CITY OF WORCESTER, MA HAZARD MITIGATION PLAN UPDATE

MARCH 2025

City of Worcester
455 Main Street
Worcester, MA 01608

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https://www.worcesterma.gov/

Prepared by:

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Acknowledgements

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

Local Adoption Resolution

CITY OF WORCESTER, MASSACHUSETTS
CITY COUNCIL
A RESOLUTION ADOPTING THE
CITY OF WORCESTER, MA HAZARD MITIGATION PLAN UPDATE
RESOLUTION NO. ____________

WHEREAS the City of Worcester recognizes the threat that natural hazards pose to people and property within the City of Worcester; and

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

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

WHEREAS adoption by the City of Worcester City Council demonstrates its commitment to hazard mitigation and achieving the goals outlined in the CITY OF WORCESTER, MA HAZARD MITIGATION PLAN UPDATE.

NOW THEREFORE, BE IT RESOLVED BY THE CITY OF WORCESTER, MA, THAT:

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

ADOPTED by a vote of ________ in favor and ________ against, and ________ abstaining, this ______________ day of ______________, ______________________.

CITY COUNCIL:

By: ___________________________________ Khrystian E. King, Vice Chairman & Councilor-at-Large

By: ___________________________________ Morris A. Bergman, Councilor-at-Large

By: ___________________________________ Donna M. Colorio, Councilor-at-Large

By: ___________________________________ Thu Nguyen, Councilor-at-Large

By: ___________________________________ Kathleen M. Toomey, Councilor-at-Large

APPROVED AS TO FORM:

By: ___________________________________ Joseph M. Petty, Mayor & Councilor-at-Large

Record of Changes

This City of Worcester, 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 City.

Table 1. Summary of Changes.

Date of Change	Entered By	Summary of Changes

Chapter 1. Introduction

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

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

The City of Worcester, 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 City of Worcester. It is difficult to predict when natural hazards will impact the planning area, but it is accurate to say that they will. By implementing the mitigation actions listed in this plan, the impact of natural hazards will be lessened.

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

Purpose of the Plan

The purpose of the Local Hazard Mitigation Plan is to provide the City of Worcester 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 City's risk and vulnerability to natural hazards.

This plan is a result of a collaborative effort between the City of Worcester 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

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

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

participated, included the Massachusetts Emergency Management Agency (MEMA), St. Vincent Hospital, the Central MA Regional Planning Commission, UMass Memorial Medical Center, National Grid, the Green Island Neighborhood, the Blackstone Watershed Collaborative, and the Worcester Regional Transit Authority.

Guiding principles for plan development

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

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

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

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

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

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

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

The HMPC identified the following list of hazards to profile:

- Average and Extreme Temperatures
- Droughts
- Earthquakes
- Flooding from Dam Failure or Overtopping

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

- Flooding from Precipitation
- Hurricanes/Tropical Storms
- Invasive Species
- Landslides
- Other Severe Weather
- Severe Winter Storms
- Tornadoes
- Wildfires/Brushfires

Mitigation Strategy

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

The hazard mitigation strategy is the culmination of work presented in the Planning Area Profile (Chapter 2), Risk Assessment (Chapter 4), and Capability Assessment (Chapter 5). It is also the result of multiple meetings and sustained public outreach. The HMPC developed the mission statement and goals shown below. The goals from the previous City of Worcester Hazard Mitigation Plan Update 2019 and the Worcester Municipal Vulnerability Preparedness Plan 2019 were revised to develop this current list. Information about the goal development process is in Chapter 6: Mitigation Strategy. The goals are considered "broad policy-type statements"[4] that represent the long-term vision for mitigating risk to natural hazards in the City of Worcester. The goal statements are not listed in a priority order.

Enhance resilience against natural hazards and the climate crisis by protecting people, property, infrastructure, and our natural, cultural, and historic assets. Our commitment is to build a city that's resilient as it is thriving—physically, socially, and economically—through policies and practices grounded in equity, inclusion, integrity, and innovation.

Figure 1. Mission Statement.

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

Enhance resilience against natural hazards and the climate crisis by protecting people, property, infrastructure, and our natural, cultural, and historic assets. Our commitment is to build a city that's resilient as it is thriving—physically, socially, and economically—through policies and practices grounded in equity, inclusion, integrity, and innovation.

Local Plans and Regulations	Refine city codes, policies, regulations, and standards to facilitate public and private development that withstands and improves our collective resilience to natural hazards, utilizing data-driven and best-practice approaches for equitable and resilient planning and site design.
Building and Infrastructure Projects	Commit to infrastructure projects that enhance durability against natural hazards and climate influences, prioritizing long-term sustainability and resilience.
Natural and Cultural Resources	Safeguard and improve our open spaces, recreational facilities, and cultural treasures to bolster community resilience.
Outreach and Education	Broaden educational initiatives targeting city staff and residents to elevate understanding of risks and encourage proactive resilience measures.
High Hazard Dams	Assess and fortify high-hazard dams, ensuring risk reduction while promoting ecological resilience.

Figure 2. Goal Statements.

Land Use and Development

Changes in Development

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

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

Worcester is a rapidly growing urban community that continued to experience major changes in development since the last plan update process was completed in 2019. According to population estimates from the US Census Bureau, the city gained more than 22,000 people during this period. Worcester remains the second-largest city in New England, and the fastest growing city with over 100,000 people in New England. As is often the case, and as stated in the City's latest comprehensive plan (Worcester Now | Next), growth of this magnitude and pace brings a change in the profile of the area, bringing in new community members who are arriving and investing in the community in new and different ways. Among other things, Worcester's recent growth has helped to make the city more diverse, racially and ethnically, and more international. This tremendous growth has also brought shifts in the age mix, household size and structure, as well as housing needs and preferences. Looking ahead, this trend of rapid growth is expected to continue as the high end of projected population growth for Worcester could be 60,000 or more new residents by 2040.[5]

These observed and projected changes in development were considered throughout the plan update process, including through the data collection and analysis phase for the risk and capability assessments, and through multiple discussions with the HMPC during the development of the mitigation strategy. The plan was revised to reflect these development trends and potential future conditions, many of which are believed to be increasing the vulnerability of Worcester to the impacts of natural hazards. At the same time, however, the City has begun to integrate hazard and climate resilience principles and practices into many of its ongoing redevelopment projects and long-term planning efforts.

[5] Worcester Now | Next. City of Worcester. March 2024.

While the city is a mostly developed urban environment, it continues to have development in previously undeveloped areas and redevelop, often with higher density, in existing developed areas. The topography of Worcester is unique with many hills and rivers; thus development has and continues to occur in floodplains, near waterways, and on steep slopes. While new construction and redevelopment are generally more resilient to hazards, due to increasingly stringent building codes, zoning regulations, and stormwater management requirements, much of the city's existing housing stock is older and often more vulnerable to natural hazards. As hazard-prone areas continue to be redeveloped to current codes and standards, the vulnerability of new or improved structures may be decreased. For example, the removal of non-elevated structures in the floodplain are typically replaced with elevated, more resilient, construction in its place. Larger redevelopment projects in these areas may also include improvements to stormwater drainage systems, reductions in impervious surface coverage, and the installation of green infrastructure or other nature-based solutions.

In terms of changes in development since the last plan update, some specific hazard-prone areas of concern include the following:

- New development and redevelopment projects continue to occur in floodplain areas. Since January 2019, more than one thousand building permits were issued in the City's Floodplain Overlay District. Some specific examples include a new gas station (75 Quinsigamond Avenue), Curtis Apartments (32 Great Brook Valley Avenue), Plumley Village (16 Laurel Street), and Sever Square Apartments (11 Sever Street). Although built in compliance with relevant building codes and flood protection standards, increased development in these areas puts people and property in areas that will likely see more frequent and severe flooding. Redevelopment of properties that have included elevations and/or floodproofing techniques include projects at 29 Endicott Street, 258 Mill Street, 575 Park Avenue, and multiple redevelopments surrounding Polar Park in the Green Island and Canal District. There are also some forthcoming projects at the Saint-Gobain redevelopment site along New Bond Street.
- New development continues to occur in areas with steep slopes, potentially increasing vulnerability to landslides, rockfalls, or other hazards associated with unstable slopes. The HMPC has identified this as a concern which could be addressed through future amendments to its Zoning Ordinance and special permit or site plan review process, which currently only applies to certain (larger scale) development thresholds and/or where slopes greater than 15% are disturbed. Also, as recommended in the City's MVP and Green Worcester Plans, creating Best Management Practices (BMPs) for land clearing and grading to avoid creating steep slopes and large retaining walls is an ongoing effort.
- Most of the city is exposed to the urban heat island effect, which HMPC members agreed should be considered a hazard-prone area for the extreme heat hazard. As more fully described in Chapter 4 (Risk Assessment), lower income families are more likely to be in the heat island effect areas, and it is believed that all new developments will exacerbate the heat island effect if

it includes tree removal and adding black surfaces such as asphalt and roofs.

In addition to the above, the City is experiencing a lot of redevelopments in areas outside of FEMA-mapped special flood hazard areas that are prone to flooding. This includes new mixed-use developments with residential occupancies in the Green Island area, much of which is the rehabilitation of historic buildings in addition to some new construction. The City is also seeing proposed new developments outside of the mapped floodplain areas but with project components at or below the horizontal extension of the nearest base flood elevation (e.g., parking garages), and thereby connected to the drainage system that is the source of flooding. The City is trying to figure out how to handle these situations, where the existing Floodplain Overlay District regulations do not apply.

While these redevelopment projects could be increasing some flood hazard vulnerabilities, they have generally resulted in an increased amounts of pervious surface and tree-planting over previous paved conditions. Examples include additional tree plantings for Worcester Housing Authority properties (i.e., Plumley Village) and the expansion of CoolPockets (small parks that can provide respite from extreme heat), which help to reduce the impact on individuals as well as the overall urban heat island effect. These changes in development may also support flood risk reduction in terms of allowing for more infiltration/absorption of stormwater, though much of the Green Island area is part of the combined sewer system where increases in waste have raised concerns over the City's ability to manage this combined waste/stormwater during larger storm events without overflow discharges.

Aside from these physical changes in development, the City continues to experience economic and social changes that may be increasing its vulnerability to hazards. Economic changes include decreases in housing affordability and increases in housing cost burden, which can lead to increases in homelessness and housing insecurity for individuals. These trends have been driven by numerous factors including the competitive real estate market, inflation, increases in cost of living, market rate housing production out-pacing affordable housing production, and the westward migration of the state's Metrowest population—the latter of which has been accelerated due to remote work options and the Worcester becoming more "desirable" community to live and work. The City's demographics also remain a concern, as an increasingly international (21%) and diverse population continues to have a large immigrant population with a broad range of languages spoken at home. A continued challenge for the City is to effectively communicate messages regarding hazard awareness, emergency preparedness, and resilience building to all members of the community, many of which already experience other social vulnerabilities (unemployment, low income levels, etc.). New informal networks for community support, such as through Worcester Together, are helping the City to address these challenges by conducting additional outreach and advocacy for the City's socially vulnerable populations.

As the population of Worcester continues to grow and additional changes in development occurs, City officials and staff will seek to further integrate hazard mitigation practices into planning and development processes. As noted in the previous plan, it is imperative that the City consider how to address the effects of continued new and redevelopment on the city's landscape as well as predicted increases in extreme storm events due to climate change. This priority has since been echoed through multiple citywide plans, including Worcester Now | Next which established "Resilience" as a Guiding Principle for the city's long-term plan for community development. It is expected that this will also be reflected through continued updates to existing development regulations, such as amending the City's floodplain regulations to bring them into alignment with the state's latest Model Floodplain Bylaw. This change and similar regulatory updates to promote hazard-resistant, climate-adaptive standards for new or improved development are included as new actions to be implemented as part of this plan's updated mitigation strategy.

Progress in Mitigation Efforts

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

Priorities in the City of Worcester have shifted to an increased focus on Diversity, Equity, and Inclusion (DEI), a greater emphasis on climate resilience, an increased focus on economic growth that includes tourism, arts, and transportation enhancements, and more affordable housing initiatives. This is obvious from review of multiple plans developed since the 2019 Hazard Mitigation Plan was written. Some of the plans reviewed to capture these current priorities were the:

- Green Worcester Sustainability and Resilience Strategic Plan (2020)
- City of Worcester Open Space & Recreation Plan (2021)
- City of Worcester Strategy Plan FY 2025-2029
- Now/Next Worcester's Citywide Plan (2024)
- Becoming Worcester, A Cultural Plan (2019)
- Worcester Urban Forest Master Plan
- Worcester Mobility Action Plan (2024)

Prior to 2025 the City's priorities were more focused on affordable housing, job training, environmental sustainability, and infrastructure improvements. There are many consistencies in priorities from 2019 to 2025 including transportation, affordable housing, economic development, and sustainability. This Hazard Mitigation Plan Update focuses on integrating climate change data, expanding community engagement, improving stormwater management, enhancing energy resilience, and increasing public awareness of natural hazard risks. These are all consistent with the ideals in an array of planning documents and in the opinions of the HMPC and the public.

The status of each mitigation action from the City's 2019 Hazard Mitigation Plan Update is included in Chapter 6 (Mitigation Strategy). The text in this chapter includes a designation of Completed, Completed & To Be Continued, Partially Completed/In Progress, Delayed, or Cancelled with a corresponding description. In addition, if the mitigation action has moved forward to this Plan's list of actions that is included.

The City continues to review and update its regulations and procedures that support natural hazard mitigation. This includes the administration of zoning regulations, building codes, and special permit and site plan review procedures that ensure new or improved development projects address risk reduction through various provisions such as stormwater and floodplain management and erosion control. Including mitigation principles into the plans named above and into City policies and budget processes illustrates how the City has leveraged mitigation concepts of reducing risk and increasing resilience from their 2019 Hazard Mitigation Plan Update.

Authority and Assurances

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

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

Plan Adoption

The City of Worcester 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 City of Worcester, 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 City of Worcester, 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 City of Worcester and its residents. The risk assessment looks at current and future vulnerabilities based on land use development including structures and infrastructure. Included in this chapter is a list of critical facilities identified by the HMPC.

Chapter 5: Capability Assessment
The Capability Assessment looks at the City's ability to mitigate risk prior to and following disaster. This chapter is structured around the following four categories: planning and regulatory, administrative, and technical, financial, as well as education and outreach. The chapter concludes with information regarding the National Flood Insurance Program (NFIP) and the Community Rating System (CRS).

Chapter 6: Mitigation Strategy
This chapter provides a blueprint for reducing losses identified in the Risk Assessment. The chapter presents the hazard mitigation goals and identifies mitigation actions in priority groupings. Each mitigation action includes essential details, such as City 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 City of Worcester Hazard Mitigation Plan Update. It also includes a plan for continuing public outreach and monitoring the implementation of the identified mitigation actions.

Appendices

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

Chapter 2: Planning Area Profile

The City of Worcester, with a population of 206,518,[6] is in Worcester County in Central Massachusetts. Worcester is the second largest city in New England and is densely populated with approximately 5,527 people per square mile.[7] The City is bordered by the Massachusetts communities of West Boylston, Shrewsbury, Grafton, Millbury, Auburn, Leicester, Paxton, and Holden.[8]

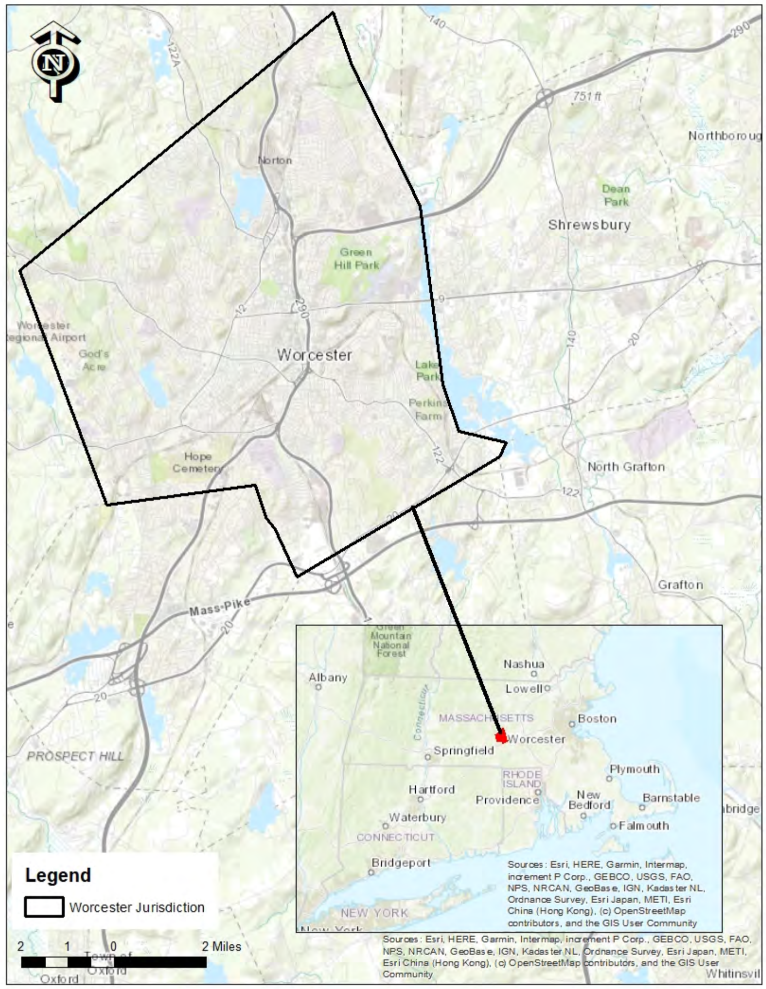

Figure 3. Worcester Base Map.

Worcester was first established as a Town in 1722 and then as a City in 1848.[9] The area was home to the native Nipmuc people followed by people who migrated from Asia. English colonists eventually arrived and purchased eight square miles of land from the Nipmuc which included the communities of Worcester, Holden, and a part of Auburn.[10]

As a primarily agricultural town, the American Revolution made Worcester evolve into an industrial city. The Blackstone Canal was completed in 1828 and was called the "port of Worcester."[11] The arrival of steam

[6] "QuickFacts Worcester city, Massachusetts." (2020). United States Census Bureau. Retrieved from https://www.census.gov/quickfacts/fact/table/worcestercitymassachusetts,US/PST045223.
[7] "QuickFacts Worcester city, Massachusetts." (2020). United States Census Bureau. Retrieved from https://www.census.gov/quickfacts/fact/table/worcestercitymassachusetts,US/PST045223.
[8] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.
[9] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.
[10] City of Worcester Cultural Plan. (2019). City of Worcester, Massachusetts.
[11] City of Worcester Cultural Plan. (2019). City of Worcester, Massachusetts.

power made Worcester self-proclaim itself as the "Heart of the Commonwealth."[12] There were a growing number of factories and railroads that led to a rapid population growth. With a strong industry, Worcester provided products such as wire, looms, monkey wrenches, grinding wheels, and more. People came from "near and far" and many from outside of the United States which brought "new traditions, languages and religions" to the City.[13] In 1949, Worcester received its first "All-America City Award" which was presented to communities that effectively addressed their most critical challenges.[14] The downtown began to be redeveloped, and the prominence of the automobile led to residents moving farther from the City center.[15]

As industry and manufacturing declined, local leaders worked to have the University of Massachusetts Medical School open in the City in 1962. Worcester saw a shift from manufacturing to education and medicine.[16] As a result, Worcester is known as the "educational, medical, and commercial hub of Central Massachusetts" due to having eight universities and colleges which include Holy Cross, Worcester Polytechnic Institute (WPI), UMass Medical, and Clark University in addition to several hospital systems. The City is also home to a large immigrant population which also adds to its diverse character.[17]

Worcester is governed by a Council-Manager form of government which includes an elected Mayor, an 11-member City Council, and a City Manager.[18]

[12] City of Worcester Cultural Plan. (2019). City of Worcester, Massachusetts.
[13] City of Worcester Cultural Plan. (2019). City of Worcester, Massachusetts.
[14] City of Worcester Cultural Plan. (2019). City of Worcester, Massachusetts.
[15] City of Worcester Cultural Plan. (2019). City of Worcester, Massachusetts.
[16] City of Worcester Cultural Plan. (2019). City of Worcester, Massachusetts.
[17] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.
[18] "Quick Facts." (2024). City of Worcester, Massachusetts. Retrieved from https://www.worcesterma.gov/quick-facts.

Figure 4. City Hall.

People

As of 2020, 61.3% of the City identified as White, 12.8% identified as Black or African American, 0.4% identified as American Indian and Alaska Native, 6.8% identified as Asian, 0.1% identified as Native Hawaiian and Other Pacific Islander, and 12.2% identified as Two or More Races. [19] Additionally, 24.6% identified as Hispanic or Latino. [20] About 23.3% of the population is foreign-born. [21] There are approximately 78,977 households in Worcester. [22] The median household income is $63,011.[23] The number of people living below the poverty level is 19.5%.[24] Almost 86% percent of the City, aged 25 years or older, has a high school or higher diploma.[25]

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[19] "QuickFacts Worcester city, Massachusetts." (2020). United States Census Bureau. Retrieved from https://www.census.gov/quickfacts/fact/table/worcestercitymassachusetts,US/PST045223.

[20] "QuickFacts Worcester city, Massachusetts." (2020). United States Census Bureau. Retrieved from https://www.census.gov/quickfacts/fact/table/worcestercitymassachusetts,US/PST045223.

[21] "QuickFacts Worcester city, Massachusetts." (2020). United States Census Bureau. Retrieved from https://www.census.gov/quickfacts/fact/table/worcestercitymassachusetts,US/PST045223.

[22] "QuickFacts Worcester city, Massachusetts." (2020). United States Census Bureau. Retrieved from https://www.census.gov/quickfacts/fact/table/worcestercitymassachusetts,US/PST045223.

[23] "QuickFacts Worcester city, Massachusetts." (2020). United States Census Bureau. Retrieved from https://www.census.gov/quickfacts/fact/table/worcestercitymassachusetts,US/PST045223.

[24] "QuickFacts Worcester city, Massachusetts." (2020). United States Census Bureau. Retrieved from https://www.census.gov/quickfacts/fact/table/worcestercitymassachusetts,US/PST045223.

[25] "QuickFacts Worcester city, Massachusetts." (2020). United States Census Bureau. Retrieved from

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

1. Annual median household income is 65% or less of the state's annual median household income.
2. Minorities make up 40% or more of the city or town's population.
3. Twenty-five percent or more of households speak English "less than very well."
4. Minorities make up 25% or more of the population *and* the annual median household income of the municipality where the neighborhood is located does not exceed 150% of the statewide annual median household income.[26]

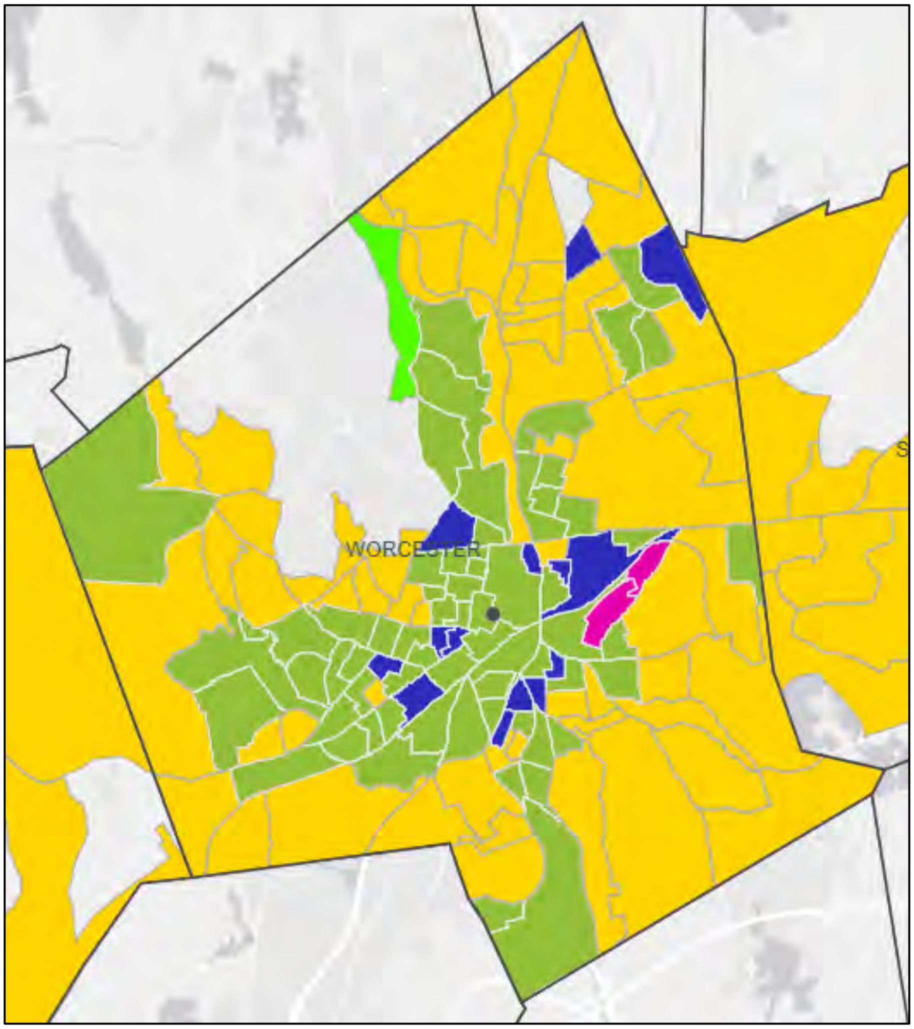
These populations are more vulnerable due to being disproportionately affected by the negative impacts of natural hazards nationwide. The data for identifying Environmental Justice Populations comes from the Executive Office of Energy and Environmental Affairs (EEA) who uses American Community Survey data.[27]

Most of Worcester fits at least one EJ criterion aside from a portion located in the northern part of the City, which can be seen in the figure below. The navy-blue areas in the center of the City and along the eastern boundary mark where the population fits the income, minority, and English isolation EJ criteria.

https://www.census.gov/quickfacts/fact/table/worcestercitymassachusetts,US/PST045223.

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

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



COLOR | EJ CRITERIA
- Minority
- Minority & Income
- Income
- Minority, Income, & English Isolation
- Minority & English Isolation

Figure 5. City of Worcester Environmental Justice Populations.

Due to being home to eight colleges and universities, it is important to note the large student population who have access and require the amenities and resources provided by the City. Furthermore, the student population's safety must be considered alongside the City's full-time residents, especially during natural hazard events. Enrollment at each of the institutions varies; however, according to the City's website the following enrollment numbers are provided:

1. Assumption University: 2,448 students
2. Clark University: 3,405 students
3. College of the Holy Cross: 2,970 students
4. Massachusetts College of Pharmacy and Health Sciences (MCPHS): 1,606 students
5. Quinsigamond Community College: 6,942 students
6. University of Massachusetts Medical School: 6,920 students

7. Worcester Polytechnic Institute: 6,920 students
8. Worcester State University: 5,724 students.[28]

Land Use and Development (Structures)

Worcester is shaped by its “manufacturing heritage” with several factories having been constructed in the valley, while workers lived in the surrounding hillsides.[29] Roadways and public transit were built to accommodate for the City’s “dramatic topography” which was defined by these hills and valleys.[30]

The City’s development during the late 19th and early 20th centuries was linked to rail lines and riverways. The dense developments, that were both commercial and residential, were concentrated around transportation routes in the “urban corn” with newer residential developments sprawling out to the more rural areas.[31]

During Worcester’s last “cycle of intensive development,” residential development continued to be shaped by new projects in outlying areas instead of in-fill development. Since the development of the City was in phases, the City’s infrastructure, environment, and school system was able to adapt to the impacts of new growth.[32]

The City has 20 zoning districts that include zones for airport, business, manufacturing, industrial, and residential uses. There are also 14 overlay districts which include four Commercial Corridors Overlay Districts, three Sign Overlay Districts, two Water Resource Protection Overlay Districts, one Adaptive Reuse Overlay District, one Airport Overlay District, and three Non-Zoning, Local Historic Districts.[33]

Natural Resources

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

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[28] “Quick Facts.” (2024). City of Worcester, Massachusetts. Retrieved from https://www.worcesterma.gov/quick-facts.

[29] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.

[30] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.

[31] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.

[32] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.

[33] “Zoning Map.” (2023). City of Worcester, Massachusetts.

Rivers and Waterways

Even though Worcester is an urban and densely populated community, it is home to many waterways. The headwaters of the Blackstone River are located within the City and the river's tributaries include Mill Brook, Beaver Brook, Tatnuck Brook, and Middle River. The Middle River is located at the confluence of Tatnuck Brook, Beaver Brook, and Kettle Brook. [34]

In addition to these rivers, there are the Mill Brook Sewer and Flood Control Conduits. Mill Brook, was once an open canal, called the Blackstone Canal, that was turned into a sewer system and flood control conduit before being walled and arched in the middle of the 1800's. The Coal Mine Brook and Poor Farm Brooks are in the City's Watershed Protection Overlay District due to their locations within the North Quinsigamond Aquifer Recharge Area [35]

Figure 6. Worcester Waterway.

Wetlands and Bodies of Water

In addition to the City's rivers and waterways, Worcester has several wetlands, swamps, marshes, and wet meadows which include:

- Broad Meadow Brook Area

[34] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.
[35] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.

- Newton Square Peat Bog
- Jamesville Pond
- Blackstone River Valley.[36]

Worcester also has four "Great Ponds" which are defined and protected by the Massachusetts Wetlands Protection Act and the Massachusetts's Department of Environmental Protection's Waterways Program.[37] A great pond is defined as "any pond or lake that contained more than 10 acres in its natural state."[38] The four ponds and lakes in Worcester include:

1. Green Hill Pond
2. Flint Pond
3. Indian Lake
4. Lake Quinsigamond.[39]

Forests

Worcester has several "naturally forested areas" and include several tree types that vary from hardwoods, white pine, and hemlock. Beech, birch, and maple "overlap" with oaks and hickories throughout the area. Some of these forested areas were negatively impacted by the Asian long-horned beetle.[40]

The City has properties that are protected forest land and are owned by the Conservation Commission. Perkins Farm has 80 acres of both young and mature woodlands that provides hiking through birch, quaking aspen, white aspen, oak, and chestnut trees. Dawson Road is a 37-acre parcel of land that is densely forested and is marked for passive recreation purposes. Donker Farm is a "traditional family subsistence farm" that has over 33 acres. The Cascades East is an almost 31-acre forested open space parcel that is adjacent to the Cascades which is a 36-acre preserved open space area.[41] Additionally, there is the Institutional Clark University Hadwen Arboretum which is home to tree varieties from all over the world that were planted in the 1800's. According to the university's website and the City's Open Space and Recreation Plan (OSRP), the arboretum is "6.4 acres of unspoiled woodland green space." There is also the City's Green Hill Park Farm which is open year-round.[42]

[36] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.
[37] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.
[38] "Massachusetts Great Ponds List." (2014). State of Massachusetts. Retrieved from
[39] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.
[40] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.
[41] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.
[42] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.

Open Space and Recreation

The City has more than 3,700 acres of protected open space.[43] From forestland to farms and parks, there are many areas located throughout Worcester that can be enjoyed by residents and visitors alike. Elm Park is a historic public park in the City. After it was purchased, it was redesigned by the firm of Frederick Law Olmsted, who also designed Central Park in New York City and Emerald Necklace in Boston. Elm Park is located on the National Register of Historic Places. Green Hill Park is also on the National Register. It became a city park in 1850 and has 500 acres of woodlands, fields, a petting zoo, ponds, and scenic memorials. Worcester has yet another park listed on the National Register of Historic Places called Salisbury Park, which is home to the famous Bancroft Tower Memorial which was built in 1900. The Park was donated to the City in 1912 by the Worcester Art Museum.[44]

Critical Facilities and Infrastructure

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

Water and Sewer Service

There are ten local water reservoir sources that provide Worcester with over 27 million gallons of drinkable water per day. The City also has emergency connections to wells and reservoirs that include Coal Mine Brook Well, Shrewsbury Well, Wachusett Reservoir, and the Quabbin Aqueduct. Not all City residents are served by the public water supply system. A small area around Mountain Street West is supplied by water purchased from the Town of Holden.[45] The City is an active member of the Upper Blackstone Clean Water District (UBCW).[46]

Waste is received at a regional wastewater treatment facility located in the Greenwood Neighborhood. The facility also processes industrial wastewater. In recent years, Worcester's Department of Public Works has worked to upgrade the regional wastewater treatment facility alongside upgrading piped sewer and stormwater systems. Approximately 10% of residences have private on-site septic; however, there are plans to reduce the number of disconnected septic systems.[47]

[43] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.
[44] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.
[45] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.
[46] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.
[47] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.

Energy

The National Grid is the electric provider for the City. According to the City's Open Space and Recreation Plan, "Worcester is home to the largest municipal solar farm in New England" which is located off Route 146 on the former Greenwood Street landfill site. The City is also working to replace all current lights with LEDs in the approximately 90 municipally owned buildings within the City, including Worcester Public Schools.[48]

> 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."*

Critical Facilities

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

The 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 City has approximately 296 critical facilities. The 38 critical facilities in Worcester that have back-up power are provided in the table below. Please note that some buildings at the Worcester Polytechnical Institute have back-up power, while some do not. This list was obtained from the previous edition of the hazard mitigation plan and the MVP-funded Community Resilience Building (CRB) plan; and reviewed by the HMPC throughout the planning process. A complete list of Critical Facilities can be found in the Appendix.

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[48] "Worcester Energy." (2024). City of Worcester, Massachusetts. Retrieved from https://www.worcesterma.gov/sustainability-resilience/worcester-energy#:~:text=Worcester%20is%20home%20to%20the,the%20former%20Greenwood%20Street%20landfill.

Table 1. List of Critical Facilities in the City of Worcester.

Name	Address
Belmont Street Community School	170 Belmont Street
Burncoat Middle School	135 Burncoat Street
Burncoat Senior High School	179 Burncoat Street
Chandler Elementary Community School	114 Chandler Street
Claremont Academy	15 Claremont Street
Columbus Park School	75 Lovell Street
DCU Center	50 Foster Street
Doherty Memorial High School	299 Highland Street
Elm Park Community School	23 N Ashland Street
Emergency Operations Center and Regional Emergency Communications	2 Coppage Drive
Emergency Operations Center and Regional Emergency Communications	50 Skyline Drive
Fanning Building	24 Chatham Street
Forrest Grove Middle School	495 Grove Street
Gates Lane School	1238 Main Street
Goddard School of Science & Technology	14 Richards Street
Guild of St. Agnes - Burncoat Street	50 Croydon Street
Jacob Hiatt Magnet School	722 Main Street
Nelson Place School	35 Nelson Place

Name	Address
Norrback Avenue School	44 Malden Street
North High School	150 Harrington Way
Parks, Recreation & Cemetery Division	50 Skyline Drive
Quinsigamond School	14 Blackstone River Road
Roosevelt School	1006 Grafton Street
Sullivan Middle School	140 Apricot Street
Union Station	2 Washington Square
Wawecus Road School	20 Wawecus Road
West Tatnuck School	300 Mower Street
Worcester East Middle School	420 Grafton Street
Worcester Emergency Medical Services	100 Providence Street
Worcester Police Department Headquarters	9-11 Lincoln Square
Worcester Polytechnic Institute	100 Institute Road
Worcester Public Library	3 Salem Square
Worcester Senior Center	128 Providence Street
Worcester Tech High School	1 Skyline Drive
YOU, Inc Carol Schmidt Village Special Education	24 Chatham Street
YWCA of Central Mass Inc.	1 Salem Square

Critical Transportation Infrastructure

Worcester has access to several state and federal highway systems. Interstates I-190 and I-290 bisect the City and provide regional connections to Central Massachusetts as well as Interstates I-495 and I-90 (Massachusetts Turnpike). Route 146 is a state highway that was reconstructed and expanded and directly connects Worcester to Providence, Rhode Island. Route 9 is a state highway that travels east west and provides a connection to Boston to the east and Amherst to the west. Route 20 and Route 122 are two other major east-west routes while Route 12, Route 70, and Route 122A are three north-south highways that pass through the City.[49]

In addition to the major roadways, the City of Worcester has over 2,000 locally listed streets. Approximately 90 miles of these streets are considered private and are "unpaved dirt roads." Some of these streets date back to 1925.[50]

Figure 7. Worcester Train Station.

The City is home to the Worcester Regional Airport which provides jet service to Central Massachusetts and access to airports in Massachusetts, New Hampshire, Connecticut, and Rhode Island. The airport was purchased in 2010 by the Massachusetts Port Authority and has since served over 750,000 passengers and provides connections to over 120 destinations.[51]

Public transportation in the City includes the Amtrack trains which connect Worcester to over 500 cities across the country. Worcester is also served by railways which includes the CSX Intermodal Terminal which is located to the east of Worcester's Union Station. The Massachusetts Bay Transportation Authority (MBTA) commuter rail operates 20 trains between Worcester Union Station and Boston South Station during the work week. There is an express service that provides direct daily connections

[49] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.
[50] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.
[51] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.

between Worcester and Boston. Additionally, the Worcester Regional Transit Authority (WRTA) operates an "expansive" bus system with service to 37 cities and towns in the region.[52] There is also a taxi service provided by Yellow Cab or Red Cab.[53]

Dams

The City of Worcester has many High Hazard Potential Dams. Some of these dams are located outside of the City. They are described in detail in Chapter 4 (Risk Assessment).

Table 2. Dams in the City of Worcester.

Dam Name	Owner	Hazard Type
Coes Reservoir Dam	City of Worcester - Department of Public Works & Parks	High
Cook's Pond Dam	Private Association or other non-profit	High
Green Hill Pond Dam	City of Worcester - Department of Public Works & Parks	High
Holden Reservoir #1	City of Worcester - Department of Public Works & Parks	High
Holden Reservoir #2	City of Worcester - Department of Public Works & Parks	High
Kettle Brook Reservoir 1	City of Worcester - Department of Public Works & Parks	High
Kettle Brook Reservoir 2	City of Worcester - Department of Public Works & Parks	High
Lynde Brook Dam	City of Worcester - Department of Public Works & Parks	High
Lynde Brook Dike	City of Worcester - Department of Public Works & Parks	High
Patch Pond Dam	City of Worcester - Department of Public Works & Parks	High
Patch Reservoir Dam	City of Worcester - Department of Public Works & Parks	High
Quinsigamond Pond Dam	City of Worcester - Conservation Commission	High
Smiths Pond Dam	Private	High
Bear Book Dam	City of Worcester - Department of Public Works & Parks	Significant
Bell Pond Dam	City of Worcester - Department of Public Works & Parks	Significant
Coes Lower Pond Dam	City of Worcester - Department of Public Works & Parks	Significant
Curtis Ponds Dam	Private - New England Power Co.	Significant
Duffy Mill Pond Dam	Private - Kettle Brook Lofts, LLC	Significant
Indian Lake Dam	State - Dept. of Transportation	Significant
Kiver Pond Dam	Private Association or other non-profit	Significant
Leesville Pond Dam	Town of Auburn	Significant
Old Cider Mill Pond Dam	City of Worcester - Conservation Commission	Significant
Parsons Reservoir Dam	City of Worcester - Conservation Commission	Significant
Salisbury Pond Dam	City of Worcester - Department of Public Works & Parks	Significant

[52] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.
[53] "Quick Facts." (2024). City of Worcester, Massachusetts. Retrieved from https://www.worcesterma.gov/quick-facts.

Dam Name	Owner	Hazard Type
Smith Mill Pond Dam	Political Subdivision OR City of Worcester - Department of Public Works & Parks	Significant

Economy

Worcester's local economy has benefited from the growth of City's educational institutions, particularly with the expansion and construction of new research centers at the University of Massachusetts Medical School, Massachusetts College of Pharmacy and Health Sciences, Worcester Polytechnic Institute, and Worcester State University. According to the 2021 Open Space and Recreation Plan, this expansion has "brought growth in residential, retail [and] commercial, food & entertainment, business and cultural developments."[54]

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

1. Educational services, healthcare and social assistance
2. Retail trade
3. Professional, scientific, and management, and administrative and waste management services.[55]

Historic and Cultural Resources

Historic and cultural resources shape a community's character and identity while also creating a sense of place for residents and visitors. Many New England cities and towns are home to significant sites and structures that capture the history and heritage of an area. Some resources may date back centuries, like burial grounds, while others can be more recent, like newly designated historic districts. Their importance lies in what they mean to a community and how they represent its people and place. Historic and cultural resources can be at risk due to the negative impacts of natural hazards and climate change. This plan identifies these resources so the HMPC may consider their vulnerability and potential need for mitigation.

A partnership between the Worcester Cultural Coalition (WCC) and the City of Worcester began in 2016. The partnership has attracted millions of visitors to Worcester by sponsoring cultural events that included street festivals, openings of new galleries, filmmaking, and concerts.[56]

There are several new development projects planned such as Polar Park and the Blackstone Heritage Corridor Visitor Center which aim to bring more tourists and residents into Worcester to explore the City's natural, cultural, and recreational assets.[57]

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[54] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.
[55] "Industry By Occupation for the Civilian Employed Population 16 Years and Over ACS 5-Year Estimates." (2020). United States Census Bureau.
[56] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.
[57] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.

Worcester has three historic districts that are defined by their historical architectural styles and heritage. These districts are as follows:

1. Massachusetts Avenue Historic District
2. Montvale Historic District
3. Crown Hill Local Historic District.[58]

The City also has seven historic parks that are located throughout the community and include:

1. Elm Park
2. Blackstone Gateway Park
3. Cider Mill Pond
4. Institute Park
5. Worcester Common
6. Green Hill Park
7. Coes Park.[59]

The City created the *City of Worcester Cultural Plan* in 2019 which "envisioned a city with strong physical and social cohesion that enables ease of movement for people of all ages, abilities, and means; a city that supports innovation and entrepreneurship, learning, and cultural opportunities for all; a city that reflects its heritage, its diverse cultures, and new ideas in its public spaces, downtown, natural and built environments, and in its neighborhoods; and a city where daily life is supported by local commerce, services, and activities related to the diverse traditions, creative expressions, and collective celebrations of all its people."[60]

[58] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.
[59] Worcester Open Space and Recreation Plan 2021-2028. (2021). City of Worcester, Massachusetts.
[60] Worcester Now | Next. (2024). City of Worcester, Massachusetts.

Chapter 3. Planning Process

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

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

A1. Does the Plan document the planning process, including how it was prepared and who was involved in the process for each jurisdiction? (Requirement §201.6(c)(1))

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

The planning process for this updated mitigation plan began in July 2024 and concluded in March 2025 (this does not include the months of plan review and adoption). The City 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.

Table 3. Planning Process Schedule.

Tasks	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Convene LHMP Committee	Kick-Off Meeting	HMPC #1	HMPC #2	Public Meeting #1	HMPC #3		HMPC #4 Public Meeting #2	HMPC #5	
Update Hazard Profiles			Draft Risk Assessment	Complete Risk Assessment					
Update Critical Facility Inventory									
Meet High Hazard Potential Dam (HHPD) Requirements		Review HHPD Plans	Conduct Outreach to HHPD Owners	Conduct HHPD Risk Analysis	Identify HHPD Actions	Prioritize Actions with HHPD & HHPD Meeting			
Update Mitigation Goals	Capability Assessment Meetings								
Update Actions		Previous Actions Meeting		New Actions Meeting	Final Mitigation Action List	Prioritize Mitigation Actions			
Plan Review, Evaluation, and Implementation							Complete Draft for HMPC Review		
Public Review of Draft								Public Review	
Review and Approval									Submit Plan to MEMA

Robert Connolly, Emergency Management Director, facilitated all activities related to the Mitigation Plan Update, including meeting logistics, data gathering, and public outreach. The Consulting Team met with Mr. Connolly on June 17, 2024, for a Kick-Off meeting to review the planning process and timeline, and to discuss developing the HMPC, collecting GIS data if possible, and determining the status of previously identified mitigation actions.

Hazard Mitigation Planning Committee

The Emergency Management Director, Robert Connolly, developed the Hazard Mitigation Planning Committee (HMPC) and was the point of contact for the Consulting Team. The HMPC included City employees and officials who represented six sectors of the community shown in Table 4 below. A full contact list of HMPC members is shown in Table 5. The HMPC met five times, July 25, 2024, September 12, 2024, November 14, 2024, December 20, 2024, and February 27, 2025. All the meetings were conducted via Zoom, however sometimes City employees gathered at their City offices. A list of participants at each of these meetings is included in the Appendix.

Table 4. Sectors of the Community Represented On HMPC.

Sectors of the Community	HMPC Members
• Emergency Management	• Chief of Emergency Management (Department of Public Health) • Chief of Office of Health and Medical Preparedness • Deputy Chief of Worcester Police Department • Director of School Safety (Worcester Public Schools) • Emergency Communications Director • Emergency Management Commissioner • Emergency Management Director • Emergency Management Director (University of Massachusetts Memorial Medical Center) • Emergency Preparedness Planner (Central Massachusetts Regional Planning Commission) • SARA Officer (Worcester Fire Department)
• Economic Development	• Assistant Chief Development Officer of Planning and Regulatory Services • Capital Projects Manager • Director of Community Development and Resiliency Planning (Central Massachusetts Regional Planning Commission)
• Environment	• Chief Sustainability Officer • Conservation Planner/Agent • Community Advocacy and Engagement Manager (Mass Audubon) • Department of Sustainability and Resiliency • Director (Department of Sustainability and Resilience) • Director of Community Development and Resiliency Planning (Central Massachusetts Regional Planning Commission)

Sectors of the Community	HMPC Members
	• Executive Director (Blackstone Watershed Collaborative) • Project Manager (Department of Sustainability and Resilience)
• Land Use and Development	• Assistant Chief Development Officer of Planning and Regulatory Services • Assistant Commissioner of Water and Sewer Operations • Assistant Director of Sewer Operations (Department of Public Works) • Capital Projects Manager • Chief of Public Facilities • Chief Sustainability Officer • Conservation Planner/Agent • Department of Sustainability and Resiliency • Director (Department of Sustainability and Resilience) • Director of Community Development and Resiliency Planning (Central Massachusetts Regional Planning Commission) • Director of Sewer Operations • Director of Water Operations • Engineer (Dams) • Interim Commissioner of Inspectional Services/Building Commissioner • Project Manager (Department of Sustainability and Resilience) • Senior Transportation Planner • Worcester Housing Authority
• Health and Social Services	• Chief of Emergency Management (Department of Public Health) • Chief of Office of Health and Medical Preparedness • Client Advocate for Elder Affairs (Worcester Senior Center) • Community Advocacy and Engagement Manager (Mass Audubon)

Sectors of the Community	HMPC Members
	• Deputy Chief of Worcester Police Department • Director of School Safety (Worcester Public Schools) • Director of Worcester Senior Center • Emergency Communications Director • Emergency Management Commissioner • Emergency Management Director (University of Massachusetts Memorial Medical Center) • Emergency Management, Construction, and General Safety Manager (University of Massachusetts Chan Medical School) • Emergency Management Director • Emergency Preparedness Planner (Central Massachusetts Regional Planning Commission) • Green Island Neighborhood Center • SARA Officer (Worcester Fire Department) • Senior Transportation Planner • Water Filtration Plant Manager
• Infrastructure	• Administrator (Worcester Regional Transit Authority) • Assistant Commissioner of Water and Sewer Operations • Assistant Director of Facilities (Worcester Public Schools) • Assistant Director of Sewer Operations (Department of Public Works) • Assistant General Manager (Worcester Regional Transit Authority) • Capital Projects Manager • Chief Sustainability Officer • Department of Sustainability and Resilience • Director (Department of Sustainability and Resilience) • Director of Community Development and Resiliency Planning (Central Massachusetts Regional Planning Commission)

Sectors of the Community	HMPC Members
	• Director of Sewer Operations • Director of Water Operations • Engineer (Dams) • Interim Commissioner of Inspectional Services/Building Commissioner • Water Filtration Plant Manager

Table 5. HMPC Members.

First Name	Last Name	Title	Affiliation	Phone	Email
Jim	Bedard	Interim Chief of Public Facilities	City of Worcester	774-418-1502	bedardj@worcesterma.gov
Nayanny	Bello-Paniagua	Sponsor Contact	National Grid	508-860-6000	Nayanny.Bello-Paniagua@nationalgrid.com
Joseph	Campbell	Assistant General Manager	Worcester Regional Transit Authority	508.453.3415	jcampbell@therta.com
David	Carl	Senior Building Inspector	City of Worcester	508-799-8544	CarlD@worcesterma.gov
Deb	Cary	Community Advocacy and Engagement Manager	Mass Audubon	508-450-5590	dcary@massaudubon.org
Robert	Connolly	Director of Emergency Management	City of Worcester	774-670-0583	connollyr@worcesterma.gov
Stefanie	Covino	Executive Director	Blackstone Watershed Collaborative	443-863-0930	stefanie@blackstonecollaborative.org
Michael	Daigneault	Director of Water Operations	City of Worcester	508-929-1300 ext. 49333	daigneaultm@worcesterma.gov
Jessica	Davis	Project Manager, Department of Sustainability and Resilience	Dept of Sustainability and Resilience	508-799-8324 x31204	davisj@worcesterma.gov
Alisa	DeLeo Laperle	Director of Emergency Communications	City of Worcester	508-799-1719 ext. 30727	deleo-laperlea@worcesterma.gov

First Name	Last Name	Title	Affiliation	Phone	Email
Sean	Divoll	Assistant Commisioner of Water/Sewer	City of Worcester	508-929-1300	divolls@worcesterma.gov
Matthew	Dufresne	Engineer, Dams	City of Worcester	508-829-4811 ext. 51206	dufresnem@worcesterma.gov
Alissa	Errede	Chief, Office of Health and Medical Preparedness	City of Worcester	508-799-8482 ext. 33158	ErredeA@worcesterma.gov
Eric	Flint	Conservation Planner/Agent	City of Worcester	508-688-0569	FlintE@worcesterma.gov
Scott	Galbraith	Senior Traffic Engineer	City of Worcester	774-670-0266	GalbraithSW@worcesterma.gov
Charles	Goodwin	Commissioner of Emergency Communications, Emergency Management, and Constituent Services	City of Worcester	508-612-1938	goodwinc@worcesterma.gov
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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 City of Worcester has a City Manager and an elected Planning Board. The Planning Board is responsible for overseeing the long-term land use patterns of Worcester through their Zoning Bylaws, Subdivision Rules and Regulations, Site Plans, Worcester Now|Next (Comprehensive Plan), and supporting planning processes.

Stakeholders were invited to participate in the planning process through the HMPC, High Hazard Potential Dam (HHPD) meeting, public meetings, individual stakeholder meetings, and plan review. Appendix A includes the agendas and flyers used to announce meetings and opportunities for participation. Press releases for each public meeting were also distributed. The Emergency Management Director, with the support of other members of the HMPC, conducted outreach specifically to local and regional agencies involved in hazard mitigation, City boards and departments that regulate development, neighboring communities, as well as organization representatives that serve socially vulnerable populations, businesses, and academic institutions.

The first HMPC Meeting was held on July 25, 2024. The meeting began with a discussion outlining the HMPC's future roles and responsibilities which included public outreach and engagement for the plan update. The HMPC aimed to work closely with local community organizations and regional partners to encourage participation, especially for vulnerable, underrepresented, and underserved populations. The meeting then turned to sharing the City's most updated plans, documents, and reports which included the Worcester Now|Next Plan, the Strategic Plan, Urban Forest Master Plan, Heat Risk Assessment, Open Space and Recreation Plan, Cultural Plan, and others. The HMPC then went on to discuss hazards to gain insight into their impact on the community. The HMPC shared that Changes in Groundwater should be considered regarding permitting and contamination which could impact or encourage adaptation solutions such as low-impact development. Droughts were said to be well-covered in their current Drought Management Plan, while flooding from precipitation and dam overtopping could benefit from more education and awareness, particularly in the Green Island Neighborhood. Additional hazards that were focused on included Other Severe Weather due to its impact on facilities with aging infrastructure. Severe Winter Storms have increased in severity and therefore negatively impacted the City in recent years. The meeting ended with discussions on changes in development which included a major development off Kelley Square as well as development in higher inundation areas. The City also shared their priorities which included involving all voices, focusing on sustainability, encouraging multi-modal transportation, and making goals more specific and actionable from the previous plan.

The second HMPC Meeting was held on September 12, 2024. The meeting began with logistics around the first public meeting and having a hybrid format that was accessible in time and location. The HMPC suggested holding a meeting at the Senior Center during their Senior Luncheons and at the Worcester Regional Transit Authority (WRTA) Operations Center. Additional outreach regarding the plan would include social media, using public access channels, mailing lists, backpack mailers, flyers for the Green Island neighborhood, and at local establishments. An overview of the capability assessment was provided and then the consulting team and HMPC discussed Worcester's capacity for improving on their various capabilities. A large concern for the HMPC was related to battery storage and potential locations near floodplains and other vulnerable areas. The City is also facing underinsurance in medium to high flood-prone areas and the HMPC stated the need to address repetitive loss properties and improve existing or future infrastructure against flooding through regulations and planning.

The meeting then went on to discuss the Risk Assessment regarding the various natural hazards faced by the City. The HMPC noted that there are several dams in and around the community and many Emergency Action Plans (EAPs) were starting to be collected. Dam breaches and potential dam removals or rehabilitations were discussed as priorities. Concerns around rockfalls behind the Fire Station and some recurring brushfires in the southeast part of the City were shared by the HMPC. Regarding high winds, some of the communication towers are likely not to withstand intense wind events and the chance of downed power lines, trees, and poles are a risk the community has had to face and will likely continue to face in the future. Additional points that were brought up in the conversation included acknowledging the several reservoirs in and around the City and how drought could impact them as well as the deep freezes and extreme cold that have impacted educational institutions, healthcare facilities, and emergency sites, such as the Police Headquarters and Fire Stations. The meeting wrapped up with goal examples related to local plans and regulations, building and infrastructure projects, natural and cultural resources, outreach and education, and high hazard dams.

The third HMPC Meeting was held on November 14, 2024. The meeting began with public meeting logistics and a discussion about sending out a survey to the community regarding the hazard mitigation plan update. The survey would be in multiple languages and run electronically using the same channels for sharing information as they would with other surveys and information in the past.

The meeting then went on to discuss hazard rankings and problem statements. Some suggestions brought up in the meeting included adding a statement that focuses on infrastructure and the prioritization of public safety buildings as well as a statement on repetitive loss properties and flood risk areas like Park Avenue from Beaver Brook, Weasel Brook, and near the old Roxbury Street. Additional information included creating mitigation actions around dam breaches and removing dams if needed, which would be further discussed at an upcoming High Hazard Potential Dam Meeting. The HMPC shared that regarding Extreme Temperatures, the City has cooling centers that have had varying levels of participation and in order to mitigate risk and combat heat islands, planting trees could help. This would also support the sustainability efforts that the City has been pursuing.

The discussion then went onto the capability assessment where a participant suggested workforce protection against heat, however the capacity to enforce this regulatory practice would be limited due to staff size. The City shared that they had just hired a grant writer, and the City also shared they were working on a Stormwater Master Plan that may speak to areas of the City that could turn into catch basins or catchment areas to mitigate flooding.

The fourth HMPC Meeting was held on December 20, 2024. The meeting began with a project update and offering the HMPC a chance to share any additional information that could support the plan update. The HMPC stated that the Blackstone Wastewater Treatment Facility is prone to flooding, though it is in neighboring Millbury, Massachusetts and that it is operated by a subcontracted management company.

The meeting then went on to discuss the survey that was being conducted to better understand resident views and experiences with natural hazards in Worcester. The survey, a Microsoft Form, was offered in English, Portuguese, and Spanish to increase accessibility and participation. The HMPC would post and share the survey link via 311, on flyers at the Senior Center and in the Library, and through email listservs. The goal was to have the survey run through the majority of January. The logistics regarding the second public meeting were then finalized. The aim of this public meeting would center around disaster preparedness and food would be provided.

Mitigation actions and timeline for completion were then discussed. The CMRPC had suggestions for some of the mitigation actions provided in the mitigation action tracker, so they were offered a chance to provide comments where needed. The HMPC also wanted to incorporate nature-based solutions and adjust the cost thresholds for each of the actions. A date was then set for the final HMPC meeting.

The fifth and final HMPC Meeting was held on February 27, 2025. The conversation focused on mitigation actions and the status of current and future actions for the updated plan. Some suggestions from the HMPC included adding a mitigation action related to installing generators at pump stations which would support the efforts of the City's Department of Public Works. Additionally, the HMPC noted that the Police Headquarters needs a new electrical system, plumbing system, and HVAC system, alongside a generator. As for an overarching mitigation action, the HMPC wanted to call out an intentional goal of requiring all projects to incorporate an evaluation of natural hazards and resilience. Another action called for interdepartmental collaborated through the project design process to support resilience. The meeting ended with a plan run through and the final steps for completion which included draft plan review by the HMPC and the public.

HHPD1: Did the plan describe the incorporation of existing plans, studies, reports and technical information for HHPDs?

In addition to the five HMPC meetings, the City and consulting team met to discuss High Hazard Potential Dams on October 24, 2024, as well as on December 17, 2024. The first meeting was with the HMPC, Department of Public Works, and a City Engineer/Dam Owner. The second meeting was with the HMPC and dam owners. Both meetings discussed the importance of including dams within the updated plan and the State Office of Dam Safety was invited to each meeting. A significant amount of infrastructure improvements and issues were shared in the first meeting on October 24, 2024. Some rehabilitation was said to be underway, but there was significantly aging infrastructure that the City and dam owners have had to work around. Additional modeling, large valve replacements, and early warning systems for dam breaches were also discussed. During the second meeting on December 17, 2024, it was noted that Worcester has thirteen High Hazard Potential Dams (HHPDs), which represent critical infrastructure in the City. The meeting participants stressed the need to assess and fortify high-hazard dams to ensure risk reduction while promoting ecological resilience. Mitigation actions that address HHPDs were suggested such as dam removal or rehabilitation, adoption or enforcement of land use regulations in inundation areas, elevating structures, and adding flood protection such as berms and floodwalls in inundation zones.

The consulting team also held three additional stakeholder meetings with the National Grid on September 17, 2024, the Police Department on September 19, 2024, and the Central Massachusetts Regional Planning Commission on January 7, 2025, to gather additional information on the critical facilities and any related mitigation actions for the updated plan. During the meeting with the National Grid, the National Grid representatives shared their hazard mitigation program regarding trees which included routine trimming and assessment of trees that have the potential of falling or causing damage. The National Grid noted that they focus on reliability of their services which could include more substations, more robust lines and wires, continued tree trimming, and maintaining a list of critical facilities that need power to be restored quickly in the event of an outage. The National Grid works closely with the City's Tree Warden for public trees, as well as communicating with private landowners if there are issues with trees on private property. Overall, the National Grid wanted to build capacity for Worcester, especially by increasing the number of substations and addressing the backyard construction that has made repairing lines and poles more difficult.

The meeting with the Police Department began with noting that the last plan did not have any police-related mitigation actions which the consulting team and HMPC aimed to address in the plan update. The Police Department shared that they have had to deal with several major incidents in the City from power outages, major water breaks, extreme weather, and vulnerable infrastructure. The Police Department stressed the need to inform the public about public safety, knowing and reevaluating evacuation routes, and environmental design for public safety.

The meeting with the Central Massachusetts Regional Planning Commission (CMRPC) was focused on discussing mitigation strategies. After an overview of the current list of mitigation actions, the meeting participants stated that the City really likes the idea of anaerobic digesters. They also wanted to include preparedness actions as well as response actions. The CMPRPC also stated that the CRS annual progress report needed to be completed by the City.

The HMPC also participated in two public meetings, one on October 28, 2024, and one on January 29, 2025. Finally, the HMPC reviewed the draft City of Worcester, MA Hazard Mitigation Plan Update prior to sending it to the Massachusetts Emergency Management Agency (MEMA) for their review in March 2025.

Public Outreach

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

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

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

Each public meeting included a PowerPoint presentation and plenty of opportunities for questions and discussion. In addition, Mentimeter was available 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.

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

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

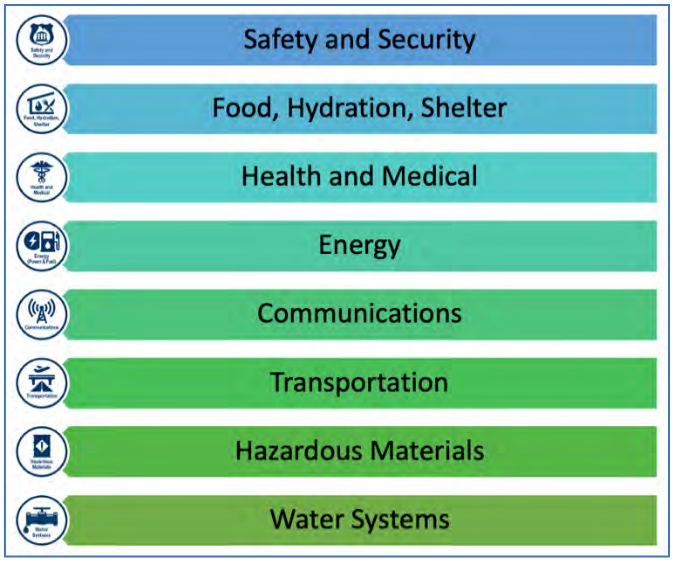


Figure 8. Community Lifelines.

Outreach for the public meetings and for plan review was sent via press release, email blasts, connecting with vulnerable populations such as the elderly community via the Senior Center and neighborhood groups, and reaching out to local and regional partners like the City's educational and medical institutions, National Grid, and the Central Massachusetts Regional Planning Commission (CMRPC). The City website (https://www.worcesterma.gov/) included announcements for meetings, the press releases were sent to local organizations, using online platforms like the City's social media pages, and posted around the City at frequented buildings such as the City Hall, Senior Center, and Library. The City thought it best to have at least one Hazard Mitigation Plan Update Public Meeting align with another City-wide meeting, such as the Senior Center Luncheon, typically held in the early afternoon to connect with their vulnerable populations more easily. The City also held a second public meeting in the evening to increase the likelihood of participation and offer an alternative time for those who could not attend a meeting midday.

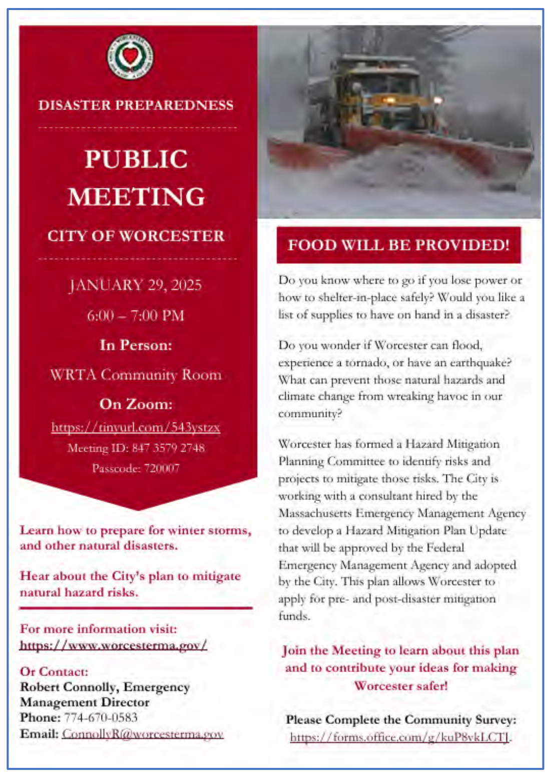


Figure 9. Public Meeting 2 Flyer.

Information gathered during the public meetings contributed to the plan's development. The first public meeting was held via Zoom and in person during a Senior Center Luncheon on **October 28, 2024**. An accurate list of participants was not gathered due to the Zoom format.

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

- Who lives and works in your community?

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

The second public meeting was held on **January 29, 2025,** virtually on Zoom and in-person in the Worcester Regional Transit Authority Community Room. The consulting team and in-person meeting participants began with introductions. An attendance sheet was organized for the three residents present, and adjustments were made to the meeting format, including the removal of the Mentimeter component.

The consulting team introduced the City's hazard mitigation plan, outlining its purpose to identify risks and develop strategies to mitigate them, which is essential for qualifying for pre- and post-disaster mitigation funding. The team then went on to share the risk assessment process, focusing on natural hazards and their impacts on community assets, while emphasizing the importance of critical facilities for community resilience. It was noted that the plan categorizes hazards by risk level and includes mitigation actions, supported by maps visualizing risks like the heat island effect and flood risk.

The consulting team also highlighted the significance of signing up for Alert Worcester for emergency alerts, encouraged the preparation of emergency kits, and discussed the plan's mission statement emphasizing equity and innovation, along with specific goals and proposed actions. It was shared that community members will have the opportunity to review the draft plan before its submission to the Massachusetts Emergency Management Agency and FEMA.

Community Survey

In addition to the two public meetings, the City sent out a community-wide survey about the Hazard Mitigation Plan update and to gather information from residents about natural hazards and their knowledge and experience on severe weather impacts. The survey was provided in electronic form via Qualtrics in English, Portuguese, and Spanish. It was advertised across all City-wide pages and social media, as well as through community groups and networks via listservs and email chains. There was a total of 160 respondents, 159 in English and 1 in Spanish.

The first figure below highlights that most survey respondents are “somewhat concerned” or “very concerned” about how severe weather and natural hazards will affect Worcester.

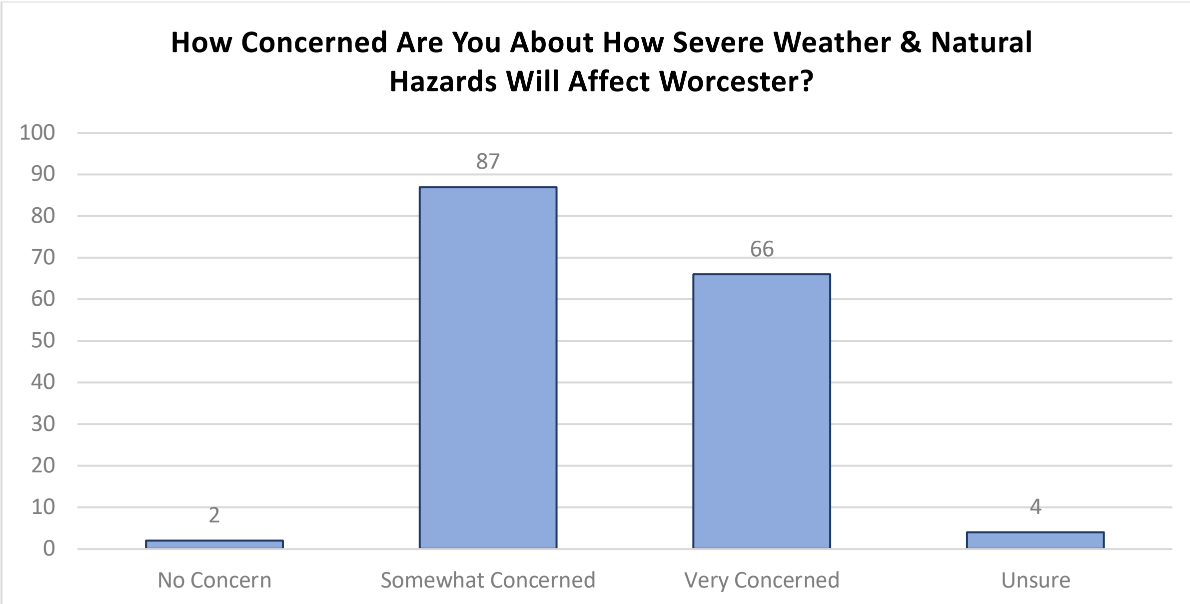


Figure 10. Survey Respondent's Concern About Severe Weather and Natural Hazards.

The second figure shows that most survey respondents believe severe weather or natural hazards will negatively affect their life, safety, and/or property.

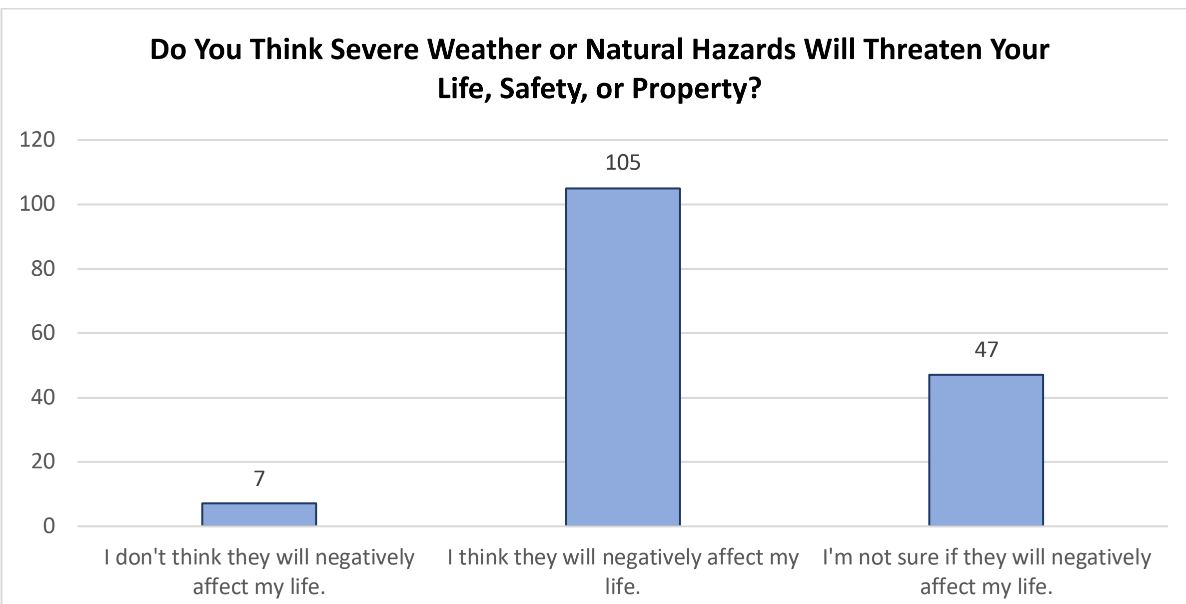


Figure 11. Survey Respondent's Belief of Severe Weather and Natural Hazards Threat to Life, Safety, or Property.

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

Table 6. Where Public Engagement Informed the Plan.

Area of the Plan Impacted	Contributions
Planning Area Profile	• The HMPC updated the list of critical facilities, shown in Appendix B. • The public also contributed information regarding current land use practices and priorities.
Planning Process	• Participated in every aspect of the planning process and made recommendations regarding how to engage the public and key stakeholders.
Risk Assessment	• Described extent of hazard impacts based on previous events. • Offered first-hand insight and experiences of City residents. • Added the qualitative review to the risk analysis for determination of the hazard risk ranking.
Capability Assessment	• Contributed plans, bylaws, and reports for review. • Completed three Capability Assessment questionnaires including the National Flood Insurance survey and the Safe Growth survey.
Mitigation Strategy	• Identified and prioritized mitigation actions based on their concerns. • Focused on the concerns raised by community members. • Offered insight on experiences with severe weather and natural hazards in the City.
Implementation Plan	• Committed to integrating this plan more thoroughly throughout City government and to posting the plan on the City's website.

List of Key Stakeholders Invited to Public Meetings

- Blackstone Watershed Collaborative
- Central Massachusetts Regional Planning Commission
- City Residents
- Mass Audubon
- National Grid
- Neighboring Communities

- University of Massachusetts Chan Medical School
- University of Massachusetts Memorial Medical Center
- Worcester Boards and Committees
- Worcester City Departments
- Worcester Public Schools

Review of Draft Plan

The City made the plan available for public review in March 2025. A press release announcing the availability to review the plan was sent and the announcement was posted to the City website. The HMPC sent emails to City employees, committees, and boards. Hard copies of the plan were kept in the Library and Senior Center. An electronic version would also be made available on the City's website. An electronically available comment form via Google alongside a hard-copy version, was provided for the public to offer feedback on the plan's content. The Emergency Management Director was available to receive comments from the public.

Chapter 4. Risk Assessment

Hazard Identification

B1. Does the plan include a description of the type, location, and extent of all natural hazards that can affect the jurisdiction? Does the plan also include information on previous occurrences of hazard events and on the probability of future hazard events? (Requirement 44 CFR § 201.6(c)(2)(i))

B2. Does the plan include a summary of the jurisdiction's vulnerability and the impacts on the community from the identified hazards? Does this summary also address NFIP-insured structures that have been repetitively damaged by floods? (Requirement 44 CFR § 201.6(c)(2)(ii))

The first step in the risk assessment was to revisit and evaluate the hazards identified for study and inclusion in the City'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 City's Municipal Vulnerability Preparedness (MVP) planning effort (completed in 2019), as well as the "ResilientMass Plan" (2023[61]) which is the formal update to the 2018 State Hazard Mitigation and Adaptation Plan (SHMCAP). As a result of this process all hazards from the prior hazard mitigation plan (adopted in 2019) remain in this updated risk assessment. For this updated assessment, some hazards have been consolidated or renamed to be consistent with the ResilientMass Plan, as further described below. The top natural hazards identified for the MVP effort are thoroughly covered in this assessment. Invasive species as a hazard was added to reflect the concern for this becoming a more prevalent challenge with projected climate change; and to ensure that the risk assessment is aligned with the ResilientMass Plan.

In summary, all relevant hazards identified in the ResilientMass Plan were carried forward and addressed in this risk assessment chapter, with the exception of coastal hazards (flooding and erosion) which are not applicable in Worcester due to its inland location. The profiled hazards are as follows:

- Average and Extreme Temperatures

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

- Droughts
- Earthquakes
- Flooding from Dam Failure or Overtopping
- Flooding from Precipitation
- Hurricanes/Tropical Storms
- Invasive Species
- Landslides
- Other Severe Weather
- Severe Winter Storms
- Tornadoes
- Wildfires/Brushfires

One “hazard” profiled in the ResilientMass Plan – “changes in groundwater” – is included as appropriate in the flood and drought hazard profiles in this plan. Furthermore, the hazard “flooding from precipitation and dam overtopping” from the ResilientMass Plan was separated into “flooding from precipitation” and “flooding from dam failure and overtopping” in this plan to facilitate review under the HHPD element of the Local Plan Review Tool.

Massachusetts Emergency Declarations

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

Table 7. Massachusetts Emergency Declarations.

Massachusetts Emergency	Start	Termination	Corresponding Federal Disaster Declaration	FEMA Public Assistance Available	Applicable to Worcester?
Storm Lee	9/15/2023	9/16/2023	Not applicable	Not applicable	Yes

Massachusetts Emergency	Start	Termination	Corresponding Federal Disaster Declaration	FEMA Public Assistance Available	Applicable to Worcester?
Severe Weather and Flooding	9/12/2023	9/16/2023	Not applicable	Not applicable	Yes
Shelter Capacity Crisis	8/8/2023	Pending	Not applicable	Not applicable	Yes, but not a natural hazard and not a FEMA declaration for Massachusetts
COVID-19	3/10/2020	5/11/2023	DR-4496-MA	All counties	Yes
Merrimack Valley Gas Explosion	9/14/2018	10/4/2018	Not applicable	Not applicable	No
Coastal Storm	3/3/2018	3/6/2018	DR-4372-MA	Essex, Norfolk, Plymouth, Bristol, Barnstable, and Nantucket Counties	No
Winter Storm	2/9/2015	2/25/2015	Not applicable	Not applicable	No
Winter Storm	1/26/2015	1/28/2015	DR-4214-MA	Worcester County and eastward	Yes
Winter Storm	2/8/2013	2/13/2013	DR-4110-MA	All counties	Yes
Hurricane Sandy	10/27/2012	11/1/2012	DR-4097-MA	Suffolk, Bristol, Plymouth, Barnstable, Dukes, and Nantucket Counties	No

Massachusetts Emergency	Start	Termination	Corresponding Federal Disaster Declaration	FEMA Public Assistance Available	Applicable to Worcester?
Nor'easter	10/29/2011	11/7/2011	DR-4051-MA	Berkshire, Franklin, Hampshire, Hampden, Worcester, and Middlesex Counties	Yes
Hurricane Irene	8/26/2011	9/6/2011	DR-4028-MA	Berkshire, Franklin, Hampshire, Hampden, Norfolk, Bristol, Plymouth, Barnstable, and Dukes Counties	No
Tornadoes	6/1/2011	6/19/2011	DR-1994-MA	Hampden and Worcester Counties	Yes

Link to Massachusetts Climate Change Assessment

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

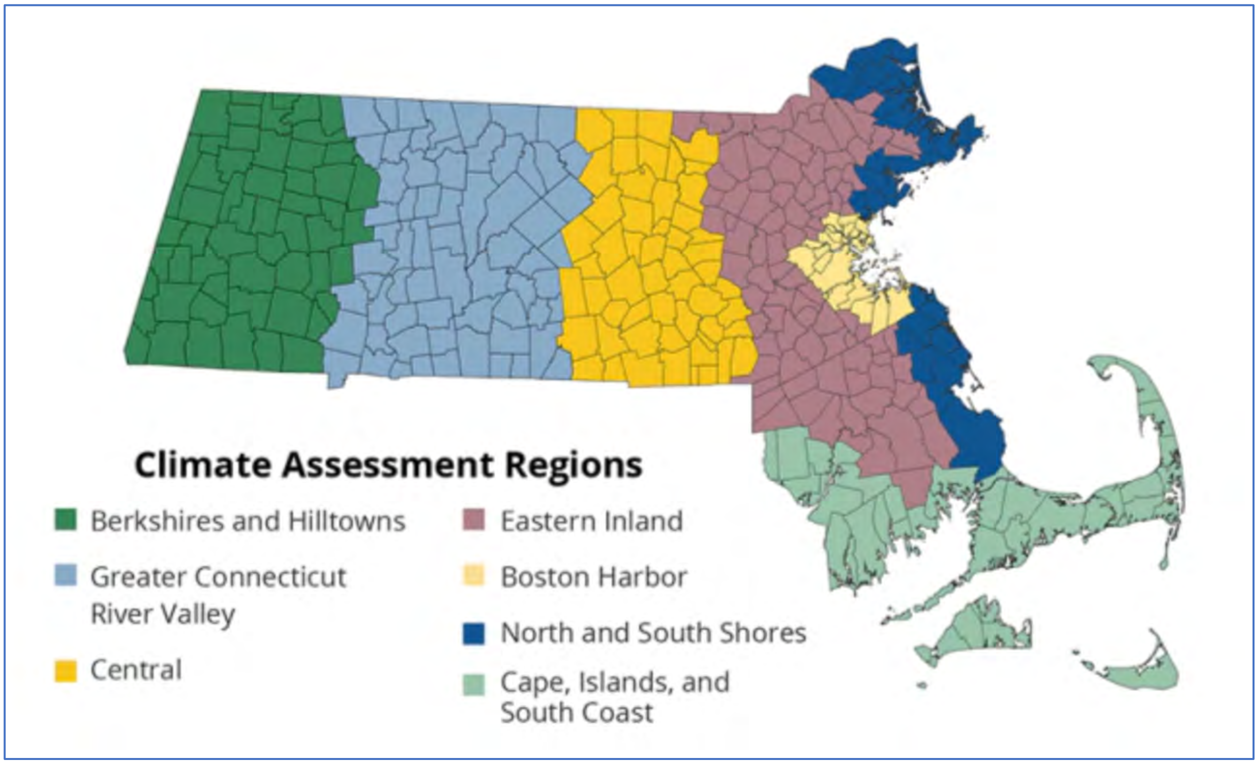


Figure 12. Climate Assessment Regions. Worcester is in the Central Region.

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

Table 8. Top Impacts of Climate Change per Sector in Central Region.

Sector	Top Impacts per Sector	Comments
Human	Reduction in food safety and security	Causes are production and supply chain issues as well as spoilage during outages
	Health and cognitive effects from extreme heat	Includes premature death and learning loss
Infrastructure	Damage to electric transmission and distribution	Causes are heat stress and extreme storms
	Loss of urban tree cover	Causes are heat, drought, and pests

Sector	Top Impacts per Sector	Comments
Natural Environment	Freshwater ecosystem degradation	Causes are warming waters, drought, and runoff
	Forest health degradation	Causes are warming temperatures, changing precipitation, wildfire frequency, and increasing pests
Governance	Increase in costs of responding to climate migration	Includes planning for abrupt increases in local populations
	Increase in demand for State and municipal services	Includes emergency response, food assistance, and health care
Economy	Reduced ability to work	For outdoor workers during extreme heat events, as well as delays in commute times
	Decrease in agricultural productivity	Causes are crop yield impacts from precipitation patterns, extreme weather, and pests

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

Table 9. How This Plan Addresses the Top Impacts of Climate Change per Sector.

Sector	Top Impacts per Sector	Approach to Incorporating Impacts
Human	Reduction in food safety and security	Some of the hazards that affect food security (i.e., droughts) are profiled in this plan. However, Worcester depends on food from other regions, and additional efforts beyond the scope of this plan will be needed to protect food safety and security.
	Health and cognitive effects from extreme heat	Extreme heat is a hazard profiled in this plan.
Infrastructure	Damage to electric transmission and distribution	Severe weather events that damage transmission and distribution are hazards profiled in this plan.

Sector	Top Impacts per Sector	Approach to Incorporating Impacts
	Loss of urban tree cover	The causes (extreme heat, drought, and invasive pests) are hazards profiled in this plan.
Natural Environment	Freshwater ecosystem degradation	Invasive species are addressed as a hazard profiled in this plan. Additional efforts beyond the scope of this plan will be needed to protect freshwater ecosystems.
	Forest health degradation	Invasive species, droughts, wildfires, and severe weather events that damage forests are hazards profiled in this plan. Additional efforts beyond the scope of this plan will be needed to protect Forest health.
Governance	Increase in costs of responding to climate migration	The capability assessment and related mitigation actions will help address increased costs related to responding to climate migration.
	Increase in demand for State and municipal services	The capability assessment and related mitigation actions will help address increased demands for municipal services.
Economy	Reduced ability to work	The individual hazards addressed in this plan can reduce ability to work, and the specific actions for each hazard will help protect lifelines and systems needed for work.
	Decrease in agricultural productivity	Causes are crop yield impacts from precipitation patterns, extreme weather, and pests; these are hazards profiled in this plan.

Hazard Profiles

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

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

Table 10. Hazard Characterization.

Category/Method	Definition
Description	Description of hazard, its characteristics, and potential effects.
Location	Describes geographic areas within the City 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 City based on best available and climate-informed science.
Vulnerability Assessment	Describes potential impact on the community, including estimated potential losses and the anticipated effects of climate change.

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

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

Average and Extreme Temperatures

According to the ResilientMass Plan, extreme heat for Massachusetts is usually defined as daily high temperatures above 90 degrees Fahrenheit (°F) which may be accompanied by high humidity. Extreme cold is considered relative to the normal climatic lows in a region. Extreme cold is a period of excessively low temperatures, particularly with the addition of wind chill. The ResilientMass Plan notes that typically in Massachusetts the highest temperatures are experienced in the southeast while the coldest are typically in the northwest. Worcester is in neither of these areas, but experiences both.

Description

> The City of Worcester Municipal Vulnerability Preparedness Plan Findings and Recommendations (2019) lists "extreme heat coupled with drought" and "ice/snowstorms coupled with extreme cold" as two of the top hazards of concern.

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

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

A heat wave is defined as three or more days of temperatures of 90°F or above. A basic definition of a heat wave implies that it is an extended period of unusually high atmosphere-related heat stress, which causes temporary modifications in lifestyle, and which may have adverse health consequences for the affected population. Heat waves cause more fatalities in the U.S. than the total of all other meteorological events combined. According to the EPA, more than 11,000 Americans have died from heat-related causes (EPA, 2016) since 1979.[62]

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

Many conditions associated with heat waves or more severe events (including high temperatures, low precipitation, strong sunlight, and low wind speeds) contribute to a worsening of air quality in several

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

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.

Location

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

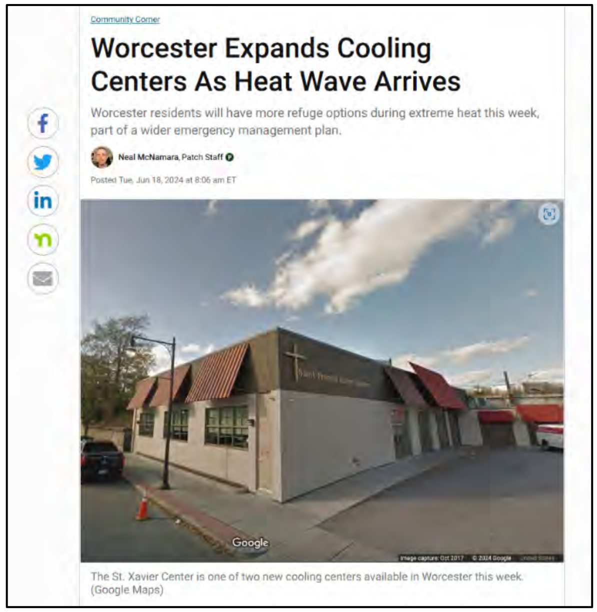
Previous Occurrences

Extreme Cold: The ResilientMass Plan notes that since 1995, there have been 120 cold weather events within the Commonwealth, ranging from Cold/Wind Chill to Extreme Cold/Wind Chill events. The NOAA Storm Events database (https://www.ncdc.noaa.gov/stormevents/) for Worcester County lists numerous extreme cold and/or wind chill events for the area of Worcester during the timeframe 2014-2024, with four separate dates listed. According to data provided by the City in August 2024, warming centers were last opened on February 1 and 2, 2023.

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

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

The NOAA Storm Events database (https://www.ncdc.noaa.gov/stormevents/) for Worcester County does not list any extreme heat events for the area of Worcester in the timeframe 2014-2024. Evidence demonstrates that several extreme heat events occurred in Worcester in July-August 2022, July-August 2023, and June-August 2024. Cooling centers were open June 18 through 21, 2024 to protect residents during a mid-June heat dome that sent temperatures into the upper 90s. According to the patch.com community news web site (pictured to the right), "Worcester in recent years has offered the senior center and main Worcester Public Library as cooling centers during regular hours. This week, the city will offer South High Community High School and the St. Xavier Center along Temple Street as new options. The new centers come after a few years of planning for extreme weather events."



The cooling centers were opened again on August 1-2, 2024, according to data provided by the City in summer 2024.

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 11. USDA Disasters Events That Refer to Extreme Temperatures.

Year	Event	Event "Begin Dates"
2023	Frost, Freeze	5/17/2023, 5/18/2023
2022	Drought, Heat and Excessive Heat	5/9/2022
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
2014	Cold, frost/freeze	12/1/2013

Extent

Extreme Cold: The extent (severity or magnitude) of extreme cold temperatures is generally measured through the Wind Chill Temperature Index. Wind Chill Temperature is the temperature that people and animals feel when they are outside, and it is based on the rate of heat loss from exposed skin by the effects of wind and cold. As the wind increases, the body loses heat at a faster rate, causing the skin's temperature to drop. The National Weather Service (NWS) issues a Wind Chill Advisory if the Wind Chill Index is forecast to dip to –15°F to – 24°F for at least 3 hours, based on sustained winds (not gusts). The NWS issues a Wind Chill Warning if the Wind Chill Index is forecast to fall to –25°F or colder for at least 3 hours. On November 1, 2001, the NWS implemented a Wind Chill Temperature Index (Figure 13) designed to more accurately calculate how cold air feels on human skin.

Wind Chill Chart

Temperature (°F)

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

Frostbite Times: 30 minutes; 10 minutes; 5 minutes

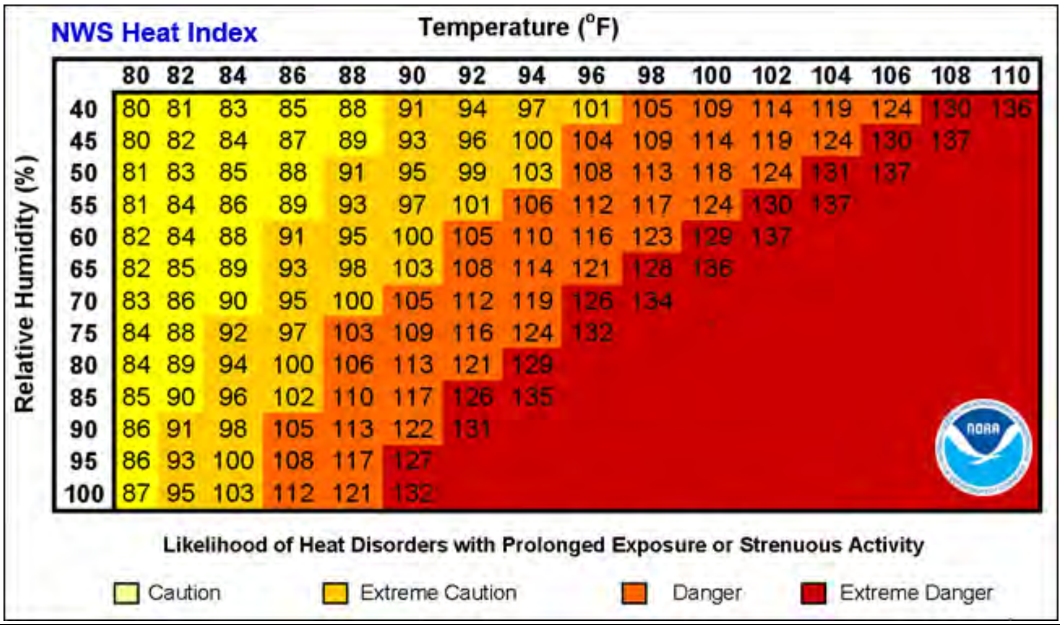
$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

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

Effective 11/01/01

Figure 13. NWS Wind Chill Temperature Index and Frostbite Risk.

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



NWS Heat Index — Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution — Extreme Caution — Danger — Extreme Danger

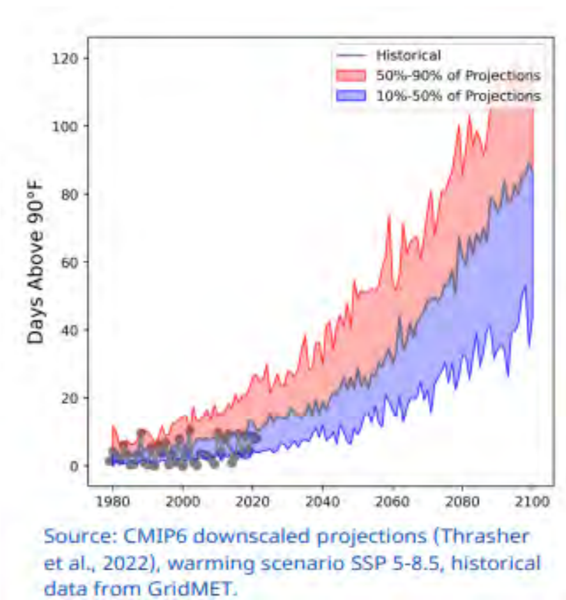
Figure 14. NWS Heat Index Chart.

Probability of Future Events

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

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

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



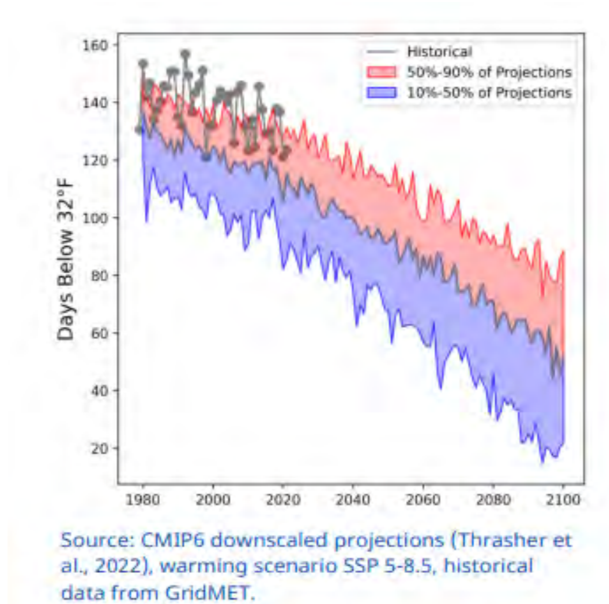


Figure 15. Projected Annual Days with Temperatures above 90 Degrees (left) and below 32 degrees (right).

Vulnerability Assessment

Exposure

Extreme temperatures impact the entire community, but some parts of the community have hot spots created by the heat-island effect. The entire City 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 impacts of excessive heat are most prevalent in developed areas, where the City 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 leads to an increase in mechanical failures. Steel rails are at risk of overheating and warping which can lead to train derailments.

Worcester has developed heat island effect maps of the City. The figure below shows the maximum temperatures in August. Areas which experience higher temperatures in the City are shown as dark brown. All these high temperature areas are in the City's Environmental Justice communities.

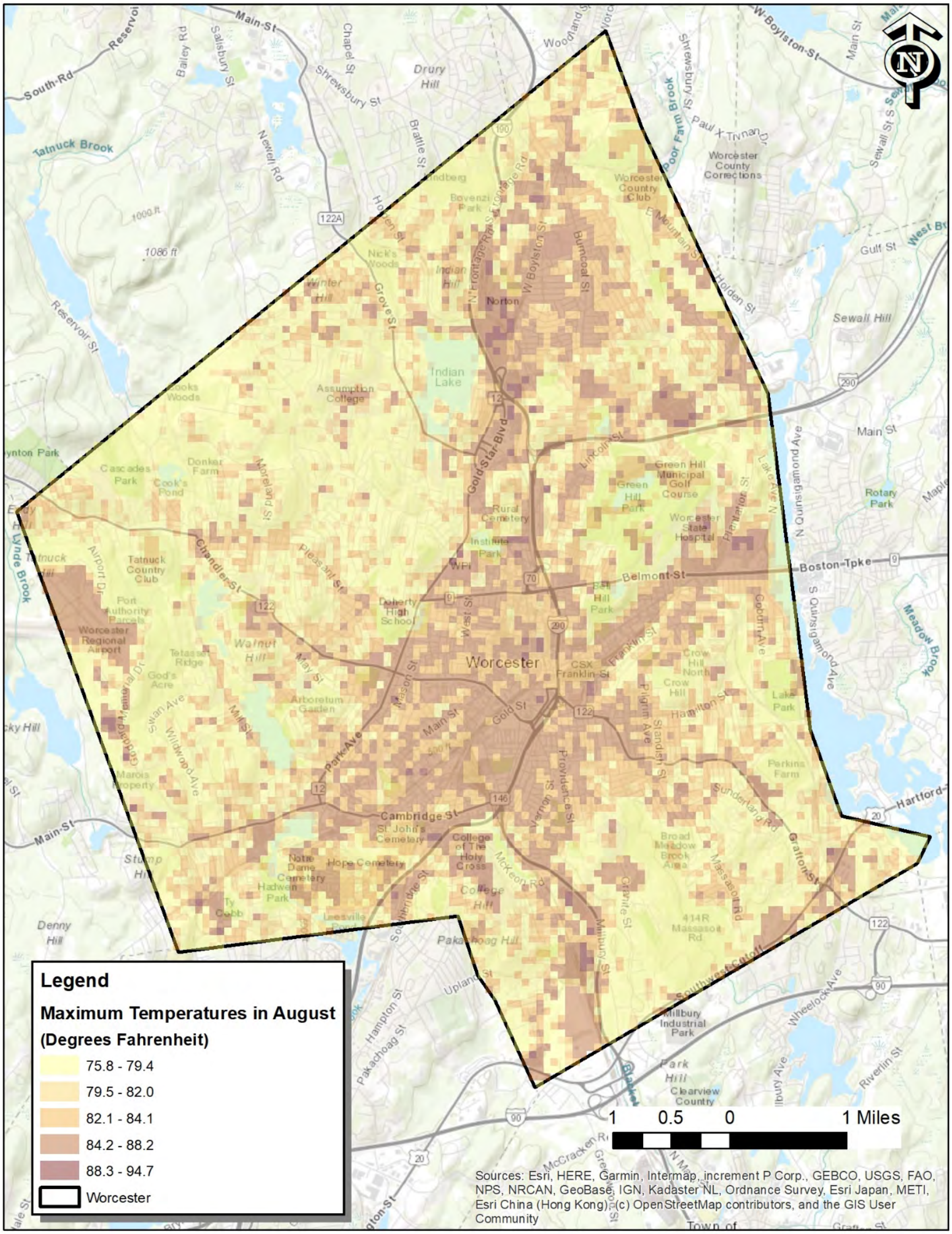


Figure 16. Maximum Temperatures in August (Heat Island Effect).

The buildings and their value in the City exposed to the higher temperatures (>87˚F) are shown in the table below.

Table 12. Buildings Exposed to Higher Temperatures (>87˚F).

Building Type	Number of Buildings in Heat Island Effect Area (Total in City)	Building Value in in Heat Island Effect Area (Total in City)
Single Family	3 (31,399)	$52,887,483 ($13,989,054,910)
Multi-Family	35 (14,496)	$298,367,147 ($23,767,111,740)
Commercial	86 (3,203)	$2,043,243,394 ($10,363,149,842)
Agricultural	0 (72)	$0 ($22,837,164)
Educational	10 (372)	$559,565,949 ($7,450,820,493)
Government	4 (155)	$82,305,183 ($647,185,275)
Religious/Non-Profit	1 (239)	$7,674,084 ($863,742,992)
Industrial	24 (220)	$507,743,660 ($1,680,656,677)
Garage/Outbuilding	0 (46)	$0 ($916,384)
Total	**163 (50,202)**	**$3,551,786,900 ($58,785,475,479)**

The population exposed to higher temperatures (>87˚F) are shown in the table below. In Worcester, lower income families are more likely to be in the heat island effect areas.

Table 13. People Exposed to Higher Temperatures (>87˚F).

Demographics	Population in Areas Exposed to Greater than 87 Degrees	Total Population
Population	10,767	206,518
Households	3,182	84,281
White	6,343 (58.9%)	110,158 (53.3%)
Black	1,465 (13.6%)	30,485 (14.8%)
American Indian	28 (0.3%)	1,019 (0.5%)
Asian	929 (8.6%)	14,688 (7.1%)
Pacific Islander	4 (0.04%)	81 (0.04%)
Other Race	1,105 (10.3%)	26,666 (12.9%)
Two or More Races	893 (8.3%)	23,421 (11.3%)
Hispanic or Latino:	2,204 (20.5%)	50,736 (24.6%)
Population under 18	1,389 (12.9%)	38,511 (18.6%)
Population over 64	1,132 (10.5%)	28,592 (13.%)

Demographics	Population in Areas Exposed to Greater than 87 Degrees	Total Population
Annual Income < $30K/year	1,187 (37.3%)	26,507 (31.5%)
Population in EJ Zone*	10,767 (100%)	197,449 (95.6%)

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 electrical system, which can lead to temporary outages. These outages can impact operations throughout the City, which can result in interruptions and delays in services. Broken pipes may cause flooding in buildings, causing property damage and loss of utility service. Some of the secondary effects presented by extreme/excessive cold include dangerous conditions to livestock and pets.

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

Population Impacts

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

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

Older adults are often at elevated risk due to a high prevalence of pre-existing and chronic conditions. In Worcester, 13.8% 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 U.S., resulting in hundreds of fatalities each year and even more heat-related illnesses. Extreme heat has a special impact on the most vulnerable segments of the population - the elderly, young children and infants, impoverished individuals, and persons who are in poor health. The high-risk population groups with specific physical, social, and economic factors that make them vulnerable include:

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

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

Environment Impacts

Extreme heat can lead to water quality issues (e.g., excess algal growth, decreased oxygen), wildlife concerns (e.g., shifts in species distribution), and impact vegetative growth when combined with drought.

Problem statements summarize vulnerabilities and risks and are included following each hazard profile. Problem statements bridge the gap between hazard risks and development of the mitigation actions. Problem statements are included for each hazard profile subsection.

Problem Statements for Extreme Temperatures.

Table 14. Problem Statements for Extreme Temperatures.

Assets	Problems Associated with Extreme Temperatures
People (including underserved communities and socially vulnerable populations)	• Extreme heat will be a significant public health threat to all residents, but especially for vulnerable populations living in older homes or homes without air conditioning. • The elderly and those with mobility issues may not be able to leave their homes and travel safely. • People working in businesses without air conditioning may be at risk of heat illness. • First responders may also be impacted by extreme temperatures. • Pets may be adversely impacted by extreme heat.
Structures (including facilities, lifelines, and critical infrastructure)	• Older homes without insulation and single-pane glass are difficult to heat and cool and may not provide safe living conditions. • Businesses that require refrigerated trucks or refrigeration units may see business losses and increased utility costs. • The electric grid may become stressed and fail during extreme heat events.
Systems (including networks and capabilities)	• Extreme heat mitigation and adaptation have not been fully integrated into existing local plans and regulations for new development, though progress is being made.
Natural, historic, and cultural resources	• Extreme heat may lead to, or exacerbate, impacts to natural systems related to wildfires and invasive species (refer to those sections). • Extreme heat may lead to water quality concerns.

Assets	Problems Associated with Extreme Temperatures
Activities that have value to the community	• Recreational activities may be adversely impacted by extreme heat.

Droughts

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

Description

The City of Worcester Municipal Vulnerability Preparedness Plan Findings and Recommendations (2019) lists "extreme heat coupled with drought" as one of the top hazards of concern.

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

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

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

The Public Works & Parks Department manages water service in Worcester through its Water Operations. Additionally, a small area of the City is supplied by the Town of Holden water system.

Reservoirs are in Leicester, Paxton, Holden, Rutland, and Princeton. Droughts can impact inflows and water levels in reservoirs.

Areas outside the City's water service area are served by private water supply wells (approximately 50, according to the previous edition of this 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 cause significant impacts depending on the affected population's ability to quickly drill a deeper or a new well or to relocate to unaffected areas. During a drought, dry soil and the increased prevalence of wildfires can increase the amount of irritants (such as pollen or smoke) in the air. Reduced air quality can have widespread deleterious health impacts but is particularly significant to the health of individuals with pre-existing respiratory health conditions like asthma (Centers for Disease Control [CDC]).

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

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

Location

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

Previous Occurrences

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

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

The City was in a Stage III drought during the drought of 2016. The following photographs are taken from the City's MVP Findings and Recommendations Report (2019).

Pine Hill Reservoir | Quinapoxet Reservoir

Figure 17. Reservoirs During Drought of 2016.

According to the Municipal Vulnerability Preparedness Plan Findings and Recommendations report, to prevent a disruption in water service during the drought of 2016, the City purchased water from the Massachusetts Water Resource Authority, pulling water from an existing interconnection with the MWRA's systems at a cost of $3 million. This unanticipated cost limited the City's capacity to respond to other issues during times of emergency.

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

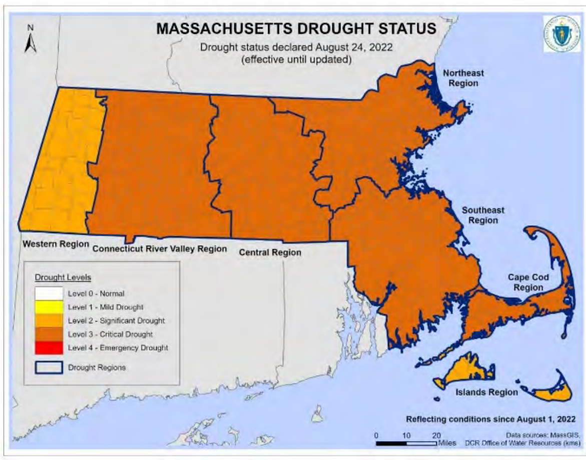
Table 15. USDA Disasters Events That Refer to Drought.

Year	Event	Event "Begin Dates"
2022	Drought	8/9/2022, 8/16/2022, 8/30/2022
2022	Drought, Heat and Excessive Heat	5/9/2022
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
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 droughts of 2020 and 2022, so-called "flashy droughts" that impacted southern New England, were sufficiently impactful in Worcester County to be included in the USDA data table above. The drought of fall 2024 was likewise considered a flashy drought, but USDA and other records were not yet available at the time of the adoption of this plan.

The following graphics depict the drought status mapping in 2022 and 2024 at their greatest extent. The press release for the drought of 2024 is presented on the following page: note the connection to the wildfire season of 2024, which is described later in this chapter.

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



The drought of 2024 followed a rainy spring and summer, and was most severe in October/November, but alleviated with rainfall in late November 2024.

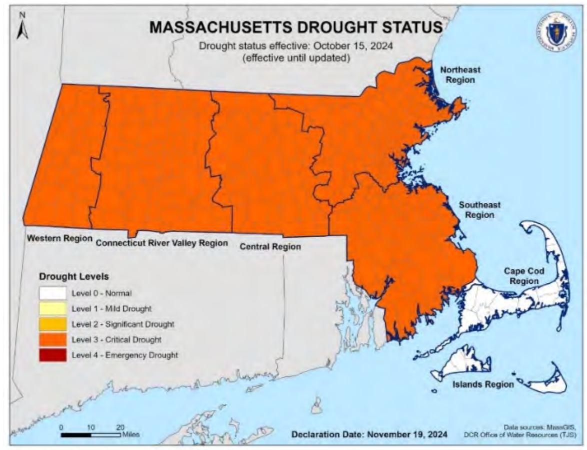


Figure 18. Drought Mapping of 2022 and 2024.

Press Release, 11/19/24 from Energy and Environmental Affairs (EEA)

With precipitation at an unprecedented low over the last three months, EEA elevated the Western, Connecticut River Valley, and Southeast regions to a Level 3 - Critical Drought. A Level 3 - Critical Drought persists in the Central and Northeast regions. As outlined in the Massachusetts Drought Management Plan, a Level 3 - Critical Drought requires detailed monitoring of drought conditions, continued coordination among state and federal agencies to communicate the implementation of water use restrictions, declaration of bans on open burning, engagement with municipalities including local Boards of Health, providing technical outreach and assistance to water suppliers and affected municipalities.

“Massachusetts is experiencing critical drought conditions that are fueling unprecedented and destructive wildfires across the state,” said Energy and Environmental Affairs Secretary Rebecca Tepper. “Climate change is reshaping our region’s weather patterns, resulting in warmer and drier fall and winter seasons. Water conservation is more important than ever. We urge municipalities, residents, and businesses - including those with private wells - to help us reduce stress on our water systems. We need to work together to ensure we have enough clean drinking water, protect wildlife habitats, and maintain effective fire control. Every small effort counts.”

Over the past 30 days, most of the state received less than an inch of rain, which is 3 to 4.5 inches below normal. Many areas recorded their lowest rainfall ever for this time of the year. Since August, when dry conditions began, all regions except the Cape and the Islands have seen an 8 to 11 inch rainfall deficit. Streamflow has also sharply decreased, especially in the Central region. This has resulted in dry brooks and streambeds, increased ponding, exposed beaches and sediments, limited fish passage, and drying ponds. Furthermore, groundwater levels are falling quickly in all regions, with the Western, Connecticut River Valley, Central, and Northeast regions showing the largest drops.

Fire activity has increased across the state because of drought conditions, leading to wildfires that are burning deeper into the soil. Due to fire conditions, the Department of Conservation and Recreation (DCR) has implemented a temporary ban of all open flame and charcoal fires within state park properties. Small portable propane grills are still allowed at campgrounds and recreation areas where grilling is permitted. This situation can make it harder to control fires and may prolong fire incidents. About 200 cities and towns have implemented temporary restrictions on all outdoor burning: residents are encouraged to follow local and state guidance on any activity that involves open flames, sparks and embers, or other ignition sources outdoors. Currently, there are approximately 37 active wildfires across the state. This year’s fire season has lasted longer because of dry conditions. Hundreds of wildfires have broken out across the state since October 1, burning more land than Massachusetts usually sees in an entire year. As firefighting efforts demand significant water resources, it's crucial for residents to practice aggressive indoor water conservation to maintain sufficient supply and pressure in public water systems.

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 2014 through 2024 were reviewed. This timeframe includes the droughts of 2015-2017 and 2020. One USDA reimbursement for the drought of 2015-2017 was applicable to the City of Worcester, for the sum of $6,879.38 payable to Farm Services at the NRCS office in Holden. The nature of this reimbursement was not clear, but it may have been related to impacts outside the City.

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, 2019). The indices are:

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

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

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

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

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

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

Probability of Future Events

Climate change will increase the probability of droughts. The Massachusetts Climate Change Assessment notes that the region will experience slight increases in the number of consecutive dry days and the number of days without rain from 2050 onward. By 2090 the number of consecutive dry days per year will increase to 33, compared to the annual statewide baseline of 31 days from 1986 to 2005. Table 16 summarizes this data and indicates the projected number of consecutive dry days according to the “high” and “low” limits of the Northeast Climate Adaptation Science Center (NE CASC) data. The City of Worcester is represented by the Greater Connecticut River Valley region.

Table 16. Number of Consecutive Dry Days (CDD) and Days without Rain (DWR) per Year.

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

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

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

Vulnerability Assessment

Exposure

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

Built Environment Impacts

Major water users are more susceptible to drought, and these include water utilities and some commercial users.

With an increased probability of drought and drought magnitude, water utilities should consider reviewing or developing extreme drought scenarios.

Population Impacts

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

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

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

Environment Impacts

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

Problem Statements for Drought

Table 17. Problem Statements for Drought.

Assets	Problems Associated with Drought
People (including underserved communities and socially vulnerable populations)	• Vulnerable communities may have difficulty accessing potable water during an emergency drought event. If the water sources are at emergency levels, having a plan to get vulnerable people water should be considered. If rates are increased to lower water demand, this may also adversely impact underserved and vulnerable communities.
Structures (including facilities, lifelines, and critical infrastructure)	• Water supply infrastructure may need to be shut down and water quality may become substandard. Businesses requiring water for daily operations may have their operations limited due to water restrictions.
Systems (including networks and capabilities)	• Outdoor water use restrictions and other water conservation measures during periods of extreme drought can be challenging to enforce, even when mandated through local declaration.
Natural, historic, and cultural resources	• Water quality may be adversely impacted by major droughts.

Assets	Problems Associated with Drought
Activities that have value to the community	• None applicable.

Earthquakes

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

Description

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

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

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

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

In some places in New England, including locations in Massachusetts, small earthquakes seem to occur with some regularity. In articles appearing in 2016, John Ebel Ph.D., a Senior Research Scientist at the

Weston Observatory, was quoted as saying “The Acton, Boxborough and Littleton areas are actually sporadically active… We tend to get a small earthquake once every three-to-five years.” It is not clear why some localities experience such clustering of earthquakes, but clusters may indicate locations where there is an increased likelihood of future earthquake activity.

Location

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

Previous Occurrences

The largest earthquake since 1900 to strike Massachusetts was a magnitude 3.9 located east of the Quabbin Reservoir in 1994. Two recent earthquakes with epicenters close to central Massachusetts included a magnitude 3.3 in the area around Westfield in 2000, and a magnitude 1.9 in the area around Northampton in 2012. The previous edition of this plan (adopted in 2019) noted that earthquakes have not been felt in Worcester.

To determine whether earthquakes have occurred more recently near or in Worcester, all events listed by Weston Observatory were reviewed for all towns in Massachusetts since the date of last edition of this plan. Listed earthquakes above magnitude 2.0 include the following very minor earthquakes, and none were near Worcester:

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

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

A magnitude 4.8 earthquake in New Jersey on April 5, 2024, was felt in Massachusetts. Residents in the Berkshires and Connecticut River valley region reporting feeling the earthquake as well as a strong aftershock later in the day. According to local news reports, residents in Worcester also felt this earthquake.

Extent

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

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

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

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

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

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

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

Table 18. Modified Mercalli Intensity.

Modified Mercalli Intensity	Description
I	Not felt except by a very few under especially favorable conditions
II	Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
III	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration similar to the passing of a truck. Duration estimated.
IV	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Felt by nearly everyone; many awakened. Some dishes and windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI	Few, if any (masonry), structures remain standing. Bridges destroyed. Rails bent greatly.
XII	Damage total. Lines of sight and level are distorted. Objects thrown in the air.

Source: USGS

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

Table 19. Modified Mercalli Intensity and Moment Magnitude.

Moment Magnitude	Typical Maximum Modified Mercalli Intensity
1.0 to 3.0	I

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

Source: USGS

Probability of Future Events

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

Vulnerability Assessment

Exposure

A major earthquake could cause severe damage to Worcester 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 the City of Worcester is vulnerable to earthquakes. Older, unreinforced masonry buildings are very susceptible to earthquakes.

To identify built environment impacts to the City, FEMA's risk assessment software, Hazus, was implemented. The economic loss results of the 1500-year event are shown in Table 20 while the results for the 2500-year event are shown in Table 21. The City's Average Annual Loss (AAL) is modeled to be $207,704.

Table 20. Building Loss for a 1500-Year Scenario.

Loss Type	Residential ($Million)	Commercial ($Million)	Other Occupancy ($Million)	Total ($Million)
Building Loss	21.49	15.99	16.58	54.06
Content Loss	6.39	6.28	7.90	20.57
Business Inventory Loss	0.00	1.15	0.34	1.49
Business Income Loss	0.27	3.34	0.50	4.11
Business Relocation Loss	1.04	3.01	4.92	8.97
Rental Income Loss	1.00	2.19	0.64	3.83
Wage Loss	0.63	4.32	1.40	6.35
Total	**30.82**	**36.28**	**32.28**	**99.38**

Table 21. Building Loss for a 2500-Year Scenario.

Loss Type	Residential ($Million)	Commercial ($Million)	Other Occupancy ($Million)	Total ($Million)
Building Loss	46.73	32.99	33.39	113.11
Content Loss	15.20	15.25	18.69	49.14
Business Inventory Loss	0.00	2.77	0.81	3.58
Business Income Loss	0.51	5.94	0.86	7.31
Business Relocation Loss	2.20	5.38	8.71	16.29
Rental Income Loss	2.02	3.79	1.11	6.92
Wage Loss	1.19	7.71	2.38	11.28
Total	**67.85**	**73.83**	**65.95**	**207.63**

Population Impacts

Populations considered most vulnerable to earthquake impacts are identified based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Senior and low-income populations are particularly susceptible. The City 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 were twenty-five injuries and three injuries requiring medical attention. For the 2500-year event there were forty-five minor injuries with eight injuries requiring medical attention.

Environment Impacts

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

Problem Statements for Earthquake

Table 22. Problem Statements for Earthquakes.

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

Flooding from Precipitation

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

Description

> The City of Worcester Municipal Vulnerability Preparedness Plan Findings and Recommendations (2019) lists "flooding from extreme precipitation" as one of the top hazards of concern.

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

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

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

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

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

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

Location

Heavy rainfall events occur regularly in Massachusetts. As a result, flooding such as riverine and drainage-related flooding affect most of the communities in the Commonwealth, including Worcester. Numerous dams are located in and upstream of Worcester. Ice jams have not reportedly occurred in Worcester, nor do rivers like the Blackstone have the typical profiles needed for ice jams. Therefore, all flood-related hazards (riverine floods and pluvial/stormwater flooding) except ice jams are believed relevant to the City.

The City's areas of flood risk are associated with the Blackstone River, the Mill Brook conduit, and the Blackstone Canal. The Mill Brook conduit work in the 1980s/1990s reportedly addressed some flooding along the watercourse, but flooding still occurs. New FEMA mapping for the Blackstone River and Nashua River basins is available as of 2024, however only one parcel in Worcester was affected by the new mapping for the Nashua River basin.

The previous edition of this hazard mitigation plan listed the following specific areas of flooding:

- The entire Green Island Area, including Brosnihan Square and ramp to Route 146 at the south, north to Ellsworth street, has been subject to recurrent flooding.

  - Washington Street and the Green Island area has repeated historical flooding for more than 100 years. An instance of flooding in October of 2016 resulting in two feet of water.
  - Elsworth Street in the Green Island area was severely flooded in 1991 & 2011.
- Quinsigamond Avenue flooded in 2014 and 2016. The neighborhoods in this area experience flooding, and the WRTA Maintenance Facility has been affected by flooding.
- Cambridge Street area has flooded regularly during heavy rain events notably impacting the railroad tracks and local businesses.
- Southbridge Street and Hammond Street have experienced severe isolated flooding.
- Southbridge Street at College Square has flooded along the Blackstone River.
- Millbury Street along the Blackstone River has flooded.
- Shrewsbury Street has flooded in extreme rain events.
- Southgate Street (under the Rail Road Bridge near its intersection with Southbridge Street) has flooded in the past such as 2009, 2012, and 2013; the location is outside of the flood zone.
- Route 20 floods under the Grafton Street overpass; a catch basin was added but the location still floods.
- Major Taylor Blvd near the DCU Center area flooded in 2016, and St. Vincent Hospital was also impacted by this flooding event.

The City's Municipal Vulnerability Preparedness Plan Findings and Recommendations report specifically draws attention to the Green Island neighborhood area, which experiences frequent and extreme cases of flooding, and notes that this is a reflection of the challenges faced by the City during periods of heavy rainfall. This is a low-lying part of Worcester's hilly landscape with a mainly impervious surface characteristic and combined sewers, which are factors that lead to increased stormwater surface runoff and local area flooding. The Green Island area serves as a drainage outlet (into the Blackstone River) for its watershed, which comprises a large portion of the City's area. During intense and/or prolonged rain events, water levels in the river begin to rise. When that happens, the stormwater cannot enter the river channel, in turn backing up into the streets, resulting in Green Island street flooding and occasional property damage.

Finally, undersized culverts are a problem citywide. These can be found in many locations, from downtown areas to the less developed outer parts of the City.

Previous Occurrences

Hurricane Diane and the accompanying flood of August 19 and 20, 1955, was the most severe flood in the history of the City of Worcester according to the previous edition of this plan. Excerpts from the FIS are copied in the previous edition of this plan and repeated here primarily for consistency:

- In Webster Square, near the confluence of Beaver and Kettle Brooks, flooding was approximately 12 feet deep. Flooding would have been more severe in the Square had the two Holden Reservoirs not been approximately three feet below their normal water surface elevations. The additional three feet of storage delayed runoff, which may otherwise have reached Webster Square at the peak of the flood. On Middle River, the Freemont Street Bridge was overtopped by one foot, and the Southbridge Street Bridge was overtopped by approximately one foot.
- Also, there was severe flooding associated with the Mill Brook Conduit in the August 1955 flood. Lamartine, Gold, and Washington Streets were under two to three feet of water, and Brosnihan Square was under five feet of water. At the intersection of Madison and Washington streets, there was three feet of water, and at the intersection of Madison and Gold Streets there was four feet. The Shrewsbury Street Brook Conduit, which is a large lateral storm drain connected to the Mill Brook Conduit, surcharged and flooded Shrewsbury Street to a depth of approximately two feet. Between Washington Square and Lincoln Square on Central Street, the surcharged Mill Brook Conduit flooded Central Street to a depth of approximately three feet.
- At Weasel Brook in the City of Worcester, overbank flooding is caused by inadequate capacity of culverts. North of Brooks Street, floodwaters again pond upstream of an inadequately sized culvert. This culvert conveys the brook underneath a factory which extends into the overbank areas on both sides of the brook. Once the pond elevation is higher than the railroad embankment to the east of the factory, flood waters flow down West Boylston Street to join the downstream pond at Brooks Street. The depth of flooding will be less than three feet, and the product of depth (in feet) and velocity (in feet per second) will be less than 15.

As noted earlier, this plan update relies primarily on a roughly ten-year lookback (2014 through 2024). The NOAA Storm Events database (https://www.ncdc.noaa.gov/stormevents/) for Worcester County lists more than 30 flood events impacting the City of Worcester for the period 2014-2024. These have been aggregated by date, grouping events together if they occurred from the same storm, and listed below.

Table 23. NCEI Severe Storm Database Entries Covering Floods in Worcester.

Date	Description	Losses Reported
7/27/14	Flash Flood: An upper level disturbance moving out of the Great Lakes initiated showers and thunderstorms over New York and New England. Southgate, Bellevue, Austin, and Southbridge Streets were flooded and impassable. Grafton Street was flooded with 8 inches of water from Barclay Street to Interstate 290 with numerous manhole covers popped off. Harding Street and West Boylston Street were flooded with up to 8 inches of water. Cars were stuck in flood waters on Quinsigamond Avenue and Plantation Street. Numerous basements were flooded on Water Street. Several lanes of Interstate 290 were flooded at Lincoln Square.	$50,000
10/24/17	Flood: Low pressure moved north through the Great Lakes. Strong low level winds brought a flow of tropical moisture ahead of the front. The tropical moisture was converted to heavy downpours, with storm rainfall totals ranging from 2 inches to 6 1/2 inches. This brought widespread urban and poor drainage flooding. Numerous streets flooded in Worcester. These include Sever Street, Hampden Street, Fruit Street, Pelham Street, Merrick Street, Highland Street at Roxbury Street, U.S, Route 20 at Grafton Street, and Austin Street at Bellevue Street. At 150 AM, Southbridge Street was flooded and impassable.	---
10/29/17	Flood: The remnants of Tropical Storm Phillipe merged with a mid-latitude system approaching the U.S. East Coast. Tropical moisture flowing north ahead of the cold front contributed to heavy downpours with one to five inches of rain reported. At 1135 PM, multiple cars were disabled in Worcester due to flooding at the junction of Southbridge and College Streets. Flooding reached a depth of three to four feet on Cambridge Street under the bridge.	$15,000
7/17/18	Flash Flood: A cold front moved east from the Great Lakes, crossing Massachusetts during the night of the 17th. Thunderstorms brought downpours in Western, Central, and Northeast Massachusetts. Two to four inches of rain fell from Westfield through Worcester to Boston. At 2:55 PM, heavy rain in Worcester brought street flooding to a depth of one foot at the intersection of	

Date	Description	Losses Reported
	Chandler Street and Murray Avenue. At 3:48 PM, heavy rain flooded Pelham Street in Worcester to a depth of three feet.	
9/18/18	Flash Flood: Post-Tropical Cyclone Florence moved up the East Coast, bringing heavy downpours and damaging thunderstorms to Massachusetts during September 18th. Storm total rainfall amounts reached two to five inches, and went as high as seven inches in parts of Worcester County. At 9:23 AM, U.S. Route 20 in Worcester was flooded at the Grafton Street overpass.	
7/6/19	Flood: A cold front advanced into a very moist, almost tropical air mass in place across southern New England. This produced a line of thunderstorms, some with torrential downpours that caused flooding. Flooding was reported on Armory Street in South Worcester with water flowing over the curb. Several feet of street flooding was reported near the intersection of Routes 20 and 122A on the border of Worcester and Millbury.	
8/7/19	Flood: A warm front moving across southern New England triggered severe thunderstorms with wind damage across western portions of southern New England from the midafternoon hours and through the evening. Another band of thunderstorms moved in from the southwest overnight, progressing to the coast before daybreak, causing some additional wind damage and some flooding. In the southern portion of Worcester, the Southbridge Street exit ramp off of I-290 eastbound had substantial flooding at the bottom of the ramp.	
8/23/20	• Flood and Flash Flood: Diurnally driven thunderstorms brought wind damage, hail, and some flooding to mainly western and central Massachusetts. • There was 3-4 ft of street flooding on Pleasant St, possibly from clogged drainage. • Washington Square was flooded to an unknown depth. • A car was stuck in flooding on the Rt 146 offramp to I-290.	$33,000

Date	Description	Losses Reported
	• The Franklin St Train Bridge was impassable due to flash flooding. • Catch basins overflowed resulting in flooding into a residence on Outlook Dr. • A vehicle drove into flood waters and got stuck on Dewey St which was impassable. • On Webster St a person was trapped when his car filled with water. • Grafton St was closed from Dana St to Warner Ave.	
8/27/20	Flood: A warm front lifting slowly northward across Connecticut and into Massachusetts helped trigger a few marginally severe thunderstorms in western and central Massachusetts in the early afternoon. • Flooding was reported on Whipple Street at Blackstone River Road with manhole covers floating. • Flooding was reported on College Street at Southbridge Street. • In the southeast part of Worcester, law enforcement reported that several cars were stuck in flooding on Route 20 at the 86 Cutoff. A few rescues of people were being conducted.	$21,000
7/9/21	Flood and Flash Flood: Tropical Storm Elsa made landfall in Rhode Island on Friday morning before moving into the Gulf of Maine. It interacted with a stalled frontal boundary and brought widespread heavy rainfall of 2 to 3.5 inches and gusty winds along the south coast, which caused scattered tree damage. • Cambridge St from Quinsigamond Ave to McKeon Rd was closed due to urban flash flooding.	---

Date	Description	Losses Reported
	• A section of Grafton St was closed due to flooding. Report forwarded by amateur radio. • Urban flash flooding at the intersection of Southbridge and Southgate Streets. Water was observed to be bubbling up out of manhole covers.	
7/17/21 through 7/18/21	Flood and Flash Flood: A relatively stationary front meandered across southern New England on the 17th and 18th while low pressure slowly moved along the front. At upper levels, an upper low was moving slowly eastward from the Great Lakes. With very moisture-laden air in place across the region, the result was heavy rain and flash flooding. Rainfall totals ranged from 3.0 to 5.6 inches in northern Connecticut and western and central Massachusetts. • Cars were stuck in flood waters at Millbury Street and McKeon Road. • Flash flood waters were up to car windshields on Dale Street. • Five cars were stuck in flood waters at Dewey Street and Parker Street. • A basement was flooded 5 inches deep at 7 Cardinal Road.	$36,000
8/19/21	Flash Flood: 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. There were numerous road closures due to urban flash flooding, after approximately 3 to 4 inches of rain fell. The following areas were flooded and impassable: William Street at Somerset Street, Southbridge Street, McKeon Road, Quinsigamond Avenue at Lamartine Street, East Central Street under the I-290 bridge, Glennie Street, Milbrook Street under the I-90 bridge, and Enid Street at Commonwealth Avenue.	$5,000

Date	Description	Losses Reported
9/2/21	Flash Flood: Tropical Depression Ida tracked northeastward from the central Appalachians and arrived in southern New England late in the day as a remnant low. One to three inches of rain fell in northwest Massachusetts, but heavy amounts of 4.0 to 6.5 inches fell south of the Mass Pike. In Worcester, numerous roads were closed due to flooding, especially on the west and south sides of the city. At 155 AM (1255 AM), Cambridge Street was flooded and impassable. At 211 AM, Merrick Street at Pelham Street was closed due to flooding. At 230 AM, parts of Southbridge Street and parts of Quinsigamond Avenue were closed due to flooding. At 318 AM, a car was stuck in flooded waters at the intersection of Cambridge Street and Kansas Street.	$1,000
8/26/22	Flood: A cold front moved into a warm and humid air mass, triggered scattered severe thunderstorms in southern New England during the mid and late afternoon. In Worcester, a section of Greenwood Street was flooded and impassable.	---
7/10/23	Flash Flood: An anomalously amplified mid-level trough moving east from the Great Lakes closed off and brought widespread showers and scattered thunderstorms which lead to flooding in western and central Massachusetts. Many roads were closed, and cars were stuck in flood waters. In Worcester, the area of 86 Southwest was flooded with 4 cars stuck in flood waters.	---
7/14/23	Flood: A cluster of thunderstorms moved northward into Connecticut during the morning ahead of a short-wave trough southwest of southern New England. The showers and thunderstorms spread northeastward into the early afternoon. • Franklin St by the railroad tracks was flooded. • A car was stuck in street flooding on Southbridge St.	---
1/10/24	Flood: A negatively tilted mid-level trough swung through New England while at the surface a low pressure center passed directly over southern New England. This inland runner brought warm air so	---

Date	Description	Losses Reported
	that all precipitation fell as rain. In Worcester at 3:17 AM, Rt 20 was closed in both directions due to flooding at Grafton St.	

Extent

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

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

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

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

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

Probability of Future Events

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

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

Vulnerability Assessment

Exposure

In Worcester, the current 1% annual chance regulatory floodplain (100-year floodplain) covers about 1,474 acres, or approximately 6.0 percent of the City. The FEMA proposed 1% annual chance regulatory floodplain (100-year floodplain) covers about 1,441 acres, or approximately 5.9 percent of the City. In addition to the 100-year floodplains, stormwater has the potential to cause localized flooding.

The Fire Station on Webster Street, WRTA maintenance facility, Department of Environmental Protection building, electrical substation, and transfer station are located in the 100-year floodplain. The Department of Children and Families is located in the 500-year floodplain. Saint Vincent Hospital and the buildings adjacent to the hospital are impacted by stormwater flooding. There are approximately 925 buildings in the floodplain including all occupancies but mostly residential. Several roads experience flooding including Southgate Street, Quinsigamond Avenue, Hammond Street, Millbury Street along the Blackstone River, Southwest Cutoff (MA-20) under the Grafton Street overpass, Major Taylor Boulevard near the DCU Center, and Pelham Street. Additionally, railroad tracks and railroad bridges, sloped roadways along Belmont Street and low bridges along Cambridge Street are susceptible to flooding. The Green Island neighborhood area is also exposed to flooding. There are 18 structures listed on the National Register of Historic Places in the floodplain. According to EPA's Toxic Release Inventory (TRI) database, there are 116 facilities which contain hazardous materials in the 100-year floodplain. These facilities include but are not limited to solid waste collection, natural gas distribution, machine tool manufacturing, and electroplating. Table 24 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 City.

Table 24. Buildings in 100-Year Floodplain.

Building Type	Number of Buildings (Total in City)	Building Value (Total in City)
Single Family	350 (31399)	$156,557,947 ($13,989,054,910)
Multi-Family	331 (14496)	$507,203,805 ($23,767,111,740)
Commercial	166 (3203)	$489,293,764 ($10,363,149,842)
Agricultural	4 (72)	$690,914 ($22,837,164)
Educational	15 (372)	$569,758,136 ($7,450,820,493)
Government	19 (155)	$21,396,382 ($647,185,275)
Religious/Non-Profit	9 (239)	$42,958,717 ($863,742,992)
Industrial	26 (220)	$244,435,758 ($1,680,656,677)
Garage/Outbuilding	5 (46)	$85,322 ($916,384)
Total	**925 (50202)**	**$244,435,758 ($58,785,475,479)**

The population exposed to the 100-year floodplain is shown in Table 25. The column on the left shows the population in and around the floodplain (wherever the Census Block overlapped with the floodplain boundary) while the column on the right shows the total population numbers for the City. The population exposed to the flood hazard is older and has a lower household income than the City as a whole.

Table 25. Population Exposed to 100-Year Floodplain (2020 U.S. Census).

Demographics	Population in and Adjacent to Floodplain	Total Population
Population	12,389	206,518
Households	5,821	84,281
White	6,311 (50.9%)	110,158 (53.3%)
Black	1,667 (13.5%)	30,485 (14.8%)
American Indian	42 (0.3%)	1,019 (0.5%)

Demographics	Population in and Adjacent to Floodplain	Total Population
Asian	1,292 (10.4%)	14,688 (7.1%)
Pacific Islander	7 (0.1%)	81 (0.04%)
Other Race	1,679 (13.6%)	26,666 (12.9%)
Two or More Races	1,391 (11.2%)	23,421 (11.3%)
Hispanic or Latino:	3,091 (24.9%)	50,736 (24.6%)
Population under 18:	2,096 (16.9%)	38,511 (18.6%)
Population over 64:	2,401 (19.4%)	28,592 (13.8%)
Annual Income < $30K/year	2,222 (38.2%)	26,507 (31.5%)
Population in EJ Zone*:	12,232 (98.7%)	189,802 (91.9%)

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

The 100-year Floodplain (FEMA) with the City's critical facilities is shown in Figure 19. The Fire Station on Webster Street, WRTA maintenance facility, Dept. of Environmental Protection building, electrical substation, and transfer station are located in the 100-year floodplain.

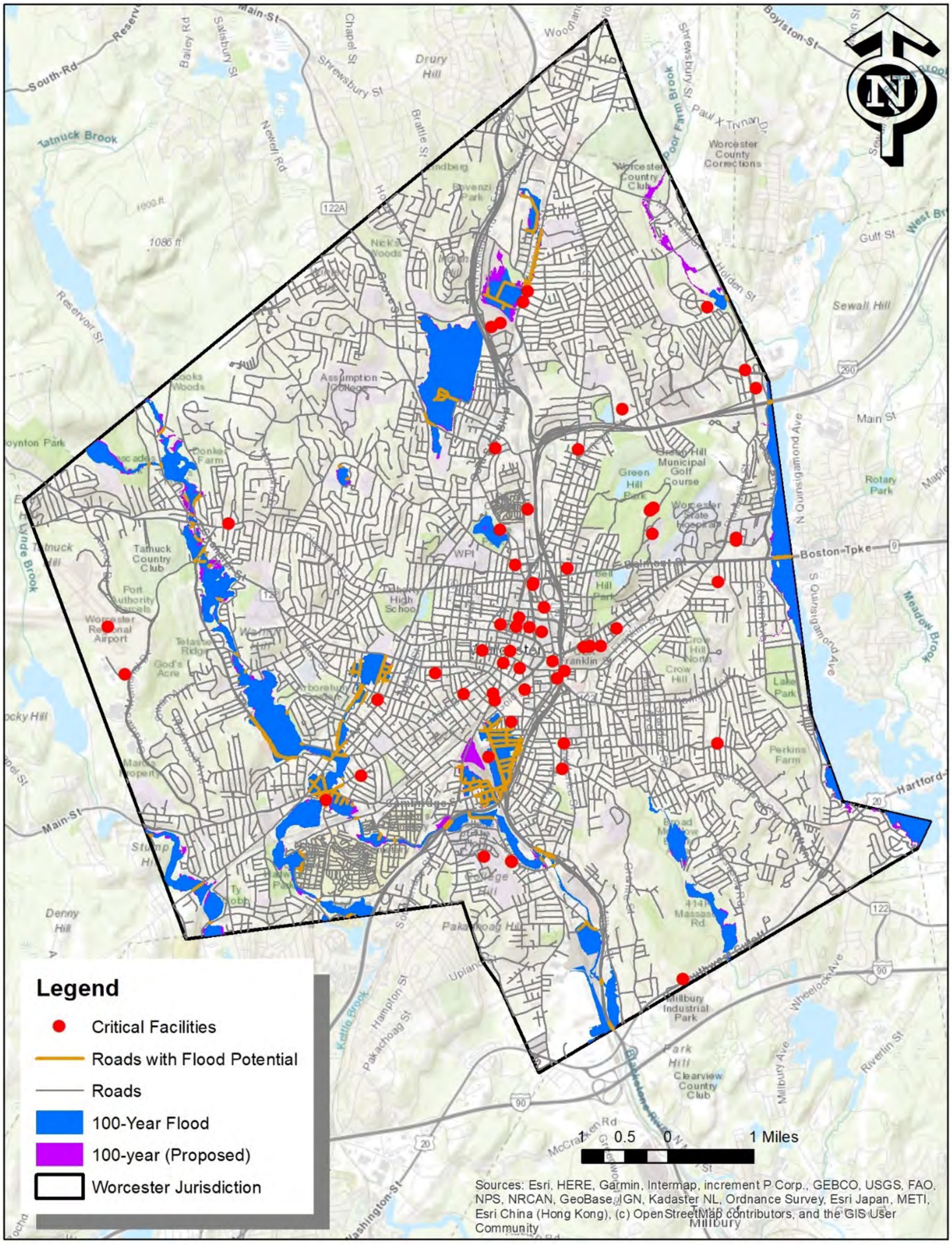


Figure 19. Worcester Critical Facilities and 100-Year Floodplain.

Built Environment Impacts

To identify built environment impacts to the City, FEMA's risk assessment software, Hazus, was implemented. Building footprint data and parcel data were 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 26. The City's AAL is calculated to be $5,332,000.

Table 26. Building Loss for the 100-Year Flood Scenario.

Loss Type	Residential ($Million)	Commercial ($Million)	Other Occupancy ($Million)	Total ($Million)
Building Loss	13.06	25.06	15.86	53.98
Content Loss	7.60	68.81	58.62	135.03
Business Inventory Loss	0.00	24.74	3.82	28.56
Business Income Loss	0.04	55.49	14.23	69.76
Business Relocation Loss	6.21	22.68	9.39	38.28
Rental Income Loss	5.22	16.51	1.42	23.15
Wage Loss	0.09	59.25	125.1	184.44
Total	**32.22**	**272.54**	**228.44**	**533.2**

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

Population Impacts

The City should be aware that senior and low-income segments of Worcester's population may be more vulnerable to hazard events due to a number of factors. Senior and low-income populations may be physically or financially unable to react and respond to a hazard event and require additional assistance. Access to information about the hazard event may be lacking, as well as access to transportation in the case of an evacuation. The location and construction quality of housing can also pose a significant risk. The City 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 over 3,000 displaced households and over 1,000 people seeking public shelter.

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

Environment Impacts

One of the major environmental impacts of a major flood would be the potential release of hazardous materials. According to EPA's Toxic Release Inventory (TRI) database, there are 116 facilities which contain hazardous materials in the 100-year floodplain.

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

Problem Statements for Flood

Table 27. Problem Statements Related to Flooding.

Assets	Problems Associated with Flood
People (including underserved communities and socially vulnerable populations)	• Older populations and lower income households in the floodplain may have difficulty evacuating. • The Green Island neighborhood experiences frequent and extreme cases of flooding, affecting numerous City residents.
Structures (including facilities, lifelines, and critical infrastructure)	• The City's areas of flood risk are associated with the Blackstone River, the Mill Brook conduit, the Blackstone Canal, and their tributaries. The Mill Brook conduit work in the 1980s/1990s reportedly addressed some flooding along the watercourse, but flooding still occurs. • The Fire Station on Webster Street, WRTA maintenance facility, Dept. of Environmental Protection building, electrical substation, and transfer station are exposed to the 100-year floodplain. • Approximately 925 buildings are in the floodplain including buildings of all occupancies.

Assets	Problems Associated with Flood
	• At least 17 flood and flash flood events were sufficiently severe to be included in the NCEI severe storm database, including damaging events in August 2020 and July 2021.
Systems (including networks and capabilities)	• Undersized culverts are a problem citywide. These can be found in many locations, from downtown areas to the less developed outer parts of the City. • Road closures may interrupt community systems including Southgate Street, Quinsigamond Avenue, Hammond Street, Millbury Street along the Blackstone River, Southwest Cutoff (MA-20) under the Grafton Street overpass, Major Taylor Boulevard near the DCU Center, and Pelham Street. Additionally, railroad tracks and railroad bridges, sloped roadways along Belmont Street and low bridges along Cambridge Street are susceptible to flooding. • The City is currently precluded from adopting higher regulatory standards to protect against flooding (must comply with State Building Code).
Natural, historic, and cultural resources	• There are 18 structures listed on the National Register of Historic Places in the floodplain.
Activities that have value to the community	• Road closures may disrupt community events.

Flooding from Dam Failure or Overtopping

A dam failure can cause severe flash flooding in the potential inundation area downstream, resulting in property damage, loss of life, destruction of infrastructure, environmental damage, and displacement of communities. Dam failure in Massachusetts is often the direct result of severe flooding, but may also be caused by insufficient maintenance, deterioration, landslides, or earthquake damage. Increases in precipitation and extreme storm events over time will result in increased risk of dam failure.

Description

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

Beaver dams are an additional dam-related concern in many rural communities, but they can occur in the suburban and undeveloped parts of Worcester. Beaver dams obstruct the flow of water and cause water levels to rise. Significant downstream flooding can occur if beaver dams break. Flooding can also occur upstream of beaver dams, though this type of flooding is addressed in the discussion about flooding earlier in the chapter.

Location

Heavy rainfall events occur regularly in Massachusetts. As a result, flooding affects nearly all of the communities in the Commonwealth, including Worcester. Numerous dams are located in and upstream of Worcester. In fact, at least 25 high hazard and significant hazard dams located in and upstream of Worcester could impact the City if they overtopped or breached. Table 28 provides information on the hazard type and ownership.

Table 28. Dam Locations, Owners, and Hazard Classes.

Dam Name	Location	Ownership Type	Owner	Hazard Class
Coes Reservoir Dam*	Worcester	Public	City of Worcester Department of Public Works & Parks	High
Cook's Pond Dam	Worcester	Private	Private Association or other non-profit	High
Green Hill Pond Dam*	Worcester	Public	City of Worcester Department of Public Works & Parks	High
Holden Reservoir #1*	Holden	Public	City of Worcester Department of Public Works & Parks	High

Dam Name	Location	Ownership Type	Owner	Hazard Class
Holden Reservoir #2*	Holden	Public	City of Worcester Department of Public Works & Parks	High
Kettle Brook Reservoir 1	Leicester	Public	City of Worcester Department of Public Works & Parks	High
Kettle Brook Reservoir 2	Leicester	Public	City of Worcester Department of Public Works & Parks	High
Lynde Brook Dam*	Leicester	Public	City of Worcester Department of Public Works & Parks	High
Lynde Brook Dike*	Leicester	Public	City of Worcester Department of Public Works & Parks	High
Patch Pond Dam*	Worcester	Public	City of Worcester Department of Public Works & Parks	High
Patch Reservoir Dam*	Worcester	Public	City of Worcester Department of Public Works & Parks	High
Quinsigamond Pond Dam	Worcester	Public	City of Worcester Conservation Commission	High
Smiths Pond Dam	Leicester	Private	Private	High
Bear Book Dam*	Worcester	Public	City of Worcester Department of Public Works & Parks	Significant
Bell Pond Dam	Worcester	Public	City of Worcester Department of Public Works & Parks	Significant
Coes Lower Pond Dam*	Worcester	Public	City of Worcester Department of Public Works & Parks	Significant
Curtis Ponds Dam	Worcester	Private	New England Power Co.	Significant
Duffy Mill Pond Dam		Private	Kettle Brook Lofts, LLC	Significant
Indian Lake Dam	Worcester	Public	MA Dept. of Transportation	Significant
Kiver Pond Dam	Worcester	Private	Private Association	Significant
Leesville Pond Dam	Worcester	Public	Town of Auburn	Significant
Old Cider Mill Pond Dam	Worcester	Public	City of Worcester Conservation Commission	Significant

Dam Name	Location	Ownership Type	Owner	Hazard Class
Parsons Reservoir Dam*	Worcester	Public	City of Worcester Conservation Commission	Significant
Salisbury Pond Dam	Worcester	Public	City of Worcester Department of Public Works & Parks	Significant
Smith Mill Pond Dam	Worcester	Public	City of Worcester Department of Public Works & Parks	Significant

*EAP was available for review

The City maintains EAPs for dams that are owned by the City and required to maintain EAPs. The general downstream inundation areas that may be subject to flooding due to dam failure are noted as follows, organized by watershed. These descriptions are meant to provide general locational characteristics. Dams without EAPs would also cause flooding downstream, but the areas may not have been mapped and are therefore not listed here.

Unnamed Brook:

- Green Hill Pond Dam: The inundation area extends downstream to the Madison Street area about two miles south of the dam, and includes residential and commercial areas. The Lincoln Square and Washington Square parts of downtown would be impacted.

Tatnuck Brook watershed and Middle River:

- Holden Reservoir #1: The inundation area extends downstream along Tatnuck Brook to its confluence with the Middle River and then another two miles along the Middle River; and includes thousands of residential and commercial properties. Holden Reservoir #2 and the other downstream impoundments and dams along the brook are in the inundation area.
- Holden Reservoir #2: The inundation area extends downstream along Tatnuck Brook to its confluence with the Middle River and then another two miles along the Middle River; and includes thousands of residential and commercial properties. The other downstream impoundments and dams along the brook are in the inundation area.
- Patch Reservoir Dam: The inundation area extends downstream to Coes Reservoir and includes mainly residential areas. The Patch Reservoir inundation area is within the Holden #1 and #2 inundation areas, as they are upstream.
- Patch Pond Dam: The inundation area extends downstream to Coes Reservoir and includes residential and commercial areas. The Patch Pond Dam inundation area is within the Holden #1 and #2 inundation areas, as they are upstream.

- Coes Reservoir Dam: The inundation area extends downstream to the confluence with the Middle River and includes residential and commercial areas. The inundation area is within the Holden #1 and #2 inundation areas, as they are upstream.
- Coes Lower Pond Dam: The inundation area extends downstream to the railroad crossing of the Middle River, and includes residential and commercial areas. The inundation area is within the Holden #1 and #2 inundation areas, as they are upstream.

Parsons Brook watershed:

- Parsons Reservoir Dam: The inundation area is complex and extends downstream to Kettle Brook and Curtis Ponds; and includes residential and commercial areas.

Bear Brook watershed:

- Bear Brook Dam: The inundation area extends downstream to Martin Luther King Jr. Boulevard and includes residential and commercial areas.

Lynd Brook and Kettle Brook watershed:

- Lynd Brook Dam and Dike: The inundation area extends downstream for many miles and includes thousands of residential and commercial properties.

Previous Occurrences

According to the previous edition of this plan, there have been no dam failures in Worcester. However, dams in neighboring towns have breached in the past. The previous edition of this plan notes that "nearly every dam along the French River was destroyed in 1955, which led to flooding in the Webster Square area of the City. Lynde Brook Dam in Leicester breached after two successive Hurricanes in 1876, which led to downstream flooding of Kettle Brook in Worcester."

Dams have been in the news frequently due to severe precipitation events occurring nationwide in the last few years. Events in the six New England states from 2022-2024 include the following:

- The Crosby Pond Dam, a significant hazard dam on Mill Brook, failed in May 2015. According to the Association of State Dam Safety Officials (ASDSO)[63], the uncontrolled release of the impoundment inundated a heavily traveled road. No one was injured, but the road was closed all day creating significant traffic delay issues.
- The Silica Pond Dam, a significant hazard dam in New Hampshire, was reported by ASDSO as having had a gate/valve failure in July 2022 that resulted in the release of the impoundment. This was not a catastrophic failure but the release of storage was caused by the deterioration and/or poor condition of the outlet valve.

[63] https://www.damsafety.org/incidents

- The George Schnopp Road Pond Dam in Hinsdale breached in October 2022. According to the Hinsdale Hazard Mitigation Plan (2024), significant damage did not occur downstream, but the experience underscored the challenges associated with dams. During the breach, five to ten million gallons of water was released rapidly to the downstream watercourse, flowing into Ashmere Lake. The Town responded with clearing and repair of George Schnopp Road, which was covered in debris and eroded partially by the flooding.
- Five dam failures were reported by ASDSO as occurring in Vermont on July 10, 2023 following a severe flood event. These included the Clarks Sawmill Dam, a low hazard dam on the Winooski River which fully failed; the Hands Mill Dam, a significant hazard dam on the Jail Branch River which fully failed; the Lyons Pond Dam, a low hazard dam on Burndt Meadow Brook which fully failed; the Quinn Lower Dam, a low hazard dam on Homer Stone Brook which fully failed; and the South Woodbury Pond Dam, a significant hazard dam on a tributary to Sabin Pond which partially breached. Several of these dams were reportedly remote and failure only discovered several days following the failure.
- A dam overtopped at Barrett Park Pond Dam in September 2023 in Leominster, resulting in downstream evacuations and emergency repairs. Floodwaters downstream caused damage to roads and properties.
- A partial dam breach on the Yantic River occurred in January 2024 in Bozrah, Connecticut, resulting in evacuations downstream in the Town of Bozrah and the City of Norwich.

Extent

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 EAPs. The state has three hazard classifications for dams:

1. 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.

2. 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.
3. Low Hazard Potential: Dams located where failure or improper operation may cause minimal property damage to others. Loss of life is not expected.

According to FEMA[64], hazard potential classification systems vary between certain states and federal agencies. However, the Massachusetts dam hazard classification system is consistent with the federal dam hazard classification system (Low, Significant, and High).

Owners of dams are required by DCR 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 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. City staff noted the importance of coordination between the City, dam owners, and the Office of Dam Safety for securing funding for dam inspections and repairs to ensure proper maintenance.

According to FEMA[64], the common dam failure modes include those in the following table. Any of these failure modes could result in an uncontrolled downstream release of water with potential downstream consequences.

Table 29. Dam Failure Modes.

Failure Type	Description
Seepage and Piping	Seepage and piping can cause internal erosion within the dam that can erode embankment or foundation materials and lead to dam failure. Evidence of piping is generally detected at the location of seepage discharge.

[64] https://www.fema.gov/sites/default/files/2020-08/fact-sheet_dam-awareness.pdf

Failure Type	Description
Overtopping (hydrologic failure)	Overtopping can cause erosion and head-cutting of embankment materials and can lead to dam failure.
Deformation	Deformation is caused by differential settlement; transverse or longitudinal cracking; or slope instability, slumps, or other slope failures. Deformation can provide a path for seepage through the dam and lead to failure. Low areas in the crest of the dam can make the dam more vulnerable to overtopping.
Liquefaction	Liquefaction can occur when the strength and stiffness of a saturated soil is reduced by earthquake shaking or other rapid loading. The weakened soil can cause the collapse of the dam.
Concrete failure	Concrete failure, structural cracking, broken masonry, and offsets at joints can lead to sudden failures.
Neglected maintenance and deterioration	Neglected maintenance and deterioration can leave a dam vulnerable to several failure modes: • Missing riprap can leave areas of an embankment unprotected and vulnerable to erosion from wave action or head-cutting during overtopping events. • Woody vegetation growing on a dam can interfere with effective dam safety monitoring. Uprooted trees can create large voids in the embankment, and roots can create preferred seepage paths, causing internal erosion problems. Vegetation can also block spillways. • Animal burrows in the embankment can cause preferred seepage paths. Livestock activity can damage embankment slopes and increase erosion potential. • Malfunctioning gates, conduits, or valves can reduce discharge capacity and cause the dam to overtop, which could lead to failure.
Other	Other problems that can leave a dam vulnerable to failure include outdated designs; hydraulically inadequate spillways; and damage from vandalism, cyber-attacks, or terrorism.

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, with the exception of flash flood warnings which can be issued only hours before a flood. 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 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.

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

Due to the pattern of meteorological conditions needed to cause serious flooding, it is unusual for a flood to occur without warning. Flash flooding, which occurs when excessive water fills either normally dry creeks or riverbeds or dramatically increases the water surface elevation on currently flowing creeks and rivers, can be less predictable. However, potential hazard areas can be warned in advance of potential flash-flooding danger. Flooding is more likely to occur due to a rainstorm when the soil is already wet and/or streams are already running high from recent previous rains.

At the present time, the NWS utilizes the flood advisory, watch, and warning products for dam-related hazards. Specific warnings are used as needed to augment these messages when a dam failure could occur. In Massachusetts, EAPs must include a “procedure for warning downstream residents if failure of the dam is imminent.” Therefore, the use of the word “imminent” is often incorporated into specific dam-related messages from local emergency managers. In Worcester, the City issues messages according to the approach outlined in its EAPs:

- Condition A – Urgent; dam failure is imminent or in progress: A dam failure is occurring or about to occur. This situation is also characteristics of flood discharges over the spillway that is causing downstream flooding or roads and buildings. An example observation to trigger Condition A is a headcut advancing upstream in a spillway.
- Condition B – Potential dam failure situation rapidly developing: For conditions that may lead to dam failure or flooding downstream. An example observation to trigger Condition B is observation of new seepage areas with cloudy water.
- Non-Failure Emergency Condition – For situations that are not typical, but have not yet threatened the operation of integrity of the dam. An example observation to trigger this condition is discharge over a secondary spillway.

The protocols from the EAPs that are described on this page are provided solely for informational purposes. For a potential dam overtopping or failure event, the EAP for the specific dam must be consulted. This hazard mitigation plan is not appropriate for emergency response related to dams.

The NWS[65] is reportedly in the process of developing alternative forecasting tools and processes that will enable River Forecast Center (RFC) and Weather Forecast Office (WFO) forecasters of different skill levels to evaluate the consequences of a potential dam failure in a relatively short period of time. This new project is designed to address the limitations of the current dam inventory data and dam break modeling approaches. Two goals should be achieved with this project: the first is to provide RFC and WFO forecasters access to quality-controlled, up-to-date dam inventory information; and the second goal is to develop a system that will integrate several dam break modeling approaches. Results from these approaches will assist forecasters in selecting the tool that could be most appropriate, given the length of time needed for execution, how quickly the results are needed, and the availability of data.

The dam classifications, modes of failure, and warning procedures outlined in this section are appropriate for the dams in Worcester and for dams that could affect Worcester; and are believed appropriate for future conditions. Response procedures in the EAPs can be revised during any of the routine updates to the EAPs.

Probability of Future Events

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

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

In light of the above, dam overtopping and failure is anticipated to be a greater risk in the future. This is believed to be the case if dam conditions are static. However, many dams are in need of maintenance, which can increase risks of failure in the future if these needs are not addressed.

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[65] https://www.weather.gov/owp/oh_hrl_hsmb_hydraulics_dam_break_analysis

Vulnerability Assessment

Exposure

At least 25 high hazard and significant hazard dams in and upstream of Worcester could impact the City. Table 28 provides information on the hazard type and ownership. This information was provided previously under *Location* and is included here for consistency with HHPD eligibility.

Table 30. Worcester Vicinity Dam Information.

Dam Name	Ownership Type	Owner	Hazard Type
Coes Reservoir Dam	Public	City of Worcester - Department of Public Works & Parks	High
Cook's Pond Dam	Private	Private Association or other non-profit	High
Green Hill Pond Dam	Public	City of Worcester - Department of Public Works & Parks	High
Holden Reservoir #1	Public	City of Worcester - Department of Public Works & Parks	High
Holden Reservoir #2	Public	City of Worcester - Department of Public Works & Parks	High
Kettle Brook Reservoir 1	Public	City of Worcester - Department of Public Works & Parks	High
Kettle Brook Reservoir 2	Public	City of Worcester - Department of Public Works & Parks	High
Lynde Brook Dam	Public	City of Worcester - Department of Public Works & Parks	High
Lynde Brook Dike	Public	City of Worcester - Department of Public Works & Parks	High
Patch Pond Dam	Public	City of Worcester - Department of Public Works & Parks	High
Patch Reservoir Dam	Public	City of Worcester - Department of Public Works & Parks	High
Quinsigamond Pond Dam	Public	City of Worcester - Conservation Commission	High
Smiths Pond Dam	Private	Private	High
Bear Book Dam	Public	City of Worcester - Department of Public Works & Parks	Significant
Bell Pond Dam	Public	City of Worcester - Department of Public Works & Parks	Significant

Dam Name	Ownership Type	Owner	Hazard Type
Coes Lower Pond Dam	Public	City of Worcester - Department of Public Works & Parks	Significant
Curtis Ponds Dam	Private	Private - New England Power Co.	Significant
Duffy Mill Pond Dam	Private	Private - Kettle Brook Lofts, LLC	Significant
Indian Lake Dam	Public	State - Dept. of Transportation	Significant
Kiver Pond Dam	Private	Private Association or other non-profit	Significant
Leesville Pond Dam	Public	Town of Auburn	Significant
Old Cider Mill Pond Dam	Public	City of Worcester - Conservation Commission	Significant
Parsons Reservoir Dam	Public	City of Worcester - Conservation Commission	Significant
Salisbury Pond Dam	Public	City of Worcester - Department of Public Works & Parks	Significant
Smith Mill Pond Dam	Public	Political Subdivision OR City of Worcester - Department of Public Works & Parks	Significant

To determine the exposure of these dams, the inundation maps were collected from each dam's EAP. These maps were digitized and integrated into a GIS where they were converted into an inundation depth using a high-resolution Digital Elevation Model (DEM). This inundation depth was used with the local inventory to determine exposure and loss shown in the next section.

Table 31 shows the dams with EAPs available to the City, the area of the inundation area resulting from a breach, and any critical facilities in the inundation areas. Several roads are also exposed to the dam inundation areas including Chandler's St., Park Ave., Highland St., Cambridge St., Main St., Stafford St., Belmont St., and Perry Ave. Parts of the rail line are also in the inundation areas.

Table 31. Critical Facilities Exposed to Dam Inundation Areas.

Dam	Area (Acres)	Critical Facilities Exposed
Bear Brook	31.1	• The Children's Garden at VNA • VNA Care Network
Coes Lower Pond	35.4	• Fire Station – Webster St.
Coes Reservoir	176.8	• Fire Station – Webster St.
Green Hill Pond	177.5	• Access Ambulance • DCU Center • St. Vincent Hospital • Tiny Explorers Early Childhood School Inc. • UMass Memorial Hospital

Dam	Area (Acres)	Critical Facilities Exposed
		• Worcester PD Back Up Servers • Worcester Police Dept. HQ • WRTA Administrative Building
Holden Reservoir #2	713.8	• Fire Station – Webster St.
Kendall Reservoir	780.9	• None
Lynde Brook Dam	738.3	• None
Lynde Brook Dike	385.5	• None
Parsons Reservoir	73.0	• None
Patch Pond	120.7	• None
Patch Reservoir	39.6	• None

The buildings, categorized by building occupancy, exposed to the dam inundation areas are shown in the tables below.

Table 32. Buildings in Bear Brook Dam Inundation Area.

Building Type	Number of Buildings in Dam Breach Inundation Area (Total in City)	Building Value in Dam Breach Inundation Area (Total in City)
Single Family	5 (31,399)	$2,721,037 ($13,989,054,910)
Multi-Family	21 (14,496)	$107,317,249 ($23,767,111,740)
Commercial	9 (3,203)	$23,998,914 ($10,363,149,842)
Agricultural	0 (72)	$0 ($22,837,164)
Educational	0 (372)	$0 ($7,450,820,493)
Government	0 (155)	$0 ($647,185,275)
Religious/Non-Profit	0 (239)	$0 ($863,742,992)
Industrial	0 (220)	$0 ($1,680,656,677)
Garage/Outbuilding	0 (46)	$0 ($916,384)
Total	**35 (50,202)**	**$134,037,201 ($58,785,475,479)**

Table 33. Buildings in Coes Lower Pond Dam Inundation Area.

Building Type	Number of Buildings in Dam Breach Inundation Area (Total in City)	Building Value in Dam Breach Inundation Area (Total in City)
Single Family	5 (31,399)	$755,563 ($13,989,054,910)
Multi-Family	12 (14,496)	$34,932,812 ($23,767,111,740)
Commercial	14 (3,203)	$25,475,409 ($10,363,149,842)
Agricultural	0 (72)	$0 ($22,837,164)

Building Type	Number of Buildings in Dam Breach Inundation Area (Total in City)	Building Value in Dam Breach Inundation Area (Total in City)
Educational	0 (372)	$0 ($7,450,820,493)
Government	1 (155)	$2,058,531 ($647,185,275)
Religious/Non-Profit	0 (239)	$0 ($863,742,992)
Industrial	1 (220)	$5,648,899 ($1,680,656,677)
Garage/Outbuilding	0 (46)	$0 ($916,384)
Total	**33 (50,202)**	**$68,871,214 ($58,785,475,479)**

Table 34. Buildings in Coes Reservoir Pond Dam Inundation Area.

Building Type	Number of Buildings in Dam Breach Inundation Area (Total in City)	Building Value in Dam Breach Inundation Area (Total in City)
Single Family	42 (31,399)	$19,827,458 ($13,989,054,910)
Multi-Family	70 (14,496)	$147,286,341 ($23,767,111,740)
Commercial	59 (3,203)	$110,902,871 ($10,363,149,842)
Agricultural	0 (72)	$0 ($22,837,164)
Educational	2 (372)	$12,627,528 ($7,450,820,493)
Government	2 (155)	$2,176,929 ($647,185,275)
Religious/Non-Profit	3 (239)	$4,248,129 ($863,742,992)
Industrial	8 (220)	$18,520,051 ($1,680,656,677)
Garage/Outbuilding	0 (46)	$0 ($916,384)
Total	**186 (50,202)**	**$315,589,307 ($58,785,475,479)**

Table 35. Buildings in Green Hill Pond Dam Inundation Area.

Building Type	Number of Buildings in Dam Breach Inundation Area (Total in City)	Building Value in Dam Breach Inundation Area (Total in City)
Single Family	17 (31,399)	$5,428,930 ($13,989,054,910)
Multi-Family	48 (14,496)	$700,697,149 ($23,767,111,740)
Commercial	63 (3,203)	$922,413,169 ($10,363,149,842)
Agricultural	0 (72)	$0 ($22,837,164)
Educational	0 (372)	$0 ($7,450,820,493)
Government	1 (155)	$15,084,762 ($647,185,275)
Religious/Non-Profit	7 (239)	$22,709,358 ($863,742,992)
Industrial	3 (220)	$28,104,261 ($1,680,656,677)
Garage/Outbuilding	0 (46)	$0 ($916,384)

Building Type	Number of Buildings in Dam Breach Inundation Area (Total in City)	Building Value in Dam Breach Inundation Area (Total in City)
Total	**139 (50,202)**	**$1,694,437,629 ($58,785,475,479)**

Table 36. Buildings in Holden Reservoir Dam #1 Inundation Area.

Building Type	Number of Buildings in Dam Breach Inundation Area (Total in City)	Building Value in Dam Breach Inundation Area (Total in City)
Single Family	423 (31,399)	$188,731,961 ($13,989,054,910)
Multi-Family	175 (14,496)	$360,295,619 ($23,767,111,740)
Commercial	113 (3,203)	$341,833,478 ($10,363,149,842)
Agricultural	1 (72)	$80,933 ($22,837,164)
Educational	8 (372)	$496,717,056 ($7,450,820,493)
Government	9 (155)	$9,111,401 ($647,185,275)
Religious/Non-Profit	9 (239)	$41,593,231 ($863,742,992)
Industrial	13 (220)	$33,738,769 ($1,680,656,677)
Garage/Outbuilding	0 (46)	$0 ($916,384)
Total	**751 (50,202)**	**$1,472,102,447 ($58,785,475,479)**

Table 37. Buildings in Holden Reservoir Dam #2 Inundation Area.

Building Type	Number of Buildings in Dam Breach Inundation Area (Total in City)	Building Value in Dam Breach Inundation Area (Total in City)
Single Family	448 (31,399)	$204,316,490 ($13,989,054,910)
Multi-Family	201 (14,496)	$373,598,327 ($23,767,111,740)
Commercial	104 (3,203)	$328,086,415 ($10,363,149,842)
Agricultural	2 (72)	$144,022 ($22,837,164)
Educational	7 (372)	$323,075,688 ($7,450,820,493)
Government	8 (155)	$9,964,749 ($647,185,275)
Religious/Non-Profit	8 (239)	$36,667,049 ($863,742,992)
Industrial	13 (220)	$33,738,769 ($1,680,656,677)
Garage/Outbuilding	1 (46)	$9,615 ($916,384)
Total	**792 (50,202)**	**$1,309,601,124 ($58,785,475,479)**

Table 38. Buildings in Lynde Brook Dam Inundation Area.

Building Type	Number of Buildings in Dam Breach Inundation Area (Total in City)	Building Value in Dam Breach Inundation Area (Total in City)
Single Family	54 (31,399)	$21,063,920 ($13,989,054,910)
Multi-Family	17 (14,496)	$28,103,261 ($23,767,111,740)
Commercial	22 (3,203)	$81,934,993 ($10,363,149,842)
Agricultural	1 (72)	$27,821 ($22,837,164)
Educational	7 (372)	$434,627,424 ($7,450,820,493)
Government	0 (155)	$0 ($647,185,275)
Religious/Non-Profit	0 (239)	$0 ($863,742,992)
Industrial	4 (220)	$26,548,874 ($1,680,656,677)
Garage/Outbuilding	0 (46)	$0 ($916,384)
Total	**105 (50,202)**	**$592,306,292 ($58,785,475,479)**

Table 39. Buildings in Lynde Brook Dike Inundation Area.

Building Type	Number of Buildings in Dam Breach Inundation Area (Total in City)	Building Value in Dam Breach Inundation Area (Total in City)
Single Family	111 (31,399)	$43,309,803 ($13,989,054,910)
Multi-Family	17 (14,496)	$12,595,831 ($23,767,111,740)
Commercial	26 (3,203)	$78,612,643 ($10,363,149,842)
Agricultural	0 (72)	$0 ($22,837,164)
Educational	0 (372)	$0 ($7,450,820,493)
Government	0 (155)	$0 ($647,185,275)
Religious/Non-Profit	1 (239)	$990,544 ($863,742,992)
Industrial	2 (220)	$4,100,628 ($1,680,656,677)
Garage/Outbuilding	0 (46)	$0 ($916,384)
Total	**157 (50,202)**	**$139,609,449 ($58,785,475,479)**

Table 40. Buildings in Parsons Reservoir Dam Inundation Area.

Building Type	Number of Buildings in Dam Breach Inundation Area (Total in City)	Building Value in Dam Breach Inundation Area (Total in City)
Single Family	72 (31,399)	$28,125,318 ($13,989,054,910)
Multi-Family	15 (14,496)	$10,666,701 ($23,767,111,740)
Commercial	8 (3,203)	$33,357,056 ($10,363,149,842)
Agricultural	0 (72)	$0 ($22,837,164)

Building Type	Number of Buildings in Dam Breach Inundation Area (Total in City)	Building Value in Dam Breach Inundation Area (Total in City)
Educational	0 (372)	$0 ($7,450,820,493)
Government	0 (155)	$0 ($647,185,275)
Religious/Non-Profit	1 (239)	$990,544 ($863,742,992)
Industrial	1 (220)	$2,050,314 ($1,680,656,677)
Garage/Outbuilding	0 (46)	$0 ($916,384)
Total	**97 (50,202)**	**$75,189,933 ($58,785,475,479)**

Table 41. Buildings in Patch Pond Dam Inundation Area.

Building Type	Number of Buildings in Dam Breach Inundation Area (Total in City)	Building Value in Dam Breach Inundation Area (Total in City)
Single Family	17 (31,399)	$6,515,045 ($13,989,054,910)
Multi-Family	0 (14,496)	$0 ($23,767,111,740)
Commercial	3 (3,203)	$969,383 ($10,363,149,842)
Agricultural	0 (72)	$0 ($22,837,164)
Educational	0 (372)	$0 ($7,450,820,493)
Government	0 (155)	$0 ($647,185,275)
Religious/Non-Profit	0 (239)	$0 ($863,742,992)
Industrial	0 (220)	$0 ($1,680,656,677)
Garage/Outbuilding	0 (46)	$0 ($916,384)
Total	**20 (50,202)**	**$7,484,428 ($58,785,475,479)**

Table 42. Buildings in Patch Reservoir Dam Inundation Area.

Building Type	Number of Buildings in Dam Breach Inundation Area (Total in City)	Building Value in Dam Breach Inundation Area (Total in City)
Single Family	61 (31,399)	$22,107,675 ($13,989,054,910)
Multi-Family	0 (14,496)	$0 ($23,767,111,740)
Commercial	0 (3,203)	$0 ($10,363,149,842)
Agricultural	0 (72)	$0 ($22,837,164)
Educational	0 (372)	$0 ($7,450,820,493)
Government	0 (155)	$0 ($647,185,275)
Religious/Non-Profit	0 (239)	$0 ($863,742,992)
Industrial	0 (220)	$0 ($1,680,656,677)
Garage/Outbuilding	0 (46)	$0 ($916,384)

Building Type	Number of Buildings in Dam Breach Inundation Area (Total in City)	Building Value in Dam Breach Inundation Area (Total in City)
Total	**61 (50,202)**	**$22,107,675 ($58,785,475,479)**

The population exposed to dam breach is shown in Table 43. The column on the left shows the population in and around the dam breach areas (wherever the Census Block overlapped with the inundation boundary) while the column on the right shows the total population numbers for the City. The population exposed has more households with a lower income, a high environmental justice population, a high Hispanic or Latino population, and an older population.

Table 43. Population Exposed to Dam Breach (2020 U.S. Census).

Demographics	Population in and Adjacent to Floodplain	Total Population
Population	19,733	206,518
Households	8,637	84,281
White	9,363 (47.4%)	110,158 (53.3%)
Black	2,918 (14.8%)	30,485 (14.8%)
American Indian	103 (0.5%)	1,019 (0.5%)
Asian	1,817 (9.2%)	14,688 (7.1%)
Pacific Islander	6 (0.1%)	81 (0.04%)
Other Race	2,950 (14.9%)	26,666 (12.9%)
Two or More Races	2,576 (13.1%)	23,421 (11.3%)
Hispanic or Latino:	5,853 (29.7%)	50,736 (24.6%)
Population under 18:	4,035 (20.4%)	38,511 (18.6%)
Population over 64:	3,235 (16.4%)	28,592 (13.8%)
Annual Income < $30K/year	3,298 (38.2%)	26,507 (31.5%)
Population in EJ Zone*:	19,538 (98.7%)	189,802 (91.9%)

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

The dam breach inundation areas with the City's critical facilities is shown in Figure 20. Table 31 provides the names of the critical facilities exposed.

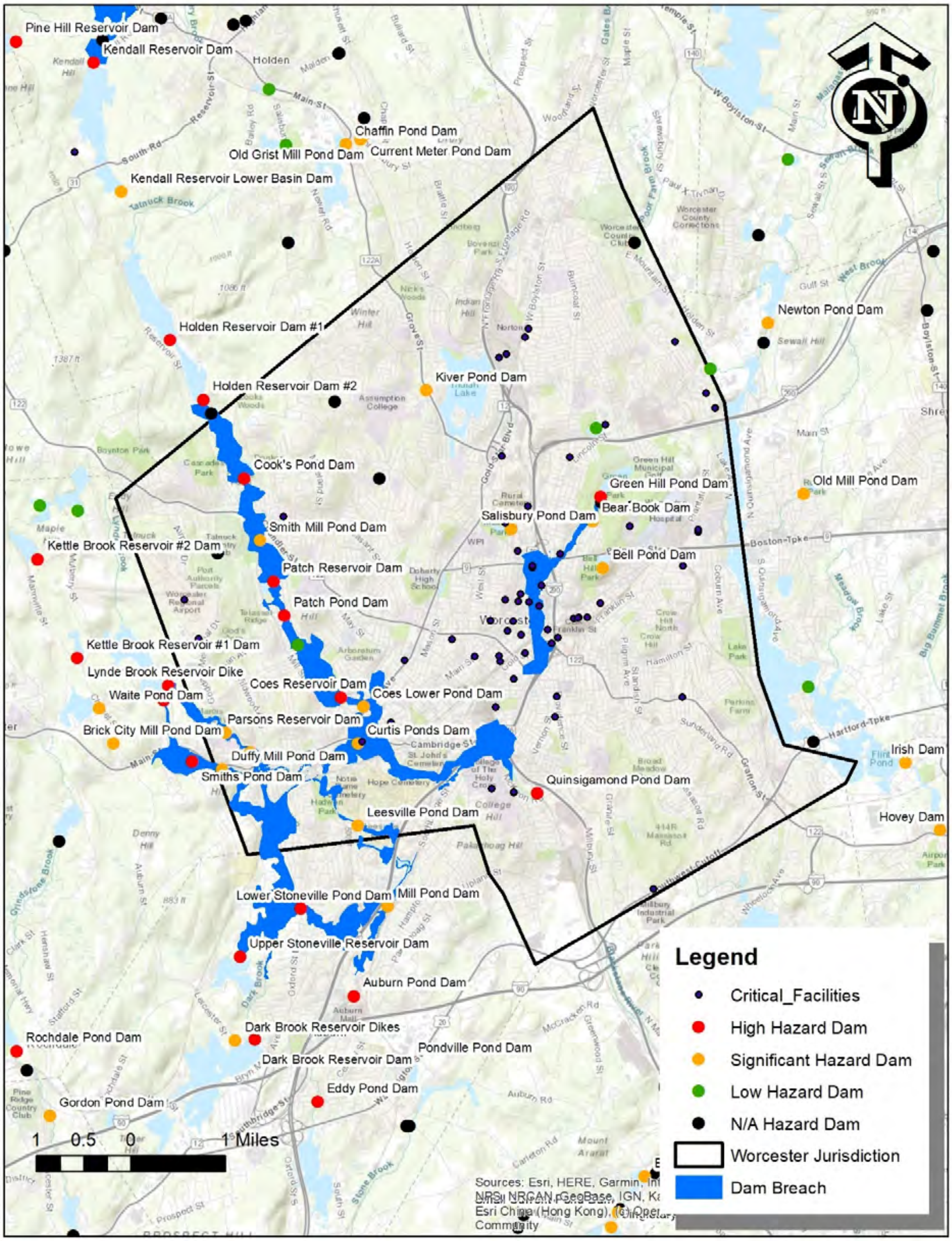


Figure 20. Worcester Critical Facilities and Dam Breach Inundation Area.

Built Environment Impacts

To identify built environment impacts to the City, FEMA's risk assessment software, Hazus, was implemented. Building footprint data and parcel data was used to update the model while the dam inundation was also integrated into the software. The economic loss results for the dam breach events are shown in the tables below. The City's AAL is calculated to be $3,900.

Table 44. Building Impacts from Bear Brook Dam Inundation.

Building Type	Number of Buildings Impacted	Building Losses	Content Losses	Inventory Losses
Single Family	2	$268,643	$149,633	$0
Multi-Family	15	$3,897,505	$2,523,446	$0
Commercial	6	$475,969	$145	$534,499
Agricultural	0	$0	$0	$0
Educational	0	$0	$0	$0
Government	0	$0	$0	$0
Religious/Non-Profit	0	$0	$0	$0
Industrial	0	$0	$0	$0
Garage/Outbuilding	0	$0	$0	$0
Total	**23**	**$4,642,117**	**$2,673,224**	**$534,499**

Table 45. Building Impacts from Coes Lower Pond Dam Inundation.

Building Type	Number of Buildings Impacted	Building Losses	Content Losses	Inventory Losses
Single Family	5	$142,258	$82,942	$0
Multi-Family	10	$5,998,078	$4,243,413	$0
Commercial	7	$1,086,343	$105	$2,070,325
Agricultural	0	$0	$0	$0
Educational	0	$0	$0	$0
Government	1	$35,375	$10	$0
Religious/Non-Profit	0	$0	$0	$0
Industrial	1	$1,540,635	$81	$504,795
Garage/Outbuilding	0	$0	$0	$0
Total	**24**	**$8,802,689**	**$4,326,551**	**$2,575,120**

Table 46. Building Impacts from Coes Reservoir Dam Inundation.

Building Type	Number of Buildings Impacted	Building Losses	Content Losses	Inventory Losses
Single Family	34	$6,270,177	$3,458,997	$0
Multi-Family	66	$53,534,993	$34,434,025	$0
Commercial	53	$18,166,612	$2,537	$24,276,856
Agricultural	0	$0	$0	$0
Educational	2	$1,136,478	$120	$0
Government	2	$341,566	$186	$0
Religious/Non-Profit	2	$243,583	$192	$0
Industrial	8	$6,043,751	$687	$1,718,009
Garage/Outbuilding	0	$0	$0	$0
Total	**167**	**$85,737,160**	**$37,896,744**	**$25,994,865**

Table 47. Building Impacts from Green Hill Pond Dam Inundation.

Building Type	Number of Buildings Impacted	Building Losses	Content Losses	Inventory Losses
Single Family	15	$2,046,482	$1,130,775	$0
Multi-Family	29	$81,782,027	$51,257,903	$0
Commercial	40	$46,397,267	$14,454,507	$15,255,154
Agricultural	0	$0	$0	$0
Educational	0	$0	$0	$0
Government	0	$0	$0	$0
Religious/Non-Profit	0	$0	$0	$0
Industrial	2	$3,771,261	$122	$1,096,078
Garage/Outbuilding	0	$0	$0	$0
Total	**86**	**$133,997,037**	**$66,843,307**	**$16,351,232**

Table 48. Building Impacts from Holden Reservoir Dam #1 Inundation.

Building Type	Number of Buildings Impacted	Building Losses	Content Losses	Inventory Losses
Single Family	349	$90,380,358	$47,362,211	$0
Multi-Family	142	$111,822,728	$69,357,042	$0
Commercial	101	$52,201,137	$5,399	$50,355,064
Agricultural	0	$0	$0	$0
Educational	8	$280,460,771	$755	$0

Building Type	Number of Buildings Impacted	Building Losses	Content Losses	Inventory Losses
Government	9	$2,897,187	$782	$0
Religious/Non-Profit	3	$1,824,678	$176	$0
Industrial	13	$11,984,656	$1,108	$3,238,352
Garage/Outbuilding	0	$0	$0	$0
Total	**625**	**$551,571,515**	**$116,727,473**	**$53,593,416**

Table 49. Building Impacts from Holden Reservoir Dam #2 Inundation.

Building Type	Number of Buildings Impacted	Building Losses	Content Losses	Inventory Losses
Single Family	325	$75,799,142	$40,580,285	$0
Multi-Family	119	$105,320,920	$64,997,886	$0
Commercial	76	$45,596,743	$4,107	$53,412,564
Agricultural	0	$0	$0	$0
Educational	5	$59,765,711	$454	$0
Government	7	$3,308,625	$664	$0
Religious/Non-Profit	1	$611,919	$100	$0
Industrial	11	$7,499,647	$665	$2,095,274
Garage/Outbuilding	0	$0	$0	$0
Total	**544**	**$297,902,707**	**$105,584,161**	**$55,507,838**

Table 50. Building Impacts from Lynde Brook Dike Inundation.

Building Type	Number of Buildings Impacted	Building Losses	Content Losses	Inventory Losses
Single Family	30	$6,276,222	$3,290,594	$0
Multi-Family	11	$8,097,422	$5,218,579	$0
Commercial	20	$18,618,199	$1,101	$21,716,456
Agricultural	1	$5,117	$64	$20,103
Educational	5	$29,557,794	$240	$0
Government	0	$0	$0	$0
Religious/Non-Profit	0	$0	$0	$0
Industrial	0	$0	$0	$0
Garage/Outbuilding	0	$0	$0	$0
Total	**67**	**$62,554,754**	**$8,510,578**	**$21,736,559**

Table 51. Building Impacts from Lynde Brook Dike Inundation.

Building Type	Number of Buildings Impacted	Building Losses	Content Losses	Inventory Losses
Single Family	98	$16,923,162	$9,277,600	$0
Multi-Family	13	$2,310,355	$1,444,829	$0
Commercial	23	$15,697,401	$1,063	$18,388,986
Agricultural	0	$0	$0	$0
Educational	0	$0	$0	$0
Government	0	$0	$0	$0
Religious/Non-Profit	0	$0	$0	$0
Industrial	2	$1,496,667	$201	$426,166
Garage/Outbuilding	0	$0	$0	$0
Total	**136**	**$36,427,585**	**$10,723,693**	**$18,815,152**

Table 52. Building Impacts from Parsons Reservoir Dam Inundation.

Building Type	Number of Buildings Impacted	Building Losses	Content Losses	Inventory Losses
Single Family	45	$4,457,696	$2,536,587	$0
Multi-Family	11	$1,210,795	$761,649	$0
Commercial	4	$1,165,490	$59	$1,648,240
Agricultural	0	$0	$0	$0
Educational	0	$0	$0	$0
Government	0	$0	$0	$0
Religious/Non-Profit	0	$0	$0	$0
Industrial	0	$0	$0	$0
Garage/Outbuilding	0	$0	$0	$0
Total	**60**	**$6,833,981**	**$3,298,295**	**$1,648,240**

Table 53. Building Impacts from Patch Pond Dam Inundation.

Building Type	Number of Buildings Impacted	Building Losses	Content Losses	Inventory Losses
Single Family	45	$4,457,696	$2,536,587	$0
Multi-Family	11	$1,210,795	$761,649	$0
Commercial	4	$1,165,490	$59	$1,648,240
Agricultural	0	$0	$0	$0
Educational	0	$0	$0	$0

Building Type	Number of Buildings Impacted	Building Losses	Content Losses	Inventory Losses
Government	0	$0	$0	$0
Religious/Non-Profit	0	$0	$0	$0
Industrial	0	$0	$0	$0
Garage/Outbuilding	0	$0	$0	$0
Total	**60**	**$6,833,981**	**$3,298,295**	**$1,648,240**

Table 54. Building Impacts from Patch Pond Dam Inundation.

Building Type	Number of Buildings Impacted	Building Losses	Content Losses	Inventory Losses
Single Family	12	$1,331,749	$747,972	$0
Multi-Family	0	$0	$0	$0
Commercial	2	$64,920	$68	$179,096
Agricultural	0	$0	$0	$0
Educational	0	$0	$0	$0
Government	0	$0	$0	$0
Religious/Non-Profit	0	$0	$0	$0
Industrial	0	$0	$0	$0
Garage/Outbuilding	0	$0	$0	$0
Total	**14**	**$1,396,669**	**$748,040**	**$179,096**

Table 55. Building Impacts from Patch Reservoir Dam Inundation.

Building Type	Number of Buildings Impacted	Building Losses	Content Losses	Inventory Losses
Single Family	51	$6,526,034	$3,625,521	$0
Multi-Family	0	$0	$0	$0
Commercial	0	$0	$0	$0
Agricultural	0	$0	$0	$0
Educational	0	$0	$0	$0
Government	0	$0	$0	$0
Religious/Non-Profit	0	$0	$0	$0
Industrial	0	$0	$0	$0
Garage/Outbuilding	0	$0	$0	$0
Total	**51**	**$6,526,034**	**$3,625,521**	**$0**

Climate change may increase the probability and magnitude of impacts to the built environment if a breach occurs.

Population Impacts

The City should be aware that senior and low-income segments of Worcester'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. The dam inundation areas have high percentages of these vulnerable populations including those in Environmental Justice areas. Access to information about the hazard event may be lacking, as well as access to transportation in the case of an evacuation. The location and construction quality of housing can also pose a significant risk. The City should be aware of the potential needs of residents within these population segments in the event of a hazard occurrence.

Climate change will increase the probability and magnitude of dam inundation impacts to the population if a breach occurs. Future inundation areas may be larger than the current modeled scenarios and new development should consider these projected conditions. Vulnerable populations should be considered when development near the current dam breach inundation areas is planned.

Environment Impacts

One of the major environmental impacts of a major flood would be the potential release of hazardous materials. According to EPA's Toxic Release Inventory (TRI) database, there are 172 facilities which contain hazardous materials in the dam breach area.

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

Problem Statements for Flooding from Dam Failure and Overtopping

Table 56. Problem Statements Related to Dam Failure and Overtopping.

Assets	Problems Associated with Dam Failure and Overtopping
People (including underserved communities and socially vulnerable populations)	• Older and lower income populations in the potential downstream inundation area may have difficulty evacuating, particularly in a short time frame.

Assets	Problems Associated with Dam Failure and Overtopping
Structures (including facilities, lifelines, and critical infrastructure)	• Local officials sometimes do not routinely receive copies and updates of EAPs for privately owned dams. Without these documents, it is harder for emergency personnel to characterize the potential downstream risks and prepare for a potential breach event. • When engineered, dam spillways were often designed to pass a discharge for a particular historic storm recurrence interval. As the frequency and magnitude of precipitation events changes, these spillways are becoming undersized relative to their design standard which places downstream areas at increased risk of experiencing inundation from a dam failure.
Systems (including networks and capabilities)	• There are several roads which may be impacted by a dam breach impacting City capabilities to respond to events.
Natural, historic, and cultural resources	• According to EPA's Toxic Release Inventory (TRI) database, 172 facilities that contain hazardous materials are located in the dam breach area.
Activities that have value to the community	• Several road closures may disrupt community 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. The impacts from high winds are the primary concern of this section.

Description

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

Hurricane season runs from June 1 to November 30. In New England, these storms are most likely to occur in August, September, and the first half of October. The ResilientMass Plan notes that this is due in large part to the fact that it takes a considerable amount of time for the waters south of Long Island to warm to the temperature necessary to sustain the storms this far north. Also, as the region progresses into the fall months, the upper-level jet stream steering winds might flow from the Great Lakes southward to the Gulf States and then back northward up the eastern seaboard. This pattern is conducive for capturing a tropical system over the Bahamas and accelerating it northward.

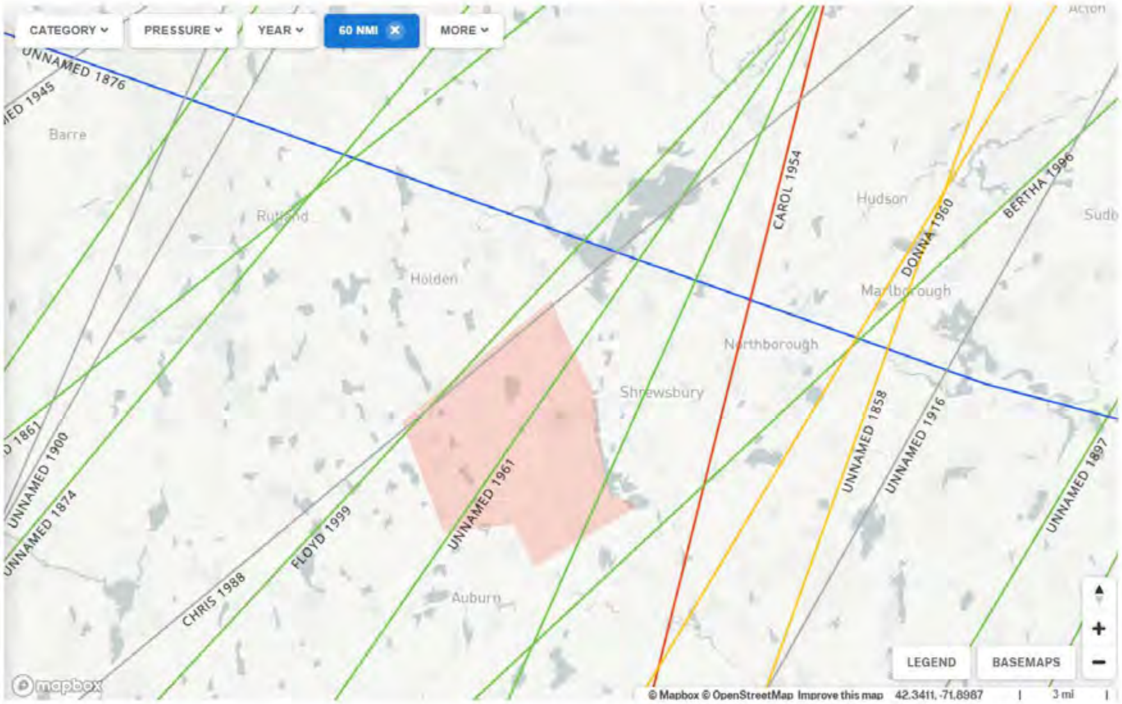
Location

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

Previous Occurrences

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

Historical Tropical Storm Tracks in the City of Worcester



Graphic courtesy of NOAA

A number of infamous tropical storms and hurricanes have passed near Worcester since recordkeeping began, including Hurricane Carol of 1954 and Donna of 1960; both of these storms were severe wind events for Worcester. Hurricane Bertha of 1996 passed close to the southeast edge of the City and caused some flooding. Named storms Chris (1988) and Floyd (1999) traveled along the northwest edge of the City, and unnamed storms of 1894 and 1961 crossed through the City. None of these storms caused significant damage in Worcester, though wind and precipitation impacts varied somewhat from neighborhood to neighborhood.

Figure 21. Historical Tropical Storm Tracks In Worcester.

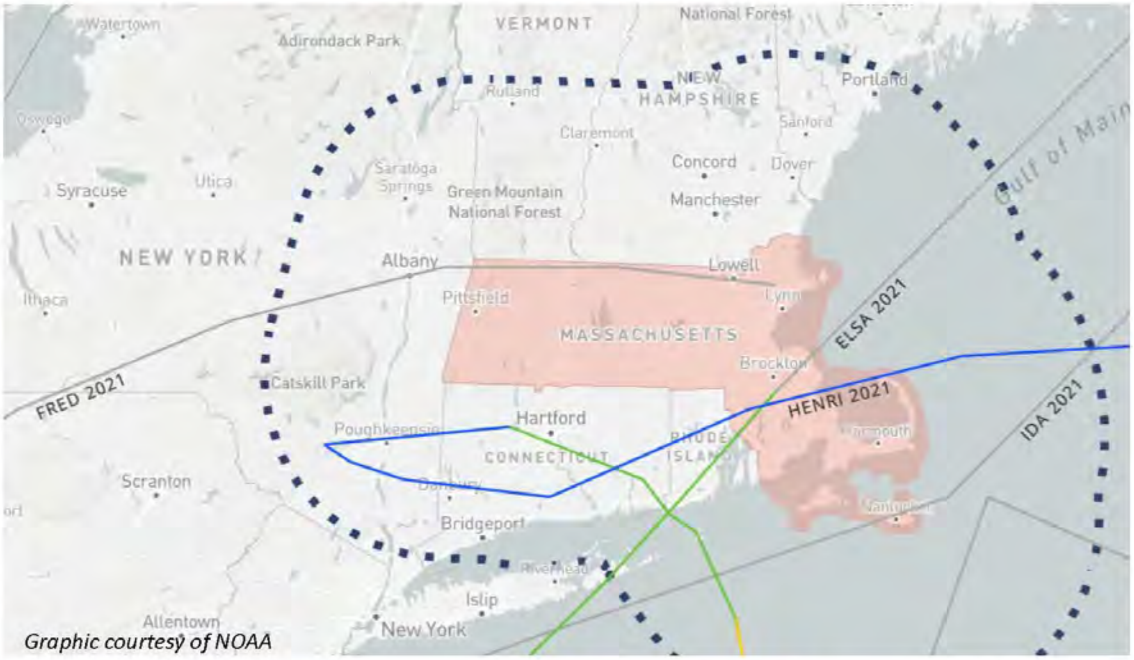
As noted elsewhere, this Plan update relies primarily on a ten-year lookback (2014 through 2024) ending with the date of plan development. During that ten-year period, only one Massachusetts emergency declaration (Storm Lee of September 2023) was associated with a tropical system. Seven tropical storm and hurricane events appeared in the NCEI inventory for Worcester County for the last ten years:

- September 21, 2017: Named storm Jose formed over the Tropical Atlantic, moving west and growing to become a Major Hurricane. Jose passed north of the Leeward Islands, then turned on a northward path north of the Dominican Republic. As he moved north, Jose diminished to a Tropical Storm during Tuesday the 19th and then stalled about 150 miles southeast of Nantucket. The storm then slowly drifted south by Friday the 22nd and started to dissipate. Jose brought strong wind gusts and heavy downpours, primarily to the islands and south coasts of Massachusetts.
- October 29, 2017: The remnants of Tropical Storm Phillipe merged with a mid-latitude system approaching the U.S. East Coast. This created an area of low pressure that moved north from the Carolinas through New York State on the 29th. The low swung a cold front through Southern New England during the early morning of the 30th. The combined system generated strong to damaging winds. Tropical moisture flowing north ahead of the cold front contributed to heavy downpours with one to five inches of rain reported.
- October 11, 2018: The remnants of Hurricane Michael moved up the East Coast, merged with an east-moving cold front, bringing up to five inches of rain to Massachusetts. The highest amounts occurred over Cape Cod and the Islands. The remnants also brought strong wind gusts to Central Massachusetts.
- August 4, 2020: Tropical Storm Isaias tracked northeast from the eastern Carolinas across the mid-Hudson Valley and into New England. The center of the storm passed close to Albany, NY on August 4th. This storm brought tropical storm force winds and moderate rainfall to western Massachusetts through the period. These winds caused widespread damage with numerous reports of downed trees and wires across Massachusetts. There was scattered, but costly damage in northern Worcester County.
- July 9, 2021: Tropical Storm Elsa made landfall in Rhode Island on Friday morning before moving into the Gulf of Maine. It interacted with a stalled frontal boundary and brought widespread heavy rainfall of 2 to 3.5 inches and gusty winds along the south coast, which caused scattered tree damage.
- August 19, 2021: The remnants of Tropical Storm Fred moved across Southern New England producing heavy rain, gusty winds, and two tornadoes - one that moved from northeast Connecticut into Worcester County and another in central Worcester County.
- August 23, 2021: Tropical Storm Henri made landfall in southwest Rhode Island around noon on August 22nd, then moved slowly northwestward and westward across northern Connecticut and

> weakened. Henri brought strong wind gusts and flash flooding. The worst flash flooding occurred in northeast Connecticut. As the remnants of Henri moved eastward across southern New England on August 23rd, it spawned three tornadoes and a waterspout in MA and also it caused some renewed flooding. The highest rainfall totals over the two-day period ranged from 5 to 6 inches in Hartford and Tolland Counties in northern Connecticut and in Franklin, Hampshire, and Hampden Counties in Massachusetts.

Four of the above NCEI-listed storms from the past decade were similarly listed in the *Previous Occurrences* section for flood risk (Tropical Storms Phillipe, Elsa, Fred, and Ida) because their flood impacts in Worcester were reported to NCEI. Overall, Worcester has been significantly impacted by tropical and post-tropical storm systems in recent years, despite none of these recent storms tracking sufficiently close to the City to appear on the map on the previous page. To help illustrate the point that severe flooding can occur – and has often occurred – from storms tracking elsewhere in Massachusetts, the storm tracks of the 2021 hurricane season are illustrated on the following graphic.

Impacts of the 2021 Hurricane Season on Massachusetts



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

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

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

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

Figure 22. Tracks for Tropical Storms that Impacted Massachusetts 2021.

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

Table 57. USDA Disasters Events That Refer to Tropical Storms.

Year	Event	Event "Begin Dates"
2021	Hurricanes, Typhoons, Tropical Storms (Elsa)	7/9/2021
2020	Wind, High Winds, Hurricanes, Typhoons, Tropical Storms (Isaias)	8/4/2020

Tropical storm activity is not typically tracked in USDA data sets. Their inclusion in the USDA dataset implies that the impacts of storms Elsa (2021) and Isaias (2020) were notable in Worcester County.

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 58. Saffir-Simpson Scale.

Saffir-Simpson Hurricane Wind Scale

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

Source: National Hurricane Center, NOAA

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

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

Probability of Future Events

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

Some researchers have suggested that the intensity of tropical cyclones has increased over the last 40 years, with some believing that there is a connection between this increase in intensity and climate change. While most climate simulations agree that greenhouse warming enhances the frequency and intensity of tropical storms, models of the climate system are still limited by resolution and computational ability. Given the history of major storms and the possibility of increased frequency and intensity of tropical storms due to climate change, it is prudent to expect that there will be hurricanes impacting Worcester 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 Worcester should be considered exposed to high winds while specific areas are exposed to hurricane surge. Figure 23 shows the 100-year windspeeds identified in the ASCE 7-98 publication.

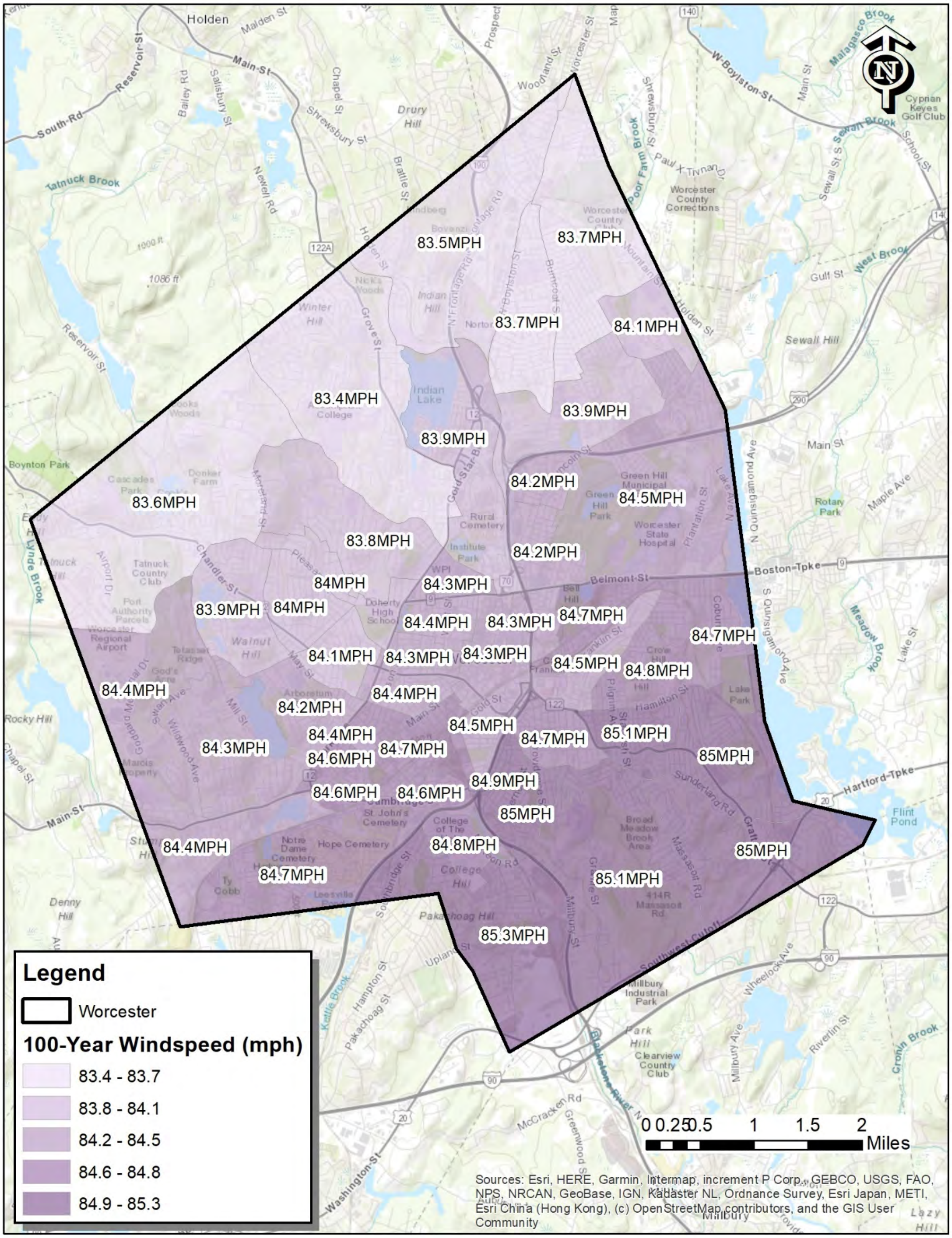


Figure 23. 100-Year Windspeeds (ASCE 7-98).

Built Environment Impacts

To identify built environment impacts to the City resulting from wind damage, FEMA's risk assessment software, Hazus, was implemented. The economic loss results of the 500-year event are shown in Table 59while the results for the 1000-year event are shown in Table 60. The City's AAL is calculated to be $6,260.

Buildings that are permanently open with bays or open sides are susceptible to wind damage since the building envelope can't be maintained. Communication antennas are vulnerable to high wind speeds and solar arrays may be impacted by very high winds. Neighborhoods with aerial utilities would be more vulnerable than neighborhoods with below ground utilities.

Table 59. Building Losses Due to Wind for a 500-Year Scenario.

Loss Type	**Residential ($Million)**	**Commercial ($Million)**	**Other Occupancy ($Million)**	**Total ($Million)**
Building Loss	266.05	65.20	66.67	**397.92**
Content Loss	48.87	20.21	31.76	**100.84**
Business Inventory Loss	0.00	2.80	2.16	**4.96**
Business Income Loss	0.00	6.01	4.98	**10.99**
Business Relocation Loss	14.37	10.44	11.88	**36.69**
Rental Income Loss	8.90	4.43	1.14	**14.47**
Wage Loss	0.00	6.98	17.67	**24.65**
Total	**338.19**	**116.07**	**136.26**	**590.52**

Table 60. Building Losses Due to Wind for a 1000-Year Scenario.

Loss Type	**Residential ($Million)**	**Commercial ($Million)**	**Other Occupancy ($Million)**	**Total ($Million)**
Building Loss	429.53	102.30	104.01	**635.84**
Content Loss	100.68	36.28	55.55	**192.51**
Business Inventory Loss	0.00	5.16	3.74	**3.24**
Business Income Loss	0.00	6.58	5.85	**5.85**

Loss Type	Residential ($Million)	Commercial ($Million)	Other Occupancy ($Million)	Total ($Million)
Business Relocation Loss	30.82	16.44	18.57	**18.38**
Rental Income Loss	16.70	7.22	1.84	**25.76**
Wage Loss	0.00	7.64	20.97	**28.61**
Total	**577.73**	**181.62**	**210.53**	**969.88**

Population Impacts

Populations considered most vulnerable to hurricane and tropical storm impacts in Worcester are identified based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. For high windspeeds, it's important to maintain the building envelope during the event. If a window or door fails, damage to the structure will be much greater. The senior and low-income populations in Worcester are particularly susceptible to extreme winds and it should be noted that there may be overlap within the two categories. The City 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 461 displaced households and 206 people seeking public shelter from the high windspeeds. For the 1000-year event, Hazus predicts that there will be 975 displaced households and 869 people seeking public shelter from the high windspeeds.

Environment Impacts

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

Problem Statements for Hurricanes/Tropical Storms

Table 61. Problem Statements for Hurricanes/Tropical Storms.

Assets	Problems Associated with Hurricanes and Tropical Storms
People (including underserved communities	• Vulnerable populations may need to be evacuated and could be displaced from their homes.

Assets	Problems Associated with Hurricanes and Tropical Storms
and socially vulnerable populations)	
Structures (including facilities, lifelines, and critical infrastructure)	• Wind may cause trees to fall into structures and infrastructure, and roadways. • Wind damage to wind-susceptible buildings such as communication antennas, aerial utilities, solar arrays, greenhouses, pavilions, gazebos, and open-walled buildings. Additional damage to commercial buildings with HVAC located on roofs. • The electric grid may go down during high wind event.
Systems (including networks and capabilities)	• First responders may have difficulty reaching people if roads are closed due to tree debris.
Natural, historic, and cultural resources	• Historic buildings may experience damage during high wind events, especially the roofing and windows. Water entering these buildings could impact important historic and cultural artifacts.
Activities that have value to the community	• A severe hurricane wind and rain event could negatively impact outdoor activities in the City.

Invasive Species

Description

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

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 plant 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.

Invasive insects are another challenge in Massachusetts. Some examples of invasive insect species include:

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

others. It does prefer oak tree leaves, however. Periodically, large populations can cause defoliation damaging and killing trees they are feeding on.

- Spotted Lanternfly (non-native pest) is an invasive insect first detected in the U.S. in 2014. It feeds on a variety of fruit, ornamental, and wood trees and could seriously impact the grape, orchard, and logging industries.

Location

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

Previous Occurrences

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

- Spongy Moth
- Winter Moth
- Hemlock Woolly Adelgid
- Southern Pine Beetle
- Emerald Ash Borer
- 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 62. Statewide Budgets for Addressing Invasive Species.

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

The previous edition of this plan includes a detailed discussion about the Asian longhorned beetle. The document explains that the beetle (ALB, *Anoplophora glabripennis*) "is a destructive wood-boring pest of maple and other hardwoods. ALB is believed to have been introduced into the United States from wood pallets and other wood packing material accompanying cargo shipments from Asia. The tree species preferred as hosts by the Asian Longhorned Beetle are hardwoods including several maple species (Norway, sugar, silver, and red maple), box elder, horse chestnut, buckeye, elm, London plane, birch, and willow. All of Worcester and several neighboring towns have been impacted by the infestation. A quarantine remains in place and public education efforts should be continued. Trees weakened by the infestation could be further damaged and impacted by natural hazards such as snowstorms and severe rain/wind events. Weakened limbs could in turn damage power lines and other infrastructure. Continued monitoring of trees should occur, especially in August, as adult beetles are most active during the summer and early fall and is the time of year when beetles are most active and mobile. The larvae that spent the previous year maturing and eating through their host trees emerge as adults and look for a new place to colonize and start the next generation."

The Worcester Open Space and Recreation Plan was updated in 2021 and notes that the ALB "creates stress on street trees, woodlands, and forested expanses" and "the entire geographic limits of the City of Worcester and part of neighboring Shrewsbury, Boylston, West Boylston, Holden and Auburn have been designated at risk to infestation."

While the previous edition of this plan and the Open Space and Recreation Plan are helpful for describing general impacts of the ALB, the Worcester Urban Forest Master Plan provides significant detail about the *specific impacts* of the ALB. The document explains that "ALB was discovered in Worcester in 2008 by a resident who found them feeding on their backyard maple trees…. While ALB feeds on a variety of hardwood tree species, it prefers maples (Acer). Unfortunately, for Worcester, the many disturbances to the urban forest over the centuries led to an overabundance of maple trees on both public and private property. This made Worcester an ideal habitat for ALB - allowing the insect's population to grow. The discovery of ALB in Worcester led to the removal of over 30,000 public and private trees which had a tremendous impact on the urban forest and the quality of life of residents, especially those in the Burncoat and Greendale areas that were hardest hit by ALB tree removals. The tree removals led to the formation of the Worcester Tree Initiative that helped to replant over 30,000 trees on public and private property in Worcester. ALB has not been found in Worcester since 2015 but it continues to be intensively managed by the USDA Animal and Plant Health Inspection Service through surveying and monitoring."

The Worcester Urban Forest Master Plan additionally notes that "65% of Worcester's street trees are susceptible to at least one significant pest or disease. Insect and diseases of particular concern for Worcester's street tree population are spotted lanternfly (*Lycorma delicatula*), Asian longhorned beetle (*Anoplophora glabripennis*), European spongy moth (*Lymantria dispar*), emerald ash borer (*Agrilus planipennis*), and oak wilt (*Ceratocystis fagacearum*)."

Aquatic invasive and nuisance species are an additional concern in Worcester. Every few years, the City contracts robust mapping of invasive aquatic species in its main recreational waterbodies. The City also conducts more frequent informal surveys in-house. Each year, the City produces a report on lake monitoring and management activities in each of the waterbodies which are part of this program. There is a section dedicated to invasive plants in each report which summarizes any management activities performed that year. General comments about the presence of aquatic species is provided below. The City has only limited information for Cooks Pond, as it is a privately owned and managed waterbody.

Table 63. Aquatic Species Appearances in Worcester.

Species	Bell Pond	Indian Lake	Coes Reservoir	Patch Reservoir*	Lake Quinsigamond
Phragmites australis (Common reed)	2022, 2023, 2024, possibly earlier than 2022 but unconfirmed	2016, 2022, 2023, 2024 – likely yearly	Not applicable	Not applicable	Not applicable
Trapa natans (water chestnut)	Not applicable	Not applicable	2018 - 2024 – in 2024 it declined to be manageable by volunteers	2017 – 2024	Observed yearly

Species	Bell Pond	Indian Lake	Coes Reservoir	Patch Reservoir*	Lake Quinsigamond
Myriophyllum spicatum (Eurasian milfoil)	Not applicable	Observed yearly until 2022**	2018, not observed in 2022 but uncertain of current condition	2017	Observed yearly
Myriophyllum heterophyllum (Variable-leaf milfoil)	Not applicable	Not applicable	Not applicable	2017	Observed yearly
Najas minor (Brittle naiad)	Not applicable	2016, not observed in 2022 but uncertain of current condition	Not applicable	Not applicable	Observed yearly
Potamogeton crispus (Curly-leaf pondweed)	Not applicable	Not applicable	Observed in Coes but uncertain years	Not applicable	Observed yearly
Cabomba caroliniana (Fanwort)	Not applicable	Not applicable	2018, not observed in 2022 but uncertain of current condition	Not applicable	Observed yearly

*Very limited records are available for Patch Reservoir

According to the City, Eurasian milfoil has not been observed in Indian Lake since an herbicide treatment was conducted in 2022. Because Indian Lake has a boat ramp and is open to motorized boats, there is a high risk of transmission again. There is a boat decontamination station set up at the boat ramp to enable boaters to clean their boats before and after use on the lake.

Some other invasive species being watching by the City, but not yet addressed in the monitoring reports, are purple loosestrife and hydrilla. Purple loosestrife is a wetland plant which is well adapted to disturbed soils. The City is interested in addressing this species before it becomes a larger issue but does not presently have the capacity to do so. Addressing purple loosestrife would require a much larger coordination effort with other parties responsible for land plants.

The City is also on the lookout for hydrilla. It has not been observed in waterbodies in the area, but it is starting to invade waterways in Connecticut and spreads very rapidly. The City does not currently have a management plan for hydrilla, but would like to start working on this as it could become a threat in the coming years.

Relative to terrestrial vegetation, the HMPC noted that Oriental bittersweet and Japanese knotwood continue to be challenges. Furthermore, vegetation favored by Spotted lanternfly will likely become a larger concern over the next few years.

Extent

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

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

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

6. The species is widespread in Massachusetts, or common in a region or habitat type(s) in the state.
7. The species has many occurrences in Massachusetts that have high numbers of individuals in minimally managed habitats.

8. The species is able to outcompete other species in the same natural plant community.
9. The species has the potential for rapid growth, for high seed or propagule production and dissemination, and for establishment in natural plant communities.

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

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

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

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

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

Table 64. Early Detection Information for Addressing Invasive Species.

Species	Common Name	Current County of Distribution (November 2010)	Notes
Arthraxon hispidus	Hairy joint grass; jointhead; small carpetgrass	Franklin (historically)	This species is not currently known in Massachusetts; it was last collected in Deerfield in 1973. This is an annual grass that co-occurs with Japanese stilt grass further south.
Butomus umbellatus	Flowering rush	Essex, Middlesex	*Butomus umbellatus* is an aquatic perennial herb which reproduces by seed dispersal or vegetatively by bulbils
Carex kobomugi	Japanese sedge; Asiatic sand sedge	Barnstable (historically)	Native to northeastern Asia, Carex kobomugi is an invasive plant that invades coastal sand dunes and can outcompete native dune-binding grasses. This species was last collected in 1973.
Egeria densa	Brazilian waterweed; Brazilian elodea	Essex, Middlesex, Norfolk, Plymouth, Worcester	This species is often confused with Hydrilla and native *Elodea* spp. but has larger, nickel-sized flowers. This is a submerged aquatic species whose rapid growth often leads to dense mats on the water surface, which crowds out native plants and damages fish and aquatic habitat. The mats can also impede boat traffic.
Glyceria maxima	Tall mannagrass; reed mannagrass	Essex	This perennial grass invades low shrub-swamps and other wetland
Heracleum mantegazzianum	Giant hogweed	Berkshire, Franklin, Hampden, Hampshire, Middlesex, Norfolk, Suffolk, Worcester	Giant hogweed is a federal noxious weed that is currently being eradicated under the U.S. Department of Agriculture’s authority. This is a perennial herb that can cause painful burns and permanent scarring to humans if they touch the plant.

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

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

The Commonwealth does not have specific classification systems for invasive insects and aquatic vegetation. Future updates of this plan will continue to check for guidance from DCR, MEMA, and other agencies.

Probability of Future Events

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

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

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

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

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

Vulnerability Assessment

Exposure

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

Built Environment Impacts

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

Population Impacts

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

Environment Impacts

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

Problem Statements for Invasive Species

Table 65. Problem Statements for Invasive Species.

Assets	Problems Associated with Invasive Species
People (including underserved communities and socially vulnerable populations)	• None apparent or projected.
Structures (including facilities, lifelines, and critical infrastructure)	• None apparent or projected.
Systems (including networks and capabilities)	• Additional City resources may be required in terrestrial and aquatic areas consistent with the species listed below.
Natural, historic, and cultural resources	• Insect and diseases of particular concern for Worcester's street tree population are spotted lanternfly, Asian longhorned beetle, European spongy moth, emerald ash borer, and oak wilt. • The discovery of ALB in Worcester led to the removal of over 30,000 public and private trees which had a tremendous impact on the urban forest and the quality of life of residents, especially those in the Burncoat and Greendale areas that were hardest hit by ALB tree removals.

Assets	Problems Associated with Invasive Species
	• Aquatic invasive and nuisance species are an additional concern in Worcester. These include common reed, water chestnut, Eurasian milfoil, variable-leaf milfoil, brittle naiad, curly-leaf pondweed, fanwort, and purple loosestrife. • Hydrilla is not yet present but a concern for the City. • Oriental bittersweet and Japanese knotwood continue to be challenges. Furthermore, vegetation favored by Spotted lanternfly will likely become a larger concern over the next few years.
Activities that have value to the community	• Recreational activities may be adversely impacted, depending on location, and especially in parks and natural areas.

Landslides

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

Description

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

Occasionally, landslides occur as a result of geologic conditions and/or slope saturation. Adverse geologic conditions exist wherever there are lacustrine or marine clays, as clays have relatively low strength. These clays often formed in the deepest parts of the glacial lakes that existed in Massachusetts following the last glaciation. These lakes include Bascom, Hitchcock, Nashua, Sudbury, Concord, and

Merrimack, among many other unnamed glacial lakes. When oversteepened or exposed in excavations, these vulnerable areas often produce classic rotational landslides.

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

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

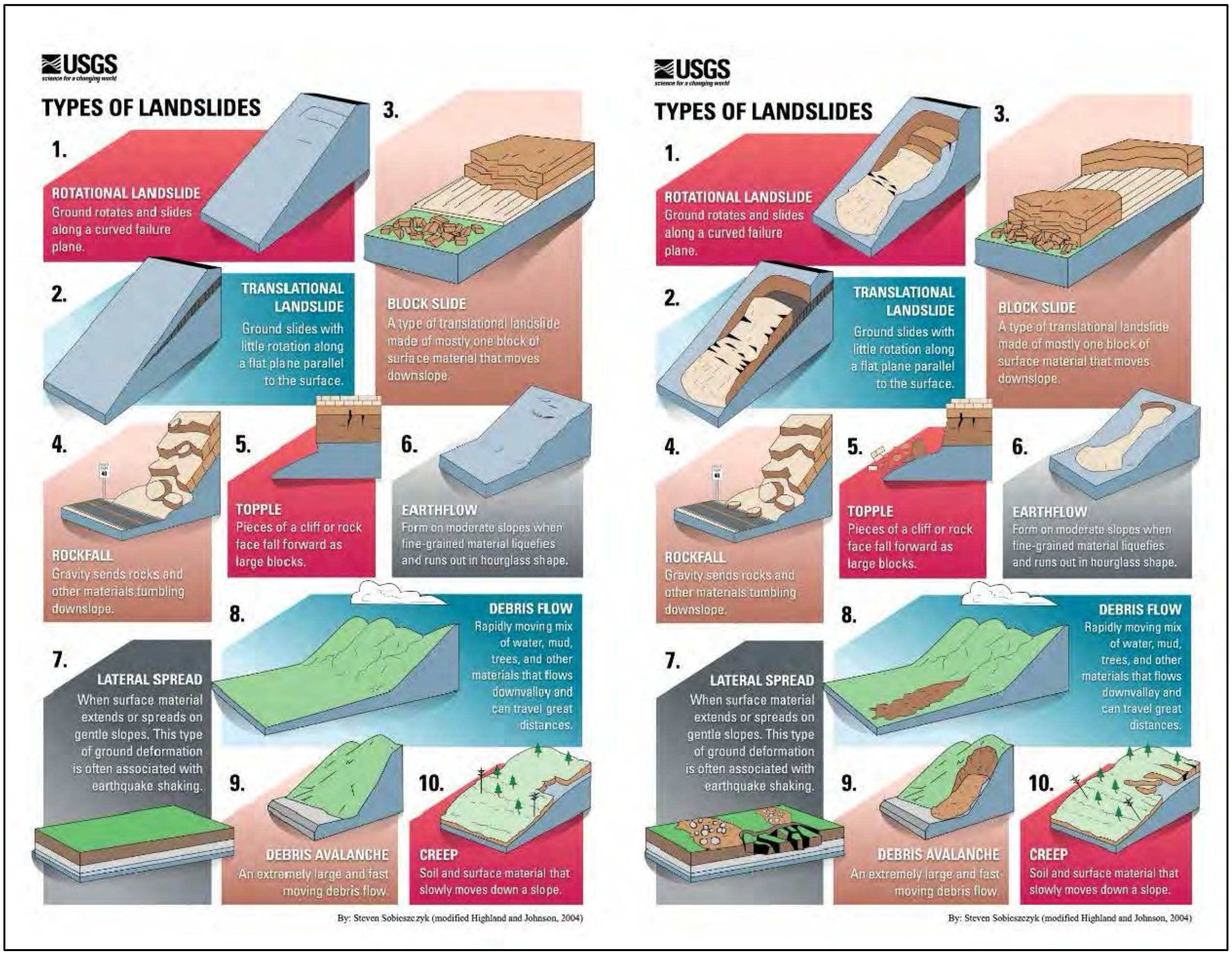


Figure 24. Types of Landslides.

Location

In 2013, the Massachusetts Geological Survey and University of Massachusetts Amherst published a Slope Stability Map of Massachusetts (Figure 25). This project, funded by the FEMA Hazard Mitigation

Grant Program, was designed to provide statewide mapping and identification of landslide hazards that can be used for community level planning as well as prioritizing high-risk areas for mitigation. The maps produced from this project should be viewed as a first-order approximation of potential landslide hazards across the state.

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

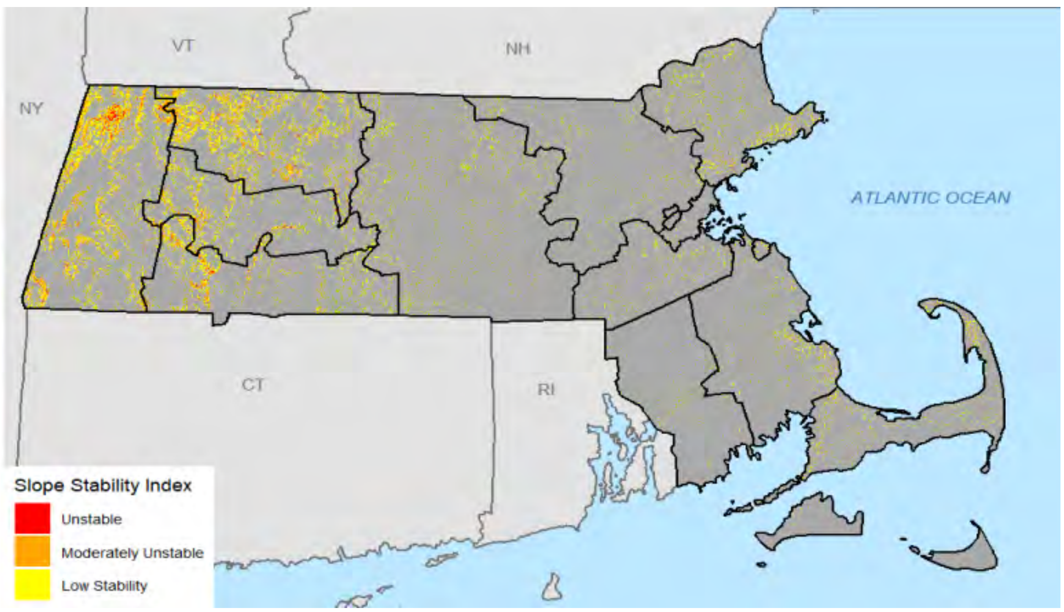


Figure 25. Slope Stability Map of Massachusetts (Created by ERG using data from Mabee & Duncan (2013)).

Previous Occurrences

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

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

While numerous landslides have occurred in the Berkshire region of Massachusetts, significant landslides have reportedly not occurred in central Massachusetts, including the Worcester area. The previous edition of this plan notes that "There are no documented previous occurrences of significant landslides in Worcester. The city is relatively hilly but, the risk of landslides is minimal." The HMPC convened for this edition of the plan noted that rockfalls and limited landslides are often associated with ongoing construction projects.

Extent

Variables that contribute to the extent of potential landslide activity in any area include soil properties, topographic position and slope, and historical incidence. Predicting a landslide is difficult, even under ideal conditions. As a result, estimations of the potential severity of landslides are informed by previous occurrences as well as an examination of landslide susceptibility. Information about previous landslides, such as the information and images from landslides after Tropical Storm Irene can provide insight as to both where landslides may occur and what types of damage may result. It is important to note, however, that landslide susceptibility identifies only areas potentially affected and does not imply a time frame when a landslide might occur. The distribution of susceptibility across the Commonwealth is depicted on the Slope Stability Map (Figure 25), with areas of higher slope instability considered to also be more susceptible to the landslide hazard.

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

- Springs, seeps, or saturated ground in areas that have not typically been wet before
- New cracks or unusual bulges in the ground, street pavements, or sidewalks
- Soil moving away from foundations
- Ancillary structures, such as decks and patios, tilting and/or moving relative to the main house
- Tilting or cracking of concrete floors and foundations
- Broken waterlines and other underground utilities

- Leaning telephone poles, trees, retaining walls, or fences
- Offset fence lines
- Sunken or down-dropped road beds
- Rapid increase in creek water levels, possibly accompanied by increased turbidity (soil content)
- Sudden decrease in creek water levels even though rain is still falling or has just recently stopped
- Sticking doors and windows, and visible open spaces indicating jambs and frames out of plumb
- A faint rumbling sound that increases in volume as the landslide nears
- Unusual sounds, such as trees cracking or boulders knocking together

Probability of Future Events

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

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 City, 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. The analysis identified one Fire Station located in the unstable or moderately unstable area.

The other building data was overlaid with the unstable and moderately unstable areas. There were 107 buildings identified in the moderately unstable area and no buildings identified in the unstable areas. Table 66 shows the result of this analysis.

Table 66. Buildings in Moderately Unstable Area.

Building Type	Number of Buildings (Total in City)	Building Value (Total in City)
Single Family	57 (31399)	$22,546,591 ($13,989,054,910)
Multi-Family	39 (14496)	$45,092,636 ($23,767,111,740)
Commercial	7 (3203)	$8,843,409 ($10,363,149,842)
Agricultural	0 (72)	$0 ($22,837,164)
Educational	2 (372)	$124,179,264 ($7,450,820,493)
Government	1 (155)	$1,000,000 ($647,185,275)
Religious/Non-Profit	1 (239)	$6,803,412 ($863,742,992)
Industrial	0 (220)	$0 ($1,680,656,677)
Garage/Outbuilding	0 (46)	$0 ($916,384)
Total	**107 (50202)**	**$208,465,311 ($58,785,475,479)**

Ninety-five of the structures in the moderately unstable areas also have environmental justice concerns.

Figure 26 shows the landslide susceptibility map for the City. The red and pink areas are more susceptible to landslides.

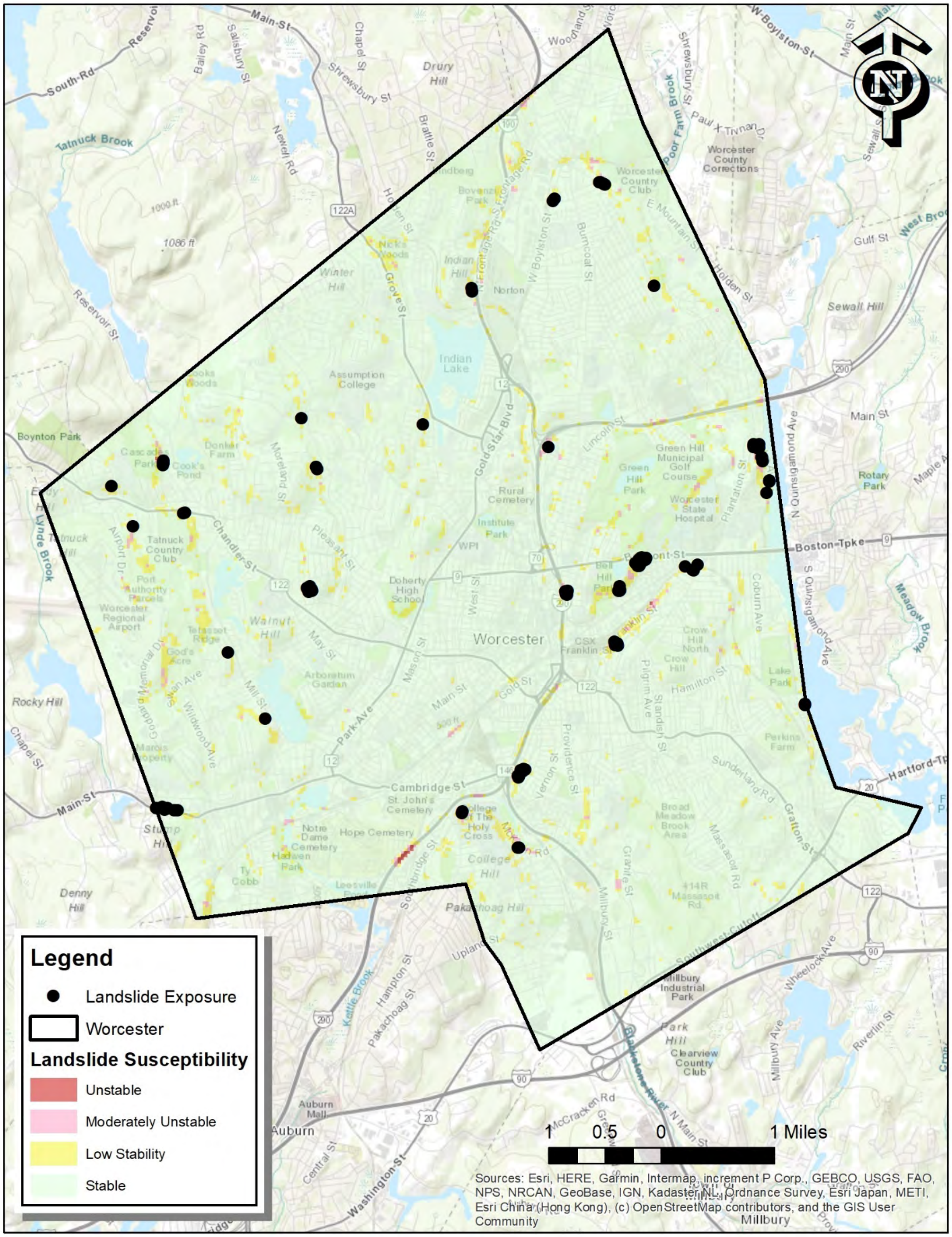


Figure 26. Landslide Map.

Built Environment Impacts

Historic data for landslide events indicate that between 1993 and 2022, no landslide events were recorded in Worcester. Still, there is a likelihood even if it's slight. Assuming a total loss for a building due to a 100-year landslide event, and the average value of a building in the moderately susceptible zone is $1,948,274, this would result in an AAL of $19,483.

Population Impacts

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

Environment Impacts

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

Problem Statements for Landslides

Table 67. Problem Statements for Landslides.

Assets	**Problems Associated with Landslides**
People (including underserved communities and socially vulnerable populations)	• Vulnerable populations in isolated areas may be cut off if a landslide impacts specific roads.
Structures (including facilities, lifelines, and critical infrastructure)	• Fire station may be impacted by landslide event. • Some residential and other structures reside adjacent to moderately unstable areas and could be impacted.
Systems (including networks and capabilities)	• Roads and rail may be impacted and could cause a hazardous material spill.
Natural, historic, and cultural resources	• Parks and other natural areas reside in or adjacent to the unstable or moderately unstable areas.

Assets	Problems Associated with Landslides
	• Increased precipitation intensity and invasive species' impacts to forests may influence future landslide risks.
Activities that have value to the community	• None apparent or projected

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. Given their unique circumstances, winter storms and tornadoes are addressed in later sections.

Description

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

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

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

- 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 entirety of Massachusetts, including the geographic extent of Worcester.

Previous Occurrences

The NOAA Storm Events database (https://www.ncdc.noaa.gov/stormevents/) for Worcester County lists numerous severe storms affecting Worcester from 2014 through 2024. The individual damage figures for these events span a large range, and given the frequency of events, the overall losses from severe storms are striking. Storm events below have been aggregated by date, grouping events together if they occurred from the same storm.

Table 68. NCEI Severe Storm Database Entries Covering Other Severe Storms in Worcester.

Date	Description	Losses Reported
2/26/16	Thunderstorm Wind: This was a very complicated weather situation as a strong low level inversion was in place over the area with a very strong low level jet just above the inversion. As showers and thunderstorms developed, the storms and heavy rain allowed the stronger winds to mix down to the surface. In other areas, temperatures warmed enough at the surface to break the inversion and allow the stronger winds to mix down. This resulted in a complicated combination of severe thunderstorm winds and high winds. Multiple trees and wires were downed throughout Worcester. Traffic light poles on Lincoln Street and Westland Street, trees on Pinecrest Drive, Sunny Hill Drive, and Hudson Street, a light pole on Millbrook Street, and numerous large tree branches on Russell Street, Crestland Circle, Paine Street, Sarrar Avenue, and Rexham Road were all downed by thunderstorm winds.	$90,000
3/17/16	Thunderstorm Wind: An upper level disturbance coupled with cold air aloft and moving into southern New England set off a complicated mix of showers and thunderstorms and non-convective winds. A tree on Mill Street in Worcester was downed onto wires by thunderstorm winds.	$5,000
7/22/16 through 7/23/16	Thunderstorm Wind: A cold front moved through southern New England and when coupled with the existing heat and humidity, resulted in showers and thunderstorms developing over much of the area. A tree on Russell Avenue was downed by thunderstorm winds. Power lines on Burncoat Street were downed by thunderstorm winds.	$10,000
8/14/16	Thunderstorm Wind: A pre-frontal trough moved through southern New England resulting in a couple of showers and thunderstorms. Power lines on Johnson Street were downed by thunderstorm winds.	$5,000
10/23/16	Strong Winds: Low pressure over northern New England, combined with a strong upper level disturbance sweeping across New England, ushered in colder air and strong to damaging wind gusts. Two trees were downed in Worcester (on Coldbrook Road	$2,000 among all affected communities

Date	Description	Losses Reported
	and South Road). The Worcester Airport reported sustained winds of 35 mph and a gust to 48 mph.	
6/27/17	Hail: A disturbance at mid-levels in the atmosphere moved from the Great Lakes across New England during the afternoon and evening. This allowed afternoon and evening thunderstorms to develop. At 318 PM, an amateur radio operator reported nickel-size hail at Worcester.	---
5/4/18	Strong Winds: A low pressure area over the Great Lakes the morning of May 4th moved to the Maritimes the morning of May 5th. As it moved, the low swung a cold front west to east through Massachusetts shortly before midnight. Winds behind the front became west to northwest and produced gusts near 50 mph overnight. At 12:20 AM, a tree was down on a house and cars on Onset Street in Worcester.	$25,000 among all affected communities
10/15/18	Strong Winds: A cold front moved east from the Great Lakes on Monday October 15th. There were several reports of trees and wires down in Eastern and Central Massachusetts. At 11:44 PM, a tree was down along Davidson Street in Worcester.	$7,000 among all affected communities
11/10/18	Strong Winds: Low pressure quickly moved across the Cape Cod Canal overnight and exited to the northeast. Strong, gusty winds followed. In Worcester at 131 PM, a large tree and power lines were down on Hillsboro Road.	$800
12/21/18	Strong Winds: A storm passing west of Massachusetts brought strong to damaging south winds to Central and Eastern Massachusetts on Friday December 21. At Noon EST a tree was blocking Perkins Street in Worcester.	$5,000 among all affected communities
1/1/19	Strong Winds: Low pressure center passing through New York State on January 1 brought strong west winds to Massachusetts. At 11:15 AM a tree fell on wires on Beaver Street in Worcester.	$12,000 among all affected communities
1/24/19	Strong Winds: Low pressure moving north from the Gulf of Mexico brought high south winds and heavy rain to Massachusetts. At 11:16 AM a tree was down on Briar Lane in Worcester.	$1,000

Date	Description	Losses Reported
2/8/19	Strong Winds: A weather system from the Midwest initially brought snow and ice to the region. The system swung a cold front through New England, followed by strong west to northwest winds. At 10:30 PM Worcester law enforcement reported a large tree down on Sunderland Road in Worcester.	$2,500 among all affected communities
2/25/19	High Winds: A storm moving north through the Great Lakes redeveloped along the Mid Atlantic coast on the 24th, then moved up the coast past Southern New England. At 11:57 AM a tree and wires were down on Grove Street in Worcester. At 2:22 PM EST the Automated Surface Observing System platform at Worcester Regional Airport measured a wind gust to 64 mph. At 7:05 PM a tree fell through the roof of a house on Columbine Street in Worcester; also, a tree was down on Richmond Street.	$10,000 among all affected communities
4/15/19	Strong Winds: Low pressure moving up the St Lawrence Valley swung a pair of cold fronts through Massachusetts. Wind Advisories were in effect for strong northwest gradient wind gusts to 40 to 50 mph, which knocked down trees and branches. At 5:43 PM in Worcester, a tree was down on Millbrook Street.	$500
7/6/19	Thunderstorm Wind: A cold front advanced into a very moist, almost tropical air mass in place across southern New England. This produced a line of thunderstorms. A tree was reported down on a car on Hooper Street in Worcester.	$2,000
8/7/19	Lightning: A warm front moving across southern New England triggered severe thunderstorms with wind damage across western portions of southern New England. In the Westwood Hills section of Worcester, a house was struck by lightning. The chimney was blown off and there was damage to eight rafters.	$3,000
10/17/19	Strong Winds: A powerful coastal storm developed along the NJ coast then moved northeast across southern. In Worcester: • Downed tree on 8 Mohican Rd. • Fallen tree on Ludlow St. • Fallen tree on Wayne St.	$2,800

Date	Description	Losses Reported
	• Trees down on Wyola Dr. • Fallen tree on Topsfield Rd.	
11/1/19	High Winds: A strong cold front moved quickly across the region. Ahead of the front it was a warm and very windy night, with many downed trees and power lines from strong south-southwest wind gusts. At 1254 AM, the Worcester Airport ASOS recorded a wind gust to 56 mph. At 145 AM, the Worcester Fire Dept. reported a power pole down and on fire on both Bishop Street and on Grafton Street. The Fire Department reported trees and wires down on Catalpa Street at 145 AM. At 618 AM, law enforcement reported a tree down on Brookshire Street and another tree down on Nanita Street.	$6,000
2/27/20	Strong Winds: Strong low pressure in New York moved north into eastern Canada. It was followed by a cold front that moved east across southern New England. The post-frontal tight pressure gradient caused strong southwest to west winds that gusted to 40 to 60 mph and caused some damage across Massachusetts. In Worcester at 737 PM, a tree was down on wires on Millbury Street.	$2,000 among all affected communities
3/13/20	Strong Winds: A cold front moved across Massachusetts in the midafternoon hours. A band of strong, gusty winds occurred along and just after the front. Scattered damage occurred in Massachusetts. The ASOS at the Worcester Airport recorded a wind gust to 51 mph at 334 PM. In Worcester at 4 PM, a tree fell onto Howe Avenue in the Tatnuck section of the city.	$500
3/29/20	Hail: Elevated instability combined with an upper level short wave trough to produce scattered severe thunderstorms during the mid evening hours. Large hail ranging from quarter to golf ball size was reported with a few of these storms. Golf ball size hail was reported via amateur radio at 756 PM in Worcester.	---
4/9/20	Strong Winds: A strong cold front joined forces with a negatively tilting upper level disturbance to produce a narrow line of severe thunderstorms late in the afternoon. Strong to damaging winds occurred in MA prior to the arrival of the front. Additionally,	$300

Date	Description	Losses Reported
	strong to locally damaging post-frontal winds occurred for a few hours into the evening across central MA. In Worcester at 531 PM, power lines were down on Rowena Road.	
4/13/20	High Winds: A powerful low pressure system tracked across the Great Lakes and brought strong and damaging winds to all of Massachusetts late morning through the evening. A strong and anomalous low level jet brought southerly wind gusts of 60-70 mph ahead of a cold front. In Worcester at 1016 AM there was a tree and wires down on Chesterfield Rd.	$1,700 among all affected communities
5/9/20	Winds were gusting to between 47 and 53 mph. 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. In Worcester at 1210 PM, a tree was down on Tarrytown Lane.	$10,000 among all affected communities
5/15/20	Thunderstorm Wind: With a warm, humid air mass in place, a strong cold front moved through southern New England. In addition, southern New England was on the southern edge of a strong jet stream aloft. The result was a quasi-linear convective system that moved through Massachusetts. It caused significant damage in places. Multiple trees were down across the City of Worcester. Law enforcement reported trees down on Maywood Street, Barnard Road, Revere Street, Perrot Street, Grafton Street, and Pioneer Road.	$5,000
8/23/20	Thunderstorm Winds and Hail: Diurnally driven thunderstorms brought wind damage, hail, and some flooding to mainly western and central Massachusetts. In Worcester, a telephone pole was snapped due to a tree falling on wires on Aylesbury St. A tree was down on Edgeworth St. Quarter sized hail was reported.	$3,500
10/7/20	Thunderstorm Wind: A squall line formed in New York State then raced eastward in the late afternoon and early evening, gathering strength as it raced across Massachusetts. Hundreds of thousands of people were left without power in southern New England, as there was widespread tree and power line damage from winds generally gusting to between 50 and 80 mph. The Storm Prediction	$5,000

Date	Description	Losses Reported
	Center classified it as a derecho. Along the line, an isolated brief tornado touched down in Millis. Prior to the derecho, strong southwest winds gusted to 40-50 mph in the early afternoon. In Worcester, numerous tree limbs were down across the city. On Beechmont Street, a tree limb fell onto a house. On Pleasant Street, a tree limb also fell onto a house. Other limbs were down on Brantwood Road, Main Street, Varnum Street, June Street, Maxwell Street, and Holly Terrace.	
11/1/20	Strong Winds: A line of heavy showers moved through in the evening hours, accompanied by a modest southerly low-level jet. Intensifying surface low pressure near the south coast of New England enhanced low level convergence. In Worcester, gusty showers knocked down a power line on Walworth Street.	$500
3/1/21	High Winds: An arctic cold front moved through southern New England. It was followed by very strong/damaging west-northwest winds. There were many reports of downed trees and at one point, more than 60,000 customers were without power in Massachusetts. In Worcester at 955 PM, the ASOS at the Worcester Airport recorded a gust to 62 mph. In Worcester at 1018 PM, a tree was down on a car on Wakefield Street. In Worcester at 1130 PM, law enforcement reported a tree down on power lines on both Grafton Road and Main Street.	$8,500 among all affected communities
3/29/21	High Winds: A strong upper level short wave trough moved through New England with a reinforcing shot of cold air. Strong to damaging westerly winds generally gusted to 50 to 60 mph during the morning and early afternoon hours. In Worcester at 1149 AM EST, the ASOS at the Worcester Airport recorded a wind gust to 58 mph.In Worcester at 657 AM, amateur radio reported a tree down on Airport Road.	$1,800 among all affected communities
7/17/21	Thunderstorm Winds: A relatively stationary front meandered across southern New England while low pressure slowly moved along the front. At upper levels, an upper low was moving slowly eastward from the Great Lakes. In Worcester, trees and wires were down on Havelock Road.	$1,300

Date	Description	Losses Reported
7/27/21	Thunderstorm Winds: A cold front entered a marginally unstable, but highly sheared environment during the late afternoon and evening hours. A broken line of severe thunderstorms moved across Massachusetts. In Worcester, a tree was down on a car at 61 Briar Lane. Power lines were down on Tacoma Street and Clark Street. A tree and wires were down on Quinapoxet Lane at Bergstrom Road. Also, a tree was down at 1222 Pleasant Street.	$8,500
8/12/21	Thunderstorm Winds: Excessive Heat Warnings were in effect across much of southern New England with temperatures well up into the 90s and dewpoints in the mid 70s, leading to development of severe thunderstorms in portions of western and central Massachusetts. In Worcester, trees and wires were down on Ferdinand St.	$1,300
8/26/22	Thunderstorm Winds: A cold front moved into a warm and humid air mass, triggered scattered severe thunderstorms in southern New England. In Worcester, trees were down on Goddard Drive, Scandinavia Avenue, and Lovell Street. A tree was down on a house at Ludlow and Main Street. Power lines were down on Boston Avenue.	$2,300
11/20/22	Strong Winds: A reinforcing shot of cold air brought strong winds to Massachusetts. In Worcester, a tree fell and hit the back of a house on South Flagg Street.	$3,000
11/30/22	Strong Winds: A strong cold front moved across southern New England, causing southerly winds that gusted to 40 to 55 mph. In Worcester, police reported a tree down at the intersection of Salisbury Street and Barry Road; a large tree down on the 700 block of Southbridge Street; and a large tree down on the 100 block of Eastern Avenue. In Worcester, police reported a tree down at the intersection of Salisbury Street and Barry Road; a large tree down on the 700 block of Southbridge Street; and a large tree down on the 100 block of Eastern Avenue.	$5,500
12/23/22	High Winds: Low pressure deepened rapidly as it tracked through the eastern Great Lakes. The storm produced damaging southeast to south winds across much of southern New England. In	$4,000 among all affected communities

Date	Description	Losses Reported
	Worcester at 912 AM, police reported trees and/or wires down on numerous streets across the city, including: Granite at Kristen St., Carpenter St., Winifred Ave., Grafton Ave., March St., and Wake Ave. In Worcester at 538 PM, a tree was down on June Street.	
2/3/23	High Winds: A major Arctic cold front blasted through southern New England. It was followed by a few rounds of strong and locally damaging wind gusts. At the Worcester Airport, the ASOS recorded a wind gust to 60 mph at 643 PM. In Worcester at 7 PM, a large tree was down on a house on Indian Lake Parkway and at 740 PM, a tree was down on wires and cars on Mallard Road and Austin Street.	$15,000 among all affected communities
7/25/23	Thunderstorm Winds: A seasonably strong shortwave trough brought scattered severe storms to Massachusetts during the afternoon and evening. • A tree was down on Chandler St. • A tree was down blocking Cardinal Rd. • A tree was down on Butternut Hill.	$1,500

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

Table 69. USDA Disasters Events That Refer to Severe Storms.

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
2014	Frost/freeze, hail	5/22/2014

Extent

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

Probability of Future Events

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

NOAA reports that there are ten downburst reports for every tornado report in the United States. This implies that there are approximately 10,000 downbursts reported in the United States each year and further implies that downbursts occur in approximately 10% of all thunderstorms in the United States annually. This figure suggests that downbursts are a relatively uncommon yet persistent hazard. Because thunderstorm event frequency is expected to slightly increase as a result of climate change, downburst event frequency is anticipated to increase.

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

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

Vulnerability Assessment

Exposure

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

Built Environment Impacts

Severe thunderstorms, and their associated hail and lightning events, brought about property damage in Worcester and adjacent towns in previous years. From 2014 until 2022, there was $268,800 in property damage to Worcester and adjacent towns. This equates to an AAL of $29,867.

Lightning has struck the public health, fire stations, and inspection services buildings on Mead Street in the past.

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 hail, microburst and thunderstorm impacts in Worcester are identified based on a number of factors including their physical and financial ability to react or respond during a hazard. Senior and low-income populations in Worcester are particularly susceptible to storms. The City should be aware of the potential needs of residents within these population segments in the event of a hazard occurrence.

Environment Impacts

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

Problem Statements for Other Severe Weather

Table 70. Problem Statements for Other Severe Weather.

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

Assets	Problems Associated with Other Severe Weather
Structures (including facilities, lifelines, and critical infrastructure)	• Given the frequency of events in and around Worcester, the impacts occur often and can occur anywhere in the City.
Systems (including networks and capabilities)	• Severe storms caused trees and wires to come down on cars and houses in at least 40 separate events from 2015 through 2024. • First responders may have difficulty reaching people if roads are closed due to tree debris.
Natural, historic, and cultural resources	• These can be adversely impacted depending on the specific locations of damage.
Activities that have value to the community	• These can be adversely impacted depending on the specific locations of damage.

Severe Winter Storms

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

> The City of Worcester Municipal Vulnerability Preparedness Plan Findings and Recommendations (2019) lists "ice/snowstorms coupled with extreme cold" as one of the top hazards of concern.

Description

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

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

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

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

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

Location

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

Previous Occurrences

Winter storms occur somewhat regularly in Massachusetts. Five of the disasters declared in Massachusetts from 2012 through 2024 were associated with winter storms, although only three covered Worcester County and therefore the City of Worcester:

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

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

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

These were likewise subject to concurrent emergency declarations in Massachusetts. The PA assistance reimbursements associated with the three above declarations totaled approximately $10,690,000 for the City of Worcester. This indicates that severe winter storms and ice storms comprise a significant expenditure for a rural community like Hardwick.

The NOAA Storm Events database (https://www.ncdc.noaa.gov/stormevents/) for Worcester County lists numerous severe winter storm events impacting Worcester for the period 2014-2024. A selection of events is provided below, with a focus on blizzards, events that were subject to disaster declarations, and typical winter storm events that produced more than a foot of snow.

Table 71. NCEI Severe Storm Database Entries Covering Winter Storms in Worcester.

Date	Description	Losses Reported
2/5/14	Heavy Snow: Seven to 14 inches of snow fell across southern Worcester County.	---
2/13/14	Heavy Snow: Eight to 13 inches of snow fell across southern Worcester County.	---
1/26/15	Blizzard: An historic winter storm brought heavy snow to southern New England with blizzard conditions. The highest snowfall totals, averaging two to three feet, extended from extreme northeast Connecticut and northwest Rhode Island into much of central and northeast Massachusetts. The storm was well-forecast, with Blizzard Watches and Winter Storm Watches issued 2 days before the snow	-- [see PA reimbursements above]

Date	Description	Losses Reported
	began. At its peak, snowfall rates of 2 to 3 inches per hour were common. In Massachusetts, blizzard conditions were officially reported in Worcester for 7 hours. Daily snowfall records were set for Worcester (31.9 inches, previous record 11.0 in 2011. In Worcester, the storm snowfall total of 34.5 inches was the greatest on record (dating back to 1892), breaking the previous record of 33.0 inches on March 31 to April 1, 1997. The governor of Massachusetts declared a travel ban that began on January 27th at midnight and was lifted county-by-county as conditions allowed. A federal disaster declaration was issued for the eastern parts of Massachusetts for this storm, allowing federal assistance for emergency work and repairs to facilities damaged by the storm.	
2/2/15	Heavy Snow: Five to 17 inches of snow fell across southern Worcester County.	---
2/8/15	Heavy Snow: Nine to 18 inches of snow fell across southern Worcester County.	---
2/14/15	Heavy Snow: Five to 13 inches of snow fell across southern Worcester County.	---
2/9/17	Heavy Snow: Eight to 14 inches of snow fell across southern Worcester County.	---
3/14/17	*[Entered as High Winds]* 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. Snow lingered in western and central sections into the late afternoon/early evening. High winds affected southern Worcester County. A gust to 55 mph was recorded at the Worcester Airport ASOS at 111 PM. At 4 PM, a tree was down on a house on Denver Terrace in Worcester and several other trees were down throughout the City.	$3,000 among all communities affected by sever wind

Date	Description	Losses Reported
	Heavy Snow: Reported snowfall totals were 14.4 inches at the Worcester Airport.	
12/23/17	Winter Weather: Ice accumulation in Southern Worcester County ranged from one-quarter to one-half inch.	$2,000 among all affected communities
1/4/18	Winter Storm: Low pressure moved north from the Florida coast and deepened, passing southeast of Nantucket on Thursday January 4. The storm reached its lowest pressure and strongest pressure gradient as it passed Southern New England. This brought heavy snow and damaging winds to Massachusetts and caused near-blizzard conditions Worcester. Ten to 17 inches of snow fell across Southern Worcester County. At 557 PM EST, the Automated Surface Observation System at Worcester Regional Airport measured a wind gust to 57 mph.	---
3/7/18	Heavy Snow: Seven to 17 inches of snow fell across southern Worcester County.	$120,000 among all affected communities
3/13/18	Winter Storm: Low pressure along the Carolina coast March 12 moved up the coast and passed offshore of Southern New England. The storm brought snow accumulations of one to two feet across Eastern Massachusetts. From 14 to 28 inches of snow fell on Southern Worcester County.	-- [see PA reimbursements above]
11/15/18	Heavy Snow: An early-season nor'easter moved from the Mid-Atlantic coast to southeastern Massachusetts. A quick thump of heavy snow occurred on the front end of the storm. Snowfall amounts ranged from only a couple of inches in southeasternmost sections of MA to 8 to 10 inches in western and northern MA. Snowfall ranged from 6 to 9 inches in southern Worcester County, with 8.4 inches at the Worcester Airport.	---
3/3/19	Winter Storm: Ten to 18 inches of snow fell across southern Worcester County.	---

Date	Description	Losses Reported
12/1/19	Heavy Snow: A storm system slowly moved across southeast Massachusetts and into the Gulf of Maine during this period. One to two feet of snow fell in much of western and northern Massachusetts. Final snow totals ranged from 11 to 17 inches. In both Worcester and Holden 17 inches of snow fell.	---
10/30/20	Heavy Snow: This was a rapidly moving upper level low and its associated upper jet max, which moved northeastward from the Mississippi Valley and low pressure again passed to the south of New England. Cold air was streaming into the region from the north. The result was some heavy, wet snow across the region, with many areas receiving 3 to 6 inches. The weight of the snow caused scattered tree and power line damage. Snow totals ranged from 4.0 to 6.6 inches in southern Worcester County, with an average around 5.5 inches. Totals of 6.5 inches were reported from trained spotters and amateur radio operators in Worcester, Milford, and Grafton. The official measurement at the Worcester Airport was 6.2 inches. In Worcester at 405 PM, a tree was down on Winifred Avenue from the weight of the snow.	$2,000 among all affected communities
12/5/20	Heavy Snow: A rapidly intensifying storm system produced strong to damaging winds and heavy rain (2-4 inches) which changed to a period of heavy snow in the higher elevations. Heavy snow fell in southern Worcester County. Some representative totals included 9.6 inches at the Worcester Airport.	---
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 southern Worcester County generally ranged from 10 to 16 inches. Some specific amounts included 12.1 inches at the Worcester Airport.	---
2/1/21	Winter Storm: 12 to 18 inches of snow fell across southern Worcester County.	---
1/28/22	Blizzard: Explosive cyclogenesis of a low pressure center off the Mid Atlantic coast brought a strong winter storm with blizzard conditions to all of southern New England. The heaviest snow, just under 30	---

Date	Description	Losses Reported
	inches, fell over southeast MA. The Worcester Airport ASOS reported blizzard conditions from 749 AM to 405 PM. The highest gust from the Worcester ASOS (KORH) which gusted to 51 mph at 1030 AM. Snowfall generally ranged from 5 to 18 inches.	
3/14/23	Heavy Snow: Strong low pressure meandered just off the southeast coast of New England before moving eastward and farther offshore. In its wake, it produced 2 to 3+ feet in northern and western MA. Lesser amounts of 6-12 were common over interior lower elevations. Snowfall amounts in southern Worcester County were highly variable. Some specific totals included 14.4 inches at the Worcester Airport.	---
1/7/24	Heavy Snow: Generally seven to 15 inches of snow fell. Some accumulations included 15.5 inches at the Worcester Airport.	---

Extent

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

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

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

Table 72. RSI Scale.

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

Source: NOAA

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

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

Probability of Future Events

The ResilientMass Plan notes that Massachusetts experiences high-impact snowstorms at approximately the rate of three per year over the past 50 years, although there is significant interannual variability in the frequency and severity of winter storms. The City 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 City should be considered exposed to the severe winter storm hazard. They report that there have been more sleet/slush/ice events than in the past.

Built Environment Impacts

The entire built environment of Worcester 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. In the past, there has been freezing of fire protection lines to healthcare and other facilities. Fire protection lines to police and fire stations could also be impacted in the future.

As Hazus doesn't support severe winter storms, and in the absence of other readily available severe winter storm models, historical data was used to determine potential losses and probabilities. From 2012 until 2024, there was $10,690,000 in storm damage in Worcester. This equates to an AAL of $822,308.

Population Impacts

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

Environment Impacts

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

Problem Statements for Severe Winter Storms

Table 73. Problem Statements for Severe Winter Storms.

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

Tornadoes

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

Description

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

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

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

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

Location

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

Previous Occurrences

Worcester has been directly impacted by tornadoes. The most devastating tornado to occur in New England was the Worcester Tornado of July 9, 1953, a category F4 tornado. The tornado passed through Barre, Rutland, Holden, Worcester, Shrewsbury, Westborough, and Southborough causing 90 deaths and over 1,300 injured. Damage estimates were placed at more than $52 million. The National Storm Prediction Center has ranked this as one of the deadliest tornadoes in the nation's history. In 1981, an F3 tornado struck Worcester, resulting in three injuries and little reported property damage.

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

The NOAA Storm Events database (https://www.ncdc.noaa.gov/stormevents/) for Worcester County lists one single EF0 tornado that occurred in Worcester during the period 2014-2024.

Table 74. NCEI Severe Storm Database Entries Covering Tornadoes in Worcester County.

Date	Description	Losses Reported
8/31/14	An upper level disturbance moved across New England in the evening. This combined with warm humid air and breaks of sunshine led to developing showers and thunderstorms. A tornado touchdown occurred near the intersection of Perry Avenue and Fairfax Road. A narrow well-defined damage path extended past Saint Vincent Hospital to Gordon Street. The most significant damage was to trees, some of which were uprooted or snapped. Some trees landed on cars causing significant damage to the cars. A couple of trees landed on houses, but there was little structural damage to the houses. A few windows were broken by tree branches.	$100,000

The NCEI database lists additional tornadoes in the Worcester area over the last decade including events in East Douglas, West Upton, Webster, Hardwick, Hubbardston, Clinton, East Bolton, and North Brookfield. All were EF0 or EF1 events.

Extent

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

Table 75. Enhanced Fujita Scale.

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

Source: National Weather Service

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

Probability of Future Events

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

Overall, it is unclear if tornado frequency will increase with climate change given the difficulty to draw conclusions based on thunderstorm statistics and the difficulty in identifying long-term trends. Nevertheless, given the City's history with tornado damage, it is prudent to assume that the probability of damage from a tornado is likely over the next few decades.

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 City should be considered exposed to the tornado hazard. Microbursts are also a concern in Worcester, as noted in the section about "other severe weather."

Built Environment Impacts

As Hazus doesn't support tornadoes, and in the absence of other readily available tornado models, historical data was used to determine potential losses. From 1953 until 2023, there was one F4 tornado that impacted Worcester and in 1981 there was one F3 tornado. The total damage was $52M. There were thirty-five events in Worcester County which produced $264.267M in property damage, 92 deaths, and 1,254 injuries. The City's average annual loss would be $732,394 while the county's average annual loss would be $3.89M.

Population Impacts

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

Environment Impacts

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

Problem Statements for Tornadoes

Table 76. Problem Statements for Tornadoes.

Assets	Problems Associated with Tornadoes
People (including underserved communities and socially vulnerable populations)	• Vulnerable populations may need support seeking protected shelter. Those without cell phones may not get weather alerts. • People without basements are susceptible to tornado impacts.
Structures (including facilities, lifelines, and critical infrastructure)	• Structures and critical infrastructure can all be impacted by tornadoes. • Roadways may be blocked due to downed trees and other debris.
Systems (including networks and capabilities)	• The electric grid may be impacted by winds and downed trees.
Natural, historic, and cultural resources	• Historic and cultural resources may be impacted by tornado winds. • Winds may damage trees and cause natural areas to close for cleanup.
Activities that have value to the community	• Outdoor events could be impacted by potential tornado activity.

Wildfires/Brushfires

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

Description

The wildfire season in Massachusetts usually begins in late March and typically culminates in early June, corresponding with the driest live fuel moisture periods of the year. April is historically the month in which wildfire risk is the highest. Drought, snowpack level, and local weather conditions can impact the length of the fire season. In 2024, wildfires caused significant damage throughout Massachusetts in the October-November time period, underscoring the close connection between drought and wildfire risk. A full page box about the fall 2024 wildfire season appears later in this section.

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

- Fuel: Without fuel, a fire will stop. Fuel can be removed naturally (when the fire has consumed all burnable fuel) or manually by mechanically or chemically removing fuel from the fire. In structure fires, removal of fuel is not typically a viable method of fire suppression. Fuel separation is important in wildfire suppression and is the basis for controlling prescribed burns and suppressing other wildfires. The type of fuel present in an area can help determine overall susceptibility to wildfires. According to the Forest Encyclopedia Network, four types of fuel are present in wildfires:
    - Ground Fuels: organic soils, forest floor duff, stumps, dead roots, buried fuels
    - Surface Fuels: the litter layer, downed woody materials, dead and live plants to 2 meters tall
    - Ladder Fuels: vine and draped foliage fuels
    - Canopy Fuels: tree crowns
- Heat: Without sufficient heat, a fire cannot begin or continue. Heat can be removed through the application of a substance, such as water, powder, or certain gasses, that reduces the amount of heat available to the fire. Scraping embers from a burning structure also removes the heat source.
- Oxygen: Without oxygen, a fire cannot begin or continue. In most wildland fires, this is commonly the most abundant element of the fire triangle and is therefore not a major factor in suppressing wildfires.
- Uninhibited Chain Reaction: The chain reaction is the feedback of heat to the fuel to produce the gaseous fuel used in the flame. In other words, the chain reaction provides the sustained heat necessary to maintain the fire. Fire suppression techniques, such as dry chemical extinguishers, break up the uninhibited chain reaction of combustion to stop a fire.

Location

The ResilientMass Plan identified areas in Barnstable, Essex, and Plymouth counties with the highest wildfire potential in the state. The ecosystems that are most susceptible to the wildfire hazard Include pine barrens in the Connecticut River Valley, marshes inundated with *Phragmites*, pine barrens and maritime grasslands in Martha's Vineyard, Nantucket, and Cuttyhunk, and the Myles Standish State Forest. Other portions of the Commonwealth are also susceptible to wildfire, particularly at the urban-wildland interface. Notwithstanding the location of Worcester in central Massachusetts, the presence of wildland interface – more than most urban communities – makes Worcester a location with wildfire risk. The HMPC convened for development of this plan noted that the Crow Hill area is a concern for wildfire risks.

In hazard mitigation plans developed for adjacent communities, the Central Massachusetts Regional Planning Commission (CMRPC) noted that air quality in central Massachusetts is adversely impacted by wildfires in other parts of the United States and Canada. Considered in the context of air quality, wildfires therefore have the potential to impact all of Worcester.

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 77. Statewide Brush Fire Counts.

Year	Total # of Events	Injuries/deaths (civilians and fire service)	Losses
2021	4159	Not reported	Not reported
2020	6,364	Not reported	Not reported
2019	2,974	12/0	$136,357
2018	3,253	1/5	$493,145
2017	4,206	20/0	$215,156
2016	7,834	40/0	$1,526,654
2015	6,962	35/0	$323,211
2014	4,627	25/0	$209,857
2013	4,968	31/3	$297,854
2012	5,857	38/0	$705,457

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

Table 78. Outdoor and Total Fire Event Figures for Worcester.

Year	Total Outdoor Fires	Total Fire Events	Reported Losses for Outdoor Fires
2012	675	1587	$2,003,278
2013	598	1454	$1,748,182
2014	406	1274	$3,925,596
2015	593	1510	$6,394,162
2016	511	1426	$4,017,228
2017	348	1270	$2,570,463
2018	334	1384	$2,973,112
2019	348	1300	$2,017,825
2020	665	1576	Not Reported
2021	356	1186	Not Reported

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

Table 79. Estimated Brush Fire Event Figures for Worcester.

Year	Estimated Brush Fires	Estimated Brush Fire Losses
2012	351	$8,949
2013	311	$8,076
2014	211	$23,405
2015	308	$30,936
2016	266	$21,300
2017	181	$17,823
2018	174	$23,407

Year	Estimated Brush Fires	Estimated Brush Fire Losses
2019	181	$14,322
2020	346	$36,209*
2021	185	$17,851*

*Estimated from Countywide figures

The previous edition of this plan noted that "there have not been any major wildfires in Worcester in recent decades. During the period 2006-2015, there were 1,442 total forest and brush fire incidents, with 499 total acres burned." The above figures compare reasonably well to the figures reported in the previous edition of this plan.

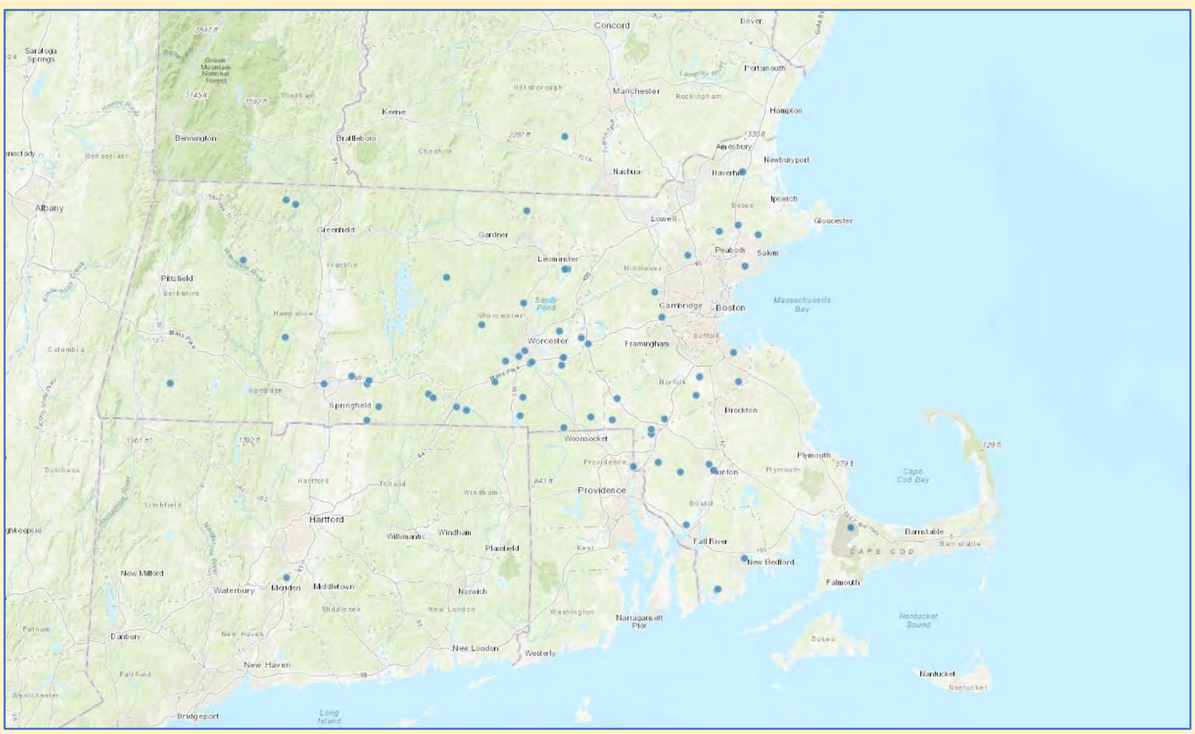
Autumn 2024 was a very active wildfire season in Massachusetts, due to the flashy drought conditions that developed after the summer and other factors. According to the Massachusetts DCR Bureau of Forest Fire Control and Forestry[66], October 2024 saw 588 acres burned across Massachusetts through 185 separate fires as of October 29th. The majority of the fires occurred during the last week of the month[67].

[66] "Massachusetts Wildfire Activity Briefing, October 29, 2024, as of 17:00", https://www.wwlp.com/wp-content/uploads/sites/26/2024/10/Massachusetts-Wildfire-Activity-Briefing-10-29-24.pdf
[67] https://www.masslive.com/news/2024/10/wildfires-spread-across-massachusetts-amid-dry-windy-weather.html

Weather in October 2024 resulted in “abnormally dry” or “moderate drought” conditions across Massachusetts, resulting in multiple wildfires. Conditions were particularly susceptible to wildfires during the last week of the month. The NWS issued a Red Flag warning on Friday, October 25. Over the weekend, 126 brush fires were reported burning over 548 acres across Massachusetts into the following week:

- The Cain Hill brush fire burned over 133 acres in Salem, Lynn, Peabody, and other communities. Two other multi-acre fires also occurred in Salem.
- The Middleton Pond brush fire burned over 250 acres in Middleton, North Reading, and Breakheart Reservation in Saugus.
- A brush fire in Millbury killed a woman in an encampment where the fire was believed to have started.
- The Papas 32-acre brush fire occurred in Canton.
- Other areas with brush fires include Brockton, Devens, Haverhill, Holden, Leonminster, Milton, New Bedford, North Andover, Springfield, Sutton, Westfield, Weston, Wilmington, Worcester

A major challenge for firefighters was limited resources with so many other fires occurring at the same time. The statewide Fire Mobilization Plan was activated to organize firefighting resources. The state National Guard was deployed to provide water drops onto the larger fires. Air quality was affected throughout the region, particularly on the North Shore with the worst air quality found in Lynn, Saugus, Swampscott, and Salem. Salem High School shut down classes early on Tuesday, 10/29 due to poor air quality, and the annual Trick or Treat festival in Reading was cancelled due to air quality concerns.



Wildfires in Massachusetts as of October 28, 2024

(National Interagency Fire Center)

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

Table 80. USDA Disasters Events That Refer to Wildfires.

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

During the meetings that were convened for this plan update, City staff noted that Worcester has not experienced major damaging wildfires.

Extent

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

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

The National Wildfire Coordinating Group defines seven classes of wildfires:

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

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

Probability of Future Events

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

Vulnerability Assessment

Exposure

To help identify potential wildfire areas for Worcester, the U.S. Forest Service's Wildfire Risk to Communities spatial data was downloaded. This data was developed in 2020 using the vegetation and wildland fuels from the LANDFIRE 2014 model with the burn probability coming from the Forest Service Fire Simulation System (FSim). To create a product with a finer resolution, the data was upsampled to the native 30m resolution of the LANDFIRE fuel and vegetation data spreading the values of the modeled burn probability into developed areas represented in LANDFIRE fuels as non-burnable. The areas with a 0.015% annual probability of burning were identified and overlaid with the critical facilities and other buildings. There were no critical facilities found in the 0.015% burn probability areas and only one commercial building found there. Table 81 shows the result of this analysis.

Table 81. Buildings in 0.015% Annual Chance Area.

Building Type	Number of Buildings in 0.015% Annual Chance Area (Total in City)	Building Value in 0.015% Annual Chance Area (Total in City)
Single Family	0 (31399)	$0 ($13,989,054,910)
Multi-Family	0 (14496)	$0 ($23,767,111,740)
Commercial	1 (3203)	$2,641,641 ($10,363,149,842)
Agricultural	0 (72)	$0 ($22,837,164)
Educational	0 (372)	$0 ($7,450,820,493)

Building Type	Number of Buildings in 0.015% Annual Chance Area (Total in City)	Building Value in 0.015% Annual Chance Area (Total in City)
Government	0 (155)	$0 ($647,185,275)
Religious/Non-Profit	0 (239)	$0 ($863,742,992)
Industrial	0 (220)	$0 ($1,680,656,677)
Garage/Outbuilding	0 (46)	$0 ($916,384)
Total	**1 (50202)**	**$2,641,641 ($58,785,475,479)**

There were no residential properties exposed to the higher burn probability areas, so the population exposed is minimal. Figure 27 shows the burn probability map from the USFS overlaid on the City. There have been recent brush fires in the southeast part of the City.

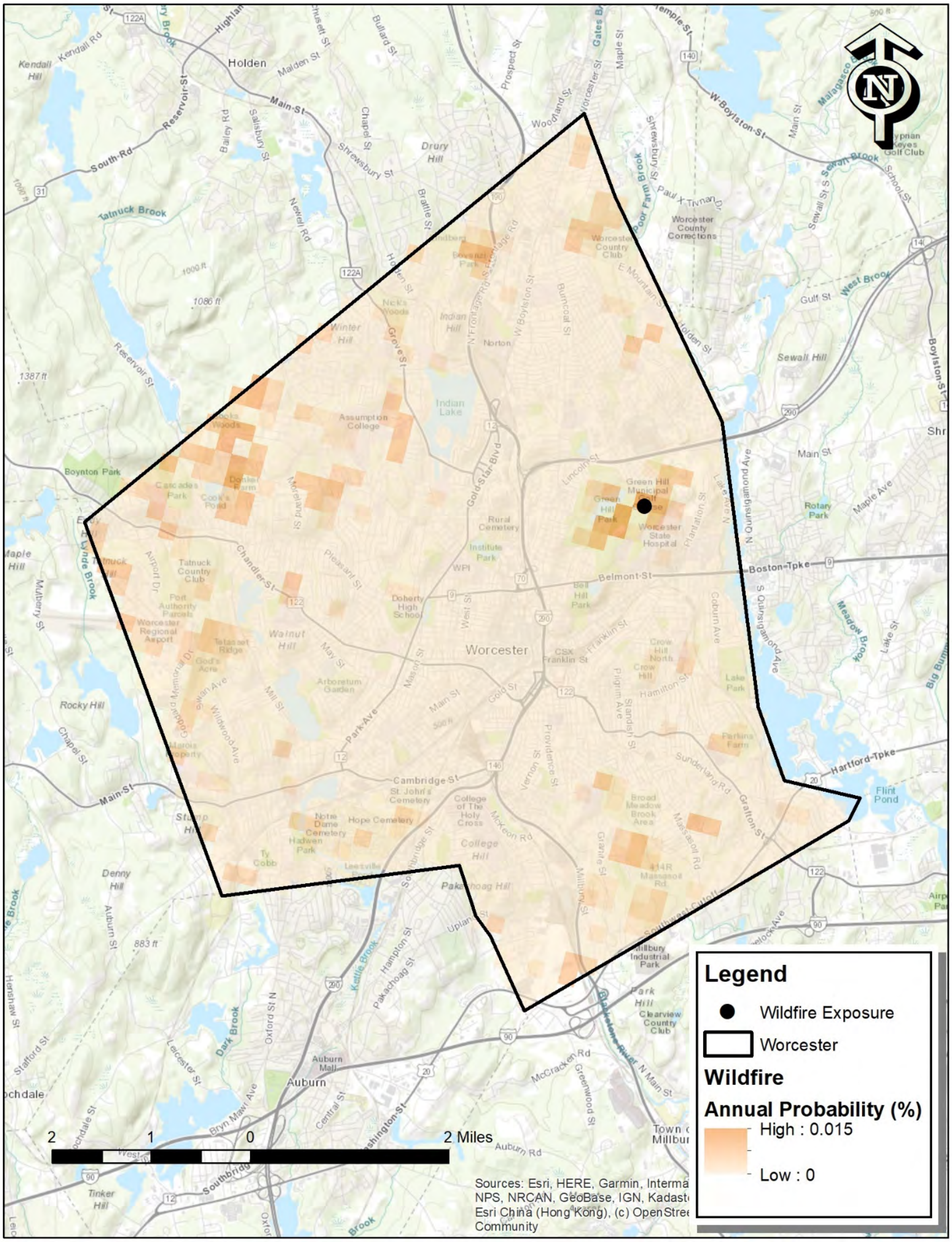


Figure 27. Wildfire Burn Probability Map.

Built Environment Impacts

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

No property damage, injuries or deaths have been recorded for the reported for major wildfires in Worcester between 2004 and 2022. Using the wildfire probabilities and building values, a loss estimate was produced for the 0.015% scenario. The losses are $2,641,641 for the .015% event and the AAL will be $396.

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

Population Impacts

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

Air quality can also be impacted due to major wildfires. The Canadian wildfires in 2022 impacted the air quality of communities throughout Massachusetts. Individuals with asthma and smoke-sensitivity could be severely impacted by poor air quality leading to life and business disruption. Animals kept outside could also be impacted by poor air quality.

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

Environment Impacts

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

Problem Statements for Wildfires

Table 82. Problem Statements for Wildfires.

Assets	Problems Associated with Wildfires
People (including underserved communities and socially vulnerable populations)	• Populations with severe asthma may be adversely impacted by wildfires in the vicinity.
Structures (including facilities, lifelines, and critical infrastructure)	• Some structures are found in the higher probability burn areas. Structures without defensible zones are more susceptible to wildfires and brush fires.
Systems (including networks and capabilities)	• Wildfires often cause roads to be closed requiring detours impacting emergency services.
Natural, historic, and cultural resources	• Wildfires may adversely impact forested and other vegetated areas of Worcester.
Activities that have value to the community	• Recreational activities may be adversely impacted by wildfires, depending on location.

National Flood Insurance Repetitive Loss Properties

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

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.

Figure 28 show the neighborhoods with repetitive loss and severe repetitive loss properties. According to data provided by Worcester, 21 repetitive loss properties and four severe repetitive loss properties are located in Worcester. The repetitive loss properties include seven single family homes, seven multi-family homes, two commercial properties, and five other non-residential properties while the severe repetitive loss properties include two commercial buildings and two other non-residential properties.

The repetitive loss properties experienced 46 incidents for a combined $1,862,940.82 in loss while the severe repetitive loss properties experienced 28 incidents for a combined $933,296.09 in loss. A summary of the City's participation and compliance with the NFIP, including current policy and historical claims statistics, is provided in Table 7 of Chapter 5 (Capability Assessment).

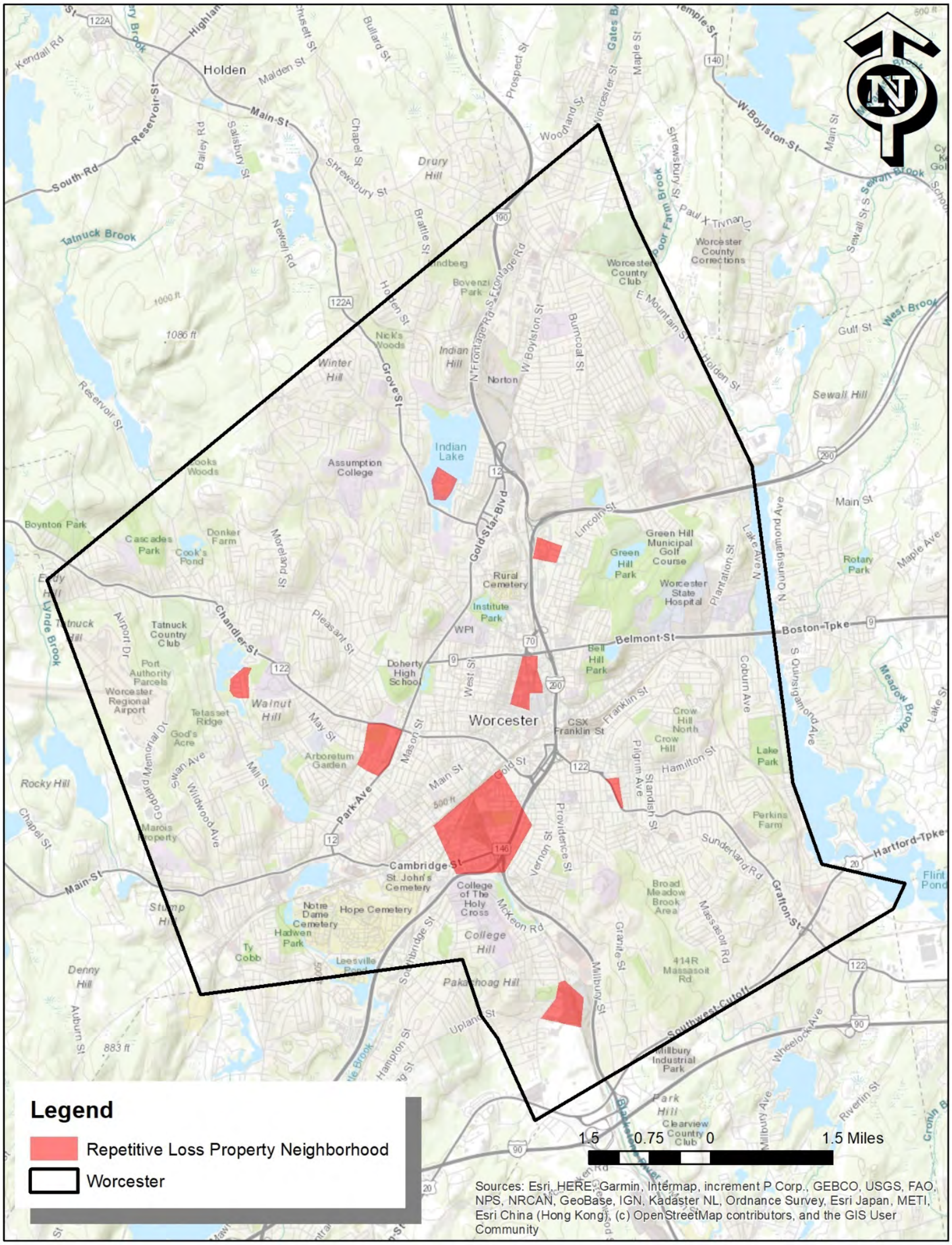


Figure 28. Neighborhoods with Repetitive Loss and Severe Repetitive Loss Properties.

Hazard Ranking

Ranking hazards helps the City 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 83 provides the hazard characteristic, level description, level criteria, level index value, and weighting value.

Table 83. 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, if any. Only minor property damage and minimal disruption to quality of life. Temporary shutdown of critical facilities.	1	30%

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

Table 84 provides the final hazard ranking for Worcester. Each hazard characteristic is assigned a value between 1 (lowest value) and 4 (highest value). When the risk values were calculated, if the value was greater than 2.7, it was assigned as a high risk hazard. If the value was greater than 2 and less than or equal to 2.7, it was assigned as a moderate risk. If the value was less than or equal to 2, it was assigned as a low risk hazard. The flooding from precipitation, severe winter storms, average and extreme temperatures, other severe weather, and drought hazards were ranked highest. The flooding from dam failure and overtopping, tornadoes, wildfires/brushfires, hurricanes/tropical storms, invasive species, and landslides were all ranked as moderate. The earthquake hazard is ranked as low.

Table 84. Final Hazard Ranking of Hazards for Worcester.

Hazards	Probability	Impact	Spatial Extent	Warning Time	Duration	Value	Rank
Flooding from Precipitation	4	3	2	3	2	3	High
Severe Winter Storms	4	2	4	1	3	3	High
Average and Extreme Temperatures	4	2	4	1	2	2.9	High
Other Severe Weather	3	3	4	2	1	2.9	High
Droughts	3	2	4	1	4	2.8	High
Flooding from Dam Failure or Overtopping	2	4	2	3	2	2.7	Mod.
Tornadoes	3	4	1	3	1	2.7	Mod.
Wildfires/Brushfires	3	2	3	3	3	2.7	Mod.
Hurricanes/Tropical Storms	3	2	4	1	2	2.6	Mod.
Invasive Species	3	1	2	3	4	2.3	Mod.
Landslides	2	2	2	4	1	2.1	Mod.
Earthquakes	1	1	4	4	1	1.9	Low

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

Table 85. Impacts from Population and Land Use.

Hazards	Changes in Population Patterns	Changes in Land Use and Development
Flooding from Precipitation and/or Dam Failures	There is a growing elderly population exposed to the floodplain: • South and West of Indian Lake • Western part of Salisbury Heights • East of Mill St. and north of Cambridge St.	Existing codes and regulations in the SFHA will help to keep flood impacts low. New development areas may produce additional flooding due to the addition of impervious surfaces.

Hazards	Changes in Population Patterns	Changes in Land Use and Development
Droughts	The City's elderly population has increased from 12.5% in 2010 to 13.8% in 2020. The poverty rate has increased slightly from 19.4% in 2010 to 19.5% in 2020.	All new developments will create more demand for limited water resources.
Landslides	There is a growing elderly population near Green Hill Park and south of Millstone Hill exposed to a moderate landslide susceptibility area.	Existing land use regulations will help to keep development out of landslide-prone areas.
Extreme Temperatures	The City's elderly population has increased from 12.5% in 2010 to 13.8% in 2020. The poverty rate has increased slightly from 19.4% in 2010 to 19.5% in 2020.	All new developments will exacerbate heat island effect if the development includes tree removal and adding black surfaces such as asphalt and roofs.
Wildfires	There is a growing elderly population near Green Hill Park with a moderate wildfire susceptibility.	Development in or adjacent to a forested or brushland area can lead to a higher risk of wildfire.
Invasive Species	Shouldn't be impacted by population changes.	Shouldn't be impacted by changes in land use and development.
Hurricanes and Tropical Storms	The City's elderly population has increased from 12.5% in 2010 to 13.8% in 2020. The poverty rate has increased slightly from 19.4% in 2010 to 19.5% in 2020.	Shouldn't be impacted by changes in land use and development.
Severe Winter Storms	The City's elderly population has increased from 12.5% in 2010 to 13.8% in 2020. The poverty rate has increased slightly from 19.4% in 2010 to 19.5% in 2020.	Shouldn't be impacted by changes in land use and development.

Hazards	Changes in Population Patterns	Changes in Land Use and Development
Tornadoes	The City's elderly population has increased from 12.5% in 2010 to 13.8% in 2020. The poverty rate has increased slightly from 19.4% in 2010 to 19.5% in 2020.	Shouldn't be impacted by changes in land use and development.
Other Severe Weather	The City's elderly population has increased from 12.5% in 2010 to 13.8% in 2020. The poverty rate has increased slightly from 19.4% in 2010 to 19.5% in 2020.	Shouldn't be impacted by changes in land use and development.
Earthquakes	Not considered.	Not considered.

Problem Statements Summary

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

Table 86. Problem Statements Summary.

Hazard	Problem Summary
Flooding from Precipitation	• The City's areas of flood risk are associated with the Blackstone River, the Mill Brook conduit, the Blackstone Canal, and their tributaries. The Mill Brook conduit work in the 1980s/1990s reportedly addressed some flooding along the watercourse, but flooding still occurs. • The Green Island neighborhood experiences frequent and extreme cases of flooding, affecting numerous City residents. • Older populations and lower income households in the floodplain may have difficulty evacuating.

Hazard	Problem Summary
	• The Fire Station on Webster Street, WRTA maintenance facility, Dept. of Environmental Protection building, electrical substation, and transfer station are exposed to the 100-year floodplain. • Approximately 925 buildings are in the floodplain including buildings of all occupancies. • At least 17 flood and flash flood events were sufficiently severe to be included in the NCEI severe storm database, including damaging events in August 2020 and July 2021. • Undersized culverts are a problem citywide. These can be found in many locations, from downtown areas to the less developed outer parts of the City. • Road closures may interrupt community systems including Southgate Street, Quinsigamond Avenue, Hammond Street, Millbury Street along the Blackstone River, Southwest Cutoff (MA-20) under the Grafton Street overpass, Major Taylor Boulevard near the DCU Center, and Pelham Street. Additionally, railroad tracks and railroad bridges, sloped roadways along Belmont Street and low bridges along Cambridge Street are susceptible to flooding. • The City is currently precluded from adopting higher regulatory standards to protect against flooding (must comply with State Building Code). • There are 18 structures listed on the National Register of Historic Places in the floodplain. • Road closures may disrupt community events.
Severe Winter Storms	• Vulnerable populations may be stranded during a winter storm event and may not be able to travel to emergency services. • The electrical grid and roadways are susceptible to failure and loss of use during storms. • Roof ice dams may cause damage to structures.

Hazard	Problem Summary
	• The City is concerned about vulnerability of the fire lines to critical facilities. • First responders may have difficulty reaching people if roads are closed due to road closures.
Average and Extreme Temperatures	• Extreme heat will be a significant public health threat to all residents, but especially for vulnerable populations living in older homes or homes without air conditioning. • The elderly and those with mobility issues may not be able to leave their homes and travel safely. • People working in businesses without air conditioning may be at risk of heat illness. • First responders may also be impacted by extreme temperatures. • Pets may be adversely impacted by extreme heat.
Other Severe Weather	• Severe storms caused trees and wires to come down on cars and houses in at least 40 separate events from 2015 through 2024. • First responders may have difficulty reaching people if roads are closed due to tree debris. • Storm damage to wind-susceptible buildings such as carports, greenhouses, and open-walled buildings. Additional damage to commercial buildings with HVAC located on roofs. • The electric grid may go down during high wind event. • The rod and gun club structures are believed vulnerable.
Droughts	• Vulnerable communities may have difficulty accessing potable water during an emergency drought event. • Water supply infrastructure may need to be shut down and water quality may become substandard. Businesses requiring water for daily operations may have their operations limited due to water restrictions.

Hazard	Problem Summary
	• Outdoor water use restrictions and other water conservation measures during periods of extreme drought can be challenging to enforce, even when mandated through local declaration.
Flooding from Dam Failure or Overtopping	• Older and lower income populations in the potential downstream inundation area may have difficulty evacuating, particularly in a short time frame. • Local officials sometimes do not routinely receive copies and updates of EAPs for privately owned dams. Without these documents, it is harder for emergency personnel to characterize the potential downstream risks and prepare for a potential breach event. • When engineered, dam spillways were often designed to pass a discharge for a particular historic storm recurrence interval. As the frequency and magnitude of precipitation events changes, these spillways are becoming undersized relative to their design standard which places downstream areas at increased risk of experiencing inundation from a dam failure.
Tornadoes	• Structures and critical infrastructure can all be impacted by tornadoes. • Roadways may be blocked due to downed trees and other debris. • The electric grid may be impacted by winds and downed trees. • Vulnerable populations may need support seeking protected shelter. Those without cell phones may not get weather alerts.
Wildfires/Brushfires	• Populations with severe asthma may be adversely impacted by wildfires in the vicinity. • Some structures are found in the higher probability burn areas. Structures without defensible zones are more susceptible to wildfires and brush fires. • Wildfires often cause roads to be closed requiring detours impacting emergency services.

Hazard	Problem Summary
Hurricanes/Tropical Storms	• Wind may cause trees to fall into structures and infrastructure, and roadways. • Wind damage to wind-susceptible buildings such as communication antennas, aerial utilities, solar arrays, greenhouses, pavilions, gazebos, and open-walled buildings. Additional damage to commercial buildings with HVAC located on roofs. • The electric grid may go down during high wind event.
Invasive Species	• Insect and diseases of particular concern for Worcester's street tree population are spotted lanternfly, Asian longhorned beetle, European spongy moth, emerald ash borer, and oak wilt. • The discovery of ALB in Worcester led to the removal of over 30,000 public and private trees which had a tremendous impact on the urban forest and the quality of life of residents, especially those in the Burncoat and Greendale areas that were hardest hit by ALB tree removals. • Aquatic invasive and nuisance species are an additional concern in Worcester. These include common reed, water chestnut, Eurasian milfoil, variable-leaf milfoil, brittle naiad, curly-leaf pondweed, fanwort, and purple loosestrife. • Hydrilla is not yet present but a concern for the City. • Oriental bittersweet and Japanese knotwood continue to be challenges. Furthermore, vegetation favored by Spotted lanternfly will likely become a larger concern over the next few years.
Landslides	• Fire station may be impacted by landslide event. • Some residential and other structures reside adjacent to moderately unstable areas and could be impacted.
Earthquakes	• Elderly people may fall during an event. • Unreinforced masonry and utility lifelines impacted. Multi-story masonry residential buildings are located in Worcester.

Chapter 5: Capability Assessment

Overview

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

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

This capability assessment was completed to not only help establish the goals and actions for the City of Worcester's hazard mitigation plan, but to also help ensure that those goals and actions are realistically achievable under current local conditions. As highlighted in FEMA's 2022 Local Mitigation Planning Policy Guide, *"describing the current capabilities provides a rationale for which mitigation projects can be undertaken to address the vulnerabilities identified in the Risk Assessment."* [68]

The capability assessment for the City of Worcester includes a comprehensive examination of several components as summarized in Table 87. It was prepared using the latest guidance and worksheets provided in FEMA's 2023 Local Mitigation Planning Handbook.[69]

Table 87. 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.

[68] Local Mitigation Planning Policy Guide. FEMA. April 2022. P. 25.
[69] Local Mitigation Planning Handbook. FEMA. May 2023. PP. 79-92 and Worksheets 4-5.

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

Review and Incorporation of Existing Plans, Studies, and Reports

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

The first step in completing the updated capability assessment was to gather and review any relevant local plans, studies, or reports completed or updated since the previous hazard mitigation plan was adopted in 2019. This information was used to help gain a current understanding of the City's current ability to mitigate risk, and how local capabilities may have changed over the past five years. The 2023 Massachusetts State Hazard Mitigation and Climate Adaptation Plan (the "ResilientMass" Plan), as well as other plans adopted by the City of Worcester in the recent past, were reviewed for consistency as well as opportunities for plan integration. The goal of this review was to support updates to this plan that easily align with and possibly incorporate key aspects of relevant plans at the state and local level.

Table 88 provides a summary of the most relevant plans, studies, reports, or sources of other technical information consulted as part of this process and how they were incorporated into this plan update.

Table 88. Relevant Plans, Studies, and Reports for Incorporation.

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

Plan / Study / Report	Summary Description / Incorporation
	withstand, rapidly recover from, adapt to, and mitigate natural hazard events. Through the ResilientMass Plan, the Commonwealth is advancing its mission to increase its capacity for addressing natural and other hazards and climate impacts through preparation, mitigation, adaptation, and risk reduction. The ResilientMass Plan includes six (6) overarching goals which were developed through a collaborative process involving the interagency ResilientMass Action Team (RMAT) and local, regional, and community partners. It also integrates the findings of the 2022 Climate Assessment with additional analysis on all current hazards that may impact the Commonwealth, as well as future risks that will increase the likelihood, frequency, and duration of hazards. Of perhaps most relevance to local communities, the ResilientMass Plan identifies the most urgent priority impacts of these risks to various regions across the Commonwealth. The ResilientMass Plan was incorporated as a key source of information for this plan update. This included the integration and consideration of the latest climate data and information for 15 hazards impacting the Commonwealth now and, in the future, with particular emphasis on those unique impacts determined for the Central region. In addition, the goals and actions included in Chapter 7 (State Strategy, Actions, and Implementation Plan) were reviewed and considered as part of the update process for Worcester's Hazard Mitigation Plan to help ensure the City's own goals and objectives are in alignment with and can be mutually supportive of the Commonwealth's overall strategy. As can be seen in Chapter 6 of this plan. several of the goals and actions identified for Worcester's updated plan address the key themes identified in the ResilientMass Plan.
Worcester Now | Next Plan (2024)	Worcester Now | Next is the City of Worcester's long-range citywide plan, which embodies the community's collective vision for the future. To actualize this vision, the plan identifies land use and zoning policy recommendations that shape the transformation of strategically identified "Growth Areas" across the city into higher-density and mixed-use areas. These areas aim to accommodate equitable employment opportunities and housing growth, and to reduce the environmental impacts of that growth by promoting transit use and walkability. Every goal, strategy, and recommendation in this plan is rooted in community- identified priorities, marking significant steps toward

Plan / Study / Report	Summary Description / Incorporation
	realizing our collective vision. The final plan is designed to provide a coordinated roadmap for the future development and evolution of the city and establish a framework for more detailed studies to come. Worcester Now | Next was reviewed and considered a critical document for incorporating into this plan update. Years in the making, this newly adopted plan is based on widespread public involvement and stitches together many other topical plans the City has completed to date, from the Green Worcester Plan to the Cultural Plan. It provides a blueprint for how the city should be shaped to advance the commonalities and shared goals of those plans. At the same time, it was sewn together based on the guiding principles of equity, inclusion, integrity, innovation, and **resilience**. The goals, strategies and recommendations for building resilience to climate change and natural hazards were incorporated into discussions with the HMPC as it relates to the updated Mitigation Strategy, with an emphasis on integrating and prioritizing actions that are consistent and mutually supportive of both plans.
City of Worcester Municipal Vulnerability Preparedness Plan: Findings & Recommendations (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, Worcester 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 City of Worcester followed the Community Resilience Building (CRB) framework with technical assistance provided by a state-certified MVP Provider, Kleinfelder. 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. A day long CRB Workshop was held on January 25, 2019, with the following central objectives: 1. Define the top climate-related hazards impacting the City; 2. Identify areas particularly vulnerable to those hazards related to the City's social, environmental, and infrastructure frameworks; 3. Identify potential challenges in addressing those issues;

Plan / Study / Report	Summary Description / Incorporation
	4. Document community strengths to assist addressing hazards; and 5. Provide recommendations to improve resilience by leveraging those community strengths as assets and reducing vulnerabilities. The resulting Summary of Findings Report and supporting materials served as a primary source of information and community-based input for incorporation into the update of this plan. These inputs include the identification of top climate change hazards (flooding from extreme precipitation; ice/snowstorms coupled with extreme cold; and extreme heat coupled with drought) 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 Worcester.
Strategic Plan (FY2025-2029)	The City of Worcester's Strategic Plan lays out an updated mission, vision, values, strategies and objectives that will guide municipal operations over the next five years. Prepared by the City Manager's Office and Administration, the plan was informed by extensive self-study, internal discussion and community input dating back to the previous FY20-24 Strategic Plan. The community engagement process included listening sessions, focus groups, surveys and feedback solicited during the development of the Worcester Now | Next Plan (described above) and other city-wide municipal plans. The mission, vision, values and objectives as stated in the Strategic Plan aim to reflect the needs and priorities of Worcester's residents while maintaining inclusive, equitable and efficient local government. As such it was reviewed and incorporated into the plan review process for the hazard mitigation plan update to ensure the recommendations and proposed actions for the Mitigation Strategy are consistent and supportive of these established needs and priorities as much as possible. This especially includes those priority areas and strategies assigned to the City's Sustainability & Resilience Department.
Urban Forest Master Plan (2023)	The City's first comprehensive Urban Forestry Master Plan (UFMP) provides a framework to assist the city in maintaining a healthy, resilient, and sustainable urban forest by continuing its legacy of management, planting, and care. The Plan highlights the current state of Worcester's urban forest and outlines recommendations and actions to manage it as a sustainable community asset. While the urban forest includes all trees in the city (those

Plan / Study / Report	Summary Description / Incorporation
	on both public and private property), this plan focuses primarily on Worcester's public street and park trees that the City of Worcester Department of Public Works and Parks is directly responsible for managing. The UFMP served as a primary source of information for review and incorporation into the Risk Assessment and Mitigation Strategy chapters of the plan update. This includes data on Worcester's changing climate, such as more extreme heat days, the impacts of the urban heat island effect, and related concerns such as invasive pests and disease. It also includes information on recommended actions that provide the benefits of hazard mitigation and building long-term community resilience to climate change.
Heat Risk Assessment (2022)	In 2022, the City completed a heat assessment which studied Worcester's temperature changes under multiple scenarios. The purpose of the study was to help the City more efficiently plan projects to combat heat, such as painting impervious pavement white and increasing tree canopy. To achieve this goal the study sought to identify how hot the City is now, where it is currently the hottest, the level of impact on vulnerable populations, and the impact of possible solutions. The assessment ranked heat risk across various areas of the community and identified specific neighborhood-level recommendations to reduce and manage these risks. The main finding is that by strategically planting 35,000 trees in dense, vulnerable areas, the City could significantly reduce extreme heat and heat-related illness. The results of the heat risk assessment provided key information in support of the Risk Assessment, including heat risk factors (exposure, sensitivity, and adaptive capacity) for vulnerable populations and total heat risk for various areas of the community. Recommended extreme heat mitigation strategies (e.g., increasing tree canopy, improving heat surveillance systems, siting cooling centers) were also incorporated into the identification and review of possible actions to be included in the Mitigation Strategy chapter of this plan.
Open Space & Recreation Plan (2021)	The Open Space and Recreation Plan (OSRP) aims to provide the City of Worcester with a blueprint for ensuring that current and future residents have ample opportunities for recreation and access to open space. As stated in the plan, it is also about making Worcester competitive and attractive in the face of a changing world with shifting priorities, and an ever-evolving local demographic. The intent of the OSRP is to evaluate and report progress

Plan / Study / Report	Summary Description / Incorporation
	made through past planning efforts, and to help guide the City's decision making about open space and recreation opportunities through 2028. The plan also intends to integrate the goals and objectives of the OSRP with other City programs and initiatives – including those that promote climate resilience. It includes information on the history, growth, and development of the community as well as a detailed environmental inventory and analysis. It also includes a community vision along with the identification of resource protection and management needs, followed by specific goals, objectives, and actions to be pursued through a seven-year Action Plan. The OSRP served as a key source of information related to Worcester's natural environment and growth and development patterns, with specific content regarding natural hazards and mitigation activities also being incorporated into this updated plan. This includes details on environmental challenges such as chronic flooding, erosion and sedimentation, combined sewer overflows, forest degradation, invasive species, and environmental equity for the risk assessment, and information on existing goals and recommended or planned activities that will help the community to mitigate hazards or adapt to climate change for the mitigation strategy.
Green Worcester Plan (2020)	The Green Worcester Plan is a strategic framework for an integrated and systematic approach to making Worcester one of the most sustainable and climate-resilient mid-sized cities in America by 2050. The Plan focuses on City leadership, goals, strategies, and actions, with the collaboration of partners across the city, including residents, institutions, businesses, nonprofits and others. The plan not only lays out steps for the city to transition to 100% clean and renewable energy by 2045, but it also identifies how the City can retrofit buildings and transportation infrastructure, invest in natural systems, and achieve social equity. The Green Worcester Plan was developed by the City's Energy & Asset Management Division (now Department of Sustainability & Resilience) over a two-year period with the collaboration of the Green Worcester Working Group and widespread public participation. It was built on the 2006 Climate Action Plan and 2019 Municipal Vulnerability Preparedness (MVP) plan to create a citywide framework for equity-driven sustainability and resilience. The 2024 Worcester Now | Next Plan (described above) is in many ways an extension of and complement to the Green Worcester Plan and has been

Plan / Study / Report	Summary Description / Incorporation
	similarly reviewed and incorporated into this plan update process as it relates to the revising the Mitigation Strategy in a manner that is consistent and mutually supportive of both plans.
Cultural Plan (2019)	Becoming Worcester, The Evolution of a Creative City: a Cultural Plan for Worcester was commissioned by the City of Worcester, the Worcester Cultural Coalition, and the Greater Worcester Community Foundation. The plan outlines actions for city agencies and local organizations to further the plan's vision of an inclusive, cohesive, diverse, and innovative Worcester. The Cultural Plan envisioned a city with strong physical and social cohesion that enables ease of movement for people of all ages, abilities, and means; a city that supports innovation and entrepreneurship, learning, and cultural opportunities for all; a city that reflects its heritage, its diverse cultures, and new ideas in its public spaces, downtown, natural and built environments, and in its neighborhoods; and a city where daily life is supported by local commerce, services, and activities related to the diverse traditions, creative expressions, and collective celebrations of all its people. Like Green Worcester (described above), many of these ambitions and ideas bridge naturally into the vision and plan framework for Now | Next (also described above), and it has been reviewed and incorporated into the plan update process to help reflect and reinforce this vision as appropriate through the Hazard Mitigation Plan.
Emergency Action Plans (2019)	The City of Worcester maintains Emergency Action Plans (EAPs) for all dams that are owned by the City and required to maintain EAPs. The purpose of EAPs is to safeguard lives and reduce damage to private and public property downstream of dam structures in the event of a dam failure. EAPs define responsibilities and provides procedures designed to identify unusual or unlikely conditions that may endanger the integrity of a dam in time to take mitigative action. In addition, EAPs provide procedures to notify the appropriate emergency management officials of possible, impending, or actual failure of the dam. All the latest available EAPs (dated 2019) for dams classified as High and Significant Hazard Potential with impacts to Worcester were reviewed and used to inform the plan update. This includes EAPS for the following dams: Bear Brook, Coes Lower Pond, Coes Reservoir, Green Hill Pond, Holden Reservoirs (1 and 2), Lynd Brook Dam and Dike, Parsons Reservoir, Patch

Plan / Study / Report	Summary Description / Incorporation
	Pond, and Patch Reservoir. Relevant data and information were incorporated into the risk assessment as deemed appropriate, especially as it relates to dam failure inundation maps that show the stream(s) which would be flooded, as well as the impacted downstream environment during potential dam failure events. These maps were digitized and integrated into the risk assessment to conduct a GIS-based vulnerability assessment to determine the exposure of critical facilities, buildings, and populations in the planning area to dam failure. They were also integrated into Hazus, FEMA's loss estimation software, to determine economic losses from dam failure inundation.
FEMA Flood Insurance Study for Worcester County (2023)	Last published by FEMA on June 21, 2023, this report constitutes the currently effective Flood Insurance Study (FIS) report for Worcester County. This latest FIS revises and updates information on the existence and severity of flood hazards for the study area, which includes the City of Worcester. The studies described in this report provide flood hazard data that are used to establish actuarial flood insurance rates and to assist communities in efforts to implement sound floodplain management. The FIS and accompanying Flood Insurance Rate Maps (FIRMs) include relevant data and information on flood hazards for Worcester, including but not limited to descriptions of principal flood problems, flooding sources, FEMA flood zone designations, base flood elevations, and discharge rates of flooding sources. This data and information were reviewed and incorporated into the plan update process by informing the risk assessment, especially as it relates to the hazard profile and vulnerability assessment that was prepared for the flood hazard.

In addition to the above plans which were determined to be most relevant for incorporation into the hazard mitigation plan update, the following plans, studies, reports, and other technical documents were reviewed to gain a clearer understanding of local capabilities and their existing or potential effects on hazard risk reduction. More information on some of these documents is provided in Table 89 in the next section.

- ***Mobility Action Plan (2024 Draft)* –** The Mobility Action Plan is a long-range transportation plan that will guide the Worcester Department of Transportation & Mobility (DTM) in execution of identified policies, programs, strategies, and projects to improve the City's transportation system. The Plan identifies challenges and opportunities within Worcester's existing transportation system and includes 4 recommended strategies for the City of Worcester to initiate and execute (safety, connectivity, equity, and sustainability). The principles of hazard mitigation and climate resilience are addressed under the goal of sustainability (for example, incorporating green infrastructure to manage stormwater, mitigate flooding, and reduce the urban heat island effect).

- ***Comprehensive Emergency Management Plan (2022)*** – The City's Comprehensive Emergency Management Plan (CEMP), and it's supporting annexes, is an all hazards plan developed to address the natural and human-caused hazards that threaten Worcester. The CEMP outlines Worcester's alignment to Homeland Security Presidential Directive 5, in that all Emergency Operations are coordinated using the Incident Command System. Further, it describes the Incident Support Model (ISM) structure of the Worcester EOC. The focus of previous CEMP versions was Preparedness and Response to all-hazards, man-made caused emergencies and natural disasters. Equal emphasis is now placed on Recovery and Prevention/Mitigation to complete the four phases of a comprehensive emergency management plan. This plan addresses incidents in which the actions of many different organizations must be coordinated, which differs from smaller scale incidents handled routinely by local emergency response personnel.
- ***Five-Year Consolidated Plan (2020-2025)*** –This plan serves as the City's Five-Year Consolidated Submission for Community Planning and Development to the U.S. Department of Housing and Urban Development (HUD) as required for entitlement cities to receive federal housing and community development funding. The Consolidated Plan allows the City to shape its housing and community development programs into coordinated strategies and helps inform progress toward community development.
- ***Integrated Water Resources Management Plan (2019)*** – The Integrated Plan identifies and evaluates infrastructure investments for the City's water resources systems, which consist of the drinking water system, wastewater and stormwater systems, and the Upper Blackstone Wastewater Treatment Facility. It addresses the most pressing health and environmental protection issues by giving priority to infrastructure investments that result in greater environmental benefits for each dollar spent. It also includes detailed analyses of the City's financial capability to implement the Plan and its affordability for residents and ratepayers. This Integrated Plan allows for significant updates on a continuing basis using adaptive management principles and represents a sound, responsible and realistic strategic plan.
- ***Worcester Historic Preservation Study (2016)*** – This study was conducted to assess historic preservation programs and related activities administered by the Worcester Historical Commission and City of Worcester. It evaluated two key historic preservation regulatory tools (demolition delay and local historic districts) currently used by the City and recommends refinements to improve their effectiveness and administration. Additionally, the study evaluated issues, opportunities and potential strategies related to the preservation and reuse of historic buildings in the context of the City's downtown area specifically.

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

Table 89. Planning and Regulatory Findings.

Planning/Regulatory Tool	**In Place?** *(Yes/No)*	**General Description / Effectiveness for Hazard Risk Reduction**
Plans		
Master/Comprehensive Plan	Yes	Worcester Now | Next is the City of Worcester's long-range citywide plan. It addresses multiple hazards (flooding, stormwater management, heat waves) in addition to other climate change related risks and stressors. Resilience is identified as a Guiding Principle for the plan and there are numerous goals and specific actions to reduce known hazard risks. The plan is considered an effective tool for promoting and implementing mitigation actions. See Table 2 for a complete description. Last adopted in 2024.
Open Space & Recreation Plan	Yes	The Open Space and Recreation Plan (OSRP) aims to provide the City of Worcester with a blueprint for ensuring that current and future residents have ample opportunities for recreation and access to open space. It includes some details on hazards and other environmental challenges such as chronic flooding, erosion and sedimentation, combined sewer overflows, forest degradation, and invasive species, and the goals, objectives and actions included in the Seven-Year Action Plan align well with natural hazard risk

Planning/Regulatory Tool	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
		reduction. See Table 88 for a complete description. Last updated in 2021.
Climate Adaptation Plan	Yes	Climate adaptation is addressed through the Green Worcester Plan described earlier in this chapter (see Table 88), especially in Chapter XI: Climate Change Resilience). Also, while not a plan per se, climate adaptation is explicitly addressed in the City's MVP Summary of Findings Report. The report identifies Worcester's top climate change hazards (flooding from extreme precipitation; ice/snowstorms coupled with extreme cold; and extreme heat coupled with drought) 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 the City's resilience to hazards. The MVP report was published in 2019, and its findings and recommendations were incorporated into the Green Worcester Plan which can effectively be used to support the implementation of mitigation actions.
Floodplain Management Plan	No	No standalone plan, however, floodplain management is addressed by the City through other plans (HMP, OSRP, MVP, etc.) and regulations as described above and elsewhere in this survey.
Stormwater Management Plan	Yes	The City's Integrated Water Resources Management Plan identifies and evaluates infrastructure investments for the City's water resources systems, including stormwater systems (see narrative following Table 88 for a more complete description). This plan was last updated in 2019. The City is also currently nearing the completion of a more focused drainage and stormwater plan. This new plan will provide a more comprehensive understanding of the municipal drainage system and its constraints in conveying stormwater runoff during peak events as well as

Planning/Regulatory Tool	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
		identify the most vulnerable areas for future flooding. Additionally, the plan will identify high risk areas that will be good candidates for future green and grey infrastructure projects. The plan covers Worcester's stormwater system, but it will not model or have suggestions for the City's combined sewage system or private lands. The Department of Sustainability and Resilience (DSR) is supporting this master planning effort with the inclusion of green infrastructure and nature-based solutions. DSR has also been looking at watershed plans for recreational waterbodies, but some HMPC members expressed that the City could be looking at a bigger picture with better coordination. There is currently no plan for maintenance or inventory of old detention basins from subdivisions where roads became public. Regulations are antiquated and in need of a comprehensive overhaul and standardization across areas of implementation. Permits are not required for many projects (and certain scale projects may get exempted), so property owners can convert pervious to impervious surfaces without mitigation.
Capital Improvements Plan	Yes	Prepared each year by the Budget Division under the Department of Administration and Finance. The Capital Improvements Plan (CIP) is based on the City's Strategic Plan and considers the priorities of the community, City Council, and administration. The CIP for 2025–2029 includes significant investment in equipment purchases (fire prevention vehicles, DPW equipment, etc.), facility improvement projects, and infrastructure projects. Can be a very effective financing tool for supporting hazard risk reduction projects and capability enhancements.
Housing Production Plan	No	This is currently under development through the City's Executive Office of Economic Development (EOED), with an expected completion in Spring 2025. EOED had previously completed an analysis of impediments to fair housing choice in support of this process. The Plan

Planning/Regulatory Tool	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
		will take a deeper look at demographic trends and projections to identify the types of housing that are most needed and should be prioritized for Worcester.
Transportation Plan	Yes	Addressed through multiple plans described earlier in this chapter, especially the Mobility Action Plan (see narrative following Table 88 for a complete description), Vision Zero Plan, and Complete Streets Prioritization Plan. Can be effective in supporting risk reduction.
Economic Development Plan	Yes	The Downtown Urban Revitalization Plan (URP) was initiated by the Worcester Redevelopment Authority (WRA) in cooperation with the City of Worcester and the Worcester City Council. The overarching vision of the URP is to build on the current momentum of downtown revitalization through strategic public investments to cultivate a safe and vibrant downtown with a strong and sustainable economic vitality. It focuses on revitalizing the downtown area by publicizing arts and tourism destinations, improving the visitor experience, attracting new or expanding existing commercial and industrial users, enhancing residential quality of life and remediating brownfields to increase developable land area. Last updated in 2016.
Historic Preservation Plan	Yes	The Worcester Historic Preservation Study was conducted to assess historic preservation programs and related activities administered by the Worcester Historical Commission and City of Worcester. The study evaluated general administration of historic preservation programs in Worcester, including two key historic preservation regulatory tools (demolition delay and local historic districts) currently used by the City, and recommends refinements to improve their effectiveness and administration. Additionally, the study evaluated issues, opportunities and potential strategies related to the preservation and reuse of

Planning/Regulatory Tool	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
		historic buildings in the context of the City's downtown area specifically. Last updated in 2016.
Emergency Operations Plan	Yes	The City's Comprehensive Emergency Management Plan (CEMP), and it's supporting annexes, is an all hazards plan developed to address the natural and human-caused hazards that threaten Worcester (see narrative following Table 88 for a complete description). Last updated in 2022. Can be an effective tool for coordinating hazard risk reduction but is more focused on incident-driven preparedness and response actions.
Continuity of Operations Plan	No	The Worcester COOP was started in 2020 but was sidelined due to the Covid-19 pandemic. The CEMP outlines a Line of Succession for the City Manager position, but no broader COOP plan exists.
Community Wildfire Protection Plan	No	N/A
Other special plans?	Yes	Including the City's Strategic Plan (FY2025-2029), Urban Forest Master Plan (2023), Green Worcester Plan (2020), and Cultural Plan (2019). See Table 88 for complete descriptions.
Building Code, Permitting, and Inspections		
Building Code	Yes	Version/Year: MA State Building Code (780 CMR), Ninth Edition, 2017
ISO Building Code Effectiveness Grading Schedule (BCEGS®) Classification	Yes	BCEGS Commercial Class: 4 BCEGS Residential Class: 4 ** Evaluation dated 2/12/2019*
ISO Public Protection Classification (PPC©)	Yes	PPC Grade (Community Classification): 02 ** Effective 8/1/2018*
Special Permit / Site Plan Review Requirements	Yes	Adopted and administered per Article V of the Zoning Ordinance and according to the City's Rules & Regulations for Site Plan Approvals (last amended

Planning/Regulatory Tool	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
		2013). Can be effective process for hazard risk reduction associated with larger scale projects, however requirements only apply to certain (larger scale) development thresholds and/or where slopes greater than 15% are disturbed.
Zoning, Land Use, and Development Regulations		
Zoning Bylaw	Yes	The City's Zoning Ordinance is intended to promote the health, safety, and general welfare of the public. Last amended in 2023, the ordinance addresses flooding, but not very effectively (see below for Floodplain Regulations). Planting provisions for trees aren't effectively addressed; needs additional resources such as a second inspector for site plan approvals to ensure compliance after project completion and enforce removals or lack of replacements to shade trees. Need tree canopy preservation and re-planting requirements. Steep slopes require site plan or subdivision review or an earth moving Special Permit (but should be moved to Planning Board vs. Zoning Board of Appeals).
Subdivision Regulations	Yes	Adopted and administered per the City's Subdivision Regulations, last amended in 2013. The regulations are considered dated and in need of updates to reflect current standards, roadway designs, stormwater management standards, etc.
Floodplain Regulations	Yes	Adopted and administered per Article VI (Floodplain Overlay District) of the Zoning Ordinance, in combination with enforcement of building code and wetlands protection requirements. Current zoning language is very loose and open to interpretation; needs update to conform with the State's model floodplain bylaw and more enforcement support.
Wetlands Protection Regulations	Yes	Adopted and administered per the City's Wetlands Protection Ordinance & Regulations, last amended in 2019. Requires no disturbance within 15 feet from wetlands, no structures within 30 feet from wetlands,

Planning/Regulatory Tool	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
		and any work within 100 feet of a catch basin leading to a surface waterbody to be pulled in for review (similar to a stormwater bylaw). Requirements also apply for any work within 25 feet of riverfront and/or in the mapped floodplain or areas that are isolated and flood. However, these requirements are administratively burdensome and do not protect isolated vegetated wetlands, vernal pools, etc.
Stormwater Management Regulations	No	The City should pursue the development of comprehensive stormwater regulations, especially as it relates to addressing future climate conditions, increasing heavy downpour events and associated design standards along with promoting Best Management Practices, Low Impact Development, and other nature-based solutions.

Massachusetts State Building Code

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

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

The current version of the MSBC is the tenth edition, which became effective on October 11, 2024, with a concurrency period with the ninth edition until July 1, 2025. The tenth edition is based on modified versions of the following 2021 codes as published by the International Code Council (ICC), which is a significant improvement over the ninth edition which was based off 2015 codes.

- The International Building Code (IBC)
- International Residential Code (IRC)
- International Existing Building Code (IEBC)
- International Mechanical Code (IMC)

- International Energy Conservation Code (IECC)
- International Swimming Pool and Spa Code (ISPSC)
- Portions of the International Fire Code (IFC)

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

Massachusetts continues to perform well in terms of objective assessments of the MSBC. For example, in its most recent "Rating the States" report, the Insurance Institute for Business and Home Safety (IBHS) ranked Massachusetts 9th (scoring 77 out of a possible 100 points on the IBHS scale). Now in its fifth edition, IBHS's 2024 report evaluates the 18 states along the Atlantic and Gulf coasts, all vulnerable to catastrophic hurricanes, based on building code adoption, enforcement, and contractor licensing. Massachusetts was a state with a downward trend in its IBHS scores since the program began in 2012 due to various actions that have weakened the MSBC, however it is expected that the 2024 adoption of higher standards, including those based on the latest (2021) International Codes through the tenth edition, will result in score increases.

The tenth edition of the MSBC also contains a series of requirements for flood-resistant design and construction that are in accordance with the ASCE 24 standard, which incorporates—and in certain areas exceeds—FEMA's NFIP construction standards. Highlights of ASCE 24 that complement the NFIP minimum requirements include requirements for building performance; flood-damage-resistant materials, utilities and service equipment, and siting considerations. Specific requirements for design flood elevations and the use of flood-resistant materials may be found in the ASCE 24 Tables included in 780 CMR. Under the tenth edition of the MSBC, a higher regulatory standard that affects development and redevelopment within mapped flood zones is the requirement that new or substantially improved buildings must be elevated so that the lowest floor surface is 2-3 feet above the FEMA base flood elevation (1% chance storm elevation from the FEMA Flood Insurance Rate Map) depending on the situation. This requirement raised the minimum freeboard standards by an additional foot from the ninth edition of the MSBC to allow for the uncertainties of mapping as well as increasing precipitation and sea level rise.

The City of Worcester administers the MSBC for all applicable projects and according to Insurance Services Office, Inc. (ISO) maintains a demonstrated commitment to code adoption and enforcement services. ISO helps distinguish communities with effective building codes through a comprehensive evaluation program called the Building Code Effectiveness Grading Schedule (BCEGS). Under BCEGS, ISO collects information on a community's building code adoption and enforcement services, analyzes the data, and then assigns a classification from 1 to 10. BCEGS Class 1 represents an exemplary commitment to building code enforcement through code administration, plan review, and field inspection. According to the latest evaluation study performed by Insurance Services Office (ISO) in 2019, the City of Worcester had a BCEGS class of 4 for 1 and 2 family dwellings and a class 4 for all other construction. It is anticipated that these classifications will only improve following ISO's next BCEGS survey based on its enforcement of the tenth edition of the MSBC as described above.

Safe Growth Survey

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

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

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

The results of the Safe Growth Survey are summarized in Table 90. This includes describing how strongly the City's planning staff agrees or disagrees with 25 statements as they relate to Worcester'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 90. Safe Growth Survey Results.

MASTER/COMPREHENSIVE PLAN	
Land Use	
1. The master/comprehensive plan includes a future land use map that clearly identifies natural hazard areas.	1 $\boxed{2}$ 3 4 5
2. Current land use policies discourage development and/or redevelopment within natural hazard areas.	1 $\boxed{2}$ 3 4 5
3. The master/comprehensive plan provides adequate space for expected future growth in areas located outside of natural hazard areas.	1 2 3 $\boxed{4}$ 5
Transportation	
4. The transportation element limits access to natural hazard areas.	1 $\boxed{2}$ 3 4 5
5. Transportation policy is used to guide future growth and development to safe locations.	1 2 $\boxed{3}$ 4 5
6. Transportation systems are designed to function under disaster conditions (e.g., evacuation, mobility for fire/rescue apparatus, etc.).	1 2 3 $\boxed{4}$ 5
Environmental Management	
7. Environmental features that serve to protect development from hazards (e.g., wetlands, riparian buffers, etc.) are identified and mapped.	1 2 3 $\boxed{4}$ 5
8. Environmental policies encourage the preservation and restoration of protective ecosystems.	1 2 3 4 $\boxed{5}$

9. Environmental policies provide incentives to development that is located outside of protective ecosystems.	1 2 3 $\boxed{4}$ 5
Public Safety	
10. The goals and policies of the master/comprehensive plan are related to and consistent with those in the hazard mitigation plan.	1 2 3 $\boxed{4}$ 5
11. Public safety is explicitly included in the master/comprehensive plan's growth and development policies.	1 2 3 $\boxed{4}$ 5
12. The monitoring and implementation section of the master/comprehensive plan covers safe growth objectives.	1 2 3 $\boxed{4}$ 5
ZONING BYLAWS	
13. The zoning bylaws conform to the master/comprehensive plan in terms of discouraging development and/or redevelopment within natural hazard areas.	1 $\boxed{2}$ 3 4 5
14. The bylaws contain natural hazard overlay zones that set conditions for land use within such zones.	1 $\boxed{2}$ 3 4 5
15. The bylaws require or encourage resilient development through density bonuses, flexibility with setback requirements, or other incentives for projects outside of natural hazard areas.	1 $\boxed{2}$ 3 4 5
16. The bylaws prohibit development within, or filling of, wetlands, floodways, and floodplains.	1 2 3 $\boxed{4}$ 5
SUBDIVISION REGULATIONS	
17. The subdivision regulations restrict the subdivision of land within or adjacent to natural hazard areas.	$\boxed{1}$ 2 3 4 5

18. The regulations provide for conservation subdivisions or cluster subdivisions to conserve environmental resources. ** Cluster is only by Special Permit in Zoning Ordinance*	1	2	3	$\boxed{4}$	5
19. The regulations allow density transfers where natural hazard areas exist.	$\boxed{1}$	2	3	4	5
CAPITAL IMPROVEMENT PROGRAM AND INFRASTRUCTURE POLICIES					
20. The capital improvement program limits expenditures on projects that would encourage development and/or redevelopment in areas vulnerable to natural hazards.	1	2	$\boxed{3}$	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	$\boxed{3}$	4	5
22. The capital improvements program provides funding for hazard mitigation projects identified in the hazard mitigation plan.	1	2	$\boxed{3}$	4	5
OTHER					
23. Economic development and/or redevelopment strategies include provisions for mitigating natural hazards or otherwise enhancing social and economic resiliency to hazards.	1	2	3	$\boxed{4}$	5
24. Local plans, policies, or regulations promote the use of green infrastructure, low impact development, or other nature-based solutions for managing stormwater and other climate hazards.	1	2	3	$\boxed{4}$	5
25. The community considers and addresses potential impacts of its plans, policies, or regulations on Environmental Justice (EJ) neighborhoods or other socially vulnerable populations.	1	2	3	$\boxed{4}$	5

Administrative and Technical Capabilities

Table 91 is based off Worksheet 4 from FEMA's Local Mitigation Planning Handbook. It was used by the HMPC to document and review the current administrative and technical capabilities of the City. These include staff and their skills and tools that can be used for mitigation planning and to implement specific mitigation actions.

Table 91. Administrative and Technical Findings.

Administrative/Technical Resource	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
Local Boards/Committees		
Planning Board	Yes	The Planning Board's responsibilities include reviewing site plans, parking plans and subdivision plans; proposing and making recommendations regarding zoning ordinance changes; and supporting long-range planning initiatives. Staffed by Planning. Reviews site plans/erosion & sediment controls/protections for drinking water supply areas. Limited effectiveness, enforcement could be stronger through Inspectional Services. Subdivisions/private streets lack meaningful enforcement.
Conservation Commission	Yes	Conservation Commission responsibilities include administering wetlands protection regulations and making recommendations on the planning, acquisition and management of property for conservation and passive recreation. Staffed by Planning. Reviews site plans/erosion & sediment controls near sensitive receptors (waterways) and within floodplains. Does not effectively address cooling/protect trees. Does not effectively address crossings/construction.
Capital Planning Committee	No	The Budget Division under the Department of Administration and Finance develops, monitors and enforces the City's operating and capital budgets. The Division developed an analytical budget process ensuring all capital requests are assessed and prioritized to formulate a sound, long-term Capital Improvement Plan.
Climate Action Committee	Yes	A major goal in the first year of the Green Worcester Plan was to form a Green Worcester Advisory Committee comprised of non-governmental stakeholders to serve as the forum for information

Administrative/Technical Resource	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
		exchange and to advise on the City's sustainability and resilience activities. The Committee was formed and began meeting at the beginning of 2022. The committee members play a critical role in the implementation of the Green Worcester Plan.
Staff		
Community Planner	Yes	Assistant Chief Development Officer, supported by additional staff in the Division of Planning & Regulatory Services (DPRS). DPRS works in coordination with other divisions of the Executive Office of Economic Development as well as other City Departments to support and guide the future development of the city. DPRS’s work related to current planning includes providing administrative support and professional services to the Planning Board, Zoning Board of Appeals, Historical Commission, and Conservation Commission to support their review of projects that fall under their purview.
Chief Building Official	Yes	Director of Code Enforcement (Building Commissioner), supported by additional staff in the Inspectional Services Department. However, more inspectors are needed for permit volumes and scale of projects in Worcester. There is also a need for additional civil site inspectors to help enforce plan compliance and handle violations/complaints, and an additional zoning enforcement officer. Planning heavily supports floodplain administration and zoning interpretations.
Civil Engineer	Yes	Director of Engineering, supported by additional staff in the Engineering Division which manages the planning, design, construction and preservation of the City's public infrastructure. The Division is responsible for streets and sidewalks projects, sewer programs, private street conversions, Conservation Commission and Planning Board issues, bridge construction and right of way permitting.

Administrative/Technical Resource	**In Place?** *(Yes/No)*	**General Description / Effectiveness for Hazard Risk Reduction**
Emergency Manager	Yes	The Emergency Management Division has 2 full time staff members, a Director and a Coordinator. These employees have taken all NIMS training courses related to their roles, and continuously seek additional training, including on topics of hazards and mitigation. Coordination between departments is excellent, a focal point for the Division, however staffing is inadequate compared to peer cities and results in difficulties during routine work and emergency operations.
Floodplain Administrator	Yes	This is part of the Building Commissioner's role but is mostly implemented by Planning. Could use a full-time, dedicated position to serve in this role to improve education and effectiveness.
Sustainability/Climate Coordinator	Yes	Chief Sustainability Officer. Since 2021, the Department of Sustainability & Resilience has been working collaboratively with the community and other departments to implement many of Green Worcester Plan goals via new policies, projects and initiatives, while encouraging action at the community level. Very supportive of hazard risk reduction efforts.
GIS Coordinator	Yes	The GIS Team has grown from 1 to 3 over the past 3 years; however, responsibilities have also increased during this time. While more can be accomplished, the team does not have all the resources needed to support GIS across all City departments and use cases. Staff are not trained in hazards and mitigation topics, though one Team member worked with FEMA flood data in a previous position so has some familiarity with hazard management. The Team has effective partnerships with some departments, especially if there are GIS power users in the department or they rely on GIS data and apps to complete their work.
Public Information Officer/Specialist	Yes	The City Manager's Office has a PIO that works closely with all departments, and the CMO has a social media

Administrative/Technical Resource	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
		team as well. They are not trained on natural hazards or mitigation topics.
Technical		
Grant writing	Yes	The pursuit, application, and administration of external grant funding sources is managed and performed with each City department. There is no formal grant writing support provided across departments though the Department of Administration & Finance performs all appropriate grant administration services.
GIS mapping and analysis	No	The GIS Team has not implemented any solutions to assess or mitigate risk.
Hazard data and information	No	N/A
Maintenance programs to reduce risk *(e.g., tree trimming, drainage clearance)*	Yes	Ongoing programs include regular tree trimmings, catch basin clearing, and street sweeping. The City's Department of Sustainability and Resilience continues to restore/expand urban tree coverage through the development of several pocket parks, including the planting of two pilot Miyawaki Forests in some of the most densely populated neighborhoods. The City also oversees a comprehensive Lakes & Ponds program that includes water quality monitoring, management planning, public outreach, and protective treatments to address a variety of threats to its main recreational waterbodies (or "blue spaces"). This includes conducting robust monitoring, mapping, and management activities for invasive aquatic species.
Acquisition of land for open space, recreation, and other public use	Yes	Planning needs additional resources to be more effective in managing spaces.
Warning systems/services *(e.g., Reverse 911, outdoor warning signs)*	Yes	The City uses CodeRed for its public alert and warning system. The Emergency Management Division is also able to use IPAWS to issue WEAs through CodeRed. These alerts can be sent to cell phones, home phones, and email.

Administrative/Technical Resource	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
Mutual Aid Agreements	Yes	DPW, WPD, WFD all have mutual aid agreements for their respective functions. The City has also opted in with MEMA under statewide mutual aid agreements (Public Safety and Public Works).

Financial Capabilities

Table 92 is based off Worksheet 4 from FEMA's Local Mitigation Planning Handbook. It was used by the HMPC to identify and review the City's eligibility and access to funding sources that can be used to support the implementation of hazard mitigation projects.

Table 92. Financial Findings.

Financial Tool/Source	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
General funds	Yes	General funds have been and may continue to be used to support staffing and for grant matches in support of hazard mitigation activities.
Capital Improvement Program (CIP) funding	Yes	The CIP process can be used identify and possibly fund initiatives or projects supportive of hazard risk reduction.
Fees for water, sewer, gas, or electric services	Yes	Sewer connection fee is higher than many communities with funds used to support stormwater management activities.
Stormwater utility fee	No	Not currently in place, however exploring this funding mechanism has been recommended in several recent plans (MVP, GWP, Urban Forest Management Plan) to support enhanced stormwater management initiatives and to incentivize best management practices on private property.
Development impact fees	No	The City often requires developers to improve site conditions along their frontage, but fees are not assessed on a project-by-project basis
General obligation bonds and/or special purpose bonds	Yes	The City issues general obligation bonds for approved capital projects, but debt financing is not considered

Financial Tool/Source	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
		appropriate for recurring costs such as operating and maintenance expenditures.
FEMA Hazard Mitigation Assistance (HMA) funds	Yes	FEMA's current HMA grant programs (BRIC, FMA, HMGP) remain a good source of external funding for implementing eligible and cost-effective mitigation projects in coordination with MEMA.
HUD Community Development Block Grant (CDBG) funds	Yes	The City is eligible for HUD CDBG and CDBG-DR funding that could be used to support the implementation of hazard mitigation actions. The City recently used CDBG funds to support redesign of Endicott/Bigelow to re-design streets for safety and greening, adding a bike path, sidewalks, rain gardens/tree filter boxes, and shade trees in the floodplain (did narrow the roadway and create fill in the floodplain though).
Other federal funding programs	Yes	Recent funding sources include ARPA, ESG, HOME, HOPWA, NPS, etc. (e.g., used ARPA funds to help reimburse low-income homeowners for part of their flood insurance costs). In addition, NOAA, EPA, USACE, and other federal agencies make grant funding available for a variety of resilience-themed projects and initiatives that the City may be eligible to pursue in the future. This includes both pre- and post-disaster funding programs that can be very effective in supporting the implementation of cost-effective hazard mitigation projects, many of which are described in FEMA's Mitigation Resource Guide.[70]
Massachusetts Municipal Vulnerability Preparedness (MVP) Action Grant funds	Yes	The Department of Sustainability and Resilience recently obtained grants to install a rain garden and solar canopy at the Senior Center, and for tree planting initiatives that include the design/installation of cool pocket parks and Miyawaki forests. As a designated "MVP Community" the City is eligible to apply for grants on its own, or as part of a regional partnership of

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

Financial Tool/Source	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
		multiple municipalities provided that the lead applicant is MVP-designated.
Massachusetts Community Preservation Act (CPA) funds	Yes	In 2022 the City passed the Community Preservation Act (CPA), and it has since hired a CPA program manager. Passage of CPA allowed the City to establish a Community Preservation Fund to support open space, historic preservation, outdoor recreation, and community housing. Monies for the fund come from a property tax surcharge (1.5% of first $100k for residential/commercial) and matching dollars from the state. Funding is expected to be available for projects in the fall of 2025 (FY26) and it can be used as an effective tool for hazard risk reduction.
Other state funding programs	Yes	Recent funding sources include MHC, EEA, LAND, PARC, and DCR Urban Forest Challenge (obtained funding to do an urban tree canopy assessment for all Conservation Commission property and baseline reports for 8 conservation commission properties). 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 City include MVP Action Grants and other annual grant programs through EEA, such as the Culvert Replacement Municipal Assistance Grant Program. Others may include Community Compact grants, Green Communities grants, etc. depending on the scope and scale of specific projects.

Education and Outreach Capabilities

Table 93 is based off Worksheet 4 from FEMA's Local Mitigation Planning Handbook. It was used by the HMPC to identify and review existing education and outreach programs that can be used or expanded upon to support local mitigation activities.

Table 93. Education and Outreach Findings.

Education & Outreach Program/Method	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
Community newsletter(s)	Yes	The Department of Sustainability & Resilience has two newsletters – Blue Space Splash (recreational waterbodies) & Green Worcester (sustainability).
Web-based / social media	Yes	The City maintains an excellent website and presence on social media platforms (Facebook, X, Instagram), in addition to Cable Access TV and a YouTube Channel. Electronic sign boards are available and used at several locations, including the Senior Center. The City also maintains the Green Worcester Dashboard, a web-based portal that showcases the progress made on the goals identified through the Green Worcester Plan. This online resource provides information, data, and success stories across many of the City's resilience and sustainability activities. Very effective tools though the City could make much better use of the web and social media for future mitigation activities.
Public Access TV, radio, etc.	Yes	The Emergency Management Division and the Department of Public Health share info on public access. Beginning in late 2024 Emergency Management is collaborating with Cable Services to do a multi-lingual preparedness series (Ready Worcester). Better use could be made of these methods in the future.
Community gatherings, festivals, celebrations, or other events	Yes	The Emergency Management Division shares some information at public events, however there is not a comprehensive disaster resilience and mitigation awareness push at these events. This could be improved upon.
Hazard awareness campaigns *(e.g., Severe Weather Awareness Week)*	No	N/A
Organizations that represent, advocate for, or interact with	Yes	It's difficult to list every organization that interacts with these groups, but there are many and they are very

Education & Outreach Program/Method	In Place? *(Yes/No)*	General Description / Effectiveness for Hazard Risk Reduction
underserved or vulnerable populations		active. They could be leveraged better for future activities.
Local citizen groups or non-profit organizations focused on environmental protection, emergency preparedness, etc.	Yes	Green Worcester Committee
Ongoing public education or information program *(e.g., responsible water use, fire safety, household preparedness)*	Yes	Multiple City departments (including DPW, Emergency Management, Fire, Planning, & Sustainability) conduct outreach and disseminate information related to hazards, emergency preparedness, and risk reduction. These current efforts could help implement future mitigation activities.
Natural disaster or safety-related school programs	Yes	There isn't any direct material that covers this topic. There would be some material in the second unit, Safety (5th, 6th, 7th and 9th grade), where the curriculum focus is on preparing in case of an emergency (i.e. house fires, how to be safe in your community, while home alone, etc.).
StormReady® certification	Yes	The City is one of 22 communities in Massachusetts that actively participates in the National Weather Service StormReady Program.
Firewise USA® certification	No	N/A
Public-private partnership initiatives addressing disaster-related issues	No	N/A

National Flood Insurance Program (NFIP) Participation and Compliance

C2. Does the Plan address each jurisdiction's participation in the NFIP and continued compliance with NFIP requirements, as appropriate? (Requirement §201.6(c)(3)(ii))

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

The City of Worcester has participated in the NFIP since 1980. As summarized in Table 94, the HMPC used Worksheet 5 from FEMA's *Local Mitigation Planning Handbook* to collect information regarding the City's participation in and compliance with the NFIP. This worksheet, in addition to responses provided through a separate *NFIP Survey* for City staff, helped the HMPC to identify areas for improvement and other ideas that could be potential mitigation actions.

Table 94. NFIP Participation and Compliance Findings.

NFIP Topic	Source of Information	Comments
Insurance Summary		
How many NFIP policies are in the community? What is the total premium and coverage?	FEMA NFIP Services, Flood Insurance Data and Analytics; State NFIP Coordinator	As of August 31, 2024, a total of 344 NFIP policies are in force. The total premium is $368,428 for a total of $107,617,000 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?	FEMA NFIP Services, Flood Insurance Data and Analytics (HUDEX report)	There has been a total of 260 claims paid since 1980, totaling $5,541,125 in losses. There have been 5 claims paid for substantial damage.
How many structures are exposed to flood risk within the community?	GIS analysis (FEMA FIRMs + building footprint data)	It has been estimated that 814 structures are at risk to the 1-percent annual chance flood, and 1,330 are at risk to the 0.2 percent annual chance flood for a combined total of 2,144 structures exposed to flood risk.

NFIP Topic	Source of Information	Comments
Are there any repetitive or severe repetitive loss structures in the community?	MEMA / FEMA	Yes – 26 repetitive loss properties which have experienced 76 insured losses that total $2,805,735 in NFIP claims payments. There are also three (3) severe repetitive loss properties with a total of 23 losses and $755,995 in total claims payments. See Chapter 4 for more details.
Describe any areas of flood risk with limited NFIP policy coverage	HMPC	No address-specific data has been made available by FEMA, but it is generally assumed that owners of property located in special flood hazard areas are underinsured when it comes to flood insurance coverage (based on only 344 current policies under the NFIP in comparison to 2,144 structures estimated to be exposed to moderate to high flood risk).
Staff Resources		
Who is responsible for floodplain management in the community? Do they serve any roles other than Community Floodplain Administrator (FPA)?	HMPC	The duties of floodplain management and implementation of the commitments and requirements of the NFIP have been assigned to the City's Director of Code Enforcement, who also serves as the Building Commissioner.
Is the Community FPA or NFIP Coordinator a Certified Floodplain Manager?	HMPC	No, however he is supported by the Conservation Planner/Agent who is a CFM.
Is floodplain management an auxiliary function?	HMPC	Yes, for the Director of Code Enforcement.
Explain NFIP administration services (e.g., permit review, GIS, inspections, engineering capability).	HMPC	All development in the Floodplain Overlay District is reviewed for compliance with the City's Zoning Ordinance, Wetland Protection regulations, and State Building Code requirements. The City complies with the NFIP by enforcing floodplain regulations, maintaining up-to-date floodplain maps, and providing information to property owners and builders regarding floodplains and

NFIP Topic	Source of Information	Comments
		building requirements. The City goes beyond minimum NFIP requirements by participating in the Community Rating System and conducting many additional floodplain management activities.
What are the barriers to running an effective NFIP program in the community, if any?	HMPC	Local contractors/engineers/architects that are not well versed in floodplain requirements – mandatory or credited continuing education trainings for these professionals could be helpful. Training – time is often a challenge to find because there is so much work to be done with current permit volumes to allow staff to take advantage of the necessary floodplain trainings. While many are available, having more free, virtual, trainings with CEUs – especially for building inspectors would be helpful. Also having NFIP trainings that talk about the MA higher standard specifics for inland communities. Staffing – the City's program would benefit from additional inspectors to both review and enforce building permits and review and enforce wetlands protection requirements and enable staff to do more proactive outreach and education. A full-time employee that is designated as a "floodplain manager" position could be effective. Support from elected officials in enforcement of the codes/requirements. Support from other city staff overseeing design and construction of projects in the floodplain to ensure proper documentation and compliance would be helpful.

NFIP Topic	Source of Information	Comments
Compliance History		
Is the community in good standing with the NFIP?	HMPC, State NFIP Coordinator, FEMA	Yes
Are there any outstanding compliance issues (i.e., current violations)?	HMPC	Two compliance issues are in the process of being resolved. Both relate to non-residential structures which need to be floodproofed.
When was the most recent Community Assistance Visit (CAV) or Community Assistance Contact (CAC)?	State NFIP Coordinator, FEMA (CIS)	Last CAV was 8/23/2018; a follow up visit was conducted on 3/20/2024.
Is a CAV or CAC scheduled or needed?	HMPC	Not at this time.
Regulation		
When did the community enter the NFIP?	State NFIP Coordinator, FEMA (CIS)	8/15/1980 (Regular Entry) 1/15/1974 (Emergency Entry)
Are the FIRMs digital or paper?	HMPC	Digital. Effective and historic FIRMs are publicly available on the City's GIS platform
Do floodplain development regulations meet or exceed FEMA or State minimum requirements? If so, in what ways?	HMPC	Floodplain regulations are administered through the enforcement of the City's Zoning and Wetlands Protection ordinances which exceed current FEMA/NFIP minimum requirements. These regulations will be routinely updated as necessary to maintain compliance with existing NFIP and State minimum standards for floodplain management. As described earlier in this chapter, higher regulatory standards are also met through the City's enforcement of the Massachusetts State Building Code (780 CMR). Other NFIP development requirements are included in the

NFIP Topic	Source of Information	Comments
		City's administration of the Commonwealth's Wetlands Protection Act Regulations (310 CMR).
How does the community enforce local floodplain regulations and monitor compliance? Explain the permitting process.	HMPC, community records	Regulation and permitting of all development in identified special flood hazard areas (Floodplain Overlay District) is handled through a combination of the building permit and wetland permitting processes. See narrative provided immediately below this table for a complete, detailed description on the City's permitting and monitoring process.
Community Rating System (CRS)		
Does the community participate in CRS? If so, what is the community's CRS Class?	HMPC, Verisk	Yes, the City entered the CRS program in 1995 and today participates as a Class 7 community.
What categories and activities provide CRS points and how can the class be improved?	Verisk	The City obtains credits across many CRS categories and elements and since the last plan update improved from a Class 9 to Class 7 community. Some of these include the following: • Effective and historic flood maps are publicly available on the City's GIS platform • Annual mailings are sent to property owners in the floodplain publicizing the City's Map Information Services. The Division of Planning & Regulatory Services provides information upon request regarding whether or not a property is in a SFHA, site-specific BFE/flooding depth, FIRM panel number, source of flooding, flood insurance information, etc. • Annual mailings are sent to property owners in repetitive loss areas advising of the higher risk and publicizing the availability of flood insurance. • The city participates in/facilitates community outreach meetings in areas prone to hazards

NFIP Topic	Source of Information	Comments
		• The city shares on social media flood safety/preparedness tips The City's current CRS Class could be improved by conducting additional NFIP Participation and Compliance activities as listed at the end of this chapter, many of which are creditable under CRS.
Does the plan include CRS planning requirements	Yes	Yes, many of the planning requirements under CRS Activity 510 are included in the plan update.

Floodplain Permitting and Monitoring Process

The Department of Inspectional Services is responsible for the building permit process, which is run through an online portal. Permit applications for properties within the SFHA are automatically flagged by the permit portal, which adds a "Floodplain Review" step that must be completed prior to the issuance of a building permit. Currently, all Floodplain Review steps are assigned to the Conservation Agent in the Planning & Regulatory Services Division, though determinations on the issuance of building permits are ultimately up to local building officials.

The Conservation Agent reviews the permit application to determine if the existing/proposed structure is located within the mapped SFHA and/or if the proposed work would constitute a Substantial Improvement (process described in greater detail in Table 9). For new construction or substantial improvement in the SFHA, an Elevation Certificate based on construction drawings is required to certify that proposed conditions meet the regulatory requirements, which is reviewed and corrected as needed by the Conservation Agent. After a building permit is issued, inspections are performed by City building officials during and at the conclusion of construction. A "Floodplain Final Signoff" review step is triggered in the building permit portal and assigned to the Conservation Agent prior to the issuance of a Certificate of Occupancy.

At this time, and Elevation Certificate or Floodproofing Certificate (as applicable) based on finished construction is required; once reviewed and accepted, the Floodplain Final Signoff review step is marked complete, and the certificate of occupancy is ultimately issued by the Department of Inspectional Services. As part of this process a "Zoning" review is required, as part of that Inspectional Services reviews for compliance with the Floodplain Overlay District which contains all federal requirements outside of those in the building code and wetlands protection regulations.

The Worcester Conservation Commission and Planning & Regulatory Services Division are responsible for the administration of the Massachusetts Wetlands Protection Act and Worcester Wetlands Protection Ordinance, which regulate the SFHA as "Bordering Land Subject to Flooding" (BLSF). Any activity that shall dredge, remove, alter, or fill BLSF requires the review and approval of the Conservation Commission through an Order of Conditions or Determination of Applicability. These regulations require that compensatory flood storage be provided at each incremental elevation to offset any displacement of flood storage below the Base Flood Elevation (BFE), when the Commission determines that the loss will cause an increase or will contribute incrementally to an increase in the horizontal extent and level of flood waters during peak flows.

Table 95 provides some additional information in response to the updated requirements included in FEMA's 2022 Local Mitigation Planning Policy Guide (Element C2-a):[71]

Table 95. Additional NFIP Participation and Compliance Information.

Required Information	Response
Adoption of NFIP minimum floodplain management criteria via local regulation.	Zoning Ordinance, Article VI - Floodplain Overlay District as amended through May 9, 2023.
Adoption of the latest effective Flood Insurance Rate Map (FIRM), if applicable.	The City's Zoning Ordinance at Article VI, Section 4 (Definition and Establishment of the Floodplain Overlay District) establishes the Floodplain District as shown on the official Flood Insurance Rate Map (FIRM) for the City of Worcester, dated July 4, 2011.
Implementation and enforcement of local floodplain management regulations to regulate and permit development in SFHAs.	See explanation of the City's permitting and monitoring process provided above.
Appointment of a designee or agency to implement the addressed commitments and requirements of the NFIP.	Per the City's Zoning Ordinance (Article VI, Section 5), the Director of Code Enforcement has been designated to serve as the City's Community Floodplain Administrator.
Description of how participants implement the substantial improvement/substantial damage provisions of their floodplain management regulations after an event.	The City implements the SI/SD provisions of its floodplain management regulations as required per the NFIP (CFR Title 44, Parts 59 through 65) and Massachusetts State Building Code (780 CMR). See narrative provided immediately

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

Required Information	Response
	below this table for a complete, detailed description of the process. The City will also coordinate with State Flood Hazard Management Program staff to assure that proper practices are followed and that a post-disaster plan will be in place to implement all SI/SD provisions.

Substantial Damage/Substantial Improvement Process

Formal Substantial Damage/Substantial Improvement (SI/SD) determinations are made by the Building Officials and/or Building Commissioner. The initial review is performed by the Conservation Agent in the "Floodplain Review" step in the building permit process described following Table 94. The Conservation Agent has taken trainings on SI/SD and FEMA's L0273 course and is a CFM. When work is proposed on a structure mapped within the SFHA, the cost estimate for the work is compared to the assessed value of the structure. These figures are determined as follows:

- The cost estimate is provided by the permit applicant and is reviewed by the Conservation Agent and Building Officials. Costs from any other work permitted in the preceding 12 months are also added into the total cost when making an SI determination.
- The assessed value is determined by using the structure's replacement cost less depreciation as identified in the City Assessor's database. If an applicant disagrees with the assessed value, they can provide an appraisal of the structure performed by a qualified professional for the City's review.

If the cost of the proposed work (including work from within the past 12-months) is less than 50% of the value of the structure, the permit applicant is provided with a "floodplain packet". This includes a checklist in which the applicant enters the total cost of work, the value of the structure, and cost of work as a percentage of the structure's value. An affidavit is signed by the contractor, attesting to accuracy of the cost estimate, and by the property owner, attesting to having reviewed the thresholds and implications of a Substantial Improvement or repair of Substantial Damage.

If the cost of the work (including work from within the past 12-months) is greater than 50% of the value of the structure, the applicant is required to provide an elevation certificate or floodproofing certificate (for non-residential structures only) showing that the structure is currently compliant with floodplain requirements or that the structure will be compliant based on proposed conditions.

If historic buildings are involved, then determinations may be made in coordination with the City's Preservation Planner and Historical Commission related to the significance of the alterations proposed and the impact on the alterations for historic structures continued historical integrity and documented as appropriate. Generally, residential units are fully discouraged at elevations at or below the Base Flood Elevation (BFE) in historic projects that may otherwise be exempt from SI/SD standards, and utilities are requested to be elevated – even though it's not required due to safety concerns.

Summary and Conclusions

The City of Worcester is a vibrant, mid-size city with relatively strong capabilities and resources to support the implementation of hazard mitigation actions. This chapter provides documentation on the existing local authorities, policies, programs, and resources to support hazard mitigation.

Some of the strongest hazard mitigation capabilities for the City of Worcester are found through the adoption and implementation of local plans, such as its recently updated citywide/comprehensive plan (Worcester Now | Next), in addition to numerous other special/functional plans such as the Urban Forest Master Plan, Green Worcester Plan, Cultural Plan, and others as described in this chapter. The City also benefits from the administration and enforcement of strong codes and regulations governing new and improved development throughout the community, in addition to strong capabilities for the routine operations and maintenance of physical infrastructure and natural resources (tree canopy, waterbodies, etc.). The has adopted multiple layers of regulations and procedures that can help reduce natural hazard risks through its Zoning Ordinance and site plan review process, the Wetlands Protection Ordinance and Regulations, Subdivision Regulations, and other local rules – though some should be reviewed and improved using current best practices for climate resilience such as those governing floodplain management, stormwater management, and extreme heat mitigation. The City has also been an active participant in FEMA's Community Rating System (CRS) since 1995 and is currently recognized among the highest rated CRS communities (Class 7) in the state for floodplain management activities that go above the minimum federal standards of the National Flood Insurance Program (NFIP).

The City employs skilled and committed staff across numerous departments to administer existing local programs, regulations, and other activities, who are supported by an active citizenry and volunteers that serve on numerous local boards and committees. The City benefits from effective collaboration and interdepartmental coordination across these various entities. Although the City's administrative and technical capabilities are considered quite strong, additional staff resources and professional development training (for City employees but also contractors, builders, etc.) would help improve the enforcement of and compliance with local codes and regulations. Additional resources would enable City staff to be more effective during peak surges (increased permit activity, larger scale projects, etc.) as well as to be more engaged in public outreach and educational activities. It could also provide them with opportunities to do more in terms of integrating hazard and climate resilience into the local planning and regulatory mechanisms they are responsible for as described above.

The City's financial capabilities are also strong in terms of its ability to leverage local and external funding sources to support hazard mitigation projects. Examples include the City's own's ability to appropriate local funds for investments in stormwater improvements, tree planting (heat mitigation), open space acquisition and conservation, CRS activities, and other emergency preparedness or community resilience building initiatives. Funding can come from a variety of local financing mechanisms including the City's General Funds, Capital Improvements Plan, and Community Preservation Fund. The City has been successful in leveraging these funds in the past in combination with a variety of external grant programs focused on building hazard/climate resilience, including federal funds in addition to competitive state grants such as EEA's MVP Action Grants. While City staff have been successful in seizing these grant opportunities for their respective programs, the creation of a full-time grant writer/administrator to work across departments would enhance its ability to pursue financing more aggressively for larger capital projects, including those addressing hazard mitigation and long-term climate adaptation.

The City is also fortunate to have many methods and tools to support public education and outreach initiatives that can support hazard mitigation, such as a routinely maintained website (with links to topics such as climate preparedness, stormwater management, flood preparedness, etc.), department-specific newsletters, social media, cable access TV, and community gathering events, in addition to many local organizations that routinely engage with and advocate for underserved or socially vulnerable populations. These resources can be used to help with increasing risk awareness and promoting emergency preparedness and hazard mitigation activities that can be accomplished on community, neighborhood, and site-specific scales.

Although the City of Worcester has strong capabilities and resources to mitigate the natural hazard risks faced by the community, it can expand and improve on the capabilities described in this chapter. Some general and specific opportunities to address existing gaps or limitations in local capabilities to reduce risk have been identified for each capability type and are further described below. Each of these opportunities were then considered by the HMPC during the plan update process as potential new mitigation actions to be included in the Mitigation Strategy.

Opportunities to Expand and Improve on Capabilities to Reduce Risk

Planning and Regulatory Capabilities

- Conduct regulatory reviews and updates to the following regulations to further require or promote hazard resistant, climate-adaptive standards for new or improved development. Use existing methods or tools for incorporating green infrastructure, low impact development, and other nature-based solutions (such as Mass Audubon's Bylaw Review Tool).
    - Zoning Ordinance
        - Site Plan Review (Article V)
        - Floodplain Overlay District (Zoning Ordinance, Article VI) – *should be updated to eliminate subjective interpretations and, at a minimum, include language consistent with the State's latest model floodplain bylaw.*
        - Water Resources Protection Overlay District (Article XII)

  - Subdivision Regulations – *can do more in terms of stormwater management and flood hazard avoidance by allowing density transfers or other methods to restrict or prohibit the subdivision of land within or adjacent to natural hazard areas.*
  - Wetlands Protection (Revised Ordinances, Chapter 6) and Wetlands Protection Ordinance & Regulations – *can be updated to provide increased protection for isolated vegetated wetlands, vernal pools, etc. by expanding required buffer zones or minimum natural vegetative buffer strips that serve as natural barriers to flooding.*
  - Planning Board Rules and Regulations for Special Permits
  - Planning Board Rules and Regulations for Site Plan Approvals

- Increase protections for preserving, restoring, and enhancing Worcester's tree canopy through more effective provisions for planting and re-planting requirements (new/replacement shade trees) to the above-referenced regulations. More tree planting along private properties and rights-of-way should also be encouraged/required as appropriate.
- Pursue the development of comprehensive stormwater management regulations, especially as it relates to addressing future climate conditions (increasing heavy downpour events) through updated design standards, limits on impervious surfaces, increased compensatory storage/on-site mitigation, and the promotion of other Best Management Practices, Low Impact Development, and other nature-based solutions. Regulations could also require more detailed hydraulic and hydrologic calculations for new developments that are proposing new stream crossings to avoid creation of restrictions and new flooding areas.
- Prepare a Continuity of Operations Plan to work in tandem with the City's Comprehensive Emergency Management Plan (CEMP).
- Coordinate with Workforce Development, the MassHire Central Region Workforce Board, employers, and other partners to explore the feasibility of addressing human health and safety vulnerabilities to extreme heat and other hazards through new workforce protections.

Administrative and Technical Capabilities

- Increase existing capabilities and resources for the Inspectional Services Department and the Division of Planning & Regulatory Services to conduct effective enforcement of local codes and regulations. Hire more inspectors to match the current permit volumes and scale of projects in Worcester, including additional inspectors to oversee continued regulatory compliance (from site plan approvals through post-construction inspections), the enforcement of rules for subdivisions and private roadways, and to handle ongoing violations, complaints, etc.
- Complete a staffing and resource needs assessment for the City's Emergency Management Division to effectively conduct routine operations that include prevention/mitigation activities in addition to disaster preparedness, response, and recovery operations as called for in the CEMP.

- Hire and formally designate a full-time Floodplain Administrator (or additional Zoning Enforcement Officer) to oversee the administration and enforcement of Floodplain Overlay District regulations and support the City's expanding list of NFIP compliance and CRS activities.
- Provide more specialized training and professional development opportunities for City employees who are engaged in community resilience planning and the implementation of hazard mitigation and/or climate adaptation projects.
- Continue to coordinate with the Central Massachusetts Regional Planning Commission (CMRPC), neighboring communities, non-profits organizations, and others on regional risk reduction projects (i.e., watershed scale).
- Expand the capacity of the Lakes and Ponds Program and support the required coordination efforts to add purple loosestrife and hydrilla to the City's ongoing mapping, monitoring, and treatment of invasive species.

Financial Capabilities

- Increase staffing capacity to pursue and capture grant funding for resilience planning, project scoping/design, and project implementation. This may include additional hires and/or professional development training opportunities for staff involved in community resilience building activities.
- Continue to expand the capacity of the City's newly hired grant writer to provide technical expertise and administrative support across multiple departments that pursue their own external funding opportunities.
- Prioritize available grant funding opportunities to pursue (FEMA Hazard Mitigation Assistance, EEA MVP Action Grants, DER's Culvert Replacement Municipal Assistance Grant Program, etc.).
- Leverage the City's Community Preservation Act (CPA) funding where possible to advance flood mitigation and watershed management in addition to other CPA objectives.
- Continuing exploring the establishment of a stormwater utility/enterprise fund as a dedicated, stable revenue source to support the City with stormwater management, flood mitigation, and green infrastructure projects in addition to meeting its MS4 permit requirements. Funds generated through the new fund could also be used to match additional federal/state funding and the hiring of a full-time stormwater manager to run the program. The fee structure for rate payers could also include stormwater "credits" to incentivize community members to reduce stormwater generation on their properties in exchange for lowered costs.

Education and Outreach Capabilities

- Increase staffing capacity to improve education/outreach efforts within departments to be more effective. This may include additional hires and/or professional development training opportunities for staff involved in community resilience building activities.

- Conduct more targeted outreach and education for the community's more vulnerable populations (i.e., environmental justice communities, seniors, non-English speakers, residents with special needs, property owners in high-risk hazard areas, those who are homebound, etc.). Some of the City's most vulnerable populations reside in the most hazardous in terms of exposure to extreme heat and other hazards.
- Increase use of the City's website and social media platforms to support low-cost public education initiatives on emergency preparedness and hazard mitigation actions for homeowners, business owners, etc.
- Formalize an Adopt-a-Drain program (similar to the City's the Adopt-A-Hydrant program) to reduce local street flooding during storms by enlisting community members to clear debris, leaves, or snow from the tops of catch basins. Combine the program with increased public education for residents on the importance of storm drain clearance and other best practices.
- Increase and track enrollment in the City's ALERTWorcester emergency notification system. Conduct promotional outreach to address gaps in enrollment, especially for the community's more vulnerable residents to ensure they are properly notified of imminent hazard threats and the preparedness/response actions they may need to take (evacuation, sheltering, cooling/warming center options, etc.).
- Promote the availability of flood insurance to all property owners and renters, especially those in areas of high to moderate flood risk.

Possible New Actions Related to NFIP Participation and Compliance

- Update the City's Zoning Ordinance to be in alignment with the State's latest Model Floodplain Bylaw.
- Continue to update and maintain repetitive loss areas based on updated FEMA NFIP and Repetitive Loss data records shared with the City.
- Improve education and outreach to community members including residents, developers, engineers, and architects to understand flood risk and properly apply the relevant federal, state, and local regulations.
- Participate in regional efforts that consider advantages to managing hazards at a watershed scale, especially where the City is experiencing challenges in finding local solutions.
- Conduct additional creditable CRS activities to ensure the City's Class 7 status in CRS is maintained and ideally upgrade from Class 7 to a Class 5 or 6 in the future. For example, consider preparing a Flood Insurance Assessment and the need for improvement through Flood Insurance Promotion as credited under CRS Activity 370.
- Review the State's *Local Floodplain Action Guide* (forthcoming in January 2025) for possible additional regulatory or administrative improvements.

- Develop a post-disaster substantial damage plan based on the latest guidance from FEMA and the State's Flood Hazard Management Program.

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 through 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))

HHPD3. Did the plan include mitigation goals to reduce long-term vulnerabilities from HHPDs?

When considering goal statements and reviewing the previous plan's goals the HMPC decided to develop a mission statement with supporting goal statements. The mission serves as the overarching goal for this plan and is shown below.

Enhance resilience against natural hazards and the climate crisis by protecting people, property, infrastructure, and our natural, cultural, and historic assets. Our commitment is to build a city that's resilient as it is thriving—physically, socially, and economically—through policies and practices grounded in equity, inclusion, integrity, and innovation.

Figure 29. Mission Statement.

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

Mitigation goals represent broad statements that are achieved through the implementation of more specific mitigation actions. These actions include both hazard mitigation policies (such as land use regulations) and hazard mitigation projects (such as structure or infrastructure projects). To develop goals for this City of Worcester, MA Hazard Mitigation Plan Update the HMPC reviewed the Hazard Mitigation Plan 2019 Update, the City of Worcester

Municipal Vulnerability Plan 2019 plan goal statements, and the goals of the State's Hazard Mitigation and Climate Adaptation Plan (SHMCAP). The City of Worcester has done a significant amount of planning since 2019 so in addition to other mitigation plans, the HMPC and the consulting team reviewed the following documents to capture the current priorities of the City to include in this plan. Those documents were:

- The Green Worcester Sustainability and Resilience Strategic Plan (2020)
- City of Worcester Open Space & Recreation Plan (2021)
- City of Worcester Strategy Plan FY 2025-2029
- Now/Next Worcester's Citywide Plan (2024)
- Becoming Worcester, A Cultural Plan (2019)
- Worcester Urban Forest Master Plan
- Worcester Mobility Action Plan (2024)

The HMPC developed the goal statements in Figure 30 to represent their vision and priorities for the City of Worcester in terms of hazard mitigation. These goals are not listed in order of priority. All the hazards identified in this plan, while not named specifically in the goal statements, are implied and many are named specifically in the mitigation actions. When achieved by way of implementing the mitigation actions identified in this plan, the City will mitigate risk posed by all identified hazards.

Local Plans and Regulations	Refine city codes, policies, regulations, and standards to facilitate public and private development that withstands and improves our collective resilience to natural hazards, utilizing data-driven and best-practice approaches for equitable and resilient planning and site design.
Building and Infrastructure Projects	Commit to infrastructure projects that enhance durability against natural hazards and climate influences, prioritizing long-term sustainability and resilience.
Natural and Cultural Resources	Safeguard and improve our open spaces, recreational facilities, and cultural treasures to bolster community resilience.
Outreach and Education	Broaden educational initiatives targeting city staff and residents to elevate understanding of risks and encourage proactive resilience measures.
High Hazard Dams	Assess and fortify high-hazard dams, ensuring risk reduction while promoting ecological resilience.

Figure 30. Goal Statements.

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

The Worcester Hazard Mitigation Plan Update, March 2019 included 83 mitigation actions. For the purposes of this plan, all the actions were reviewed for their status and relevance. Table 96 shows the previous plan's 83 mitigation actions and the status of each. In addition to their status, if an action was moved forward to this plan the final column indicates the title of the new action.

Table 96. Status of Previous Plan's List of Mitigation Actions.

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
1	Weasel Brook becomes restricted at an improper culvert inlet causing restrictions. Not under City control. Work with stakeholders to upgrade culvert	Partially Completed / In Progress	Planning & Department of Public Works staff have been working with the new owner (New Garden Park, Inc.) of the former St. Gobain properties to better understand the issues in this area as they plan to re-development of the larger site. New Garden Park, Inc. has developed an H&H to better understand and revise the flood elevations in the area, a LOMR has been submitted to FEMA for review. Pending results from FEMA and progression of redevelopment plans for the southern part of the site, discussions will continue with the private property owners about measures that could help reduce or alleviate flooding in the area. However, substantial constraints remain given that the infrastructure is on private property and one structure is beneath a building. The city is separately developing a drainage model of its public infrastructure in the area and intends to feed the H&H data into that system to create a more complete model.	YES - updated/revised description provided at right, if applicable	Resolve Weasel Brook flooding issues.
2	Maintain street sweeping policy effectiveness to increase stormwater management.	Completed	All Residential Roads are swept 2 times a year. Central Business District is swept 6 times a week. Arterial Roads are swept once a week.	NO - explanation provided at left	
3	Clean Catch Basins at least every two years or more often as needed.	Completed + To Be Continued	Catch Basins are cleaned every 2 years at a minimum (more frequently for known problem locations). Stormwater Treatment Devices are	NO - explanation	

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
			cleaned on an as-needed basis, based on monitoring and manufacturer recommendations.	provided at left	
4	Continue and expand Rain Barrel Program, especially target, educate and make available to lower income residents	Completed	Available during yearly advertised ordering period. Demonstrations occur at public events and promotions and education are provided on social media and in partnership with local organizations. The City has distributed 179 rain barrels since 2021.	NO - explanation provided at left	
5	Update at the Senior Center Lightning Surge Protection for the building Electrical Distribution system	Delayed	"Due to staffing changes" - determine if Senior Center is willing to be an extended emergency shelter, need to be a part of HPMC. Senior Center may be used as a shelter.	YES - updated/revised description provided at right, if applicable	Expand network of Climate Centers to meet the needs of residents who may require relief from extreme temperatures and power outages.
6	At the Senior Center install an Auxiliary Fuel tank for Emergency Generator (to increase from 2 to 7+ day supply for emergency shelter needs)	Delayed	"Due to staffing changes" - determine if Senior Center is willing to be an extended emergency shelter, need to be a part of HPMC. Senior Center may be used as a shelter.	YES - updated/revised description provided at right, if applicable	Expand network of Climate Centers to meet the needs of residents who may require relief from extreme temperatures and power outages.
7	Repair/replace City Hall Roof	Partially Completed / In Progress	Obtained funding and approvals from the Historic Commission; construction has yet to commence.	YES - updated/revised description	Repair/replace City Hall Roof

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
				provided at right, if applicable	
8	At Dept. of Inspectional Services design and install Fire Alarm radio box and resolve ground fault issue with Fire Alarm Panel	Canceled	Not deemed a priority at this time.	NO - explanation provided at left	
9	Integrate disaster mitigation into transportation projects.	Partially Completed / In Progress	The City has created a Transportation & Mobility Department to further planning and re-design work around our roadways. The DTM will collaborate with the TAG, city departments, and community stakeholders in planning and re-design efforts including members of police/fire/and other staff to help infuse thinking for such mitigation into design projects. The City has also begun a Mobility Action Plan and considers resiliency work for stormwater management and heat effects in its streetscaping and design work.	YES - updated/revised description provided at right, if applicable	Integrate disaster mitigation into transportation projects by incorporating risk assessments and resilience measures into planning, design, and construction.
10	Develop rockfall protection system for McKeon Rd. Fire Station to be capable of absorbing the impact of the falling rocks	Delayed	Fire Department has not instituted a protection system due to budget and staff time.	YES - updated/revised description provided at right, if applicable	Implement mitigation strategies to mitigate risk to City Fire Department Facilities located in or near flood zones or at risk to rockfalls.

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
11	Upgrade Kettle Brook #4 control structure, repair gates	Completed		NO - explanation provided at left	
12	Investigate Johnson Tunnel, upgrade drainage	Delayed	The City has closed the Johnson Tunnel while it evaluates potential options for repairing and permanently closing it. The City is also working with a developer who wants to temporarily use the tunnel during construction of a building that will sit above it. A decision on the fate of the tunnel is expected by the completion of the building by the developer.	NO - explanation provided at left	
13	Shaft 3/ Quinapoxet pipeline Rehabilitation Project	Completed + To Be Continued	Phase 1 is complete; Phase 2 is under construction.	NO - explanation provided at left	
14	Shaft 3 Pump Station Upgrades	Delayed	"Priority Schedule" ?	YES - updated/revised description provided at right, if applicable	Pump station assessments and upgrades.
15	Wachusett Pump Station Upgrades	Delayed	"Priority Schedule" ?	YES - updated/revised description provided at	Pump station assessments and upgrades.

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
				right, if applicable	
16	Wachusett Pipeline Investigation/ Rehabilitation	Canceled	"Priority Schedule" ?	YES - updated/revised description provided at right, if applicable	Pump station assessments and upgrades.
17	Storage Tank upgrade (Indian Hill)	Completed		NO - explanation provided at left	
18	Olean Street Pump Station upgrades	Partially Completed / In Progress	Assessments currently ongoing to identify issues.	YES - updated/revised description provided at right, if applicable	Pump station assessments and upgrades.
19	Worcester Diversion Project- repairs to dam, tunnel, morning glory, channel	Completed		NO - explanation provided at left	
20	Green Island Flood Mitigation	Delayed	"Timeline" ?	YES - updated/revised description provided at	Green Island flood mitigation.

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
				right, if applicable	
21	Headworks Dam located in Holden, MA, tree removal needed	Completed		NO - explanation provided at left	
22	Holden Reservoir Dam #1 needs spillway maintenance	Partially Completed / In Progress	Evaluation phase	YES - updated/revised description provided at right, if applicable	Evaluate spillway capacities for Kettle Brook Reservoir Nos. 1, 2, and 3.
23	Holden Reservoir Dam #2 needs trees to be removed	Completed	Transition strategy to monitor and conduct maintenance.	YES - updated/revised description provided at right, if applicable	Conduct Hydraulic & Hydrologic studies for flooding sources and develop current flood maps to replace FEMA's outdated maps.
24	Kettle Brook Reservoir #1 Dam needs spillway maintenance	Partially Completed / In Progress	Evaluation phase	YES - updated/revised description provided at right, if applicable	Evaluate spillway capacities for Kettle Brook Reservoir Nos. 1, 2, and 3.

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
25	Kettle Brook Reservoir #2 Dam needs spillway maintenance	Partially Completed / In Progress	Evaluation phase	YES - updated/revised description provided at right, if applicable	Evaluate spillway capacities for Kettle Brook Reservoir Nos. 1, 2, and 3.
26	Kettle Brook Reservoir #3 Dam needs spillway maintenance	Partially Completed / In Progress	Evaluation phase	YES - updated/revised description provided at right, if applicable	Evaluate spillway capacities for Kettle Brook Reservoir Nos. 1, 2, and 3.
27	Pine Hill Reservoir Dam needs to be repaired	Partially Completed / In Progress	Design Stage	YES - updated/revised description provided at right, if applicable	Conduct repairs for Pine Hill Reservoir Dam.
28	Coes Reservoir Dam spillway needs repair	Completed		NO - explanation provided at left	
29	Patch Pond Dam needs to be rehabilitated	Partially Completed / In Progress	Design Stage	YES - updated/revised description	Conduct repairs for Quinsigamond Pond and Patch Pond Dams.

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
				provided at right, if applicable	
30	Patch Reservoir Dam needs repair	Completed		NO - explanation provided at left	
31	Poor Farm Pond Dam needs to be decommissioned	Delayed	Pending funding and support	YES - updated/revised description provided at right, if applicable	Remove Poor Farm Pond Dam.
32	Develop a comprehensive interdepartmental record-keeping system of all hazards and disasters happening in the city – past and present.	Partially Completed / In Progress	WebEOC implementation has begun, custom pages and dashboards are going to be created for this purpose.	YES - updated/revised description provided at right, if applicable	Benefit-cost analysis review for hazard mitigation projects.
33	Parsons Reservoir Dam-seek funds for a decommissioning study	Delayed	This project has not reached the top of the priority list.	YES - updated/revised description provided at right, if applicable	Conduct Hydraulic & Hydrologic studies for flooding sources and develop current flood maps to replace FEMA's outdated maps.

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
34	Create/review citywide processes for data collection, sharing during and after hazard events. Create evaluation process post-event to improve responses/issues resulting from the event and share effective strategies/best practices going forward. Evaluate status quo relative to Best Practices.	Partially Completed / In Progress	WebEOC has completed implementation. All City Departments have access to upload data for analysis by EM. WEM has deployed the ESRI Emergency Management Solution - further improving the GIS and Dashboard capabilities for the Division.	NO - explanation provided at left	
35	Seek grants relating to hazard mitigation, collaborate with planning agencies	Completed + To Be Continued	The city collaborates with CMPRC, FEMA, and MEMA regularly. Funding has been provided through state programs, such as the MVP to assist projects - including a new green street design pilot on Endicott Street and development of a drainage system model, updating infrastructure information.	NO - explanation provided at left	
36	Continuing to build strong relationships with feds/state/county by hosting trainings/meetings in our facility as well as attending all other related meetings with intentions of strengthening networks. Participate in drills with outside partners.	Completed + To Be Continued	The Division has hosted multiple regional meetings and trainings at the EOC. Joint exercises and trainings with MEMA/HMCC and HECCMA to further build relationships with regional partners. Division attends all outside meetings and exercises with partners as invited.	NO - explanation provided at left	

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
37	Continue to actively engage with utilities community liaison. Continue to allow space for National Grid and other utilities as needed at EOC	Completed + To Be Continued	EM attends annual meetings with National Grid and Eversource. Each utility has a dedicated community liaison that works closely with city departments; National Grid is active with EM's Emergency Operations Center (EOC). Satellite workspace is available for all utilities to use at the City's EOC.	NO - explanation provided at left	
38	Upgrade notification/warning system upgrade to current software, as needed. Improve updates on social media before, during and post storm events	Partially Completed / In Progress	CodeRED is being updated to a more modern platform for improved warning capabilities. Division now engages in multiple community outreach events every month to spread preparedness education. Work needs to be done on improving the ability to leverage social media.	YES - updated/revised description provided at right, if applicable	Upgrade notification/warning systems with measures to reach socially vulnerable populations.
39	Develop a formal Shelter Plan. Inventory shelter/emergency resources. Identify what services are available at the different shelters (e.g. food preparation, potable water, backup electrical power, heat, showers, etc.) and whether the location of different shelters will be impacted by different hazards (i.e. whether flooding will make the shelter inaccessible to some residents). This	Partially Completed / In Progress	Shelter Plan will be formally known as the Mass Care Annex in the CEMP. Site Surveys have been completed at potential shelter sites to identify available services.	YES - updated/revised description provided at right, if applicable	Expand network of Climate Centers to meet the needs of residents who may require relief from extreme temperatures and power outages.

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
	would help ensure that suitable shelters are available for different types of natural hazards				
40	Develop policy to locate generators on city owned buildings on roofs, when possible.	Canceled	This may not be the best idea according to the Chief of Facilities.	NO - explanation provided at left	
41	Develop program to monitor properties and known flood areas for impacts after major flood events.	Delayed	Web EOC will help with tracking flood events and impacted areas. Volunteer network proposed to help monitor stormwater system model in rain events and report and document flooding. WEM working with GIS Department to leverage ArcGIS Emergency Management Solution. Department of Sustainability and Resilience developed a citizen science project requesting volunteers to send in documented flood conditions; the program had little success to-date.	YES - updated/revised description provided at right, if applicable	Conduct Hydraulic & Hydrologic studies for flooding sources and develop current flood maps to replace FEMA's outdated maps.
42	Improve information available to residents regarding flood hazards (e.g. in retrofitting structures); make information available at all permit offices throughout the City.	Completed + To Be Continued	Brochures remain available at Public Works, Building, and Planning offices. Information is available on-line and distributed at public events.	YES - updated/revised description provided at right, if applicable	Create a new “Natural Hazard Mitigation” portion of the City's website by posting this plan on the web and expanding information regarding natural hazards.

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
43	Improve accessibility of existing and new information about protection from hazards (flooding, water conservation, etc.) on the City's website. Include cross-references/links to similar pages (e.g. stormwater/flooding on Department of Public Works &P page, all other hazards on EM page).	Completed + To Be Continued	Additional improvements to be made, changes to GIS are being implemented to enhance the amounts of information available, and to coordinate among webpages. Extreme heat and flood projection data will be added as well as street trees which are expected to go-live as part of a GIS migration project expected in the next two months.	YES - updated/revised description provided at right, if applicable	Create a new “Natural Hazard Mitigation” portion of the City's website by posting this plan on the web and expanding information regarding natural hazards.
44	Create guidance and information to help educate property owners and residents about the benefits of wetlands to increase compliance with regulations	Partially Completed / In Progress	DPRS is developing a brochure for lake associations to provide residents with docks access to information on permitting. Permitting software includes new language about requirements and requires conservation sign-off. DPRS also intends to begin mailings to property owners near wetlands to remind them of the need for obtaining permits for work in areas near wetlands. DPRS has prepared and given presentations to the public on the importance and function of wetlands and floodplains and distributed brochures at public events such as the Landlord Summit and State of the Lakes and via continuing education courses with the Central MA Realtors Association.	YES - updated/revised description provided at right, if applicable	Create a new “Natural Hazard Mitigation” portion of the City's website by posting this plan on the web and expanding information regarding natural hazards.

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
45	Attend pertinent community meetings with stakeholder groups (e.g. watershed/way groups) to provide education and information about flood hazards and wetland protection.	Completed + To Be Continued	DPRS and Department of Public Works staff continue to host and provide information about the same, including at the City's annual State of the Lakes event and Landlord Summit	NO - explanation provided at left	
46	Improve education about and reporting of illegal dumping in storm drains, wetlands and waterways. Create awareness of connection of storm drains to natural resource areas. Storm drain stenciling projects, signage of how to report illegal dumping near storm drains (especially in CSO areas)	Partially Completed / In Progress	Stenciling continues and new signage is proposed to be installed at Parks with replicated wetlands and rain gardens for educational purposes. Stenciling near catch basins has happened.	YES - updated/revised description provided at right, if applicable	Further develop and conduct public education and outreach programs for residents and property owners in the City regarding hazards.
47	Evaluate existing mechanisms for information sharing with residents/owners and streamline and harness these to share additional information regarding hazards. Explore ability to use electronic permitting processes to flag permits	Completed	Recent changes to permitting software (now open gov) have permitted changes to review work-flows and automatic requirements triggered by geography to help improve information flows. Software allows for communication directly with applicants enabling resource sharing. Current outreach projects involve floodplain areas and staff are being trained in understanding substantial	NO - explanation provided at left	

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
	sought in flood hazard areas to help facilitate sharing of information with property owners (e.g. information on flood insurance and/or mitigating properties, etc.).		improvement and flood insurance basics to educate residents.		
48	Create new “Natural Hazard Mitigation” webpage; Post maps and plan on the City’s Website.	Delayed	Staffing improved, initial conversations started and resources being collected for posting to the City website.	YES - updated/revised description provided at right, if applicable	Create a new “Natural Hazard Mitigation” portion of the City's website by posting this plan on the web and expanding information regarding natural hazards.
49	Continue and expand outreach programs including National Preparedness Month, National Night Out, social media, community presentation, and various community meetings, and other events	Completed + To Be Continued	We have been re-engaging with in-person community preparedness education including tabling, presentations, work has begun on offering preparedness education in multiple languages.	YES - updated/revised description provided at right, if applicable	Further develop and conduct public education and outreach programs for residents and property owners in the City regarding hazards.
50	Maintain and improve educational outreach as part of Community Rating System including, educating residents in flood prone	Partially Completed / In Progress	Continue outreach (spring & fall) to RL area property owners. Collaboration with lake associations on-going to improve education around floodplain values.	YES - updated/revised description provided at	Maintain and improve floodplain management practices to increase awareness, minimize flood damage and

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
	area and repetitive loss properties.			right, if applicable	increase the City's Community Rating System score.
51	Educate community about water conservation; continue including information on water bills and NPDES permits.	Partially Completed / In Progress	Use of social media and utility bills to alert to drought conditions and discourage unnecessary use of water.	YES - updated/revised description provided at right, if applicable	Further develop and conduct public education and outreach programs for residents and property owners in the City regarding hazards.
52	Encourage utilization of low cost training opportunities and harness existing resources, such as FEMA brochures, to help educate resident and property owners in the City regarding hazards.	Partially Completed / In Progress	Brochures remain available at Public Works, Building, and Planning offices. Information is available on-line and distributed at public events.	YES - updated/revised description provided at right, if applicable	Increase the knowledge and use of mitigation/resilience best practices by City staff.
53	Educate renters on actions they can take to mitigate and prepare for disaster.	Partially Completed / In Progress	Using social media to reach this audience.	YES - updated/revised description provided at right, if applicable	Further develop and conduct public education and outreach programs for residents and property owners in the City regarding hazards.

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
54	Ensure Unified Incident Command program remains up to date.	Completed	WFD/PD use unified command, ongoing work to familiarize rest of City Depts. on ICS/NIMS concepts	NO - explanation provided at left	
55	Update/implement relevant recommendations into the Open Space & Recreation Plan. Use Mass Audubon's Mapping and Prioritizing Parcels for Resilience to prioritize conservation areas and overlay with flood prone areas and soils able to infiltrate. Note these as critical for restoration and implementation of LID BMPs.	Completed	New open space plan was adopted in 2021 and implementation of strategies has begun. DPRS is working with a consultant to develop baseline plans for various properties and assess tree canopy benefits and health to help prioritize hazard tree management and understand cooling benefits.	NO - explanation provided at left	
56	Update the Wetlands Protection Ordinance/Zoning Ordinance to address establish clear stormwater requirements for all projects (e.g. requirements for re-charge - new and re-development; clarify "maximum extent practical" as defined in 310 CMR 10. Outline clear	Partially Completed / In Progress	Staff is supporting state efforts to further update stormwater standards statewide and require more progressive precipitation estimates that project future totals based on climate change. Work to develop policies around hazard trees and other limited exceptions is ongoing. Staff is developing a paving permit and regulations to help ensure unauthorized expansions of impervious surface are controlled and revised for regulatory compliance.	YES - updated/revised description provided at right, if applicable	Improve stormwater management regulations.

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
	requirements for creation/use of LID/Green Infrastructure improvements). Consider adoption of minor exemptions where there are public benefits from such activities. Investigate requiring preliminary plans to ensure LID is incorporated early on and can be adjusted based on Conservation Commission recommendation				
57	Develop open space property acquisition prioritization matrix. Use MAPPR to prioritize conservation areas and overlay with flood prone areas and soils able to infiltrate. Note these as critical for restoration and implementation of LID BMPs.	Canceled	Delayed due to MAPPR program being down. The City has criteria it is using.	NO - explanation provided at left	
58	Incorporate Hazard Mitigation Planning recommendations and elements in the Master Plan and ensure Master	Completed	Long Range plan has been adopted by the Planning Board and recommenda overhauls for stormwater regulations, implementation of a tree removal/canopy protection ordinance and reductions in parking as well as infrastructure	NO - explanation provided at left	

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
	Plan process evaluates HMP concerns		assessments to understand deficiencies and ability to support growth, also prioritizes growth in areas with transit access to help keep residents connected to resources and amenities.		
59	Update/implement relevant recommendations in the Climate Action Plan	Completed	Climate Action Plan has been supplemented by the Green Worcester Plan with new strategies for resiliency. Urban Forestry Master Plan, heat-risk modeling and Greenhouse Gas Inventories are now complete and effectively replace the CAP.	NO - explanation provided at left	
60	Consider updates to Subdivision Regulations to encourage LID use, design standards, and cluster developments to protect open-space, reduce imperviousness, and increase buffers to wet areas. Potentially require preliminary plans to ensure LID is incorporated early on and can be adjusted based on PB recommendations. Cluster Development changes: Increase required minimum amount of OS protected. Connect to city's OS plan. Change from	Delayed	Encountered resource constraints due to staffing changes. Projects for mitigation are under design such as the Endicott/Bigelow Streets project. Changes to Zoning are planned in a Zoning Ordinance Overhaul expected to commence in FY25.	YES - updated/revised description provided at right, if applicable	Improve stormwater management regulations.

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
	cluster to OSRD to include 4-step design process.				
61	Consider adopting additional limitations on imperviousness into zoning and/or wetland regulations.	Partially Completed / In Progress	Zoning Ordinance was amended in 2020 to incorporate limitations to impervious area within residentially zoned front-yards. Paving permits remain in development by ISD, after pushback in implementation of a draft permit.	YES - updated/revised description provided at right, if applicable	Improve stormwater management regulations.
62	Update Zoning Ordinance to modernize parking requirements in order to reduce impervious surfaces through means such as shared parking, mixed-use credits, lower parking minimums, parking maximums, and flexible parking requirements.	Partially Completed / In Progress	Parking studies and efforts to review existing requirements are being conducted by DPRS and will continue through the Master Plan update. Expected as an early-action of the long-range plan in FY25.	YES - updated/revised description provided at right, if applicable	Improve stormwater management regulations.
63	Evaluate best-practices for hazard mitigation regulations for new and re-development. Create "resiliency" review checklists for new/re-development projects relative to hazard mitigation best practices for use in zoning, planning, and conservation	Partially Completed / In Progress	DPRS generally requests this for pre-development consultations and during permitting. Staff and the Conservation Commission have started requesting that applicants use the NOAA Atlas 14 upper confidence interval in drainage calculations to increase the precipitation totals that stormwater systems are designed to handle.	YES - updated/revised description provided at right, if applicable	Improve stormwater management regulations.

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
	permitting reviews. Identify ways to incorporate requirements of resiliency BMPs into regulations/ordinances.				
64	Further partnerships with and support for local land protection and management of open space specific to protection from natural hazards (e.g. GWLT, Mass Audubon, etc.). Develop prevention and monitoring programs to avoid illegal dumping in wetlands on such entity owned protected spaces.	Partially Completed / In Progress	The city continues to investigate open space opportunities in partnership with GWLT and Mass Audubon. No programs related to illegal dumping have yet commenced, however annual earth-day cleanups are coordinated with volunteers. Ad-hoc programming at problem areas are implemented with cameras and signage. Baselines are being developed for certain properties as part of a grant which will help ID these areas.	NO - explanation provided at left	
65	Develop zoning regulations pertaining to land clearing and/or alteration of steep grades to prevent off-site adverse impacts with regard to stormwater/flooding and erosion. Include best practices and requirements for working with natural landform and topography to avoid the creation of steep slopes and use of	Delayed	Research commenced, drafting has yet to start due to staffing constraints. Staff anticipate canopy coverage as an early action item of the long-range plan in FY26.	YES - updated/revised description provided at right, if applicable	Improve stormwater management regulations.

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
	large retaining walls. Minimize clearing/grading MEP. Create standards within SPR for >15% slope such as setbacks and limiting drop offs; consider reducing to 10% slope.				
66	Implement additional requirements for stormwater management (create storage capacity) for substantial improvement/re-development of existing flood prone properties.	Delayed	Priority should be decreased in favor of citywide requirements for SW management. City projects continue to evaluate opportunities for stormwater recharge and detention.	YES - updated/revised description provided at right, if applicable	Improve stormwater management regulations.
67	Evaluate feasibility of requiring all new utility service infrastructure to be underground (includes putting underground: Power/cable/fiber optics).	Delayed	Priority should be decreased. Awaiting results of National Grid pilot.	NO - explanation provided at left	
68	Explore the feasibility of converting existing aerial utility infrastructure (includes putting underground: Power/cable/fiber optics) when streets are resurfaced, or work is	Delayed	Priority should be decreased. Awaiting results of National Grid pilot.	NO - explanation provided at left	

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
	conducted on city- owned property.				
69	Develop formal process for providing feedback on MEPA projects.	Completed + To Be Continued	DPRS now monitors publications and reviews all projects within the city, providing comments via Planning Board. Change to maintain review.	NO - explanation provided at left	
70	Consider use of Zoning (e.g. existing floodplain district) to evaluate the extent of appropriate uses for new development located in the floodplain.	Delayed	Anticipate review to co-inside with adoption of new model bylaw when the next RiskMap updates are completed (expected in the 2024 calendar year).	YES - updated/revised description provided at right, if applicable	Create restoration requirements for redevelopment projects to provide additional water storage in floodplains.
71	Investigate opportunities to create restoration requirements for redevelopment projects in the floodplain/riverfront areas to provide additional storage capacity and riparian zones.	Partially Completed / In Progress	Research and draft regulations commenced, awaiting review, refinement and support and capacity to finalize.	YES - updated/revised description provided at right, if applicable	Create restoration requirements for redevelopment projects to provide additional water storage in floodplains.
72	Consider development regulations that would require adding flood storage capacity/mitigation measures (e.g. rain gardens, drywells, etc.) in susceptible areas, such the Green Island and	Delayed	Encountered resource constraints due to staffing changes. Projects for mitigation are under design such as the Endicott/Bigelow Streets project.	YES - updated/revised description provided at right, if applicable	Update Zoning Ordinance to require nature based solutions.

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
	Beaverbrook areas of the City.				
73	Investigate feasibility of buy-back programs for high-risk or Repetitive Loss residential structures.	Delayed	Encountered resource constraints due to staffing changes. Anticipate exploration in FY25.	YES - updated/revised description provided at right, if applicable	Maintain and improve floodplain management practices to increase awareness, minimize flood damage and increase the City's Community Rating System score.
74	Actively monitor and enforce all aspects of the state building code for all construction activities	Partially Completed / In Progress	Inspectional Services continues to enforce the current state building code (International Building Code with Massachusetts Amendments). DPRS now assists with floodplain property reviews providing assistance with EC review and SI evaluation of all building permit applications.	YES - updated/revised description provided at right, if applicable	Inventory unreinforced masonry and brick buildings owned by the City which may be vulnerable to earthquakes.
75	Work to actively enforce the Massachusetts Wetlands Protection Act & City of Worcester Wetlands Protection Ordinance and require oversight of projects located in close proximity to storm- drain inlet components.	Completed + To Be Continued	The Conservation Commission continues to enforce the Wetlands Protection Act and accompanying Regulations – requiring pre-development permitting, inspecting sites for compliance during construction, and utilizing an array of enforcement tools to ensure compliance through to project completion and site stabilization. Additionally, Worcester has a more restrictive local wetlands protection ordinance which regulates activities within 100’ of any surface system storm-drain inlet and	NO - explanation provided at left	

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
			provides specific limitations on work within 15-30' of a wetland or stream.		
76	Review best practices and identify those that could be implemented in Worcester, update HMP priorities annually,	Partially Completed / In Progress	Ongoing capability.	NO - explanation provided at left	
77	Update Hazard Mitigation Plan on a 5-year basis	Partially Completed / In Progress	Due in 2024. Anticipate commencement of planning process, pending replenishment of funding to award grant application that's been approved by MEMA.	YES - updated/revised description provided at right, if applicable	Update and maintain the Hazard Mitigation Plan.
78	Work with Central Mass Regional Planning Commission to maintain up to date evacuation routes, expand on evacuation planning.	Partially Completed / In Progress	Current plans and evacuation routes are not sufficient and need to be updated.	YES - updated/revised description provided at right, if applicable	Expand current evacuation planning efforts and coordinate with additional organizations.
79	Take part in the Municipal Vulnerability Preparedness Program and become certified.	Partially Completed / In Progress	Continued certification; received grant to develop a Senior Center green infrastructure project; 2 Miyawaki Forests and 2 Cool Pocket Designs.	YES - updated/revised description provided at right, if applicable	Participate in the Municipal Vulnerability Preparedness Program and submit grant applications as appropriate.

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
80	Conduct a Threat and Hazards Risk Identification Analysis. This is similar to the current Hazard Vulnerability Plan but includes technological and man-made hazards. It also identifies targets for preparedness levels	Delayed	Due to staffing changes	YES - updated/revised description provided at right, if applicable	Update the City's Threat and Hazard Identification and Risk Assessment (THIRA).
81	Formation of Community Emergency Response Team (CERT), A volunteer group that is trained and equipped to support response efforts in the City of Worcester	Completed	WEM has a designated CERT Program Manager. CERT will continue to be a core component of EM. Does not need to be in the HMP	NO - explanation provided at left	
82	Conduct a Neighborhood-Based Urban Heat Risk Assessment to model urban heat, estimate heat-related mortality to rank most vulnerable areas, as well as building scenarios for urban heat management and heat wave response planning efforts, etc.	Completed	Seek funding to develop related implementation plans to enable tree planting to address impacts in conjunction with the Urban Forestry Master Plan, coordinating with EOED related to use of tax-title properties and plan for ensuring appropriate locations and numbers of cooling centers. Grants have funded 2 Miyawaki Forests (construction in progress) and 2 Cool Pocket Designs underway by end of FY24.	YES - updated/revised description provided at right, if applicable	Conduct urban heat island mitigation by planting trees, opening cooling centers, and designing low heat areas.
83	Develop an Urban Forestry Master Plan to inventory and keep inventoried public	Partially Completed	In process of receipt of public comment.	NO - explanation	

Action #	Action Description	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
	trees, develop practices to improve and replace ageing canopy and BMPs for planting, removal, and maintenance of existing trees within the public realm, etc.	/ In Progress		provided at left	

Municipal Vulnerability Preparedness Plan

The Municipal Vulnerability Preparedness (MVP) plan was developed in June 2019 and is called the City of Worcester Municipal Vulnerability Preparedness Plan: Findings & Recommendations and includes 18 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 Worcester's MVP were reviewed and considered when developing mitigation actions for this plan update. Priority actions from the MVP were included in this plan update including investing in the City's Stormwater System, education regarding climate change, and protecting open space.

Comprehensive Range of Mitigation Actions

C4. Does the Plan identify and analyze a comprehensive range of specific mitigation actions and projects for each jurisdiction being considered to reduce the effects of hazards, with emphasis on new and existing buildings and infrastructure? (Requirement §201.6(c)(3)(ii))

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

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

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

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

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

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

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

Figure 31. Process of Identifying a Range of Mitigation Actions.

The HMPC and the public considered four mitigation action categories defined in Figure 32 below when considering solutions to identified problems.

Local Plans and Regulations

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

Structure and Infrastructure

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

Natural Systems Protection

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

Education and Awareness Programs

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

Figure 32. Types of Mitigation Actions.

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

Table 97. Examples of Mitigation Actions in Each Category.

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

Mitigation Action Category	Examples of Mitigation Actions
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 • Mailings to residents in hazard-prone areas

The HMPC also included specific dam risk mitigation activities such as those shown in Table 98 below taken from FEMA's Hurricane and Flood Mitigation Handbook for Public Facilities (https://www.fema.gov/sites/default/files/documents/fema_p-2181-fact-sheet-2-3-dams-and-reservoirs_0.pdf).

Table 98. Dam Risk Mitigation Activities.

Type of Dam Risk Mitigation Activity	Description
Emergency Action Plans	• Develop and practice an Emergency Action Plan (EAP). EAPs include actions dam owners take to mitigate risk, coordinate with emergency management, issue early warnings, create inundation maps, and delineate responsibilities for those who manage an incident.
Improve Dam Stability	• Reduce the Slope • Use Buttressing • Use Anchoring
Increase Spillway Capacity	• Expand Existing Spillway • Add a New Spillway
Increase Temporary Storage Capacity	• Raise the Dam Height
Control Surface Erosion	• Use Armoring

Type of Dam Risk Mitigation Activity	Description
	• Build a Parapet Wall • Build a Cutoff Wall to Address Headcutting
Reduce Seepage and Internal Erosion	• Install a Blanket Drain • Install a Filter Diaphragm • Install a Reverse Filter • Install a Seepage Cutoff Wall
Address Foundation Issues	• Install a Grout Curtain • Install a Foundation Cutoff Wall

The Association of State Dam Safety Officials (https://damsafety.org/Roadmap) includes the following recommendations for mitigating risk and the HMPC considered each one:

Dam Owners Should:

- Maintain and operate dams to assure that they do not fail. Work with state local officials to mitigate the consequences of failures and incidents.
- Inform local officials of risks associated with dams.
- Develop emergency action plans (EAP) for every high-hazard potential dam. Use a nationally accepted model/guide. Integrate exercising into the planning process.
- Have a dam failure inundation map created as part of the EAP development process. Share plans and maps with local planners and first responders.
- Work with the state or federal regulator to comply with safety standards.
- Hire experienced professional engineers to oversee dam safety engineering issues.
- Attend educational programs when offered by organizations and agencies.

Emergency and Floodplain Managers Should:

- Open lines of communication with State and Federal dam safety agencies to improve planning and preparedness for dam failures or incidents.
- Participate in educational programs to become more aware of dams and how they intersect with emergency and floodplain management.
- Encourage improved land use planning at the local level so that communication about how dams affect local areas is more accurately known and considered in future planning.

Additional mitigation actions considered by the HMPC for dams included:

- Rehabilitation or removal
- Adopting or enforcing land use ordinances in inundation zones
- Elevating structures in inundation zones
- Adding flood protection measures such as berms, floodwalls, and floodproofing in inundation zones
- Managing the watershed to reduce erosion and sediment inflow.
- Public education.

In addition to this quantitative approach to identifying mitigation actions, the HMPC took a qualitative approach through the public outreach and engagement process to identify mitigation actions. Mitigation actions supporting underserved communities and environmental justice communities were specifically considered by the HMPC. They also focused on actions to the built environment both buildings and infrastructure as well as future development or redevelopment. The resulting list of mitigation actions includes at a minimum one action for each hazard identified. In several instances multiple actions address an identified hazard and problem.

Potential mitigation actions for each identified hazard and problem identified in the Risk Assessment are shown in the table below in order of risk. Hazards are listed in order of risk. Some of these mitigation actions are included in the Action Plan; some were not included because of cost-benefit-analysis outcomes. The HMPC considered the pros and cons of all possible mitigation actions.

Table 99. Possible Mitigation Actions for Each Hazard.

Hazard	Possible Mitigation Actions
Flooding from Precipitation	• Redo outdated flood maps. • Improve stormwater regulations. • Improve Community Rating System (CRS) rating.
Severe Winter Storms	• Replace or install generators on critical facilities. • Coordinate closely with National Grid to prevent power outages and to return power to critical facilities.
Average and Extreme Temperatures	• Create urban heat islands.

Hazard	Possible Mitigation Actions
	• Identify additional heating and cooling center locations (Climate Centers).
Other Severe Weather	• Continue evacuation planning and coordinate with additional organizations.
Droughts	• Increase water use efficiency to mitigate drought risk.
Flooding from Dam Failure or Overtopping	• Remove dams. • Replace dam spillways. • Expand inundation modeling and dam failure scenarios.
Tornadoes	• Conduct public education about natural hazard threats.
Wildfires/Brushfires	• Improve Worcester Fire Department capacity to withstand extreme weather.
Hurricanes/Tropical Storms	• Safeguard radio infrastructure from high winds.
Invasive Species	• Participate in the MVP program. • Build capacity in the lakes and ponds program.
Landslides	• Upgrade notification systems to reach socially vulnerable populations.
Earthquakes	• Participate in regional debris management planning. • Inventory unreinforced masonry buildings for retrofit.

The HMPC considered each of the hazard risks and problems identified in terms of the following Community Rating System (CRS) categories:

a. Preventive Activities

b. Floodplain Management Regulatory/current & future conditions

c. Property Protection Activities

d. Natural Resource Protection Activities

e. Emergency Services Activities

f. Structural Projects

g. Public Information Activities

The HMPC reviewed a comprehensive range of specific mitigation actions to reduce the effects of hazards as described in the risk assessment, with emphasis on addressing the vulnerability of new and existing buildings and infrastructure. This systematic review also included the consideration of numerous opportunities to expand and improve the City's capabilities to reduce risk as identified in the capability assessment. The actions and opportunities explored by the HMPC covered a variety of mitigation measures including preventive activities, property protection, natural resource protection, structural projects, public information activities, and emergency services.

The HMPC considered the protection of existing properties and natural resources a top priority, along with limiting risk to new development and redevelopment. Although most of Worcester has been developed, the City does have open space and environmentally sensitive areas that need preservation. Actions to support these priorities are included in other City planning documents and were well supported by the HMPC when identifying mitigation actions. Examples include acquiring repetitive loss properties, removing dams, and stormwater and zoning regulation reviews.

The HMPC also reviewed a range of structural projects and public information activities designed to help reduce the vulnerability of existing buildings and populations to potential hazard impacts. These actions included new hazard mapping activities, site-specific building and infrastructure improvements, community education initiatives, and more targeted outreach campaigns to vulnerable populations. Although not the focus of the City's mitigation strategy, actions related to improving emergency preparedness and response activities, such as shelter and generator upgrades, were also considered for incorporation into the plan as new actions for the City to pursue.

Table 100. Mitigation Actions with Corresponding CRS Categories.

Community Rating System Categories	Action #	Action Title
A. Preventive Activities	10	Expand inundation modeling for dam failure scenarios and planning.
	16	Improve stormwater management regulations.
	18	Update and maintain the Hazard Mitigation Plan.
	19	Develop a Floodplain Manager position in the City and use this position to expand floodplain education and outreach.
	23	Update the City's Threat and Hazard Identification and Risk Assessment (THIRA).
	24	Formalize a process for interdepartmental review of all City construction/infrastructure projects.

Community Rating System Categories	Action #	Action Title
	28	Increase protections for preserving, restoring, and enhancing Worcester's tree canopy through more effective provisions for planting and replanting requirements (new/replacement shade trees) in local regulations.
	29	Participate in the Municipal Vulnerability Preparedness Program and submit grant applications as appropriate.
	31	Green Island flood mitigation.
	32	Consider updates to Subdivision Regulations for resilient land use.
	33	Develop an inventory and maintenance plan for detention/infiltration basins.
	34	Benefit-cost analysis review for hazard mitigation projects.
	36	Integrate resilient design principles and practices into City projects.
	41	Build capacity within the Planning Division.
	43	Update Zoning Ordinance to require nature based solutions.
	44	Consider use of Zoning Ordinance (e.g. existing Floodplain Overlay District) to evaluate the extent of appropriate uses for new development located in the floodplain.
	45	Create restoration requirements for redevelopment projects to provide additional water storage in floodplains.
	46	Integrate disaster mitigation into transportation projects by incorporating risk assessments and resilience measures into planning, design, and construction.
	47	Investigate the feasibility of forming a Stormwater Utility.
B. Floodplain Management Regulatory current and future conditions	17	Conduct Hydraulic & Hydrologic studies for flooding sources and develop current flood maps to replace FEMA's outdated maps.
Emergency Services Activities	2	Replace Worcester's Police Headquarters generator to provide continuity of operations and protect emergency response activities.
	4	Develop the Mass Care Annex to the CEMP to function as a sheltering plan.
	5	Upgrade notification/warning systems with measures to reach socially vulnerable populations.
	6	Expand current evacuation planning efforts and coordinate with additional organizations.
	8	Expand network of Climate Centers to meet the needs of residents who may require relief from extreme temperatures and power outages.
	9	Develop and implement a system for monitoring high water levels throughout the City.
	35	Participate in Regional Debris Management Planning

Community Rating System Categories	Action #	Action Title
Natural Resource Protection Activities	7	Conduct urban heat island mitigation by planting trees, opening cooling centers, and designing low heat areas.
	14	Increase water use efficiency to mitigate drought risk.
	40	Leverage the City's Community Preservation Act (CPA) funding where possible to advance flood mitigation and watershed management in addition to other CPA objectives.
	49	Build capacity within Lakes and Pond Program.
	50	Develop an Invasive Species Response and Management Plan.
Property Protection Activities	20	Acquire Repetitive Loss Properties to mitigate risk.
	26	Safeguard Radio Infrastructure against high winds.
	27	Implement mitigation strategies to mitigate risk to City Fire Department Facilities located in or near flood zones or at risk to rockfalls.
	39	Improve Worcester Fire Department ability to withstand extreme weather.
	42	Inventory unreinforced masonry and brick buildings owned by the City which may be vulnerable to earthquakes.
	48	Repair or replace City Hall's Roof.
Public Information Activities	1	Maintain and improve floodplain management practices to increase awareness, minimize flood damage and increase the City's Community Rating System score.
	21	Increase the knowledge and use of mitigation/resilience best practices by City staff.
	22	Collaborate with existing fire education efforts to promote forest health and wildfire education to be delivered in schools and public events.
	25	Further develop and conduct public education and outreach programs for residents and property owners in the City regarding hazards.
	38	Create a new "Natural Hazard Mitigation" portion of the City's website by posting this plan on the web and expanding information regarding natural hazards.
Structural Projects	3	Remove Poor Farm Pond.
	11	Conduct repairs for Pine Hill Reservoir Dam.
	12	Conduct repairs for Quinsigamond Pond and Patch Pond Dams.
	13	Evaluate spillway capacities for Kettle Brook Reservoir Nos. 1, 2, and 3.
	15	Right size culverts throughout the City based on risk.
	30	Resolve Weasel Brook flooding issues.
	37	Pump station assessments and upgrades.

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))

HHPD4: Did the plan include actions that address HHPDs and prioritize mitigation actions to reduce vulnerabilities from HHPDs?

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

Table 11. Essential Details for Mitigation Actions.

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

The priority order was chosen based on weighing costs versus benefits. It was imperative for the City to determine if the costs associated with an action were reasonable compared to the corresponding benefits. To do this, the HMPC developed a prioritization table that included eight categories of criteria; these are detailed in the table below. Each category was assigned points with priority criteria given the highest points. The most points an action could earn was 22. Actions that scored 15 points or higher were ranked as High priority. Actions that scored between 13-14 points were considered Medium, and actions that scored under 12 points were considered low priority. High Hazard Dams were given their own prioritization ranking due to their significance as a critical asset.

Table 12. Priority Ranking System.

	Criteria Category	**Description**	**Detailed Ranking and Associated Points**
1	Hazards Addressed	What level of hazards does the measure provide protection against?	High (Flooding from Precipitation, Severe Winter Storms, Extreme Temperatures, Other Severe Weather, Droughts) = 3 Medium (Flood from Dam Failure, Tornadoes, Wildfires and Brush Fires, Extreme Temperatures, Hurricanes and Tropical Storms, Invasive Species, Landslides) = 2 Low (Earthquakes) = 1
2	High Hazard Dams	How much does the measure mitigate dam risk?	Specific Risk Mitigation = 3 Some Risk Mitigation = 2 No Risk Mitigation = 0
3	Approximate Cost	How much will the measure cost to implement?	Low (Under $25k) = 3 Medium ($25k - $250k) = 2 High ($250k - $5 million) = 1 Very High (over $5 million) = 0
4	Equity Focus	Does the measure provide support to Environmental Justice (EJ) and other Vulnerable Populations?	Direct Support = 3 Indirect Support = 2 No Support = 0
5	Protection of Lives	How effective is the measure in protecting lives and mitigating injuries	Direct Support = 3 Moderate Indirect Support = 2

	Criteria Category	Description	Detailed Ranking and Associated Points
		resulting from the targeted hazard(s)?	Minor Indirect Support = 1 None = 0
6	Protection of Critical Facilities or Infrastructure	Does the measure provide protection of critical facilities and infrastructure?	Yes = 3 No = 0
7	Natural Resource Protection	Does the measure provide protection of natural resources?	Yes = 2 No = 0
8	Alignment with Objectives	Does the measure align with the HMP objectives?	Yes =2 No =0

All the actions are listed in Table 101 in order of priority with the actions corresponding details. Additional tables are included in Appendix B. The breakdown of priority ranking points for each action is included in Appendix B. Readers of this Plan must understand that the mitigation action list is aspirational, it does not mean that the HMPC is confident that all actions may be implemented in the span of five years.

Table 101. Hazard Mitigation Actions.

1	**Maintain and improve floodplain management practices to increase awareness, minimize flood damage and increase the City's Community Rating System score.**	
High	Action Description	Maintain and improve current activities credited by the Community Rating System program such as educating residents in flood zones and repetitive loss areas. Conduct outreach to property owners affected by upcoming FEMA risk map updates. Undertake additional creditable Community Rating System activities to reduce flood risk and improve community awareness. Conduct additional creditable CRS activities to ensure the City’s Class 7 status in CRS is maintained and ideally upgrade from Class 7 to a Class 5 or 6 in the future.
	Lead Position	Assistant Chief Development Officer - Planning & Regulatory Services
	Supporting Agencies	Chief Sustainability Officer, Director of Emergency Management
	Cost	Low

	Potential Funding Sources	Planning & Regulatory Services Budget
	Hazards	Flooding from Precipitation, Other Severe Weather, Hurricanes/Tropical Storms
	Implementation Schedule	2025-2030
2	**Replace Worcester's Police Headquarters generator to provide continuity of operations and protect emergency response activities.**	
High	Action Description	Worcester Police Headquarters has aging electrical and generator infrastructure and houses critical information systems whose disruption would have cascading effects throughout the city. This includes impacts on emergency services and government operations. The Headquarters requires and upgraded electrical system and a new generator, and relays.
	Lead Position	Worcester Police Chief
	Supporting Agencies	Chief of Public Facilities
	Cost	High
	Potential Funding Sources	FEMA Hazard Mitigation Grant Program, FEMA Building Resilient Infrastructure and Communities (BRIC)
	Hazards	Flooding from Precipitation, Severe Winter Storms, Extreme Temperatures, Other Severe Weather, Flooding from Dam Failure, Tornadoes, Wildfires/Brushfires, Hurricanes/Tropical Storms, Landslides, Earthquakes
	Implementation Schedule	2026-2029
3	**Remove Poor Farm Pond.**	
High	Action Description	The next project would likely be the removal of Poor Farm Pond. This is a small, shallow pond located on the Worcester/Shrewsbury line near Route 70. We have already performed a feasibility study for this project. It was well received by residents and advocacy groups.
	Lead Position	Assistant Commissioner of Water/Sewer Operations
	Supporting Agencies	Chief Sustainability Officer
	Cost	Very High
	Potential Funding Sources	Massachusetts Executive Office of Energy and Environmental Affairs (EEA): MA Dam and Seawall Repair or Removal Fund, Massachusetts Department of Environmental Protection (MassDEP): Massachusetts Clean Water Trust (CWT) – State Revolving Fund (SRF) Loans,

		Massachusetts Emergency Management Agency (MEMA): Hazard Mitigation Grants, Massachusetts Department of Conservation and Recreation (DCR): FEMA High Hazard Potential Dam (HHPD) Grant Program, U.S. Army Corps of Engineers (USACE): Dam Rehabilitation Assistance
	Hazards	Flooding from Dam Failure
	Implementation Schedule	2025-2030
4	**Develop the Mass Care Annex to the CEMP to function as a sheltering plan.**	
High	Action Description	The Mass Care Annex is in development, in 2025 the City will seek stakeholder feedback, host a workshop, and conduct a tabletop exercise. The Annex will include Sheltering, Feeding, CPOD, Pet-Shelter, and Special Considerations.
	Lead Position	Director of Emergency Management
	Supporting Agencies	Red Cross Disaster Program Manager Luca Calvani, Director of Accessibility Patricia LaFore, Esq.
	Cost	Low
	Potential Funding Sources	Department of Emergency Communications and Management Budget
	Hazards	Flooding from Precipitation, Severe Winter Storms, Extreme Temperatures, Other Severe Weather, Flooding from Dam Failure, Tornadoes, Wildfires/Brushfires, Hurricanes/Tropical Storms, Droughts, Invasive Species, Landslides, Earthquakes
	Implementation Schedule	2025-2026
5	**Upgrade notification/warning systems with measures to reach socially vulnerable populations.**	
High	Action Description	Emergency Management is seeking a replacement for its current notification system CodeRED. A new system is needed to identify high hazard areas with vulnerable populations. The City would also like to install PA / Siren systems to improve Alert/Warning capability. The PA/Siren systems will allow for an additional alerting method and will improve efforts to warn citizens who may not have an ability to receive an IPAWS message.
	Lead Position	Director of Emergency Management
	Supporting Agencies	Director of Emergency Communications, Director of Accessibility
	Cost	Medium

	Potential Funding Sources	FEMA Hazard Mitigation Grant Program (HMGP), FEMA Building Resilient Infrastructure and Communities (BRIC)
	Hazards	Flooding from Precipitation, Severe Winter Storms, Extreme Temperatures, Other Severe Weather, Flooding from Dam Failure, Tornadoes, Wildfires/Brushfires, Hurricanes/Tropical Storms, Droughts, Invasive Species, Landslides, Earthquakes
	Implementation Schedule	2027-2030
6	**Expand current evacuation planning efforts and coordinate with additional organizations.**	
High	Action Description	Central Mass Regional Planning Commission, Worcester Regional Transit Authority, Worcester Police Department, and Emergency Management will review current evacuation routes, assess hazards along routes and make changes as needed. Eliminate silos on evac planning for improved coordination on using GIS and IPAWS. Host public hearings to get feedback and to learn more about how community members would approach evacuating. Emphasize during planning, those needing transportation assistance.
	Lead Position	Director of Emergency Management
	Supporting Agencies	Worcester Fire Chief, Worcester Police Chief , Assistant Chief Development Officer - Planning & Regulatory Services, Commissioner of Transportation and Mobility , CMRPC , WRTA General Manager , Director of Accessibility.
	Cost	Medium
	Potential Funding Sources	USDOT Promoting Resilient Operations for Transformative, Efficient, and Cost-saving Transportation Program, FEMA Building Resilient Infrastructure and Communities, FHA Surface Transportation Block Grant Program
	Hazards	Flooding from Precipitation, Severe Winter Storms, Other Severe Weather, Flooding from Dam Failure, Tornadoes, Wildfires/Brushfires, Hurricanes/Tropical Storms, Landslides
	Implementation Schedule	2025-2027
7	**Conduct urban heat island mitigation by planting trees, opening cooling centers, and designing low heat areas.**	
High	Action Description	Conduct a Neighborhood-Based Urban Heat Risk Assessment to model urban heat, estimate heat-related mortality to rank most vulnerable areas, as well as building scenarios for urban heat management and heat wave response planning efforts, etc. Seek funding to develop

		related implementation plans to enable tree planting to address impacts in conjunction with the Urban Forestry Master Plan, coordinating with EOED related to use of tax-title properties and plan for ensuring appropriate locations and numbers of cooling centers. Grants have funded 2 Miyawaki Forests (construction in progress) and 2 Cool Pocket Designs underway by end of FY24.
	Lead Position	Chief Sustainability Officer
	Supporting Agencies	Assistant Chief Development Officer - Planning & Regulatory Services, Director of Emergency Management, Assistant Commissioner of Parks, Director of Public Facilities
	Cost	Medium
	Potential Funding Sources	Massachusetts Executive Office of Energy and Environmental Affairs (EEA): Municipal Vulnerability Preparedness (MVP) Program, Inflation Reduction Act: Environmental and Climate Justice Community Change Grant Program, U.S. EPA: Environmental and Climate Justice Program
	Hazards	Extreme Temperatures
	Implementation Schedule	2026-2028
8	**Expand network of Climate Centers to meet the needs of residents who may require relief from extreme temperatures and power outages.**	
High	Action Description	The city is without a sufficient network of centers for extreme heat or cold emergencies. Identify community partners and facility upgrades to create more areas that can provide relief from the weather.
	Lead Position	Director of Emergency Management
	Supporting Agencies	Chief Sustainability Officer, Assistant Chief Development Officer - Planning & Regulatory Services
	Cost	Medium
	Potential Funding Sources	FEMA Hazard Mitigation Grant Program (HMGP), FEMA Building Resilient Infrastructure and Communities (BRIC), Central Mass Regional Planning Commission (CMRPC) support
	Hazards	Severe Winter Storms, Extreme Temperatures, Other Severe Weather
	Implementation Schedule	2025-2028
9	**Develop and implement a system for monitoring high water levels throughout the City.**	
High	Action Description	Data and community input will be used to determine areas that experience or are likely to experience flooding. From there we will research low cost solutions to monitor water levels such as stream gauges and water level sensors. We will choose locations to pilot solutions before expanding to a "citywide" network of sensors. Sensor

		data will be monitored through the eventual Worcester Situational Awareness Dashboard to improve early alert and warning for the public
	Lead Position	Assistant Commissioner of Water/Sewer Operations
	Supporting Agencies	Assistant Chief Development Officer - Planning & Regulatory Services
	Cost	Medium
	Potential Funding Sources	FEMA Hazard Mitigation Grant Program, FEMA Building Resilient Infrastructure and Communities (BRIC)
	Hazards	Flooding from Precipitation, Other Severe Weather, Hurricanes/Tropical Storms
	Implementation Schedule	2026-2030
10	**Expand inundation modeling for dam failure scenarios and planning.**	
High	Action Description	Create a priority list of dams for new inundation modeling for failure scenarios. Data will be used for Dam EAPs, evacuation zone planning, mass notification, as well as training and exercise.
	Lead Position	Assistant Commissioner of Water/Sewer Operations
	Supporting Agencies	CMRPC, Director of Emergency Management, Director of Engineering
	Cost	Medium
	Potential Funding Sources	FEMA Hazard Mitigation Grant Program, FEMA Building Resilient Infrastructure and Communities, Central Mass Regional Planning Commission Flood Mitigation Assistance, National Science Foundation Engineering for Natural Hazards Grant
	Hazards	Flooding from Dam Failure
	Implementation Schedule	2026-2028
11	**Conduct repairs for Pine Hill Reservoir Dam.**	
High	Action Description	The Department of Public Works is currently working out the scope of the investigation/design for repairs to Pine Hill Reservoir with a consultant. This work should take place within the next 1-2 years. Following the investigation and design, we plan to perform the repairs hopefully in the next 2-3 years.
	Lead Position	Assistant Commissioner of Water/Sewer Operations
	Supporting Agencies	Director of Engineering
	Cost	Very High

	Potential Funding Sources	Massachusetts Executive Office of Energy and Environmental Affairs (EEA): MA Dam and Seawall Repair or Removal Fund, Massachusetts Department of Environmental Protection (MassDEP): Massachusetts Clean Water Trust (CWT) – State Revolving Fund (SRF) Loans, Massachusetts Emergency Management Agency (MEMA): Hazard Mitigation Grants, Massachusetts Department of Conservation and Recreation (DCR): FEMA High Hazard Potential Dam (HHPD) Grant Program, U.S. Army Corps of Engineers (USACE): Dam Rehabilitation Assistance
	Hazards	Flooding from Dam Failure
	Implementation Schedule	2025-2030
12	**Conduct repairs for Quinsigamond Pond and Patch Pond Dams.**	
High	Action Description	The Department of Public Works is actively working with Tighe & Bond on design work for Quinsig Pond and Patch Pond Dams. Hopefully, this work would be finished in the next year, with the implementation to follow. These projects should be finished in the next 1-3 years
	Lead Position	Assistant Commissioner of Water/Sewer Operations
	Supporting Agencies	Director of Engineering
	Cost	Very High
	Potential Funding Sources	Massachusetts Executive Office of Energy and Environmental Affairs (EEA): MA Dam and Seawall Repair or Removal Fund, Massachusetts Department of Environmental Protection (MassDEP): Massachusetts Clean Water Trust (CWT) – State Revolving Fund (SRF) Loans, Massachusetts Emergency Management Agency (MEMA): Hazard Mitigation Grants, Massachusetts Department of Conservation and Recreation (DCR): FEMA High Hazard Potential Dam (HHPD) Grant Program, U.S. Army Corps of Engineers (USACE): Dam Rehabilitation Assistance
	Hazards	Flooding from Dam Failure
	Implementation Schedule	2025-2030
13	**Evaluate spillway capacities for Kettle Brook Reservoir Nos. 1, 2, and 3.**	
High	Action Description	Following the work at Pine Hill Reservoir, we plan to look at the spillway capacities of Kettle Brook Reservoir Nos. 1, 2, and 3 to address spillway design issues. These projects should take place in the next 3-5 years.
	Lead Position	Assistant Commissioner of Water/Sewer Operations

	Supporting Agencies	Director of Engineering
	Cost	Very High
	Potential Funding Sources	Massachusetts Executive Office of Energy and Environmental Affairs (EEA): MA Dam and Seawall Repair or Removal Fund, Massachusetts Department of Environmental Protection (MassDEP): Massachusetts Clean Water Trust (CWT) – State Revolving Fund (SRF) Loans, Massachusetts Emergency Management Agency (MEMA): Hazard Mitigation Grants, Massachusetts Department of Conservation and Recreation (DCR): FEMA High Hazard Potential Dam (HHPD) Grant Program, U.S. Army Corps of Engineers (USACE): Dam Rehabilitation Assistance
	Hazards	Flooding from Dam Failure
	Implementation Schedule	2025-2030
14	**Increase water use efficiency to mitigate drought risk.**	
High	Action Description	Increase water use efficiency through water conservation plans and drought management plans that meet state guidelines provided by EEA, establish water rate structures that promote conservation and efficiency, perform system wide water audits; address and minimize outdoor water use; invest in enhanced education and outreach to the public and water suppliers and in particular to EJ communities and under-resourced communities on water efficiency and water conservation. Additionally, test, validate, revise current drought management plans with workshops and tabletop exercises.
	Lead Position	Commissioner Public Works
	Supporting Agencies	Assistant Commissioner of Water/Sewer Operations, Chief Sustainability Officer
	Cost	Medium
	Potential Funding Sources	Department of Public Works Budget
	Hazards	Extreme Temperatures, Droughts
	Implementation Schedule	2026-2030
15	**Right size culverts throughout the City based on risk.**	
High	Action Description	Several culverts in the city would benefit from right-sizing. Inventory culverts and rank order them to prioritize improvements based on the potential risk.
	Lead Position	Assistant Commissioner of Water/Sewer Operations

	Supporting Agencies	Director of Engineering, Director of Sewer, Director of Water
	Cost	High
	Potential Funding Sources	FEMA Hazard Mitigation Grant Program (HMGP), FEMA Building Resilient Infrastructure and Communities (BRIC), Massachusetts Department of Environmental Protection (MA DEP) Culvert Replacement Grant, Environmental Protection Agency (EPA): Water Infrastructure Finance and Innovation Act (WIFIA) Loans, Central Mass Regional Planning Commission (CMRPC): Flood Mitigation Assistance, Central Mass Regional Planning Commission (CMRPC): EDA Public Works Program
	Hazards	Flooding from Precipitation, Severe Winter Storms, Other Severe Weather, Flooding from Dam Failure, Tornadoes, Hurricanes/Tropical Storms
	Implementation Schedule	2025-2030
16	**Improve stormwater management regulations.**	
	Action Description	Update ordinances and regulations (e.g., Wetlands Protection Ordinance, Zoning Ordinance, Subdivision Regulations, etc.) to establish clear stormwater requirements for all projects. Examples could include strengthening requirements for precipitation data and recharge volume, additional requirements for flood prone properties, encourage the use of LID / green infrastructure, and clarification of expectations for stormwater standards when applicable to the "maximum extent practicable". Investigate requiring preliminary plans to ensure LID is incorporated early on.
High	Lead Position	Assistant Chief Development Officer - Planning & Regulatory Services
	Supporting Agencies	Assistant Commissioner of Water/Sewer Operations, Chief Sustainability Officer
	Cost	Medium
	Potential Funding Sources	Planning & Regulatory Services Budget
	Hazards	Flooding from Precipitation, Other Severe Weather, Hurricanes/Tropical Storms
	Implementation Schedule	2026-2030
17	**Conduct Hydraulic & Hydrologic studies for flooding sources and develop current flood maps to replace FEMA's outdated maps.**	

Medium	Action Description	Conduct Hydraulic & Hydrologic studies for flooding sources with outdated FEMA information to develop accurate flood maps and base flood elevations and use these to revise inaccurate FEMA mapping through LOMR requests. Perform modeling to understand the interaction between drainage infrastructure and natural systems affects flooding.
	Lead Position	Assistant Chief Development Officer - Planning & Regulatory Services
	Supporting Agencies	Assistant Commissioner of Water/Sewer Operations, Chief Sustainability Officer, Director of Engineering, Chief Information Officer
	Cost	High
	Potential Funding Sources	Central Mass Regional Planning Commission (CMRPC): Flood Mitigation Assistance, FEMA Building Resilient Infrastructure and Communities (BRIC, National Science Foundation (NSF): Engineering for Natural Hazards Grant
	Hazards	Flooding from Precipitation, Flooding from Dam Failure or Overtopping, Hurricanes/Tropical Storms
	Implementation Schedule	2026-2030
18	**Update and maintain the Hazard Mitigation Plan.**	
Medium	Action Description	Continue to track HMP implementation, with annual reporting to FEMA. A Hazard Mitigation Working Group will be convened for quarterly meetings to review hazard mitigation progress across departments. Develop complete plan updates every 4 years for FEMA approval.
	Lead Position	Director of Emergency Management
	Supporting Agencies	All City Departments
	Cost	Low
	Potential Funding Sources	Division of Emergency Management Budget
	Hazards	Flooding from Precipitation, Severe Winter Storms, Extreme Temperatures, Other Severe Weather, Flooding from Dam Failure, Tornadoes, Wildfires/Brushfires, Hurricanes/Tropical Storms, Droughts, Invasive Species, Landslides, Earthquakes
	Implementation Schedule	2025-2030
19	**Develop a Floodplain Manager position in the City and use this position to expand floodplain education and outreach.**	

Medium	Action Description	Add a full time staff position in the Planning Division (e.g. "Floodplain Manager") to support the City's floodplain management activities, which include public outreach, permit application review, site inspections, mapping, CRS program implementation, etc.
	Lead Position	Assistant Chief Development Officer - Planning & Regulatory Services
	Supporting Agencies	CHRO, Director of Emergency Management
	Cost	Medium
	Potential Funding Sources	Planning & Regulatory Services Budget (tax levy)
	Hazards	Flooding from Precipitation, Other Severe Weather, Hurricanes/Tropical Storms
	Implementation Schedule	2025-2026
20	**Acquire Repetitive Loss Properties to mitigate risk.**	
Medium	Action Description	Investigate feasibility of implementing buyout programs for high-risk or Repetitive Loss residential structures.
	Lead Position	Assistant Chief Development Officer - Planning & Regulatory Services
	Supporting Agencies	CMRPC
	Cost	High
	Potential Funding Sources	FEMA: Hazard Mitigation Grant Program (HMGP), FEMA Flood Mitigation Assistance (FMA) Program
	Hazards	Flooding from Precipitation, Other Severe Weather, Hurricanes/Tropical Storms
	Implementation Schedule	2026-2030
21	**Increase the knowledge and use of mitigation/resilience best practices by City staff.**	
Medium	Action Description	Encourage use of low cost training opportunities and harness existing resources (from FEMA, MEMA, EEA, etc.) including webinars, conferences, and other professional development opportunities.
	Lead Position	Chief Sustainability Officer
	Supporting Agencies	Director of Emergency Management, Assistant Chief Development Officer - Planning & Regulatory Services
	Cost	Low
	Potential Funding Sources	Department of Sustainability and Resilience Budget, FEMA Hazard Mitigation Grant Program
	Hazards	Flooding from Precipitation, Severe Winter Storms, Extreme Temperatures, Other Severe Weather, Flooding from Dam Failure,

		Tornadoes, Wildfires/Brushfires, Hurricanes/Tropical Storms, Droughts, Invasive Species, Landslides, Earthquakes
	Implementation Schedule	2025-2028
22	**Collaborate with existing fire education efforts to promote forest health and wildfire education to be delivered in schools and public events.**	
Medium	Action Description	Collaborate with existing fire education efforts to promote forest health and wildfire education to be delivered in schools and public events
	Lead Position	Worcester Fire Chief
	Supporting Agencies	Chief Sustainability Officer, Director of Emergency Management, Director of Cable Services, Director of Accessibility
	Cost	Low
	Potential Funding Sources	Worcester Fire Department Budget, Department of Sustainability and Resilience Budget
	Hazards	Extreme Temperatures, Other Severe Weather, Wildfires/Brushfires, Droughts
	Implementation Schedule	2025-2030
23	**Update the City's Threat and Hazard Identification and Risk Assessment (THIRA).**	
Medium	Action Description	Create an updated THIRA for the City to further inform planning and mitigation efforts.
	Lead Position	Director of Emergency Management
	Supporting Agencies	CMRPC, Health and Human Services Commissioner
	Cost	Medium
	Potential Funding Sources	Division of Emergency Management Budget
	Hazards	Flooding from Precipitation, Severe Winter Storms, Extreme Temperatures, Other Severe Weather, Flooding from Dam Failure, Tornadoes, Wildfires/Brushfires, Hurricanes/Tropical Storms, Droughts, Invasive Species, Landslides, Earthquakes
	Implementation Schedule	2026-2030
24	**Formalize a process for interdepartmental review of all City construction/infrastructure projects.**	
Medium	Action Description	Develop a formal process for all municipal construction/infrastructure projects to be undergo an interdepartmental review (similar to IRT meetings for private development) to solicit feedback and input into

		project design at an early, conceptual stage to evaluate what hazards a project may be able to address and how. Projects would again return for a secondary review as they reach completion. This process would ensure the city takes every advantage of potential design solutions to address hazards in every project and help further improve communication about potential project synergies, ensuring city projects are addressing as many hazards as possible through coordinated design.
	Lead Position	City Manager
	Supporting Agencies	Commissioner of Public Works, Commissioner of Transportation, Commissioner of Inspectional Services, Chief Development Officer, Chief of Public Facilities
	Cost	Low
	Potential Funding Sources	Executive Office of Economic Development Budget
	Hazards	Flooding from Precipitation, Extreme Temperatures
	Implementation Schedule	2025-2030
25	**Further develop and conduct public education and outreach programs for residents and property owners in the City regarding hazards.**	
Medium	Action Description	The City has prioritized resident outreach and education. Activities to date have included an MVP funded Resiliency Day. Create awareness of connection of storm drains to natural resource areas. Storm drain stenciling projects, signage of how to report illegal dumping near storm drains (especially in CSO areas). Formalize an Adopt-a-Drain program (similar to the City's the Adopt-A-Hydrant program) to reduce local street flooding during storms by enlisting community members to clear debris, leaves, or snow from the tops of catch basins. Combine the program with increased public education for residents.
	Lead Position	Chief Sustainability Officer
	Supporting Agencies	Director of Emergency Management, Assistant Chief Development Officer - Planning & Regulatory Services, GIS Manager, Director of Accessibility
	Cost	Medium
	Potential Funding Sources	Department of Sustainability and Resilience Budget, FEMA Hazard Mitigation Grant Program
	Hazards	Flooding from Precipitation, Severe Winter Storms, Extreme Temperatures, Other Severe Weather, Flooding from Dam Failure,

		Tornadoes, Wildfires/Brushfires, Hurricanes/Tropical Storms, Droughts, Invasive Species, Landslides, Earthquakes
	Implementation Schedule	2025-2030
26	**Safeguard Radio Infrastructure against high winds.**	
Medium	Action Description	Assess the radio infrastructure at Coppage Dr and Skyline Dr to determine if current equipment is properly rated for high-wind events. Replace infrastructure that does not meet current ratings to protect against future storms
	Lead Position	Emergency Communications Commissioner
	Supporting Agencies	Department of Public Facilities Capital Projects Manager
	Cost	Medium
	Potential Funding Sources	Massachusetts Technology Collaborative (Mass Tech): Public Safety Communication Grants, Central Region Homeland Security Advisory Council (CRHSAC), FEMA Hazard Mitigation Grant Program (HMGP), FEMA Building Resilient Infrastructure and Communities (BRIC), National Telecommunications and Information Administration (NTIA): Public Safety Communications Grants
	Hazards	Severe Winter Storms, Tornadoes, Hurricanes/Tropical Storms
	Implementation Schedule	2026-2030
27	**Implement mitigation strategies to mitigate risk to City Fire Department Facilities located in or near flood zones or at risk to rockfalls.**	
Medium	Action Description	The Webster Square, Mkeon Road, and Grove Street Headquarters stations are located in or adjacent to flood zones and regulatory floodways. Study their vulnerabilities and implement strategies to mitigate the risk and ensure continuity of operations. Additionally investigate and develop a rockfall protection system for Mckeon Road Station.
	Lead Position	Worcester Fire Chief
	Supporting Agencies	Department of Public Facilities Capital Projects Manager
	Cost	Medium
	Potential Funding Sources	FEMA Hazard Mitigation Grant Program (HMGP), FEMA Building Resilient Infrastructure and Communities (BRIC), Central Mass Regional Planning Commission (CMRPC) support

	Hazards	Flooding from Precipitation, Flooding from Dam Failure or Overtopping, Landslides, Earthquakes
	Implementation Schedule	2026-2029
28	**Increase protections for preserving, restoring, and enhancing Worcester's tree canopy through more effective provisions for planting and replanting requirements (new/replacement shade trees) in local regulations.**	
Medium	Action Description	Worcester suffers from the Urban Heat Island Effect. Prioritize Urban Forestry MP, and Green Worcester recommendations for green projects. Install shade architecture and misting systems in areas where natural solutions are not possible. Improve bus stops along evacuation routes with more shade. More tree planting along private properties and rights-of-way should also be encouraged/required as appropriate.
	Lead Position	Chief Sustainability Officer
	Supporting Agencies	Assistant Chief Development Officer - Planning & Regulatory Services
	Cost	Medium
	Potential Funding Sources	U.S. Department of Transportation (USDOT) Promoting Resilient Operations for Transformative, Efficient, and Cost-saving Transportation Program, FEMA Building Resilient Infrastructure and Communities (BRIC), Central Mass Regional Planning Commission (CMRPC) support
	Hazards	Extreme Temperatures
	Implementation Schedule	2026-2029
29	**Participate in the Municipal Vulnerability Preparedness Program and submit grant applications as appropriate.**	
Medium	Action Description	Participate in MVP 2.0 and continue developing eligible mitigation/adaptation projects for funding through the MVP Action Grant program on an annual basis.
	Lead Position	Assistant Chief Development Officer - Planning & Regulatory Services
	Supporting Agencies	Chief Sustainability Officer
	Cost	Low
	Potential Funding Sources	Massachusetts Executive Office of Energy and Environmental Affairs (EEA) Municipal Vulnerability Preparedness (MVP) Program
	Hazards	Flooding from Precipitation, Other Severe Weather, Hurricanes/Tropical Storms

Medium	Implementation Schedule	2025-2030
30	**Resolve Weasel Brook flooding issues.**	
Medium	Action Description	Repair the culverts along Weasel Brook to mitigate the flood risk.
	Lead Position	Assistant Commissioner of Water/Sewer Operations
	Supporting Agencies	Director of Engineering
	Cost	High
	Potential Funding Sources	Massachusetts Division of Ecological Restoration (DER): Culvert Replacement Municipal Assistance Grant Program, U.S. Department of Transportation's Federal Highway Administration: National Culvert Removal, Replacement, and Restoration Grant Program
	Hazards	Flooding from Precipitation, Other Severe Weather, Hurricanes/Tropical Storms
	Implementation Schedule	2025-2028
31	**Green Island flood mitigation.**	
Medium	Action Description	The 2016 Green Island Flood Study and the 2004 CSO Long Term Control Plan are undergoing updates. Implement those findings when the studies are completed to mitigate flood risk.
	Lead Position	Director of Engineering
	Supporting Agencies	Assistant Commissioner of Water/Sewer Operations
	Cost	Very High
	Potential Funding Sources	USDOT Promoting Resilient Operations for Transformative, Efficient, and Cost-saving Transportation Program, FEMA Hazard Mitigation Grant Program, Central Mass Regional Planning Commission (CMRPC) assistance accessing Economic Development Administration (EDA) Public Works Program, National Science Foundation Engineering for Natural Hazards Grant
	Hazards	Flooding from Precipitation, Other Severe Weather, Hurricanes/Tropical Storms
	Implementation Schedule	2025-2028
32	**Consider updates to Subdivision Regulations for resilient land use.**	
Medium	Action Description	Consider updates to Subdivision Regulations to encourage LID use, design standards, and cluster developments to protect open space, reduce imperviousness, and increase buffers to wet areas. Potentially

		require preliminary plans to ensure LID is incorporated early on and can be adjusted based on PB recommendations. Cluster Development changes: Increase required minimum amount of OS protected. Connect to city's OS plan. Change from cluster to OSRD to include 4-step design process.
	Lead Position	Assistant Chief Development Officer - Planning & Regulatory Services
	Supporting Agencies	Chief Sustainability Officer
	Cost	Medium
	Potential Funding Sources	Planning & Regulatory Services Budget
	Hazards	Flooding from Precipitation, Severe Winter Storms, Extreme Temperatures, Other Severe Weather, Flooding from Dam Failure, Tornadoes, Wildfires/Brushfires, Hurricanes/Tropical Storms, Droughts, Invasive Species, Landslides, Earthquakes
	Implementation Schedule	2026-2030
33	**Develop an inventory and maintenance plan for detention/infiltration basins.**	
Low	Action Description	The city has inherited maintenance responsibility for drainage infrastructure associated with new public streets from subdivisions, which are now in need of maintenance, but little as-built information exists in municipal records and no resources exist to monitor or maintain this infrastructure which could help reduce flooding or create opportunities to allow more detention and infiltration
	Lead Position	Assistant Commissioner of Water/Sewer Operations
	Supporting Agencies	Assistant Chief Development Officer
	Cost	High
	Potential Funding Sources	Department of Environmental Protection (DEP): Sewer Overflow and Stormwater Reuse Municipal Grant (OSG), DEP: Section 319 Nonpoint Source Competitive Grants
	Hazards	Flooding from precipitation
	Implementation Schedule	2027-2028
34	**Benefit-cost analysis review for hazard mitigation projects.**	
Low	Action Description	Collect and validate data across City departments to support accurate benefit-cost analysis (BCA) for hazard mitigation projects. This process will ensure that mitigation measures are prioritized based on comprehensive, reliable data, demonstrating cost-effectiveness and

		long-term community benefits. By fostering interdepartmental collaboration, the City can identify and address infrastructure vulnerabilities, improve project outcomes, and enhance resilience against future hazards. Use the FEMA Benefit Cost Analysis tool.
	Lead Position	Assistant Chief Development Officer - Planning & Regulatory Services
	Supporting Agencies	Director of Engineering, Assistant Commissioner of Water/Sewer Operations , Department of Public Facilities Capital Projects Manager, Chief Sustainability Officer
	Cost	Low
	Potential Funding Sources	Planning and Regulatory Services Budget
	Hazards	Flooding from Precipitation, Severe Winter Storms, Extreme Temperatures, Other Severe Weather, Flooding from Dam Failure, Tornadoes, Wildfires/Brushfires, Hurricanes/Tropical Storms, Droughts, Invasive Species, Landslides, Earthquakes
	Implementation Schedule	2025-2027
35	**Participate in Regional Debris Management Planning**	
Low	Action Description	Participate in CMRPC efforts to conduct Regional Debris Management Planning. Deploy the Debris Management Solution through ArcGIS. Modify existing Debris Management plans to align with regional plan. Worcester Emergency Management will host workshops, trainings, and exercises with DPW and GIS to develop debris management capability within the city.
	Lead Position	Director of Emergency Management
	Supporting Agencies	CMRPC, GIS Manager, Department of Public Works Commissioner, MassDOT
	Cost	Low
	Potential Funding Sources	Massachusetts Emergency Management Agency (MEMA): Disaster Debris Management Grants, Municipal Vulnerability Preparedness (MVP) Program, FEMA Building Resilient Infrastructure and Communities (BRIC) Grant
	Hazards	Other Severe Weather, Tornadoes, Hurricanes/Tropical Storms, Landslides, Earthquakes
	Implementation Schedule	2026-2028
36	**Integrate resilient design principles and practices into City projects.**	
Low	Action Description	Incorporate hazard mitigation and climate resilience into planning and land use projects managed by the City.

	Lead Position	Department of Public Facilities Capital Projects Manager
	Supporting Agencies	Chief Sustainability Officer
	Cost	Medium
	Potential Funding Sources	Planning and Regulatory Services Budget
	Hazards	Flooding from Precipitation, Severe Winter Storms, Extreme Temperatures, Other Severe Weather, Flooding from Dam Failure, Tornadoes, Wildfires/Brushfires, Hurricanes/Tropical Storms, Droughts, Invasive Species, Landslides, Earthquakes
	Implementation Schedule	2025-2028
37	**Pump station assessments and upgrades.**	
Low	Action Description	Replace the historic slate roof at City Hall to prevent further damage from precipitation. Ensuring the roof's resilience improves the facility's structure and preserves continuity of operations and Government benefits. The schematic design is complete.
	Lead Position	Assistant Commissioner of Water/Sewer Operations
	Supporting Agencies	Director of Engineering
	Cost	High
	Potential Funding Sources	Central Mass Regional Planning Commission (CMRPC) assistance accessing Economic Development Administration (EDA) Public Works Program, Department of Public Works Budget
	Hazards	Flooding from Precipitation, Severe Winter Storms, Other Severe Weather, Tornadoes, Hurricanes/Tropical Storms
	Implementation Schedule	2026-2028
38	**Create a new "Natural Hazard Mitigation" portion of the City's website by posting this plan on the web and expanding information regarding natural hazards.**	
Low	Action Description	Develop the City's website to include education material from multiple departments regarding hazards and hazard mitigation. This portion of the website should include imagery and graphics, as well as ArcGIS Story maps. Connecting hazards to real world expected impacts, and personal impacts is a good way to communicate risk. Include cross-references/links to similar pages (e.g. stormwater/flooding on Department of Public Works &P page, all other hazards on EM page). Improve accessibility of existing and new information about protection from hazards (flooding, water conservation, etc.) on the City's website.

	Lead Position	Director of Emergency Management
	Supporting Agencies	Chief Information Officer, Chief Sustainability Officer Assistant Chief Development Officer
	Cost	Medium
	Potential Funding Sources	Division of Emergency Management Budget
	Hazards	Flooding from Precipitation, Severe Winter Storms, Extreme Temperatures, Other Severe Weather, Flooding from Dam Failure, Tornadoes, Wildfires/Brushfires, Hurricanes/Tropical Storms, Droughts, Invasive Species, Landslides, Earthquakes
	Implementation Schedule	2025-2030
39	**Improve Worcester Fire Department ability to withstand extreme weather.**	
Low	Action Description	Evaluate all WFD stations for their capability to withstand and continue operations during extreme weather. Purchase new, or improve current generators, mitigate flood risk, and ensure facilities are safe for firefighters.
	Lead Position	Worcester Fire Chief
	Supporting Agencies	Chief of Public Facilities, Director of Emergency Management
	Cost	High
	Potential Funding Sources	Municipal Vulnerability Preparedness (MVP) Program, FEMA Building Resilient Infrastructure and Communities (BRIC) Grant
	Hazards	Flooding from Precipitation, Landslides, Earthquakes
	Implementation Schedule	2026-2030
40	**Leverage the City's Community Preservation Act (CPA) funding where possible to advance flood mitigation and watershed management in addition to other CPA objectives.**	
Low	Action Description	Assess flood risk posed to housing and historic buildings that are preserved by the Community Preservation Act. Identify projects that would effectively mitigate flood risk to these areas. Acquire land in support of hazard mitigation by creating open spaces.
	Lead Position	Assistant Chief Development Officer - Planning & Regulatory Services
	Supporting Agencies	Worcester's Community Preservation Committee, Chief Financial Officer, Assistant Chief Development Officer - Planning & Regulatory Services
	Cost	Low

	Potential Funding Sources	Community Development Department Budget
	Hazards	Flooding from Precipitation, Other Severe Weather, Hurricanes/Tropical Storms
	Implementation Schedule	2026-2030
41	**Build capacity within the Planning Division.**	
Low	Action Description	Expand the capacity of the Planning Division. New resources would support the expansion of staff resource to improve community education/awareness capacities; programs related to floodplain management; the ability to conduct restoration projects on existing conservation land to address invasives, erosion, and flooding; the ability to modernize codes and regulations to support resilience to address heat islands, clearcutting, and improved improve stormwater management. This is an essential precursor to fulfilling many other strategies outlined in this plan.
	Lead Position	Chief Development Officer
	Supporting Agencies	City Manager, Chief Financial Officer, Human Resources Director, Chief Sustainability Officer
	Cost	Medium
	Potential Funding Sources	Executive Office of Economic Development Budget
	Hazards	Flooding from Precipitation, Extreme Temperatures, Droughts, Wildfires/Brushfires, Invasive Species, Landslides
	Implementation Schedule	2025-2026
42	**Inventory unreinforced masonry and brick buildings owned by the City which may be vulnerable to earthquakes.**	
Low	Action Description	Conduct a study which identifies ways that these buildings can meet the Massachusetts State Building Code seismic standards.
	Lead Position	Chief of Public Facilities
	Supporting Agencies	Director of Emergency Management
	Cost	Medium
	Potential Funding Sources	FEMA Building Resilient Infrastructure and Communities (BRIC), FEMA National Earthquake Hazards Reduction Program
	Hazards	Earthquakes
	Implementation Schedule	2028-2030

43	**Update Zoning Ordinance to require nature based solutions.**	
Low	Action Description	Explore options to update the City's Zoning Ordinance to reduce flood risks through nature based solutions, including but not limited to the following: (1) modernizing parking requirements in order to reduce impervious surfaces through means such as shared parking, mixed-use credits, lower parking minimums, parking maximums, and flexible parking requirements; (2) adopting additional limitations on imperviousness; (3) adopting development regulations that would require adding flood storage capacity/mitigation measures (e.g. rain gardens, drywells, etc.) in susceptible areas, such the Green Island and Beaverbrook areas of the City.
	Lead Position	Assistant Chief Development Officer - Planning & Regulatory Services
	Supporting Agencies	Chief Development Officer
	Cost	Medium
	Potential Funding Sources	Executive Office of Economic Development
	Hazards	Flooding from Precipitation, Severe Winter Storms, Extreme Temperatures, Other Severe Weather, Flooding from Dam Failure, Tornadoes, Wildfires/Brushfires, Hurricanes/Tropical Storms, Droughts, Invasive Species, Landslides
	Implementation Schedule	2026-2030

44	**Consider use of Zoning Ordinance (e.g. existing Floodplain Overlay District) to evaluate the extent of appropriate uses for new development located in the floodplain.**	
Low	Action Description	Anticipate review to coincide with adoption of new model bylaw when the next RiskMap updates are completed (expected in the 2025 calendar year).
	Lead Position	Assistant Chief Development Officer - Planning & Regulatory Services
	Supporting Agencies	Chief Development Officer
	Cost	Medium
	Potential Funding Sources	Executive Office of Economic Development
	Hazards	Flooding from Precipitation, Other Severe Weather, Hurricanes/Tropical Storms
	Implementation Schedule	2026-2030

45	**Create restoration requirements for redevelopment projects to provide additional water storage in floodplains.**	
Low	Action Description	Investigate opportunities to create restoration requirements for redevelopment projects in the floodplain/riverfront areas to provide additional storage capacity and riparian zones. Explore options through zoning, stormwater management, wetlands protection, or other regulations.
	Lead Position	Assistant Chief Development Officer - Planning & Regulatory Services
	Supporting Agencies	Worcester Conservation Commission, Department of Public Works
	Cost	Medium
	Potential Funding Sources	EPA Clean Water State Revolving Fund (CWSRF), FEMA Flood Mitigation Assistance (FMA) Program, USDA Natural Resources Conservation Service (NRCS) – Environmental Quality Incentives Program (EQIP), HUD Community Development Block Grants (CDBG) and CDBG-Disaster Recovery (CDBG-DR), Massachusetts Municipal Vulnerability Preparedness (MVP) Program
	Hazards	Flooding from Precipitation, Other Severe Weather, Hurricanes/Tropical Storms
	Implementation Schedule	2025-2027

46	**Integrate disaster mitigation into transportation projects by incorporating risk assessments and resilience measures into planning, design, and construction.**	
Low	Action Description	Prioritize investments in infrastructure that reduce vulnerability to hazards. Collaborate with transportation agencies, engineers, and emergency management to align mitigation strategies with long-term goals for sustainability and resilience.
	Lead Position	Commissioner of Transportation and Mobility
	Supporting Agencies	Assistant Chief Development Officer - Planning & Regulatory Services, Director of Emergency Management, WRTA General Manager, Director of Accessibility
	Cost	High
	Potential Funding Sources	U.S. Department of Transportation (USDOT): Promoting Resilient Operations for Transformative, Efficient, and Cost-saving Transportation Program, FEMA Building Resilient Infrastructure and Communities (BRIC)
	Hazards	Flooding from Precipitation, Severe Winter Storms, Extreme Temperatures, Other Severe Weather, Flooding from Dam Failure,

		Tornadoes, Wildfires/Brushfires, Hurricanes/Tropical Storms, Droughts, Invasive Species, Landslides, Earthquakes
	Implementation Schedule	2026-2027
47	**Investigate the feasibility of forming a Stormwater Utility.**	
Low	Action Description	Continuing exploring the establishment of a stormwater utility/enterprise fund as a dedicated, stable revenue source to support the City with stormwater management, flood mitigation, and green infrastructure projects in addition to meeting its MS4 permit requirements. Funds generated through the new fund could also be used to match additional federal/state funding and the hiring of a full-time stormwater manager to run the program. The fee structure for rate payers could also include stormwater "credits" to incentivize community members to reduce stormwater generation on their properties in exchange for lowered costs.
	Lead Position	Commissioner Public Works
	Supporting Agencies	Worcester City Manager's Office, Worcester City Council, Assistant Chief Development Officer - Planning & Regulatory Services, Assistant Commissioner of Water/Sewer Operations
	Cost	Medium
	Potential Funding Sources	Massachusetts Municipal Vulnerability Preparedness (MVP) Program, Massachusetts Clean Water Trust (CWT): Asset Management Planning Grants, Massachusetts Department of Environmental Protection (MassDEP):604(b) Water Quality Grants, Massachusetts Department of Environmental Protection (MassDEP): MS4 Municipal Assistance Grants, FEMA Building Resilient Infrastructure and Communities (BRIC) Grant
	Hazards	Flooding from Precipitation, Other Severe Weather, Hurricanes/Tropical Storms
	Implementation Schedule	2025-2027
48	**Repair or replace City Hall's Roof.**	
Low	Action Description	Replace the historic slate roof at City Hall to prevent further damage from precipitation. Ensuring the roof's resilience improves the facility's structure and preserves continuity of operations and Government benefits. The schematic Design is complete.
	Lead Position	Chief of Public Facilities
	Supporting Agencies	City Manager's Office

	Cost	Very High
	Potential Funding Sources	Tax Appropriation or Community Preservation Act (CPA) Funds
	Hazards	Severe Winter Storms, Other Severe Weather, Tornadoes, Hurricanes/Tropical Storms
	Implementation Schedule	2025-2028
49	**Build capacity within Lakes and Pond Program.**	
Low	Action Description	Expand the capacity of the Lakes and Ponds Program and support the required coordination efforts to add purple loosestrife and hydrilla to the City's ongoing mapping, monitoring, and treatment of invasive species. Deploy the Invasive Species Management ArcGIS Solution for mapping, monitoring, and treatment efforts. Explore the Conservation Outreach ArcGIS solution for public outreach.
	Lead Position	Chief Sustainability Officer
	Supporting Agencies	Assistant Commissioner of Parks, Chief Information Officer, Director of Emergency Management, Director of Accessibility
	Cost	Medium
	Potential Funding Sources	Massachusetts Department of Environmental Protection (MassDEP): Invasive Species Program, Massachusetts Department of Fish and Game (MassWildlife): Aquatic Invasive Species Program, Massachusetts Environmental Trust (MET) Grants, Massachusetts Lakes and Ponds Program (MassDEP), U.S. Fish and Wildlife Service (USFWS): Aquatic Invasive Species Program, U.S. Army Corps of Engineers: Invasive Species Program
	Hazards	Extreme Temperatures, Invasive Species
	Implementation Schedule	2026-2028
50	**Develop an Invasive Species Response and Management Plan.**	
Low	Action Description	Develop an integrated Invasive Species Management and Emergency Response Plan for invasive pest and terrestrial species as well as aquatic invasives, including federally regulated species, that pose a significant risk to the city. Deploy the Invasive Species Management ArcGIS Solution for mapping, monitoring, and treatment efforts.
	Lead Position	Chief Sustainability Officer
	Supporting Agencies	Assistant Commissioner of Parks, Chief Information Officer, Director of Emergency Management
	Cost	Medium

	Potential Funding Sources	Massachusetts Department of Conservation and Recreation (DCR): Invasive Plant Grants, Massachusetts Division of Fisheries and Wildlife (MassWildlife): Habitat Management Grants, Massachusetts Environmental Trust (MET) Grants, Massachusetts Municipal Vulnerability Preparedness (MVP) Program, U.S. Fish and Wildlife Service (USFWS): Aquatic Invasive Species Grant Program, National Fish and Wildlife Foundation (NFWF): Pulling Together Initiative (PTI) Grant
	Hazards	Invasive Species
	Implementation Schedule	2026-2028

Table 102 shows the mitigation actions that specifically target vulnerable populations and Table 103 shows
the mitigation actions that specifically target buildings and infrastructure. Each table lists the actions in order of priority. The City owns several dams, and some need repair, removal or increased monitoring. Mitigation actions to address these dams are shown in Table 104.

Table 102. Actions that Target Vulnerable Populations.

Action #	Action Title
2	Replace Worcester's Police Headquarters generator to provide continuity of operations and protect emergency response activities.
4	Develop the Mass Care Annex to the CEMP to function as a sheltering plan.
5	Upgrade notification/warning systems with measures to reach socially vulnerable populations.
6	Expand current evacuation planning efforts and coordinate with additional organizations.
7	Conduct urban heat island mitigation by planting trees, opening cooling centers, and designing low heat areas.
8	Expand network of Climate Centers to meet the needs of residents who may require relief from extreme temperatures and power outages.
20	Acquire Repetitive Loss Properties to mitigate risk.
21	Increase the knowledge and use of mitigation/resilience best practices by City staff.
22	Collaborate with existing fire education efforts to promote forest health and wildfire education to be delivered in schools and public events.
25	Further develop and conduct public education and outreach programs for residents and property owners in the City regarding hazards.

Table 103. Actions that Target Buildings and Infrastructure.

Action #	Action Title
2	Replace Worcester's Police Headquarters generator to provide continuity of operations and protect emergency response activities.
3	Remove Poor Farm Pond.
5	Upgrade notification/warning systems with measures to reach socially vulnerable populations.
8	Expand network of Climate Centers to meet the needs of residents who may require relief from extreme temperatures and power outages.
11	Conduct repairs for Pine Hill Reservoir Dam.
12	Conduct repairs for Quinsigamond Pond and Patch Pond Dams.
13	Evaluate spillway capacities for Kettle Brook Reservoir Nos. 1, 2, and 3.
15	Right size culverts throughout the City based on risk.
20	Acquire Repetitive Loss Properties to mitigate risk.
24	Formalize a process for interdepartmental review of all City construction/infrastructure projects.
26	Safeguard Radio Infrastructure against high winds.
27	Implement mitigation strategies to mitigate risk to City Fire Department Facilities located in or near flood zones or at risk to rockfalls.
28	Increase protections for preserving, restoring, and enhancing Worcester’s tree canopy through more effective provisions for planting and replanting requirements (new/replacement shade trees) in local regulations.
30	Resolve Weasel Brook flooding issues.
33	Develop an inventory and maintenance plan for detention/infiltration basins.
37	Pump station assessments and upgrades.
39	Improve Worcester Fire Department ability to withstand extreme weather.
42	Inventory unreinforced masonry and brick buildings owned by the City which may be vulnerable to earthquakes.
48	Repair or replace City Hall's Roof.

Table 104. Actions that Target High Hazard Dam Mitigation.

Action #	Action Title
3	Remove Poor Farm Pond.
10	Expand inundation modeling for dam failure scenarios and planning.
11	Conduct repairs for Pine Hill Reservoir Dam.
12	Conduct repairs for Quinsigamond Pond and Patch Pond Dams.
13	Evaluate spillway capacities for Kettle Brook Reservoir Nos. 1, 2, and 3.
14	Increase water use efficiency to mitigate drought risk.

Action #	Action Title
17	Conduct Hydraulic & Hydrologic studies for flooding sources and develop current flood maps to replace FEMA's outdated maps.
30	Resolve Weasel Brook flooding issues.

Possible Funding Sources

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

Federal Emergency Management Agency (FEMA) Mitigation Grants

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

- **Building Resilient Infrastructure and Communities (BRIC)**
  BRIC is a new FEMA hazard mitigation program designed to replace the agency's former HMA Pre-Disaster Mitigation (PDM) grant program, aiming to categorically shift the federal focus away from reactive disaster spending and toward research-supported, proactive investment in community resilience. It is a result of recent amendments made to Section 203 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) by Section 1234 of the Disaster Recovery Reform Act of 2018 (DRRA). BRIC will support states, local communities, tribes, and territories as they undertake hazard mitigation projects reducing the risks they face from natural hazards. The BRIC program's guiding principles are supporting communities through capability- and capacity-building; encouraging and enabling innovation; promoting partnerships; enabling large projects; maintaining flexibility; and providing consistency.

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

are determined based on a percentage of the funds spent on FEMA's Public and Individual Assistance programs.

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

- **Rehabilitation of High Hazard Potential Dams**

  The President signed the Water Infrastructure Improvements for the Nation Act or the "WIIN Act," on Dec. 16, 2016, which adds a new grant program under FEMA's National Dam Safety Program (33 U.S.C. 467f). Section 5006 of the Act, Rehabilitation of High Hazard Potential Dams, provides technical, planning, design, and construction assistance in the form of grants for rehabilitation of eligible high hazard potential dams. This is an annual funding opportunity. Town governments as well as private dam owners are eligible for the program which is managed by the state.

Additional funding opportunities to support Dam Removal

- NOAA- Community Based Restoration Grant Program
- U.S. Fish and Wildlife Service – National Fish Passage Program
- U.S. Army Corps of Engineers – Section 206 Aquatic Ecosystem Restoration Program
- U.S. Forest Service – Support for Dam Removal

Municipal Vulnerability Preparedness Action Grants[72]
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.

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

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

Project types include:

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

accidents, outreach to improve emergency and contingency planning, and/or identifying existing contaminated sites that pose chemical dispersion risks during flood events.

- ***Nature-Based Storm-Damage Protection, Drought Mitigation, Water Quality, and Water Infiltration Techniques*** – Projects that utilize natural resources and pervious surfaces to manage coastal and inland flooding, erosion, and other storm damage, such as stormwater wetlands and bio-retention systems, and other Smart Growth and Low Impact Development techniques.

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

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

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

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

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

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

Chapter 7. Plan Integration and Maintenance

The City's Emergency Management Director is the primary point of contact for the Hazard Mitigation Plan's 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 City, 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 City understands the value of this plan and its positive mitigation impact and intends to continue updating this plan and implementing its strategies.

Continued Public Participation

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

Public participation is an integral component of the mitigation planning process and will continue to be essential as this plan is implemented and updated over time. Including the public in the plan's implementation and in plan updates by offering opportunities for public input and education creates a plan that represents the broadest range of community members.

The Emergency Management Director will assume the lead for public engagement. This position will be supported by the Office of Health and Medical Preparedness, Elder Affairs, Community Development & Resiliency Planning, and the Worcester Housing Authority. Other City departments will assist. The City of Worcester has successfully included the public in other planning endeavors such as the Green Worcester Plan, the Strategic Plan 2025-2029, and the Open Space and Recreation Plan, methods used for the development of these plans will be used to implement the mitigation plan.

This plan includes several public education actions that will actively engage the public toward increased preparedness and decreased hazard risks. Beyond implementing the mitigation actions, the City will offer workshops, survey the public when necessary, and expand online offerings through the City's website.

The Emergency Management Director intends to involve the public throughout the five-year implementation of this plan, as well as in the reviewing and updating processes. Public 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 City websites and through standard meeting laws.

- Posting news and announcements on social media pages.
- Conducting outreach to local community organizations and businesses.
- Hosting public presentations and meetings throughout the plan's process to acquire feedback and input from stakeholders.
- Post copies of the plan on the City's website and have hard copies available at the public library and in the Emergency Management Office.
- Continue to work with vulnerable populations, local organizations, private industry, regional agencies, and adjacent communities as this plan is implemented.

Method and Schedule for Keeping the Plan Current

D2. Is there a description of the method and schedule for keeping the plan current (monitoring, evaluating and updating the mitigation plan within a 5-year cycle)? (Requirement §201.6(c)(4)(i))

The HMPC and the City of Worcester recognize the importance of keeping the mitigation plan up to date. The HMPC will meet twice a year for the purposes of implementing and maintaining the Hazard Mitigation Plan. They will notify the public prior to meetings. This work includes monitoring, evaluating, and updating the plan over a five-year period. Overall, the responsibility for monitoring the Plan rests with the Emergency Management Director.

Process to Track Actions

__MONITORING__ means tracking the implementation of the plan over time.

The Emergency Management Director 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 City 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 City experiences a large-scale disaster, the Emergency Management Director will assemble an HMPC meeting to update the list of mitigation actions and review their order based on current priorities.

Process to Evaluate Effectiveness of the Plan

__EVALUATING__ means assessing the effectiveness of the plan at achieving its stated purpose and goals.

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

At the first meeting in July, the HMPC will review the effectiveness of the planning process, public and stakeholder engagement, risk analysis, and the mitigation strategy, including its implementation. It is recommended that the HMPC use the worksheet provided in Appendix C. Beyond considering the planning process, the HMPC will seek to answer the following questions to determine if the plan is effective at mitigating risk to City residents, the built environment, and the natural environment.

- Can the HMPC identify success stories of losses avoided because of hazard mitigation measures implemented? Can the HMPC identify political, social, and economic successes?
- Have the mitigation actions implemented achieved benefits beyond the cost of mitigation?
- Have the implemented mitigation actions saved lives or protected property?
- Does the list of mitigation actions coincide with the City's priorities? Do additional actions need to be added?

Process to Update the Plan

***UPDATING** means reviewing and revising the plan at least once every five years.*

At each semi-annual meeting, the HMPC will review the plan's goal statements and mitigation action status. If necessary, the goal statements and mitigation actions may be revised to reflect current City priorities. In addition, the HMPC will discuss methods for continuing to integrate the mitigation plan with other plans, processes, and projects in the City.

The National Dam Safety Program Act has authorized FEMA to provide High Hazard Potential Dams (HHPD) Rehabilitation Grant Program assistance for the rehabilitation of dams that do not meet minimum safety standards and pose substantial risk to life and property.[73] The City of Worcester is interested in accessing the HHPD grant funds and have designed this plan to meet criteria outlined in Element G: High Hazard Potential Dams. To continue meeting the requirements of Element G the HMPC will answer the following questions during plan update meetings:

- Do we have new or updated plans, studies, reports or technical information regarding the HHPDs?
- How does the risk assessment need to be updated to accurately reflect dam risk?
- Have the mitigation goals related to the HHPDs been implemented and do they need to be amended to reflect current conditions and priorities in the City?

[73] Local Mitigation Planning Policy Guide, FEMA, Effective April 19, 2023, p.32.

- Have the mitigation actions that addressed HHPDs been implemented and do new actions aimed at reducing vulnerabilities from HHPDs need to be added?

The figure below indicates the five-year schedule for updating this plan.

Year 1	Year 2	Year 3	Year 4	Year 5
•Seek grant funding for mitigation actions •Gather the HMPC in January and July	•Seek grant funding for mitigation actions •Gather the HMPC in January and July	•Seek FEMA BRIC funding for plan update •Seek grant funding for mitigation actions •Gather the HMPC in January and July	•Begin the plan update process •Seek grant funding for mitigation actions •Gather the HMPC in January and July	•Complete the plan update process - adopt the new plan •Seek grant funding for mitigation actions •Gather the HMPC in January and July

Figure 20. Plan Update and Implementation Schedule.

The National Dam Safety Program Act has authorized FEMA to provide High Hazard Potential Dams (HHPD) Rehabilitation Grant Program assistance for the rehabilitation of dams that do not meet minimum safety standards and pose substantial risk to life and property.[74] The City of Worcester is interested in accessing the HHPD grant funds and have designed this plan to meet criteria outlined in Element G: High Hazard Potential Dams. To continue meeting the requirements of Element G the HMPC will answer the following questions during plan update meetings:

- Do we have new or updated plans, studies, reports or technical information regarding the HHPDs?
- How does the risk assessment need to be updated to accurately reflect dam risk?
- Have the mitigation goals related to the HHPDs been implemented and do they need to be amended to reflect current conditions and priorities in the City?
- Have the mitigation actions that addressed HHPDs been implemented and do new actions aimed at reducing vulnerabilities from HHPDs need to be added?

[74] Local Mitigation Planning Policy Guide, FEMA, Effective April 19, 2023, p.32.

System to Integrate this Plan with Existing Planning Mechanisms

D3. Does the Plan describe a process by which local governments will integrate the requirements of the mitigation plan into other planning mechanisms, such as comprehensive or capital improvement plans, when appropriate? (Requirement §201.6(c)(4)(ii))

***INTEGRATE** means to include hazard mitigation principles, vulnerability information and mitigation actions into other existing community planning to leverage activities that have co-benefits, reduce risk and increase resilience.*

For the City of Worcester to succeed in reducing hazard risks over the long term, the information, ideas, conclusions, and strategic recommendations of this hazard mitigation plan should be integrated throughout government operations. Effective integration means to include mitigation principles, vulnerability information, and mitigation actions into other existing community planning mechanisms to leverage activities that have co-benefits, reduce risk, and increase resilience. Many other local plans and processes will present opportunities to address hazard mitigation in a way that can support multiple community objectives, so an important part of maintaining and implementing this hazard mitigation plan will be to identify and capitalize on these opportunities to leverage activities that have co-benefits (including but not limited to risk reduction). The City's successful integration of natural hazards mitigation and climate adaptation into its long-range citywide plan (Worcester Now | Next) demonstrates this type of integration by stressing the importance of resilience principles and strategies across various elements of this separate planning document.

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 Worcester. 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):

- Worcester Now | Next Plan (2024)
- Strategic Plan (FY2025-2029)
- Urban Forest Master Plan (2023)
- Open Space & Recreation Plan (2021)
- Green Worcester Plan (2020)
- Cultural Plan (2019)
- Municipal Vulnerability Preparedness Plan (2019)

***PLANNING MECHANISMS** refers to the governance structures used to manage local land use development and community decision-making, such as budgets, comprehensive plans, capital improvement plans, economic development strategies, climate action plans or other long-range plans.*

Additional opportunities to integrate the requirements of this plan into other local planning mechanisms shall continue to be identified through future meetings of the HMPC and through the five-year review process described in this chapter. Other planning mechanisms include local regulations and existing code enforcement procedures (i.e., zoning bylaws, site plan review, etc.), internal municipal policies, special projects or initiatives, and other routine government or community decision-making activities such as capital improvement planning and the City'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 City to be the most effective and appropriate method to identify, prioritize, and implement local hazard mitigation actions. In moving forward, however, the City will consider the incorporation of some other plan documents into the hazard mitigation plan, such as any future iterations of the City's MVP Plan, Green Worcester Plan, or related climate adaptation planning efforts.

Responsible Parties for Plan Implementation and Maintenance

Worcester, MA

Robert Connolly

Director of Emergency Management

City of Worcester

2 Coppage Drive, Worcester, MA 01603

Phone: 774-670-0583

Email: connollyr@worcesterma.gov

For State resources:

Massachusetts Emergency Management Agency:

Address: 400 Worcester Road, Framingham, MA 01702-5399

Phone: 508-820-2000 (MEMA Headquarters and Communications Center)

or 978-328-1500 (MEMA Region 1 Office)

Website: https://www.mass.gov/orgs/massachusetts-emergency-management-agency

For Federal resources:

Federal Emergency Management Agency:

Address: 220 Binney Street, Cambridge, MA 02142

Phone: 877-336-2734

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

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

Acronyms

Appendix A. Planning Process Supporting Materials

Hazard Mitigation Planning Committee Meetings

HMPC Meeting Participants

First Name	Last Name	Title	Affiliation	Phone	Email	Kick-Off Meeting 6/17/2024	HMPC #1 7/25/2024	HMPC #2 9/12/24	HMPC #3 11/14/2024	HMPC #4 12/20/2024	HMPC #5 02/27/2025
Jim	Bedard	Interim Chief of Public Facilities	City of Worcester	774-418-1502	bedardj@worcesterma.gov	☐	☐	☐	☑	☐	☐
Nayanny	Bello-Paniagua	Sponsor Contact	National Grid	508-860-6000	Nayanny.Bello-Paniagua@nationalgrid.com	☐	☐	☐	☐	☑	☑
Joseph	Campbell	Assistant General Manager	Worcester Regional Transit Authority	508.453.3415	jcampbell@therta.com	☐	☐	☐	☑	☐	☐
David	Carl	Senior Building Inspector	City of Worcester	508-799-8544	CarlD@worcesterma.gov	☐	☐	☐	☐	☐	☐
Deb	Cary	Community Advocacy and Engagement Manager	Mass Audobon	508-450-5590	dcary@massaudubon.org	☐	☐	☐	☐	☐	☑
Robert	Connolly	Director of Emergency Management	City of Worcester	774-670-0583	connollyr@worcesterma.gov	☑	☑	☑	☑	☑	☑
Stefanie	Covino	Executive Director	Blackstone Watershed Collaborative	443-863-0930	stefanie@blackstonecollaborative.org	☐	☑	☐	☐	☐	☐
Michael	Daigneault	Director of Water Operations	City of Worcester	508-929-1300 ext. 49333	daigneaultm@worcesterma.gov	☐	☐	☐	☑	☐	☐
Jessica	Davis	Project Manager, Department of Sustainability and Resilience	City of Worcester	508-799-8324 x31204	davisj@worcesterma.gov	☐	☑	☑	☐	☑	☐
Alisa	DeLeo Laperle	Director of Emergency Communications	City of Worcester	508-799-1719 ext. 30727	deleo-laperlea@worcesterma.gov	☐	☐	☐	☐	☐	☐
Sean	Divoll	Assistant Commisioner of Water/Sewer	City of Worcester	508-929-1300	divolls@worcesterma.gov	☐	☑	☐	☐	☐	☐
Matthew	Dufresne	Engineer, Dams	City of Worcester	508-829-4811 ext. 51206	dufresnem@worcesterma.gov	☐	☑	☑	☑	☑	☑
Alissa	Errede	Chief, Office of Health and Medical Preparedness	City of Worcester	508-799-8482 ext. 33158	ErredeA@worcesterma.gov	☐	☐	☑	☐	☐	☑
Eric	Flint	Conservation Planner/Agent	City of Worcester	508-688-0569	FlintE@worcesterma.gov	☑	☑	☑	☑	☑	☑
Scott	Galbraith	Senior Traffic Engineer	City of Worcester	774-670-0266	GalbraithSW@worcesterma.gov					☑	☐
Charles	Goodwin	Commissioner of Emergency Communications, Emergency Management, and Constituent Services	City of Worcester	508-612-1938	goodwinc@worcesterma.gov	☐	☑	☐	☐	☐	☐
Marc	Granato	Emergency Preparedness Planner	Central Massachusetts Regional Planning Commission	508-459-3374	mgranato@cmrpc.org	☑	☑	☑	☑	☑	☐
Alycia	Grant	Emergency Preparedness Coordinator	City of Worcester	508-799-1840	granta@worcesterma.gov	☐	☑	☑	☑	☑	☑
Ryan	Hacker	Assistant Director of Facilities	Worcester Public Schools	774-418-1780	hackerr@worcesterschools.net	☐	☑	☐	☐	☐	☐
Patricia	Hainsworth	Client Advocate Elder Affairs	Worcester Senior Center	508-799-1232 ext. 48012	hainsworthp@worcesterma.gov					☑	☐
Dave	Harris	Director of Sewer Operations	City of Worcester	508-799-1480 ext. 49001	harrisd@worcesterma.gov	☐	☑	☐	☐	☐	☐
David	Horne	Interim Commissioner of Inspectional Services, Building Commissioner	City of Worcester	508-799-1214 ext. 33018	horned@worcesterma.gov	☐	☐	☐	☐	☐	☐
Andrew	Loew	Director, Community Development & Resiliency Planning	Central Massachusetts Regional Planning Commission	508-459-3339	aloew@cmrpc.org	☑	☐	☐	☐	☐	☐
Scott	Loh	Manager, Emergency Management, Construction, and General Safety	UMass Chan Medical School	6087758400	scott.loh@umassmed.edu	☐	☑	☑	☐	☐	☑
Paula	Lomas	Water Filtration Plant Manager	City of Worcester	508-799-1513 ext. 51108	lomasp@worcesterma.gov	☐	☑	☑	☑	☐	☑
Dylan	Ludy	Department of Public Works - Assistant Director of Sewer Operations	City of Worcester	508-929-1300 rxt. 49011	ludyd@worcesterma.gov	☐	☐	☐	☐	☐	☑
Richard	Mallea	Building Inspector	City of Worcester	508-799-1198 ext. 33003	maileart@worcesterma.gov					☑	☐
Edward	McGinn	Deputy Chief of Worcester Police Department	City of Worcester	508-799-8600 ext. 10090	mcginne@worcesterma.gov	☐	☑	☑	☑	☐	☑
Stephen	McGurn	SARA Officer	Worcester Fire Department	774-248-2697	mcgurns@worcesterma.gov					☐	☐
Matt	Morse	Director of School Safety	Worcester Public Schools	774-242-3366	morsem@worcesterschools.net	☐	☐	☐	☐	☐	☐
Sarah	Mount	Energy Analyst	City of Worcester	508-799-8324 ext. 31205	mounts@worcesterma.gov	☐	☐	☐	☑	☐	☐
Colin	Novick	Executive Director	The Greater Worcester Land Trust	508-795-3838	colin@gwlt.org					☑	☐
John	Odell	Chief Sustainability Officer	City of Worcester	508-799-8325	odellj@worcesterma.gov	☐	☐	☑	☐	☑	☐
Brian	Pigeon	Senior Transportation Planner	City of Worcester	508-929-1300	PigeonB@worcesterma.gov	☐	☐	☐	☐	☐	☐
Jarrid	Pike	Emergency Management Director	UMASS Memorial Medical Center	774-437-3447	jarrid.pike@umassmemorial.org	☐	☐	☐	☐	☐	☐
Peter	Proulx	Worcester Housing Authority	Worcester Housing Authority	508-635-3000	Proulx@worcesterha.org	☐	☑	☑	☑	☐	☑
Joshua	Rickman	Administrator	Worcester Regional Transit Authority	508-688-9076	JRickman@TheRTA.com	☐	☐	☐	☐	☐	☐
Maureen	Schwab	Green Island Neighborhood Center	Green Island Neighborhood	508-890-2737	maureen_schwab@yahoo.com	☐	☑	☑	☑	☐	☑
Michelle	Smith	Assistant Chief Development Officer - Planning & Regulatory Services	City of Worcester	508-799-1400 ext. 31436	smithm@worcesterma.gov	☑	☑	☑	☑	☑	☑
Kerry	Tetreault	Director of Safety and Training	Worcester Regional Transit Authority	508-688-9076	ktetreault@therta.com	☐	☐	☑	☐	☐	☐
David	Trabucco	Director of Operations	Worcester Regional Transit Authority	508-688-9076	dtrabucco@therta.com	☐	☐	☑	☑	☑	☑
Matthew	Urban	Capital Projects Manager	City of Worcester	774-242-0287 ext. 29536	UrbanM@worcesterma.gov	☐	☑	☑	☑	☐	☑
Afriany	Ventura	Senior Transportation Planner	City of Worcester	508-929-1300 ext. 49031	ventura-padillaa@worcesterma.gov					☑	☐
Amy	Waters	Director, Worcester Senior Center	City of Worcester	508-799-1232 ext. 48013	watersa@worcesterma.gov	☐	☐	☐	☑	☐	☐
Luba	Zhaurova	Director of Projects, Sustainability and Resilience	City of Worcester	508-799-8324 ext. 31200	zhauroval@worcesterma.gov	☐	☐	☐	☐	☑	☐

HMPC Meeting Agendas

KICK OFF MEETING AGENDA

CITY OF WORCESTER, MA HAZARD MITIGATION PLAN UPDATE

DATE:	06/17/2024
TIME:	11:00-12:00PM
ZOOM:	https://us02web.zoom.us/j/85160707003?pwd=S1JhYkxyZ3o0U1JPL1R1U1YwaExhUT09 Meeting ID: 851 6070 7003 Passcode: 585628

AGENDA ITEMS

I. **Project Introduction**

II. **Timeline and Tasks**

III. **Developing a Hazard Mitigation Planning Committee (HMPC)**

IV. **Sharing GIS Data**

V. **Updating Mitigation Actions**

VI. **Scheduling a HMPC Meeting for October**

ACTION ITEMS

I. Develop the HMPC

II. Sharing GIS Data & Relevant Resources

III. Updating Mitigation Action Tracker with Action Status

IV. Scheduling a HMPC Meeting for July

HMPC MEETING #1 AGENDA

CITY OF WORCESTER, MA HAZARD MITIGATION PLAN UPDATE

DATE: THURSDAY, 07/25/2024

TIME: 10:00-11:30AM

ZOOM: https://us02web.zoom.us/j/83434366953?pwd=37CCWRpf7i0lasCw5LbSEOsabj1IZI.1
MEETING ID: 834 3436 6953
PASSCODE: 740651

AGENDA ITEMS

- I. **Introductions**
- II. **Project Introduction**
  - i. Project Timeline
  - ii. HMPC Responsibilities
- III. **Public and Stakeholder Engagement**
- IV. **Capability Assessment**
- V. **Hazard Identification**
- VI. **Goals and Mitigation Actions**
- VII. **Next Steps**

ACTION ITEMS

- I. Capability Assessment Surveys
- II. Update Critical Facility List
- III. Share GIS Data and Maps
- IV. Meet with Jamie for Mitigation Actions

HMPC MEETING #2 AGENDA

CITY OF WORCESTER, MA HAZARD MITIGATION PLAN UPDATE

DATE: THURSDAY, 09/12/2024

TIME: 10:00-11:30AM

ZOOM: https://us02web.zoom.us/j/85938614058?pwd=ofb0T2IHPcSoCXbX92L2teGdbkSsaP.1
MEETING ID: 859 3861 4058
PASSCODE: 743648

AGENDA ITEMS

I. **Public Meeting Outreach**
   i. Outreach Efforts
   ii. Website and Social Media
II. **Capability Assessment Update**
   i. Key Plans Reviewed
   ii. Where are Strengths and Challenges Discussion
III. **Risk Assessment**
   i. Hazards and Critical Facilities Identified
   ii. Hazus Impacts
   iii. Problems Identified Including High Hazard Areas
   iv. Mitigation Actions Discussion
IV. **Mitigation Strategy**
   i. Goal Statements
   ii. Developing Mitigation Actions
V. **City Priorities and Changes in Development**

ACTION ITEMS

I. **Pictures**
II. **Outreach for Public Meeting**
III. **Develop New Mitigation Actions**

HMPC MEETING #3 AGENDA

CITY OF WORCESTER, MA HAZARD MITIGATION PLAN UPDATE

DATE: 11/14/2024

TIME: 10:00-11:30AM

ZOOM: https://us02web.zoom.us/j/83817039350?pwd=yEn6mVaazjL2Ivr3EN3uzbjuaJbY6E.1
Meeting ID: 838 1703 9350
Passcode: 487800

AGENDA ITEMS

I. **Project Update**
II. **Risk Assessment**
  i. Risk Ranking
  ii. Problem Statements
III. **Capability Assessment Update**
  i. Opportunities Identified
IV. **Mitigation Strategy**
  i. Discuss New Mitigation Actions
V. **Plan Implementation**

ACTION ITEMS

I. HMPC #4 Date – December 2024
II. New Mitigation Actions

HMPC MEETING #4 AGENDA

CITY OF WORCESTER, MA HAZARD MITIGATION PLAN UPDATE

DATE: FRIDAY, 12/20/2024
TIME: 10:00-11:30AM
ZOOM: https://us02web.zoom.us/j/85135576385?pwd=jYLJYYoiqyuSsbA5S11MyXXaXs2GN2.1
MEETING ID: 851 3557 6385
PASSCODE: 287737

AGENDA ITEMS

I. **Project Update**
II. **Public Engagement**
   i. Survey
III. **Mitigation Actions**
   i. List Review Including Prioritization
IV. **Timeline for Completion**

ACTION ITEMS

I. Survey Outreach
II. Finalizing the Mitigation Actions

HMPC MEETING #5 AGENDA

CITY OF WORCESTER, MA HAZARD MITIGATION PLAN UPDATE

DATE: THURSDAY, 02/27/2025

TIME: 10:00-11:00AM

ZOOM: https://us02web.zoom.us/j/85690944307?pwd=EtZGIHb51ekGb536SMNQnQlaLj1gAA.1

MEETING ID: 856 9094 4307

PASSCODE: 949297

AGENDA ITEMS

I. **Project Update and Timeline**
II. **Final Hazard List Ranking**
III. **Mitigation Actions**
   i. Prioritization
   ii. Action Review
IV. **Plan Review**
V. **Schedule for Completion**
VI. **To Do List**

ACTION ITEMS

I. Pictures
II. Plan Review
III. Outreach for Public Review

HIGH HAZARD DAMS MEETING

CITY OF WORCESTER, MA HAZARD MITIGATION PLAN UPDATE

DATE:	12/17/2024
TIME:	12:30 PM – 1 PM
MS TEAMS:	https://teams.microsoft.com/l/meetup-join/19%3ameeting_ODBhZTRmMzktYjYwYS00MmYyLWE3OWEtOGFiNzcyZThmYWNl%40thread.v2/0?context=%7b%22Tid%22%3a%22f25998dd-1be6-42c6-a44c-8785f3e6deb6%22%2c%22Oid%22%3a%22f39cc804-9c48-4c4e-beb3-de1ba04da4b2%22%7d Meeting ID: 286 542 884 496 Passcode: 5NX34pv2

AGENDA ITEMS

1. **Mitigation Planning Introduction**
    a. Overview and background to mitigation planning.
    b. Addressing High Hazard Potential Dams in the HMP Update
2. **Emergency Action Plans and other Resources**
    a. Any additional resources to share?
3. **Dam Risk Summaries**
    a. Downstream risks
4. **Mitigation Strategy**
    a. Discuss Potential Mitigation Actions.
5. **Next Steps**

Public Outreach

Home | Announcements | Public Invited to Attend Hazard Mitigation Plan Meeting

CITY OF WORCESTER, MA

Eric D. Batista
City Manager

PUBLIC INVITED TO ATTEND HAZARD MITIGATION PLAN MEETING

FOR IMMEDIATE RELEASE: 10/23/2024 3:10 PM

WORCESTER, Mass. – The City of Worcester Emergency Communications & Management is soliciting public feedback and input as the department works to update its Hazard Mitigation Plan.

The Hazard Mitigation Plan details all the natural hazard risks that may impact the city and includes a list of potential actions to mitigate those risks.

The City of Worcester encourages all residents and business owners to attend the department's public meeting to share ideas and gather feedback regarding which hazards present the greatest risks, which areas of the city are most susceptible to damage, and steps to mitigate risks.

A Hazard Mitigation Plan, approved by the Federal Emergency Management Agency (FEMA) and adopted by the City, allows the municipality to apply for pre- and post-disaster hazard mitigation grant funds. The development of this plan includes public participation.

The meeting will be held in person at the Worcester Senior Center and via Zoom.

- Monday, Oct. 28, 2024 | 1 to 2 p.m.
- Worcester Senior Center, 128 Providence St.
- Zoom Information:
  - https://us02web.zoom.us/j/83448254390?pwd=q6QL8Wic8GL2rPaqDBlWsCPX7AAXVC.1
  - Passcode: 390840

PUBLIC MEETING #1 AGENDA

CITY OF WORCESTER, MA HAZARD MITIGATION PLAN UPDATE

DATE: MONDAY, OCTOBER 28, 2024

TIME: 1:00-2:00PM

IN-PERSON: Senior Center, 128 Providence Street, Worcester, MA 01604

ZOOM: https://us02web.zoom.us/j/83448254390?pwd=q6QL8Wic8GL2rPaqDBlWsCPX7AAXVC.1
Meeting ID: 834 4825 4390
Passcode: 390840

AGENDA ITEMS

1. **Introductions**
2. **What is Hazard Mitigation? What is a Hazard Mitigation Plan?**
3. **Identify Natural Hazards and High Hazard Areas**
4. **Identify Critical Facilities**
5. **Brainstorm Possible Mitigation Actions**
6. **Next Steps**

CITY OF WORCESTER, MA

PUBLIC MEETING

SHARE YOUR IDEAS FOR REDUCING RISK TO NATURAL HAZARDS AND CLIMATE CHANGE

Do you wonder if Worcester can flood, experience a tornado, or have an earthquake? What can prevent those natural hazards and climate change from wreaking havoc in our community?

Join the meeting to learn about this important project and to share your ideas for making Worcester more resilient to natural hazards and climate change.

Worcester has formed a Hazard Mitigation Planning Committee to identify risks and projects to mitigate those risks. The City is working with a consultant hired by the Massachusetts Emergency Management Agency to develop a Hazard Mitigation Plan Update that will be approved by the Federal Emergency Management Agency and adopted by the City. This plan allows Worcester to apply for pre- and post-disaster mitigation funds.

10/28/2024

1:00 pm – 2:00 pm

Via Zoom & Senior Center

HTTPS://WWW.WORCESTERMA.GOV/ FOR MEETING DETAILS OR CONTACT EMERGENCY MANAGEMENT DIRECTOR, ROBERT CONNOLLY AT 774-670-0583 OR CONNOLLYR@WORCESTERMA.GOV

PUBLIC MEETING #2 AGENDA

CITY OF WORCESTER, MA HAZARD MITIGATION PLAN UPDATE

DATE: **WEDNESDAY, JANUARY 29, 2025**

TIME: **6:00-7:00PM**

IN-PERSON: WRTA Community Room (42 Quinsigamond Avenue, Worcester, MA)

ZOOM: https://us02web.zoom.us/j/84735792748?pwd=Dbny4wbxuSsybcfKwY3Y2vdzawrCWH.1

Meeting ID: 847 3579 2748
Passcode: 720007

AGENDA ITEMS

I. **Introduction**
   i. Disaster Preparedness, Mitigation, Response, Recovery

II. **What is Hazard Mitigation?**
   i. Benefits of Hazard Mitigation Plan
   ii. How the Plan was Developed

III. **Ways to Prepare Your Home and Family**
   i. Learn and Plan
   ii. Check and Build
   iii. Practice and Help

IV. **Risk Assessment Process**
   i. Identified Hazards and Critical Facilities

V. **Hazard Mitigation Strategy**
   i. Mitigation Plan Goals
   ii. Review of Actions

VI. **Plan Review**
   i. What to Expect and How to Review

VII. **Timeline for Completion**

DISASTER PREPAREDNESS

PUBLIC MEETING

CITY OF WORCESTER

JANUARY 29, 2025

6:00 – 7:00 PM

In Person:

WRTA Community Room

On Zoom:

https://tinyurl.com/543ystzx

Meeting ID: 847 3579 2748

Passcode: 720007

Learn how to prepare for winter storms, and other natural disasters.

Hear about the City's plan to mitigate natural hazard risks.

For more information visit:
https://www.worcesterma.gov/

Or Contact:
Robert Connolly, Emergency Management Director
Phone: 774-670-0583
Email: ConnollyR@worcesterma.gov

FOOD WILL BE PROVIDED!

Do you know where to go if you lose power or how to shelter-in-place safely? Would you like a list of supplies to have on hand in a disaster?

Do you wonder if Worcester can flood, experience a tornado, or have an earthquake? What can prevent those natural hazards and climate change from wreaking havoc in our community?

Worcester has formed a Hazard Mitigation Planning Committee to identify risks and projects to mitigate those risks. The City is working with a consultant hired by the Massachusetts Emergency Management Agency to develop a Hazard Mitigation Plan Update that will be approved by the Federal Emergency Management Agency and adopted by the City. This plan allows Worcester to apply for pre- and post-disaster mitigation funds.

Join the Meeting to learn about this plan and to contribute your ideas for making Worcester safer!

Please Complete the Community Survey:
https://forms.office.com/g/kuP8vkLCTJ.

CITY OF WORCESTER

HAZARD MITIGATION PLAN COMMUNITY MEETING

WEDNESDAY, JANUARY 28TH, 2025

NAME	AGENCY (IF APPLICABLE) OR CONSTITUENT?
Maureen Schwab	Green Island resident group
Lee Bourget	Citizen
David Ferrini	Citizen
Eric Flint	City of Worcester - DPRS
Alycia Grant	City Of Worcester - WEM
Michelle Smith	City of Worcester - DPRS

Appendix B. Mitigation Actions.

Priority Ranking Points

Table 105. Priority Ranking Points for Each Action.

Action #	Action Title	Hazards Addressed	High Hazard Dams	Approximate Cost	Equity Focus	Protection of Lives	Protection of Critical Facilities or Infrastructure	Protection of Natural Resources	Alignment with Objectives	Total
1	Maintain and improve floodplain management practices to increase awareness, minimize flood damage and increase the City's Community Rating System score.	3	2	3	2	2	3	2	2	19
2	Replace Worcester's Police Headquarters generator to provide continuity of operations and protect emergency response activities.	3	2	1	3	3	3	0	2	17
3	Remove Poor Farm Pond.	2	3	0	2	3	3	2	2	17
4	Develop the Mass Care Annex to the CEMP to function as a sheltering plan.	3	2	3	3	3	0	0	2	16
5	Upgrade notification/warning systems with measures to	3	2	2	3	3	1	0	2	16

Action #	Action Title	Hazards Addressed	High Hazard Dams	Approximate Cost	Equity Focus	Protection of Lives	Protection of Critical Facilities or Infrastructure	Protection of Natural Resources	Alignment with Objectives	Total
	reach socially vulnerable populations.									
6	Expand current evacuation planning efforts and coordinate with additional organizations.	3	2	2	3	3	1	0	2	16
7	Conduct urban heat island mitigation by planting trees, opening cooling centers, and designing low heat areas.	3	0	2	3	3	3	0	2	16
8	Expand network of Climate Centers to meet the needs of residents who may require relief from extreme temperatures and power outages.	3	0	2	3	3	3	0	2	16
9	Develop and implement a system for monitoring high water levels throughout the City.	3	0	2	2	2	3	2	2	16
10	Expand inundation modeling for dam failure scenarios and planning.	2	3	2	0	3	3	0	2	15
11	Conduct repairs for Pine Hill Reservoir Dam.	2	3	0	2	3	3	0	2	15
12	Conduct repairs for Quinsigamond Pond and Patch Pond Dams.	2	3	0	2	3	3	0	2	15

Action #	Action Title	Hazards Addressed	High Hazard Dams	Approximate Cost	Equity Focus	Protection of Lives	Protection of Critical Facilities or Infrastructure	Protection of Natural Resources	Alignment with Objectives	Total
13	Evaluate spillway capacities for Kettle Brook Reservoir Nos. 1, 2, and 3.	2	3	0	2	3	3	0	2	15
14	Increase water use efficiency to mitigate drought risk.	3	3	2	2	1	0	2	2	15
15	Right size culverts throughout the City based on risk.	3	2	1	0	2	3	2	2	15
16	Improve stormwater management regulations.	3	0	2	2	1	3	2	2	15
17	Conduct Hydraulic & Hydrologic studies for flooding sources and develop current flood maps to replace FEMA's outdated maps.	3	3	1	0	2	3	0	2	14
18	Update and maintain the Hazard Mitigation Plan.	3	2	3	2	2	0	0	2	14
19	Develop a Floodplain Manager position in the City and use this position to expand floodplain education and outreach.	3	2	2	2	1	0	2	2	14
20	Acquire Repetitive Loss Properties to mitigate risk.	3	0	1	3	3	0	2	2	14
21	Increase the knowledge and use of	3	0	3	3	1	0	2	2	14

Action #	Action Title	Hazards Addressed	High Hazard Dams	Approximate Cost	Equity Focus	Protection of Lives	Protection of Critical Facilities or Infrastructure	Protection of Natural Resources	Alignment with Objectives	Total
	mitigation/resilience best practices by City staff.									
22	Collaborate with existing fire education efforts to promote forest health and wildfire education to be delivered in schools and public events.	3	0	3	3	1	0	2	2	14
23	Update the City's Threat and Hazard Identification and Risk Assessment (THIRA).	3	2	2	0	1	3	0	2	13
24	Formalize a process for interdepartmental review of all City construction/infrastructure projects.	3	2	3	0	0	3	0	2	13
25	Further develop and conduct public education and outreach programs for residents and property owners in the City regarding hazards.	3	0	2	3	3	0	0	2	13
26	Safeguard Radio Infrastructure against high winds.	3	0	2	0	3	3	0	2	13
27	Implement mitigation strategies to mitigate risk to City Fire Department	3	0	2	0	3	3	0	2	13

Action #	Action Title	Hazards Addressed	High Hazard Dams	Approximate Cost	Equity Focus	Protection of Lives	Protection of Critical Facilities or Infrastructure	Protection of Natural Resources	Alignment with Objectives	Total
	Facilities located in or near flood zones or at risk to rockfalls.									
28	Increase protections for preserving, restoring, and enhancing Worcester's tree canopy through more effective provisions for planting and replanting requirements (new/replacement shade trees) in local regulations.	3	0	2	2	2	0	2	2	13
29	Participate in the Municipal Vulnerability Preparedness Program and submit grant applications as appropriate.	3	0	3	2	1	0	2	2	13
30	Resolve Weasel Brook flooding issues.	3	3	1	0	1	0	2	2	12
31	Green Island flood mitigation.	3	0	0	2	3	0	2	2	12
32	Consider updates to Subdivision Regulations for resilient land use.	3	0	2	0	2	3	0	2	12
33	Develop an inventory and maintenance plan for detention/infiltration basins.	3	0	1	0	1	3	2	2	12

Action #	Action Title	Hazards Addressed	High Hazard Dams	Approximate Cost	Equity Focus	Protection of Lives	Protection of Critical Facilities or Infrastructure	Protection of Natural Resources	Alignment with Objectives	Total
34	Benefit-cost analysis review for hazard mitigation projects.	3	2	3	0	1	0	0	2	11
35	Participate in Regional Debris Management Planning	3	2	3	0	1	0	0	2	11
36	Integrate resilient design principles and practices into City projects.	3	0	2	0	2	0	2	2	11
37	Pump station assessments and upgrades.	3	0	1	0	2	3	0	2	11
38	Create a new “Natural Hazard Mitigation” portion of the City's website by posting this plan on the web and expanding information regarding natural hazards.	3	0	2	2	2	0	0	2	11
39	Improve Worcester Fire Department ability to withstand extreme weather.	3	0	1	0	2	3	0	2	11
40	Leverage the City’s Community Preservation Act (CPA) funding where possible to advance flood mitigation and watershed management in addition to other CPA objectives.	3	0	3	0	1	0	2	2	11

Action #	Action Title	Hazards Addressed	High Hazard Dams	Approximate Cost	Equity Focus	Protection of Lives	Protection of Critical Facilities or Infrastructure	Protection of Natural Resources	Alignment with Objectives	Total
41	Build capacity within the Planning Division.	3	0	0	0	1	3	2	2	11
42	Inventory unreinforced masonry and brick buildings owned by the City which may be vulnerable to earthquakes.	1	0	2	0	2	3	0	2	10
43	Update Zoning Ordinance to require nature based solutions.	3	0	2	0	1	0	2	2	10
44	Consider use of Zoning Ordinance (e.g. existing Floodplain Overlay District) to evaluate the extent of appropriate uses for new development located in the floodplain.	3	0	2	0	1	0	2	2	10
45	Create restoration requirements for redevelopment projects to provide additional water storage in floodplains.	3	0	2	0	1	0	2	2	10
46	Integrate disaster mitigation into transportation projects by incorporating risk assessments and resilience measures into planning, design, and construction.	3	0	1	0	1	3	0	2	10

Action #	Action Title	Hazards Addressed	High Hazard Dams	Approximate Cost	Equity Focus	Protection of Lives	Protection of Critical Facilities or Infrastructure	Protection of Natural Resources	Alignment with Objectives	Total
47	Investigate the feasibility of forming a Stormwater Utility.	3	0	2	0	0	3	0	2	10
48	Repair or replace City Hall's Roof.	3	0	0	0	1	3	0	2	9
49	Build capacity within Lakes and Pond Program.	3	0	2	0	0	0	2	2	9
50	Develop an Invasive Species Response and Management Plan.	2	0	2	0	0	0	2	2	8

Types of Mitigation Actions

Table 106. Mitigation Actions Sorted by Action Category.

Mitigation Category	Action #	Action Title
Local Plans and Regulations	4	Develop the Mass Care Annex to the CEMP to function as a sheltering plan.
	6	Expand current evacuation planning efforts and coordinate with additional organizations.
	9	Develop and implement a system for monitoring high water levels throughout the City.
	10	Expand inundation modeling for dam failure scenarios and planning.
	16	Improve stormwater management regulations.
	17	Conduct Hydraulic & Hydrologic studies for flooding sources and develop current flood maps to replace FEMA's outdated maps.
	18	Update and maintain the Hazard Mitigation Plan.
	19	Develop a Floodplain Manager position in the City and use this position to expand floodplain education and outreach.
	23	Update the City's Threat and Hazard Identification and Risk Assessment (THIRA).
	29	Participate in the Municipal Vulnerability Preparedness Program and submit grant applications as appropriate.
	31	Green Island flood mitigation.
	32	Consider updates to Subdivision Regulations for resilient land use.
	34	Benefit-cost analysis review for hazard mitigation projects.
	35	Participate in Regional Debris Management Planning
	36	Integrate resilient design principles and practices into City projects.
	41	Build capacity within the Planning Division.
	43	Update Zoning Ordinance to require nature based solutions.
	44	Consider use of Zoning Ordinance (e.g. existing Floodplain Overlay District) to evaluate the extent of appropriate uses for new development located in the floodplain.
	45	Create restoration requirements for redevelopment projects to provide additional water storage in floodplains.
	46	Integrate disaster mitigation into transportation projects by incorporating risk assessments and resilience measures into planning, design, and construction.
	47	Investigate the feasibility of forming a Stormwater Utility.
Structure and Infrastructure Projects	2	Replace Worcester's Police Headquarters generator to provide continuity of operations and protect emergency response activities.
	3	Remove Poor Farm Pond.
	5	Upgrade notification/warning systems with measures to reach socially vulnerable populations.

Mitigation Category	Action #	Action Title
	8	Expand network of Climate Centers to meet the needs of residents who may require relief from extreme temperatures and power outages.
	11	Conduct repairs for Pine Hill Reservoir Dam.
	12	Conduct repairs for Quinsigamond Pond and Patch Pond Dams.
	13	Evaluate spillway capacities for Kettle Brook Reservoir Nos. 1, 2, and 3.
	15	Right size culverts throughout the City based on risk.
	20	Acquire Repetitive Loss Properties to mitigate risk.
	24	Formalize a process for interdepartmental review of all City construction/infrastructure projects.
	26	Safeguard Radio Infrastructure against high winds.
	27	Implement mitigation strategies to mitigate risk to City Fire Department Facilities located in or near flood zones or at risk to rockfalls.
	28	Increase protections for preserving, restoring, and enhancing Worcester's tree canopy through more effective provisions for planting and replanting requirements (new/replacement shade trees) in local regulations.
	30	Resolve Weasel Brook flooding issues.
	33	Develop an inventory and maintenance plan for detention/infiltration basins.
	37	Pump station assessments and upgrades.
	39	Improve Worcester Fire Department ability to withstand extreme weather.
	42	Inventory unreinforced masonry and brick buildings owned by the City which may be vulnerable to earthquakes.
	48	Repair or replace City Hall's Roof.
Natural Systems Protection	7	Conduct urban heat island mitigation by planting trees, opening cooling centers, and designing low heat areas.
	14	Increase water use efficiency to mitigate drought risk.
	40	Leverage the City's Community Preservation Act (CPA) funding where possible to advance flood mitigation and watershed management in addition to other CPA objectives.
	49	Build capacity within Lakes and Pond Program.
	50	Develop an Invasive Species Response and Management Plan.
Education and Awareness Programs	1	Maintain and improve floodplain management practices to increase awareness, minimize flood damage and increase the City's Community Rating System score.
	21	Increase the knowledge and use of mitigation/resilience best practices by City staff.
	22	Collaborate with existing fire education efforts to promote forest health and wildfire education to be delivered in schools and public events.

Mitigation Category	Action #	Action Title
	25	Further develop and conduct public education and outreach programs for residents and property owners in the City regarding hazards.
	38	Create a new “Natural Hazard Mitigation” portion of the City's website by posting this plan on the web and expanding information regarding natural hazards.

Actions Sorted by Goal Statement

Table 107. Mitigation Actions Sorted by Goal Statement.

Goal	Action #	Action Title
Local Plans and Regulations	4	Develop the Mass Care Annex to the CEMP to function as a sheltering plan.
	6	Expand current evacuation planning efforts and coordinate with additional organizations.
	9	Develop and implement a system for monitoring high water levels throughout the City.
	10	Expand inundation modeling for dam failure scenarios and planning.
	16	Improve stormwater management regulations.
	17	Conduct Hydraulic & Hydrologic studies for flooding sources and develop current flood maps to replace FEMA's outdated maps.
	18	Update and maintain the Hazard Mitigation Plan.
	19	Develop a Floodplain Manager position in the City and use this position to expand floodplain education and outreach.
	23	Update the City's Threat and Hazard Identification and Risk Assessment (THIRA).
	29	Participate in the Municipal Vulnerability Preparedness Program and submit grant applications as appropriate.
	31	Green Island flood mitigation.
	32	Consider updates to Subdivision Regulations for resilient land use.
	34	Benefit-cost analysis review for hazard mitigation projects.
	35	Participate in Regional Debris Management Planning
	36	Integrate resilient design principles and practices into City projects.
	41	Build capacity within the Planning Division.
	43	Update Zoning Ordinance to require nature based solutions.
	44	Consider use of Zoning Ordinance (e.g. existing Floodplain Overlay District) to evaluate the extent of appropriate uses for new development located in the floodplain.

Goal	Action #	Action Title
	45	Create restoration requirements for redevelopment projects to provide additional water storage in floodplains.
	46	Integrate disaster mitigation into transportation projects by incorporating risk assessments and resilience measures into planning, design, and construction.
	47	Investigate the feasibility of forming a Stormwater Utility.
Buildings and Infrastructure Projects	2	Replace Worcester's Police Headquarters generator to provide continuity of operations and protect emergency response activities.
	5	Upgrade notification/warning systems with measures to reach socially vulnerable populations.
	8	Expand network of Climate Centers to meet the needs of residents who may require relief from extreme temperatures and power outages.
	15	Right size culverts throughout the City based on risk.
	20	Acquire Repetitive Loss Properties to mitigate risk.
	24	Formalize a process for interdepartmental review of all City construction/infrastructure projects.
	26	Safeguard Radio Infrastructure against high winds.
	27	Implement mitigation strategies to mitigate risk to City Fire Department Facilities located in or near flood zones or at risk to rockfalls.
	28	Increase protections for preserving, restoring, and enhancing Worcester's tree canopy through more effective provisions for planting and replanting requirements (new/replacement shade trees) in local regulations.
	30	Resolve Weasel Brook flooding issues.
	33	Develop an inventory and maintenance plan for detention/infiltration basins.
	37	Pump station assessments and upgrades.
	39	Improve Worcester Fire Department ability to withstand extreme weather.
	42	Inventory unreinforced masonry and brick buildings owned by the City which may be vulnerable to earthquakes.
	48	Repair or replace City Hall's Roof.

Goal	Action #	Action Title
Natural and Cultural Resources	7	Conduct urban heat island mitigation by planting trees, opening cooling centers, and designing low heat areas.
	14	Increase water use efficiency to mitigate drought risk.
	40	Leverage the City's Community Preservation Act (CPA) funding where possible to advance flood mitigation and watershed management in addition to other CPA objectives.
	49	Build capacity within Lakes and Pond Program.
	50	Develop an Invasive Species Response and Management Plan.
Outreach and Education	1	Maintain and improve floodplain management practices to increase awareness, minimize flood damage and increase the City's Community Rating System score.
	21	Increase the knowledge and use of mitigation/resilience best practices by City staff.
	22	Collaborate with existing fire education efforts to promote forest health and wildfire education to be delivered in schools and public events.
	25	Further develop and conduct public education and outreach programs for residents and property owners in the City regarding hazards.
	38	Create a new "Natural Hazard Mitigation" portion of the City's website by posting this plan on the web and expanding information regarding natural hazards.
High Hazard Dams	3	Remove Poor Farm Pond.
	11	Conduct repairs for Pine Hill Reservoir Dam.
	12	Conduct repairs for Quinsigamond Pond and Patch Pond Dams.
	13	Evaluate spillway capacities for Kettle Brook Reservoir Nos. 1, 2, and 3.

Actions Sorted by Lead Position

Table 108. Mitigation Actions Sorted by Lead Position.

Action Lead	Action #	Action Title
Assistant Chief Development Officer - Planning & Regulatory Services	**1**	Maintain and improve floodplain management practices to increase awareness, minimize flood damage and increase the City's Community Rating System score.
	17	Conduct Hydraulic & Hydrologic studies for flooding sources and develop current flood maps to replace FEMA's outdated maps.
	19	Develop a Floodplain Manager position in the City and use this position to expand floodplain education and outreach.
	20	Acquire Repetitive Loss Properties to mitigate risk.
	29	Participate in the Municipal Vulnerability Preparedness Program and submit grant applications as appropriate.
	32	Consider updates to Subdivision Regulations for resilient land use.
	34	Benefit-cost analysis review for hazard mitigation projects.
	40	Leverage the City's Community Preservation Act (CPA) funding where possible to advance flood mitigation and watershed management in addition to other CPA objectives.
	43	Update Zoning Ordinance to require nature based solutions.
	44	Consider use of Zoning Ordinance (e.g. existing Floodplain Overlay District) to evaluate the extent of appropriate uses for new development located in the floodplain.
Worcester Police Chief	**2**	Replace Worcester's Police Headquarters generator to provide continuity of operations and protect emergency response activities.
Assistant Commissioner of Water/Sewer Operations	**3**	Remove Poor Farm Pond.
	9	Develop and implement a system for monitoring high water levels throughout the City.
	10	Expand inundation modeling for dam failure scenarios and planning.
	15	Right size culverts throughout the City based on risk.
	30	Resolve Weasel Brook flooding issues.
Director of Emergency Management	**4**	Develop the Mass Care Annex to the CEMP to function as a sheltering plan.
	5	Upgrade notification/warning systems with measures to reach socially vulnerable populations.
	6	Expand current evacuation planning efforts and coordinate with additional organizations.

Action Lead	Action #	Action Title
	8	Expand network of Climate Centers to meet the needs of residents who may require relief from extreme temperatures and power outages.
	18	Update and maintain the Hazard Mitigation Plan.
	23	Update the City's Threat and Hazard Identification and Risk Assessment (THIRA).
	35	Participate in Regional Debris Management Planning
	38	Create a new “Natural Hazard Mitigation” portion of the City's website by posting this plan on the web and expanding information regarding natural hazards.
Chief Sustainability Officer	7	Conduct urban heat island mitigation by planting trees, opening cooling centers, and designing low heat areas.
	21	Increase the knowledge and use of mitigation/resilience best practices by City staff.
	25	Further develop and conduct public education and outreach programs for residents and property owners in the City regarding hazards.
	28	Increase protections for preserving, restoring, and enhancing Worcester’s tree canopy through more effective provisions for planting and replanting requirements (new/replacement shade trees) in local regulations.
	49	Build capacity within Lakes and Pond Program.
	50	Develop an Invasive Species Response and Management Plan.
Assistant Commissioner of Water/Sewer Operations	11	Conduct repairs for Pine Hill Reservoir Dam.
	12	Conduct repairs for Quinsigamond Pond and Patch Pond Dams.
	13	Evaluate spillway capacities for Kettle Brook Reservoir Nos. 1, 2, and 3.
Commissioner Public Works	14	Increase water use efficiency to mitigate drought risk.
	47	Investigate the feasibility of forming a Stormwater Utility.
Assistant Chief Development Officer - Planning & Regulatory Services	16	Improve stormwater management regulations.
	45	Create restoration requirements for redevelopment projects to provide additional water storage in floodplains.
Worcester Fire Chief	22	Collaborate with existing fire education efforts to promote forest health and wildfire education to be delivered in schools and public events.
	27	Implement mitigation strategies to mitigate risk to City Fire Department Facilities located in or near flood zones or at risk to rockfalls.

Action Lead	Action #	Action Title
	39	Improve Worcester Fire Department ability to withstand extreme weather.
City Manager	**24**	Formalize a process for interdepartmental review of all City construction/infrastructure projects.
Emergency Communications Commissioner	**26**	Safeguard Radio Infrastructure against high winds.
Director of Engineering	**31**	Green Island flood mitigation.
Assistant Commissioner of Water/Sewer Operations	**33**	Develop an inventory and maintenance plan for detention/infiltration basins.
	37	Pump station assessments and upgrades.
Department of Public Facilities Capital Projects Manager	**36**	Integrate resilient design principles and practices into City projects.
Chief Development Officer	**41**	Build capacity within the Planning Division.
Chief of Public Facilities	**42**	Inventory unreinforced masonry and brick buildings owned by the City which may be vulnerable to earthquakes.
Commissioner of Transportation and Mobility	**46**	Integrate disaster mitigation into transportation projects by incorporating risk assessments and resilience measures into planning, design, and construction.
Chief of Public Facilities	**48**	Repair or replace City Hall's Roof.

Appendix C. Plan Implementation and Review Supporting Materials.

Plan Update Evaluation Worksheet

Table 109. Plan Update Evaluation Worksheet.

Plan Section	Considerations	Explanation
Planning Process	Should the City 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 City, 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 City 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 110.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: WorcesterFlood

Flood Scenario: 100year

Print Date: Friday, September 6, 2024

Disclaimer:
Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific Flood. These results can be improved by using enhanced inventory data and flood hazard information.

HAZUS™

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FEMA

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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 20 square miles and contains 2,084 census blocks. The region contains over 79 thousand households and has a total population of 206,434 people. The distribution of population by State and County for the study region is provided in Appendix B.

There are an estimated 42,264 buildings in the region with a total building replacement value (excluding contents) of 27,735 million dollars. Approximately 85.67% of the buildings (and 52.92% of the building value) are associated with residential housing.

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Building Inventory

General Building Stock

Hazus estimates that there are 42,264 buildings in the region which have an aggregate total replacement value of 27,735 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	14,676,681	52.9%
Commercial	6,852,443	24.7%
Industrial	1,455,817	5.2%
Agricultural	16,127	0.1%
Religion	579,479	2.1%
Government	669,773	2.4%
Education	3,485,019	12.6%
Total	**27,735,339**	**100%**

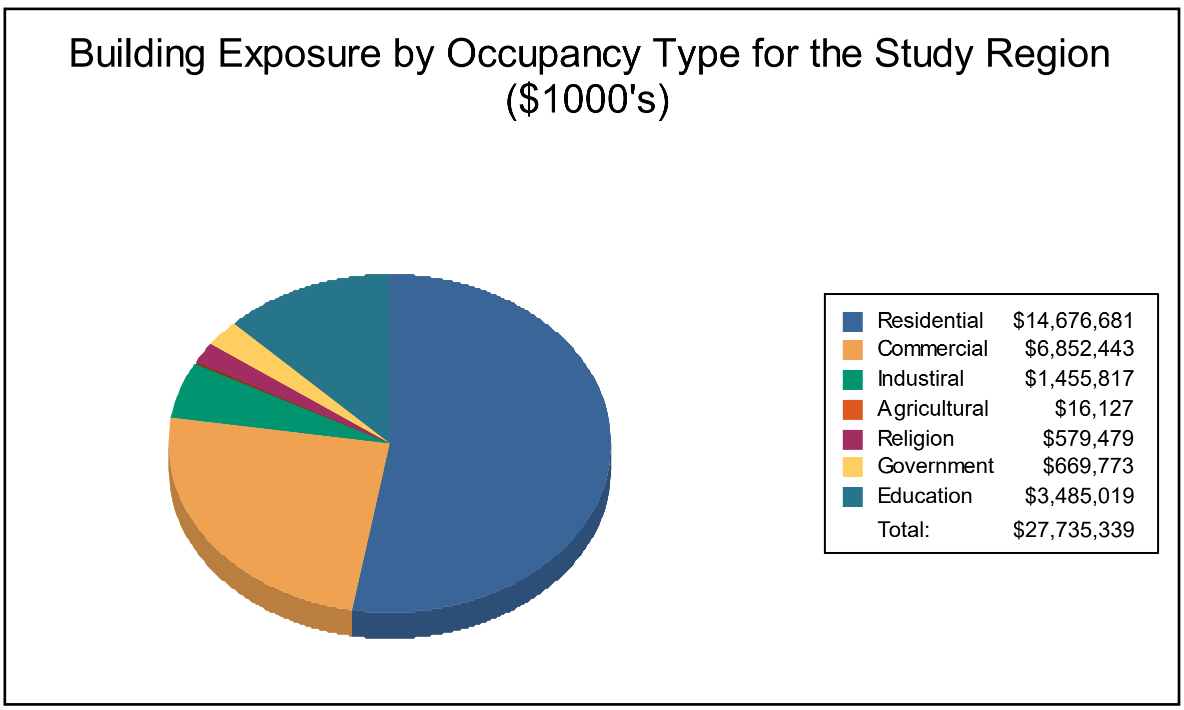
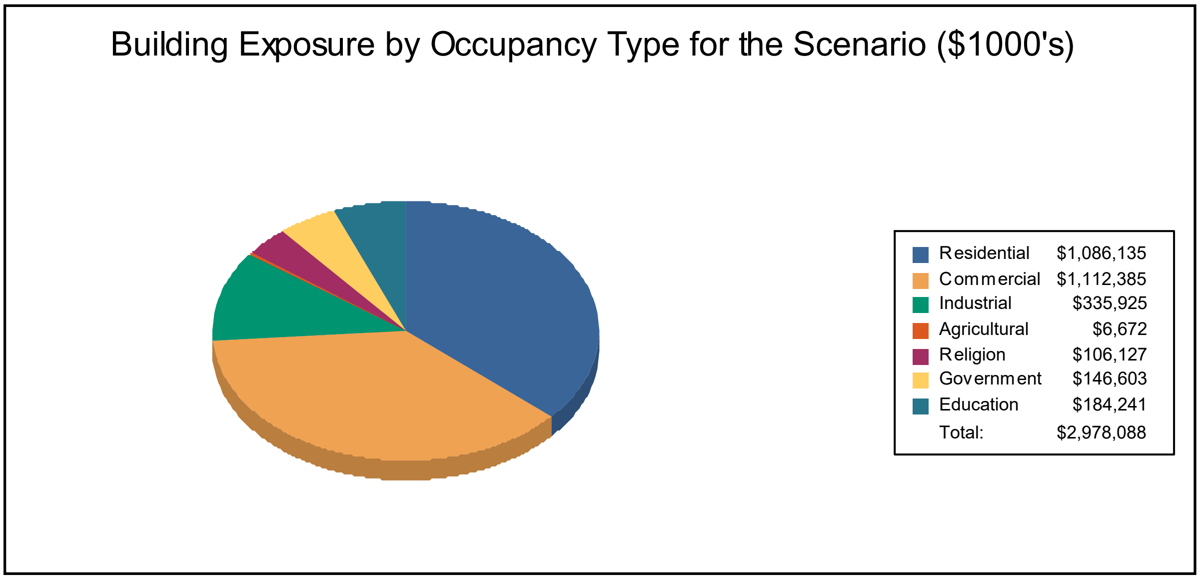


Table 2
Building Exposure by Occupancy Type for the Scenario

Occupancy	Exposure ($1000)	Percent of Total
Residential	1,086,135	36.5%
Commercial	1,112,385	37.4%
Industrial	335,925	11.3%
Agricultural	6,672	0.2%
Religion	106,127	3.6%
Government	146,603	4.9%
Education	184,241	6.2%
Total	**2,978,088**	**100%**



Essential Facility Inventory

For essential facilities, there are 8 hospitals in the region with a total bed capacity of 1,407 beds. There are 75 schools, 11 fire stations, 10 police stations and 1 emergency operation center.

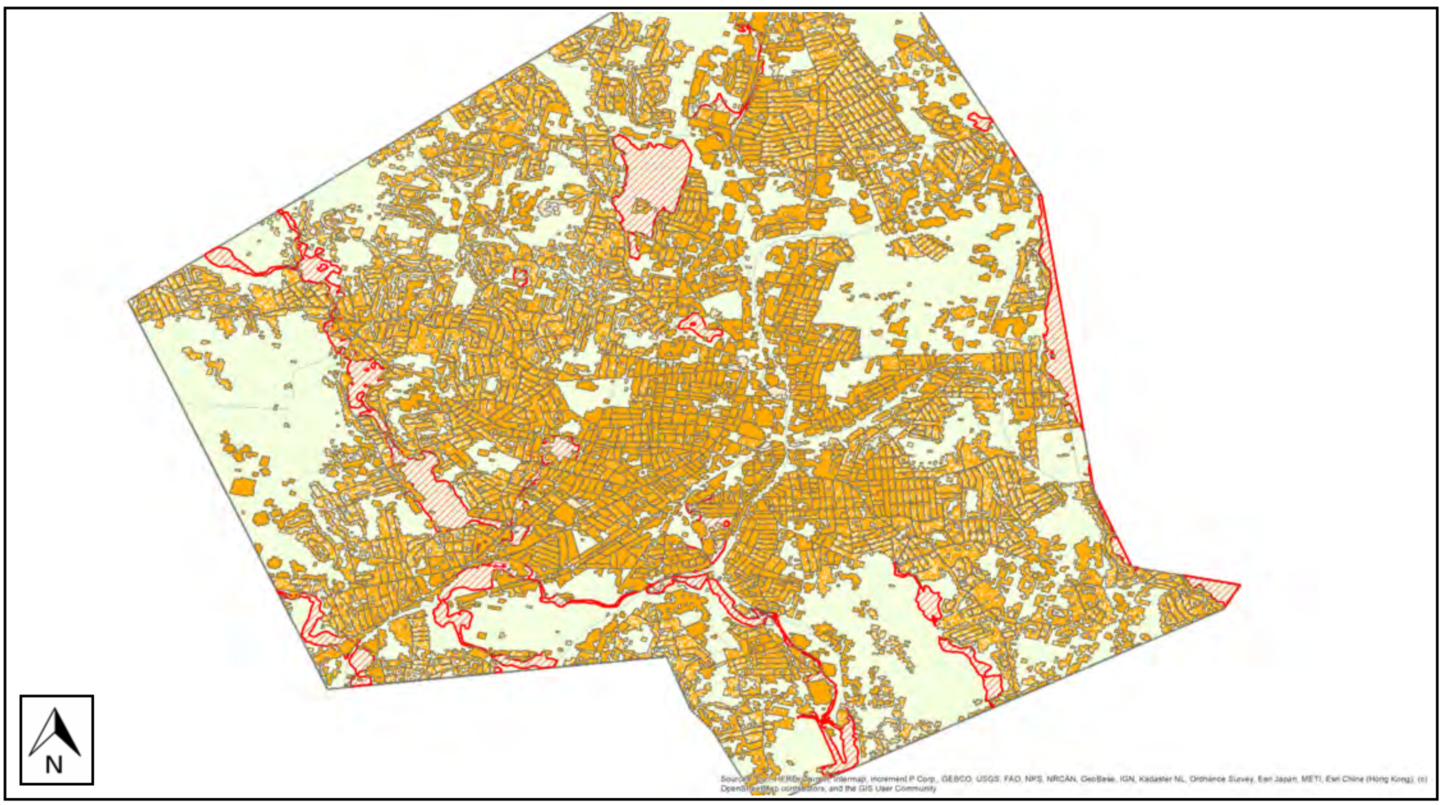
Flood Scenario Parameters

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

Study Region Name:	WorcesterFlood
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 45 buildings will be at least moderately damaged. This is over 68% 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

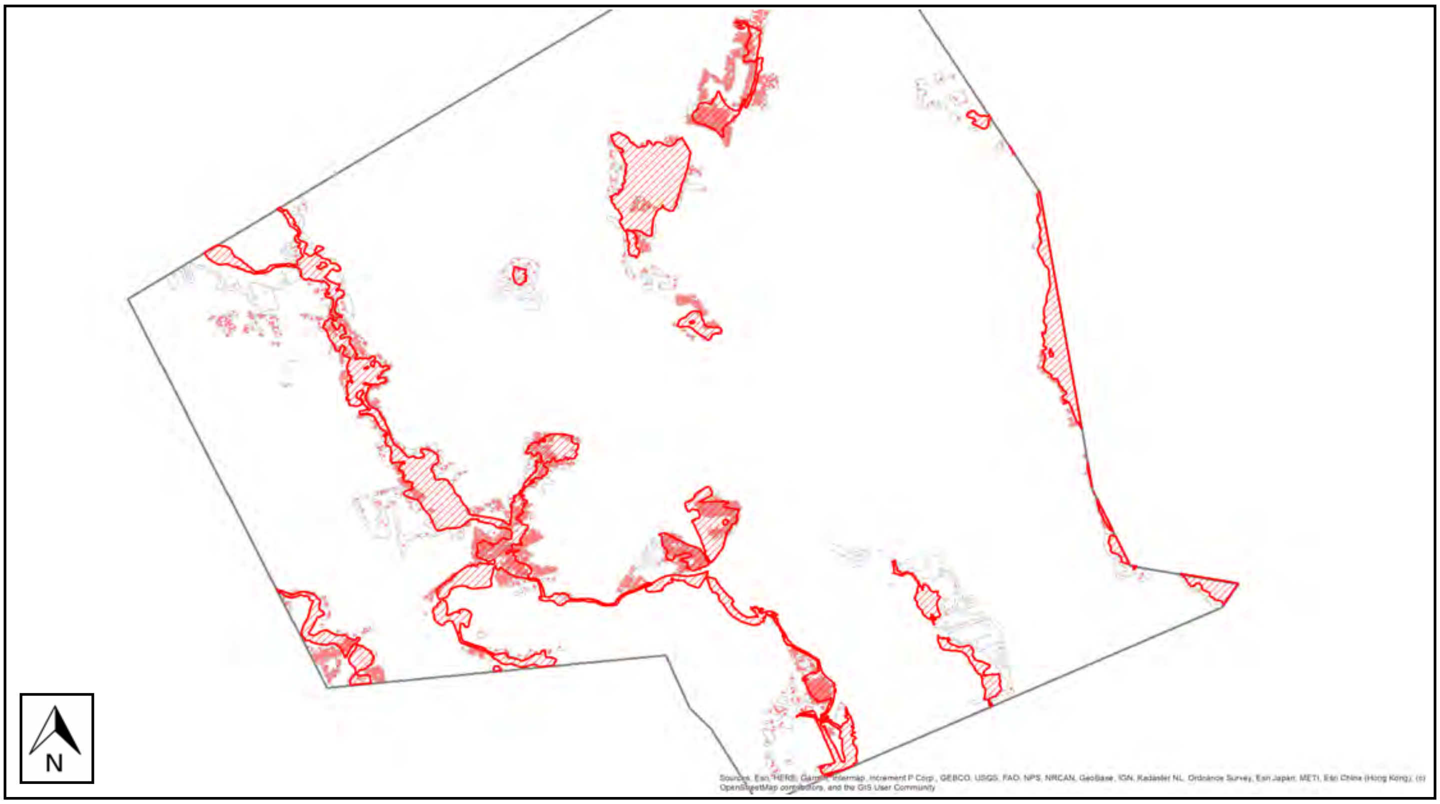


Table 3: Expected Building Damage by Occupancy

	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	4	57	3	43	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	113	73	32	21	8	5	2	1	0	0	0	0
Total	**117**		**35**		**8**		**2**		**0**		**0**	

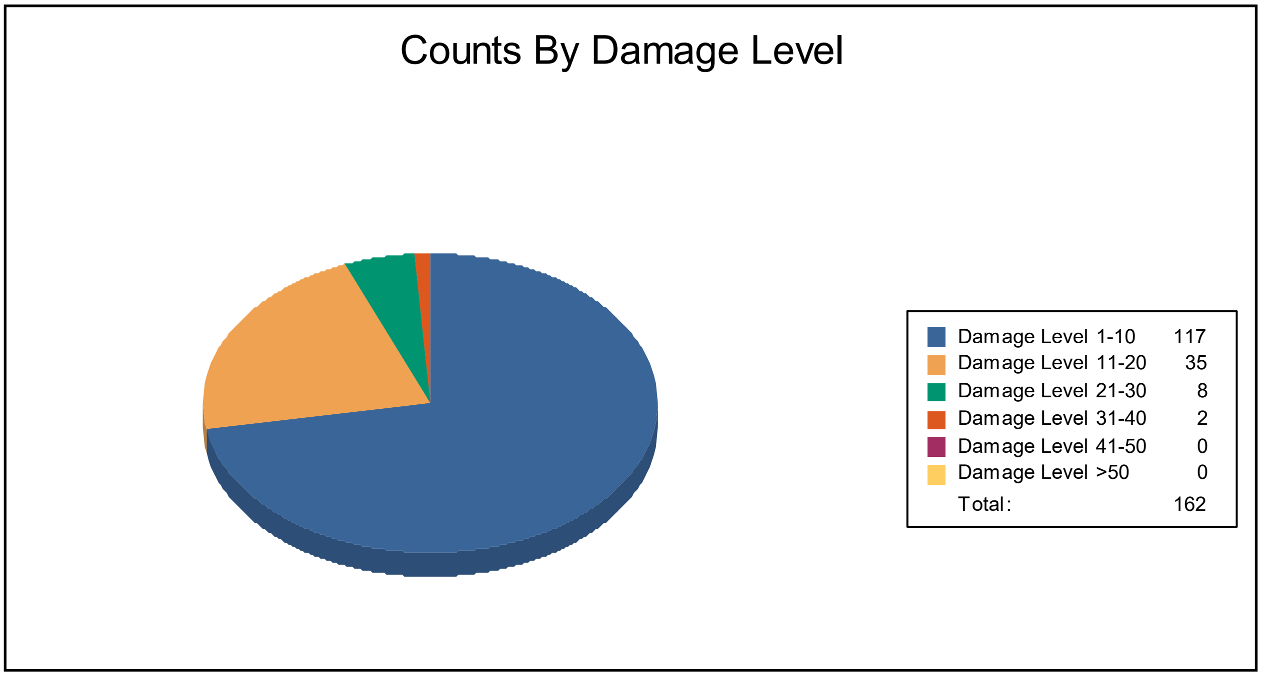


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Table 4: Expected Building Damage by Building Type

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	5	100	0	0	0	0	0	0	0	0	0	0
Steel	1	100	0	0	0	0	0	0	0	0	0	0
Wood	107	72	32	21	8	5	2	1	0	0	0	0

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Essential Facility Damage

Before the flood analyzed in this scenario, the region had 1,407 hospital beds available for use. On the day of the scenario flood event, the model estimates that 1,407 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	1	0	0	0
Fire Stations	11	1	0	1
Hospitals	8	0	0	0
Police Stations	10	0	0	0
Schools	75	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.

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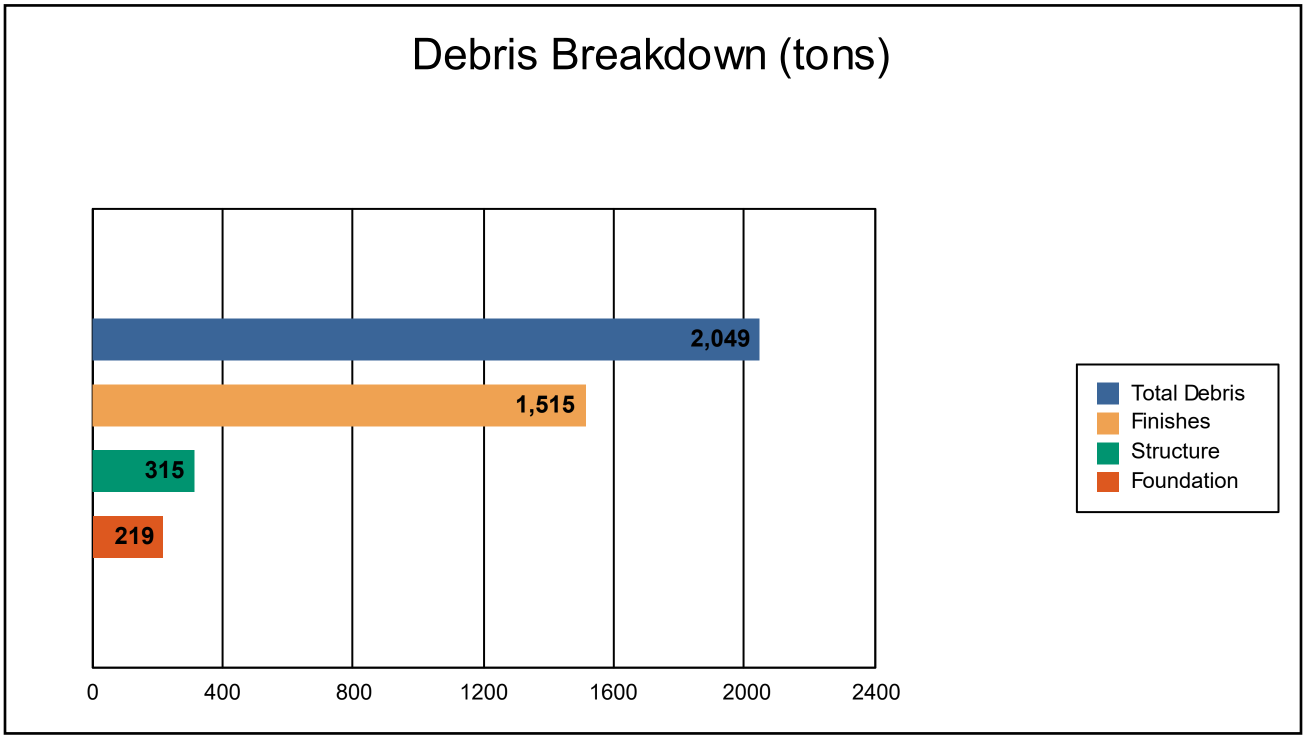
Induced Flood Damage

Debris Generation

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

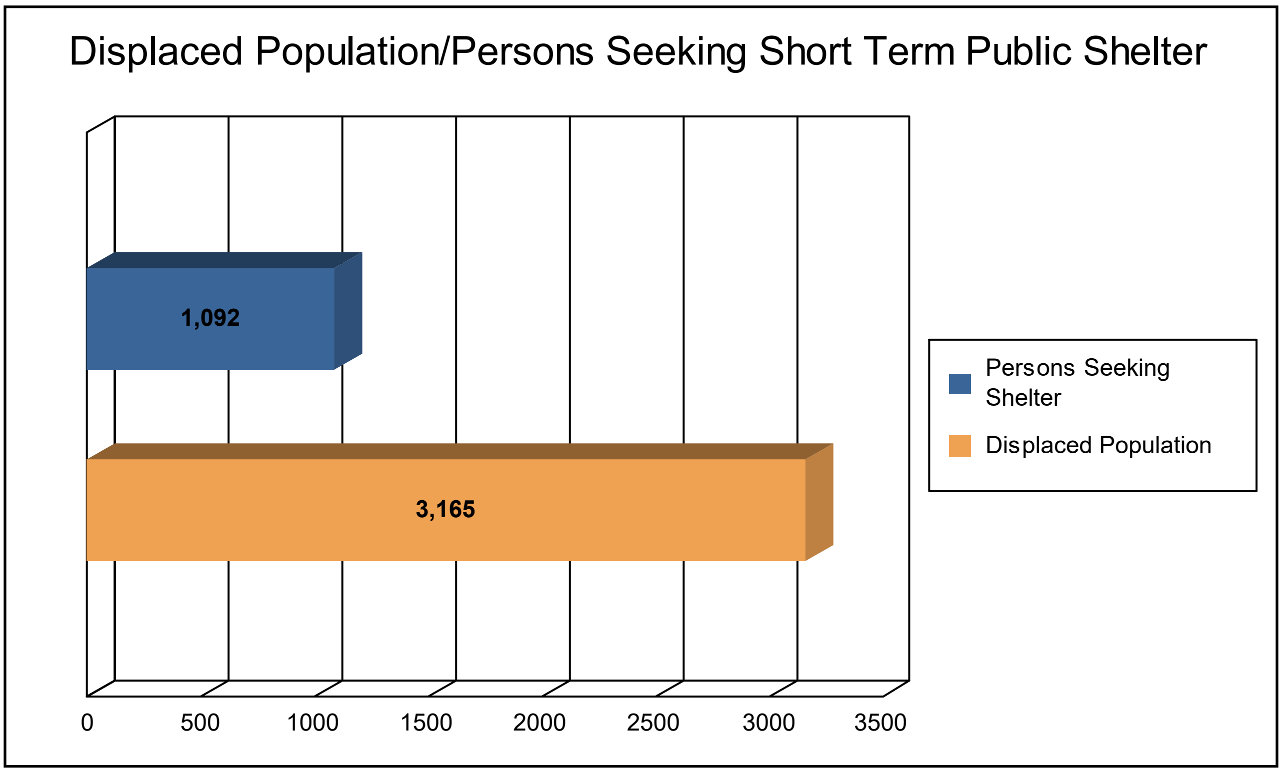


The model estimates that a total of 2,049 tons of debris will be generated. Of the total amount, Finishes comprises 74% of the total, Structure comprises 15% of the total, and Foundation comprises 11%. If the debris tonnage is converted into an estimated number of truckloads, it will require 82 truckloads (@25 tons/truck) to remove the debris generated by the flood.

Social Impact

Shelter Requirements

Hazus estimates the number of households that are expected to be displaced from their homes due to the flood and the associated potential evacuation. Hazus also estimates those displaced people that will require accommodations in temporary public shelters. The model estimates 1,055 households (or 3,165 of people) will be displaced due to the flood. Displacement includes households evacuated from within or very near to the inundated area. Of these, 1,092 people (out of a total population of 206,434) will seek temporary shelter in public shelters.



Economic Loss

The total economic loss estimated for the flood is 533.21 million dollars, which represents 17.90 % 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 217.57 million dollars. 59% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 6.05% of the total loss. Table 6 below provides a summary of the losses associated with the building damage.

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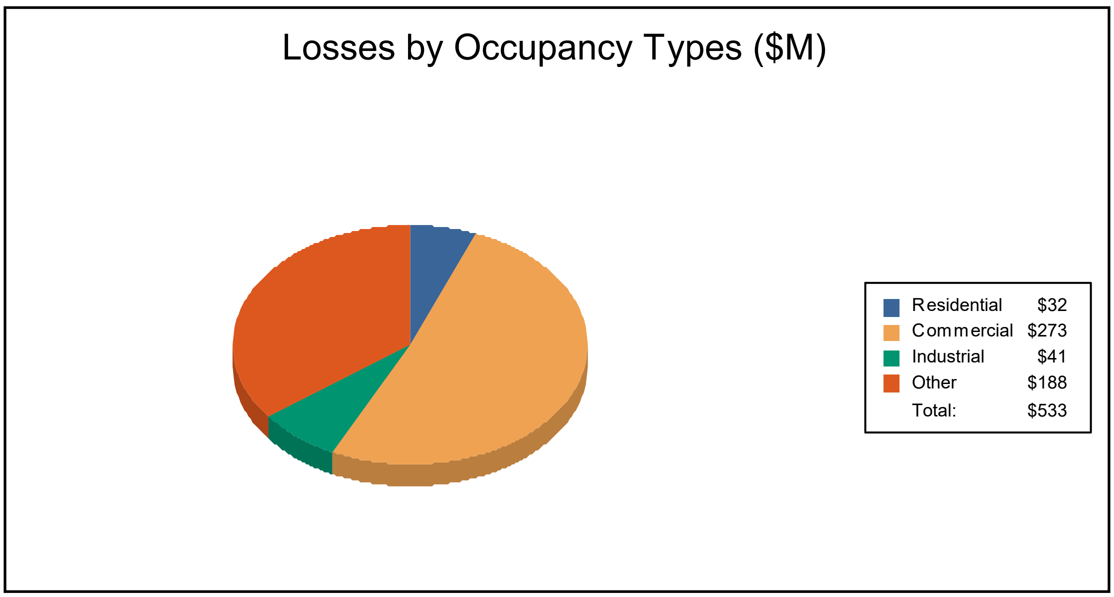
Table 6: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Building Loss						
	Building	13.06	25.06	9.70	6.16	53.98
	Content	7.60	68.81	24.62	34.00	135.03
	Inventory	0.00	24.74	3.71	0.11	28.56
	Subtotal	**20.66**	**118.61**	**38.02**	**40.27**	**217.57**
Business Interruption						
	Income	0.04	55.49	0.75	13.48	69.76
	Relocation	6.21	22.68	0.67	8.72	38.28
	Rental Income	5.22	16.51	0.20	1.22	23.16
	Wage	0.09	59.25	1.09	124.01	184.44
	Subtotal	**11.57**	**153.93**	**2.70**	**147.44**	**315.64**
ALL	**Total**	**32.23**	**272.54**	**40.72**	**187.71**	**533.21**



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	206,434	14,676,681	13,058,658	27,735,339
Total	**206,434**	**14,676,681**	**13,058,658**	**27,735,339**
Total Study Region	**206,434**	**14,676,681**	**13,058,658**	**27,735,339**

Hazus: Hurricane Global Risk Report

Region Name: WorcesterWind

Hurricane Scenario: Probabilistic 500-year Return Period

Print Date: Tuesday, September 17, 2024

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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 29.73 square miles and contains 46 census tracts. There are over 79 thousand households in the region and a total population of 206,518 people. The distribution of population by State and County is provided in Appendix B.

There are an estimated 42 thousand buildings in the region with a total building replacement value (excluding contents) of 27,739 million dollars. Approximately 86% of the buildings (and 53% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

Hazus estimates that there are 42,264 buildings in the region which have an aggregate total replacement value of Table 1 presents the relative distribution of the value with respect to the general occupancies. Appendix B provi distribution of the building value by State and County.

Building Exposure by Occupancy Type

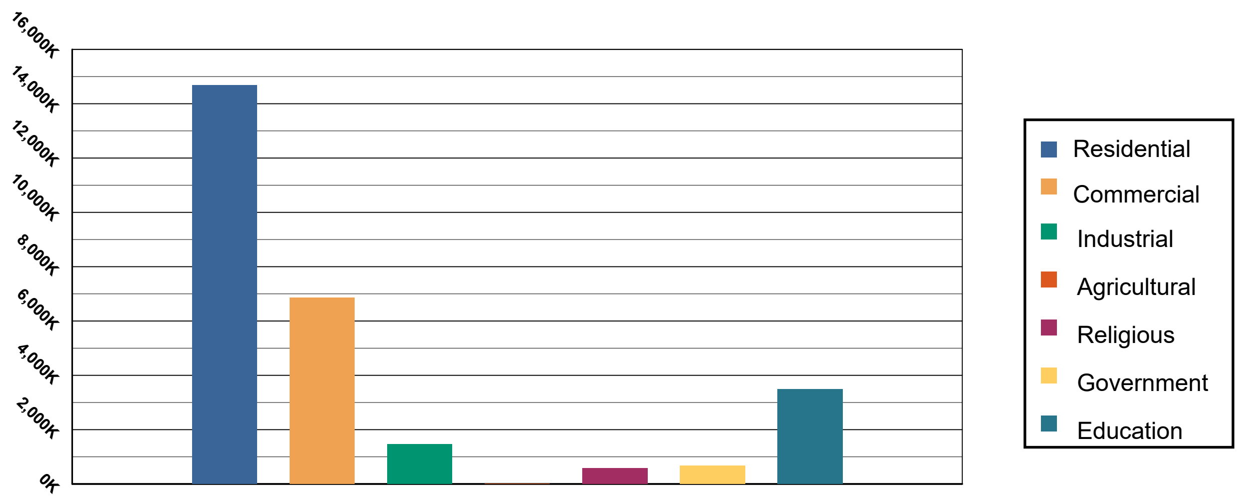


Table 1: Building Exposure by Occupancy Type

Occupancy	Exposure ($1000)	Percent of Tot
Residential	14,678,677	52.92%
Commercial	6,853,626	24.71%
Industrial	1,456,006	5.25%
Agricultural	16,138	0.06%
Religious	579,599	2.09%
Government	669,862	2.41%
Education	3,485,050	12.56%
Total	**27,738,958**	**100.00%**

Essential Facility Inventory

For essential facilities, there are 8 hospitals in the region with a total bed capacity of 1,407 beds. There are 75 schools, 11 fire stations, 10 police stations and 1 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 1,752 buildings will be at least moderately damaged. This is over 4% of the total number of buildings in the region. There are an estimated 97 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.

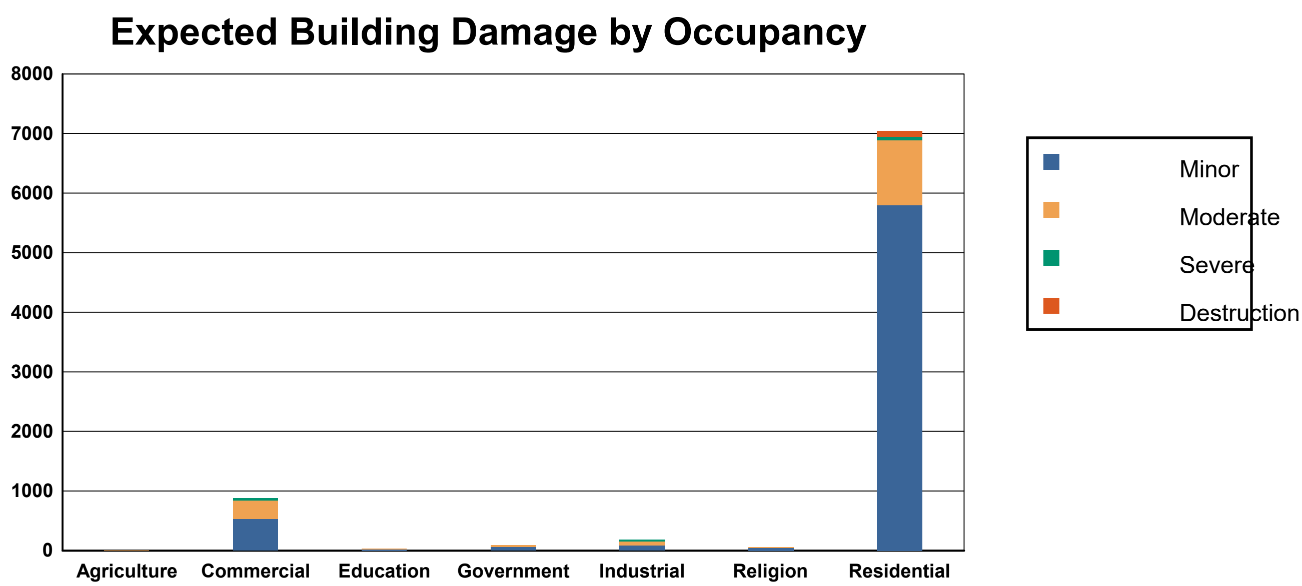


Table 2: Expected Building Damage by Occupancy : 500 - year Event

Occupancy	None Count	None (%)	Minor Count	Minor (%)	Moderate Count	Moderate (%)	Severe Count	Severe (%)	Destruction Count	Destruction (%)
Agriculture	44	83.29	5	9.90	2	4.32	1	2.30	0	0.18
Commercial	3,417	79.45	535	12.43	312	7.26	37	0.85	0	0.01
Education	96	76.00	18	14.27	12	9.49	0	0.24	0	0.00
Government	386	81.07	63	13.28	25	5.35	1	0.29	0	0.00
Industrial	545	74.44	87	11.93	73	10.03	25	3.47	1	0.13
Religion	311	84.15	43	11.76	14	3.79	1	0.31	0	0.00
Residential	29,164	80.55	5,798	16.01	1,092	3.01	58	0.16	95	0.26
Total	**33,963**		**6,550**		**1,531**		**124**		**97**	

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

Building Type	None		Minor		Moderate		Severe		Destruction	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	434	80.73	76	14.13	26	4.74	2	0.39	0	0.00
Masonry	3,266	82.42	501	12.64	169	4.27	24	0.61	3	0.06
MH	14	91.02	1	5.04	0	2.72	0	0.09	0	1.13
Steel	1,515	64.84	365	15.62	408	17.48	48	2.06	0	0.00
Wood	29,173	82.45	5,319	15.03	745	2.11	56	0.16	87	0.25

Essential Facility Damage

Before the hurricane, the region had 1,407 hospital beds available for use. On the day of the hurricane, the model estimates that 1,407 hospital beds (100%) are available for use by patients already in the hospital and those injured by the hurricane. After one week, 100% of the beds will be in service. By 30 days, 100% will be operational.

Thematic Map of Essential Facilities

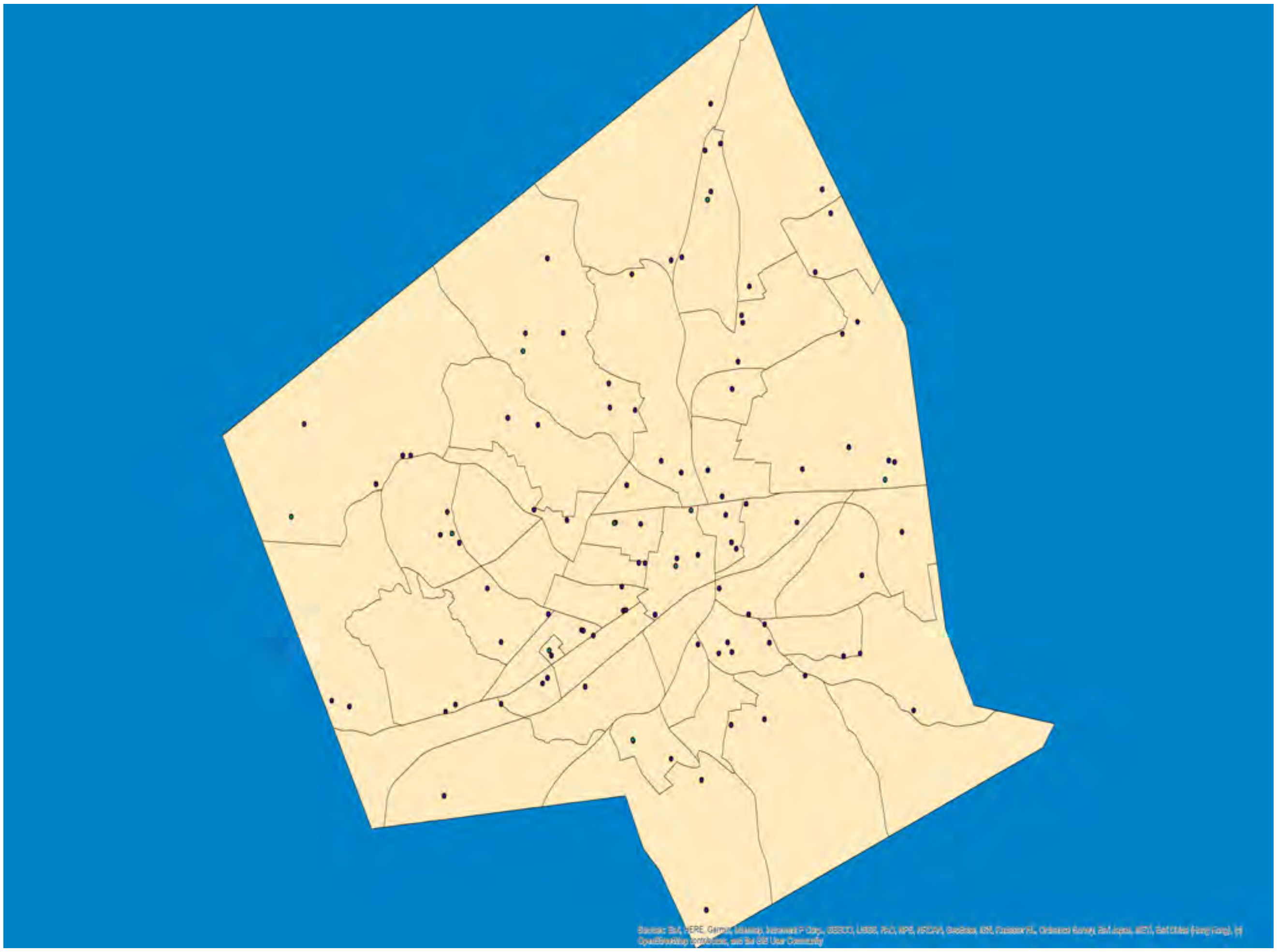
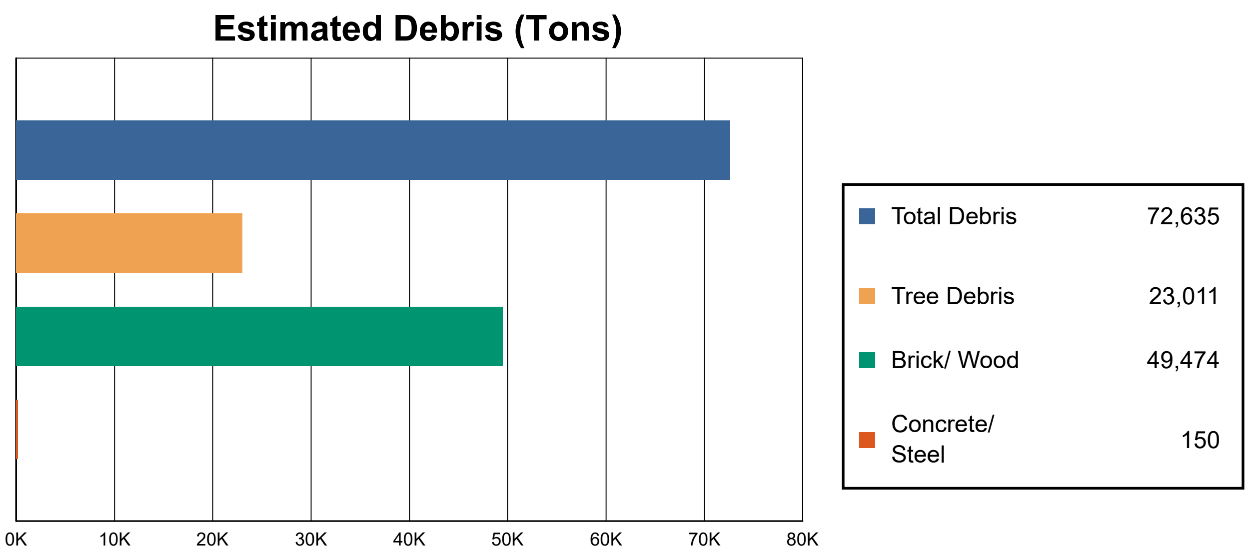


Table 4: Expected Damage to Essential Facilities

		# Facilities		
Classification	**Total**	**Probability of at Least Moderate Damage > 50%**	**Probability of Complete Damage > 50%**	**Expected Loss of Use < 1 day**
EOCs	1	0	0	1
Fire Stations	11	0	0	11
Hospitals	8	0	0	8
Police Stations	10	0	0	10
Schools	75	0	0	17

Induced Hurricane Damage

Debris Generation

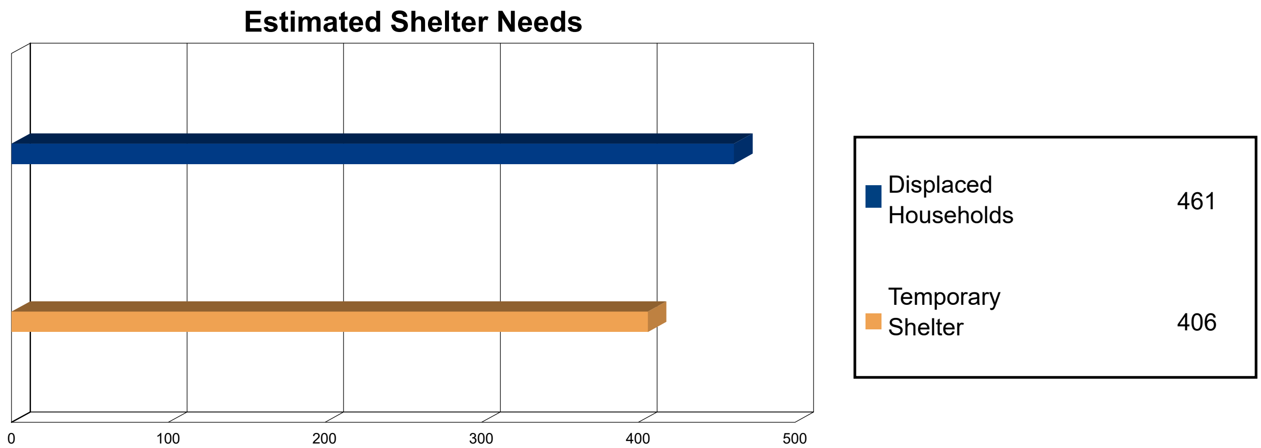


Hazus estimates the amount of debris that will be generated by the hurricane. The model breaks the debris into four general categories: a) Brick/Wood, b) Reinforced Concrete/Steel, c) Eligible Tree Debris, and d) Other Tree Debris. This distinction is made because of the different types of material handling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

The model estimates that a total of 72,635 tons of debris will be generated. Of the total amount, 4,286 tons (6%) is Other Tree Debris. Of the remaining 68,349 tons, Brick/Wood comprises 72% 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 1985 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 18,725 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 461 households to be displaced due to the hurricane. Of these, 406 people (out of a total population of 206,518) will seek temporary shelter in public shelters.

Economic Loss

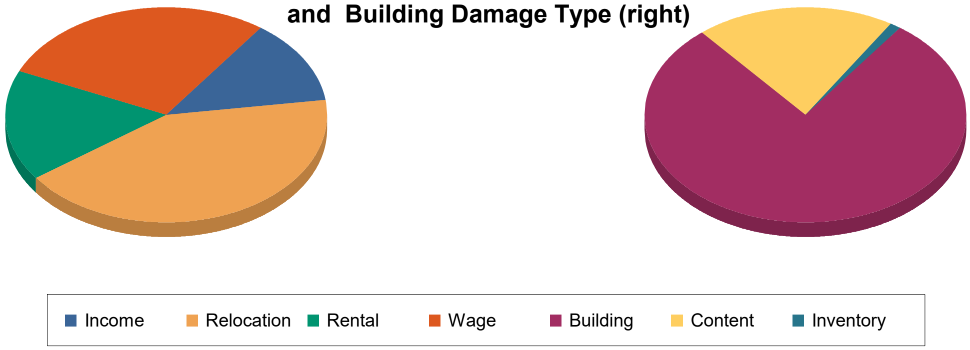
The total economic loss estimated for the hurricane is 590.5 million dollars, which represents 2.13 % of the total replacement value of the region's buildings.

Building-Related Losses

The building related losses are broken into two categories: direct property damage losses and business interruption losses. The direct property damage losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the hurricane. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the hurricane.

The total property damage losses were 591 million dollars. 15% 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 57% 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

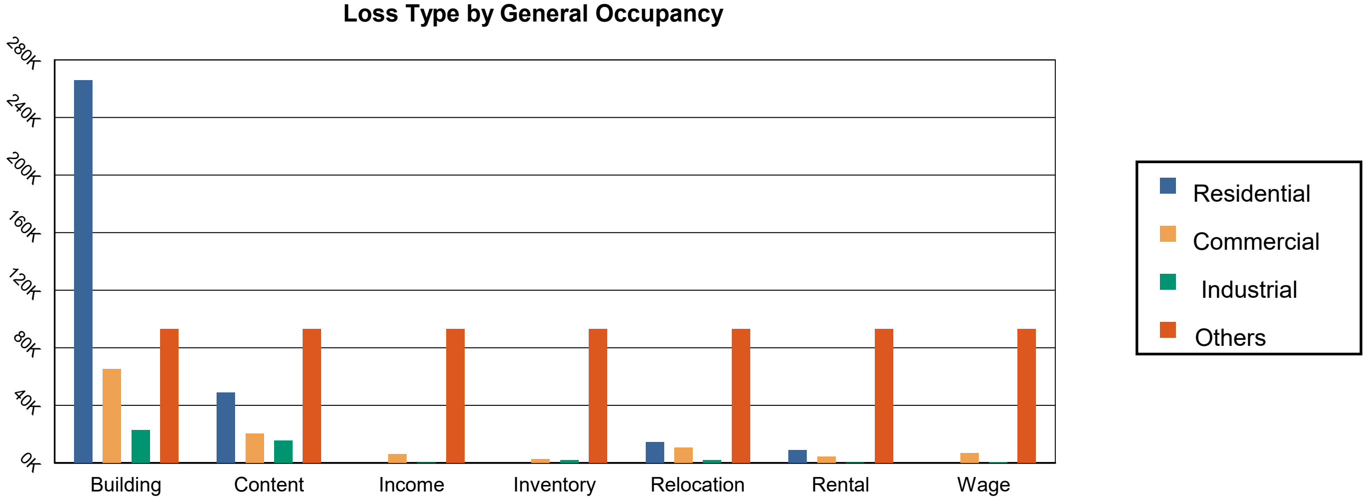


Table 5: Building-Related Economic Loss Estimates

(Thousands of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Property Damage						
	Building	266,054.40	65,200.56	22,968.26	43,702.82	397,926.04
	Content	48,866.25	20,213.14	15,452.04	16,308.06	100,839.50
	Inventory	0.00	2,797.33	2,046.26	113.30	4,956.89
	Subtotal	**314,920.65**	**88,211.03**	**40,466.57**	**60,124.19**	**503,722.43**
Business Interruption Loss						
	Income	0.57	6,013.69	262.78	4,713.76	10,990.79
	Relocation	14,372.23	10,438.02	1,792.15	10,087.08	36,689.48
	Rental	8,900.56	4,434.59	218.74	919.01	14,472.91
	Wage	1.33	6,976.60	408.68	17,265.13	24,651.74
	Subtotal	**23,274.70**	**27,862.90**	**2,682.35**	**32,984.97**	**86,804.92**

Total

Total	**338,195.35**	**116,073.93**	**43,148.91**	**93,109.16**	**590,527.35**

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	206,518	14,678,677	13,060,281	27,738,958
Total	**206,518**	**14,678,677**	**13,060,281**	**27,738,958**
Study Region Total	**206,518**	**14,678,677**	**13,060,281**	**27,738,958**

Hazus: Hurricane Global Risk Report

Region Name: WorcesterWind

Hurricane Scenario: Probabilistic 1000-year Return Period

Print Date: Tuesday, September 17, 2024

Table of Contents

General Description of the Region

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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.

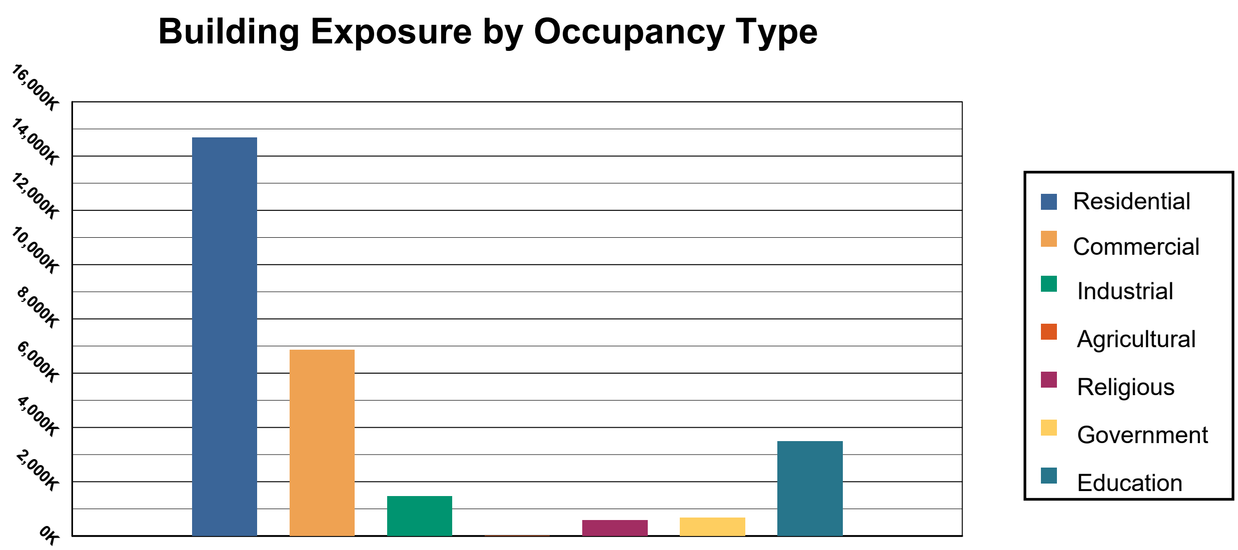
The geographical size of the region is 29.73 square miles and contains 46 census tracts. There are over 79 thousand households in the region and a total population of 206,518 people. The distribution of population by State and County is provided in Appendix B.

There are an estimated 42 thousand buildings in the region with a total building replacement value (excluding contents) of 27,739 million dollars. Approximately 86% of the buildings (and 53% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

Hazus estimates that there are 42,264 buildings in the region which have an aggregate total replacement value of Table 1 presents the relative distribution of the value with respect to the general occupancies. Appendix B provi distribution of the building value by State and County.



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Occupancy	Exposure ($1000)	Percent of Tot
Residential	14,678,677	52.92%
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Agricultural	16,138	0.06%
Religious	579,599	2.09%
Government	669,862	2.41%
Education	3,485,050	12.56%
Total	**27,738,958**	**100.00%**

Essential Facility Inventory

For essential facilities, there are 8 hospitals in the region with a total bed capacity of 1,407 beds. There are 75 schools, 11 fire stations, 10 police stations and 1 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 2,965 buildings will be at least moderately damaged. This is over 7% of the total number of buildings in the region. There are an estimated 247 buildings that will be completely destroyed. The definition of the 'damage states' is provided in the Hazus Hurricane technical manual. Table 2 below summarizes the expected damage by general occupancy for the buildings in the region. Table 3 summarizes the expected damage by general building type.

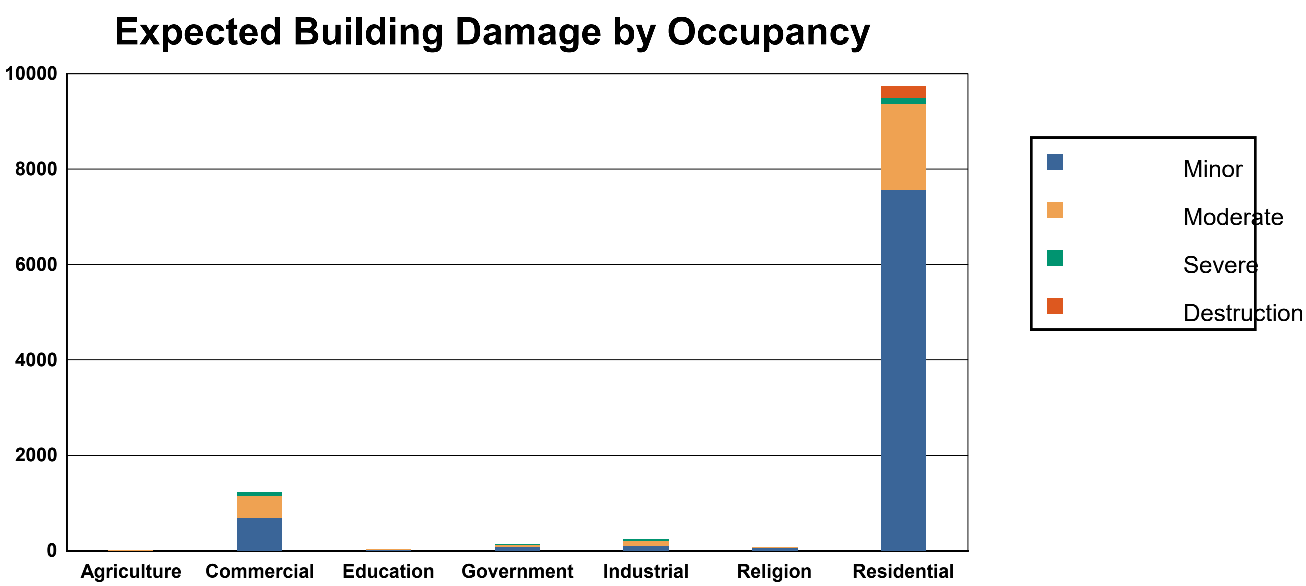


Table 2: Expected Building Damage by Occupancy : 1000 - year Event

	None		Minor		Moderate		Severe		Destruction	
Occupancy	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Agriculture	40	76.40	7	13.27	3	6.25	2	3.71	0	0.37
Commercial	3,080	71.60	683	15.87	468	10.89	69	1.61	1	0.03
Education	85	67.49	22	17.61	18	14.18	1	0.71	0	0.00
Government	345	72.47	83	17.43	44	9.23	4	0.88	0	0.00
Industrial	481	65.69	107	14.66	101	13.76	41	5.63	2	0.27
Religion	284	76.87	59	15.86	24	6.51	3	0.76	0	0.00
Residential	26,460	73.08	7,564	20.89	1,800	4.97	140	0.39	243	0.67
Total	**30,774**		**8,525**		**2,458**		**260**		**247**	

Table 3: Expected Building Damage by Building Type : 1000 - year Event

Building Type	None		Minor		Moderate		Severe		Destruction	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	385	71.51	99	18.38	48	8.92	6	1.19	0	0.00
Masonry	2,947	74.35	657	16.58	300	7.58	53	1.34	6	0.15
MH	13	85.22	1	7.37	1	4.95	0	0.27	0	2.18
Steel	1,283	54.91	413	17.69	558	23.89	82	3.50	0	0.02
Wood	26,702	75.47	7,054	19.94	1,280	3.62	120	0.34	224	0.63

Essential Facility Damage

Before the hurricane, the region had 1,407 hospital beds available for use. On the day of the hurricane, the model estimates that 1,407 hospital beds (100%) are available for use by patients already in the hospital and those injured by the hurricane. After one week, 100% of the beds will be in service. By 30 days, 100% will be operational.

Thematic Map of Essential Facilities

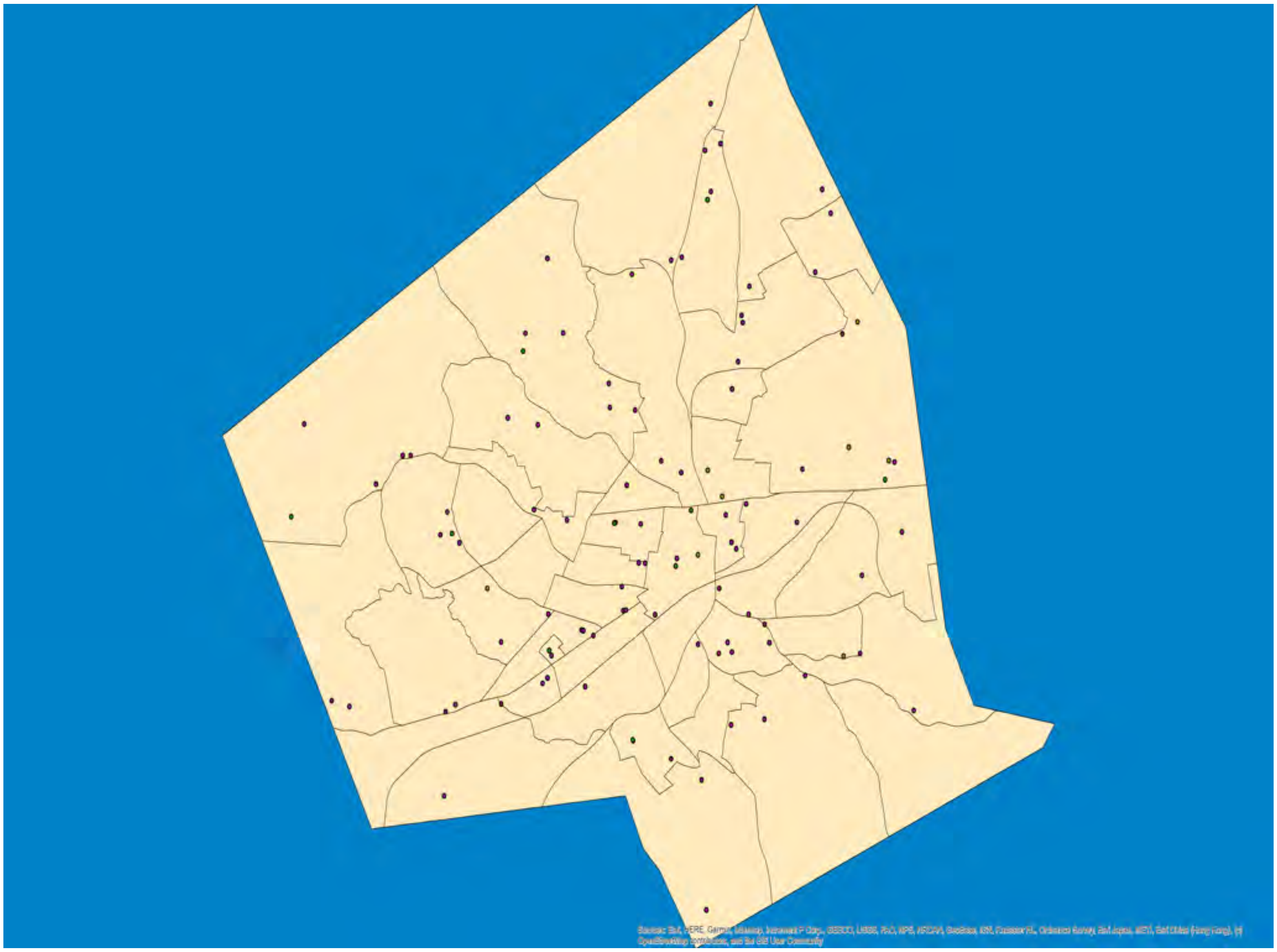
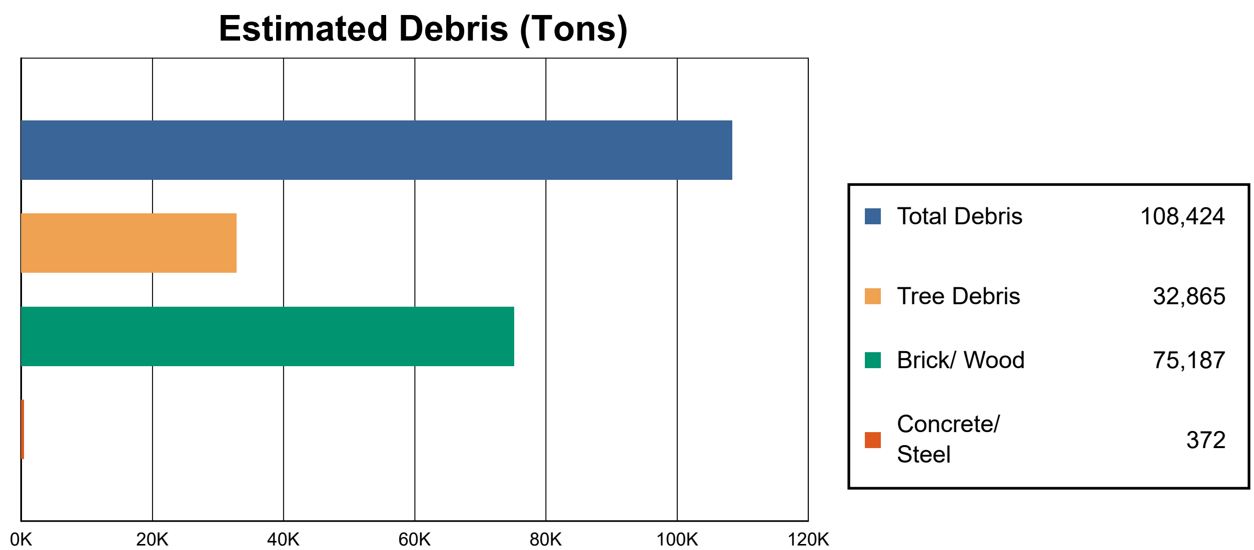


Table 4: Expected Damage to Essential Facilities

		# Facilities		
Classification	**Total**	**Probability of at Least Moderate Damage > 50%**	**Probability of Complete Damage > 50%**	**Expected Loss of Use < 1 day**
EOCs	1	0	0	1
Fire Stations	11	0	0	11
Hospitals	8	0	0	8
Police Stations	10	0	0	10
Schools	75	6	0	5

Induced Hurricane Damage

Debris Generation

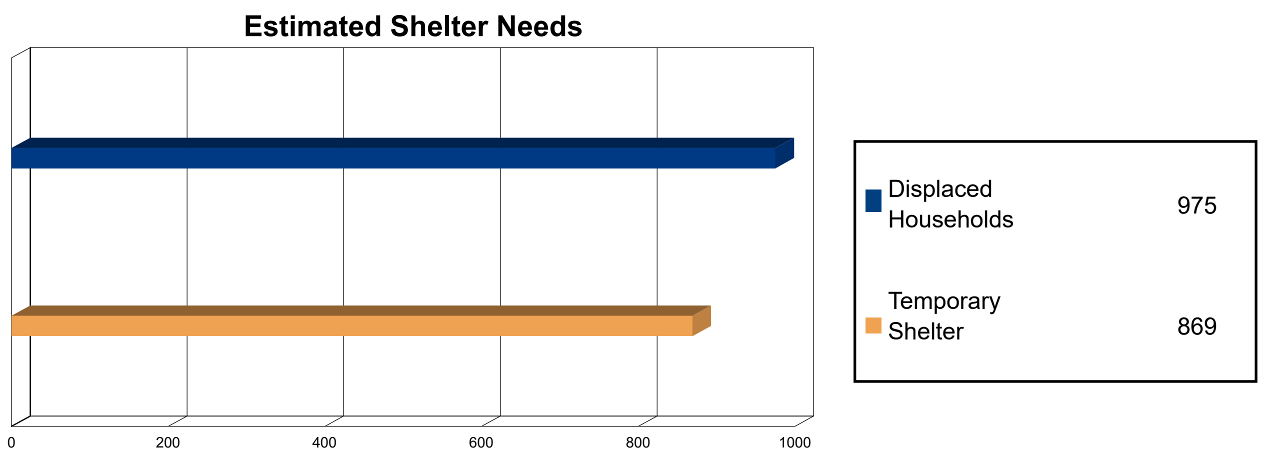


Hazus estimates the amount of debris that will be generated by the hurricane. The model breaks the debris into four general categories: a) Brick/Wood, b) Reinforced Concrete/Steel, c) Eligible Tree Debris, and d) Other Tree Debris. This distinction is made because of the different types of material handling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

The model estimates that a total of 108,424 tons of debris will be generated. Of the total amount, 6,316 tons (6%) is Other Tree Debris. Of the remaining 102,108 tons, Brick/Wood comprises 74% of the total, Reinforced Concrete/Steel comprises of 0% of the total, with the remainder being Eligible Tree Debris. If the building debris tonnage is converted to an estimated number of truckloads, it will require 3022 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 26,549 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 975 households to be displaced due to the hurricane. Of these, 869 people (out of a total population of 206,518) will seek temporary shelter in public shelters.

Economic Loss

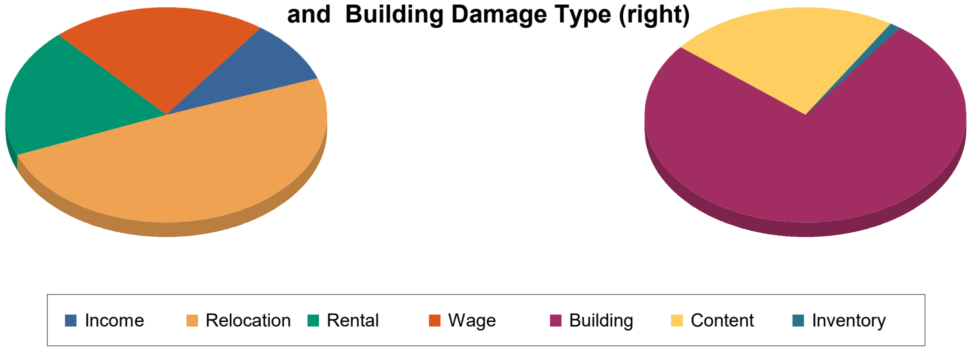
The total economic loss estimated for the hurricane is 969.9 million dollars, which represents 3.50 % of the total replacement value of the region's buildings.

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 970 million dollars. 14% 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 60% 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

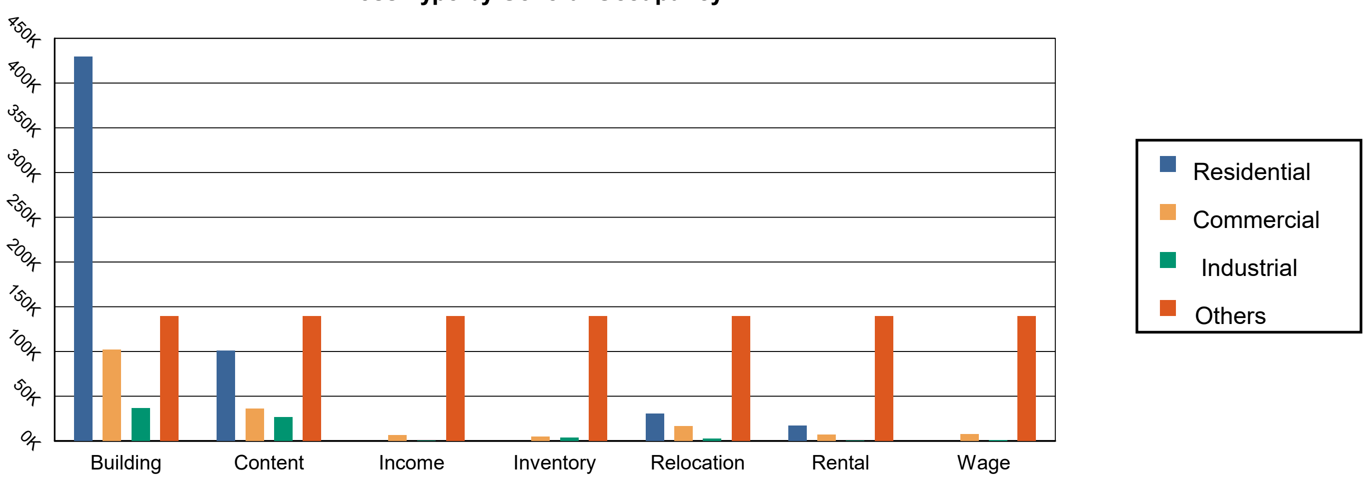


Table 5: Building-Related Economic Loss Estimates

(Thousands of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Property Damage						
	Building	429,533.89	102,299.23	36,667.19	67,340.22	635,840.53
	Content	100,684.60	36,282.27	26,806.26	28,744.17	192,517.30
	Inventory	0.00	5,162.12	3,538.96	203.29	8,904.37
	Subtotal	**530,218.49**	**143,743.62**	**67,012.42**	**96,287.67**	**837,262.20**
Business Interruption Loss						
	Income	4.01	6,580.63	405.11	5,448.29	12,438.05
	Relocation	30,815.50	16,443.27	2,696.92	15,868.54	65,824.23
	Rental	16,697.66	7,221.60	349.56	1,490.18	25,758.99
	Wage	9.44	7,643.87	638.15	20,326.91	28,618.36
	Subtotal	**47,526.61**	**37,889.36**	**4,089.74**	**43,133.92**	**132,639.63**

Total

Total	577,745.10	181,632.98	71,102.16	139,421.59	969,901.83

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	206,518	14,678,677	13,060,281	27,738,958
Total	**206,518**	**14,678,677**	**13,060,281**	**27,738,958**
Study Region Total	**206,518**	**14,678,677**	**13,060,281**	**27,738,958**

Hazus: Earthquake Global Risk Report

Region Name: WorcesterEarthquak

Earthquake Scenario: 1500year

Print Date: September 18, 2024

Disclaimer:
Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

HAZUS™ FEMA

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 38.45 square miles and contains 46 census tracts. There are over 79 thousand households in the region which has a total population of 206,518 peopleF. The distribution of population by Total Region and County is provided in Appendix B.

There are an estimated 42 thousand buildings in the region with a total building replacement value (excluding contents) of 27,738 (millions of dollars). Approximately 86.00 % of the buildings (and 53.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 5,453 and 91 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

Hazus estimates that there are 42 thousand buildings in the region which have an aggregate total replacement value of 27,738 (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 84% 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 8 hospitals in the region with a total bed capacity of 1,407 beds. There are 75 schools, 11 fire stations, 10 police stations and 1 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 5,544.00 (millions of dollars). This inventory includes over 133.59 miles of highways, 119 bridges, 1,271.33 miles of pipes.

Table 1: Transportation System Lifeline Inventory

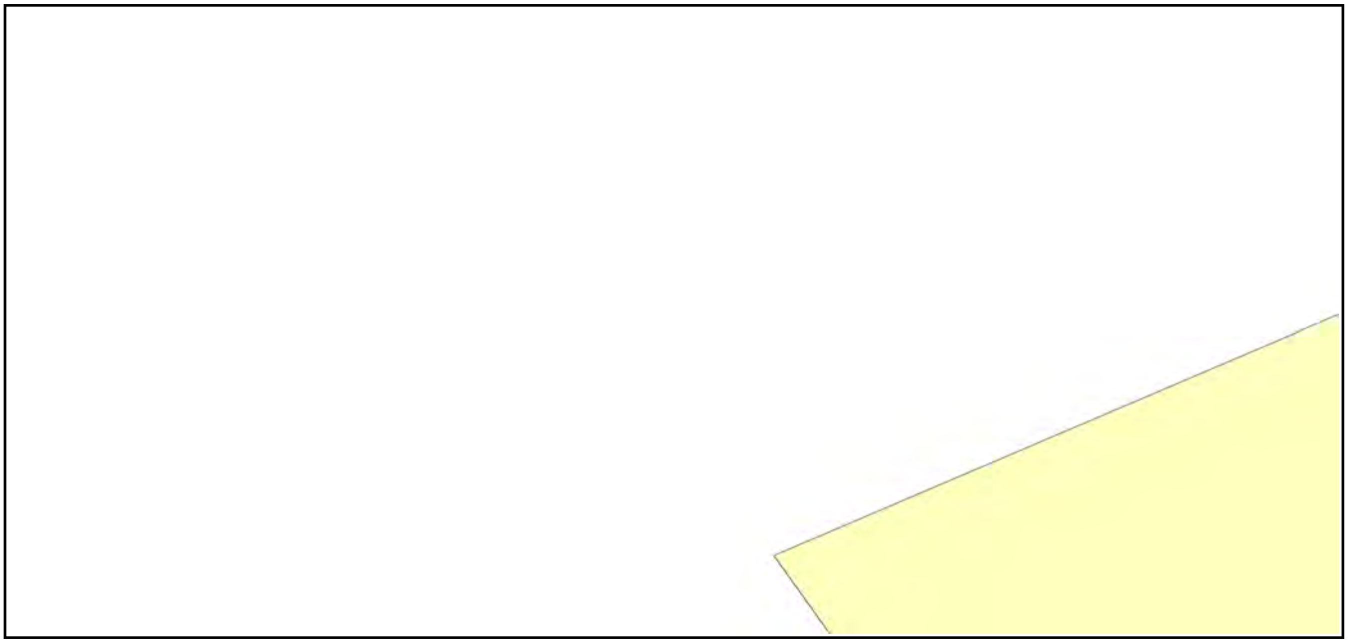
System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	119	704.0582
	Segments	174	1443.2502
	Tunnels	1	5.9010
		Subtotal	**2153.2094**
Railways	Bridges	10	51.9000
	Facilities	9	23.9670
	Segments	40	3216.2389
	Tunnels	0	0.0000
		Subtotal	**3292.1059**
Light Rail	Bridges	0	0.0000
	Facilities	0	0.0000
	Segments	0	0.0000
	Tunnels	0	0.0000
		Subtotal	**0.0000**
Bus	Facilities	0	0.0000
		Subtotal	**0.0000**
Ferry	Facilities	0	0.0000
		Subtotal	**0.0000**
Port	Facilities	0	0.0000
		Subtotal	**0.0000**
Airport	Facilities	1	1.2412
	Runways	1	7.1127
		Subtotal	**8.3539**
		Total	**5,453.70**

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	20.4607
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**20.4607**
Waste Water	Distribution Lines	NA	12.2764
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**12.2764**
Natural Gas	Distribution Lines	NA	8.1843
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**8.1843**
Oil Systems	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**0.0000**
Electrical Power	Facilities	3	49.6291
		Subtotal	**49.6291**
Communication	Facilities	4	0.4640
		Subtotal	**0.4640**
		Total	**91.00**

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	6.50
Depth (km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Direct Earthquake Damage

Building Damage

Hazus estimates that about 240 buildings will be at least moderately damaged. This is over 1.00 % 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

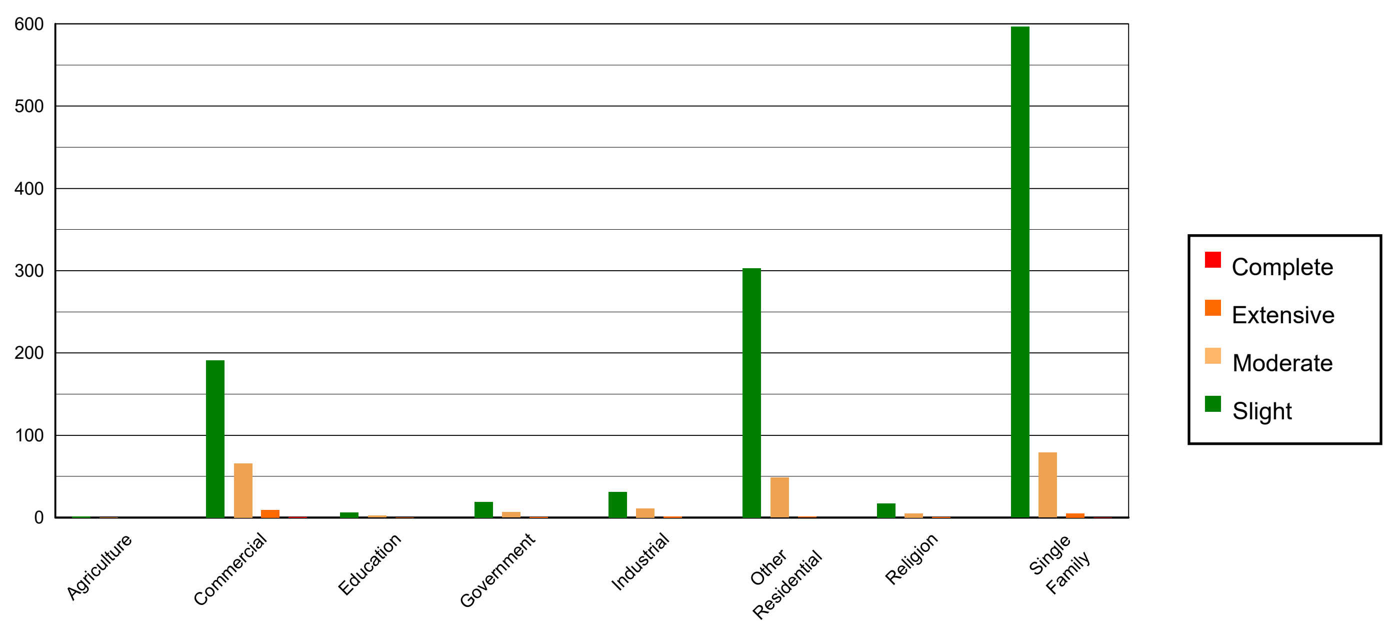


Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	50.94	0.12	1.58	0.14	0.43	0.19	0.05	0.25	0.00	0.26
Commercial	4033.24	9.87	191.24	16.39	66.21	30.16	9.54	49.11	0.78	51.22
Education	117.00	0.29	6.39	0.55	2.27	1.04	0.31	1.60	0.02	1.62
Government	449.26	1.10	19.19	1.64	6.63	3.02	0.87	4.46	0.06	3.94
Industrial	687.99	1.68	31.15	2.67	11.15	5.08	1.59	8.18	0.12	7.76
Other Residential	11076.01	27.11	303.31	26.00	48.50	22.10	1.16	5.99	0.02	1.13
Religion	345.99	0.85	17.06	1.46	5.18	2.36	0.70	3.60	0.06	4.02
Single Family	24096.53	58.98	596.69	51.15	79.12	36.05	5.21	26.80	0.46	30.07
Total	**40,857**		**1,167**		**219**		**19**		**2**	

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

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	34532.93	84.52	773.17	66.27	77.35	35.24	1.23	6.32	0.00	0.00
Steel	2264.48	5.54	65.85	5.64	21.40	9.75	1.83	9.41	0.00	0.25
Concrete	283.10	0.69	7.08	0.61	1.96	0.90	0.09	0.44	0.00	0.03
Precast	237.50	0.58	7.48	0.64	3.43	1.56	0.58	3.00	0.00	0.03
RM	32.79	0.08	0.50	0.04	0.12	0.06	0.01	0.05	0.00	0.00
URM	3491.54	8.55	310.87	26.65	114.51	52.18	15.68	80.71	1.51	99.68
MH	14.61	0.04	1.68	0.14	0.70	0.32	0.01	0.07	0.00	0.00
Total	**40,857**		**1,167**		**219**		**19**		**2**	

*Note:

RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 1,407 hospital beds available for use. On the day of the earthquake, the model estimates that only 1,276 hospital beds (91.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 97.00% of the beds will be back in service. By 30 days, 99.00% 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	8	0	0	8
Schools	75	0	0	75
EOCs	1	0	0	1
PoliceStations	10	0	0	10
FireStations	11	0	0	11

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	174	0	0	174	174
	Bridges	119	0	0	119	119
	Tunnels	1	0	0	1	1
Railways	Segments	40	0	0	40	40
	Bridges	10	0	0	10	10
	Tunnels	0	0	0	0	0
	Facilities	9	0	0	9	9
Light Rail	Segments	0	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	0	0	0	0	0
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	1	0	0	1	1
	Runways	1	0	0	1	1

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	3	0	0	3	3
Communication	4	0	0	4	4

Table 8 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (miles)	Number of Leaks	Number of Breaks
Potable Water	636	3	1
Waste Water	381	1	0
Natural Gas	254	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	79,157	0	0	0	0	0
Electric Power		0	0	0	0	0

Induced Earthquake Damage

Fire Following Earthquake

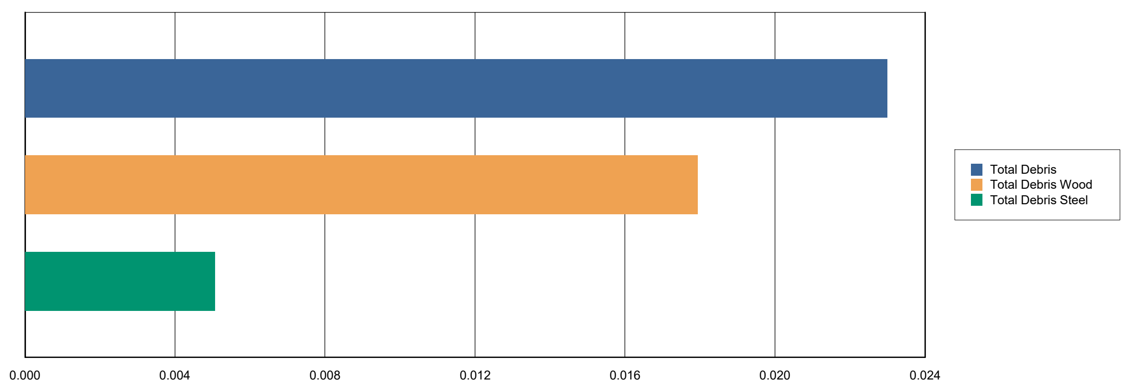
Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. Hazus uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 1 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 23,000 tons of debris will be generated. Of the total amount, Brick/Wood comprises 78.00% 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 920 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Earthquake Debris (millions of tons)



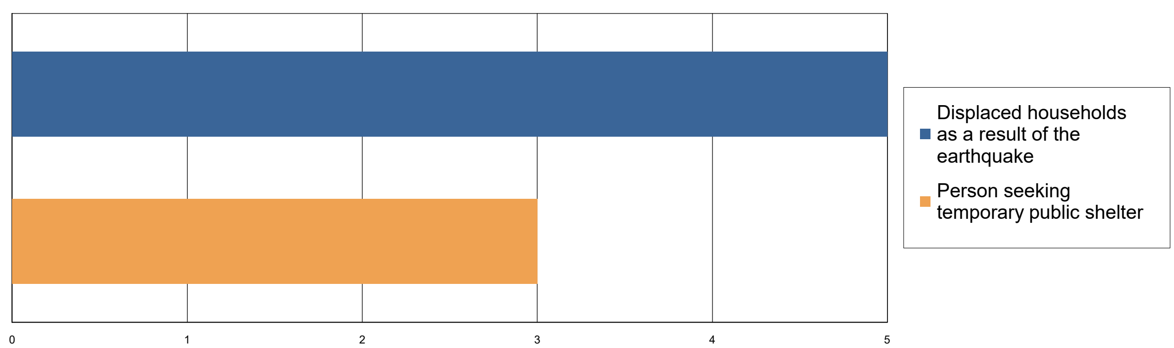
Brick/ Wood	Reinforced Concrete/Steel	Total Debris	Truck Load
0.02	0.01	0.02	920 (@25 tons/truck)

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 5 households to be displaced due to the earthquake. Of these, 3 people (out of a total population of 206,518) 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
5	3

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	0.20	0.03	0.00	0.00
	Commuting	0.00	0.00	0.00	0.00
	Educational	0.00	0.00	0.00	0.00
	Hotels	0.00	0.00	0.00	0.00
	Industrial	0.24	0.03	0.00	0.01
	Other-Residential	3.35	0.24	0.01	0.02
	Single Family	1.91	0.16	0.01	0.02
	Total	**6**	**0**	**0**	**0**
2 PM	Commercial	12.57	1.66	0.14	0.26
	Commuting	0.00	0.00	0.00	0.00
	Educational	8.58	1.11	0.09	0.16
	Hotels	0.00	0.00	0.00	0.00
	Industrial	1.78	0.24	0.02	0.04
	Other-Residential	1.05	0.08	0.00	0.01
	Single Family	0.57	0.05	0.00	0.01
	Total	**25**	**3**	**0**	**0**
5 PM	Commercial	8.44	1.13	0.10	0.18
	Commuting	0.00	0.00	0.00	0.00
	Educational	2.54	0.33	0.02	0.04
	Hotels	0.00	0.00	0.00	0.00
	Industrial	1.11	0.15	0.01	0.02
	Other-Residential	1.29	0.10	0.00	0.01
	Single Family	0.72	0.06	0.00	0.01
	Total	**14**	**2**	**0**	**0**

Economic Loss

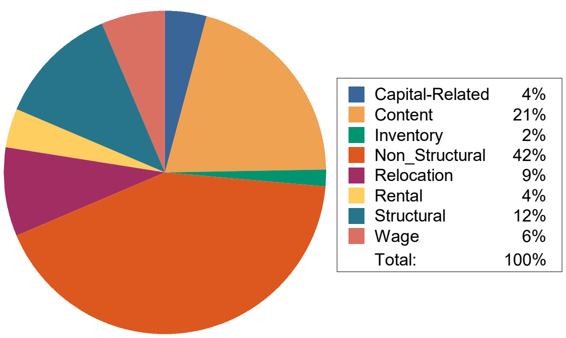
The total economic loss estimated for the earthquake is 103.30 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

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 99.40 (millions of dollars); 23 % 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 31 % 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)

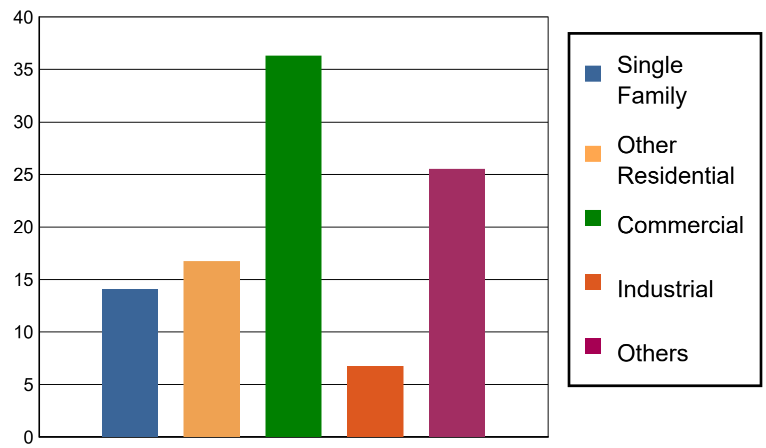


Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.0000	0.6285	4.3155	0.1261	1.2794	6.3495
	Capital-Related	0.0000	0.2676	3.3437	0.0783	0.4264	4.1160
	Rental	0.1832	0.8149	2.1934	0.0620	0.5732	3.8267
	Relocation	0.5973	0.4427	3.0137	0.3035	4.6214	8.9786
	Subtotal	**0.7805**	**2.1537**	**12.8663**	**0.5699**	**6.9004**	**23.2708**
Capital Stock Losses							
	Structural	1.5774	1.4979	4.9507	0.9759	3.0746	12.0765
	Non_Structural	8.5562	9.8637	11.0388	2.9008	9.6254	41.9849
	Content	3.1945	3.1981	6.2826	1.9704	5.9269	20.5725
	Inventory	0.0000	0.0000	1.1499	0.3241	0.0172	1.4912
	Subtotal	**13.3281**	**14.5597**	**23.4220**	**6.1712**	**18.6441**	**76.1251**
	Total	**14.11**	**16.71**	**36.29**	**6.74**	**25.54**	**99.40**

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	1443.2502	0.0000	0.00
	Bridges	704.0582	0.0070	0.00
	Tunnels	5.9010	0.0004	0.01
	Subtotal	**2153.2094**	**0.0074**	
Railways	Segments	3216.2389	0.0000	0.00
	Bridges	51.9000	0.0000	0.00
	Tunnels	0.0000	0.0000	0.00
	Facilities	23.9670	1.0657	4.45
	Subtotal	**3292.1059**	**1.0657**	
Light Rail	Segments	0.0000	0.0000	0.00
	Bridges	0.0000	0.0000	0.00
	Tunnels	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Bus	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Ferry	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Port	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Airport	Facilities	1.2412	0.0529	4.26
	Runways	7.1127	0.0000	0.00
	Subtotal	**8.3539**	**0.0529**	
	Total	**5,453.67**	**1.13**	

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	20.4607	0.0123	0.06
	Subtotal	**20.4607**	**0.0123**	
Waste Water	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	12.2764	0.0062	0.05
	Subtotal	**12.2764**	**0.0062**	
Natural Gas	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	8.1843	0.0021	0.03
	Subtotal	**8.1843**	**0.0021**	
Oil Systems	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Electrical Power	Facilities	49.6291	2.7425	5.53
	Subtotal	**49.6291**	**2.7425**	
Communication	Facilities	0.4640	0.0121	2.61
	Subtotal	**0.4640**	**0.0121**	
	Total	**91.01**	**2.78**	

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	206,518	14,678	13,060	27,738
Total Region		**206,518**	**14,678**	**13,060**	**27,738**

Hazus: Earthquake Global Risk Report

Region Name: WorcesterEarthquak

Earthquake Scenario: 2500year

Print Date: September 18, 2024

Disclaimer:
Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

HAZUS™ FEMA

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 38.45 square miles and contains 46 census tracts. There are over 79 thousand households in the region which has a total population of 206,518 peopleF. The distribution of population by Total Region and County is provided in Appendix B.

There are an estimated 42 thousand buildings in the region with a total building replacement value (excluding contents) of 27,738 (millions of dollars). Approximately 86.00 % of the buildings (and 53.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 5,453 and 91 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

Hazus estimates that there are 42 thousand buildings in the region which have an aggregate total replacement value of 27,738 (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 84% 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 8 hospitals in the region with a total bed capacity of 1,407 beds. There are 75 schools, 11 fire stations, 10 police stations and 1 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 5,544.00 (millions of dollars). This inventory includes over 133.59 miles of highways, 119 bridges, 1,271.33 miles of pipes.

Table 1: Transportation System Lifeline Inventory

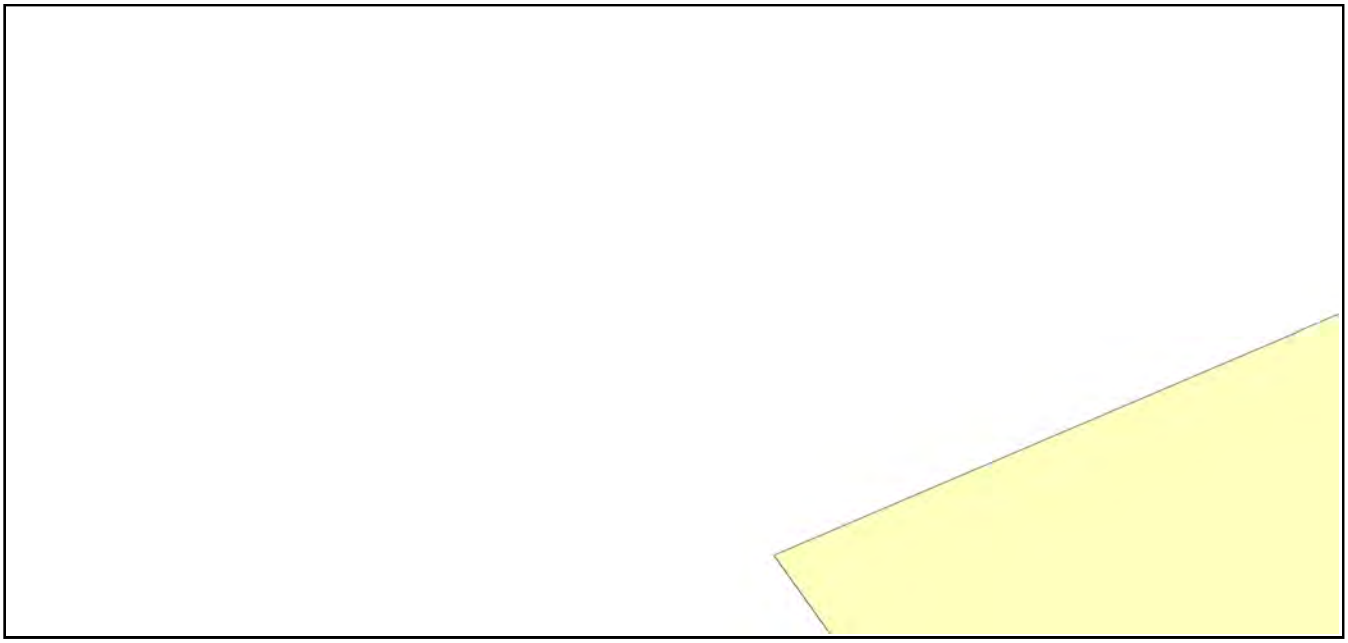
System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	119	704.0582
	Segments	174	1443.2502
	Tunnels	1	5.9010
		Subtotal	**2153.2094**
Railways	Bridges	10	51.9000
	Facilities	9	23.9670
	Segments	40	3216.2389
	Tunnels	0	0.0000
		Subtotal	**3292.1059**
Light Rail	Bridges	0	0.0000
	Facilities	0	0.0000
	Segments	0	0.0000
	Tunnels	0	0.0000
		Subtotal	**0.0000**
Bus	Facilities	0	0.0000
		Subtotal	**0.0000**
Ferry	Facilities	0	0.0000
		Subtotal	**0.0000**
Port	Facilities	0	0.0000
		Subtotal	**0.0000**
Airport	Facilities	1	1.2412
	Runways	1	7.1127
		Subtotal	**8.3539**
		Total	**5,453.70**

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	20.4607
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**20.4607**
Waste Water	Distribution Lines	NA	12.2764
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**12.2764**
Natural Gas	Distribution Lines	NA	8.1843
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**8.1843**
Oil Systems	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**0.0000**
Electrical Power	Facilities	3	49.6291
		Subtotal	**49.6291**
Communication	Facilities	4	0.4640
		Subtotal	**0.4640**
		Total	**91.00**

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	6.50
Depth (km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Direct Earthquake Damage

Building Damage

Hazus estimates that about 466 buildings will be at least moderately damaged. This is over 1.00 % of the buildings in the region. There are an estimated 3 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

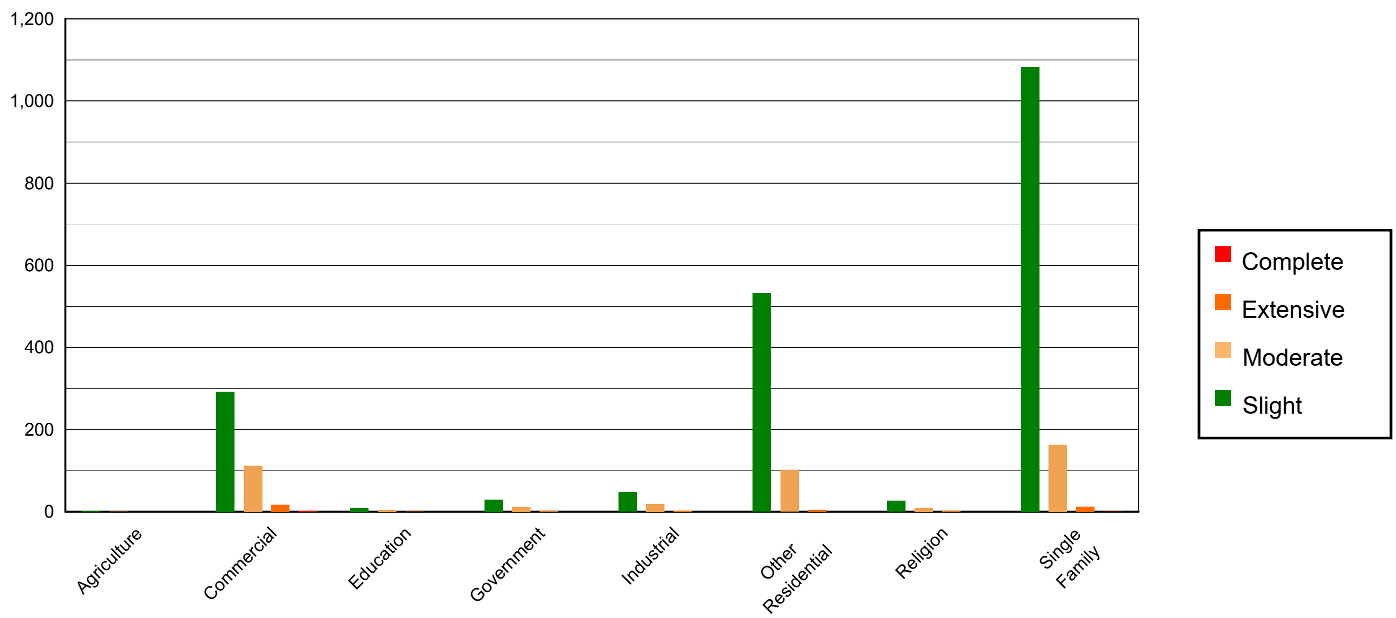


Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	49.43	0.12	2.67	0.13	0.79	0.19	0.10	0.24	0.01	0.27
Commercial	3875.88	9.74	292.71	14.46	112.36	26.63	18.27	44.02	1.78	51.83
Education	111.93	0.28	9.54	0.47	3.87	0.92	0.60	1.44	0.06	1.66
Government	433.05	1.09	29.48	1.46	11.62	2.75	1.70	4.10	0.14	4.10
Industrial	661.90	1.66	47.69	2.36	19.06	4.52	3.08	7.43	0.27	7.85
Other Residential	10790.45	27.13	532.36	26.30	101.96	24.17	4.17	10.04	0.06	1.75
Religion	332.32	0.84	26.37	1.30	8.84	2.10	1.33	3.20	0.14	4.03
Single Family	23518.20	59.13	1083.16	53.52	163.41	38.73	12.26	29.53	0.98	28.51
Total	**39,773**		**2,024**		**422**		**41**		**3**	

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

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	33758.34	84.88	1441.80	71.24	178.20	42.24	6.34	15.28	0.00	0.00
Steel	2197.65	5.53	109.09	5.39	42.51	10.07	4.24	10.23	0.07	2.08
Concrete	274.99	0.69	12.66	0.63	4.32	1.02	0.25	0.61	0.00	0.09
Precast	229.47	0.58	12.25	0.61	6.10	1.45	1.16	2.81	0.01	0.22
RM	32.02	0.08	1.06	0.05	0.32	0.07	0.03	0.07	0.00	0.00
URM	3267.24	8.21	444.82	21.98	189.29	44.86	29.43	70.92	3.35	97.60
MH	13.48	0.03	2.30	0.11	1.18	0.28	0.04	0.10	0.00	0.01
Total	**39,773**		**2,024**		**422**		**41**		**3**	

*Note:
RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 1,407 hospital beds available for use. On the day of the earthquake, the model estimates that only 1,213 hospital beds (86.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 94.00% of the beds will be back in service. By 30 days, 99.00% 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	8	0	0	8
Schools	75	0	0	75
EOCs	1	0	0	1
PoliceStations	10	0	0	10
FireStations	11	0	0	11

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	174	0	0	174	174
	Bridges	119	0	0	119	119
	Tunnels	1	0	0	1	1
Railways	Segments	40	0	0	40	40
	Bridges	10	0	0	10	10
	Tunnels	0	0	0	0	0
	Facilities	9	0	0	9	9
Light Rail	Segments	0	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	0	0	0	0	0
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	1	0	0	1	1
	Runways	1	0	0	1	1

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	3	0	0	3	3
Communication	4	0	0	4	4

Table 8 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (miles)	Number of Leaks	Number of Breaks
Potable Water	636	6	1
Waste Water	381	3	1
Natural Gas	254	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	79,157	0	0	0	0	0
Electric Power		0	0	0	0	0

Induced Earthquake Damage

Fire Following Earthquake

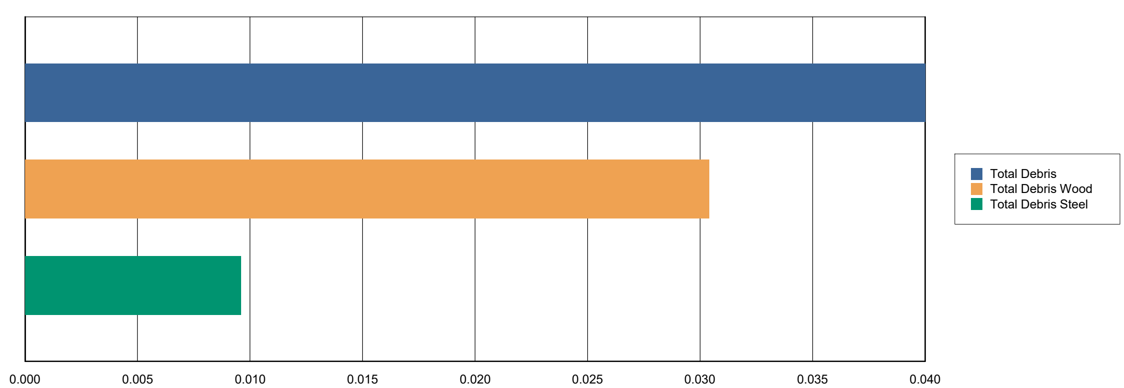
Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. Hazus uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 1 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 40,000 tons of debris will be generated. Of the total amount, Brick/Wood comprises 76.00% 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 1,600 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Earthquake Debris (millions of tons)



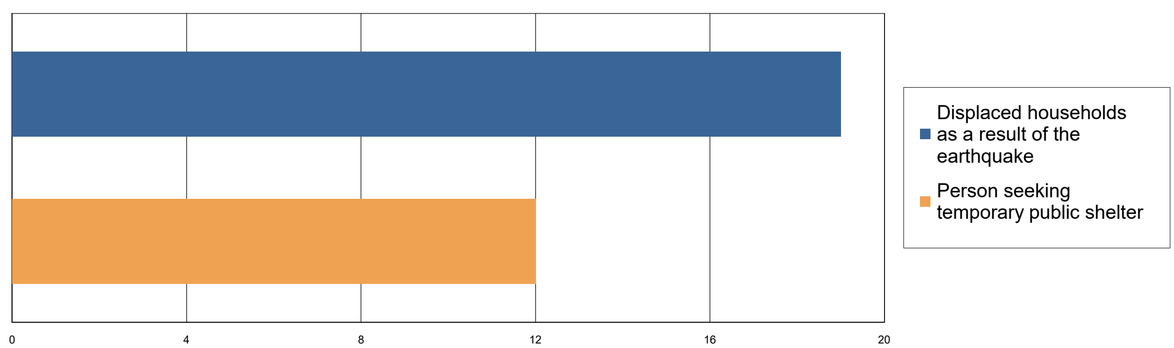
Brick/ Wood	Reinforced Concrete/Steel	Total Debris	Truck Load
0.03	0.01	0.04	1,600 (@25 tons/truck)

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 19 households to be displaced due to the earthquake. Of these, 12 people (out of a total population of 206,518) 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
19	12

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	0.37	0.05	0.00	0.01
	Commuting	0.00	0.00	0.00	0.00
	Educational	0.00	0.00	0.00	0.00
	Hotels	0.00	0.00	0.00	0.00
	Industrial	0.44	0.06	0.01	0.01
	Other-Residential	6.59	0.53	0.02	0.04
	Single Family	3.73	0.33	0.02	0.04
	Total	**11**	**1**	**0**	**0**
2 PM	Commercial	22.92	3.30	0.31	0.58
	Commuting	0.00	0.00	0.00	0.00
	Educational	15.34	2.20	0.20	0.37
	Hotels	0.00	0.00	0.00	0.00
	Industrial	3.24	0.48	0.05	0.09
	Other-Residential	2.08	0.18	0.01	0.01
	Single Family	1.12	0.11	0.01	0.01
	Total	**45**	**6**	**1**	**1**
5 PM	Commercial	15.37	2.25	0.22	0.40
	Commuting	0.00	0.00	0.00	0.00
	Educational	4.51	0.64	0.06	0.10
	Hotels	0.00	0.00	0.00	0.00
	Industrial	2.02	0.30	0.03	0.05
	Other-Residential	2.54	0.21	0.01	0.02
	Single Family	1.41	0.13	0.01	0.02
	Total	**26**	**4**	**0**	**1**

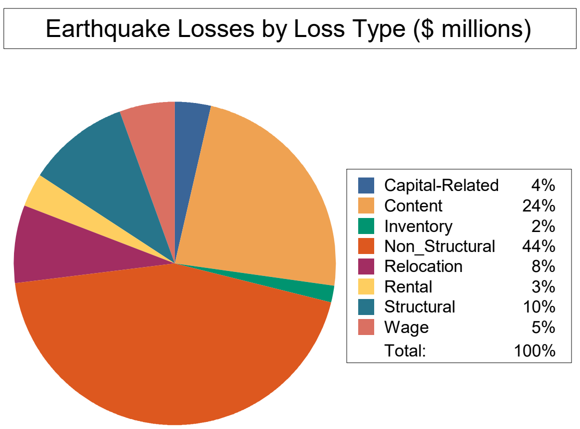
Economic Loss

The total economic loss estimated for the earthquake is 215.35 (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 207.63 (millions of dollars); 20 % 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 33 % of the total loss. Table 11 below provides a summary of the losses associated with the building damage.



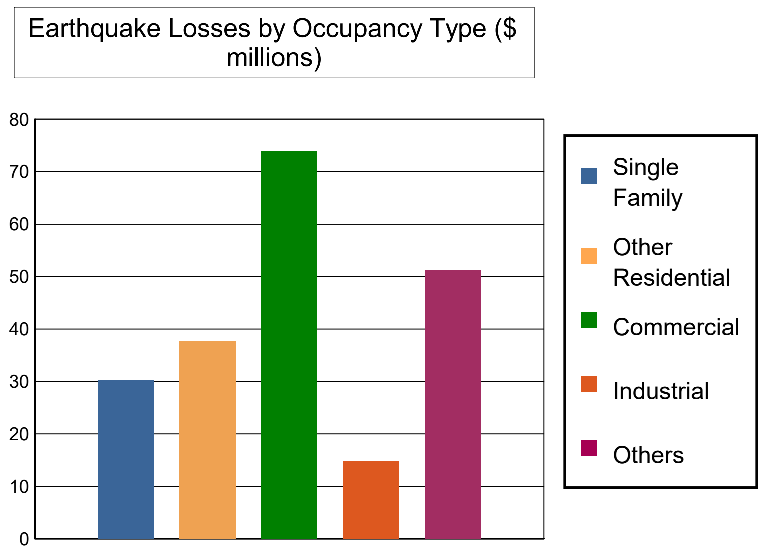


Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.0000	1.1932	7.7085	0.2190	2.1657	11.2864
	Capital-Related	0.0000	0.5080	5.9429	0.1362	0.7190	7.3061
	Rental	0.3718	1.6456	3.7929	0.1075	1.0040	6.9218
	Relocation	1.2404	0.9638	5.3830	0.5351	8.1798	16.3021
	Subtotal	**1.6122**	**4.3106**	**22.8273**	**0.9978**	**12.0685**	**41.8164**
Capital Stock Losses							
	Structural	3.0606	2.9021	8.7079	1.6935	5.3373	21.7014
	Non_Structural	18.1892	22.5764	24.2823	6.6520	19.7030	91.4029
	Content	7.3873	7.8086	15.2500	4.7076	13.9786	49.1321
	Inventory	0.0000	0.0000	2.7660	0.7736	0.0395	3.5791
	Subtotal	**28.6371**	**33.2871**	**51.0062**	**13.8267**	**39.0584**	**165.8155**
	Total	**30.25**	**37.60**	**73.83**	**14.82**	**51.13**	**207.63**

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	1443.2502	0.0000	0.00
	Bridges	704.0582	0.0353	0.01
	Tunnels	5.9010	0.0026	0.04
	Subtotal	**2153.2094**	**0.0379**	
Railways	Segments	3216.2389	0.0000	0.00
	Bridges	51.9000	0.0000	0.00
	Tunnels	0.0000	0.0000	0.00
	Facilities	23.9670	1.7035	7.11
	Subtotal	**3292.1059**	**1.7035**	
Light Rail	Segments	0.0000	0.0000	0.00
	Bridges	0.0000	0.0000	0.00
	Tunnels	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Bus	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Ferry	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Port	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Airport	Facilities	1.2412	0.0844	6.80
	Runways	7.1127	0.0000	0.00
	Subtotal	**8.3539**	**0.0844**	
	Total	**5,453.67**	**1.83**	

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	20.4607	0.0248	0.12
	Subtotal	**20.4607**	**0.0248**	
Waste Water	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	12.2764	0.0125	0.10
	Subtotal	**12.2764**	**0.0125**	
Natural Gas	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	8.1843	0.0043	0.05
	Subtotal	**8.1843**	**0.0043**	
Oil Systems	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Electrical Power	Facilities	49.6291	5.8213	11.73
	Subtotal	**49.6291**	**5.8213**	
Communication	Facilities	0.4640	0.0277	5.97
	Subtotal	**0.4640**	**0.0277**	
	Total	**91.01**	**5.89**	

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	206,518	14,678	13,060	27,738
Total Region		**206,518**	**14,678**	**13,060**	**27,738**