U.S. Department of Homeland Security
FEMA Region I
99 High Street, Sixth Floor
Boston, MA 02110-2132

FEMA

Dawn Brantley, Acting Director
Massachusetts Emergency Management Agency
400 Worcester Road
Framingham, Massachusetts 01702-5399

Acting Director Brantley:

The U.S. Department of Homeland Security, Federal Emergency Management Agency (FEMA) Region I Mitigation Division has approved the Town of Harvard, MA Hazard Mitigation Plan Update effective **January 20, 2023** through **January 19, 2028** in accordance with the planning requirements of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), as amended, the National Flood Insurance Act of 1968, as amended, and Title 44 Code of Federal Regulations (CFR) Part 201.

With this plan approval, the jurisdiction is eligible to apply to the Massachusetts Emergency Management Agency for mitigation grants administered by FEMA. Requests for funding will be evaluated according to the eligibility requirements identified for each of these programs. A specific mitigation activity or project identified in this community's plan may not meet the eligibility requirements for FEMA funding; even eligible mitigation activities or projects are not automatically approved.

The plan must be updated and resubmitted to the FEMA Region I Mitigation Division for approval every five years to remain eligible for FEMA mitigation grant funding.

Thank you for your continued commitment and dedication to risk reduction demonstrated by preparing and adopting a strategy for reducing future disaster losses. Should you have any questions, please contact Brigitte Ndikum-Nyada at (617) 378-7951 or brigitte.ndikum-nyada@fema.dhs.gov.

Sincerely,

Dean Savramis
Mitigation Division Director
DHS, FEMA Region I

DS: bnn

cc: Jeffrey Zukowski, Hazard Mitigation Planner, MEMA
Marybeth Groff, CFM, Hazard Mitigation & Climate Adaptation Coordinator
Beth Dubrawski, Hazard Mitigation Contract Specialist, MEMA

LOCAL MITIGATION PLAN REVIEW TOOL - Final
Town of Harvard, MA

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

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

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

Jurisdiction: Town of Harvard, MA	**Title of Plan:** Town of Harvard, MA Hazard Mitigation Plan Update	**Date of Plan:** July 2022 **Resubmit:** 11/29/2022
Single or Multi-jurisdiction plan? Single jurisdiction	**New Plan or Plan Update?** Update	
Local Point of Contact: Rick Sicard **Title:** Fire Chief, Emergency Management Director **Agency/Address:** Harvard Fire Department **Phone Number:** 978-391-5953 **E-Mail:** rsicard@harvard-ma.gov	**Regional Point of Contact:** N/A **Title:** **Agency/Address:** **Phone Number:** **E-Mail:**	

State Reviewer:	**Title:**	**Date:**
Jeffrey Zukowski	Hazard Mitigation Planner	10/5/2022; 11/29/2022 & 12/28/2022

FEMA Reviewer:	**Title:**	**Date:**
Jay Neiderbach Brigitte Ndikum-Nyada	FEMA Community Planner Community Planner	10/5/2022 - 11/3/2022 11/14/22- 11/17/22; 12/13/22 & 1/23 & 1/24/23.
Date Received in FEMA Region I	10/5/2022; 11/29/2022 & 12/28/2022	
Plan Not Approved	Requires Revisions 11/17/2022	
Plan Approvable Pending Adoption	12/13/2022	
Plan Adopted	12/20/2022	
Plan Approved	**01/20/2023**	
Plan will expire	01/19/2028	

SECTION 1:
REGULATION CHECKLIST

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

1. REGULATION CHECKLIST **Regulation** (44 CFR 201.6 Local Mitigation Plans)	**Location in Plan** (section and/or page number)	**Met**	**Not Met**
ELEMENT A. PLANNING PROCESS			
A1. Does the Plan document the planning process, including how it was prepared and who was involved in the process for each jurisdiction? (Requirement §201.6(c)(1))	pp. 26-36, 175-184	X	
A2. Does the Plan document an opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, agencies that have the authority to regulate development as well as other interests to be involved in the planning process? (Requirement §201.6(b)(2))	Chapter 3 p.29-36 Appendix A p.178-184	X	
A3. Does the Plan document how the public was involved in the planning process during the drafting stage? (Requirement §201.6(b)(1))	Chapter 3 p.29-36 Appendix A p.178-184	X	
A4. Does the Plan describe the review and incorporation of existing plans, studies, reports, and technical information? (Requirement §201.6(b)(3))	pp. 119-123	X	
A5. Is there discussion of how the community(ies) will continue public participation in the plan maintenance process? (Requirement §201.6(c)(4)(iii))	p. 171	X	
A6. Is there a description of the method and schedule for keeping the plan current (monitoring, evaluating and updating the mitigation plan within a 5-year cycle)? (Requirement §201.6(c)(4)(i))	pp. 171-174, 214-215	X	
ELEMENT A: REQUIRED REVISIONS			
ELEMENT B. HAZARD IDENTIFICATION AND RISK ASSESSMENT			
B1. Does the Plan include a description of the type, location, and extent of all natural hazards that can affect each jurisdiction(s)? (Requirement §201.6(c)(2)(i))	Chapter 4 p.37-113	X	
B2. Does the Plan include information on previous occurrences of hazard events and on the probability of future hazard events for each jurisdiction? (Requirement §201.6(c)(2)(i))	Chapter 4 p.37-113	X	

1. REGULATION CHECKLIST **Regulation** (44 CFR 201.6 Local Mitigation Plans)	**Location in Plan** (section and/or page number)	**Met**	**Not Met**
B3. Is there a description of each identified hazard's impact on the community as well as an overall summary of the community's vulnerability for each jurisdiction? (Requirement §201.6(c)(2)(ii))	pp. 39-117	X	
B4. Does the Plan address NFIP insured structures within the jurisdiction that have been repetitively damaged by floods? (Requirement §201.6(c)(2)(ii))	p. 115	X	
ELEMENT B: REQUIRED REVISIONS			
ELEMENT C. MITIGATION STRATEGY			
C1. Does the plan document each jurisdiction's existing authorities, policies, programs and resources and its ability to expand on and improve these existing policies and programs? (Requirement §201.6(c)(3))	pp. 123-140	X	
C2. Does the Plan address each jurisdiction's participation in the NFIP and continued compliance with NFIP requirements, as appropriate? (Requirement §201.6(c)(3)(ii))	p. 133-137, 145	X	
C3. Does the Plan include goals to reduce/avoid long-term vulnerabilities to the identified hazards? (Requirement §201.6(c)(3)(i))	pp. 11-12	X	
C4. Does the Plan identify and analyze a comprehensive range of specific mitigation actions and projects for each jurisdiction being considered to reduce the effects of hazards, with emphasis on new and existing buildings and infrastructure? (Requirement §201.6(c)(3)(ii))	pp. 151-166	X	
C5. Does the Plan contain an action plan that describes how the actions identified will be prioritized (including cost benefit review), implemented, and administered by each jurisdiction? (Requirement §201.6(c)(3)(iv)); (Requirement §201.6(c)(3)(iii))	Chapter 6 p. 153-166 Appendix B p.185-213	X	
C6. Does the Plan describe a process by which local governments will integrate the requirements of the mitigation plan into other planning mechanisms, such as comprehensive or capital improvement plans, when appropriate? (Requirement §201.6(c)(4)(ii))	pp. 14, 144, 169-170	X	
ELEMENT C: REQUIRED REVISIONS **C5.c: "Ongoing"** is not considered a timeframe to implement a mitigation action in the mitigation strategy. Identify what is specifically proposed to be done as the action and when or how long will it take to complete within the 5-year planning period. If this is ongoing, it then becomes part of an existing mitigation or recovery capability.			
ELEMENT D. PLAN REVIEW, EVALUATION, AND IMPLEMENTATION (applicable to plan updates only)			
D1. Was the plan revised to reflect changes in development? (Requirement §201.6(d)(3))	pp. 13, 18-19	X	
D2. Was the plan revised to reflect progress in local mitigation efforts? (Requirement §201.6(d)(3))	pp. 143-146	X	
D3. Was the plan revised to reflect changes in priorities? (Requirement §201.6(d)(3))	p. 14	X	

1. REGULATION CHECKLIST **Regulation** (44 CFR 201.6 Local Mitigation Plans)	**Location in Plan** (section and/or page number)	**Met**	**Not Met**
ELEMENT D: REQUIRED REVISIONS			
ELEMENT E. PLAN ADOPTION			
E1. Does the Plan include documentation that the plan has been formally adopted by the governing body of the jurisdiction requesting approval? (Requirement §201.6(c)(5))	Signed Adoption Certificate is on file. Approval date **1/20/2023**	X	
E2. For multi-jurisdictional plans, has each jurisdiction requesting approval of the plan documented formal plan adoption? (Requirement §201.6(c)(5))	N/A		
ELEMENT E: REQUIRED REVISIONS			
ELEMENT F. ADDITIONAL STATE REQUIREMENTS (OPTIONAL FOR STATE REVIEWERS ONLY; NOT TO BE COMPLETED BY FEMA)			
F1.			
F2.			
ELEMENT F: REQUIRED REVISIONS			

SECTION 2:
PLAN ASSESSMENT

A. Plan Strengths and Opportunities for Improvement

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

Element A: Planning Process

Strengths:

- Key land use and mitigation stakeholders were included in the planning process, such as the Nashua River Watershed Association, the Harvard Climate Initiative Committee, and the Devens Economic District. Inclusion of a range of community officials further encouraged a comprehensive approach to mitigation.
- A range of existing studies, reports, and plans were reviewed and incorporated, including *The Impact of Climate Change on Agriculture: Harvard, Massachusetts,* and the Town's 2016 Master Plan.
- There are details about decisions and topics discussed during each meeting of the planning team. This information will be a useful record for tracking and evaluating the plan over time.
- The public outreach process was extensive, with notices making it clear that public input was welcome. Public meetings included presentations with discussion questions to help guide conversation.
- The plan includes details about how plan maintenance will occur, such as specific questions to be asked for evaluation and tracking.

Opportunities for Improvement:

- Consider ways to further encourage public participation for people who cannot attend the meeting, such as providing the questionnaire and presentations online.
- Describe any limitations in the available data. Identifying limitations will help inform plan updates and help identify the need for additional studies.
- The following elements were addressed in the resubmitted revised plan: **A2-b.** The plan must provide the agency or organization represented and the person's position or title within the agency. Please identify the position or title of the person who represented the Nashua River Watershed Association and Harvard Conservation Trust. (including these: *Devens Economic District, the Harvard Conservation Trust, the Climate Initiative Committee, and the school district.)* **A3-a.** The plan must document how the public was given the opportunity to be involved in the planning process and how their feedback was incorporated into the plan. Please describe how the comments collected by the Fire Chief on the draft of the plan (described on page 36), were incorporated into the plan. **B2-a.** The plan must include the probability of future events for each identified hazard. Please provide more information on the probability of dam failure, ice jams, and ice storms.

Element B: Hazard Identification and Risk Assessment

Strengths:

- The risk assessment addresses how each hazard potentially affects socially vulnerable populations and underserved communities.
- At the end of the risk assessment, the community's key vulnerabilities are summarized using problem statements. The risk assessment lays the path for a successful analysis of mitigation actions.

Opportunities for Improvement:

- Identify dams in upstream communities that may pose a risk to neighborhoods and assets.
- Consider the 0.2% (500-year flood) risk of flood when assessing the risk to development.
- Provide a longer timeframe when discussing previous occurrences, as well as details about the impacts. This can give a more accurate picture of future risks.
- The following elements were addressed in the resubmitted revised plan: B**1-c.** The hazard profile must include information on location and extent. Please provide more information about: 1) Location and extent for the streams with the potential to cause localized flooding that are described under "Exposure" on page 45 .2) Extent of ice storms

Element C: Mitigation Strategy

Strengths:

- The plan includes detailed information about how the community participates in the National Flood Insurance Program and how it will continue to comply with the program's requirements.
- The plan includes a detailed description of how current capabilities could be expanded or improved, helping to identify actions for the mitigation strategy.
- The plan describes the vulnerabilities addressed by each mitigation action, creating a strong connection between the risk assessment and mitigation strategy sections of the plan.
- The plan's goals and mitigation actions are integrated with other community planning efforts. This integration will encourage better implementation of the mitigation strategy.
- The plan indicates that the STAPLEE method was used to prioritize proposed mitigation actions.

Opportunities for Improvement:

- Provide more details about what mitigation actions will entail and the tasks that will be involved.
- The following element was addressed in the resubmitted revised plan: **C5-c.** The plan must identify the expected timeframes for completion of each mitigation action. Please include a start and end date for mitigation actions. Many mitigation actions are given a timeframe of "ongoing."

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

Strengths:

- In considering changes to the community's priorities, the planning team went beyond re-prioritizing mitigation actions to also incorporate additional information on risk.

Opportunities for Improvement:

- Including a discussion of lessons learned about implementing mitigation actions would strengthen the plan, as would a short narrative on some "success stories" about their implementation.
- Consider including a discussion on how mitigation activities have increased the community's resilience and support other long-term community planning goals.
- Provide more information about the specific developments that have occurred in the past 5 years, such as their location, size, exact number, etc.. Include any risk mitigation measures that these developments incorporated.
- In the next plan update, mitigation actions carried forward to the new updated plan must not have status as **'delayed,'** "partially completed and to be continued" or "completed and to be continued." If these actions status are correctly stated, like "completed and to be continued," the Town must consider converting them into programs or capabilities. Ensure all such actions have relevant explanations as to why they are delayed and why they were not completed.

B. Resources for Implementing Your Approved Plan

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

Technical Assistance:

FEMA

- Climate Resilience in Action | FEMA.gov: This page showcases efforts happening across the country, every day, to strengthen our communities. Together, we can build a climate resilient nation.
- FEMA Climate Change: Provides resources that address climate change.
- FEMA Library: FEMA publications can be downloaded from the library website. These resources may be especially useful in public information and outreach programs. Topics include building and construction techniques, NFIP policies, and integrating historic preservation and cultural resource protection with mitigation.
- FEMA RiskMAP: Technical assistance is available through RiskMAP to assist communities in identifying, selecting, and implementing activities to support mitigation planning and risk reduction. Attend RiskMAP discovery meetings that may be scheduled in the state, especially any in neighboring communities with shared watersheds boundaries.
- Mitigation Ideas (fema.gov)

Other Federal

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

State

- Massachusetts Emergency Management Agency: The Massachusetts State Hazard Mitigation Officer (SHMO) and State Mitigation Planner(s) can provide guidance regarding grants, technical assistance, available publications, and training opportunities.
- Massachusetts Departments of Conservation and Recreation and Environmental Protection can provide technical assistance and resources to communities seeking to implement their hazard mitigation plans.
- https://www.mass.gov/guides/floodplain-management Massachusetts 2020 Model Floodplain Bylaws. https://msc.fema.gov/portal
- MA Mapping Portal: Interactive mapping tool with downloadable data

Not for Profit

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

Funding Sources:

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

TOWN OF HARVARD, MA HAZARD MITIGATION PLAN UPDATE

JULY 2022

Town of Harvard

13 Ayer Road

Harvard, MA 01451

TOWN OF HARVARD, MA HAZARD MITIGATION PLAN UPDATE

July 2022

Town of Harvard

13 Ayer Road

Harvard, MA 01451

https://www.harvard-ma.gov

Prepared by:

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Acknowledgements

The Town of Harvard would like to thank the following people for supporting the development of this plan. This group was considered the Hazard Mitigation Planning Committee throughout the planning process.

- James Babu, Police Chief
- Jeff Hayes, Building Official
- Timothy Kilhart, Department of Public Works Director
- Pat Natoli, Public Safety Administrator
- Christopher Ryan, Director of Community and Economic Development
- Richard Sicard, Fire Chief

E1. Does the Plan include documentation that the plan has been formally adopted by the governing body of the jurisdiction requesting approval? (Requirement §201.6(c)(5))

Local Adoption Resolution

TOWN OF HARVARD, MASSACHUSETTS
BOARD OF SELECTMEN
A RESOLUTION ADOPTING THE
TOWN OF HARVARD, MA HAZARD MITIGATION PLAN UPDATE

WHEREAS, the Town of Harvard established a Committee to prepare the TOWN OF HARVARD, MA HAZARD MITIGATION PLAN UPDATE and

WHEREAS, the Town of Harvard participated in the development of the TOWN OF HARVARD, MA HAZARD MITIGATION PLAN UPDATE;

and WHEREAS, the Town of Harvard, MA contains several potential future projects to mitigate potential impacts from natural hazards in the Town of Harvard, and

WHEREAS, a duly noticed public meeting was held by the Harvard Board of Selectmen on _____ for the public and municipality to review prior to consideration of this resolution; and

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

NOW, THEREFORE BE IT RESOLVED that the Town of Harvard Board of Selectmen formally approves and adopts the TOWN OF HARVARD, MA HAZARD MITIGATION PLAN UPDATE, in accordance with M.G.L. c. 40.

ADOPTED AND SIGNED by the Harvard Board of Selectmen on this Dec. 20, 2022.

Rich D. Maiore, Chair	Erin McBee, Vice Chair
Don Ludwig, Clerk	Charles Oliver, Member
Kara Minar, Member	

Record of Changes

This Town of Harvard, 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 mitigation as "the effort to reduce loss of life and property by lessening the impact of disasters. Mitigation is taking actions now – before the next disaster – to reduce human and financial consequences later (analyzing risk, reducing risk, insuring against risk.)"[1]

"The purpose of mitigation planning is to identify policies and actions that can be implemented over the long term to reduce risk and future losses. Mitigation plans form the foundation for a community's long-term strategy to reduce disaster losses and break the cycle of disaster damage, reconstruction, and repeated damage. The planning process is as important as the plan itself. It creates a framework for risk-based decision making to reduce damages to lives, property, and the economy from future disasters."[2]

"Disaster Mitigation Act (DMA) 2000 (Public Law 106-390)[3] 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."[4]

The Town of Harvard, 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 Harvard. 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.

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[1] What is Mitigation? (2014). Federal Emergency Management Agency. Retrieved January 2014 from http://www.fema.gov/what-mitigation

[2] Multi-Hazard Mitigation Planning. (2014). Federal Emergency Management Agency. Retrieved January 2014 from http://www.fema.gov/multi-hazard-mitigation-planning

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

[4] Disaster Mitigation Act of 2000. (2014). Federal Emergency Management Agency. Retrieved January 2014 from http://www.fema.gov/media-library/assets/documents/4596?id=1935

Purpose of the Plan

The purpose of the Local Hazard Mitigation Plan is to provide the Town of Harvard 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. FEMA supports local mitigation planning to achieve the following:

- Foster partnerships among all levels of government.
- Develop and strengthen non-governmental and private partnerships.
- Promote more disaster-resilient and sustainable communities.
- Reduce the costs associated with disaster response and recovery by promoting mitigation activities.[5]

This plan is a result of a collaborative effort between the Town of Harvard 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 participated, included the Lucy Wallace, President, Nashua River Watershed Association, the Massachusetts Emergency Management Agency (MEMA), and the Devens Economic District. Inclusion of underserved and socially vulnerable populations was a priority of the HMPC.

Guiding principles for plan development

The HMPC adhered to the following guiding principles in the plan's development.[6]

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

Identified Hazards

The HMPC identified the following list of hazards to profile. They are shown in order of climate change interaction for consistency with the State Hazard Mitigation and Climate Adaptation Plan (SHMCAP).

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

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

Table 2. Hazards Considered.

Primary Climate Change Interactions	Hazards
Changes in Precipitation	Flooding *(including heavy rain, snow melt, dam failure, ice jams, beavers, etc.)* Drought Landslide
Rising Temperatures	Average/Extreme Temperatures Wildfires Infectious Disease Invasive Species
Extreme Weather	Hurricanes/Tropical Storms Severe Winter Storm/Nor'easter *(including heavy snow, ice storms, blizzard)* Tornadoes Other Severe Weather *(including high winds, severe thunderstorms, etc.)*
Non-Climate Influenced Hazards	Earthquake

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, risk assessment, and capability assessment. It is also the result of multiple meetings and sustained public outreach. The HMPC developed the four goals shown below. The goals from the 2015 Montachusett Region Natural Hazard Mitigation Plan Update were revised to include one mission statement, and three goal statements, shown in the figures below. Information about the goal development process is in Chapter 6: Mitigation Strategy. These goals are considered "broad policy-type statements"[7] that represent the long-term vision for mitigating risk to natural hazards in the Town of Harvard.

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

Mission Statement

- Reduce or eliminate risk to people, property, and infrastructure from natural hazards and climate change.

Figure 1. Mission Statement.

Critical Facilities and Infrastructure

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

Public Education and Outreach

- Conduct public outreach and education regarding how to mitigate risk posed by natural hazards and climate change.

Capacity Building and Planning

- Expand the Town's capacity to mitigate risk by including hazard mitigation concepts into local plans and regulations and collaborating with regional partners.

Figure 2. Goal Statements.

Plan Update and Changes

This section details some of the changes incorporated into this plan based on development, status of mitigation actions, and current Town priorities. Details regarding critical facilities and land use may be found in Chapter 4. Risk and Vulnerability Assessment. Details regarding land use and capabilities may be found in Chapter 5. Capability Assessment. This plan serves as a total revision and update to the Town of Harvard portions of the 2015 Montachusett Region Natural Hazard Mitigation Plan Update.

Changes in Development and Vulnerability

D1. Was the plan revised to reflect changes in development? (Requirement §201.6(d)(3))

The plan was revised to reflect changes in development as described throughout the plan. The critical facility list was amended to reflect the current priorities in the Town of Harvard. This included removing facilities in Devens, and adding facilities identified in the MVP. Harvard did not conduct a substantial amount of building since the previous plan was adopted. As mentioned in Chapter 2, several multi-family homes and condominiums were built but there was not a change in Town-owned buildings. The development did not increase the risk to natural hazards.

The Harvard Planning Board reviews and approves the division of land under the State Subdivision Control Law (MGL. Ch. 41) and the Harvard Subdivision Controls (Chapter 130); serves as a special permit granting authority under the State Zoning Act (MGL. Ch. 40A) and the Harvard Protective (Zoning) Bylaw (Chapter 125); and guides the process of Zoning Bylaw amendments under the State Zoning Act (MGL. Ch. 40A). Members are appointed to three-year term, except for associate member, who is appointed annually.

Under State Law, the Board is charged with the responsibility of protecting the health, safety and welfare of Harvard's residents. Guided by the General Laws of the Commonwealth of Massachusetts, the Harvard Protective (Zoning) Bylaw, the 2016 Harvard Master Plan and citizen's comments and concerns, the Board strives to preserve and enhance the integrity of Harvard's rural character through the use of these regulatory tools, while safeguarding property owners' rights. The Board recommends and specifies changes to development proposals to achieve these goals. Board members and staff strive to work with both project proponents and citizens to help shape projects so as to minimize the impact to the community.

Additional information regarding development, such as population changes and land use may be found in Chapter 2. Planning Area Profile. Additional information regarding vulnerability is included in Chapter 4. Risk Assessment. Finally, the HMPC did amend hazard mitigation actions to mitigate risk based on current and future development patterns.

Progress in Mitigation Efforts

D2. Was the plan revised to reflect progress in local mitigation efforts? (Requirement §201.6(d)(3))

Chapter 6: Mitigation Strategy details the previously identified mitigation actions from the 2015 Montachusett Region Natural Hazard Mitigation Plan Update and their status in 2022. Each of these actions is listed as completed, in progress, or delayed. A description of the status is given. The HMPC used this information to determine if the actions should now be considered capabilities of the Town or if they should move forward as mitigation actions in this new plan. The current mitigation action list represents present and future needs for the Town of Harvard.

Changes in Priority Since 2014

D3. Was the plan revised to reflect changes in priorities? (Requirement §201.6(d)(3))

The biggest change in priority since the 2015 Montachusett Region Natural Hazard Mitigation Plan Update is how the Town understands the current and potential impacts of climate change. Harvard completed a *Community Resilience Building Workshop Summary of Findings, June 2019* (Harvard's Municipal Vulnerability Preparedness (MVP) Plan which identified climate change adaptation actions the Town can take for improved resiliency. The goal statements were revised to include climate change. Several actions were added to reflect the Town's priority to mitigate risk and improve resiliency to climate change.

The other significant change in priority was due to the Covid-19 Pandemic. The Core Team added Infectious Disease to the list of hazards reviewed. Like communities nationwide the Covid-19 Pandemic impacted local government function and citizen expectations. This plan was created through virtual meetings to avoid the spread of disease. The mitigation actions created include consideration of infectious disease risk and mitigation, primarily through citizen education and increased local government capacity.

Hazard Mitigation Plan Integration Since Previous Plan

The previous Hazard Mitigation Plan was integrated into the Town's MVP plan. This is the most significant instance of plan integration. Covered in the MVP plan and then integrated into the planning process for this plan was invasive species. Moving forward the Climate Initiative Committee (CIC) worked collaboratively with the HMPC to include the mitigation strategy in the Climate Action Plan they are developing.

Authority and Assurances

The Town of Harvard 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 town, State or Federal laws and regulations, as required in 44 CFR 201.6.

The HMPC recognizes the following FEMA publications:

- Local Mitigation Planning Handbook (March 2013)
- Local Mitigation Plan Review Guide (October 2011)
- Demonstrating Good Practices Within Local Hazard Mitigation Plans (January 2017, FEMA Region 1)

Plan Adoption

The Town of Harvard 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 Harvard, 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 Harvard completely, 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 Harvard and its citizens. 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, and education and outreach. The chapter concludes with information regarding the National Flood Insurance Program and a list of specific opportunities to expand and improve on the Town's capabilities to reduce current and future hazard risks.

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 order of priority. 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 Harvard 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 Report.

Chapter 2. Planning Area Profile

The Town of Harvard is located on the eastern end of the Montachusett Region in North Central Massachusetts. It is bordered by Ayer and Shirley to the north; Littleton, Boxborough, and Stow to the east; Bolton to the south; and Lancaster to the west. Devens is a regional enterprise zone and census-designated place which includes portions of the towns of Ayer, Shirley, and Harvard. Devens is the successor to Fort Devens. Harvard is located 22 miles northeast of Worcester, 31 miles northwest of Boston, 81 miles from Springfield, and 206 miles from New York City.

The Town of Harvard covers an area of approximately 27 square miles with a resident population of 6,520 according to the 2010 Census and 6,851 according to the 2020 Census; this represents an increase of 5% over ten years. Harvard has a population density of 254 people per square mile, up from 242 in 2010. There are 2,251 housing units in the town, up from 2,047 units in 2010; this represents an increase of 10% over ten years. The average household size was 2.76 people in 2010 and 3.02 in 2020. These figures demonstrate modest growth in Harvard from 2010 to 2020.

Harvard is characterized by colonial and Victorian homes, churches, town hall and library clustered around a historic common; winding roads lined with trees and often marked by stone walls; many historic farmhouses and several working apple and peach orchards in outlying areas; and the four centuries old village of Still River with its stunning western vistas.

Residents enjoy the intimacy of a small town, with its Fourth of July parade, Apple Blossom Festival and many other events, the majority of which take place in the vicinity of the historic town common. Another amenity is Bare Hill Pond, a 330-acre lake where swimming, sailing and canoeing lessons are offered in the summer and cross-country skiing and skating take place in winter. Over 2,000 acres of conservation land are located throughout the town, much of it interconnected by walking trails.

As noted in *The Impact of Climate Change on Agriculture: Harvard, Massachusetts* (June 2019), agriculture is an integral component of Harvard's economy, character, and sense of community. The large commercial operations such as Westward Orchards (273 acres), Doe Orchards (63 acres), and Carlson Orchards (123 acres) make a significant contribution both to Harvard's economy and the texture of its open space. However, agriculture in Harvard also consists of commercial farmers and hobbyists, both plant-based and animal-based, and conducted at large scales and small ones. Over 100 farms are in the town. This report included several key conclusions based on a survey of agricultural entities:

- The focus of farming in Harvard is fruit and vegetable production, primarily orchards. These include tree fruits, berry crops, grapes, and cool-weather crops.
- Smaller farms were more likely to have animals and livestock. Livestock included poultry and eggs, beekeeping, horses, ponies and mules, sheep and goats, hogs and pigs, and cattle and calves.

- Other than hay, field crops are not significant within the Town. However, some corn, grains, oilseeds, dry beans, and dry peas, and wheat production can be found.

Harvard's top four employers outside of Devens are Bromfield School, Enterprise Tech Inc., Eze Software Group, and the Hildreth School (Harvard Elementary School).

Development Trends

On March 31, 2016, the Planning Board voted to accept Harvard's Master Plan from the Master Plan Steering Committee. This vote culminated a four-year effort to prepare this important document that will shape the preservation and development of Harvard for ten years. The Master Plan consists of 2 parts: a Phase 1 report, Vision and Goals, and the Phase 2 report, The Master Plan. Phase 1 involved an extensive community participation process in which citizens expressed their opinions in workshops and a survey to help establish the broad objectives to guide the growth of Harvard in the coming decade. Phase 2 contains a detailed analysis of current conditions in Harvard and provides specific directions for how the Town can achieve its goals.

According to the Master Plan, Harvard added 69 single-family homes, 77 condominiums, and 42 senior apartments to its total housing supply from 2006 through 2016. The fact that multi-family condominiums and rental units surpassed the production of single-family homes is not indicative of a long-term trend, for many towns that experienced a shift in demand toward multi-unit dwellings and smaller housing units a decade ago and have since witnessed a reversion to single-family home development. Most multi-family housing in Harvard has developed via the comprehensive permit process, which is why the new condominiums and apartments include low- or moderate-income units. They provide an additional public benefit as well: on average, Harvard's multifamily units occupy just 0.38 acres per unit, compared with the 3.7 acres per unit for single-family homes. Nevertheless, it is worth noting that two-thirds of Harvard's affordable housing units (built with comprehensive permits) are located off Ayer Road north of Route 2, largely but not entirely in areas the Town has zoned for commercial uses.

The Municipal Vulnerability Preparedness report *Community Resilience Building Workshop Summary of Findings* (2019) notes that Harvard's residential development is "widely distributed and intermingled with undeveloped lands, the environmental impacts of this development will be felt across Harvard's ecosystems. As new buildings are built, the location of that development relative to existing development, town services, and natural resources should be carefully considered to maximize the use of existing infrastructure and minimize the impact on natural resources."

The Master Plan notes that Harvard has very little commercial development. The only noticeable commercial presence can be found in the Commercial (C) District, which extends along Ayer Road about 1.4 miles between Route 2 and the intersection of Ayer Road and Myrick Lane. Except for a

development of multiuse buildings at 188 Ayer Road created under a special permit provision that Harvard instituted
in 2004, businesses here are mostly in sprawled, single-unit structures on large paved lots interrupted by residential and agricultural uses and open space. This physical arrangement and low-density build-out makes the C District an auto-oriented area.

The Town believes that future development, especially in the next five years during the timeframe of this plan, will proceed like the last 10-15 years of development patterns. None of the anticipated growth will subject additional development to flood risks. However, additional development at the wildland interface will create additional risks to wildfire losses.

Environmental Justice Populations

According to the Massachusetts Environmental Justice (EJ) Viewer, one census tract in Harvard is an EJ tract: Block Group 6, Census Tract 7614; Criteria: Minority, with total minority population is 49%. This census tract is partly within Devens and entirely within Harvard. The median household income is $134,417, equal to 157 % of the Massachusetts median. Overall, Harvard has a median household income of $156,667, which is significantly higher than the median in the EJ tract. This information suggests that the income levels noted in the EJ viewer are not contributing to the inclusion of the single census tract as an EJ tract.

Water and Sewer Service

According to the *Community Resilience Building Workshop Summary of Findings,* the Town of Harvard relies primarily on private septic systems a very limited Town sewer district. Expanding the Town sewer system might be necessary if the Town wishes to add development; such expansion could address failing residential and commercial systems if that becomes an issue. The Town Center is served by a small public water system. Most of the town's properties are served by private wells. Some non-residential properties are served by their own small transient non-community and non-transient non-community water systems.

Critical Facilities

The previous edition of the plan noted that the term "critical facilities" is used to describe all manmade structures or other improvements that, because of their function, size, service area, or uniqueness, have the potential to cause serious bodily harm, extensive property damage, or disruption of vital socioeconomic activities if they are destroyed, damaged, or if their functionality is impaired.

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.

The previous edition of the plan noted that critical facilities commonly include all public and private facilities that a community considers essential for the delivery of vital services and for the protection of the community. They usually 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.

A list of the critical facilities in Harvard is provided below as Table 3. This list was obtained from the previous edition of the hazard mitigation plan and the MVP-funded Community Resilience Building (CRB) plan; and edited through a review by the HMPC in March and April 2022. Critical facilities located in Devens were listed in the previous plan but removed by the HMPC with the goal of condensing the list to represent only critical facilities in Harvard.

One unique nature of the Town of Harvard's critical facility list is that it includes several properties mainly because they are served by their own small transient non-community and non-transient non-community water systems (for example, Harvard Plaza). In a town with a more expansive public water system, some of these critical facilities would merely be categorized as essential facilities because they could presumably tolerate an extended power outage.

Table 3. Critical Facilities.

Facility	Address	Listed in Prior Plan?	In MVP CRB?	Standby Power?	Use or Comment
Harvard Town Hall	13 Ayer Road	Y			
Harvard Transfer Station	47 Depot Road	Y			
Harvard Wastewater Treatment Plant	59-83 Massachusetts Avenue	Y			
Harvard Post Office	215 Ayer Road	Y			
Harvard Public Library	9 Pond Road	Y	Y		
Harvard Public Library (Old)	7 Fairbanks Street	Y			
Harvard Public Safety Building	40 Ayer Road	Y		Y	
Harvard DPW	47 Depot Road	Y	Y	Y	
Fire Department Center Station Tower	13 Elm St	Y		Y	
Fire Department Center Station EOC	11 Elm Street	Y		Y	
Fire Department Still River Station	231 Still River Road	Y		Y	
Fire Station #1 (Old Ambulance Building)	13 Ayer Road	Y			
Harvard Ambulance Squad	40 Ayer Road	Y		Y	
Cell Tower	60 Old Shirley Rd	Y			
Cell Tower	47 Poor Farm Rd	Y			
Cell Tower	Brown Rd	Y			
Cell Tower	336 Old Littleton Road				
Bowers Brook Apartments	196 Ayer Road	Y			Elderly Housing
Bromfield School	14 Massachusetts Avenue	Y	Y	Y	Shelter, cooling, and heating

Facility	Address	Listed in Prior Plan?	In MVP CRB?	Standby Power?	Use or Comment
Camp Green Eyre Girl Scout Camp	65 Still River Road	Y			Listed because it's a PWS*
Carlson Orchards Alt. Cell Tower	115 Oak Hill Road	Y		Y	Comm Tower
Carlson Solar Farm	115 Oak Hill Road	Y			Solar Field
Concord Hillside Medical Associates	16 Lancaster City Road	Y			Listed because it's a PWS*
Congregational Church	5 Still River Rd	Y			Church
DCR Fire tower	44 Pinnacle Road	Y		Y	Comm Tower
Dunkin Donuts	188 Ayer Road	Y			Listed because it's a PWS*
Foxglove Apartments	253 Ayer Road	Y			Elderly Housing
Friendly Crossways	247 Littleton Cty Road	Y			Listed because it's a PWS*
Fruitlands Museum	102 Prospect Hill Road	Y			Listed because it's a PWS*
Harvard Plaza	285 Ayer Road	Y			Listed because it's a PWS*
Hildreth Elementary School	27 Massachusetts Avenue	Y	Y	Y	Cooling and heating center
Hildreth House (was Council on Aging, will become Town Offices)	15 Elm Street	Y	Y		Possibly a Cooling and heating center
Hillside Garage	36 Ayer Road	Y			"Other Critical Facility"
Immaculate Heart of Mary	282 Still River Road	Y			School
Offices At Harvard Park LLC	200 Ayer Road	Y			Listed because it's a PWS
Harvard Solar Garden	295 Ayer Road				Solar Field

Facility	Address	Listed in Prior Plan?	In MVP CRB?	Standby Power?	Use or Comment
St. Benedicts Church	252 Still River Road	Y			Church
St. Theresa's Church	17 Still River Road	Y			Church
The Appleworks	325 Ayer Road	Y			Listed because it's a PWS
Unitarian Church	9 Ayer Road	Y			Church
Verizon Station	4 Littleton Rd	Y			HazMat Site/Communications
Village Nursery School	40 Poor Farm Road	Y			Early Ed & Child Care
Bolton Road Rock Well #3 (03g)	Bolton Road	Y			Water Supply
Bolton Road Water Tower	Bolton Road	Y			Water Storage
Pond Road Rock Well #2 (02g)	Pond Road	Y			Water Supply
Pond Road Rock Well #5 (05g)	Pond Road	Y			Water Supply

**As stated in 310 CMR 22.02, a Public Water System means a system for the provision to the public of piped water for human consumption if such system has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days of the year" (Mass GIS, 2014).*

According to the *Community Resilience Building Workshop Summary of Findings* (2019), the lack of designated cooling and warming shelters for extreme temperature events is a significant vulnerability for the community. Air conditioners and generators are present at the library and the police training room, but neither has the capacity to hold a large number of people. The distribution of fire stations and the location of the Department of Public Works (DPW) can limit the capacity for emergency response, especially if major roads are blocked by fallen trees. While Harvard is close to Nashoba Valley Medical Center, Emerson Hospital, and several urgent care centers in neighboring towns, no medical centers are located within the Town.

A final major infrastructure vulnerability identified by the report is the state of utility systems. Power lines are highly susceptible to damage from fallen branches and trees during storm events. Coupled with the inadequate number of alternative power sources (generators and batteries) in Harvard, this has been known to lead to town-wide power failures and road closures.

Critical Transportation Infrastructure

A list of the critical overpasses, underpasses, and bridges is provided below as Table 4. This list was obtained from the previous edition of the hazard mitigation plan and edited through a review by the local planning team in March and April 2022.

Table 4. Critical Transportation Infrastructure.

Facility	Address	Listed in Prior Plan?	Use or Comment
Old Littleton Road overpass/Route 2	Old Littleton Road	Y	Overpass
Poor Farm Road overpass/ Route 2	Poor Farm Road	Y	Overpass
Railroad Overpass	Rail Line & Nashua River (Depot Rd)	Y	Overpass
Route 110/111 overpass/Route 2	Ayer Road	Y	Overpass
Stow Road underpass/Route 495	Stow Road	Y	Overpass
Littleton Road overpass/Route 2	Littleton Road	Y	Overpass
Depot Road underpass/Route 2	Depot Road	Y	Underpass
Barnum Bridge	West Main Street at Ayer/Shirley	Y	Bridge with water

Dams

The DCR Office of Dams Safety lists 11 dams in the Town of Harvard as shown in Table 49. Bare Hill Pond Dam and Horse Meadows Dam are classified as significant hazards.

High hazard dams must be inspected every two-years, significant hazard every five years, and low Hazards dams every 10 years. Owners of dams are responsible for having their dam inspected. MGL Chapter 253 and 302 CMR 10.00 requires that dam owners prepare, maintain and update Emergency Action Plans for all High Hazard Potential dams and certain Significant Hazard Potential dams.

Table 5. Dams.

Dam	Hazard Code	Owner
Elizabeth Pond Dam	Low Hazard	Private
Saw Mill Pond Dam	N/A	Private
Old Mill Pond Dam	N/A	Private
Burt Mill Pond Dam	N/A	Private

Lower Wegatepa Pond Dam	N/A	Private
Farm Pond Dam	N/A	Public
Fish Pond Dam	N/A	Public
Water Supply Reservoir Dam	N/A	Public
Old Reservoir Dam	N/A	Public
Bare Hill Pond Dam	Significant Hazard	Public
Horse Meadows Dam	Significant Hazard	Private

*N/A – Information not available as the dam is non-jurisdictional.

Non-jurisdictional dams are not regulated by the Office of Dam Safety or under their jurisdiction. Typically, these dams are under 6 feet in height and/or under 15 acre-feet in storage and do not have an assigned 'Hazard Code'. Dams owned and regulated by the Federal Government are also typically non-jurisdictional but DO have an assigned Hazard Code.

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 Plan Review Guide (dated October 1, 2011)

The Federal Emergency Management Agency's recently released; Local Mitigation Planning Policy Guide (Released April 19, 2022, Effective April 19, 2023) was considered but all requirements may not be included. 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 through 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 March 2022 and concluded in August 2022 (this does not include the months of plan review and adoption). The Town developed a Municipal Vulnerability Preparedness (MVP) Program summary of findings in 2019. This planning effort contributed to the update of the mitigation plan. Below is a graphical display of the plan development timeline. The months with one check mark indicate a Hazard Mitigation Planning Committee (HMPC) meeting was held and the months with two check marks indicate that a public meeting was also held. The Director of Community and Economic Development served as the point person for this project until he left the position, and the Fire Chief became the lead. This person facilitated all activities related to the mitigation plan update, including meeting logistics, data gathering, and public outreach.

Table 6. Planning Process Timeline.

Project Tasks	Feb 2022	Mar 2022	Apr 2022	May 2022	Jun 2022	Jul 2022	Aug 2022
1. Convene Hazard Mitigation Planning Committee		✓	✓✓	✓		✓✓	
2. Create/Update Hazard Profiles for Each Hazard							
3. Facility Inventory							
4. Vulnerability							
5. Mitigation Goals							
6. Actions							
7. Maintenance							
8. Public Review of Draft							
9. Review and Approval							

Hazard Mitigation Planning Committee

A Hazard Mitigation Planning Committee (HMPC) was formed to support the planning process. This team included Town employees. Key stakeholders, such as Neil Angus, Environmental Planner, Devens Enterprise Commission were invited to meetings but not considered a part of the HMPC. A list of HMPC members is shown in the list below. The HMPC met four times, March 4, 2022, April 13, 2022, May 24, 2022, and June 16, 2022. All the meetings were conducted via Zoom due to the Covid-19 Pandemic, however sometimes Town employees gathered at the Town offices. It should be mentioned that members from the Harvard Climate Initiative Committee participated in all HMPC meetings and actively participated in the development of this plan. A list of participants at each of these meetings is included in Appendix A.

- James Babu, Police Chief
- Jeff Hayes, Building Official
- Timothy Kilhart, Department of Public Works Director
- Pat Natoli, Public Safety Administrator

- Christopher Ryan, Director of Community and Economic Development
- Richard Sicard, Fire Chief

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, **March 4, 2021**, was an opportunity for Christopher Ryan, Director of Community and Economic Development and the Consulting Team to introduce the project and expectations for the HMPC. These included providing supporting data, identifying, and prioritizing mitigation actions, conducting public outreach, and reviewing the draft and final mitigation plan. Lucy Wallace, a member of the Climate Initiative Committee (CIC), participated in the meeting and described the Climate Action Plan being developed in Harvard. When discussing who else to include on the HMPC, it was determined by the Town Administrator to keep the HMPC small, and to engage a larger audience as needed. This larger audience included schools, ambulance service, and the Lucy Wallace, President, Nashua River Watershed Association. Also discussed at length was the Town of Devens. Devens is managed by MassDevelopment, the state's finance and development agency. Devens is recognized as a model for military base reuse. Devens includes several prisons. The Town of Harvard does not have jurisdiction in Devens but does work closely with them. During this meeting the HMPC agreed to add invasive species, and infectious disease to the list of hazards studied in the Hazard Mitigation Plan. They agreed to organize the hazards by Primary Climate Change Interaction for consistency with the SHMCAP.

The second HMPC meeting, **April 13, 2022**, gave the consulting team an opportunity to show initial hazard maps, to discuss the critical facility list in more detail, and to discuss hazard occurrences since the previous plan was written. The group reviewed the list of critical facilities and agreed to remove those in Devens. They added the Hildreth Elementary School as a shelter because it has a generator and may be considered a shelter in the future. The Council on Aging is scheduled to have a new building. The current Council on Aging has been used as a warming and cooling center. Infrastructure added to the critical facility list included wells on Pond Road. A discussion about hazard occurrences included flooding on Eldridge Road, drought impacts that included fire ponds drying-up, trees down, a microburst and invasive species. The Town has done extensive management of invasive species on conservation lands.

The third HMPC Meeting, **May 24, 2022**, gave the consulting team an opportunity to share results from the risk and vulnerability assessment and the capability assessment. The group discussed the potential impact of heavy rains on areas that have culverts which need upgrading. The HMPC encouraged the consulting team to review the Apple Country report which identifies culverts in need of repair. When discussing capabilities, the HMPC reported that they have pushed zoning updates to 2023. The HMPC reviewed the previous plan's goal statements and decided to add a mission statement to their plan which state's, "Reduce or eliminate risk to people, property, and infrastructure from natural hazards and climate change." They then added three goals that included critical facilities and infrastructure, public education and outreach, and capacity building and planning. The meeting concluded with discussion about ranking hazard mitigation actions.

The final HMPC Meeting, **June 16, 2022**, provided an opportunity to review the final list of mitigation actions and their priority ranking. In addition, the HMPC discussed outreach for the final public meeting and for plan review. The HMPC agreed to place hard copies of the plan in the Town Clerk's office and in the library. They agreed to post a copy of the recorded public meeting on the Town's website. Digital versions of the plan were to be posted on the Fire Department's website, the Town Website, and the Climate Initiative group site. The Council on Aging agreed to put a notice in their monthly newsletter.

The HMPC also participated in two public meetings, one on April 14, 2022, and one on June 30, 2022. These were also attended via Zoom. Finally, the HMPC reviewed the draft Town of Harvard, MA Hazard Mitigation Plan Update prior to sending it to the Massachusetts Emergency Management Agency (MEMA) for their review in late July 2022.

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 public in the mitigation planning process. The purpose of public outreach and stakeholder involvement 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

The public outreach strategy included two Public Meetings, and an opportunity for the public to review the draft plan. Both meetings were hosted virtually due to the Covid-19 pandemic. Each meeting included a PowerPoint presentation and plenty of opportunity for questions and discussion. In addition, Mentimeter was used to facilitate input from meeting participants. 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. The meetings were advertised by the Town by way of the Town website (see image below), by email invitation to key stakeholders, and through department announcements. A list of participants and copies of outreach materials for each meeting are included in the Appendix A.

Figure 3. Public Meeting for 4/14/2022 Announcement.

The first public meeting occurred on April 14, 2022, and over 20 people participated. This meeting emphasized identification of hazards and critical facilities. Participants gave feedback regarding what they have noticed in terms of climate change and how the Town can address these changes. When asked, “what buildings, organizations, or infrastructure, do people rely on?” the follow responses were captured.

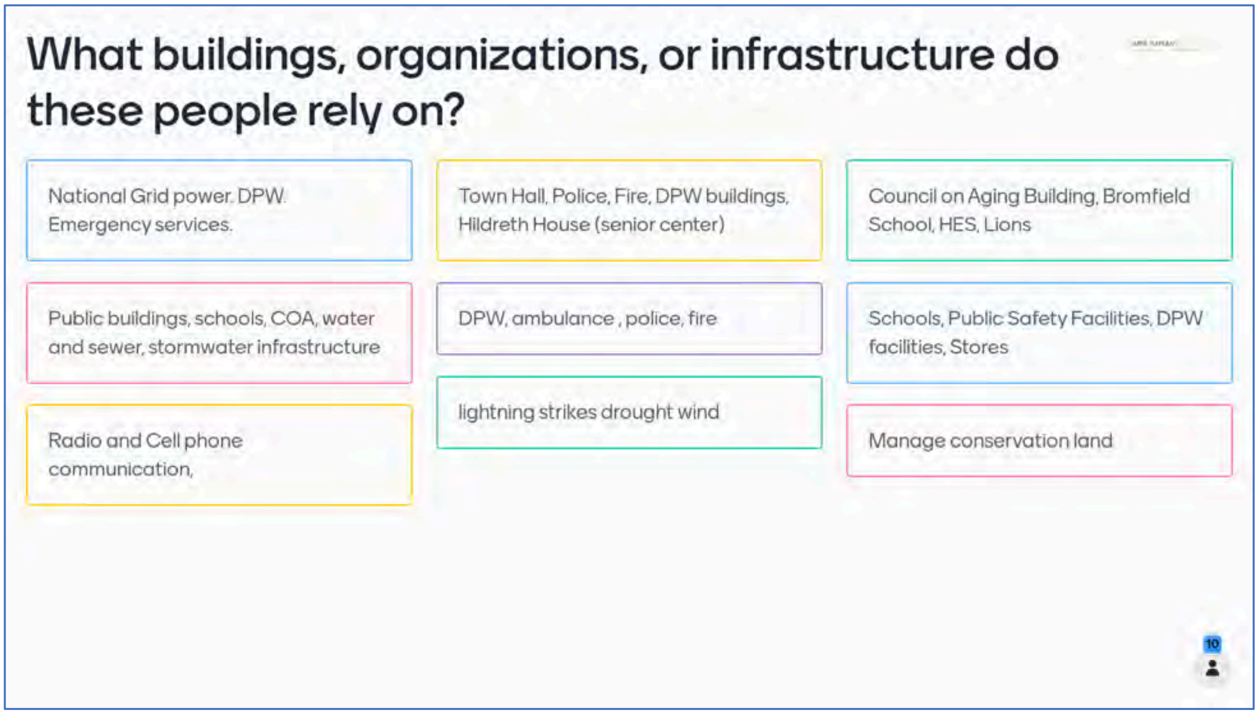


Figure 4. Public Meeting Critical Facilities and Infrastructure Identification.

When asked about weather related hazards that may impact identified buildings or infrastructure, the following results were captured.

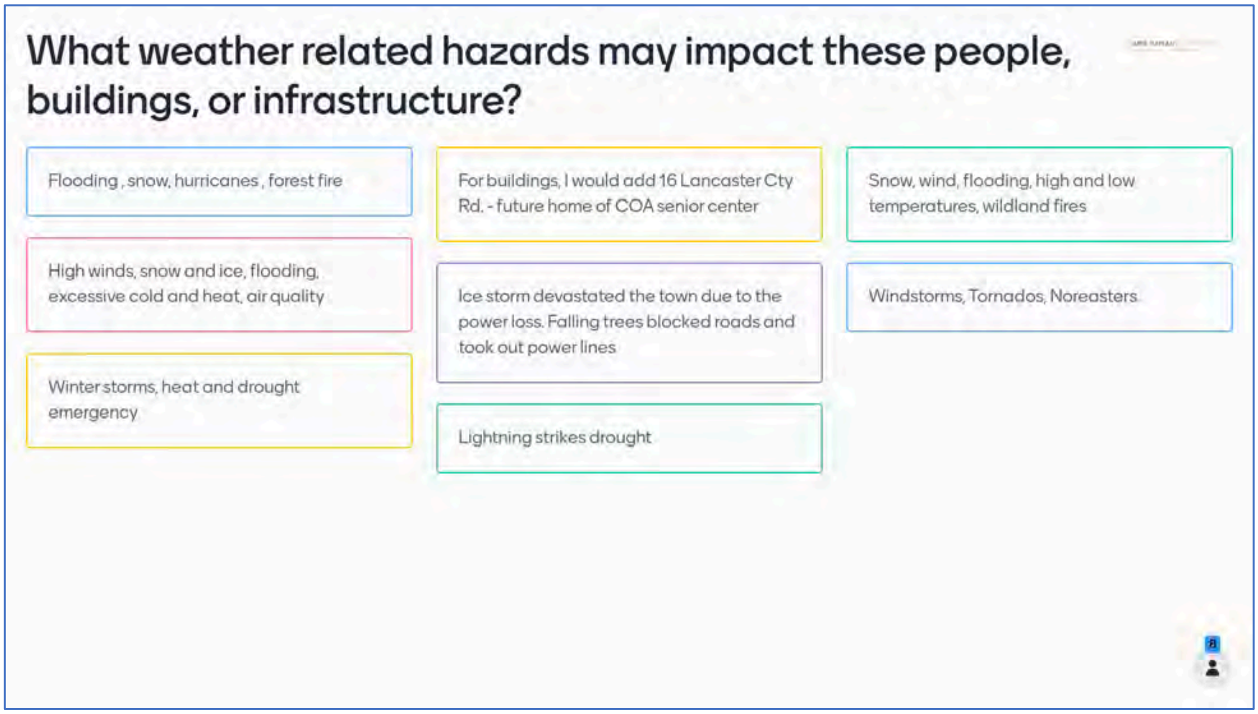


Figure 5. Public Meeting Natural Hazard Identification Responses.

The concept of hazard mitigation was introduced to meeting participants and then they were asked, "what can be done to lessen the impact of natural hazards on people, buildings, and infrastructure?" Responses to this question included:

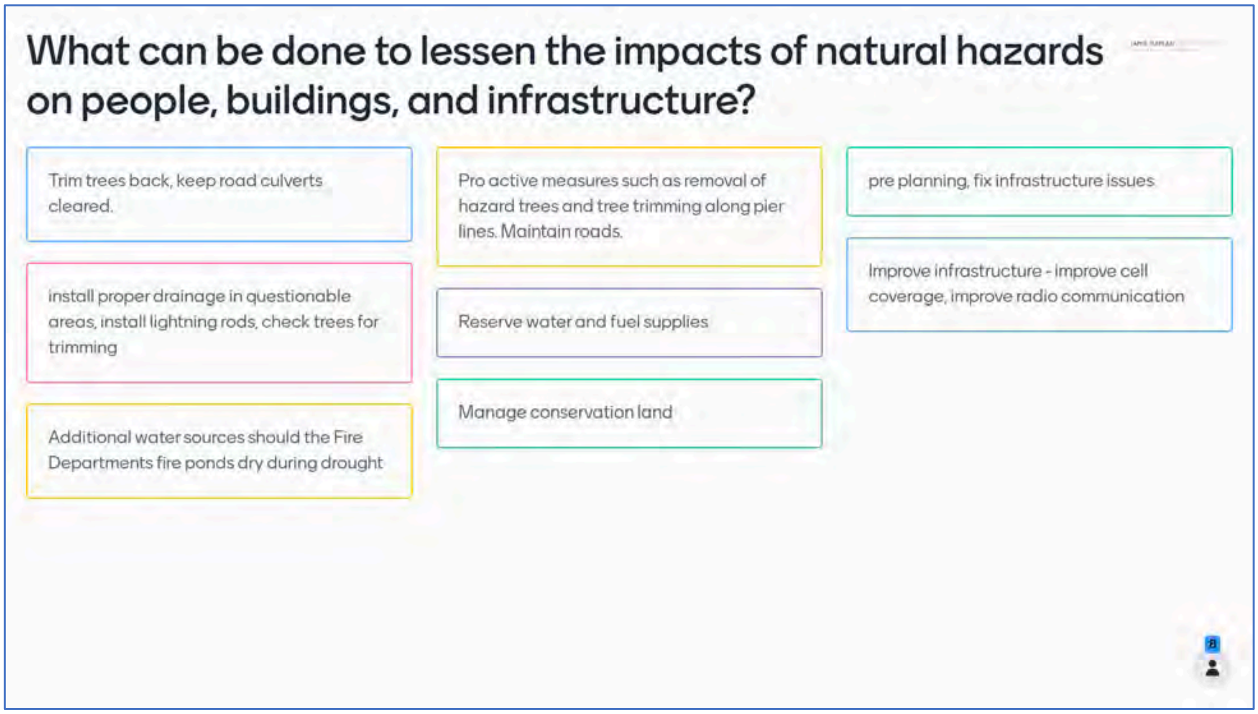


Figure 6. Public Meeting Mitigation Suggestions.

The second public meeting occurred on June 30, 2022, twenty-five people participated in this meeting. A similar set of questions, to the first public meeting, was asked to stimulate public participation. In addition, more specifics regarding hazard identification and mitigation actions were discussed. To identify high hazard areas, the public were asked, “which areas of Harvard are most susceptible to natural hazards?” Their responses are in the figure below.

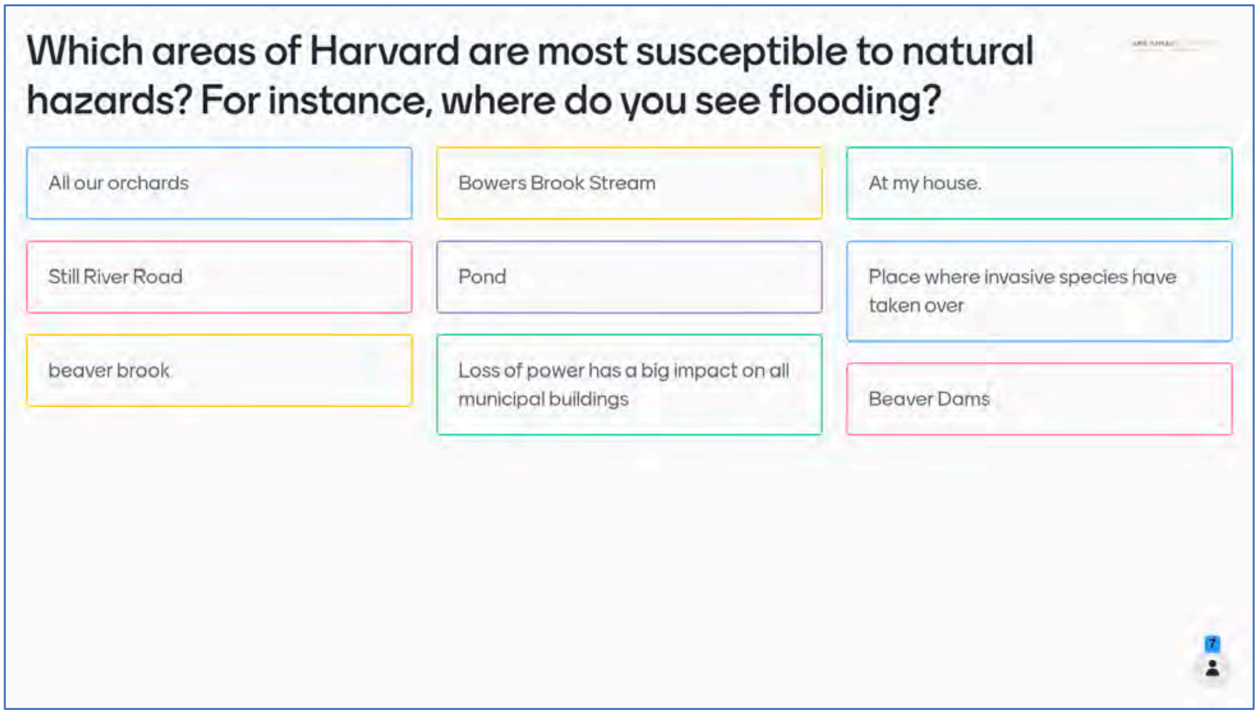


Figure 7. Public Meeting High Hazard Area Responses.

Prior to introducing meeting participants to the list of mitigation actions developed by the HMPC, participants were asked, "what can be done to make Harvard more resilient to natural hazards and climate change?" Responses spanned two slides, the first is shown below.

Figure 8. Public Meeting Mitigation Action Identification Responses.

To close the meeting, participants were encouraged to mitigate risk on their own properties. They identified the following actions as potential ways residents could make their homes or businesses more resilient.

- Solar panels
- Clear hazard trees
- Heat pump
- Use gray water
- Be aware of vulnerable neighbors
- Cut down dead trees and invasive plants
- Have back-up power and supplies for two weeks

To give neighboring communities and regional agencies an opportunity to participate in the planning process, the HMPC sent personal invitations to their contacts in the Towns of Boxborough, Littleton, and Bolton. They also reached key stakeholders who participated in the planning process including Neil Angus, Environmental Planner, Devens Economic District, the Lucy Wallace, President, Nashua River Watershed Association, volunteer trustees and associate trustees, Harvard Conservation Trust, Ellen Sachs Leicher, Chair, Climate Initiative Committee and member Lucy Wallace. These stakeholders, including the Montachusett Regional Planning Commission (MRPC) were invited to review the draft plan.

Review of Draft Plan

The Town made the plan available for public review beginning August 8, 2022. A press release announcing the availability to review the plan was sent and the announcement was posted to the Town website. The HMPC also sent emails to stakeholders announcing the ability to review the plan. Announcements were also posted on social media and mentioned in meetings with stakeholders and the public. The Fire Chief collected comments from the public. Comments were collected from the Director of the Harvard Council on Aging (COA) and from a couple of representatives from the Harvard Climate Initiative Committee (HCIC). The COA Director had a couple of questions about wording and critical facility use. The Planning Process was amended to emphasize the level of involvement by the HCIC throughout the planning process. Corrections to the Capability Assessment were made to reflect current activities such as the addition of the Bare Hill Watershed Management Committee. All comments from the Fire Chief, the Council on Aging and the Harvard Climate Initiative Committee were incorporated throughout the plan.

Chapter 4. Risk and Vulnerability Assessment

Hazard Identification

The first step in the risk assessment was to revisit and evaluate the hazards identified for study and inclusion the Town's previous 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 recent Municipal Vulnerability Preparedness (MVP) planning effort, as well as the 2018 State Hazard Mitigation and Adaptation Plan (SHMCAP).[8] As a result of this process all hazards from the 2015 plan remain included in this updated assessment except for major urban fire, which was noted as a low risk and not profiled in the previous risk assessment. For this updated assessment, some hazards have been consolidated or renamed to be consistent with the SHMCAP, as further described below.

The top four natural hazards identified for the MVP effort are thoroughly covered in this assessment, which include pests/invasive species, extreme precipitation, extreme temperatures and temperature swings, and ice storms. In addition to the hazards carried forward from the previous plan, two new hazards have been identified and incorporated into the assessment, Infectious Disease and Invasive Species. Infectious disease was added based on the local impacts of the Covid-19 pandemic as well the community's growing concern for pests and vector-borne diseases. Invasive species was added to reflect the concern for this becoming a more prevalent hazard with projected climate changes and so that the risk assessment is aligned with the SHMCAP.

With the addition of invasive species, all relevant hazards as identified in the SHMCAP were considered and addressed in this risk assessment for Harvard. Due to the community's inland location, coastal hazards identified in the SHMCAP are not included (such as sea level rise, coastal flooding, coastal erosion, and tsunami).

To better reflect the relationship between natural hazards and changing climate and weather patterns, each of the individual hazards identified for the updated risk assessment have been reorganized and categorized according to their primary interaction with climate change. These new categories are consistent with the SHMCAP and include the following:

- Changes in Precipitation

[8] Massachusetts State Hazard Mitigation and Climate Adaptation Plan. 2018.

- Rising Temperatures
- Extreme Weather
- Non-Climate Influenced Hazards

Individual hazards are also grouped within each category according to their primary hazard (for example, all flooding-related hazards are listed under "Flooding" in the Changes in Precipitation category). This includes specific hazards as identified in the Town's previous plan as shown in *italics* in Table 7 below. This new classification for identified hazards was done for the plan update to consolidate and be consistent with the state's current hazard classification scheme per the SHMCAP.

Table 7 provides an abbreviated list of the 12 primary hazards included in the update risk assessment.

Table 7. Town of Harvard's Hazards.

Primary Climate Change Interactions	Hazards
Changes in Precipitation	Flooding *(including heavy rain, snow melt, dam failure, ice jams, beavers, etc.)* Drought Landslide
Rising Temperatures	Average/Extreme Temperatures Wildfires Infectious Disease Invasive Species
Extreme Weather	Hurricanes/Tropical Storms Severe Winter Storm/Nor'easter *(including heavy snow, ice storms, blizzard)* Tornadoes Other Severe Weather *(including high winds, severe thunderstorms, etc.)*
Non-Climate Influenced Hazards	Earthquake

Hazard Profiles

B1. Does the Plan include a description of the type, location, and extent of all natural hazards that can affect each jurisdiction(s)? (Requirement §201.6(c)(2)(i))

B2. Does the Plan include information on previous occurrences of hazard events and on the probability of future hazard events for each jurisdiction? (Requirement §201.6(c)(2)(i))

B3. Is there a description of each identified hazard's impact on the community as well as an overall summary of the community's vulnerability for each jurisdiction? (Requirement §201.6(c)(2)(ii))

The risk assessment for the Massachusetts State Hazard Mitigation and Climate Adaptation Plan (SHMCAP) describes the natural hazards that have the potential to impact the Commonwealth, providing the underlying narrative for this hazard profile for the Town of Harvard. This section is organized by climate change interaction category, consistent with the SHMCAP. Because this section repeats information from the SHMCAP, some citations have been removed for brevity. The original citations can be found in the SHMCAP.

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 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 ten-year lookback (2012 through 2021)* ending with the date of plan development (2022). 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.

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.

Primary Climate Change Interaction: Changes in Precipitation

Flooding Including Dam Failures and Ice Jams

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. In an inland community such as Harvard, flooding is the result of moderate precipitation over several days, intense precipitation over a short period, or melting snowpack. Increases in precipitation and extreme storm events will result in increased inland flooding. Common types of flooding are described below.

> The Town of Harvard Community Resilience Building Workshop Summary of Findings (June 2019) lists "Extreme Precipitation" as one of the top four hazards of concern.

Description

<u>Riverine Flooding</u>: Riverine flooding often occurs after heavy rain. Areas of the state with high slopes and minimal soil cover (such as found in western 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 as a result 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.

<u>Drainage-Related Flooding</u>: 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.

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 super-cooled 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.

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 the 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. Alteration of the landscape by beavers is a natural process that creates habitat for shore birds, mammals, and rare amphibians. However, beaver ponds can flood structures, roads, and utilities, causing costly and potentially dangerous situations. Beaver activity can also pollute drinking water supplies. Mitigation measures suggested by Massachusetts Division of Fish and Wildlife (MassWildlife) and other agencies can help communities and homeowners deal with nature’s master builders. Until 1996, when a ballot initiative passed restricting the practice, Massachusetts residents were permitted to trap beavers. That change in policy caused a spike in the beaver population, which, in turn, led to a sharp increase in complaints about beaver activity and its effects. The law was modified in 2000 so that town Board of Health members could issue emergency trapping permission outside of the usual trapping season. State law makes it illegal for any person to disturb or tear open a beaver dam or beaver lodge without written permission from MassWildlife and the local Conservation Commission or Department of Environmental Protection. Permits are needed to disturb a beaver dam for any reason in Massachusetts. Even dams that cause flooding require permits to be breached.

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, riverine flooding and drainage-related flooding affect the majority of the communities in the Commonwealth, including Harvard. Dam failure has the potential to impact areas downstream of dams, including river corridors in Harvard. Ice jams, if they occurred, would be limited to a short segment of the Nashua River that forms the town line.

Previous Occurrences

The Town's previous hazard mitigation plan (developed for the Montachusett Region) notes that the flood of March 2010 caused the Nashua River to experience its worst flood in decades, resulting in substantial flooding in Lancaster, adjacent to Harvard along the river.

As noted earlier, this plan update relies primarily on a ten-year lookback (2012 through 2021) ending with the date of plan development. From 2012 through 2021, none of the disaster declarations in Massachusetts that cover Worcester County were related to flood impacts in Worcester County. Likewise, the NOAA Storm Events database (https://www.ncdc.noaa.gov/stormevents/) does not list any flood events affecting Harvard in that timeframe.

According to the previous edition of this plan, ice jams have not occurred along the Nashua River near Harvard. However, the branch of the Nashua River in Leominster experienced ice jams in the past. Dam failures have not impacted Harvard.

Notwithstanding the relative quiet in the last ten years, flood risks have not decreased in Harvard, and critical infrastructure such as roadways will remain at risk.

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 each 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. 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 NWS's 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 river, can be less predictable. However, potential hazard areas can be warned in advanced 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.

Dams are a special consideration within the Extent characterization for floods. prepare, maintain, and update Emergency Action Plans. Many dams in Massachusetts were built in the 19th Century without the benefit of modern engineering design and construction oversight. Dams can fail because of structural problems due to age and/or lack of proper maintenance. Dam failure can also be the result of structural damage caused by an earthquake or flooding brought on by severe storm events. The Massachusetts Department of Conservation and Recreation (DCR) is the agency responsible for regulating dams in the state (M.G.L. Chapter 253, Section 44, and the implementing regulations 302 CMR 10.00). The DCR was also responsible for conducting dam inspections until 2002, when state law was changed to place the responsibility and cost of inspections on the owners of the dams. In accordance with the new regulations, which went into effect in 2005, dam owners must register, inspect, and maintain dams in good operating condition. Owners of High Hazard Potential dams and certain Significant Hazard Potential dams are also required to prepare, maintain, and update Emergency Action Plans. The state has three hazard classifications for dams:

- High Hazard Potential: Dams located where failure or improper operation will likely cause loss of life and serious damage to homes, industrial or commercial facilities, important public utilities, main highways, or railroads.
- Significant Hazard Potential: Dams located where failure or improper operation may cause loss of life and damage to homes, industrial or commercial facilities, secondary highways or railroads or cause interruption of use or service of relatively important facilities.
- Low Hazard Potential: Dams located where failure or improper operation may cause minimal property damage to others. Loss of life is not expected.

Owners of dams are required to hire a qualified engineer to inspect and report results using the following inspection schedule:

- High Hazard Potential dams – 2 years
- Significant Hazard Potential dams – 5 years

- Low Hazard Potential dams – 10 years

The time intervals represent the maximum time between inspections. More frequent inspections may be performed at the discretion of the state. Owners of High Hazard Potential dams and certain Significant Hazard Potential dams are also required to prepare, maintain, and update Emergency Action Plans (EAPs). Dams and reservoirs licensed and subject to inspection by the Federal Energy Regulatory Commission (FERC) are excluded from the provisions of the state regulations provided that all FERC-approved periodic inspection reports are provided to the DCR. FERC inspections of high and significant hazard projects are conducted on a yearly basis. All other dams are subject to the regulations unless exempted in writing by DCR.

Probability of Future Events

The frequency of hazard events of disaster declaration proportions is defined by the number of federally declared disaster events for the Commonwealth over a specified period of time. The historical record indicates the Commonwealth has experienced 22 coastal and inland flood-related disaster declaration events from 1954 to 2017. In the northeast, precipitation has increased by 17% from the baseline level recorded in the period from 1901 to 1960 to present-day levels measured from 2011 to 2012. Therefore, based on these figures, the Commonwealth may experience a flood event of disaster declaration proportions approximately once every three years.

However, the frequency of flooding varies significantly based on watershed, riverine reach, and location along each reach. Additionally, it is important to note that floods of lesser magnitude occur at a much higher frequency. The SHMCAP notes that in the ten-year period 2007 to 2017, the NOAA Storm Events Database reports that there were 433 flood events in Massachusetts, which is an average of more than 43 floods per year. The Town of Harvard should assume that the probability of future flood events is moderate to high. However, given the characteristics of the Nashua River and other streams in Harvard, the probability of ice jams is low.

According to information from the MA DCR Office of Dam Safety, 11 dams are in Harvard, and two (Bare Hill Pond Dam and Horse Meadows Dam) are rated as significant hazard. Harvard has not been impacted by a dam failure in recent history. However, residents located downstream of Bare Hill Pond Dam, Horse Meadows Dam, or a dam of lesser hazard class could be at risk if a failure were to occur. This type of event has a low probability. Overall, dam failure has a low probability of occurring.

Vulnerability Assessment

Exposure

In Harvard, the 1% annual chance floodplain (100-year floodplain) covers about 2,080 acres, or approximately 12 percent of the town. In addition to the 100- year floodplain, there are streams and ponds in Harvard with the potential to cause localized flooding including Bowers Brook, Cold Spring

Brook, Willow Brook, and Bare Hill Pond. The Harvard 2019 Community Resilience Building Workshop identifies undersized culverts and lower capacity water retention areas along Patton Road and Barnum Road as concerns for the community.

There are currently no critical facilities located in the 100- or 500-year floodplain. There are 20 buildings in the 100-year floodplain and 32 buildings in the 500-year floodplain. None of these buildings are part of an environmental justice community. Table 9 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 9. Buildings in 100-Year Floodplain

Building Type	Number of Buildings (Total in Town)	Building Value (Total in Town)
Single Family	12 (2,470)	$2,704,600 ($871,871,300)
Multi-Family	4 (376)	$1,398,500 ($213,219,100)
Commercial	0 (86)	$0 ($32,313,900)
Educational	0 (21)	$0 ($32,207,300)
Government	0 (56)	$0 ($37,111,900)
Religious/Non-Profit	4 (58)	$329,236 ($42,072,100)
Agriculture	0 (24)	$0 ($1,864,400)
Total	**20 (3,091)**	**$4,432,336 ($1,230,660,000)**

The population exposed to the 100-year floodplain is shown in Table 10. The column in 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 (not including Devens). There is a younger and older population exposed to the flood hazard. A larger Asian population is exposed to the flood hazard than Town average and language considerations should be considered.

Table 10. Population Exposed to 100-Year Floodplain (2020 U.S. Census)

Population in and Adjacent to Floodplain	Total Population
Population: 2,641	Population: 5,461
Households: 1,043	Households: 2,093
White: 2,211 (83.7%)	White: 4,637 (85.0%)
Black: 33 (1.2%)	Black: 62 (1.1%)
American Indian: 5 (0.2%)	American Indian: 10 (0.2%)
Asian: 217 (8.2%)	Asian: 366 (6.7%)
Other Race: 41 (1.6%)	Other Race: 67 (1.2%)
Two or More Races: 134 (5.1%)	Two or More Races: 319 (5.8%)
Hispanic or Latino: 73 (2.8%)	Hispanic or Latino: 163 (3.0%)
Population under 18: 707 (26.8%)	Population under 18: 1,469 (26.9%)
Population over 64: 509 (19.3%)	Population over 64: 1,036 (19.0%)

Population in and Adjacent to Floodplain	Total Population
Annual Income < $30K/year: 74 (7.1%)	Annual Income < $30K/year: 144 (6.9%)
Population in EJ Zone: 0 (0%)	Population in EJ Zone: 0 (0%)

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.

Although, there aren't any high hazard dams in Harvard, there are significant dams in and around the Town which may cause damage if breached. Table 11 shows the dams in Harvard.

Table 11. Dams in Vicinity

Name	Ownership	Hazard Type
Bare Hill Pond Dam	Public (Town of Harvard)	Significant
Horse Meadows Dam	Private	Significant
Elizabeth Pond Dam	Private	Low
Farm Pond Dam	Public (Town of Harvard)	N/A
Fish Pond Dam	Public (Town of Harvard)	N/A
Water Supply Reservoir Dam	Public (Town of Harvard)	N/A
Old Reservoir Dam	Public (Town of Harvard)	N/A
Saw Mill Pond Dam	Private	N/A
Old Mill Pond Dam	Private	N/A
Burt Mill Pond Dam	Private	N/A
Lower Wegatepa Pond Dam	Private	N/A

The 100-year Floodplain (FEMA) with the Town's critical facilities is shown in Figure 9. None of the critical facilities are found in the 100-year floodplain. However, there are two buildings from the Girl Scout Camp and the St. Benedict Priory are found in the 100-year floodplain. There are additional impacts in Devens to a medical facility and a water utility as well. These impacts are in an environmental justice community.

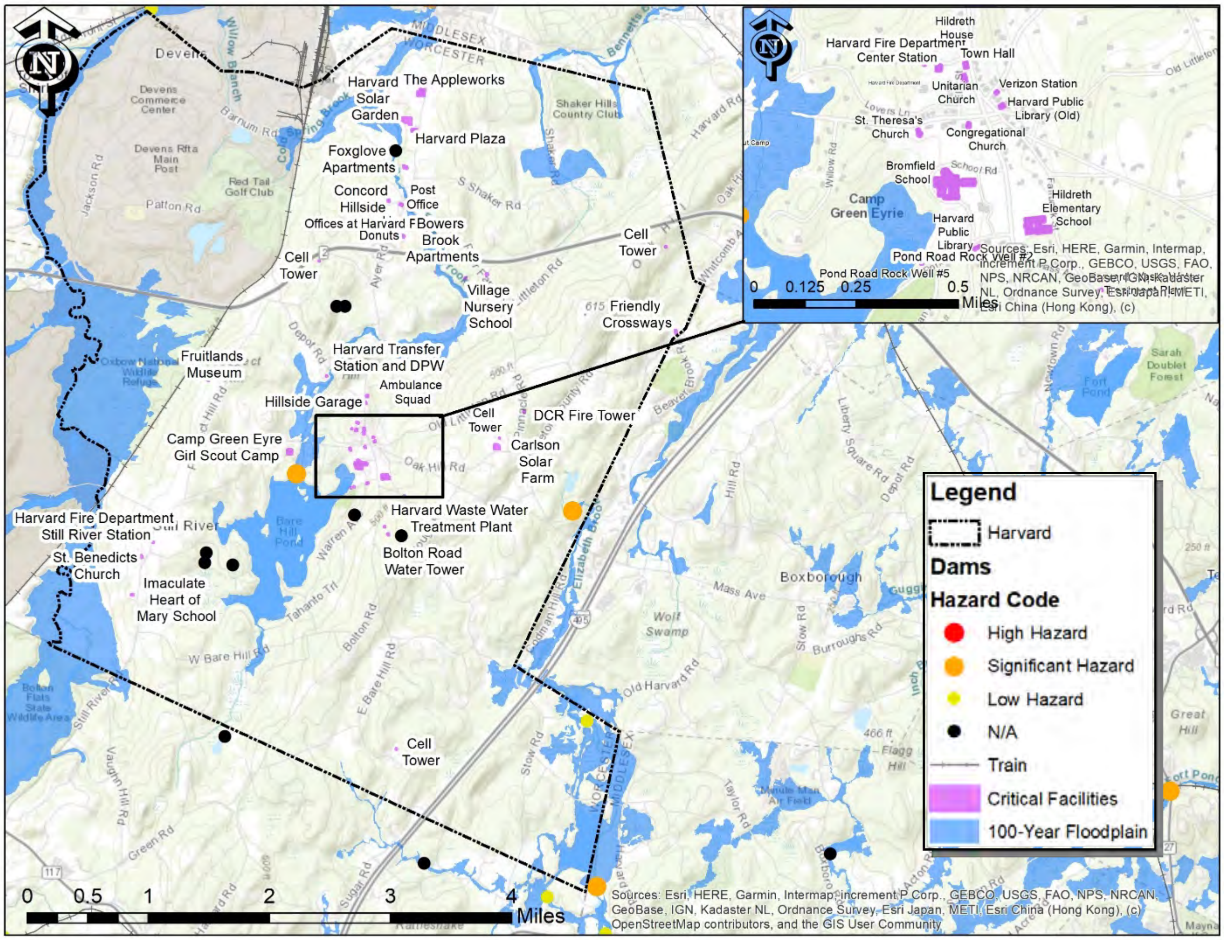


Figure 9: Harvard Critical Facilities and 100-Year Floodplain

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 12. The Town's Average Annual Loss (AAL) is calculated to be $137,400.

Table 12. Building Loss for the 100-Year Flood Scenario

Loss Type	**Residential ($Million)**	**Commercial ($Million)**	**Other Occupancy ($Million)**	**Total ($Million)**
Building Loss	3.48	0.74	0.56	**4.78**
Content Loss	1.66	1.67	1.04	**4.37**

Loss Type	Residential ($Million)	Commercial ($Million)	Other Occupancy ($Million)	Total ($Million)
Business Inventory Loss	0.00	0.02	0.11	**0.13**
Business Income Loss	0.03	1.06	0.18	**1.27**
Business Relocation Loss	0.43	0.18	0.09	**0.7**
Rental Income Loss	0.14	0.13	0.01	**0.28**
Wage Loss	0.08	0.94	1.19	**2.21**
Total	**5.82**	**4.74**	**3.18**	**13.74**

Population Impacts

The Town should be aware that senior and low-income segments of Harvard'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. Table 10 shows the number of senior and low-income residents in Harvard. 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 less than 20 displaced households and minimal public shelter needs.

Environment Impacts

One of the major environmental impacts of a major flood would be the potential release of hazardous materials. Although most of the major buildings have been built out of the floodplain, there are some sheds in the floodplain. Sheds sometimes contain gasoline, oils, and mechanical equipment.

Droughts

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

Description

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

- Meteorological drought is a measure of departure of precipitation from normal.
- Hydrological drought is related to the effects of precipitation shortfalls on stream flows and on reservoir and groundwater levels.
- 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.
- Socioeconomic drought is associated with the supply and demand of economic goods with elements of meteorological, hydrological, and agricultural drought.
- 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 DEP requires all PWSs to maintain an emergency preparedness plan.

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 may be a significant impact 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 number 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 (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

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. As a result, the Massachusetts Drought Management Plan (DMP) assesses drought conditions in six regions: Western, Connecticut River Valley, Central, Northeast, Southeast, and Cape and Islands. A regional approach allows customization of drought actions and conservation measures to address particular situations in each region; and allows for the determination of a drought on a watershed basis. Droughts have the potential to impact the entirety of Harvard.

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 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.

The impacts of the drought of 2015-2017 were significant in Harvard. According to the local planning team, half of the fire ponds in Harvard were dry by 2017. This is a good example of the impacts of one hazard (drought) leading to increased risks of another hazard (wildfires), as the fire ponds were unavailable for fire suppression.

The drought of 2015-2017 was also a significant disruption to the Town's agricultural community. 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 droughts in Worcester County are listed below.

Table 13. Drought Events.

Year	Event	Event "Begin Dates"
2020	Drought	5/26/2020, 8/18/2020, 9/15/2020, 9/22/2020, 9/29/2020
2018	Drought	7/15/2018, 7/17/2018
2017	Drought	3/3/2017

Year	Event	Event "Begin Dates"
2016	Drought, wildfire, excessive heat, high winds, insects	8/2/2016, 8/16/2016, 8/30/2016
2016	Drought, wildfire, excessive heat, high winds, insects	7/5/2016
2015	Drought	2/1/2015, 4/1/2015
2014	Drought	7/1/2014

The drought of 2015-2017 is carried through several of the line items in the table above. The drought of 2020 was the so-called "flashy drought" that impacted southern New England. Flashy droughts are described below.

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 2021 were reviewed. This timeframe includes the droughts of 2015-2017 and 2020. USDA payments originated from the livestock forage program; the emergency assistance for livestock, bees, and fish; the emergency conservation program; and the non-insured assistance program. Figures for Harvard during this ten-year period add to $164,287. This figure should not be construed as representing the entirety of drought losses in Harvard.

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.

Extent

Drought is defined by a combined look at several indices as detailed in the Massachusetts DMP (EOEEA and MEMA, 2013). The indices are:

- SPI for 3-, 6-, and 12-month time periods
- Precipitation as a percent of normal (or historic average) for 2-, 3-, 6-, and 12-month time periods
- Crop Moisture Index
- Keetch-Byram Drought Index

- Groundwater levels
- Stream flow
- Reservoir levels

These indices are analyzed monthly to generate 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, Advisory, Watch, Warning,* 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 EOEEA, 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 2013 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.

Droughts develop over long periods of time relative to other hazards. However, flashy droughts are changing these norms (AMS, 2017). Flashy droughts may develop quickly or quickly intensify a developing or existing drought. The 2016-2017 drought is an example. Dry conditions from late 2015 lingered through the winter, with scattered groundwater levels reporting below normal and less than normal snowpack heading into spring 2016. Impacts were first seen in March 2016 in stream flows, groundwater levels, and reservoirs showing the long-term deficit. Then, as precipitation dramatically dropped below normal from June through September 2016, the entire state experienced record low stream flows and groundwater levels.

NOAA and others are advancing the science of early warning for droughts like the early warnings for floods and earthquakes to better project flashy 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 seven 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

Using data collected since 1850, the probability of the precipitation index of the DMP exceeding the threshold at each drought level was calculated. On a monthly basis over the 162-year period of record from 1850 to 2012, there is a 2% chance of being in a drought warning level.

Table 14. Frequency of Drought Events Exceeding the Precipitation Index of the DMP.

Level	Frequency Since 1850	Probability in Any Given Month
Emergency	5 occurrences	1% chance
Warning	5 occurrences	2% chance
Watch	46 occurrences	8% chance
Source: EOEEA and MEMA		

The likely range of consecutive dry days per year is projected to increase by up to nearly 20 days per year in 2090, compared to the annual statewide baseline of approximately 16 days per year from 1971 to 2001. Table 4-16 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.

Projected Continuous Dry Days by Planning Year

Table 15. Projected Continuous Dry Days by Planning Year.

Planning Year	2030	2050	2070	2100
Projected Range of Consecutive Dry Days	16.44-17.94	16.34-18.64	15.94-18.94	16.34-19.64
Source: resilient MA, 2018				

These projections suggest that the average time between rain events is likely to remain constant; however, individual drought events could still increase in frequency and severity.

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, farmers using irrigated agriculture, mining operations, and some commercial users.

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. Homeowners with a shallow well could also be more vulnerable to a drought. Table 10 summarizes the senior and low-income populations in Harvard. 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.

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.

Environment Impacts

Some agriculture found in Worcester County may be more susceptible to drought. Typically, agriculture with a small or immature root system is more susceptible. Farmers not incorporating rotational grazing, deep-rooted legumes into pastures, warm-season perennial, and annual grasses into grazing system, and utilizing commodities (brewer's grain, corn gluten, and soybean hulls) to extend pastures and stock are more at risk to drought.

Drought also amplifies the risk of loss of biodiversity and affects animal and plant species. Economic impacts include reductions of income to farmers, and 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.

The insured losses for Worcester County were identified to be $183,629 over 22 years (USDA) for an AAL of $8,347. The Drought in 2016 resulted in more than $156K in losses mostly to apples and corn. Instead of using a population index to identify the Town losses from the County losses, a land index was developed, Harvard Land/Worcester County Land = 0.017. This results in a Harvard loss of $142.

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 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.

Location

In 2013, the Massachusetts Geological Survey and University of Massachusetts Amherst published a Slope Stability Map of Massachusetts. 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 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 Harvard. Due to the hilly topography in parts of the Town of Harvard, some areas of town may be more susceptible to landslide than others.

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.

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. Notwithstanding these risks, very few landslides have been reported in Harvard.

Extent

Variables that contribute to the extent of potential landslide activity in any particular 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 T.S. 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, 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 roadbeds
- 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 defined by the number of events over a specified period of time. The SHMCAP notes that from 1996 to 2012, eight noteworthy events triggered one or more slides in the Commonwealth. However, because many landslides are minor and occur unobserved in remote areas, the true number of landslide events is probably higher. The SHMCAP estimated that about 30 or more landslide events occurred in the period between 1986 and 2006. This roughly equates to one to three landslide events each year in Massachusetts.

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.

The other building data was overlaid with the unstable and moderately unstable areas.

Table 16 shows the result of this analysis. No buildings were found in the unstable area. Five buildings, all single-family homes, were found in the moderately unstable area.

Table 16. Buildings in Moderately Unstable Area

Building Type	Number of Buildings (Total in Town)	Building Value (Total in Town)
Single-Family	5 (2,470)	$1,609,000 ($871,871,300)

Nearly all the Census Blocks including those that have been identified as environmental justice concerns contain moderately unstable areas.

Figure 10 shows the landslide susceptibility map for the Town. The red and pink areas are more susceptible to landslides.

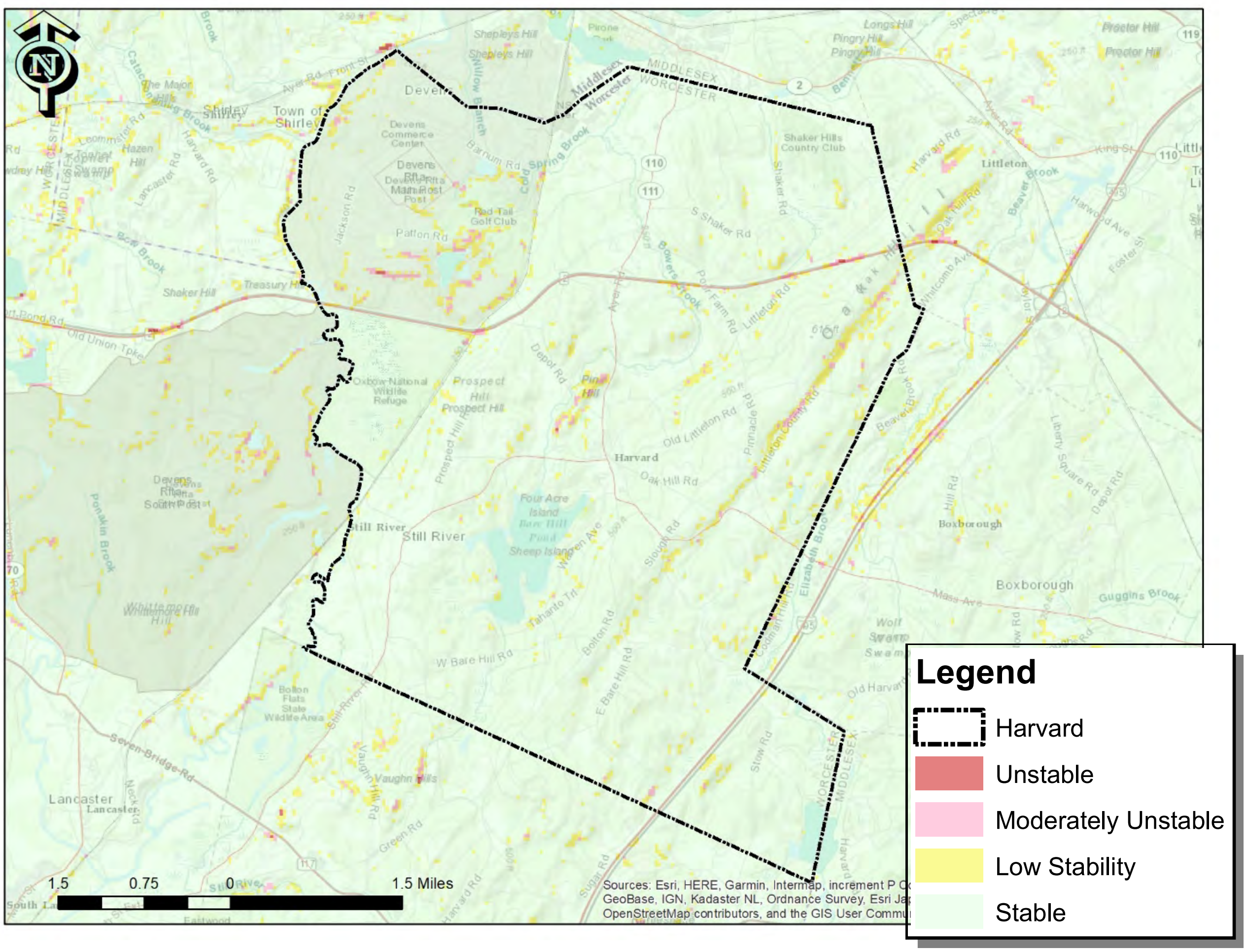


Figure 10: Landslide Susceptibility Map

Built Environment Impacts

Historic data for landslide events indicate that between 1993 and 2022, no landslide events were recorded in Harvard. Still, there is a likelihood even if it's slight. Reviewing the buildings at higher risk, they are fairly spread out across the Town making an event damaging more than one property unlikely. We'll assume 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 $321,800. This would result in an AAL of $3,218.

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. Table 10 summarizes the senior and low-income populations in Harvard. The town should be aware of the potential needs of residents within these population segments in the event of a hazard occurrence.

Environment Impacts

There are unstable and moderately unstable areas around some transportation routes. These routes may be used to transport hazardous materials through the Town.

Primary Climate Change Interaction: Changing Temperatures

Extreme Temperatures

According to the SHMCAP, extreme heat for Massachusetts is usually defined as a period of three or more consecutive days above 90 degrees Fahrenheit (°F), but more generally as a prolonged period of excessively hot weather which may be accompanied by high humidity. Extreme cold is also considered relative to the normal climatic lows in a region. Extreme cold temperatures are characterized by the ambient air temperature dropping to approximately 0°F or below.

> The Town of Harvard Community Resilience Building Workshop Summary of Findings (June 2019) lists "Extreme Temperatures and Temperature Swings" as one of the top four hazards of concern.

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 3 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 SHMCAP, more than 9,000 Americans have died from heat-related ailments (EPA, 2016) since the 1970s.

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." Even in a rural town like Harvard, minor heat impacts can develop along developed transportation corridors. Heat islands can affect communities by increasing peak energy demand during the summer, air conditioning costs, air pollution and GHG 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 (UCI, 2017).

Location

According to the NOAA, Massachusetts is made up of three climate divisions: Western, Central, and Coastal. Average annual temperatures vary slightly over the divisions, with annual average temperatures of around 46°F in the Western division (area labeled "1" in the figure), 49°F in the Central division (area labeled "2" in the figure) and 50°F in the Coastal division (area labeled "3" in the figure). Harvard is located in the Central division. Because extreme temperature events occur more frequently and vary more in the inland regions where temperatures are not moderated by the ocean, Harvard is believed at risk.

Previous Occurrences

Extreme Cold: The SHMCAP notes that since 1994, there have been 33 cold weather events within the Commonwealth, ranging from Cold/Wind Chill to Extreme Cold/Wind Chill events.

Extreme Heat: The SHMCAP notes that according to the NOAA's Storm Events Database (accessed in March 2018 for that planning process) there have been 43 warm weather events (ranging from Record Warmth/Heat to Excessive Heat events) since 1995. The most current event in the database occurred in July 2013. 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.

The NOAA Storm Events database (https://www.ncdc.noaa.gov/stormevents/) for Worcester County does not list any extreme heat events for the Harvard area in the timeframe 2012-2021. Cold events are typically reported with winter storms, and will be described in the winter storm section of this chapter.

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 Worcester County are listed below.

Table 17. Events Related to Extreme Temperatures in Worcester County.

Year	Event	Event Begin Dates
2020	Frost/freeze	5/6/2020
2019	Extreme cold, temperature fluctuations	12/1/2018
2016	Drought, wildfire, excessive heat, high winds, insects	8/2/2016, 8/16/2016, 8/30/2016
2016	Frost/freeze, unseasonably warm temps.	2/12/2016, 2/14/2016
2016	Drought, wildfire, excessive heat, high winds, insects	7/5/2016
2016	Frost/freeze, unseasonably warm temps.	2/1/2016

Year	Event	Event Begin Dates
2014	Frost/freeze, hail	5/22/2014
2013	Extreme heat, excessive humidity	5/8/2013

Interestingly, some of the temperature swings reported by USDA occur within short timeframes, such as the "frost/freeze, unseasonably warm temps" reported in February 2016. These temperature swings can be damaging to agriculture as well as infrastructure.

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 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 designed to more accurately calculate how cold air feels on human skin. Figure 4-42 shows the Wind Chill Temperature Index.

Extreme Heat: The NWS issues a Heat Advisory when the NWS Heat Index is forecast to reach 100 to 104°F for 2 or more hours. 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. The relationship between these variables and the levels at which the NWS considers various health hazards to become relevant are shown in Figure 4-43. It is important to know that the heat index values are devised for shady, light wind conditions. 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.

Probability of Future Events

The SHMCAP notes that Massachusetts averaged 2.4 declared cold weather events and 0.8 extreme cold weather events annually between January 2013 and October 2017. The year 2015 was a particularly notable one, with seven cold weather events, including three extreme cold/wind chill events, as compared to no cold weather events in 2012 and one in 2013. The SHMCAP notes that an average of between four and five heat waves occur annually in Massachusetts.

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. In the last decade, U.S. daily record high temperatures have occurred twice as often as record lows (as 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.).

The NE CASC data 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.

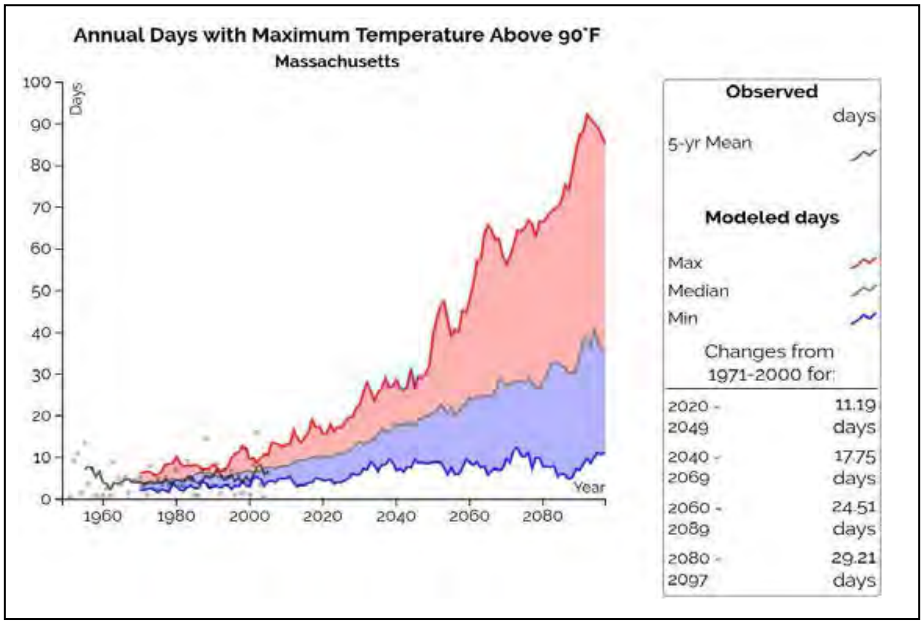


Figure 11. Annual Days with Maximum Temperatures.

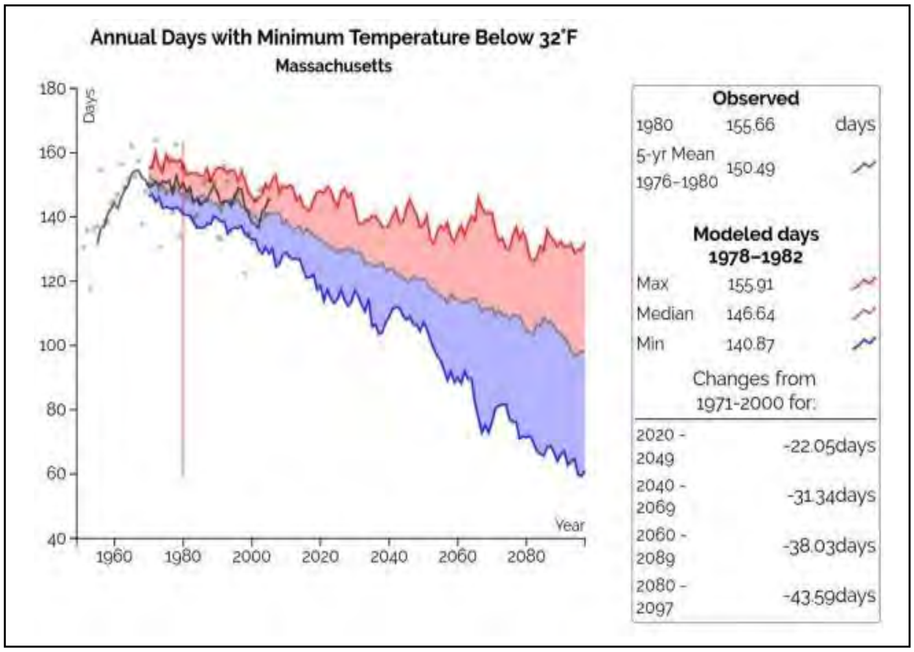


Figure 12. Annual Days with Minimum Temperatures.

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 campus, 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.

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 Harvard, 19.0% 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.

Environment Impacts

In the agriculture community, livestock, such as rabbits, poultry, pigs, and cows are severely impacted by heat waves. Ill-timed high temperatures inhibit crop yields and wheat, corn, and other yields can all be significantly reduced by extreme high temperatures at key development stages.

The insured losses caused by extreme temperatures for Worcester County were identified to be $11,035 over 22 years (USDA) for an AAL of $502. Extreme temperatures in 2005 resulted in more than $10K in losses mostly to apples and non-specified crops. Instead of using a population index to identify the Town losses from the County losses, a land index was developed, Harvard Land/Worcester County Land = 0.017. This results in a Harvard loss of $9.

Wildfires

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 FEMA, there are three different classes of wildland fires: surface fires, ground fires and crown fires. The most common type of wildland fire is a surface fire that burns slowly along the floor of a forest, killing or damaging trees. A ground fire burns on or below the forest floor and is usually started by lightning. Crown fires move quickly by jumping along the tops of trees. A crown fire may spread rapidly, especially under windy conditions.

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 gases, 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

According to the SHMCAP, the ecosystems that are most susceptible to the wildfire hazard are pitch pine, scrub oak, and oak forests, as these areas contain the most flammable vegetative fuels. Other portions of the Commonwealth are also susceptible to wildfire, particularly at the urban-wildland interface. Due to its rural, forested characteristics and linear patterns of development, the entirety of Harvard is believed at risk of wildfires.

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 18. Wildfire Events.

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

In Harvard, fire event counts back to 2012 were as follows:

Table 19. Fire Events in Harvard.

Year	Total Outdoor Fires	Total Fire Events	Reported Losses for Outdoor Fires
2019	10	35	$66,616
2018	9	22	$42,210
2017	2	19	$4,916
2016	11	19	$7,584
2015	19	40	$74,589
2014	17	38	$153,939

Year	Total Outdoor Fires	Total Fire Events	Reported Losses for Outdoor Fires
2013	12	28	$1,886
2012	10	18	$10,278

Notwithstanding the numbers in the above table, the local planning team noted that no “large” wildfires have occurred in the last five years. The figures in the table (10 events in 2019, 9 events in 2018) may represent small brush fires.

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.). Wildfires are also measured by their behavior, including total heat release during burnout of fuels (BTU per square foot) and whether they are crown-, ground-, or surface-burning fires. 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 Fire Control. Early detection is achieved by trained Bureau observers who staff the statewide network of 42 operating fire towers. 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. A fire's peak burning period generally is between 1 p.m. and 6 p.m. 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.

Vulnerability Assessment

While wildland fires have not been a significant problem in Harvard, there is always a possibility that changing land use patterns and weather conditions will increase a community's vulnerability. For example, drought conditions can make forests and other open, vegetated areas more vulnerable to ignition. Once the fire starts, it will burn hotter and be harder to extinguish.

Exposure

To help identify potential wildfire areas for the Town, 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 .05% and .03% probability of burning was identified and overlaid with the critical facilities and other buildings. There were no critical facilities found in the .05% or .03% burn probability areas. *The other building data was overlaid with the .05 and .03% areas. Table 20 shows the result of this analysis. One building, the St. Benedict Priory was found in the .05% burn probability area while 53 buildings were found in the .03% burn probability area.*

Table 20. Buildings in 0.05% and 0.03% Annual Chance Area

Building Type	Number of Buildings (Total in Town)	Building Value (Total in Town)
Single Family	48 (2,470)	$17,160,200 ($871,871,300)
Multi-Family	2 (376)	$913,900 ($213,219,100)
Government	1 (56)	$185,300 ($37,111,900)
Religious/Non-Profit	3 (58)	$1,265,000 ($42,072,100)
Total	**54**	**$19,524,400 ($1,230,660,000)**

The population exposed to the 0.03% probability area is shown in Table 21. The column in the left shows the population in and around the 0.03% 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 lower annual income than the Town average.

Table 21. Population Exposed to 0.03% Annual Chance Wildfire (2020 U.S. Census)

Population in and Adjacent to 0.03% Wildfire Area	Total Population
Population: 550	Population: 5,461
Households: 221	Households: 2,093
White: 503 (91.5%)	White: 4,637 (85.0%)
Black: 5 (0.9%)	Black: 62 (1.1%)
American Indian: 1 (0.2%)	American Indian: 10 (0.2%)
Asian: 17 (3.1%)	Asian: 366 (6.7%)
Other Race: 6 (1.1%)	Other Race: 67 (1.2%)
Two or More Races: 18 (3.3%)	Two or More Races: 319 (5.8%)
Hispanic or Latino: 9 (1.6%)	Hispanic or Latino: 163 (3.0%)
Population under 18: 120 (21.8%)	Population under 18: 1,469 (26.9%)
Population over 64: 130 (23.6%)	Population over 64: 1,036 (19.0%)
Annual Income < $30K/year: 24 (10.9%)	Annual Income < $30K/year: 144 (6.9%)
Population in EJ Zone: 0 (0%)	Population in EJ Zone: 0 (0%)

Figure 13 shows the burn probability map from the USFS overlaid on the Town.

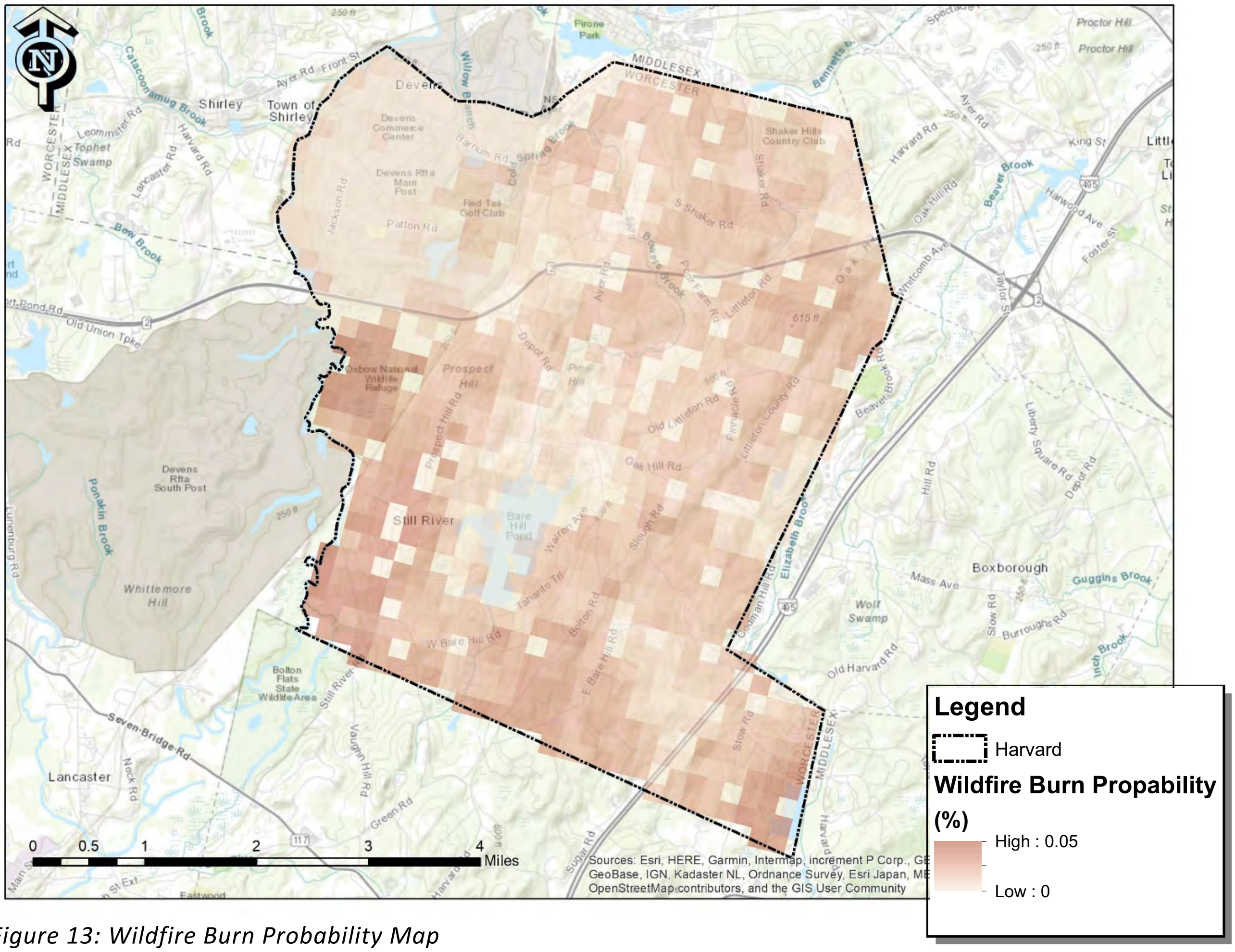


Figure 13: Wildfire Burn Probability Map

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 brushfires in Harvard between 2004 and 2022. Using the wildfire probabilities and building values, a loss estimate was produced for the 0.03% scenario. The losses are shown in Table 22 and the AAL will be $10,033.

Table 22. Building Loss for a 0.03% Annual Chance Scenario

Loss Type	Residential ($Million)	Commercial ($Million)	Other Occupancy ($Million)	Total ($Million)
Building Loss	$18.1	$0	$1.5	**$19.6**
Content Loss	$9.0	$0	$1.5	**$10.5**
Total	**$27.1**	**$0**	**$3.0**	**$30.1**

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. Table 21 summarizes the senior and low-income populations in Harvard. The town should be aware of the potential needs of residents within these population segments in the event of a hazard occurrence.

Environment Impacts

Many of the natural features in the Town are susceptible to wildfire including the trees, agriculture, livestock, and parks. Agriculture not directly burned by the fire can suffer from smoke taint.

Infectious Diseases

The SHMCAP does not address infectious diseases as a profiled hazard. While major disease outbreaks are uncommon, public health emergencies can become standalone disasters that compound the threat of other natural hazards and exceed local and state capacity. Precedent for federal assistance due to public health emergencies has been set including West Nile Virus (2000), a mosquito-borne disease, for which a federal emergency declaration was made in New York and New Jersey; and the COVID-19 pandemic, which resulted in a major disaster declaration in all states, territories, and the District of Columbia. Given that COVID-19 has resulted in excessive public expenditures and resulted in a disaster declaration, and in light of heightened concerns about tick and mosquito-borne illnesses, this plan addresses infectious diseases.

Description

Public health risks, such as those presented by infectious diseases and vector-borne illnesses, are present within every community. An infectious disease is one that is caused by micro-organisms, such as bacteria, viruses, and parasites. A vector-borne illness is an infectious disease that is transmitted to humans by blood-feeding arthropods, including ticks, mosquitoes, and fleas, or in some cases by mammals (e.g., rabies). Infectious diseases cause illness, suffering and even death, and place an enormous financial burden on society.

Most infectious diseases are caused by pathogens that can be spread, directly or indirectly, from person to person. Such diseases may be seasonal (seasonal influenza) or result, in the case of new diseases, result in a global pandemic. Infectious disease dynamics depend on a range of factors, including land use, human behavior, climate, efficacy of healthcare services, population dynamics of vectors, population dynamics of intermediate hosts and the evolution of the pathogens themselves. Many of these diseases require continuous monitoring, as they present seasonal threats to the general population.

A communicable disease is an illness caused by an infectious agent or its toxic products that develops when the agent or its product is transmitted from an infected person, animal, or arthropod to a susceptible host. Infectious agents include viruses, bacteria, fungi, parasites, or aberrant proteins called prions. The infectious agent might spread by one of several mechanisms, including contact with the infected individual or his or her bodily fluids, contact with contaminated items or a vector, or contact with droplets or aerosols. An infection, which is the actual spread of the infectious agent or its toxic product, is not synonymous with disease because an infection may not lead to the development of clinical signs or symptoms.

Influenza (flu) spreads mainly from person to person by droplets from the nose or throat that are released when an infected person coughs or sneezes. It happens every year and is more common in the fall and winter. An estimated 19 million influenza illnesses occur in the United States each year. People at highest risk for flu-related complications include children younger than 5 years (especially those younger than 2 years old), adults 65 years of age and older, pregnant women, and people who have certain medical conditions such as asthma, heart disease, chronic lung disease, kidney disease, or weakened immune systems due to disease or medication.

In Massachusetts, state public health officials rely on local boards of health, healthcare providers, laboratories, and other public health personnel to report the occurrence of notifiable diseases as required by law. An epidemic emerges when an infectious disease occurs suddenly in numbers that are more than normal expectancy. Infectious disease outbreaks put a strain on the healthcare system and may cause continuity issues for local businesses. These outbreak incidents are a danger to emergency responders, healthcare providers, schools, and the public. This can include influenza (e.g., H1N1), pertussis, West Nile virus, and many other diseases. A pandemic is an epidemic that has spread over a large area, that is, it is prevalent throughout an entire country, continent, or the whole world.

On March 11, 2020, the World Health Organization (WHO) officially declared the Coronavirus disease 2019 (COVID-19) outbreak a pandemic due to the global spread and severity of the disease. COVID-19 is a respiratory illness that can spread from person to person. COVID-19 is a highly contagious, viral upper respiratory illness that was first detected in China in late 2019. The virus quickly spread throughout the world and has resulted in a global pandemic ongoing at the time of this plan. COVID-19 symptoms include cough, difficulty breathing, fever, muscle pain, and loss of taste or smell. Severe cases may result in death, especially in individuals over the age of 65 or with underlying medical conditions, such as diabetes, lung disease, asthma, obesity, or those who are immunocompromised. COVID-19 spreads from person to person through respiratory droplets in the air or on surfaces.

Location

The entire Commonwealth of Massachusetts and Town of Harvard are considered at risk to the infectious diseases addressed in this chapter.

Previous Occurrences

Pandemic influenza episodes that were global outbreaks spread were observed in 1918, 1957, 1968, and in 2009 with the novel H1N1 strain. The 2009 H1N1 outbreak, though not considered a serious threat, still affected some residents in Massachusetts with nearly 2,000 confirmed cases and 33 deaths. The great influenza epidemic of 1918 killed millions worldwide and would likely cause hundreds to thousands of deaths in Massachusetts should a similar outbreak occur today. It is anticipated that a more serious strain of the usual flu will occur some year and that vaccines might not be ready in time to combat rapid spread.

The most significant recent occurrence of infectious disease for Harvard is that of COVID-19. Approximately 2 million cases and 21,000 deaths have been reported in Massachusetts. As of the end of June 2022, approximately 211,681 cases and 2,662 deaths were reported for Worcester County. The federal designation for the Massachusetts Covid-19 Pandemic is DR-4496-MA, with incident period January 20, 2020, and continuing. The Major Disaster Declaration was issued March 27, 2020.

Vector-borne diseases continue to pose a significant threat to communities across Massachusetts. Blacklegged (deer) ticks and dog ticks are found throughout Massachusetts and may spread different diseases. The most common tick-borne diseases in Massachusetts are Lyme Disease, Babesiosis, and Anaplasmosis. Other diseases that are rare, but still occur, are Tularemia, Rocky Mountain spotted fever, Borrelia miyamotoi, and Powassan virus. Tickborne figures for Worcester County are available at https://www.mass.gov/lists/monthly-tick-borne-disease-reports; a summary for the last three calendar years is provided below.

Table 23. Tickborne Statistics.

Year	Emergency Department Visits	Number of Tick-Borne Disease Visits	Rate (per 10,000) of Tick-borne Disease Visits
2021	340,683	214	6.28
2020	313,179	188	6

Year	Emergency Department Visits	Number of Tick-Borne Disease Visits	Rate (per 10,000) of Tick-borne Disease Visits
2019	381,891	277	7.25

Mosquito-borne diseases are also a seasonal threat. West Nile Virus (WNV) and Eastern Equine Encephalitis (EEE or "Triple E") are viruses that occur in Massachusetts and can cause illness ranging from a mild fever to more serious disease like encephalitis or meningitis. Other diseases spread by mosquitoes may affect people when traveling in other regions of the world such as Zika virus, Dengue fever, and Chikungunya.

Extent

Well-established scales for characterizing total impacts of infectious diseases are not present for applied uses such as a hazard mitigation plan. Nevertheless, commonly accepted methods are in place for characterizing active transmission, such as color scales (yellow, orange, red). Future editions of this plan will provide updates to measures of extent. Johns Hopkins continues to provide a very comprehensive dashboard of information for all regions of the U.S. including Massachusetts. County-level data can also be accessed (https://coronavirus.jhu.edu/region/us/massachusetts).

Probability of Future Events

Probability of infectious disease in the planning area is extremely variable. Many public health risks occur seasonally and are ongoing, such as the common cold and influenza. Major disease outbreaks such as the current COVID-19 pandemic are much less common but can last for long periods. Based on the information available regarding occurrences of greatest concern, the infectious disease hazard has been assigned a probability of likely for the foreseeable future.

The COVID-19 pandemic has the potential to continue to some degree over the next several years, even as vaccines continue to be developed are distributed. The Town of Harvard is continually updating community mitigation measures and guidance in close consultation with Massachusetts Department of Public Health and based on new information from the CDC.

The effects of climate change will result in an increase in the probability and/or frequency of some infectious diseases. Those infectious diseases that are currently present in Massachusetts and which may be exacerbated by climate change are already exhibiting increased prevalence in New England. For example, with both temperature and precipitation expected to increase in Massachusetts, West Nile Virus mosquito vector activity will likely increase, as well as the vector's period of activity. Similarly, between 1964 and 2010, counts of Eastern Equine Encephalitis (EEE) have continued to rise in New England, though they remain constant in the southeastern states.

The United States is already seeing a significant increase in vector-borne infectious diseases. According to the CDC, the number of reported disease cases from mosquito, tick, and flea bites tripled from 2004 to 2016, and mosquito-borne disease epidemics are happening more frequently. Annual cases of Lyme disease have increased over the last decade, and with shrinking winters, the potential for infection through tick bite continues to grow. Given increasing trends for global travel, several other diseases not typically observed in Massachusetts could continue to make their way back to the state through infected travelers. COVID-19 is the most recent and severe example of this threat. Another example is the Zika virus, transmitted from infected mosquitoes to humans, which received international attention during an outbreak in 2015 and persists today.

Vulnerability Assessment

Exposure

The risk associated with communicable disease in the region has not been formally quantified, due to the difficulty in predicting specific occurrences, and the lack of complete data on impacts. However, the potential risk and impact of communicable diseases is often presumed to be very high in the chaos that follows natural disasters (WHO, 2006).

Natural disasters, particularly meteorological and geological events such as hurricanes, floods, and earthquakes, can bring about serious health consequences. These disasters can affect vector breeding sites and vector-borne disease transmission. In a flood hazard area, initial flooding may wash away existing mosquito breeding sites, but standing-water caused by heavy rainfall or overflow of rivers can create new breeding sites. This can result (with typically some weeks delay) in an increase of the vector population and potential for disease transmission, depending on the local mosquito vector species and its preferred habitat. The crowding of infected and susceptible hosts, a weakened public health infrastructure and interruptions of ongoing control programs are all risk factors for vector-borne disease transmission.

The major causes of communicable disease from natural disasters can be categorized into four areas: Infections due to contaminated food and water, respiratory infections, vector, and insect borne diseases, and infections due to wounds and injuries. The most common causes of morbidity and mortality in this situation are diarrheal disease and acute respiratory infections.

- Waterborne diseases: Diarrheal disease outbreaks can arise subsequent to drinking-water contamination and have been reported after flooding and related movement. Hepatitis A and E have fecal-oral transmission in areas with poor water sanitation.
- Diseases associated with crowding: Acute respiratory infections are the main cause of morbidity and mortality among unsettled people and are seen predominantly in children less than 5 years old.
- Vector-borne diseases: The most common vector-borne diseases are carried by mosquitoes and ticks and include Lyme Disease, Rocky Mountain Spotted Fever, West Nile Virus, and

Eastern equine encephalitis. Environmental changes after disaster could increase vector breeding sites and proliferation of disease vectors.

- Infections due to wounds and injuries: The potentially significant threats to persons suffering a wound are tetanus, staphylococci, and streptococci.

Built Environment Impacts

All human-occupied critical facilities are assumed to be at risk of contamination from a communicable disease. If facilities supporting emergency response lost their functionality because of contamination, delays in emergency services could result. Additionally, with a significant human disease outbreak, resources of health care systems such as ambulance services, hospitals, and medical clinics could quickly become overwhelmed. In most cases, critical infrastructure would not be affected by communicable disease. Scenarios that would affect infrastructure include the contamination of the water supplies and diseases that require special provisions in the treatment of wastewater. Should an epidemic necessitate quarantine or incapacitate a significant portion of the population, support of and physical repairs to infrastructure may be delayed, and services may be disrupted for a time due to limitations in getting affected employees to work.

Population Impacts

High death counts during a natural disaster (either human or animal) can indicate an increased risk of outbreaks associated with the size, health status, and living conditions of the population displaced by the natural disaster. Crowding, inadequate water and sanitation, and poor access to health services, often characteristic of sudden population displacement, increase the risk of communicable disease transmission.

Populations that are vulnerable to communicable diseases include the economically disadvantaged, racial and ethnic minorities, the uninsured, low-income children, the elderly, the homeless, and those with other chronic health conditions, including severe mental illness. It may also include rural residents, who often encounter barriers to accessing healthcare services, transportations, or the internet.

Environment Impacts

Infectious diseases can also impact livestock and other animals. Some of the most common communicable diseases include Eastern Equine Encephalitis, Equine Herpes Virus, West Nile Virus, and Avian Influenza. While Zoonotic diseases (those transmissible between humans and animals or via an animal vector) are also a concern for the region, those events are best addressed in a pandemic or contagious disease plan rather than this hazard mitigation plan.

Invasive Species

According to the SHMCAP, invasive species are defined as non-native species that cause or are likely to cause harm to ecosystems, economies, and/or public health (NISC 2006). The focus of this section is on invasive terrestrial plants, as this is the most studied and managed typed of invasive; information for invasive aquatic flora and fauna (including marine species) is also provided when relevant.

The Town of Harvard Community Resilience Building Workshop Summary of Findings (June 2019) lists "Pests and Invasive Species" as one of the top four hazards of concern.

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.

MIPAG recognized 69 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 criteria:

- Be nonindigenous to Massachusetts.
- Have the biologic potential for rapid and widespread dispersion and establishment in minimally managed habitats.
- Have the biologic potential for dispersing over spatial gaps away from the site of introduction.
- Have the biologic potential for existing in high numbers away from intensively managed artificial habitats.
- Be naturalized in Massachusetts (persists without cultivation in Massachusetts).
- Be widespread in Massachusetts or at least common in a region or habitat in the state.
- Have many occurrences of numerous individuals in Massachusetts that have high numbers of individuals forming dense stands in minimally managed habitats.
- Be able to outcompete other species in the same natural plant community.

- Have the potential for rapid growth, for high seed or propagule production and dissemination, and for establishment in natural plant communities.

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 causes 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 woolly 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 damage rendered by invasive species is significant. Experts estimate that about 3 million acres within the U.S. are lost each year to invasive plants (Pulling Together, 1997, from Mass.gov "Invasive Plant Facts"). The massive scope of this hazard means that the entire Commonwealth experiences impacts from these species. 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 Harvard 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. Invasive plants most often seen in Harvard include Burning Brush, Hemlock, Milfoil and Knotweed. Invasives of current concern to forest health (https://www.mass.gov/service-details/current-forest-health-threats) in Worcester County are reportedly:

- Beech Leaf Disease
- Gypsy Moth
- Winter Moth
- Hemlock Woolly Adelgid
- Southern Pine Beetle
- Emerald Ash Borer
- White Pine Needlecast
- Asian Longhorned Beetle

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 24. Invasive Species Budget.

FY Year	Budget
2022	$277,838

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

The Town's Community Resilience Building Workshop Summary of Findings addresses the presence of invasive species. For example, the document notes:

- "In an effort to manage invasive plant species in the pond, the Bare Hill Pond Watershed Management Committee has been periodically conducting drawdowns of the pond since 2002. Drawdowns have ranged in depth from 1.5' in 2002, to as high as 7' in 2011, when more depth was needed for a beach excavation project. In 2013, the pond was left alone to see if a lower drawdown frequency would work, but there was a minor resurgence of some invasives. The impacts of climate change could have a major impact on this method of invasive species control. In order to conduct a drawdown, ideal conditions are consistently cold consecutive days with little rain or snow, which will be increasingly unlikely as climate change causes more extreme and less predictable weather. Additionally, the dam system is in need of higher capacity for storm-water detention and drainage in general. Other identified vulnerabilities related to storm-water management are erosion and the runoff of contaminants from nearby properties into the water supply and wetlands, which further compounds the problem of invasive species growth" and
- "Invasive plant species also occur town-wide, particularly along roadsides."

During the local planning team meetings held for this update, committee members indicated that the Town frequently deals with Japanese Knotweed that adversely impacts culverts.

Extent

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.

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.

Probability of Future Events

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 2000, 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 and CZM 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 plants 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 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. The Town's budget may not be enough to remove and process trees if an invasive pest does enough damage.

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 trees and orchards, forested areas, agriculture, and other, natural 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.

The insured losses caused by invasive insects for Worcester County were identified to be $27,338 over 22 years (USDA) for an AAL of $1,243. Insect damage in 2012 resulted in more than $13K in losses mostly to apples and non-specified crops. Instead of using a population index to identify the Town losses from the County losses, a land index was developed, Harvard Land/Worcester County Land = 0.017. This results in a Harvard loss of $21.

Primary Climate Change Interaction: Extreme Weather Events

Hurricanes and Tropical Storms

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.

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.

Figure 14. Tree Down from High Winds in Harvard.

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 SHMCAP 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 entirely of Massachusetts, including the geographic extent of Harvard.

Previous Occurrences

The SHMCAP notes that hurricanes and tropical storms occur somewhat regularly in Massachusetts. As noted elsewhere, this plan update relies primarily on a ten-year lookback (2012 through 2021) ending with the date of plan development. During that ten-year period, only one declared disaster in Massachusetts (SuperStorm Sandy of October 2012) was associated with a tropical system, and the impacts to central Massachusetts were minimal.

Nevertheless, Harvard was impacted by some of the series of tropical and post-tropical storm systems that impacted Massachusetts in 2021. These storms occurred in July, August, and September 2021 as follows:

- T.S. Elsa - July 9, 2021
- T.S. Fred - August 19, 2021
- T.S. Henri - August 22-23, 2021
- T.D. Ida - September 1, 2021

The Town of Harvard suffered moderate impacts from at least two of these events. The recorded precipitation associated with T.S. Ida was 3.7" according to NBCBoston, which is substantial although it would not have caused widespread flooding. Other locations in Massachusetts experienced higher rainfall totals and experienced more significant flooding, especially from storm Ida.

The NOAA Storm Events database (https://www.ncdc.noaa.gov/stormevents/) for Worcester County lists several high wind and flood events in Harvard for the period 2012-2021, and one is associated with one of the tropical systems listed above: *"The remnants of Tropical Storm Fred moved across Southern New England producing heavy rain, gusty winds, and two tornadoes - one that moved from northeast Connecticut into Worcester County and another in central Worcester County. In Harvard, multiple trees were down on Houghton Lane. Damage of $2,000 was reported."*

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 two events related to tropical storms in Worcester County are listed below.

Table 25. Tropical Storms in Worcester County.

Year	Event	Event Begin Dates
2021	Hurricane/tropical storm (Elsa)	7/9/2021
2020	Hurricane (Isaias), high wind	8/4/2020

In summary, a combination of the USDA reports, the NOAA Storm Events database, and precipitation records demonstrates that the storms associated with Isaias (2020), Elsa (2021), Fred (2021), and Ida (2021) all adversely impacted Worcester County and specifically impacted Harvard. Even without the presence of a catastrophic hurricane striking Harvard, less severe tropical storms and remnants have created significant disruptions and necessitated public expenditures.

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 26. Saffir-Simpson Hurricane Wind 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:

- After T.S. Irene passed through the region in late August 2011, many areas of the Commonwealth were without power for more than five days.
- T.S. Isaias of August 2020 caused significant damage in Massachusetts and widespread outages in Connecticut.

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 SHMCAP notes that Massachusetts experiences an average of one storm every other year or 0.5 storms per year. Storms severe enough to receive FEMA disaster declarations are far rarer, occurring every 9 years on average. According to NOAA, a Category 1 hurricane can be expected to make landfall in/near southern New England once every 17 years. A Category 2 hurricane could be expected to make landfall once every 39 years, and a Category 3 hurricane has a calculated return period of 68 to 70 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. However, 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 Harvard 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 Harvard should be considered exposed to high winds. Figure 15 shows the 100-year windspeeds identified in the ASCE 7-98 publication.

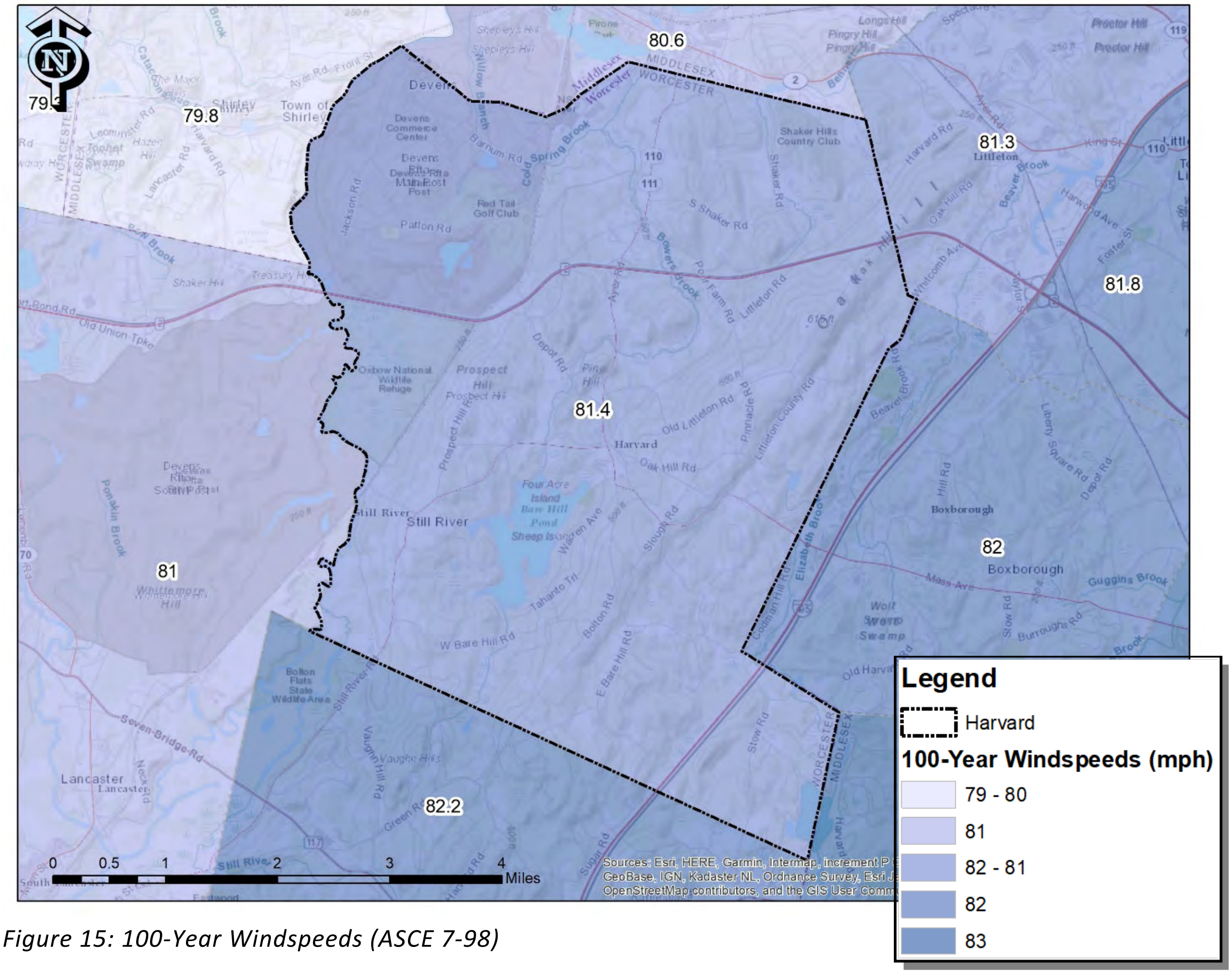


Figure 15: 100-Year Windspeeds (ASCE 7-98)

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. The economic loss results of the 500-year event are shown in Table 27 while the results for the 1000-year event are shown in Table 28. The Town's Average Annual Loss (AAL) is calculated to be $227,000.

Table 27. Building Loss for a 500-Year Scenario

Loss Type	**Residential ($Million)**	**Commercial ($Million)**	**Other Occupancy ($Million)**	**Total ($Million)**
Building Loss	12.2	0.3	0.3	**12.8**
Content Loss	6.1	0.1	0.1	**6.3**
Business Inventory Loss	0	0	0	**0**
Business Income Loss	0	0.1	0	**0.1**
Business Relocation Loss	0.2	0.1	0	**0.3**
Rental Income Loss	0.1	0	0	**0.1**
Wage Loss	0	0.1	0.1	**0.2**
Total	**18.6**	**0.7**	**0.5**	**19.8**

Table 28. Building Loss for a 1000-Year Scenario

Loss Type	**Residential ($Million)**	**Commercial ($Million)**	**Other Occupancy ($Million)**	**Total ($Million)**
Building Loss	**19.1**	**0.7**	**0.6**	**20.4**
Content Loss	9.5	0.1	0.2	**9.8**
Business Inventory Loss	0	0	0	**0**
Business Income Loss	0	0.1	0	**0.1**
Business Relocation Loss	0.3	0.1	0.1	**0.5**
Rental Income Loss	0.2	0.1	0	**0.3**
Wage Loss	0	0.1	0.2	**0.3**
Total	**29.1**	**1.2**	**1.1**	**31.4**

Population Impacts

Populations considered most vulnerable to hurricane and tropical storm impacts in Harvard 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. Table 10 summarizes the senior and low-income populations in Harvard. 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.

For the 500-year event, Hazus predicts that there will be less than five displaced households from the high windspeeds alone. However, if the rainfall leads to flooding, families may be displaced (see flood section). For the 1000-year event, Hazus predicts less than ten displaced households with minimal public shelter requirements.

Environment Impacts

Hurricanes can cause damage to agriculture, and other, natural areas. Some areas of the Town may be out of service until trees are removed. Strong winds can also impact agriculture including apple orchards.

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 Harvard Community Resilience Building Workshop Summary of Findings (June 2019) lists "Ice Storms" as one of the top four 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. Overall, winter storms can affect the entirely of Massachusetts, including the geographic extent of Harvard.

Previous Occurrences

Winter storms occur somewhat regularly in Massachusetts. Although four of the disasters declared in Massachusetts from 2012 through 2021 were associated with winter storms, only three of the four covered Worcester County and therefore the Town of Harvard:

- Massachusetts Severe Winter Storm, Snowstorm, and Flooding (DR-4110-MA)
  - Incident Period: February 8, 2013 - February 9, 2013
  - Major Disaster Declaration declared on April 19, 2013

  - PA for entire state
- Massachusetts Severe Winter Storm, Snowstorm, and Flooding (DR-4214-MA)
  - Incident Period: January 26, 2015 - January 28, 2015
  - Major Disaster Declaration declared on April 13, 2015
  - PA for Worcester County and eastward
- Massachusetts Severe Winter Storm and Flooding (DR-4372-MA)
  - Incident Period: March 2, 2018 - March 3, 2018
  - Major Disaster Declaration declared on June 25, 2018
  - PA for Norfolk, Essex, Bristol, Plymouth, Cape and Islands
- Massachusetts Severe Winter Storm and Snowstorm (DR-4379-MA)
  - Incident Period: March 13, 2018 - March 14, 2018
  - Major Disaster Declaration declared on July 19, 2018
  - PA for Worcester, Middlesex, Suffolk, Norfolk, Essex Counties

Only 25 miles southwest of Harvard, the Worcester Regional Airport recorded its greatest one-day snowfall on record (31.9”) on January 27, 2015, during event DR-4214-MA listed above. The PA assistance reimbursements for the Town of Harvard associated with the winter storms of 2013, 2015, and 2018 summed to $142,000 against a total cost of approximately $189,000, indicating that the events were likely impactful but not catastrophic for Harvard.

Figure 16. Extreme Winter Storm in Harvard.

The NOAA Storm Events database (https://www.ncdc.noaa.gov/stormevents/) for Worcester County lists only three winter storm events impacting Harvard for the period 2012-2021 (although one was tagged as a high wind event and not a winter storm):

- 3/14/17 – High Wind: A major winter storm moved up the east coast, hugging the southern NJ coast then moving rapidly northeast across southern Rhode Island and interior southeast Massachusetts. The storm dropped 12 to nearly 20 inches of snow across much of western, central, and northeastern Massachusetts, with lesser amounts in the southeast, where a changeover to rain occurred in the late morning and early afternoon. Snowfall rates of 3 inches per hour were observed in western MA. Gusty winds to 30-50 mph were common in the interior. At 111 PM, the Worcester Airport ASOS recorded a wind gust to 55 mph. At 534 PM, amateur radio reported a tree down in Harvard on Still River Road. Damage of $4,000 was reported from all towns impacted.
- 3/13/18 – Winter Storm (this is DR-4379-MA, listed above): Low pressure along the Carolina coast March 12 moved up the coast and passed offshore of Southern New England on March 13, moving off through the Maritimes on March 14. From seven to 22 inches of snow fell on Northern Worcester County. At 2:05 PM EST a tree was reported down on wires on Finn Road in Harvard. Damage of $2,000 was reported for this incident of downed wires.
- 12/16/20 – Heavy Snow: A storm system produced heavy snow, strong to damaging winds, and minor coastal flooding in southern New England. Heavy snow in northern Worcester County generally ranged from 9 to 15 inches. Some specific amounts included 10.0 inches in Harvard. Winds generally were gusting to 25 to 35 mph. Damage figures were not reported.

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 winter storms in Worcester County are listed below.

Table 29. Winter Storms in Worcester County.

Year	Event	Event Begin Dates
2019	Extreme cold, temperature fluctuations	12/1/2018
2016	Frost/freeze, unseasonably warm temps.	2/12/2016, 2/14/2016
2016	Frost/freeze, unseasonably warm temps.	2/1/2016
2014	Cold, frost/freeze	12/1/2013

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 as depicted in Table 4-64. The RSI is similar to 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.

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

Table 30. RSI Index. 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 in order to help the state to prepare for the incident.

Probability of Future Events

The SHMCAP notes that Massachusetts experiences high-impact snowstorms at approximately the rate of one per year, although there is significant interannual variability in the frequency and severity of winter storms. The Town of Harvard 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 Harvard 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 will be used to determine potential losses and probabilities. From 1954 until 2022, there was $31.356M in property damage to Worcester County. This equates to an AAL of $1,146,000. To make this more relevant to the Town itself, the population of Harvard (5,461) was divided by the population of Worcester County (862,111) to create a population index (0.0063). That index is then multiplied by the county's AAL to get $7,259, the Town's AAL.

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. Table 10 summarizes the senior and low-income populations in Harvard. 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

Severe winter storms can cause damage to agriculture and other, natural areas. Some areas of the Town may be out of service until roads are cleared and trees are removed. Tree farms can be also damaged from extreme winter events.

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.

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 (1995) occurred in May.

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 1,253 tornadoes per year, 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 SHMCAP notes that the area at greatest risk for a tornado touchdown runs from central to northeastern Massachusetts. Nevertheless, tornadoes can affect the entirely of Massachusetts, including the geographic extent of Harvard.

Previous Occurrences

The previous edition of this plan notes that Worcester County has been an area of the state where many significant tornadoes in Massachusetts have occurred. Since 1950, there have been 15 tornados in the Montachusett Region, the most recent of which occurred in 2015. According to the SHMCAP, the most destructive tornado in New England history was the Worcester tornado of June 9, 1953. The F4 tornado hit at about 3:30 p.m. The funnel quickly intensified, carving a 46-mile path of death and destruction as it moved through seven towns. The twister tore through Barre, Rutland, Holden, Worcester, Shrewsbury, Westborough, and Southborough. It killed 90 people and left approximately 1,200 people injured. The National Storm Prediction Center has ranked this as one of the deadliest tornadoes in the nation’s history. With wind speeds between 200 to 260 mph, the force of the tornado carried debris miles away and into the Atlantic Ocean.

According to the previous edition of this plan, several tornadoes have been reported near Harvard. Although none passed directly through Harvard, the Lancaster tornado (F1) of 1957 passed along the Harvard town line where Devens in located. Reported damage was in the range of $5,000 to $50,000.

The NOAA Storm Events database (https://www.ncdc.noaa.gov/stormevents/) for Worcester County lists a variety of severe storms in Harvard from 2012 through 2021, but none were caused by or associated with tornadoes.

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.

Scale	Wind speed		Relative frequency	Potential damage	
	mph	km/h			
EF0	65–85	105–137	53.5%	Minor damage. Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over. Confirmed tornadoes with no reported damage (i.e., those that remain in open fields) are always rated EF0.	
EF1	86–110	138–178	31.6%	Moderate damage. Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.	
EF2	111–135	179–218	10.7%	Considerable damage. Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.	
EF3	136–165	219–266	3.4%	Severe damage. Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.	
EF4	166–200	267–322	0.7%	Extreme damage to near-total destruction. Well-constructed houses and whole frame houses completely leveled; cars thrown and small missiles generated.	
EF5	>200	>322	<0.1%	Massive Damage. Strong frame houses leveled off foundations and swept away; steel-reinforced concrete structures critically damaged; high-rise buildings have severe structural deformation. Incredible phenomena will occur.	

Figure 17. Enhanced Fujita Scale.

Source: Linn County EMA and reprinted from SHMCAP

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 SHMCAP, the Commonwealth experienced 171 tornadoes from 1950 to 2017, or an average annual occurrence of 2.6 tornado events per year. In the last 20 years, the average frequency of these events has been 1.7 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).

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 1954 until 2022, there was $264.267M in property damage to Worcester County. This equates to an AAL of $9,787,667. To make this more relevant to the Town itself, the population of Harvard (5,461) was divided by the population of Worcester County (862,111) to create a population index (0.0063). That index is then multiplied by the county's AAL to get $61,662, the Town's AAL.

Population Impacts

Populations considered most vulnerable to tornado impacts in Harvard 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. Table 10 summarizes the senior and low-income populations in Harvard. 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 agriculture, and other, natural areas. Some areas of the Town may be out of service until trees are removed.

Other Severe Weather

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.

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:

- 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.
- 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 entirely of Massachusetts, including the geographic extent of Harvard.

Previous Occurrences

The NOAA Storm Events database (https://www.ncdc.noaa.gov/stormevents/) for Worcester County lists a variety of severe storms affecting Harvard from 2012 through 2021. The individual damage figures for these events appear nominal but given the frequency of events, the overall losses from severe storms are striking.

- 5/25/12 – Hail: An upper-level disturbance moved through Southern New England, igniting showers and thunderstorms across the area. Many of these storms produced small to large size hail thanks to very cold temperatures aloft. Golfball size hail damaged a Massachusetts Environmental Police cruiser as it traveled between Interstate 495 and Route 2 through the center of Harvard. Damage of $5,000 was reported.
- 8/4/15 – Thunderstorm Wind: 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. Two trees were downed by thunderstorm winds, with one of them blocking one side of Route 111. Damage of $5,000 was reported.

- 8/13/16 – Lightning: Heat, humidity, and a back door cold front all contributed to the development of showers and thunderstorms across southern New England. These storms resulted in damaging winds and localized flooding. A barn on Still River Depot Road was struck by lightning, causing a small fire on the 2nd floor. Damage of $10,000 was reported.
- 6/18/18 – Thunderstorm Wind: A cold front moved from the Great Lakes across New England. 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 5:35 PM EST a large tree and wires were reported down on Warren Avenue in Harvard. Damage of $2,000 was reported.
- 11/3/18 – Strong Wind: Low pressure over New York City early in the morning on November 3rd rapidly intensified as it moved northeastward across New England. As the strong low passed to our north, strong to damaging westerly winds developed during the afternoon. Winds gusted to 45-50 mph across northern Worcester County. At 146 PM EDT, in Harvard, a tree was down on Woodside Road. Damage of $1,500 was reported from all towns impacted.
- 12/21/18 – Strong Wind: A storm passing west of Massachusetts brought strong to damaging south winds to Central and Eastern Massachusetts. The same storm also brought one to four inches of rain. At 10:27 AM EST a tree was reported down and blocking Warren Avenue in Harvard. Damage of $5,000 was reported from all towns impacted.
- 1/8/20 – Strong Wind: Behind a departing ocean storm cold NW winds became gusty bringing some gusts near 50kts and some damage to wires and trees. An amateur radio operator reported the top half of a tree down on Prospect Hill Rd in Harvard. Damage of $500 was reported.
- 3/4/20 – Strong Wind: Low pressure over Maine strengthened into a powerful cyclone over the Canadian maritime provinces. The cold front swept across New England, with strong west-northwest winds causing scattered damage in mainly northern and eastern Massachusetts. Winds generally were gusting to 40 to 45 mph. At 1210 PM EST, the ASOS at Worcester Airport (KORH) recorded a gust to 44 mph. In Harvard at 1 PM EST, one tree was reported down on Stow Road. Damage of $500 was reported.
- 5/9/20 – High Wind: Strong low pressure in the Gulf of Maine was exiting the region, but there was a strong northwest flow of air in its wake. Winds gusted to 45 to 55 mph across the region, causing scattered areas of downed trees, some which fell onto cars and homes. Winds generally were gusting to between 45 and 53 mph. At 444 PM EST, the Worcester Airport (KORH) recorded at 47 mph gust. In Harvard at 1050 AM EST, a large tree was down. Damage of $3,600 was reported from all towns impacted.

The previous edition of this plan noted that in Harvard, six severe wind events (including thunderstorms) and one hail event occurred in the 20-year period from 1996 and 2015. Given that seven events were reported in the recent lookback from 2012 through 2021, it appears that severe wind events are either occurring more frequently or are being reported more frequently. This is consistent with statements made by the local planning committee during the planning process for this update. Furthermore, during the public meeting on June 30, 2022, that were held in connection with the planning process, one attendee noted that the Hildreth House (a critical facility) was hit by lightning several years ago.

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 severe winds in Worcester County are listed below.

Table 31. Agricultural Disasters Related to Severe Winds.

Year	Event	Event Begin Dates
2016	Drought, wildfire, excessive heat, **high winds**, insects	8/2/2016, 8/16/2016, 8/30/2016
2016	Drought, wildfire, excessive heat, **high winds**, insects	7/5/2016
2012	**High Winds**, excessive rains	8/10/2012

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 NWS 10-1605 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 more than 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 SHMCAP notes that over the ten-year period between January 1, 2008, and December 31, 2017, a total of 435 high wind events occurred in Massachusetts on 124 days, and an annual average of 43.5 events occurred per year. This is consistent with the figure from the SHMCAP that thunderstorms typically occur on 20 to 30 days each year in Massachusetts, which is a subset of the 43.5 high wind event days.

NOAA reports that there are 10 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 33 people per year died from lightning strikes in the United States from 2004 to 2013. 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 SHMCAP notes that 8 fatalities and 145 injuries have occurred in Massachusetts because of lightning events between 1993 and 2017 (NCDC, 2017).

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.

Climate models show projections that the frequency and intensity of severe thunderstorms (which include tornadoes, hail, and winds) will increase (USGCRP, 2017).

Vulnerability Assessment

Exposure

The entire built environment of Harvard 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 significant property wreckage in Worcester County in previous years. Thunderstorms and hail with associated wind damage, caused an average annual property loss of $234K or $2.575M over 11 years to Worcester County. Using the population index, the Harvard AAL is $1,474.

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 Harvard are identified based on a number of factors including their physical and financial ability to react or respond during a hazard. Table 10 summarizes the senior and low-income populations in Harvard. 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

Thunderstorms and microbursts can cause damage to agriculture, and other, natural areas. Some areas of the Town may be out of service until trees are removed. Severe thunderstorms have caused minimal damage to agriculture to Worcester County over the last 21 years.

Non Climate-Induced Hazards

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 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 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 (USGS, 2012).

In some places in New England, including locations in Massachusetts, small earthquakes seem to occur with some regularity. For example, since 1985 there has been a small earthquake approximately every 2.5 years within a few miles of Littleton. 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 Harvard or to occur elsewhere and be felt anywhere in Harvard.

Previous Occurrences

To determine whether earthquakes have occurred recently near or in Harvard, all events listed by Weston Observatory were reviewed for all towns in Massachusetts for a five-year lookback. Listed earthquakes above magnitude 2.0 include:

- 12/21/18 – 3 mk WSW of Gardner, 2.1/2.1 [Mn*/Mc**]
- 8/21/19 – 2 km SSE of Wareham, 1.7/2.4
- 12/3/19 – 4 km SSE of Plymouth, 1.6/2.2
- 11/8/20 – 11 mk SW of New Bedford, 3.8/3.4
- 11/22/20 – 12 km WSW of New Bedford, 1.7/2.6

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

These are very minor earthquakes.

On June 22, 2010, a magnitude 5.8 earthquake in Canada could be felt in Worcester County. No damage was reported, but residents stated they felt the quake and were unnerved by the experience. On August 23, 2011, an earthquake measuring 5.8 on the Richter scale centered in Virginia was felt throughout the northeast, prompting the evacuation of several multi-story buildings in the Worcester County region, but causing no property damage or personal injury.

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. It 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 is 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 32. Modified Mercalli Intensity Scale.

Modified Mercalli Intensity	Description
I	Not felt except by a very few under especially favorable conditions

Modified Mercalli Intensity	Description
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.
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.

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

Table 33. Comparison of Richter Scale to Modified Mercalli Intensity Scale. 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 14% to 20% of gravity in northern Worcester County having a 2% probability of being exceeded in 50 years.

Vulnerability Assessment

Exposure

A major earthquake could cause severe damage to Harvard 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 Worcester County during this period, causing no damage to property. The entire built environment of Harvard is vulnerable to earthquakes. Older, unreinforced masonry buildings are very susceptible to earthquakes.

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. The economic loss results of the 1500-year event are shown in Table 34 while the results for the 2500-year event are shown in Table 35. The Town's Average Annual Loss (AAL) is modeled to be $31,790.

Table 34. Building Loss for a 1500-Year Scenario

Loss Type	Residential ($Million)	Commercial ($Million)	Other Occupancy ($Million)	Total ($Million)
Building Loss	**6.3**	**1.4**	**1.3**	**9**
Content Loss	2.3	0.7	0.8	**3.8**
Business Inventory Loss	0.0	0.0	0.1	**0.1**
Business Income Loss	0.0	0.3	0.0	**0.3**
Business Relocation Loss	0.2	0.2	0.1	**0.5**
Rental Income Loss	0.1	0.2	0.0	**0.3**
Wage Loss	0.0	0.3	0.1	**0.4**
Total	**8.9**	**3.1**	**2.4**	**14.4**

Table 35. Building Loss for a 2500-Year Scenario

Loss Type	Residential ($Million)	Commercial ($Million)	Other Occupancy ($Million)	Total ($Million)
Building Loss	12.9	2.6	2.4	**17.9**
Content Loss	4.9	1.4	1.5	**7.8**
Business Inventory Loss	0.0	0.0	0.2	**0.2**
Business Income Loss	0.0	0.5	0.0	**0.5**
Business Relocation Loss	0.5	0.4	0.3	**1.2**
Rental Income Loss	0.3	0.3	0.0	**0.6**
Wage Loss	0.0	0.5	0.1	**0.6**
Total	**18.6**	**5.7**	**4.5**	**28.8**

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. Table 10 summarizes the senior and low-income populations in Harvard. 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.

Hazus was used to model injuries and fatalities for the 1500- and 2500-year events. For the 1500-year event, there are few minor injuries not requiring medical attention. For the 2500-year event some minor injuries not requiring medical attention and a few injuries requiring a paramedic.

Environment Impacts

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

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

Table 36: 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	
	Likely	Between 10 and 100% annual probability	3	
	Highly Likely	100% annual probability	4	
Impact	Minor	Very few injuries, in any. Only minor property damage and minimal disruption on quality of life. Temporary shutdown of critical facilities.	1	30%
	Limited	Minor injuries only. More than 10% of property in affected area damaged or destroyed. Complete shudown of critical facilities for more than one day.	2	
	Critical	Mulitiple deaths/injuires possible. More than 25% of property in affected area damaged or destroyed. Complete shutdown of critical faicliteis 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 37 provides the final hazard ranking for Harvard. 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 3, it was assigned as a high-risk hazard. If the value was greater than 2 and less than or equal to 3, 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 extreme temperatures and severe winter storms hazards were ranked highest. The flood, wildfires/brushfires, hurricanes/wind, thunderstorms, drought, infectious disease, invasive species, and earthquakes are all ranked as moderate. The landslide and tornado hazards are ranked as low.

Table 37: Final Hazard Ranking of Hazards for Harvard

Hazards	Probability	Impact	Spatial Extent	Warning Time	Duration	Value	Rank
Flood	4	2	2	4	2	2.8	Mod.
Landslide	1	2	1	4	1	1.6	Low
Wildfires/Brushfires	2	2	3	3	3	2.4	Mod.
Hurricanes/Wind	2	4	4	1	2	2.9	Mod.
Severe Winter Storms	4	3	4	1	3	3.3	High
Tornadoes	1	3	1	3	1	1.8	Low
Thunderstorms	4	2	4	2	1	2.9	Mod.
Earthquakes	1	3	4	4	1	2.5	Mod.
Drought	2	3	4	1	4	2.8	Mod
Extreme Temperatures	4	2	4	2	2	3.0	High
Infectious Disease	4	2	4	1	2	2.9	Mod
Invasive Species	3	2	4	2	4	2.9	Mod

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))

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 FEMA during the completion of the Town's previous hazard mitigation plan, there are no repetitive loss properties located in Harvard. It is believed by Town officials that this is still the case. To confirm this information for the 2022 plan update, current NFIP data on repetitive loss structures for the community was sought from FEMA through multiple requests, including through the Massachusetts State NFIP Coordinator, State Hazard Mitigation Officer, and direct communication by the consultant team with FEMA Region 1. However, these requests are still pending. As suggested by the FEMA Region 1 Planning Staff to MEMA staff during its annual State Consultation (May 12, 2022), any updated information on repetitive loss properties will be included as a later addition to this plan update once the pending data request is granted. Please also note that 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).

Problem Statements

As suggested in FEMA's Local Mitigation Planning Handbook[9], the following problem statements were developed upon the completion and review of all risk assessment tasks. These statements are 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 future plan updates to reflect the most current information resulting from the risk assessment.

Primary Hazards of Concern (High Hazard Rankings)

- Severe Winter Storms
- Extreme Temperatures

Primary Impacts, Geographic Areas, and/or Vulnerable Assets of Concern

- Wind and Winter Storm Damage and Power Outages: The dispersed pattern of development and heavily forested landscape make the Town's residents vulnerable to sustained power outages caused by winter storms and severe winds that bring down trees and power lines. Power outages create major social and economic disruptions to the community and can lead to additional life/safety threats and secondary hazard events that extend beyond the initial cause. The Town should focus on both preventative mitigation techniques (such as pruning and hazard tree management or undergrounding powerlines) as well as emergency response measures to expedite power restoration as much as possible.
- Extreme Heat: Extreme heat events are projected to become more frequent and severe, with potentially major impacts to the community's more vulnerable populations (such as seniors, those without air conditioning, and outdoor farm/orchard workers). Updated plans and procedures for the Town's response to these events are recommended along with public outreach materials that can be useful during summer months and in advance of forecasted heat waves (providing information on individual preparedness activities, cooling centers, etc.).
- Intense Precipitation: Due to the projected and observed increase in heavy precipitation events, the Town is concerned with the impacts more frequent and extreme rainfall events will have on the community (roadway flooding, infrastructure failure, property damages, crop losses, etc.). The Town should focus on assessing and enhancing stormwater drainage capabilities in known problem areas with improved conveyance and detention/retention measures, with emphasis on

[9] Local Mitigation Planning Policy Guide. FEMA. March 2013. P. 5-2.

green infrastructure and nature-based solutions, while continuing to protect and/or enhance the natural and beneficial functions of floodplains, wetlands, and other natural systems. Vulnerable community assets located in high-risk areas (such as the Girl Scout Camp and St. Benedict Priory) should also be routinely considered for possible risk awareness and/or flood mitigation measures.

- Drought and Wildfires: While the Town has managed to address small wildfires and brush fires as they occur each year, increasing risks are posed by the impacts of droughts, which have reduced or eliminated the capacity of fire ponds in the last few years. The Town should focus on fire suppression and rapid deployment for addressing future wildfires (including the creation of more fire ponds) and may wish to consider joining the national Firewise USA program to promote more public outreach and involvement in wildfire risk reduction efforts.
- Vulnerability of Agricultural Sector: Droughts, invasive species, intense precipitation, and extreme temperatures may pose unique challenges to the agricultural sector, an important economic and unique cultural asset for the community. Agricultural resiliency efforts should be supported by specific actions that the Town as well as local orchards and other agribusiness can take to minimize the impact of these hazards and future adverse climate conditions.
- Critical Facilities: Standby power (typically generators) are needed for some critical facilities, and additional cooling centers are desirable for extreme heat management.

Chapter 5. Capability Assessment

Capability Assessment Purpose

The purpose of conducting a capability assessment is to determine the ability of a community to mitigate hazard risks and to identify potential opportunities for establishing or enhancing specific mitigation policies, programs, or projects. 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 their implementation. A capability assessment helps to determine which types of mitigation actions are practical and likely to be implemented over time based on a local jurisdiction's existing authorities, policies, programs, and resources available to support such implementation. This analysis will identify any critical capability gaps or shortfalls, as well the key strengths or positive measures already in place and which should continue to be supported.

The capability assessment serves as the foundation for designing an effective mitigation strategy. It not only helps establish the goals and actions for the Town of Harvard's hazard mitigation plan, but it ensures 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."*[10]

The capability assessment for the Town of Harvard includes a comprehensive examination of several components as summarized in Table 7.

Table 38. 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.
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.
Capability Assessment Conclusions	A summary of capability findings.

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

Review and Incorporation of Existing Studies

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 the capability assessment was to gather and review existing plans and other related documents to gain an understanding of the Town's ability to mitigate risk. A summary of the most relevant plans is provided below.

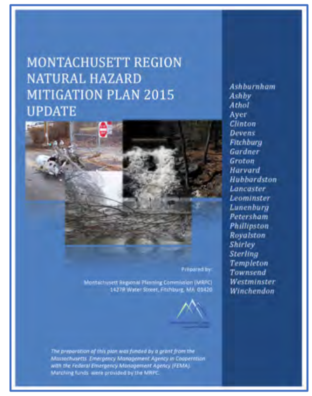
State Hazard Mitigation and Climate Adaptation Plan (2018)

The Commonwealth's 2018 State Hazard Mitigation and Climate Adaptation Plan (SHMCAP) is an innovative, first-of-its-kind statewide plan that fully integrates a traditional hazard mitigation plan with a climate change adaptation plan. The SHMCAP fulfills two important requirements, including (1) updating the 2013 State Hazard Mitigation Plan as required by Federal regulations (44 CFR Part 201.4); and (2) fulfilling requirements for a state climate adaptation plan per Massachusetts Executive Order 569. The SHMCAP has five goals as shown below:[11]

- Enhance the Commonwealth's resiliency to natural hazards and climate change by integrating programs and building institutional capacity.
- Reduce the impacts of natural hazards and climate change with forward-looking policies, plans, and regulations.
- Understand our vulnerabilities and risks and develop immediate and long-term risk reduction strategies for current and future conditions using the best available science.
- Increase the resilience of State and local government, people, natural systems, the built environment, and the economy by investing in performance-based solutions.
- Support implementation of this plan through increased education, awareness, and incentives for action for state agencies, local governments, private industry, non-profits, and the public.

The Town of Harvard's Hazard Mitigation Plan is consistent and aligned with the SHMCAP. The goals in the following chapter include several of the themes shown in the State plan, including the integration of hazard mitigation and climate adaptation strategies in local policies, plans, and regulations; improving public education and awareness; building local capacity; and reducing risk to people, property, and infrastructure to natural hazards and climate change. In addition, as seen in Chapter 4, the risk assessment has been updated to be organized using the same hazard classification scheme as used for the SHMCAP.

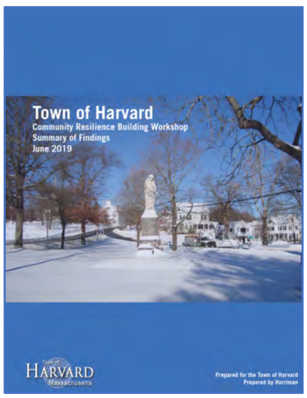
[11] Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018. P. 7-2.



Montachusett Region Natural Hazard Mitigation Plan 2015 Update

The Town of Harvard was part of the Montachusett Region multi-jurisdiction hazard mitigation. This plan was reviewed carefully for details about Harvard such as capabilities, hazards, and mitigation actions. The plan includes 10 goal statements, 27 objectives, and thirteen actions. All the mitigation actions identified in this plan for Harvard were considered for inclusion in this plan. The goals were revised and consolidated, and the objectives were eliminated.

Town of Harvard Community Resilience Building Workshop – Summary of Findings (2019)



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 2018, Harvard 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 Harvard followed the Community Resilience Building (CRB) framework with technical assistance provided by a state-certified MVP Provider, Harriman. The CRB methodology is an "anywhere at any scale" format that draws on stakeholders' wealth of information and experience to foster dialogue about a community's strengths and vulnerabilities. As an agricultural and residential community, Harvard is faced with a unique set of challenges and impacts related to climate change. For this reason, the Town sponsored two half-day agricultural workshops in February and March 2019 to focus specifically on these issues. These were followed by two three-hour CRB workshops in April 2019 which addressed the broader impacts of climate change on Harvard outside of the agriculture industry. Specifically, the goals of the workshops were to:

- Define top local, natural, and climate-related hazards of concern.
- Identify existing and future strengths and vulnerabilities.
- Develop prioritized actions for the community.
- Identify immediate opportunities to collaboratively advance actions to increase resilience.

The Town's resulting Summary of Findings Report and supporting materials served as a primary source of information and community-based inputs for the update to this plan update. These inputs include the identification of top climate-influenced hazards (including pests/invasive species, extreme precipitation, extreme temperatures/temperature swings, and ice storms) 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 Harvard.

The Impact of Climate Change on Agriculture: Harvard, Massachusetts (2019)

This report is a companion to the Community Resilience Building Workshop – Summary of Findings report described above and was completed as part of the same MVP planning process. It focuses on agriculture: the concerns raised during the process, the data collected, and the preferred actions identified by participants in the process. It includes a more detailed description of how climate hazards are projected to impact the town's agricultural resources, along with a series of recommended strategies to address these unique climate vulnerabilities. The key takeaway from this process is that climate change is not the only pressure on agriculture in the Town of Harvard, is not the current immediate pressure. However, the cost of strategies to adapt to or mitigate the impacts of climate change on farming operations adds pressure to the limited resources, particularly financial, that farmers have.

Town of Harvard Housing Production Plan (2017)

The Housing Production Plan is designed to guide the expansion of affordable housing opportunities in Harvard. It represents a management tool for ensuring that timely progress is made toward meeting the Town's affordable housing goals. It is based on a comprehensive needs assessment and a thorough analysis of existing conditions, demographic trends, and local and regional market forces. It identifies the constraints that have limited affordable housing production in Harvard, and the Town's efforts to mitigate them. It also identifies opportunities and lays out the strategies the Town will pursue to meet its goal of providing housing for families across a broad range of income, age and needs.

Harvard's Housing Production Plan describes the mix of housing units required to address the identified needs and a time frame for their production. It recommends several regulatory reforms and strategies to expand local development capacity. It includes preservation strategies as well as new production initiatives, and it anticipates a significant role for both private and Town-initiated development.

Town of Harvard Master Plan (2016)

The Town's 2016 update to its Master Plan (last updated in 2002) is the result of numerous public input sessions and committee meetings and sets out a clear path for guiding the Town forward over the next ten-year planning horizon. The plan establishes a community vision for the future that is centered on achieving long-term sustainability. It also identifies a set of goals and objectives that define the principles by which the Town of Harvard will evaluate all future courses of action.

The Master Plan contains individual chapters that address the various elements required by Massachusetts Master Plan Law, including Land Use, Natural Resources & Open Space, Population & Housing, Harvard's Economy, Cultural Resources, Community Services & Facilities, and Circulation &

Traffic. Additional chapters report on the status of Devens, discuss Opportunities and Challenges, and provide implementation actions for each element. Natural hazards and pre-disaster mitigation strategies are not thoroughly integrated into the plan, though related issues such as stormwater management and Areas of Environmental Concern (ACESs), including floodplains, are addressed in the Natural Resources & Open Space element. Appendix 1 also contains a detailed Development Suitability Analysis that considers environmentally sensitive areas that are not suitable for building, such as wetlands, floodplains, and water supply protection areas.

Town of Harvard Open Space & Recreation Plan (2016)

This sixth update to the Open Space & Recreation Plan represents the Town's comprehensive approach to protecting its abundant scenic and natural resources, and to provide recreational opportunities for the public. It is intended to be used as a tool by local leaders to help ensure that the Town maintains its scenic beauty and landscape character, while working to accommodate growth and the increased demand for recreational facilities. The Plan contains (1) a compilation and analysis of the Town's natural resources - its waterways, forests, and wildlife habitats; (2) an existing inventory of all permanently protected and unprotected open space and outdoor recreational facilities within the Town; and (3) detailed maps showing special landscape features, water resources, open spaces, habitat, and zoning.

As it relates to hazard mitigation, the plan identifies and describes the benefits of preserving the Town's open space and natural resources, particularly as it relates flood risk reduction through the protection of wetlands and floodplains. It also includes a section that addresses the potential impacts of climate change including a greater frequency and severity of storm events, the spread of invasive species and infectious diseases, and how people interact with the natural environment because of health concerns. It also describes how the challenge of maintaining working agricultural lands as part of Harvard's landscape will be increased due to climate change, noting that local farmers in particular will be vulnerable to unseasonable weather like early springs, late frosts, ice storms, and damaging hail.

Hazard Mitigation Plans and MVP plans from surrounding communities were reviewed. The HMPC reviewed these plans for information regarding hazards and their impact as well as for mitigation action ideas. The HMPC looked specifically for actions that they may want to replicate as well as for opportunities to collaborate with other communities. The list of some of the plans reviewed is below:

- Town of Bolton Hazard Mitigation Plan 2018 Update
- Town of Boxborough Hazard Mitigation Plan, November 2010
- Town of Littleton Hazard Mitigation Plan 2017 Update

In addition to the above plans which were determined to be most relevant for the hazard mitigation plan update, the following plans, studies, reports, and other technical documents were reviewed to gain a clearer understanding of their existing or potential effects on hazard risk reduction:

- Ecological Restoration and Resiliency Opportunities Table – summarizes the results of the Apple Country Natural Climate Solutions Project, including the identification of specific actions for the Town of Harvard to undertake to implement nature-based solutions that increase the resilience and adaptive capacity of the region's ecological, economic, and physical infrastructure.

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 39 is based on Worksheet 4.1 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.

Table 39. Planning and Regulatory Findings

Planning/Regulatory Tool	Responsible Authority	General Description and Effectiveness for Hazard Risk Reduction
Plans		
Comprehensive/Master Plan	Planning Board	As described above, natural hazards and pre-disaster mitigation strategies are not explicitly integrated into the plan, though related issues are addressed and consistent with hazard risk reduction (such as preserving open space and protecting natural landscapes).
Open Space & Recreation Plan	Open Space Committee	As described above, the Town's OSRP is considered an effective tool that is consistent with hazard risk reduction, particularly as it relates to addressing flood mitigation and climate change adaptation.
Housing Production Plan	Planning Board, Select Board, Municipal Affordable Housing Trust	Although the plan doesn't directly relate to hazard risk reduction, it does identify wetlands, floodplains, and steep slopes as environmental constraints to new development. See above for a more complete description.
Economic Development Plan	Planning Board	Included in Master Plan (Chapter 5: Harvard's Economy)
Capital Improvements Plan	Capital Planning and	Can be an effective tool for the planning, phasing, and funding of infrastructure improvements and

Planning/Regulatory Tool	Responsible Authority	General Description and Effectiveness for Hazard Risk Reduction
	Investment Committee	other capital projects in support of hazard risk reduction.
Emergency Operations Plan	Fire Department	Updated in 2021 An Emergency Action Plan is near completion for Bare Hill Pond Dam.
Continuity of Operations Plan	Fire Department	Updated in 2022
Transportation Plan	Transportation Advisory Committee	Included in Master Plan (Chapter 8: Circulation & Traffic). The Committee is currently focused on Ayer/road corridor but also looking at bikeways and walkways.
Stormwater Management Plan	Department of Public Works	N/A – Harvard is exempt from MS4 permitting due to a waiver letter from the U.S. EPA Region 1, dated April 13, 2015. Recently however the Town adopted Bylaw provisions that enhanced the regulation of activities outside wetlands that impact runoff and stormwater to further control the risk of stormwater runoff.
Other special plans? (e.g., brownfields redevelopment, disaster recovery, climate adaptation)	Harvard Climate Initiative Committee	MVP plans/reports (described above) Currently developing a Climate Action Plan. Harvard also partnered with the Town of Bolton and Devens on the *Apple Country Natural Climate Solutions Project*. This project focused on farms, turf fields, wetlands, and forests for ideas regarding nature-based solutions for protection of these resources.
Building Code, Permitting, and Inspections		
Building Code	Building Commissioner	Version/Year: 780 CMR 9th edition of MA state building code & 2015 IRC/IBC codes. These includes numerous provisions for reducing risks posed by natural hazards (e.g., flood-resistant construction, seismic design standards, wind, and snow load requirements, etc.).
Building Code Effectiveness Grading Schedule (BCEGS)	ISO/Verisk	unknown
ISO Fire Protection Rating	ISO/Verisk	unknown
Site Plan Review Requirements	Planning Board	

Planning/Regulatory Tool	Responsible Authority	General Description and Effectiveness for Hazard Risk Reduction
Zoning and Development Regulations		
Zoning Bylaws	Planning Board	Yes – Effective tool for hazard risk reduction through multiple regulatory standards and provisions for managing growth and future development, including those cited below. This includes Protective (Zoning) Bylaws and other regulations that establish overlay districts as well as the type and use standards along with other conditions for new/improved construction. However more can be done to address long-term sustainability and climate action principles and goals. The Town believes that that current zoning bylaws can be greatly enhanced with best practice and innovative provisions related to environmental protection, sustainability, and climate action.
Subdivision Regulations	Planning Board	Chapter 130 of the Town Code. Effective for ensuring safety in case of fire, flood, panic, and other emergencies, and for ensuring compliance with the Protective (Zoning) Bylaw and other laws and ordinances regulating the use of land and access to it; and for securing the adequate provision for water, sewerage, drainage, underground utility services, fire, police, ambulance, and other similar equipment.
Floodplain Regulations	Planning Board (enforced by Building Commissioner and Conservation Commission)	Chapter 125-54 of the Protective (Zoning) Bylaws establishes floodplain overlay districts. Effective for reducing risk in known special flood hazard areas, and in combination with other regulations (Wetlands and Subdivision Control), supports the regulation of all activities in wetlands and stormwater control protection provisions to prevent flooding from site work, and other planning controls.
Stormwater Management Regulations	Department of Public Works	Stormwater management standards are and continue to be enforced through various bylaws (i.e., Wetlands Protection, Subdivision Control, Sewer Commission Rules & Regulations, etc.). The Conservation Commission recently updated their regulations, Chapter 147, to include detailed stormwater requirements consistent with the State's and

Planning/Regulatory Tool	Responsible Authority	General Description and Effectiveness for Hazard Risk Reduction
		requiring a reduction of volume and rate by 5 percent.
Other hazard-specific regulations or ordinances?	Various – see at right	Erosion Control Bylaw (Planning Board) Wastewater Management Regulations (Water & Sewer Commission)

Safe Growth Survey

As part of the assessment for planning and regulatory capabilities, the Town's Director of Community and Economic Development was asked to complete 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 Harvard 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 future 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 40. This includes describing how strongly the Town's planning staff agrees or disagrees with 25 statements as they relate to the Town of Harvard'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 40. Safe Growth Survey Results

COMPREHENSIVE/MASTER PLAN	
Land Use	
1. The comprehensive/master plan includes a future land use map that clearly identifies natural hazard areas.	[1] 2 3 4 5
2. Current land use policies discourage development and/or redevelopment within natural hazard areas.	1 2 3 [4] 5
3. The comprehensive/master plan provides adequate space for expected future growth in areas located outside of natural hazard areas.	1 2 3 [4] 5
Transportation	
4. The transportation element limits access to natural hazard areas.	1 2 [3] 4 5
5. Transportation policy is used to guide future growth and development to safe locations.	1 2 [3] 4 5
6. Transportation systems are designed to function under disaster conditions (e.g., evacuation, mobility for fire/rescue apparatus, etc.).	1 [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 [4] 5
8. Environmental policies encourage the preservation and restoration of protective ecosystems.	1 2 [3] 4 5
9. Environmental policies provide incentives to development that is located outside of protective ecosystems.	1 2 3 [4] 5
Public Safety	
10. The goals and policies of the comprehensive/master plan are related to and consistent with those in the hazard mitigation plan.	1 [2] 3 4 5

COMPREHENSIVE/MASTER PLAN	
11. Public safety is explicitly included in the comprehensive/master plan's growth and development policies.	1 [2] 3 4 5
12. The monitoring and implementation section of the comprehensive/master plan covers safe growth objectives.	1 2 [3] 4 5
ZONING BYLAWS	
13. The zoning bylaws conform to the comprehensive/master plan in terms of discouraging development and/or redevelopment within natural hazard areas.	1 2 [3] 4 5
14. The bylaws contain natural hazard overlay zones that set conditions for land use within such zones.	1 2 3 [4] 5
15. Rezoning procedures recognize natural hazard areas as limits on zoning changes that allow greater intensity or density of use.	1 2 [3] 4 5
16. The bylaws prohibit development within, or filling of, wetlands, floodways, and floodplains.	1 2 3 4 [5]
SUBDIVISION REGULATIONS	
17. The subdivision regulations restrict the subdivision of land within or adjacent to natural hazard areas.	1 2 [3] 4 5
18. The regulations provide for conservation subdivisions or cluster subdivisions to conserve environmental resources.	1 2 3 [4] 5
19. The regulations allow density transfers where hazard areas exist.	[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 [2] 3 4 5
21. Infrastructure policies limit the extension of existing facilities and services that would encourage development in areas vulnerable to natural hazards.	1 [2] 3 4 5

COMPREHENSIVE/MASTER PLAN					
22. The capital improvements program provides funding for hazard mitigation projects identified in the hazard mitigation plan.	1	2	[3]	4	5
OTHER					
23. Small area or corridor plans recognize the need to avoid or mitigate natural hazards.	[1]	2	3	4	5
24. The building code contains provisions to strengthen or elevate new or substantially improved construction to withstand hazard forces.	1	2	[3]	4	5
25. Economic development and/or redevelopment strategies include provisions for mitigating natural hazards or otherwise enhancing social and economic resiliency to hazards.	1	2	3	[4]	5

Administrative and Technical Capabilities

Table 41 is based on Worksheet 4.1 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 41. Administrative and Technical Findings

Administrative/Technical Resource	Full-time (FT) / Part-time (PT) / Volunteer (V)	General Description and Effectiveness for Hazard Risk Reduction
Administration		
Planning Board	1 FT, 1 PT, 6 volunteers	The Planning Board is charged with the responsibility of protecting the health, safety, and welfare of Harvard's residents. Guided by the State Laws, the Harvard Protective (Zoning) Bylaw, the 2016 Harvard Master Plan and citizen's comments and concerns, the Board strives to preserve and enhance the integrity of Harvard's rural character using these regulatory tools, while safeguarding property owners' rights. The Board recommends and specifies changes to development proposals to achieve these goals. Board members and staff strive to work with both project proponents and citizens to help shape

Administrative/Technical Resource	Full-time (FT) / Part-time (PT) / Volunteer (V)	General Description and Effectiveness for Hazard Risk Reduction
		projects to minimize the impact to the community.
Conservation Commission	1 PT, 6 volunteers	The Conservation Commission is responsible for administering the Wetland Protection Act (Ch.131 S40) and the Harvard Wetland Protection Bylaw. The Commission issues permits for activities in and near wetlands, floodplains, banks, river front areas, beaches, vernal pools, and surface water. The Commission is the official agency charged with the protection of the community's natural resources and management of town owned Conservation Land, currently ~1832 acres. The Commission also advises other town boards and officials on conservation issues that relate to their area of responsibility.
Hazard Mitigation Planning Committee	5 PT	The HMPC consists of five core team members from key departments (Public Safety, Fire, Police, DPW, and Building) who are supported by many other local stakeholders. Considered very effective in terms implementing and maintaining this plan.
Maintenance Programs to Reduce Risk (e.g., tree trimming, drainage clearance)	1 FT, 1 PT, 1 volunteer	Regular cleaning of catch basins, storm drains, and culverts. Periodic cleaning of waterways needed (i.e., remove trash, debris, etc.). DPW also does a brush mowing yearly, trims trees/branches as necessary, and works with the Tree Warden to remove hazard trees.
Mutual Aid Agreements	Yes	Statewide Public Safety and Public Works Municipal Mutual Aid Agreements are in place.
Land Steward Committee	Volunteer	Helps with the management of invasive species.
Staff		
Chief Building Official	1 FT	Staffing inadequate with multiple duties. Yes, trained. Effective coordination.
Floodplain Administrator	PT (multiple positions)	The Town has not yet formally designated a community Floodplain Administrator, however applicable duties and responsibilities are carried out by multiple staff.
Emergency Manager	1 PT	

Administrative/Technical Resource	Full-time (FT) / Part-time (PT) / Volunteer (V)	General Description and Effectiveness for Hazard Risk Reduction
Community Planner	1 FT	Director of Planning
Civil Engineer	None	N/A
GIS Coordinator	None	N/A
Resource Development Staff or Grant Writers	None	N/A
Conservation Agent	1 FT	
Public Information Officer	None	N/A
Technical		
Staff with knowledge of land development and land management practices	2 FT and 2 PT	
Staff trained in construction practices related to buildings and/or infrastructure	1 FT	
Staff with an understanding of natural hazards and risk mitigation	1 FT and 1 PT	
Hazards data and information	1 PT	
Warning systems/services (e.g., Reverse 911, outdoor warning signals, etc.)	Yes (Fire Department)	Subscribed to Blackboard Connect CTY for "reverse 911" notifications and the Town has an electronic notification siren at 11 Elm Street.

Financial Capabilities

Table 42 is based on Worksheet 4.1 from FEMA's *Local Mitigation Planning Handbook*. It was used by the HMPC to identify the Town's eligibility and access to funding sources that can be used to support the implementation of hazard mitigation projects.

Table 42. Financial Findings

Financial Tool/Source	Accessible for Hazard Mitigation (Yes/No)	General Description and Effectiveness for Hazard Risk Reduction
General funds	Yes	Bare Hill Watershed Management Committee
Capital Improvement Program (CIP) funding	Maybe	The Town's Capital Planning and Investment Committee reviews capital expense items submitted for consideration by various town

Financial Tool/Source	Accessible for Hazard Mitigation (Yes/No)	General Description and Effectiveness for Hazard Risk Reduction
		departments, boards or committees and determine if the proposed item represents a genuine need and if the proposed cost is reasonable. The Capital Committee shall also determine if alternative sources of funding were explored and upon their review, prioritize items to be funded.
Special purpose taxes	No	N/A
Fees for water, sewer, gas, or electric services	No	N/A
Stormwater utility fee	No	N/A
Development impact fees	No	N/A
Incur debt through general obligation bonds and/or special tax bonds	No	N/A
Incur debt through private activities	No	N/A
FEMA Hazard Mitigation Assistance (HMA)	Yes	The Town has applied for HMGP grants in the past.
HUD Community Development Block Grant (CDBG)	No	N/A
Other federal funding programs	Yes	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.
State funding programs	Yes	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 to pursue in the future include MVP Action Grants and other programs through EEA, such as the Culvert Replacement Municipal Assistance Grant Program.
Other Resources	Yes	The Town received a grant from the Nashua River Watershed Association to address four culverts that needed to be resized.

Education and Outreach Capabilities

Table 43 is based on Worksheet 4.1 from FEMA's *Local Mitigation Planning Handbook*. It was used by the HMPC to identify education and outreach programs that can be used to support mitigation activities.

Table 43. Education and Outreach Findings

Program/Method	Yes/No	Description and Effectiveness for Hazard Risk Reduction
Local citizen groups or non-profit organizations focused on environmental protection, emergency preparedness, access and functional needs populations, etc.	Yes	Harvard Climate Initiative Committee, Conservation Commission, Harvard Conservation Trust
Ongoing public education or information program (e.g., responsible water use, fire safety, household preparedness, environmental education)	Yes	Fire Department hosts Open House to increase awareness and educate property owners on action they can take to reduce risk. Pamphlets on fire safety and wildfire prevention are also routinely distributed (S.A.F.E. and Senior S.A.F.E.). DPW sends out a consumer confidence report yearly telling people how to protect the public water supply and how to conserve water.
Natural disaster or safety-related school programs	Yes	Student Awareness of Fire Education (S.A.F.E.) program.
StormReady certification	No	N/A
Firewise USA® certification	No	N/A
Public-private partnership initiatives addressing disaster-related issues	No	N/A
Other programs/methods?	Yes	Links to FEMA information on Town website Public Access Television

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))

As summarized in Table 44, the HMPC used Worksheet 4.3 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* completed by the Town's Economic Development and Public Works Directors, helped the HMPC to identify areas for improvement and other ideas that could be potential mitigation actions. These actions, including those related to continued compliance with NFIP requirements, are identified and further discussed in Chapter 6 (Mitigation Strategy).

Table 44. 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?	State NFIP Coordinator, FEMA (PIVOT)	As of May 6, 2022, a total of 7 NFIP policies are in force. The total premium is $3,996 for a total of $2,450,000 in coverage.
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?	State NFIP Coordinator, FEMA (PIVOT, CIS)	There have been no claims paid in the community.
How many structures are exposed to flood risk within the community?	GIS analysis (FEMA FIRMs + building footprint data)	It has been estimated that 24 structures are at risk to the 1-percent annual chance flood, and 36 are at risk to the 0.2 percent annual chance flood for a combined total of 60 structures exposed to flood risk.
Describe any areas of flood risk with limited NFIP policy coverage	N/A	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 7 current policies under the NFIP in comparison to 60 structures estimated to be exposed to moderate to high flood risk).
Staff Resources		
Is the Community FPA or NFIP Coordinator certified?	N/A	The Town has not formally designated a community Floodplain Administrator but will do upon adopting the MA 2020 State Model Floodplain Bylaw.

NFIP Topic	Source of Information	Comments
Is floodplain management an auxiliary function?	HMPC	Yes – split between multiple departments (Economic Development, Conservation, Building, Public Works)
Provide an explanation of NFIP administration services (e.g., permit review, GIS, education or outreach, inspections, engineering capability)	MA 2020 Model Floodplain Bylaw	Typical services include (1) understanding the regulations for floodplain development; (2) ensuring that permits are applied for when development of any kind is proposed in the floodplain; (3) involvement with the permit process and/or permit application review; (4) coordinating with other local departments as needed; (5) notifying adjacent communities prior to alteration of a watercourse; (6) dealing with compliance issues and enforcement actions such as correcting violations; and (7) maintaining records of floodplain development, and keeping FEMA current and historic maps available for public inspection.
What are the barriers to running an effective NFIP program in the community, if any?	HMPC	Lack of dedicated staffing. The community has limited resources available beyond the preparation of the hazard report for the Bare Hill Pond Dam and enforcement of the protective By-Law. That said, there is good local knowledge of the small streams and Bare Hill Pond.
Compliance History		
Is the community in good standing with the NFIP?	State NFIP Coordinator, FEMA	Yes
Are there any outstanding compliance issues (i.e., current violations)?	State NFIP Coordinator, FEMA	No
When was the most recent Community Assistance Visit (CAV) or Community Assistance Contact (CAC)?	State NFIP Coordinator, FEMA (CIS)	Last CAC was 09/28/2001 Last CAV was 01/27/2003
Is a CAV or CAC scheduled or needed?	HMPC	No
Regulation		

NFIP Topic	Source of Information	Comments
When did the community enter the NFIP?	State NFIP Coordinator, FEMA (CIS)	06/15/1983 (Regular Entry) 06/25/1975 (Emergency Entry)
Are the FIRMs digital or paper?	FEMA Map Service Center	Digital (effective July 16, 2014).
Do floodplain development regulations meet or exceed FEMA or State minimum requirements? If so, in what ways?	Chapter 125-54 of the Protective (Zoning) Bylaws	Floodplain regulations are met through the Town's Zoning Bylaws (Chapter 125), which meet all current FEMA/NFIP requirements and State minimum requirements. These regulations will be routinely updated as necessary to maintain compliance with existing NFIP and State minimum standards for floodplain management.
Provide an explanation of the permitting process.	Community Records	Local permitting process is conducted per Chapter 125-54 of the Protective (Zoning) Bylaws and enforced by the Building Commissioner (municipal staff) and Conservation Commission staffed by the Town's Conservation Agent.
Community Rating System (CRS)		
Does the community participate in CRS?	HMPC	No, however the Town will continue to explore the benefits of CRS participation as Risk Rating 2.0 goes into effect and as updates to the CRS program are made by FEMA.
What is the community's CRS Class Ranking?	N/A	N/A
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 but will not be evaluated or scored for credit until the Town decides to apply for CRS participation.

Table 8 provides some additional information in response to the updated requirements included in FEMA's 2022 Local Mitigation Planning Policy Guide:[12]

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

Table 45. Additional NFIP Participation and Compliance Information

Required Information	Response
Adoption of NFIP minimum floodplain management criteria via local regulation.	Chapter 125-54 of the Protective (Zoning) Bylaws. The Town follows all mandatory standards of the NFIP in addition to those set forth by the Massachusetts Wetlands Protection Act regarding floodplain development.
Adoption of the latest effective Flood Insurance Rate Map (FIRM), if applicable.	Chapter 125-54 of the Town's Protective (Zoning) Bylaws establishes the Floodplain District as shown on the official Flood Insurance Rate Map (FIRM) for the Town of Harvard dated July 16, 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 7.
Appointment of a designee or agency to implement the addressed commitments and requirements of the NFIP.	The Town has not formally appointed a designee or agency but will do upon adopting the MA 2020 State Model Floodplain Bylaw.
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 thru 65) and Massachusetts State Building Code (780 CMR). The Town will also coordinate with State Flood Hazard Management Program to assure that proper practices are followed and that a post-disaster plan will be in place to implement all SI/SD provisions.

Conclusions

As exemplified by previous hazard mitigation, climate adaptation, and similar sustainability plans and initiatives, the Town of Harvard is capable and committed building a resilient community in the face of increasing hazards and climate change. The Town has led by example and continues to pursue innovative and creative ways to address these global challenges through local action. Initiatives taken and supported by the Select Board and Town Meeting have routinely demonstrated that the Town of Harvard has strong capabilities and resources to adopt and implement hazard risk reduction measures. These measures include a variety of planning and regulatory initiatives (i.e., wetlands protection, stormwater management, etc.) as well as the Town's investment in resilience-themed projects and outreach campaigns. This includes multiple efforts launched through MVP Action Grants and continuing today, such as the Town's Community Resilience Working Group (CRWG), which has more recently been replaced with Harvard's Climate Initiative.

Although Harvard is well-positioned to mitigate the natural hazard risks faced by the community, the Town can expand and improve on the capabilities described in this chapter. 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

- Update existing Zoning Bylaws through a series of amendments related to hazard mitigation, climate adaptation, and overall environmental sustainability. This has been envisioned as a comprehensive, multi-jurisdictional project in coordination with the towns of Athol and Ayer.
- Incorporate Nature-based Solutions (NbS) into existing Town bylaws (including through the above recommendation), and through future application of implementation, publicize and promote their effectiveness for hazard risk reduction through a demonstration site for people to visit and learn more about NbS practices.
- Integrate plans (HMP, MVP, and other resilience-themed plans/reports) into a consolidated document, website, etc. This includes integrating future iterations of its MVP plans and reports (for example, under EEA's rollout of MVP Planning 2.0) into this Hazard Mitigation Plan through amendments or revisions that can occur before the next 5-year plan update.
- Increase and maintain coordination with the Devens Enterprise Commission (DEC), the regulatory and permitting authority for the neighboring community of Devens. The Town partnered with the DEC on the Apple Country Natural Climate Solutions Project, and more recently the DEC coordinated the production of the Devens Forward Climate Action and Resiliency Plan, a collaboration between staff, community members, and outside experts that addresses how to build resilience against growing climate change impacts in Devens. The DEC offers additional technical expertise in NbS, including green infrastructure and low impact development.
- Add a future land use map that clearly identifies natural hazard areas to the Town's Master Plan during the next update.
- Develop methods to help ensure the Town's capital improvement program limits expenditures on projects that would encourage development and/or redevelopment in areas vulnerable to natural hazards. This could include infrastructure policies that limit the

extension of existing facilities and services that would encourage development in areas vulnerable to natural hazards.

Administrative and Technical Capabilities

- Provide more hours for Board of Health staff (Covid-19 revealed they need more hours).
- Hire additional DPW personnel and purchase additional equipment for drainage system maintenance (determined by staff as necessary to conduct this work more effectively).
- Increase staffing to support multiple duties assigned to the Building Commissioner.
- Develop GIS data and maps relevant to agriculture (local farms in Harvard) to assist with future geospatial analysis in support of hazard mitigation and climate adaptation planning efforts.
- Continue to routinely inventory supplies at existing shelters; and develop a needs list and storage requirements to ensure the availability of adequate supplies during an emergency.
- Coordinate with DEC in terms of pre-event planning and leveraging the ability to share resources during emergencies. The US Army should be considered a nearby resource in terms of shared resources/regional coordination with Fire and DPW (shared equipment/resources).

Financial Capabilities

- Continue to coordinate with neighboring communities as it relates to positioning the Town to pursue and capture future grant funding for regional hazard risk reduction projects. This is particularly true for federal mitigation grants available through FEMA's HMA grant programs (BRIC, HMGP, FMA) as well as MVP Action Grants through the Massachusetts MVP program.
- Leverage opportunities with the Town's Capital Planning and Investment Committee to help fund priority hazard mitigation and climate adaptation projects, particularly when combined with alternative/external grant funding sources when a local cost-share increases the Town's chances for a grant award.

Education and Outreach Capabilities

- Continue to integrate natural hazard risk reduction as a core theme for Harvard's Climate Initiative, especially as it relates to community education and opportunities for residents to take actions in support of the Town's sustainability and resiliency.
- Identify specific methods to further engage Environmental Justice communities in the region's hazard mitigation and climate adaptation efforts, including more coordination with Devens and other neighboring communities with EJ populations.

- Educate property owners about how to mitigate risk to their properties such as installing backflow valves, removing debris, and other low-cost and/or Do-It-Yourself projects for risk reduction.

Possible New Actions Related to NFIP Participation and Compliance

- Formally designate a community Floodplain Administrator (FPA).
- Encourage/support Certified Floodplain Manager (CFM) certification for the position to be formally designated as the Town's FPA.
- Employ broader staffing to assist with NFIP participation and compliance. This includes designating departments/positions with specific NFIP-related roles and responsibilities, linking those staff with proper training and educational opportunities.
- Adopt the 2020 MA State Model Floodplain Bylaw to assure that the Town's current bylaws and ordinances (Zoning Bylaw Chapter 125-54) contain the necessary and proper language for compliance with the NFIP and state requirements. This will also help the Town in continuing to limit new development within the 100-year floodplain and to prohibit the storage of hazardous materials within the Floodplain District. It also requires the formal designation of a community Floodplain Administrator (staff position).
- To assist with implementing substantial damage provisions of the NFIP, develop a local post-disaster substantial damage plan in coordination with the State Flood Hazard Management Program and the Massachusetts Local Guidance for NFIP Substantial Damage Planning.

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))

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 Harvard, MA Hazard Mitigation Plan Update the HMPC reviewed the previous plan's goal statements, the Municipal Vulnerability Preparedness (MVP) plan goal statements, and the goals of the State's Hazard Mitigation and Climate Adaptation Plan (SHMCAP).

There is one overall goal statement in the Montachusett Region Hazard Mitigation Plan from 2016 for Harvard, and ten objectives. Then there is a goal statement and objectives for each hazard studied, flooding, beavers, hurricanes and tornadoes, winter related hazards, dam failure, earthquakes, drought, wildfires/brushfires, and weather extremes. They each read similarly to this overall goal statement, "To reduce the loss of life, property, infrastructure and cultural resources throughout the town of Harvard from natural disasters through a multiple hazard mitigation program that involves increased coordination, planning, education, and capital improvements."[13] The HMPC revised these goal statements and objectives by combining them into one mission statement, and three goal statements that include the addition of climate change, and the priorities developed through the mitigation actions. Mention of specific hazards was removed to prevent accidentally eliminating a potential hazard.

[13] Montachusett Region Hazard Mitigation Plan, May 2016. P.293.

Mission Statement

- Reduce or eliminate risk to people, property, and infrastructure from natural hazards and climate change.

Figure 18. Mission Statement.

After careful review of the MVP Plan and the Montachusett Region Hazard Mitigation Plan from 2016, it was clear that climate change needed to be added to the mission statement and goal statements. In addition, three categories of mitigation action were created: public engagement, capacity building, and infrastructure and critical facilities. The following goal statements were developed for each category:

Critical Facilities and Infrastructure

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

Public Education and Outreach

- Conduct public outreach and education regarding how to mitigate risk posed by natural hazards and climate change.

Capacity Building and Planning

- Expand the Town's capacity to mitigate risk by including hazard mitigation concepts into local plans and regulations and collaborating with regional partners.

Figure 19. Goal Statements.

The mitigation actions from Montachusett Region Hazard Mitigation Plan from 2014 were reviewed for their status and relevance to this plan update. The following table shows the previous plan's thirteen mitigation actions and the status of each. Some of the actions that were marked as "delayed" or "to be continued" were included in this plan in combination with other actions, some were deemed no longer relevant. The actions marked as "partially completed or in progress" were not moved forward because the Town is not seeking additional funding for them. The final column in the table indicates the location of any actions moved forward to this plan update.

Table 46. Status of 2014 Mitigation Actions.

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action #/Description (if applicable)
1	Identify Existing Shelters that are Earthquake Resistant as well as Outside of Floodplain (and Dam Inundation) Areas to ensure that shelters are available to reduce or eliminate risk to human life.	Completed + To Be Continued	New Harvard Elementary School falls under current building code.	NO - explanation provided at left	#4, Updating Town Bylaws and Zoning Bylaws to prioritize hazard mitigation, climate adaptation and resiliency. Implementing this action will ensure shelters and are located appropriately.
2	Increase awareness by educating property owners on actions that they can take to reduce risk to property through internet and by hosting an Open House at the Fire Department, Develop and Distribute an Educational Pamphlet on Fire Safety and Prevention (SAFE PROGRAM) (SENIOR SAFE) and wildfire prevention.	Completed + To Be Continued	This is an ongoing project and will continue.	YES - updated/revised description provided at right, if applicable	#21 and #22, These actions include education and outreach programs.
3	Inventory Supplies at Existing Shelters and Develop a Needs List and Storage Requirements to ensure the available of adequate supplies during a natural hazard. Supplies must be adequate to eliminate or reduce risk to human life.	Partially Completed / In Progress	We have all Emergency Management Equipment in a new trailer, but this equipment needs to be gone through to ensure it is still good.	NO - explanation provided at left	
4	Identify all structures throughout the town that need to be Elevated above the Base-Flood Elevation. Once identified educate those property owners regarding their options for mitigation	Delayed	Now that we have a new building commissioner the Fire Department can work with him to complete this task	YES - updated/revised description provided at right, if applicable	#14 and #15, These actions include adopting the 202 MA State Model Floodplain Bylaw, identifying a Floodplain Administrator, and expanding the Town's capacity to mitigate flood risk. Actions # 21 and 22 include education and outreach.

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action #/Description (if applicable)
5	To develop a priority list and possibly seek funding through the Hazard Mitigation Grant Program (HMGP) for the replacement of undersized culverts throughout Town to reduce or eliminate flooding risk.	Delayed	This action was delayed due to staff time but is necessary and will be moved to the updated plan.	YES - updated/revised description provided at right, if applicable	Action #12, Replace culverts based on need.
6	Educate property owners regarding options for mitigating their properties from flooding through outreach programs that address measures that residents can take (i.e. installing backflow valves, securing debris, etc.)	Partially Completed / In Progress	Have provided links to FEMA through our website that addresses these issues. However, lack of time from personnel has delayed us on pursuing outreach programs to address this.	YES - updated/revised description provided at right, if applicable	#21 and #22, These actions include education and outreach programs.
7	Continue participation in the National Flood Insurance Program to enable property owners to purchase insurance protection against flood losses.	Partially Completed / In Progress	Harvard participates in the NFIP but is interested in expanding compliance and implementation.	YES - updated/revised description provided at right, if applicable	#14 and #15, These actions include adopting the 202 MA State Model Floodplain Bylaw, identifying a Floodplain Administrator, and expanding the Town's capacity to mitigate flood risk. Actions # 21 and 22 include education and outreach.
8	Enforce state building codes related to design loads to include wind effects generated from atmospheric related hazards.	Partially Completed / In Progress	This action needs to continue with education and enforcement.	YES - updated/revised description provided at right, if applicable	Action #2, Enforce state building codes.

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action #/Description (if applicable)
9	Identify areas with potential for brush fires to track community vulnerability by developing and maintaining a data base.	Partially Completed / In Progress	This action needs to continue with brush clearing, fire breaks, and fire ponds.	YES - updated/revised description provided at right, if applicable	Action #16, Identify areas prone to brush fires and mitigate this risk with brush clearing, building fire breaks, and maintaining fire ponds or cisterns.
10	Utilize interactive mapping application prepared by MRPC/CMRPC to update critical infrastructure and simulate real time evacuation scenarios to mitigate hazards to the public.	Partially Completed / In Progress	We have updated the critical infrastructure list but have not done anything else.	YES - updated/revised description provided at right, if applicable	Action #8, Expand GIS capacity to support hazard mitigation and climate adaptation efforts.
11	Maintain "beaver diverters" and water control devices to mitigate flooding.	Partially Completed / In Progress	Beavers continue to pose a threat.	YES - updated/revised description provided at right, if applicable	Action #13, Install and maintain beaver management devices to mitigate flood risk.
12	Implement recommendations regarding natural hazard mitigation in existing planning documents including the master plan, five year action plan of the open space and recreation plan and the emergency evacuation plan	Partially Completed / In Progress	This is an ongoing action and is reflected in the MVP.	YES - updated/revised description provided at right, if applicable	This action is reflected in multiple actions in the 2022 plan. Including #3 Develop a Climate Adaptation Plan that is consistent with the Hazard Mitigation Plan and MVP.
13	Establish Asset Management Inventory and Condition Database and Management Plan to ensure that vital equipment needed for hazards is in working condition to mitigate natural hazards.	Cancelled	This action is not relevant.	NO - explanation provided at left	

The Municipal Vulnerability Preparedness (MVP) plan was developed in 2019 and includes twenty-eight 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 Harvard'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 relevance in the Hazard Mitigation Plan. Recommendations that are not specifically included in this plan have a blank third column in the table below. Some recommendations are preparedness, response, or recovery actions that would not be relevant to this plan.

Table 47. MVP Recommendations in the Mitigation Plan.

#	MVP Recommendation	2022 Hazard Mitigation Plan Action # & Description
	Highest Priority	
1	Create an implementation committee to manage the process of creating and monitor implementation of a comprehensive Climate Action Plan that would include, at minimum, the following planning modules: - A town-wide tree/forest management plan that would address trees on public lands and public rights-of-way - Land stewardship plan - Invasive species planning - An agricultural action plan - Coordinate emergency management planning with climate change vulnerabilities that includes vulnerable populations and road system interconnectivity	Action #5, Develop a Climate Adaptation Plan that is consistent with the Hazard Mitigation Plan and MVP.
2	Establish a Climate Vulnerability Liaison within Town government responsible for capital planning oversight.	
3	Create an emergency response network and a medical professional network to coordinate professional and volunteer-based emergency and medical response teams. This combined network should include Town public safety departments (police, fire, Board of Health, Council on Aging, DPW), existing or new CERTs (Civilian Emergency Response Teams), and existing volunteer organizations, such as Harvard's Snowmobile Club.	Action #8, Develop a Medical Reserve Corps.
	High Priority	

#	MVP Recommendation	2022 Hazard Mitigation Plan Action # & Description
4	Establish and equip The Bromfield School as a stay-over shelter with a prepared management plan. Establish and equip Hildreth House as a cooling and warming shelter with amenities like phone charging and hot coffee.	Action #12 includes adding a generator to the Elementary School so it can function as a heating and cooling center.
5	Add more alternative power sources (generators and batteries) to all municipal buildings.	Action #12 includes adding a generator to the Elementary School and the new Council on Aging facility so they can function as a heating and cooling center.
6	Strengthen the Town's website for cross-cultural communication, preparation, and coordination.	Action #13 prioritizes vulnerable populations, and Actions #23 and #24 include education and outreach.
7	Provide opportunities for cross-cultural exchanges to connect disparate groups. Implement public awareness and education programming pertaining to farm success planning.	Action #13 prioritizes vulnerable populations, and Actions #23 and #24 include education and outreach.
8	Monitor, manage, maintain, and preserve public lands. Educate private landowners on best practices for collective stewardship.	Action #6 includes land protection. Actions #23 and #24 include education and outreach.
9	Remove invasive plant species from conservation lands and plant native species where ecological edges and buffer zones have been disturbed.	Action #9 calls for the removal of invasive species.
10	Provide education in systems-thinking and stewardship (i.e., fertilizers and ecological buffers.)	Actions #23 and #24 include education and outreach.
11	Create and implement a comprehensive regional strategy for land stewardship including best practices for bittersweet removal and deer fencing.	Action #9 calls for the removal of invasive species.
12	Support the "Pond Committee" who oversees the monitoring and management of Bare Hill Pond.	Action #1 includes flood control, algae blooms, and pond biodiversity as well as education. Action #6 includes water quality protection; Action #10 includes removing invasive plant species from conservation land.
13	Continue and support the work of the Board of Health which provides educational programming pertaining to	Actions #23 and #24 include education and outreach.

#	MVP Recommendation	2022 Hazard Mitigation Plan Action # & Description
	public health and disease control including tick control methods.	
14	Provide educational programming on pollinators and pollinator habitat and the impacts of spraying for ticks and mosquitoes on pollinator species.	Actions #23 and #24 include education and outreach.
	Moderate Priority	
16	Evaluate, design, expand, and upgrade the culvert system and maintain a budget for emergency repairs and replacements.	Action #14 includes replacing culverts as needed.
17	Evaluate, plan, and implement an expanded storm-water detention system and maintain a budget for emergency repairs and replacements.	Action #22 relates to stormwater management.
18	Adopt a by-law and seek funding for town-wide evaluation and recommendations for improving drainage and storm-water management.	
19	Plan for expanded emergency response capacity. Improve facilities and implement plans to coordinate the department of public works, fire, and EMT.	
20	Tamper roads to create crowns for water run-off.	
21	Implement vegetative buffers along roadsides.	Action #9 implements vegetative buffers.
22	Improve erosion control.	Action #9 implements vegetative buffers.
23	Create a shared information base to foster better community understanding.	Actions #23 and #24 include education and outreach.
24	Provide educational programming on invasive species.	Actions #23 and #24 include education and outreach.
25	Create, identify, and coordinate a “metagroup” of community groups and neighborhood organizations for improved cross-cultural communication.	
26	Provide education and monitor the proper disposal or conservation of older trees.	Actions #23 and #24 include education and outreach.

#	MVP Recommendation	2022 Hazard Mitigation Plan Action # & Description
27	Monitor Bare Hill Pond for algae blooms. Improve and expand infrastructure as needed.	Action #1 mentions algal blooms and monitoring water.
28	Provide educational programming on the rhododendron threat, soil health, integrated pest management (IPM), and inter-planting (planting companion plantings to maximize land use, reduce the impacts of disease and pests, and improve soil health).	Actions #23 and #24 include education and outreach.
	Lower Priority	
29	Evaluate road conditions and secure funding as needed to improve infrastructural resilience.	Action #14 includes replacing culverts as needed.
30	Evaluate private septic systems to identify problematic locations. Evaluate the vulnerabilities, advantages, and funding needed to expand the Town sewer system.	Action #7 addresses water protection including wells.
31	Maintain a budget for shelter supplies.	
32	Collate strategies for hazards pertaining to settlement patterns in small New England towns.	
33	Evaluate and improve road connectivity and redundancies through systems planning.	
34	Include Devens' vulnerable populations in planning efforts.	Devens was not directly addressed via mitigation actions.
35	Assess and create a plan to connect all vulnerable populations to coordinate emergency response.	Action #13 prioritizes mitigating risk to vulnerable populations.
36	Create and implement a Land Stewardship/Bare Hill Pond and Watershed Plan.	
37	Improve erosion control through use of silt fencing and hay bales; establish a bylaw to enforce.	Action #6 addresses Town Bylaws and Zoning Bylaws. Action #7 addresses water quality and land protection.
38	Test wells and water sources for contamination, educate the public about risks and best practices for management. Prioritize land around wetlands, ecological buffers, and groundwater resources.	Action #6 focuses on water quality and testing. Actions #23 and #24 include education and outreach.

#	MVP Recommendation	2022 Hazard Mitigation Plan Action # & Description
39	Aid the Harvard Conservation Trust and the Sudbury Valley Trustees in conserving more land and implementing more public outreach and education.	
40	Build aquifer cisterns and fire ponds.	Action #16 includes fire protection cisterns and fire ponds.
41	Provide educational programming pertaining to crops and farming in Harvard. Topics to include adjusting crops to the growing season, using Hoop Houses (greenhouses), transitioning to more southern varieties of apples, using nutrient sprays such as Manganese to improve calcium uptake, micro-nutrients, raised plant beds, and smudge pots to prevent frost on small farms.	Actions #23 and #24 include education and outreach.
42	Create a community water bank and appoint an agricultural liaison for expert consultations.	

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))

Each of the actions to be considered for this plan update were organized by which goal they supported. All the actions supporting each goal were combined with relevant MVP recommendations. This list was considered with potential new actions based on the results of the risk and capability assessments, including the specific problem statements and enhancement opportunities identified as part of those assessments.

Beyond reviewing the mitigation actions from previous plans, the HMPC considered a comprehensive range of mitigation actions. During each HMPC meeting, the group was educated on the possible range of mitigation actions. The Federal Emergency Management Agency's (FEMA) online Mitigation Ideas publication was shared, and the following list of example actions was shared electronically with the HMPC.

Table 48. Types 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 • 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

Mitigation Action Category	Examples of Mitigation Actions
	• Mailings to residents in hazard-prone areas
Preparedness and Response Actions	• Creating mutual aid agreements with neighboring communities to meet emergency response needs • Purchasing radio communications equipment for the Fire Department • Developing procedures for notifying citizens of available shelter locations during and following an event

The HMPC considered previously identified actions, areas of weakness and mitigation opportunities identified in the risk assessment and capability assessment, as well as the possible types of mitigation actions when developing the action list for this plan update.

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))

An online Mitigation Action Tracker was developed for the Town to track the implementation of each mitigation action. The Mitigation Action Tracker is a Google Sheet with separate tabs showing pre-sorted actions and can sort the list of actions based on several criteria or essential details. The details listed below are included to facilitate the Town's ability to sort through the actions as well as to apply for grant funding.

- Action Title
- Action Description
- Implementation Timeline
- Responsible Department
- Supporting Agencies
- Potential Funding Sources
- Estimated Cost
  - High (over $100,000)
  - Medium ($20,000 - $100,000)

  - Low (under $20,000)
- Hazard(s) Addressed
- Critical Facility Protection
- Type of Mitigation Action
- Associated Goal Statement

Details sorting the actions are included in Appendix B.

- Action Priority Ranking Consideration
- Hazards Addressed and Critical Facilities Protected
- Type of Mitigation Actions
- Mitigation Actions Sorted by Goal Statement

The HMPC conducted a "STAPLEE" analysis for each action to prioritize the actions. The Town of Harvard used STAPLEE for the previous plan and felt comfortable with the system. The STAPLEE analysis assisted the HMPC in determining the effectiveness of each action in accomplishing the mission of the plan and the goal statements. STAPLEE analyses stands for Social, Technical, Administrative, Political, Legal, Economic, and Environmental aspects of each action. The HMPC rated each criteria using a scare of 1 to 3 (Good=3, Average=2, Poor=1). The HMPC prioritized actions that protect socially vulnerably populations, protect future development, and account for future climate projections. Criteria for each part of STAPLEE is defined below.

- Social: Is the proposed action socially acceptable to the community? Are there equity issues involved that would mean that one segment of the community is treated unfairly?
- Technical: Will the proposed strategy work? Will it create more problems than it solves?
- Administrative: Can the community implement the action? Is there someone to coordinate and lead the effort?
- Political: Is the action politically acceptable? Is there public support both to implement and to maintain the action?
- Legal: Is the community authorized to implement the proposed action? Is there a clear legal basis or precedent for this activity?
- Economic: What are the costs of this action? Does the cost seem reasonable for the size of the problem and the likely benefits?
- Environmental: How will the action impact the environment? Will the action need environmental regulatory approvals?

STAPLEE scores were totaled and ranged between 12 and 19. Actions that scored above 16 were considered High priority, actions between 14-15 were considered Medium priority, and actions between 12-13 were considered Low priority. The Town recognizes that they may implement actions in any order. The priority list is meant to function as a guide. STAPLEE scores for each action are shown in Appendix B. The HMPC also considered the difference between cost and benefit. All actions in the plan are considered beneficial; the benefit outweighs the cost.

Below is a list of all mitigation actions sorted by priority. There is at least one action identified for each natural hazard profiled in this plan. All the risks identified in this plan are addressed and emphasis is placed on mitigating risk to community lifelines. All actions include an anticipated implementation timeline from 1 to 5 years. Most projects do not have currently have funding; therefore, it is difficult to know the exactly when they will be completed. These timeline estimates are based on the amount of time necessary to complete a project once funding becomes available. The highest-ranking actions are shown in red, the medium priority actions in orange, and the low priority actions in green. The HMPC and the Town Select Board understand that mitigation actions may not be implemented in order of priority, they may be implemented in the order by which they receive funding. The actions are also included in Appendix B sorted by Type of Mitigation Action.

Table 49. 2022 Hazard Mitigation Actions.

#	Action	Action Description	Estimated Cost	Potential Funding Source	Lead Department	Implementation Schedule
High Priority Mitigation Actions						
1	Implement down-stream flood control and monitor for water health, algae blooms, and biodiversity of pond. Provide education and outreach to the public regarding these issues.	• Hire scientific/technical consultant to monitor water, implement mitigation actions to address algal blooms. Update the Land Stewardship/Bare Hill Pond Watershed Management Plan. • Algae blooms impact water-related activities and the health of the environment. Educating the community and expanding infrastructure may prevent algae blooms and their impact.	Low under $20,000	Town Meeting grants a Project and then a Warrant Article for Funding	Bare Hill Pond Watershed Management Committee	1-5 Years
2	Catalog all permitted BMP's (stormwater control measures) to develop compliance procedures to maintain stormwater storage capacity.		Low under $20,000	Town Meeting grants a Project and then a Warrant Article for Funding	Conservation Commission	3 Years
3	Enforce state building codes.	To mitigate potential risks from atmospheric hazards generating strong winds, the Town will enforce MA State Building Codes related	Low under $20,000	FEMA BRIC or HMGP or	Building Commissioner	1-5 Years

#	Action	Action Description	Estimated Cost	Potential Funding Source	Lead Department	Implementation Schedule
		to design loads. Provide continuing education for the Building Commissioner.		Town Meeting grants a Project and then a Warrant Article for Funding		
4	Be aggressive and creative regarding the pursuit of funding for hazard mitigation and climate action goals. This should include community-centered and regional opportunities to address local and regional hazard risk reduction projects.	• Pursue MVP Action Grants and other grants with neighboring communities. • Leverage opportunities with other sources, such as the Town's Capital Planning and Investment Committee, to help fund priority hazard mitigation and climate adaptation projects, particularly when combined with alternative/external grant funding sources when a local cost-share increases the Town's chances for a grant award.	Low under $20,000	MVP, FEMA BRIC or HMGP, EPA Sewer Overflow and Stormwater Reuse Municipal Grant Program	Harvard Climate Initiative Committee and Emergency Management	1-5 Years
5	Develop a Climate Adaptation Plan that is consistent with the Hazard Mitigation Plan and MVP.	Develop a Climate Adaptation Plan that includes mitigation actions and is consistent with the mitigation strategy. This plan should emphasize community education and	Low under $20,000	Town Meeting grants a Project and then	Harvard Climate Initiative Committee	1 Year

#	Action	Action Description	Estimated Cost	Potential Funding Source	Lead Department	Implementation Schedule
		opportunities for residents to support the Town's sustainability and resiliency.		a Warrant Article for Funding		
6	Update Town Bylaws and Zoning Bylaws to prioritize hazard mitigation, climate adaptation and resiliency.	Incorporate Nature-based Solutions (NbS) into Town Bylaws. Update Zoning Bylaws through a series of amendments related to hazard mitigation, climate adaptation, and overall environmental sustainability. Publicize and promote effectiveness of NbS through a demonstration site and outreach materials.	Medium $20,000-$100,000	MVP	Planning Board and Harvard Climate Initiative Committee	2 Years
7	Implement a plan of ongoing water quality protection through continuing the regular testing of wells and other water sources. Maintain and enhance robust land protection around wetlands, ecological buffers, and groundwater sources, as applicable.	• The Town shall continue the diligent testing of well water quality and address issues in a timely manner as they arise. Consider connectivity to Devens system for Center and Ayer Road. • Revise and update land protection regulations and bylaws as necessary.	Medium $20,000-$100,000	MVP	Planning Board, Conservation Agent, Water Commission, Board of Health	3 Years
8	Develop a Medical Reserve Corps.	Create an emergency response network and a medical professional network to coordinate professional and volunteer-based emergency and medical response teams.	Low under $20,000	Town Meeting grants a Project	Emergency Management & Police Department	3-5 Years

#	Action	Action Description	Estimated Cost	Potential Funding Source	Lead Department	Implementation Schedule
		This combined network should include Town public safety departments (police, fire, Board of Health, Council on Aging, DPW), existing or new CERTs (Civilian Emergency Response Teams), and existing volunteer organizations, such as Harvard's Snowmobile Club.		and then a Warrant Article for Funding		
9	Remove invasive plant species from conservation lands and plant native species where ecological edges and buffer zones have been disturbed. Implement vegetative buffers along roadsides.		High over $100,000	MVP	Conservation Commission	1-5 Years
10	Expand GIS capacity to support hazard mitigation and climate adaptation planning efforts.	Develop GIS data and maps relevant to agriculture (local farms in Harvard) to assist with future geospatial analysis in support of hazard mitigation and climate adaptation planning efforts.	Low under $20,000	Town Meeting grants a Project and then a Warrant Article for Funding	Town Administrator	2 Years
11	Add back-up power to the Town Hall.		Medium $20,000-$100,000	FEMA HMGP or BRIC	Emergency Management	2 Years

#	Action	Action Description	Estimated Cost	Potential Funding Source	Lead Department	Implementation Schedule
12	Add a generator to the new Council on Aging facility and formalize the Elementary School as a cooling or warming center.		Medium $20,000-$100,000	FEMA HMGP or BRIC	Emergency Management	2 Years
13	Prioritize vulnerable populations in Harvard when mitigating natural hazard risks and climate adaptation measures.	In order to effectively mitigate risk to vulnerable populations the Town must understand their locations and needs.	Low under $20,000	Town Meeting grants a Project and then a Warrant Article for Funding	Council on Aging	1-5 Years
14	Replace culverts based on need.	Develop a list of town-owned culverts, including those identified in the Apple Country and MVP reports, and rank them to prioritize those that need to be replaced or upgraded to mitigate flood risk. The DPW applied for a DER culvert grant on March 14, 2022 for data gathering and design costs for a culvert on Scott Rd.	Medium $20,000-$100,000	MA DER Culvert Replacement Municipal Assistance Grant Program, FEMA BRIC or	DPW	1-5 Years

#	Action	Action Description	Estimated Cost	Potential Funding Source	Lead Department	Implementation Schedule
				HMGP, MVP		
15	Install and maintain beaver management devices to mitigate flooding risk.		Low under $20,000	Town Meeting grants a Project and then a Warrant Article for Funding	Conservation Commission & DPW	1-5 Years
Medium Priority Mitigation Actions						
16	Identify areas prone to brush fires and mitigate this risk with brush clearing, building fire breaks, and maintaining fire ponds or cisterns.		Medium $20,000-$100,000	Town Meeting grants a Project and then a Warrant Article for Funding	Fire Department	1-5 Years
17	Expand the Town's management of trees by routinely examining trees, trimming or	Invasive species, drought, and climate change are damaging trees which increases the risk of trees toppling during storms.	Medium $20,000-$100,000	National Grid, Town Meeting	Tree Warden & Elm Commission	1-5 Years

#	Action	Action Description	Estimated Cost	Potential Funding Source	Lead Department	Implementation Schedule
	removing unhealthy trees, and educating the public about tree health.	Educate homeowners how to be aware of sick trees on their properties.		grants a Project and then a Warrant Article for Funding		
18	Expand capacity to mitigate flood risk and support the National Flood Insurance Program (NFIP) by formally designating a community Floodplain Administrator (FPA), supporting the FPA to be certified as a Certified Floodplain Manager (CFM).	This includes designating departments/positions with specific NFIP-related roles and responsibilities and linking those staff with proper training and educational opportunities.	Low under $20,000	Town Meeting grants a Project and then a Warrant Article for Funding	Town Planner	1 Year
19	Adopt the 2020 MA State Model Floodplain Bylaw.	Adopt the 2020 MA State Model Floodplain Bylaw to assure that the Town's current bylaws and ordinances (Zoning Bylaw Chapter 125-54) contain the necessary and proper language for compliance with the NFIP and state requirements.	Low under $20,000	MVP	Planning Board	2 Years
20	Fill vacant staff positions and increase positions to support implementation	Fill Community and Economic Development Director Position, add a Sustainability Coordinator position, add hours for the	High over $100,000	Town Meeting grants a	Select Board & Town Administrator	4 Years

#	Action	Action Description	Estimated Cost	Potential Funding Source	Lead Department	Implementation Schedule
	of mitigation actions and climate adaptation.	Board of Health staff, add additional DPW personnel, and support for the Building Commissioner.		Project and then a Warrant Article for Funding		
21	Establish energy resilience for public buildings and other critical facilities by installing solar panels or other renewable source and add back-up power, as funding opportunities arise.	• Solar and other renewables add a self-sufficiency factor to critical facilities and infrastructure and reduce risk. • Backup battery power further reduces the risk and adds needed redundancy.	High over $100,000	FEMA HMGP or BRIC	Permanent Building Committee and Energy Committee	4 Years
Low Priority Mitigation Actions						
22	Evaluate, plan, and implement an expanded stormwater detention system, purchase additional equipment for drainage, and maintain a budget for emergency repairs and replacements.		High over $100,000	FEMA BRIC, HMGP or MVP	Department of Public Works and CFM	3 Years
23	Update and maintain the Town managed websites	• Websites should include information regarding hazard mitigation, disaster	Low under $20,000	Town Meeting	Town Administrator	5 Years

#	Action	Action Description	Estimated Cost	Potential Funding Source	Lead Department	Implementation Schedule
	with hazard mitigation and climate adaptation information.	preparedness, disaster response and recovery. Use the following websites at a minimum, Town, Harvard Climate Initiative Committee, BOH, COA, and Fire Departments. • To facilitate implementation and maintenance as well as public awareness, the Town may wish to integrate plans (HMP, MVP, Master Plan, and other resilience-themed plans/reports) into a consolidated document and/or topic website, to facilitate their implementation and maintenance.		grants a Project and then a Warrant Article for Funding		
24	Develop a robust education program for residents and business owners that includes all natural hazards, climate adaptation, and hazard mitigation.	Educate property owners about how to mitigate risk to their properties such as installing backflow valves, removing debris, installing solar power, and disposing of older trees.	Low under $20,000	FEMA BRIC, HMGP or MVP	Emergency Management and Harvard Climate Initiative Committee	1-5 Years

The table below shows how the problems identified at the end of Chapter 4. Risk Assessment are addressed through at least one mitigation action.

Table 50. Problem Statements Addressed by Mitigation Actions.

Problem	Mitigation Action(s)
Severe Winter Storms	#2 - Catalog all permitted BMP's (stormwater control measures) to develop compliance procedures to maintain stormwater storage capacity. #11, #12 – Back-up power for Town Hall, Council on Aging, and Elementary School. #17 – Expand the Town's management of trees. #21 – Establish energy resilience for public buildings and critical facilities.
Extreme Temperatures	#11, #12 – Back-up power for Town Hall, Council on Aging, and Elementary School. #21 – Establish energy resilience for public buildings and critical facilities.
Power Outages – Wind & Winter Storms	#11, #12 – Back-up power for Town Hall, Council on Aging, and Elementary School. #21 – Establish energy resilience for public buildings and critical facilities.
Intense Precipitation – Flooding, Wetlands, Infrastructure	#1 – Down-stream flood control and monitoring water health. #14 – Replace culverts based on need. #15 – Install beaver management devices. #18 – Expand capacity to mitigate flood risk through NFIP participation. #19 – Adopt the 2020 MA State Model Floodplain Bylaw. #22 – Evaluate, plan, and implement an expanded stormwater detention system.
Drought and Wildfires	#5 – Develop a Climate Adaptation Plan.

Problem	Mitigation Action(s)
	#6 – Update Town Bylaws and Zoning Bylaws to prioritize hazard mitigation, climate adaptation, and resiliency. #16 – Mitigate fire risk with brush clearing, fire breaks, fire ponds and cisterns.
Agriculture Vulnerability	#1 – Down-stream flood control and monitoring water health. #7 – Water quality protection.
Back-up Power	#11, #12 – Back-up power for Town Hall, Council on Aging, and Elementary School. #21 – Establish energy resilience for public buildings and critical facilities.

Possible Funding Sources

All the mitigation actions included in this plan have identified one or more potential funding sources. The HMPC 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 to keep in mind when identifying or implementing mitigation actions.

<u>Federal Emergency Management Agency (FEMA) Mitigation Grants</u>

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.

<u>Municipal Vulnerability Preparedness Action Grants</u>[14]

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:

- Completed application template

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

- 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 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.

System to Integrate this Plan with other Planning Mechanisms

C6. Does the Plan describe a process by which local governments will integrate the requirements of the mitigation plan into other planning mechanisms, such as comprehensive or capital improvement plans, when appropriate? (Requirement §201.6(c)(4)(ii))

For the Town of Harvard to succeed in reducing hazard risks over the long term, the information, conclusions, and recommendations of this hazard mitigation plan should be integrated throughout government operations. 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 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 Harvard. 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):

- Town of Harvard Master Plan
- Town of Harvard Community Resilience Building Workshop – Summary of Findings (MVP Plan)
- Town of Harvard Open Space & Recreation Plan
- Town of Harvard Housing Production Plan

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.

Chapter 7. Plan Implementation and Maintenance

The Hazard Mitigation Planning Committee (HMPC) will 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 intend to continue updating this plan and implementing the plan's strategies.

Continued Public Participation

A5. 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 mitigation. 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 Fire Chief will take the lead in soliciting participation from the public. 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, the Fire Department website, and via flyers and press releases. The Council on Aging will put notices in their monthly newsletter as appropriate. Flyers will be posted in frequently visited locations including the Library, Council on Aging, and Town Clerk's office.
- Representatives from the Devens and the private sector will join Town officials in implementing mitigation actions and participating in plan update meetings.
- Copies of this plan will remain on the Town's website; and a hard copy will be kept in the Town Clerk's office and the library for public review. Updates to the plan will also be posted on the Town's website.
- The Town of Harvard continue to work with private industry, regional agencies, and adjacent communities as this plan is implemented.

Method and Schedule for Keeping the Plan Current

A6. Is there a description of the method and schedule for keeping the plan current (monitoring, evaluating and updating the mitigation plan within a 5-year cycle)? (Requirement §201.6(c)(4)(i))

The HMPC and the Town of Harvard recognize the importance of keeping the mitigation plan up to date. Keeping the plan current includes monitoring, evaluating, and updating the plan over a five-year period. The overall responsibility for monitoring the implementation of the plan rests with the HMPC members, led by the Fire Chief. The Harvard Climate Initiative Committee intends to play an active role in plan implementation.

Process to Track Actions

Together the Fire Chief 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 (January and July) to all Department Heads responsible for a mitigation action and to relevant Town 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.

If the Town experiences a large-scale disaster, the Fire Chief will assemble a HMPC meeting to update the list of mitigation actions and review their order based on current priorities.

Process to Evaluate Effectiveness of the Plan

The HMPC has agreed to meet on a semi-annual basis to review the implementation of the mitigation plan. The first meeting will take place in January; the second, in July.

At the first meeting (January 2023), 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.

Process to Update the Plan

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 prepare a one-page brief regarding each semi-annual HMPC meeting to share with the Select Board and to post on the Town 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), the Devens Enterprise Commission, and the Montachusett Regional Planning Commission (MRPC).

The Town of Harvard 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 Fire Chief will serve as the Project Manager for the update process.

Responsible Parties for Plan Implementation and Maintenance

Fire Chief Rick Sicard

Harvard Fire Department

13 Ayer Road

Harvard, MA 01451

978-456-3648

Website: http://harvardfire.com

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: 99 High Street, Boston, MA 02110

Phone: 877-336-2734

Email: fema-r1-info@fema.dhs.gov

Website: https://www.fema.gov/region-i-ct-me-ma-nh-ri-vt

Appendix A. Planning Process Supporting Materials

Hazard Mitigation Planning Committee Meetings

HMPC Meeting Participants 3/4/2022

Name	Position	Affiliation
Liz Allard	Land Use Administrator	Town of Harvard
Bill Bohn	Risk Assessment Lead	Sobis Inc.
Jamie Caplan	Principal, Project Manager	Jamie Caplan Consulting LLC
David Murphy	Mitigation Specialist	Resilient Land and Water
Pat Natoli	Public Safety Administrator	Town of Harvard
Christopher Ryan	Director of Community and Economic Development	Town of Harvard
Chief Sicard	Fire Chief	Town of Harvard
Lucy Wallace	Climate Initiative Committee	Town of Harvard
Jeff Zukowski	Hazard Mitigation Planner	MA Emergency Management Agency

HMPC Meeting Participants 4/13/2022

Name	Position	Affiliation
Liz Allard	Land Use Administrator	Town of Harvard
Jamie Caplan	Principal, Project Manager	Jamie Caplan Consulting LLC
Jeff Hayes	Building Official	Town of Harvard
Lynn Kelly	Town Clerk	Town of Harvard
Tim Kilhart	DPW Director	Town of Harvard

Ellen Sachs Leicher	Chair	Harvard Climate Initiative Committee
Pat Natoli	Public Safety Administrator	Town of Harvard
Darrin Punchard	Deputy Project Manager	Punchard Consulting LLC
Christopher Ryan	Director of Community and Economic Development	Town of Harvard
Chief Sicard	Fire Chief	Town of Harvard
Lucy Wallace	Climate Initiative Committee	Town of Harvard
Jeff Zukowski	Hazard Mitigation Planner	MA Emergency Management Agency

HMPC Meeting Participants 5/24/2022

Name	Position	Affiliation
Neil Angus	Environmental Planner	Devens Enterprise Commission
Bill Bohn	Risk Assessment Lead	Sobis Inc.
Jamie Caplan	Principal, Project Manager	Jamie Caplan Consulting LLC
Jeff Hayes	Building Official	Town of Harvard
Tim Kilhart	DPW Director	Town of Harvard
Ellen Sachs Leicher	Chair	Harvard Climate Initiative Committee
Sharon McCarthy	Board of Health	Town of Harvard
Chris Mitchell	Board of Health	Town of Harvard
Pat Natoli	Public Safety Administrator	Town of Harvard
Christopher Ryan	Director of Community and Economic Development	Town of Harvard
Chief Sicard	Fire Chief	Town of Harvard

Name	Position	Affiliation
Debbie Thompson	Council on Aging	Town of Harvard
Lucy Wallace	Climate Initiative Committee	Town of Harvard
Jeff Zukowski	Hazard Mitigation Planner	MA Emergency Management Agency

HMPC Meeting Participants 6/16/2022

Name	Position	Affiliation
Jamie Caplan	Principal, Project Manager	Jamie Caplan Consulting LLC
Ellen Sachs Leicher	Chair	Harvard Climate Initiative Committee
Christopher Ryan	Director of Community and Economic Development	Town of Harvard
Chief Sicard	Fire Chief	Town of Harvard
Lucy Wallace	Climate Initiative Committee	Town of Harvard
Jeff Zukowski	Hazard Mitigation Planner	MA Emergency Management Agency

Public Meeting Outreach

Press Release for April 14, 2022, Public Meeting

PRESS RELEASE For Immediate Release March 24, 2022	Contact: Christopher J. Ryan Director of Community & Economic Development Town of Harvard 978-456-4100 x.323

Town of Harvard Invites the Public to a Meeting to Learn About the Hazard Mitigation Plan Update

The Town of Harvard is developing a Hazard Mitigation Plan that identifies and prioritizes actions the Town can take to mitigate the impacts of natural hazards and climate change. Citizen participation is essential.

A virtual public meeting will be held on:

- Thursday, April 14, 2022
- 4:30 pm - 5:30 pm

You can join the meeting at the **Senior Center** or on your computer.

- https://us02web.zoom.us/j/89617192870?pwd=WVUzbHpreno4bmkwbUMvVW9MdE1SZz09
- Meeting ID: 896 1719 2870
- Passcode: 428239

At the meeting, you will have an opportunity to contribute your ideas for making the Town more resilient to natural hazards such as flooding, snowstorms, high winds, and extreme temperatures. This plan is being developed by a Hazard Mitigation Planning Committee comprised of Town officials and local stakeholders. Jamie Caplan Consulting LLC, a Northampton, MA based firm, is leading this effort on behalf of the Town and the Massachusetts Emergency Management Agency. Federal Emergency Management Agency (FEMA) approval, and Town adoption, of the Hazard Mitigation Plan allows the Town to apply for pre- and post-disaster hazard mitigation grant funds.

Harvard developed a Municipal Vulnerability Preparedness (MVP) plan in 2019 that also identified possible actions to mitigate risks to natural hazards and climate change. The Hazard Mitigation Plan will include all of those identified actions still relevant today.

For questions regarding this project, please contact Christopher J. Ryan, Director of Community & Economic Development, Phone: 978-456-4100 x.323, cryan@harvard-ma.gov.

Flyer for April 14, 2022, Public Meeting

APRIL 14, 2022

PUBLIC MEETING ON ZOOM

Harvard's Hazard Mitigation Planning Committee is updating the Town's Hazard Mitigation Plan. This plan serves as a strategy for reducing current and future risks of natural hazards and climate change. The public is invited to learn about the Hazard Mitigation Plan and share their ideas for reducing impacts associated with natural hazards, such as flooding, winter storms and hurricanes. Approved by FEMA, the plan allows the Town to apply for pre-disaster mitigation grant funding.

Hazard Mitigation Public Meeting

April 14, 2022

4:30pm - 5:30pm

Zoom Link on Town Website

Share your ideas to make Town more resilient to natural hazards such as floods, drought, high winds, and winter storms.

FOR MORE INFORMATION CONTACT

Christopher J. Ryan
Director of Community & Economic Development

978-456-4100 x.323

cryan@harvard-ma.gov

Email Invitation for Public Meeting on April 14, 2022

Harvard Public and Stakeholders,

The Town of Harvard is inviting you to a public meeting regarding development of the Town's Hazard Mitigation Plan. This plan serves as a strategy for reducing current and future risks of natural hazards and climate change. I hope you will attend and share your ideas for reducing the impacts of hazards such as high winds, flooding, and winter storms. Our FEMA-approved plan allows the Town to receive pre- and post-disaster mitigation grant funding.

- **Public Meeting**
  - Thursday, April 14, 2022
  - 4:30 pm - 5:30 pm

  - Attend via Zoom
  - Zoom link: https://us02web.zoom.us/j/89617192870?pwd=WVUzbHpreno4bmkwbUMvVW9MdE1SZz09
  - Meeting ID: 896 1719 2870
  - Passcode: 428239

  - This meeting will include an update from our consulting team, Jamie Caplan Consulting LLC, and plenty of opportunity for you to contribute your thoughts about lessening our risk to natural hazards and climate change.

Attached is a flyer you are welcome post and share broadly. Everyone is welcome to attend.

Please let me know if you have any questions about the meeting.

Sincerely,

Christopher Ryan, Director of Community and Economic Development
Town of Harvard

Press Release for June 30, 2022, Public Meeting

PRESS RELEASE For Immediate Release June 16, 2022	Contact: Rick Sicard Fire Chief Town of Harvard 978-456-3381

Town of Harvard Invites the Public to a Meeting to Learn About the Hazard Mitigation Plan Update

The Town of Harvard is developing a Hazard Mitigation Plan that identifies and prioritizes actions the Town can take to mitigate the impacts of natural hazards and climate change. Citizen participation is essential.

A virtual public meeting will be held on:

- June 30, 2022
- 6:00 pm – 7:00 pm

You can join the meeting on your computer.

- https://us02web.zoom.us/j/89041093181?pwd=Mm1jcHBTNXVCbGh3aUNtT2hvcTQ5dz09
- Meeting ID: 890 4109 3181
- Passcode: 733125

At the meeting, you will have an opportunity to contribute your ideas for making the Town more resilient to natural hazards such as flooding, snowstorms, high winds, and extreme temperatures. This plan was developed by a Hazard Mitigation Planning Committee comprised of Town officials and local stakeholders. Jamie Caplan Consulting LLC, a Northampton, MA based firm, led this effort on behalf of the Town and the Massachusetts Emergency Management Agency. Federal Emergency Management Agency (FEMA) approval, and Town adoption, of the Hazard Mitigation Plan allows the Town to apply for pre- and post-disaster hazard mitigation grant funds.

Harvard developed a Municipal Vulnerability Preparedness (MVP) plan in 2019 that also identified possible actions to mitigate risks to natural hazards and climate change. The Hazard Mitigation Plan includes all of those identified actions still relevant today.

For questions regarding this project, please contact Fire Chief Rick Sicard, Phone: 978-456-3381, rsicard@harvard-ma.gov.

Flyer for June 30, 2022, Public Meeting

JUNE 30, 2022

PUBLIC MEETING ON ZOOM

Harvard's Hazard Mitigation Planning Committee has updated the Town's Hazard Mitigation Plan. This plan serves as a strategy for reducing current and future risks of natural hazards and climate change. The public is invited to learn about the Hazard Mitigation Plan and share their ideas for reducing impacts associated with natural hazards, such as flooding, winter storms and hurricanes. Approved by FEMA, the plan allows the Town to apply for pre-disaster mitigation grant funding.



Hazard Mitigation Public Meeting

June 30, 2022
6:00pm - 7:00pm

Zoom Link on Town Website

Share your ideas to make Town more resilient to natural hazards such as floods, drought, high winds, and winter storms.

FOR MORE INFORMATION CONTACT

Fire Chief Rick Sicard

978-456-3381

rsicard@harvard-ma.gov

Flyer for Public Review

DRAFT PLAN NEEDS PUBLIC REVIEW

Access the plan on the Town's Homepage or in the Town Clerk's office or in the Library.

Available until 8/19/2022

Harvard's Hazard Mitigation Planning Committee has updated the Town's hazard mitigation plan. This plan serves as a strategy for reducing current and future risks of natural hazards and climate change. Approved by FEMA, the plan allows the Town to apply for pre-disaster mitigation grant funding.

TOWN OF HARVARD, MA HAZARD MITIGATION PLAN UPDATE
JULY 2022

Town of Harvard
13 Ayer Road
Harvard, MA 01451

FOR MORE INFORMATION OR TO SHARE YOUR COMMENTS

Fire Chief Rick Sicard

Town of Harvard

Phone: 978-456-3648 Email: rsicard@harvard-ma.gov

Press Release for Public Review

PRESS RELEASE
For Immediate Release
August 5, 2022

Contact: Fire Chief Rick Sicard
Town of Harvard
978-456-3381

Draft Plan Needs Public Review
Town of Harvard Hazard Mitigation Plan Update

The Town of Harvard has developed 2022 Hazard Mitigation Plan that identifies and prioritizes actions the Town can take to mitigate the impacts of natural hazards and climate change. Citizen participation is essential.

The public is invited to review and comment on the draft plan.

- Access the plan on the Town's website: https://www.harvard-ma.gov
- View a hard copy in the Town Clerk's Office or in the Library
- Comment between August 5, 2022 – August 19, 2022

To provide comments

- Contact: Fire Chief Rick Sicard
- Phone: 978-456-3381
- Email: rsicard@harvard-ma.gov

Harvard's Hazard Mitigation Planning Committee has developed this plan as a strategy for reducing current and future natural hazards risks and impacts from climate change. When implemented the Hazard Mitigation Plan makes the Town more resilient to natural hazards such as flooding, snowstorms, high winds, and extreme temperatures. Town officials and local stakeholders developed this plan with 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 apply for pre- and post-disaster hazard mitigation grant funds.

For questions regarding this project, please contact Fire Chief Rick Sicard, Town of Harvard, Phone: 978-456-3381 or rsicard@harvard-ma.gov.

Appendix B. Mitigation Actions.

Action Priority Ranking Consideration

#	Action	Priority	Social	Technical	Administrative	Political	Legal	Economic	Environmental	STAPLEE Score
1	Implement down-stream flood control and monitor for water health, algae blooms, and biodiversity of pond. Provide education and outreach to the public regarding these issues.	High	3	3	2	3	3	2	3	19
2	Catalog all permitted BMP's (stormwater control measures) to develop compliance procedures to maintain stormwater storage capacity.	High	3	3	3	3	3	2	2	19
3	Enforce state building codes.	High	3	2	3	3	3	2	2	18
4	Be aggressive and creative regarding the pursuit of funding for hazard mitigation and climate action goals. This should	High	3	3	3	3	3	2	1	18

#	Action	Priority	Social	Technical	Administrative	Political	Legal	Economic	Environmental	STAPLEE Score
	include community-centered and regional opportunities to address local and regional hazard risk reduction projects.									
5	Develop a Climate Adaptation Plan that is consistent with the Hazard Mitigation Plan and MVP.	High	3	3	2	2	3	2	3	18
6	Update Town Bylaws and Zoning Bylaws to prioritize hazard mitigation, climate adaptation and resiliency.	High	2	3	3	2	3	2	3	18
7	Implement a plan of ongoing water quality protection through continuing the regular testing of wells and other water sources. Maintain and enhance robust land protection around wetlands, ecological buffers, and groundwater sources, as applicable.	High	3	2	2	3	3	2	3	18

#	Action	Priority	Social	Technical	Administrative	Political	Legal	Economic	Environmental	STAPLEE Score
8	Develop a Medical Reserve Corps.	High	3	3	2	3	3	3	1	18
9	Remove invasive plant species from conservation lands and plant native species where ecological edges and buffer zones have been disturbed. Implement vegetative buffers along roadsides.	High	3	2	2	3	3	1	3	17
10	Expand GIS capacity to support hazard mitigation and climate adaptation planning efforts.	High	3	2	3	3	3	1	2	17
11	Add back-up power to the Town Hall.	High	3	3	3	3	3	1	1	17
12	Add a generator to the new Council on Aging facility and formalize the Elementary School as a cooling or warming center.	High	3	3	3	3	3	1	1	17
13	Prioritize vulnerable populations in Harvard when mitigating natural hazard risks and	High	3	2	2	3	3	2	1	16

#	Action	Priority	Social	Technical	Administrative	Political	Legal	Economic	Environmental	STAPLEE Score
	climate adaptation measures.									
14	Replace culverts based on need.	High	3	2	2	2	3	1	3	16
15	Install and maintain beaver management devices to mitigate flooding risk.	High	3	2	2	3	3	1	2	16
16	Identify areas prone to brush fires and mitigate this risk with brush clearing, building fire breaks, and maintaining fire ponds or cisterns.	Medium	3	2	2	3	3	1	1	15
17	Expand the Town's management of trees by routinely examining trees, trimming or removing unhealthy trees, and educating the public about tree health.	Medium	3	2	2	2	3	1	2	15
18	Expand capacity to mitigate flood risk and support the National Flood Insurance Program (NFIP) by formally designating a community	Medium	2	3	1	2	3	2	2	15

#	Action	Priority	Social	Technical	Administrative	Political	Legal	Economic	Environmental	STAPLEE Score
	Floodplain Administrator (FPA), supporting the FPA to be certified as a Certified Floodplain Manager (CFM).									
19	Adopt the 2020 MA State Model Floodplain Bylaw.	Medium	2	2	2	2	3	1	3	15
20	Fill vacant staff positions and increase positions to support implementation of mitigation actions and climate adaptation.	Medium	1	3	2	1	3	1	3	14
21	Establish energy resilience for public buildings and other critical facilities by installing solar panels or other renewable source and add back-up power, as funding opportunities arise.	Medium	2	3	2	2	3	1	1	14
22	Evaluate, plan, and implement an expanded stormwater detention system, purchase additional	Low	2	1	2	2	3	1	2	13

#	Action	Priority	Social	Technical	Administrative	Political	Legal	Economic	Environmental	STAPLEE Score
	equipment for drainage, and maintain a budget for emergency repairs and replacements.									
23	Update and maintain the Town managed websites with hazard mitigation and climate adaptation information.	Low	2	2	2	1	3	1	2	13
24	Develop a robust education program for residents and business owners that includes all natural hazards, climate adaptation, and hazard mitigation.	Low	2	1	2	1	3	1	2	12

Hazards Addressed and Critical Facilities Protected

#	Action	Critical Facility	Priority	Flood	Landslide	Wildfires and Brushfires	Hurricanes and Wind	Severe Winter Storms	Tornadoes	Thunderstorms	Earthquakes	Drought	Extreme Temperatures	Infectious Disease	Invasive Species
1	Implement down-stream flood control and monitor for water health, algae blooms, and biodiversity of pond. Provide education and outreach to the public regarding these issues.	No	High	Yes											Yes

#	Action	Critical Facility	Priority	Flood	Landslide	Wildfires and Brushfires	Hurricanes and Wind	Severe Winter Storms	Tornadoes	Thunderstorms	Earthquakes	Drought	Extreme Temperatures	Infectious Disease	Invasive Species
2	Catalog all permitted BMP's (stormwater control measures) to develop compliance procedures to maintain stormwater storage capacity.	Yes	High	Yes				Yes		Yes					
3	Enforce state building codes.	Yes	High	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

#	Action	Critical Facility	Priority	Flood	Landslide	Wildfires and Brushfires	Hurricanes and Wind	Severe Winter Storms	Tornadoes	Thunderstorms	Earthquakes	Drought	Extreme Temperatures	Infectious Disease	Invasive Species
4	Be aggressive and creative regarding the pursuit of funding for hazard mitigation and climate action goals. This should include community-centered and regional opportunities to address local and regional hazard risk reduction projects.	No	High	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

#	Action	Critical Facility	Priority	Flood	Landslide	Wildfires and Brushfires	Hurricanes and Wind	Severe Winter Storms	Tornadoes	Thunderstorms	Earthquakes	Drought	Extreme Temperatures	Infectious Disease	Invasive Species
5	Develop a Climate Adaptation Plan that is consistent with the Hazard Mitigation Plan and MVP.	No	High	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6	Update Town Bylaws and Zoning Bylaws to prioritize hazard mitigation, climate adaptation and resiliency.	No	High	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

#	Action	Critical Facility	Priority	Flood	Landslide	Wildfires and Brushfires	Hurricanes and Wind	Severe Winter Storms	Tornadoes	Thunderstorms	Earthquakes	Drought	Extreme Temperatures	Infectious Disease	Invasive Species
7	Implement a plan of ongoing water quality protection through continuing the regular testing of wells and other water sources. Maintain and enhance robust land protection around wetlands, ecological buffers, and groundwater sources, as applicable.	No	High	Yes								Yes	Yes	Yes	
8	Develop a Medical Reserve Corps.	No	High	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

#	Action	Critical Facility	Priority	Flood	Landslide	Wildfires and Brushfires	Hurricanes and Wind	Severe Winter Storms	Tornadoes	Thunderstorms	Earthquakes	Drought	Extreme Temperatures	Infectious Disease	Invasive Species
9	Remove invasive plant species from conservation lands and plant native species where ecological edges and buffer zones have been disturbed. Implement vegetative buffers along roadsides.	No	High												Yes
10	Expand GIS capacity to support hazard mitigation and climate adaptation planning efforts.	No	High	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
11	Add back-up power to the Town Hall.	Yes	High	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

#	Action	Critical Facility	Priority	Flood	Landslide	Wildfires and Brushfires	Hurricanes and Wind	Severe Winter Storms	Tornadoes	Thunderstorms	Earthquakes	Drought	Extreme Temperatures	Infectious Disease	Invasive Species
12	Add a generator to the new Council on Aging facility and formalize the Elementary School as a cooling or warming center.	Yes	High	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
13	Prioritize vulnerable populations in Harvard when mitigating natural hazard risks and climate adaptation measures.	No	High	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
14	Replace culverts based on need.	No	High	Yes			Yes	Yes	Yes	Yes					

#	Action	Critical Facility	Priority	Flood	Landslide	Wildfires and Brushfires	Hurricanes and Wind	Severe Winter Storms	Tornadoes	Thunderstorms	Earthquakes	Drought	Extreme Temperatures	Infectious Disease	Invasive Species
15	Install and maintain beaver management devices to mitigate flooding risk.	No	High	Yes			Yes	Yes	Yes	Yes					
16	Identify areas prone to brush fires and mitigate this risk with brush clearing, building fire breaks, and maintaining fire ponds or cisterns.	No	Medium			Yes									

#	Action	Critical Facility	Priority	Flood	Landslide	Wildfires and Brushfires	Hurricanes and Wind	Severe Winter Storms	Tornadoes	Thunderstorms	Earthquakes	Drought	Extreme Temperatures	Infectious Disease	Invasive Species
17	Expand the Town's management of trees by routinely examining trees, trimming, or removing unhealthy trees, and educating the public about tree health.	No	Medium				Yes	Yes	Yes	Yes					

#	Action	Critical Facility	Priority	Flood	Landslide	Wildfires and Brushfires	Hurricanes and Wind	Severe Winter Storms	Tornadoes	Thunderstorms	Earthquakes	Drought	Extreme Temperatures	Infectious Disease	Invasive Species
18	Expand capacity to mitigate flood risk and support the National Flood Insurance Program (NFIP) by formally designating a community Floodplain Administrator (FPA), supporting the FPA to be certified as a Certified Floodplain Manager (CFM).	No	Medium	Yes			Yes	Yes	Yes	Yes					
19	Adopt the 2020 MA State Model Floodplain Bylaw.	No	Medium	Yes			Yes	Yes	Yes	Yes					

#	Action	Critical Facility	Priority	Flood	Landslide	Wildfires and Brushfires	Hurricanes and Wind	Severe Winter Storms	Tornadoes	Thunderstorms	Earthquakes	Drought	Extreme Temperatures	Infectious Disease	Invasive Species
20	Fill vacant staff positions and increase positions to support implementation of mitigation actions and climate adaptation.	No	Medium	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
21	Establish energy resilience for public buildings and other critical facilities by installing solar panels or other renewable source and add back-up power, as funding opportunities arise.	Yes	Medium	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

#	Action	Critical Facility	Priority	Flood	Landslide	Wildfires and Brushfires	Hurricanes and Wind	Severe Winter Storms	Tornadoes	Thunderstorms	Earthquakes	Drought	Extreme Temperatures	Infectious Disease	Invasive Species
22	Evaluate, plan, and implement an expanded stormwater detention system, purchase additional equipment for drainage, and maintain a budget for emergency repairs and replacements.	Yes	Low	Yes			Yes	Yes	Yes	Yes					
23	Update and maintain the Town managed websites with hazard mitigation and climate adaptation information.	No	Low	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

#	Action	Critical Facility	Priority	Flood	Landslide	Wildfires and Brushfires	Hurricanes and Wind	Severe Winter Storms	Tornadoes	Thunderstorms	Earthquakes	Drought	Extreme Temperatures	Infectious Disease	Invasive Species
24	Develop a robust education program for residents and business owners that includes all natural hazards, climate adaptation, and hazard mitigation.	No	Low	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Types of Mitigation Actions

#	Action	Priority
Education and Awareness Programs		
23	Update and maintain the Town managed websites with hazard mitigation and climate adaptation information.	Low
24	Develop a robust education program for residents and business owners that includes all natural hazards, climate adaptation, and hazard mitigation.	Low
Local Plans and Regulations		
2	Catalog all permitted BMP's (stormwater control measures) to develop compliance procedures to maintain stormwater storage capacity.	High
3	Enforce state building codes.	High
4	Be aggressive and creative regarding the pursuit of funding for hazard mitigation and climate action goals. This should include community-centered and regional opportunities to address local and regional hazard risk reduction projects.	High
5	Develop a Climate Adaptation Plan that is consistent with the Hazard Mitigation Plan and MVP.	High
6	Update Town Bylaws and Zoning Bylaws to prioritize hazard mitigation, climate adaptation and resiliency.	High
8	Develop a Medical Reserve Corps.	High
10	Expand GIS capacity to support hazard mitigation and climate adaptation planning efforts.	High
13	Prioritize vulnerable populations in Harvard when mitigating natural hazard risks and climate adaptation measures.	High
18	Expand capacity to mitigate flood risk and support the National Flood Insurance Program (NFIP) by formally designating a community Floodplain Administrator (FPA), supporting the FPA to be certified as a Certified Floodplain Manager (CFM).	Medium
19	Adopt the 2020 MA State Model Floodplain Bylaw.	Medium

20	Fill vacant staff positions and increase positions to support implementation of mitigation actions and climate adaptation.	Medium
Natural Systems Protection		
1	Implement down-stream flood control and monitor for water health, algae blooms, and biodiversity of pond. Provide education and outreach to the public regarding these issues.	High
7	Implement a plan of ongoing water quality protection through continuing the regular testing of wells and other water sources. Maintain and enhance robust land protection around wetlands, ecological buffers, and groundwater sources, as applicable.	High
9	Remove invasive plant species from conservation lands and plant native species where ecological edges and buffer zones have been disturbed. Implement vegetative buffers along roadsides.	High
15	Install and maintain beaver management devices to mitigate flooding risk.	High
16	Identify areas prone to brush fires and mitigate this risk with brush clearing, building fire breaks, and maintaining fire ponds or cisterns.	Medium
Structure and Infrastructure Projects		
11	Add back-up power to the Town Hall.	High
12	Add a generator to the new Council on Aging facility and formalize the Elementary School as a cooling or warming center.	High
14	Replace culverts based on need.	High
17	Expand the Town's management of trees by routinely examining trees, trimming, or removing unhealthy trees, and educating the public about tree health.	Medium
21	Establish energy resilience for public buildings and other critical facilities by installing solar panels or other renewable source and add back-up power, as funding opportunities arise.	Medium

22	Evaluate, plan, and implement an expanded stormwater detention system, purchase additional equipment for drainage, and maintain a budget for emergency repairs and replacements.	Low

Mitigation Actions Sorted by Goal Statement

#	Action	Estimated Cost	Potential Funding Source	Lead Department	Supporting Partners & Departments	Implementation Schedule	Priority
Capacity Building and Planning							
1	Implement down-stream flood control and monitor for water health, algae blooms, and biodiversity of pond. Provide education and outreach to the public regarding these issues.	Low under $20,000	Town Meeting grants a Project and then a Warrant Article for Funding	Bare Hill Pond Watershed Management Committee	Board of Health, DPW, Conservation Commission	1-5 Years	High
3	Enforce state building codes.	Low under $20,000	FEMA or Town Meeting grants a Project and then a Warrant Article for Funding	Building Commissioner	Commission on Disabilities, Permanent Building Committee	1-5 Years	High
4	Be aggressive and creative regarding the pursuit of funding for hazard mitigation and climate action goals. This should include community-centered and regional opportunities to address local and	Low under $20,000	MVP, FEMA, EPA Sewer Overflow and Stormwater Reuse	Harvard Climate Initiative Committee and	Harvard Climate Initiative Committee	1-5 Years	High

#	Action	Estimated Cost	Potential Funding Source	Lead Department	Supporting Partners & Departments	Implementation Schedule	Priority
	regional hazard risk reduction projects.		Municipal Grant Program	Emergency Management			
5	Develop a Climate Adaptation Plan that is consistent with the Hazard Mitigation Plan and MVP.	Low under $20,000	Town Meeting grants a Project and then a Warrant Article for Funding	Harvard Climate Initiative Committee	Harvard Climate Initiative Committee Partners	1 Year	High
6	Update Town Bylaws and Zoning Bylaws to prioritize hazard mitigation, climate adaptation and resiliency.	Medium $20,000-$100,000	MVP	Planning Board and Harvard Climate Initiative Committee	Harvard Climate Initiative Committee, Conservation Commission	2 Years	High
8	Develop a Medical Reserve Corps.	Low under $20,000	Town Meeting grants a Project and then a Warrant Article for Funding	Emergency Management & Police Department	Department of Public Works, Harvard School Committee, Board of Health, Council on Aging	3-5 Years	High

#	Action	Estimated Cost	Potential Funding Source	Lead Department	Supporting Partners & Departments	Implementation Schedule	Priority
10	Expand GIS capacity to support hazard mitigation and climate adaptation planning efforts.	Low under $20,000	Town Meeting grants a Project and then a Warrant Article for Funding	Town Administrator		2 Years	High
13	Prioritize vulnerable populations in Harvard when mitigating natural hazard risks and climate adaptation measures.	Low under $20,000	Town Meeting grants a Project and then a Warrant Article for Funding	Council on Aging	Fire Department/Police Department	1-5 Years	High
18	Expand capacity to mitigate flood risk and support the National Flood Insurance Program (NFIP) by formally designating a community Floodplain Administrator (FPA), supporting the FPA to be certified as a Certified Floodplain Manager (CFM).	Low under $20,000	Town Meeting grants a Project and then a Warrant Article for Funding	Town Planner	Harvard Climate Initiative Committee, Conservation Commission, Building Commissioner/Facilities Manager	1 Year	Medium
19	Adopt the 2020 MA State Model Floodplain Bylaw.	Low under $20,000	MVP	Planning Board	Building Commissioner/Facilities	2 Years	Medium

#	Action	Estimated Cost	Potential Funding Source	Lead Department	Supporting Partners & Departments	Implementation Schedule	Priority
					Manager, Floodplain Administrator		
20	Fill vacant staff positions and increase positions to support implementation of mitigation actions and climate adaptation.	High over $100,000	Town Meeting grants a Project and then a Warrant Article for Funding	Select Board & Town Administrator	Conservation Commission, Board of Health, Harbormaster	4 Years	Medium
Critical Facilities and Infrastructure							
2	Catalog all permitted BMP's (stormwater control measures) to develop compliance procedures to maintain stormwater storage capacity.	Low under $20,000	Town Meeting grants a Project and then a Warrant Article for Funding	Conservation Commission		3 Years	High
7	Implement a plan of ongoing water quality protection through continuing the regular testing of wells and other water sources. Maintain and enhance robust land protection around wetlands, ecological buffers, and groundwater sources, as applicable.	Medium $20,000-$100,000	MVP	Planning Board, Conservation Agent, Water Commission, Board of Health	Department of Public Works	3 Years	High

#	Action	Estimated Cost	Potential Funding Source	Lead Department	Supporting Partners & Departments	Implementation Schedule	Priority
9	Remove invasive plant species from conservation lands and plant native species where ecological edges and buffer zones have been disturbed. Implement vegetative buffers along roadsides.	High over $100,000	MVP	Conservation Commission	Garden Club	1-5 Years	High
11	Add back-up power to the Town Hall.	Medium $20,000-$100,000	FEMA HMGP or BRIC	Emergency Management	Town Administrator, Harvard School Committee	2 Years	High
12	Add a generator to the new Council on Aging facility and formalize the Elementary School as a cooling or warming center.	Medium $20,000-$100,000	FEMA HMGP or BRIC	Emergency Management	Town Administrator, Harvard School Committee	2 Years	High
14	Replace culverts based on need.	Medium $20,000-$100,000	MA DER Culvert Replacement Municipal Assistance Grant Program, FEMA BRIC or HMGP, MVP	DPW	Floodplain Administrator	1-5 Years	High
15	Install and maintain beaver management devices to mitigate flooding risk.	Low under $20,000	Town Meeting grants a	Conservation Commission & DPW	Department of Public Works	1-5 Years	High

#	Action	Estimated Cost	Potential Funding Source	Lead Department	Supporting Partners & Departments	Implementation Schedule	Priority
			Project and then a Warrant Article for Funding				
16	Identify areas prone to brush fires and mitigate this risk with brush clearing, building fire breaks, and maintaining fire ponds or cisterns.	Medium $20,000-$100,000	Town Meeting grants a Project and then a Warrant Article for Funding	Fire Department	GIS Manager	1-5 Years	Medium
17	Expand the Town's management of trees by routinely examining trees, trimming, or removing unhealthy trees, and educating the public about tree health.	Medium $20,000-$100,000	National Grid, Town Meeting grants a Project and then a Warrant Article for Funding	Tree Warden & Elm Commission	Department of Public Works, National Grid	1-5 Years	Medium
21	Establish energy resilience for public buildings and other critical facilities by installing solar panels or other renewable source and add back-up power, as funding opportunities arise.	High over $100,000	FEMA HMGP or BRIC	Permanent Building Committee and Energy Committee	Building Commission/Facilities Manager, Fire Department/Emergency Management	4 Years	Medium

#	Action	Estimated Cost	Potential Funding Source	Lead Department	Supporting Partners & Departments	Implementation Schedule	Priority
22	Evaluate, plan, and implement an expanded stormwater detention system, purchase additional equipment for drainage, and maintain a budget for emergency repairs and replacements.	High over $100,000	FEMA BRIC, HMGP or MVP	Department of Public Works and CFM		3 Years	Low
Public Education and Outreach							
23	Update and maintain the Town managed websites with hazard mitigation and climate adaptation information.	Low under $20,000	Town Meeting grants a Project and then a Warrant Article for Funding	Town Administrator		5 Years	Low
24	Develop a robust education program for residents and business owners that includes all natural hazards, climate adaptation, and hazard mitigation.	Low under $20,000	FEMA BRIC, HMGP or MVP	Emergency Management and Harvard Climate Initiative Committee	Harvard Climate Initiative Committee	1-5 Years	Low

Appendix C. Plan Implementation and Review Supporting Materials.

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>
<tr><th colspan="5">Mitigation Action Progress Worksheet</th></tr>
<tr><td>Progress Report Period</td><td colspan="2">From Date</td><td colspan="2">To Date</td></tr>
<tr><td>Action/Project Title</td><td colspan="4"></td></tr>
<tr><td>Responsible Department</td><td colspan="4"></td></tr>
<tr><td>Contact Name</td><td colspan="4"></td></tr>
<tr><td>Contact Phone/Email</td><td colspan="4"></td></tr>
<tr><td>Project Description</td><td colspan="4"></td></tr>
<tr><td>Project Goal</td><td colspan="4"></td></tr>
<tr><td>Project Objective</td><td colspan="4"></td></tr>
<tr><td>Project Cost</td><td colspan="4"></td></tr>
<tr><td colspan="5">Project Status</td></tr>
<tr><td>Date of Project Approval</td><td>Date of Project Start</td><td>Anticipated Date of Completion</td><td>Project Canceled</td><td>Project Delayed</td></tr>
<tr><td colspan="5">Explanation of Delay or Cost Overruns</td></tr>
<tr><td colspan="5">Project Report Summary</td></tr>
<tr><td colspan="5">What was accomplished for this project during this reporting period?</td></tr>
<tr><td colspan="5">What obstacles, problems, or delays did the project encounter?</td></tr>
<tr><td colspan="5">Plans for next reporting period.</td></tr>
</table>

Appendix D. Hazus Reports

Hazus: Flood Global Risk Report

Region Name: HarvardFL

Flood Scenario: 100year

Print Date: Monday, May 23, 2022

Disclaimer:

This version of Hazus utilizes 2010 Census Data.
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 27 square miles and contains 399 census blocks. The region contains over 2 thousand households and has a total population of 6,520 people (2010 Census Bureau data). The distribution of population by State and County for the study region is provided in Appendix B.

There are an estimated 2,274 buildings in the region with a total building replacement value (excluding contents) of 1,225 million dollars. Approximately 87.55% of the buildings (and 79.88% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

Hazus estimates that there are 2,274 buildings in the region which have an aggregate total replacement value of 1,225 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	978,467	79.9%
Commercial	128,744	10.5%
Industrial	69,531	5.7%
Agricultural	5,860	0.5%
Religion	21,925	1.8%
Government	10,412	0.9%
Education	9,956	0.8%
Total	**1,224,895**	**100%**

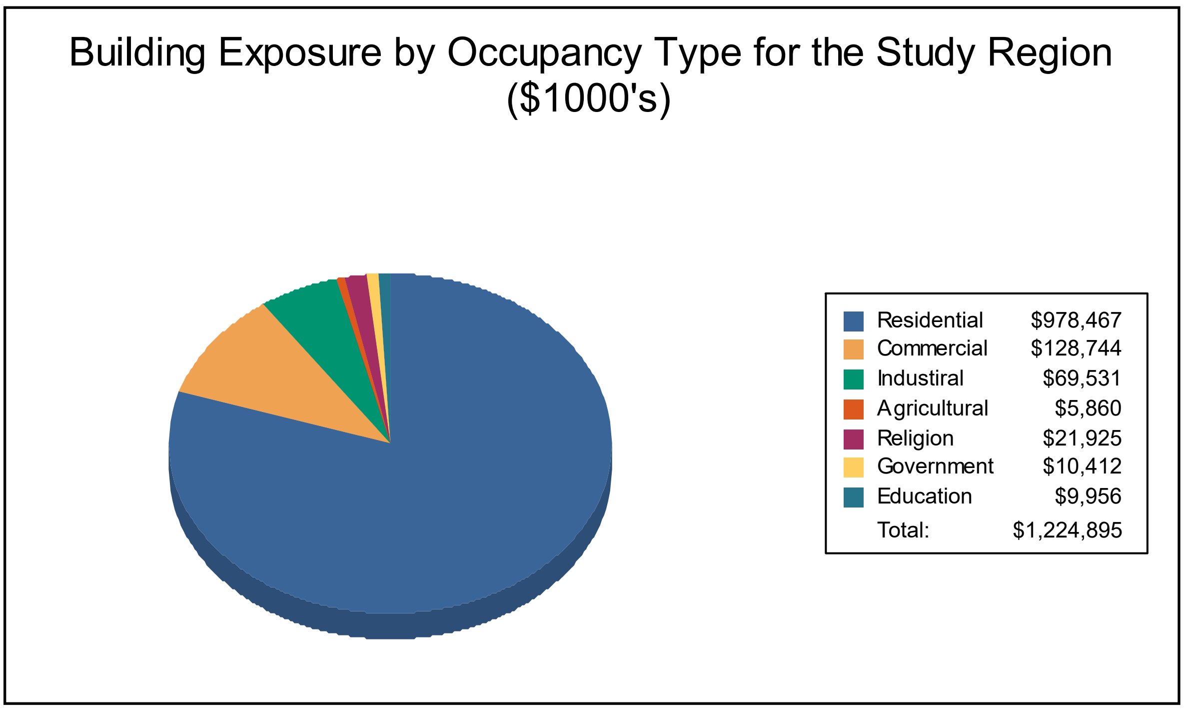
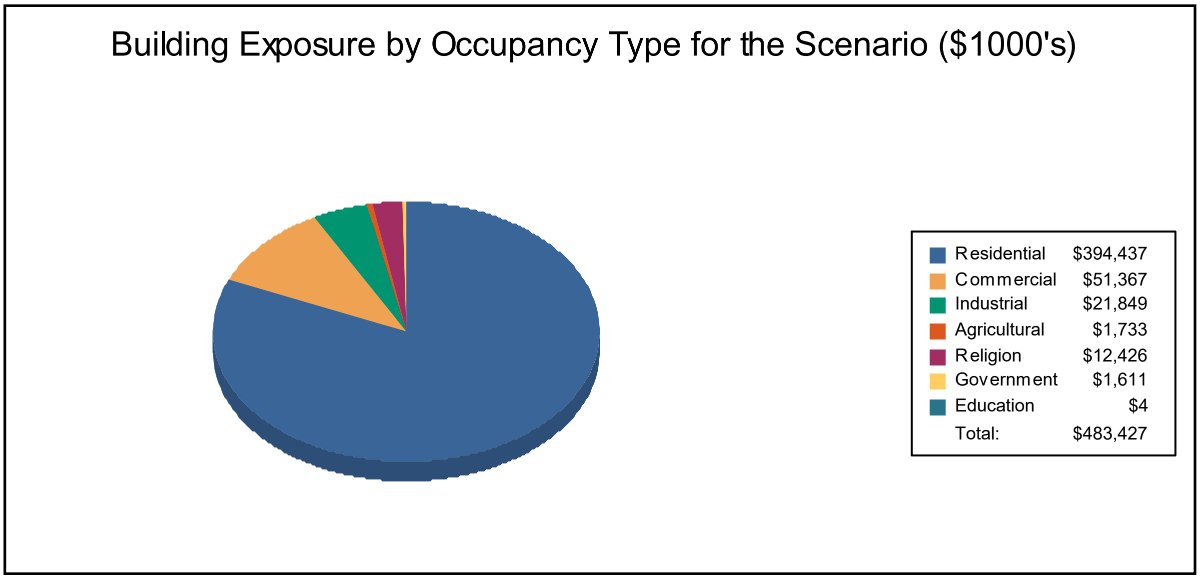


Table 2
Building Exposure by Occupancy Type for the Scenario

Occupancy	Exposure ($1000)	Percent of Total
Residential	394,437	81.6%
Commercial	51,367	10.6%
Industrial	21,849	4.5%
Agricultural	1,733	0.4%
Religion	12,426	2.6%
Government	1,611	0.3%
Education	4	0.0%
Total	**483,427**	**100%**



Essential Facility Inventory

For essential facilities, there are no hospitals in the region with a total bed capacity of no beds. There are 6 schools, 3 fire stations, 1 police station and 2 emergency operation centers.

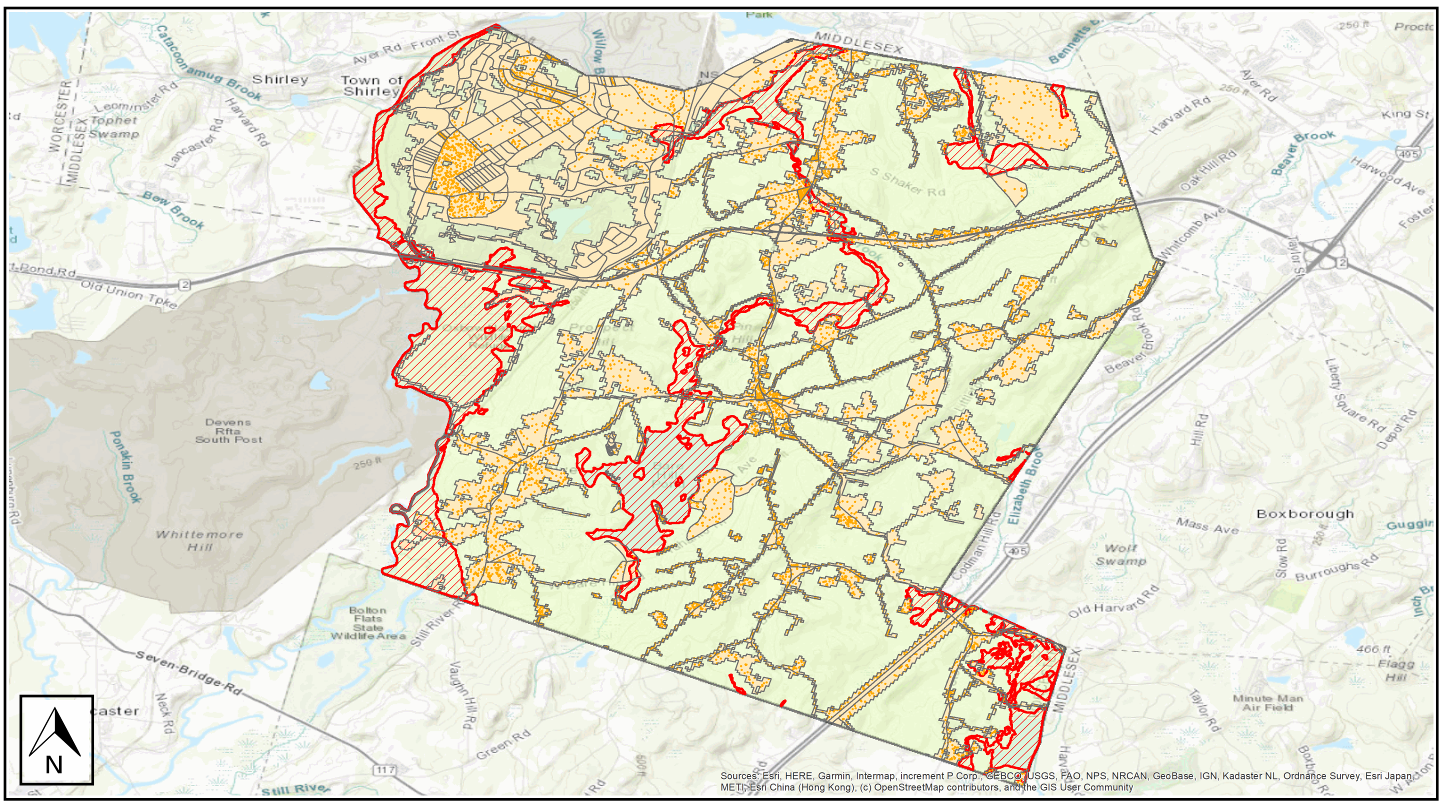
Flood Scenario Parameters

Hazus used the following set of information to define the flood parameters for the flood loss estimate provided in this report.

Study Region Name:	HarvardFL
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 0% 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

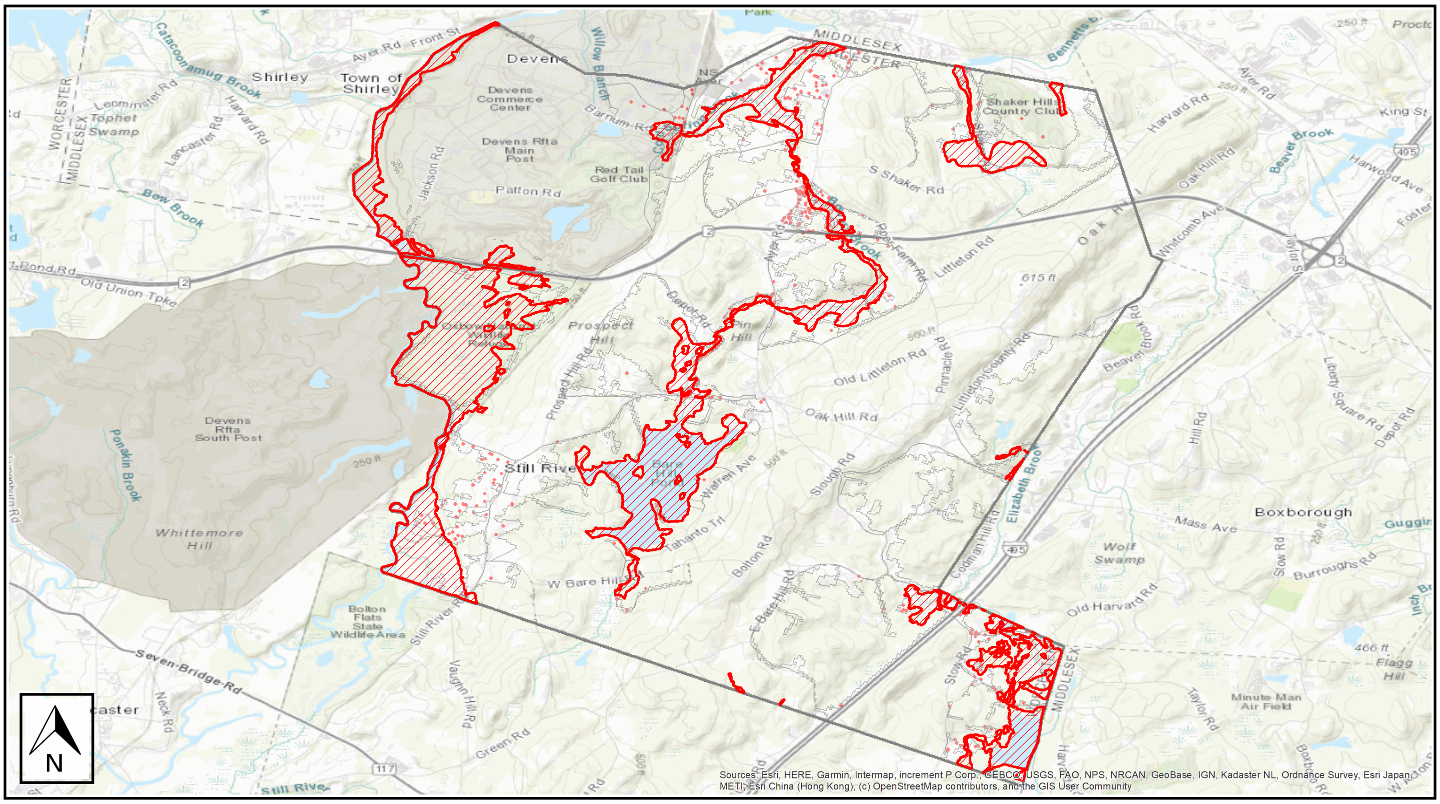


Table 3: Expected Building Damage by Occupancy

	1-10		11-20		21-30		31-40		41-50		>50	
Occupancy	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
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	0	0	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	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0**		**0**		**0**		**0**		**0**		**0**	

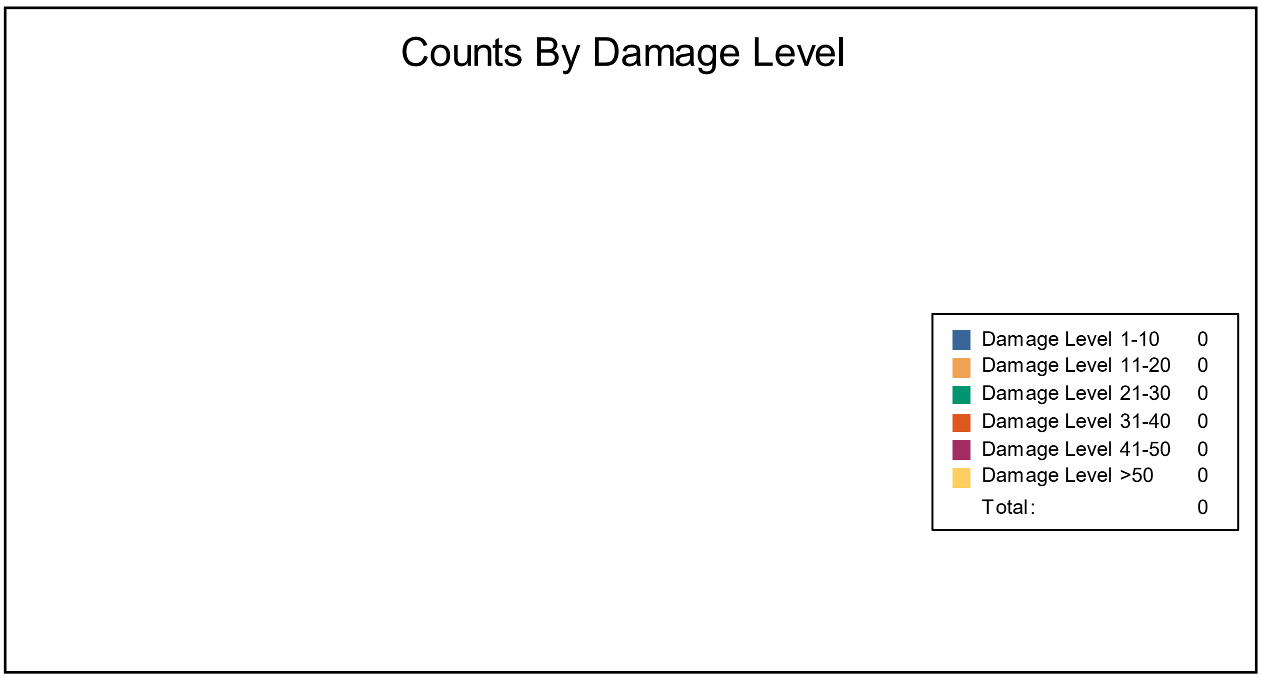


Table 4: Expected Building Damage by Building Type

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	0	0	0	0	0	0	0	0	0	0	0	0
Wood	0	0	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	3	0	0	0
Hospitals	0	0	0	0
Police Stations	1	0	0	0
Schools	6	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

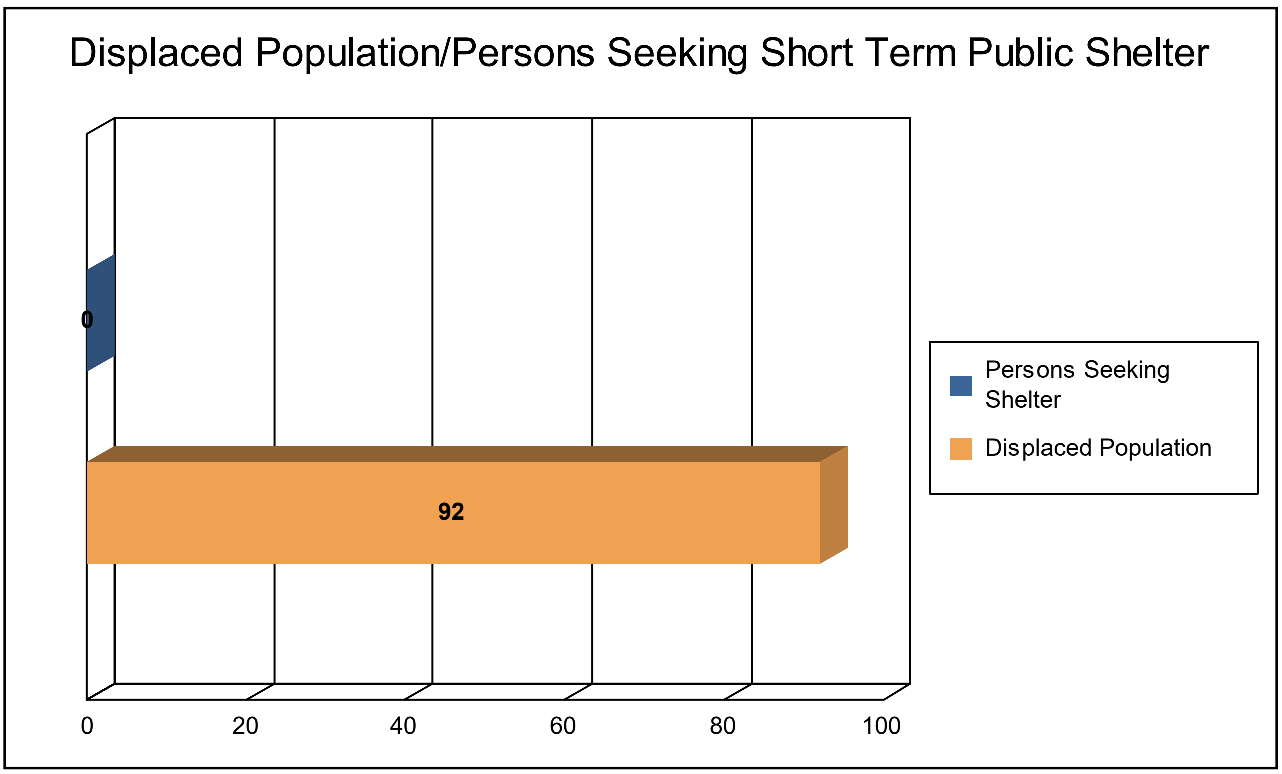
Hazus estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories: 1) Finishes (dry wall, insulation, etc.), 2) Structural (wood, brick, etc.) and 3) Foundations (concrete slab, concrete block, rebar, etc.). This distinction is made because of the different types of material handling equipment required to handle the debris.

Analysis has not been performed for this Scenario.

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 31 households (or 92 of people) will be displaced due to the flood. Displacement includes households evacuated from within or very near to the inundated area. Of these, 0 people (out of a total population of 6,520) will seek temporary shelter in public shelters.



Economic Loss

The total economic loss estimated for the flood is 14.46 million dollars, which represents 2.99 % of the total replacement value of the scenario buildings.

Building-Related Losses

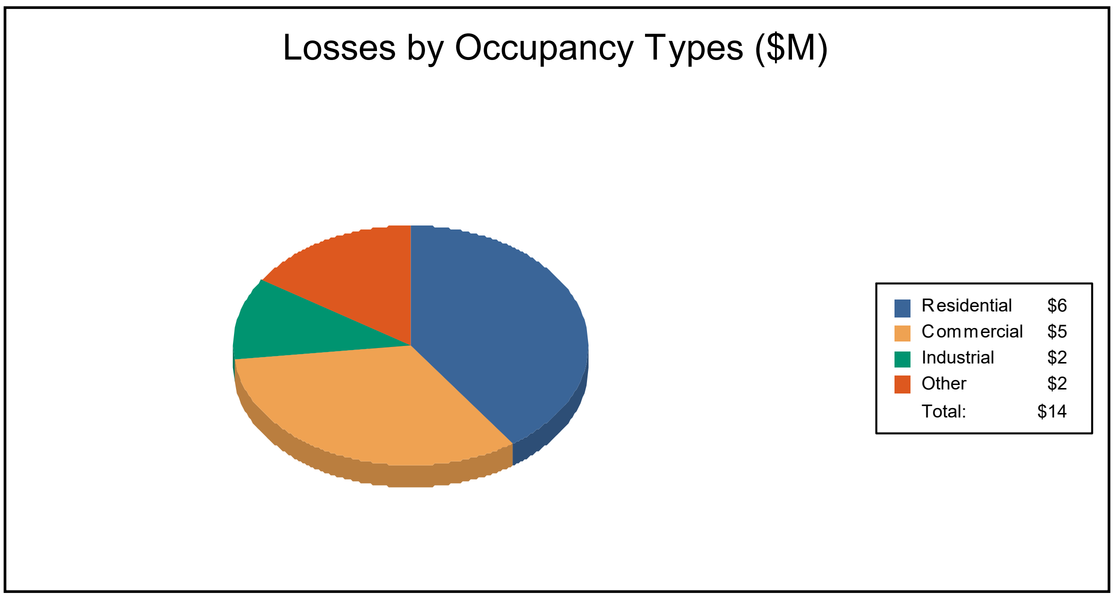
The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability 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 10.01 million dollars. 31% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 40.25% 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	3.48	0.74	0.43	0.13	4.77
	Content	1.66	1.67	1.03	0.75	5.10
	Inventory	0.00	0.02	0.11	0.00	0.13
	Subtotal	**5.14**	**2.43**	**1.57**	**0.87**	**10.01**
Business Interruption						
	Income	0.03	1.06	0.01	0.17	1.26
	Relocation	0.43	0.18	0.01	0.08	0.70
	Rental Income	0.14	0.13	0.00	0.01	0.28
	Wage	0.08	0.94	0.02	1.17	2.21
	Subtotal	**0.68**	**2.31**	**0.04**	**1.43**	**4.45**
ALL	**Total**	**5.82**	**4.73**	**1.60**	**2.30**	**14.46**



Appendix A: County Listing for the Region

Massachusetts

- Worcester

Appendix B: Regional Population and Building Value Data

	Population	Building Value (thousands of dollars)		
		Residential	Non-Residential	Total
Massachusetts				
Worcester	6,520	978,467	246,428	1,224,895
Total	**6,520**	**978,467**	**246,428**	**1,224,895**
Total Study Region	**6,520**	**978,467**	**246,428**	**1,224,895**

EARTHQUAKE · WIND · FLOOD · TSUNAMI

Hazus: Hurricane Global Risk Report

Region Name: HarvardWind

Hurricane Scenario: Probabilistic 100-year Return Period

Print Date: Monday, May 23, 2022

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 27.17 square miles and contains 1 census tracts. There are over 1 thousand households in the region and a total population of 6,520 people (2010 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 2 thousand buildings in the region with a total building replacement value (excluding contents) of 1,225 million dollars (2014 dollars). Approximately 88% of the buildings (and 80% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

Hazus estimates that there are 2,274 buildings in the region which have an aggregate total replacement value of 1,225 million (2014 dollars). Table 1 presents the relative distribution of the value with respect to the general occupancies. Appendix B provides a general distribution of the building value by State and County.

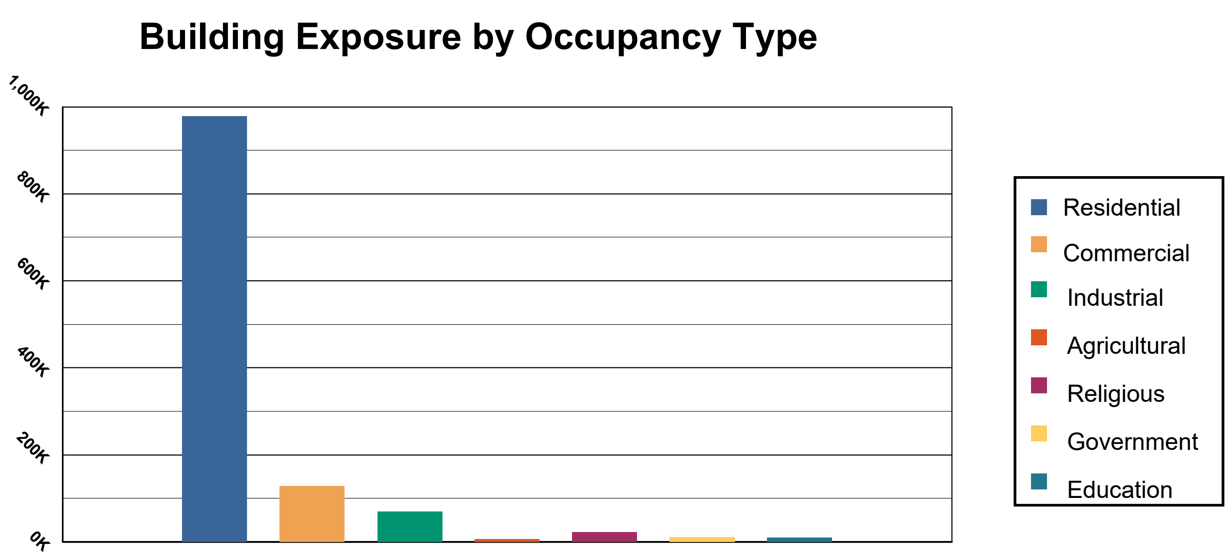


Table 1: Building Exposure by Occupancy Type

Occupancy	Exposure ($1000)	Percent of Tot
Residential	978,467	79.88%
Commercial	128,744	10.51%
Industrial	69,531	5.68%
Agricultural	5,860	0.48%
Religious	21,925	1.79%
Government	10,412	0.85%
Education	9,956	0.81%
Total	**1,224,895**	**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 6 schools, 3 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 1 buildings will be at least moderately damaged. This is over 0% 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.

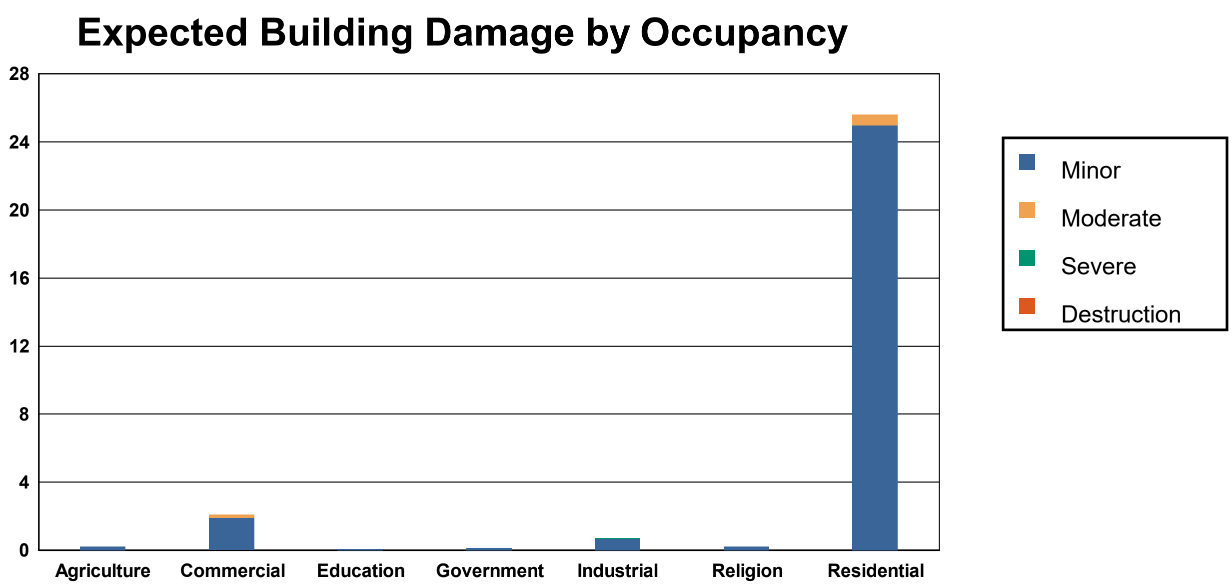


Table 2: Expected Building Damage by Occupancy : 100 - year Event

	None		Minor		Moderate		Severe		Destruction	
Occupancy	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Agriculture	17.77	98.72	0.21	1.15	0.02	0.11	0.00	0.02	0.00	0.00
Commercial	167.92	98.77	1.90	1.12	0.18	0.10	0.00	0.00	0.00	0.00
Education	4.94	98.88	0.06	1.10	0.00	0.02	0.00	0.00	0.00	0.00
Government	10.87	98.85	0.13	1.14	0.00	0.01	0.00	0.00	0.00	0.00
Industrial	56.29	98.76	0.68	1.19	0.02	0.04	0.00	0.00	0.00	0.00
Religion	21.78	99.01	0.21	0.96	0.01	0.03	0.00	0.00	0.00	0.00
Residential	1,965.39	98.71	24.98	1.25	0.61	0.03	0.01	0.00	0.00	0.00
Total	**2,244.97**		**28.17**		**0.84**		**0.02**		**0.00**	

Table 3: Expected Building Damage by Building Type : 100 - year Event

Building Type	None		Minor		Moderate		Severe		Destruction	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	28	98.11	1	1.86	0	0.03	0	0.00	0	0.00
Masonry	169	98.22	3	1.65	0	0.12	0	0.01	0	0.00
MH	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Steel	120	98.73	1	1.20	0	0.07	0	0.00	0	0.00
Wood	1,929	98.86	22	1.11	0	0.02	0	0.00	0	0.00

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.

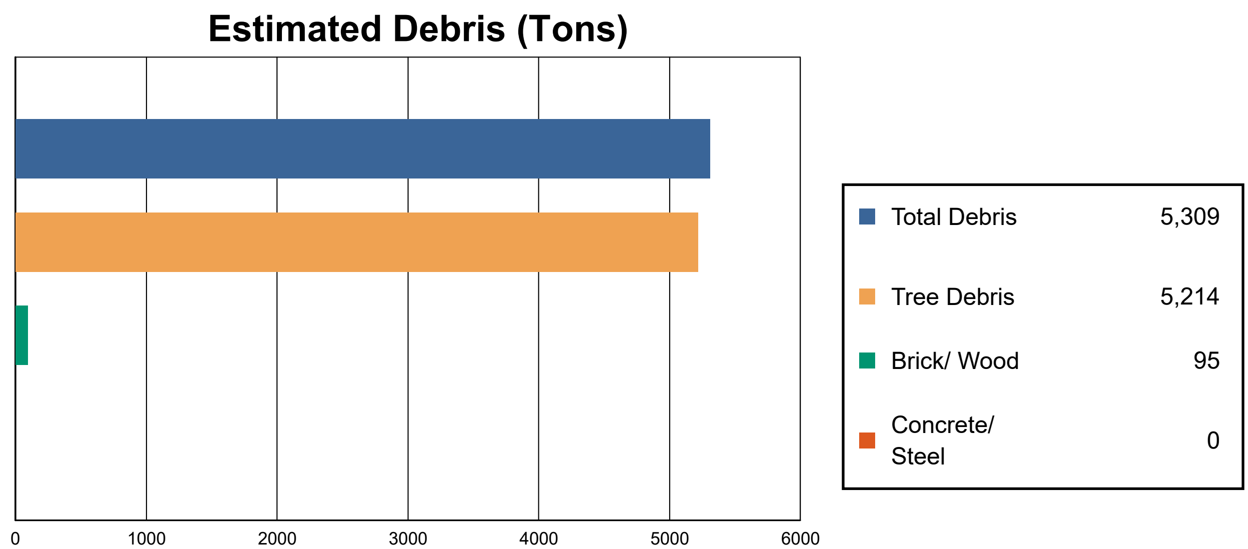
Thematic Map of Essential Facilities with greater than 50% moderate

Table 4: Expected Damage to Essential Facilities

Classification	Total	# Facilities: Probability of at Least Moderate	# Facilities: Probability of Complete Damage > 50%	# Facilities: Expected Loss of Use < 1 day
EOCs	2	0	0	2
Fire Stations	3	0	0	3
Police Stations	1	0	0	1
Schools	6	0	0	6

Induced Hurricane Damage

Debris Generation

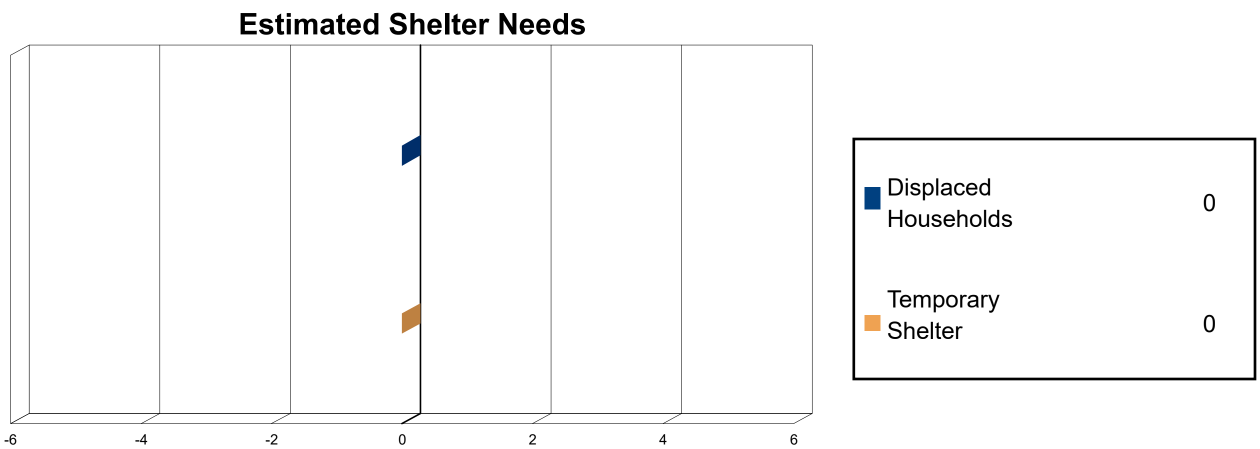


Hazus estimates the amount of debris that will be generated by the hurricane. The model breaks the debris into four general categories: a) Brick/Wood, b) Reinforced Concrete/Steel, c) Eligible Tree Debris, and d) Other Tree Debris. This distinction is made because of the different types of material handling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

The model estimates that a total of 5,309 tons of debris will be generated. Of the total amount, 4,568 tons (86%) is Other Tree Debris. Of the remaining 741 tons, Brick/Wood comprises 13% 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 4 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 646 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 0 households to be displaced due to the hurricane. Of these, 0 people (out of a total population of 6,520) will seek temporary shelter in public shelters.

Economic Loss

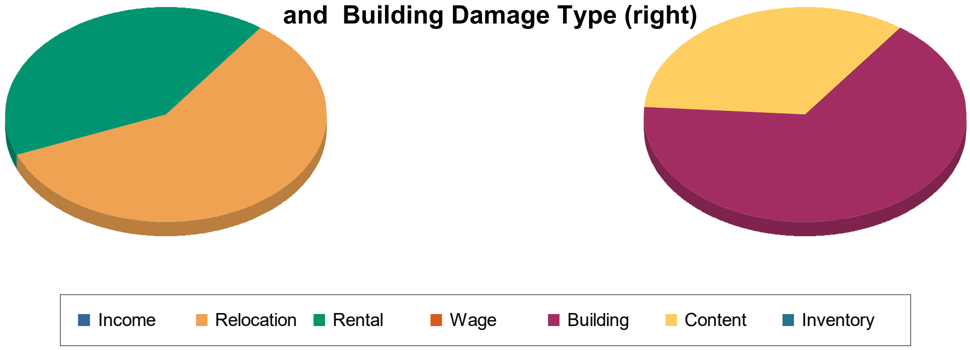
The total economic loss estimated for the hurricane is 5.7 million dollars, which represents 0.46 % of the total replacement value of the region's buildings.

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 6 million dollars. 0% 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 98% 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	3,657.75	56.01	21.54	15.57	3,750.87
	Content	1,931.33	0.00	0.00	0.00	1,931.33
	Inventory	0.00	0.00	0.00	0.00	0.00
	Subtotal	**5,589.08**	**56.01**	**21.54**	**15.57**	**5,682.21**
Business Interruption Loss						
	Income	0.00	0.00	0.00	0.00	0.00
	Relocation	2.55	0.88	0.09	0.10	3.63
	Rental	2.54	0.00	0.00	0.00	2.54
	Wage	0.00	0.00	0.00	0.00	0.00
	Subtotal	**5.09**	**0.88**	**0.09**	**0.10**	**6.17**

<u>Total</u>

Total	**5,594.18**	**56.90**	**21.62**	**15.68**	**5,688.38**

Appendix A: County Listing for the Region

Massachusetts

- Worcester

Appendix B: Regional Population and Building Value Data

		Building Value (thousands of dollars)		
	Population	Residential	Non-Residential	Total
Massachusetts				
Worcester	6,520	978,467	246,428	1,224,895
Total	**6,520**	**978,467**	**246,428**	**1,224,895**
Study Region Total	**6,520**	**978,467**	**246,428**	**1,224,895**

Hazus: Hurricane Global Risk Report

Region Name: HarvardWind

Hurricane Scenario: Probabilistic 500-year Return Period

Print Date: Monday, May 23, 2022

Disclaimer:
This version of Hazus utilizes 2010 Census Data.
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 27.17 square miles and contains 1 census tracts. There are over 1 thousand households in the region and a total population of 6,520 people (2010 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 2 thousand buildings in the region with a total building replacement value (excluding contents) of 1,225 million dollars (2014 dollars). Approximately 88% of the buildings (and 80% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

Hazus estimates that there are 2,274 buildings in the region which have an aggregate total replacement value of 1,225 million (2014 dollars). Table 1 presents the relative distribution of the value with respect to the general occupancies. Appendix B provides a general distribution of the building value by State and County.

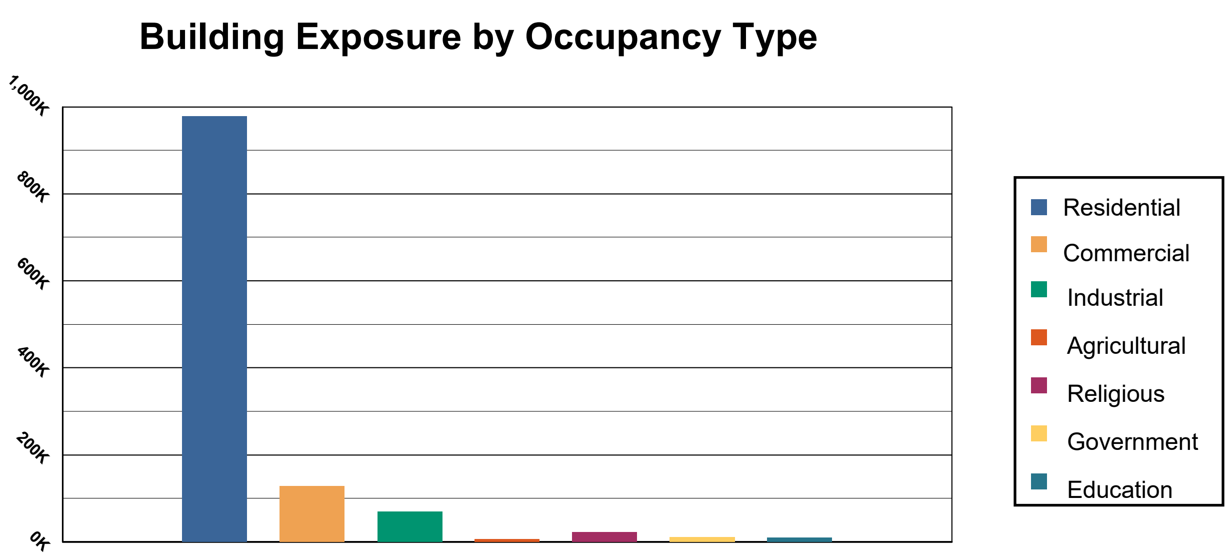


Table 1: Building Exposure by Occupancy Type

Occupancy	Exposure ($1000)	Percent of Tot
Residential	978,467	79.88%
Commercial	128,744	10.51%
Industrial	69,531	5.68%
Agricultural	5,860	0.48%
Religious	21,925	1.79%
Government	10,412	0.85%
Education	9,956	0.81%
Total	**1,224,895**	**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 6 schools, 3 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 23 buildings will be at least moderately damaged. This is over 1% 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.

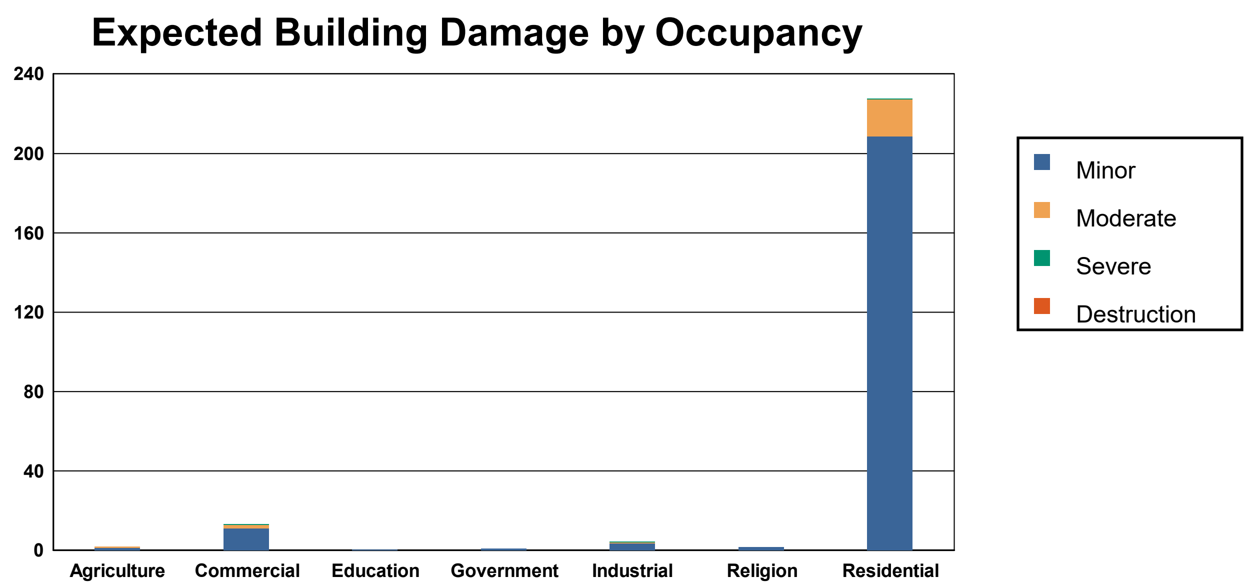


Table 2: Expected Building Damage by Occupancy : 500 - year Event

	None		Minor		Moderate		Severe		Destruction	
Occupancy	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Agriculture	16.11	89.52	1.46	8.10	0.29	1.59	0.13	0.74	0.01	0.05
Commercial	156.76	92.21	11.08	6.52	1.90	1.12	0.26	0.15	0.00	0.00
Education	4.66	93.30	0.31	6.23	0.02	0.46	0.00	0.01	0.00	0.00
Government	10.28	93.44	0.67	6.10	0.05	0.45	0.00	0.01	0.00	0.00
Industrial	52.79	92.61	3.58	6.28	0.50	0.87	0.13	0.23	0.01	0.01
Religion	20.40	92.71	1.50	6.84	0.09	0.43	0.00	0.02	0.00	0.00
Residential	1,763.37	88.57	208.43	10.47	18.93	0.95	0.09	0.00	0.18	0.01
Total	**2,024.37**		**227.04**		**21.78**		**0.62**		**0.20**	

Table 3: Expected Building Damage by Building Type : 500 - year Event

Building Type	None		Minor		Moderate		Severe		Destruction	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	26	89.68	3	9.02	0	1.30	0	0.01	0	0.00
Masonry	154	89.52	15	8.57	3	1.70	0	0.20	0	0.01
MH	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Steel	113	92.74	7	6.04	1	1.04	0	0.18	0	0.00
Wood	1,737	89.03	198	10.17	15	0.78	0	0.02	0	0.00

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.

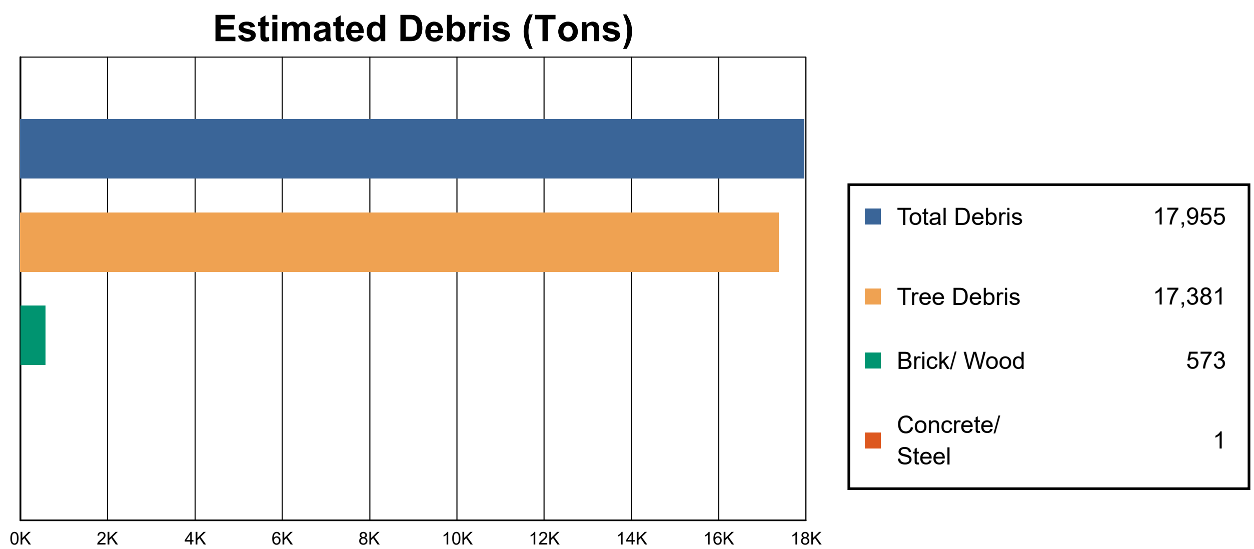
Thematic Map of Essential Facilities with greater than 50% moderate

Table 4: Expected Damage to Essential Facilities

		# Facilities		
Classification	**Total**	**Probability of at Least Moderate**	**Probability of Complete Damage > 50%**	**Expected Loss of Use < 1 day**
EOCs	2	0	0	2
Fire Stations	3	0	0	3
Police Stations	1	0	0	1
Schools	6	0	0	6

Induced Hurricane Damage

Debris Generation

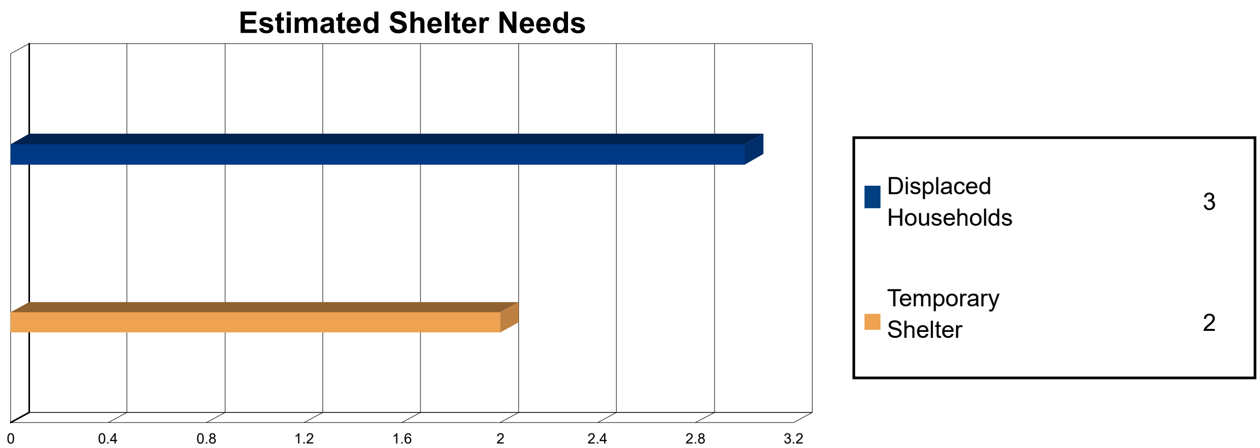


Hazus estimates the amount of debris that will be generated by the hurricane. The model breaks the debris into four general categories: a) Brick/Wood, b) Reinforced Concrete/Steel, c) Eligible Tree Debris, and d) Other Tree Debris. This distinction is made because of the different types of material handling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

The model estimates that a total of 17,955 tons of debris will be generated. Of the total amount, 15,227 tons (85%) is Other Tree Debris. Of the remaining 2,728 tons, Brick/Wood comprises 21% 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 23 truckloads (@25 tons/truck) to remove the building debris generated by the hurricane. The number of Eligible Tree Debris truckloads will depend on how the 2,154 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 3 households to be displaced due to the hurricane. Of these, 2 people (out of a total population of 6,520) will seek temporary shelter in public shelters.

Economic Loss

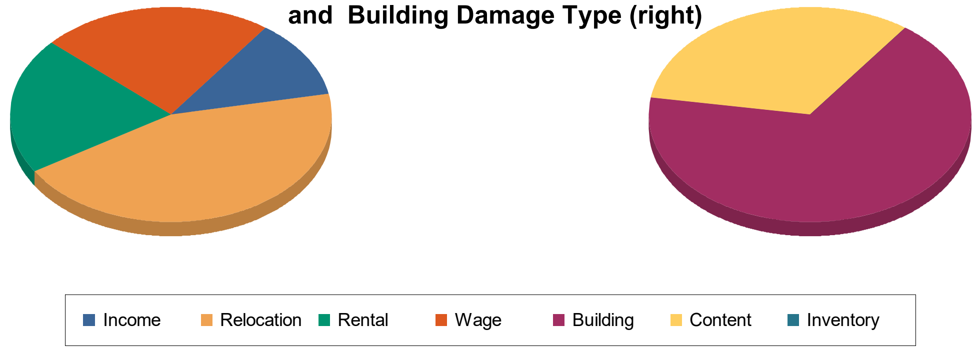
The total economic loss estimated for the hurricane is 19.7 million dollars, which represents 1.61 % of the total replacement value of the region's buildings.

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 20 million dollars. 3% 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 94% 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

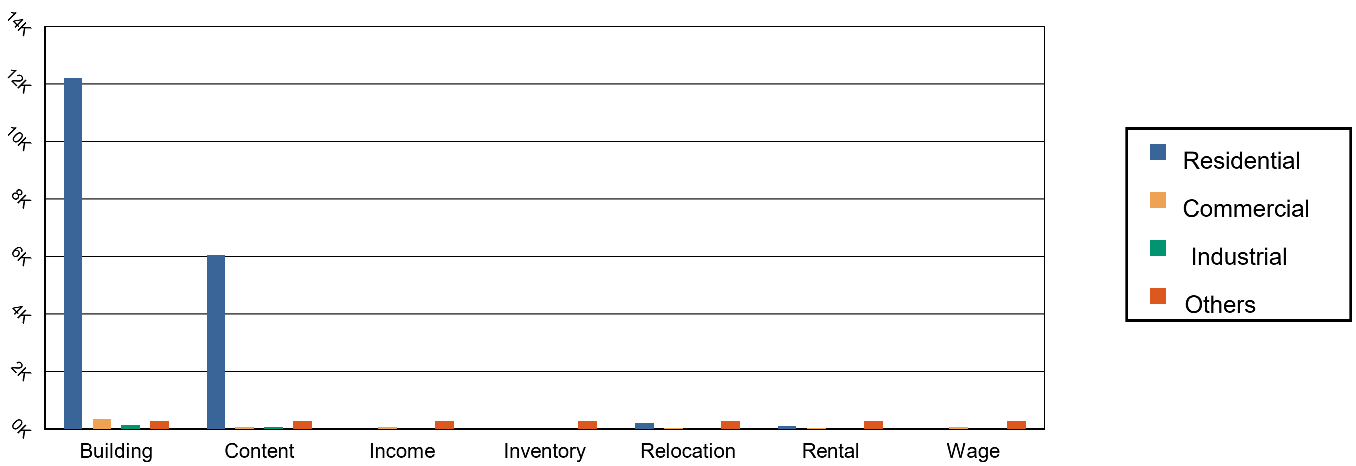


Table 5: Building-Related Economic Loss Estimates

(Thousands of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
<u>Property Damage</u>						
	Building	12,224.64	340.29	159.76	115.78	12,840.47
	Content	6,052.48	53.19	59.08	18.62	6,183.38
	Inventory	0.00	0.89	8.36	0.85	10.11
	Subtotal	**18,277.12**	**394.37**	**227.20**	**135.26**	**19,033.95**
<u>Business Interruption Loss</u>						
	Income	0.00	59.75	1.76	14.43	75.94
	Relocation	202.68	51.40	6.83	16.61	277.53
	Rental	94.34	31.83	1.32	1.79	129.27
	Wage	0.00	55.11	2.94	90.01	148.05
	Subtotal	**297.02**	**198.08**	**12.85**	**122.83**	**630.79**

Total

Total	**18,574.14**	**592.46**	**240.05**	**258.10**	**19,664.74**

Appendix A: County Listing for the Region

Massachusetts

- Worcester

Appendix B: Regional Population and Building Value Data

		Building Value (thousands of dollars)		
	Population	Residential	Non-Residential	Total
Massachusetts				
Worcester	6,520	978,467	246,428	1,224,895
Total	**6,520**	**978,467**	**246,428**	**1,224,895**
Study Region Total	**6,520**	**978,467**	**246,428**	**1,224,895**

Hazus: Earthquake Global Risk Report

Region Name: HarvardTownEQ

Earthquake Scenario: 1500year

Print Date: May 22, 2022

Disclaimer:
This version of Hazus utilizes 2010 Census Data.
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 27.16 square miles and contains 1 census tracts. There are over 1 thousand households in the region which has a total population of 6,520 people (2010 Census Bureau data). The distribution of population by Total Region and County is provided in Appendix B.

There are an estimated 2 thousand buildings in the region with a total building replacement value (excluding contents) of 1,224 (millions of dollars). Approximately 88.00 % of the buildings (and 80.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 356 and 17 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

Hazus estimates that there are 2 thousand buildings in the region which have an aggregate total replacement value of 1,224 (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 86% 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 6 schools, 3 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 373.00 (millions of dollars). This inventory includes over 31.07 miles of highways, 16 bridges, 528.79 miles of pipes.

Table 1: Transportation System Lifeline Inventory

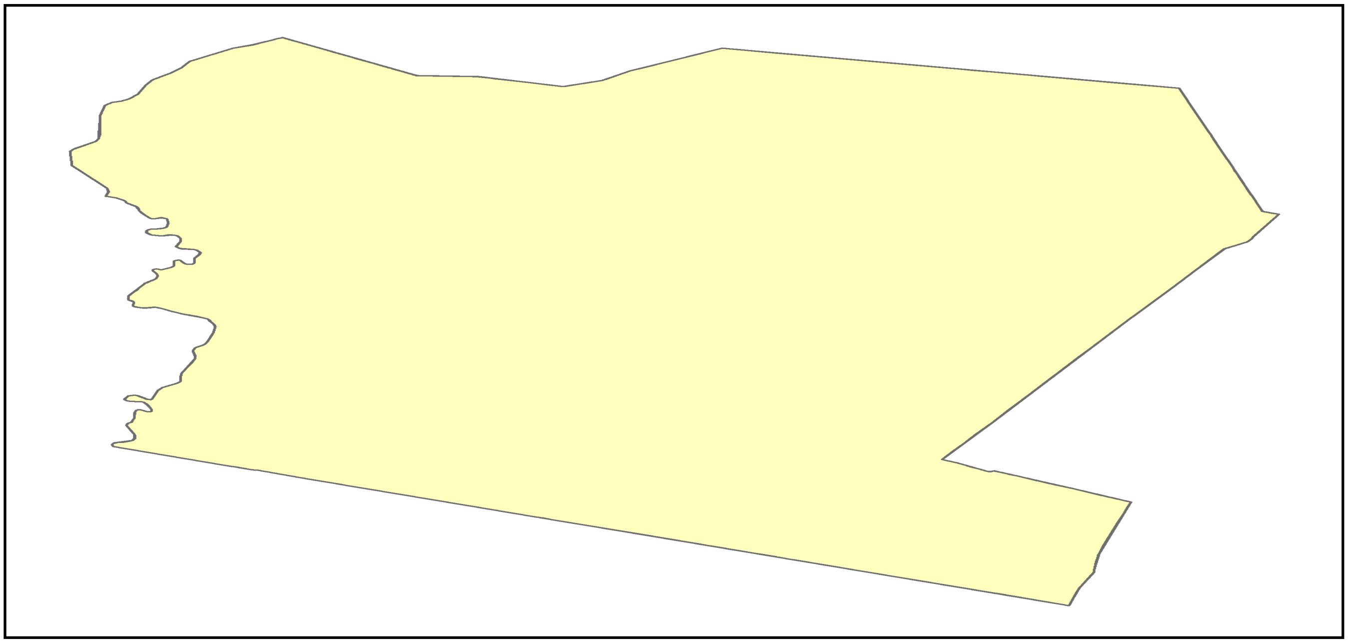
System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	16	35.6620
	Segments	15	270.1205
	Tunnels	0	0.0000
		Subtotal	**305.7825**
Railways	Bridges	2	10.7214
	Facilities	1	2.6630
	Segments	13	22.0021
	Tunnels	0	0.0000
		Subtotal	**35.3865**
Light Rail	Bridges	0	0.0000
	Facilities	0	0.0000
	Segments	1	15.5899
	Tunnels	0	0.0000
		Subtotal	**15.5899**
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	**356.80**

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	8.5151
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**8.5151**
Waste Water	Distribution Lines	NA	5.1091
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**5.1091**
Natural Gas	Distribution Lines	NA	3.4060
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**3.4060**
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	**17.00**

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	1500year
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 51 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

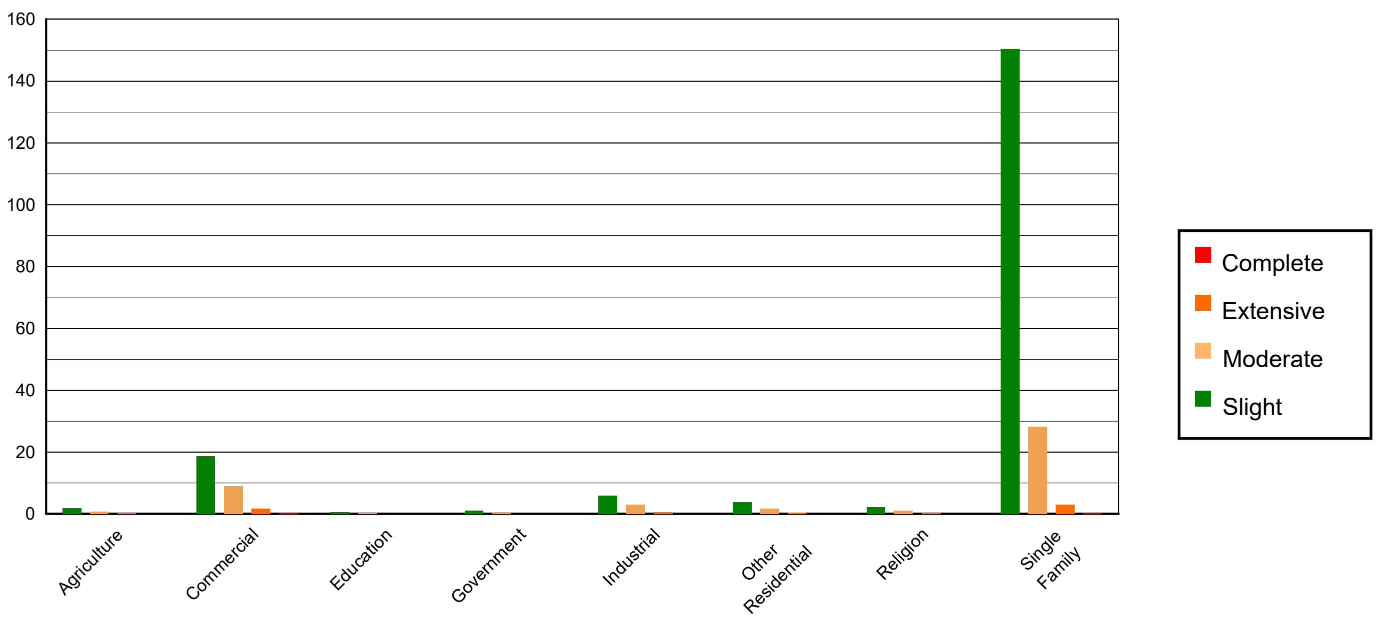


Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	15.06	0.74	2.01	1.09	0.78	1.74	0.14	2.32	0.01	1.81
Commercial	140.56	6.90	18.59	10.07	8.99	20.10	1.70	28.19	0.16	28.80
Education	4.19	0.21	0.51	0.28	0.25	0.56	0.04	0.72	0.00	0.85
Government	9.22	0.45	1.11	0.60	0.57	1.26	0.10	1.59	0.01	1.47
Industrial	47.54	2.33	5.84	3.16	3.04	6.80	0.54	8.95	0.04	7.67
Other Residential	35.04	1.72	3.91	2.12	1.70	3.79	0.32	5.22	0.03	6.10
Religion	18.34	0.90	2.29	1.24	1.11	2.48	0.23	3.84	0.03	5.07
Single Family	1768.08	86.75	150.37	81.44	28.32	63.27	2.97	49.17	0.26	48.23
Total	**2,038**		**185**		**45**		**6**		**1**	

Table 4: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Wood	1780.09	87.34	146.40	79.29	22.57	50.43	1.34	22.22	0.00	0.00
Steel	104.55	5.13	11.30	6.12	5.86	13.10	0.87	14.42	0.04	6.53
Concrete	17.18	0.84	2.08	1.13	1.09	2.44	0.10	1.70	0.00	0.81
Precast	7.38	0.36	1.04	0.57	0.95	2.11	0.26	4.37	0.01	0.99
RM	22.03	1.08	2.07	1.12	1.57	3.50	0.34	5.60	0.00	0.53
URM	106.78	5.24	21.75	11.78	12.72	28.43	3.12	51.68	0.50	91.14
MH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**2,038**		**185**		**45**		**6**		**1**	

*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	6	0	0	6
EOCs	2	0	0	2
PoliceStations	1	0	0	1
FireStations	3	0	0	3

Transportation Lifeline Damage

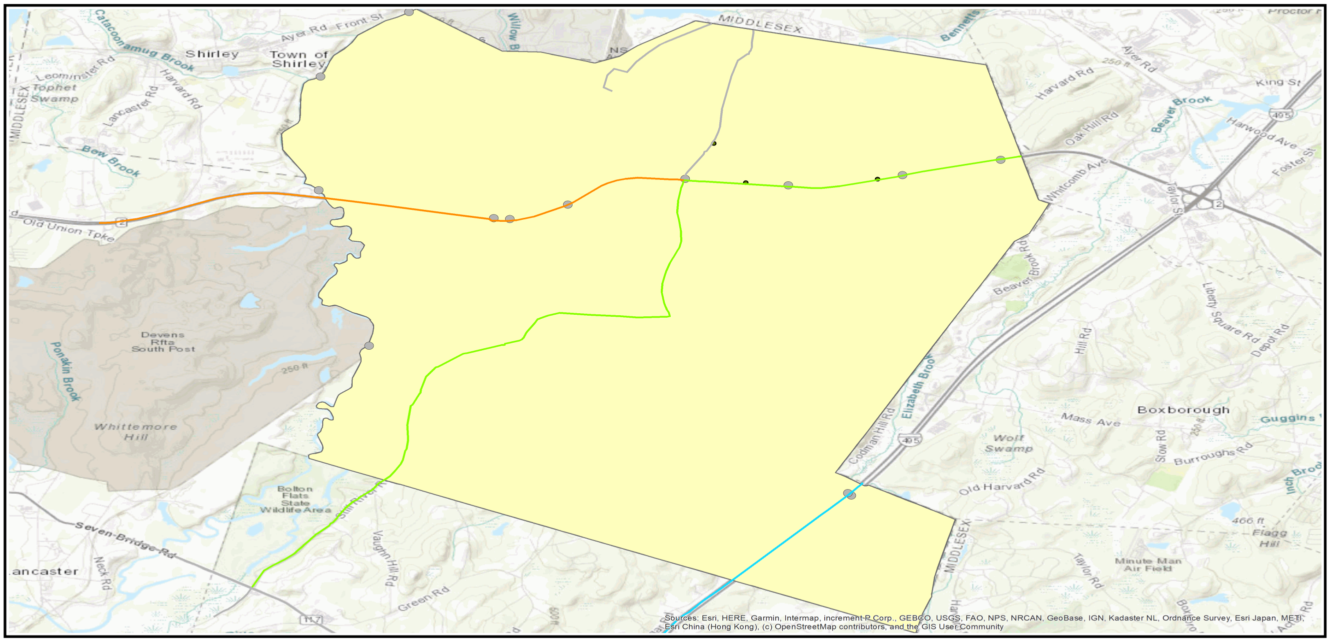


Table 6: Expected Damage to the Transportation Systems

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	15	15
	Bridges	16	0	0	16	16
	Tunnels	0	0	0	0	0
Railways	Segments	13	0	0	13	13
	Bridges	2	0	0	2	2
	Tunnels	0	0	0	0	0
	Facilities	1	0	0	1	1
Light Rail	Segments	1	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	265	2	0
Waste Water	159	1	0
Natural Gas	106	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	1,893	0	0	0	0	0
Electric Power		0	0	0	0	0

Induced Earthquake Damage

Fire Following Earthquake

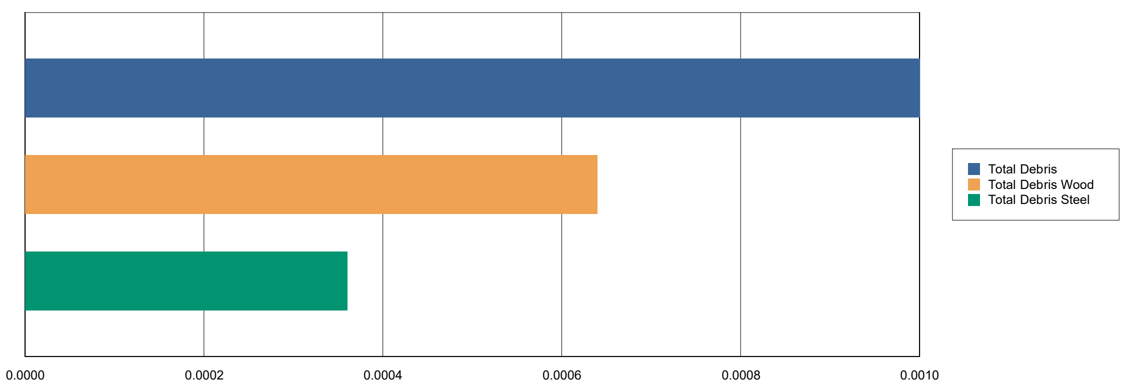
Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. Hazus uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there 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 64.00% 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)



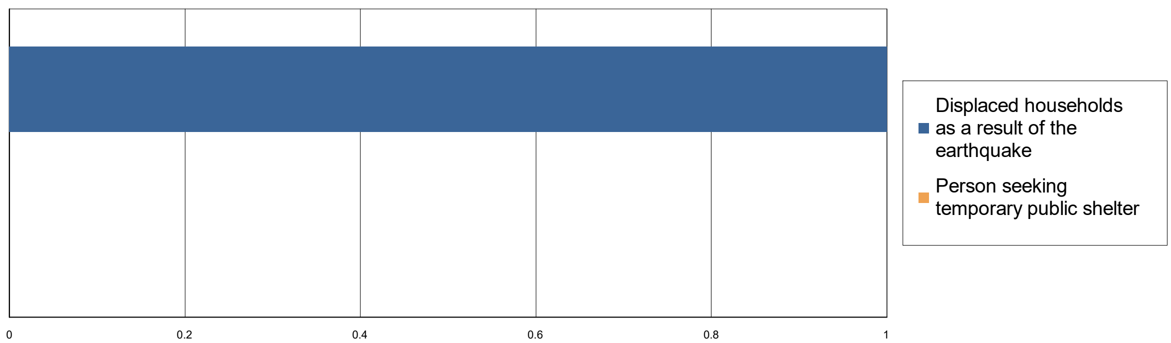
Brick/ Wood	Reinforced Concrete/Steel	Total Debris	Truck Load
0.00	0.00	0.00	40 (@25 tons/truck)

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 1 households to be displaced due to the earthquake. Of these, 0 people (out of a total population of 6,520) 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
1	0

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	0.02	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	0.26	0.04	0.00	0.01
	Single Family	0.72	0.08	0.01	0.01
	Total	**1**	**0**	**0**	**0**
2 PM	Commercial	1.17	0.18	0.02	0.03
	Commuting	0.00	0.00	0.00	0.00
	Educational	0.55	0.09	0.01	0.02
	Hotels	0.00	0.00	0.00	0.00
	Industrial	0.16	0.02	0.00	0.00
	Other-Residential	0.06	0.01	0.00	0.00
	Single Family	0.16	0.02	0.00	0.00
	Total	**2**	**0**	**0**	**0**
5 PM	Commercial	0.88	0.14	0.01	0.03
	Commuting	0.00	0.00	0.00	0.00
	Educational	0.05	0.01	0.00	0.00
	Hotels	0.00	0.00	0.00	0.00
	Industrial	0.10	0.01	0.00	0.00
	Other-Residential	0.10	0.02	0.00	0.00
	Single Family	0.28	0.03	0.00	0.01
	Total	**1**	**0**	**0**	**0**

Economic Loss

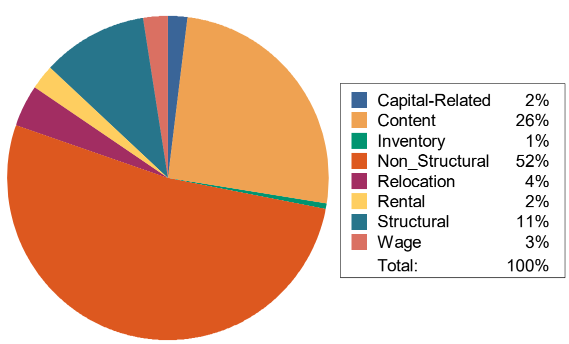
The total economic loss estimated for the earthquake is 15.41 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

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 14.98 (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 62 % 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)

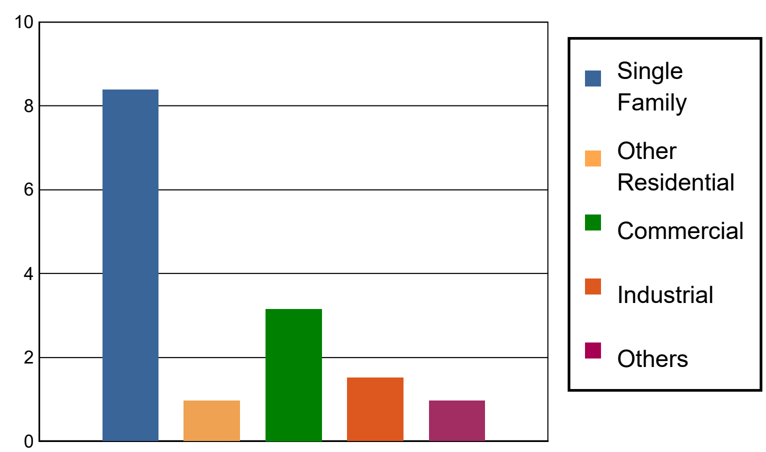


Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.0000	0.0238	0.2945	0.0159	0.0452	0.3794
	Capital-Related	0.0000	0.0101	0.2571	0.0094	0.0060	0.2826
	Rental	0.0731	0.0749	0.1724	0.0085	0.0124	0.3413
	Relocation	0.2453	0.0242	0.2339	0.0484	0.0982	0.6500
	Subtotal	**0.3184**	**0.1330**	**0.9579**	**0.0822**	**0.1618**	**1.6533**
Capital Stock Losses							
	Structural	0.8522	0.1417	0.3306	0.1405	0.1304	1.5954
	Non_Structural	5.0671	0.5333	1.1252	0.6877	0.4056	7.8189
	Content	2.1481	0.1640	0.7213	0.5182	0.2697	3.8213
	Inventory	0.0000	0.0000	0.0109	0.0813	0.0038	0.0960
	Subtotal	**8.0674**	**0.8390**	**2.1880**	**1.4277**	**0.8095**	**13.3316**
	Total	**8.39**	**0.97**	**3.15**	**1.51**	**0.97**	**14.98**

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	270.1205	0.0000	0.00
	Bridges	35.6620	0.0195	0.05
	Tunnels	0.0000	0.0000	0.00
	Subtotal	**305.7825**	**0.0195**	
Railways	Segments	22.0021	0.0000	0.00
	Bridges	10.7214	0.0001	0.00
	Tunnels	0.0000	0.0000	0.00
	Facilities	2.6630	0.3911	14.69
	Subtotal	**35.3865**	**0.3912**	
Light Rail	Segments	15.5899	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	**15.5899**	**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	**356.76**	**0.41**	

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	8.5151	0.0087	0.10
	Subtotal	**8.5151**	**0.0087**	
Waste Water	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	5.1091	0.0043	0.08
	Subtotal	**5.1091**	**0.0043**	
Natural Gas	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	3.4060	0.0015	0.04
	Subtotal	**3.4060**	**0.0015**	
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	**17.03**	**0.01**	

Appendix A: County Listing for the Region

Worcester,MA

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Massachusetts					
	Worcester	6,520	978	246	1,224
Total Region		**6,520**	**978**	**246**	**1,224**

Hazus: Earthquake Global Risk Report

Region Name: HarvardTownEQ

Earthquake Scenario: 2500year

Print Date: May 22, 2022

Disclaimer:

This version of Hazus utilizes 2010 Census Data.

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 27.16 square miles and contains 1 census tracts. There are over 1 thousand households in the region which has a total population of 6,520 people (2010 Census Bureau data). The distribution of population by Total Region and County is provided in Appendix B.

There are an estimated 2 thousand buildings in the region with a total building replacement value (excluding contents) of 1,224 (millions of dollars). Approximately 88.00 % of the buildings (and 80.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 356 and 17 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

Hazus estimates that there are 2 thousand buildings in the region which have an aggregate total replacement value of 1,224 (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 86% 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 6 schools, 3 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 373.00 (millions of dollars). This inventory includes over 31.07 miles of highways, 16 bridges, 528.79 miles of pipes.

Table 1: Transportation System Lifeline Inventory

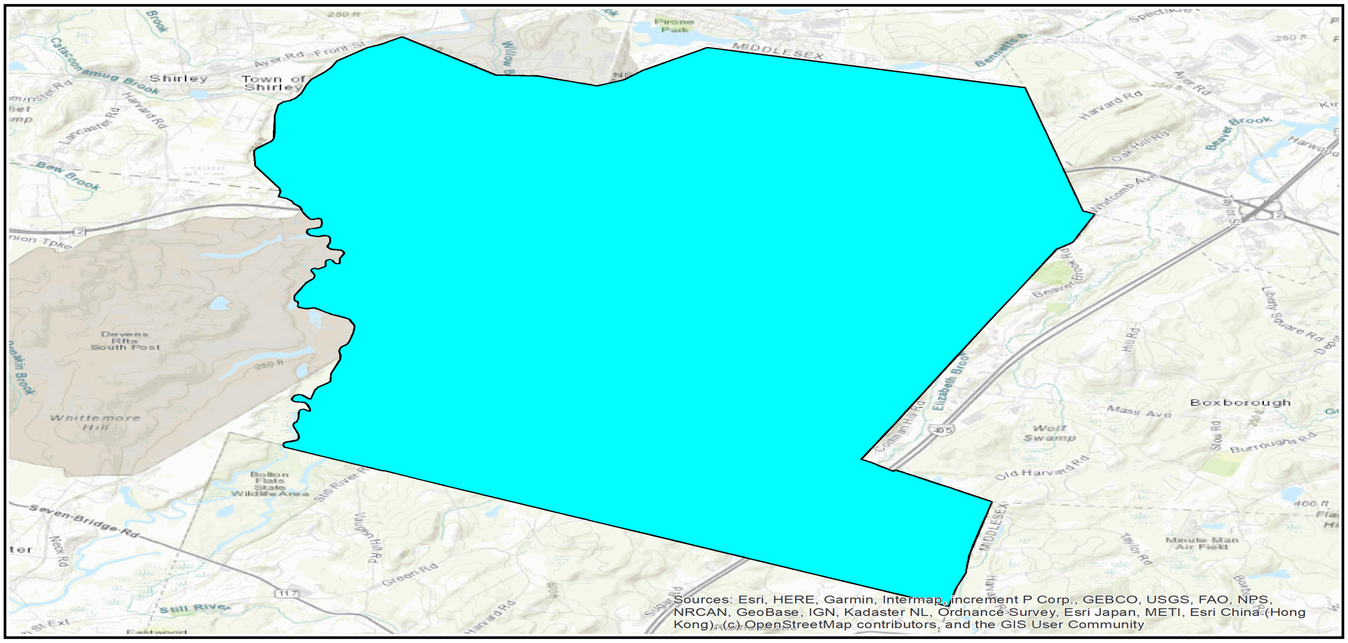
System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	16	35.6620
	Segments	15	270.1205
	Tunnels	0	0.0000
		Subtotal	**305.7825**
Railways	Bridges	2	10.7214
	Facilities	1	2.6630
	Segments	13	22.0021
	Tunnels	0	0.0000
		Subtotal	**35.3865**
Light Rail	Bridges	0	0.0000
	Facilities	0	0.0000
	Segments	1	15.5899
	Tunnels	0	0.0000
		Subtotal	**15.5899**
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	**356.80**

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	8.5151
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**8.5151**
Waste Water	Distribution Lines	NA	5.1091
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**5.1091**
Natural Gas	Distribution Lines	NA	3.4060
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**3.4060**
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	**17.00**

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	2500year
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 96 buildings will be at least moderately damaged. This is over 4.00 % of the buildings in the region. There are an estimated 1 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

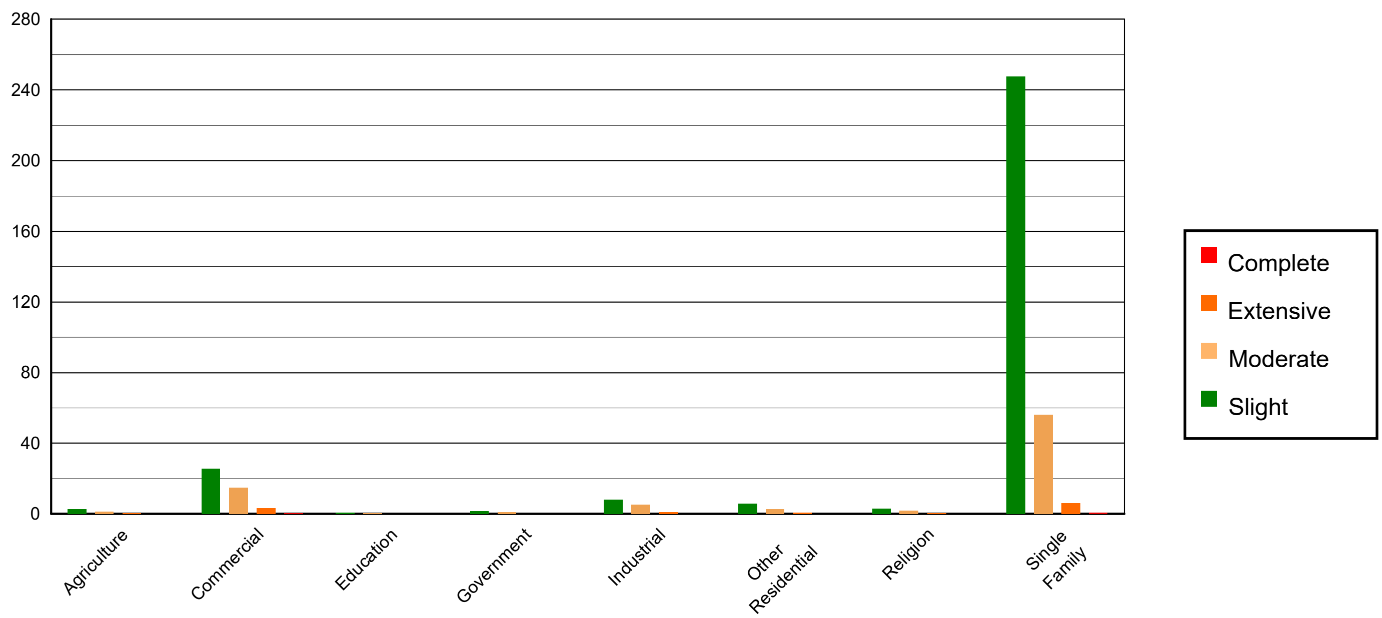


Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	13.54	0.72	2.85	0.96	1.32	1.58	0.27	2.26	0.02	1.70
Commercial	125.77	6.68	25.67	8.69	14.89	17.85	3.31	27.48	0.36	25.86
Education	3.76	0.20	0.71	0.24	0.43	0.51	0.09	0.72	0.01	0.76
Government	8.26	0.44	1.55	0.53	0.97	1.16	0.20	1.63	0.02	1.37
Industrial	42.60	2.26	8.09	2.74	5.13	6.15	1.09	9.03	0.10	7.16
Other Residential	31.80	1.69	5.69	1.93	2.82	3.39	0.61	5.06	0.08	5.40
Religion	16.51	0.88	3.21	1.09	1.78	2.14	0.44	3.62	0.06	4.36
Single Family	1639.59	87.13	247.53	83.82	56.10	67.23	6.04	50.19	0.74	53.39
Total	**1,882**		**295**		**83**		**12**		**1**	

Table 4: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	1653.59	87.87	244.85	82.91	48.51	58.14	3.26	27.09	0.20	14.03
Steel	94.20	5.01	16.04	5.43	10.39	12.45	1.88	15.65	0.10	7.54
Concrete	15.35	0.82	2.89	0.98	1.95	2.34	0.25	2.07	0.01	1.05
Precast	6.34	0.34	1.33	0.45	1.45	1.73	0.51	4.25	0.02	1.33
RM	19.62	1.04	2.91	0.98	2.71	3.25	0.76	6.32	0.01	0.70
URM	92.73	4.93	27.29	9.24	18.43	22.09	5.37	44.62	1.05	75.35
MH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**1,882**		**295**		**83**		**12**		**1**	

*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	6	0	0	6
EOCs	2	0	0	2
PoliceStations	1	0	0	1
FireStations	3	0	0	3

Transportation Lifeline Damage

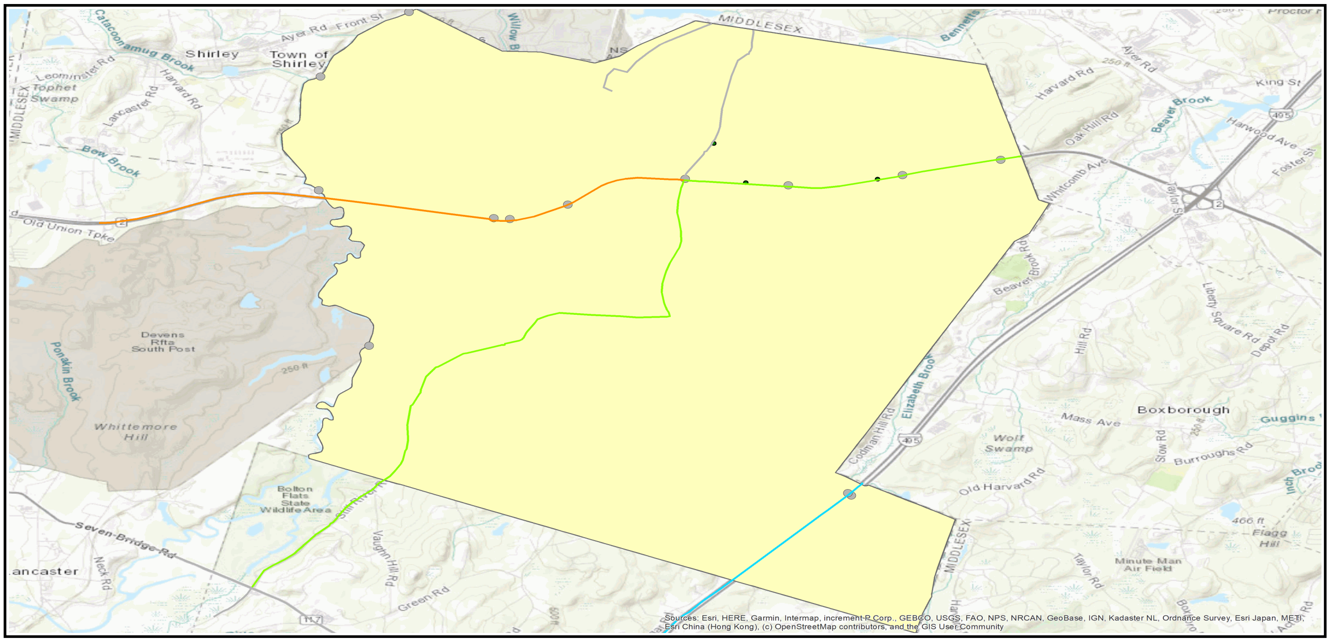


Table 6: Expected Damage to the Transportation Systems

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	15	15
	Bridges	16	0	0	16	16
	Tunnels	0	0	0	0	0
Railways	Segments	13	0	0	13	13
	Bridges	2	0	0	2	2
	Tunnels	0	0	0	0	0
	Facilities	1	0	0	1	1
Light Rail	Segments	1	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	265	4	1
Waste Water	159	2	0
Natural Gas	106	1	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	1,893	0	0	0	0	0
Electric Power		0	0	0	0	0

Induced Earthquake Damage

Fire Following Earthquake

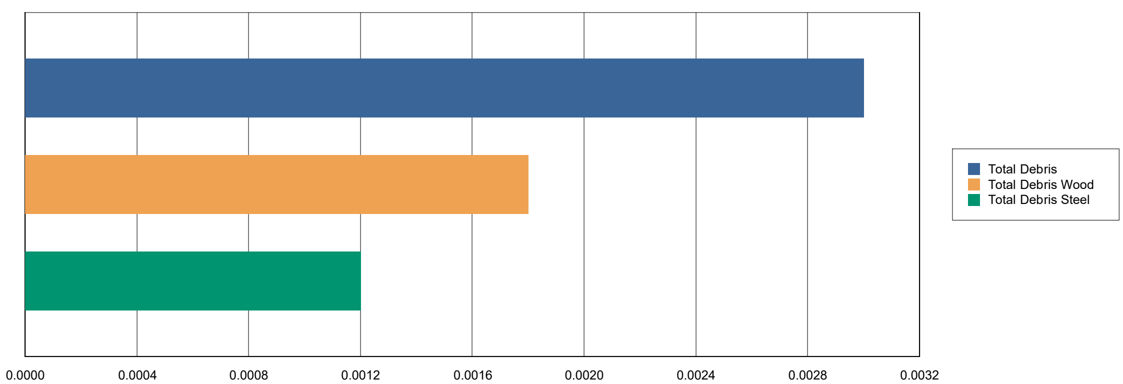
Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. Hazus uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there 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 3,000 tons of debris will be generated. Of the total amount, Brick/Wood comprises 60.00% 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 120 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Earthquake Debris (millions of tons)



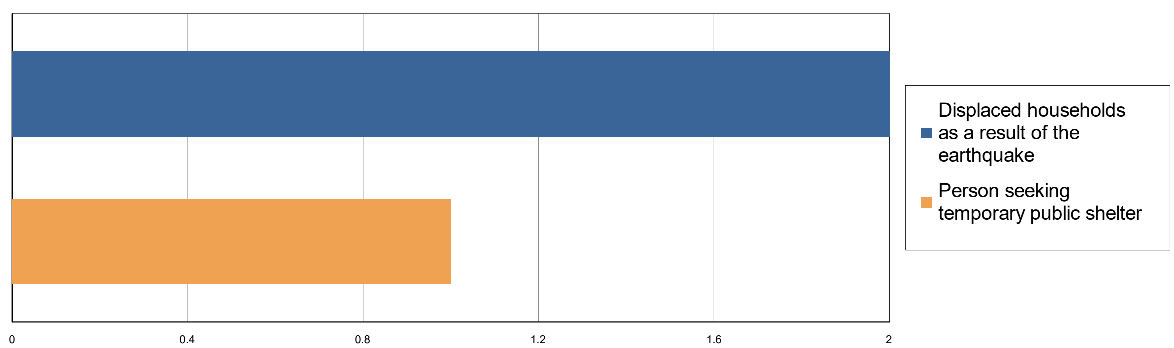
Brick/ Wood	Reinforced Concrete/Steel	Total Debris	Truck Load
0.00	0.00	0.00	120 (@25 tons/truck)

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 2 households to be displaced due to the earthquake. Of these, 1 people (out of a total population of 6,520) 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
2	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	0.03	0.01	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	0.01	0.00	0.00
	Other-Residential	0.47	0.08	0.01	0.02
	Single Family	1.38	0.17	0.01	0.03
	Total	**2**	**0**	**0**	**0**
2 PM	Commercial	2.13	0.36	0.04	0.07
	Commuting	0.00	0.00	0.00	0.00
	Educational	1.01	0.18	0.02	0.04
	Hotels	0.00	0.00	0.00	0.00
	Industrial	0.30	0.05	0.00	0.01
	Other-Residential	0.10	0.02	0.00	0.00
	Single Family	0.30	0.04	0.00	0.01
	Total	**4**	**1**	**0**	**0**
5 PM	Commercial	1.60	0.28	0.03	0.06
	Commuting	0.00	0.00	0.00	0.00
	Educational	0.08	0.01	0.00	0.00
	Hotels	0.00	0.00	0.00	0.00
	Industrial	0.19	0.03	0.00	0.01
	Other-Residential	0.19	0.03	0.00	0.01
	Single Family	0.53	0.07	0.01	0.01
	Total	**3**	**0**	**0**	**0**

Economic Loss

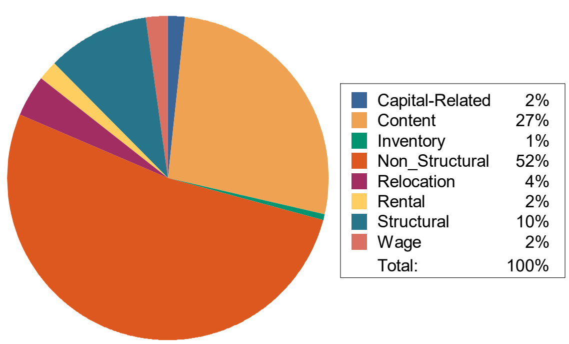
The total economic loss estimated for the earthquake is 29.63 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

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 28.97 (millions of dollars); 10 % 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 64 % 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)

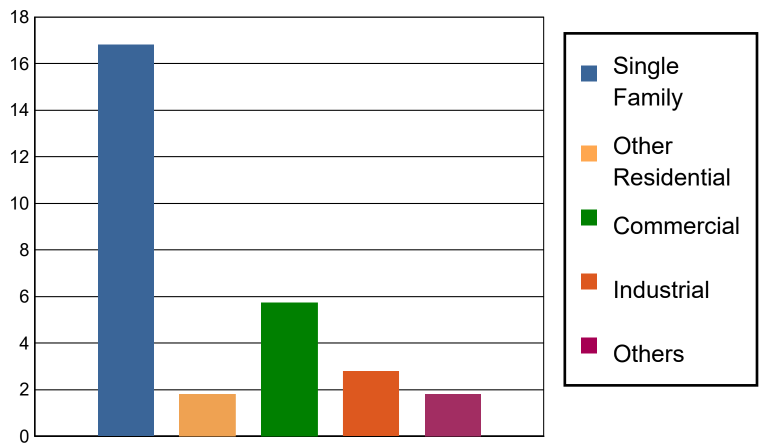


Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.0000	0.0452	0.5180	0.0290	0.0768	0.6690
	Capital-Related	0.0000	0.0193	0.4572	0.0173	0.0104	0.5042
	Rental	0.1444	0.1331	0.2955	0.0151	0.0222	0.6103
	Relocation	0.4955	0.0419	0.4138	0.0865	0.1759	1.2136
	Subtotal	**0.6399**	**0.2395**	**1.6845**	**0.1479**	**0.2853**	**2.9971**
Capital Stock Losses							
	Structural	1.6030	0.2510	0.5842	0.2521	0.2308	2.9211
	Non_Structural	10.0157	1.0008	2.0724	1.2592	0.7603	15.1084
	Content	4.5544	0.3229	1.3760	0.9778	0.5274	7.7585
	Inventory	0.0000	0.0000	0.0208	0.1533	0.0072	0.1813
	Subtotal	**16.1731**	**1.5747**	**4.0534**	**2.6424**	**1.5257**	**25.9693**
	Total	**16.81**	**1.81**	**5.74**	**2.79**	**1.81**	**28.97**

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	270.1205	0.0000	0.00
	Bridges	35.6620	0.0618	0.17
	Tunnels	0.0000	0.0000	0.00
	Subtotal	**305.7825**	**0.0618**	
Railways	Segments	22.0021	0.0000	0.00
	Bridges	10.7214	0.0006	0.01
	Tunnels	0.0000	0.0000	0.00
	Facilities	2.6630	0.5708	21.43
	Subtotal	**35.3865**	**0.5714**	
Light Rail	Segments	15.5899	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	**15.5899**	**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	**356.76**	**0.63**	

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	8.5151	0.0160	0.19
	Subtotal	**8.5151**	**0.0160**	
Waste Water	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	5.1091	0.0080	0.16
	Subtotal	**5.1091**	**0.0080**	
Natural Gas	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	3.4060	0.0028	0.08
	Subtotal	**3.4060**	**0.0028**	
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	**17.03**	**0.03**	

Appendix A: County Listing for the Region

Worcester,MA

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Massachusetts					
	Worcester	6,520	978	246	1,224
Total Region		**6,520**	**978**	**246**	**1,224**