 208 · Northampton, MA 01060
Phone: 413-586-0867 · Fax: 413-727-8282 · www.jamiecaplan.com

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Acknowledgements

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- Edward Cataldo, Building Commissioner, Town of Boxborough
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- John Szewczyk, Chief of Police, Town of Boxborough
- Wendy Trinks, Coordinator Community/Social Services, Town of Boxborough
- Alexander Wade, Director of Land Use and Permitting, Town of Boxborough

F1. For single-jurisdictional plans, has the governing body of the jurisdiction formally adopted the plan to be eligible for certain FEMA assistance? (Requirement §201.6(c)(5))

Local Adoption Resolution

TOWN OF BOXBOROUGH, MASSACHUSETTS
SELECT BOARD
A RESOLUTION ADOPTING THE
TOWN OF BOXBOROUGH, MA HAZARD MITIGATION PLAN UPDATE
RESOLUTION NO. ___________

WHEREAS the Town of Boxborough recognizes the threat that natural hazards pose to people and property within the Town of Boxborough; and

WHEREAS the Town of Boxborough has prepared a multi-hazard mitigation plan, hereby known as TOWN OF BOXBOROUGH, MA HAZARD MITIGATION PLAN UPDATE in accordance with federal laws, including the Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended; the National Flood Insurance Act of 1968, as amended; and the National Dam Safety Program Act, as amended; and

WHEREAS the TOWN OF BOXBOROUGH, MA HAZARD MITIGATION PLAN UPDATE identifies mitigation goals and actions to reduce or eliminate long-term risk to people and property in the Town of Boxborough from the impacts of future hazards and disasters; and

WHEREAS adoption by the Town of Boxborough Select Board demonstrates its commitment to hazard mitigation and achieving the goals outlined in the TOWN OF BOXBOROUGH, MA HAZARD MITIGATION PLAN UPDATE.

NOW THEREFORE, BE IT RESOLVED BY THE TOWN OF BOXBOROUGH, MA, THAT:

Section 1. In accordance with M.G.L. c. 40, the Town of Boxborough Select Board adopts the TOWN OF BOXBOROUGH, MA HAZARD MITIGATION PLAN UPDATE. While content related to the Town of Boxborough may require revisions to meet the plan approval requirements, changes occurring after adoption will not require Town of Boxborough to re-adopt any further iterations of the plan. Subsequent plan updates following the approval period for this plan will require separate adoption resolutions.

ADOPTED by a vote of ________ in favor and ________ against, and ________ abstaining, this _______ day of _______, ________________.

By: ___________________________________ Kristin Hilberg, Chair

ATTEST: By: ___________________________________ Priya Sundaram, Clerk

APPROVED AS TO FORM: By: ___________________________________

Record of Changes

This Town of Boxborough, MA Hazard Mitigation Plan Update will be reviewed and approved on a biannual basis by the HMPC and following any major disasters. All updates and revisions to the plan will be tracked and recorded in the following table. This process will ensure the most recent version of the plan is disseminated and implemented by the Town.

Table 1. Summary of Changes.

Date of Change	Entered By	Summary of Changes

Chapter 1. Introduction

The Federal Emergency Management Agency (FEMA) defines hazard mitigation per the Code of Federal Regulations (CFR) 44 Section 201.2 as "any **sustained** action taken to reduce **or eliminate** the **long-term risk** to human life and property from hazards."

"Disaster Mitigation Act (DMA) 2000 (Public Law 106-390)[1] provides the legal basis for FEMA mitigation planning requirements for State, local and Indian Tribal governments as a condition of mitigation grant assistance. DMA 2000 amended the Robert T. Stafford Disaster Relief and Emergency Assistance Act by repealing the previous mitigation planning provisions and replacing them with a new set of requirements that emphasize the need for State, local, and Indian Tribal entities to closely coordinate mitigation planning and implementation efforts."[2]

The Town of Boxborough, Massachusetts created this plan as part of an ongoing effort to reduce the negative impacts and costs from damages associated with natural hazards, such as nor'easters, floods, and hurricanes. This plan meets the requirements of the Disaster Mitigation Act 2000. More importantly, the plan was created to reduce loss of life, land, and property due to natural hazards that affect the Town of Boxborough. It is difficult to predict when natural hazards will impact the planning area, but it is accurate to say that they will. By implementing the mitigation actions listed in this plan, the impact of natural hazards will be lessened.

Local Mitigation Plans must be updated at least once every five years to remain eligible for FEMA hazard mitigation project grants. A local jurisdiction must review and revise its plan to reflect changes in development, progress in local mitigation efforts, and changes in priorities, and resubmit it for approval within five (5) years to continue to be eligible for mitigation project grants.

Purpose of the Plan

The purpose of the Local Hazard Mitigation Plan is to provide the Town of Boxborough with a comprehensive examination of all natural hazards affecting the area, as well as a framework for informed decision-making regarding the selection of cost-effective mitigation actions. When implemented, these mitigation actions will reduce the Town's risk and vulnerability to natural hazards.

This plan is a result of a collaborative effort between the Town of Boxborough and the surrounding communities. Throughout the development of the plan, the Hazard Mitigation Planning Committee (HMPC) consulted the public and key stakeholders for input regarding identified goals, mitigation actions, risk assessment, and mitigation implementation strategy. A sample of key stakeholders who

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[1] Disaster Mitigation Act of 2000, Pub. L. 106-390, as amended

[2] Disaster Mitigation Act of 2000. https://www.congress.gov/106/plaws/publ390/PLAW-106publ390.pdf

participated, included the Massachusetts Emergency Management Agency (MEMA) and the Metropolitan Area Planning Council (MAPC).

Guiding principles for plan development

The HMPC adhered to the following guiding principles in the plan's development.[3]

- Plan and invest for the future.
- Collaborate and engage early.
- Integrate community planning.

This plan update meets the requirements outlined 44 CFR § 201.6(d)(3). These requirements are included in the plan in the green call-out boxes, like the one below.

> A local jurisdiction must review and revise its plan to reflect changes in development, progress in local mitigation efforts, and changes in priorities, and resubmit it for approval within 5 years in order to continue to be eligible for mitigation project grant funding.

Yellow call-out boxes like the one to the right, are definitions taken from the Federal Emergency Management Agency Local Policy Guide, April 2023. These are included throughout the plan for reference and explanation.

The HMPC prioritized mitigating impacts of climate change, mitigating risk to vulnerable communities, and protecting the built environment both today and in the future.

> ***COMMUNITY RESILIENCE*** *is the ability of a community to prepare for anticipated hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions. Activities such as disaster preparedness (which includes prevention, protection, mitigation, response and recovery) and reducing community stressors (the underlying social, economic and environmental conditions that can weaken a community) are key steps to resilience.*[1]

The HMPC identified the following list of hazards to profile. They are shown in alphabetical order below.

- Drought
- Earthquakes
- Extreme Temperatures
- Flooding
- Hurricanes/Tropical Storms
- Invasive Species

[3] Federal Emergency Management Agency. (April 19, 2022). Local Mitigation Planning Policy Guide, p.13.

- Landslides
- Other Severe Weather
- Severe Winter Storms
- Tornadoes
- Wildfires or Brush Fires

Mitigation Strategy

C3. Does the Plan include goals to reduce/avoid long-term vulnerabilities to the identified hazards? (Requirement §201.6(c)(3)(i))

The hazard mitigation strategy is the culmination of work presented in the Planning Area Profile (Chapter 2), Risk Assessment (Chapter 4), and Capability Assessment (Chapter 5). It is also the result of multiple meetings and sustained public outreach. The HMPC developed the goals shown below. The goals from the previous Town of Boxborough Hazard Mitigation Plan, 2010 and the Town's Municipal Vulnerability Preparedness Plan (MVP), 2021 were revised to develop this current list. Information about the goal development process is in Chapter 6 (Mitigation Strategy). The goals are considered "broad policy-type statements"[4] that represent the long-term vision for mitigating risk to natural hazards in the Town of Boxborough.

[4] Federal Emergency Management Agency. (2013). *Local Mitigation Planning Handbook,* p. 6.

SAVE LIVES and PROPERTY

- Reduce risk to people and property from natural hazards and climate change.

Infrastructure

- Mitigate risk to critical facilities and infrastructure from natural hazards and climate change.

Capacity

- Expand the Town's capacity to mitigate risk by adopting a culture of hazard mitigation through regulations, planning, and regional collaboration.

Natural Resources

- Implement actions that minimize risk from climate change and natural hazards to preserve or restore the functions of natural systems.

Education

- Educate all stakeholders about the value of hazard mitigation and how to implement it in their work, businesses, and homes.

Figure 1. Mitigation Plan Goal Statements.

Land Use and Development

Changes in Development

E1. Was the plan revised to reflect changes in development? (Requirement §201.6(d)(3))

The Town of Boxborough continues to experience slow and steady growth, but it has not experienced significant changes in development that have occurred in hazard-prone areas since the last plan update in 2010. Although the community grew rapidly during the 1970s and 1990s, it grew much more slowly during the 2000s. Recent development has been scattered throughout the Town with mostly low-density, single-family home development on large lots rather than denser subdivisions. One exception is the Enclave Housing Development, a 50-unit housing complex consisting of two-family dwellings and reserved exclusively for age-restricted occupancy (constructed in at the intersection of Massachusetts

***CHANGES IN DEVELOPMENT** means recent development (for example, construction completed since the last plan was approved), potential development (for example, development planned or under consideration by the jurisdiction), or conditions that may affect the risks and vulnerabilities of the jurisdictions (for example, climate change, declining populations or projected increases in population, or foreclosures) or shifts in the needs of underserved communities or gaps in social equity. This can also include changes in local policies, standards, codes, regulations, land use regulations and other conditions.*

Avenue and Stow Road). Commercial development activities were mostly located along existing transportation corridors and office parks, but none of these development activities occurred within known hazard areas.

The Town's current priorities and ongoing efforts to preserve and protect open space and other natural or environmentally sensitive areas have been quite effective at restricting hazardous development. Although there is a significant amount of land that is potentially developable, future growth elsewhere in the community is also limited by infrastructural, environmental, and regulatory constraints, as well as a reticence toward increased development. For example, the Town's current (2016) Master Plan focuses on maintaining Boxborough's traditional values of rural open space, agricultural and conservation lands, and historic roots while fostering a balanced economic environment. It explains that the "preservation of the ecological, agricultural, historic, and scenic resources that contribute to the community's rural character is of critical importance to the community." As a result, there has been a noted change in housing policy/strategy for the Town in recent years, with greater priority being placed on enhancing existing building stock versus increasing it through new development projects. The Town's more recent (2023) Open Space and Recreation Plan affirms the importance of preserving the openness of the landscape and the quality of environmental resources and has also begun to incorporate climate resiliency as a key value for the community.

Also, as further described in Chapter 5 (Capability Assessment), land use and development projects in Boxborough are regulated through the Town's zoning bylaw and other regulations which prevent or restrict activities that could lead to increased hazard vulnerability. This includes preventing irresponsible development in its designated Flood Plain District in addition to the Town's own wetlands protection regulations, subdivision regulations, and stormwater management rules and regulations that continue to be reviewed and updated on a regular basis. However, as noted by the HMPC as part of the plan update process, one area of required improvement is better alignment between the Town's zoning bylaw and the Master Plan. The existing zoning bylaw is tailored to site specific regulation, with few resources for long-term planning. Aside from the Open Space Commercial Development Permit (OSCD), there are no measures to effectively direct development in the community. This has resulted in some inherent conflicting policies, such as requiring larger building footprints through increased floor area totals and maximum building height restrictions (i.e., encouraging building out versus building up, which goes against the Town's land conservation goals). The focus on site specific development has limited the Town's comprehensive strategy and embedded itself in policy, so a more detailed strategy to align investment with action is needed to maximize implementation.

A related area of concern has to do with the Town's aggressive pursuit of more protected open space and conservation land. Nearly all vacant, developable land is being targeted for conservation, without consideration of long-term economic impact. It was noted by the HMPC that a strategy could be taken to focus the conservation efforts to certain areas, such as hazard-prone areas or lands adjacent to existing trails or recreation sites, and excluding land not otherwise connected. Similarly, as noted above, revisiting site specific regulations will be important. This plan update reflects these issues through recommended capability improvement opportunities and new mitigation actions, and they will remain areas of focus for the Town moving forward.

Despite these issues the Town doesn't anticipate any proposed or planned future development to occur in hazard-prone areas or that would otherwise increase the risks and vulnerabilities of the community to hazards. As noted above, most new growth that occurs in Boxborough is generally single-family residential and in conventional, low-density subdivisions on vacant, buildable land. However, as described in Chapter 4 (Risk Assessment), it is anticipated that climate change and projected future conditions will increase possible threats that are associated with multiple hazards. Among the greatest concerns for Boxborough is the expected increase in the frequency and/or severity of flooding caused by extreme rainfall or other severe weather events, along with periods of drought and extreme heat. Increasing risks associated with these hazards could result in more frequent and/or more severe impacts to the community and especially those populations considered to be more vulnerable to their effects as described in Chapter 4.

Progress in Mitigation Efforts

E2. Was the plan revised to reflect changes in priorities and progress in local mitigation efforts? (Requirement §201.6(d)(3))

Priorities in the Town of Boxborough are in the process of changing. The Town had a 75% turn-over in Select Board members in 2023. The new Select Board is focused more specifically on economic development than the previous Select Board. The previous priority was, and current interest of the Sustainability Committee, is focused on being a "green" community and increasing climate resilience. While these two perspectives can oppose each other, the HMPC is looking for a nod from this Plan of how to achieve both goals. In addition, the Master Plan has recently expired, and the Town intends to incorporate priorities from this Plan in a Master Plan update. Finally, the priority in the previous Plan was creating new housing and that priority has shifted to supporting existing housing with rental and emergency assistance and repair and maintenance. The Town has shifted focus away from new construction. The development of the new Master Plan will incorporate the Town's current priorities of long-range planning.

The status of each mitigation action from the 2010 Multi-Hazard Mitigation Plan is included in Chapter 6 (Mitigation Strategy). The text in this chapter includes a designation of Completed, Completed & To Be Continued, Partially Completed/In Progress, Delayed, or Cancelled with a description. In addition, if the mitigation action has moved forward to this Plan's list of actions that is indicated.

The 2010 Multi-Hazard Mitigation Plan concepts were integrated throughout Town plans developed since 2010 including the following plans:

- Housing Production Plan (2015)

- Boxborough 2030 – Master Plan (2016)
- Municipal Vulnerability Preparedness (MVP) / Community Resilience Building (CRB) Summary of Findings Report (2021)
- Community Preservation Plan (2021)
- Open Space and Recreation Plan (2023)

In addition, local regulations such as the Zoning Bylaws amended in 2022 include the integration of mitigation concepts and policies. Including mitigation principles into these plans and into Town policies and budget processes was the way the Town to leveraged concepts of reducing risk and increasing resilience from the 2010 Multi-Hazard Mitigation Plan.

Authority and Assurances

The Town of Boxborough will continue to comply with all applicable Federal laws and regulations during the periods for which it receives grant funding, in compliance with 44 CFR 201.6. It will amend its plan whenever necessary to reflect changes in City, State or Federal laws and regulations, as required in 44 CFR 201.6. The list of laws and regulations the Town with adhere to is below.

- Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), as amended.
- National Flood Insurance Act of 1968, as amended.
- National Dam Safety Program Act (Pub. L. 92-367), as amended.
- 44 CFR Part 201 Mitigation Planning.
- 44 CFR, Part 60, Subpart A, including § 60.3 Flood plain management criteria for flood-prone areas.
- 44 CFR Part 77 Flood Mitigation Grants[10].
- 44 CFR Part 206 Subpart N. Hazard Mitigation Grant Program.

Plan Adoption

The Town of Boxborough will adopt the Plan when it has received "approved-pending adoption" status from the Federal Emergency Management Agency (FEMA). The Certificate of Adoption is included on page 7.

Document Overview

Below is a summary of the Town of Boxborough, MA Hazard Mitigation Plan Update chapters, including appendices. The planning process closely adhered to FEMA guidelines and to the intent of those guidelines.

Chapter 2: Planning Area Profile

The Planning Area Profile chapter describes the Town of Boxborough, including history, population, government, and infrastructure.

Chapter 3: Planning Process

The Planning Process chapter documents the methodology and approach of the hazard mitigation planning process. The chapter summarizes the HMPC meetings and the public outreach process (including public meetings). This chapter guides the reader through the process of generating this plan and reflects its open and inclusive public involvement process.

Chapter 4: Risk Assessment

The Risk Assessment identifies the natural hazard risks to the Town of Boxborough and its residents. The risk assessment looks at current and future vulnerabilities based on land use development including structures and infrastructure. Included in this chapter is a list of critical facilities identified by the HMPC.

Chapter 5: Capability Assessment

The Capability Assessment looks at the Town's ability to mitigate risk prior to and following disaster. This chapter is structured around the following four categories: planning and regulatory, administrative, and technical, financial, as well as education and outreach. The chapter concludes with information regarding the National Flood Insurance Program (NFIP).

Chapter 6: Mitigation Strategy

This chapter provides a blueprint for reducing losses identified in the Risk Assessment. The chapter presents the hazard mitigation goals and identifies mitigation actions in priority groupings. Each mitigation action includes essential details, such as Town lead, potential funding sources, and implementation timeframe.

Chapter 7: Plan Implementation and Maintenance

The Plan Implementation and Maintenance establishes a system and mechanism for periodically monitoring, evaluating, and updating the Town of Boxborough Hazard Mitigation Plan Update. It also includes a plan for continuing public outreach and monitoring the implementation of the identified mitigation actions.

Appendices

The Appendices includes documentation regarding the planning process, the list of mitigation actions and the *Hazus* Reports.

Chapter 2: Planning Area Profile

The Town of Boxborough, with a population of 5,506[5], is in Middlesex County just 25 miles northwest of Boston. The Town has a land area of 10.4 square miles. Neighboring communities include Littleton to the north, Stow to the south, Acton to the east, and Harvard to the west. Boxborough's rural character, very low housing density, and limited mixed-used Town Center has led to the Town being categorized as a "Country Suburb" by the Metropolitan Area Planning Council (MAPC).[6] The figure below shows the Town's boundaries and its location in Massachusetts.

[5] QuickFacts Boxborough Town, Berkshire County, Massachusetts. (2022). United States Census Bureau.

[6] Town of Boxborough Open Space and Recreation Plan 2022-2027. (2023). Town of Boxborough, Massachusetts.

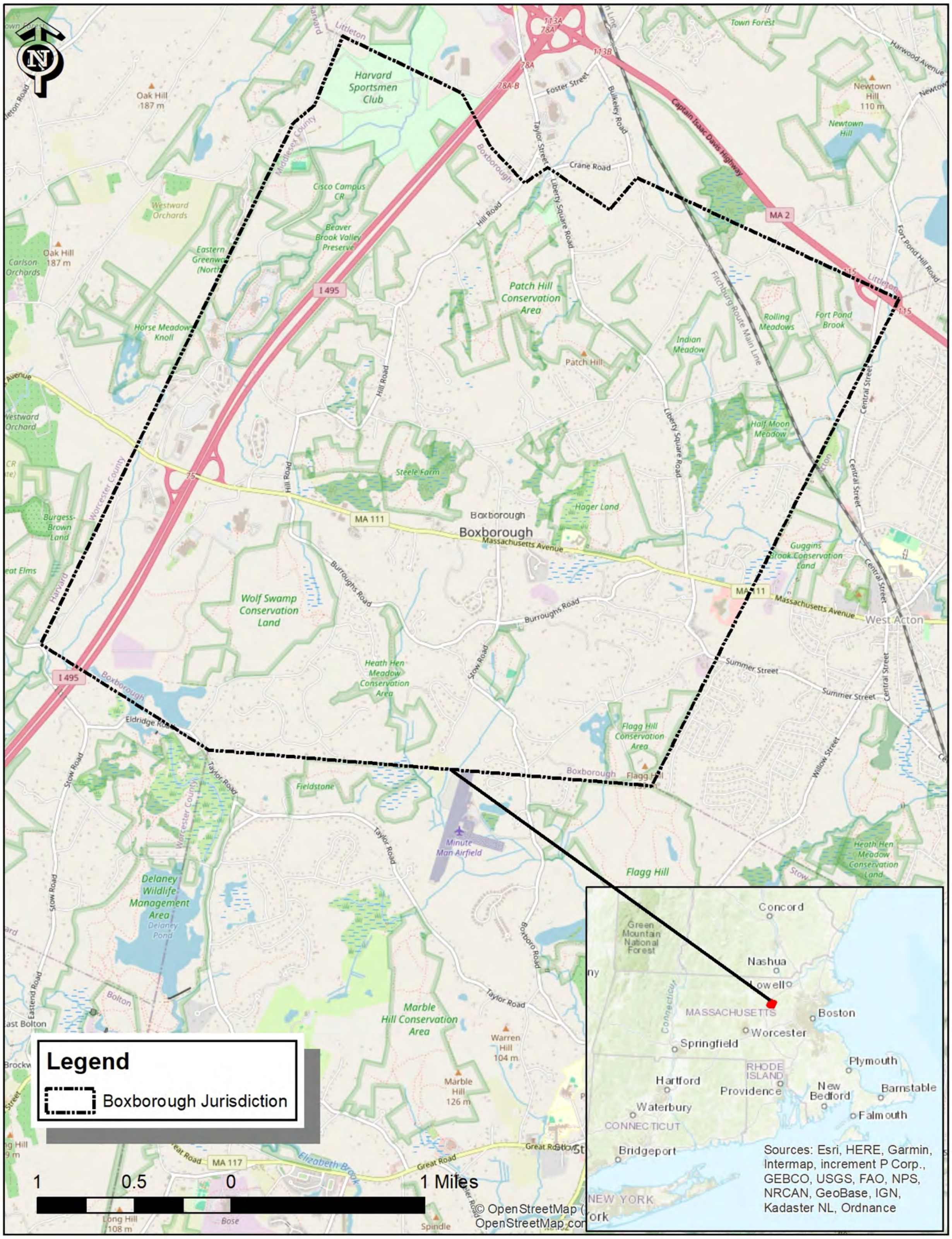

Figure 2. Boxborough Base Map.

Boxborough was originally described as a small farming town. In 1775, the Town's founding families acquired an old meeting house from the Town of Harvard and transported it to the hilltop intersection of Hill Road and Middle Road. A small center village started to grow around the meeting house and the Town was eventually incorporated in 1835. Though Boxborough held onto its agricultural character with dispersed farms that grew grain and raised livestock, there were a few small gristmills, sawmills, and cooperages alongside some manufacturing like shoemaking and comb-making. Boxborough's economy remained almost entirely agricultural throughout the 19th century.[7]

In 1860, the "heart of the town was still dominated by an ancient oak forest of perhaps a thousand acres" and was both visited and documented by naturalist, poet, and philosopher Henry David Thoreau. The woods were lumbered as part of the Civil War efforts which transformed them into crop and grazing lands. Dairy farms became increasingly important in the Town in addition to large orchards and poultry raising. Farming continued through the 1970s, but farming of all types has since declined in Boxborough.[8]

After the industry shifted away from farming, more development took place in the Town with the expansion of several multi-family buildings and office parks. The increasing development and land use change led to a focus on conserving the community's natural landscape to protect the Town's unique natural resources.[9]

The Town has a Town Administrator and Select Board form of government. The Town Administrator is the Chief Operating Officer and coordinates general administration, human resources, procurement, and public inquiries for the Town.[10]

People

As of 2020, 69.5% of the Town identified as White, 9.4% identified as Black or African American, 17.5% of the population identified as Asian, and 1.4% identified as Hispanic or Latino. The foreign-born population in Town is 25.7%. There are approximately 2,166 households in Boxborough and the median household income is $151,207. The number of people living in poverty is 4.0 %. Ninety-seven percent of the Town, aged 25 years or older, have a high school or higher diploma.[11]

The State of Massachusetts' defines "Environmental Justice Populations" as areas of a community where at least one of the following criteria it true:

[7] Town of Boxborough Open Space and Recreation Plan 2022-2027. (2023). Town of Boxborough, Massachusetts.

[8] Town of Boxborough Open Space and Recreation Plan 2022-2027. (2023). Town of Boxborough, Massachusetts.

[9] Town of Boxborough Open Space and Recreation Plan 2022-2027. (2023). Town of Boxborough, Massachusetts.

[10] Town Administrator. (n.d.). Town of Boxborough, Massachusetts.

[11] QuickFacts Boxborough Town, Middlesex County, Massachusetts. (2022). United States Census Bureau.

1. Annual median household income is 65% or less of the state's annual median household income.
2. Minorities make up 40% or more of the city or town's population.
3. Twenty-five percent or more of households speak English "less than very well."
4. Minorities make up 25% or more of the population *and* the annual median household income of the municipality where the neighborhood is located does not exceed 150% of the statewide annual median household income.[12]

These populations are more vulnerable due to being disproportionately affected by the negative impacts of natural hazards nationwide. The data for identifying Environmental Justice Populations comes from the Executive Office of Energy and Environmental Affairs (EEA) who uses American Community Survey data.[13]

The entirety of Boxborough falls under the "Minority" Environmental Justice Criteria with each of the three census block groups having 31-36% of a Minority population present in the community.[14]

Land Use and Development (Structures)

The predominant land uses in Town are single-family homes and open space. Even though agriculture played a large role in the development and character of the Town, it only accounts for about 3% of land use today. [15]

The growth and development patterns in Boxborough are scattered with many low-density, single-family homes located on large lots. There are a few areas with concentrated commercial development that can be found adjacent to Interstate 495.[16] Boxborough is primarily a rural Town.

The Town has seven underlying zoning districts which can be found in the list below.

1. Agricultural-Residential Zoning District
2. Residential-1 Zoning District
3. Business District
4. Business-1 District
5. Office Park District

[12] "Environmental Justice Populations in Massachusetts." (2024). Commonwealth of Massachusetts. https://www.mass.gov/info-details/environmental-justice-populations-in-massachusetts

[13] "Environmental Justice Populations in Massachusetts." (2024). Commonwealth of Massachusetts. https://www.mass.gov/info-details/environmental-justice-populations-in-massachusetts

[14] "Massachusetts 2020 Environmental Justice Populations Map Viewer." (2022). State of Massachusetts.

[15] Town of Boxborough Open Space and Recreation Plan 2022-2027. (2023). Town of Boxborough, Massachusetts.

[16] Town of Boxborough Open Space and Recreation Plan 2022-2027. (2023). Town of Boxborough, Massachusetts.

6. Town Center District
7. Industrial-Commercial District.[17]

In addition to these seven zoning districts, the Town also has four overlay districts which include an Aquifer Protection Overlay, Flood Plain Overlay, Wireless Communication Facilities Overlay, and Recreational Marijuana Establishments Overlay.[18]

A map of Boxborough's seven zoning districts can be found below.

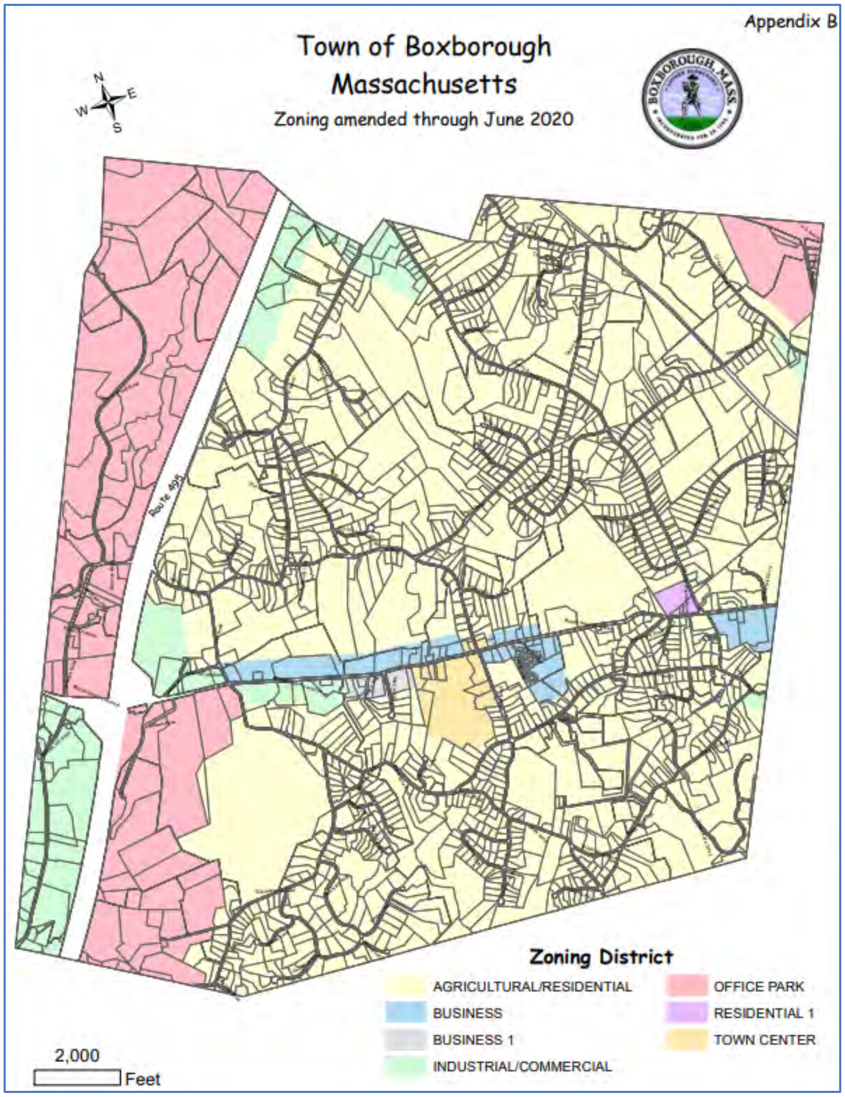

Figure 1. Zoning District Map of Boxborough.

[17] Town of Boxborough Open Space and Recreation Plan 2022-2027. (2023). Town of Boxborough, Massachusetts.

[18] Town of Boxborough Open Space and Recreation Plan 2022-2027. (2023). Town of Boxborough, Massachusetts.

Natural Resources

Natural resources provide habitats for plants and animals, increase biodiversity, and support various ecosystems while also providing recreational opportunities and access to the natural environment. Natural resources include features such as bodies of water like rivers and wetlands and open space like forests and parks. These features play an important part in maintaining environmental sustainability and life, but they are also threatened by natural hazards and climate change. As a result, they need to be protected and managed in order to mitigate risk to people and the built environment, prevent irreparable damage to the resources themselves, and lessen the impacts of major threats such as floods or drought.

Rivers

There are no major rivers in Boxborough, however, there are six named brooks that drain via intermediaries into the Merrimack River, and they are listed in alphabetical order as follows:

1. Beaver Brook
2. Elizabeth Brook
3. Fort Pond Brook
4. Guggins Brook
5. Health Hen Meadow Brook
6. Inches Brook.[19]

Surface Water

The Town is located within the Sudbury, Assabet, and Concord River Watershed (SuAsCo) and partially within the Merrimack Watershed. Surface water flows into Boxborough from run-off coming from a series of hills in Harvard and from wetlands associated with the Littleton Heron Rookery.[20]

Boxborough has five small ponds that provide recreational opportunities and habitat for wildlife. The ponds and their size are lifted in alphabetical order as follows:

1. Flerra Pond – 3/4 of an acre
2. Flagg Hill Pond – 12 acres
3. Eldridge Pond – 2 acres
4. Muddy Pond – 1 acre
5. Fort Pond Brook Pond – 2 acres.[21]

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[19] Town of Boxborough Open Space and Recreation Plan 2022-2027. (2023). Town of Boxborough, Massachusetts.

[20] Town of Boxborough Open Space and Recreation Plan 2022-2027. (2023). Town of Boxborough, Massachusetts.

[21] Town of Boxborough Open Space and Recreation Plan 2022-2027. (2023). Town of Boxborough, Massachusetts.

Wetlands

Wetlands in Boxborough are distributed throughout the Town. The larger wetlands that play an important role in the Town's ecology are Wolf Swamp, Heath Hen Meadow Brook wetlands, Beaver Brook wetlands, and Guggins Brook wetlands. The Town has a local Wetlands Bylaw that sets a 100-foot protective buffer in addition to the Massachusetts Wetlands Protection Act.[22]

Open Space and Recreation

Approximately one third of the Town's 6,600 acres is protected as Town-owned conservation land, land held in a non-profit land trust (Boxborough Conservation Trust and Sudbury Valley Trustees), privately-owned land with agricultural, open space, conservation, or historical restrictions, State land (Fisheries and Wildlife Division), or privately-owned land that is temporarily protected.[23]

Critical Facilities and Infrastructure

Critical facilities and infrastructure are considered community lifelines; towns rely on these facilities before, during, and after a disaster. Critical facilities and infrastructure are important to identify and manage because of the services and access they provide daily. Mitigating risks related to natural hazards and climate change improves a town's resilience and economic vitality.

Water & Sewer Service

There is no municipal water supply in Town, aside from a small system that serves Town buildings. There are 24 privately-owned public water supply systems that serve homes and businesses while the Littleton Water Department provides water to Central Street and parts of Leonard Road. All other properties rely on private wells for potable water.[24]

For fire protection, Boxborough has 20 cisterns and several fire ponds located throughout the Town. The fire ponds range from 60,000 to two million gallons and are located on Beaver Brook Road, Burroughs Road, Massachusetts Avenue, Old Harvard Road, Paddock Lane, Pine Hill Road, and Stow Road. [25]

There are some privately-owned wastewater facilities that serve large commercial sites like the Boxborough Regency and Campanelli Campus as well as housing developments and some commercial properties.[26] The Town does not have a municipal sewage system.

[22] Town of Boxborough Open Space and Recreation Plan 2022-2027. (2023). Town of Boxborough, Massachusetts.
[23] Community Preservation Plan. (2021). Town of Boxborough, Massachusetts.
[24] Town of Boxborough Open Space and Recreation Plan 2022-2027. (2023). Town of Boxborough, Massachusetts.
[25] Town of Boxborough Open Space and Recreation Plan 2022-2027. (2023). Town of Boxborough, Massachusetts.
[26] Town of Boxborough Open Space and Recreation Plan 2022-2027. (2023). Town of Boxborough, Massachusetts.

Waste Management

The Town's Department of Public Works runs a transfer and recycling center for residential waste. Residents interested in trash pick-up hire commercial services. [27]

Critical Facilities

The term "critical facilities" is often used to describe structures necessary for a community to respond and recover in emergency situations. These facilities often include emergency response facilities (fire stations, police stations, rescue squads, and emergency operation centers [EOCs]), custodial facilities (jails and other detention centers, long-term care facilities, hospitals, and other health care facilities), schools, emergency shelters, utilities (water supply, wastewater treatment facilities, and power), communications facilities, and any other assets determined by the community to be of critical importance for the protection of the health and safety of the population. The adverse effects of damaged critical facilities can extend far beyond direct physical damage. Disruption of health care, fire, and police services can impair search and rescue, emergency medical care, and even access to damaged areas.

> The Local Mitigation Planning Handbook (FEMA, 2013) explains that *"Critical facilities are structures and institutions necessary for a community's response to and recovery from emergencies. Critical facilities must continue to operate during and following a disaster to reduce the severity of impacts and accelerate recovery. When identifying vulnerabilities, it is important to consider both the structural integrity and content value of critical facilities and the effects of interrupting their services to the community."*

The number and nature of critical facilities in a community can differ greatly from one jurisdiction to another, and usually includes both public and private facilities. Each community needs to determine the relative importance of the publicly and privately owned facilities that deliver vital services, provide important functions, and protect special populations.

A list of the critical facilities in Boxborough is provided in the table below. This list was obtained from the previous edition of the hazard mitigation plan and the MVP-funded Community Resilience Building (CRB) plan; and reviewed by the HMPC throughout the planning process.

The Boxborough Fire Station and Boxborough Police Station are the only two facilities with back-up power. The Blanchard Memorial School serves as the Town's heating and cooling center.

[27] Town of Boxborough Open Space and Recreation Plan 2022-2027. (2023). Town of Boxborough, Massachusetts.

Table 2. Critical Facilities List.

Name	**Address**
Town Hall	29 Middle Road
Boxborough Fire Station	502 Massachusetts Avenue
Boxborough Police Station	520 Massachusetts Avenue
Dept. of Public Works Garage	873 Massachusetts Avenue
Blanchard Memorial School	493 Massachusetts Avenue
Ice Rink	34 Massachusetts Avenue
Regency Hotel	242 Adams Place
Albert J. Sargent Memorial Library	427 Massachusetts Avenue
Water Pump Station	1 Commercial Street
Communications Towers	85 Swanson Road 423 Massachusetts Avenue 575 Middle Road
Cell Towers	90 Central Street 317 Codman Hill Road 278 Codman Hill Road
Fire Ponds	92 Park Street

Critical Transportation Infrastructure

Boxborough's primary arterial roads are Interstate 495, Route 2, and Route 111. There are also several "collector roads" that connect local access roads to these three arterial roads. The MBTA Commuter Rail's Fitchburg Line runs through Boxborough but does not stop in the Town. The Boxborough Council of Aging operates vans services on various weekdays. In 2021, this service provided over 840 rides to old adults and residents with disabilities.

Minute Man Air Field, a privately-owned, public use airport, that has facilities to land twin engine planes is in Boxborough and the neighboring Town of Stow.[28]

Dams

There are no high or significant hazard dams in Boxborough. There is one privately-owned dam on Guggins Brook alongside a beaver dam located on a Massachusetts Bay Transportation Authority (MBTA) property.

Economy

Major employers in the Town are:

[28] Town of Boxborough Open Space and Recreation Plan 2022-2027. (2023). Town of Boxborough, Massachusetts.

1. Campanelli-Trigate Boxborough Sub, LLC
2. Advanced Micro Devices
3. Symantec
4. Vibologics
5. Arranta Bio
6. Boxborough Regency
7. National Testing Services
8. Veterinary Dental Services
9. Nashoba Valley Olympiad
10. Papalia Home Services. [29]
11. TUV Rheinland
12. Medtronic
13. Intel

Boxborough has a strong office sector and job base, in addition to a large commercial area that serves as a regional employment center for high-wage jobs. Fifteen percent of all businesses in the Town are small and home-based.[30]

As of 2020, Boxborough's top three industries by occupation according to the United States Census include:

1. Professional, scientific, and management, and administrative and waste management services
2. Educational services, healthcare and social assistance
3. Manufacturing.[31]

Historic and Cultural Resources

Historic and cultural resources shape a community's character and identity while also creating a sense of place for residents and visitors. Many New England cities and towns are home to significant sites and structures that capture the history and heritage of an area. Some resources may date back centuries, like burial grounds, while others can be more recent, like newly designated historic districts. Their importance lies in what they mean to a community and how they represent its people and place.

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[29] Town of Boxborough Open Space and Recreation Plan 2022-2027. (2023). Town of Boxborough, Massachusetts.

[30] Boxborough 2030: A Master Plan for the Town of Boxborough, Massachusetts. (2016). Town of Boxborough, Massachusetts.

[31] "Industry By Occupation for the Civilian Employed Population 16 Years and Over ACS 5-Year Estimates." (2020). United States Census Bureau.

Historic and cultural resources can be at risk due to the negative impacts of natural hazards and climate change. This plan identifies these resources so the HMPC may consider their vulnerability and potential need for mitigation.

The Town has several historical, cultural, and scenic resources, which include the “Cathedral of Trees'' along Route 111, the Boxborough Museum, and four original one-room schoolhouses (three of which have been converted to residences). Additionally, residents and visitors can find old carriage roads, historic mill sites, the old Town Center, and a smallpox grave site. [32] There are several designated scenic roads in the Town that can be accessed by residents and visitors in the area.[33]

Boxborough has two sites on the State Register of Historic Places which includes the Boxborough Old Town Center that is made up of 72 properties along Hill Road, Middle Road, and Picnic Street. This area is a National Register District and was established as such in 2006. The other is the Levi Wetherbee Farm (Steele Farm) which is located at 484 Middle Road. This site has 12 properties that are listed as National Register Individual Properties with colonial and federal architecture. Boxborough’s Historical Commission is interested in designating the current Town Center as a Historic Place, as well.[34]

All these historical and cultural resources must be considered in future hazard mitigation planning due to the risk of the Town’s significant districts, sites, and structures being damaged or threatened by natural hazards and climate change.

[32] Town of Boxborough Open Space and Recreation Plan 2022-2027. (2023). Town of Boxborough, Massachusetts.

[33] Town of Boxborough Open Space and Recreation Plan 2022-2027. (2023). Town of Boxborough, Massachusetts.

[34] Town of Boxborough Open Space and Recreation Plan 2022-2027. (2023). Town of Boxborough, Massachusetts.

Chapter 3. Planning Process

The planning process was developed in full compliance with the current planning requirements of the Federal Emergency Management Agency (FEMA) per the following rules and regulations:

- Robert T. Stafford Disaster Relief and Emergency Assistance Act (Public Law 93-288), as amended by the Disaster Mitigation Act of 2000
- Code of Federal Regulations – Title 44, Chapter 1, Part 201 (§201.6: Local Mitigation Plans)
- Federal Emergency Management Agency Local Mitigation Planning Policy Guide, (Released April 19, 2022, Effective April 19, 2023)
- In addition, the plan was prepared with the suggestions found in the Demonstrating Good Practices Within Local Hazard Mitigation Plans, FEMA Region 1, January 2017.

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))

A priority through the planning process was equity, which FEMA defines as the "consistent and systematic fair, just and impartial treatment for all individuals." This was a central theme throughout the planning process and effort was made to develop an inclusive planning process. The whole community (individuals, communities, private and nonprofit sectors, faith-based organizations, and all levels of government) were given an opportunity to participate.

The planning process for this updated mitigation plan began in September 2023 and concluded in April 2024 (this does not include the months of plan review and adoption). The Town developed a Municipal Vulnerability Preparedness (MVP) Program summary of findings in 2021. This planning effort contributed to the update of the mitigation plan. Below is a graphical display of the plan development timeline.

	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Task 1. Convene Local HMPC	Kick-off Meeting	HMPC Meeting	HMPC Meeting	Public Meeting	HMPC Meeting		HMPC Meeting & Public Meeting	
Task 2. Update Hazard Profiles								
Task 3. Update Critical Facility Inventory								

	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Task 4. Update Mitigation Goals								
Task 5. Update Mitigation Actions								
Task 6. Plan Review, Evaluation, and Implementation							Complete Draft for HMPC Review	
Task 7. Public Review of Draft							Public Review	
Task 8. Review and Approval								Submit Plan to MEMA

Figure 3. Planning Process Timeline.

Hazard Mitigation Planning Committee

The Director of Land Use and Permitting, Alexander Wade, developed the Hazard Mitigation Planning Committee (HMPC) and was the point of contact for the Consulting Team. The HMPC included Town employees and residents who represented five sectors of the community shown in the table below. A full list of HMPC members is shown in the table after that. The HMPC met four times, October 24, 2023, November 28, 2023, January 23, 2024, and March 12, 2024. All the meetings were conducted via Zoom, however sometimes Town employees gathered at their Town offices. A list of participants at each of these meetings is included in Appendix A.

Table 3. Sectors of the Community Represented on the HMPC.

Sectors of the Community	HMPC Members
• Emergency Management	• Assistant Emergency Management Director • Interim Fire Chief/Emergency Management Director • Police Chief
• Economic Development	• Director of Land Use and Permitting • Planning Board Member • Select Board Chair

Sectors of the Community	HMPC Members
	• Town Administrator • Assistant Town Administrator
• Land Use and Development	• Building Commissioner • Director of Land Use and Permitting • Director of Public Works • Environmental Planner • Planning Board Member • Select Board Chair • Town Administrator • Assistant Town Administrator
• Health and Social Services	• Assistant Emergency Management Director • Board of Health Administrator • Community Services Coordinator • Council on Aging Coordinator • Interim Fire Chief/Emergency Management Director • Police Chief • Principal (Blanchard Memorial School) • Town Clerk
• Infrastructure	• Building Commissioner • Director of Land Use and Permitting • Director of Public Works • Environmental Planner • Planning Board Member • Select Board Chair • Town Administrator • Assistant Town Administrator

Table 4. HMPC Members.

First Name	Last Name	Title	Affiliation	Phone	Email
Edward	Cataldo	Building Commissioner	Town of Boxborough	978-264-1725	ecataldo@boxborough-ma.gov
Kim	Dee	Council on Aging Coordinator	Town of Boxborough	978-264-1717	kdee@boxborough-ma.gov
Shawn	Gray	Interim Fire Chief/Emergency Management Director	Town of Boxborough	978-264-1776	sgray@boxborough-ma.gov
Rebecca	Harris	Town Clerk	Town of Boxborough	978-264-1727	rharris@boxborough-ma.gov
Kristin	Hillberg	Select Board Chair	Town of Boxborough	978-264-1712	selectboard@boxborough-ma.gov
Rajon	Hudson	Assistant Town Administrator	Town of Boxborough	978-264-1718	rhudson@boxborough-ma.gov
Michael	Johns	Town Administrator	Town of Boxborough	978-264-1717	mjohns@boxborough-ma.gov
Kat	Kobylt	Environmental Planner	Metropolitan Area Planning Council (MAPC)	617-933-0700	kkobylt@mapc.org
Edward	Kukkala	Director of Public Works	Town of Boxborough	978-264-1792	ekukkula@boxborough-ma.gov
Dana	Labb	Principal (Blanchard Memorial School)	Town of Boxborough	978-263-4569	n/a
Cindy	Markowitz	Planning Board Member	Town of Boxborough	978-264-1723	n/a
Steven	Patriarca	Assistant Emergency Management Director	Town of Boxborough	978-881-4106	spatriarca@boxborough-ma.gov

Kim	Pelser	Board of Health Administrator	Town of Boxborough	978-264-1726	kpelser@boxborough-ma.gov
Rodoshi	Sinha	Environmental Planner	Metropolitan Area Planning Council (MAPC)	617-933-0700	rsinha@mapc.org
John	Szewczyk	Police Chief	Town of Boxborough	978-264-1760	jszewczyk@boxborough-ma.gov
Wendy	Trinks	Community Services Coordinator	Town of Boxborough	978-264-1735	wtrinks@boxborough-ma.gov
Alexander	Wade	Director of Land Use and Permitting	Town of Boxborough	978-264-1723	awade@boxborough-ma.gov
Jeffrey	Zukowski	Hazard Mitigation Planner	MA Emergency Management Agency	508-820-1422	jeffrey.zukowski@state.mas.us

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))

The first HMPC Meeting was held on October 24, 2023, and provided an opportunity for the consulting team and the Director of Land Use and Permitting to introduce the HMPC to the mitigation planning process. After an introduction to the plan, the HMPC identified natural hazards and critical facilities as well as noted the presence of their environmental justice (EJ) population. The HMPC recognized the need for targeted outreach to the EJ population and decided to reach out to vulnerable communities such as the elderly population through the Council on Aging, posting information on cable television, and posting in local newspapers.

Regarding natural hazards, the Town has heating and cooling centers at the local library, school, and Boxborough Regency Hotel; however, no one used the spaces recently. The Town has no public water supply and have entered into an agreement to purchase water from an adjacent community. Most residents rely on private wells, and some have needed to drill deeper or access water. Flooding is an issue for Boxborough and impacts many roadways including Depot Road and Route 111. There have been several culvert replacements to address flooding.

The Building Commissioner is the designated Floodplain Administrator, and the Town has updated their Floodplain By-Laws and maps. The Town has had significant turnover in staff and the current staff is eager to expand on their knowledge. Potential mitigation actions were also discussed which included adding an Associate Planner and Conservation Agent. Boxborough's goals are to move forward with economic development while also considering sustainability.

The second HMPC meeting, held on November 28, 2023, began with a discussion about public outreach for the Town's first public meeting. The HMPC identified the following ways to spread the word about the meeting, making announcements at the Select Board meeting, emailing all Town Boards and Committee Chairs, sharing a flyer and invitation with the Council on Aging and Community Services Coordinator, and posting information on social media and through other community networks.

The discussion then turned to the Town's capabilities. The HMPC stated that they had recently passed a Tree Protection By-Law which discouraged removal of trees and set aside funds for reforestation. The Fire and Police Chiefs were working on refining the Town's Comprehensive Emergency Management Plan. The HMPC stated that the Town has a good organizational structure and good leadership, but there needs to be more focus on risk reduction and looking ahead to future Town needs. The meeting ended with a discussion on different hazards, which included a constantly blocked man-made dam due to beavers and replacing culverts throughout the Town. The HMPC noted that the Town is not very walkable. To improve infrastructure, the Town must increase staffing capacity. The Town is also "catching up" with development and there will be growth in the business sector along major roadways; however, that development sits over an aquifer which has raised concerns.

The focus for the third HMPC meeting, held on January 23, 2024, began with a discussion of the public meeting and how the online Mentimeter tool worked well. The plan to increase attendance for the second meeting was to align the meeting with a Select Board meeting since they are the most attended meetings in Town.

The meeting then went onto a discussion of hazards, hazard rankings, and the creation of mitigation actions. The HMPC noted that rainstorms have become an issue because of downed trees and power outages. Littleton Electric is very quick to respond, but there is no warning time for these events. They also spoke about trees as hazards due to blocked roadways, the added time to remove fallen trees, and re-routing during clean-up. Additional notes include educating landlords on drought actions, so they are informed on the state of water in the Town, as well as Boxborough using drought tolerant plants and implementing water restrictions as needed.

The HMPC stated that for the future implementation of the Hazard Mitigation Plan Update, the Director of Land Use and Permitting will schedule a meeting twice a year and meet post-disaster as needed. They will also work to align the goals of the Mitigation Plan Update with their Town's Master Plan.

The focus for the fourth HMPC meeting, held on March 12, 2024, was planning for the Public Review of the Plan. The Town will have hard copy versions in the Planning Office and Library. They will collect comments and offer a Google Form for plan review feedback. To ensure the public knows the plan is out for review, the HMPC wants to link with the Police Chief's Community Policy Project outreach, while also reaching out to Town and local planners, regional organizations, local nonprofits, and vulnerable population areas through the Housing Authority.

The discussion then went onto hazard rankings and focused on drought and wildfires/brushfires which are major concerns for the community. The Town then discussed the plan implementation and have an idea to keep the plan as a "living document" like their Master Plan so that it continues to be integrated into Town processes, goals, and objectives.

The HMPC also participated in two public meetings, one on December 11, 2023, and one on March 11, 2024. Finally, the HMPC reviewed the draft Town of Boxborough, MA Hazard Mitigation Plan Update prior to sending it to the Massachusetts Emergency Management Agency (MEMA) for their review in April 2024.

Public Outreach

A3. Does the Plan document how the public was involved in the planning process during the drafting stage? (Requirement §201.6(b)(1))

The Public Outreach Strategy was designed to involve the whole community in the mitigation planning process. The public was engaged in the planning process during the drafting of the plan and prior to plan approval through two public workshops (a flyer for the first workshop is shown below). Each public meeting was held virtually. The public was also given a chance to look over the plan and provide feedback prior to its review by MEMA or FEMA. The purpose of public engagement was to:

- Generate public interest in mitigation planning.
- Identify and accommodate special populations.
- Solicit public input.
- Engage local stakeholders.
- Create opportunities for public and local stakeholders to be actively involved in the mitigation planning process.

***COMMUNITY LIFELINES** are the most fundamental services in the community that, when stabilized, enable all other aspects of society.*

Each public meeting included a PowerPoint presentation and plenty of opportunity for questions and discussion. In addition, Mentimeter was used to facilitate input from meeting participants in the first public meeting. This has proven to be an effective tool when engaging people who may not be comfortable speaking up in a virtual meeting. The HMPC participated in each meeting.

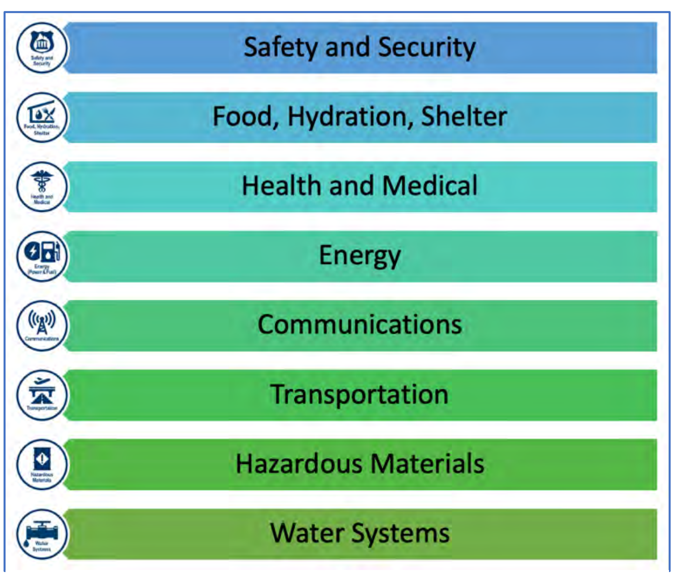

Figure 4. Community Lifelines.

Representatives from all community lifelines were included in public engagement efforts. Community lifelines are a driving force behind FEMA's strategic goals for building a culture of preparedness and readying the nation for catastrophic disasters. The eight community lifelines can be a powerful tool for local governments when evaluating risk and developing mitigation actions. The HMPC considered the eight community lifelines when conducting outreach through this planning process. The eight community lifelines and their respective components are shown in the figure below.

Outreach for the public meetings and for plan review was sent via press release, email blasts, flyer postings, and reaching out to adjacent communities. The Town website https://www.boxborough-ma.gov/ included announcements for meetings, as did Town social media sites. The press releases were sent to local news outlets. Flyers were sent all Town Boards and Committees, posted in Town buildings, and sent to neighboring communities.

Information gathered during the public meetings contributed to the plan's development. Both public meetings were held in a hybrid environment and were part of Selectboard Meetings.

The first public meeting was on **December 11, 2023**. Ten people attended the meeting via Zoom and many were in-person with the Selectboard..

The meeting asked participants a series of questions to engage them and help them understand the process of developing a hazard mitigation plan. The questions are listed below.

Figure 5. Public Meeting Flyer.

- Who lives and works in your community?
- What buildings and infrastructure are critical to your community?
- What weather related hazards can impact your community?
- Name specific locations in your community that flood or are vulnerable to natural hazards.
- What can be done to mitigate risks you have identified? Think of activities to protect the people, buildings, and infrastructure named previously.

When asked "What do you like most about Boxborough?" the following answers were given:

- The people
- Rural feel
- People, open space, excellent public services,
- Quiet, and lots of trees,
- The Support from the Community
- Our diverse community with excellent schools
- People
- The community and its engaged population that brings together a diversity of opinions.

When asked about concerns about natural hazards in the Town of Boxborough the following responses were provided in a Word Cloud:

Figure 6. Natural Hazard Word Cloud from Public Meeting.

The meeting participants also discussed several critical facilities that they believed the Town relies on before, during, and after a disaster. Many of the facilities aligned with what the HMPC had discussed in previous meetings. A Word Cloud of the participants' responses can be found below:

Figure 7. Critical Facilities Word Cloud from Public Meeting.

The second public meeting was held on **March 8, 2024,** 12 people were on Zoom and 7 people were in the room with the Select Board. A member of the Emergency Reserve Corps was in the room and made a brief introduction and agreed to collaborate on the review of the Hazard Mitigation Plan. The Consulting Team reviewed the Hazard Mitigation Plan Update and answered questions or concerns. One Select Board Member wondered if drought should be ranked higher in the list of natural hazard risk. People in the room explained that since drought occurs gradually over time the Town has ample opportunity to prepare and respond compared with other hazards that pose a sudden threat.

Contributions from the HMPC and public engagement impacted the plan in multiple ways. The table below indicates some of the contributions, others are included above and throughout the plan.

Table 4. Areas Where the HMPC and the Public Informed the Planning Process.

Area of the Plan Impacted	Contributions
Planning Area Profile	• The HMPC updated the list of critical facilities, shown in Appendix B. They also contributed information regarding current land use practices and priorities.
Planning Process	• Participated in every aspect of the planning process and made recommendations regarding how to engage the public and key stakeholders.

Area of the Plan Impacted	Contributions
Risk Assessment	• Described extent of hazard impacts based on previous events. • Offered first-hand insight and experiences of Town residents. • Added the qualitative review to the risk analysis for determination of the hazard risk ranking.
Capability Assessment	• Contributed plans, bylaws, and reports for review. • Completed three Capability Assessment questionnaires including the National Flood Insurance survey and the Safe Growth survey.
Mitigation Strategy	• Identified and prioritized mitigation actions based on their concerns. • Focused on the concerns raised by community members.
Implementation Plan	• Committed to integrating this plan more thoroughly throughout Town government and to posting the plan on the Town's website.

List of Key Stakeholders Invited to Public Meetings

The following groups were considered "key stakeholders" and invited to public meetings and to review the draft plan.

- Members of all Boxborough Committees
- Members of all Boxborough Boards
- Town of Boxborough Employees
- Town of Littleton
- Town of Stow
- Town of Acton
- Town of Harvard
- Metropolitan Area Planning Council (MAPC)

Review of Draft Plan

The Town made the plan available for public review in April 2024. A press release announcing the availability to review the plan was sent and the announcement was posted on social media and to the Town website. The HMPC sent emails to Town employees, committees, and boards. Hard copies of the plan were kept in the Planning Office and Library. Two comment forms were completed. The Director of Land Use and Permitting was available to receive comments from the public.

Feedback included adding Asian Jumping Worms to the list of invasive species and the Littleton Electric Light and Water Department tree trimming program to the Capability Assessment.

Chapter 4. Risk Assessment

Hazard Identification

RISK *for the purpose of hazard mitigation planning, is the potential for damage or loss created by the interaction of natural hazards with assets, such as buildings, infrastructure, or natural and cultural resources.*

The first step in the risk assessment was to revisit and evaluate the hazards identified for study and inclusion in the Town's previous draft hazard mitigation plan. This was a key topic of discussion at the first Hazard Mitigation Planning Committee (HMPC) meeting, along with the consideration of any additional hazards to include in the updated risk assessment. While only natural hazards are required to be addressed by FEMA, other hazards such as technological and human-caused hazards may be included if they are of significant concern to the community and determined to be a mitigation priority.

In completing the updated hazard identification process, the HMPC considered the results of the Town's Municipal Vulnerability Preparedness (MVP) planning effort (completed in 2021), as well as the "ResilientMass Plan" (2023[35]) which is the formal update to the 2018 State Hazard Mitigation and Adaptation Plan (SHMCAP). As a result of this process all hazards from the prior hazard mitigation plan (adopted in 2010) remain in this updated risk assessment. For this updated assessment, some hazards have been consolidated or renamed to be consistent with the ResilientMass Plan, as further described below. The top natural hazards identified for the MVP effort are thoroughly covered in this assessment. Invasive species as a hazard was added to reflect the concern for this becoming a more prevalent challenge with projected climate change; and to ensure that the risk assessment is aligned with the ResilientMass Plan.

All relevant hazards identified in the ResilientMass Plan were therefore carried forward and addressed in this risk assessment chapter. The profiled hazards are as follows:

- Average/Extreme Temperatures
- Drought
- Earthquakes
- Flooding from Precipitation and Dam Overtopping
- Hurricanes and Tropical Storms
- Invasive Species
- Landslides

[35] https://www.mass.gov/doc/resilientmass-plan-2023

- Other Severe Weather
- Severe Winter Storms
- Tornadoes
- Wildfires

One "hazard" profiled in the ResilientMass Plan – "changes in groundwater" – is included as appropriate in the flood and drought hazard profiles in this plan.

Massachusetts Emergency Declarations

The Town of Boxborough has been subject to numerous federal disaster declarations along with the entirety of Middlesex County. Some of these disaster declarations correspond to emergency declarations in portions of Massachusetts. The following table cross-references the 13 Massachusetts emergency declarations starting in 2011 with the corresponding federal disaster declarations. All the Massachusetts emergency declarations corresponding to Boxborough have involved natural hazards addressed in this plan except for the shelter capacity crisis, which is not a natural hazard and not profiled in this plan. Hazards that do not appear in this table (i.e., earthquakes) have not been subject to Massachusetts emergency declarations.

Table 5. Massachusetts Emergency Declarations.

Massachusetts Emergency	Start	Termination	Corresponding Federal Disaster Declaration	FEMA Public Assistance Available	Applicable to Boxborough?
Storm Lee	9/15/2023	9/16/2023	Not applicable	Not applicable	Yes
Severe Weather and Flooding	9/12/2023	9/16/2023	Not applicable	Not applicable	Yes
Shelter Capacity Crisis	8/8/2023	Pending	Not applicable	Not applicable	Yes, but not a natural hazard and not a FEMA declaration for Massachusetts
COVID-19	3/10/2020	5/11/2023	DR-4496-MA	All counties	Yes

Massachusetts Emergency	Start	Termination	Corresponding Federal Disaster Declaration	FEMA Public Assistance Available	Applicable to Boxborough?
Merrimack Valley Gas Explosion	9/14/2018	10/4/2018	Not applicable	Not applicable	No
Coastal Storm	3/3/2018	3/6/2018	DR-4372-MA	Essex, Norfolk, Plymouth, Bristol, Barnstable, and Nantucket Counties	No
Winter Storm	2/9/2015	2/25/2015	Not applicable	Not applicable	No
Winter Storm	1/26/2015	1/28/2015	DR-4214-MA	Middlesex County and eastward	Yes
Winter Storm	2/8/2013	2/13/2013	DR-4110-MA	All counties	Yes
Hurricane Sandy	10/27/2012	11/1/2012	DR-4097-MA	Suffolk, Bristol, Plymouth, Barnstable, Dukes, and Nantucket Counties	No
Nor'easter	10/29/2011	11/7/2011	DR-4051-MA	Berkshire, Franklin, Hampshire, Hampden, Worcester, and Middlesex Counties	Yes
Hurricane Irene	8/26/2011	9/6/2011	DR-4028-MA	Berkshire, Franklin, Hampshire, Hampden, Norfolk, Bristol,	No

Massachusetts Emergency	Start	Termination	Corresponding Federal Disaster Declaration	FEMA Public Assistance Available	Applicable to Boxborough?
				Plymouth, Barnstable, and Dukes Counties	
Tornadoes	6/1/2011	6/19/2011	DR-1994-MA	Hampden and Worcester Counties	No

Link to Massachusetts Climate Change Assessment

The *2022 Massachusetts Climate Change Assessment* report was issued in December 2022 (https://www.mass.gov/info-details/massachusetts-climate-change-assessment#read-the-report-). This report provided statements about the impacts of climate change in five sectors within each of seven designated regions of Massachusetts. Boxborough is in the "Eastern Inland" region shown in maroon in the figure below.

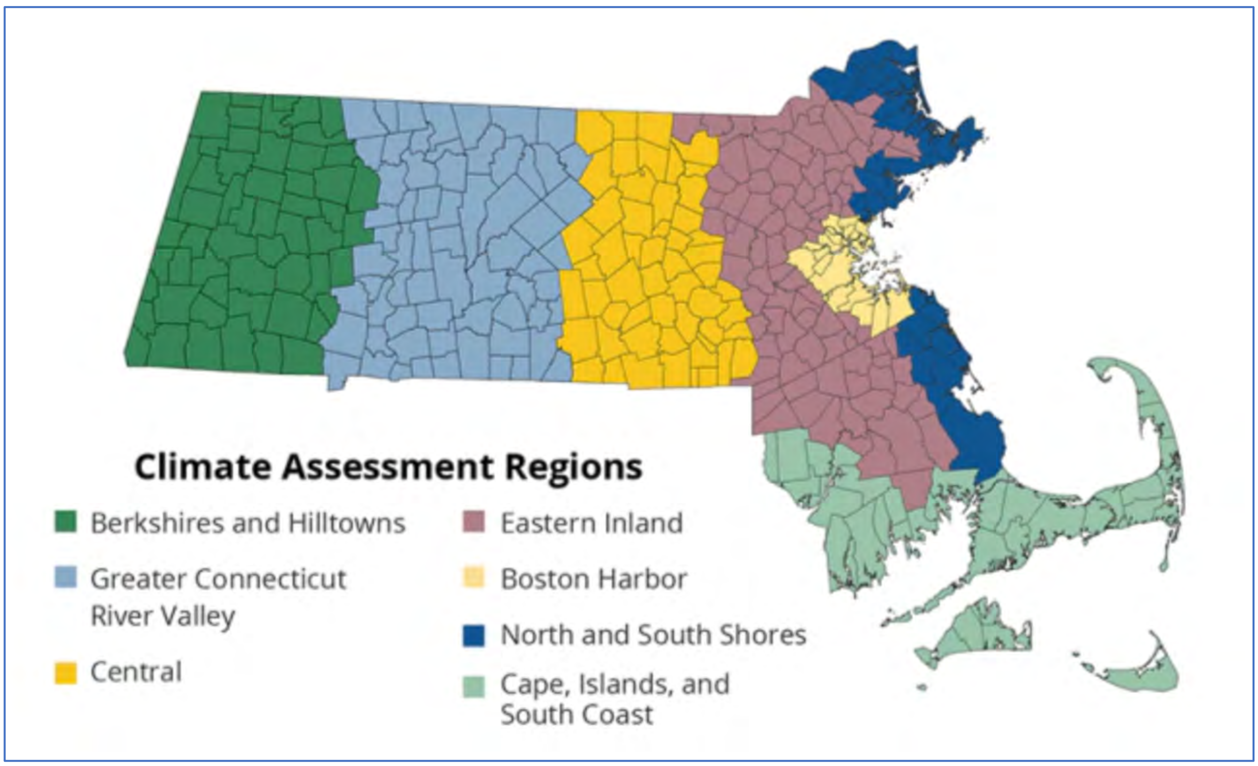

Figure 8. Climate Assessment Regions. Boxborough is in the Eastern Inland Region.

The table below lists the top two or three impacts of climate change in each of the five sectors within this region.

Table 6. Top Impacts of Climate Change per Sector in Eastern Inland Region.

Sector	Top Impacts per Sector	Comments
Human	Increase in vector-borne disease incidence and bacterial infections	Including West Nile Virus and Lyme due to favorable conditions for mosquitos and ticks
	Reduction in food safety and security	Causes are production and supply chain issues as well as spoilage during outages
Infrastructure	Damage to electric transmission and distribution	From heat stress and extreme storms
	Damage to buildings	Causes are heavy rainfall and overwhelmed drainage
	Damage to rails and loss of rail/transit service	Causes are flooding and track buckling from heat
Natural Environment	Freshwater ecosystem degradation	Causes are warming waters, drought, and runoff
	Forest health degradation	Causes are warming temperatures, changing precipitation, wildfire frequency, and increasing pests
Governance	Increase in costs of responding to climate migration	Includes planning for abrupt increases in local populations
	Increase in demand for State and municipal services	Includes emergency response, food assistance, and health care
Economy	Reduced ability to work	For outdoor workers during extreme heat events, as well as delays in commute times
	Reduction in availability of affordably priced housing	Causes are direct damage (floods) and scarcity caused by demand

The Town proposes to incorporate these top climate change impacts in this edition of its plan as outlined below.

Table 7. How This Plan Addresses the Top Impacts of Climate Change per Sector.

Sector	Top Impacts per Sector	Approach to Incorporating Impacts
Human	Increase in vector-borne disease incidence and bacterial infections	Vector-borne and infectious diseases are a hazard profiled in this plan.
	Reduction in food safety and security	Some of the hazards that affect food security (i.e., droughts) are profiled in this plan. However, Boxborough depends on food from other regions, and additional efforts beyond the scope of this plan will be needed to protect food safety and security.
Infrastructure	Damage to electric transmission and distribution	Severe weather events that damage transmission and distribution are hazards profiled in this plan.
	Damage to buildings	Severe weather events and floods that damage buildings are hazards profiled in this plan.
	Damage to rails and loss of rail/transit service	Severe weather events, floods, and extreme heat events that damage transit systems are hazards profiled in this plan.
Natural Environment	Freshwater ecosystem degradation	Invasive species are addressed as a hazard profiled in this plan. Additional efforts beyond the scope of this plan will be needed to protect freshwater ecosystems.
	Forest health degradation	Invasive species, droughts, wildfires, and severe weather events that damage forests are hazards profiled in this plan. Additional efforts beyond the scope of this plan will be needed to protect Forest health.
Governance	Increase in costs of responding to climate migration	The capability assessment and related mitigation actions will help address increased costs related to responding to climate migration.
	Increase in demand for State and municipal services	The capability assessment and related mitigation actions will help address increased demands for municipal services.

Sector	Top Impacts per Sector	Approach to Incorporating Impacts
Economy	Reduced ability to work	The individual hazards addressed in this plan can reduce ability to work, and the specific actions for each hazard will help protect lifelines and systems needed for work.
	Reduction in availability of affordably priced housing	The individual hazards addressed in this plan can reduce the availability of affordably priced housing, and the specific actions for each hazard will help protect housing options and opportunities.

Hazard Profiles

B1. Does the plan include a description of the type, location, and extent of all natural hazards that can affect the jurisdiction? Does the plan also include information on previous occurrences of hazard events and on the probability of future hazard events? (Requirement 44 CFR §201.6(c)(s)(i))

B2. Does the plan include a summary of the jurisdiction's vulnerability and the impacts on the community from the identified hazards? Does the summary also address NFIP-insured structures that have been repetitively damaged by floods? (Requirement 44 CFR §201.6(c)(s)(ii))

***IMPACTS** are the consequences or effects of each hazard on the participant's assets identified in the vulnerability assessment. For example, impacts could be described by referencing historical disaster damages with an estimate of potential future losses (such as percentage of damage vs. total exposure).*

The risk assessment for the ResilientMass Plan describes the natural hazards that have the potential to impact the Commonwealth and provides the underlying narrative for this hazard profile for the Town. Because this section repeats information from the ResilientMass Plan, some citations have been removed for brevity. The original citations can be found in the ResilientMass Plan.

Profiles have been developed for each identified hazard, organized by primary climate change interaction. Hazard profiles include the following sections: Hazard Description, Location, Previous Occurrences, Extent, Probability of Future Events, and Vulnerability Assessment; these are described in the table below.

Table 8. Hazard Characterization.

Category/Method	Definition
Description	Description of hazard, its characteristics, and potential effects.
Location	Describes geographic areas within the town that are affected by the hazard.
Previous Occurrences	Provides information on the history of previous hazard events for the region, including their impacts on people and property.
Extent	Describes potential strength or magnitude of a hazard. Where possible, extent is described using established scales.
Probability of Future Events	Describes likelihood of future hazard occurrences in the town based on best available and climate-informed science.
Vulnerability Assessment	Describes potential impact on the community, including estimated potential losses and the anticipated effects of climate change.

To describe previous occurrences, this plan update highlights major events from history but relies primarily on a roughly ten-year lookback (2014 through 2023) ending with any events from the date of plan development (2023-2024). This helps maintain a concise narrative. Where applicable, narratives about warning times (i.e., floods, heat advisories, and wildfires) are incorporated into the *"Extent"* subsections.

> ***VULNERABILITY*** *is a description of which assets, including structures, systems, populations and other assets as defined by the community, within locations identified to be hazard prone, are at risk from the effects of the identified hazard(s).*

The vulnerability assessment characterizes how hazards have impacted and may impact the different aspects of the community. In the vulnerability assessment sub-sections, the magnitude and likelihood of a hazard event are evaluated, and impacts are quantified using hazard models. Some hazards, like earthquakes and winter storms, will impact the entire community while other hazards, like floods and landslides, impact specific locations in the community. The areas that could be impacted are defined as the community's exposure. The results of the vulnerability assessment are used to help identify mitigation measures the community may take to lessen the impact and better understand their benefits.

Average and Extreme Temperatures

> The Town of Boxborough Community Resilience Building Workshop Summary of Findings (2021) lists "drought and extreme temperatures" as a top hazard of concern.

According to the ResilientMass Plan, extreme heat for Massachusetts is usually defined as daily high temperatures above 90 degrees Fahrenheit (°F) which may be accompanied by high humidity. Extreme cold is also considered relative to the normal climatic lows in a region. Extreme cold is a period of excessively low temperatures, particularly with the addition of wind chill. The ResilientMass Plan notes that typically in Massachusetts the highest temperatures are experienced in the southeast while the coldest are typically in the northwest where Boxborough is located.

Description

Extreme cold is a dangerous situation that can result in health emergencies for susceptible or vulnerable people, such as those without shelter or who are stranded or who live in homes that are poorly insulated or without heat. Extreme cold events are events when temperatures drop well below normal in an area. When winter temperatures drop significantly below normal, staying warm and safe can become a challenge. Extremely cold temperatures often accompany a winter storm, which may also cause power failures and icy roads. During cold months, carbon monoxide may be high in some areas because the colder weather makes it difficult for car emission control systems to operate effectively, and temperature inversions can trap the resulting pollutants closer to the ground.

Likewise, extreme heat is a dangerous situation that can result in health emergencies for susceptible and vulnerable people, such as those without shelter or who are stranded or who live in homes that are poorly insulated or without adequate cooling.

A heat wave is defined as three or more days of temperatures of 90°F or above. A basic definition of a heat wave implies that it is an extended period of unusually high atmosphere-related heat stress, which causes temporary modifications in lifestyle, and which may have adverse health consequences for the affected population. Heat waves cause more fatalities in the U.S. than the total of all other meteorological events combined. According to the EPA, more than 11,000 Americans have died from heat-related causes (EPA, 2016) since 1979.[36]

Heat impacts can be particularly significant in urban areas. Buildings, roads, and other infrastructure replace open land and vegetation. Dark-colored asphalt and roofs also absorb more of the sun's energy. These changes cause urban areas to become warmer than the surrounding areas. This forms "islands" of higher temperatures, often referred to as "heat islands." Heat islands can affect communities by increasing peak energy demand during the summer, air conditioning costs, air pollution and greenhouse gas emissions, heat-related illness and death, and water quality degradation (EPA).

Many conditions associated with heat waves or more severe events (including high temperatures, low precipitation, strong sunlight, and low wind speeds) contribute to a worsening of air quality in several ways. High temperatures can increase the production of ozone from volatile organic compounds and other aerosols. Weather patterns that bring high temperatures can also transport particulate matter air pollutants from other areas of the continent. Additionally, atmospheric inversions and low wind speeds allow polluted air to remain in one location for a prolonged period of time.

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[36] https://www.epa.gov/climate-indicators/climate-change-indicators-heat-related-deaths#:~:text=Some%20statistical%20approaches%20estimate%20that,set%20shown%20in%20Figure%201.

Location

The Massachusetts Climate Assessment (2022) explains that recent efforts to characterize extreme heat have underscored that risks are present throughout the entire commonwealth. Therefore, the entire geography of Boxborough is subject to extreme heat. As with the entire commonwealth, Boxborough is also exposed to extreme cold temperatures.

Previous Occurrences

Extreme Cold: The ResilientMass Plan notes that since 1995, there have been 120 cold weather events within the Commonwealth, ranging from Cold/Wind Chill to Extreme Cold/Wind Chill events. The NOAA Storm Events database (https://www.ncdc.noaa.gov/stormevents/) for Middlesex County lists several extreme cold and/or wind chill events for the area of Boxborough during the timeframe 2014-2023, with most listed in 2015 and 2016.

Extreme Heat: The ResilientMass Plan notes that according to the NOAA's Storm Events Database there have been 118 warm weather events (Heat to Excessive Heat events) between 2010 and 2022. Excessive heat results from a combination of temperatures well above normal and high humidity. Whenever the heat index values meet or exceed locally or regionally established heat or excessive heat warning thresholds, an event is reported in the database.

In 2012, Massachusetts temperatures broke 27 heat records. Most of these records were broken between June 20 and June 22, 2012, during the first major heat wave of the summer to hit Massachusetts and the East Coast. In July 2013, a long period of hot and humid weather occurred throughout New England. One fatality occurred on July 6, when a postal worker collapsed as the Heat Index reached 100°F. August 2022 was the hottest August on record for the Commonwealth, and 2020 and 2022 were the two hottest records for the state. Boston experienced two six-day heat waves and 17 days above 90 degrees in 2022.

The NOAA Storm Events database (https://www.ncdc.noaa.gov/stormevents/) for Middlesex County does lists only one extreme heat event for the area of Boxborough in the timeframe 2014-2023. Evidence demonstrates that several extreme heat events occurred in Boxborough in July-August 2022 and July-August 2023. The Boxborough Regency Hotel and library were reportedly available as cooling centers in 2022 or 2023.

USDA declares agricultural disasters as needed for a variety of hazards. Information can be found at https://www.fsa.usda.gov/programs-and-services/disaster-assistance-program/disaster-designation-information/index. The events related to extreme temperatures in Middlesex County are listed below.

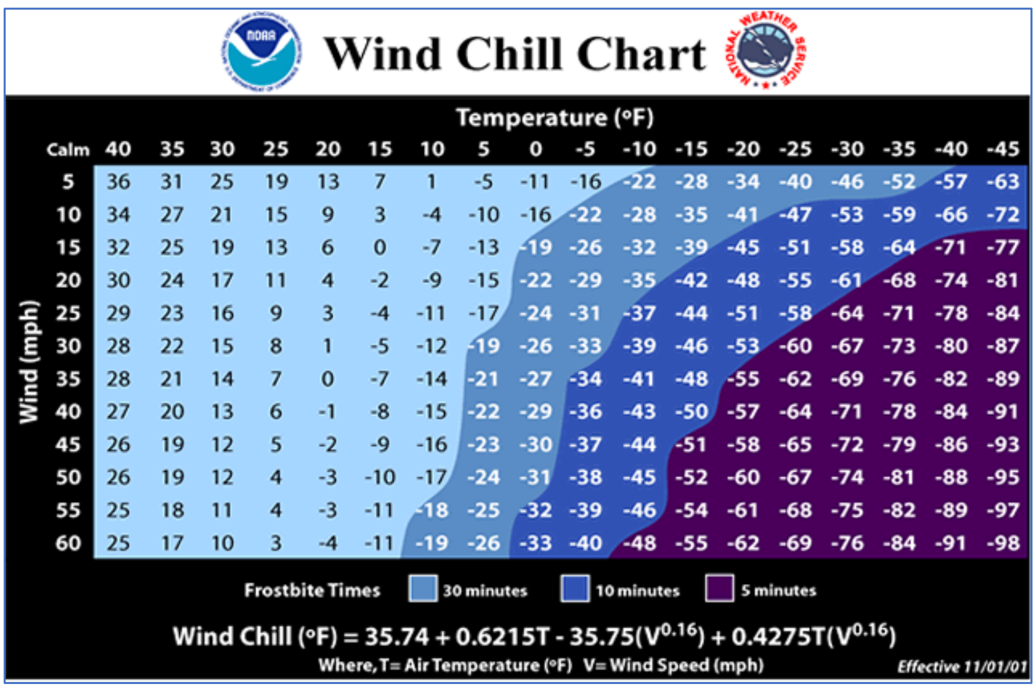
Table 9. USDA Disasters Events That Refer to Extreme Temperatures.

Year	Event	Event "Begin Dates"
2019	Cool/cold, below normal temps	12/1/2018

2016	Drought, high winds, wildfire, excessive heat, insects	8/24/2016, 9/21/2016
2016	Heat, Excessive Heat, Frost, Freeze	4/30/2016
2014	Frost, Freeze, Below normal temps	12/1/2013

Extent

Extreme Cold: The extent (severity or magnitude) of extreme cold temperatures is generally measured through the Wind Chill Temperature Index. Wind Chill Temperature is the temperature that people and animals feel when they are outside, and it is based on the rate of heat loss from exposed skin by the effects of wind and cold. As the wind increases, the body loses heat at a faster rate, causing the skin's temperature to drop. The National Weather Service (NWS) issues a Wind Chill Advisory if the Wind Chill Index is forecast to dip to –15°F to – 24°F for at least 3 hours, based on sustained winds (not gusts). The NWS issues a Wind Chill Warning if the Wind Chill Index is forecast to fall to –25°F or colder for at least 3 hours. On November 1, 2001, the NWS implemented a Wind Chill Temperature Index (Figure 9) designed to more accurately calculate how cold air feels on human skin.



Wind Chill Chart

Temperature (°F)

Wind (mph) / Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

Figure 9. NWS Wind Chill Temperature Index and Frostbite Risk.

Extreme Heat: The NWS issues a Heat Advisory when the NWS Heat Indices are between 95 and 99 degrees for two or more hours or two consecutive days, or if they are between 100 and 104 degrees for two or more hours in a single day. The NWS issues an Excessive Heat Warning if the Heat Index is forecast to reach 105°F or higher for 2 or more hours. The NWS Heat Index is based both on temperature and relative humidity and describes a temperature equivalent to what a person would feel at a baseline humidity level. It is scaled to the ability of a person to lose heat to their environment. Exposure to full sunshine can increase heat index values by up to 15°F. Also, strong winds, particularly with very hot, dry air, can increase the risk of heat-related impacts.

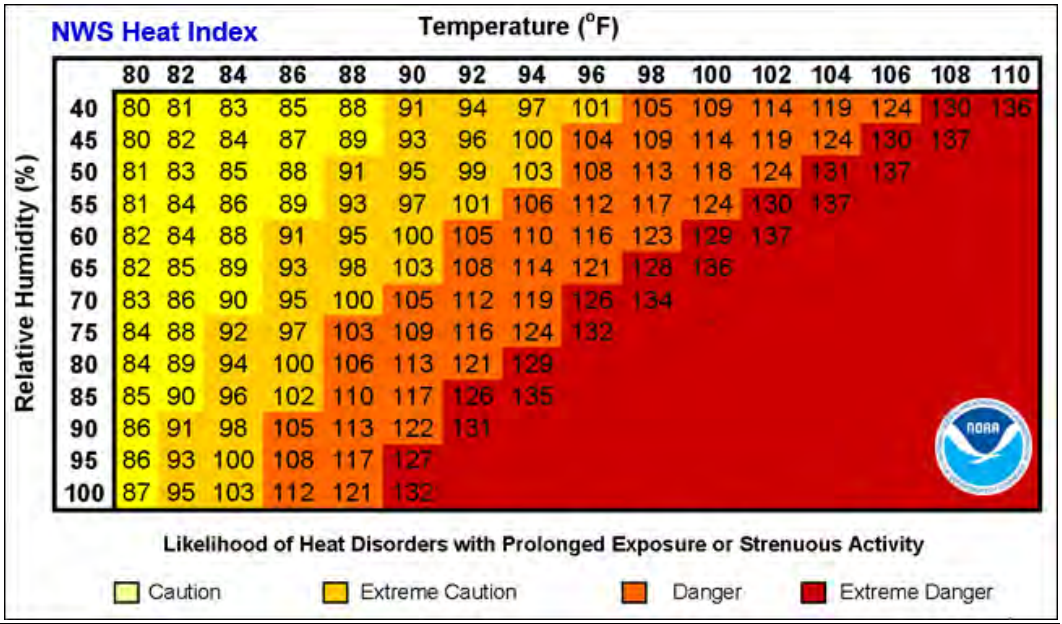


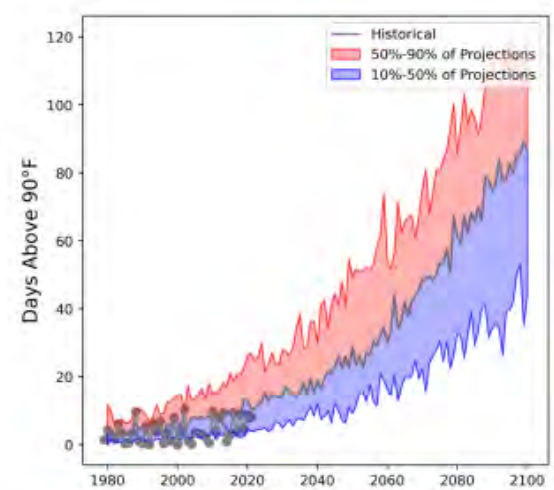
Figure 10. NWS Heat Index Chart.

Probability of Future Events

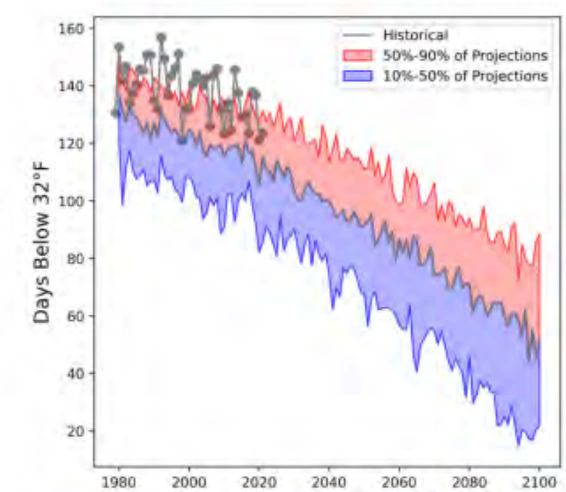
The ResilientMass Plan notes that Massachusetts averaged three declared cold weather events and two extreme cold weather events annually between January 2018 and October 2022. The years 2018 and 2019 were particularly notable, with 10 cold weather events in each year, including five extreme cold/wind chill events in 2018 and six in 2019. The ResilientMass Plan also notes that there was an average of 3.6 heat events and two excessive heat events between January 2018 and December 2022. Many practitioners believe that some heat wave related circulation patterns are occurring more frequently due to climate change.

There are a number of climatic phenomena that determine the number of extreme weather events in a specific year. However, there are significant long-term trends in the frequency of extreme hot and cold events. Since 2010, U.S. daily record high temperatures have occurred over eight times as often as record low. This is compared to a nearly 1:1 ratio in the 1950s. Models suggest that this ratio could climb to 20:1 by midcentury, if GHG emissions are not significantly reduced (C2ES, n.d.).

Various climate forecasts support the trends of an increased frequency of extreme hot weather events and a decreased frequency of extreme cold weather events. High, low, and average temperatures in Massachusetts are all likely to increase significantly over the next century as a result of climate change. The graphics below (from resilient MA, 2018) show the projected annual days with maximum temperature above 90 degrees and projected annual days with minimum temperature below 32 degrees.



Source: CMIP6 downscaled projections (Thrasher et al., 2022), warming scenario SSP 5-8.5, historical data from GridMET.



Source: CMIP6 downscaled projections (Thrasher et al., 2022), warming scenario SSP 5-8.5, historical data from GridMET.

Figure 11. Projected Annual Days with Temperatures above 90 Degrees (left) and below 32 degrees (right).

Vulnerability Assessment

Exposure

Extreme temperatures are not a hazard with a defined geographic boundary. The entire Town should be considered exposed to the hazard. Excessive heat can occur at any time during the year but is most dangerous during the summer between June and August when average temperatures are at their highest.

Built Environment Impacts

The impact of excessive heat is most prevalent in developed areas, where the Town lacks a tree canopy. Secondary impacts of excessive heat are severe strain on the electrical power system and potential brownouts or blackouts. Extreme heat can have a negative impact on transportation. Highways and roads are damaged by excessive heat as asphalt roads soften and concrete roads expand and can buckle, crack, or shatter. Moreover, concrete has been known to "explode," lifting chunks of concrete and putting those nearby at serious risk. Stress is also placed on automobile cooling systems, diesel trucks, and railroad locomotives which lead to an increase in mechanical failures. Steel rails are at risk of overheating and warping which can lead to train derailments.

Extreme cold weather poses a significant threat to utility production, which in turn threatens facilities and operations that rely on utilities, specifically climate stabilization. As temperatures drop and stay low, increased demand for heating places a strain on the heating system, which can lead to temporary outages. These outages can impact operations throughout the Town, which can result in interruptions and delays in services. Broken pipes may cause flooding in buildings, causing property damage and loss of utility service. Some of the secondary effects presented by extreme/excessive cold include dangerous conditions to livestock and pets.

Climate change will increase the probability of extreme temperatures which may impact utilities, transportation, and especially older structures. Future development should consider keeping more mature trees, less dark asphalt areas, and more natural areas.

Population Impacts

Extreme cold events are predicted to decrease in the future, while extreme heat days, as well as average temperatures are projected to increase. The projected increase in extreme heat and heat waves is the source of one of the key health concerns related to climate change. Prolonged exposure to high temperatures can cause heat-related illnesses, such as heat cramps, heat exhaustion, heat stroke, and death. Heat exhaustion is the most common heat-related illness and if untreated, it may progress to heat stroke. People who perform manual labor, particularly those who work outdoors, are at increased risk for heat-related illnesses. Prolonged heat exposure and the poor air quality and high humidity that often accompany heat waves can also exacerbate pre-existing conditions, including respiratory illnesses, cardiovascular disease, and mental illnesses.

The greatest danger from extreme cold is to people, as prolonged exposure can cause frostbite or hypothermia, and can become life threatening. Body temperatures that are too low affect the brain, making it difficult for the victim to think clearly or move well. This makes hypothermia particularly dangerous for those suffering from it, as they may not understand what is happening to them or what to do about it. Hypothermia is most likely at very cold temperatures but can occur at higher temperatures (above 40 degrees Fahrenheit) if the person exposed is also wet from rain, sweat, or submersion. Warning signs of hypothermia include shivering, exhaustion, confusion, fumbling hands, memory loss, slurred speech, or drowsiness. In infants, symptoms include bright red, cold skin and very low energy. A person with hypothermia should receive medical attention as soon as possible, as delays in medical treatment may result in death.

Older adults are often at elevated risk due to a high prevalence of pre-existing and chronic conditions. In Boxborough, 23.5% of the population is over age 64. People who live in older housing stock and in housing without air conditioning have increased vulnerability to heat-related illnesses. Power failures are more likely to occur during heat waves, affecting the ability of residents to remain cool during extreme heat. Individuals with pre-existing conditions and those who require electric medical equipment may be at increased risk during a power outage. Heat impacts are more likely to be felt by residents without air conditioning, by those who work outdoors, and those with underlying health conditions.

Extreme heat can pose severe and life-threatening problems for people. According to the NWS, it is one of the leading weather-related killers in the United States, resulting in hundreds of fatalities each year and even more heat-related illnesses. Extreme heat has a special impact on the most vulnerable segments of the population - the elderly, young children and infants, impoverished individuals, and persons who are in poor health. The high-risk population groups with specific physical, social, and economic factors that make them vulnerable include:

- Older persons (age > 65)
- Infants (age < 1)
- Homeless population
- Very low- and low-income persons
- People who are socially isolated
- People with mobility restrictions or mental impairments
- People taking certain medications (e.g., for high blood pressure, depression, insomnia)
- People engaged in vigorous outdoor exercise or work or those under the influence of drugs or alcohol.

Climate change will increase the rate of heat illness and need for cool spaces. Outdoor workers and vulnerable populations will need to be considered during extreme heat events.

Environment Impacts

Extreme heat can lead to water quality issues, wildlife concerns, and impact vegetative growth when combined with drought.

Problem Statements for Extreme Temperatures.

Table 10. Problem Statements for Extreme Temperatures.

Assets	Problems Associated with Extreme Temperatures
People (including underserved communities and socially vulnerable populations)	• Extreme heat will be a significant public health threat to all residents, but especially for vulnerable populations living in older homes or homes without air conditioning. • The elderly and those with mobility issues may not be able to leave their homes and travel safely.

Assets	Problems Associated with Extreme Temperatures
	• People working in businesses without air conditioning may be at risk of heat illness. • First responders may also be impacted by extreme temperatures. • Pets may be adversely impacted by extreme heat.
Structures (including facilities, lifelines, and critical infrastructure)	• Older homes without insulation and single-pane glass are difficult to heat and cool and may not provide safe living conditions. • Businesses that require refrigerated trucks or refrigeration units may see business losses and increased utility costs. • The electric grid may become stressed and fail during extreme heat events.
Systems (including networks and capabilities)	• Extreme heat mitigation and adaptation has not been fully integrated into existing local plans and regulations for new development, though progress is being made.
Natural, historic, and cultural resources	• Extreme heat may lead to, or exacerbate, impacts to natural systems related to wildfires and invasive species (refer to those sections). • Extreme heat may lead to water quality concerns.
Activities that have value to the community	• Recreational activities may be adversely impacted by extreme heat.

Droughts

Droughts are typically defined as periods of deficient precipitation. How this deficiency is experienced can depend on factors such as land use, the existence of dams, and water supply withdrawals or diversions. Droughts can vary widely in duration, severity, and local impact.

> The Town of Boxborough Community Resilience Building Workshop Summary of Findings (2021) lists “drought and extreme temperatures” as a top hazard of concern.

Description

The National Drought Mitigation Center references five common, conceptual definitions of drought:

1. Meteorological drought is a measure of departure of precipitation from normal.
2. Hydrological drought is related to the effects of precipitation shortfalls on stream flows and on reservoir and groundwater levels.
3. Agricultural drought links various characteristics of meteorological and hydrological drought to agricultural impacts and occurs when there is not enough water available for a particular crop to grow at a particular time.
4. Socioeconomic drought is associated with the supply and demand of economic goods with elements of meteorological, hydrological, and agricultural drought.
5. Ecological drought is an episodic deficit in water availability that drives ecosystems beyond thresholds of vulnerability and impacts ecosystem services.

Drought conditions can cause a shortage of water for human consumption and reduce local firefighting capabilities. Public water suppliers may struggle to meet system demands while maintaining adequate pressure for fire suppression and meeting water quality standards. The Massachusetts Department of Environmental Protection (DEP) requires all public water systems (PWSs) to maintain an emergency preparedness plan.

Two water districts provide water service in Boxborough; these are the Gilbertville Water District and Wheelwright Water District. Areas outside these service areas are served by private water supply wells. Droughts can affect the two water district and private wells. Hundreds of private wells are believed present in Boxborough. Private well owners can be vulnerable to droughts. With declining groundwater levels, well owners may experience dry wells or sediment in their water due to the more intense pumping required to pull water from the bedrock or overburden aquifer. Wells may also develop a concentration of pollutants, which may include nitrates and heavy metals depending on local geology.

The loss of clean water for consumption and for sanitation cause significant impacts depending on the affected population's ability to quickly drill a deeper or a new well or to relocate to unaffected areas. During a drought, dry soil and the increased prevalence of wildfires can increase the amount of irritants (such as pollen or smoke) in the air. Reduced air quality can have widespread deleterious health impacts but is particularly significant to the health of individuals with pre-existing respiratory health conditions like asthma (Centers for Disease Control [CDC]).

Lowered water levels can result in direct environmental health impacts, as the concentration of contaminants in swimmable bodies of water will increase when less water is present. Harmful algal blooms may occur, closing recreational areas.

One primary hazard in this plan that is commonly associated with drought is wildfire. A prolonged lack of precipitation dries out soil and vegetation, which becomes increasingly susceptible to ignition as the duration of the drought extends. A drought may increase the probability of a wildfire occurring.

Location
Massachusetts Drought Management Plan (DMP, 2019) assesses drought conditions in seven regions: Western, Connecticut River Valley, Central, Northeast, Southeast, and Cape Cod, and Islands. A regional approach allows customization of drought actions and conservation measures to address situations in each region; and allows for the determination of a drought on a watershed basis. This approach recognizes that parts of Massachusetts can experience significantly different weather patterns due to topography, distance from coastal influence, as well as a combination of regional, national, and global weather patterns. Droughts have the potential to impact the entirety of Boxborough, which is located in the Central region.

The Town of Boxborough lacks a municipal public water system. Almost the entire Town depends on bedrock wells for water supply, including the small non-community water systems located along the I-495 corridor. However, the Littleton water system is extending water service to Boxborough. This will change drought communication. Littleton water restrictions will become effective in the part of Boxborough served.

Previous Occurrences
The Commonwealth of Massachusetts has never received a Presidential Disaster Declaration for a drought-related disaster. However, several substantial droughts have occurred over the past 100 years. Massachusetts experienced its most significant drought on record in the 1960s. The severity and duration of the drought caused significant impacts on both water supplies and agriculture.

Although short or relatively minor droughts occurred over the 50 years following the drought of the 1960s, the next long-term event began in March 2015 when Massachusetts began experiencing widespread abnormally dry conditions. In July 2016, based on a recommendation from the Drought Management Task Force (DMTF), the Secretary of the Executive Office of Energy and Environmental Affairs (EOEEA) declared a Drought Watch for Central and Northeast Massachusetts and a Drought Advisory for Southeast Massachusetts and the Connecticut River Valley. Drought warnings were issued in five out of six drought regions of the state. Many experts stated that this drought was the worst in more than 50 years. DMTF declared an end to the drought in May 2017 with a return to wetter-than-normal conditions.

USDA declares agricultural disasters as needed for a variety of hazards. Information can be found at https://www.fsa.usda.gov/programs-and-services/disaster-assistance-program/disaster-designation-information/index. The line items related to droughts in Middlesex County are listed below, corresponding to 2015-2016, 2020, and 2022.

Table 11. USDA Disasters Events That Refer to Drought.

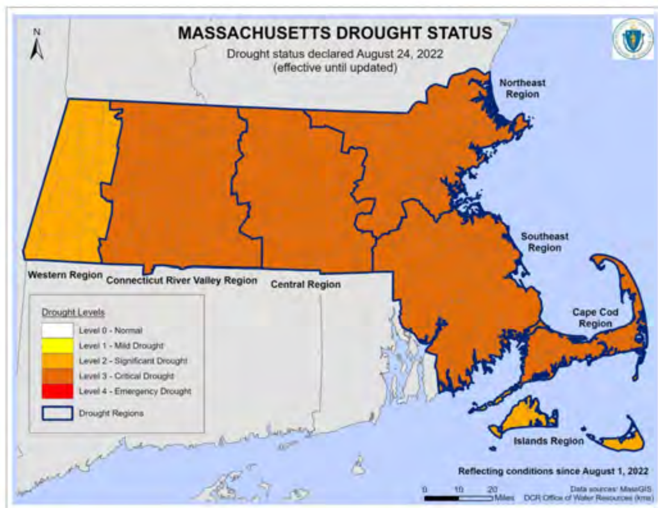
Year	Event	Event “Begin Dates”

2022	Drought	8/9/2022, 8/16/2022
2020	Drought	8/18/2020, 9/29/2020
2016	Drought, high winds, wildfire, excessive heat, insects	8/24/2016, 9/21/2016
2015	Drought	2/1/2015

The drought of 2020, a so-called "flashy drought" that impacted southern New England, was sufficiently impactful in Middlesex County to be included in the USDA data table above. Flashy droughts are described below under *Extent*.

Applying the same ten-year lookback as the severe storms database review, USDA payments to Massachusetts agricultural sectors for drought impacts associated with events from 2012 through 2022 were reviewed. This timeframe includes the droughts of 2015-2017 and 2020. USDA reimbursements for droughts have summed to only $107 in Boxborough over the last decade (for one recipient via the emergency assistance program for livestock and bees). Nevertheless, according to the Town, agriculture and farming are important parts of the community.

The drought of 2022 is typical of a flashy drought; it was most severe in August, but alleviated by rainfall in September 2022.



The severity of a drought depends on the degree of moisture deficiency, duration, spatial extent, and location relative to resources or assets. The drought of the 1960s is the drought of record because duration, spatial extent, moisture deficiency, and impact all contributed to historic levels. In contrast, the severity of the 2016-2017 drought was due to impacts on natural resources (record low stream flows and groundwater levels), many water supplies, farms, and agriculture and to the swift onset of the drought.

The Community Resilience Building Summary Report explains that many residents in the Town of Boxborough rely on private wells for drinking water. Particularly in the western portion of Town, the water quality and water quantity of these wells are vulnerable to drought and flood impacts (e.g., potential flood impacts from the MassDOT salt storage area on Swanson Road). As of 2021, Boxborough's Water Resources Committee was reviewing alternative sources for wells in the western portion of Town. As noted earlier in this section, the Littleton water system is being extended into Boxborough.

Extent

Drought is defined by a combined look at several indices as detailed in the Massachusetts DMP (EOEEA and MEMA, 2019). The indices are:

- Precipitation: The Standard Precipitation Index, which is widely used, is based on monthly precipitation totals from Massachusetts Department of Conservation and Recreation's (DCR) Precipitation Program and the NWS.
- Streamflow: Is an early indicator of impacts to rivers, streams, wetlands, and other riparian habitats.
- Groundwater: This provides information on impacts over a longer period of time due to groundwater recharge rates.
- Lakes and Impoundments: Captures the effects on surface water including lakes, ponds, water supply, and flood control reservoirs.
- Fire Danger: The Keetch Byram Drought Index indicates fire potential and flammability of organic matter.
- Evapotranspiration: The Crop Moisture Index is used to assess short-term or current conditions of dryness or wetness relative to agricultural crops.

These indices are monitored weekly to generate a monthly hydrological conditions report and used to determine the onset, severity, and end of droughts. Five levels of increasing drought severity are defined in the DMP: *Normal, Mild, Significant, Critical,* and *Emergency*. The drought levels are associated with actions outlined in the DMP. Recommendations of drought levels are made by the DMTF to the Secretary of the EEA, who then declares the drought level for each region of the state.

Other entities may measure drought conditions by these or other criteria more relevant to their operations. For example, water utilities may calculate the days of supply remaining. Farmers may assess soil moisture and calculate the water deficit for specific plants to determine irrigation needs or decide to change their crop based on the deficit or harvest early for non-irrigated crops.

The five drought levels in the 2019 DMP provide a basic framework for taking actions to assess, communicate, and respond to drought conditions. Under the "Normal" condition, data are routinely collected, assessed, and distributed. When drought conditions are identified, the four drought levels escalate moving to heightened action, which may include increased data collection and assessment, interagency communication, public education and messaging, recommendations for water conservation measures, and a state of emergency issued by the Governor. At the "Emergency" level, mandatory water conservation measures may be enacted. These regionally declared drought levels and associated state actions are intended to communicate and provide guidance to the public and stakeholders across industries to enable them to respond early and effectively and to reduce impacts. Individual public water suppliers may have their own drought management plan, drought levels, and associated actions, which they may follow at all levels except at the Emergency level when mandatory actions may be required.

NOAA and others are advancing the science of early warning for droughts like the early warnings for floods and earthquakes to better project flashy, or fast-onset, droughts. Based on projected climate change, the distributions of precipitation events will continue to become more extreme, with periods of minimal rain alternating with extreme rain events. Therefore, developing ways to project and adapt to flash droughts may be critical for sectors such as agriculture and water supply.

The Massachusetts Water Resources Commission publishes the hydrologic condition report monthly, which includes the six drought indices and the National Climate Prediction Center's U.S. Monthly and Seasonal Drought Outlooks. The National Drought Mitigation Center produces a weekly Drought Monitor map. In accordance with the DMP, drought declarations are made monthly.

Probability of Future Events

Climate change will increase the probability of droughts. The Massachusetts Climate Change Assessment notes that the region will experience slight increases in the number of consecutive dry days and the number of days without rain from 2050 onward. By 2090 the number of consecutive dry days per year will increase to 33, compared to the annual statewide baseline of 31 days from 1986 to 2005. Table 12 summarizes this data and indicates the projected number of consecutive dry days according to the "high" and "low" limits of the Northeast Climate Adaptation Science Center (NE CASC) data. The Town of Boxborough is represented by the Eastern Inland region.

Table 12. Number of Consecutive Dry Days (CDD) and Days without Rain (DWR) per Year.

Region	Baseline		2030		2050		2070		2090	
	CDD	DWR	CDD	DWR	CDD	DWR	CDD	DWR	CDD	DWR
Berkshire and Hilltowns	29	159	29	161	30	165	30	167	31	170
Greater Connecticut River Valley	31	171	31	172	32	175	32	178	33	181
Central	32	180	32	182	32	185	33	188	33	192
Eastern Island	32	186	32	181	32	185	33	188	33	193
Boston Harbor	31	192	31	185	32	192	32	194	33	198
North and South Shores	31	184	31	182	32	187	32	190	33	195
Cape, Islands, and South Coast	31	186	31	182	32	187	32	191	33	194
Statewide	**31**	**176**	**31**	**175**	**31**	**179**	**32**	**182**	**33**	**187**

CDD = Consecutive Dry Days per Year (ResilientMass, Steinschneider & Najibi (2022))
DWR = Days Without Rain per Year (MA Climate Assessment (Commonwealth of Massachusetts, 2022))

These projections suggest that the days without precipitation are likely to increase across the Commonwealth, while the number of consecutive dry days will vary across the state while increasing over the coming decades.

Vulnerability Assessment

Exposure

Drought is a gradual phenomenon, and its condition occurs naturally in a broad geographic area. The entire Town would be exposed to drought conditions.

Built Environment Impacts

Major water users are more susceptible to drought, and these include water utilities and some commercial users. With an increased probability of drought and drought magnitude, water utilities should consider reviewing or developing extreme drought scenarios.

Population Impacts

Populations considered most vulnerable to drought impacts are identified based on a number of factors including their physical and financial ability to react or respond during a hazard. Senior and low-income populations are particularly susceptible. The Town should be aware of the potential needs of residents within these population segments in the event of a hazard occurrence.

Socioeconomic impacts of the drought may also include anxiety and depression about economic impact, health problems associated with poor water quality, fewer recreational activities, higher incidents of heat stroke, and even loss of human life.

With an increased probability of drought and increased drought magnitude, and the potential of increased water costs, vulnerable populations may be more severely impacted in the future.

Environment Impacts

Although agriculture is limited in the Town, there are some natural areas which may be adversely impacted by drought. Drought amplifies the risk of loss of biodiversity and affects animal and plant species. Economic impacts include higher food and lumber prices. Drought can shrink the food supplies of animals and plants dependent on water and damage their habitats. Sometimes the environmental damage caused by a drought is temporary, and other times it is irreversible.

Problem Statements for Drought

Table 13. Problem Statements for Drought.

Assets	Problems Associated with Drought
People (including underserved communities and socially vulnerable populations)	• Vulnerable communities may have difficulty accessing potable water during an emergency drought event. If the water sources are at emergency levels, having a plan to get vulnerable people water should be considered. If rates are increased to lower water demand, this may also adversely impact underserved and vulnerable communities.
Structures (including facilities, lifelines, and critical infrastructure)	• Water supply infrastructure may need to be shut down and water quality may become substandard. Businesses requiring water for daily operations may have their operations limited due to water restrictions.
Systems (including networks and capabilities)	• Outdoor water use restrictions and other water conservation measures during periods of extreme drought can be challenging to enforce, even when mandated through local declaration. • Drought communications will need to change as the water system from Littleton is extended into Boxborough.
Natural, historic, and cultural resources	• Water quality may be adversely impacted by major droughts. PFAS is already believed a challenge in Boxborough.
Activities that have value to the community	• None applicable. • Some agricultural operations may be increasingly impacted in the future.

Earthquakes

An earthquake is the vibration of the Earth's surface that follows a release of energy in the Earth's crust. New England experiences intraplate earthquakes because it is located within the interior of the North American plate. Although damaging earthquakes are rare in Massachusetts, low-magnitude earthquakes occur regularly in the state.

Description

An earthquake is a sudden rapid shaking of the earth caused by the breaking and shifting of rock beneath the earth's surface. Earthquakes can cause buildings and bridges to collapse; disrupt gas, electric, and telephone lines; and often cause landslides, flash floods, fires, avalanches, and tsunamis. Earthquakes can occur at any time without warning.

The underground point of origin of an earthquake is called its focus; the point on the surface directly above the focus is the epicenter. Earthquakes are described based on their magnitude and intensity as explained below under *Extent*.

New England's earthquakes appear to be the result of the cracking of the crustal rocks due to compression as the North American Plate is being very slowly squeezed by the global plate movements. As a result, New England epicenters do not follow the major mapped faults of the region, nor are they confined to particular geologic structures or terrains. Because earthquakes have been detected all over New England, seismologists suspect that a strong earthquake could be centered anywhere in the region. Furthermore, the mapped geologic faults of New England currently do not provide any indications detailing specific locations where strong earthquakes are most likely to be centered.

In addition to earthquakes occurring within the Commonwealth, earthquakes in other parts of New England can impact widespread areas. Large earthquakes in Canada, which is more seismically active than New England, can affect buildings in Massachusetts. This is due in part to the fact that earthquakes in the eastern U.S. are felt over a larger area than those in the western U.S. The difference between seismic shaking in the East versus the West is primarily due to the geologic structure and rock properties that allow seismic waves to travel farther without weakening (United States Geological Survey [USGS], 2012).

In some places in New England, including locations in Massachusetts, small earthquakes seem to occur with some regularity. In articles appearing in 2016, John Ebel Ph.D., a Senior Research Scientist at the Weston Observatory, was quoted as saying "The Acton, Boxborough and Littleton areas are sporadically active… We tend to get a small earthquake once every three-to-five years." It is not clear why some localities experience such clustering of earthquakes, but clusters may indicate locations where there is an increased likelihood of future earthquake activity.

Location

Given the above discussion, the potential exists for earthquakes to occur within Boxborough or to occur elsewhere and be felt in Boxborough.

Previous Occurrences

The largest earthquake since 1900 to strike Massachusetts was a magnitude 3.9 located east of the Quabbin Reservoir in 1994. Two recent earthquakes with epicenters close to central Massachusetts included a magnitude 3.3 in the area around Westfield in 2000, and a magnitude 1.9 in the area around Northampton in 2012.

The previous edition of this plan noted that earthquakes have not occurred Boxborough. To determine whether earthquakes have occurred recently near or in Boxborough, all events listed by Weston Observatory were reviewed for all towns in Massachusetts since the date of last edition of this plan. Listed earthquakes above magnitude 2.0 include the following very minor earthquakes, and none were near Boxborough:

- 12/21/18 – 3 km WSW of Gardner, MA, 2.1/2.1 [Mn*/Mc**]
- 8/21/19 – 2 km SSE of Wareham, MA, 1.7/2.4
- 12/3/19 – 4 km SSE of Plymouth, MA, 1.6/2.2
- 11/8/20 – 11 km SW of New Bedford, MA, 3.8/3.4
- 11/22/20 – 12 km WSW of New Bedford, MA, 1.7/2.6
- 7/25/21 – 5 km W of Peabody, MA, 1.4/2.5
- 1/1/22 – 13 km N of Rockport, MA, 2.3/3.0
- 3/4/22 – 5 km WSW of Orange, MA, 2.2/2.7
- 3/19/22 – 36 km ENE of Rockport, MA, 1.4/2.2

*Mn is the Nuttli Magnitude (see *Extent* below)
**Mc is the Coda Duration Magnitude (see *Extent* below)

Extent

Magnitude is an estimate of the relative size or strength of an earthquake and is related to the amount of seismic energy released at the hypocenter of the earthquake. It is based on the amplitude of earthquake waves recorded on instruments that have a common calibration. The magnitude of an earthquake is thus represented by a single instrumentally determined value recorded by a seismograph, which records the varying amplitude of ground oscillations.

The Richter scale was developed in 1935 and was used exclusively until the 1970s. The scale set the magnitude of an earthquake based on the logarithm of the amplitude of recorded waves. Being logarithmic, each whole number increase in magnitude represents a tenfold increase in measured strength. Earthquakes with a magnitude of about 2.0 or less are usually called "microearthquakes" and are generally only recorded locally. Earthquakes with magnitudes of 4.5 or greater are strong enough to be recorded by seismographs all over the world.

As more seismograph stations were installed around the world following the 1930s, it became apparent that the method developed by Richter was valid only for certain frequency and distance ranges, particularly in the southwestern United States. New magnitude scales that are an extension of Richter's original idea were developed for other areas. In particular, the Moment magnitude scale (Mw) was developed in the 1970s to replace the Richter scale and has been in official use by the USGS since 2002.

According to USGS, these multiple methods are used to estimate the magnitude of an earthquake because no single method is capable of accurately estimating the size of all earthquakes. Some magnitude types are calculated to provide a consistent comparison to past earthquakes, and these scales are calibrated to the original Richter scale. However, differences in magnitude of up to 0.5 can be calculated for the same earthquake through different techniques. In general, Moment magnitude provides an estimate of earthquake size that is valid over the complete range of magnitudes and so is commonly used today.

Although Moment magnitude is the most common measure of earthquake size for medium and larger earthquakes, the USGS does not calculate Mw for earthquakes with a magnitude of less than 3.5 which is the more common situation for Massachusetts. Localized Richter scales or other scales are used to calculate magnitudes for smaller earthquakes.

Regionally, the Weston Observatory utilizes two scales to track the magnitude of earthquakes. These include the Nuttli magnitude (Mn) for North America east of the Rocky Mountains and is more appropriate for the relatively harder continental crust in Connecticut compared to California. Weston Observatory also utilizes the Coda Duration magnitude (Mc), which is based on the duration of shaking at a particular station. The advantages of the Coda Duration magnitude are that this method can quickly estimate the magnitude before the exact location of the earthquake is known.

The effect of an earthquake on the earth's surface is called the intensity. The Modified Mercalli Intensity Scale consists of a series of key responses such as people awakening, movement of furniture, damage to chimneys, and total destruction. This scale, composed of 12 increasing levels of intensity that range from imperceptible shaking to catastrophic destruction, is designated by Roman numerals. It is an arbitrary ranking based on observed effects.

Table 14. Modified Mercalli Intensity.

Modified Mercalli Intensity	Description
I	Not felt except by a very few under especially favorable conditions
II	Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
III	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration similar to the passing of a truck. Duration estimated.
IV	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Felt by nearly everyone; many awakened. Some dishes and windows broken. Unstable objects overturned. Pendulum clocks may stop.

Modified Mercalli Intensity	Description
VI	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI	Few, if any (masonry), structures remain standing. Bridges destroyed. Rails bent greatly.
XII	Damage total. Lines of sight and level are distorted. Objects thrown in the air.

Source: USGS

A comparison of Richter magnitude to typical Modified Mercalli intensity is presented below.

Table 15. Modified Mercalli Intensity and Moment Magnitude.

Moment Magnitude	Typical Maximum Modified Mercalli Intensity
1.0 to 3.0	I
3.0 to 3.9	II to III
4.0 to 4.9	IV to V
5.0 to 5.9	VI to VII
6.0 to 6.9	VII to IX
7.0 and above	VIII or higher

Source: USGS

Probability of Future Events

Earthquake location and magnitude probabilities are exceptionally difficult to predict in Massachusetts. Minor earthquakes are relatively common in New England, but damaging earthquakes are not. Therefore, USGS instead characterizes the probability of ground acceleration rather than estimating a probability of magnitude. The Seismic Hazard Map for the state of Massachusetts (USGS) shows a peak ground acceleration of 8% to 10% of gravity in Boxborough having a 2% probability of being exceeded in 50 years.

Vulnerability Assessment

Exposure

A major earthquake could cause severe damage to Boxborough buildings, including older structures that were built before a 1975 law requiring new buildings to withstand earthquakes. Other associated concerns are debris management issues including debris removal and identification of disposal sites.

Built Environment Impacts

Historic data for earthquake events indicate that between 1991 and 2022, no major (>5.0 magnitude) earthquakes were recorded in Middlesex County during this period, causing no damage to property. The entire built environment of Boxborough is vulnerable to earthquakes. Older, unreinforced masonry buildings are very susceptible to earthquakes. The fire station is vulnerable to earthquakes due to it's condition.

To identify built environment impacts to the Town, FEMA's risk assessment software, Hazus, was implemented. The economic loss results of the 1500-year event are shown in Table 16while the results for the 2500-year event are shown in Table 17. The Town's Average Annual Loss (AAL) is modeled to be $15,197.

Table 16. Building Loss for a 1500-Year Scenario.

Loss Type	**Residential ($Million)**	**Commercial ($Million)**	**Other Occupancy ($Million)**	**Total ($Million)**
Building Loss	2.54	0.89	1.06	**4.48**
Content Loss	0.90	0.45	0.64	**1.98**
Business Inventory Loss	0.00	0.04	0.08	**0.12**
Business Income Loss	0.01	0.18	0.01	**0.20**
Business Relocation Loss	0.11	0.11	0.09	**0.31**
Rental Income Loss	0.09	0.09	0.02	**0.19**
Wage Loss	0.02	0.19	0.03	**0.25**
Total	**3.66**	**1.95**	**1.93**	**7.54**

Table 17. Building Loss for a 2500-Year Scenario.

Loss Type	Residential ($Million)	Commercial ($Million)	Other Occupancy ($Million)	Total ($Million)
Building Loss	5.53	1.84	2.23	**9.60**
Content Loss	2.16	1.04	1.45	**4.65**
Business Inventory Loss	0.00	0.09	0.19	**0.28**
Business Income Loss	0.02	0.32	0.02	**0.36**
Business Relocation Loss	0.22	0.20	0.16	**0.59**
Rental Income Loss	0.16	0.15	0.04	**0.35**
Wage Loss	0.04	0.34	0.06	**0.45**
Total	**8.14**	**4.00**	**4.14**	**16.28**

Population Impacts

Populations considered most vulnerable to earthquake impacts are identified based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Senior and low-income populations are particularly susceptible. The Town should be aware of the potential needs of residents within these population segments in the event of a hazard occurrence.

Hazus was used to model injuries and fatalities for the 1500- and 2500-year events. For the 1500-year event, there are fewer than 5 injuries requiring medical attention and no injuries requiring medical attention. For the 2500-year event there are up to 5 minor injuries not requiring medical attention with no injuries requiring medical attention.

Environment Impacts

The environment may be impacted by cascading impacts from the earthquake, such as a truck accident or train derailment caused by track or road damage, landslide, or dam breach. This could result in a hazardous material release.

Problem Statements for Earthquakes

Table 18. Problem Statements for Earthquakes.

Assets	Problems Associated with Earthquakes
People (including underserved communities and socially vulnerable populations)	• Vulnerable populations located in unreinforced masonry structures may sustain injuries. • Elderly people may fall during events.
Structures (including facilities, lifelines, and critical infrastructure)	• Unreinforced masonry and utility lifelines impacted. • Utility systems impacted.
Systems (including networks and capabilities)	• None apparent or projected.
Natural, historic, and cultural resources	• Historical buildings constructed out of unreinforced masonry are susceptible and may be impacted.
Activities that have value to the community	• None apparent or projected.

Flooding from Precipitation and Dam Overtopping

The Town of Boxborough Community Resilience Building Workshop Summary of Findings (2021) lists "flooding" as one of the top hazards of concern.

Nationally, flooding causes more damage annually than any other severe weather event. Flooding in Massachusetts is often the direct result of frequent weather events such as coastal storms, nor'easters, tropical storms, hurricanes, heavy rains, and snowmelt. Increases in precipitation and extreme storm events will result in increased inland flooding. Common types of flooding are described below.

Description

River and Stream Flooding: River and stream flooding often occurs after heavy rain. Areas of the state with high slopes and minimal soil cover (such as found in central Massachusetts) are particularly susceptible to flash flooding caused by rapid runoff that occurs in heavy precipitation events and in combination with spring snowmelt, which can contribute to riverine flooding. Frozen ground conditions can also contribute to low rainfall infiltration and high runoff events that may result in riverine flooding. Some of the worst riverine flooding in Massachusetts' history occurred because of strong nor'easters and tropical storms in which snowmelt was not a factor. Tropical storms can produce very high rainfall rates and volumes of rain that can generate high runoff when soil infiltration rates are exceeded.

Floodplains are the low, flat, and periodically flooded lands adjacent to rivers, lakes, and oceans. These areas are subject to geomorphic and hydrologic processes. Floodplains may be broad, as when a river crosses an extensive flat landscape, or narrow, as when a river is confined. These areas form a complex physical and biological system that supports a variety of natural resources and flood storage.

Drainage-Related Flooding: Drainage systems are designed to remove surface water from developed areas as quickly as possible to prevent localized flooding on streets and adjacent properties. They make use of a conveyance system that channels water away from a developed area to surrounding streams, bypassing natural processes of water infiltration into the ground, groundwater storage, and evapotranspiration. Flooding from overwhelmed drainage entails floods caused by increased water runoff due to development and drainage systems that are not capable of conveying high flows. Since drainage systems reduce the amount of time the surface water takes to reach surrounding streams, flooding can occur more quickly and reach greater depths than if there were no urban development at all. In almost any community with some degree of development, basement, roadway, and infrastructure flooding can result in significant damage due to poor or insufficient stormwater drainage.

Dam Overtopping: Dam overtopping is caused by floods that exceed the capacity of the dam, and it can occur as a result of inadequate spillway design, settlement of the dam crest, blockage of spillways, and other factors. Overtopping accounts for one-third of all dam failures in the U.S. The two primary types of dam failure are catastrophic failure (characterized by the sudden, rapid, and uncontrolled release of impounded water) and design failure (which occurs as a result of minor overflow events). There are a number of ways in which climate change could alter the flow behavior of a river, causing conditions to deviate from what a dam was designed to handle. For example, more extreme precipitation events could increase the frequency of intentional discharges. Many other climate impacts, including shifts in seasonal and geographic rainfall patterns, could also cause the flow behavior of rivers to deviate from previous hydrographs. When flows are greater than expected, spillway overflow events (often referred to as “design failures”) can occur. These overflows result in increased discharges downstream and increased flooding potential. Therefore, although climate change will not increase the probability of catastrophic dam failure, it may increase the probability of design failures.

Beaver Dams: Additional causes of flooding include beaver dams. Beaver dams obstruct the flow of water and cause water levels to rise. Significant downstream flooding can occur if beaver dams break.

Ice Jam: An ice jam is an accumulation of ice that acts as a natural dam and restricts the flow of a body of water. A freeze-up jam usually occurs in early winter to midwinter during extremely cold weather when supercooled water and ice formations extend to nearly the entire depth of the river channel. This type of jam can act as a dam and begin to back up the flowing water behind it. A breakup jam, forms as a result of the breakup of the ice cover at ice-out, causing large pieces of ice to move downstream, potentially piling up at culverts, around bridge abutments, and at curves in river channels. Breakup ice jams occur when warm temperatures and heavy rains cause rapid snowmelt. The melting snow, combined with the heavy rain, causes frozen rivers to swell. The rising water breaks the ice layers into large chunks, which float downstream and often pile up near narrow passages and obstructions (bridges and dams). Ice jams may build up to a thickness great enough to raise the water level and cause flooding upstream of the obstruction.

Secondary Hazards: The most problematic secondary hazards for flooding are fluvial erosion, riverbank erosion, and landslides affecting infrastructure and other assets located within floodplains. Without the space required along river corridors for natural physical adjustment, such changes in rivers after flood events can be more harmful than the actual flooding. The impacts from these secondary hazards are especially prevalent in the upper courses of rivers with steep gradients, where floodwaters may pass quickly and without much damage, but scour the banks, edging buildings, and structures closer to the river channel or cause them to fall in. Landslides can occur following flood events when high flows oversaturate soils on steep slopes, causing them to fail. These secondary hazards also affect infrastructure.

Roadways and bridges are impacted when floods undermine or wash out supporting structures. Dams may fail or be damaged, compounding the flood hazard for downstream communities. Failure of wastewater treatment plants from overflow or overtopping of hazardous material tanks and the dislodging of hazardous waste containers can occur during floods as well, releasing untreated wastewater or hazardous materials directly into storm sewers, rivers, or the ocean. Flooding can also impact public water supplies and the power grid in similar ways, through inundation and/or erosion.

Location

Heavy rainfall events occur regularly in Massachusetts. As a result, inland flooding such as riverine and drainage-related flooding affect most of the communities in the Commonwealth, including Boxborough. Ice jams are likely not a risk given the stream profiles in Boxborough. A few dams are located in and upstream of Boxborough. Therefore, all flood-related hazards except for ice jams (riverine floods, stormwater flooding, dam overtopping) are believed relevant to the Town of Boxborough.

The Community Resilience Building Summary Report (2021) for Boxborough notes that flooding is a concern in the following areas:

- Littlefield Road near Central Street
- Depot Road near Wildlife Management Area and intersection with Liberty Square Road
- Liberty Sq Rd at the intersection with the Guggins Brook culvert
- Davidson Road
- Burroughs Road near Wolf Swamp

- Sargent Road
- Near intersection of Hill Road and Cunningham Road
- Route 111 crossing of Elizabeth Brook
- Near intersection of Hill Road and Barteau Lane
- Northern end of land near Cisco campus, near border with Harvard Sportsman's Club
- State-owned road Route 111 historically floods due to low spots in road. MassDOT and the Town are improving sections of the road and installing a sidewalk. Once work is complete, an additional assessment of other low spots should be conducted.
- Road flooding may limit access to the transfer station on Codman Hill Road as there is only one access road.

About half of these above locations were listed in the previous edition of this hazard mitigation plan. While somewhat dated (2010), the list from the previous edition of this plan is presented below for consistency:

- Old Harvard Road – Flooding: This site at the end of Old Harvard Road near Eldridge Pond has experienced basement flooding and minor roadway flooding. A culvert was replaced in the area several years ago.
- Barteau Lane / Hill Road – Flooding / Beaver Activity: This site near Beaver Brook has experienced flooding due to beaver activity and as a result has been subject to septic and well contamination.
- Davidson Road – Flooding / Beaver Activity: Davidson Road near Herons Pond has experienced flooding due to beaver activity. A culvert has been replaced at this location and the Town continues to monitor the area.
- Herons Pond – Flooding / Beaver Activity: Beavers at Herons Pond have caused flooded areas.
- Littlefield Road – Flooding: Flooding has occurred at Littlefield Road where it crosses Fort Pond Brook, causing the brook to overtop the road. This area is located within floodplain.
- Massachusetts Avenue – Flooding / Beaver Activity: This area near Guggins Brook behind the Blanchard school has flooded as a result of beaver activity and has caused potential for contamination at nearby wells.

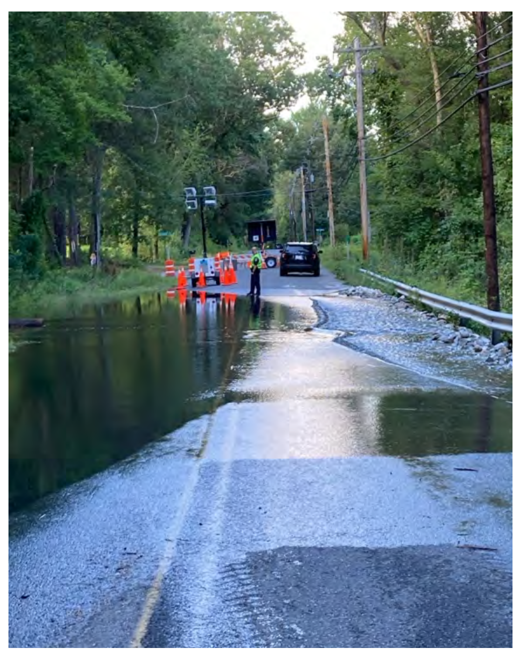


Figure 12. Road Flooding.

- Applewood Village – Flooding / Beaver Activity: The Applewood condominium complex located along the eastern border of Town, has experienced flooding and septic failures due to beaver activity in Acton conservation land. The Town of Acton has drained the ponding with some success.
- Codman Hill Road – Flooding / Beaver Activity: This site near 60 Codman Hill has experienced flooding due to beaver activity along Elizabeth Brook.

Previous Occurrences

Specific floods events are not described in the previous edition of this plan. As noted earlier, this plan update relies primarily on a roughly ten-year lookback (2014 through 2023). The NOAA Storm Events database (https://www.ncdc.noaa.gov/stormevents/) for Middlesex County lists two flood events impacting the Boxborough area for the period 2014-2023. There were no losses reported.

Table 19. NCEI Severe Storm Database Entries Covering Floods in Boxborough.

Date	Description
7/23/13	*Flood.* A couple of upper level disturbances moved over southern New England while at the surface a slow moving warm front drifted north across the area. This ignited showers and thunderstorms across much of the area. Southwest flow at the surface provided a deep layer of moisture with high dewpoints and high precipitable water values, which resulted in heavy rainfall with the showers and thunderstorms. Anywhere from one to four inches of rain fell with these storms, sometimes within a very short period of time, which resulted in flash flooding in many locations. Route 2 and Interstate 495 were flooded with six inches of water.
12/9/14	*Flood.* A strong coastal storm brought wintry precipitation, heavy rain, and strong winds to much of southern New England. A mix of precipitation brought freezing drizzle, snow, and sleet to northwestern portions of the area while heavy rain was widespread. The on-ramp to Interstate 495 northbound from Route 111 was partially closed due to flooding.

The HMPC members reported that frequent washouts at stream crossings are not occurring, but culvert conditions and capacities are a concern. Beaver dams are also a concern in Boxborough.

According to the previous edition of this plan, there have been no dam failures in Boxborough. However, HMPC members noted that the dam on Guggins Brook is becoming more challenging to maintain, and action may be needed.

Extent

The frequency and severity of flooding are measured using a discharge probability, which is the probability that a certain river discharge (flow) will be equaled or exceeded in a given year. Flood studies use historical records to determine the probability of occurrence for the different discharge levels. The flood frequency equals 100 divided by the discharge probability. For example, the “100-year discharge” has a 1 percent chance of being equaled or exceeded in any given year. The “annual flood” is the greatest flood event expected to occur in a typical year. These measurements reflect statistical averages only; it is possible for two or more floods with a 100-year or higher recurrence interval to occur in a short time period. The same flood can have different recurrence intervals at different points on a river.

The 1% annual chance flood is the standard used by most federal and state agencies. It is used by the National Flood Insurance Program (NFIP) to guide floodplain management and determine the need for flood insurance. The extent of flooding associated with a 1% annual probability of occurrence (the base flood or 100-year flood) is called the 100-year floodplain, which is used as the regulatory boundary by many agencies. Also referred to as the Special Flood Hazard Area (SFHA), this boundary is a convenient tool for assessing vulnerability and risk in flood-prone communities. The term “500-year flood” is the flood that has a 0.2% chance of being equaled or exceeded each year. Base flood elevations and the boundaries of the 1% annual chance (100-year) and the 0.2% annual chance (500-year) floodplains are shown on Flood Insurance Rate Maps (FIRMs), which are the principal tools for identifying the extent and location of the flood hazard.

Both the 100-year and the 500-year floodplains are determined based on past events. As a result, the flood maps do not reflect projected changes in precipitation events.

Flooding in Massachusetts is forecast and classified by the National Weather Service (NWS) Northeast River Forecast Center as minor, moderate, or severe based upon the types of impacts that occur. Minor flooding is considered “disruptive” flooding that causes impacts such as road closures and flooding of recreational areas and farmland. Moderate flooding can involve land with structures becoming inundated. Major flooding is a widespread, life-threatening event. River forecasts are made at many locations in the state containing USGS river gauges with established flood elevations and levels that correspond to each of the degrees of flooding.

Due to the pattern of meteorological conditions needed to cause serious flooding, it is unusual for a flood to occur without warning. Flash flooding, which occurs when excessive water fills either normally dry creeks or riverbeds or dramatically increases the water surface elevation on currently flowing creeks and rivers, can be less predictable. However, potential hazard areas can be warned in advance of potential flash-flooding danger. Flooding is more likely to occur due to a rainstorm when the soil is already wet and/or streams are already running high from recent previous rains. NOAA’s Northeast River Forecast Center provides flood warnings for Massachusetts, relying on monitoring data from the USGS stream gauge network. Notice of potential flood conditions is generally available several days in advance. State agency staff also monitor river, weather, and forecast conditions throughout the year. Notification of potential flooding is shared among state agency staff, including the Massachusetts Emergency Management Agency (MEMA) and the Office of Dam Safety. The NWS provides briefings to state and local emergency managers and provides notifications to the public via traditional media and social networking platforms.

Probability of Future Events

Although it can be complex to forecast, scientists expect that there will be an overall increase of precipitation on an annual basis across Massachusetts. It is expected that precipitation patterns will become more variable over time, with fewer days with precipitation, but heavier and more intense events when it does rain or snow. Most areas across the state are expected to have small increases in annual total precipitation, but a substantial change in seasonal precipitation patterns.

Climate change will increase the probability of flooding caused by intense precipitation. The National Climate Assessment and NCEI both project more fall, winter, and spring precipitation as well as more intense precipitation. As noted in the ResilientMass Plan, extreme river flow events are projected to increase, elevating the probability of damaging floods. In addition, smaller flood events are likely to occur more frequently. For example, the current 24-hour 10-year storm (about 3 inches) could double in frequency by 2050 in western and central Massachusetts and triple in frequency in coastal regions.

Vulnerability Assessment

Exposure

In Boxborough, the 1% annual chance floodplain (100-year floodplain) covers about 661.9 acres, or approximately 9.9 percent of the Town. In addition to the 100- year floodplains, stormwater has the potential to cause localized flooding.

The fire station is impacted by flooding periodically. The floodplain goes around the Blanchard Memorial School and although the school isn't impacted directly, operations may be impacted by flood events. There are approximately eleven buildings in the floodplain including single family homes, commercial, and industrial buildings. Additionally, several roads experience flooding including Liberty Square Road, Depot Road, Mass Avenue, and Old Harvard Road. The Massachusetts Bay Transportation Authority (MBTA) rail crosses the floodplain in Boxborough and may be impacted. There are no structures listed on the National Register of Historic Places in the floodplain. According to EPA's Toxic Release Inventory (TRI) database, there is one facility which contains hazardous materials (Muirfield Mechanical, LLC)) in the 100-year floodplain. However, there are several facilities which contain hazardous materials that are adjacent to the floodplain. All of the buildings in the floodplain are part of an environmental justice community. Table 20 shows the types of buildings exposed to the flood and their value. The number in parathesis shows the total number of buildings and building values for the Town.

Table 20. Buildings in 100-Year Floodplain.

Building Type	Number of Buildings (Total in City)	Building Value (Total in City)
Single Family	7 (1,496)	$1,466,700 ($529,303,600)
Multi-Family	0 (138)	$0 ($1,106,362,200)
Mixed-Use	0 (27)	$0 ($5,951,200)
Commercial	3 (83)	$401,200 ($86,371,200)

Building Type	Number of Buildings (Total in City)	Building Value (Total in City)
Educational	0 (5)	$0 ($2,315,400)
Government	0 (26)	$0 ($33,649,000)
Religious/Non-Profit	0 (25)	$0 ($16,279,700)
Industrial	1 (40)	$120,000 ($180,200,000)
Garage/Outbuilding	0 (7)	$0 ($100,100)
Vacant	0 (6)	$0 ($273,000)
Total	**11 (1,853)**	**$1,987,900 ($1,960,805,400)**

The population exposed to the 100-year floodplain is shown in **Error! Reference source not found.**. The column on the left shows the population in and around the floodplain (wherever the Census Block overlapped with the floodplain boundary) while the column on the right shows the total population numbers for the Town. There is a large Asian population and EJ community in the floodplain.

Table 21. Population Exposed to 100-Year Floodplain (2020 U.S. Census).

Demographics	Population in and Adjacent to Floodplain	Total Population
Population	4,015	5,506
Households	1,720	2,362
White	2,696 (67.2%)	3,753 (68.2%)
Black	89 (2.2%)	120 (2.2%)
American Indian	4 (0.1%)	5 (0.1%)
Asian	900 (22.4%)	1,189 (21.6%)
Pacific Islander	1 (0.0%)	1 (0.0%)
Other Race	72 (1.8%)	83 (1.5%)
Two or More Races	253 (6.3%)	355 (6.4%)
Hispanic or Latino:	171 (4.3%)	218 (4.0%)
Population under 18:	876 (21.8%)	1,217 (22.1%)
Population over 64:	410 (10.2%)	577 (10.5%)
Annual Income < $30K/year	202 (11.7%)	276 (11.7%)
Population in EJ Zone*	4,015 (100.0%)	5,506 (100.0%)

**Massachusetts Office of Energy and Environmental Affairs, 2022*

Although dams and their associated impoundments provide many benefits to a community, such as water supply, recreation, hydroelectric power generation, and flood control, they also pose a potential risk to lives and property. Dam failure is not a common occurrence, but dams do represent a potentially disastrous hazard. When a dam fails, the potential energy of the stored water behind the dam is instantly released, oftentimes with catastrophic consequences as the water rushes in a torrent downstream flooding an area known as an "inundation area." The number of casualties and the amount of property damage will depend upon the timing of the warning provided to downstream residents, the number of people living or working in the inundation area, and the number of structures in the inundation area.

There are no high or significant hazard dams in Boxborough, but there is a significant hazard dam just to the west of the Town. There is one dam on Guggins Brook that does not have a hazard assignment. Table 22 identifies the dams within the Town.

Additionally, there is a beaver dam on the MBTA property which could breach and cause impacts.

Table 22. Dams in Vicinity.

Name	Ownership	Hazard Type
Guggins Brook Dam	Public	N/A

The 100-year Floodplain (FEMA) with the Town's critical facilities is shown in Figure 13. The fire station is exposed to the flood hazard. Train tracks do cross the 100-year floodplain and may be vulnerable to flooding.

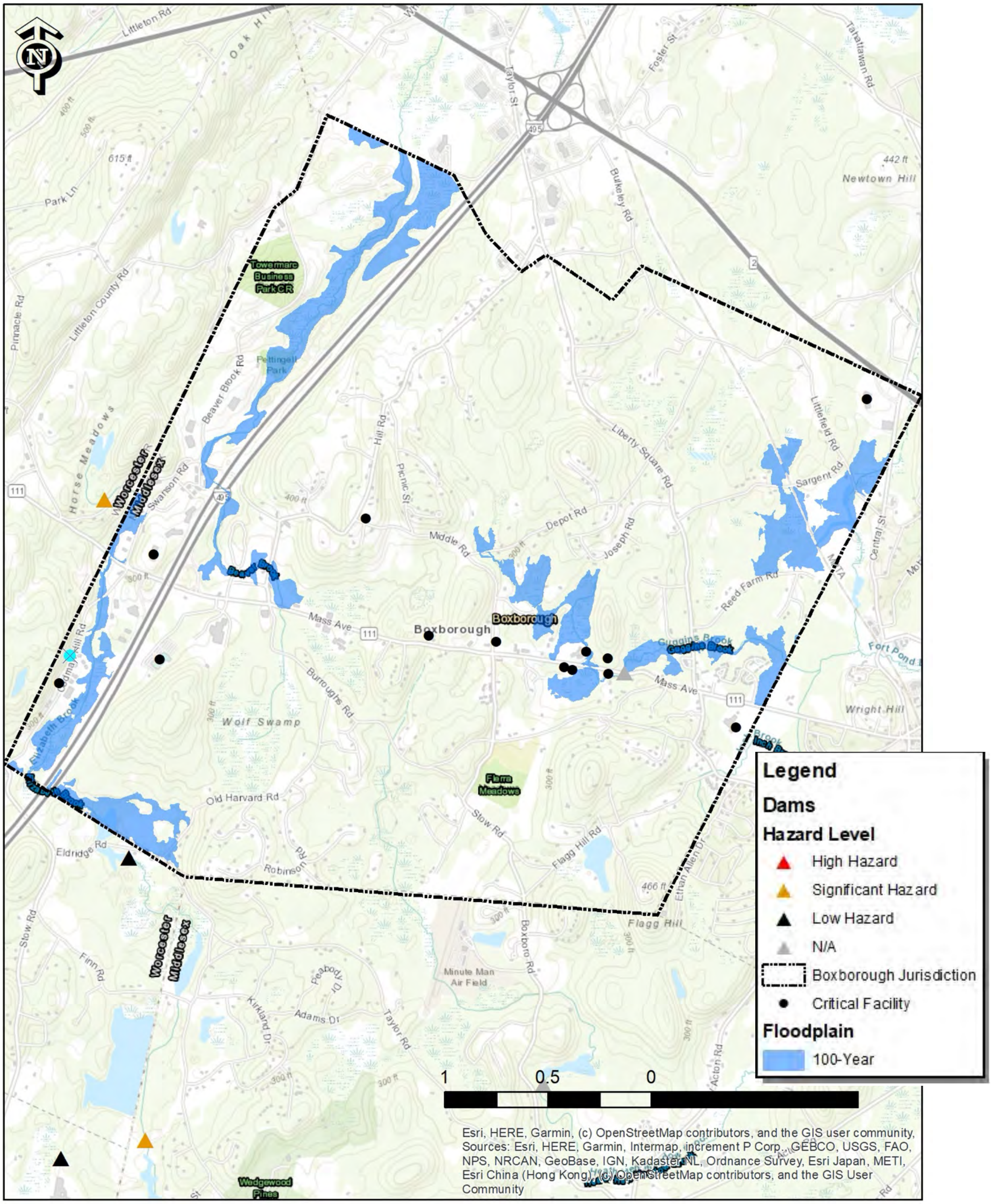


Figure 13. Boxborough Critical Facilities and 100-Year Floodplain.

Built Environment Impacts

To identify built environment impacts to the Town, FEMA's risk assessment software, Hazus, was implemented. Building footprint data and parcel data was used to update the model while the latest floodplain was also integrated into the software. The economic loss results of the 100-year event are shown in Table 23. The Town's Average Annual Loss (AAL) is calculated to be $62,100.

Table 23. Building Loss for the 100-Year Flood Scenario.

Loss Type	Residential ($Million)	Commercial ($Million)	Other Occupancy ($Million)	Total ($Million)
Building Loss	0.86	0.03	0.50	**1.39**
Content Loss	0.37	0.10	1.47	**1.94**
Business Inventory Loss	0.00	0.01	0.16	**0.17**
Business Income Loss	0.07	0.21	0.11	**0.39**
Business Relocation Loss	0.29	0.02	0.08	**0.39**
Rental Income Loss	0.20	0.01	0.02	**0.23**
Wage Loss	0.16	0.14	1.40	**1.70**
Total	**1.95**	**0.52**	**3.74**	**6.21**

Climate change will increase the probability and magnitude of flood impacts to the built environment. Future floodplains may be larger than the current FEMA modeled floodplain and new development, including the Enclave development should consider these projected conditions. These new developments may cause additional stormwater issues which should be considered too.

Population Impacts

The Town should be aware that senior and low-income segments of Boxborough's population may be more vulnerable to hazard events due to a number of factors. Senior and low-income populations may be physically or financially unable to react and respond to a hazard event and require additional assistance. Access to information about the hazard event may be lacking, as well as access to transportation in the case of an evacuation. The location and construction quality of housing can also pose a significant risk. The Town should be aware of the potential needs of residents within these population segments in the event of a hazard occurrence.

Using the Hazus software, the 100-year flood scenario results showed that there would be approximately 30 displaced households and 40 people seeking public shelter.

Climate change will increase the probability and magnitude of flood impacts to the population. Future floodplains may be larger than the current FEMA modeled floodplain and new development should consider these projected conditions. Vulnerable populations should be considered when development near the current floodplain is planned.

Environment Impacts

One of the major environmental impacts of a major flood would be the potential release of hazardous materials. According to EPA's Toxic Release Inventory (TRI) database, there is one facility which contains hazardous materials (Murfield Mechanical, LLC)) in the 100-year floodplain. However, there are several facilities which contain hazardous materials that are adjacent to the floodplain.

Climate change will increase the probability and magnitude of flood impacts which may include environmental impacts due to hazardous materials release. Facilities which contain hazardous materials should be considered when new development is planned.

Problem Statements for Flood

Problem statements summarize risk and vulnerability and are included following each hazard profile. The problem statements were developed to bridge the gap between identified hazard and development of the mitigation actions. Problem statements are included in each hazard profile section.

Table 24. Problem Statements Related to Flooding.

Assets	**Problems Associated with Flood**
People (including underserved communities and socially vulnerable populations)	• Older populations in the floodplain may have difficulty evacuating. • The school is adjacent to the floodplain and contains vulnerable populations.
Structures (including facilities, lifelines, and critical infrastructure)	• Potential exposed structures include: o Fire station and areas near the Blanchard Memorial School. o Undersized culverts. • Area adjacent to beaver dam on MBTA property.
Systems (including networks and capabilities)	• Road closures may interrupt community systems including Liberty Square Road, Depot Road, Mass Avenue, and Old Harvard Road.

Assets	Problems Associated with Flood
	• The Town is currently precluded from adopting higher regulatory standards to protect against flooding (must comply with State Building Code).
Natural, historic, and cultural resources	• According to EPA's Toxic Release Inventory (TRI) database, there is one facility which contains hazardous materials (Murfield Mechanical, LLC)) in the 100-year floodplain. However, there are several facilities which contain hazardous materials that are adjacent to the floodplain.
Activities that have value to the community	• Several road closures may disrupt community events.

Hurricanes and Tropical Storms

The Town of Boxborough Community Resilience Building Workshop Summary of Findings (2021) lists "strong storms" as one of the top hazards of concern.

Flooding in Massachusetts is often the direct result of tropical storms and hurricanes. These powerful storms can also cause significant widespread damage due to high winds. The impacts from high winds are the primary concern of this section.

Description

Tropical cyclones (tropical depressions, tropical storms, and hurricanes) that affect New England form over the warm, moist waters of the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico. Tropical systems customarily come from a southerly direction and when they accelerate up the East Coast of the U.S., most take on a distinct appearance that is different from a typical hurricane. Although rain is often limited in the areas south and east of the track of the storm, these areas can incur the worst winds and storm surge. Dangerous flooding occurs most often to the north and west of the track of the storm. An additional threat associated with a tropical system making landfall is the possibility of tornado generation. Tornadoes would generally occur in the outer bands to the north and east of the storm, a few hours to as much as 15 hours prior to landfall.

Hurricane season runs from June 1 to November 30. In New England, these storms are most likely to occur in August, September, and the first half of October. The ResilientMass Plan notes that this is due in large part to the fact that it takes a considerable amount of time for the waters south of Long Island to warm to the temperature necessary to sustain the storms this far north. Also, as the region progresses into the fall months, the upper-level jet stream steering winds might 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.

Location

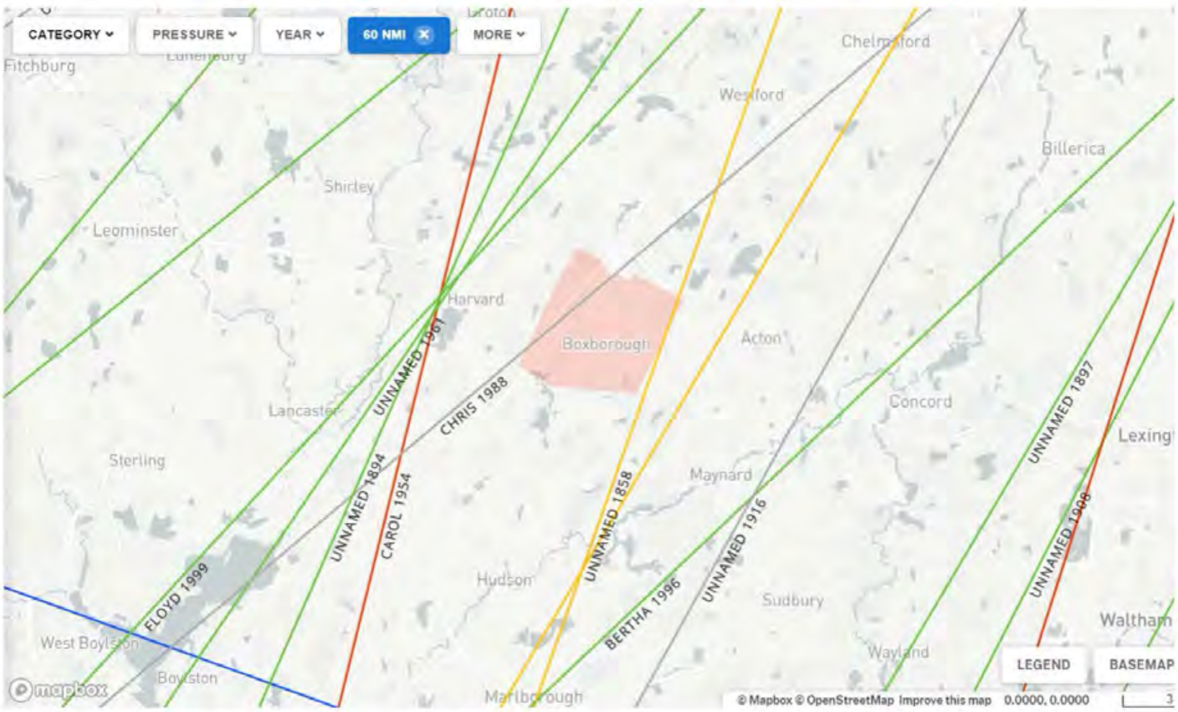
Tropical storms and hurricanes can affect the entirety of Massachusetts, including the geographic extent of Boxborough.

Previous Occurrences

The ResilientMass Plan notes that hurricanes and tropical storms occur somewhat regularly in Massachusetts. Recent notable events include Tropical Storm Isaias (2020), Tropical Depression Henri (2021), and Tropical Storm Else (2021). Historical tropical system tracks near and through are depicted on the following page. This mapping is available from NOAA and updated continuously.

Figure 14. Vehicle Damage from Trees Falling.

Historical Tropical Storm Tracks in the Town of Boxborough



Graphic courtesy of NOAA

A number of tropical storms and hurricanes have passed near or through Boxborough since recordkeeping began. Unnamed storms crossed through the town in 1858, 1869, 1894, 1897, 1908, 1916, and 1961; only the 1858 and 1869 storms are believed likely to have caused widespread damage in the town. Hurricanes Carol (1954) and Donna (1960) were both significant storms that caused wind damage throughout the region. Storms Bertha (1996) and Floyd (1999) caused little wind damage but produced minor to significant flooding in the region.

Figure 15. Historical Tropical Storm Tracks In Boxborough.

The Community Resilience Building Summary Report for Boxborough notes that “the Town has experienced multiple disruptive and damaging weather events, including Tropical Storm Irene (August 2011), Tropical Storm Sandy (October 2012), winter Nor’easter Nemo (February 2013), winter Nor’easter Quinn (March 2018), and Hurricane Barry (August 2019). These storms brought heavy rain-induced inland flooding, wind damage to trees, and snow that caused widespread damage to Boxborough and many other Massachusetts communities.

As noted elsewhere, this Plan update relies primarily on a ten-year lookback (2014 through 2023) ending with the date of plan development. During that ten-year period, only one Massachusetts emergency declaration (Storm Lee of September 2023) was associated with a tropical system, but it is not yet in the NCEI database of severe storms for Middlesex County. Eight tropical storm and hurricane events appeared in the NCEI inventory for Middlesex County for the last 11 years:

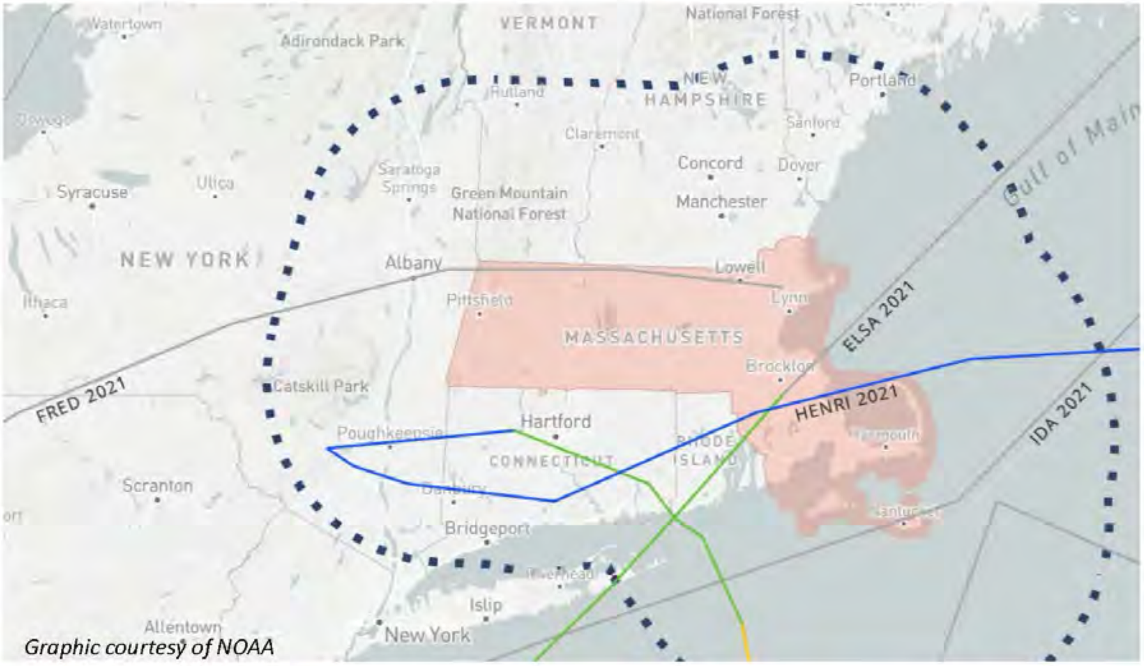
- June 7, 2013: The remnants of Tropical Storm Andrea tracked across southeastern Massachusetts bringing heavy rain (3-5 inches) to much of southern New England. This resulted in significant urban flooding, particularly across eastern Massachusetts and Rhode Island, as well as river and small stream flooding. It also contributed to record high rainfall across the area for the month of June. Two to five inches of rain fell across Middlesex County. Mount Pleasant Street was flooded under the railroad bridge in Billerica.
- September 5, 2016: Hermine was named on August 31st as it intensified to a tropical storm in the Gulf of Mexico. After moving off the coast of North Carolina, Hermine moved northeast, then north, then west, meandering south of southern New England for several days in early September. Hermine's effects on southern New England were rather minimal. Rainfall added up to less than an inch for most locations and winds were generally below tropical storm force. Because trees were still fully leaved and we had higher wind gusts, there was some wind damage.
- September 20, 2017: Named storm Jose formed over the Tropical Atlantic, moving west and growing to become a Major Hurricane. Jose passed north of the Leeward Islands, then turned on a northward path north of the Dominican Republic. As he moved north, Jose diminished to a Tropical Storm. Jose brought strong wind gusts and heavy downpours, primarily to the islands and south coasts of Massachusetts.
- October 29, 2017: The remnants of Tropical Storm Phillipe merged with a mid-latitude system approaching the U.S. East Coast. This created an area of low pressure that moved north from the Carolinas through New York State on the 29th. The low swung a cold front through Southern New England during the early morning of the 30th. The combined system generated strong to damaging winds. Tropical moisture flowing north ahead of the cold front contributed to heavy downpours with one to five inches of rain reported.
- August 4, 2020: Tropical Storm Isaias tracked northeast from the eastern Carolinas across the mid-Hudson Valley and into New England. The center of the storm passed close to Albany, NY on

August 4th. This storm brought tropical storm force winds and moderate rainfall to western Massachusetts through the period. These winds caused widespread damage with numerous reports of downed trees and wires across Massachusetts.

- July 9, 2021: Tropical Storm Elsa made landfall in Rhode Island on Friday morning before moving into the Gulf of Maine. It interacted with a stalled frontal boundary and brought widespread heavy rainfall of 2 to 3.5 inches and gusty winds along the south coast, which caused scattered tree damage.
- August 19, 2021: The remnants of Tropical Storm Fred moved across Southern New England producing heavy rain, gusty winds, and two tornadoes.
- August 23, 2021: Tropical Storm Henri made landfall in southwest Rhode Island around noon on August 22nd, then moved slowly northwestward and westward across northern Connecticut and weakened. Henri brought strong wind gusts and flash flooding. The worst flash flooding occurred in northeast Connecticut. As the remnants of Henri moved eastward across southern New England on August 23rd, it spawned three tornadoes and a waterspout in MA and also it caused some renewed flooding. The highest rainfall totals over the two-day period ranged from 5 to 6 inches in Hartford and Tolland Counties in northern Connecticut and in Franklin, Hampshire, and Hampden Counties in Massachusetts.

Boxborough was only moderately impacted by the tropical and post-tropical storm systems listed above. The storm tracks of 2021 are illustrated on the following graphic.

Impacts of the 2021 Hurricane Season on Massachusetts



T.S. Elsa crossed eastern Massachusetts on July 9, delivering wind and flooding rains while transitioning to an extratropical storm later that day. Approximately 2 to 4 inches of rain were recorded in many towns. MBTA commuter rail trains were delayed on the Worcester line due to flooding, and Route 146 was flooded. About 11,000 Eversource customers in Massachusetts lost power.

Extratropical Storm Fred crossed northern Massachusetts lengthwise on August 19 and 20, delivering flooding rains to parts of southern New England. Flooding in Massachusetts was worst in the Worcester area. Approximately 2 to 4 inches of rain were recorded in many towns.

T.D. Henri crossed eastern Massachusetts on August 24, delivering flooding rains to parts of southern New England. Prior to crossing Massachusetts, the storm looped through Connecticut and New York on August 22-24. The path and slow movement of the storm contributed to widespread flooding in all three states, made worse due to the conditions caused by storm Fred only a few days before. Approximately 1 to 4.5 inches of rain were recorded in many towns. About 12,000 Eversource customers in Massachusetts lost power.

Extratropical Storm Ida passed south of New England and crossed Nantucket on September 2, delivering flooding rains to parts of southern New England. The precipitation from Ida was more intense than expected, and it caused widespread flooding. Approximately 2 to 6 inches of rain were recorded in many towns. About 4,000 people in Massachusetts lost power.

Figure 16. Tracks for Tropical Storms that Impacted Massachusetts 2021.

Even without the presence of a catastrophic hurricane striking Boxborough recently, less severe tropical storms and remnants such as those described above have created disruptions and necessitated public expenditures to deal with outages and debris.

Extent

Hurricanes are measured according to the Saffir-Simpson scale, which categorizes or rates hurricanes from 1 (minimal) to 5 (catastrophic) based on their intensity. This is used to give an estimate of the potential property damage and flooding expected along the coast from a hurricane landfall. Wind speed is the determining factor in the scale, inherently leaving out any measure of precipitation and flooding.

Table 25. Saffir-Simpson Scale.

Saffir-Simpson Hurricane Wind Scale

	Sustained Winds	Types of Damage Due to Hurricane Winds
1	74-95 mph 64-82 kt 119-153 km/h	**Damaging winds will produce some damage:** Well-constructed framed homes could have damage to roof, shingles, vinyl siding, and gutters. Large branches of trees will snap, and shallow-rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96-110 mph 83-95 kt 154-177 km/h	**Very strong, damaging winds will cause widespread damage:** Well-constructed framed homes could sustain major roof and siding damage. Many shallow-rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3 (major)	111-129 mph 96-112 kt 178-208 km/h	**Dangerous winds will cause extensive damage:** Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4 (major)	130-156 mph 113-136 kt 209-251 km/h	**Extremely dangerous winds will cause devastating damage:** Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5 (major)	157 mph or higher 137 kt or higher 252 km/h or higher	**Catastrophic damage will occur:** A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Source: National Hurricane Center, NOAA

Tropical storms and tropical depressions, while generally less dangerous than hurricanes, can be deadly. The winds of tropical depressions and tropical storms are usually not the greatest threat; rather, the rains, flooding, and severe weather associated with the tropical storms are what customarily cause more significant problems. Nevertheless, serious power outages can also be associated with these types of events.

The NWS issues a hurricane warning when sustained winds of 74 mph or higher are expected in a specified area in association with a tropical, subtropical, or post-tropical cyclone. A warning is issued 36 hours in advance of the anticipated onset of tropical-storm-force winds. A hurricane watch is announced when sustained winds of 74 mph or higher are possible within the specified area in association with a tropical, subtropical, or post-tropical cyclone. A watch is issued 48 hours in advance of the anticipated onset of tropical-storm-force winds (NWS, 2013).

Probability of Future Events

The ResilientMass Plan explains that Massachusetts experiences a tropical storm or hurricane about once every two years on average, with NOAA estimating the recurrence of any category hurricane between 13 to 30 years, and a Category 3 hurricane occurrence every 50 to 60 years.

Some researchers have suggested that the intensity of tropical cyclones has increased over the last 40 years, with some believing that there is a connection between this increase in intensity and climate change. While most climate simulations agree that greenhouse warming enhances the frequency and intensity of tropical storms, models of the climate system are still limited by resolution and computational ability. Given the history of major storms and the possibility of increased frequency and intensity of tropical storms due to climate change, it is prudent to expect that there will be hurricanes impacting Boxborough in the future that may be of greater frequency and intensity than in the past.

Vulnerability Assessment

Exposure

High winds and heavy rain and/or hail associated with hurricanes and tropical storms can cause damage to utilities, structures, roads, trees (potentially causing vehicle accidents) and injuries and death. Other associated concerns are debris management issues including debris removal and identification of disposal sites. All assets in Boxborough should be considered exposed to high winds while specific areas are exposed to hurricane surge. Figure 17 shows the 100-year windspeeds identified in the ASCE 7-98 publication.

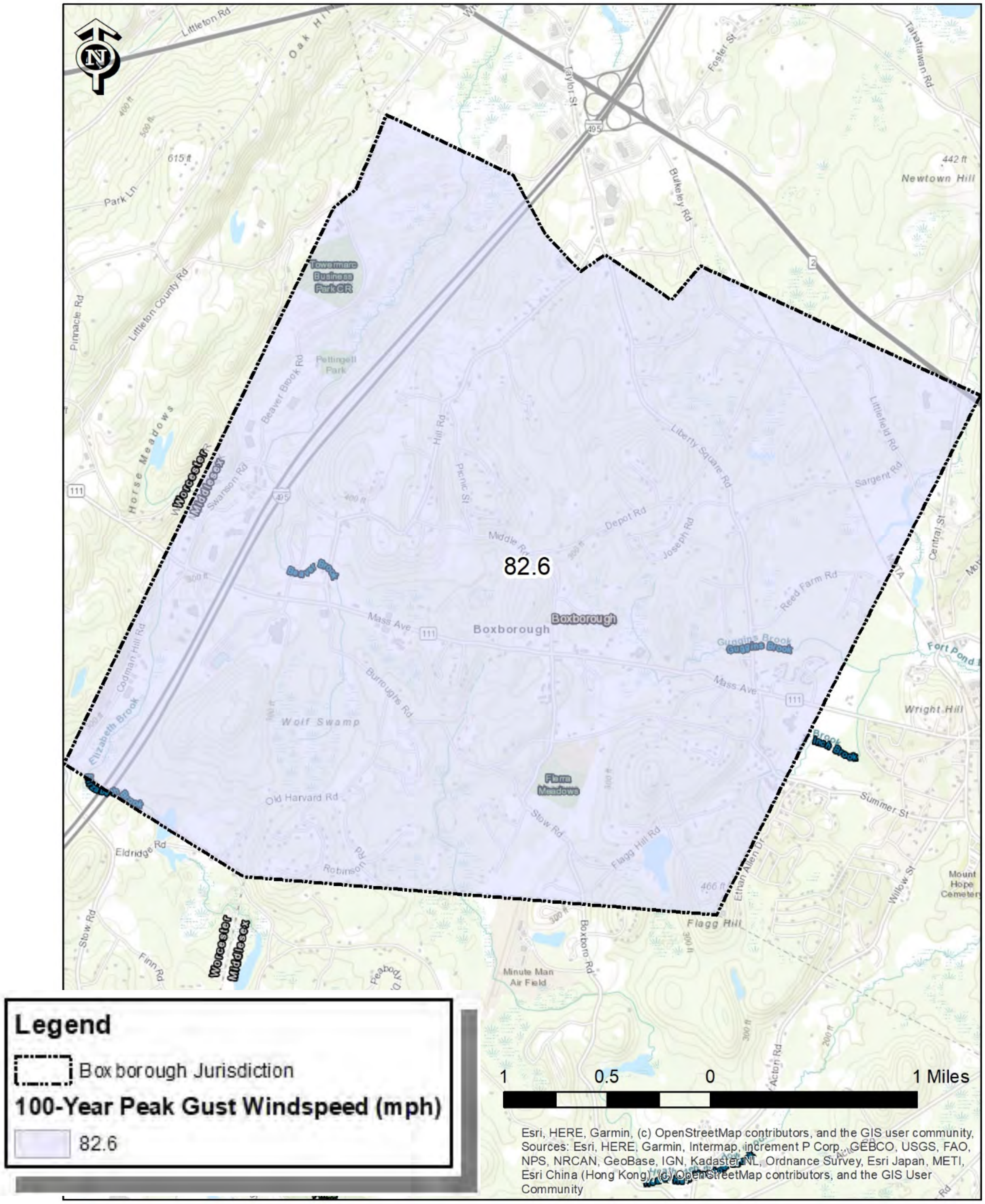


Figure 17. 100-Year Windspeeds (ASCE 7-98).

Built Environment Impacts

To identify built environment impacts to the Town resulting from wind damage, FEMA's risk assessment software, Hazus, was implemented. The economic loss results of the 500-year event are shown in Table 26 while the results for the 1000-year event are shown in Table 27. The Town's Average Annual Loss (AAL) is calculated to be $393,092.

Buildings that are permanently open with bays or open sides are susceptible to wind damage since the building envelope can't be maintained.

Table 26. Building Losses Due to Wind for a 500-Year Scenario.

Loss Type	Residential ($Million)	Commercial ($Million)	Other Occupancy ($Million)	Total ($Million)
Building Loss	16.95	0.76	0.70	**18.41**
Content Loss	8.37	0.15	0.23	**8.75**
Business Inventory Loss	0.00	0.02	0.03	**0.05**
Business Income Loss	0.00	0.12	0.02	**0.14**
Business Relocation Loss	0.35	0.09	0.57	**1.01**
Rental Income Loss	0.25	0.05	0.01	**0.31**
Wage Loss	0.00	0.10	0.11	**0.21**
Total	**25.92**	**1.29**	**1.67**	**28.88**

Table 27. Building Losses Due to Wind for a 1000-Year Scenario.

Loss Type	Residential ($Million)	Commercial ($Million)	Other Occupancy ($Million)	Total ($Million)
Building Loss	23.06	1.22	1.21	**25.49**
Content Loss	11.28	0.29	0.49	**12.06**
Business Inventory Loss	0.00	0.03	0.62	**0.65**
Business Income Loss	0.00	0.19	0.04	**0.23**
Business Relocation Loss	0.63	0.17	0.12	**0.92**
Rental Income Loss	0.40	0.10	0.02	**0.52**
Wage Loss	0.00	0.17	0.24	**0.41**

Loss Type	Residential ($Million)	Commercial ($Million)	Other Occupancy ($Million)	Total ($Million)
Total	**35.37**	**2.17**	**2.74**	**40.28**

Population Impacts

Populations considered most vulnerable to hurricane and tropical storm impacts in Boxborough are identified based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. For high windspeeds, it's important to maintain the building envelope during the event. If a window or door fails, damage to the structure will be much greater. The senior and low-income populations in Boxborough are particularly susceptible to extreme winds and it should be noted that there may be overlap within the two categories. The Town should be aware of the potential needs of residents within these population segments in the event of a hazard occurrence.

For the 500-year event, Hazus predicts that there will be up to five displaced households and nobody seeking public shelter from the high windspeeds. For the 1000-year event, Hazus predicts that there will be up to ten displaced households and nobody seeking public shelter from the high windspeeds.

Environment Impacts

Hurricanes can cause damage to parks, and other, natural areas. Some areas of the Town may be out of service until trees are removed.

Problem Statements for Hurricanes/Tropical Storms

Table 28. Problem Statements for Hurricanes/Tropical Storms.

Assets	Problems Associated with Hurricanes and Tropical Storms
People (including underserved communities and socially vulnerable populations)	• Vulnerable populations may need to be evacuated and could be displaced from their homes.
Structures (including facilities, lifelines, and critical infrastructure)	• Wind may cause trees to fall into structures and infrastructure, and roadways.

Assets	Problems Associated with Hurricanes and Tropical Storms
	• Wind damage to wind-susceptible buildings such as carports, greenhouses, pavilions, gazebos, and open-walled buildings. Additional damage to commercial buildings with HVAC located on roofs. • The electric grid may go down during high wind event.
Systems (including networks and capabilities)	• First responders may have difficulty reaching people if roads are closed due to tree debris.
Natural, historic, and cultural resources	• Historic buildings may experience damage during high wind events, especially the roofing and windows. Water entering these buildings could impact important historic and cultural artifacts.
Activities that have value to the community	• A severe hurricane wind and rain event could negatively impact outdoor activities in the Town.

Invasive Species

The ResilientMass Plan defines invasive species as non-native species that cause or are likely to cause harm to ecosystems, economies, and/or public health (USDA). The focus of this section is on invasive terrestrial plants, as this is the most studied and managed type of invasive; information for invasive aquatic flora and fauna is also provided when relevant.

Description

The Massachusetts Invasive Plant Advisory Group (MIPAG), a collaborative representing organizations and professionals concerned with the conservation of the Massachusetts landscape, is charged by EOEEA to provide recommendations to the Commonwealth to manage invasive species. MIPAG defines invasive plants as "non-native species that have spread into native or minimally managed plant systems in Massachusetts [causing] economic or environmental harm by developing self-sustaining populations and becoming dominant and/or disruptive to those systems." These species have biological traits that provide them with competitive advantages over native species, particularly because in a new habitat they are not restricted by the biological controls of their native habitat. As a result, these invasive species can monopolize natural communities, displacing many native species and causing widespread economic and environmental damage.

Some examples of invasive insect species include:

- Nantucket Pine Tip Moth (native pest) is a moth with heads, bodies, and appendages covered with gray scales with mottled rusty-red markings. Larvae cause damage to young trees (up to five years old) by feeding inside growing shoots, buds, and conelets. The preferred host is the loblolly pine.

- Bark Beetles (native pest) include more than 600 species of beetles which serve in important ecological roles in small numbers where they live in dead, weakened, and dying host conifer trees.
- Forest Tent Caterpillar (native pest) has the biggest footprint of any indigenous tent caterpillar in North America (Furniss and Carolin 1977) and is a major defoliator of a variety of deciduous hardwood trees. The caterpillars spin silken mats on the trunks and large branches of trees where they molt and feed. Forest Tent Caterpillars can reach outbreak proportions causing massive defoliation of host trees and becoming a nuisance to people.
- Pine Reproduction Weevils (native pest) is a very dark, elongate, oval insect up to 1/2 inch long with indistinct to distinct gray or pale orange spots of scales on the wings and thorax. They feed at night on the conifer seedlings or near the tips of branches of larger plants. Females lay their eggs on the roots of these trees. The weevils breed in all species of pines, hemlocks, junipers, spruces, firs, and cedars.
- Hardwood Borers (native pest) usually attack hardwoods experiencing some kind of stress although the clear-wing moths attack healthy trees. These insects attack the tree year after year and may eventually weaken it enough that it is prone to wind breakage. Some borers develop in the root system damaging young trees.
- Hemlock Wooly and Balsam Wooly Adelgid (non-native pest) is a very small, invasive, aphid-like insect that attacks North American hemlocks (Hemlock Wooly) and firs (Balsam Wooly). They can be identified by the white wooly masses that form on the underside of branches at the base of the tree's needles. They stay at this location for the rest of their lives. Their feeding disrupts the flow of nutrients to the tree twigs and needles leading to a decline in tree health and mortality in 4 to 10 years.
- Gypsy Moth (non-native pest) is an insect which feeds on a large variety of tree leaves from oak, maple, apple, crabapple, hickory, basswood, aspen, willow, birch, pine, spruce, hemlock, and others. It does prefer oak tree leaves, however. Periodically, large populations can cause defoliation damaging and killing trees they are feeding on.
- Spotted Lanternfly (non-native pest) is an invasive insect first detected in the U.S. in 2014. It feeds on a variety of fruit, ornamental, and wood trees and could seriously impact the grape, orchard, and logging industries.

Location

The entire Commonwealth is vulnerable to invasive species. Types of species can vary by location, elevation, ecosystem, and habitat type, as well as land and water use. Furthermore, the ability of invasive species to travel distances (either via natural mechanisms or accidental human interference) allows these species to propagate rapidly over a large geographic area. Similarly, in open freshwater and marine ecosystems, invasive species can quickly spread once introduced, as there are generally no physical barriers to prevent establishment, outside of physiological tolerances, and multiple opportunities for transport to new locations (by boats, for example). The entire geographic area of Boxborough is believed at risk for invasive species propagation.

Previous Occurrences

Invasive species do not represent a singular event but rather an ongoing or emerging problem, so it is difficult to measure the frequency of occurrences. A comprehensive list of invasives can be found at https://www.massnrc.org/mipag/invasive.htm. Invasives of current concern to forest health (https://www.mass.gov/service-details/current-forest-health-threats) in Middlesex County are reportedly:

- Asian Jumping Worms
- Emerald Ash Borer
- Gypsy Moth
- Hemlock Woolly Adelgid
- Southern Pine Beetle
- White Pine Needlecast
- Winter Moth

The annual budget to address invasive species in Massachusetts has fluctuated over time but, in general, appears to have decreased. This likely implies a lack of resources rather than a decrease in risk. The following figures are from https://budget.digital.mass.gov/summary/fy22/enacted/energy-and-environmental-affairs/environmental-affairs/20000100.

Table 29. Statewide Budgets for Addressing Invasive Species.

FY Year	Budget
2022	$277,838
2021	$146,348
2020	$4,150,000
2019	$3,831,135
2018	$4,347,000
2017	$6,046,870

The Boxborough Community Resilience Building Summary Report (2021) noted that "Workshop participants expressed concern about an increase in invasive species throughout the Town. Invasive species of concern include garlic mustard, purple loosestrife, Japanese knotweed, bittersweet, and other species."

The Boxborough Open Space and Recreation Plan (2022) includes a table of vegetation commonly found in Boxborough. The table includes honeysuckle, autumn olive, multiflora rose, Canada thistle, oriental bittersweet, common buckthorn, purple loosestrife, European barberry, glossy buckhorn, reed canary grass, winger euonymus [all species are copied herein using the common names presented in the Open Space and Recreation Plan].

Extent

MIPAG recognizes 74 plant species as "Invasive," "Likely Invasive," or "Potentially Invasive." The criteria for an "Invasive" species are listed below; the other assigned categories are associated with lower scores on the criteria checklist. The criteria for invasive animal species are less well-defined, but many of the same characteristics (including a non-Massachusetts origin and the ability to out-compete native species) are similar. In order to be considered "Invasive" by MIPAG, a plant species must meet the following complex set of criteria:

1. Be nonindigenous to Massachusetts.
2. Have the biologic potential for rapid and widespread dispersion and establishment in minimally managed habitats.
3. Have the biologic potential for dispersing over spatial gaps away from the site of introduction.
4. Have the biologic potential for existing in high numbers away from intensively managed artificial habitats.
5. Be naturalized in Massachusetts (persists without cultivation in Massachusetts).

If a species meets criteria 1–4 and criterion 5, it may be considered "invasive" or "likely invasive" in Massachusetts. If it does not meet criterion 5, it may be considered "potentially invasive" if it meets criteria 13–15 below.

6. The species is widespread in Massachusetts, or common in a region or habitat type(s) in the state.
7. The species has many occurrences in Massachusetts that have high numbers of individuals in minimally managed habitats.
8. The species is able to outcompete other species in the same natural plant community.
9. The species has the potential for rapid growth, for high seed or propagule production and dissemination, and for establishment in natural plant communities.

If a species meets the initial five criteria and criteria 6–9 at this time, it may be considered a "likely invasive" species in Massachusetts if it also meets at least one of the following three criteria:

10. The species has at least one occurrence in Massachusetts that has high numbers of individuals forming dense stands in minimally managed habitats.
11. The species has the potential, based on its biology, colonization history outside its native range, and likelihood of range expansion or change in biologic potential from climate change predictions, to become invasive in Massachusetts.
12. The species is acknowledged to be invasive in nearby states, but its status in Massachusetts is unknown or unclear. This may result from lack of field experience with the species or from difficulty in species determination or taxonomy.

If the species meets the basic criteria for invasiveness (criteria 1–4) but is not naturalized in Massachusetts (criterion 5), the species may be considered "potentially invasive" in Massachusetts if it meets the following three criteria (criteria 13–15):

13. The species, if it becomes naturalized in Massachusetts, based on its biology and biologic potential, would pose an imminent threat to the biodiversity of Massachusetts and
14. Its naturalization in Massachusetts is anticipated, and
15. The species has a documented history of invasiveness in other areas outside its native range including expansion of range and/or change in biological potential from climate change predictions

The MIPAG has developed a list of Early Detection plant species according to an established set of criteria that includes MIPAG classification as an *invasive, likely invasive,* or *potentially invasive* ecological threat and one of these three criteria: *limited prevalence in Massachusetts, partial containment potential,* or *public health threat.* The Early Detection table includes the documented distribution of a species by county.

Table 30. Early Detection Information for Addressing Invasive Species.

Species	Common Name	Current County of Distribution (November 2010)	Notes
Arthraxon hispidus	Hairy joint grass; jointhead; small carpetgrass	Franklin (historically)	This species is not currently known in Massachusetts; it was last collected in Deerfield in 1973. This is an annual grass that co-occurs with Japanese stilt grass further south.

Species	Common Name	Current County of Distribution (November 2010)	Notes
Butomus umbellatus	Flowering rush	Essex, Middlesex	*Butomus umbellatus* is an aquatic perennial herb which reproduces by seed dispersal or vegetatively by bulbils
Carex kobomugi	Japanese sedge; Asiatic sand sedge	Barnstable (historically)	Native to northeastern Asia, Carex kobomugi is an invasive plant that invades coastal sand dunes and can outcompete native dune-binding grasses. This species was last collected in 1973.
Egeria densa	Brazilian waterweed; Brazilian elodea	Essex, Middlesex, Norfolk, Plymouth, Worcester	This species is often confused with Hydrilla and native *Elodea* spp. but has larger, nickel-sized flowers. This is a submerged aquatic species whose rapid growth often leads to dense mats on the water surface, which crowds out native plants and damages fish and aquatic habitat. The mats can also impede boat traffic.
Glyceria maxima	Tall mannagrass; reed mannagrass	Essex	This perennial grass invades low shrub-swamps and other wetland
Heracleum mantegazzianum	Giant hogweed	Berkshire, Franklin, Hampden, Hampshire, Middlesex, Norfolk, Suffolk, Worcester	Giant hogweed is a federal noxious weed that is currently being eradicated under the U.S. Department of Agriculture's authority. This is a perennial herb that can cause painful burns and permanent scarring to humans if they touch the plant.
Hydrilla verticillata	Hydrilla; water-thyme; Florida elodea	Barnstable, Plymouth, Worcester	Hydrilla is an invasive non-native submerged plant. This plant grows and reproduces rapidly, displacing native species, hampering recreational uses, and slowing water flow. Hydrilla, once

Species	Common Name	Current County of Distribution (November 2010)	Notes
			established, can replace native vegetation and affect fish populations.
Myriophyllum aquaticum	Parrot-feather; water-feather; Brazilian watermilfoil	Norfolk	Parrot-feather is a perennial aquatic plant native to South America. This plant typically grows in freshwater, with a preference for areas with high nutrient contents. Parrot-feather has been introduced worldwide for use in indoor and outdoor aquaria.
Nymphoides peltata	Yellow floating heart	Hampden, Middlesex, Worcester	Yellow floating heart is native to Asia and now is found in over 15 states in the U.S. This plant forms dense mats on the water surface, restricting light penetration into the water and decreasing air exchange between the water's surface and the atmosphere. Algae can be shaded out by this plant, resulting in food chain disruptions for an entire lake.
Persicaria perfoliata syn.: Polygonum perfoliatum	Mile-a-minute vine or weed; Asiatic tearthumb	Barnstable, Essex, Franklin, Norfolk, Plymouth, Suffolk	Mile-a-minute vine is a barbed vine that can grow up to 6 inches a day. This vine smothers other herbaceous plants, shrubs, and even trees by growing over them and blocking their access to sunlight.
Peuraria montana ssp. lobata	Kudzu; Japanese arrowroot	Barnstable, Bristol, Essex, Middlesex, Plymouth, County	Kudzu is native to Japan and southeast China and was introduced to the U.S. during the Philadelphia Centennial Exposition in 1876. Once established, kudzu can grow at a rate of a foot per day, with mature vines as long as 100 feet.

Species	Common Name	Current County of Distribution (November 2010)	Notes
Senecio jacobaea	Tansy ragwort; stinking Willie; stinking Billy	Essex County Suffolk County Middlesex County	This biennial herb is a weedy plant that infests woodlands, pastures, and hayfields. This plant is toxic to all classes of livestock but most toxic to cattle and horses. The plant can cause chronic liver disease, and affected animals usually die within a few weeks after ingesting it
Trapa natans	Water chestnut	Berkshire, Bristol, Essex, Franklin, Hamden, Hampshire, Middlesex, Suffolk, Worcester	Water chestnut is an annual aquatic species with both floating and submerged leaves.

Probability of Future Events

Once established, invasive species often escape notice for years or decades. Introduced species that initially escaped many decades ago are only now being recognized as invasives. Because these species can occur anywhere (on public or private property), new invasive species often escape notice until they are widespread, and eradication is impractical. As a result, early and coordinated action between public and private landholders is critical to preventing widespread damage from an invasive species.

The USDA Animal and Plant Health Inspection Service (APHIS) manages the Plant Protection and Quarantine (PPQ) Program which safeguards U.S. agriculture and natural resources from the introduction, establishment, and spread of plant pests and noxious weeds. PPQ is the lead federal agency for plant health emergencies and works closely with federal, state, and local agencies; universities; industries; and private entities in developing and implementing science-based framework designed to protect against invasive pests and diseases.

Massachusetts has a variety of laws and regulations in place that attempt to mitigate the impacts of these species. The Department of Agricultural Resources (DAR) maintains a list of prohibited plants for the state, which includes federally noxious weeds as well as invasive plants recommended by MIPAG and approved for listing by DAR. Species on the DAR list are regulated with prohibitions on importation, propagation, purchase, and sale in the Commonwealth. Additionally, the Massachusetts Wetlands Protection Act (310 CMR 10.00) includes language requiring all activities covered by the Act to account for, and take steps to prevent, the introduction or propagation of invasive species.

In 2002, Massachusetts passed an Aquatic Invasive Species Management Plan, making the Commonwealth eligible for federal funds to support and implement the plan through the federal Aquatic Nuisance Prevention and Control Act. MassDEP, DCR, CZM, and Massachusetts Institute of Technology Sea Grant College Program are part of the Northeast Aquatic Nuisance Species Panel, which was established under the federal Aquatic Nuisance Species Task Force. This panel allows managers and researchers to exchange information and coordinate efforts on the management of aquatic invasive species. The Commonwealth also has several resources pertaining to terrestrial invasive species, such as the Massachusetts Introduced Pest Outreach Project, although a strategic management plan has not yet been prepared for these species. All these efforts are aimed at reducing the probability of future occurrences.

Notwithstanding the above efforts, the presence of invasive species is ongoing, and it is difficult to quantify the future frequency of these occurrences. Increased rates of global trade and travel have created many new pathways for the dispersion of exotic species. As a result, the frequency with which these threats have been introduced has increased significantly. Increased international trade in ornamental plants is particularly concerning because many of the invasive plant species in the U.S. were originally imported as ornamentals. Furthermore, they are expected to be an increasing problem due to a changing climate and projected increases in non-native plant and animal infestations. For this reason and based on the fact invasive species are already an ongoing issue for the region, this hazard has been assigned a probability of highly likely.

Vulnerability Assessment

Exposure

The entire Town of Boxborough has the potential to be exposed to invasive pests. Climate change will make the area more attractive to pests who have not been found there traditionally.

Built Environment Impacts

Although the built environment is not as susceptible to pests as the natural environment, it can help spread the invasive species. This includes trains and vehicles that could move the species from one location to another. Trees, which are damaged or killed by invasive pests, can become hazards to people, property, utility lines, and roadways when they fall. Many dead trees in one area can also become fuel for wildfires interconnecting the two hazards.

Population Impacts

The direct population impacts are minimal. However, the indirect impacts could destroy livelihoods.

Environment Impacts

Most of the natural features in the Town have some susceptible pests including the parks and other forested areas. Trees that have been damaged by other events such as fire, wind, flooding, and animal browsing are more susceptible to diseases and pests. Certain species of trees are more susceptible based on the need of the damaging organism. Climate change will increase the probability of invasive pests which will pose increased environmental impacts in the future.

Problem Statements for Invasive Species

Table 31. Problem Statements for Invasive Species.

Assets	Problems Associated with Invasive Species
People (including underserved communities and socially vulnerable populations)	• None apparent or projected.
Structures (including facilities, lifelines, and critical infrastructure)	• None apparent or projected.
Systems (including networks and capabilities)	• Additional DPW resources may be required in areas where invasive species need attention.
Natural, historic, and cultural resources	• Invasive species are problematic throughout the Town and have been verified in Patch Hill Conservation Area, Wolf Swamp Conservation Land, and along the rail line.
Activities that have value to the community	• Recreational activities may be adversely impacted, depending on location, and especially in parks and natural areas.

Landslides

The term “landslide” includes a wide range of ground movements such as rock falls, deep failure of slopes, and shallow debris flows. The most common types of landslides in Massachusetts include translational debris slides, rotational slides, and debris flows. Most of these events are caused by a combination of unfavorable geologic conditions (silty clay or clay layers contained in glaciomarine, glaciolacustrine, or thick till deposits), steep slopes, and/or excessive wetness leading to excess pore pressures in the subsurface.

Description

Historical landslide data for the Commonwealth suggests that most landslides are preceded by two or more months of higher-than-normal precipitation, followed by a single, high-intensity rainfall of several inches or more (Mabee and Duncan, 2013). This precipitation can cause slopes to become saturated. Landslides associated with slope saturation occur predominantly in areas with steep slopes underlain by glacial till or bedrock. Bedrock is relatively impermeable relative to the unconsolidated material that overlies it. Similarly, glacial till is less permeable than the soil that forms above it. Thus, there is a permeability contrast between the overlying soil and the underlying, and less permeable, unweathered till and/or bedrock. Water accumulates on this less permeable layer, increasing the pore pressure at the interface, leading to a failure or slide.

Occasionally, landslides occur as a result of geologic conditions and/or slope saturation. Adverse geologic conditions exist wherever there are lacustrine or marine clays, as clays have relatively low strength. These clays often formed in the deepest parts of the glacial lakes that existed in Massachusetts following the last glaciation. These lakes include Bascom, Hitchcock, Nashua, Sudbury, Concord, and Merrimack, among many other unnamed glacial lakes. When oversteepened or exposed in excavations, these vulnerable areas often produce classic rotational landslides.

Landslides can also be caused by external forces, including both undercutting (due to flooding or wave action) and construction. Undercutting of slopes during flooding or coastal storm events is a major cause of property damage. Streams and waves erode the base of the slopes, causing them to oversteepen and eventually collapse.

USGS provides the following graphic to depict different types of landslides. The images on the left side represent starting conditions whereas the images on the right represent conditions at the end of the slide event. Numbers 1, 2, 3, and 8 are considered most frequent in Massachusetts.

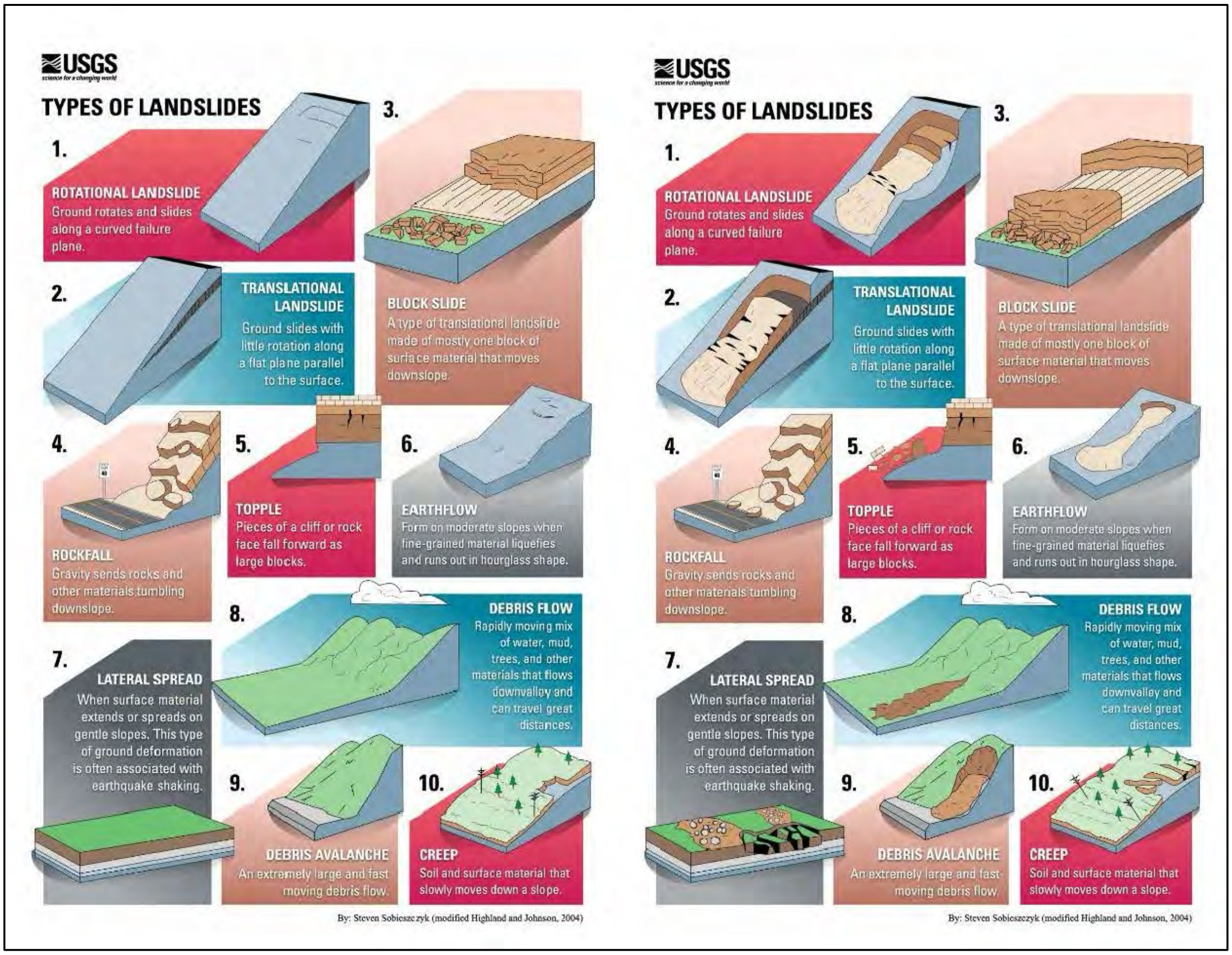


Figure 18. Types of Landslides.

Location

In 2013, the Massachusetts Geological Survey and University of Massachusetts Amherst published a Slope Stability Map of Massachusetts (Figure 19). This project, funded by the FEMA Hazard Mitigation Grant Program, was designed to provide statewide mapping and identification of landslide hazards that can be used for community level planning as well as prioritizing high-risk areas for mitigation. The maps produced from this project should be viewed as a first-order approximation of potential landslide hazards across the state.

The Slope Stability Map (below) categorizes areas of Massachusetts into stability zones, and the categorization is correlated to the probability of instability in each zone. The probability of instability metric indicates how likely each area is to be unstable, based on the parameters used in the analysis. According to the map, these unstable areas are located throughout the Commonwealth. Landslide risk is therefore assumed present in Boxborough.

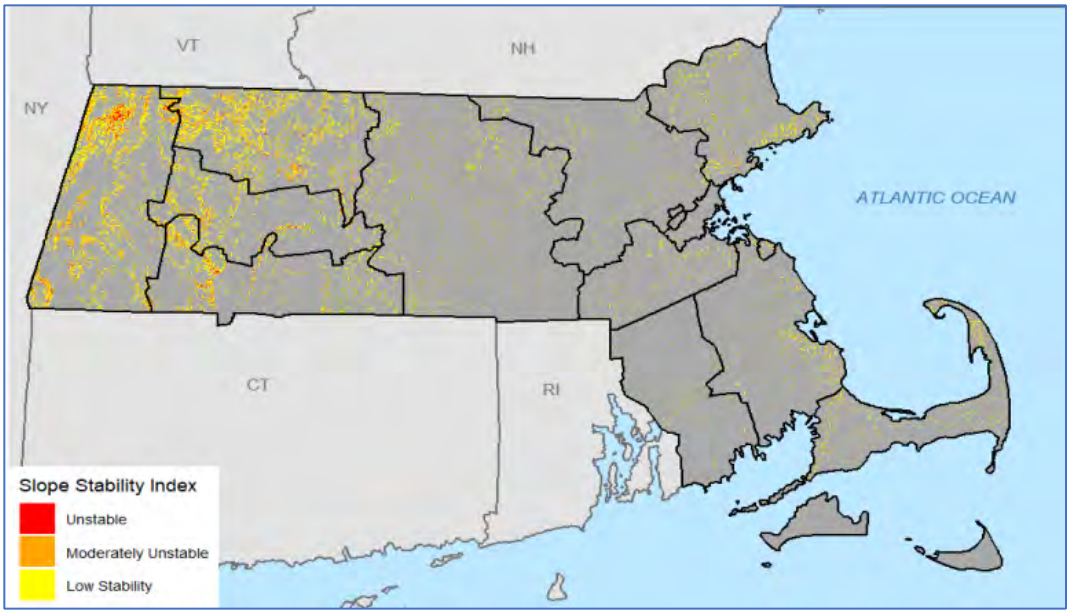


Figure 19. Slope Stability Map of Massachusetts (Created by ERG using data from Mabee & Duncan (2013)).

Previous Occurrences

Nationwide, landslides constitute a major geologic hazard because they are widespread, occur in all 50 states, and cause approximately $1 billion to $2 billion in damages and more than 25 fatalities on average each year. In Massachusetts, landslides tend to be more isolated in size and pose threats to highways and structures that support fisheries, tourism, and general transportation. According to the U.S. Landslide Inventory, there were 14 landslide incidents between 2008 and 2017. During this timeframe the Massachusetts Geological Survey reported three landslides or mudflows that resulted in infrastructural damage.

Landslides commonly occur shortly after other major natural disasters, such as earthquakes and floods, which can exacerbate relief and reconstruction efforts. Many landslide events may have occurred in remote areas, causing their existence or impact to go unnoticed. Expanded development and other land uses may contribute to the increased number of landslide incidences and/or the increased number of reported events in the recent record.

While numerous landslides have occurred in Massachusetts, significant landslides have not occurred in Boxborough. According to the HMPC, a steep slope behind one residential property may pose a landslide risk, but a failure has not occurred.

Extent

Variables that contribute to the extent of potential landslide activity in any area include soil properties, topographic position and slope, and historical incidence. Predicting a landslide is difficult, even under ideal conditions. As a result, estimations of the potential severity of landslides are informed by previous occurrences as well as an examination of landslide susceptibility. Information about previous landslides, such as the information and images from landslides after Tropical Storm Irene can provide insight as to both where landslides may occur and what types of damage may result. It is important to note, however, that landslide susceptibility identifies only areas potentially affected and does not imply a time frame when a landslide might occur. The distribution of susceptibility across the Commonwealth is depicted on the Slope Stability Map (Figure 19), with areas of higher slope instability considered to also be more susceptible to the landslide hazard.

Characterizing the warning time before landslides can be challenging. Mass movements can occur suddenly or slowly. The velocity of movement may range from a slow creep of inches per year to many feet per second, depending on slope angle, material, and water content. Some methods used to monitor mass movements can provide an idea of the type of movement and the amount of time prior to failure. It is also possible to determine the areas that are at risk during general time periods. Assessing the geology, vegetation, and amount of predicted precipitation for an area can help in these predictions. However, there is no practical warning system for individual landslides. The current standard operating procedure is to monitor situations on a case-by-case basis and respond after the event has occurred. Generally accepted warning signs for landslide activity include the following:

- Springs, seeps, or saturated ground in areas that have not typically been wet before
- New cracks or unusual bulges in the ground, street pavements, or sidewalks
- Soil moving away from foundations
- Ancillary structures, such as decks and patios, tilting and/or moving relative to the main house
- Tilting or cracking of concrete floors and foundations
- Broken waterlines and other underground utilities
- Leaning telephone poles, trees, retaining walls, or fences
- Offset fence lines
- Sunken or down-dropped road beds
- Rapid increase in creek water levels, possibly accompanied by increased turbidity (soil content)
- Sudden decrease in creek water levels even though rain is still falling or has just recently stopped
- Sticking doors and windows, and visible open spaces indicating jambs and frames out of plumb
- A faint rumbling sound that increases in volume as the landslide nears
- Unusual sounds, such as trees cracking or boulders knocking together

Probability of Future Events

The probability of future occurrences is generally defined by the number of events over a specified period of time. The ResilientMass Plan notes that between 2008 and 2017, there were at least 14 reported landslide occurrences. However, because many landslides are minor and occur unobserved in remote areas, the true number of landslide events is probably higher. Generally speaking, landslides are most likely to occur during periods of higher than average or extreme precipitation, particularly in areas that have experienced disturbance from wildfire, drought, invasive species, recent development, or vegetation or tree removal. For these reasons, the probability of future occurrence is believed moderate to high.

Vulnerability Assessment

Exposure

While landslides are rare, their impacts can be devastating, including loss of property, disruption to infrastructure, and injury and death. Continued development, particularly on steep slopes or unstable soils, increases the chances that landslides will be a danger. Other associated concerns are debris management issues including debris removal and identification of disposal sites.

To help identify potential landslide areas for the Town, the slope stability index developed by the Massachusetts Geological Survey was used. The unstable and moderately unstable regions were queried out of the data and overlaid with the critical facilities and other buildings. There were no critical facilities found in the unstable or moderately unstable area. There is a ledge near Summer Road and has old retaining wall structures.

The other building data was overlaid with the unstable and moderately unstable areas. There were ten buildings found in the moderately unstable area and no buildings found in the unstable areas. Table 32 shows the result of this analysis.

Table 32. Buildings in Moderately Unstable Area.

Building Type	Number of Buildings (Total in City)	Building Value (Total in City)
Single Family	9 (1,496)	$2,404,300 ($529,303,600)
Multi-Family	0 (138)	$0 ($1,106,362,200)
Mixed-Use	0 (27)	$0 ($5,951,200)
Commercial	0 (83)	$0 ($86,371,200)
Educational	0 (5)	$0 ($2,315,400)
Government	0 (26)	$0 ($33,649,000)
Religious/Non-Profit	0 (25)	$0 ($16,279,700)
Industrial	0 (40)	$0 ($180,200,000)
Garage/Outbuilding	1 (7)	$30,100 ($100,100)
Vacant	0 (6)	$0 ($273,000)
Total	**10 (1,853)**	**$2,434,400 ($1,960,805,400)**

All of the structures in the moderately unstable areas also have environmental justice concerns.

Figure 20 shows the landslide susceptibility map for the Town. The red and pink areas are more susceptible to landslides.

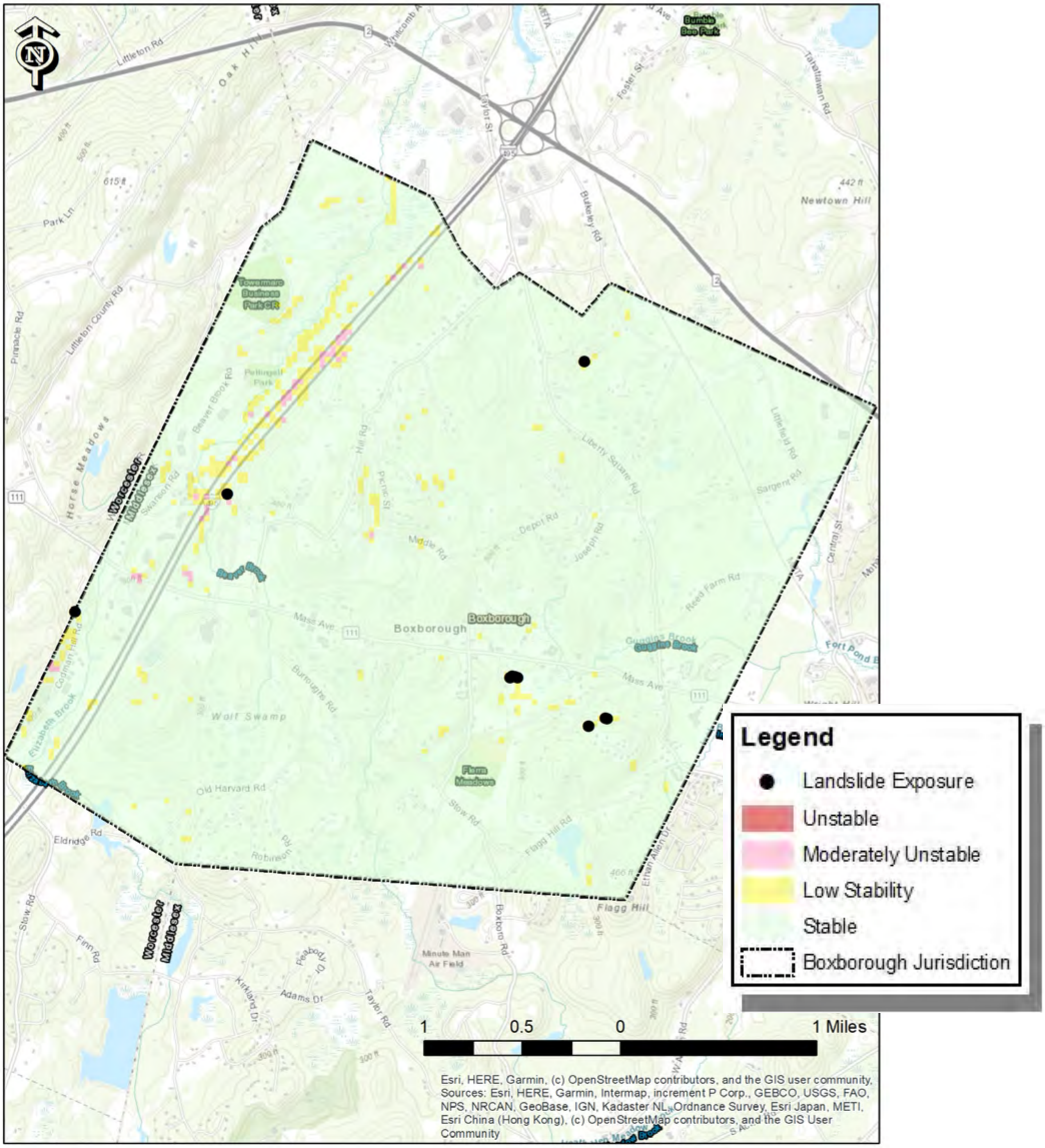


Figure 20. Landslide Susceptibility Map.

Built Environment Impacts

Historic data for landslide events indicate that between 1993 and 2022, no landslide events were recorded in Boxborough. Still, there is a likelihood even if it's slight. For example, according to the HMPC, a steep slope behind one residential property may pose a landslide risk. Assuming a total loss for a building due to a 100-year landslide event. The average value of a building in the moderately susceptible zone is $2,434,400. This would result in an AAL of $24,344.

Population Impacts

Populations considered most vulnerable to landslide impacts are identified based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. The Town should be aware of the potential needs of residents within the elderly and low income population segments in the event of a hazard occurrence.

Environment Impacts

There are few unstable and moderately unstable areas around the transportation routes (roads and train tracks) used to move hazardous materials.

Problem Statements for Landslides

Table 33. Problem Statements for Landslides.

Assets	Problems Associated with Landslides
People (including underserved communities and socially vulnerable populations)	• Vulnerable populations in isolated areas may be cut off if a landslide impacts specific roads.
Structures (including facilities, lifelines, and critical infrastructure)	• Some residential and other structures reside adjacent to moderately unstable areas and could be impacted. • A steep slope behind one residential property is believed a landslide risk.
Systems (including networks and capabilities)	• Roads and rail may be impacted and could cause a hazardous material spill.
Natural, historic, and cultural resources	• Some historical properties reside in or adjacent to the unstable or moderately unstable areas.

Assets	Problems Associated with Landslides
Activities that have value to the community	• None apparent or projected

Other Severe Weather

The Town of Boxborough Community Resilience Building Workshop Summary of Findings (2021) lists "strong storms" as one of the top hazards of concern.

Several frequent natural hazards in Massachusetts – particularly strong winds and extreme precipitation events – occur outside of notable storm events. This section discusses the nature and impacts of these hazards, as well as ways in which they are likely to respond to climate change. Winter storms and tornadoes are addressed in later sections.

Description

Thunderstorms: A thunderstorm is a storm originating in a cumulonimbus cloud. Cumulonimbus clouds produce lightning, which locally heats the air to 50,000 degrees Celsius, which in turn produces an audible shock wave known as thunder. Frequently during thunderstorm events, heavy rain and gusty winds are present. Less frequently, hail is present, which can become very large in size. Tornadoes can also be generated during these events. An average thunderstorm is 15 miles across and lasts 30 minutes, but severe thunderstorms can be much larger and longer.

Three basic components are required for a thunderstorm to form: moisture, rising unstable air, and a lifting mechanism. The sun heats the surface of the earth, which warms the air above it. If this warm surface air is forced to rise, it will continue to rise as long as it weighs less and stays warmer than the air around it. As the warm surface air rises, it transfers heat from the surface of the earth to the upper levels of the atmosphere (the process of convection). The water vapor it contains begins to cool, releasing the heat, and the vapor condenses into a cloud. The cloud eventually grows upward into areas where the temperature is below freezing. Some of the water vapor turns to ice, and some of it turns into water droplets. Both have electrical charges. When a sufficient charge builds up, the energy is discharged in a bolt of lightning, which causes the sound waves we hear as thunder.

Downbursts: A downburst is a severe localized wind blasting down from a thunderstorm. They are more common than tornadoes. Depending on the size and location of downburst events, the destruction to property may be significant. Downbursts fall into two categories:

1. Microbursts affect an area less than 2.5 miles in diameter, last 5 to 15 minutes, and can cause damaging winds up to 168 mph.
2. Macrobursts affect an area at least 2.5 miles in diameter, last 5 to 30 minutes, and can cause damaging winds up to 134 mph.

An organized, fast-moving line of microbursts traveling across large areas is known as a "derecho." These occasionally occur in Massachusetts. Downburst activity is, on occasion, mistaken for tornado activity. Both storms have very damaging winds (downburst wind speeds can exceed 165 mph) and are very loud. These "straight line" winds are distinguishable from tornadic activity by the pattern of destruction and debris such that the best way to determine the damage source is to fly over the area.

Hail: Hailstones are chunks of ice that grow as updrafts in thunderstorms keep them in the atmosphere. Most hailstones are smaller in diameter than a dime, but stones weighing more than 1.5 pounds have been recorded. NOAA has estimates of the velocity of falling hail ranging from 9 meters per second (m/s) (20 mph) for a 1-centimeter (cm)-diameter hailstone to 48 m/s (107 mph) for an 8 cm, 0.7 kilogram stone.

Lightning: Lightning is a discharge of electricity that occurs between the positive and negative charges within the atmosphere or between the atmosphere and the ground. According to NOAA, the creation of lightning during a storm is a complicated process that is not fully understood. In the initial stages of development, air acts as an insulator between the positive and negative charges. However, when the potential between the positive and negative charges becomes too great, a discharge of electricity (lightning) occurs. In-cloud lightning occurs between the positive charges near the top of the cloud and the negative charges near the bottom. Cloud-to-cloud lightning occurs between the positive charges near the top of the cloud and the negative charges near the bottom of a second cloud. Cloud-to-ground lightning is the most dangerous. In summertime, most cloud-to-ground lightning occurs between the negative charges near the bottom of the cloud and positive charges on the ground.

Location

High wind events, thunderstorms, lightning, and hail can affect the entirety of Massachusetts, including the geographic extent of Boxborough.

Previous Occurrences

The NOAA Storm Events database (https://www.ncdc.noaa.gov/stormevents/) for Middlesex County lists numerous severe storms affecting the area of Boxborough from 2014 through 2023. The individual damage figures for these events appear nominal but given the frequency of events, the overall losses from severe storms are striking.

Table 34. NCEI Severe Storm Database Entries Covering Other Severe Storms in Boxborough.

Date	Description	Losses Reported
11/27/13	*Strong Wind.* An anomalously strong low level jet coupled with strong pressure falls associated with a low pressure region approaching southern New England resulted in strong to damaging winds across southern New England. Damage was largely to trees.	$30,000 in adjacent towns

Date	Description	Losses Reported
8/14/15	*Thunderstorm Wind.* The second severe weather event for the day occurred north of the Massachusetts Turnpike. This severe weather was triggered by an approaching cold front from the west. As these storms developed across western Massachusetts, they began to produce wind gusts of 50 to 60 mph. Trees and wires on Massachusetts Avenue were downed by thunderstorm winds.	$10,000
8/2/17	*Thunderstorm Wind.* A mid-level disturbance moved across Southern New England, tapping very moist and unstable air to create showers and thunderstorms. Some showers and storms produced heavy downpours and strong wind gusts. At 215 PM, a large tree was down on wires on Stow Road in Boxborough.	$1,000
6/18/18	*Thunderstorm Wind.* A cold front moved from the Great Lakes across New England during the night of the 18th. The air mass ahead of the cold front was very warm and very humid. Showers and thunderstorms developed well ahead of the front over New York and Pennsylvania, then moved east into New England. There were numerous reports of wind damage in northern and western Massachusetts. At 5:50 PM, a tree was down on Depot Road in Boxborough. At the same time, a tree was also down in Hill Road in Boxborough.	$2,000
7/5/20	*Thunderstorm Wind.* A cold front and upper level trough combined to produce a few severe thunderstorms in northeast Massachusetts during the evening. In Boxboro, a tree was down on Saras Way. A large tree was down on Massachusetts Avenue by Stow Road and also near the fire station. A large tree and power lines were down on Pine Hill Road.	$3,300
10/7/20	A squall line formed in New York State then raced eastward in the late afternoon and early evening, gathering strength as it raced across Massachusetts. Hundreds of thousands of people were left without power in southern New England, as there was widespread tree and power line damage from winds generally gusting to between 50 and 80 mph. The Storm Prediction Center officially classified it as a derecho.	$6,500 in other communities

The HMPC noted that $15,000 in damage occurred to the public access room in the Town Hall during a severe storm in September 2023.

USDA declares agricultural disasters as needed for a variety of hazards. Information can be found at https://www.fsa.usda.gov/programs-and-services/disaster-assistance-program/disaster-designation-information/index. The line items for events related to severe winds and hail in Middlesex County are listed below.

Table 35. USDA Disasters Events That Refer to Severe Storms.

Year	Event	Event "Begin Dates"
2016	Drought, high winds, wildfire, excessive heat, insects	8/24/2016, 9/21/2016
2014	Hail, Frost, Freeze	5/22/2014

Extent

The strength of thunderstorms is typically measured in terms of its effects, namely the speed of the wind, the presence of significant lightning, and the size of hail. High winds are defined by the NWS as sustained non-convective winds of 35 knots (40 mph) or greater lasting for 1 hour or longer, or gusts of 50 knots (58 mph) or greater for any duration (NCDC, 2018). A thunderstorm is classified as "severe" when it produces damaging wind gusts in excess of 58 mph (50 knots), hail that is 1 inch in diameter or larger (quarter size), or a tornado (NWS, 2013).

Probability of Future Events

According to the NWS, an average of 100,000 thunderstorms per year occur in the United States. The ResilientMass Plan notes that over the 15-year period between January 1, 2008, and December 31, 2022, a total of 911 high wind events occurred in Massachusetts on 198 days, and an annual average of 61 events occurred per year. Southern New England typically experienced 10 to 15 days a year with severe thunderstorms, with Massachusetts experiencing between nine and 27 thunderstorm days per year. Climate models show projections that the frequency and intensity of severe thunderstorms (which include tornadoes, hail, and winds) will increase (USGCRP, 2017). Furthermore, the ResilientMass Plan reports that, according to the Localized Constructed Analog's climate change models, thunderstorm event frequency is expected to slightly increase as a result of climate change.

NOAA reports that there are ten downburst reports for every tornado report in the United States. This implies that there are approximately 10,000 downbursts reported in the United States each year and further implies that downbursts occur in approximately 10% of all thunderstorms in the United States annually. This figure suggests that downbursts are a relatively uncommon yet persistent hazard.

An average of 21 people per year died from lightning strikes in the United States from 2013 to 2023. Most lightning deaths and injuries occur outdoors, with 45% of lightning casualties occurring in open fields and ballparks, 23% under trees, and 14% involving water activities. The ResilientMass Plan notes that 8 fatalities and 148 injuries have occurred in Massachusetts as a result of lightning events between 1990 and 2022 (NOAA, 2022). Given that thunderstorm event frequency is expected to slightly increase as a result of climate change, it is likely that risks associated with lightning may increase.

According to NOAA's National Weather Service, hail caused two deaths and an average of 27 injuries per year in the United States from 2004 to 2013. Given that thunderstorm event frequency is expected to slightly increase as a result of climate change, it is likely that risks associated with hail may increase.

Vulnerability Assessment

Exposure

The entire built environment of Boxborough is vulnerable to the high winds and/or flooding from a severe weather event.

Built Environment Impacts

Severe thunderstorms, and their associated hail and lightning events, brought about property damage in Boxborough and adjacent towns in previous years. From 2014 until 2022, there was $2,720,000 in property damage to Boxborough and adjacent towns. This equates to an AAL of $302,222.

Population Impacts

Some traffic accidents associated with storm events include injuries and deaths. However, the number of injuries and deaths reported for accidents is generally low. Populations considered most vulnerable to tornado, microburst and thunderstorm impacts in Boxborough are identified based on a number of factors including their physical and financial ability to react or respond during a hazard. Senior and low-income populations in Boxborough are particularly susceptible to storms. The Town should be aware of the potential needs of residents within these population segments in the event of a hazard occurrence.

Environment Impacts

Thunderstorms and microbursts can cause damage to parks and other, natural areas. Some areas of the Town may be out of service until trees are removed.

Problem Statements for Other Severe Weather

Table 36. Problem Statements for Other Severe Weather.

Assets	Problems Associated with Other Severe Weather
People (including underserved communities and socially vulnerable populations)	• People in Boxborough have been frequently disrupted by severe weather events and other more frequent wind and thunderstorm events. Vulnerable populations may be isolated if roads are closed.

Assets	Problems Associated with Other Severe Weather
Structures (including facilities, lifelines, and critical infrastructure)	• The individual damages for frequent severe weather events appear nominal, but given the frequency of events in and around Boxborough, the impacts occur often and can occur anywhere in the Town. • Wind damage to wind-susceptible buildings such as carports, greenhouses, pavilions, gazebos, and open-walled buildings. Additional damage to commercial buildings with HVAC located on roofs.
Systems (including networks and capabilities)	• First responders may have difficulty reaching people if roads are closed due to tree debris.
Natural, historic, and cultural resources	• These can be adversely impacted depending on the specific locations of damage.
Activities that have value to the community	• These can be adversely impacted depending on the specific locations of damage.

Severe Winter Storms

Severe winter storms include ice storms, nor'easters, heavy snow, blowing snow, and other extreme forms of winter precipitation. These are often accompanied by very low temperatures, which were previously addressed.

> The Town of Boxborough Community Resilience Building Workshop Summary of Findings (2021) lists "strong storms" as one of the top hazards of concern.

Description

Blizzard: A blizzard is a winter snowstorm with sustained or frequent wind gusts to 35 mph or more, accompanied by blowing snow that reduces visibility to or below a quarter of a mile (NWS, 2018). These conditions must be the predominant condition over a 3-hour period. Extremely cold temperatures are often associated with blizzard conditions but are not a formal part of the definition. However, the hazard created by the combination of snow, wind, and low visibility increases significantly with temperatures below 20ºF. A severe blizzard is categorized as having temperatures near or below 10°F, winds exceeding 45 mph, and visibility reduced by snow to near zero.

Storm systems powerful enough to cause blizzards usually form when the jet stream dips far to the south, allowing cold air from the north to clash with warm air from the south. Blizzard conditions often develop on the northwest side of an intense storm system. The difference between the lower pressure in the storm and the higher pressure to the west creates a tight pressure gradient, resulting in strong winds and extreme conditions due to the blowing snow. Blowing snow is wind-driven snow that reduces visibility to 6 miles or less, causing significant drifting. Blowing snow may be snow that is falling and/or loose snow on the ground picked up by the wind.

Ice Storms: Ice storm conditions are defined by liquid rain falling and freezing on contact with cold objects, creating ice buildups of one-fourth of an inch or more. These can cause severe damage to vegetation, utilities, and structures. An ice storm warning, which is now included in the criteria for a winter storm warning, is issued when a half inch or more of accretion of freezing rain is expected. This may lead to dangerous walking or driving conditions and the pulling down of power lines and trees. Ice pellets are another form of freezing precipitation, formed when snowflakes melt into raindrops as they pass through a thin layer of warmer air. The raindrops then refreeze into particles of ice when they fall into a layer of subfreezing air near the surface of the earth. Finally, sleet occurs when raindrops fall into subfreezing air thick enough that the raindrops refreeze into ice before hitting the ground. The difference between sleet and hail is that sleet is a wintertime phenomenon whereas hail falls from convective clouds (usually thunderstorms), often during the warm spring and summer months.

Nor'easters: A nor'easter is a storm that occurs along the East Coast of North America. A nor'easter is characterized by a large counterclockwise wind circulation around a low-pressure center that often results in heavy snow, high winds, and rain. A nor'easter gets its name from its continuously strong northeasterly winds blowing in from the ocean ahead of the storm and over the coastal areas.

Nor'easters are among winter's most ferocious storms. These winter weather events are notorious for producing heavy snow, rain, and oversized waves that crash onto Atlantic beaches, often causing beach erosion and structural damage. These storms occur most often in late fall and early winter. The storm radius is often as much as 100 miles, and nor'easters often sit stationary for several days, affecting multiple tide cycles and causing extended heavy precipitation. Sustained wind speeds of 20 to 40 mph are common during a nor'easter, with short-term wind speeds gusting up to 50 to 60 mph.

Location

Although the entire Commonwealth may be considered at risk to the hazard of severe winter storms, higher snow accumulations appear to be prevalent at higher elevations in Western and Central Massachusetts, and along the coast where snowfall can be enhanced by additional ocean moisture. Ice storms occur most frequently in the higher-elevation portions of Western and Central Massachusetts. Coastal communities of the Commonwealth are more susceptible to the impacts of a Nor'easter, which can bring heavy snow. Overall, winter storms can affect the entirely of Massachusetts, including the geographic extent of Boxborough.

Previous Occurrences

Winter storms occur somewhat regularly in Massachusetts. Five of the disasters declared in Massachusetts from 2012 through 2022 were associated with winter storms, although only three covered Middlesex County and therefore the Town of Boxborough:

- Massachusetts Severe Winter Storm and Snowstorm (DR-4379-MA)
  Incident Period: March 13, 2018 - March 14, 2018
  Public Assistance (PA) reimbursements eligible for Worcester County and eastward

- Massachusetts Severe Winter Storm, Snowstorm, and Flooding (DR-4214-MA)
  Incident Period: January 26, 2015 - January 28, 2015
  PA reimbursements eligible for Worcester County and eastward

- Massachusetts Severe Winter Storm, Snowstorm, and Flooding (DR-4110-MA)
  Incident Period: February 8, 2013 – February 9, 2013
  PA reimbursements eligible for entire state

These were likewise subject to concurrent emergency declarations in Massachusetts. The PA assistance reimbursements associated with the three above declarations totaled approximately $207,000 for the Town of Boxborough. This indicates that severe winter storms comprise a significant expenditure for a rural community like Boxborough.

The Community Resilience Building Summary Report for Boxborough notes that "the Town has experienced multiple disruptive and damaging weather events, including Tropical Storm Irene (August 2011), Tropical Storm Sandy (October 2012), winter Nor'easter Nemo (February 2013), winter Nor'easter Quinn (March 2018), and Hurricane Barry (August 2019). These storms brought heavy rain-induced inland flooding, wind damage to trees, and snow that caused widespread damage to Boxborough and many other Massachusetts communities."

The NOAA Storm Events database (https://www.ncdc.noaa.gov/stormevents/) for Middlesex County lists numerous severe winter storm events impacting the Boxborough area for the period 2014-2023. A selection of events is provided below, including the three declared disasters listed above.

Table 37. NCEI Severe Storm Database Entries Covering Winter Storms in Boxborough.

Date	Description
2/8/13	An historic winter storm deposited tremendous amounts of snow over all of southern New England, mainly from the mid-afternoon on Friday, February 8 and lasting into the daylight hours of Saturday, February 9. Nineteen to 29 inches of snow fell across western Middlesex County.
3/7/13	Nine to 22 inches of snow fell across western Middlesex County.
3/18/13	Four to 13 inches of snow fell across western Middlesex County.

Date	Description
12/14/13	Five to 10 inches of snow fell across western Middlesex County.
12/17/13	Two to eight inches of snow fell across western Middlesex County. The lesser amounts fell in the western parts of the county.
1/2/14	Six to 14 inches of snow fell across western Middlesex County.
2/5/14	Seven to 13 inches of snow fell across western Middlesex County.
2/13/14	Four to 12 inches of snow fell across western Middlesex County.
2/18/14	Four to ten inches of snow fell across western Middlesex County.
1/26/15	An historic winter storm brought heavy snow to southern New England with blizzard conditions to much of Rhode Island and eastern Massachusetts, beginning during the day on Monday, January 26 and lasting into the early morning hours of Tuesday, January 27. The highest snowfall totals, averaging two to three feet, extended from extreme northeast Connecticut and northwest Rhode Island into much of central and northeast Massachusetts, including greater Boston. Twenty to 36 inches of snow fell across western Middlesex County. Some of the highest totals reported included Acton (34 inches) next to Boxborough.
2/2/15	Six to 16 inches of snow fell across western Middlesex County.
2/8/15	Seven to 20 inches of snow fell across western Middlesex County.
2/14/15	Twelve to 18 inches of snow fell across western Middlesex County.
2/5/16	Five to eleven inches of snow fell across western Middlesex County.
2/9/17	Seven to eleven inches on snow fell on Western Middlesex County.
3/14/17	Snowfall totals were mainly in the 9 to 12 inch range across much of western Middlesex County.

Date	Description
1/4/18	Seven to seventeen inches of snow fell across Western Middlesex County.
3/7/18	From eight to sixteen inches of snow fell on Western Middlesex County.
3/13/18	A storm brought snow accumulations of one to two feet across Eastern Massachusetts. From twelve to twenty-seven inches of snow fell on Western Middlesex County.
3/3/19	From eight to 16 inches of snow fell on Western Middlesex County.
12/1/19	Final snow totals ranged from 12 to 22 inches of snow in western Middlesex county.
12/16/20	Heavy snow ranged from 9.0 to 15.2 inches across western Middlesex County.
2/1/21	Snowfall amounts generally ranged from 14 to 18 inches.
1/28/22	Snowfall ranged from 11 to 17 inches.

Extent

Snowfall is a component of multiple hazards, including nor'easters and severe winter storms. Two scores, the *Regional Snowfall Index (RSI) and the NESIS*, are described in this section.

Since 2005, the RSI has become the descriptor of choice for measuring winter events that impact the eastern two-thirds of the U.S. The RSI ranks snowstorm impacts on a scale system from 1 to 5. The RSI is like the Fujita scale for tornadoes or the Saffir-Simpson scale for hurricanes, except that it includes an additional variable: population. The RSI is based on the spatial extent of the storm, the amount of snowfall, and population (NOAA, n.d.).

The RSI is a regional index. Each of the six climate regions (identified by the NOAA National Centers for Environmental Information) in the eastern two-thirds of the nation has a separate index. The RSI incorporated region-specific parameters and thresholds for calculating the index. The RSI is important because, with it, a storm event and its societal impacts can be assessed within the context of a region's historical events. Snowfall thresholds in Massachusetts (in the Northeast region) are 4, 10, 20, and 30 inches of snowfall, while thresholds in the Southeast U.S. are 2, 5, 10, and 15 inches.

Table 38. RSI Scale.

Category	RSI Value	Event Description
1	1 to 3	Notable
2	3 to 6	Significant
3	6 to 10	Major
4	10 to 18	Crippling
5	18+	Extreme

Source: NOAA

Prior to the use of the RSI, the Northeast Snowfall Impact Scale, developed by Paul Kocin of The Weather Channel and Louis Uccellini of the NWS, was used to characterize, and rank high- impact northeast snowstorms with large areas of 10-inch snowfall accumulations and greater. In contrast to the RSI, which is a regional index, NESIS is a quasi-national index that is calibrated to Northeast snowstorms. NESIS has five categories. The RSI and NESIS approaches do not include separate scales for ice storms; in general, ice storm extent is expressed on a case-by-case basis, and forecasts will provide the information needed to determine how to prepare and respond.

Meteorologists can often predict the likelihood of a severe storm or nor'easter. This can give several days of warning time. The NOAA's NWS monitors potential events and provides extensive forecasts and information several days in advance of a winter storm to help the state to prepare for the incident.

Probability of Future Events

The ResilientMass Plan notes that Massachusetts experiences high-impact snowstorms at approximately the rate of three per year over the past 50 years, although there is significant interannual variability in the frequency and severity of winter storms. The Town of Boxborough should assume that winter storms are likely, even if the impacts of climate change will shift the timing to a shorter winter season. Heavy wet snowfall may be more common in the future. The overall probability of winter storms of all kinds, including blizzards and ice storms, is believed high.

Vulnerability Assessment

Exposure

Heavy snowfall coupled with low temperatures often results in increases in traffic accidents; disruptions in transportation, commerce, government, and education; utility outages due to falling trees, branches, and other objects; personal injuries associated with slippery surfaces and freezing temperatures; and numerous other problems. Specific damages associated with severe winter storm (snow) events include:

- Injuries and fatalities associated with accidents, low temperatures, power loss, falling objects and accidents associated with frozen and slippery surfaces and snow accumulation

- Increases in the frequency and impact of traffic accidents, resulting in personal injuries
- Ice-related damage to trees, building and infrastructure inventory, and utilities (power lines, bridges, substations, etc.)
- Roads damaged through freeze and thaw processes
- Stress on the local shelters and emergency response infrastructure
- Lost productivity that occurs when people cannot go to work, school, or stores due to inclement conditions

The entire Town should be considered exposed to the severe winter storm hazard.

Built Environment Impacts

The entire built environment of Boxborough is vulnerable to a severe winter storm. New England's climate offers no immunity to the potential damaging effects of severe winter storms. Some minimum damage is anticipated annually, with potential extensive damage occurring about once every 10 years.

Since Hazus doesn't support severe winter storms and there aren't other readily available severe winter storm models, historical data was used to determine potential losses and probabilities. From 2014 until 2023, there was $464,900 in storm damage in and around Boxborough. This equates to an AAL of $46,490.

Population Impacts

As discussed above, some traffic accidents associated with storm events include injuries and in limited cases, deaths. However, the number of injuries and deaths reported for accidents is generally low. Populations considered most vulnerable to severe winter storm impacts are identified based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Senior and low-income populations in Boxborough are particularly susceptible and the Town should be aware of the potential needs of residents within these population segments in the event of a hazard occurrence.

Environment Impacts

Severe winter storms can cause damage to parks and other, natural areas. Some areas of the Town may be out of service until roads are cleared and trees are removed.

Problem Statements for Severe Winter Storms

Table 39. Problem Statements for Severe Winter Storms.

Assets	Problems Associated with Severe Winter Storms
People (including underserved communities and socially vulnerable populations)	• Vulnerable populations may be stranded during a winter storm event and may not be able to travel to emergency services.
Structures (including facilities, lifelines, and critical infrastructure)	• Roof ice dams may cause damage to structures. • Severe winter storms comprised a substantial expenditure for Boxborough over the course of the last decade. • The electrical grid and roadways are susceptible to failure and loss of use during storms.
Systems (including networks and capabilities)	• First responders may have difficulty reaching people if roads are closed due to road closures.
Natural, historic, and cultural resources	• Severe storms may damage trees in natural areas, and historical and cultural sites.
Activities that have value to the community	• Outdoor activities may be adversely impacted by severe winter storms.

Tornadoes

Tornadoes are a relatively infrequent occurrence but can be very destructive when they occur. While small tornadoes in outlying areas cause little to no damage, larger tornadoes in populated sections of Massachusetts have historically caused significant damage, injury, and death through the destruction of trees, buildings, vehicles, and power lines.

> The Town of Boxborough Community Resilience Building Workshop Summary of Findings (2021) lists "strong storms" as one of the top hazards of concern.

Description

A tornado is a narrow rotating column of air that extends from the base of a cumulonimbus cloud to the ground. The observable aspect of a tornado is the rotating column of water droplets, dust, and debris caught in the column. Tornadoes are the most violent of all atmospheric storms.

Tornadoes can form from individual cells within severe thunderstorm squall lines. They can also form from an isolated supercell thunderstorm. They can be spawned by tropical cyclones or the remnants thereof, and weak tornadoes can even occur from little more than a rain shower if air is converging and spinning upward.

Most tornadoes occur in the late afternoon and evening hours when the heating is the greatest. The most common months for tornadoes to occur are June, July, and August, although the Great Barrington tornado occurred in May 1995 and caused extensive damage.

A waterspout is a rapidly rotating column of air extending from the cloud base (typically a cumulonimbus thunderstorm) to a water surface, such as a bay or the ocean. They can be formed in the same way as regular tornadoes or can form on a clear day with the right amount of instability and wind shear. Tornadic waterspouts can have wind speeds of 60 to 100 mph, but since they do not move very far, they can often be navigated around. They can become a threat to land if they drift onshore.

Location

The U.S. experiences an average of 1,230 tornadoes per year from 1991 to 2020, more than any other country (NOAA, n.d.). Because Massachusetts experiences fewer tornadoes than other parts of the country, residents may be less prepared to react to a tornado. The ResilientMass Plan notes that Massachusetts is located within the FEMA Wind Zone II, with Zone IV typically experiencing the greatest number and strongest tornadoes. According to the FEMA National Risk Index most of the state has a "relatively low" risk of strong wind. The ResilientMass Plan notes that the area at greatest risk for a tornado touchdown runs from central to northeastern Massachusetts. Boxborough is inside of this area.

Previous Occurrences

The most devastating tornado to occur in New England was the Worcester Tornado of July 9, 1953, a category F4 tornado. The tornado passed through Barre, Rutland, Holden, Worcester, Shrewsbury, Westborough, and Southborough causing 90 deaths and over 1,300 injured. Damage estimates were placed at more than $52 million. The National Storm Prediction Center has ranked this as one of the deadliest tornadoes in the nation's history. Boxborough was not directly impacted by this tornado, but the proximity is notable.

The most recent severe tornado (F3 or stronger) to impact Massachusetts occurred June 1, 2011, affecting communities in Hampden and Worcester Counties. The EF3 tornado touched down in Westfield and traveled through West Springfield, Springfield, Wilbraham, Monson, Brimfield, and Sturbridge. The tornado caused extensive property damage and resulted in a FEMA disaster declaration.

The NOAA Storm Events database (https://www.ncdc.noaa.gov/stormevents/) for Middlesex County does not list any tornadoes in Boxborough during the period 2014-2023. However, the following two occurred nearby in this timeframe:

- August 22, 2016: EF-1 tornado occurred in Concord (east of Boxborough). Most of the damage was concentrated in an area beginning near the intersection of Lexington Road and Alcott Road and continuing up to the neighborhood of Alcott and Independence Roads. Numerous trees were uprooted or had the tops sheared off. These subsequently blocked roads, damaged homes, and downed power lines, cutting off power to the neighborhood. In addition, utility poles were downed either from the wind or from the downed power lines. Thirty-nine houses in this area were damaged to some degree. Only one house suffered significant structural damage.
- August 23, 2021: EF-0 tornado occurred associated with Storm Henri, causing minor damage along Great Road (State Highway 117) in Stow very near the Stow Police Department Headquarters. This tornado knocked down a large tree as well as a large branch, which fell across the road.

Extent

The NWS rates tornadoes using the Enhanced Fujita scale (EF scale), which does not directly measure wind speed but rather the amount of damage created. This scale derives 3-second gusts estimated at the point of damage based on the assignment of 1 out of 8 degrees of damage to a range of different structure types. These estimates vary with height and exposure. This method is considerably more sophisticated than the original Fujita scale, and it allows surveyors to create more precise assessments of tornado severity.

Table 40. Enhanced Fujita Scale.

EF Rating	Wind Speeds	Expected Damage		
EF-0	65-85 mph	'Minor' damage: shingles blown off or parts of a roof peeled off, damage to gutters/siding, branches broken off trees, shallow rooted trees toppled.		
EF-1	86-110 mph	'Moderate' damage: more significant roof damage, windows broken, exterior doors damaged or lost, mobile homes overturned or badly damaged.		
EF-2	111-135 mph	'Considerable' damage: roofs torn off well constructed homes, homes shifted off their foundation, mobile homes completely destroyed, large trees snapped or uprooted, cars can be tossed.		
EF-3	136-165 mph	'Severe' damage: entire stories of well constructed homes destroyed, significant damage done to large buildings, homes with weak foundations can be blown away, trees begin to lose their bark.		
EF-4	166-200 mph	'Extreme' damage: Well constructed homes are leveled, cars are thrown significant distances, top story exterior walls of masonry buildings would likely collapse.		
EF-5	> 200 mph	'Massive/incredible' damage: Well constructed homes are swept away, steel-reinforced concrete structures are critically damaged, high-rise buildings sustain severe structural damage, trees are usually completely debarked, stripped of branches and snapped.		

Source: National Weather Service

Tornado watches and warnings are issued by the local NWS office. A tornado watch is released when tornadoes are possible in an area. A tornado warning means a tornado has been sighted or indicated by weather radar. The current average lead time for tornado warnings is 13 minutes. Occasionally, tornadoes develop so rapidly that little, if any, advance warning is possible.

Probability of Future Events

According to the ResilientMass Plan, the Commonwealth experienced 190 tornadoes from 1950 to 2021, or an average annual occurrence of 2.6 tornado events per year. From 1995 to 2021, the average frequency of these events has been 2.06 events per year (NOAA, 2018). Massachusetts experienced an average of 1.4 tornadoes per 10,000 square feet annually between 1991 and 2010, less than half of the national average of 3.5 tornadoes per 10,000 square feet per year (NOAA, n.d.). As highlighted in the National Climate Assessment, tornado activity in the U.S. has become more variable, and increasingly so in the last two decades. While the number of days per year that tornadoes occur has decreased, the number of tornadoes on these days has increased. Climate models show projections that the frequency and intensity of severe thunderstorms (which include tornadoes, hail, and winds) will increase (USGCRP, 2017). Overall, it is unclear if tornado frequency will increase with climate change given the difficulty to draw conclusions based on thunderstorm statistics and the difficulty in identifying long-term trends.

Vulnerability Assessment

Exposure

High winds, heavy rain, lightning and/or hail associated with tornados, thunderstorms and microbursts can cause damage to utilities, structures, roads, trees (potentially causing vehicle accidents) and injuries and death. The entire Town should be considered exposed to the tornado hazard.

Built Environment Impacts

Since Hazus doesn't support tornadoes and there aren't other readily available tornado models, historical data will be used to determine potential losses and probabilities. From 1955 until 2023, there was no property damage to Boxborough due to tornadoes. However, there were nineteen events in Middlesex County which produced $4.891M in property damage, one death, and six injuries. The county's average annual loss would be $412K.

Population Impacts

Populations considered most vulnerable to tornado impacts in Boxborough are identified based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Senior and low-income populations in Boxborough. It should be noted that there may be overlap within the two categories, so that the total number of persons exposed may be lower than what is shown in the table. However, the Town should be aware of the potential needs of residents within these population segments in the event of a hazard occurrence.

Environment Impacts

Tornadoes can cause damage to parks, and other, natural areas. Some areas of the Town may be out of service until trees are removed.

Problem Statements for Tornadoes

Table 41. Problem Statements for Tornadoes.

Assets	Problems Associated with Tornadoes
People (including underserved communities and socially vulnerable populations)	• Vulnerable populations may need support seeking protected shelter. Those without cell phones may not get weather alerts. • People without basements are susceptible to tornado impacts.

Assets	Problems Associated with Tornadoes
Structures (including facilities, lifelines, and critical infrastructure)	• Structures and critical infrastructure can all be impacted by tornadoes. • Roadways may be blocked due to downed trees and other debris. • Wind damage to wind-susceptible buildings such as carports, greenhouses, pavilions, gazebos, and open-walled buildings. Additional damage to commercial buildings with HVAC located on roofs.
Systems (including networks and capabilities)	• The electric grid may be impacted by winds and downed trees.
Natural, historic, and cultural resources	• Historic and cultural resources may be impacted by tornado winds. • Winds may damage trees and cause natural areas to close for cleanup.
Activities that have value to the community	• Outdoor events could be impacted by potential tornado activity.

Wildfires/Brushfires

A wildfire can be defined as any non-structure fire that occurs in vegetative wildland that contains grass, shrub, leaf litter, and forested tree fuels. Wildfires in Massachusetts are caused by natural events, human activity, or prescribed fire. Wildfires often begin unnoticed but spread quickly, igniting brush, trees, and potentially homes.

Description

The wildfire season in Massachusetts usually begins in late March and typically culminates in early June, corresponding with the driest live fuel moisture periods of the year. April is historically the month in which wildfire risk is the highest. Drought, snowpack level, and local weather conditions can impact the length of the fire season.

According to the National Fire Protection Agency, several elements (known as the fire tetrahedron) must be present in order to have any type of fire:

- Fuel: Without fuel, a fire will stop. Fuel can be removed naturally (when the fire has consumed all burnable fuel) or manually by mechanically or chemically removing fuel from the fire. In structure fires, removal of fuel is not typically a viable method of fire suppression. Fuel separation is important in wildfire suppression and is the basis for controlling prescribed burns and suppressing other wildfires. The type of fuel present in an area can help determine overall susceptibility to wildfires. According to the Forest Encyclopedia Network, four types of fuel are present in wildfires:

- Ground Fuels: organic soils, forest floor duff, stumps, dead roots, buried fuels
- Surface Fuels: the litter layer, downed woody materials, dead and live plants to 2 meters tall
- Ladder Fuels: vine and draped foliage fuels
- Canopy Fuels: tree crowns

- Heat: Without sufficient heat, a fire cannot begin or continue. Heat can be removed through the application of a substance, such as water, powder, or certain gasses, that reduces the amount of heat available to the fire. Scraping embers from a burning structure also removes the heat source.
- Oxygen: Without oxygen, a fire cannot begin or continue. In most wildland fires, this is commonly the most abundant element of the fire triangle and is therefore not a major factor in suppressing wildfires.
- Uninhibited Chain Reaction: The chain reaction is the feedback of heat to the fuel to produce the gaseous fuel used in the flame. In other words, the chain reaction provides the sustained heat necessary to maintain the fire. Fire suppression techniques, such as dry chemical extinguishers, break up the uninhibited chain reaction of combustion to stop a fire.

Location

The ResilientMass Plan identified areas in Barnstable, Essex, and Plymouth counties with the highest wildfire potential in the state. The ecosystems that are most susceptible to the wildfire hazard Include pine barrens in the Connecticut River Valley, marshes inundated with *Phragmites*, pine barrens and maritime grasslands in Martha's Vineyard, Nantucket, and Cuttyhunk, and the Myles Standish State Forest. Other portions of the Commonwealth are also susceptible to wildfire, particularly at the urban-wildland interface. Notwithstanding the location of Boxborough in central Massachusetts, the presence of wildland interface and vast rural areas makes Boxborough a location with wildfire risk.

Previous Occurrences

Several notable wildfires have occurred in Massachusetts history, although none has ever resulted in a FEMA disaster declaration. Smaller fires such as brush fires are somewhat easier to characterize. According to statewide data sets (https://www.mass.gov/service-details/fire-data-and-statistics), the number of brush fire events per year from 2012 through 2019 ranged from about 3,000 in 2019 to almost 8,000 in the drought year of 2016.

Table 42. Statewide Brush Fire Counts.

Year	Total # of Events	Injuries/deaths (civilians and fire service)	Losses
2019	2,974	12/0	$136,357
2018	3,253	1/5	$493,145
2017	4,206	20/0	$215,156
2016	7,834	40/0	$1,526,654
2015	6,962	35/0	$323,211
2014	4,627	25/0	$209,857
2013	4,968	31/3	$297,854
2012	5,857	38/0	$705,457

According to this statewide data set, fire event counts back to 2012 were as follows for Boxborough:

Table 43. Outdoor and Total Fire Event Figures for Boxborough.

Year	Total Outdoor Fires	Total Fire Events	Reported Losses for Outdoor Fires
2012	19	28	$4,071
2013	10	16	$0
2014	11	16	$0
2015	21	30	$753,433
2016	22	26	$37,653
2017	14	22	$222,727
2018	8	14	$13,142
2019	14	21	$0
2020	18	28	$0
2021	13	27	$0

Applying the fraction of outdoor fire incidents that are typically brush fires in Massachusetts (52%) and the fraction of fire losses that are typically from brush fires in Massachusetts (0.2%), an alternate set of figures for brush fires in Boxborough is presented below.

Table 44. Estimated Brush Fire Event Figures for Boxborough.

Year	Estimated Brush Fires	Estimated Brush Fire Losses
2012	10	$11
2013	5	$0
2014	6	$0
2015	11	$2,045
2016	11	$85
2017	7	$665
2018	4	$44
2019	7	$0
2020	9	$1,022*
2021	7	$3,504*

*Estimated from Countywide figures

The above estimates compare reasonably well to the figures reported in the previous edition of this plan. According to local officials that contributed to the previous edition, "natural fires in Boxborough are not a significant issue. The Town sees approximately 10 brush fires annually, but these fires do not usually cause property damage or injuries." Nevertheless, during the planning meetings for this update, the HMPC noted that brush fires are increasing in frequency throughout Boxborough.

USDA declares agricultural disasters as needed for a variety of hazards. Information can be found at https://www.fsa.usda.gov/programs-and-services/disaster-assistance-program/disaster-designation-information/index. The single line item related to wildfires in Middlesex County is listed below; this line corresponds to the drought of 2016.

Table 45. USDA Disasters Events That Refer to Wildfires.

Year	Event	Event "Begin Dates"
2016	Drought, high winds, wildfire, excessive heat, insects	8/24/2016, 9/21/2016

Extent

Unfragmented and heavily forested areas of the state are vulnerable to wildfires, particularly during droughts. The greatest potential for significant damage to life and property from fire exists in areas designated as wildland-urban interface areas. A wildland-urban interface area defines the conditions where highly flammable vegetation is adjacent to developed areas.

Fires can be classified by physical parameters such as their fireline intensity, or Byram's intensity, which is the rate of energy per unit length of the fire front (BTU [British thermal unit] per foot of fireline per second) (NPS, n.d.). Following a fire event, the severity of the fire can be measured by the extent of mortality and survival of plant and animal life aboveground and belowground and by the loss of organic matter (NPS, n.d.).

The National Wildfire Coordinating Group defines seven classes of wildfires:

- Class A: 0.25 acre or less
- Class B: more than 0.25 acre, but less than 10 acres
- Class C: 10 acres or more, but less than 100 acres
- Class D: 100 acres or more, but less than 300 acres
- Class E: 300 acres or more, but less than 1,000 acres
- Class F: 1,000 acres or more, but less than 5,000 acres
- Class G: 5,000 acres or more

Early detection of wildfires is a key part of the overall efforts of the Massachusetts Bureau of Forest Fire Control. Early detection is achieved by trained Bureau observers who staff 22 of the 42 operating fire towers statewide. During periods of high fire danger, the Bureau conducts county-based fire patrols in forested areas. These patrols assist cities and towns in prevention efforts and allow for the quick deployment of mobile equipment for suppression of fires during their initial stage. If a fire breaks out and spreads rapidly, residents may need to evacuate within days or hours. Once a fire has started, fire alerting is reasonably rapid in most cases. The rapid spread of cellular and two-way radio communications in recent years has further contributed to a significant improvement in warning time.

Probability of Future Events

It is difficult to predict the likelihood of wildfires in a probabilistic manner because a number of factors affect fire potential and because some conditions (e.g., ongoing land use development patterns, location, and fuel sources) exert changing pressure on the wildland-urban interface zone. The Massachusetts Climate Change Assessment report suggests that wildfire risk will increase over time in association with extreme heat events and changing precipitation and droughts. The following discussion helps characterize the risk further for Boxborough.

Vulnerability Assessment

Exposure

To help identify potential wildfire areas for Boxborough, the U.S. Forest Service's Wildfire Risk to Communities spatial data was downloaded. This data was developed in 2020 using the vegetation and wildland fuels from the LANDFIRE 2014 model with the burn probability coming from the Forest Service Fire Simulation System (FSim). To create a product with a finer resolution, the data was upsampled to the native 30m resolution of the LANDFIRE fuel and vegetation data spreading the values of the modeled burn probability into developed areas represented in LANDFIRE fuels as non-burnable. The areas with a 0.02% annual probability of burning were identified and overlaid with the critical facilities and other buildings. There were no critical facilities found in the 0.02% burn probability areas and thirty-seven buildings including single family home and industrial buildings found there. Table 46 shows the result of this analysis.

Table 46. Buildings in 0.02% Annual Chance Area.

Building Type	Number of Buildings (Total in City)	Building Value (Total in City)
Single Family	35 (1,496)	$17,848,600 ($529,303,600)
Multi-Family	0 (138)	$0 ($1,106,362,200)
Mixed-Use	0 (27)	$0 ($5,951,200)
Commercial	0 (83)	$0 ($86,371,200)
Educational	0 (5)	$0 ($2,315,400)
Government	0 (26)	$0 ($33,649,000)
Religious/Non-Profit	0 (25)	$0 ($16,279,700)
Industrial	2 (40)	$1,935,000 ($180,200,000)
Garage/Outbuilding	0 (7)	$0 ($100,100)
Vacant	0 (6)	$0 ($273,000)
Total	**37 (1,853)**	**$19,783,600 ($1,960,805,400)**

The population exposed to the 0.02% probability area is shown in Table 47. The column in the left shows the population in and around the 0.02% probability wildfire area (wherever the Census Block overlapped with the wildfire area) while the column on the right shows the total population numbers for the Town. There is an older population exposed to the wildfire hazard with a large environmental justice community than the Town average.

Table 47. Population Exposed to 0.02% Annual Chance Wildfire (2020 U.S. Census).

Demographics	Population in and Adjacent to 0.02% Wildfire Area	Total Population
Population	428	5,506
Households	147	2,362
White	282 (65.9%)	3,753 (68.2%)
Black	9 (2.1%)	120 (2.2%)
American Indian	1 (0.2%)	5 (0.1%)
Asian	115 (26.9%)	1,189 (21.6%)
Pacific Islander	0 (0.0%)	1 (0.0%)
Other Race	4 (0.9%)	83 (1.5%)
Two or More Races	17 (4.0%)	355 (6.4%)
Hispanic or Latino:	10 (2.3%)	218 (4.0%)
Population under 18:	59 (13.8%)	1,217 (22.1%)
Population over 64:	23 (5.4%)	577 (10.5%)
Annual Income < $30K/year	20 (13.6%)	276 (11.7%)
Population in EJ Zone*	428 (100.0%)	5,506 (100.0%)

**Massachusetts Office of Energy and Environmental Affairs, 2022*

Figure 21 shows the burn probability map from the USFS overlaid on the Town.

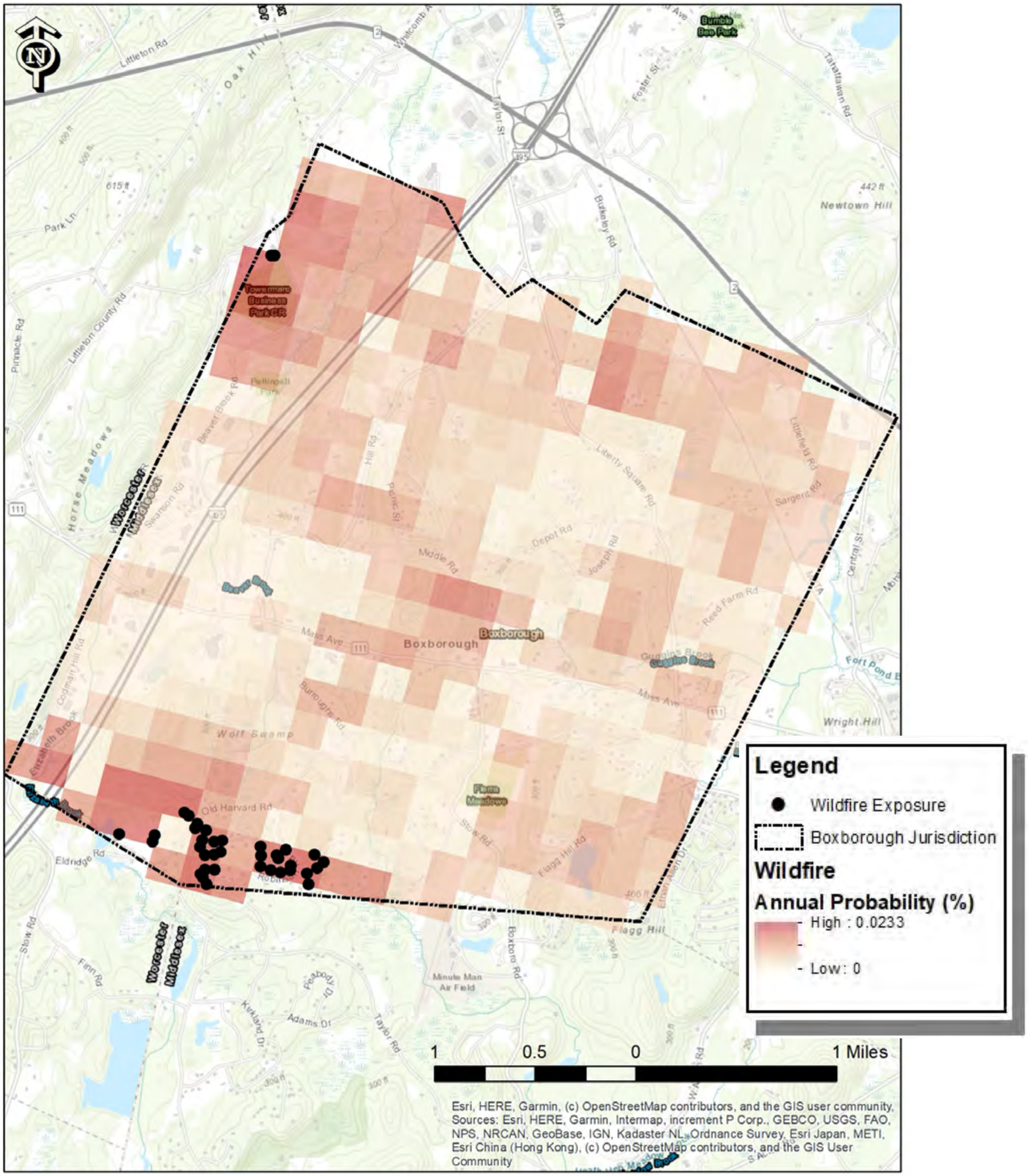


Figure 21. Wildfire Burn Probability Map.

Built Environment Impacts

A major out-of-control wildfire can damage property, utilities and forested land; create smoke that can cause breathing problems; and injure or kill people. Other associated concerns are debris management issues including debris removal and identification of disposal sites.

No property damage, injuries or deaths have been recorded for the reported for major wildfires in Boxborough between 2004 and 2022. Using the wildfire probabilities and building values, a loss estimate was produced for the 0.02% scenario. The losses are $19,783,600 for the .02% event and the AAL will be $9,892.

Climate change will increase the probability of brushfires which could lead to additional property damage. Future development in forested and other high-fuel areas also could lead to additional increases in the probability of brushfires.

Population Impacts

Populations considered most vulnerable to wildfire impacts are identified based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Senior and low-income populations in Boxborough are particularly susceptible to wildfires. The Town should be aware of the potential needs of residents within these population segments in the event of a hazard occurrence.

With the increased probability of brushfires outside of the Town in the future due to climate change, populations may be impacted more often due to air quality issues.

Environment Impacts

Many of the natural features in the Town are susceptible to wildfire including the trees and parks.

Problem Statements for Wildfires

Table 48. Problem Statements for Wildfires.

Assets	Problems Associated with Wildfires
People (including underserved communities and socially vulnerable populations)	• Populations with severe asthma may be adversely impacted by wildfires in the vicinity.

Assets	Problems Associated with Wildfires
Structures (including facilities, lifelines, and critical infrastructure)	• Several residential structures are found in the higher probability burn areas. Structures without defensible zones are more susceptible to wildfires and brush fires. • The Town believes that brush fires may be increasing in frequency.
Systems (including networks and capabilities)	• Wildfires often cause roads to be closed requiring detours impacting emergency services.
Natural, historic, and cultural resources	• Wildfires may adversely impact forested and other vegetated areas of Boxborough.
Activities that have value to the community	• Recreational activities may be adversely impacted by wildfires, depending on location.

National Flood Insurance Repetitive Loss Properties

B4. Does the Plan address NFIP insured structures within the jurisdiction that have been repetitively damaged by floods? (Requirement §201.6(c)(2)(ii))

***REPETITIVE LOSS STRUCTURE** means a structure covered under an NFIP flood insurance policy that (1) has incurred flood-related damage on two occasions, in which the cost of repair, on average, equaled or exceeded 25% of the value of the structure at the time of each such flood event; and (2) at the time of the second incidence of flood-related damage, the contract for flood insurance contains increased cost of compliance coverage.*

According to FEMA, repetitive loss properties are those for which two or more losses of at least $1,000 each have been paid under the National Flood Insurance Program (NFIP) within any 10-year period since 1978. Severe repetitive loss properties are residential properties that have at least four NFIP payments over $5,000 each and the cumulative amount of such claims exceeds $20,000, or at least two separate claims payments with the cumulative amount exceeding the market value of the building.

According to data provided by MEMA, repetitive loss properties and severe repetitive loss properties are not located in Boxborough. A summary of the Town's participation and compliance with the NFIP, including current policy and historical claims statistics, is provided in Table 7 of Chapter 5 (Capability Assessment).

***SEVERE REPETITIVE LOSS** structure means a structure that is covered under an NFIP flood insurance policy and has incurred flood-related damage (1) for which four or more separate claims have been made under flood insurance coverage, with the amount of each claim (including building and contents payments) exceeding $5,000 and with the cumulative amount of such claims payments exceeding $20,000; or (2) for which at least two separate flood insurance claims payments (building payments only) have been made, with cumulative amount of such claims exceeding the value of the insured structure.*

Hazard Ranking

Ranking hazards helps the Town set goals and mitigation priorities. To compare the risk of different hazards, and prioritize which are more significant, requires a scoring system for equalizing the units of analysis. As not all hazards assessed in this plan have precisely quantifiable probability or impact data, a scoring system based on multi-criteria decision analysis (MCDA) methodology was developed to rank all the hazards. This multi-criteria ranking analysis approach prioritizes hazard risk based on a blend of quantitative factors from the available data, such as historical data, local knowledge, public survey, and Hazus assessment. This hazard ranking analysis assigns varying degrees of risk to five categories for each of the hazards, including: probability (how often it can occur), impact (economic, social, and environmental loss), spatial extent (the size of the area affected), warning time (how long does a community have to prepare for the event), and duration. Each degree of risk was assigned a value ranging from 1 to 4. The weighting factor derived from a review of best practice plans. Some of these hazard characteristics, like probability and impact, are more important than others and are weighted more heavily.

To calculate a rank score value for a given hazard, the assigned risk value for each category was multiplied by the weighting factor. The sum of all five categories represents the final rank score, as demonstrated in the following equation:

Hazard Score Value = [(Probability x 30%) + (Impact x 30%) + (Spatial Extent x 20%) + (Warning Time x 10%) + (Duration x 10%)]

Table 49 provides the hazard characteristic, level description, level criteria, level index value, and weighting value.

Table 49. Hazard Ranking Criteria.

Hazard Characteristic	Degree of Risk			Assigned Weighting Factor
	Level	Criteria	Index Value	
Probability	Unlikely	Less than 1% annual probability	1	30%
	Possible	Between 1 and 10% annual probability	2	

Hazard Characteristic	Degree of Risk			Assigned Weighting Factor
	Level	Criteria	Index Value	
	Likely	Between 10 and 100% annual probability	3	
	Highly Likely	100% annual probability	4	
Impact	Minor	Very few injuries, if any. Only minor property damage and minimal disruption to quality of life. Temporary shutdown of critical facilities.	1	30%
	Limited	Minor injuries only. More than 10% of property in the affected areas damaged or destroyed. Complete shutdown of critical facilities for more than one day.	2	
	Critical	Multiple deaths/injuries possible. More than 25% of property in affected areas damaged or destroyed. Complete shutdown of critical facilities for more than one week.	3	
	Catastrophic	High number of deaths/injuries possible. More than 50% of property in affected area damaged or destroyed. Complete shutdown of critical facilities for 30 days or more.	4	
Spatial Extent	Negligible	Less than 1% of area affected	1	20%
	Small	Between 1 and 10% of area affected	2	
	Moderate	Between 10 and 50% of area affected	3	
	Large	Between 50 and 100% of area affected	4	
Warning Time	Long	More than 24 hours	1	10%
	Moderate	12 to 24 hours	2	
	Short	6 to 12 hours	3	
	Very short or no warning	less than 6 hours	4	
Duration	Very short	Less than 6 hours	1	10%
	Short	Less than 24 hours	2	
	Moderate	Less than one week	3	
	Long	More than one week	4	

Table 50 provides the final hazard ranking for Boxborough. Each hazard characteristic is assigned a value between 1 (lowest value) and 4 (highest value). When the risk values were calculated, if the value was greater than 2.7, it was assigned as a high risk hazard. If the value was greater than 2 and less than or equal to 2.7, it was assigned as a moderate risk. If the value was less than or equal to 2, it was assigned as a low risk hazard. The flood, severe winter storms, average and extreme temperatures, and hurricanes and tropical storms hazards were ranked highest. The other severe weather, wildfires/brushfires, invasive species, droughts, landslides, and tornadoes were all ranked as moderate. The earthquake hazard is ranked as low.

Table 50. Final Hazard Ranking of Hazards for Boxborough.

Hazards	Probability	Impact	Spatial Extent	Warning Time	Duration	Value	Rank
Flooding from Precipitation and Dam Overtopping	4	4	3	3	2	3.5	High
Severe Winter Storms	4	2	4	1	3	3	High
Average and Extreme Temperatures	4	2	4	1	2	2.9	High
Hurricanes and Tropical Storms	3	3	4	1	2	2.9	High
Wildfires/Brushfires	3	2	3	3	3	2.7	Mod.
Other Severe Weather	3	2	4	2	1	2.6	Mod.
Droughts	2	2	4	1	4	2.5	Mod.
Landslides	2	3	2	4	1	2.4	Mod.
Tornadoes	2	4	1	3	1	2.4	Mod.
Invasive Species	3	1	2	3	4	2.3	Mod.
Earthquakes	1	1	4	4	1	1.9	Low

The following table summarizes changes in population patterns and land use and development and how those impact hazards.

Table 51. Impacts from Population and Land Use.

Hazards	Changes in Population Patterns	Changes in Land Use and Development
Flooding Including Dam Failures and Ice Jams	There is a growing elderly population exposed to the floodplain: • East of Stow Rd., north of Burroughs Rd., and south of Massachusetts Ave. • Area around Guggins Brook. • Area south of Depot Rd. and north of Cobleigh Rd.	Existing codes and regulations in the SFHA will help to keep flood impacts low. New development areas may produce additional flooding due to the addition of impervious surfaces.

Hazards	Changes in Population Patterns	Changes in Land Use and Development
Droughts	The Town's elderly population has increased from 9.2% in 2010 to 10.3% in 2020. The number of people living below the poverty line has decreased from 2010 to 2020.	All new developments will create more demand for limited water resources.
Landslides	There is a growing elderly population north of Liberty Square Rd. and areas south of Massachusetts Ave. and East of Stow Rd.	Existing land use regulations will help to keep development out of landslide-prone areas.
Extreme Temperatures	The Town's elderly population has increased from 9.2% in 2010 to 10.3% in 2020. The number of people living below the poverty line has decreased from 2010 to 2020.	All new developments will exacerbate heat island effect if the development includes tree removal and adding black surfaces such as asphalt and roofs.
Wildfires	There is a growing elderly population south of Old Harvard Rd. with a moderate wildfire susceptibility.	Development in or adjacent to a forested or brushland area can lead to a higher risk of wildfire.
Infectious Diseases	The Town's elderly population has increased from 9.2% in 2010 to 10.3% in 2020. The number of people living below the poverty line has decreased from 2010 to 2020.	Shouldn't be impacted by changes in land use and development.
Invasive Species	Shouldn't be impacted by population changes.	Shouldn't be impacted by changes in land use and development.
Hurricanes and Tropical Storms	The Town's elderly population has increased from 9.2% in 2010 to 10.3% in 2020. The number of people living	Shouldn't be impacted by changes in land use and development.

Hazards	Changes in Population Patterns	Changes in Land Use and Development
	below the poverty line has decreased from 2010 to 2020.	
Severe Winter Storms	The Town's elderly population has increased from 9.2% in 2010 to 10.3% in 2020. The number of people living below the poverty line has decreased from 2010 to 2020.	Shouldn't be impacted by changes in land use and development.
Tornadoes	The Town's elderly population has increased from 9.2% in 2010 to 10.3% in 2020. The number of people living below the poverty line has decreased from 2010 to 2020.	Shouldn't be impacted by changes in land use and development.
Other Severe Weather	The Town's elderly population has increased from 9.2% in 2010 to 10.3% in 2020. The number of people living below the poverty line has decreased from 2010 to 2020.	Shouldn't be impacted by changes in land use and development.
Earthquakes	Not considered.	Not considered.

Problem Statements Summary

The following problem statements reflect a summary of the problem statements included at the end of each hazard profile. They were designed to briefly summarize the key hazard risks and vulnerabilities to the community based on potential impacts and losses from future events. They are among the issues of greatest concern and were used to assist in the identification and analysis of potential mitigation actions for Chapter 6 (Mitigation Strategy). These problem statements will be reviewed and revised as needed during plan updates to reflect the most current information resulting from the risk assessment.

Table 52. Problem Statements Summary.

Hazard	Problem Summary

Flood	• Older populations in the floodplain may have difficulty evacuating.
	• The school is adjacent to the floodplain and contains vulnerable populations.
	• Potential exposed structures include:
	    • Fire station and areas near the Blanchard Memorial School.
	    • Undersized culverts.
	    • Area adjacent to beaver dam on MBTA property.
	• Road closures may interrupt community systems including Liberty Square Road, Depot Road, Massachusetts Avenue, and Old Harvard Road.
	• According to EPA's Toxic Release Inventory (TRI) database, there is one facility which contains hazardous materials (Murfield Mechanical, LLC)) in the 100-year floodplain. However, there are several facilities which contain hazardous materials that are adjacent to the floodplain.

Severe Winter Storms	• Vulnerable populations may be stranded during a winter storm event and may not be able to travel to emergency services. • The electrical grid and roadways are susceptible to failure and loss of use during storms. • First responders may have difficulty reaching people if roads are closed due to road closures.
Average and Extreme Temperatures	• Extreme heat will be a significant public health threat to all residents, but especially for vulnerable populations living in older homes or homes without air conditioning. • The electric grid may become stressed and fail during extreme heat events. • The elderly and those with mobility issues may not be able to leave their homes and travel safely.

Hazard	Problem Summary
	• People working in businesses without air conditioning may be at risk of heat illness.
Hurricanes/Tropical Storms	• Wind may cause trees to fall into structures and infrastructure, and roadways. • Wind damage to wind-susceptible buildings such as carports, greenhouses, and open-walled buildings. Additional damage to commercial buildings with HVAC located on roofs. • The electric grid may go down during high wind event.
Wildfires/Brushfires	• Populations with severe asthma may be adversely impacted by wildfires in the vicinity. • Several residential structures are found in the higher probability burn areas. Structures without defensible zones are more susceptible to wildfires and brush fires. • Wildfires often cause roads to be closed requiring detours impacting emergency services. • The Town believes that brush fires may be increasing in frequency.
Other Severe Weather	• First responders may have difficulty reaching people if roads are closed due to tree debris. • Storm damage to wind-susceptible buildings such as carports, greenhouses, and open-walled buildings. Additional damage to commercial buildings with HVAC located on roofs. • The electric grid may go down during high wind event.
Droughts	• Vulnerable communities may have difficulty accessing potable water during an emergency drought event. • Water supply infrastructure may need to be shut down and water quality may become substandard. Businesses requiring water for daily operations may have their operations limited due to water restrictions. PFAS is already a challenge in Boxborough’s wells.

Hazard	Problem Summary
	• Outdoor water use restrictions and other water conservation measures during periods of extreme drought can be challenging to enforce, even when mandated through local declaration. • Drought communications will need to change as the water system from Littleton is extended into Boxborough. • Some agricultural operations may be increasingly impacted in the future.
Landslides	• Vulnerable populations in isolated areas may be cut off if a landslide impacts specific roads. • Some historical, residential, commercial, and other structures reside adjacent to moderately unstable areas and could be impacted. • A steep slope behind one residential property is believed a landslide risk. • Roads and rail may be impacted and could cause a hazardous material spill.
Tornadoes	• Vulnerable populations may need support seeking protected shelter. Those without cell phones may not get weather alerts. • Structures and critical infrastructure can all be impacted by tornadoes. • Roadways may be blocked due to downed trees and other debris. • The electric grid may be impacted by winds and downed trees. • Wind damage to wind-susceptible buildings such as carports, greenhouses, pavilions, gazebos, and open-walled buildings. Additional damage to commercial buildings with HVAC located on roofs.
Invasive Species	• Invasive species are problematic throughout the Town and have been verified in Greylock Glen, Ragged Mountain, and along the train tracks. • Additional DPW resources may be required in critical areas.
Earthquakes	• Elderly population may fall during an event.

Hazard	Problem Summary
	• Unreinforced masonry and utility lifelines impacted. • Fire Station impacted.

Chapter 5: Capability Assessment

Overview

The capability assessment is an evaluation of the existing tools and resources available to the Town of Boxborough for increasing its resilience to hazards, with the primary purpose of identifying opportunities to improve or enhance these capabilities. Coupled with the risk assessment, this serves as the foundation for designing an actionable and effective hazard mitigation strategy.

As in any planning process, it is important to establish which goals or actions are feasible based on the organizational capacity of those agencies or departments tasked with plan implementation. This capability assessment helps determine which types of mitigation actions are practical and likely to be completed over time based on Boxborough's existing authorities, policies, programs, and resources available to support them. It also helps identify any critical capability gaps or limitations to address through corrective actions, as well the key strengths or positive measures in place that should continue to be supported or expanded upon to improve local mitigation capabilities.

This capability assessment was completed to not only help establish the goals and actions for the Town of Boxborough's hazard mitigation plan, but to also help ensure that those goals and actions are realistically achievable under current local conditions. As highlighted in FEMA's 2022 Local Mitigation Planning Policy Guide, *"describing the current capabilities provides a rationale for which mitigation projects can be undertaken to address the vulnerabilities identified in the Risk Assessment."*[37]

The capability assessment for the Town of Boxborough includes a comprehensive examination of several components as summarized in Table 53. It was prepared using the latest guidance and worksheets provided in FEMA's 2023 Local Mitigation Planning Handbook.[38]

Table 53. Capability Assessment Components.

Components	**Description**
Planning and Regulatory Capabilities	Local plans, policies, codes, and ordinances that are relevant to reducing the potential impacts of hazards.
Administrative and Technical Capabilities	Local human resources and their skills/tools that can be used to support mitigation activities.
Financial Capabilities	Fiscal resources the community has access to for helping to fund hazard mitigation projects.

[37] Local Mitigation Planning Policy Guide. FEMA. April 2022. P. 25.

[38] Local Mitigation Planning Handbook. FEMA. May 2023. PP. 79-92 and Worksheets 4-5.

Components	Description
Education and Outreach Capabilities	Local programs and methods already in place that can be used to support mitigation activities.
NFIP Participation and Compliance	Summary of information relevant to the community's participation in the NFIP and continued compliance with NFIP requirements.

Review and Incorporation of Existing Plans, Studies, and Reports

A4. Does the Plan describe the review and incorporation of existing plans, studies, reports, and technical information? (Requirement §201.6(b)(3))

The first step in completing the updated capability assessment was to gather and review any relevant local plans, studies, or reports completed or updated since the previous hazard mitigation plan was adopted in 2010. This information was used to help gain a current understanding of the Town's current ability to mitigate risk, and how local capabilities may have changed over the past 13 years. The 2023 Massachusetts State Hazard Mitigation and Climate Adaptation Plan (the "ResilientMass" Plan), as well as other plans adopted by the Town of Boxborough in the recent past, were reviewed for consistency as well as opportunities for plan integration. The goal of this review was to support updates to this plan that easily align with and possibly incorporate key aspects of relevant plans at the state and local level.

Table 54 provides a summary of the most relevant plans, studies, reports, or sources of other technical information consulted as part of this process and how they were incorporated into this plan update.

Table 54. Relevant Plans, Studies, and Reports for Incorporation.

Plan / Study / Report	Summary Description / Incorporation
ResilientMass Plan: The Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2023)	The 2023 ResilientMass Plan is an update to the Commonwealth's innovative State Hazard Mitigation and Climate Adaptation Plan (SHMCAP) that was developed in a highly collaborative manner to fully integrate a hazard mitigation plan and a climate change adaptation plan. The ResilientMass Plan identifies strategies and specific, measurable actions that state agencies can take—individually or through interagency partnerships—to address risks to the human health and safety, communities, critical assets and infrastructure, natural resources, governance, and economy of the Commonwealth. The ResilientMass Plan aims to ensure the Commonwealth is prepared to withstand, rapidly recover from, adapt to, and mitigate natural hazard events.

Plan / Study / Report	Summary Description / Incorporation
	Through the ResilientMass Plan, the Commonwealth is advancing its mission to increase its capacity for addressing natural and other hazards and climate impacts through preparation, mitigation, adaptation, and risk reduction. The ResilientMass Plan includes six (6) overarching goals which were developed through a collaborative process involving the interagency ResilientMass Action Team (RMAT) and local, regional, and community partners. It also integrates the findings of the 2022 Climate Assessment with additional analysis on all current hazards that may impact the Commonwealth, as well as future risks that will increase the likelihood, frequency, and duration of hazards. Of perhaps most relevance to local communities, the ResilientMass Plan identifies the most urgent priority impacts of these risks to various regions across the Commonwealth. The ResilientMass Plan was incorporated as a key source of information for this plan update. This included the integration and consideration of the latest climate data and information for 15 hazards impacting the Commonwealth now and, in the future, with particular emphasis on those unique impacts determined for the Eastern Inland region. In addition, the goals and actions included in Chapter 7 (State Strategy, Actions, and Implementation Plan) were reviewed and considered as part of the update process for Boxborough's Hazard Mitigation Plan to help ensure the Town's own goals and objectives are in alignment with and can be mutually supportive of the Commonwealth's overall strategy. As can be seen in Chapter 6 of this plan. several of the goals and actions identified for Boxborough's updated plan address the key themes identified in the ResilientMass Plan.
Town of Boxborough Municipal Vulnerability Preparedness (MVP) / Community Resilience Building (CRB) Summary of Findings Report (2021)	The Commonwealth's Municipal Vulnerability Preparedness (MVP) program provides support for cities and towns in Massachusetts to plan for resiliency and implement key climate change adaptation actions for resiliency. In 2020, Boxborough was awarded an MVP Planning Grant to assess its vulnerability to and prepare for climate change impacts, build community resilience, and receive designation from the Executive Office of Energy and Environmental Affairs (EEA) as an MVP Community. Communities with this designation become eligible for MVP Action Grant funding and other opportunities to support the implementation of priority climate adaptation actions. In completing the MVP planning process, the Town of Boxborough followed the Community Resilience Building (CRB) framework with technical assistance provided by a state-certified MVP Provider, Comprehensive Environmental, Inc. The CRB methodology is an "anywhere at any scale" format that draws

Plan / Study / Report	Summary Description / Incorporation
	on stakeholders' wealth of information and experience to foster dialogue about a community's strengths and vulnerabilities. A web-based MVP Planning Workshop was held on November 5, 2020, with a series of exercises designed to solicit and organize input from participants to achieve the following objectives: 1. Identify the Town's top local natural and climate-related hazards of concern. 2. Identify the Town's strengths and vulnerabilities relative to top hazards. 3. Identify and prioritize actions to reduce vulnerabilities or improve strengths. 4. Determine the Town's overall top priority actions. The resulting Summary of Findings Report and supporting materials served as a primary source of information and community-based input for incorporation into the update of this plan. These inputs include the identification of top climate-influenced hazard categories (flooding; strong storms; and drought and extreme temperatures) and vulnerable areas or community assets (infrastructural, societal, and environmental), current community concerns and challenges presented by these hazards, current strengths and assets, and specific, prioritized recommendations to improve resilience in Boxborough.
Open Space and Recreation Plan (2023)	The Open Space and Recreation Plan (OSRP) is to provide the Town of Boxborough with a blueprint for ensuring that current and future residents have ample opportunities for recreation and access to open space. It is intended to help inform the Town's decision making about open space and recreation land and opportunities through 2027. The plan also intends to retain the character of Boxborough by establishing a diverse system of interconnected open space areas and to provide quality recreation programs for all residents to enjoy. It includes information on the history, growth, and development of the community as well as a detailed environmental inventory and analysis. It also includes a community vision along with the identification of resource protection and management needs, followed by specific goals, objectives, and actions to be pursued through plan implementation. The OSRP served as a key source of information related to Boxborough's demographics, growth and development patterns, and the natural environment, with specific content regarding natural hazards and mitigation activities also being incorporated into this updated plan. This includes details on environmental challenges such as climate change, development and

Plan / Study / Report	Summary Description / Incorporation
	stormwater impacts, chronic flooding, forestry issues and vegetative invasive species for the risk assessment, and information on existing goals and recommended or planned activities that will help the community to mitigate hazards or adapt to climate change for the mitigation strategy.
Boxborough2030 (Master Plan, 2016)	Boxborough2030 serves as the Town's comprehensive planning and decision-making guide through 2030, with the goal of helping Boxborough achieve and maintain its vision of "A Rural, Engaged Community for All." Boxborough2030 not only speaks to preserving the Town's rural landscape, educational system, and conservation lands, but it also addresses many other topics which are less often contemplated such as housing, economic enhancement, energy efficiency, and transportation. Notably among the most significant guidance included in the plan for potential action is to establish strategies for energy conservation, carbon footprint reduction, and climate change resiliency. Boxborough2030's plan documents served as primary sources for current information and data that were reviewed and integrated into the hazard mitigation plan update. This included content relating to the physical, environmental, and demographic characteristics of Boxborough, as well as the community's collective vision for the future and the key goals and strategies to achieve that vision. The Recommendations & Implementation Plan includes a series of relevant recommendations that were incorporated into the mitigation planning process, including several strategies focused on natural resource protection, preserving open space and other natural areas, building resiliency to climate change.
FEMA Flood Insurance Study for Middlesex County (2023)	Last revised by FEMA on June 8, 2023, this report constitutes the revised preliminary Flood Insurance Study (FIS) report for Middlesex County. This latest FIS revises and updates information from the currently effective (2016) FIS report on the existence and severity of flood hazards for the study area, which includes the Town of Boxborough. The studies described in this report provide flood hazard data that will, once formally adopted as final/effective, be used to establish actuarial flood insurance rates and to assist communities in efforts to implement sound floodplain management. The FIS and accompanying Flood Insurance Rate Maps (FIRMs) include relevant data and information on flood hazards for Boxborough, including but not limited to descriptions of principal flood problems, flooding sources, FEMA flood zone designations, base flood elevations, and discharge rates of

Plan / Study / Report	Summary Description / Incorporation
	flooding sources. This data and information were reviewed and incorporated into the plan update process by informing the risk assessment, especially as it relates to the hazard profile and GIS-based vulnerability assessment that was prepared for the flood hazard.

In addition to the above plans which were determined to be most relevant for incorporation into the hazard mitigation plan update, the following plans, studies, reports, and other technical documents were reviewed to gain a clearer understanding of local capabilities and their existing or potential effects on hazard risk reduction. More information on some of these documents is provided in Table 55 in the next section.

- ***Stormwater Management Plan (2023)*** – The Town's Stormwater Management Plan (SWMP) is maintained in compliance with MS4 permit requirements as administered by the U.S. Environmental Protection Agency and Massachusetts Department of Environmental Protection (MassDEP). The SWMP describes and details the activities and measures that will be implemented to meet the terms and conditions of the MS4 permit. It is focused on reducing pollutants in stormwater runoff versus mitigating flood hazards. The main elements of the Town's stormwater management program are (1) a public education program in order to affect public behavior causing stormwater pollution, (2) an opportunity for the public to participate and provide comments on the stormwater program, (3) a program to effectively find and eliminate illicit discharges within the MS4 (4) a program to effectively control construction site stormwater discharges to the MS4, (5) a program to ensure that stormwater from development projects entering the MS4 is adequately controlled by the construction of stormwater controls, and (6) a good housekeeping program to ensure that stormwater pollution sources on municipal properties and from municipal operations are minimized.
- ***Annual Town Report (2022) –*** The Annual Town Report contains updated facts about Boxborough and a series of reports and information from the Town's various departments, boards, commissions, and other officials.
- ***Boxborough Climate Change Survey Results (2021) –*** This presentation document summarizes the results of a Climate Change Survey conducted by the Boxborough Sustainability Committee with Town residents from November 29, 2020, through February 18, 2021. Key takeaways are that Boxborough residents believe that climate change is real, want to learn more, want to take action to mitigate the impacts of climate change, and believe government, business, and community partnerships should lead to climate change action in Boxborough.
- ***Community Preservation Plan (2021) –*** The purpose of the 2021 Boxborough Community Preservation Plan is to provide the Town of Boxborough with a guide for evaluating and selecting Community Preservation Act (CPA) proposals for recommendation to Boxborough voters at Town Meeting. This includes proposed projects to achieve the Town's goals for (1)

open space protection for conservation, agriculture, and outdoor recreation; (2) enhancement of community housing; and (3) preservation of historic resources.

- ***Boxborough Economic Development Committee Report Summary (2021)*** – This report summarizes the results of an economic development study conducted by UMASS Amherst, Center for Economic Development under its School of Landscape Architecture (LARP), to help define a framework for implementing the economic development objectives envisioned in the Boxborough2030 Master Plan.
- ***Operations and Maintenance Plan (2020) –*** This plan, prepared for the Town's Department of Public Works (DPW), includes operation and maintenance (O&M) procedures to reduce the impact of stormwater runoff from municipal operations and facilities to town-owned stormwater infrastructure. The Standard Operating Procedures (SOPs) developed as part of this plan are focused on reducing or eliminating contamination that may enter the Town's stormwater system and water resources.
- ***Housing Production Plan (2015) –*** This plan includes a comprehensive housing needs assessment that describes the characteristics of the Town's existing housing stock and housing market, identifies constraints to housing development, and establishes goals for affordable housing in Boxborough with specific implementation strategies for each goal. These implementation strategies were based on a five-year action plan, so this plan is considered outdated and in need of an update.
- ***Housing Needs Assessment (2012)*** – Although somewhat dated, this report analyzes the housing needs for the Town of Boxborough as identified in 2012. It takes into consideration the impact of population growth, education, housing trends and housing inventory.

Planning and Regulatory Capabilities

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))

Table 55 is based off Worksheet 4 from FEMA's Local Mitigation Planning Handbook. It was used by the HMPC to document and review the current planning and regulatory capabilities of the Town including local plans, policies, codes, and ordinances that are relevant to reducing the potential impacts of hazards. Some additional information on how effectively these plans and regulatory tools are being used for hazard mitigation purposes can be found under the Safe Growth Survey and NFIP Participation and Compliance sections of this chapter.

Table 55. Planning and Regulatory Findings.

Planning/Regulatory Tool	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
Plans		
Master/Comprehensive Plan	Yes	The Town's current Master Plan (Boxborough2030) was last updated in 2016 and will be updated again in 2028-2029. See Table 54 for more information on Boxborough2030.
Open Space & Recreation Plan	Yes	The Town's current Open Space and Recreation Plan (OSRP) was recently updated and adopted in 2023. See Table 54 for more information on the Town's OSRP.
Climate Adaptation Plan	No	Although technically not a full climate adaptation plan per se, the Town's 2021 MVP Summary of Findings Report does include a basic assessment of key strengths and vulnerabilities and identifies a series of recommended actions to reduce the impacts of Boxborough's top climate hazards. See Table 2 for more details on the MVP report. Effective in terms of identifying and prioritizing actions to build community resilience for specific hazards through continued coordination and integration with this hazard mitigation plan.
Floodplain Management Plan	No	No standalone plan, though floodplain management is addressed as a key component of this Hazard Mitigation Plan.
Stormwater Management Plan	Yes	The Town's Stormwater Management Plan (SWMP) addresses compliance with MS4 permit. Includes maintenance of drainage system but not focused on hazards. Last updated in 2021. More details on the SWMP are provided in the previous section following Table 2.
Capital Improvements Plan	Yes	The Boxborough Capital Budget Committee (CapCom) exists to establish, track, and recommend the Town's long-term capital needs for items over $10,000 and a useful life of more than 5 years. CapCom reviews the capital plan with Town departments and committees and regularly updates the Capital Plan, which is

Planning/Regulatory Tool	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
		presented to the Town on Capital Saturday. If Capital Saturday will not occur in a specific year, then the plan will be presented to a joint meeting of the Select Board and Finance Committee (FinCom). The final plan for the upcoming fiscal year will then be presented by FinCom in their report in the Spring ATM Warrant.
Housing Production Plan	Yes	The Town's Housing Production Plan is out of date and should be updated. More details are provided in the previous section following Table 2.
Transportation Plan	No	The Town relies on regional transportation plans, though local priorities and strategies are also addressed in the Town's Master Plan, Boxborough2030. The Town is in the process of updating its Complete Streets Prioritization Plan and is coordinating with MART on a regional bus route.
Economic Development Plan	No	No plan exists; however, the Town did recently complete a scenarios analysis in coordination with a UMass Regional Planning Fall studio.
Historic Preservation Plan	No	No plan in place, however the Town does have a Historical Commission and local regulations such as the Demolition Delay Bylaw which focus on preserving historically significant buildings.
Emergency Operations Plan	In Progress	The Town's development of a modern Comprehensive Emergency Management Plan (CEMP) is underway.
Continuity of Operations Plan	No	N/A
Community Wildfire Protection Plan	No	N/A
Other special plans?	Yes	Complete Streets Prioritization Plan
Building Code, Permitting, and Inspections		
Building Code	Yes	Version/Year: MA State Building Code (780 CMR), Ninth Edition, 2017
ISO Building Code Effectiveness Grading		

Planning/Regulatory Tool	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
Schedule (BCEGS®) Classification		
ISO Public Protection Classification (PPC©)	Yes	PPC Grade (Community Classification): Class 05
Special Permit / Site Plan Review Requirements	Yes	Special Permits are addressed under Section 2.3 of the Town's Zoning Bylaw and administered by the Board of Appeals or Planning Board, acting as the Special Permit Granting Authority (SPGA). The SPGA may grant a special permit only if it determines that the structure(s) or use(s) proposed will not have adverse effects which outweigh its benefits on either the town or the neighborhood, in view of the characteristics of the site and of the proposal in relation to that site. The determination includes but is not limited to consideration of traffic flow and safety, stormwater drainage, impact on the natural environment, impact on health, etc. Applications for a special permit may require site plan approval as addressed under Section 2.5 of the Zoning Bylaw. Very effective in terms of supporting hazard risk reduction through existing procedures. The site plan review regulations are stringent and are triggered under the majority of circumstances and include review criteria that include conservation of trees and open space.
Zoning, Land Use, and Development Regulations		
Zoning Bylaw	Yes	The Town's Zoning Bylaw (last amended in 2022) was established for many purposes that include but are not limited to securing safety from fire, flood, panic, and other dangers. Very effective at supporting hazard risk reduction through multiple articles and sections and in combination with other rules or regulations as further described in this table. This includes generally enforcing the conservation of land and trees.
Subdivision Regulations	Yes	The Town's Rules and Regulations Governing the Subdivision of Land (last amended in 2012) were adopted for the purpose of protecting the safety,

Planning/Regulatory Tool	**In Place?** *(Yes/No)*	**General Description / Effectiveness for Hazard Risk Reduction**
		convenience, and welfare of residents by regulating the laying out and construction of ways in subdivisions, providing access to the several lots therein, but which have not become public ways, and ensuring sanitary conditions in subdivisions and in proper cases parks and open areas. The regulations include design standards, drainage and stormwater detention requirements, natural resource protection requirements, and other specifications that all help reduce the risk of creating hazards during the subdivision process. When applied to the subdivision of land, the Town's rules and regulations account for preservation of land. They further require early notification to MassDOT and circulation of proposals to local staff and experts.
Floodplain Regulations	Yes	Section 8.2 (Flood Plain District) of the Town's Zoning Bylaw establishes and regulates activities within flood hazard areas with the purpose of ensuring public safety through reducing the threats to life and personal injury; to eliminate new hazards to emergency response officials; to prevent the occurrence of public emergencies resulting from water quality contamination and pollution due to flooding; to avoid the loss of utility services which if damaged by flooding would disrupt or shut down the utility network; to reduce costs associated with the response and cleanup of flooding conditions; and to reduce damage to public and private property. Last amended in 2014, these regulations are slated to be updated and adopted in 2024 in conformance with the State's Model Floodplain Bylaw as further described in this chapter. Very effective in reducing the long-term risk of flood hazards throughout the Town's identified special flood hazard areas as depicted on the latest Flood Insurance Rate Map for Middlesex County (2023).
Wetlands Protection Regulations	Yes	The Town maintains its own Wetland Bylaw (last amended in 2010) which compliments the State's

Planning/Regulatory Tool	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
		Wetlands Protection Act. The bylaw is strictly enforced by the Conservation Commission to preserve and protect wetlands in the Town by regulating and controlling activities deemed to have a significant effect upon the functions and characteristics of such wetlands, including but not limited to flood control, erosion control, storm damage prevention, and the protection of land containing wildlife, recreation, and aesthetics. These regulations effectively help to reduce flood hazards by prohibiting certain activities and uses deemed to have a significant effect upon the functions and characteristics of any wetland or within 100 feet of any wetlands.
Stormwater Management Regulations	Yes	The Town's Stormwater Bylaw and Stormwater Management Rules and Regulations (adopted in 2022) work in tandem for pre and post-construction management activities. These require increased stormwater control for any disturbance of land greater than one acre. The Planning Board will review proposals and enforce violations, with requirements to demonstrate metrics to success.

Massachusetts State Building Code

All municipalities in the state must adopt and enforce the current Massachusetts State Building Code (MSBC). The MSBC consists of a series of international model codes and any state-specific amendments adopted by the Board of Building Regulations and Standards (BBRS). The BBRS regularly updates the state building codes as new information and technology becomes available and change is warranted.

The MSBC is separated into two distinct volumes: The Residential volume regulates all one- and two-family structures and townhouses that are three stories or less, as well as their accessory structures. The Base volume regulates all structures that are not covered by the Residential regulations.

The current version of the MSBC is the Ninth Edition, which became effective on October 20, 2017. The Town of Boxborough began enforcing the Ninth Edition for all applicable projects as required by January 1, 2018. The Ninth Edition code is based on modified versions of the following 2015 codes as published by the International Code Council (ICC).*

- The International Building Code (IBC)

- International Residential Code (IRC)
- International Existing Building Code (IEBC)
- International Mechanical Code (IMC)
- International Energy Conservation Code (IECC)
- International Swimming Pool and Spa Code (ISPSC)
- Portions of the International Fire Code (IFC)

** Although the Ninth Edition of the code is still in effect, members of the BBRS have voted that the next edition of the MSBC will be based on modified versions of the 2021 International Codes. The content of these codes is still under review by the BBRS, but it is anticipated that the Tenth Edition of the code will be available for use in 2024.*

The Commonwealth of Massachusetts requires mandatory enforcement of the MSBC and does not allow local amendments to the residential code. In addition, the Commonwealth adopts a plumbing and electrical code. The Commonwealth also has a program in place for code official certification, which includes taking code classes prior to examination and certification, requires continuing education, and allows consumers to file complaints against inspectors. Massachusetts also requires licensing of general, plumbing, electrical, and roofing contractors; requires licensing candidates to pass an examination prior to licensing; and requires continuing education.

Massachusetts continues to perform well in terms of objective assessments of the MSBC. For example, in its most recent "Rating the States" report, the Insurance Institute for Business and Home Safety (IBHS) ranked Massachusetts 9th (scoring 78 out of a possible 100 points on the IBHS scale). Now in its fourth edition, IBHS's 2021 report evaluates the 18 states along the Atlantic and Gulf coasts, all vulnerable to catastrophic hurricanes, based on building code adoption, enforcement, and contractor licensing.

Lastly, as noted in the table above, the MSBC contains a series of requirements for flood-resistant design and construction that are in accordance with the ASCE 24 standard, which incorporates—and in certain areas exceeds—FEMA's NFIP construction standards. Highlights of ASCE 24 that complement the NFIP minimum requirements include requirements for building performance; flood-damage-resistant materials, utilities and service equipment, and siting considerations. Specific requirements for design flood elevations and the use of flood-resistant materials may be found in the ASCE Tables included in 780 CMR Section 1612.4. For example, a higher regulatory standard that affects development and redevelopment in the Town's mapped special flood hazard areas include a requirement that new or substantially improved buildings must be elevated so that the lowest floor surface is at least 1 foot above the FEMA base flood elevation.

Safe Growth Survey

As part of the assessment for planning and regulatory capabilities, the Town Planner completed a *Safe Growth Survey*. This unique survey instrument was drawn from the Safe Growth Audit concept developed for the American Planning Association (APA) to help communities evaluate the extent to which they are positioned to grow safely relative to natural hazards. The survey covered six topic areas including the following:

- Land Use
- Transportation
- Environmental Management
- Public Safety, Zoning Ordinance
- Subdivision Regulations
- Capital Improvement Program and Infrastructure Policies

While somewhat of a subjective exercise, the Safe Growth Survey was used to provide some measure of how adequately existing planning mechanisms and tools for the Town of Boxborough were being used to address the notion of safe growth. In addition, the survey instrument was aimed at further integrating the subject of hazard risk management into the dialogue of local community planning and to possibly consider and identify new actions as it relates to those local planning policies or programs already in place or under development. It is anticipated that the Safe Growth Survey will be used again during plan updates to help measure progress over time and to continue identifying possible mitigation actions as it relates to future growth and community development practices, and how such actions may better be incorporated into local planning mechanisms.

The results of the Safe Growth Survey are summarized in Table 56. This includes describing how strongly the Town's planning staff agrees or disagrees with 25 statements as they relate to Boxborough's current plans, policies, and programs for guiding future community growth and development, according to the following scale:

1=Strongly Disagree 2=Somewhat Disagree 3=Neutral 4=Somewhat Agree 5=Strongly Agree

Table 56. Safe Growth Survey Results.

MASTER/COMPREHENSIVE PLAN	
Land Use	
1. The master/comprehensive plan includes a future land use map that clearly identifies natural hazard areas.	$\boxed{1}$ 2 3 4 5
2. Current land use policies discourage development and/or redevelopment within natural hazard areas.	1 2 $\boxed{3}$ 4 5

MASTER/COMPREHENSIVE PLAN						
3.	The master/comprehensive plan provides adequate space for expected future growth in areas located outside of natural hazard areas.	1	$\boxed{2}$	3	4	5
Transportation						
4.	The transportation element limits access to natural hazard areas.	1	2	$\boxed{3}$	4	5
5.	Transportation policy is used to guide future growth and development to safe locations.	1	2	$\boxed{3}$	4	5
6.	Transportation systems are designed to function under disaster conditions (e.g., evacuation, mobility for fire/rescue apparatus, etc.).	1	$\boxed{2}$	3	4	5
Environmental Management						
7.	Environmental features that serve to protect development from hazards (e.g., wetlands, riparian buffers, etc.) are identified and mapped.	1	2	3	$\boxed{4}$	5
8.	Environmental policies encourage the preservation and restoration of protective ecosystems.	1	2	3	$\boxed{4}$	5
9.	Environmental policies provide incentives to development that is located outside of protective ecosystems.	$\boxed{1}$	2	3	4	5
Public Safety						
10.	The goals and policies of the master/comprehensive plan are related to and consistent with those in the hazard mitigation plan.	1	$\boxed{2}$	3	4	5
11.	Public safety is explicitly included in the master/comprehensive plan’s growth and development policies.	1	2	$\boxed{3}$	4	5

MASTER/COMPREHENSIVE PLAN					
12. The monitoring and implementation section of the master/comprehensive plan covers safe growth objectives.	1	2	$\boxed{3}$	4	5
ZONING BYLAWS					
13. The zoning bylaws conform to the master/comprehensive plan in terms of discouraging development and/or redevelopment within natural hazard areas.	1	2	$\boxed{3}$	4	5
14. The bylaws contain natural hazard overlay zones that set conditions for land use within such zones.	1	2	$\boxed{3}$	4	5
15. The bylaws require or encourage resilient development through density bonuses, flexibility with setback requirements, or other incentives for projects outside of natural hazard areas.	1	$\boxed{2}$	3	4	5
16. The bylaws prohibit development within, or filling of, wetlands, floodways, and floodplains.	1	2	3	4	$\boxed{5}$
SUBDIVISION REGULATIONS					
17. The subdivision regulations restrict the subdivision of land within or adjacent to natural hazard areas.	1	2	$\boxed{3}$	4	5
18. The regulations provide for conservation subdivisions or cluster subdivisions to conserve environmental resources.	1	2	$\boxed{3}$	4	5
19. The regulations allow density transfers where natural hazard areas exist.	$\boxed{1}$	2	3	4	5
CAPITAL IMPROVEMENT PROGRAM AND INFRASTRUCTURE POLICIES					
20. The capital improvement program limits expenditures on projects that would encourage development and/or redevelopment in areas vulnerable to natural hazards.	1	$\boxed{2}$	3	4	5

MASTER/COMPREHENSIVE PLAN	
21. Infrastructure policies limit the extension of existing facilities and services that would encourage development in areas vulnerable to natural hazards.	1 2 $\boxed{3}$ 4 5
22. The capital improvements program provides funding for hazard mitigation projects identified in the hazard mitigation plan.	1 2 $\boxed{3}$ 4 5
OTHER	
23. Economic development and/or redevelopment strategies include provisions for mitigating natural hazards or otherwise enhancing social and economic resiliency to hazards.	$\boxed{1}$ 2 3 4 5
24. Local plans, policies, or regulations promote the use of green infrastructure, low impact development, or other nature-based solutions for managing stormwater and other climate hazards.	1 2 3 $\boxed{4}$ 5
25. The community considers and addresses potential impacts of its plans, policies, or regulations on Environmental Justice (EJ) neighborhoods or other socially vulnerable populations.	1 2 3 $\boxed{4}$ 5

Administrative and Technical Capabilities

Table 57 is based off Worksheet 4 from FEMA's Local Mitigation Planning Handbook. It was used by the HMPC to document and review the current administrative and technical capabilities of the Town. These include staff and their skills and tools that can be used for mitigation planning and to implement specific mitigation actions.

Table 57. Administrative and Technical Findings.

Administrative/Technical Resource	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
Local Boards/Committees		
Planning Board	Yes	The Planning Board and Town Planner frequently coordinate with staff and Emergency Services in the review of applications. The Planning Board utilizes PLACES associates for independent engineering review,

Administrative/Technical Resource	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
		who considered stormwater, compliance with bylaws, and emergency protocol.
Conservation Commission	Yes	The Conservation Commission (ConCom) has adopted local wetlands bylaws to reinforce their authority and further protect natural resources. The ConCom utilizes PLACES associates for independent engineering review.
Capital Planning Committee	Yes	The Boxborough Capital Budget Committee (CapCom), as further described in Table 54, annually reviews projects and invites presentations from Town departments to advocate for improvements.
Climate Action Committee	No	N/A
Other relevant boards/committees?	Yes	The Climate Action Committee regularly considers methods of reducing carbon emissions and fuel dependence. The Boxborough Building Committee is actively considering options to better meet the facility needs of the Town's Police and Fire Departments.
Staff		
Community Planner	Yes	Current staffing is limited to one Town Planner and is not considered adequate to cover all assigned duties. A budget item for adding an Associate Planner has been submitted which would help in terms of the Town's capability to be more effective in its long-term planning and project implementation activities, including those that will support hazard risk reduction efforts.
Chief Building Official	Yes	Staffing levels are sufficient, utilizing a Building Commissioner (½ time), multiple inspectors (on call), regional health services (contracted - on call), and a skilled admin who coordinates the entire office (reduced full time).
Civil Engineer	No	Town Engineering services are contracted through PLACES Associates but are not in house. These are skilled and sufficient services but are shared amongst many clients/communities.

Administrative/Technical Resource	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
Emergency Manager	Yes	The Town's Fire Chief serves as the Emergency Management Director (EMD). While the Fire Department has effectively filled staffing needs, the Police Department is actively hiring. The Town recently moved to a regional dispatch model to support both departments.
Floodplain Administrator	Yes	The Town's Building Commissioner is responsible for administration of the Town's floodplain regulations and implementation of the commitments and requirements of the NFIP and State Building Code.
Sustainability/Climate Coordinator	No	N/A
GIS Coordinator	No	Currently falls under the Town Planner, who has an introductory level of experience.
Public Information Officer/Specialist	No	N/A
Technical		
Grant writing	Yes	Highly capable Town Planner who can employ interns to bolster the Town's grant writing capacity.
GIS mapping and analysis	Yes	A limited capability is available on hand, with more capable resources available through the Metropolitan Area Planning Council (MAPC).
Hazard data and information	Yes	Some data is collected, but limited resources are available.
Maintenance programs to reduce risk *(e.g., tree trimming, drainage clearance)*	Yes	The Town's Department of Public Works (DPW) maintains street trees, right of ways, and oversees all work. DPW staff have worked on many hazard areas year round and sufficiently maintained roadways in the winter. In working with CEI, the DPW plans for stormwater mitigation and hazard reduction.
Acquisition of land for open space, recreation, and other public use	Yes	This is actively pursued by the Town's Conservation and Recreation Commissions. The Town actively exercises its right-of-first refusal on Chapter Lands.

Administrative/Technical Resource	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
Warning systems/services *(e.g., Reverse 911, outdoor warning signs)*	Yes	The Town of Boxborough, in partnership with the Littleton Electric and Light Department, implements the CodeRED notification system. The system allows local public safety agencies and utilities to notify residents of emergencies in a quick and efficient manner. Examples of the system's use included announcements related to emergency road closures, contaminated water, power outages, evacuations, etc.
Mutual Aid Agreements	Yes	Mutual aid agreements are in place with many partners in the region.

Financial Capabilities

Table 58 is based off Worksheet 4 from FEMA's Local Mitigation Planning Handbook. It was used by the HMPC to identify and review the Town's eligibility and access to funding sources that can be used to support the implementation of hazard mitigation projects.

Table 58. Financial Findings.

Financial Tool/Source	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
General funds	Yes	The Town annually funds MS4 and related work through its general fund.
Capital Improvement Program (CIP) funding	Yes	The Town annually funds MS4 and related work through its Capital Plan.
Special purpose taxes	Yes	The Town regularly leverages Community Preservation funding for land acquisition and improvements to recreation/open space lands. See below (Massachusetts CPA funds) for more info.
Fees for water, sewer, gas, or electric services	No	Littleton Electric Light and Water Departments provide electrical service to the town and will soon provide limited water service. Fees collected go to Littleton and are not controlled by the Town.
Stormwater utility fee	No	N/A
Development impact fees	No	N/A

Financial Tool/Source	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
General obligation bonds and/or special purpose bonds	No	N/A
FEMA Hazard Mitigation Assistance (HMA) funds	Yes	FEMA's current HMA grant programs (BRIC, FMA, HMGP) remain a good source of external funding for implementing eligible and cost-effective mitigation projects in coordination with MEMA.
HUD Community Development Block Grant (CDBG) funds	No	Due to AMI levels, the Town of Boxborough is largely unable to access CDBG funding.
Other federal funding programs	Yes	NOAA, EPA, USACE, and other federal agencies do make grant funding available for a variety of resilience-themed projects and initiatives that the Town may be eligible to pursue in the future. This includes both pre- and post-disaster funding programs that can be very effective in supporting the implementation of cost-effective hazard mitigation projects, many of which are described in FEMA's Mitigation Resource Guide.[39]
Massachusetts Municipal Vulnerability Preparedness (MVP) Action Grant funds	Yes	The MVP Action Grant offers financial resources to communities that are seeking to advance priority climate adaptation actions to address climate change impacts resulting from extreme weather, sea level rise, inland and coastal flooding, severe heat, and other climate impacts. As a designated "MVP Community" the Town is eligible to apply for grants on its own, or as part of a regional partnership of multiple municipalities provided that the lead applicant is MVP-designated. To date the Town has not leveraged these available funds.
Massachusetts Community Preservation Act (CPA) funds	Yes	In 2014 the Town of Boxborough passed the Community Preservation Act (CPA). Passage of CPA allowed the Town to establish a Community Preservation Fund to support open space, historic preservation, outdoor recreation, and community housing. Monies for the fund come from a property tax surcharge (1%) and matching dollars from the state.

[39] Mitigation Resource Guide. FEMA. March 2021.

Financial Tool/Source	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
		Effective tool for hazard risk reduction as funds have been and can continue to be used for the acquisition of undeveloped land in the floodplain.
Other state funding programs		The Commonwealth makes a variety of funding programs available on a routine basis to support local risk reduction projects. Some of the most applicable opportunities for the Town include MVP Action Grants and other annual grant programs through EEA, such as the Culvert Replacement Municipal Assistance Grant Program. Others may include Community Compact grants, Green Communities grants, etc. depending on the scope and scale of specific projects. The Town has recently received grant funding for a Downtown Village conceptual study and has been successful in other state grant funds for infrastructure and technical assistance in recent years.
Private or non-profit grants, loans, or funding	No	N/A

Education and Outreach Capabilities

Table 59 is based off Worksheet 4 from FEMA's Local Mitigation Planning Handbook. It was used by the HMPC to identify and review existing education and outreach programs that can be used or expanded upon to support local mitigation activities.

Table 59. Education and Outreach Findings.

Education & Outreach Program/Method	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
Community newsletter(s)	Yes	Multiple departments maintain newsletters including the Council on Aging, Community Services, Veteran Services, etc. These can be used to disseminate information and educational news in an effort to mitigate hazards.
Web-based / social media	Yes	The Town Website is actively being improved and has been updated roughly every five years. The Town does maintain a social media presence through multiple

Education & Outreach Program/Method	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
		departments, but new and innovative methods could still be engaged with (Threads, Tik Tok, etc.).
Public Access TV, radio, etc.	Yes	A local access contract and regional agreement exists with Littleton to host BXB TV. This provides a dedicated resource to communicate with the public and broadcast meetings.
Community gatherings, festivals, celebrations, or other events	Yes	Regular gatherings are hosted, including Fifers Day and Town Hall events. These provide opportunities to meet with the public directly and in a disarming setting.
Hazard awareness campaigns *(e.g., Severe Weather Awareness Week)*	No	N/A
Organizations that represent, advocate for, or interact with underserved or vulnerable populations	Yes	The Town's Community and Social services departments communicate with these populations and can disseminate information as needed. The Town Planner further maintains HOA lists and communication with 40B developments. MAPA has regularly been used for translation needs.
Local citizen groups or non-profit organizations focused on environmental protection, emergency preparedness, etc.	Yes	The Boxborough Conservation Trust has been an active participant in land conservation for over 25 years, assisting in the preservation and acquisition of land.
Ongoing public education or information program *(e.g., responsible water use, fire safety, household preparedness)*	Yes	The Fire Department's Public Education division seeks to provide the highest quality education programs to members of the Boxborough community of all ages. Programs include Child Passenger Safety Program, CPR/First Aid/AED Programs, Fire Extinguisher Training Fire Safety Programs for Seniors, pre-school visits and education, and the SAFE Program (Student Awareness Fire Education). Also, under the Town's MS4 permitting program, a large amount of educational material is produced and shared each year. Fliers are circulated online and are published at town hall. Topics include water conservation, pollution prevention, and leaf/lawn care.

Education & Outreach Program/Method	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
Natural disaster or safety-related school programs	Yes	SAFE Program (Student Awareness Fire Education) at Blanchard School and Life Skills at R.J. Grey Junior High in Acton.
StormReady® certification	No	N/A
Firewise USA® certification	No	N/A
Public-private partnership initiatives addressing disaster-related issues	No	N/A

National Flood Insurance Program (NFIP) Participation and Compliance

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))

The National Flood Insurance Program (NFIP) is a program created by the United States Congress in 1968. The NFIP has two purposes: to share the risk of flood losses through flood insurance and to reduce flood damages by restricting floodplain development. The program enables property owners in participating communities to purchase insurance protection, administered by the government, against losses from flooding, and requires flood insurance for all federally backed loans or lines of credit that are secured by existing buildings, manufactured homes, or buildings under construction, that are in FEMA-mapped special flood hazard areas in a community that participates in the NFIP. The availability of NFIP policy coverage is limited to communities that adopt adequate land use and control measures with effective enforcement provisions to reduce flood damages by restricting development in areas exposed to flooding. There are now more than 20,000 participating communities across the United States and its territories.

The Town of Boxborough has participated in the NFIP since 1978. As summarized in Table 60, the HMPC used Worksheet 5 from FEMA's *Local Mitigation Planning Handbook* to collect information regarding the Town's participation in and compliance with the NFIP. This worksheet, in addition to a separate *NFIP Survey* for the Town Planner and Community Floodplain Administrator, helped the HMPC to identify areas for improvement and other ideas that could be potential mitigation actions.

Table 60. NFIP Participation and Compliance Findings.

NFIP Topic	Source of Information	Comments
Insurance Summary		
How many NFIP policies are in the community? What is the total premium and coverage?	FEMA NFIP Services, Flood Insurance Data and Analytics; State NFIP Coordinator	As of December 31, 2023, a total of 14 NFIP policies are in force. The total premium is $9,644 for a total of $4,365,000 in coverage. The average premium paid per policy is $689.
How many claims have been paid in the community? What is the total amount of paid claims? How many of the claims were for substantial damage?	FEMA NFIP Services, Flood Insurance Data and Analytics (HUDEX report)	There have been no claims paid since the Town joined the NFIP in 1978.
How many structures are exposed to flood risk within the community?	GIS analysis (FEMA FIRMs + building footprint data)	It is estimated that 12 structures are at risk to the 1-percent annual chance flood, and 16 are at risk to the 0.2 percent annual chance flood for a combined total of 28 structures exposed to flood risk.
Are there any repetitive or severe repetitive loss structures in the community?	MEMA / FEMA	No repetitive loss properties in the community.
Describe any areas of flood risk with limited NFIP policy coverage	HMPC	No address-specific data has been made available by FEMA, but it is generally assumed that owners of property located in special flood hazard areas are underinsured when it comes to flood insurance coverage (based on only 14 current policies under the NFIP in comparison to 28 structures estimated to be exposed to moderate to high flood risk).
Staff Resources		
Who is responsible for floodplain management in the community? Do they serve	Town Planner	The duties of floodplain management and implementation of the commitments and requirements of the NFIP are performed as an

NFIP Topic	Source of Information	Comments
any roles other than Community Floodplain Administrator (FPA)?		auxiliary function by the Town's Building Commissioner.
Is the Community FPA or NFIP Coordinator a Certified Floodplain Manager?	Town Planner	No
Is floodplain management an auxiliary function?	Town Planner	Yes, for the Building Commissioner.
Explain NFIP administration services (e.g., permit review, GIS, inspections, engineering capability).	Town Planner	All developments in the Town's Flood Plain District, including structural and non-structural activities, are reviewed for compliance with the Town's Zoning Bylaw and State Building Code. The Town complies with the NFIP by enforcing these floodplain regulations and providing information to property owners and builders regarding floodplains and building requirements. The Town offers FIRMs and other relevant information for those interested in learning more about flood risk, mitigation options, and the purchase of flood insurance.
What are the barriers to running an effective NFIP program in the community, if any?	Town Planner	The Town will need to update its bylaw to meet the new model floodplain bylaws. The Office of Land Use and Permitting will then expend budget for updated training of the Building Commissioner, Town Planner, and/or the anticipated new Associate Town Planner. The current bylaw is outdated and does not meet model bylaw standards, which provides greater instruction on enforcement; adoption of new bylaws and increased training should allow for adequate enforcement.
Compliance History		
Is the community in good standing with the NFIP?	Town Planner, State NFIP	Yes

NFIP Topic	Source of Information	Comments
	Coordinator, FEMA	
Are there any outstanding compliance issues (i.e., current violations)?	Town Planner	No
When was the most recent Community Assistance Visit (CAV) or Community Assistance Contact (CAC)?	State NFIP Coordinator, FEMA (CIS)	Last CAC was 9/28/2000 Last CAV was 8/29/2002
Is a CAV or CAC scheduled or needed?	Town Planner	No
Regulation		
When did the community enter the NFIP?	State NFIP Coordinator, FEMA (CIS)	9/15/1978 (Regular Entry) 4/11/1975 (Emergency Entry)
Are the FIRMs digital or paper?	Town Planner	Digital
Do floodplain development regulations meet or exceed FEMA or State minimum requirements? If so, in what ways?	Town Planner	Floodplain regulations are administered through the enforcement of the Town's Zoning Bylaws which follow all current FEMA/NFIP minimum requirements. These regulations will be routinely updated as necessary to maintain compliance with existing NFIP and State minimum standards for floodplain management. As described earlier in this chapter, higher regulatory standards are also met through the Town's enforcement of the Massachusetts State Building Code (CMR 780). Other floodplain development requirements are included in the Town's administration of the Commonwealth's Wetlands Protection Act Regulations (310 CMR 10).
How does the community enforce local floodplain regulations and monitor	Town Planner	All development in the Flood Plain District, including structural and nonstructural activities whether permitted by right or by special permit

NFIP Topic	Source of Information	Comments
compliance? Explain the permitting process.		must comply with the regulations noted above. In Zones A and AE no encroachments, including fill, new construction, substantial improvements, or other development shall be made unless certifications by a registered professional engineer or architect are provided by the applicant to the Inspector of Buildings proving that the proposed encroachment, construction, improvement, or development will not result in any increase in the water surface elevation of the 100- year flood.
Community Rating System (CRS)		
Does the community participate in CRS? If so, what is the community's CRS Class?	Town Planner	No
What categories and activities provide CRS points and how can the class be improved?	N/A	N/A
Does the plan include CRS planning requirements	Yes	Yes, many of the planning requirements under CRS Activity 510 are included in the plan update.

Table 61 provides some additional information in response to the updated requirements included in FEMA's 2022 Local Mitigation Planning Policy Guide (Element C2-a):[40]

Table 61. Additional NFIP Participation and Compliance Information.

Required Information	Response
Adoption of NFIP minimum floodplain management criteria via local regulation.	Adopted under the Town's Zoning Bylaw at Article 8.2 (Flood Plain District).
Adoption of the latest effective Flood Insurance Rate Map (FIRM), if applicable.	Adopted under the Town's Zoning Bylaw at Article 8.2.4 (Location of Flood Plain District) which establishes the Flood Plain District to include all special flood hazard areas as shown

[40] Local Mitigation Planning Policy Guide. FEMA. April 2022. P. 26.

Required Information	Response
	on the applicable panels of the Middlesex County Flood Insurance Rate Map (FIRM) dated July 7, 2014.
Implementation and enforcement of local floodplain management regulations to regulate and permit development in SFHAs.	See explanation of the Town's permitting process provided in Table 60.
Appointment of a designee or agency to implement the addressed commitments and requirements of the NFIP.	The Town's Building Commissioner is tasked with implementing the commitments and requirements of the NFIP, making sure Boxborough remains in compliance with all relevant codes and standards for floodplain management.
Description of how participants implement the substantial improvement/substantial damage provisions of their floodplain management regulations after an event.	The Town implements the SI/SD provisions of its floodplain management regulations as required per the NFIP (CFR Title 44, Parts 59 through 65) and Massachusetts State Building Code (780 CMR). The Town will also coordinate with State Flood Hazard Management Program staff to assure that proper practices are followed and that a post-disaster plan will be in place to implement all SI/SD provisions.

Summary and Conclusions

The Town of Boxborough is a small, suburban community with relatively strong capabilities and resources to support the implementation of hazard mitigation actions. This chapter provides documentation on the existing local authorities, policies, programs, and resources to support hazard mitigation.

The primary hazard mitigation capabilities for the Town of Boxborough are found through the local administration and enforcement of strong codes and regulations in combination with the maintenance and preservation of protective natural features such as the community's existing open space and conservation areas. From its agricultural roots, Boxborough has long cherished its open and wooded spaces and that tradition continues today in terms of the way it is actively managing growth and development. As summarized in this chapter, the Town's master plan and existing zoning bylaw support long-term planning and site-specific regulation, respectively, though the two are not always in alignment (identified as an opportunity for future enhancement/alignment). The Town's Select Board, members of local boards and committees, and Town staff all work well together to develop, implement, and update policies and plans to promote the safety of its residents and minimize risk to the community. This includes many regulations and procedures that reduce natural hazard risks, such as the Town's floodplain management regulations which continue to be reviewed and improved along with other local standards, such as those for stormwater management and wetlands protection. The Town's site plan review regulations are stringent and are triggered under many circumstances, which is very effective in terms of supporting the Town's goals and purposes as adopted through these local regulations.

The Town employs skilled and committed staff across numerous departments to administer existing local programs, regulations, and other activities, who are supported by an active citizenry and volunteers that serve on numerous local boards and committees. The Town benefits from effective collaboration and interdepartmental coordination across these various entities. For example, the Planning Board and Town Planner frequently coordinate with staff and Emergency Services in the review of development applications to consider public safety and hazard-related issues. Although the Town's administrative and technical capabilities are generally considered strong, existing staff resources do get stretched thin with department staff often working on multiple projects or other priorities that can take time and/or possible focus away from hazard mitigation and other longer-term resilience initiatives. For example, current staffing is limited to one Town Planner and is not considered adequate to cover all assigned duties, including those that fall outside routine day-to-day operations such as grant writing. Staffing for most other departments is considered adequate, and while some services are contracted out or done in cooperation with the support of the Metropolitan Area Planning Commission (MAPC), these resources are skilled and considered generally sufficient for meeting the Town's administrative and technical needs.

Fortunately, the Town's financial capabilities are strong in terms of its ability to leverage local and external funding sources to support hazard mitigation projects. Examples include the Town's ability to appropriate local funds approved through Town Meeting for investments in open space conservation, stormwater management, and other infrastructure improvements. Funding can come from a variety of local financing mechanisms including the Town's operating budget, Capital Plan, and Community Preservation Fund. The Town has been successful in leveraging these funds in the past and is committed to pursuing additional funding from external sources of grant funding that it is eligible to receive, including those identified as priority funding sources for hazard mitigation and climate adaptation. The Town is also fortunate to have many methods and tools to support public education and outreach initiatives that can support hazard mitigation, such as a regularly maintained website, multiple newsletters, social media platforms, cable access TV, and more. These resources can be used to help with increasing risk awareness and promoting emergency preparedness and hazard mitigation activities that can be accomplished on community, neighborhood, and site-specific scales.

Although the Town of Boxborough has relatively high capabilities and is well-positioned to mitigate the natural hazard risks faced by the community, it can expand and improve on the capabilities described in this chapter. Some general and specific opportunities to address existing gaps or limitations in local capabilities to reduce risk have been identified for each capability type and are further described below.

Each of these opportunities were then considered by the HMPC during the plan update process as potential new mitigation actions to be included in the Mitigation Strategy.

Opportunities to Expand and Improve on Capabilities to Reduce Risk

Planning and Regulatory Capabilities

- Integrate hazard mitigation and climate resilience into future updates of key plans (Master Plan, Open Space and Recreation Plan, Community Preservation Plan) in alignment with the Hazard Mitigation Plan.
- Adopt the State's latest (2020) Model Floodplain Bylaw in combination with the adoption of FEMA's latest Effective (2023) Flood Insurance Rate Maps.
- Continue exploring the use Transfer of Development Rights (TDRs), density bonuses, and other zoning tools for directing growth and development away from high-risk areas.
- Conduct bylaw reviews and updates for climate resilience/adaptation (incorporating Low Impact Development, green infrastructure, and other nature-based solutions). Leverage existing methods such as Mass Audubon's Bylaw Review Tool.

Administrative and Technical Capabilities

- Hire Associate Town Planner (full-time).
- Formally designate a local Floodplain Administrator.
- Build staff capacity for mitigation activities through increased training and professional development opportunities for FT and PT staff.
- Develop systems or practices that can help the Town to better cope with staff turnover and the resulting loss of institutional knowledge.
- Build and maintain in-house GIS capabilities to support hazard mitigation and other community planning/project initiatives.
- Develop system/process for maintaining hazard impact/loss data.
- Increase funding for Emergency Management through a dedicated annual budget item/appropriation.

Financial Capabilities

- Integrate long-term risk reduction/resilience as a key principle for the annual Town Budget and Capital Plan process.
- Leverage the Community Preservation Fund to support acquisition and preservation of floodplains and other high-risk areas.
- Prioritize and dedicate resources for pursuing recurring grant funding opportunities to mitigate hazards (FEMA, MVP, CDBG, etc.).

- Continue to coordinate with MAPC, neighboring communities, non-profits organizations, and others on regional risk reduction projects.

Education and Outreach Capabilities

- Leverage the Town's website, social media, department newsletters, and community events for risk communication and promotion of low-cost or do-it-yourself mitigation and preparedness activities.
- Identify and seek to address any unmet needs related to targeted outreach/education for the community's more vulnerable populations.
- Expand the Fire Department's ongoing public education programs to address natural hazards and mitigation topics.

Possible New Actions Related to NFIP Participation and Compliance

- Incentivize and cover the cost of floodplain administration training.
- Host routine informational sessions on flood/floodplain risks.
- Produce educational material for year-round flood risk awareness, especially for property owners with buildings in high-risk zones.
- Use FEMA Elevation Certificates for all floodplain development.
- Use floodplain development review form/checklist to document the review of all activities in the floodplain during the permitting process.
- Restrict certain uses or types of floodplain development (e.g., use of fill, storage of hazardous materials, critical facilities, etc.)
- Develop a Post-Disaster Substantial Damage Plan.
- Review the State's *Local Floodplain Action Guide* (forthcoming in 2024) for possible zoning or administrative improvements.

Chapter 6. Mitigation Strategy

The hazard mitigation strategy is the culmination of work presented in the planning area profile, risk assessment and capability assessment. It is also the result of multiple meetings and thorough public outreach. The work of the Hazard Mitigation Planning Committee (HMPC) was essential in developing the mitigation goals and actions included in this chapter. As described in Chapter 3 (Planning Process), the HMPC worked in a consistent, coordinated manner to identify and prioritize the goals and mitigation actions for this Plan.

Mitigation Goals

C3. Does the Plan include goals to reduce/avoid long-term vulnerabilities to the identified hazards? (Requirement §201.6(c)(3)(i))

__GOALS__ are broad, long-term policy and vision statements that explain what is to be achieved by implementing the mitigation strategy.

Mitigation goals represent broad statements that are achieved through the implementation of more specific mitigation actions. These actions include both hazard mitigation policies (such as land use regulations) and hazard mitigation projects (such as structure or infrastructure projects). To develop goals for this Town of Boxborough Hazard Mitigation Plan the HMPC reviewed the 2010 draft plan's goal statements, the 2021 Municipal Vulnerability Preparedness (MVP) plan goal statements, and the goals of the State's Hazard Mitigation and Climate Adaptation Plan (SHMCAP).

The HMPC developed the goal statements in the figure below to represent their vision and priorities for the Town of Boxborough in terms of hazard mitigation. All the hazards identified in this plan, while not named specifically in the goals, are implied and many are named specifically in the mitigation actions. When achieved by way of implementing the mitigation actions identified in this plan, the Town will mitigate risk posed by all identified hazards.

SAVE LIVES and PROPERTY

- Reduce risk to people and property from natural hazards and climate change.

Infrastructure

- Mitigate risk to critical facilities and infrastructure from natural hazards and climate change.

Capacity

- Expand the Town's capacity to mitigate risk by adopting a culture of hazard mitigation through regulations, planning, and regional collaboration.

Natural Resources

- Implement actions that minimize risk from climate change and natural hazards to preserve or restore the functions of natural systems.

Education

- Educate all stakeholders about the value of hazard mitigation and how to implement it in their work, businesses, and homes.

Figure 22. Mitigation Plan Goal Statements.

The 2010 Town of Boxborough Hazard Mitigation Plan included 10 mitigation actions. For the purposes of this plan, all the actions were reviewed for their status and relevance. The following table shows the previous plan's 10 actions and the status of each. In addition to their status, if an action was moved forward to this plan the final column indicates the title of the new action.

E2-b. Was the plan revised to reflect changes in priorities and progress in local mitigation efforts? (Requirement §201.6(d)(3))

Table 62. Status of 2010 Mitigation Actions.

Action #	Action Title	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title (if applicable)
A	Back-up Generator for Hager Well House that serves the Blanchard School, Library, Fire Station, and Police Station	Completed	Completed following funding at FY 13 Annual Town Meeting.	NO - explanation provided at left	
B	Backup Generator for the Blanchard School	Completed	Completed following funding at FY 13 Annual Town Meeting.	NO - explanation provided at left	
C	Ladder Truck for the Fire Department to Reach the Housing Units in 40B Developments	Delayed	The department has not yet been able to purchase the Ladder Truck, in large part due to funding available.	NO - explanation provided at left	
D	Better maintenance of Access Roads in Conservation, Recreation and Remote Areas to Better Access Brush Fires	Partially Completed / In Progress	The maintenance roads and parking areas are regularly checked or cleared by the DPW. This is an ongoing effort.	NO - explanation provided at left	
E	ATV Vehicle for the Fire Department to Better Access Remote Areas	Partially Completed / In Progress	The department has not yet been able to purchase the ATV. The Department and the Office of Land Use and Permitting are	NO - explanation provided at left	

Action #	Action Title	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title (if applicable)
	in the Event of a Brush Fire		considering grant sources that could pay for such a vehicle.		
F	Further Public Education on the Town Website for Natural Hazard Emergency Preparedness	Delayed	It is unknown whether previous administrations participated in such online education materials. The website was migrated several years ago, and record of the previous site is limited. No such materials are available online at this time.	YES - updated/revised description provided at right, if applicable	Further public education on the Town website for natural hazard mitigation and preparedness.
G	Assessment of Dam at Guggins Brook	Delayed	The Dam in question has been monitored for flood risk by the School and DPW. DPW has regularly cleared the dam of debris, which has become a greater hazard over time.	YES - updated/revised description provided at right, if applicable	Assessment of Dam at Guggins Brook.
H	Continuation of Ongoing Replacement of Drainage Pipes and Outdated Infrastructure	Partially Completed / In Progress	As an MS4 community, Boxborough regularly evaluates its various drainage structures. Further, the DPW submits infrastructure improvements to the capital plan annually.	YES - updated/revised description provided at right, if applicable	Replacement of Drainage Pipes and Outdated Infrastructure.
I	Continuation of Open Space Protection and Land Acquisition	Partially Completed / In Progress	The Town has regularly acquired lad for open space and recreation purposes. Annual Town meeting regularly votes in favor of land acquisitions to create or preserve open space.	YES - updated/revised description provided at right, if applicable	Open Space Protection and Land Acquisition.

Action #	Action Title	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title (if applicable)
J	Stormwater Revisions to Subdivision and Site Plan Regulations	Completed + To Be Continued	The Town has adopted several Stormwater Measures and in 2022 adopted the MS4 compliant Pre and Post Construction Stormwater Bylaw, which is triggered for any project over 1 Acre in disturbance.	YES - updated/revised description provided at right, if applicable	Stormwater Revisions to Subdivision and Site Plan Regulations.

The Municipal Vulnerability Preparedness (MVP) plan, called the Town of Boxborough Community Resilience Building Workshop Summary of Findings was developed in 2021 and includes 20 recommendations. The MVP is part of a Massachusetts state-wide initiative through the Executive Office of Energy and Environmental Affairs (EEA) to provide support to cities and towns to plan for resiliency and implement climate change adaptation actions. The recommendations identified in Boxborough's MVP were reviewed and considered when developing mitigation actions for this plan update. Below is the list of MVP Recommendations with notes regarding their status and relevance in the Hazard Mitigation Plan. Some of the notes include the name of the department that reported the comments.

Table 63. Status comments on MVP recommendations.

MVP Recommendation	Notes / Comments
Top Three Recommendations	
1. Road Flooding Study - Conduct a town-wide stormwater study to assess and further prioritize areas for re-design and retrofit to minimize flooding.	The Town participates in MS4 and is currently conducting an asset management study. This is an ongoing and regular process, funded by the Town budget.
2. Identify Alternative Drinking Water Sources - Boxborough's Water Resources Committee is currently reviewing alternative sources for wells in the western portion of Town. Based on the results of the Committee's work, explore options for supplemental funding sources to acquire identified land.	The Water Resources Committee is preparing an RFP for a comprehensive water resource study. The report will consider alternate single point sources of water and strategies to improve overall water quality
3. Conversion of Town-Owned Vehicles to Electric of Hybrid - Convert select town vehicles to electric or hybrid vehicles where appropriate. In addition, consider other locations in town to install electric charging station such as the Town Hall.	Some departments have begun this process, with police purchasing hybrid vehicles and the library installing a charge point. The Town is seeking green communities' designation and will adopt a fuel efficient vehicles policy in the process.
Higher Priority	
Review the list of conservation priorities in the OSRP and develop a list of additional priorities which reflect climate change resiliency goals. This effort could include additional flood modeling relative to potential future higher intensity storms associated with climate change or a review of vegetation that may be at risk due to increased temperatures.	The OSRP was updated in 2023 and the priority parcels list included consideration of high flood areas.
Identify "climate-resilient" tasks that would be included in the development of the new Public	The new public safety building is in the site selection process as of 2024. If annual town

Safety and Health Building (Police and Fire Departments).	meeting appropriates the funding, we will pursue building design and consider this item at that time.
Identify key parcels for future water supply climate resiliency in regards to water level and water quality. Drinking water impacts in private wells, particularly in the western portion of town may be at risk due to climate change.	The water resources committee is conducting a town wide water study, which will address this goal.
Moderate Priority	
Conduct a study to determine the feasibility of relocating the DPW yard or installing stormwater BMPs and secondary containment for material storage at the facility to decrease flood risk. The DPW yard is located adjacent to wetlands and houses DPW stockpiles, the town salt shed, and a fueling station. It is also the location for household hazardous waste collection. Flooding of this facility due to climate change could result in the discharge of hazardous materials to adjacent wetlands.	The DPW site is being surveyed now, opening the door for future improvements.
Determine the feasibility of retrofitting existing buildings to support solar arrays and develop a program to encourage solar on residential properties.	The Town has updated its solar bylaws and has removed barriers to residential solar. Solar on town buildings has not yet been investigated.
Review recently-conducted energy audits of town-owned buildings to determine locations that may be appropriate for solar installation and to update town facilities as recommended in the audits to reduce greenhouse gas emissions.	The Town is conducting audits on all buildings as part of its baseline energy audits for Green Community Designation. This will provide up to date data on areas of improvement.
Lower Priority	
Conduct a study to determine alternative options for accessing the transfer station, as road flooding may limit access to the facility.	This will be conducted between 2025 and 2026 and remains a priority for the community.
To limit wind damage to municipal utility infrastructure, review options to strengthen town regulations by increasing the size of vegetation buffers required for new developments and redevelopment.	The Town has adopted a tree preservation bylaw that make removal of street trees more difficult, though not impossible. Regulation should be considered to offset the tree zones from utilities.
Explore adding mobile devices to the current public alert system as it may not be available to	Mobile devices can be added to the reverse 911 system, voluntarily. Education can be done to encourage sign up for emergency alert system.

all populations (e.g., renters, people without landlines).	
Assess potential for library to be used as a cooling/warming station if it had a backup generator/solar battery.	The Library is being used as a cooling center in the warmer months.
Continue to provide for mosquito control as needed in response to potential increased mosquito activity due to a warming climate. Provide additional clinics at the new Public Health and Safety Building to address increased health needs associated with climate change (e.g., mosquito-borne diseases, respiratory illnesses).	The Town continues to fund mosquito control by regional services. This includes spraying to reduce spawning and population.
Assess possibility of expanding Boxborough Rental Assistance Program (BRAP) to assist vulnerable populations in climate change-related needs such as air conditioning and heating. Consult with town counsel to determine if the "No Aid" amendment would limit funds for private residents.	The Housing Board is developing a "HOPE" program that would fund capital improvements in affordable units, but the program is not ready for administration at this time. The programs should be further developed for administration by Metro West Community Development and rolled out in future fiscal years.
Review the initial culvert assessment conducted by the North Atlantic Aquatic Connectivity Collaborative and conduct engineering and design as needed to retrofit the top three priority culverts identified as barriers to aquatic connectivity (Beaver Brook Road (just north of Fifer's Field), Hill Road/Barteau Lane, and Rt.111 crossing at Beaver Brook).	The DPW will pursue this is the coming years, using the support of the municipal culvert grant program.
Develop a town-wide management plan for invasive species and develop a public education program to inform the public about invasive species.	The Town's Conservation Commission intends to pursue invasives management in the coming year, leveraging regional resources and organizations.
Work with the USDA-NRCS to assess climate resiliency needs for at-risk farmers in Boxborough. Identify funding options available.	This will be brought to the Agricultural Commission in 2024 for outreach and consideration.
Assess opportunities for tree planning, buffer zone improvements, reforestation, etc. to provide natural air quality protection.	The Town's recently adopted tree preservation bylaws will discourage large scale tree removal and has established a fund to allow town reforestation over time. Boxborough Electric Light and Water Department has a tree planting program for residences.

Assess town facilities to install electric charging stations.	The Library has installed electric charging stations, and more buildings will be considered during green communities' designation.

Comprehensive Range of Mitigation Actions

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))

***A MITIGATION ACTION** is a measure, project, plan or activity proposed to reduce current and future vulnerabilities described in the risk assessment.*

Identifying a range of mitigation actions was a process that included identifying and analyzing problem statements developed in Chapter 4 (Risk Assessment) for each hazard profiled. The HMPC considered 5 key assets when defining problem statements for the Town of Boxborough. These are:

1. People (including underserved communities and socially vulnerable populations)
2. Structures (including facilities, lifelines, and critical infrastructure)
3. Systems (including networks and capabilities)
4. Natural, historic, and cultural resources
5. Activities that have value to the community

In addition to problem statements, Chapter 4 (Risk Assessment) considered Changes in Population Patterns and Changes in Land Use and Development for each hazard profiled.

Chapter 5 (Capability Assessment) included potential actions in each of FEMA's mitigation action categories (plans and regulations, structure and infrastructure, natural resources protection, and education and awareness).

The HMPC considered the problem statements, changes in population and land use, Capability Assessment recommendations and the status of previously identified mitigation actions and MVP recommendations to develop a list of mitigation actions for this plan update. The HMPC sought to solve problems identified with the mitigation actions.

This process is illustrated in the figure below. The first column Hazards, indicates the natural hazards considered in the plan in the order of High, Medium, or Low Risk, as reviewed in the Risk Assessment (Chapter 4). The second column, Problems to Assets, indicates that the hazards caused problems in the categories of people, structures, systems, natural, historic, and cultural resources, and activities that have value to the community. The third column, Mitigation Actions, shows the four categories of mitigation action.

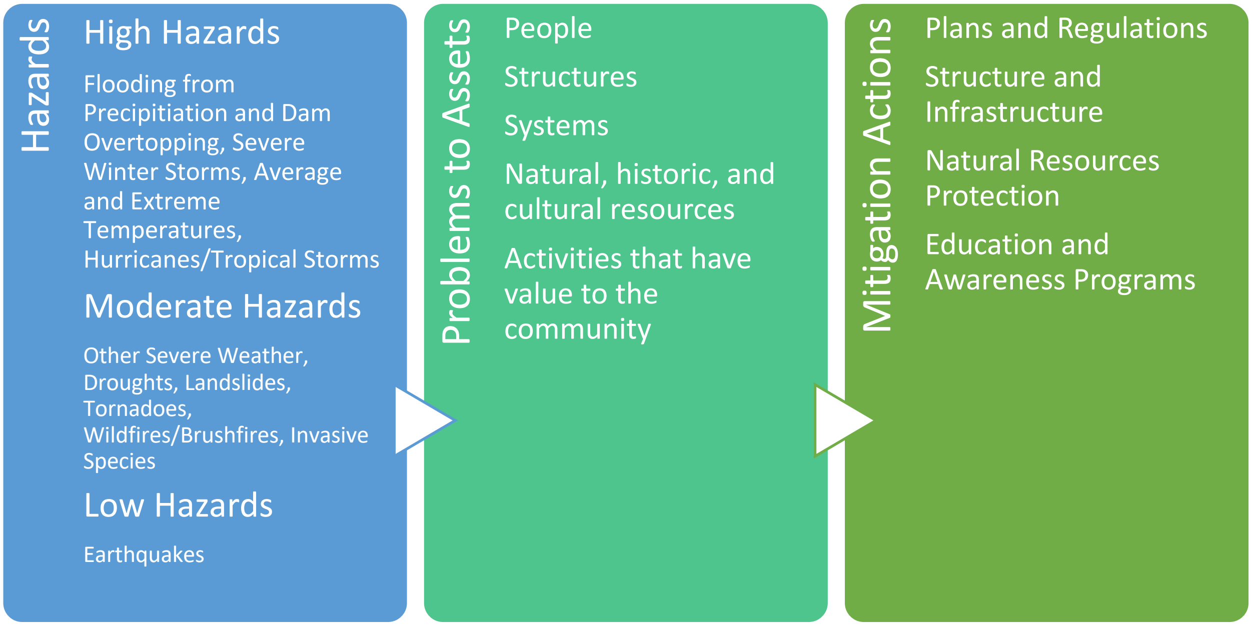


Figure 23. Process of Identifying a Range of Mitigation Actions.

In addition to this quantitative approach to identifying mitigation actions, the HMPC took a qualitative approach through the public outreach and engagement process to identify mitigation actions. Mitigation actions supporting underserved communities and environmental justice communities were specifically considered by the HMPC. They also focused on actions to the built environment both buildings and infrastructure as well as future development or redevelopment. The resulting list of mitigation actions includes at a minimum one action for hazard identified. In several instances multiple actions address an identified hazard and problem. For instance, flooding is addressed through multiple actions. The HMPC and the public considered four mitigation action categories defined in Figure 24 below when considering solutions to identified problems.

Local Plans and Regulations

- Government authorities, policies, or codes that shape how land and buildings are developed and maintained.

Structure and Infrastructure

- Projects modifying existing infrastructure to remove it from a hazard area, or building new structures in ways that reduce the impacts of hazards.

Natural Systems Protection

- Actions that reduce damage and losses, and that preserve or restore the functions of natural systems.

Education and Awareness Programs

- Sustained programs to teach the public and decision makers about hazard risks and community mitigation programs.

Figure 24. Four Types of Mitigation Actions.

Examples of actions in each of the above categories are shown in the table below.

Table 64. Examples of Mitigation Actions.

Mitigation Action Category	Examples of Mitigation Actions
Local Plans and Regulations	• Comprehensive plans • Land use ordinances • Subdivision regulations • Development review • Building codes and enforcement • NFIP Community Rating System • Capital improvement programs • Open space preservation • Stormwater management regulations and master plans
Structure and Infrastructure Projects	• Acquisitions and elevations of structures in flood-prone areas • Utility undergrounding • Structural retrofits • Floodwalls and retaining walls • Detention and retention structures • Culverts
Natural Systems Protection	• Sediment and erosion control • Stream corridor restoration

Mitigation Action Category	Examples of Mitigation Actions
	• Forest management • Conservation easements • Wetland restoration and preservation
Education and Awareness Programs	• Radio or television spots • Websites with maps and information • Real estate disclosure • Presentations to school groups or neighborhood organizations • Mailings to residents in hazard-prone areas

Potential mitigation actions for each identified hazard and problem identified in the Risk Assessment are shown Table 65 below. Hazards are listed in order of risk. Some of these mitigation actions are included in the Action Plan; some were not included because of cost-benefit-analysis outcomes or inconsistency with Town priorities.

Table 65. Possible Mitigation Actions.

Hazard	**Possible Mitigation Actions**
Flooding from Precipitation and Dam Overtopping	• Prioritize chronic flood sites for funding and capital planning. • Replace culverts and bridges as necessary based on an annual review. • Adopt new FIRM maps and the MA Model Floodplain Bylaw.
Severe Winter Storms	• School System Civics program for land use planning and hazard mitigation. • Mitigate beaver risk.
Average and Extreme Temperatures	• Open Space Protection and Land Acquisition. • Add heating and cooling centers.
Hurricanes/Tropical Storms	• Stormwater Revisions to Subdivision and Site Plan Regulations. • Mandate high wind building codes for landscape structures.
Other Severe Weather	• Replacement of Drainage Pipes and Outdated Infrastructure.

Hazard	Possible Mitigation Actions
Droughts	• Drought education.
Landslides	• Update Bylaws to prohibit grading in residential areas to mitigate landslide risk.
Tornadoes	• Further public education on the Town website for natural hazard mitigation and preparedness.
Wildfires/Brushfires	• Explore the need for municipal cisterns.
Invasive Species	• Develop an invasive species and water pollution management plan, that includes education for privately owned facilities.
Earthquakes	• Mitigate risk to low income housing buildings. • Replace the Fire Station building.

Mitigation Action Plan

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))

The HMPC then had the job to create a cost-effective mitigation action plan that included projects to address the identified hazards, areas of risk and vulnerable assets. An online Mitigation Action Tracker was developed for the Town to track the implementation of each mitigation action. The Mitigation Action Tracker was an online spreadsheet with separate cells showing each action's essential details. These column labels (essential details) listed below are included to facilitate the Town's ability to sort through the actions as well as to apply for grant funding.

Table 66. Essential Details for Mitigation Actions.

Essential Details	Detail Description
Action Title	Typically, a short description of the mitigation action.

Essential Details	Detail Description
Action Description	A detailed description of the action that includes the purpose or what natural hazard or problem may be mitigated by implementing the mitigation action.
Action Lead	A position in Town government responsible for implementing the action.
Supporting Organizations	A possible list of supporting partners, these may be Town departments, regional organizations, state agencies or adjacent communities.
Potential Funding Source(s)	A list of possible grant sources or the location in the Town's budget for the funding necessary to implement the mitigation action.
Implementation Schedule	A timeline within 5 years (the life of the plan) that the Town hopes to implement the action.
Estimated Cost	An estimated cost designated as high, medium, or low. The Town considered these cost "buckets" because it is impossible to identify an exact cost for each mitigation action.
Hazard(s) Addressed	All the natural hazards that the action may mitigate are listed.

The priority order was chosen based on weighing costs versus benefits. It was imperative for the Town to determine if the costs associated with an action were reasonable compared to the corresponding benefits. To do this, the HMPC developed a prioritization table that included seven categories of criteria; these are detailed in the able below. Each category was assigned points with priority criteria given the highest points. The most points an action could earn was 22. Actions that scored 17 points or higher were ranked as High priority. Actions that scored between 14-15 points were considered Medium, and actions that scored 10-13 points were considered low priority.

Table 67. Priority Ranking System.

	Criteria Category	Description	Detailed Ranking and Associated Points
1	Hazards Addressed	What level of hazards does the measure provide protection against?	High (Flooding from Precipitation and Dam Overtopping, Severe Winter Storms, Average and Extreme Temperatures, Hurricanes/Tropical Storms) = 3 Medium (Other Severe Weather, Droughts, Landslides, Tornadoes, Wildfires/Brushfires, Invasive Species) = 2 Low (Earthquakes) = 1

	Criteria Category	Description	Detailed Ranking and Associated Points
2	Approximate Cost	How much will the measure cost to implement?	Low (Under $10k) = 3 Medium ($10k - $100k) = 2 High over $100k) = 1
3	Implementation Timeline	How long will it take to implement the action?	1-2 Years = 3 3-4 Years = 2 5 or more Years = 1
4	Equity Focus	Does the measure provide support to Environmental Justice (EJ) and other Vulnerable Populations?	Direct Support = 3 Indirect Support = 2 No Support = 0
5	Protection of Lives	How effective is the measure in protecting lives and mitigating injuries resulting from the targeted hazard(s)?	Major Support = 3 Moderate Support = 2 Minor Support = 1 None = 0
6	Protection of Critical Facilities or Infrastructure	Does the measure provide protection of critical facilities and infrastructure?	Yes = 3 No = 0
7	Natural Resource Protection	Does the measure provide protection of natural resources?	Yes = 2 No = 0
8	Alignment with Objectives	Does the measure align with the HMP objectives?	Yes =2 No =0

All the actions are listed in Table 68 in order of priority with the action's essential details. Additional tables are included in Appendix B. The breakdown of priority ranking points for each action is included in Appendix B. Readers of this plan must understand that the mitigation action list is aspirational, it does not mean that the HMPC is confident that all actions may be implemented in the span of five years.

Table 68. Boxborough Hazard Mitigation Actions.

1	**Assessment of Dam at Guggins Brook.**	
High	**Action Description**	Continuation of previous activity and expansion. Evaluate the dam at Guggins Brook for permanent replacement or demolition, with the current dam at risk of collapse. Limited flow puts the Hagar bridge at risk, a natural resource observation path, and an emergency escape route from the school. Collapse of the dam would lead to flooding of Rt 111.
	Lead Position	Department of Public Works Director
	Supporting Agencies	Town Planner, Town's Engineering Consultant, Conservation Commission
	Cost	High
	Potential Funding Sources	MA Division of Ecological Restoration (DER): Culvert Replacement Municipal Assistance, MA Executive Office of Energy and Environmental Affairs: MVP Action Grant, MA Executive Office of Economic Development: Community One Stop for Growth
	Hazards	Flooding from Precipitation and Dam Overtopping, Severe Winter Storms, Hurricanes/Tropical Storms, Other Severe Weather
	Implementation Schedule	2024-2026

2	Prioritize chronic flood sites for funding and capital planning.	
High	**Action Description**	Build off of the 2021 Community Resilience Building Workshop, and OSRP, by evaluating and prioritizing the following chronic flood risk sites: • Littlefield Road near Central Street; • Depot Road near Wildlife Management Area and intersection with Liberty Square Road; • Davidson Road; • Burroughs Road near Wolf Swamp; • Sargent Road • Near intersection of Hill Road and Cunningham Road; • Route 111 crossing of Elizabeth Brook; • Near intersection of Hill Road and Barteau Lane; • Northern end of land near Cisco campus, near border with Harvard Sportsmen's Club; • State-owned road Route 111 historically floods due to low spots in road. MassDOT and the Town are improving sections of the road and installing a sidewalk. Once work is complete, an additional assessment of other low spots should be conducted. • Road flooding may limit access to the transfer station on Codman Hill Road as there is only one access road Following prioritization, funding sources can be determined for various improvements, and capital planning can align for Town Investment.
	Lead Position	Department of Public Works Director
	Supporting Agencies	Town Planner, Finance Committee, Capital Committee
	Cost	Medium
	Potential Funding Sources	MA Executive Office of Energy and Environmental Affairs: MVP Action Grant, Community Compact Best Practice, USDA: Tree Assistance Program (TAP) Grant
	Hazards	Flooding from Precipitation and Dam Overtopping, Severe Winter Storms, Hurricanes/Tropical Storms, Other Severe Weather, Tornadoes
	Implementation Schedule	2025-2029

3	Drought education.	
High	Action Description	Many people have dug new wells to accommodate those that have run dry. This recent rise is unaffordable to homeowners and signals a recurring risk to homeowners. With the implementation of a waterline in the west of Town, we must educate the community on best practices for personal water management and how to follow our neighboring town's summer schedule.
	Lead Position	Water Resources Committee
	Supporting Agencies	Town Planner, Littleton Electric Light and Water Departments
	Cost	Low
	Potential Funding Sources	Office of Land Use and Permitting Budget
	Hazards	Extreme Temperatures, Droughts
	Implementation Schedule	2024-2029

4	Adopt new FIRM maps and the MA Model Floodplain Bylaw.	
High	Action Description	In preparation for the next available FIRM maps, the Town will update its Floodplain Bylaw and adopt new FEMA FIRM maps to ensure compliance.
	Lead Position	Town Planner
	Supporting Agencies	Planning Board, Selectboard, Building Department
	Cost	Low
	Potential Funding Sources	Office of Land Use and Permitting Budget
	Hazards	Flooding from Precipitation and Dam Overtopping
	Implementation Schedule	2024

5	Replacement of Drainage Pipes and Outdated Infrastructure.	
Medium	Action Description	As an MS4 community, Boxborough regularly evaluates it's various drainage structures. Further, the Department of Public Works submits infrastructure improvements to the Capital Plan annually.
	Lead Position	Department of Public Works Director
	Supporting Agencies	Town Planner
	Cost	High
	Potential Funding Sources	MA Division of Ecological Restoration (DER): Culvert Replacement Municipal Assistance, MA Executive Office of Energy and Environmental Affairs: MVP Action Grant, MA Executive Office of Economic Development: Community One Stop for Growth
	Hazards	Flooding from Precipitation and Dam Overtopping, Severe Winter Storms, Hurricanes/Tropical Storms, Other Severe Weather
	Implementation Schedule	2024-2029

6	Open Space Protection and Land Acquisition.	
Medium	Action Description	Develop a policy for how the Town acquires land, make the link to how it's tied to mitigation, build public safety building, and build a community center - could be an emergency center for seniors, office space needed. Prioritize preservation of land parcels based on connectivity and flood risk. Make the connection that lack of safety facilities and equipment, forces height restriction on structures and forces developers to build out instead of up; resulting in greater impervious surface layer.
	Lead Position	Town Planner
	Supporting Agencies	Conservation Commission, Agricultural Commission, Planning Board, Community Preservation Committee, Boxborough Conservation Trust, Sudbury Valley Trustees
	Cost	High
	Potential Funding Sources	Community Preservation Act, MA Executive Office of Energy and Environmental Affairs (EEA): Local Acquisitions for Natural Diversity (LAND) Grant Program
	Hazards	Drought, Flooding, Extreme Temps, Severe Weather, Wildfires or Brush Fires
	Implementation Schedule	2024-2029

7	Stormwater Revisions to Subdivision and Site Plan Regulations.	
Medium	**Action Description**	In the next phase of MS4 compliance, the Town will consider updates to its subdivision rules and regulations, to facilitate better stormwater controls. These may include the implementation of nature based design solutions, or low impact development strategies. The same consideration will be given to the site plan review rules and regulations.
	Lead Position	Town Planner
	Supporting Agencies	Planning Board, Building Department, MA Department of Conservation and Recreation, FEMA
	Cost	Medium
	Potential Funding Sources	MA Best Practices Program: Community Compact Cabinet: Community Compact Best Practice Areas, MA Executive Office of Energy and Environmental Affairs: MVP Action Grant
	Hazards	Flooding from Precipitation and Dam Overtopping, Severe Winter Storms, Hurricanes/Tropical Storms, Other Severe Weather, Tornadoes
	Implementation Schedule	2024-2025

8	Mitigate risk to low income housing buildings.	
Medium	**Action Description**	Develop and implement a local grant program to flexibly support the capital improvement of low to moderate income units. Prioritize those applications that make emergency or near emergency repairs to roofs, foundations, etc... Priority repairs would include those that reduce flood and storm damage to a property.
	Lead Position	Housing Board Chair
	Supporting Agencies	Town Planner, Community Preservation Committee, Finance Committee
	Cost	High
	Potential Funding Sources	Boxborough Affordable Housing Trust, Community Preservation Act
	Hazards	Flooding from Precipitation and Dam Overtopping, Severe Winter Storms, Hurricanes/Tropical Storms, Other Severe Weather, Tornadoes, Earthquakes
	Implementation Schedule	2024-2026

9	**Extension of the Littleton Water Line.**	
Medium	**Action Description**	Support the construction of a Littleton Water line that extends through Swanson and Codman Hill Road. This will provide clean drinking water to the Town's lowest income residents, where there is currently a high prevalence of salt and PFAS in private water supplies.
	Lead Position	Town Administrator
	Supporting Agencies	Department of Public Works, Water Resources Committee, Town Planner, Littleton Electric Light and Water Departments
	Cost	High
	Potential Funding Sources	MA Department of Environmental Protection (DEP): State Revolving Fund (SRF) Loan Program
	Hazards	Extreme Temperatures, Droughts, Invasive Species
	Implementation Schedule	2024-2026

10	**Develop and fund an Emergency Management Budget.**	
Medium	**Action Description**	Collaborate with the Finance Committee to introduce and maintain an Emergency Management budget, intended to support training, improvements, and emergency response capacity. Improve response capacity and communications via Nashoba Valley Regional Dispatch District (NVRDD).
	Lead Position	Fire Chief/Emergency Management Director
	Supporting Agencies	Police Department, Department of Public Works
	Cost	Medium
	Potential Funding Sources	Fire Department Budget, MEMA Emergency Management Performance Grant (EMPG)
	Hazards	All Hazards
	Implementation Schedule	2024-2026

11	Replace culverts and bridges as necessary based on an annual review.	
Medium	Action Description	The following areas are known to be of concern based on the Community Resilience Building Workshop and the Opens Space and Recreation Plan. Littlefield Road near Central Street Depot Road near Wildlife Management Area and intersection with Liberty Square Road Davidson Road Burroughs Road near Wolf Swamp Sargent Road Near intersection of Hill Road and Cunningham Road Route 111 crossing of Elizabeth Brook Near intersection of Hill Road and Barteau Lane Northern end of land near Cisco campus, near border with Harvard Sportsmen's Club State-owned road Route 111 historically floods due to low spots in road. MassDOT and the Town are improving sections of the road and installing a sidewalk. Once work is complete, an additional assessment of other low spots should be conducted.
	Lead Position	Department of Public Works Director
	Supporting Agencies	Town Planner
	Cost	High
	Potential Funding Sources	FEMA BRIC, MA Executive Office of Energy and Environmental Affairs: MVP Action Grant, MA Division of Ecological Restoration (DER): Culvert Replacement Municipal Assistance
	Hazards	Flooding from Precipitation and Dam Overtopping, Severe Winter Storms, Hurricanes/Tropical Storms, Other Severe Weather
	Implementation Schedule	2024-2029

12	Educate vulnerable and environmental justice populations about disaster mitigation and preparedness.	
Medium	Action Description	To address the education of our Town-wide Environmental Justice population, minority populations, the Town will provide targeted education on: - disaster/weather preparedness - Water conservation - flood risk and land management. This will be done through education materials, public forums, and neighborhood outreach.
	Lead Position	Town Planner
	Supporting Agencies	Diversity Equity and Inclusion Committee, Fire Department, Police Department, Building Department, Health Department
	Cost	Low
	Potential Funding Sources	Office of Land Use and Permitting Budget
	Hazards	All Hazards
	Implementation Schedule	2024-2029

13	School System Civics program for land use planning and hazard mitigation.	
Medium	Action Description	Collaborate with the Elementary, Middle, and High Schools, to support the use of local civics projects in ongoing curriculum and extracurricular clubs. This will include support of the Middle School Civics Fair, by providing resources, planning documents, and databases, allowing the students to research their own self-guided project. Additionally, we will continue to present annually to the High School Environmental Science class, on land use and environmental topics.
	Lead Position	Town Planner
	Supporting Agencies	Town Clerk, and several boards and committees, Regional School System
	Cost	Low
	Potential Funding Sources	Office of Land Use and Permitting Budget
	Hazards	All Hazards
	Implementation Schedule	2024-2029

14	**Address Beaver Dam issues that create flooding on Depot Road, and cause problems on Route 111 near the school and Fire Station.**	
Low	**Action Description**	Explore trapping or alternative strategies to reduce beaver dams in high problem areas that frequently flood the Town's major travel way.
	Lead Position	Department of Public Works Director
	Supporting Agencies	Town Planner, Conservation Commission, Board of Health
	Cost	Medium
	Potential Funding Sources	Department of Public Works Budget
	Hazards	Flooding from Precipitation and Dam Overtopping, Severe Winter Storms, Hurricanes/Tropical Storms, Other Severe Weather
	Implementation Schedule	2024-2029

15	**Explore the need for municipal cisterns.**	
Low	**Action Description**	Explore the need for municipally owned cisterns, to combat a lack of public water supply and support fire services in neighborhoods not otherwise serviced.
	Lead Position	Fire Chief
	Supporting Agencies	Town Planner, Water Resources Committee
	Cost	Medium
	Potential Funding Sources	Capital Plan Budget with conversion to warrant article upon Town review
	Hazards	Extreme Temperatures, Droughts, Wildfires/Brushfires
	Implementation Schedule	2024-2026

16	Update Bylaws to prohibit grading in residential areas to mitigate landslide risk.	
Low	**Action Description**	Implement low-impact-development measures within the Boxborough Zoning Bylaw, to reduce the risk of landslide on new developments. This action is further supported by the Town's MS4 requirements.
	Lead Position	Planning Board Chair
	Supporting Agencies	Town Planner, Department of Public Works
	Cost	Medium
	Potential Funding Sources	Capital Plan Budget with conversion to warrant article upon Town review
	Hazards	Landslides, Flooding
	Implementation Schedule	2025-2026

17	Further public education on the Town website for natural hazard mitigation and preparedness.	
Low	**Action Description**	Invest in updating the Town website with education materials, a resource database, and social media links to keep the public informed on disaster preparedness. This can be coupled with the Town's recent Google migration and can improve communication with the public.
	Lead Position	Town Planner
	Supporting Agencies	Fire Department, Police Department, Department of Public Works, Building Department, Nashoba Regional Boards of Health
	Cost	Low
	Potential Funding Sources	Office of Land Use and Permitting Budget
	Hazards	All Hazards
	Implementation Schedule	2024-2029

18	**Educate neighborhoods with an increased wildfire risk due to dead trees how to mitigate their risk.**	
Low	**Action Description**	Based on high wildfire risk mapping, prepare mailings and offer neighborhood education on ways to reduce wildfire risk and safe fire practices.
	Lead Position	Fire Chief
	Supporting Agencies	Metropolitan Area Planning Council (MAPC), Town Planner
	Cost	Low
	Potential Funding Sources	USDA: Tree Assistance Program (TAP) Grant
	Hazards	Extreme Temperatures, Drought, Invasive Species, Wildfires/Brushfires
	Implementation Schedule	2024-2029

19	**Develop an invasive species and water pollution management plan, that includes education for privately owned facilities.**	
Low	**Action Description**	Working with local non-profits, land stewards, and the Town Conservation Commission, the Town will develop an invasive species and water pollution management plan. This will be implemented on Town owned land and will include education materials for privately owned facilities. Information materials will be circulated to property owners with parcels of large size to encourage good property management practices.
	Lead Position	Conservation Commission Chair
	Supporting Agencies	Boxborough Conservation Trust, Sudbury Valley Trustees, Town Planner, Land Stewards
	Cost	Medium
	Potential Funding Sources	Cooperative Invasive Species Management Area (CISMA): Sudbury-Assabet-Concord River Watershed
	Hazards	Invasive Species
	Implementation Schedule	2024-2026

Table 69 shows the mitigation actions that specifically target vulnerable populations and Table 70 shows the mitigation actions that specifically target buildings and infrastructure. Each table lists the actions in order of priority.

Table 69. Actions that Target Vulnerable Populations.

Action #	Action Title
3	Drought education.
8	Mitigate risk to low income housing buildings.
9	Extension of the Littleton Water Line.
12	Educate vulnerable and environmental justice populations about disaster mitigation and preparedness.

Table 70. Actions that Target Buildings and Infrastructure.

Action #	Action Title
1	Assessment of Dam at Guggins Brook.
2	Prioritize chronic flood sites for funding and capital planning.
5	Replacement of Drainage Pipes and Outdated Infrastructure.
8	Mitigate risk to low income housing buildings.
9	Extension of the Littleton Water Line.
11	Replace culverts and bridges as necessary based on an annual review.
15	Explore the need for municipal cisterns.

Possible Funding Sources

All the mitigation actions included in this plan have identified one or more potential funding sources. The HMWG focused on projects eligible for MVP Grant funding and FEMA BRIC funding. Below is a list of some of the federal and state funding mechanisms that may assist in implementing mitigation actions.

Federal Emergency Management Agency (FEMA) Mitigation Grants

The Federal Emergency Management Agency (FEMA) makes grant funding available for a range of mitigation activities via several Hazard Mitigation Assistance (HMA) programs. These grant programs provide funding for eligible mitigation activities that reduce disaster losses and protect life and property from future disaster damages. They are not intended to fund repair, replacement, or deferred maintenance activities but are rather designed to assist in developing long-term, cost-effective improvements that will reduce risk to natural hazards.

- **Building Resilient Infrastructure and Communities (BRIC)**
  BRIC is a new FEMA hazard mitigation program designed to replace the agency's former HMA Pre-Disaster Mitigation (PDM) grant program, aiming to categorically shift the federal focus away from reactive disaster spending and toward research-supported, proactive investment in community resilience. It is a result of recent amendments made to Section 203 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) by Section 1234 of the Disaster Recovery Reform Act of 2018 (DRRA). BRIC will support states, local communities, tribes, and territories as they undertake hazard mitigation projects reducing the risks they face

from natural hazards. The BRIC program's guiding principles are supporting communities through capability- and capacity-building; encouraging and enabling innovation; promoting partnerships; enabling large projects; maintaining flexibility; and providing consistency.

- **Hazard Mitigation Grant Program (HMGP)**
  The HMGP is authorized under Section 404 of the Stafford Act. The HMGP provides grants to states, tribes, and local governments to implement long-term hazard mitigation measures after a major disaster declaration. The purpose of the HMGP is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster. A key purpose of the HMGP is to ensure that any opportunities to take critical mitigation measures to protect life and property from future disasters are not lost during the recovery and reconstruction process following a disaster. HMGP is typically available only in the months after a federal disaster declaration, as funding amounts are determined based on a percentage of the funds spent on FEMA's Public and Individual Assistance programs.

- **Flood Mitigation Assistance (FMA) Program**
  The FMA program was created as part of the National Flood Insurance Reform Act (NFIRA) of 1994 (42 U.S.C. 4101) with the goal of reducing or eliminating claims under the NFIP. FEMA provides FMA funds to assist states and communities with implementing measures that reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insurable under the NFIP. The long-term goal of FMA is to reduce or eliminate claims under the NFIP through mitigation activities. One limitation of the FMA program is that it is generally used to provide mitigation for structures that are insured or located in Special Flood Hazard Areas (SFHAs) as mapped by FEMA. Federal funding for this nationally competitive grant program is generally an annual allocation (subject to Congressional appropriation) and eligibility is linked to a community's good standing in the NFIP.

Municipal Vulnerability Preparedness Action Grants[41]

The MVP Action Grant offers financial resources to municipalities seeking to advance priority climate adaptation actions to address climate change impacts resulting from extreme weather, sea level rise, inland and coastal flooding, severe heat, and other climate impacts.

Responses to the RFR may be submitted by municipalities who have received designation from the Executive Office of Energy and Environmental Affairs (EEA) as a Climate Change Municipal Vulnerability Preparedness (MVP) Community, or "MVP Community." All projects are required to provide monthly updates, project deliverables, a final project report, and a brief project summary communicating lessons learned. The municipality is also required to match 25% of total project cost using cash or in-kind contributions. All proposals must include the following:

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[41] State of Massachusetts. *MVP Action Grant.* https://www.mass.gov/service-details/mvp-action-grant.

- Completed application template
- Project budget and deliverables
- MVP yearly progress report describing any relevant work toward advancing community priorities since earning MVP designation
- Statement of match
- Letters of support from landowner (if applicable), partners, and the public

Project types include:

- ***Detailed Vulnerability and Risk Assessment*** – In-depth vulnerability or risk assessment of a particular sector, location, or other aspect of the municipality.
- ***Public Education and Communication*** – Projects that increase public understanding of climate change impacts within and beyond the community and foster effective partnerships to develop support.
- ***Local Bylaws, Ordinances, Plans, and other Management Measures*** – Projects to develop, amend, and implement local ordinances, bylaws, standards, plans, and other management measures to reduce risk and damages from extreme weather, heat, flooding, and other climate change impacts.
- ***Redesigns and Retrofits*** – Engineering and construction projects to redesign, plan, or retrofit vulnerable community facilities and infrastructure (e.g., wastewater treatment plants, culverts, and critical municipal roadways/evacuation routes) to function over the life of the infrastructure given projected climate change impacts.
- ***Energy Resilience Strategies*** — Projects that incorporate clean energy generation, such as micro grids, and that are paired with resilience enabling technology to maintain electrical and/or heating and cooling services at critical facilities.
- ***Chemical Safety and Climate Vulnerabilities*** — Projects that seek to engage the business and manufacturing community through assistance or training on identifying vulnerabilities to chemical releases due to severe weather events, reducing use of toxic or hazardous chemicals, outreach to improve operations and maintenance procedures to prevent chemical releases and accidents, outreach to improve emergency and contingency planning, and/or identifying existing contaminated sites that pose chemical dispersion risks during flood events.
- ***Nature-Based Storm-Damage Protection, Drought Mitigation, Water Quality, and Water Infiltration Techniques*** – Projects that utilize natural resources and pervious surfaces to manage

coastal and inland flooding, erosion, and other storm damage, such as stormwater wetlands and bio-retention systems, and other Smart Growth and Low Impact Development techniques.

- ***Nature-Based, Infrastructure and Technology Solutions to Reduce Vulnerability to Extreme Heat and Poor Air Quality*** – Projects that utilize natural resources, vegetation, and increasing pervious surface to reduce ambient temperatures, provide shade, increase evapotranspiration, improve local air quality, and otherwise provide cooling services within the municipality.

- ***Nature-Based Solutions to Reduce Vulnerability to other Climate Change Impacts*** – Nature-based projects that address other impacts of climate change such as extreme weather, damaging wind and power outages, and increased incidence of pests and vector-borne illnesses and other public health issues.

- ***Acquisition of Land to Achieve a Resiliency Objective*** — Land purchases are eligible for grant funding if the parcel has been identified through a climate vulnerability assessment as an appropriate location for a specific eligible adaptation activity to occur, such as accommodating an infrastructure or facility redesign or retrofit project, providing natural flood storage to reduce downstream flooding, or removal of pavement and planting of trees to reduce flooding and heat island effects.

- ***Ecological Restoration and Habitat Management to Increase Resiliency*** — Projects that repair or improve natural systems for community and ecosystem adaptation, such as right-sizing culverts, dam removal, restoration of coastal wetlands, etc.

- ***Subsidized Low Income Housing Resilience Strategies*** — Investments in resiliency measures for affordable housing to protect vulnerable populations that may not have the resources to recover from an extreme climate event.

- ***Mosquito Control Districts*** — Projects to reduce the risk to public health from mosquito-borne illness and to increase mosquito surveillance and control capacity by incentivizing municipalities not in an organized mosquito control project or district to form a new mosquito control district or join an existing mosquito control district. Also funding for municipalities currently in a mosquito control district for new or proactive mosquito control measures.

Chapter 7. Plan Implementation and Maintenance

The Town's Director of Land Use and Permitting is the primary point of contact for the Hazard Mitigation Plan's implementation and maintenance. This position will work collaboratively with the Hazard Mitigation Planning Committee (HMPC) and the police and fire departments to implement the mitigation strategy and specific mitigation actions outlined in this plan, and update and maintain the plan according to the guidelines below. The HMPC includes key stakeholders in the Town, who will use the plan's goals, as well as continued analysis of hazard risks and capabilities, to weigh the available resources against the costs and benefits for each mitigation action. The Town understands the value of this plan and its positive mitigation impact and intends to continue updating this plan and implementing its strategies.

Continued Public Participation

D1. Is there discussion of how the community(ies) will continue public participation in the plan maintenance process? (Requirement §201.6(c)(4)(iii))

Public participation is an integral component of the mitigation planning process and will continue to be essential as this plan is implemented and updated over time. Based on the high level of interest in the mitigation planning process and in the Municipal Vulnerability Preparedness project, Town residents and stakeholders are interested in hazard mitigation and climate adaptation. The HMPC included several education and outreach mitigation actions designed to engage the public. The Town intends to involve the public throughout the five-year implementation of this plan, as well as in the reviewing and updating processes. The Director of Land Use and Permitting will take the lead in soliciting participation from the public with support from other Town departments. This participation will take multiple forms, including all of those outlined in the Chapter 3 (Planning Process) of this plan. Efforts to involve the public include:

- Advertising on the Town's website and through standard meeting laws.
- Posting news and announcements on the Town's social media pages.
- Conducting outreach to local community organizations and businesses.
- Hosting public presentations and meetings throughout the plan's process to acquire feedback and input from stakeholders.
- Record all meetings to play on the Town's cable channel and add links to the Town's website.
- Post copies of the plan on the Town's website and keep hard copies in the Town Hall and in the Library for public review.
- Continue to work with vulnerable populations, local organizations, private industry, regional agencies, and adjacent communities as this plan is implemented.

Method and Schedule for Keeping the Plan Current

D2. 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))

The HMPC and the Town of Boxborough recognize the importance of keeping the mitigation plan up to date. The HMPC will meet twice a year for the purposes of implementing and maintaining the Hazard Mitigation Plan. This work includes monitoring, evaluating, and updating the plan over a five-year period. Overall, the responsibility for monitoring the Plan rests with the Director of Land Use and Permitting.

Process to Track Actions

MONITORING *means tracking the implementation of the plan over time.*

The Director of Land Use and Permitting and the HMPC will maintain the Mitigation Action Tracker (a tool to record the status of each mitigation action). They will send a reminder email with a link to the web-based Mitigation Action Tracker on a semi-annual basis (November/December and April/May) to all Department Heads responsible for a mitigation action and to relevant Town boards and committees. They may also distribute the Mitigation Action Progress Worksheet (shown in Appendix C) for Department Heads who prefer a form over a digital spreadsheet. The Town will also review the mitigation action list during annual check-in meetings regarding the Master Plan.

If the Town experiences a large-scale disaster, the Director of Land Use and Permitting will assemble an HMPC meeting to update the list of mitigation actions and review their order based on current priorities.

Process to Evaluate Effectiveness of the Plan

EVALUATING *means assessing the effectiveness of the plan at achieving its stated purpose and goals.*

The HMPC has agreed to meet on a bi-annual basis to review the implementation of the mitigation plan. The first meeting will take place in November/December; the second, in April/May.

At the first meeting (Nov/Dec 2024), the HMPC will review the effectiveness of the planning process, public and stakeholder engagement, risk analysis, and the mitigation strategy, including its implementation. It is recommended that the HMPC use the worksheet provided in Appendix C. Beyond considering the planning process, the HMPC will seek to answer the following questions to determine if the plan is effective at mitigating risk to Town residents, the built environment, and the natural environment.

- Can the HMPC identify success stories of losses avoided because of hazard mitigation measures implemented? Can the HMPC identify political, social, and economic successes?

- Have the mitigation actions implemented achieved benefits beyond the cost of mitigation?
- Have the implemented mitigation actions saved lives or protected property?
- Does the list of mitigation actions coincide with the Town's priorities? Do additional actions need to be added?

Process to Update the Plan

***UPDATING** means reviewing and revising the plan at least once every five years.*

At each semi-annual meeting, the HMPC will review the plan's goal statements and mitigation action status. If necessary, the goal statements and mitigation actions may be revised to reflect current Town priorities. In addition, the HMPC will discuss methods for continuing to integrate the mitigation plan with other plans, processes, and projects in the Town.

They will brief Select Board as requested and post any significant updates to the Plan to the Town's website. The HMPC recognizes the value in keeping the public and key stakeholders informed about the implementation and status of the mitigation plan.

HMPC members will continue to participate in regional and state-based meetings to stay current with best risk-mitigation practices. Such meetings may include the Massachusetts Emergency Management Agency (MEMA), Metropolitan Area Planning Council (MAPC), and Massachusetts Department of Conservation and Recreation (DCR). The HMPC will also participate in land use planning and mitigation planning meetings with their neighbors, Littleton, Stow, Acton, and Harvard.

The Town of Boxborough agrees to update and adopt this mitigation plan on a five-year basis. The update will include a comprehensive review and planning process like the one used to develop this mitigation plan update. It will update the mitigation action list, current land use practices, collect and review best available data, review the capability assessment, and engage the public and stakeholders. This process will occur according to FEMA guidelines. The HMPC will seek funding for the development of the plan update **two years** before the plan expires. The plan update process gives the Town the chance to add and/or re-prioritize mitigation actions based on current risk, capabilities, and public/stakeholder suggestions. The Director of Land Use and Permitting will serve as the Project Manager for the update process. The figure below illustrates the update timeline.

Year 1	Year 2	Year 3	Year 4	Year 5
• Seek grant funding for mitigation actions • Gather the HMPC in April/May and November/ December	• Seek grant funding for mitigation actions • Gather the HMPC in April/May and November/ December	• Seek FEMA BRIC funding for plan update • Seek grant funding for mitigation actions • Gather the HMPC in April/May and November/ December	• Begin the plan update process • Seek grant funding for mitigation actions • Gather the HMPC in April/May and November/ December	• Complete the plan update process - adopt the new plan • Seek grant funding for mitigation actions • Gather the HMPC in April/May and November/ December

Figure 25. Plan Update and Implementation Schedule.

The National Dam Safety Program Act has authorized FEMA to provide High Hazard Potential Dams (HHPD) Rehabilitation Grant Program assistance for the rehabilitation of dams that do not meet minimum safety standards and pose substantial risk to life and property.[42] Towns interested in accessing the HHPD grant must have an approved local hazard mitigation plan and meet criteria outlined in Element G: High Hazard Potential Dams. Element G is optional for local governments. While this Plan update did not address Element G requirements, the Town of Boxborough will consider adding Element G during the next Plan update. Meeting the requirements of Element G include answering the following questions:

- Did the plan describe the incorporation of existing plans, studies, reports and technical information for HHPDs?
- Did the plan address HHPDs in the risk assessment?
- Did the plan include mitigation goals to reduce long-term vulnerabilities from HHPDs?
- Did the plan include actions that address HHPDs, and prioritize mitigation actions to reduce vulnerabilities from HHPDs?

[42] Local Mitigation Planning Policy Guide, FEMA, Effective April 19, 2023, p.32.

Responsible Parties for Plan Implementation and Maintenance

Boxborough, MA

Alexander Wade, Director of Land Use and Permitting

Town of Boxborough

29 Middle Road, Boxborough, MA 01719

Phone: 978-264-1726

Email: awade@boxborough-ma.gov

For State resources:

Massachusetts Emergency Management Agency:

Address: 400 Worcester Road, Framingham, MA 01702-5399

Phone: 508-820-2000 (MEMA Headquarters and Communications Center)

or 978-328-1500 (MEMA Region 1 Office)

Website: https://www.mass.gov/orgs/massachusetts-emergency-management-agency

For Federal resources:

Federal Emergency Management Agency:

Address: 220 Binney Street, Cambridge, MA 02142

Phone: 877-336-2734

Email: fema-r1-info@fema.dhs.gov

Website: https://www.fema.gov/region-i-ct-me-ma-nh-ri-vt

System to Integrate this Plan with Existing Planning Mechanisms

D3. 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))

> ***INTEGRATE** means to include hazard mitigation principles, vulnerability information and mitigation actions into other existing community planning to leverage activities that have co-benefits, reduce risk and increase resilience.*

For the Town of Boxborough to succeed in reducing hazard risks over the long term, the information, ideas, conclusions, and strategic recommendations of this hazard mitigation plan should be integrated throughout government operations. Effective integration means to include mitigation principles, vulnerability information, and mitigation actions into other existing community planning mechanisms to leverage activities that have co-benefits, reduce risk, and increase resilience. Many other local plans and processes will present opportunities to address hazard mitigation in a way that can support multiple community objectives, so an important part of maintaining and implementing this hazard mitigation plan will be to identify and capitalize on these opportunities to leverage activities that have co-benefits (including but not limited to risk reduction). The Town's introduction of climate change content into its recently updated Open Space and Recreation Plan and establishing "climate change resiliency" as a strategic priority for its Master Plan demonstrates this type of integration by stressing the importance of hazard risk reduction strategies being included in these separate planning documents.

The HMPC will remain tasked with helping to ensure that all new or updated local plan documents are informed by and consistent with the goals and actions of this hazard mitigation plan and will not contribute to increased hazard vulnerability in Boxborough. Specifically, this includes but is not limited to the implementation or future updates to the following local plans as identified and further described in Chapter 5 (Capability Assessment):

- Municipal Vulnerability Preparedness (MVP) / Community Resilience Building (CRB) Summary of Findings Report (2021)
- Open Space and Recreation Plan (2023)
- Boxborough 2030 – Master Plan (2016)
- Community Preservation Plan (2021)
- Housing Production Plan (2015)

***PLANNING MECHANISMS** refers to the governance structures used to manage local land use development and community decision-making, such as budgets, comprehensive plans, capital improvement plans, economic development strategies, climate action plans or other long-range plans.*

Additional opportunities to integrate the requirements of this plan into other local planning mechanisms shall continue to be identified through future meetings of the HMPC and through the five-year review process described in this chapter. Other planning mechanisms include local regulations and existing code enforcement procedures (i.e., zoning bylaws, site plan review, etc.), internal municipal policies, special projects or initiatives, and other routine government or community decision-making activities such as capital improvement planning and the Town's annual budget process. Emphasis for identifying these integration opportunities will be placed on those governance structures used to manage local land use and community development in both the pre-disaster and post-disaster environment. Also, as it relates to implementing specific mitigation actions identified in this plan, it will be the responsibility of each assigned lead department to determine additional measures that can support action completion or enhancement. This includes integrating mitigation actions from this plan into other local planning documents, processes, or mechanisms as deemed appropriate and most effective.

While it is recognized that there are many possible benefits to integrating components of this plan into other local planning mechanisms, the routine maintenance of this stand-alone plan is considered by the Town to be the most effective and appropriate method to identify, prioritize, and implement local hazard mitigation actions. In moving forward, however, the Town will consider the incorporation of some other plan documents into the hazard mitigation plan, such as any future iterations of the Town's MVP Plan or related climate adaptation planning efforts.

Acronyms

AAL	Average Annual Loss
AED	Automated External Defibrillators
APA	American Planning Association
APHIS	Animal and Plant Health Inspection Service
ASCE	American Society of Civil Engineers
BBRS	Board of Building Regulations and Standards
BCEGS	Building Code Effectiveness Grading Schedule
BRIC	Building Resilient Infrastructure and Communities
BRAP	Boxborough Rental Assistance Program
BTU	British Thermal Unit
C2ES	Center for Climate and Energy Solutions
CapCom	Capital Budget Committee
CAV	Community Assistance Visit
CAC	Community Assistance Contact
CDBG	Community Development Block Grant
CDC	Centers for Disease Control and Prevention
CDD	Consecutive Dry Days
CEMP	Comprehensive Emergency Management Plan
CFR	Code of Federal Regulations
CIP	Capital Improvement Program
CIS	Community Information System
CISMA	Cooperative Invasive Species Management Area
CMR	Code of Massachusetts Regulations
ConCom	Conservation Commission
CPA	Community Preservation Act
CRB	Community Resilience Building
CRS	Community Rating System
CZM	Coastal Zone Management
DAR	Department of Agricultural Resources
DCR	Department of Conservation and Recreation
DEP	Department of Environmental Protection
DER	Division of Ecological Restoration
DMA	Disaster Mitigation Act
DMP	Drought Management Plan
DMTF	Drought Management Task Force
DOT	Department of Transportation
DPW	Department of Public Works
DRRA	Disaster Recovery Reform Act
DWR	Days Without Rain

EEA	Energy and Environmental Affairs
EF	Enhanced Fujita
EJ	Environmental Justice
EMD	Emergency Management Director
EMPG	Emergency Management Performance Grant
EOC	Emergency Operations Center
EOEEA	Executive Office of Energy and Environmental Affairs
EPA	Environmental Protection Agency
ERG	Eastern Research Group, Inc.
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flooding Insurance Study
FinCom	Financial Committee
FMA	Flooding Mitigation Assistance
FPA	Floodplain Administrator
FSim	Forest Service Fire Simulation System
FT	Full Time
FY	Fiscal Year
GHG	Greenhouse Gas
GIS	Geographic Information Systems
HHPD	High Hazard Potential Dam
HMA	Hazard Mitigation Assistance
HMGP	Hazard Mitigation Grant Program
HMPC	Hazard Mitigation Planning Committee
HOA	Homeowners Association
HVAC	Heating, Ventilation, and Air Conditioning
IBC	International Building Code
IBHS	Insurance Institute for Business and Home Safety
ICC	International Code Council
IEBC	International Existing Building Code
IECC	International Energy Conservation Code
IFC	International Fire Code
IMC	International Mechanical Code
IRC	International Residential Code
ISO	International Organization for Standardization
ISPSC	International Swimming Pool and Spa Code
LAND	Local Acquisitions for Natural Diversity
MAPC	Metropolitan Area Planning Council
MART	Montachusett Regional Transit Authority
MBTA	Massachusetts Bay Transportation Authority
MCDA	Multi-Criteria Decision Analysis

MEMA	Massachusetts Emergency Management Agency
MGL	Massachusetts General Law
MIPAG	Massachusetts Invasive Plant Advisory Group
MPH	Miles Per Hour
MSBC	Massachusetts State Building Code
MVP	Municipal Vulnerability Preparedness
NCDC	National Climatic Data Center
NCEI	National Centers for Environmental Information
NE CASC	Northeast Climate Adaptation Science Center
NESIS	Northeast Snowfall Impact Scale
NFIP	National Flooding Insurance Program
NFIRA	National Flood Insurance Reform Act
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NVRDD	Nashoba Valley Regional Dispatch District
NWS	National Weather Service
O&M	Operation and Maintenance Plan
OSCD	Open Space Commercial Development
OSRP	Open Space and Recreation Plan
PA	Public Assistance
PDM	Pre-Disaster Mitigation
PFAS	Per-and Polyfluoroalkyl Substances
PPC	Public Protection Classification
PPQ	Plant Protection and Quarantine
PT	Part Time
PWS	Public Water Systems
RMAT	ResilientMass Action Team
RRP	Rapid Recovery Plan
RSI	Regional Snowfall Index
SAFE	Student Awareness Fire Education
SFHA	Special Flood Hazard Areas
SHMCAP	State Hazard Mitigation and Adaptation Plan
SI/SD	Substantial Improvement/Substantial Damage
SOP	Standard Operating Procedures
SPGA	Special Permit Granting Authority
SRF	State Revolving Fund
SWMP	Stormwater Management Plan
TAP	Tree Assistance Program
TDR	Transfer of Development Rights
TRI	Toxic Release Inventory

US	United States
USACE	United States Army Corps of Engineers
USC	U.S. Code
USDA	United States Department of Agriculture
USDA-NRCS	United States Department of Agriculture-Natural Resources Conservation Service
USGS	United States Geological Survey
USGCRP	U.S. Global Change Research Program

Appendix A. Planning Process Supporting Materials

Hazard Mitigation Planning Committee Meetings

HMPC Meeting Participants

First Name	Last Name	Title	Affiliation	Phone	Email	HMPC #1 10/24/2023	HMPC #2 11/28/2023	HMPC #3 1/23/2024	HMPC #4 3/12/2024
Edward	Cataldo	Building Commissioner	Town of Boxborough	978-264-1725	ecataldo@boxborough-ma.gov	☑	☐	☑	☐
Kim	Dee	Council on Aging Coordinator	Town of Boxborough	978-264-1717	kdee@boxborough-ma.gov	☐	☐	☑	☐
Shawn	Gray	Interim Fire Chief/Emergency Management Director	Town of Boxborough	978-264-1776	sgray@boxborough-ma.gov	☑	☐	☑	☐
Rebecca	Harris	Town Clerk	Town of Boxborough	978-264-1727	rharris@boxborough-ma.gov	☐	☐	☐	☐
Kristin	Hillberg	Select Board Chair	Town of Boxborough	978-264-1712	selectboard@boxborough-ma.gov	☐	☐	☐	☐
Rajon	Hudson	Assistant Town Administator	Town of Boxborough	978-264-1718	rhudson@boxborough-ma.gov	☑	☑	☑	☑
Michael	Johns	Town Administrator	Town of Boxborough	978-264-1717	mjohns@boxborough-ma.gov	☑	☑	☑	☑
Kat	Kobylt	Environmental Planner	Metropolitan Area Planning Council (MAPC)	617-933-0700	kkobylt@mapc.org	☐	☐	☑	☐
Edward	Kukkala	Director of Public Works	Town of Boxborough	978-264-1792	ekukkula@boxborough-ma.gov	☑	☑	☑	☑
Dana	Labb	Principal (Blanchard Memorial School)	Town of Boxborough	978-263-4569	N/A	☐	☐	☐	☐
Cindy	Markowitz	Planning Board Member	Town of Boxborough	978-264-1723	cmarkowitz@boxborough-ma.gov	☐	☐	☑	☑
Steven	Patriarca	Assistant Emergency Management Director	Town of Boxborough	978-881-4106	spatriarca@boxborough-ma.gov	☑	☐	☑	☑
Kim	Pelser	Board of Health Administrator	Town of Boxborough	978-264-1726	kpelser@boxborough-ma.gov	☐	☐	☑	☐
Rodoshi	Sinha	Environmental Planner	Metropolitan Area Planning Council (MAPC)	617-933-0700	rsinha@mapc.org	☐	☐	☑	☐
John	Szewczyk	Chief of Police	Town of Boxborough	978-264-1760	jszewczyk@boxborough-ma.gov	☑	☑	☑	☑
Wendy	Trinks	Community Services Coordinator	Town of Boxborough	978-264-1735	wtrinks@boxborough-ma.gov	☐	☐	☑	☑
Alexander	Wade	Director of Land Use and Permitting	Town of Boxborough	978-264-1723	awade@boxborough-ma.gov	☑	☑	☑	☑

HMPC Meeting Agendas

JAMIE CAPLAN CONSULTING LLC
Emergency Management Services

KICK-OFF MEETING

TOWN OF BOXBOROUGH, MA HAZARD MITIGATION PLAN UPDATE

DATE: 9/28/2023

TIME: 11:00-12:00PM

ZOOM: https://us02web.zoom.us/j/82180346855?pwd=UFBkVlZYcHdHajFKbVpkZUlvMG5TQT09
Meeting ID: 821 8034 6855
Passcode: 869524

AGENDA ITEMS

I. Project Introduction
II. Timeline and Tasks
III. Developing a Hazard Mitigation Planning Committee (HMPC)
IV. Sharing GIS Data
V. Updating Mitigation Actions
VI. Scheduling a HMPC Meeting for October

ACTION ITEMS

I. Develop the HMPC
II. Share GIS Data & Relevant Resources
III. Update Mitigation Action Tracker with Action Status
IV. Schedule a HMPC Meeting for October

JAMIE CAPLAN CONSULTING LLC
Emergency Management Services

HMPC MEETING #1

TOWN OF BOXBOROUGH, MA HAZARD MITIGATION PLAN UPDATE

DATE: 10/24/2023

TIME: 9:00-10:30AM

ZOOM: https://us02web.zoom.us/j/84280985438?pwd=QlICSFlOZ3pjeXQzNW9FeWU0ZE5rZz09
Meeting ID: 842 8098 5438
Passcode: 055800

AGENDA ITEMS

I. Introductions
- i. HMPC Members and Consulting Team

II. Introduction to Hazard Mitigation Planning
- i. What's in a Hazard Mitigation Plan?
- ii. Planning Timeline
- iii. HMPC Responsibilities

III. Plan Development
- i. Plans and Policies
- ii. Public and Stakeholder Engagement
- iii. Hazard Identification
- iv. Critical Facilities
- v. Capability Assessment
- vi. Mitigation Strategy

ACTION ITEMS

I. HMPC Meeting #2 Week of November 27th

II. Capability Assessment Surveys

III. Mitigation Action Tracker

IV. Stakeholder Engagement

V. GIS and Critical Facilities

JAMIE CAPLAN CONSULTING LLC
Emergency Management Services

HMPC MEETING #2

TOWN OF BOXBOROUGH, MA HAZARD MITIGATION PLAN UPDATE

DATE: 11/28/2023

TIME: 9:00-10:30AM

ZOOM: https://us02web.zoom.us/j/82366851621?pwd=Sm1selEwVzNrWVB2djB6bXlmM1ZPZz09
Meeting ID: 823 6685 1621
Passcode: 111771

AGENDA ITEMS

- **I.** Project Update and Loose Ends
- **II.** Public Meeting Outreach
  - i. Outreach Efforts
  - ii. Website and Social Media
- **III.** Capability Assessment Update
  - i. Key Plans Reviewed
  - ii. Survey Status
  - iii. Where are Strengths and Challenges Discussion
- **IV.** Risk Assessment
  - i. Hazards and Critical Facilities Identified
  - ii. Hazus Impacts
  - iii. Problems Identified Including High Hazard Areas
  - iv. Mitigation Actions Discussion
- **V.** Mitigation Strategy
  - i. Goal Statements
  - ii. Developing New Mitigation Actions
- **VI.** Town Priorities and Changes in Development

ACTION ITEMS

- **I.** HMPC Meeting #3
- **II.** Tie Up Loose Ends
- **III.** Pictures
- **IV.** Outreach for Public Meeting
- **V.** New Mitigation Actions

HMPC MEETING #3 AGENDA

TOWN OF BOXBOROUGH, MA HAZARD MITIGATION PLAN UPDATE

DATE:	1/23/2024
TIME:	9:00-10:30AM
ZOOM:	https://us02web.zoom.us/j/87387942037?pwd=LzZFcXdKbUY5RGFERzNIOG1lTXk5Zz09 Meeting ID: 873 8794 2037 Passcode: 545534

AGENDA ITEMS

I. **Project Update and Loose Ends**

II. **Risk Assessment**
   i. Risk Ranking
   ii. Problem Statements

III. **Capability Assessment Update**
   i. Opportunities Identified

IV. **Public Meeting**
   i. Date and Outreach Efforts

V. **Mitigation Strategy**
   i. Essential Details for New Actions
   ii. Action Prioritization

VI. **Plan Implementation**

ACTION ITEMS

I. Public Meeting Date and Outreach

II. HMPC #4 Date

III. Pictures

IV. New Mitigation Actions

HMPC MEETING #4 AGENDA

TOWN OF BOXBOROUGH, MA HAZARD MITIGATION PLAN UPDATE

DATE: TUESDAY, 03/12/2024

TIME: 9:00-10:30AM

ZOOM: https://us02web.zoom.us/j/87430706881?pwd=cFhUUyt6ZXE5TTd1bjFiOHpiUm5xdz09
MEETING ID: 874 3070 6881
PASSCODE: 431877

AGENDA ITEMS

I. **Project Update and Loose Ends**

II. **Public Engagement**
    i. Outreach for Public Meeting and Plan Review

III. **Final Hazard List Ranking**

IV. **Mitigation Actions**
    i. List Review Including Prioritization

V. **Plan Review**
    i. Essential Details for New Actions
    ii. Action Prioritization

VI. **Timeline for Completion**

ACTION ITEMS

I. Public Meeting Outreach

II. Plan Review

Public Outreach

JAMIE CAPLAN CONSULTING LLC
Emergency Management Services

PUBLIC MEETING

TOWN OF BOXBOROUGH, MA HAZARD MITIGATION PLAN UPDATE

DATE:	12/11/2023
TIME:	7:30-8:30PM
ZOOM:	
	Meeting ID:
	Passcode:

AGENDA ITEMS

I. Introductions

II. What is Hazard Mitigation? What is a Hazard Mitigation Plan?

III. Identify Natural Hazards

IV. Identify Critical Facilities

V. Brainstorm Possible Mitigation Actions

VI. Next Steps

TOWN OF BOXBOROUGH, MA

PUBLIC MEETING

SHARE YOUR IDEAS FOR REDUCING RISK TO NATURAL HAZARDS AND CLIMATE CHANGE

Do you wonder if Boxborough can flood, experience a tornado, or have an earthquake? What can prevent those natural hazards and climate change from wreaking havoc in our community?

Join the meeting to learn about this important project and to share your ideas for making Boxborough more resilient to natural hazards and climate change.

Boxborough has formed a Hazard Mitigation Planning Committee to identify risks and projects to mitigate those risks. The Town is working with a consultant hired by the Massachusetts Emergency Management Agency to develop a Hazard Mitigation Plan that will be approved by the Federal Emergency Management Agency and adopted by the Town. This plan allows Boxborough to apply for pre- and post-disaster mitigation funds.

12/11/2023

7:30 pm – 8:30 pm Join the Selectboard Meeting or Join on Zoom

HTTPS://WWW.BOXBOROUGH-MA.GOV FOR MEETING DETAILS OR CONTACT ALEXANDER WADE, DIRECTOR OF LAND USE AND PERMITTING 978-264-1723 OR AWADE@BOXBOROUGH-MA.GOV

PRESS RELEASE
For Immediate Release
December 4, 2023

Contact: Alexander Wade
Director of Land Use and Permitting
Town of Boxborough
978-264-1723

Public Meeting Invitation

Identify Natural Hazard Risks and Recommend Mitigation Actions

Do you wonder if Boxborough can flood, experience a tornado, or have an earthquake? What is the worst that can happen in Boxborough? What can prevent those natural hazards and others from wreaking havoc?

Fortunately, the Town of Boxborough is developing an update to their Hazard Mitigation Plan. This plan details all the natural hazard risks that may impact the Town and includes a list of potential actions to mitigate those risks.

The Town of Boxborough encourages all residents and business owners to come to a public meeting to share your ideas and gather your feedback regarding which hazards present the greatest risks, which areas of Town are most susceptible to damage, and what you would like to see done to mitigate these risks?

We cannot stop winter storms, heavy rains, high winds, or earthquakes but we do not have to suffer severe consequences. The Town of Boxborough hopes you will join our first of two Public Meetings on December 11, 2023, at 7:30 pm.

Town leaders have formed a Hazard Mitigation Planning Committee (HMPC), and with a grant from the Massachusetts Emergency Management Agency (MEMA) this Committee is developing the Hazard Mitigation Plan Update. A Hazard Mitigation Plan, approved by the Federal Emergency Management Agency (FEMA), and adopted by the Town, allows the Town to apply for pre- and post-disaster hazard mitigation grant funds. Development of this plan includes **public** participation.

Public participation is essential to the development of a Hazard Mitigation Plan that represents the interests of all residents and mitigates risk to all natural hazards and the impacts of climate change.

Meeting will be held in-person at the Selectboard Meeting and via Zoom

- Monday, December 11, 2023
- 7:30 pm – 8:30 pm
- In-Person at the Selectboard Meeting or on Zoom
- Zoom Link Here
- Meeting ID:
- Passcode:

For questions regarding this plan, please contact Alexander Wade, Director of Land Use and Permitting, 978-264-1723 or awade@boxborough-ma.gov.

PUBLIC MEETING #2 AGENDA

TOWN OF BOXBOROUGH, MA HAZARD MITIGATION PLAN UPDATE

DATE: MONDAY, MARCH 11, 2024

TIME: 7:45-8:30PM

IN-PERSON: ATTEND IN PERSON AT THE SELECTBOARD MEETING

ZOOM: https://us02web.zoom.us/j/83223541072?pwd=bVRGdXp2VzhaYVRackt2a0o5dFd2UT09

Meeting ID: 832 2354 1072

Passcode: 484987

AGENDA ITEMS

I. **Project Introduction**

II. **What is Hazard Mitigation?**
  - i. Benefits of Hazard Mitigation
  - ii. How the Plan was Developed

III. **Risk Assessment Process**
  - i. Critical Facility Identification
  - ii. Hazard Identification
  - iii. Where are the hazards experienced?
  - iv. What are your biggest concerns?

IV. **Hazard Mitigation Strategy**
  - i. Types of Mitigation Actions
  - ii. What are your recommendations for hazard mitigation?
  - iii. Review of actions

V. **Plan Review**
  - i. What to expect and how to review

VI. **Timeline for Completion**

TOWN OF BOXBOROUGH, MA

PUBLIC MEETING

SHARE YOUR IDEAS FOR REDUCING RISK TO NATURAL HAZARDS AND CLIMATE CHANGE

Do you wonder if Boxborough can flood, experience a tornado, or have an earthquake? What can prevent those natural hazards and climate change from wreaking havoc in our community?

Join our **second public meeting** to learn about this important project and to **share your ideas** for making Boxborough **more resilient** to natural hazards and climate change.

Boxborough has formed a Hazard Mitigation Planning Committee to identify projects to mitigate the risks caused by natural hazards and climate change.

The Town is working with a consultant hired by the Massachusetts Emergency Management Agency to develop a Hazard Mitigation Plan that will be approved by the Federal Emergency Management Agency and adopted by the Town. This plan allows Boxborough to apply for pre- and post-disaster mitigation funds.

03/11/2024
7:00 pm – 8:00 pm
Join via Zoom!

HTTPS://WWW.BOXBOROUGH-MA.GOV FOR MEETING DETAILS OR CONTACT ALEXANDER WADE, DIRECTOR OF LAND USE AND PERMITTING 978-264-1723 OR AWADE@BOXBOROUGH-MA.GOV

FOR IMMEDIATE RELEASE

The Town of Boxborough Welcomes Community Input on Hazard Mitigation Plan Update

Boxborough, Massachusetts – March 1, 2024

Do you wonder if Boxborough can flood, experience a tornado, or have an earthquake? What can prevent those natural hazards and others from wreaking havoc?

The Town is extending an invitation to the community to participate in a public meeting as it develops an update to their Hazard Mitigation Plan. This plan details all the natural hazard risks that may impact the Town and includes potential actions to mitigate those risks.

Meeting Information:

- **Monday, March 11, 2024**
- **7:45 pm – 8:30 pm**
- **Join the Selectboard Meeting in Person or Join on Zoom**
- https://us02web.zoom.us/j/83223541072?pwd=bVRGdXp2VzhaYVRackt2a0o5dFd2UT09
- Meeting ID: 832 2354 1072
- Passcode: 484987

The Town encourages all residents and business owners to attend this public meeting to share ideas and offer feedback on which hazards present the greatest risks, which areas of Town are most susceptible to damage, and what you would like to see done to mitigate these risks.

The Hazard Mitigation Planning Committee, in partnership with Jamie Caplan Consulting LLC, a Northampton, MA-based firm, is developing the plan with a grant from the Massachusetts Emergency Management Agency (MEMA). FEMA approval, coupled with Town adoption, will enable Boxborough to access pre- and post-disaster hazard mitigation grant funds.

For Further Inquiries:

- *Alexander Wade, Director of Land Use and Permitting*
- *Phone: 978-264-1723*
- *Email: awade@boxborough-ma.gov*

Public participation is essential to a Hazard Mitigation Plan. This Plan needs to represent the interests of all community members while working to mitigate risk to natural hazards and the impacts of climate change.

The Town looks forward to a collaborative effort in building a resilient and secure future!
###

FOR IMMEDIATE RELEASE

The Town of Boxborough Invites Community Input on Hazard Mitigation Plan Update

Boxborough, Massachusetts – April 16, 2024

The Hazard Mitigation Planning Committee of Boxborough has developed a comprehensive Hazard Mitigation Plan that identifies and prioritizes strategies to mitigate the impacts of natural hazards and climate change on our community.

Engage with the Draft Plan:

- Online Access: Visit the Town's website at https://www.boxborough-ma.gov/ to review the draft plan.
- In-Person Review: Hard copies are available for review at the Town Planner's Office located at 29 Middle Road, Boxborough, MA 01719 and at the library.

Commentary Period: April 16, 2024 – April 30, 2024

How to Provide Feedback:

- Complete the Google Form provided on the Town's website and available in hard copy at the designated viewing locations.

Boxborough's Hazard Mitigation Planning Committee has developed this plan as a strategy for our Town against existing and future natural hazard threats and the evolving challenges posed by climate change. Implementation of this plan will significantly enhance our resilience to hazards such as flooding, snowstorms, high winds, and extreme temperatures.

Town officials and local stakeholders developed this plan with funding support from the Massachusetts Emergency Management Agency. Federal Emergency Management Agency (FEMA) approval, and Town adoption, of the Hazard Mitigation Plan Update allows the Town to pursue pre- and post-disaster hazard mitigation grant opportunities.

For Further Inquiries:

- **Alexander Wade, Director of Land Use and Permitting**
- **Phone:** 978-264-1723
- **Email:** awade@boxborough-ma.gov

Public engagement lies at the core of our Hazard Mitigation Plan. It is imperative that this plan reflects the diverse perspectives and priorities of our community members as we move to mitigate risks posed by natural hazards and climate change.

The Town looks forward to a collaborative effort in building a resilient and secure future!
###

THE TOWN OF BOXBOROUGH WELCOMES COMMUNITY INPUT ON HAZARD MITIGATION PLAN UPDATE

Join Us in Building a Resilient Future for Boxborough, MA!

WHAT?

Review and provide feedback on the Hazard Mitigation Plan Update drafted by Boxborough's Hazard Mitigation Planning Committee.

HOW?

- For Online Access: https://www.boxborough-ma.gov/ to read the draft plan.
- In-Person Viewing: Hard copies available at the Town Planner's Office & Library.
- Complete the Google Form on the Town's website or at designated locations to provide feedback.

WHEN?

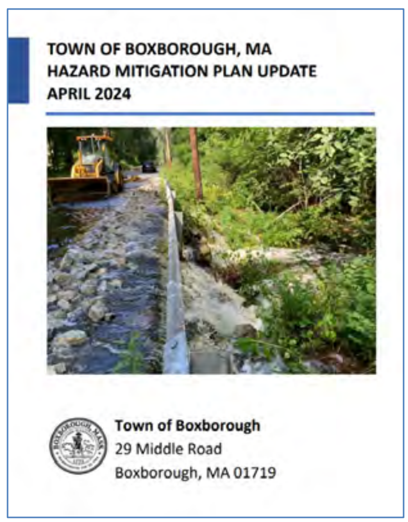
- Commentary Period: **April 16, 2024 – April 30, 2024**

WHY?

- Strengthen our community's resilience to natural hazards and climate change impacts, such as flooding, snowstorms, high winds, and extreme temperatures.

CONTACT FOR INQUIRIES

- Alexander Wade, Director of Land Use and Permitting
- Phone: 978-264-1723
- Email: awade@boxborough-ma.gov



Appendix B. Mitigation Actions.

Priority Ranking Points

Table 71. Priority Ranking Points for each action.

Action #	Action Title	Hazards Addressed	Approximate Cost	Implementation Timeline	Equity Focus	Protection of Lives	Protection of Critical Facilities or Infrastructure	Protection of Natural Resources	Alignment with Objectives	Total
1	Assessment of Dam at Guggins Brook.	3	1	2	1	3	3	2	2	**17**
2	Prioritize chronic flood sites for funding and capital planning.	3	2	1	2	2	3	2	2	**17**
3	Drought education.	3	3	1	3	2	3	0	2	**17**
4	Adopt new FIRM maps and the MA Model Floodplain Bylaw.	3	3	3	0	1	3	2	2	**17**
5	Replacement of Drainage Pipes and Outdated Infrastructure.	3	1	1	1	2	3	2	2	**15**
6	Open Space Protection and Land Acquisition.	3	1	1	1	2	3	2	2	**15**
7	Stormwater Revisions to Subdivision and Site Plan Regulations.	3	2	3	1	1	3	0	2	**15**

Action #	Action Title	Hazards Addressed	Approximate Cost	Implementation Timeline	Equity Focus	Protection of Lives	Protection of Critical Facilities or Infrastructure	Protection of Natural Resources	Alignment with Objectives	Total
8	Mitigate risk to low income housing buildings.	3	1	2	3	3	0	0	2	**14**
9	Extension of the Littleton Water Line.	3	1	2	3	3	0	0	2	**14**
10	Develop and fund an Emergency Management Budget.	3	2	2	0	2	3	0	2	**14**
11	Replace culverts and bridges as necessary based on an annual review.	3	1	1	2	2	3	0	2	**14**
12	Educate vulnerable and environmental justice populations about disaster mitigation and preparedness.	3	3	1	3	2	0	0	2	**14**
13	School System Civics program for land use planning and hazard mitigation.	3	3	1	2	1	0	2	2	**14**
14	Address Beaver Dam issues that create flooding on Depot Road, and cause problems on Route 111	3	2	1	0	2	3	0	2	**13**

Action #	Action Title	Hazards Addressed	Approximate Cost	Implementation Timeline	Equity Focus	Protection of Lives	Protection of Critical Facilities or Infrastructure	Protection of Natural Resources	Alignment with Objectives	Total
	near the school and Fire Station.									
15	Explore the need for municipal cisterns.	3	2	2	2	2	0	0	2	**13**
16	Update Bylaws to prohibit grading in residential areas to mitigate landslide risk.	2	2	3	1	1	0	2	2	**13**
17	Further public education on the Town website for natural hazard mitigation and preparedness.	3	3	1	2	1	0	0	2	**12**
18	Educate neighborhoods with an increased wildfire risk due to dead trees how to mitigate their risk.	3	3	1	0	1	0	2	2	**12**
19	Develop an invasive species and water pollution management plan, that includes education for privately owned facilities.	2	2	2	0	0	0	2	2	**10**

Types of Mitigation Actions

Table 72. Mitigation Actions Sorted by Type.

Mitigation Category	Action #	Action Title
Local Plans and Regulations	4	Adopt new FIRM maps and the MA Model Floodplain Bylaw.
	7	Stormwater Revisions to Subdivision and Site Plan Regulations.
	10	Develop and fund an Emergency Management Budget.
	16	Update Bylaws to prohibit grading in residential areas to mitigate landslide risk.
	19	Develop an invasive species and water pollution management plan, that includes education for privately owned facilities.
Structure and Infrastructure	1	Assessment of Dam at Guggins Brook.
	2	Prioritize chronic flood sites for funding and capital planning.
	5	Replacement of Drainage Pipes and Outdated Infrastructure.
	8	Mitigate risk to low income housing buildings.
	9	Extension of the Littleton Water Line.
	11	Replace culverts and bridges as necessary based on an annual review.
	15	Explore the need for municipal cisterns.
Natural Systems Protection	6	Open Space Protection and Land Acquisition.
	14	Address Beaver Dam issues that create flooding on Depot Road, and cause problems on Route 111 near the school and Fire Station.
Education and Awareness Programs	3	Drought education.
	12	Educate vulnerable and environmental justice populations about disaster mitigation and preparedness.
	13	School System Civics program for land use planning and hazard mitigation.
	17	Further public education on the Town website for natural hazard mitigation and preparedness.
	18	Educate neighborhoods with an increased wildfire risk due to dead trees how to mitigate their risk.

Actions Sorted by Goal Statement

Table 73. Mitigation Actions Sorted by Goal Statement and Priority.

Goal Category	Action #	Action Title
Save Lives and Property	1	Assessment of Dam at Guggins Brook.
	15	Explore the need for municipal cisterns.
	18	Educate neighborhoods with an increased wildfire risk due to dead trees how to mitigate their risk.
Infrastructure	2	Prioritize chronic flood sites for funding and capital planning.
	5	Replacement of Drainage Pipes and Outdated Infrastructure.
	7	Stormwater Revisions to Subdivision and Site Plan Regulations.
	8	Mitigate risk to low income housing buildings.
	9	Extension of the Littleton Water Line.
	11	Replace culverts and bridges as necessary based on an annual review.
Capacity	4	Adopt new FIRM maps and the MA Model Floodplain Bylaw.
	10	Develop and fund an Emergency Management Budget.
	16	Update Bylaws to prohibit grading in residential areas to mitigate landslide risk.
	19	Develop an invasive species and water pollution management plan, that includes education for privately owned facilities.
Natural Resources	6	Open Space Protection and Land Acquisition.
	14	Address Beaver Dam issues that create flooding on Depot Road, and cause problems on Route 111 near the school and Fire Station.
Education	3	Drought education.
	12	Educate vulnerable and environmental justice populations about disaster mitigation and preparedness.
	13	School System Civics program for land use planning and hazard mitigation.
	17	Further public education on the Town website for natural hazard mitigation and preparedness.

Actions Sorted by Hazard

Table 74. Mitigation Actions Sorted by Hazard.

Natural Hazards	Action #	Action Title
All Hazards	**10**	Develop and fund an Emergency Management Budget.
	12	Educate vulnerable and environmental justice populations about disaster mitigation and preparedness.
	13	School System Civics program for land use planning and hazard mitigation.
	17	Further public education on the Town website for natural hazard mitigation and preparedness.
Drought, Flooding, Extreme Temps, Severe Weather, Wildfires or Brush Fires	**6**	Open Space Protection and Land Acquisition.
Extreme Temperatures, Drought, Invasive Species, Wildfires/Brushfires	**18**	Educate neighborhoods with an increased wildfire risk due to dead trees how to mitigate their risk.
Extreme Temperatures, Droughts	**3**	Drought education.
Extreme Temperatures, Droughts, Invasive Species	**9**	Extension of the Littleton Water Line.
Extreme Temperatures, Droughts, Wildfires/Brushfires	**15**	Explore the need for municipal cisterns.
Flooding from Precipitation and Dam Overtopping	**4**	Adopt new FIRM maps and the MA Model Floodplain Bylaw.
Flooding from Precipitation and Dam Overtopping, Severe Winter Storms, Hurricanes/Tropical Storms, Other Severe Weather	**1**	Assessment of Dam at Guggins Brook.
	5	Replacement of Drainage Pipes and Outdated Infrastructure.
	11	Replace culverts and bridges as necessary based on an annual review.
	14	Address Beaver Dam issues that create flooding on Depot Road, and cause problems on Route 111 near the school and Fire Station.
Flooding from Precipitation and Dam Overtopping, Severe Winter Storms, Hurricanes/Tropical Storms, Other Severe Weather, Tornadoes	**2**	Prioritize chronic flood sites for funding and capital planning.
	7	Stormwater Revisions to Subdivision and Site Plan Regulations.

Flooding from Precipitation and Dam Overtopping, Severe Winter Storms, Hurricanes/Tropical Storms, Other Severe Weather, Tornadoes, Earthquakes	**8**	Mitigate risk to low income housing buildings.
Invasive Species	**19**	Develop an invasive species and water pollution management plan, that includes education for privately owned facilities.
Landslides, Flooding	**16**	Update Bylaws to prohibit grading in residential areas to mitigate landslide risk.

Actions Sorted by Lead Position

Table 75. Mitigation Actions Sorted by Action Lead.

Action Lead	Action #	Action Title
Conservation Commission Chair	19	Develop an invasive species and water pollution management plan, that includes education for privately owned facilities.
Fire Chief	15	Explore the need for municipal cisterns.
	18	Educate neighborhoods with an increased wildfire risk due to dead trees how to mitigate their risk.
Department of Public Works Director	1	Assessment of Dam at Guggins Brook.
	2	Prioritize chronic flood sites for funding and capital planning.
	5	Replacement of Drainage Pipes and Outdated Infrastructure.
	11	Replace culverts and bridges as necessary based on an annual review.
	14	Address Beaver Dam issues that create flooding on Depot Road, and cause problems on Route 111 near the school and Fire Station.
Water Resources Committee	3	Drought education.
Town Planner	4	Adopt new FIRM maps and the MA Model Floodplain Bylaw.
	6	Open Space Protection and Land Acquisition.
	7	Stormwater Revisions to Subdivision and Site Plan Regulations.
	12	Educate vulnerable and environmental justice populations about disaster mitigation and preparedness.
	13	School System Civics program for land use planning and hazard mitigation.
	17	Further public education on the Town website for natural hazard mitigation and preparedness.
Housing Board Chair	8	Mitigate risk to low income housing buildings.
Town Administrator	9	Extension of the Littleton Water Line.
Fire Chief/Emergency Management Director	10	Develop and fund an Emergency Management Budget.
Planning Board Chair	16	Update Bylaws to prohibit grading in residential areas to mitigate landslide risk.

Actions Sorted by Implementation Schedule

Table 76. Mitigation Actions Sorted by Implementation Schedule.

Implementation Schedule	Action #	Action Title
2024	4	Adopt new FIRM maps and the MA Model Floodplain Bylaw.
2024-2025	7	Stormwater Revisions to Subdivision and Site Plan Regulations.
2024-2026	1	Assessment of Dam at Guggins Brook.
	8	Mitigate risk to low income housing buildings.
	9	Extension of the Littleton Water Line.
	10	Develop and fund an Emergency Management Budget.
	15	Explore the need for municipal cisterns.
	19	Develop an invasive species and water pollution management plan, that includes education for privately owned facilities.
2024-2029	3	Drought education.
	5	Replacement of Drainage Pipes and Outdated Infrastructure.
	6	Open Space Protection and Land Acquisition.
	11	Replace culverts and bridges as necessary based on an annual review.
	12	Educate vulnerable and environmental justice populations about disaster mitigation and preparedness.
	13	School System Civics program for land use planning and hazard mitigation.
	14	Address Beaver Dam issues that create flooding on Depot Road, and cause problems on Route 111 near the school and Fire Station.
	17	Further public education on the Town website for natural hazard mitigation and preparedness.
	18	Educate neighborhoods with an increased wildfire risk due to dead trees how to mitigate their risk.
2025-2026	16	Update Bylaws to prohibit grading in residential areas to mitigate landslide risk.
2025-2029	2	Prioritize chronic flood sites for funding and capital planning.

Appendix C. Plan Implementation and Review Supporting Materials.

Plan Update Evaluation Worksheet

Table 77. Plan Update Evaluation Worksheet.

Plan Section	Considerations	Explanation
Planning Process	Should the town invite any additional stakeholders to participate in the planning process? What public outreach activities have occurred? How can public involvement be improved?	
Risk Assessment	What disasters has the town, or the region experienced? Should the list of hazards be modified? Are new data sources, maps or studies available? If so, what have they revealed, and should the information be incorporated into the plan update? Has development in the region occurred and could it create or reduce risk?	
Capability Assessment	Has the town adopted new policies, plans, regulations, or reports that could be incorporated into this plan? Are there different or additional administrative, human, technical, and financial resources available for mitigation planning? Are there different or new education and outreach programs and resources available for mitigation activities?	
Mitigation Strategy	Is the mitigation strategy being implemented as anticipated? Were the cost and timeline estimate accurate? Should new mitigation actions be added to the Action Plan? Should existing mitigation actions be revised or removed from the plan? Are there new obstacles that were not anticipated in the plan that will need to be considered in the next plan update? Are there new funding sources to consider? Have elements of the plan been incorporated into other planning mechanisms?	
Implementation Plan	Was the plan monitored and evaluated as anticipated? What are needed improvements to the plan implementation procedures?	

Mitigation Action Progress Worksheet

Table 78. Mitigation Action Progress Worksheet.

Mitigation Action Progress Worksheet				
Progress Report Period	From Date		To Date	
Action/Project Title				
Responsible Department				
Contact Name				
Contact Phone/Email				
Project Description				
Project Goal				
Project Objective				
Project Cost				
Project Status				
Date of Project Approval	Date of Project Start	Anticipated Date of Completion	Project Canceled	Project Delayed
Explanation of Delay or Cost Overruns				
Project Report Summary				
What was accomplished for this project during this reporting period?				
What obstacles, problems, or delays did the project encounter?				
Plans for next reporting period.				

Appendix D. Hazus Reports

Hazus: Flood Global Risk Report

Region Name: Boxborough_Flood

Flood Scenario: 100year

Print Date: Monday, November 27, 2023

Disclaimer:
Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific Flood. These results can be improved by using enhanced inventory data and flood hazard information.

Table of Contents

General Description of the Region

Hazus is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). The primary purpose of Hazus is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The flood loss estimates provided in this report were based on a region that included 1 county(ies) from the following state(s):

- Massachusetts

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is approximately 2 square miles and contains 61 census blocks. The region contains over 2 thousand households and has a total population of 5,506 people. The distribution of population by State and County for the study region is provided in Appendix B.

There are an estimated 1,808 buildings in the region with a total building replacement value (excluding contents) of 1,330 million dollars. Approximately 84.51% of the buildings (and 69.28% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

Hazus estimates that there are 1,808 buildings in the region which have an aggregate total replacement value of 1,330 million dollars. Table 1 and Table 2 present the relative distribution of the value with respect to the general occupancies by Study Region and Scenario respectively. Appendix B provides a general distribution of the building value by State and County.

Table 1
Building Exposure by Occupancy Type for the Study Region

Occupancy	Exposure ($1000)	Percent of Total
Residential	921,524	69.3%
Commercial	192,619	14.5%
Industrial	153,060	11.5%
Agricultural	5,026	0.4%
Religion	3,185	0.2%
Government	24,450	1.8%
Education	30,288	2.3%
Total	**1,330,152**	**100%**

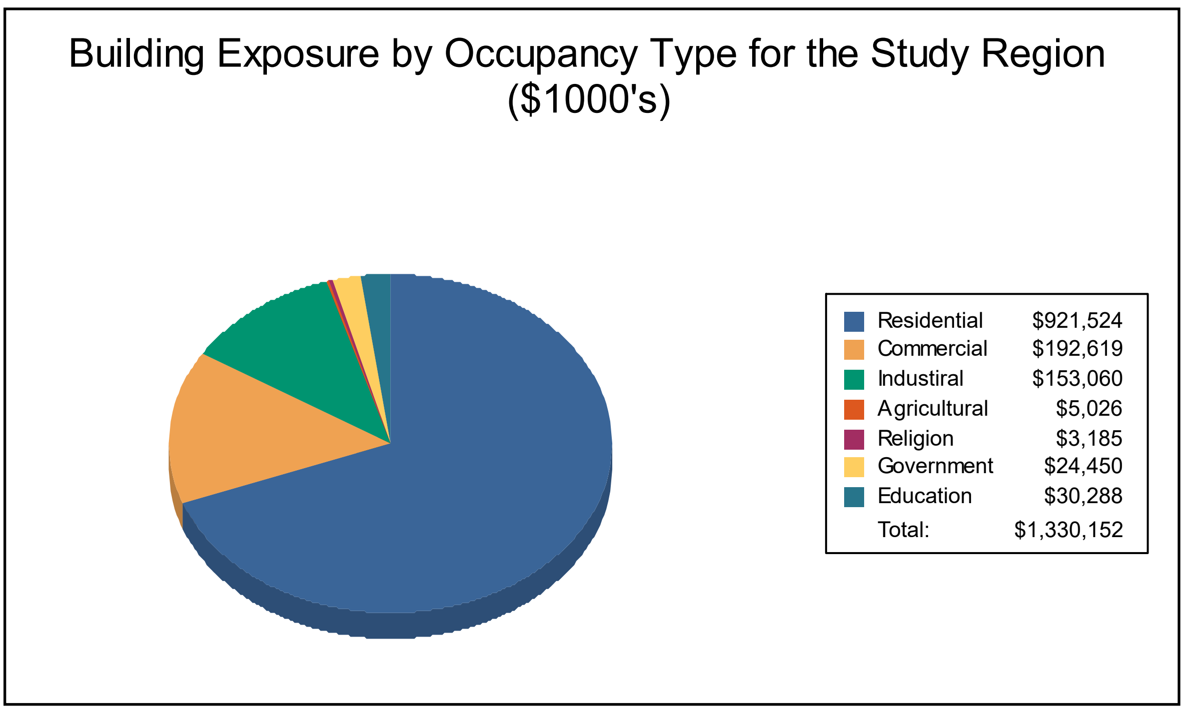
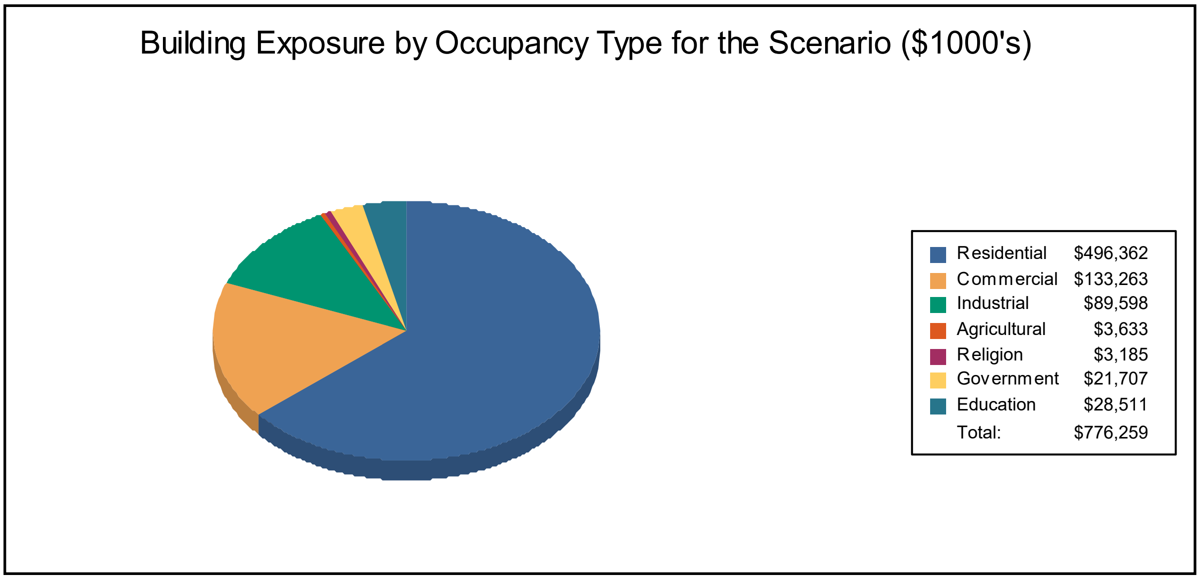


Table 2
Building Exposure by Occupancy Type for the Scenario

Occupancy	Exposure ($1000)	Percent of Total
Residential	496,362	63.9%
Commercial	133,263	17.2%
Industrial	89,598	11.5%
Agricultural	3,633	0.5%
Religion	3,185	0.4%
Government	21,707	2.8%
Education	28,511	3.7%
Total	**776,259**	**100%**



Essential Facility Inventory

For essential facilities, there are no hospitals in the region with a total bed capacity of no beds. There are 1 school, 1 fire station, 1 police station and 2 emergency operation centers.

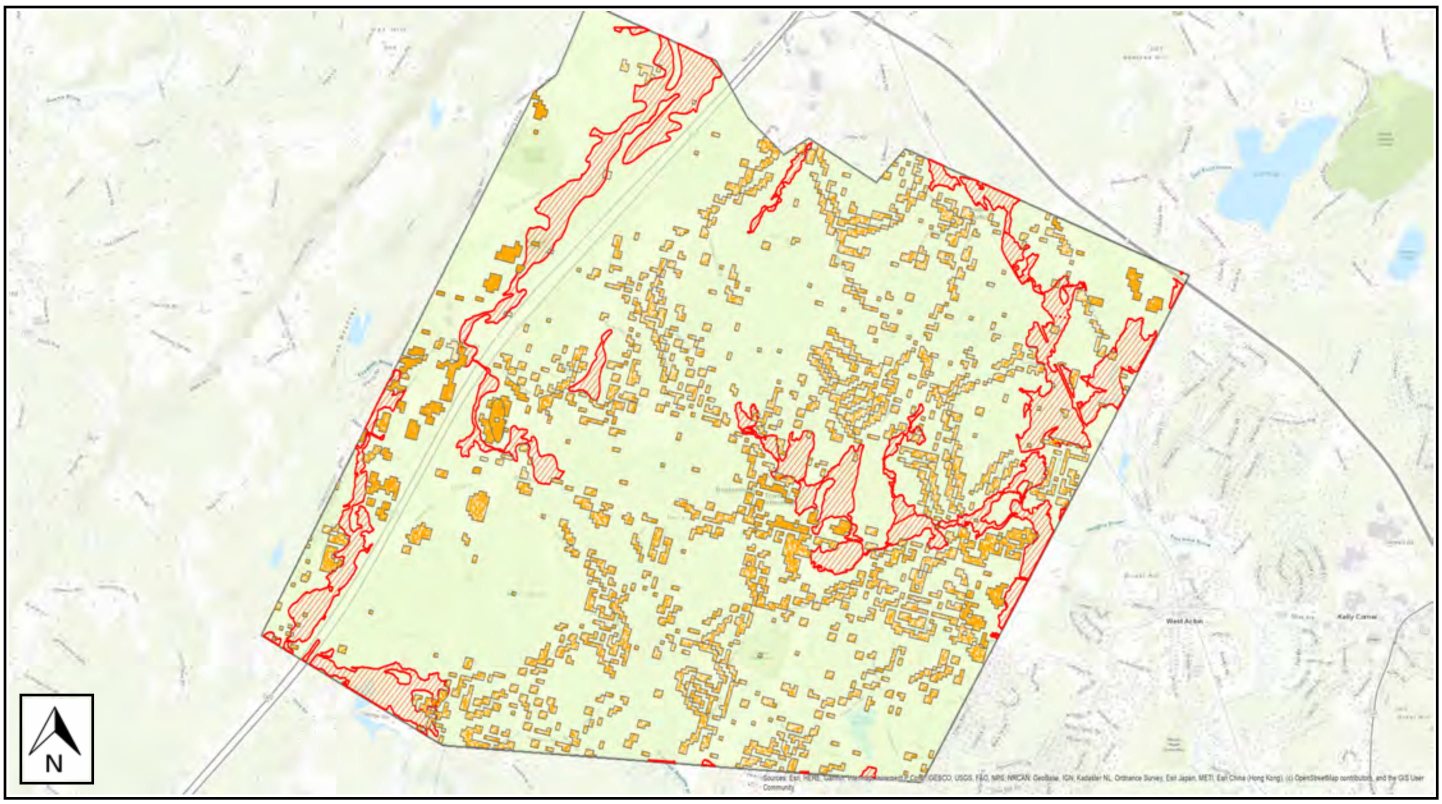
Flood Scenario Parameters

Hazus used the following set of information to define the flood parameters for the flood loss estimate provided in this report.

Study Region Name:	Boxborough_Flood
Scenario Name:	100year
Return Period Analyzed:	100
Analysis Options Analyzed:	No What-Ifs

Study Region Overview Map

Illustrating scenario flood extent, as well as exposed essential facilities and total exposure



Building Damage

General Building Stock Damage

Hazus estimates that about 0 buildings will be at least moderately damaged. This is over 100% of the total number of buildings in the scenario. There are an estimated 0 buildings that will be completely destroyed. The definition of the 'damage states' is provided in the Hazus Flood Technical Manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 summarizes the expected damage by general building type.

Total Economic Loss (1 dot = $300K) Overview Map

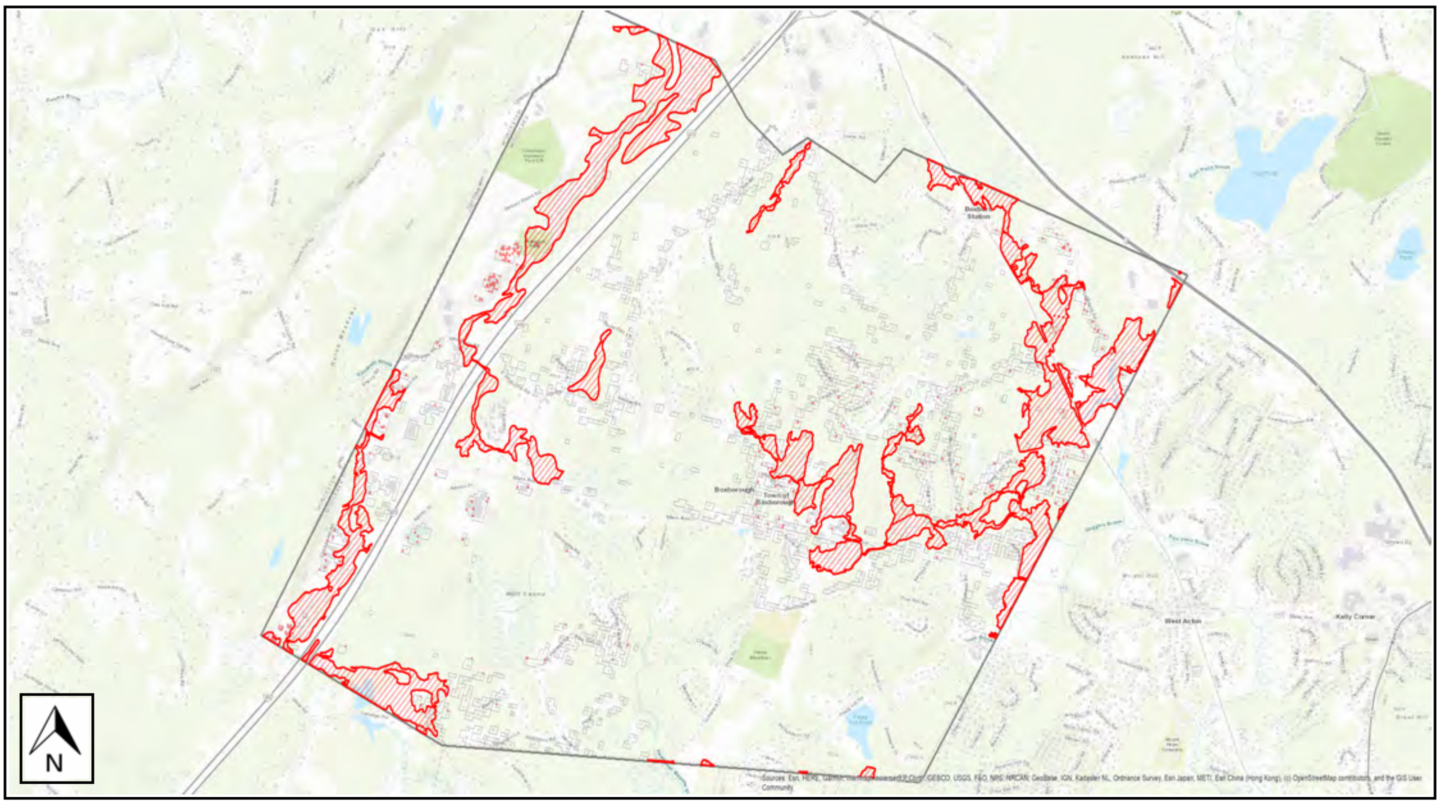


Table 3: Expected Building Damage by Occupancy

Occupancy	1-10 Count	1-10 (%)	11-20 Count	11-20 (%)	21-30 Count	21-30 (%)	31-40 Count	31-40 (%)	41-50 Count	41-50 (%)	>50 Count	>50 (%)
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0
Commercial	0	0	0	0	0	0	0	0	0	0	0	0
Education	0	0	0	0	0	0	0	0	0	0	0	0
Government	1	100	0	0	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0	0	0	0	0
Religion	0	0	0	0	0	0	0	0	0	0	0	0
Residential	2	100	0	0	0	0	0	0	0	0	0	0
Total	**3**		**0**		**0**		**0**		**0**		**0**	

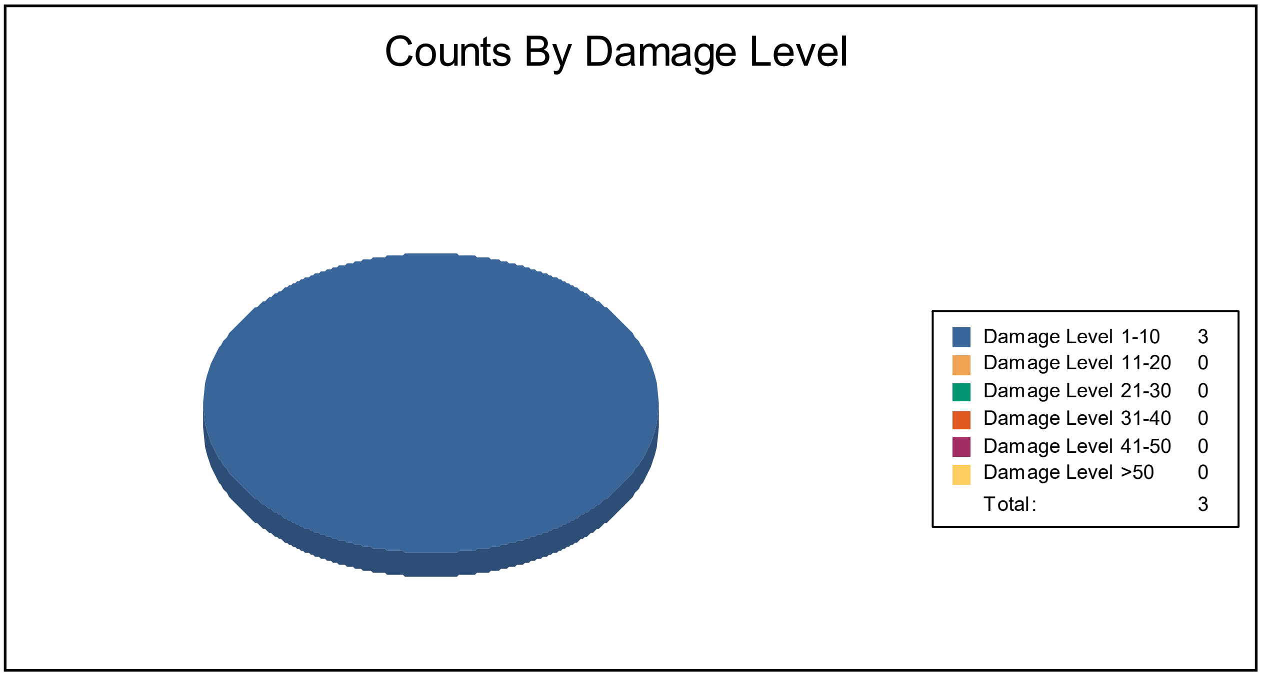


Table 4: Expected Building Damage by Building Type

Building Type	1-10		11-20		21-30		31-40		41-50		>50	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	0	0	0	0	0	0	0	0	0	0	0	0
ManufHousing	0	0	0	0	0	0	0	0	0	0	0	0
Masonry	0	0	0	0	0	0	0	0	0	0	0	0
Steel	1	100	0	0	0	0	0	0	0	0	0	0
Wood	2	100	0	0	0	0	0	0	0	0	0	0

Essential Facility Damage

Before the flood analyzed in this scenario, the region had 0 hospital beds available for use. On the day of the scenario flood event, the model estimates that 0 hospital beds are available in the region.

Table 5: Expected Damage to Essential Facilities

		# Facilities		
Classification	Total	At Least Moderate	At Least Substantial	Loss of Use
Emergency Operation Centers	2	0	0	0
Fire Stations	1	0	0	0
Hospitals	0	0	0	0
Police Stations	1	0	0	0
Schools	1	0	0	0

If this report displays all zeros or is blank, two possibilities can explain this.

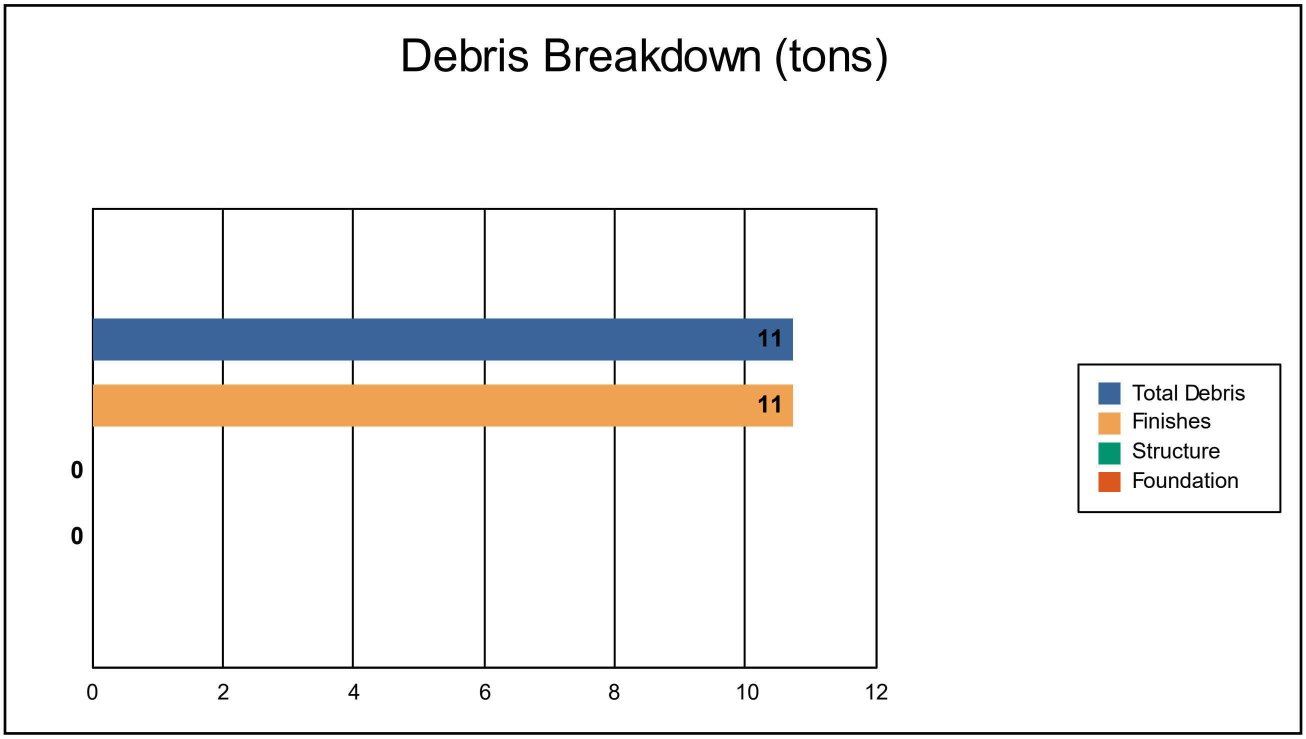
(1) None of your facilities were flooded. This can be checked by mapping the inventory data on the depth grid.

(2) The analysis was not run. This can be tested by checking the run box on the Analysis Menu and seeing if a message box asks you to replace the existing results.

Induced Flood Damage

Debris Generation

Hazus estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories: 1) Finishes (dry wall, insulation, etc.), 2) Structural (wood, brick, etc.) and 3) Foundations (concrete slab, concrete block, rebar, etc.). This distinction is made because of the different types of material handling equipment required to handle the debris.

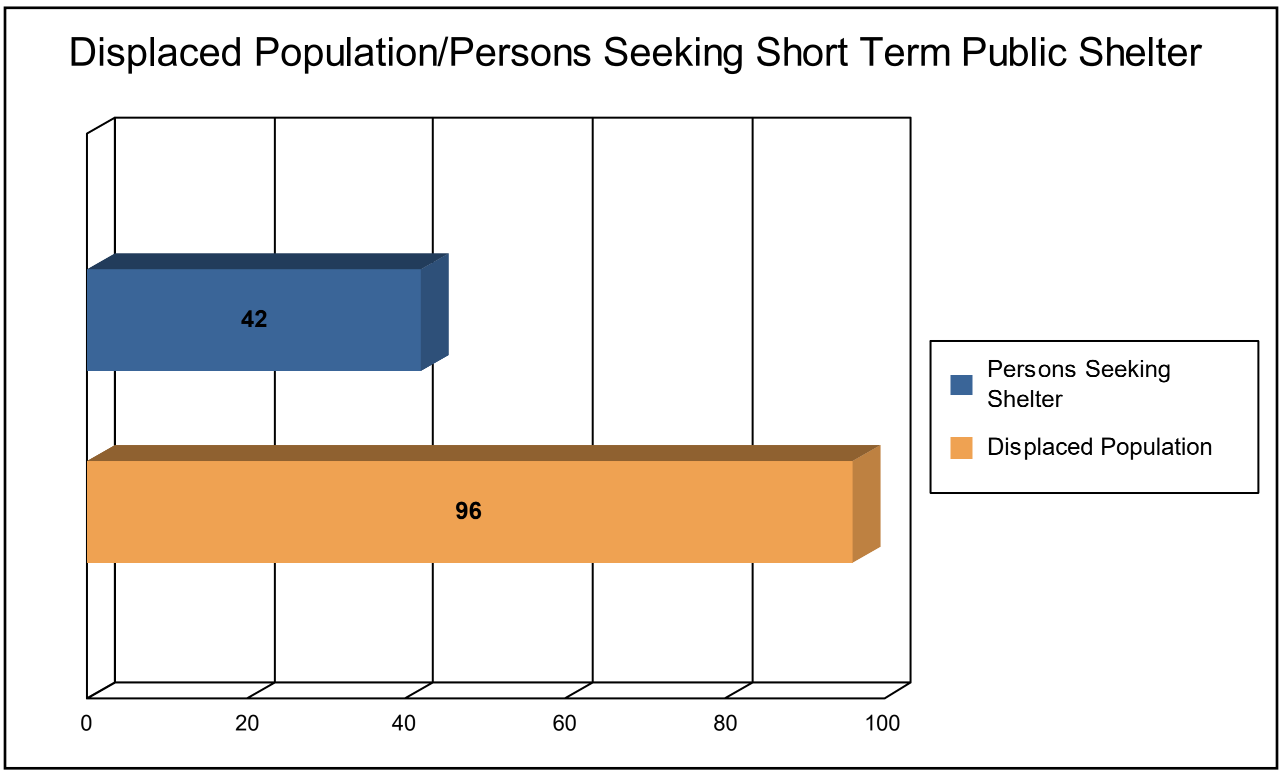


The model estimates that a total of 11 tons of debris will be generated. Of the total amount, Finishes comprises 100% of the total, Structure comprises 0% of the total, and Foundation comprises 0%. If the debris tonnage is converted into an estimated number of truckloads, it will require 1 truckloads (@25 tons/truck) to remove the debris generated by the flood.

Social Impact

Shelter Requirements

Hazus estimates the number of households that are expected to be displaced from their homes due to the flood and the associated potential evacuation. Hazus also estimates those displaced people that will require accommodations in temporary public shelters. The model estimates 32 households (or 96 of people) will be displaced due to the flood. Displacement includes households evacuated from within or very near to the inundated area. Of these, 42 people (out of a total population of 5,506) will seek temporary shelter in public shelters.



Economic Loss

The total economic loss estimated for the flood is 6.19 million dollars, which represents 0.80 % of the total replacement value of the scenario buildings.

Building-Related Losses

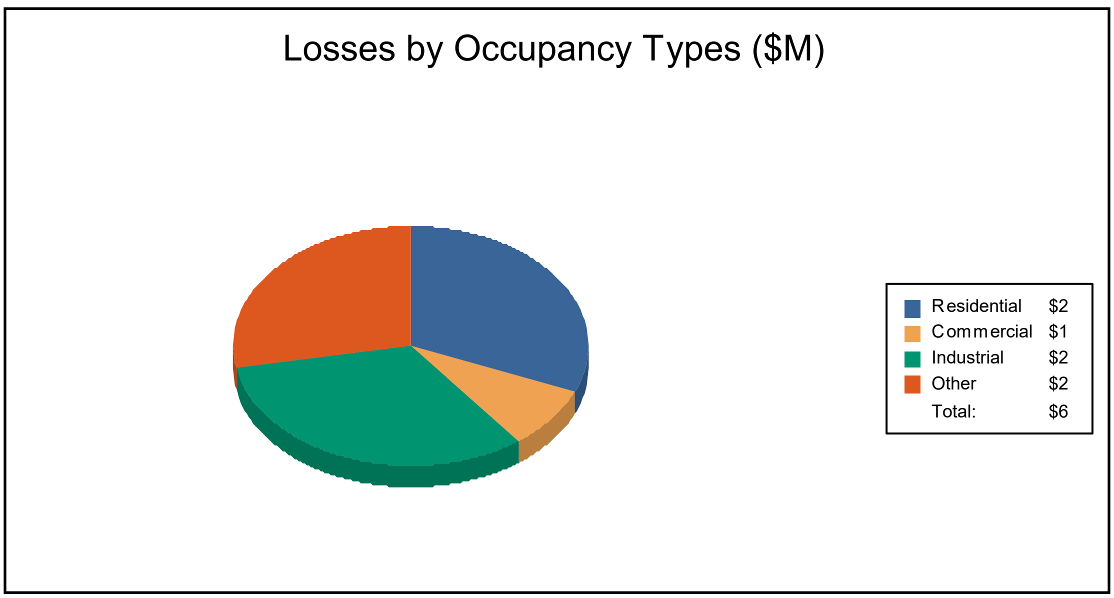
The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the flood. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the flood.

The total building-related losses were 3.49 million dollars. 44% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 31.51% of the total loss. Table 6 below provides a summary of the losses associated with the building damage.

Table 6: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Building Loss						
	Building	0.86	0.03	0.47	0.03	1.39
	Content	0.37	0.10	1.23	0.24	1.94
	Inventory	0.00	0.01	0.16	0.00	0.17
	Subtotal	**1.23**	**0.15**	**1.85**	**0.27**	**3.49**
Business Interruption						
	Income	0.07	0.21	0.03	0.08	0.38
	Relocation	0.29	0.02	0.05	0.03	0.39
	Rental Income	0.20	0.01	0.01	0.01	0.23
	Wage	0.16	0.14	0.05	1.35	1.71
	Subtotal	**0.72**	**0.37**	**0.14**	**1.47**	**2.70**
ALL	**Total**	**1.95**	**0.52**	**1.99**	**1.74**	**6.19**



Appendix A: County Listing for the Region

Massachusetts

- Middlesex

Appendix B: Regional Population and Building Value Data

		Building Value (thousands of dollars)		
	Population	Residential	Non-Residential	Total
Massachusetts				
Middlesex	5,506	921,524	408,628	1,330,152
Total	**5,506**	**921,524**	**408,628**	**1,330,152**
Total Study Region	**5,506**	**921,524**	**408,628**	**1,330,152**

Hazus: Hurricane Global Risk Report

Region Name: Boxborough_Wind

Hurricane Scenario: Probabilistic 500-year Return Period

Print Date: Monday, November 27, 2023

Disclaimer:
Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific Hurricane. These results can be improved by using enhanced inventory data.

Table of Contents

General Description of the Region

Hazus is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of Hazus is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The hurricane loss estimates provided in this report are based on a region that includes 1 county(ies) from the following state(s):

- Massachusetts

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 10.41 square miles and contains 1 census tracts. There are over 2 thousand households in the region and a total population of 5,506 people. The distribution of population by State and County is provided in Appendix B.

There are an estimated 1 thousand buildings in the region with a total building replacement value (excluding contents) of 1,330 million dollars. Approximately 85% of the buildings (and 69% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

Hazus estimates that there are 1,808 buildings in the region which have an aggregate total replacement value of Table 1 presents the relative distribution of the value with respect to the general occupancies. Appendix B provi distribution of the building value by State and County.

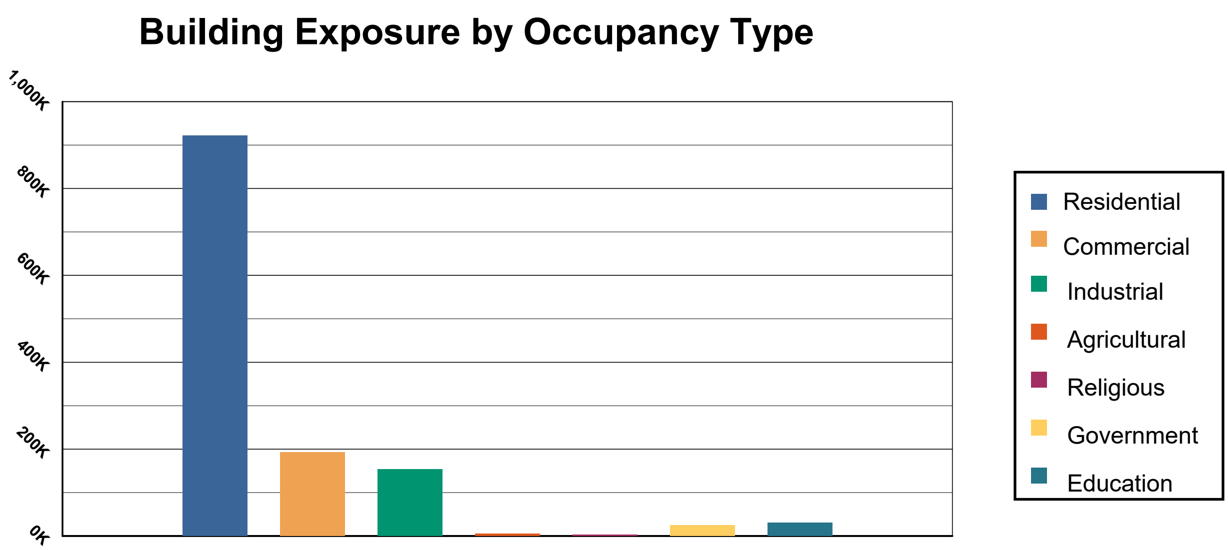


Table 1: Building Exposure by Occupancy Type

Occupancy	Exposure ($1000)	Percent of Tot
Residential	921,524	69.28%
Commercial	192,619	14.48%
Industrial	153,060	11.51%
Agricultural	5,026	0.38%
Religious	3,185	0.24%
Government	24,450	1.84%
Education	30,288	2.28%
Total	**1,330,152**	**100.00%**

Essential Facility Inventory

For essential facilities, there are no hospitals in the region with a total bed capacity of no beds. There are 1 schools, 1 fire stations, 1 police stations and 2 emergency operation facilities.

Hurricane Scenario

Hazus used the following set of information to define the hurricane parameters for the hurricane loss estimate provided in this report.

Scenario Name:	Probabilistic
Type:	Probabilistic

Building Damage

General Building Stock Damage

Hazus estimates that about 36 buildings will be at least moderately damaged. This is over 2% of the total number of buildings in the region. There are an estimated 0 buildings that will be completely destroyed. The definition of the 'damage states' is provided in the Hazus Hurricane technical manual. Table 2 below summarizes the expected damage by general occupancy for the buildings in the region. Table 3 summarizes the expected damage by general building type.

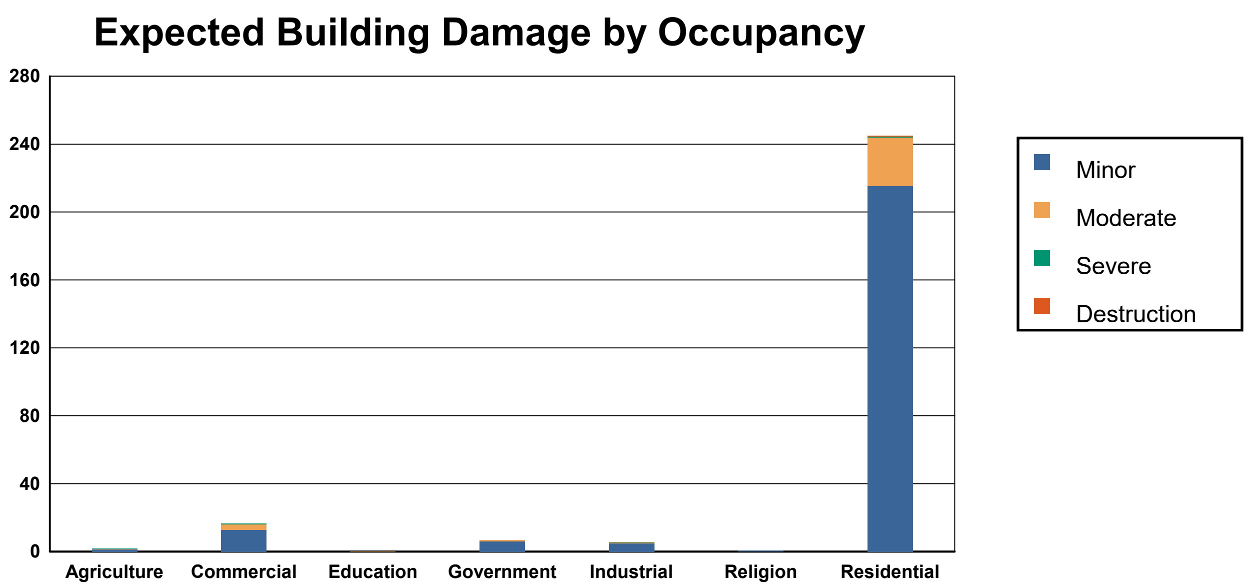


Table 2: Expected Building Damage by Occupancy : 500 - year Event

	None		Minor		Moderate		Severe		Destruction	
Occupancy	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Agriculture	9.32	84.69	1.25	11.38	0.28	2.58	0.14	1.24	0.01	0.12
Commercial	120.56	88.00	12.73	9.29	3.11	2.27	0.60	0.44	0.00	0.00
Education	1.79	89.70	0.18	9.14	0.02	1.12	0.00	0.05	0.00	0.00
Government	65.11	90.43	6.14	8.53	0.73	1.01	0.02	0.03	0.00	0.00
Industrial	47.29	89.23	4.77	9.00	0.80	1.50	0.13	0.25	0.01	0.01
Religion	4.45	88.97	0.50	9.97	0.05	1.01	0.00	0.05	0.00	0.00
Residential	1,283.08	83.97	215.30	14.09	28.65	1.88	0.64	0.04	0.34	0.02
Total	**1,531.59**		**240.87**		**33.64**		**1.54**		**0.36**	

Table 3: Expected Building Damage by Building Type : 500 - year Event

Building Type	None		Minor		Moderate		Severe		Destruction	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	23	88.93	2	9.50	0	1.54	0	0.03	0	0.00
Masonry	110	82.42	16	12.14	7	5.28	0	0.14	0	0.02
MH	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Steel	117	89.48	11	8.06	3	1.99	1	0.46	0	0.00
Wood	1,253	84.56	207	13.95	21	1.42	1	0.05	0	0.02

Essential Facility Damage

Before the hurricane, the region had no hospital beds available for use. On the day of the hurricane, the model estimates that 0 hospital beds (0%) are available for use by patients already in the hospital and those injured by the hurricane. After one week, none of the beds will be in service. By 30 days, none will be operational.

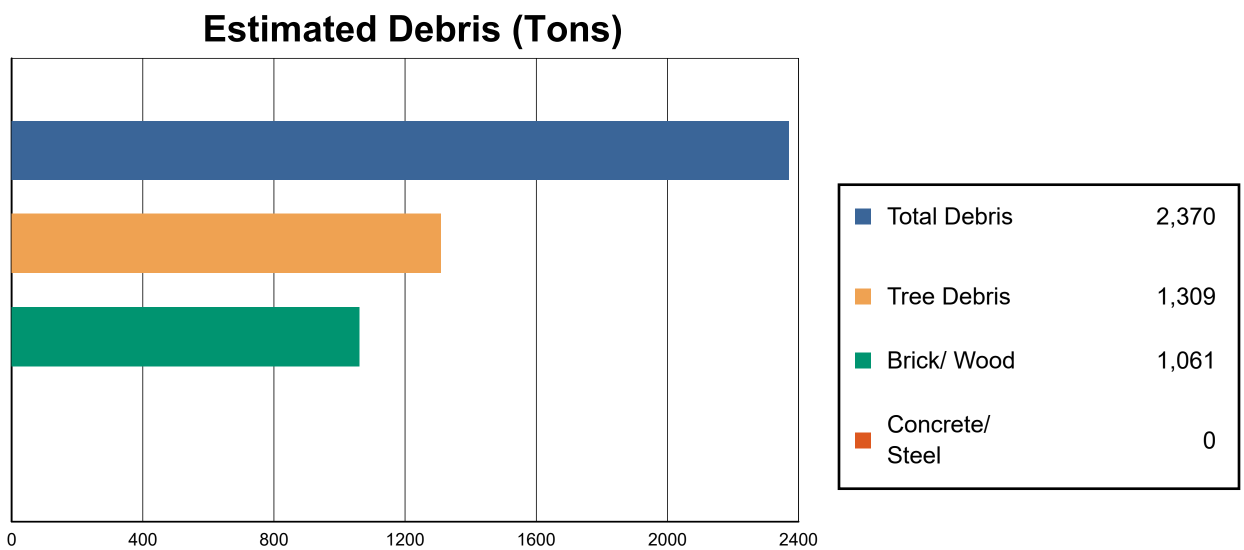
Thematic Map of Essential Facilities

Table 4: Expected Damage to Essential Facilities

		# Facilities		
Classification	**Total**	**Probability of at Least Moderate Damage > 50%**	**Probability of Complete Damage > 50%**	**Expected Loss of Use < 1 day**
EOCs	2	0	0	2
Fire Stations	1	0	0	1
Police Stations	1	0	0	1
Schools	1	0	0	1

Induced Hurricane Damage

Debris Generation

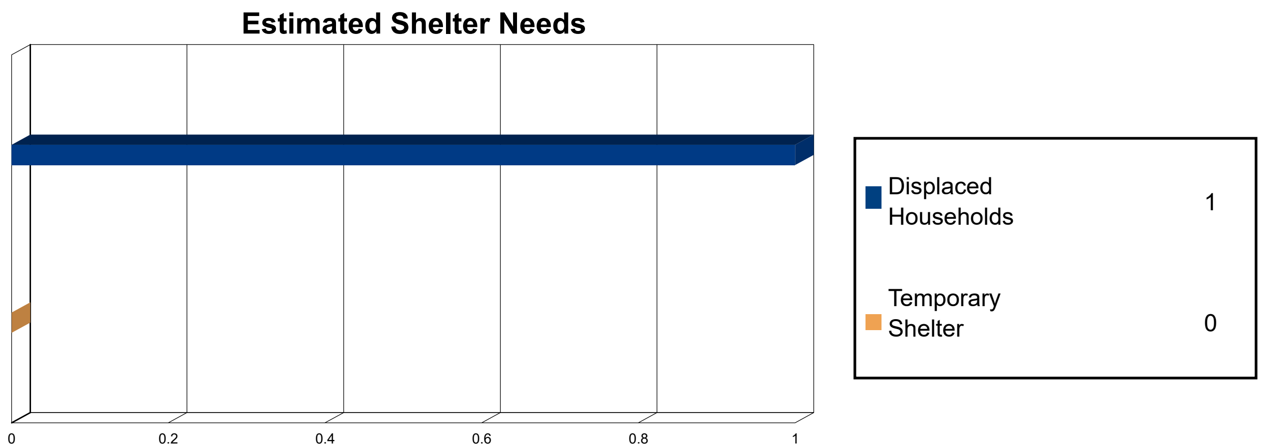


Hazus estimates the amount of debris that will be generated by the hurricane. The model breaks the debris into four general categories: a) Brick/Wood, b) Reinforced Concrete/Steel, c) Eligible Tree Debris, and d) Other Tree Debris. This distinction is made because of the different types of material handling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

The model estimates that a total of 2,370 tons of debris will be generated. Of the total amount, 929 tons (39%) is Other Tree Debris. Of the remaining 1,441 tons, Brick/Wood comprises 74% of the total, Reinforced Concrete/Steel comprises of 0% of the total, with the remainder being Eligible Tree Debris. If the building debris tonnage is converted to an estimated number of truckloads, it will require 42 truckloads (@25 tons/truck) to remove the building debris generated by the hurricane. The number of Eligible Tree Debris truckloads will depend on how the 380 tons of Eligible Tree Debris are collected and processed. The volume of tree debris generally ranges from about 4 cubic yards per ton for chipped or compacted tree debris to about 10 cubic yards per ton for bulkier, uncompacted debris.

Social Impact

Shelter Requirement



Hazus estimates the number of households that are expected to be displaced from their homes due to the hurricane and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 1 households to be displaced due to the hurricane. Of these, 0 people (out of a total population of 5,506) will seek temporary shelter in public shelters.

Economic Loss

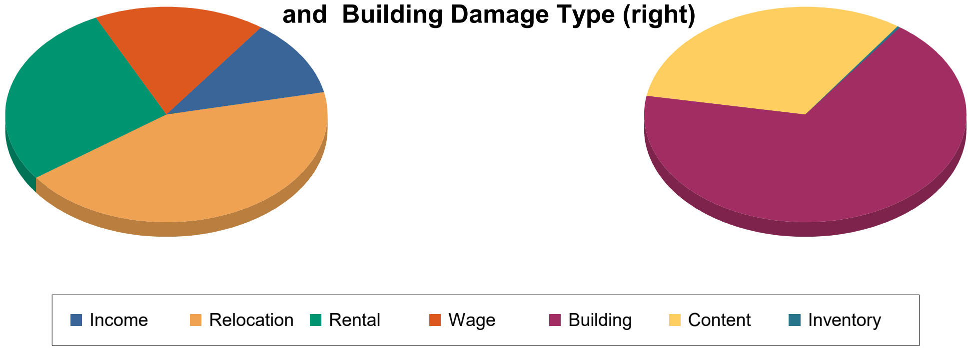
The total economic loss estimated for the hurricane is 28.4 million dollars, which represents 2.13 % of the total replacement value of the region's buildings.

Building-Related Losses

The building related losses are broken into two categories: direct property damage losses and business interruption losses. The direct property damage losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the hurricane. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the hurricane.

The total property damage losses were 28 million dollars. 4% of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 91% of the total loss. Table 5 below provides a summary of the losses associated with the building damage.

Loss by Business Interruption Type (left)
and Building Damage Type (right)



Loss Type by General Occupancy

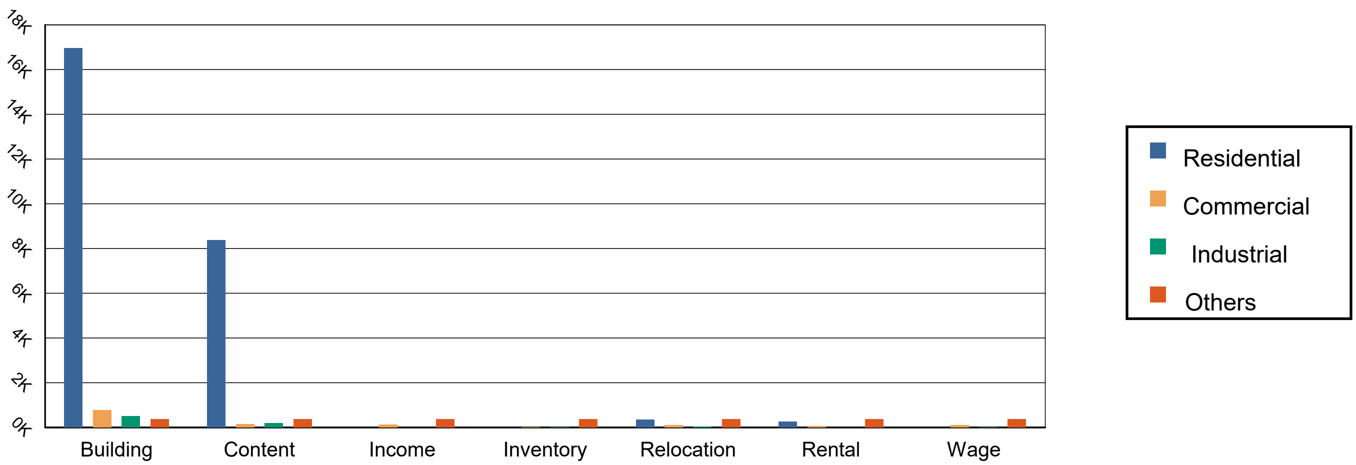


Table 5: Building-Related Economic Loss Estimates

(Thousands of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Property Damage						
	Building	16,948.52	763.88	508.82	191.59	18,412.81
	Content	8,368.38	148.38	201.37	33.51	8,751.64
	Inventory	0.00	17.03	20.87	10.17	48.08
	Subtotal	**25,316.89**	**929.29**	**731.07**	**235.28**	**27,212.54**
Business Interruption Loss						
	Income	0.00	116.92	5.15	13.00	135.07
	Relocation	345.71	94.65	30.89	26.38	497.64
	Rental	254.67	54.17	4.66	3.04	316.55
	Wage	0.00	96.46	8.05	94.39	198.91
	Subtotal	**600.39**	**362.21**	**48.76**	**136.82**	**1,148.16**

Total

Total	25,917.28	1,291.50	779.83	372.10	28,360.70

Appendix A: County Listing for the Region

Massachusetts
- Middlesex

Appendix B: Regional Population and Building Value Data

		Building Value (thousands of dollars)		
	Population	Residential	Non-Residential	Total
Massachusetts				
Middlesex	5,506	921,524	408,628	1,330,152
Total	**5,506**	**921,524**	**408,628**	**1,330,152**
Study Region Total	**5,506**	**921,524**	**408,628**	**1,330,152**

Hazus: Hurricane Global Risk Report

Region Name: Boxborough_Wind

Hurricane Scenario: Probabilistic 1000-year Return Period

Print Date: Monday, November 27, 2023

Table of Contents

General Description of the Region

Hazus is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of Hazus is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The hurricane loss estimates provided in this report are based on a region that includes 1 county(ies) from the following state(s):

- Massachusetts

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 10.41 square miles and contains 1 census tracts. There are over 2 thousand households in the region and a total population of 5,506 people. The distribution of population by State and County is provided in Appendix B.

There are an estimated 1 thousand buildings in the region with a total building replacement value (excluding contents) of 1,330 million dollars. Approximately 85% of the buildings (and 69% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

Hazus estimates that there are 1,808 buildings in the region which have an aggregate total replacement value of Table 1 presents the relative distribution of the value with respect to the general occupancies. Appendix B provi distribution of the building value by State and County.

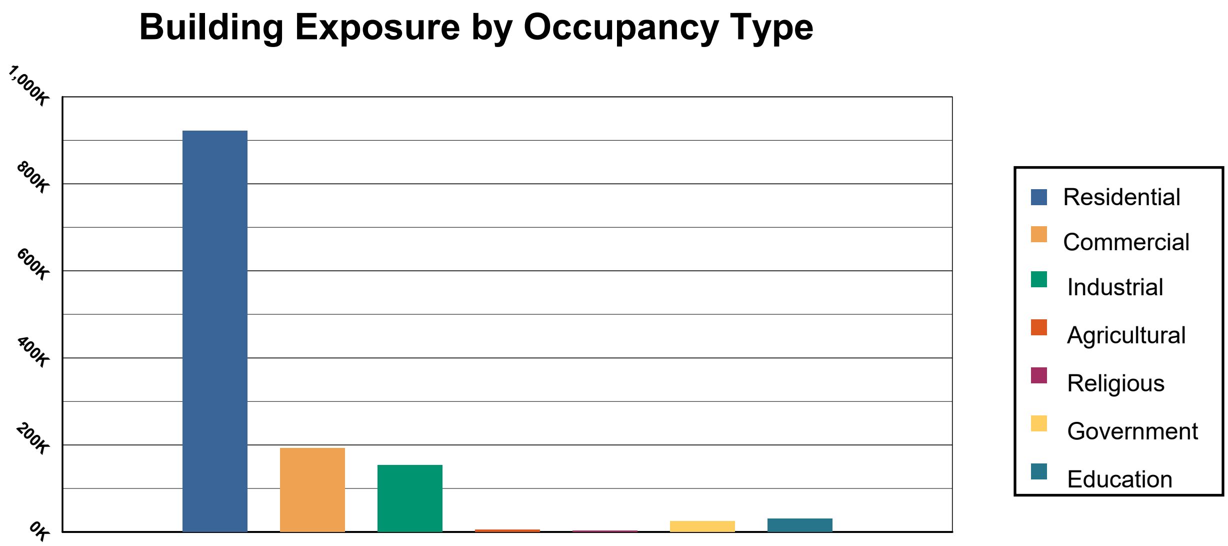


Table 1: Building Exposure by Occupancy Type

Occupancy	Exposure ($1000)	Percent of Tot
Residential	921,524	69.28%
Commercial	192,619	14.48%
Industrial	153,060	11.51%
Agricultural	5,026	0.38%
Religious	3,185	0.24%
Government	24,450	1.84%
Education	30,288	2.28%
Total	**1,330,152**	**100.00%**

Essential Facility Inventory

For essential facilities, there are no hospitals in the region with a total bed capacity of no beds. There are 1 schools, 1 fire stations, 1 police stations and 2 emergency operation facilities.

Hurricane Scenario

Hazus used the following set of information to define the hurricane parameters for the hurricane loss estimate provided in this report.

Scenario Name:	Probabilistic
Type:	Probabilistic

Building Damage

General Building Stock Damage

Hazus estimates that about 63 buildings will be at least moderately damaged. This is over 3% of the total number of buildings in the region. There are an estimated 1 buildings that will be completely destroyed. The definition of the 'damage states' is provided in the Hazus Hurricane technical manual. Table 2 below summarizes the expected damage by general occupancy for the buildings in the region. Table 3 summarizes the expected damage by general building type.

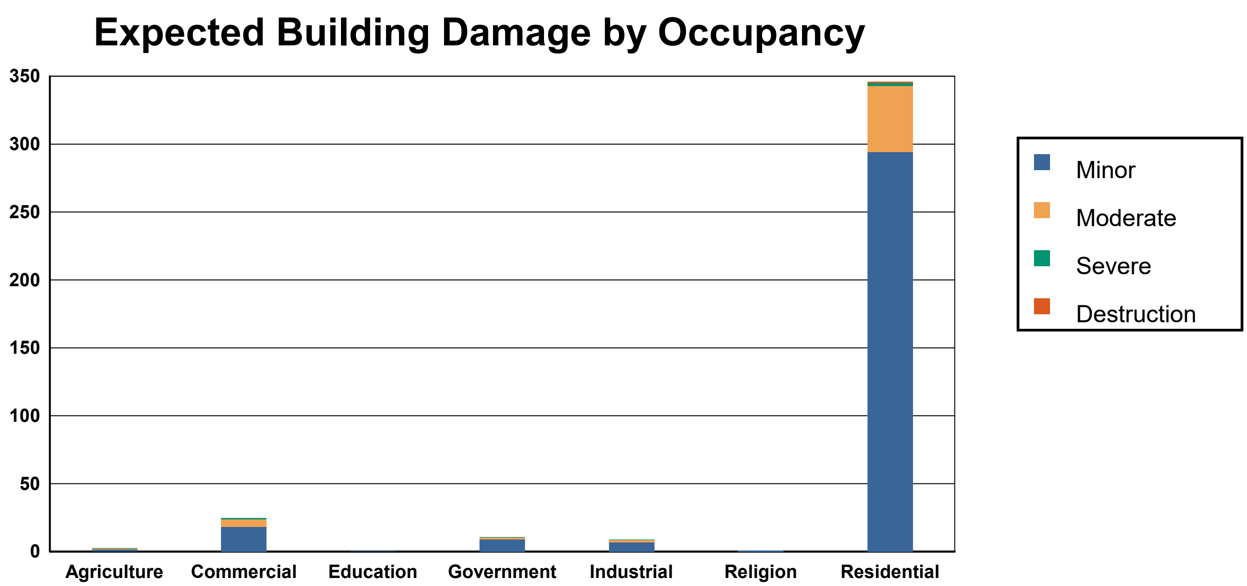


Table 2: Expected Building Damage by Occupancy : 1000 - year Event

	None		Minor		Moderate		Severe		Destruction	
Occupancy	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Agriculture	8.56	77.80	1.73	15.77	0.46	4.17	0.22	2.02	0.03	0.24
Commercial	112.43	82.07	18.12	13.23	5.36	3.91	1.08	0.79	0.01	0.01
Education	1.68	84.12	0.26	13.25	0.05	2.52	0.00	0.12	0.00	0.00
Government	61.32	85.17	8.93	12.41	1.68	2.33	0.07	0.10	0.00	0.00
Industrial	44.28	83.55	6.82	12.87	1.62	3.06	0.26	0.49	0.02	0.03
Religion	4.16	83.15	0.72	14.50	0.11	2.24	0.01	0.11	0.00	0.00
Residential	1,182.12	77.36	294.12	19.25	48.64	3.18	2.07	0.14	1.06	0.07
Total	**1,414.55**		**330.71**		**57.91**		**3.71**		**1.12**	

Table 3: Expected Building Damage by Building Type : 1000 - year Event

Building Type	None		Minor		Moderate		Severe		Destruction	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	22	83.16	3	13.44	1	3.29	0	0.10	0	0.00
Masonry	101	75.91	21	16.02	10	7.75	0	0.28	0	0.04
MH	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Steel	110	83.94	15	11.57	5	3.61	1	0.86	0	0.01
Wood	1,156	78.01	285	19.20	38	2.59	2	0.13	1	0.07

Essential Facility Damage

Before the hurricane, the region had no hospital beds available for use. On the day of the hurricane, the model estimates that 0 hospital beds (0%) are available for use by patients already in the hospital and those injured by the hurricane. After one week, none of the beds will be in service. By 30 days, none will be operational.

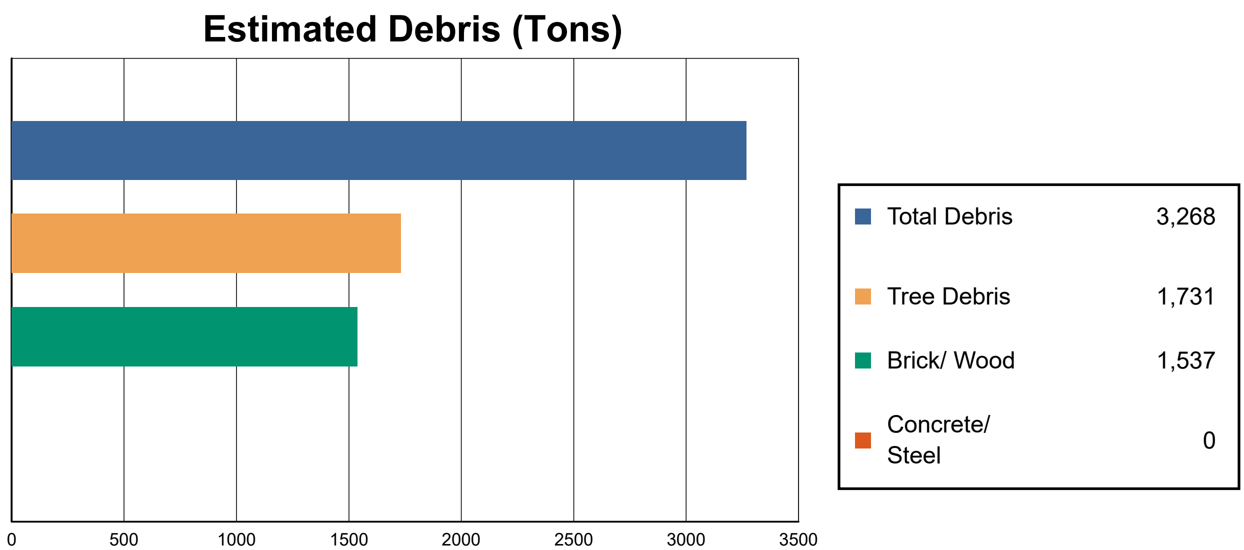
Thematic Map of Essential Facilities

Table 4: Expected Damage to Essential Facilities

		# Facilities		
Classification	**Total**	**Probability of at Least Moderate Damage > 50%**	**Probability of Complete Damage > 50%**	**Expected Loss of Use < 1 day**
EOCs	2	0	0	2
Fire Stations	1	0	0	1
Police Stations	1	0	0	1
Schools	1	0	0	1

Induced Hurricane Damage

Debris Generation

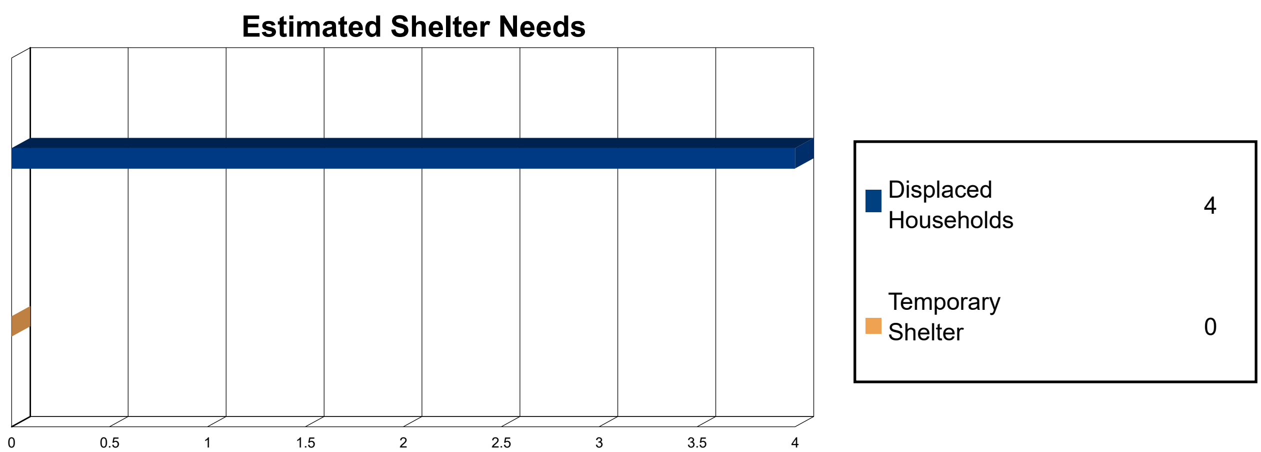


Hazus estimates the amount of debris that will be generated by the hurricane. The model breaks the debris into four general categories: a) Brick/Wood, b) Reinforced Concrete/Steel, c) Eligible Tree Debris, and d) Other Tree Debris. This distinction is made because of the different types of material handling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

The model estimates that a total of 3,268 tons of debris will be generated. Of the total amount, 1,229 tons (38%) is Other Tree Debris. Of the remaining 2,039 tons, Brick/Wood comprises 75% of the total, Reinforced Concrete/Steel comprises of 0% of the total, with the remainder being Eligible Tree Debris. If the building debris tonnage is converted to an estimated number of truckloads, it will require 61 truckloads (@25 tons/truck) to remove the building debris generated by the hurricane. The number of Eligible Tree Debris truckloads will depend on how the 502 tons of Eligible Tree Debris are collected and processed. The volume of tree debris generally ranges from about 4 cubic yards per ton for chipped or compacted tree debris to about 10 cubic yards per ton for bulkier, uncompacted debris.

Social Impact

Shelter Requirement



Hazus estimates the number of households that are expected to be displaced from their homes due to the hurricane and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 4 households to be displaced due to the hurricane. Of these, 0 people (out of a total population of 5,506) will seek temporary shelter in public shelters.

Economic Loss

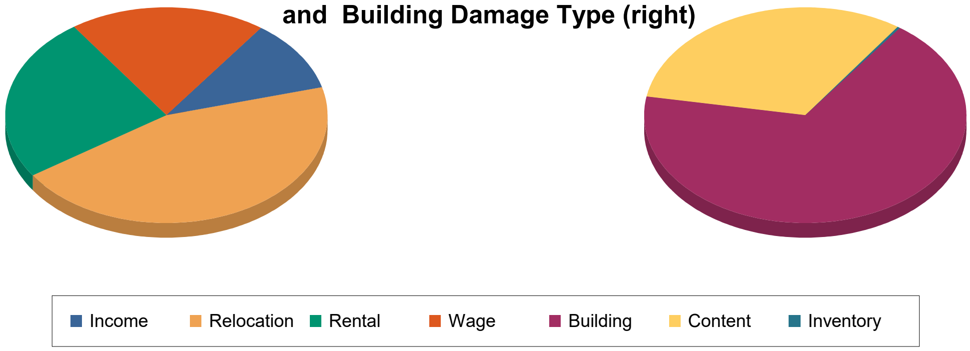
The total economic loss estimated for the hurricane is 39.7 million dollars, which represents 2.99 % of the total replacement value of the region’s buildings.

Building-Related Losses

The building related losses are broken into two categories: direct property damage losses and business interruption losses. The direct property damage losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the hurricane. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the hurricane.

The total property damage losses were 40 million dollars. 5% of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 89% of the total loss. Table 5 below provides a summary of the losses associated with the building damage.

Loss by Business Interruption Type (left) and Building Damage Type (right)



Loss Type by General Occupancy

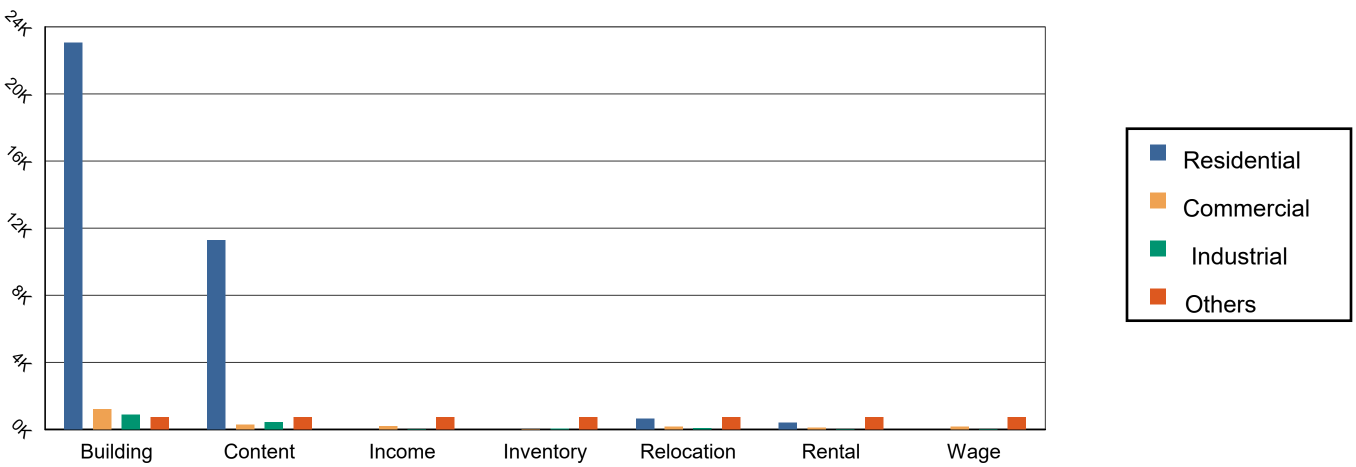


Table 5: Building-Related Economic Loss Estimates

(Thousands of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Property Damage						
	Building	23,059.94	1,219.39	891.46	322.33	25,493.12
	Content	11,280.57	287.30	420.34	73.17	12,061.38
	Inventory	0.00	32.17	43.83	18.05	94.05
	Subtotal	**34,340.51**	**1,538.85**	**1,355.63**	**413.55**	**37,648.55**
Business Interruption Loss						
	Income	0.00	191.46	12.43	23.94	227.83
	Relocation	633.26	167.16	68.70	55.86	924.98
	Rental	399.18	96.19	12.78	7.50	515.66
	Wage	0.00	166.36	19.76	224.18	410.30
	Subtotal	**1,032.44**	**621.17**	**113.67**	**311.48**	**2,078.76**

<u>Total</u>

Total	**35,372.96**	**2,160.02**	**1,469.30**	**725.03**	**39,727.31**

Appendix A: County Listing for the Region

Massachusetts

- Middlesex

Appendix B: Regional Population and Building Value Data

		Building Value (thousands of dollars)		
	Population	Residential	Non-Residential	Total
Massachusetts				
Middlesex	5,506	921,524	408,628	1,330,152
Total	**5,506**	**921,524**	**408,628**	**1,330,152**
Study Region Total	**5,506**	**921,524**	**408,628**	**1,330,152**

Hazus: Earthquake Global Risk Report

Region Name: Boxborough_EQ

Earthquake Scenario: 1500-year

Print Date: November 27, 2023

Disclaimer:
Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

Table of Contents

General Description of the Region

Hazus-MH is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences. The primary purpose of Hazus is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The earthquake loss estimates provided in this report was based on a region that includes 1 county(ies) from the following state(s):

Massachusetts

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 10.41 square miles and contains 1 census tracts. There are over 2 thousand households in the region which has a total population of 5,506 peopleF. The distribution of population by Total Region and County is provided in Appendix B.

There are an estimated 1 thousand buildings in the region with a total building replacement value (excluding contents) of 1,330 (millions of dollars). Approximately 85.00 % of the buildings (and 69.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 4,602 and 3 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

Hazus estimates that there are 1 thousand buildings in the region which have an aggregate total replacement value of 1,330 (millions of dollars) . Appendix B provides a general distribution of the building value by Total Region and County.

In terms of building construction types found in the region, wood frame construction makes up 82% of the building inventory. The remaining percentage is distributed between the other general building types.

Critical Facility Inventory

Hazus breaks critical facilities into two (2) groups: essential facilities and high potential loss facilities (HPL). Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants and hazardous material sites.

For essential facilities, there are 0 hospitals in the region with a total bed capacity of beds. There are 1 schools, 1 fire stations, 1 police stations and 2 emergency operation facilities. With respect to high potential loss facilities (HPL), there are no dams identified within the inventory. The inventory also includes no hazardous material sites, no military installations and no nuclear power plants.

Transportation and Utility Lifeline Inventory

Within Hazus, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail, bus, ports, ferry and airports. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The lifeline inventory data are provided in Tables 1 and 2.

The total value of the lifeline inventory is over 4,605.00 (millions of dollars). This inventory includes over 19.26 miles of highways, 3 bridges, 110.60 miles of pipes.

Table 1: Transportation System Lifeline Inventory

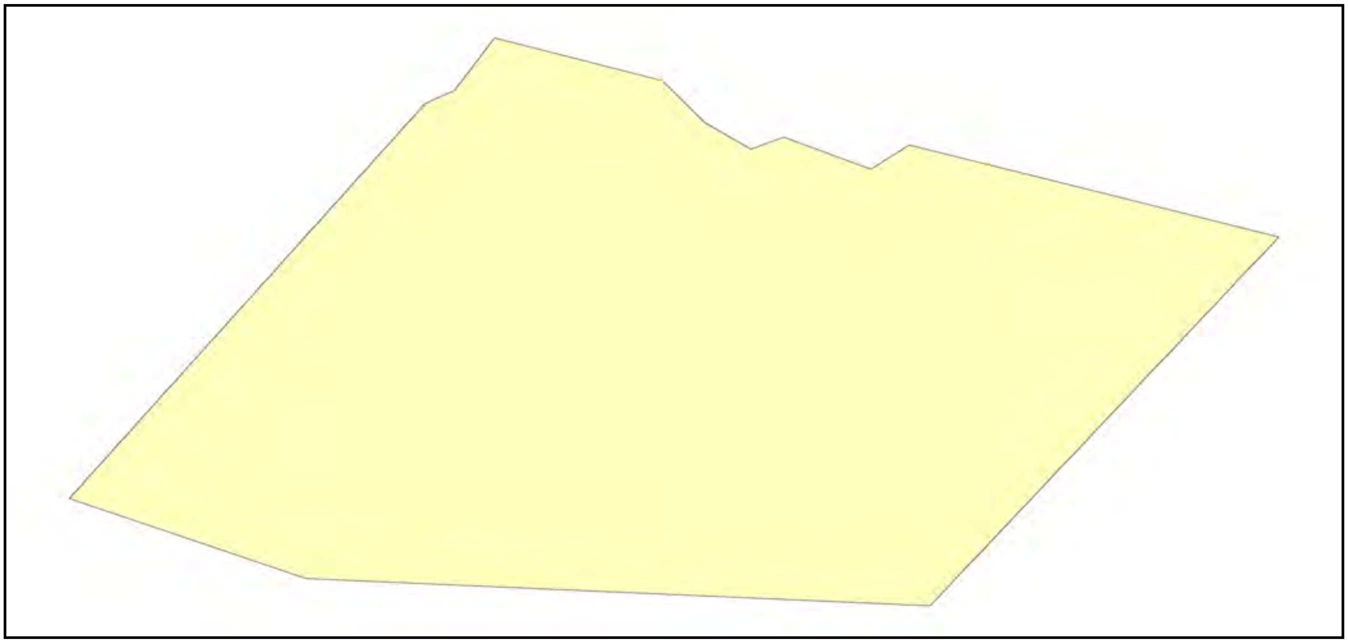
System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	3	18.3033
	Segments	15	197.9416
	Tunnels	0	0.0000
		Subtotal	**216.2449**
Railways	Bridges	4	20.7600
	Facilities	0	0.0000
	Segments	2	4365.9130
	Tunnels	0	0.0000
		Subtotal	**4386.6730**
Light Rail	Bridges	0	0.0000
	Facilities	0	0.0000
	Segments	0	0.0000
	Tunnels	0	0.0000
		Subtotal	**0.0000**
Bus	Facilities	0	0.0000
		Subtotal	**0.0000**
Ferry	Facilities	0	0.0000
		Subtotal	**0.0000**
Port	Facilities	0	0.0000
		Subtotal	**0.0000**
Airport	Facilities	0	0.0000
	Runways	0	0.0000
		Subtotal	**0.0000**
		Total	**4,602.90**

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	1.7810
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**1.7810**
Waste Water	Distribution Lines	NA	1.0686
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**1.0686**
Natural Gas	Distribution Lines	NA	0.7124
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**0.7124**
Oil Systems	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**0.0000**
Electrical Power	Facilities	0	0.0000
		Subtotal	**0.0000**
Communication	Facilities	0	0.0000
		Subtotal	**0.0000**
		Total	**3.60**

Earthquake Scenario

Hazus uses the following set of information to define the earthquake parameters used for the earthquake loss estimate provided in this report.



Scenario Name	1500-year
Type of Earthquake	Probabilistic
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	1,500.00
Longitude of Epicenter	NA
Latitude of Epicenter	NA
Earthquake Magnitude	6.00
Depth (km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Direct Earthquake Damage

Building Damage

Hazus estimates that about 16 buildings will be at least moderately damaged. This is over 1.00 % of the buildings in the region. There are an estimated 0 buildings that will be damaged beyond repair. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the Hazus technical manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 below summarizes the expected damage by general building type.

Damage Categories by General Occupancy Type

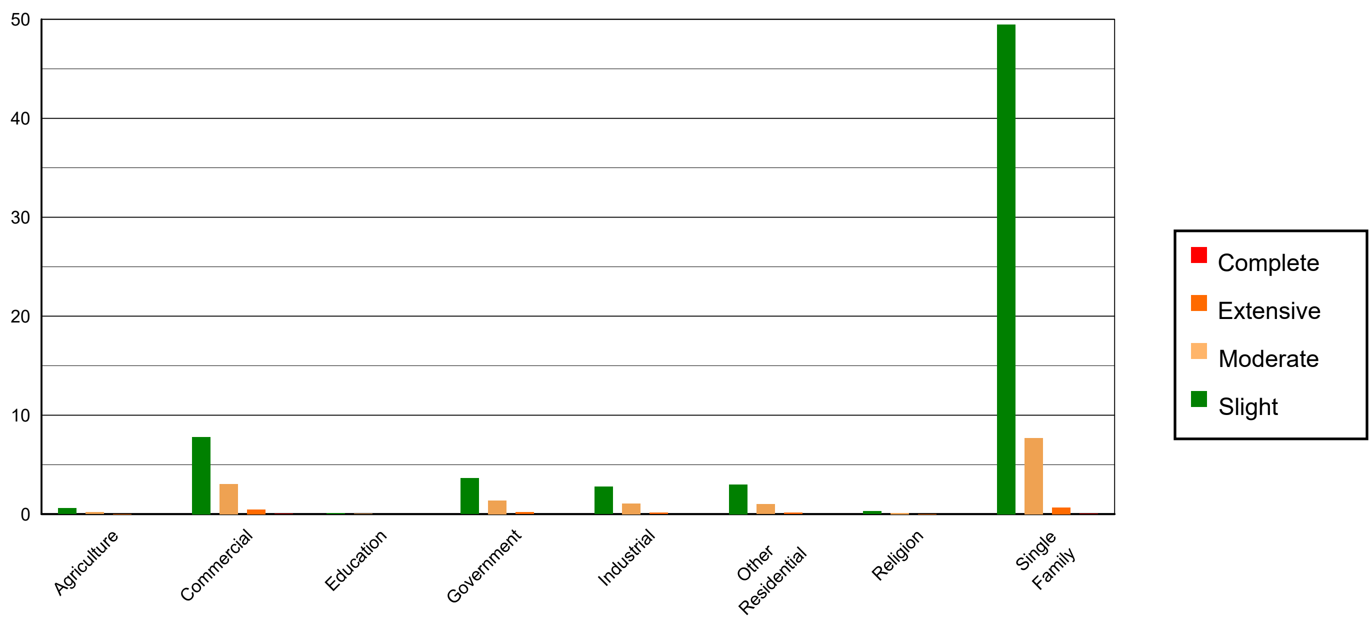


Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	10.18	0.59	0.60	0.89	0.19	1.30	0.03	1.66	0.00	1.14
Commercial	125.64	7.29	7.80	11.53	3.05	20.96	0.47	27.94	0.03	24.94
Education	1.84	0.11	0.11	0.16	0.04	0.28	0.01	0.36	0.00	0.37
Government	66.79	3.87	3.64	5.38	1.37	9.42	0.19	10.94	0.01	7.76
Industrial	49.00	2.84	2.76	4.07	1.08	7.44	0.15	8.99	0.01	6.23
Other Residential	58.85	3.41	2.99	4.42	1.00	6.84	0.15	9.00	0.01	10.73
Religion	4.56	0.26	0.29	0.43	0.12	0.84	0.02	1.23	0.00	1.45
Single Family	1407.09	81.62	49.47	73.11	7.70	52.92	0.68	39.89	0.06	47.37
Total	**1,724**		**68**		**15**		**2**		**0**	

Table 4: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	1436.72	83.34	46.87	69.27	5.19	35.64	0.14	8.53	0.00	0.00
Steel	133.29	7.73	6.04	8.93	2.06	14.16	0.20	12.00	0.00	0.00
Concrete	20.17	1.17	0.99	1.46	0.34	2.31	0.02	1.06	0.00	0.00
Precast	8.31	0.48	0.64	0.95	0.46	3.15	0.09	5.59	0.00	0.50
RM	23.06	1.34	1.19	1.76	0.71	4.86	0.11	6.70	0.00	0.00
URM	102.40	5.94	11.93	17.63	5.81	39.88	1.12	66.13	0.13	99.50
MH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**1,724**		**68**		**15**		**2**		**0**	

*Note:

RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had hospital beds available for use. On the day of the earthquake, the model estimates that only hospital beds (%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, % of the beds will be back in service. By 30 days, % will be operational.

Table 5: Expected Damage to Essential Facilities

		# Facilities		
Classification	**Total**	**At Least Moderate Damage > 50%**	**Complete Damage > 50%**	**With Functionality > 50% on day 1**
Hospitals	0	0	0	0
Schools	1	0	0	1
EOCs	2	0	0	2
PoliceStations	1	0	0	1
FireStations	1	0	0	1

Transportation Lifeline Damage

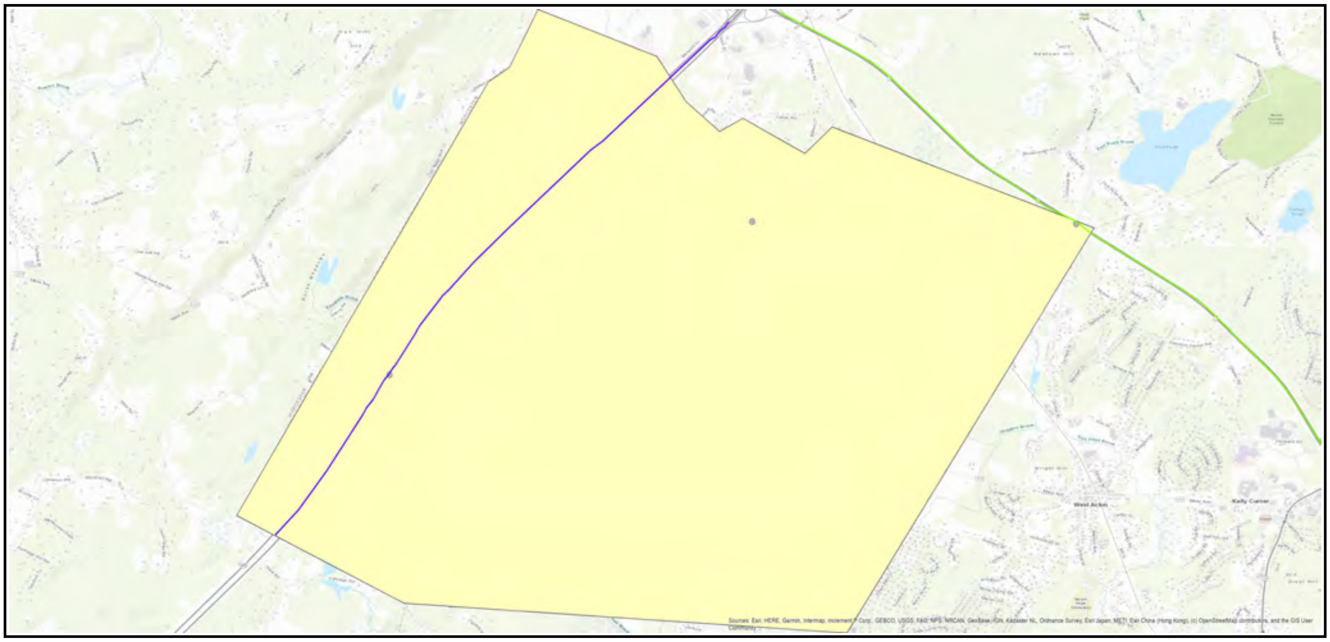


Table 6: Expected Damage to the Transportation Systems

System	Component	Number of Locations_				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 %	
					After Day 1	After Day 7
Highway	Segments	15	0	0	7	7
	Bridges	3	0	0	3	3
	Tunnels	0	0	0	0	0
Railways	Segments	2	0	0	1	1
	Bridges	4	0	0	4	4
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Light Rail	Segments	0	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	0	0	0	0	0
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	0	0	0	0	0
	Runways	0	0	0	0	0

Table 6 provides damage estimates for the transportation system.

Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only. If ground failure maps are not provided, damage estimates to these components will not be computed.

Tables 7-9 provide information on the damage to the utility lifeline systems. Table 7 provides damage to the utility system facilities. Table 8 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, Hazus performs a simplified system performance analysis. Table 9 provides a summary of the system performance information.

Table 7 : Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	0	0	0	0	0
Waste Water	0	0	0	0	0
Natural Gas	0	0	0	0	0
Oil Systems	0	0	0	0	0
Electrical Power	0	0	0	0	0
Communication	0	0	0	0	0

Table 8 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (miles)	Number of Leaks	Number of Breaks
Potable Water	55	0	0
Waste Water	33	0	0
Natural Gas	22	0	0
Oil	0	0	0

Table 9: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	2,261	0	0	0	0	0
Electric Power		0	0	0	0	0

Induced Earthquake Damage

Fire Following Earthquake

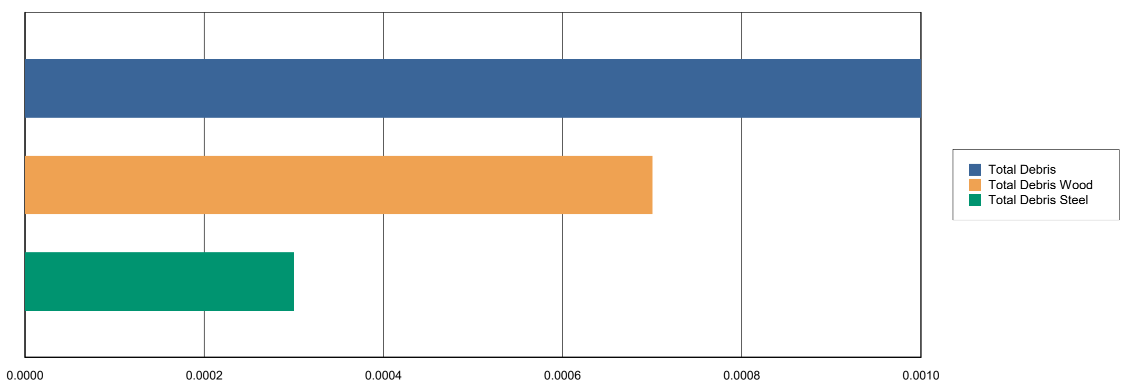
Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. Hazus uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 0 ignitions that will burn about 0.00 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 0 people and burn about 0 (millions of dollars) of building value.

Debris Generation

Hazus estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 1,000 tons of debris will be generated. Of the total amount, Brick/Wood comprises 70.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 40 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Earthquake Debris (millions of tons)



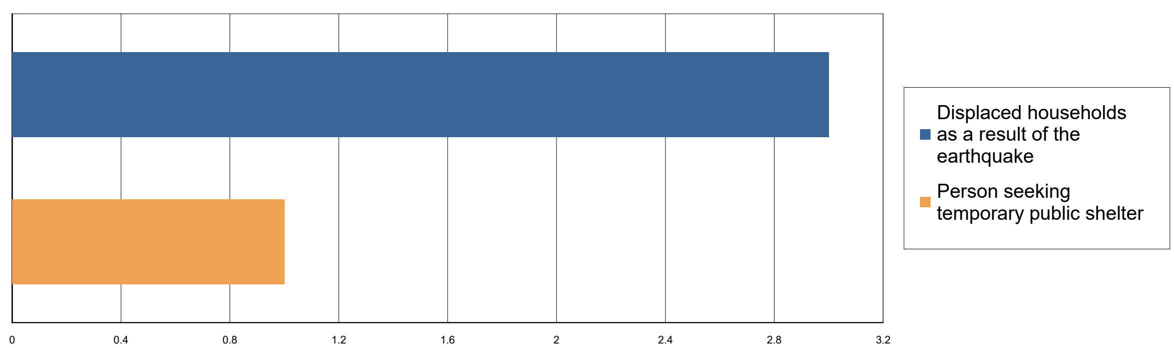
Brick/ Wood	Reinforced Concrete/Steel	Total Debris	Truck Load
0.00	0.00	0.00	40 (@25 tons/truck)

Social Impact

Shelter Requirement

Hazus estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 3 households to be displaced due to the earthquake. Of these, 1 people (out of a total population of 5,506) will seek temporary shelter in public shelters.

Displaced Households/ Persons Seeking Short Term Public Shelter



Displaced households as a result of the earthquake	Persons seeking temporary public shelter
3	1

Casualties

Hazus estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

· Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
· Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
· Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
· Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table 10 provides a summary of the casualties estimated for this earthquake

Table 10: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	0.01	0.00	0.00	0.00
	Commuting	0.00	0.00	0.00	0.00
	Educational	0.00	0.00	0.00	0.00
	Hotels	0.00	0.00	0.00	0.00
	Industrial	0.02	0.00	0.00	0.00
	Other-Residential	0.11	0.01	0.00	0.00
	Single Family	0.19	0.02	0.00	0.00
	Total	**0**	**0**	**0**	**0**
2 PM	Commercial	0.34	0.04	0.00	0.01
	Commuting	0.00	0.00	0.00	0.00
	Educational	0.06	0.01	0.00	0.00
	Hotels	0.00	0.00	0.00	0.00
	Industrial	0.14	0.02	0.00	0.00
	Other-Residential	0.03	0.00	0.00	0.00
	Single Family	0.05	0.00	0.00	0.00
	Total	**1**	**0**	**0**	**0**
5 PM	Commercial	0.24	0.03	0.00	0.00
	Commuting	0.00	0.00	0.00	0.00
	Educational	0.00	0.00	0.00	0.00
	Hotels	0.00	0.00	0.00	0.00
	Industrial	0.09	0.01	0.00	0.00
	Other-Residential	0.04	0.01	0.00	0.00
	Single Family	0.07	0.01	0.00	0.00
	Total	**0**	**0**	**0**	**0**

Economic Loss

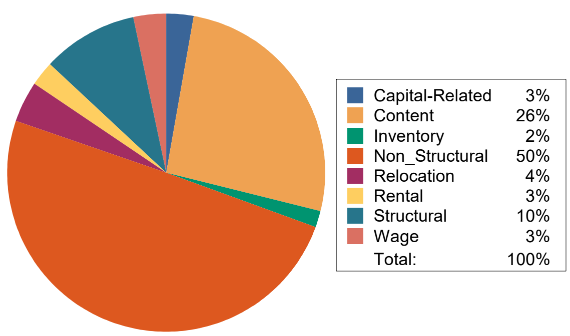
The total economic loss estimated for the earthquake is 7.54 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

The total building-related losses were 7.54 (millions of dollars); 13 % of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 49 % of the total loss. Table 11 below provides a summary of the losses associated with the building damage.

Earthquake Losses by Loss Type ($ millions)



Earthquake Losses by Occupancy Type ($ millions)

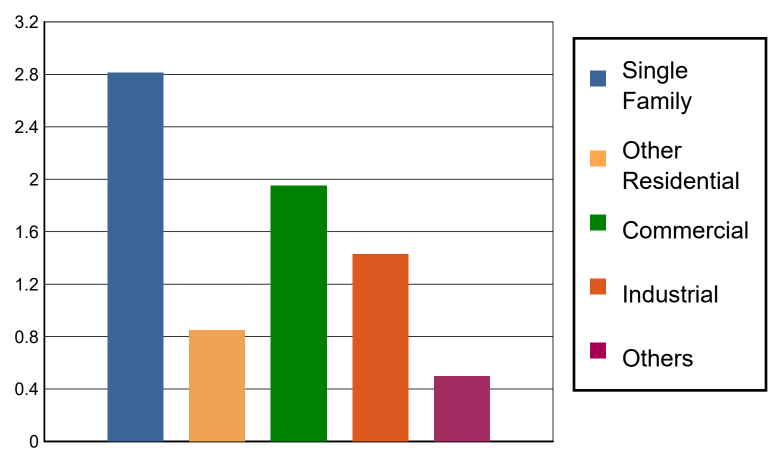


Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.0000	0.0232	0.1925	0.0119	0.0212	0.2488
	Capital-Related	0.0000	0.0098	0.1799	0.0073	0.0023	0.1993
	Rental	0.0250	0.0602	0.0890	0.0126	0.0080	0.1948
	Relocation	0.0838	0.0265	0.1139	0.0474	0.0418	0.3134
	Subtotal	**0.1088**	**0.1197**	**0.5753**	**0.0792**	**0.0733**	**0.9563**
Capital Stock Losses							
	Structural	0.2745	0.0801	0.1971	0.1245	0.0602	0.7364
	Non_Structural	1.6858	0.4949	0.6934	0.6619	0.2094	3.7454
	Content	0.7452	0.1526	0.4470	0.4920	0.1432	1.9800
	Inventory	0.0000	0.0000	0.0399	0.0719	0.0100	0.1218
	Subtotal	**2.7055**	**0.7276**	**1.3774**	**1.3503**	**0.4228**	**6.5836**
	Total	**2.81**	**0.85**	**1.95**	**1.43**	**0.50**	**7.54**

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, Hazus computes the direct repair cost for each component only. There are no losses computed by Hazus for business interruption due to lifeline outages. Tables 12 & 13 provide a detailed breakdown in the expected lifeline losses.

Table 12: Transportation System Economic Losses
(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	197.9416	0.0000	0.00
	Bridges	18.3033	0.0000	0.00
	Tunnels	0.0000	0.0000	0.00
	Subtotal	**216.2449**	**0.0000**	
Railways	Segments	4365.9130	0.0000	0.00
	Bridges	20.7600	0.0000	0.00
	Tunnels	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**4386.6730**	**0.0000**	
Light Rail	Segments	0.0000	0.0000	0.00
	Bridges	0.0000	0.0000	0.00
	Tunnels	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Bus	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Ferry	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Port	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Airport	Facilities	0.0000	0.0000	0.00
	Runways	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
	Total	**4,602.92**	**0.00**	

Table 13: Utility System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	1.7810	0.0015	0.08
	Subtotal	**1.7810**	**0.0015**	
Waste Water	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	1.0686	0.0007	0.07
	Subtotal	**1.0686**	**0.0007**	
Natural Gas	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	0.7124	0.0003	0.04
	Subtotal	**0.7124**	**0.0003**	
Oil Systems	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Electrical Power	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Communication	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
	Total	**3.56**	**0.00**	

Appendix A: County Listing for the Region

Middlesex,MA

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Massachusetts					
	Middlesex	5,506	921	408	1,330
Total Region		**5,506**	**921**	**408**	**1,330**

Hazus: Earthquake Global Risk Report

Region Name: Boxborough_EQ

Earthquake Scenario: 2500-year

Print Date: November 27, 2023

Disclaimer:
Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

Table of Contents

General Description of the Region

Hazus-MH is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences. The primary purpose of Hazus is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The earthquake loss estimates provided in this report was based on a region that includes 1 county(ies) from the following state(s):

Massachusetts

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 10.41 square miles and contains 1 census tracts. There are over 2 thousand households in the region which has a total population of 5,506 peopleF. The distribution of population by Total Region and County is provided in Appendix B.

There are an estimated 1 thousand buildings in the region with a total building replacement value (excluding contents) of 1,330 (millions of dollars). Approximately 85.00 % of the buildings (and 69.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 4,602 and 3 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

Hazus estimates that there are 1 thousand buildings in the region which have an aggregate total replacement value of 1,330 (millions of dollars) . Appendix B provides a general distribution of the building value by Total Region and County.

In terms of building construction types found in the region, wood frame construction makes up 82% of the building inventory. The remaining percentage is distributed between the other general building types.

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For essential facilities, there are 0 hospitals in the region with a total bed capacity of beds. There are 1 schools, 1 fire stations, 1 police stations and 2 emergency operation facilities. With respect to high potential loss facilities (HPL), there are no dams identified within the inventory. The inventory also includes no hazardous material sites, no military installations and no nuclear power plants.

Transportation and Utility Lifeline Inventory

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The total value of the lifeline inventory is over 4,605.00 (millions of dollars). This inventory includes over 19.26 miles of highways, 3 bridges, 110.60 miles of pipes.

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Light Rail	Bridges	0	0.0000
	Facilities	0	0.0000
	Segments	0	0.0000
	Tunnels	0	0.0000
		Subtotal	**0.0000**
Bus	Facilities	0	0.0000
		Subtotal	**0.0000**
Ferry	Facilities	0	0.0000
		Subtotal	**0.0000**
Port	Facilities	0	0.0000
		Subtotal	**0.0000**
Airport	Facilities	0	0.0000
	Runways	0	0.0000
		Subtotal	**0.0000**
		Total	**4,602.90**

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	1.7810
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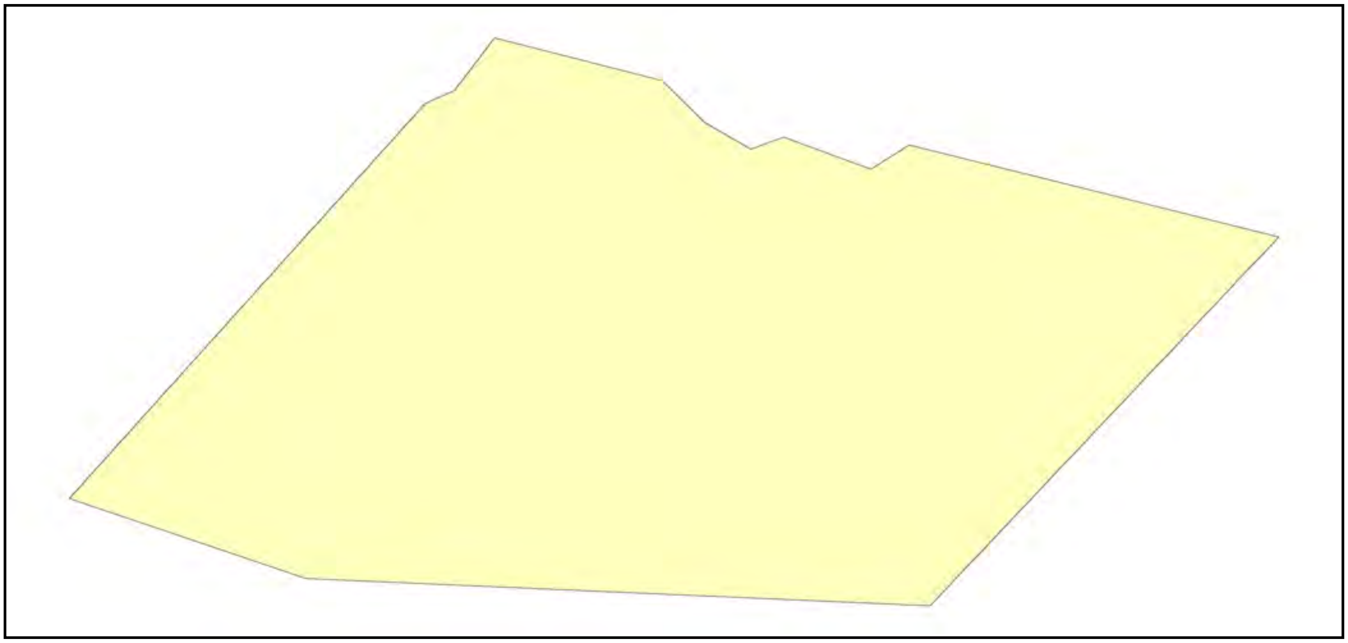
	Pipelines	0	0.0000
		Subtotal	**1.7810**
Waste Water	Distribution Lines	NA	1.0686
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**1.0686**
Natural Gas	Distribution Lines	NA	0.7124
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**0.7124**
Oil Systems	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**0.0000**
Electrical Power	Facilities	0	0.0000
		Subtotal	**0.0000**
Communication	Facilities	0	0.0000
		Subtotal	**0.0000**
		Total	**3.60**

Earthquake Scenario

Hazus uses the following set of information to define the earthquake parameters used for the earthquake loss estimate provided in this report.



Scenario Name	2500-year
Type of Earthquake	Probabilistic
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	2,500.00
Longitude of Epicenter	NA
Latitude of Epicenter	NA
Earthquake Magnitude	7.00
Depth (km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Direct Earthquake Damage

Building Damage

Hazus estimates that about 31 buildings will be at least moderately damaged. This is over 2.00 % of the buildings in the region. There are an estimated 0 buildings that will be damaged beyond repair. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the Hazus technical manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 below summarizes the expected damage by general building type.

Damage Categories by General Occupancy Type

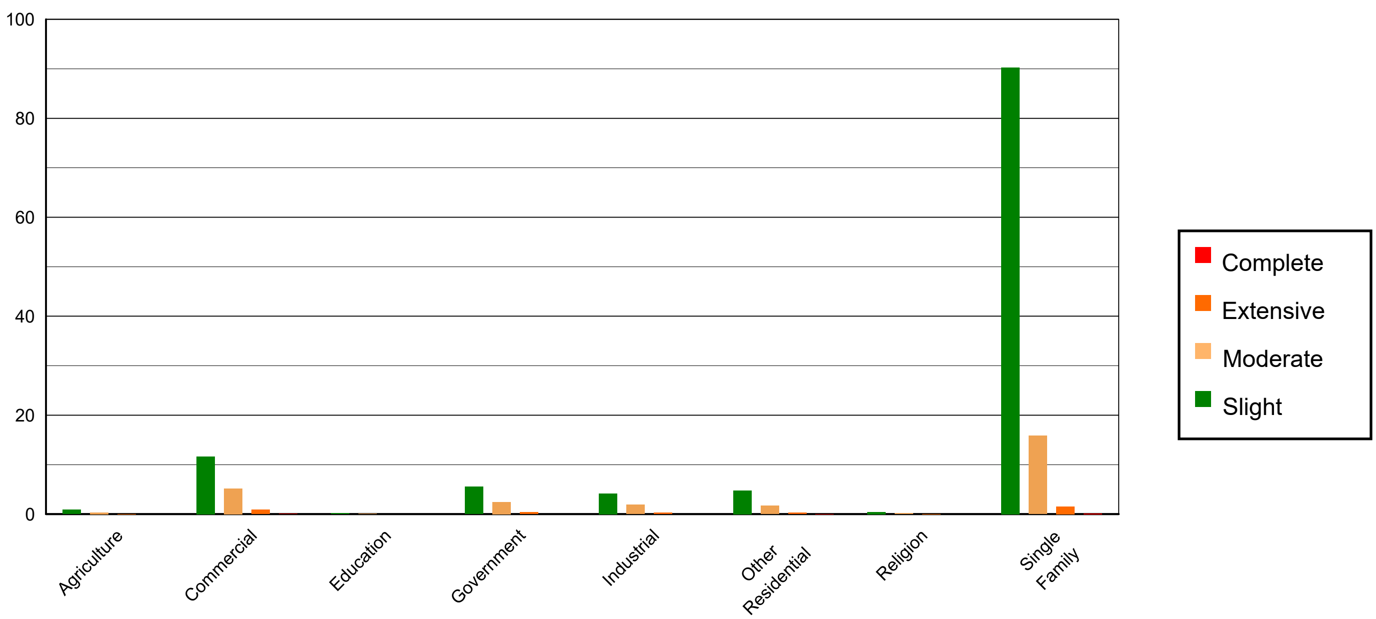


Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	9.68	0.58	0.93	0.79	0.33	1.19	0.06	1.57	0.00	1.18
Commercial	119.10	7.18	11.67	9.89	5.23	18.82	0.93	25.98	0.07	25.22
Education	1.75	0.11	0.16	0.14	0.07	0.26	0.01	0.34	0.00	0.38
Government	63.60	3.84	5.54	4.70	2.45	8.84	0.38	10.60	0.02	8.22
Industrial	46.59	2.81	4.17	3.53	1.92	6.90	0.31	8.66	0.02	6.54
Other Residential	56.17	3.39	4.79	4.06	1.71	6.17	0.30	8.35	0.03	10.59
Religion	4.32	0.26	0.44	0.37	0.20	0.72	0.04	1.11	0.00	1.42
Single Family	1357.21	81.84	90.25	76.52	15.86	57.10	1.55	43.39	0.14	46.45
Total	**1,658**		**118**		**28**		**4**		**0**	

Table 4: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	1388.20	83.71	87.97	74.59	12.17	43.84	0.58	16.21	0.00	0.00
Steel	127.62	7.70	9.52	8.07	3.99	14.37	0.47	13.11	0.00	1.63
Concrete	19.20	1.16	1.58	1.34	0.68	2.44	0.05	1.39	0.00	0.35
Precast	7.73	0.47	0.88	0.74	0.72	2.60	0.18	4.99	0.00	0.64
RM	21.94	1.32	1.71	1.45	1.19	4.29	0.23	6.52	0.00	0.00
URM	93.73	5.65	16.29	13.81	9.02	32.47	2.06	57.78	0.29	97.38
MH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**1,658**		**118**		**28**		**4**		**0**	

*Note:

RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had hospital beds available for use. On the day of the earthquake, the model estimates that only hospital beds (%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, % of the beds will be back in service. By 30 days, % will be operational.

Table 5: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		At Least Moderate Damage > 50%	Complete Damage > 50%	With Functionality > 50% on day 1
Hospitals	0	0	0	0
Schools	1	0	0	1
EOCs	2	0	0	2
PoliceStations	1	0	0	1
FireStations	1	0	0	1

Transportation Lifeline Damage

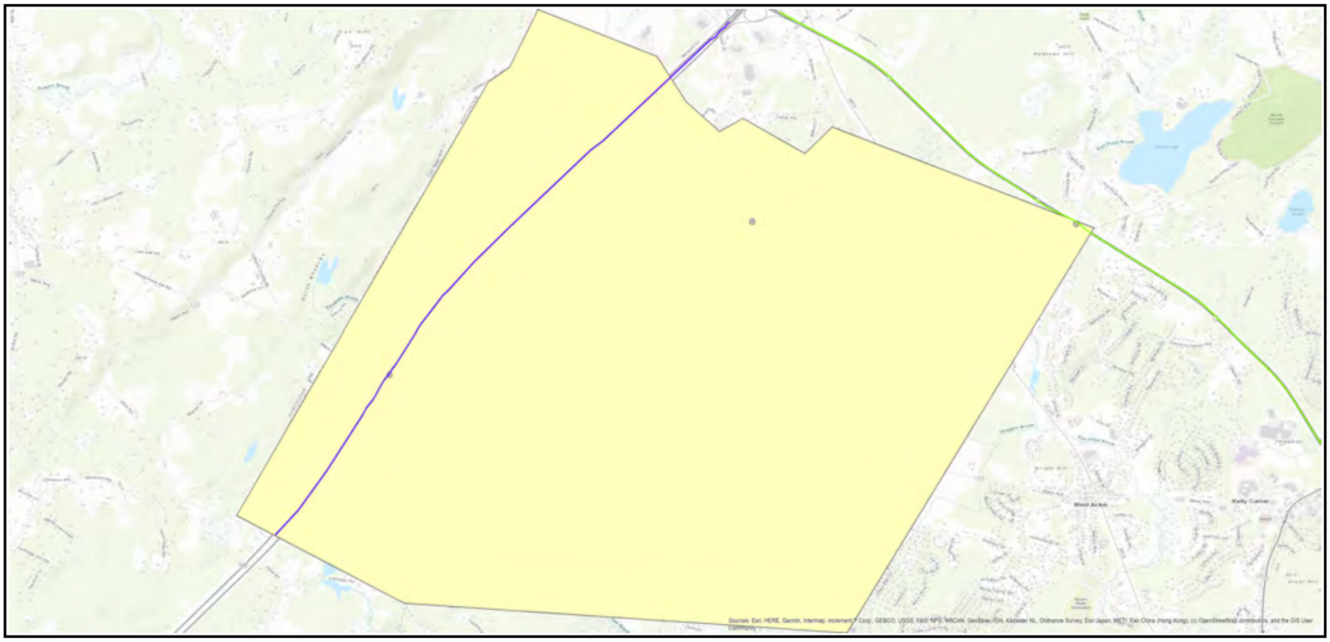


Table 6: Expected Damage to the Transportation Systems

System	Component	Number of Locations_				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 %	
					After Day 1	After Day 7
Highway	Segments	15	0	0	7	7
	Bridges	3	0	0	3	3
	Tunnels	0	0	0	0	0
Railways	Segments	2	0	0	1	1
	Bridges	4	0	0	4	4
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Light Rail	Segments	0	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	0	0	0	0	0
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	0	0	0	0	0
	Runways	0	0	0	0	0

Table 6 provides damage estimates for the transportation system.

Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only. If ground failure maps are not provided, damage estimates to these components will not be computed.

Tables 7-9 provide information on the damage to the utility lifeline systems. Table 7 provides damage to the utility system facilities. Table 8 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, Hazus performs a simplified system performance analysis. Table 9 provides a summary of the system performance information.

Table 7 : Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	0	0	0	0	0
Waste Water	0	0	0	0	0
Natural Gas	0	0	0	0	0
Oil Systems	0	0	0	0	0
Electrical Power	0	0	0	0	0
Communication	0	0	0	0	0

Table 8 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (miles)	Number of Leaks	Number of Breaks
Potable Water	55	1	0
Waste Water	33	0	0
Natural Gas	22	0	0
Oil	0	0	0

Table 9: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	2,261	0	0	0	0	0
Electric Power		0	0	0	0	0

Induced Earthquake Damage

Fire Following Earthquake

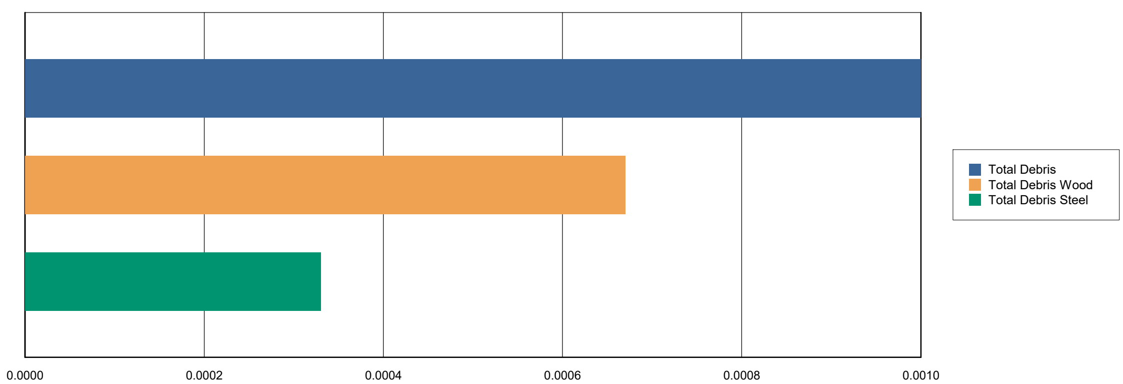
Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. Hazus uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 0 ignitions that will burn about 0.00 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 0 people and burn about 0 (millions of dollars) of building value.

Debris Generation

Hazus estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 1,000 tons of debris will be generated. Of the total amount, Brick/Wood comprises 67.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 40 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Earthquake Debris (millions of tons)



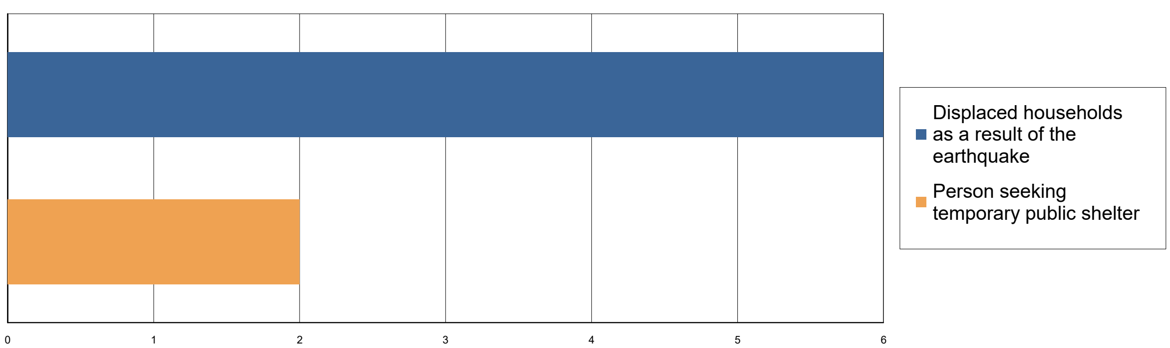
Brick/ Wood	Reinforced Concrete/Steel	Total Debris	Truck Load
0.00	0.00	0.00	40 (@25 tons/truck)

Social Impact

Shelter Requirement

Hazus estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 6 households to be displaced due to the earthquake. Of these, 2 people (out of a total population of 5,506) will seek temporary shelter in public shelters.

Displaced Households/ Persons Seeking Short Term Public Shelter



Displaced households as a result of the earthquake	Persons seeking temporary public shelter
6	2

Casualties

Hazus estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

- Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
- Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table 10 provides a summary of the casualties estimated for this earthquake

Table 10: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	0.01	0.00	0.00	0.00
	Commuting	0.00	0.00	0.00	0.00
	Educational	0.00	0.00	0.00	0.00
	Hotels	0.00	0.00	0.00	0.00
	Industrial	0.04	0.00	0.00	0.00
	Other-Residential	0.20	0.03	0.00	0.01
	Single Family	0.37	0.04	0.00	0.01
	Total	**1**	**0**	**0**	**0**
2 PM	Commercial	0.63	0.09	0.01	0.02
	Commuting	0.00	0.00	0.00	0.00
	Educational	0.11	0.02	0.00	0.00
	Hotels	0.00	0.00	0.00	0.00
	Industrial	0.26	0.04	0.00	0.01
	Other-Residential	0.05	0.01	0.00	0.00
	Single Family	0.09	0.01	0.00	0.00
	Total	**1**	**0**	**0**	**0**
5 PM	Commercial	0.45	0.07	0.01	0.01
	Commuting	0.00	0.00	0.00	0.00
	Educational	0.00	0.00	0.00	0.00
	Hotels	0.00	0.00	0.00	0.00
	Industrial	0.16	0.02	0.00	0.00
	Other-Residential	0.08	0.01	0.00	0.00
	Single Family	0.14	0.02	0.00	0.00
	Total	**1**	**0**	**0**	**0**

Economic Loss

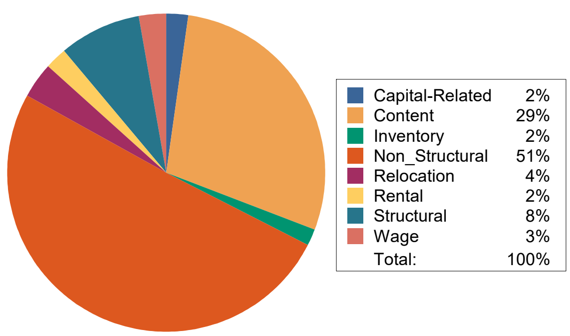
The total economic loss estimated for the earthquake is 16.29 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

The total building-related losses were 16.28 (millions of dollars); 11 % of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 50 % of the total loss. Table 11 below provides a summary of the losses associated with the building damage.

Earthquake Losses by Loss Type ($ millions)



Earthquake Losses by Occupancy Type ($ millions)

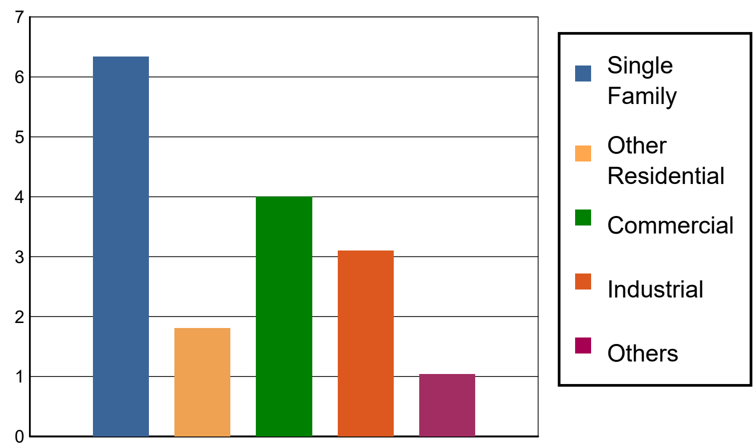


Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.0000	0.0439	0.3446	0.0219	0.0367	0.4471
	Capital-Related	0.0000	0.0186	0.3240	0.0134	0.0040	0.3600
	Rental	0.0517	0.1089	0.1542	0.0226	0.0147	0.3521
	Relocation	0.1763	0.0479	0.2039	0.0859	0.0771	0.5911
	Subtotal	**0.2280**	**0.2193**	**1.0267**	**0.1438**	**0.1325**	**1.7503**
Capital Stock Losses							
	Structural	0.5457	0.1438	0.3505	0.2230	0.1082	1.3712
	Non_Structural	3.7623	1.0787	1.4942	1.4526	0.4440	8.2318
	Content	1.7983	0.3621	1.0385	1.1217	0.3299	4.6505
	Inventory	0.0000	0.0000	0.0919	0.1638	0.0237	0.2794
	Subtotal	**6.1063**	**1.5846**	**2.9751**	**2.9611**	**0.9058**	**14.5329**
	Total	**6.33**	**1.80**	**4.00**	**3.10**	**1.04**	**16.28**

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, Hazus computes the direct repair cost for each component only. There are no losses computed by Hazus for business interruption due to lifeline outages. Tables 12 & 13 provide a detailed breakdown in the expected lifeline losses.

Table 12: Transportation System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	197.9416	0.0000	0.00
	Bridges	18.3033	0.0000	0.00
	Tunnels	0.0000	0.0000	0.00
	Subtotal	**216.2449**	**0.0000**	
Railways	Segments	4365.9130	0.0000	0.00
	Bridges	20.7600	0.0000	0.00
	Tunnels	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**4386.6730**	**0.0000**	
Light Rail	Segments	0.0000	0.0000	0.00
	Bridges	0.0000	0.0000	0.00
	Tunnels	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Bus	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Ferry	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Port	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Airport	Facilities	0.0000	0.0000	0.00
	Runways	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
	Total	**4,602.92**	**0.00**	

Table 13: Utility System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	1.7810	0.0030	0.17
	Subtotal	**1.7810**	**0.0030**	
Waste Water	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	1.0686	0.0015	0.14
	Subtotal	**1.0686**	**0.0015**	
Natural Gas	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	0.7124	0.0005	0.07
	Subtotal	**0.7124**	**0.0005**	
Oil Systems	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Electrical Power	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Communication	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
	Total	**3.56**	**0.01**	

Appendix A: County Listing for the Region

Middlesex,MA

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Massachusetts					
	Middlesex	5,506	921	408	1,330
Total Region		**5,506**	**921**	**408**	**1,330**