CITY OF FITCHBURG

2020 HAZARD MITIGATION PLAN– MUNICIPAL VULNERABILITY PREPAREDNESS PLAN

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EXECUTIVE SUMMARY

Hazard mitigation planning is a proactive process used to systematically identify policies, actions, and tools that can be used to reduce the dangers to life and property from natural hazard events. Climate adaptation planning recognizes that climate change will exacerbate the vulnerabilities and risks associated with natural hazards. The City of Fitchburg completed a planning process focused on both hazard mitigation planning and climate adaptation, which provides a robust assessment and implementation plan to build the City's resilience. The City is now eligible for hazard mitigation funding through the Federal Emergency Management Agency (FEMA) and climate adaptation funding through the Massachusetts Executive Office of Energy and Environmental Affairs' Municipal Vulnerability Preparedness (MVP) Grant Program.

Planning Process

The Hazard Mitigation Plan and Municipal Vulnerability Preparedness Plan (HMP-MVP Plan) was led by the Fitchburg's Department of Public Works and completed through the following steps.

1) Convened a core team of municipal department heads who provided key input through meeting, online surveys, and interviews.
2) Created a set of hazard mitigation and climate adaptation goals.
3) Engaged the public through a Community Resilience Building Workshop and online public engagement techniques.
4) Established a list of critical facilities and assets.
5) Conducted a vulnerability and risk assessment of historic hazards and the potential impact of climate change.
6) Documented the City's capacity to mitigate and respond to hazards.
7) Detailed progress on the Fitchburg's previously identified action items.
8) Developed an action and implementation strategy.
9) Sought public feedback on the final document.

Hazard Mitigation and Climate Adaptation Goals

The City endorsed the following set of hazard mitigation and climate adaptation goals.

- Develop programs and mitigation measures to protect the following from current natural hazards and future impacts anticipated from climate change:
    - Vulnerable populations and residents.
    - Economic development, commercial, industrial, and residential property.
    - Cultural and historic resources.
    - Critical infrastructure and the built environment.
    - Essential services, such as electric power delivery and drinking water supply.
    - Conservation land, open space, and other natural assets.
- Develop hazard mitigation and climate adaptation measures that employ nature-based solutions and protect the natural environment.
- Incorporate climate adaptation strategies and climate change projections as an integral factor in all City departments, committees, and boards.
- Incorporate climate adaptation and hazard mitigation measures into local plans, bylaws, regulations, and other planning tools to protect critical infrastructure and property, and to encourage resilient development.
- Stay up to date on emerging risks associated with climate change.
- Prioritize payment for all phases of the emergency management cycle, including mitigation, preparation, response, and recovery.

- Increase awareness and provide resources for hazard mitigation to businesses and residents through outreach and education.
- Identify and seek funding for measures to mitigate or eliminate each known significant hazard area and reduce the impacts of climate change.
- Facilitate collaboration in hazard mitigation planning and climate adaptation with local businesses, institutions, non-profits, surrounding communities, and state, regional and federal agencies.
- Prevent and reduce the loss of life, injury, public health impacts, and property damages from natural hazards and the anticipated impacts of climate change.

Vulnerability and Risk

Among the communities of Middlesex County, hazard mitigation and climate adaptation planning tend to focus on flooding because it is one of the most likely natural hazards to impact these communities. However, the Fitchburg's HMP-MVP Plan assesses the potential impacts from a variety of natural disasters including:

Flooding	Extreme Temperatures	Severe Thunderstorms, Wind, and Tornadoes	Nor'easters, Ice Storms, and Severe Snowstorms

The HMP-MVP Plan documents the location and exposure hundreds critical facilities and assets. Among them are emergency services, roads, utilities, social services, and natural resources.

Hazard Mitigation and Climate Adaptation Strategy

Through the planning process, forty-two high priority hazard mitigation and climate adaptation measures were identified covering the following topics:

- Dam Safety
- Culverts and Stormwater Drainage
- Roads and Bridges
- Erosion Control and Critical Facilities Protection
- Communications with Residents
- Shelters
- Municipal Buildings and Services
- Tree Canopy

Next Steps

Fitchburg is dedicated to implementing the findings of this plan and documenting the process. As a now eligible community for funding through the MVP Program and FEMA, the City will look to secure resources, and to work with regional and local stakeholders, to complete the projects identified herein. The City will also continue to document hazard impacts and needed improvements to the City's capacity to mitigate and adapt. Lastly, the City will proactively incorporate the hazard mitigation and climate adaptation goals into municipal planning, budgeting, and operations. By doing so, Fitchburg will be ready to update this plan in five years to maintain its eligibility for grant funding.

1.0 INTRODUCTION

The City of Fitchburg, led by the Department of Public Works, prepared a joint Hazard Mitigation Plan and Municipal Vulnerability Preparedness Plan (HMP-MVP Plan) to create a strategy to reduce the impacts of natural hazards and climate change within the community and the region. The Fitchburg HMP-MVP Plan was adopted by the City Council on Date to update and replace the Montachusett Region Natural Hazard Mitigation Plan 2015 Update.

1.1 What is a Hazard Mitigation Plan?

Natural hazards, such as earthquakes, hurricanes, and flooding, can result in loss of life, disruptions to everyday life, and property damage. Hazard mitigation is the effort to reduce these impacts through community planning, policy changes, education programs, infrastructure projects, and other activities (FEMA, 2020a). Hazard mitigation planning uses a stepped process with participation from a wide range of stakeholders to:

1. define local hazards,
2. assess vulnerabilities and risks,
3. review current mitigation measures, and
4. develop priority action items.

The resulting plan and implementation saves lives and money. For every dollar spent on federal hazard mitigation grants, an average of six dollars are saved (FEMA, 2018a). In other words, investments in preventative measures to reduce property damage and other negative impacts caused by natural hazards is less costly compared to the costs of repair or disaster response if nothing was done. There are many additional benefits of mitigation planning. HMPs increase public awareness of natural hazards that may affect the community. They allow state, local, and tribal governments to work together and combine hazard risk reduction with other community goals and plans. HMPs focus resources and attention on the community's greatest vulnerabilities.

Figure 1-1. FEMA Hazard Mitigation Planning Saves Money Graphic (FEMA, 2018a)

By completing an HMP, municipalities also become eligible for specific federal funding and allow the use of potential funding sources to reflect a community's priorities. Hazard mitigation funding is available through the Federal Emergency Management Agency (FEMA), as summarized in the table below. To be eligible for FEMA Grants, local governments are required to prepare an HMP meeting the requirements established in the *Robert T. Stafford Disaster Relief and Emergency Assistance A*ct, and as amended by the *Disaster Mitigation Act of 2000.*

Table 1-1. FEMA Grants

FEMA Grants	Purpose
Hazard Mitigation Grant Program (HMGP)	Helps communities implement hazard mitigation measures following a Presidential Major Disaster Declaration.
Pre-Disaster Mitigation Program (PDM)	Assists in implementing a sustained pre-disaster natural hazard mitigation program, in order to reduce risk to the population and structures from future hazard events.
Public Assistance Grant Program (PA)	Provides supplemental grants so that communities can quickly respond and recover from major disasters or emergencies.
Fire Management Assistance Grant Program (FMAG)	Available for the mitigation, management, and control of fires on publicly or privately owned forests or grasslands.

(FEMA, 2020b)

1.2 What is a Municipal Vulnerability Preparedness Plan?

In 2017, the Massachusetts Executive Office of Energy and Environmental Affairs (EEA) initiated the Commonwealth's Municipal Vulnerability Preparedness (MVP) grant program to help communities become more resilient to the impacts of climate change. The program provides two grant phases. The first grant phase is the planning grant, which funds a planning process to identify priorities action items to address vulnerabilities and utilize strengths in preparation for climate change. The MVP planning process includes convening a team of municipal staff, engaging stakeholders in a Community Resilience Building (CRB) Workshop following a guidebook developed by the Nature Conservancy (n.d.) and engaging the public. Communities that complete the planning grant program become eligible for the second phase of MVP grant funding (action grants) and receive increased standing in other state grant programs. MVP action grants fund the implementation of priority climate adaptation actions described in the MVP Plan. Since these action grants are only distributed to Massachusetts municipalities, they are much less competitive than similar grants awarded at the national level.

Community Resilience Building Workshop Guidebook

The Community Resilience Building Workshop Guidebook provides a process for developing resilience action plans. The process has been implemented and successful in over four hundred communities. The process is rich in information and dialogue and results in actionable plans and strong collaboration.

The Community Resilience Building Workshop Guidebook's central objectives are to:

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

1.3 Combining Hazard Mitigation and Municipal Vulnerability Preparedness Planning in Fitchburg

The City of Fitchburg received an MVP Planning Grant to prepare a combined MVP and HMP plan. Many of the required steps of the MVP process also satisfy requirements for updating an HMP. As a result, the City prepared this joint HMP-MVP Plan in accordance with FEMA guidelines for hazard mitigation planning (*Title 44 Code of Federal Regulations (CFR) 201.*6) and with the Massachusetts Executive Office of Energy & Environmental Affairs' (EEA) requirements. This enabled Fitchburg to consider the impacts of climate change in its hazard mitigation planning, following the lead established by the Commonwealth when it adopted the first-ever Massachusetts State Hazard Mitigation and Climate Adaptation Plan (EEA and EOPSS, 2018). Fitchburg was specifically interested in incorporating climate resilience and future rainfall data into capital planning and design of its stormwater infrastructure to reduce flooding.

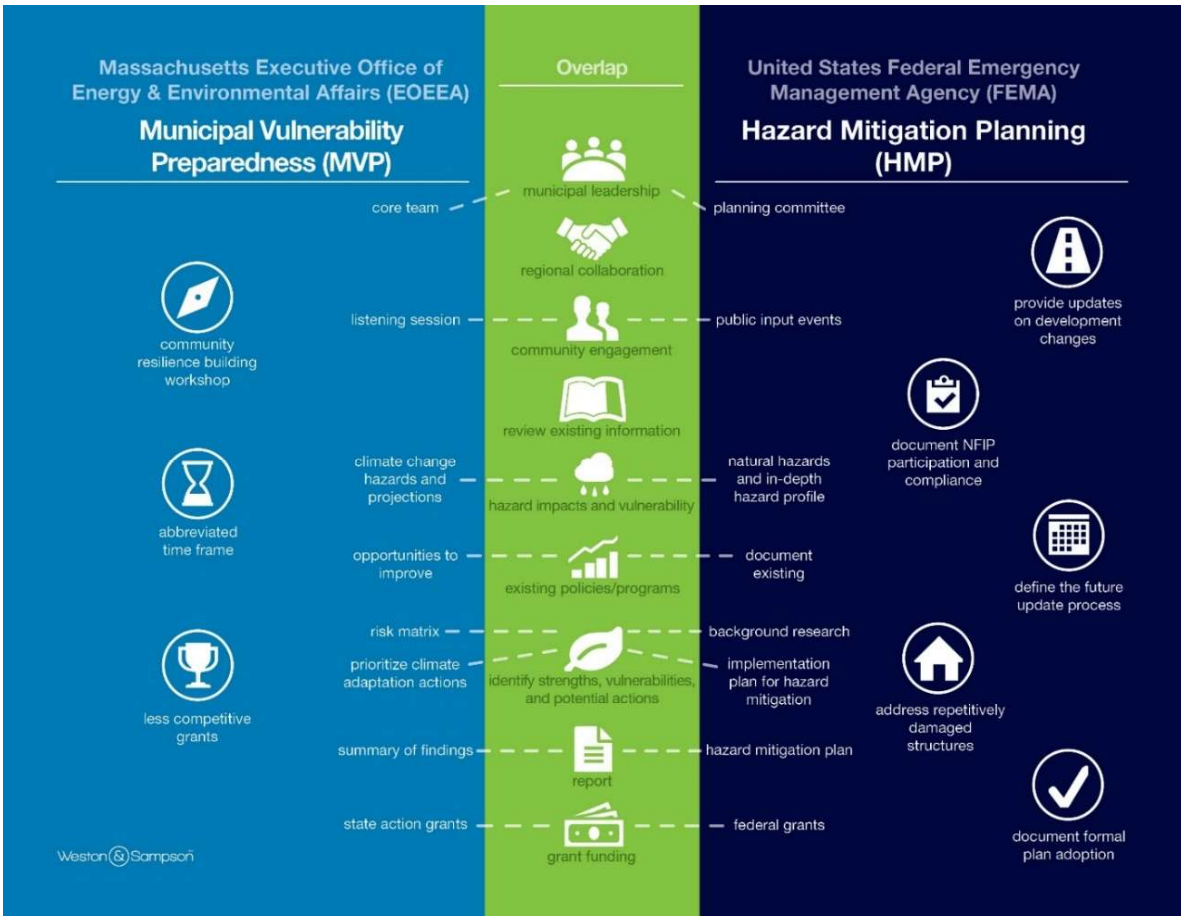


Figure 1-2. Comparison of the MVP and HMP Process (Weston & Sampson)

Facilitating discussion among stakeholders about creating a safer, more resilient community is an important aspect of the natural hazard and climate change impact mitigation planning process. The involvement of a variety of stakeholders in the development of a plan leads to results that better reflect the City's values and priorities. Additionally, the plan is more likely to have greater community support and success in implementing mitigation strategies that reduce risk.

The planning and outreach strategy used to develop this HMP-MVP Plan collected input from three categories of stakeholders:

1. The Core Team, which includes representation from municipal leadership
2. Local, regional, and State stakeholders who could be vulnerable to, or provide strength against, natural hazards and climate change
3. The public, who live and work in the City

1.4 Planning Process Summary

1.4.1 Core Team

The City of Fitchburg convened the Core Team to act as a steering committee for the development of the HMP-MVP Plan. The Core Team met on November 1, 2019 to set goals for the planning process, provide input on historic hazard events, and to plan for the Workshop. The Core Team was then continuously engaged through regular emails, interviews, and the review of deliverables. The Core Team met a second time on April 23, 2020 to discuss the hazard mitigation and climate adaptation strategies and updates to the previous plan. More information on these meetings is included in Appendix A. The Core Team played an important role in identifying critical infrastructure, involving key stakeholders, and capturing the City's current capacity to mitigate hazards alongside ongoing operations. Members of the Core Team are listed in Table 1-2.

Table 1-2. Fitchburg's Core Team

Name	Title/Organization
Ralph Baker	Nashua River Watershed Association/ Fitchburg Greenway Committee
Mark Barbadoro	Building Commissioner
Nicolas Bosonetto	Public Works Commissioner/City Engineer
Stephen Curry	Director of the Health Department
John Deline, Jr.	Deputy Commissioner of Water Supply
Stephen DiNatale	Mayor
Nick Erickson	Civil Engineer
Joel Kaddy	City Councilor, Ward 3
Richard Liberatore	Lieutenant, Fire Department / FEMA Director
Ernest Martineau	Police Chief
Jeffrey Murawski	Deputy Commissioner of Wastewater
Mike O'Hara	Principal Planner / Planning Board Agent
Tricia Pistone	Montachusett Opportunity Council
Tom Skwierawski	Executive Director of Community Development
AJ Tourigny	Chief of Staff
Beth Walsh	City Councilor, Ward 6

The Core Team also suggested or made available reports, maps, and other pertinent information related to natural hazards and climate change impacts in Fitchburg. These included:

- Economic Development Strategic Plan (City of Fitchburg, 2018)
- Fitchburg Open Space & Recreation Plan (Fitchburg, 2014)

- USACE Inspection Report of Nashua River Flood Control System (2018)
- Community Resource Guide (n.d)
- Montachusett Region Hazard Mitigation Plan (MRPC, 2016)
- City of Fitchburg Master Plan 2017 (Fitchburg, 2017)
- Massachusetts Climate Change Projections (NECSC, 2018)
- Massachusetts Climate Change Adaptation Report (EEA, 2011)
- Massachusetts State Hazard Mitigation and Climate Change Adaptation (EEA and EOPSS, 2018)
- Local Mitigation Planning Handbook, May 2017 (FEMA, 2017a)
- Flood Insurance Rate Maps (FEMA, 1991)
- Storm Event Database, National Center for Environmental Information (NOAA, 2019)
- National Water Information System (USGS)
- Decennial Census (US Census Bureau, 2010)
- American Community Survey, 5-year estimates (US Census Bureau, 2014-2018)

1.4.2 Stakeholder Involvement - Community Resilience Building (CRB) Workshop and Beyond

Stakeholders with subject matter expertise and local knowledge and experience, including public officials, regional organizations, neighboring communities, environmental organizations, and local institutions, were invited to engage throughout the planning process. The stakeholder list available in Appendix C represented various perspectives and was used as an invitee list to the CRB Workshop, to promote both listening sessions, and to seek comment on the draft report. The stakeholder list included:

- Members of agencies that have the authority to regulate development, including the Planning Board, Conservation Commission, Fire Department, Building Department, and the Department of Public Works.
- Municipal staff members of the Engineering Division, Water and Sewer Division, Police Department, and Health Department, among many others.
- Representatives of organizations that serve vulnerable populations, including schools, Arc of Opportunity, and Montachusett Opportunity Council.
- State and regional representatives, including members of the Montachusett Regional Planning Commission, Nashua River Watershed Association, Massachusetts Emergency Management Agency (MEMA), and Army Corps of Engineers.
- Neighboring communities of Westminster, Lunenburg, Ashby, and Leominster.

On March 10, 2020, twenty-three of the stakeholders met to participate in the Community Resilience Building (CRB) Workshop. During the first part of the CRB Workshop, Weston & Sampson provided information about natural hazards and climate change. Participants also identified top hazards and infrastructural, societal, and environmental features in the City that are vulnerable to, or provide strength against, these climate challenges. During the second part of the Workshop, participants identified and prioritized key actions that would improve the City's resiliency to natural and climate-related hazards. Materials related to the workshop are included in Appendix C.

Figure 1-3. Mayor DiNatale at Fitchburg's CRB Workshop
(Photo courtesy: Weston and Sampson)

1.4.3 Listening Session

To gather information from the public and to educate the public on hazard mitigation and climate change, the City hosted two public listening sessions. Both listening sessions were advertised online through the website and social media in both English and Spanish. We also solicited support to post flyers and to advertise the event through the stakeholder list, which included help from Montachusett Opportunity Council to reach their network of over 400 people. The first listening session was at the Senior Center, held prior to the workshop on February 25th, 2020, to discuss the overall strengths and vulnerabilities in Fitchburg. The project team had planned to dynamically poll the audience and collect feedback in real-time. However, three people attended the workshop, so the team adapted and was able to spend more time discussing the questions in more depth with attendees.

The second listening session was held virtually due to the public health concerns surrounding COVID-19 on April 16th, 2020. The second listening session presented the results of Community Resilience Building Workshop and a summary of the HMP-MVP Plan in both English and Spanish. A screenshot of the Webinar presentation is shown in Figure 1-4.

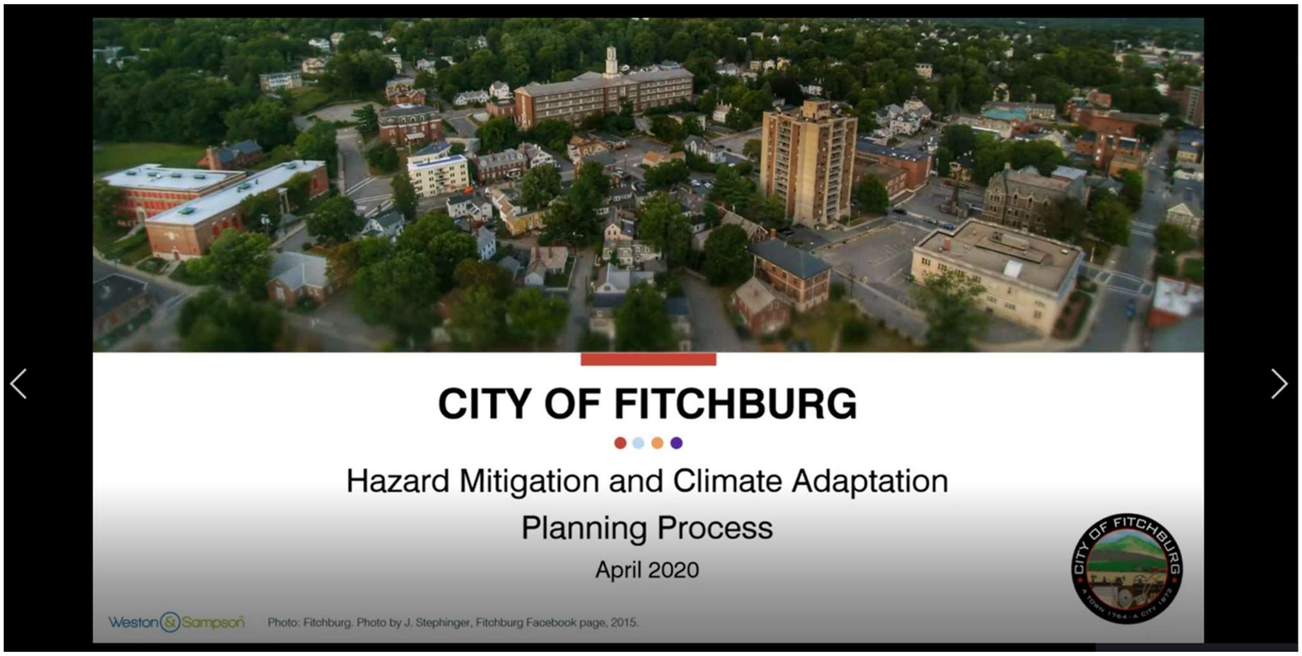


Figure 1-4. Screenshot of Fitchburg's Virtual Public Listening Session Webinar

The second listening session was recorded for posting online, and online surveys have been developed in both Spanish and English. Figure 1-5 shows the announcement for the online survey. Using the City's website for community engagement has facilitated a robust discussion between the project team and Fitchburg residents through both in-person and virtual formats. More information about the meetings and public comments are available in Appendix C.

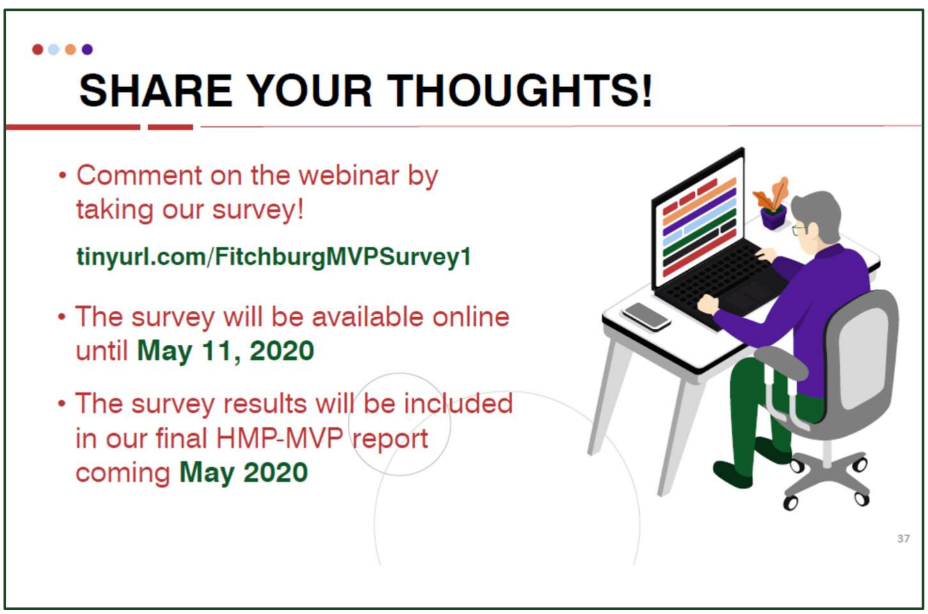


Figure 1-5. A screenshot of the announcement for the Online Survey

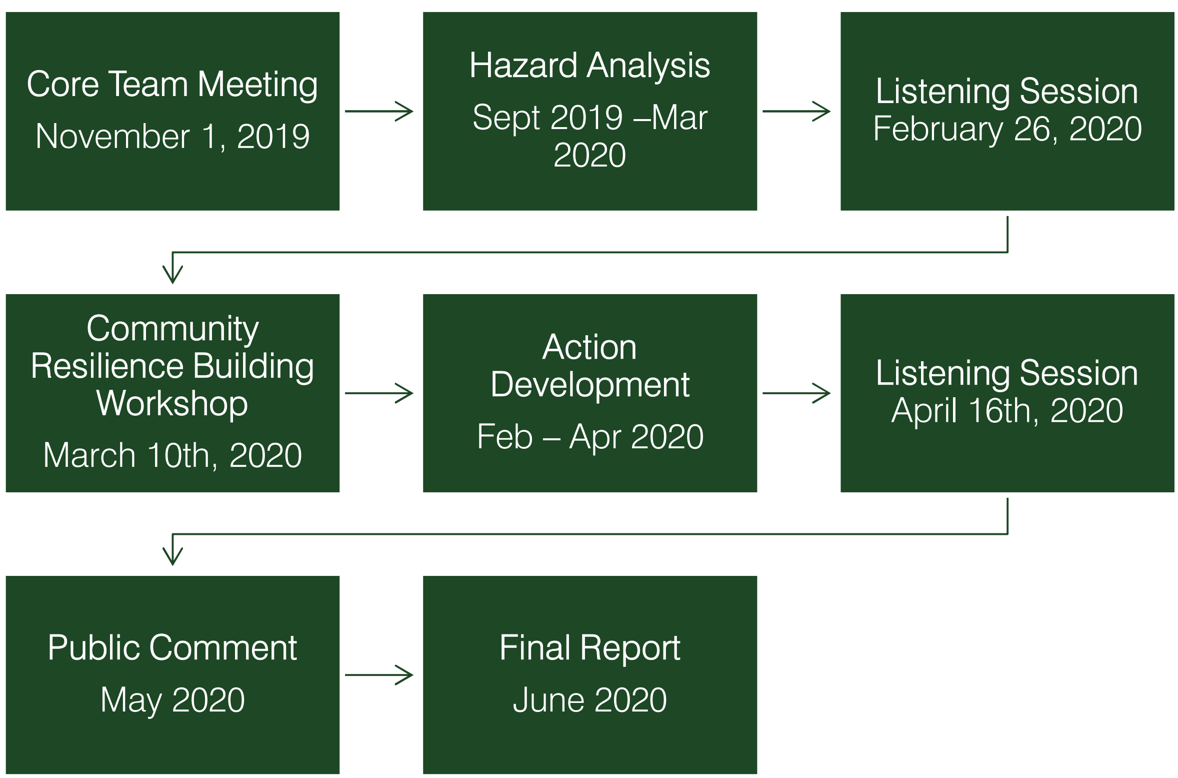
1.4.4 Report Layout

The report presents the results of the planning process, which was informed by input received from the Core Team and during the CRB Workshop and Listening Sessions. This report is organized as follows:

1. Chapter 1: Project introduction and overview
2. Chapter 2: Hazard mitigation and climate adaptation goals
3. Chapter 3: Community profile; societal, economic, infrastructural, and environmental features; land use and development, critical facilities, and vulnerable populations
4. Chapter 4: Detailed assessment of the City's vulnerability and strengths by hazard type. The hazard types include flooding, wind-related risks (such as hurricanes, tropical storms, tornadoes, nor'easters, and severe thunderstorms), winter storms, geological hazards (such as earthquakes and landslides), brush fires, extreme temperatures, and drought. Each profile also describes the hazards historic occurrences and impact, frequency, level of risk, and climate change projections.
5. Chapter 5: Summary of the existing mitigation measures the City is currently undertaking
6. Chapter 6: An update of the progress made since the last HMP
7. Chapter 7: An action plan for next steps
8. Chapter 8: Plan adoption, maintenance, and implementation

1.5 Planning Timeline

The HMP-MVP planning process proceed according to the timeline below.



2.0 HAZARD MITIGATION AND CLIMATE ADAPTATION GOALS

The City of Fitchburg Core Team convened to review and discuss the hazard mitigation and climate adaptation goals for the HMP-MVP Plan. The following goals were developed and endorsed by the Core Team:

- Develop programs and mitigation measures to protect the following from current natural hazards and future impacts anticipated from climate change:
    - Vulnerable populations and residents.
    - Economic development, commercial, industrial, and residential property.
    - Cultural and historic resources.
    - Critical infrastructure and the built environment.
    - Essential services, such as electric power delivery and drinking water supply.
    - Conservation land, open space, and other natural assets.
- Develop hazard mitigation and climate adaptation measures that employ nature-based solutions and protect the natural environment.
- Incorporate climate adaptation strategies and climate change projections as an integral factor in all City departments, committees, and boards.
- Incorporate climate adaptation and hazard mitigation measures into local plans, bylaws, regulations, and other planning tools to protect critical infrastructure and property, and to encourage resilient development.
- Stay up to date on emerging risks associated with climate change.
- Prioritize payment for all phases of the emergency management cycle, including mitigation, preparation, response, and recovery.
- Increase awareness and provide resources for hazard mitigation to businesses and residents through outreach and education.
- Identify and seek funding for measures to mitigate or eliminate each known significant hazard area and reduce the impacts of climate change.
- Facilitate collaboration in hazard mitigation planning and climate adaptation with local businesses, institutions, non-profits, surrounding communities, and state, regional and federal agencies.
- Prevent and reduce the loss of life, injury, public health impacts, and property damages from natural hazards and the anticipated impacts of climate change.

3.0 COMMUNITY PROFILE

3.1 Community Background

The City of Fitchburg is a former industrial city in the State of Massachusetts. Founded in the mid-17th century, the City received its name in 1764 (City of Fitchburg website). Participants in the CRB Workshop commented on the City's sense of community and residents' willingness to offer a helping hand. The City is diverse in many aspects, with a varied topography, neighborhood types that range from rural to urban, and residents that represent diverse backgrounds.

Fitchburg was originally wilderness used for hunting and gathering by local Native Americans. European colonization of the area began in the mid-1600s (University of Massachusetts Boston, 2018). Fitchburg was an agrarian community for the next 150 years, before emerging as the industrial and textile center of north-central Massachusetts. The City's population quadrupled between 1870 and 1920. However, after the closing of textile factories, the population growth was stagnant, and the composition of the population changed. Many higher-income families left for surrounding suburban communities and lower-income households moved into the City's neighborhoods. Fitchburg's economic challenges continued with the decline of local manufacturing. However, over the last decade, Fitchburg has begun to see improvements with active local efforts to bolster economic activity. As one CRB Workshop participant noted, a visitor can walk around Fitchburg and see the City's potential.

Figure 3-1. Left to right: Societal, Infrastructural, and Environmental features of the City of Fitchburg
(Photo courtesy: City Staff and Website)

3.2 Societal Features

Fitchburg is classified as a Gateway City, which is defined under Section 3A of Chapter 23A of the General Laws of Massachusetts as, "a municipality with a population greater than 35,000 and less than 250,000 with a median household income below the Commonwealth's average and a rate of educational attainment of a bachelor's degree or above that is below the Commonwealth's average." The City strives to preserve its historic characteristics, including those represented by the Crocker Field Historic District and the Monument Park Historic District (City of Fitchburg, 2014). Fitchburg also has one documented ancient Native American site and twelve documented historic archaeological sites (Fitchburg Reconnaissance Report, DCR).

Fitchburg has approximately 40,737 residents and in many respects is similar to Massachusetts as a whole (US Census Bureau, 2014-2018). The City of Fitchburg is similar to the State's demographic averages for age distribution, residents with disabilities, and households with limited English fluency. Fitchburg differs from the State's demographic averages for race and ethnicity representation, income and poverty statistics, educational attainment, and renter occupancy. Fitchburg is home to more residents who are white and fewer people of color than Massachusetts overall. Fitchburg's percentage of Hispanic residents is nearly double the Commonwealth's average. Many of the City's Hispanic residents are Puerto Rican. The City's median household income is nearly $25,000 less than the state's average. Fitchburg's poverty rate is 6% higher. The number of Fitchburg residents with a bachelor's degree or higher is approximately half that of the Commonwealth. More information is included in the table below.

Table 3-1. Population Demographics

	2018	Fitchburg	Massachusetts
	Population	40,737	6,602,149
	Under 18	22%	20%
65+	Over 65 Years Old	14%	17%
	White	81%	77%
	Black or African American	5%	8%
	Asian	4%	7%
	Two or More Races	4%	4%
	Other Races	7%	5%
	Hispanic	26%	12%
	Bachelor's Degree or Higher	21%	45%
$	Median Household income	$55,277	$79,835
	Poverty Rate	16%	10%
	With a Disability	15%	12%
	Limited English-Speaking Households	5%	6%
	Renter-Occupancy Rate	47%	38%
	Renters Burdened by Housing Cost	53%	50%

(U.S. Census Bureau, 2014-2018)

Residents who are at a high degree of risk during their day-to-day lives are also more vulnerable during an extreme event. In Fitchburg, seniors, youth, people with disabilities, and low-income residents are considered vulnerable. Vulnerable populations may be at a greater risk of isolation for a variety of reasons, including lack of access to personal transportation, lack of social support, and limited English fluency (if emergency communications are shared in English). Residents with barriers to building personal resilience may also be vulnerable, including those with limited income. Fitchburg also has several Environmental Justice (EJ) neighborhoods. According to Massachusetts Department of Environmental Protection (MassDEP, 2010), EJ neighborhoods have one or more of the following characteristics:

- Income: Block group whose annual median household income is equal to or less than 65 percent of the statewide median ($62,072 in 2010).
- Minority: 25% or more of the residents identify as a race other than white.
- English Isolation: 25% or more of households have no one over the age of 14 who speaks English only or very well.

Figure 3-2 identifies Environmental Justice communities in the City of Fitchburg (next page). The State has defined these neighborhoods in recognition that extreme events have historically disproportionally impacted vulnerable communities. Engaging vulnerable residents in decision making is a critical part of equitable climate change planning processes.

3.2.1 CRB Workshop Discussion of Societal Features

CRB Workshop participants identified key societal features of Fitchburg that are most vulnerable to, or provide protection against, natural hazards and climate change impacts.

Table 3-2. Societal Features in Fitchburg

Strengths	Vulnerabilities
• Partnership with Salvation Army and surrounding communities • Heating and cooling stations and shelters • Fitchburg State University • Communication systems • Grocery stores and local businesses • Certified Emergency Response Team and volunteers • Services provided by schools, emergency services, private, and non-profit entities • Diverse community with many talents and perspectives	• Pets during emergencies • Need for programs to support growing mental health and substance use concerns • Need for more emergency training • Households with limited English-speaking abilities if communication is not translated • Residents at-risk of isolation or in need of additional support (possibly youth and seniors) • Residents with barriers to building personal resilience (possibly low-income residents or residents experiencing homelessness) • Flooding of businesses and the economic impact of hazards • Aging housing stock

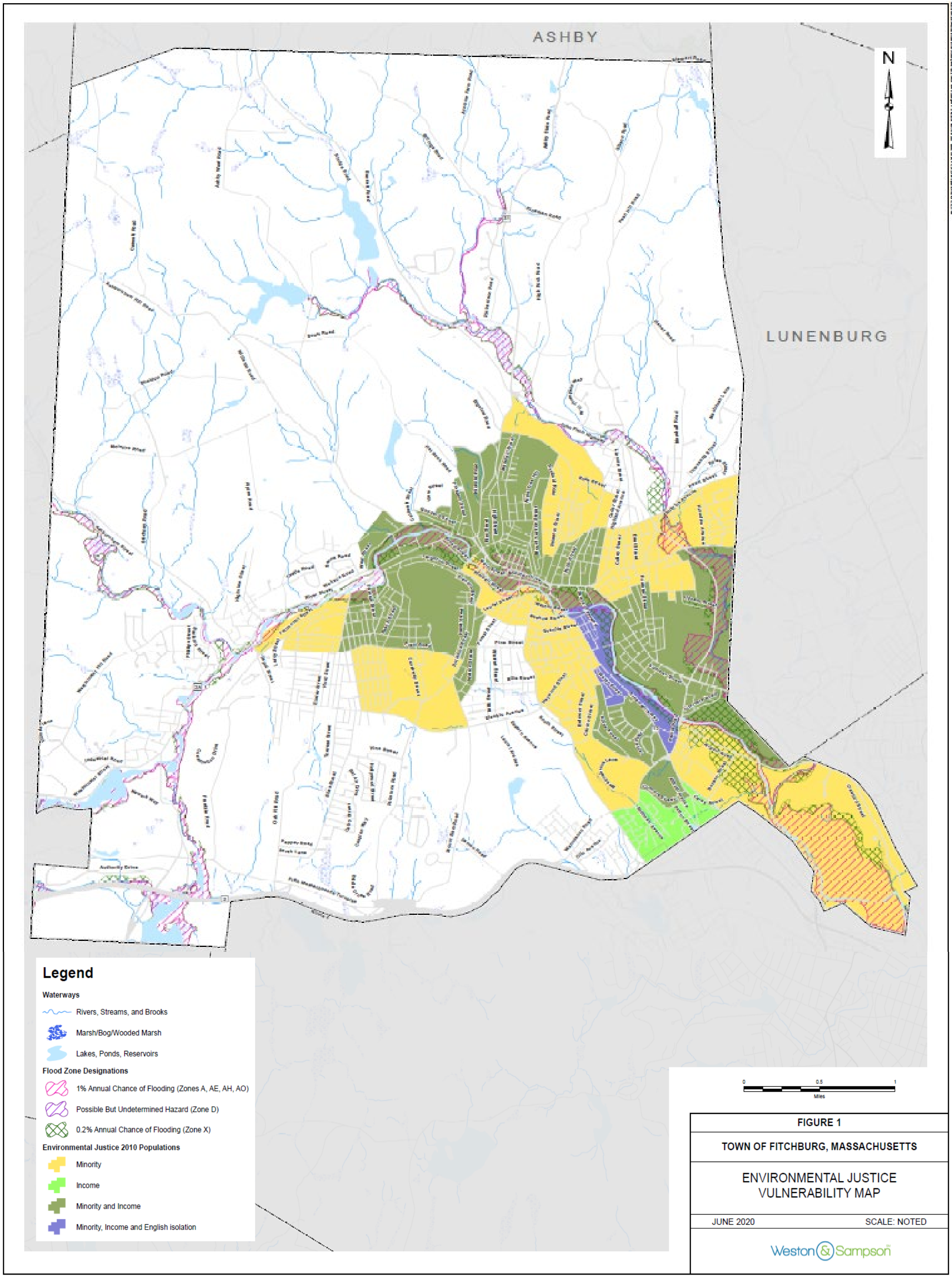


Figure 3-2. Environmental Justice Community Map

3.3 Economic Features

Economic growth and development will positively influence the City's ability to adapt to climate change. Since 2001, the number of businesses in Fitchburg has increased nearly 16%, but almost all are small employers with fewer than five employees (Economic Development Strategic Plan, City of Fitchburg, 2018). The number of jobs fell by 10% during this time. Nearly half of all businesses have fewer than five employees. Large employers with more than 100 employees are primarily in the healthcare and social assistance, manufacturing, and retail fields. Other top employment industries in the City include education, leisure, and hospitality. Communication between the City and businesses about hazard mitigation planning efforts, communication, and developing emergency protocols are key to improving resilience. By supporting local businesses and smart economic growth, Fitchburg also ensures that supplies and food are locally available in the aftermath of an extreme event. As a regional hub for grocery shopping and retail, this is critical to supporting regional resilience.

The health care, social services, and education industries are expected to experience the most growth in the region in the future (Economic Development Strategic Plan, City of Fitchburg, 2018). There is significant unmet demand in the City's food service and drinking retail sector. Fitchburg envisions a future with more mixed-use development and is encouraging its identity as a university city. Future economic growth and strategic planning should consider the needs of a changing environment. For example, improving internet access and bandwidth to allow employees to work from home when roads are impassable. In addition, employers should consider how to keep employees safe during increased temperature and heat wave conditions.

How and where development occurs is critical. There is significant commercial activity in the City center and along John Fitch Highway, which are also in or near the floodplain. New development and redevelopment in this area should account for future flood levels in building design and should invest in resiliency measures. More broadly, new development should be encouraged outside of the floodplain with resiliency considerations for additional hazards such as earthquakes and extreme temperatures. Resilient, mixed-use development that provides public co-benefits such as walkability and sustainable designs that reduce energy demands is also recommended.

3.4 Infrastructure Features

The City of Fitchburg covers 28 square miles in the northern section of Worcester County in the Wachusett Valley. Route 2, or the George Stanton Highway, provides direct access to and from Boston, which is only 46 miles east. Fitchburg is also just north of I-190, which connects the City to Worcester. Fitchburg maintains over two hundred miles of roads, while State roadways are maintained by MassDOT. The City and MassDOT are also responsible for bridge maintenance. There are several bridges with low load restrictions, are not highly rated, or are in need of repair, including Oak Hill Road Bridge, Rindge Road, First Street/Railroad Street (which is a rail bridge), and Westminster Hill Road. Fitchburg has two MBTA commuter rail stations: Fitchburg Station is located on Main Street and Wachusett Station is located on Authority Drive. Local and area bus service is provided by the Montachusett Area Regional Transit. The City's urbanized core has several painted bicycle lanes and sidewalks. Fitchburg has identified several priority projects to improve bicycle and pedestrian mobility in their Complete Streets Implementation Plan, which could possibly overlap with resilient roadway upgrades.

Most of Fitchburg is connected to the public drinking water supply. A small portion of residents in the northern rural areas of the City have private wells. The City sources most of the drinking water from the Meetinghouse and Lovell Reservoirs, where the drinking water treatment plants are located. Bickford

Pond can be pumped into Mare Meadow Reservoir and then pumped from Mare Meadow into Meetinghouse as needed. Wachusett Lake reserved as a backup water supply. Ashby Compensating Reservoir flows into Fitchburg Reservoir, which then flows into Lovell Reservoir. Scott Reservoir can be used as a backup to feed into Lovell by backflowing through an old transmission conduit (the Shattuck conduit). The Water Division needs a new supervisory control and data acquisition (SCADA) system. Approximately 93% of the population is serviced by the public sewer system and the remaining 7% is supported by on-site septic. In some places in the City, the sewer and stormwater systems are combined. The City is currently working to eliminate all combined stormwater-sewer systems to reduce water pollution and provide better service as part of a Consent Decree. Since 2012, the City has successfully completed three sewer separation projects, two phases of their sewer system evaluation survey (SSES), a hydraulic model and capacity assessment, a Water Management Plan, and a chemically enhanced primary treatment upgrade project. Unitil is the City's electric and gas provider.

The City has many municipal facilities that are aging. City Hall is currently being updated, but the Department of Public Works, Fire Department, and Police Department all need new facilities. See Section 3.7 for more information on critical facilities in Fitchburg. See Chapter 4 for information on dams and the North Nashua River Flood Reduction System.

3.4.1 CRB Workshop Discussion of Existing Infrastructure

CRB Workshop participants identified key infrastructure features in Fitchburg that are most vulnerable to, or provide protection against, natural hazards and climate change impacts.

Table 3-3. Infrastructural Features in Fitchburg

Strengths	Vulnerabilities
• Wastewater management facility • Water supply and surrounding protected forested area • School could serve as possible shelter space • Public transit provides additional mobility • Municipal and emergency services • Improved redundancies in electric grid	• Roadways and bridges prone to flooding • Aging bridges • Undersized stormwater conveyance • Combined stormwater-sewer system • Lack of emergency response capacity and equipment • Downtown public safety • Aging dams • Emergency service facilities in the floodplain • Aging municipal buildings • Bank erosion near airport and wastewater treatment plant • Electric substation flooding and need for maintenance

3.5 Environmental Features

Steep topography and the North Nashua River are iconic environmental features in Fitchburg. Fitchburg also has a substantial amount of open space, recreational, and agricultural land owned by the Commonwealth, the City, non-profits, and private entities. More than half of the open space is owned by the City. Two land trusts preserve over 500 acres of publicly accessible land, primarily around the Mass Audubon Society's Flat Rock Wildlife Sanctuary and the North County Land Trust's Crocker Conservation Area (City of Fitchburg, 2018). The City has a plethora of ponds, streams, wetland crossings, lakes, and brooks.

Like many New England communities, Fitchburg has environmental challenges linked to their industrial past. Many sites have had real or perceived soil and groundwater contamination, and several have been remediated (City of Fitchburg, 2014). Although several brownfield locations are scattered throughout Fitchburg, there are no EPA superfund sites. Several potentially hazardous locations are identified in Section 3.7.

Contaminated sites located along the North Nashua river are vulnerable to flooding and leaching, which could spread contamination downstream. Stormwater runoff from roadways, yards, and the previously mentioned combined stormwater-sewer system are other contributors to water quality concerns.

Fitchburg has several areas classified as BioMap 2 Core Habitats or BioMap 2 Critical Natural Landscapes (Massachusetts Division of Fisheries and Wildlife, 2012). Core Habitat is a specific area necessary to promote the long-term persistence of rare species. Critical Natural Landscapes are areas that are minimally impacted by development and, if protected, will provide habitat for wide-ranging native species, support intact ecological processes, maintain connectivity among habitats, and enhance ecological resilience. Five of Fitchburg's roads are designated Scenic Roads (City of Fitchburg, 2014). There are three farms in the Agricultural Preservation Restrictions. Seventeen percent of Fitchburg's lands is conserved in perpetuity (MassAudubon, 2020).

3.5.1 CRB Workshop Discussion of the Environment

CRB Workshop participants identified key environmental features in Fitchburg that are most vulnerable to, or provide protection against, natural hazards and climate change impacts.

Table 3-4. Environmental Features in Fitchburg

Strengths	Vulnerabilities
• Open Space, parks, trails • Nashua River Watershed Association • Urban and rural dimensions • Opportunity for green infrastructure and renewable energy sources • Tree canopy and grant award to plant more trees • Recreational opportunities on North Nashua River and tributaries	• Flooding of waterbodies • Pollutants in waterbodies • Hazardous commercials/industrial landfills/brownfields • Topography and steep terrain • Trees and forested areas vulnerable to wind damage and drought • Invasive species

3.6 Land Use and Recent Development

According to the Massachusetts Assessor Database (2020), which was also used in the flood vulnerability analysis in Chapter 4, Fitchburg has the following land use compilation. Residential is the primary land use (51%). Governmental properties make up 18% of Fitchburg, however, many of the governmental properties are forested natural land or open space (Figure 3-3). To supplement this analysis, MassAudubon's most recent Losing Ground Statistics are reported following the lead of the Fitchburg Open Space and Recreation Plan. Fitchburg had 83 acres of new development between 2012 and 2017. Between 2012 and 2019, 492 acres were permanently conserved. Much of the northern tier of the city is undeveloped.

The city's largest retail area is along the John Fitch Highway and other major arterial roads in the city. Industrial uses are predominately located along the North Nashua River and in the areas of Princeton Road and Airport Road.

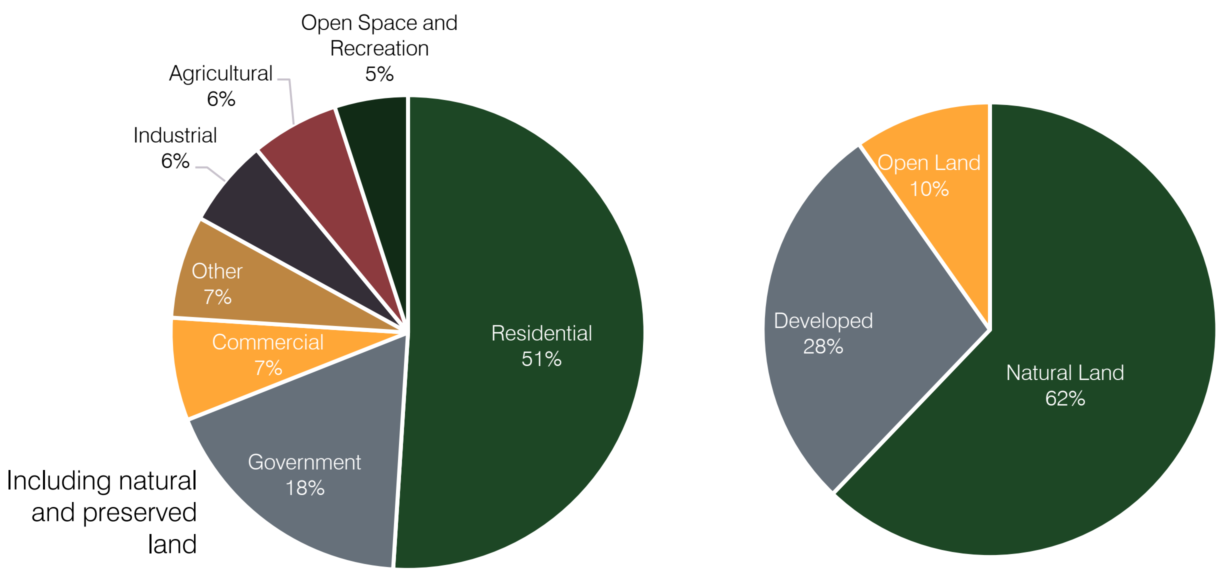


Figure 3-3. Land Use in Fitchburg using the Massachusetts Assessor's Database (Left); MassAudubon's Development Statistics (Right)

The Estimated Build-out table (Table 3-5) provides comparison between number of constructed homes in each Census Tract vs. the total number of homes that could be built in that area. A residential buildout analysis under Vision 2020 plan of City's Master Plan indicated the highest potential for additional development would be in The South Side neighborhood (City of Fitchburg, 1998). The Upper Cleghorn neighborhood has the highest percent build out at 86.6%. The remaining privately owned and forested land encompassing 58% of the City of Fitchburg may be attractive for development. There is potential for zoning updates to preserve the forested areas of the City. Besides loss of natural habitat, stormwater impacts are a growing concern and new regulatory updates may be necessary to reduce polluted runoff from entering waterways.

Table 3-5. Estimated Build-Out for City of Fitchburg

Census Tract	Location	Current Lots	Additional Lots	Total Buildout	% Built Out
7101	South-east Fitchburg, east of the River, to Lunenburg Street	932	84	1016	91.7%
7102	South-Central Fitchburg	1919	1792	3711	51.7%
7103	West Fitchburg	968	1657	2625	36.9%
7104	Upper Cleghorn	697	108	805	86.6%
7105	Lower Cleghorn	632	119	751	84.2%
7106	The South Side	1689	517	2206	76.6%
7107	Downtown, lower Main Street to Academy Street	200	38	238	84.0%
7108	The College Neighborhood, Intown north of Academy Street	1067	586	1653	64.5%
7109	Fitchburg State College	5	11	16	31.3%
7110	South of Pearl Street, North of Lunenburg Street	752	151	903	83.3%
7111	Northern Fitchburg	1382	3895	5277	26.2%
Total		**10,243**	**8958**	**19,201**	**53.3%**

Source: Land Use Section, City of Fitchburg Master Plan (1998)

The Community Development Department provided a list of recent developments (which were defined as occurred during the last ten years) and planned developments (see Table 3-6). The list includes several multifamily units and residential complexes, a brewery, multiple cannabis cultivation developments, two manufacturing and industrial sites, and some mixed-use properties.

Table 3-6. Current and Future Developments in Fitchburg

Name of Development	Address	Type of Development	# housing units	Sqft. commercial /industrial	Date of completion
Gionet	587 South St.	Mixed-use (Multifamily) & Professional (Medical office)	20	4,500	Residential 2021, Office: TBD
Harper Furniture	10 Main St., Summer St.	Mixed-use (multifamily) & Retail/Office	44	10,000	2021
Game on Fitchburg	Westminster Hill Rd.	Indoor/Outdoor Facility for soccer, etc.	N/A	115,000	2021
Gateway Village	255 Main St.	Multifamily Residential	112	N/A	TBD
Gateway Apts II	Snow/North Street	Multifamily Residential	150	5000	TBD

Name of Development	Address	Type of Development	# housing units	Sqft. commercial /industrial	Date of completion
Fitchburg Arts Community	62, 82 Academy St.	Residential - Artist's preferred housing	62	N/A	TBD
Seney PUD	Off Meadowbrook rd.	11 duplexes	22	N/A	TBD
Green Rd Brewing	265 Summer St.	Brewery/Taproom	N/A	3,200	Fall 2020
Garden Remedies	307 Airport Rd	Cannabis Cultivation	N/A	Total 115,000;Max. 20,000 grow canopy	2017
Apothca	99 Development Dr.	Cannabis Cultivation	N/A	Total 36,500;Max. 22,000 grow canopy	2018
Revolutionary Clinics	One Oak Hill Rd.	Cannabis Cultivation	N/A	Max. 70,000 grow canopy	2018
Atlantic Medicinal Partners	744 Crawford St.	Cannabis Cultivation	N/A	Max. 20,000 grow canopy	Summer 2020
Blue Collar Botany	644 River St.	Cannabis Cultivation	N/A	Total 9,000; Max. 4,600 grow canopy	TBD
Native Sun Wellness	140 Industrial Rd.	Cannabis Cultivation	N/A	Total 75,000;Max. 10,000 grow canopy	TBD
NS AJO Holdings	20 Authority Dr	Cannabis Cultivation	N/A	Total 9,000; Max. 5,000 grow canopy	Late 2020
The Hub Craft	25 Newport St.	Cannabis Cultivation	N/A	Total 23,000; Max. 5,000 grow canopy	2021 (Proposed)
The Fresh Connection-Boston	175 Kimball St.	Cannabis Cultivation	N/A	Total 48,000; Max. 10,000 grow canopy	2021 (Proposed)
A Cannabis Grower (to be named later)	310 Broad St.	Cannabis Cultivation	N/A	Total 58,000;Max. 1000 grow canopy	TBD
Apical, LLC	431 Westminster St.	Cannabis Cultivation	N/A	Total 204,000;Max. 50,000 grow canopy	2021
Wastewater Treatment Adaptive Reuse	230 Princeton Road	Green Energy Manufacturing		16 acres (30,000 square feet)	TBD, currently out to an

Name of Development	Address	Type of Development	# housing units	Sqft. commercial /industrial	Date of completion
					RFEI, then RFP
Fitchburg Sandpit Site	0 Airport Road	Industrial	N/A	43.5 acres owned by FRA	2023
Fitchburg Lagoons	0 Princeton Road	Mixed-Use		Over 40 acres owned by the City; Potentially more depending on privately-owned section (Georgia Pacific)	2025

(Shared by Community Development Staff, 2020)

3.7 Critical Facilities and Vulnerable Populations

Critical facilities are extremely essential components to the City's function and protecting them from natural hazards is paramount. Critical facilities include:

1. Resources that can be utilized to respond and recover from natural hazards
2. Facilities where additional assistance might be needed
3. Hazardous sites that could be dangerous if compromised during a natural disaster

Critical facilities in the City of Fitchburg have been identified with help from knowledgeable City staff, MassGIS data, existing city and regional plans, and the assessment of other City features presented in previous sections. Critical facilities and vulnerable populations have been broken into four categories: Emergency Response, Non-Emergency Response, Dangerous/Hazard Materials and Facilities, and Facilities and Populations to Protect.

Table 3-7. Category 1 - Emergency Response Facilities

Police and Fire Department	
Fitchburg- Central Fire Station	33 North Street
Fitchburg- Summer Street Fire Station	42 John Fitch Highway
Fitchburg- Oak Hill Fire Station	231 Fairmont Street
Fitchburg Police Department	20 Elm Street
Emergency Operations Center	
Fitchburg Senior Citizen's Center	14 Wallace Avenue
Communications Infrastructure	
Communication Tower	Flat Rock Road
Verizon Switching Facility MA873207	676 Main Street
Verizon Tower	259 High Rock Road
Verizon Tower	609 Wanoosnoc Road
Radio Towers	Alpine Road
Fitchburg Radio Towers	1080 Franklin Road
Fitchburg Communication Tower	795 High Rock Road

Fire Department Communication Tower	Pratt Road
Emergency Shelters	
FSC- McKay Public School	67 Rindge Road
Fitchburg High School	140 Arnhow Farm Road
Memorial Intermediate School	615 Rollstone Street
Reingold Elementary School	70 Reingold Avenue
BF Brown Arts Vision School	62 Academy Street
Crocker Elementary School	200 Bigelow Road
Saint Bernard's Central Catholic High School	45 Harvard Street
South Street Elementary School	376 South Street
Wallace Civic Center	1000 John Fitch Highway
Fitchburg Senior Citizen's Center	14 Wallace Avenue
Emergency Dispensing Sites	
Crocker Elementary School	200 Bigelow Road
Fitchburg High School	140 Arnhow Farm Road
Fitchburg Senior Citizen's Center	14 Wallace Avenue
FSC- McKay Public School	67 Rindge Road
Memorial Intermediate School	615 Rollstone Street
Reingold Elementary School	70 Reingold Avenue
Saint Bernard's Central Catholic High School	45 Harvard Street
South Street Elementary School	376 South Street
Wallace Civic Center	1000 John Fitch Hwy.
Fitchburg Municipal Airport	563 Crawford Street

Table 3-8. Category 2 - Non-Emergency Response Facilities

City Facilities	
Fitchburg City Hall	166 Boulder Drive
Fitchburg Department of Public Works	301 Broad Street
Fitchburg District Courthouse	100 Elm Street
Fitchburg Public Library	610 Main Street
Water Supply System	
Meetinghouse Reservoir	West Princeton Road, Westminster
Regional Filtration Plant	18 Hager Park Road, Westminster
Lovell Reservoir and Treatment Plant	1200 Rindge Road
Scott Tank and Reservoir	Thurston Road
Oakhill Tank	Franklin Road
Overlook Tank	Flat Rock Road
Falulah Filtration Plant	1200 Rindge Road
Booster Pump Station	25 Royal Plaza Dr
Bickford Pond	

Mare Meadow Reservoir	
Wachusett Lake	
Ashby Compensating Reservoir	
Fitchburg Reservoir	
Falulah Water Storage Tanks	990 Rindge Road
Wastewater Supply System	
West Wastewater Facility	401 Princeton Road
East Wastewater Facility	0 Lanides Lane
Pump Station 1	49 Cobbler Drive
Pump Station 2	75 Sawyer Passway
Pump Station 3	230 Princeton Rd
Transportation Facilities	
First Student Bus	203 Airport Road
Van Pool Transportation Services	47 Summit Street
Train Station MBTA Commuter Rail	100 Main Street
Train Station MBTA Wachusett Commuter Rail	55 Authority Drive
Fitchburg Municipal Airport	567 Crawford Street
Utilities	
Unitil	357 Electric Avenue, Lunenburg

Table 3-9. Category 3 - Dangerous/Hazardous Materials and Facilities

Hazmat Sites	
Omnova Solutions Inc.	119 Authority Drive
DRS Technologies	166 Boulder Drive
Fitchburg State University	160 Pearl Street
Neward America	100 Neward Way
Mocron Products Inc.	25 Sawyer Passway
Steel Fab Inc.	Oak Hill Road
Central Steam Plant	465 Westminster Street
Mar Lee Mold Company, Inc.	207 Authority Drive
Airgas East Inc.	510 Crawford Street
Ryder Fuel Services #0152A	215 Crawford Street
First Student Bus	203 Airport Road
Simonds International Corp.	139 Intervale Road
Jiffy Lube	541 John Fitch Highway
Grief	100 Newark Ave
Micron Products Inc.	41 Sawyer Passway
Verizon Switching Facility MA873207	676 Main Street
Fitchburg Communication Tower	795 High Rock Road
Falulah Filtration Plant	1200 Rindge Road
Fitchburg- East Wastewater Treatment Facility	24 Lanides Lane
MART Garage	R1427 Water Street
Montouri Oil Corp.	125 Main Street
Penske	210 Airport Road
Avery Dennison Corp	224 Industrial Road
Fitchburg Blueberry Lane Landfill (closed)	41 Blueberry Lane
Fitchburg Landfill (Inactive)	1 Collide Park Ave

Former James River Mill 8 Sludge (Inactive)	85 Princeton Road
Star Cleaners	278-280 Lunenburg
British American Club	1 Simonds Rd
Conquest Video	227 Lunenburg Street
Seaboard Folding Box Corp.	35 Daniels Street
Apt Complex	12 - 16 Boyle Court
Independent Cleaners	1 Wallace Rd
Chemdesign Corp	99 Development Road
Matthews Realty Trust	314 John Fitch Hwy
Ast Vault Willow St. Trust	26 Willow Street
Pauls Plate Glass	289 Water Street
Warehouse	640 Crawford Street
Central Plaza Shopping Center	130 Water Street
Commercial Street Realty Trust	40 Commercial Street
Winthrop Steel Co Inc.	53 Prescott Street
Fitchburg Department of Public Works	301 Broad Street
Route 2A	321 Lunenburg Street
Coolidge Park	Pearl Street at John Fitch Hwy
Former Vogue Wall Coverings	68 Airport Road
Proposed CVS Pharmacy 505	Main Street and North Street
Arrhythmia Research Technology	24 Sawyer Passway
Solar Farms	115 Sawyer Passway
Midtown Beef Co	87 Water Street
Underground Storage Tanks	
Ryder Truck Maint.	215 Cranford Street
Francis L. Piermarocchi	232 Airport Road
Petrullo Construction Co. Inc.	28 King Street
East Fitchburg Yard	0 Summer Street
United Co-Operative Farmers, Inc.	402 Broad Street
Montachusett Reg. Vocat. School	1050 Westminster Street
Sunoco	569 Electric Ave
Wachusett Potato Chip Co., Inc	783 Water Street
Francis L. Piermarocchi, Inc	232 Falulah Road
Webber Lumber & Supply Co., Inc	275 Summer Street
West Wastewater Facility	401 Princeton Road
East Wastewater Facility	0 Lanides Lane
City of Fitchburg/Dept of Public Works	301 Broad Street
Demers Bros Inc.	269 Summer Street
George's Citgo Station	130 Lunenburg Street
Paul J. Leclair - Paul's Mobil	938 Main Street
Leon Bellio Eastside Mobil	115 Lunenburg Street
Chemdesign Corporation	99 Development Road
Frank Swett	6 Lunenburg Street
Frank A Swett	10 Lunenburg Street
Nissen Baking Co., Inc	189 Crawford Road
B&D Auto Repair	228 Bemis Road Rear
Paul's Service Station	252 Kimball Street
East Side Energy Group	1200 Main Street
Fitchburg State College	160 Pearl Street
Coca-Cola Co Lowell & Futch	201 Lunenburg Street
Sumer Street Fire Station	0 John Fitch Hwy

Simonds Industries Inc.	0 Intervale Road
Pearson's Auto Radiator Serv.	173 Bemis Road
Montuori Oil Corp.	0 Laurel Street
Delongchamp Automobile Co., Inc.	222 Lunenburg Street
Benson Realty Corp	161 Benson Street
General Electric Company	166 Boulder Drive
Mc Cues Getty	656 Water Street
Main Street Self Serv	0 Main Street
Rohmteck Inc.	119 Authority Drive
Dufour Motors	356 River Street
Oak Hill Contry Club	0 Oak Hill Road
Kmart #4444	140 Whalon Street
Fire Department, City of Fitchburg	28 Oliver Street
Mobil Oil #06GG6	129 South Street & Whalen Street
Rivers Bros Inc.	112 Lunenburg Street
Exxon Co. #-5764	511 Electric Ave
Pelletier's Building Supply Co	133 Water Street
Fitchburg Gas & Electric	285 John Fitch Hwy
Gasoline Merchants, Inc.	249 Kimball Street
Water Street Gulf	447 Water Street
P.B. Morrill	2 Ashby State Road
Main Street Gulf	1022 Main Street
Sherman V. Allen Inc.	0 Garland Street
Sherman V. Allen Inc.	236 Lunenburg Street
Sherman V. Allen Inc.	237 Lunenburg Street
Ronald Boudreao	20 Pratt Street
Fitcburg Sunoco	880 Water Street
Technographics Fitchburg Paper C	601 River Street
James River-Fitchburg, Inc.	0 Old Princeton Road
American Can Company	16 Benson Street
D & D Truck Service, Inc	91 Laurel Street
Mechanic Street Texaco	267 Mechanic Street
Cumberland Farms	479 Electric Avenue
Cumberland Farms #2071	347 River Street
Wanno Sunoco	942 South Street
New England Telephone	676 Main Street
Citgo	449 Mechanic Street
Vogue Wallcoverings	68 Auroirt Road
Ami Trucklease Corporation	210 Falulah Road
Burbank Hospital	0 Nichols Road
Fitchburg Creamery Inc.	25 Ashby State Road
Roadway Express, Inc.	88 Benson Street
Sanitoy Inc	0 Nursery Lane
Cleghorn Oil Inc	25 Pratt Street
Airport Comm., City of Fitchburg	0 Fitchburg Municipal Airport
Cristy Corporation	260 Authority Dr
Sunoco	240 Lunenburg Street
Booster Pump Station	25 Royal Plaza Dr
Montachusett Reg Transit Authority	1427 R Water Street
Speedee Oil Change & Tune-Up	370 John Fitch Hwy
Montvori Oil Corp	2 Boulder Dr

Johnny's Service Station	339 River Street
Joseph R. Morin Inc.	23 Woodbury Ave
Fitchburg Plumbing Supply Co.Inc.	64 Main Street
Fitchburg Municipal Airport	0 Crawford Street
Fitchburg United	1289 Water Street
Fairway Construction Inc.	12 Linda Street
Sherman Allen Inc.	0 Route 2
Chartered Buses Inc.	203 Airport Road

Table 3-10. Category 4 - Vulnerable Populations and Community Facilities

Housing Authority Properties, Elderly Housing Communities, and Long-Term Care Centers	
Durkin Apartments	50 Day Street
Daniel Heights	16 Daniel Street
Wallace Tower	54 Wallace Avenue
Canton Valley Terrace	1 Valley Street
Pleasant Street Residence	132 Pleasant Street
Group/Town View Tower	16 Prichard Street
Fitchburg Green Apartments	350 Water Street
Joseph's House	279 Daniels Street
The Sundial	29 Merriam Parkway
Green Acres Village	13 Normandy Road
Blossom Court Apartments	37-43 Blossom Street
The Gables of Fitchburg	935 John Fitch Hwy.
Golden Living Center	1199 John Fitch Highway
Caldwell Home- Extended Care	10 Prospect Street
The Highlands, A Life Care Center	335 Nichols Street
Hillcrest Nursing Center	94 Summer Street
James Manor Rest Home	222 South Street
Bethel House Rest Home	82 Mechanic Street
Homeless Shelter	
	199 Summer Street
	53 Lunenburg St
	356B Broad Street #4
Institutions of Higher Learning	
Fitchburg State University- Main Campus	160 Pearl Street
Mount Wachusett Community College	326 Nichols Road
Schools and Daycares	
McKay Arts Academy	67 Rindge Road
Crocker Elementary School	200 Bigelow Road
Reingold Elementary School	70 Reingold Avenue
South Street Elementary School	376 South Street
Longsjo Middle School	98 Academy Street
Memorial Middle School	615 Rollstone Street
Fitchburg High School	140 ArnHow Farm Road
Goodrich Academy	111 Goodrich Street
Montachusett Regional Vocational Technical School	1050 Westminster Street
North Central Charter Essential School	500 Rindge Road
Applewild School	120 Prospect Street
St. Bernard’s Elementary	254 Summer Street
St. Bernard’s High School	45 Harvard Street
Irfan, Rebecca	32 3RD Street

Deitzel, Sharon	372 Franklin Road
MOC Child Care & Head Start Services Center / Hosp	110 South Street
Del Orbe, Fatima	179 Summer Street
Northwest Child Development Center of Fitchburg	1400 John Fitch Hwy
Cintron, Adela F.	177 Harrison Avenue
Ngah, Jennifer	541 Arnhow Farm Rd
Barbagallo, Sandra	37 Anita Drive
Stewart, Cheryl	81 Legros Street
Acevedo, Cornelia	9 Ross Street
MOC Child Care and Head Start Services	133 Prichard Street
Fernandez, Rachael	213 Bishop Road
Sosa, GABRIELA	194 Summer Street
Burgos, Aida	355 Pearl Street
Montachusett Regional YMCA Preschool / Kindergarten	55 Wallace Avenue
Slattery, Erin C.	132 Canton Street
Montoya, Giovany	937 Main St Floor 2
Gomez, Patricia	43 Maple Street
Leone, Cheryl	226 Ashby State Road
Silvera, Silvia	107 Daniels Street
Burbank Child Development Center	265 Nichols Road
Children's Aid Child Care Center	1480 John Fitch Hwy
Diaz, Amber	174 Sanborn Street
Cintron, Ana	80 Lawrence Street
Fisher, Julie	46 Farmer Avenue
Aubuchon, Kathleen	491 5th Massachusetts Tpk
Bourque, Kimberly	145 East Street
Spare, Nano T.	12 William Street
Sicard, Diane	149 Highview Street
Selin, Kelly	510 Rollstone Road
Benoit-St. Onge, Pamela	470 Blossom Street
Sinkus, Diana	48 Kaysha Drive
Lizardo, Yisel	22 Columbia Ave
Fuentes, Julie	18 Davis St. #1
Torres, Maragaria	112 Cedar Street
Sanderson, Carol	60 Phillips Passway
Emma, Amy Beth	21 Gloria Avenue
Maclean, Marites	44 Townsend Street
Rojas, Brenda	9 Crown St. Apt. 2
Sadowski, Rebecca L.	74 Whittemore Street
Sacred Heart Preschool and Child Care Center	22 Cottage Street
Becerril, Isabel	111 Canton Street
Manning, Erica	391 Mount Elam Road
Alvarado, Jacqueline	9 Sheridan Street
Tammaro, Melissa	104 Loiselle Avenue
Tabales, Nicole	4 Harrison Ave
Tabales, Nicole	42 Skyview Drive
Maverick Street Family Center	98 Maverick Street
Reyes, Mayra	33 Pearl Street
Ramos, Olga	185 Hazel Street Apt 2
Lacourse, Angelica	21 Hazel Street
Howe, Patricia	31 Charles Street

Guild of St. Agnes - Fitchburg Preschool/School	62 Dover Street
Mendoza, Maria	494 Rollstone Street
Messiah Lutheran Preschool	780 Rindge Rd
Meyer, Heidy	52 Winter Street
Amezcua, Eva	22 Hale Street
Kinsman, Xan	12 Pleasantview Ave
Christian, Diane	100 Abbott Ave
Rodriguez, Elisa I.	15 Wildwood Drive
Cote, Debra T.	124 Depot Street
Hernandez, Maria E.	35 Nutting Street
Caban, Robin	418 Pratt Road
Daigle, Denise	48 Exeter Street
Bylund, Pamela L.	85 Highview Street
Rodriguez, Gretchen	7 Orchard Street
Busy Bees Preschool Center, Inc.	3 Harugari Street
Kids Stop	184 Clarendon Street
Kozy Kids Day Care	372 Franklin Road
Healthcare Services	
Radiology Program @Health Alliance CAN	275 Nichols Road
Veterans Hospice	69 High Street
Health Alliance Hospital-BURBANK CA	275 Nichols Road
Care Net Pregnancy Resource Center	326 Nichols Road
Community Health Connections	275 Nichols Road
LUK Crisis Center	545 Westminster Street
Action Health Services-mobile	275 Nichols Road
Community Health Link Lipton Counsel	275 Nichols Road
Community Health Connection FHC	140 Arnhow Farm Road
Counseling & Assessment Clinic	76 Summer Street
Multicultural Wellness Center	76 summer Street
Reliant Medical Group	370 Lunenburg Street
Riverfront Counseling Center	76 Summer Street
Spectrum Health Systems Inc.	76 Summer Street
Umass Memorial MRI & Imaging Center	275 Nichols Road
CareWell Urgent Care	380 John Fitch Highway
Residential Program Facility	
Seven Hills	149 Pepper Road
Horizon House Male STARR Program	27 Myrtle Avenue
Bridge - STARR	101 South Street
Crisis Center - Therapeutic Foster Care	545 Westminster Street
Seven Hills	33 Cathy Street
Horizon House Female Program	846 Westminster Street
Seven Hills - Kimball Road Program	83 Kimball Road
Food Supply Stores	
CVS Pharmacy	57 Rollstone Road
CVS Pharmacy	96 Water Street
CVS Pharmacy	436 John Fitch Highway
Walgreens	571 John Fitch Highway
Market Basket	399 John Fitch Highway
Market Basket	130 Water Street
JD's Variety	259 Franklin Road
Twin City Market	59 Whalon Street

Millbury Fish Market	60 Bemis Road
Family Dollar	133 Water Street
Dollar Tree	1011 Water Street
Gas Stations	
	115 Lunenburg Street
	129 Whalon Street
	240 Lunenburg Street
	267 Mechanic Street
	656 Water Street
	75 Main Street
	880 Water Street
	237 Lunenburg Street
	449 Mechanic Street
	942 South Street
	479 Electric Avenue
	1313 Water Street
	120 Mass State Hwy, MA-2A
	249 Kimball Street
	2 Boulder Drive
	376 River Street
	339 River Street
	216 Bemis Street
	487 Princeton Road
Hotel/Motel	
Great Wolf Lodge	150 Great Wolf Drive
Howarth House Bed and Breakfast	81 Ross Street
Religious Center	
Masjid Baitul Zikr	370 Main Street
First Baptist Church of Fitchburg	1400 John Fitch Highway
Horizon Christian Fellowship	356 Broad Street
Salvation Army Corps	739 Water Street
Faith Christian Ministries	40 Boutelle Street
Fitchburg Church of the Nazarene	800 South Street
Christ Church	569 Main Street
St Anthony of Padua Church	84 Salem Street
Fitchburg Seventh Day Advent	205 Summer Street
First Parish Unitarian	923 Main Street
St Joseph's Catholic Church	49 Woodland Street
Emanuel Lutheran Church	1200 John Fitch Highway
St Francis of Assisi	Sheridan Street
Messiah Lutheran Church-Missouri Synod	750 Rindge Road
Beth Eden Baptist Church	350 Ashburnham Street
New Life Spanish Christian Church	63 Fairmount Street
Elm Street Congregational	264 Elm Street
Fitchburg Spanish SDA Church	179 Pratt Street
Rollstone Congregational Church	199 Main Street

Table 3-11. Category 5 - Dams

Dams in Fitchburg	
Arden Mills Dam	Nichols St. Dam
Arden-Duck Mill Dam	North Nashua River Mill #4 Dam
Electric Station Dam	North Nashua River Mill #6 Dam
Falulah Reservoir Dam	North Nashua River Mill #9 Dam
Greene's Pond Dam	Overlook Reservoir Dam
James Pond Dam	Overlook Reservoir Dike
Kimball Rd. Dam	Putnams Pond Dam
Lovell Reservoir Dam	Saima Pond Dam
Lovell Reservoir Dike	Scott Reservoir Dam
Lower Spring Pond Dam	Snows Mill Pond Dam
Marshal Reservoir Dam	Swimming Pool Dam
McTaggarts Pond Dam	Upper Sawmill Pond Dam
Mill Pond #1 Dam	Upper Spring Pond Dam
Mirror Lake Dam	Wastewater Treatment Plant Dam
Nichols Pond Dam	Weyerhauser Dam
Dams Owned by Fitchburg Outside of City Limits	
Ashby Reservoir Dam	Mare Meadow Reservoir Dam
Bickford Pond Dam	Meetinghouse Pond Reservoir Dam
Bickford Pond Dike	Smith Pond Dam
Fitchburg Reservoir North Dam	Wachusett Lake Dam
Fitchburg Reservoir South Dam	Wyman Pond Compensating Reservoir Dam
Fitchburg Reservoir South Dike	

4.0 HAZARD PROFILES, RISK ASSESSMENT & VULNERABILITIES

Each hazard profile contains information on the areas vulnerable to the hazard, documentation of historic events, a risk and vulnerability assessment, and related climate change projections. The risk and vulnerability assessment examines both the frequency and severity of hazards and their potential impact to the City of Fitchburg. Each hazard risk and vulnerability assessment uses previous occurrences and climate projections to identify high risk areas and the likelihood that a hazard will occur. The vulnerability analysis looks at various factors in the community, including existing and future buildings, infrastructure, and critical facilities. In some cases, an estimate of the potential dollar loss to vulnerable structures is available. Land uses and development trends were also considered as part of the flood vulnerability assessment.

The hazard profiles were updated with information from the 2013 Massachusetts State Hazard Mitigation Plan (MEMA and DCR, 2013); the 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan (SHMCAP; EEA and EOPSS, 2018) and additional research and assessment conducted by the project team. The Core Team, CRB Workshop, and Listening Session results provided local accounts of each hazard. A Geographic Information System (GIS) assessment was conducted to analyze the potential impact of flooding in Fitchburg on current and future development. FEMA's Hazus software was used to model the potential damage of hurricanes and earthquakes.

4.1 Overview of Hazards and Impacts

4.1.1 Massachusetts State Hazard Mitigation and Climate Adaptation

The 2013 Massachusetts State Hazard Mitigation Plan (MEMA and DCR, 2013) and the 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan (SHMCAP; EEA and EOPSS, 2018) examined the natural hazards that have the potential to impact the Commonwealth. These plans summarize the frequency and severity of hazards of greatest concern. The frequency classification ranges from very low to high. Severity classifications are a range from minor severity to catastrophic.

Definitions used in the Commonwealth of Massachusetts State Hazard Mitigation Plan

Frequency

- *Very low frequency*: events that occur less frequently than once in 100 years (less than 1% per year)
- *Low frequency*: events that occur from once in 50 years to once in 100 years (1% to 2% per year)
- *Medium frequency*: events that occur from once in 5 years to once in 50 years (2% to 20% per year)
- *High frequency*: events that occur more frequently than once in 5 years (Greater than 20% per year)

Severity

- *Minor*: Limited and scattered property damage; limited damage to public infrastructure and essential services not interrupted; limited injuries or fatalities.
- *Serious*: Scattered major property damage; some minor infrastructure damage; essential services are briefly interrupted; some injuries and/or fatalities.
- *Extensive*: Widespread major property damage; major public infrastructure damage (up to several days for repairs); essential services are interrupted from several hours to several days; many injuries and/or fatalities.
- *Catastrophic*: Property and public infrastructure destroyed; essential services stopped; numerous injuries and fatalities.

Table 4-1 summarizes the frequency and severity of hazard risk in the overall State. These frequency and severity classifications for the State will provide an idea to the City in prioritizing mitigation actions for each hazard.

Table 4-1. Massachusetts Hazard Risk Summary

Hazard	Frequency	Severity
	Massachusetts	Massachusetts
Inland Flooding	High (1 flood disaster declaration event every 3 years; 43 floods per year of lesser magnitude)	Serious to Catastrophic
Dam failures	Very Low	Extensive to Catastrophic
Coastal Hazards	High (6 events per year over past 10 years)	Serious to Extensive
Tsunami	Very Low (1 event every 39 years on East Coast, 0 in MA)	Extensive to Catastrophic
Hurricane/Tropical Storm	High (1 storm every other year)	Serious to Catastrophic
High Wind (Severe Weather)	High (43.5 events per year)	Minor to Extensive
Tornadoes (Severe Weather)	High (1.7 events per year)	Serious to Extensive
Thunderstorms	High (20 to 30 events per year)	Minor to Extensive
Nor'easter	High (1 to 4 events per year)	Minor to Extensive
Snow and Blizzard (Severe Winter Weather)	High (1 per year)	Minor to Extensive
Ice Storms (Severe Winter Weather)	High (1.5 per year)	Minor to Extensive
Earthquake	Very Low (10-15% probability of magnitude 5.0 or greater in New England in 10 years)	Minor to Catastrophic
Landslide	Low (once every two years in western MA)	Minor to Extensive
Brush Fires	High (at least 1 per year)	Minor to Extensive
Extreme Temperatures	High (1.5 cold weather and 2 hot weather events per year)	Minor to Serious

Hazard	Frequency	Severity
	Massachusetts	Massachusetts
Drought	High (8% chance of "Watch" level drought per month [recent droughts in 2016 and 1960s])	Minor to Serious

Table adapted from the 2018 SHMCAP and 2013 Massachusetts State Hazard Mitigation Plan

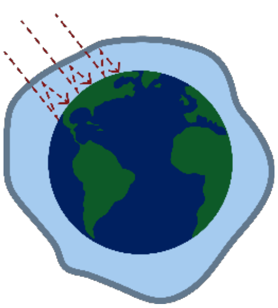
Not all hazards included in the 2018 State Hazard Mitigation and Climate Adaptation Plan or the 2013 Massachusetts State Hazard Mitigation Plan apply to the City of Fitchburg. Given Fitchburg's inland location, coastal hazards and tsunamis are unlikely to affect the City. Given the type of fires that have occurred in Fitchburg's history, the City will focus on brush fires rather than wildfires. It is assumed that the entire City of Fitchburg and its critical facilities are exposed to earthquakes, high wind events, hurricanes, winter storms, temperature extremes, and snow and ice, to a similar extent. Flood risk from riverine flooding is elevated in the vicinity of flood zones. Landslides are more likely in areas with more unstable soils types.

4.1.2 Federally Declared Disasters in Massachusetts

Tracking historic hazards and federally declared disasters that occur in Massachusetts, and more specifically Worcester County, helps planners understand the possible extent and frequency of hazards. Historically, Massachusetts has experienced multiple types of hazards, including flooding, blizzards, and hurricanes. Since 2000, there have been 29 storms in Massachusetts that resulted in federal or state disaster declarations. 22 disaster declarations occurred in Worcester County. Federally declared disasters present additional FEMA grant opportunities for regional recovery and mitigation projects. The hazard profiles included in this chapter contain more information about federally declared disasters.

4.1.3 Impacts of Climate Change

Many of the hazards that Fitchburg commonly experiences are projected to worsen due to climate change. Climate change refers to changes in regional weather patterns that are linked to warming of the Earth's atmosphere as a result of both human activity and natural fluctuations. The Earth's atmosphere



has naturally occurring greenhouse gases (GHGs) like carbon dioxide (CO2) that capture heat and contribute to the regulation of the Earth's climate. When fossil fuels (including oil, coal and gas) are burned, GHGs are released into the atmosphere and the Earth's temperature tends to increase. The global temperature increase affects the jet stream and climate patterns. Due to these changes, the future climate in Massachusetts is expected to resemble historic climate patterns of Southern New England or Mid-Atlantic States more closely, depending upon GHG emission scenarios. Climate change has already started to impact Massachusetts and these trends are likely to continue. Climate change is likely to affect Massachusetts's typical precipitation cycle, leading to more intense rainfall and storms and more episodic or flash droughts. Temperatures will increase in both summer and winter. Each of the hazard profiles provided below includes more detail on how hazard frequency and intensity is likely to shift with climate change.

4.1.4 Top Hazards as Defined in the CRB Workshop

Workshop participants were asked to identify the four top hazards/climate change impacts that Fitchburg faces. Extensive discussion led to the selection of the following:

- Flooding
- Severe Thunderstorms, Wind, and Tornadoes
- Extreme Temperatures
- Nor'easters, Ice Storms, and Severe Snowstorms

The workshop was designed to bring stakeholders together to brainstorm action items that will facilitate a climate resilient future while also supporting the City's unique features and characteristics. Concerns related to hazardous events such as flooding, and snowstorms were topics of discussion. Stakeholders cited building placements in flood zones and limited parking during snowstorms and discussed possible improvements. Workshop participants also reviewed challenges impacting the school system, vulnerable populations, and available housing. There was extensive discussion about winter storms, wind causing power outages, and the potential for future events to worsen in frequency and severity. Stakeholders described how power outages from severe storms can leave many residents without power for extended periods. Fitchburg has a large number of trees, which can be a great strength to the community, but can also be a challenge when they cause damage to overhead power lines and strong storms. Workshop participants highlighted that access to power and backup power sources during natural hazard events is one of the most pressing issues. There was discussion about cutting back tree cover to eliminate tree hazards over power lines.

Another prevalent natural hazard identified for Fitchburg was flooding of the North Nashua River. Workshop participants discussed examples of localized flooding experienced during extreme precipitation events. Areas that experience recurring flooding may limit emergency access to assist vulnerable populations during an extreme event. There was discussion about emergency evacuation procedures for these populations. The sizing of storm water drainpipes in lower lying areas, as well as hilly areas where drainage issues occur, is critical. These drains will need to be updated to accommodate flash flooding events.

4.2 Flood-Related Hazards

Flooding was among the four main hazards identified by participants during Fitchburg's CRB Workshop. Flooding can be caused by various weather events including hurricanes, extreme precipitation, thunderstorms, nor'easters, and winter storms. Flooding can be both riverine (topping the banks of streams, rivers, ponds) and from stormwater that is not properly infiltrated into the ground. While Fitchburg experiences these events, the impacts of climate change will likely lead to increasingly severe storms and increasingly severe impacts. The impacts of flooding include injury or death, property damage, and traffic disruption. The winter and spring thaw can also bring flooding challenges to the city, with clogged catch basins or ice flowing into dams.

Flood hazards are directly linked to erosion, which can compromise receiving water quality, slope stability, and the stability of building foundations. This puts current and future structures and populations located near steep embankments at risk. Erosion can also undercut streambeds and scour around stream crossing, creating a serious risk to roadways. Residents identified erosion occurring near the airport and the South Wastewater Treatment Plant. Figure 4-1 shows the impact of precipitation on the State.

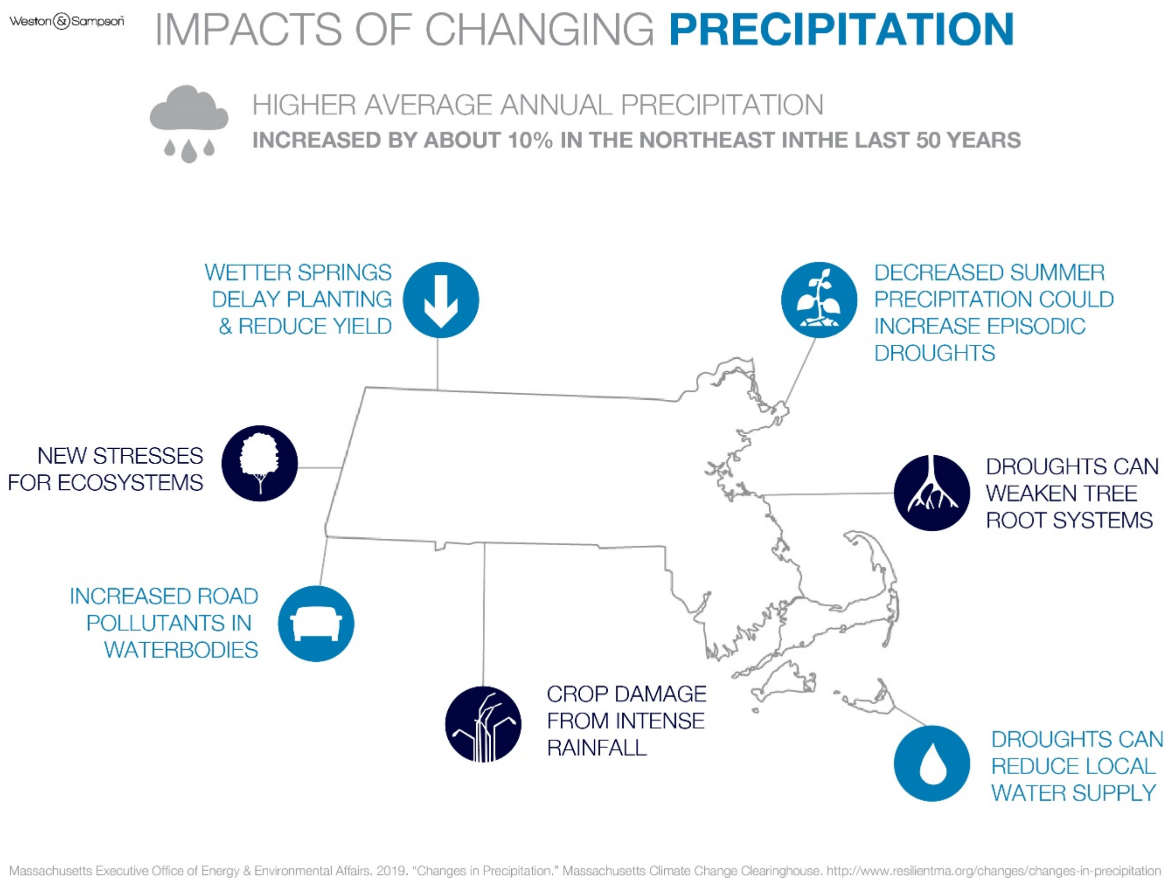


Figure 4-1. Impact of changing precipitation in future on the State of Massachusetts

Areas within the FEMA Flood Zones, repetitive loss sites, and local areas identified as flood prone are more vulnerable to the impacts of flooding. The following sub-sections provide more information on historic flooding events, potential flood hazards, a vulnerability assessment, locally identified areas of flooding, and information on the risk of dam failures. The vulnerability assessment of flood hazard areas was informed by the FEMA NFIP Flood Insurance Rate Maps (FIRMs) and a GIS vulnerability analysis. Flooding events in Fitchburg have been classified as a high frequency event. 2013 Massachusetts State Hazard Mitigation Plan, this hazard occurs more frequently than once in 5 years or greater than 20% per year.

4.2.1 Areas Vulnerable to Flooding

4.2.1.1 <u>Riverine Flooding</u>

The entire City of Fitchburg is located within the North Nashua River Watershed. There are numerous rivers, streams, ponds, wetland crossings, lakes, and reservoirs. The North Nashua River runs through the southern portion of the City and is at some points parallel to Main Street. Greene Pond is located east of John Fitch Highway. Overlook, Falulah, Lowell, and Scotts Reservoirs are in the west/northwest area within the City boundaries of Fitchburg. Residents identified flooding in the area surrounding John Fitch Highway.

FEMA Flood Insurance Rate Maps (FIRM) designate areas likely to experience flooding. The FIRM delineates both the special flood hazard areas and the risk premium zones under the NFIP. This includes high risk areas that have a one percent chance of being flooded in any year (often referred to as the "100-year floodplain"), which under the NFIP, is linked to mandatory flood insurance purchase requirements for federally backed mortgage loans. It also identifies moderate to low risk areas, defined as the area with a 0.2 percent chance of flooding in any year (often referred to as the "500-year floodplain"). The definitions of these flood zones are provided below. FEMA-designated flood zones for Fitchburg (FEMA, 1991) are included in Appendix B. The FEMA flood zone surrounds most of the water bodies and wetlands areas listed in the previous paragraph.

Flood Insurance Rate Map Zone Definitions

Zone A (1% annual chance): Zone A is the flood insurance rate zone corresponding to the 100-year floodplains that are determined in the Flood Insurance Study (FIS) by approximate methods. Detailed hydraulic analyses are not performed for such areas, therefore, no BFEs (Base Flood Elevations) or depths are shown within this zone. Mandatory flood insurance purchase requirements apply.

Zone AE and A1-A30 (1% annual chance): Zones AE and A1-A30 are the flood insurance rate zones that correspond to the 100-year floodplains that are determined in the FIS by detailed methods. In most instances, BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone. Mandatory flood insurance purchase requirements apply.

Zone X (0.2% annual chance): Zone X is the flood insurance rate zone that corresponds to the 500-year floodplains that are determined in the Flood Insurance Study (FIS) by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no BFEs or depths are shown within this zone.

Source: (FEMA, 2019b) https://www.fema.gov/flood-zones

Repetitive Loss Sites

As defined by FEMA and the NFIP, a repetitive loss property is any insured property which the NFIP has paid two or more flood claims of $1,000 or more in any given 10-year period since 1978 (FEMA, 2019e). There are 4 repetitive loss properties in Fitchburg (Table 4-2). Three properties are residential buildings and one property is a non-residential building (FEMA, 2019g). Two of the City's repetitive loss buildings are located within the Zone A floodplain. The remaining two repetitive loss buildings are located within B, C, or X zones, which are defined by FEMA as areas of moderate or minimal flood hazard. One of the repetitive loss structures is not insured (DCR, 2020a).

Table 4-2. Summary of Repetitive Loss Properties

Repetitive loss structure details	Number of properties
Repetitive Loss Buildings (Total)	4
Repetitive Loss Buildings (Insured)	3
Repetitive Losses (Total)	15
Repetitive Losses (Insured)	13
Repetitive Loss Payments (Total)	$197,562.54
Building	$192,043.53
Contents	$5,519.01
Repetitive Loss Payments (Insured)	$186,513.17
Building	$180,994.16
Contents	$5,519.01

(Source: FEMA 2019g; DCR, 2020a)

Notably, repetitive loss data only includes buildings that qualify for the repetitive loss designation, which does not represent all losses due to flooding. The number of buildings that experience losses due to flooding is likely higher than what is reported above.

Stormwater Flooding

Stormwater flooding occurs during a precipitation event where the rate of rainfall is greater than the capacity of the stormwater management system. This may be due to an undersized culvert, poor drainage, topography, high amounts of impervious surfaces, or debris that causes the stormwater system to function below its design standard. In these cases, the stormwater management system becomes overwhelmed, causing water to inundate roadways and properties. In the City of Fitchburg, the combined stormwater sewer system causes additional capacity and public health concerns. The City has many old stone culverts that were installed over 100 years ago and only some of their locations are known. They are often undersized and structurally deficient.

Most stormwater systems in Massachusetts are aging and have been designed with rainfall data that is no longer accurate. Figure 4-2 shows how anticipated rainfall during design storms has increased from 1961 to 2015, especially for the larger 24-hour, 100-year event. Green infrastructure or low impact development improvements can help reduce demand on the existing stormwater system by increasing infiltration on-site. Rain gardens and pervious pavement are two examples of possible strategies. Upsizing culverts with new rainfall data is also recommended.

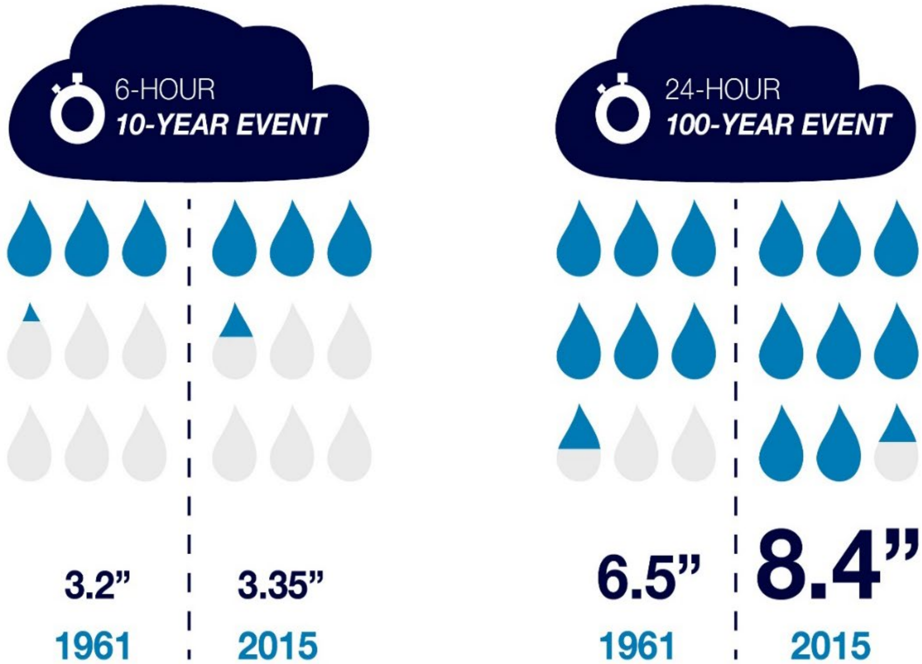


Figure 4-2. Stormwater Design Standards (NOAA TP 40, 1961 and

Hydrographs, or graphs of the streamflow, can be used to illustrate the impact of impervious surface and stormwater runoff. Hydrographs of natural streams generally see a gradual increase in the amount of flow during rain events as stormwater flows into the waterways via the surface and groundwater. Hydrographs of urban streams generally have a large spike, which indicates stormwater rushing into the waterbody through conveyance systems and off impervious surfaces.

The U.S. Geological Survey (USGS) manages a streamflow gauging station on the North Nashua River. As Figure 4-3 indicates, the discharge exceeded seven hundred cubic feet on April 13, 2020 (USGS 01094400 North Nashua River at Fitchburg, MA, as of April 20, 2020) after a large spike in the flow. The large spike could indicate that much of the stormwater is not being infiltrated into the ground, but rather directed into the North Nashua River. Fitchburg’s terrain is also very hilly in places with ledge and hard pan soil layers, which can create high volumes of runoff and challenges for groundwater recharge.

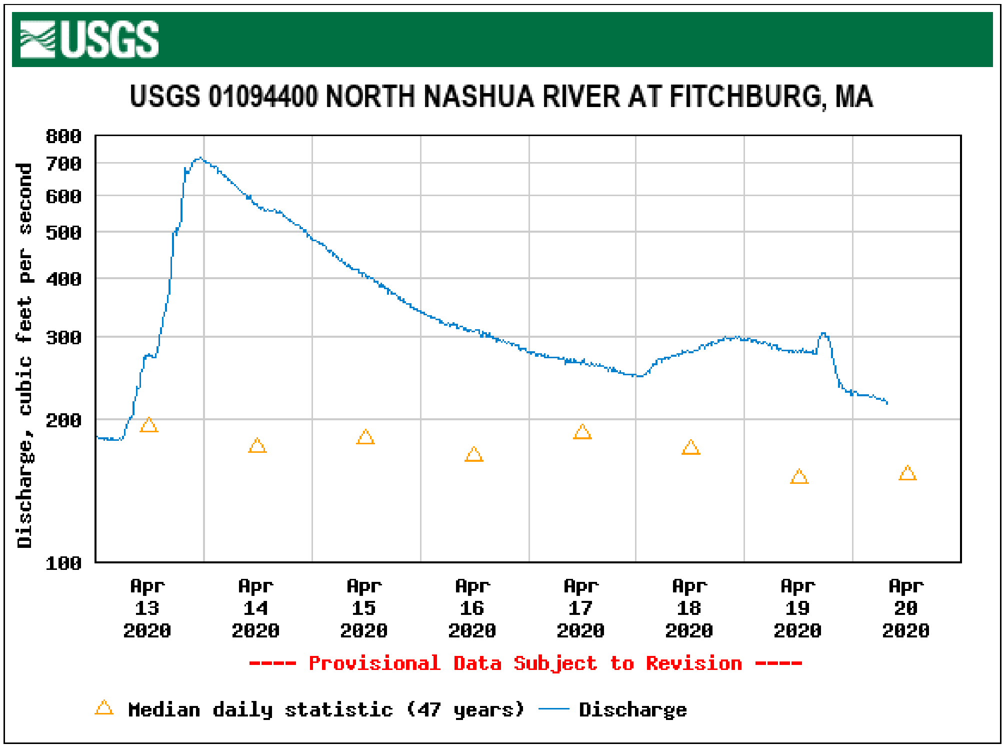


Figure 4-3 USGS Streamflow Discharge (USGS water data as of April 20, 2020)

<u>Locally Identified Areas of Flooding</u>

Fitchburg City staff and CRB Workshop participants helped identify local areas of flooding. These areas may not directly overlap with the FEMA-designated flood zones previously discussed. However, these areas have been noted to flood during a significant rain event. This is often due to topography and/or insufficient drainage. The City has recently made some repairs to the flood reduction system in the Downtown area, improved drainage on Columbia Road, and made several other updates to reduce the impact of flood events. Table 4-3 below identifies the local areas that are prone to flooding.

Table 4-3. Locally Identified Areas of Flooding

Location	Description
Fitchburg Municipal Airport	In flood zone
Fitchburg City Hall	In flood zone
Fitchburg DPW Headquarters	In flood zone
Fitchburg Senior Citizen's Center	In flood zone
Electrical Substation #4	
The Arc of Opportunity	In flood zone
Fitchburg-East Wastewater Treatment Facility	In flood zone
John Fitch Highway, Pearl Hill Road, Main Street	Poor drainage
Princeton Road (Rt. 31) underpass	

Location	Description
Punch Brook	Causes Downtown and basement flooding in many buildings on Main Street, leading to power outages
River Street @ Wallace Road	Updated/fixed
Shea Street	
Columbia Ave./Dewey Street	
Broad Street	
Boulder Ave	
Fitchburg Commuter Rail Station	In flood zone
Homeless Shelter	In flood zone
Riverfront Park	In flood zone

4.2.2 Historic Flood Events

Flood Events in Fitchburg

NOAA's National Centers for Environmental Information Storm Events Database (NOAA, 2019a) provides information on previous flood and flash flood events for Worcester County. Flash flood events are considered by the NOAA's Storm Events Database as "A life-threatening, rapid rise of water into a normally dry area beginning within minutes to multiple hours of the causative event (e.g., intense rainfall, dam failure, ice jam)" (US Department of Commerce et al., 2018, p.A-15). Floods are considered, "Any high flow, overflow, or inundation by water which causes damage. In general, this would mean the inundation of a normally dry area caused by an increased water level in an established watercourse, or ponding of water, that poses a threat to life or property" (US Department of Commerce et al., 2018, p.A-20).

Between 2000 and 2019, the City of Fitchburg had 14 floods and flash flood events that are identified below in Table 4-4. Although some of the events caused property damages, there were no deaths reported.

Table 4-4: Fitchburg Flooding Events 2000-2019

Event Date	Type of Flooding	Property Damage ($)	Description
4/22/2000	Flood and Flash Flood	$0	Low pressure moving across southeast New England brought heavy rain to much of central and eastern Massachusetts. Many areas received 3 to 5 inches of rain, resulting in widespread urban flooding and minor flooding of rivers and streams. Specific crests of rivers which went into flood include the North Nashua River at Fitchburg (6.54 feet at 315 am on the 22nd).
9/25/2001	Flash Flood	$0	Localized torrential rainfall caused significant urban flooding in Fitchburg and Leominster. The official storm total at Fitchburg Airport was 4.03 inches, most of which fell in a three-hour period. Over one foot of water flooded Route 2 near the intersection with Route 12.

Event Date	Type of Flooding	Property Damage ($)	Description
4/1/2004	Flood	$0	Widespread minor to moderate flooding impacted many rivers in southern New England, as a result of 2 to 4 inches of rain over a three-day period. North Nashua River at Fitchburg caused flooding in the surrounding area.
4/16/2007	Flood	$500,000	An unusually strong and slow-moving coastal storm caused major flooding along the North Nashua River in Fitchburg. A crest of 8.6 feet was recorded at 5:30 AM on the 16th (flood stage is 6.5 feet). This may have surpassed the previous record high crest, which occurred in April 2007. Widespread flooding was reported along the river in Fitchburg, where several roads were impassable.
7/2/2009	Flash Flood	$5,000	Thunderstorms accompanied by heavy rain and flooding across southern New England from a slow-moving front. Numerous streets were closed in Fitchburg, Leominster, and Sterling due to flooding. A car was stuck in flood waters on Shay Street in Fitchburg.
3/14/2010	Flood	$2,700,000	A stacked low-pressure system and a strong southeasterly wind event caused widespread rainfall totals of up to ten inches. This resulted in major flooding across eastern Massachusetts and Rhode Island, including small stream, urban, and poor drainage flooding, prompting the Governor of Massachusetts to declare a state of emergency followed by a federal disaster declaration for seven Massachusetts counties. Several roads in Fitchburg and surrounding cities were closed due to flooding.
3/29/2010	Flood	$4,050,000	A low-pressure system brought heavy rain to much of Southern New England during this time. Three to seven inches of rain fell across portions of Worcester County. Several roads and basements flooded in Fitchburg and surrounding cities.
7/19/2010	Flood	$0	Scattered severe thunderstorms produced wind damage and large hail, mainly in central Massachusetts. Several cars were stuck in flood waters on Route 12 in Fitchburg.
3/7/2011	Flood	$25,000	An area of low pressure resulted in heavy rains with amounts ranging from 2 to 5 inches across coastal and interior New England on top of melting snows. This large amount of water flowing into various basins resulted in flooding of tributaries and major rivers, inundating local neighborhoods and roadways. In Fitchburg, several roadways flooded, including John

Event Date	Type of Flooding	Property Damage ($)	Description
			Fitch Highway, River Street at Wallace Road, and Columbia, Shea, and Cathy Streets. In addition, the Fire Department pumped out about two dozen basements that were flooded.
7/1/2013	Flash Flood	$0	Heavy rain and rotating thunderstorms caused two feet of flooding along portions of Route 2 in Fitchburg.
8/13/2016	Flash Flood	$40,000	Heat, humidity, and a following cold front all contributed to the development of showers and thunderstorms across southern New England. These storms resulted in damaging winds and localized flooding. In Fitchburg, water was a foot deep on John Fitch Highway and the adjoining parking lot.
10/21/2016	Flash Flood	$75,000	Three to five inches of rain fell within the matter of a few hours during the evening of October 21, which resulted in urban flash flooding in Worcester and surrounding areas. In Fitchburg, flash flooding closed a section of the John Fitchburg Highway and a car was stuck in flood waters on Shelley Avenue.
8/2/2017	Flash Flood	$0	Showers and storms produced heavy downpours and strong wind gusts. Water two feet deep was reported on State Route 31 north of Fitchburg.
10/29/2017	Flood	$15,000	An area of low pressure generated strong to damaging winds, especially in Eastern Massachusetts. Tropical moisture flowing north ahead of the cold front contributed to heavy downpours with one to five inches of rain reported. John Fitch Highway in Fitchburg was flooded.
9/18/2018	Flash Flood	$0	Post-Tropical Cyclone Florence moved up the East Coast. Moderate flooding was reported under several railroad underpasses southwest of Fitchburg, including Princeton Road and State Route 2A.

NOAA's National Centers for Environmental Information Storm Events Database (data downloaded on 04/2020)

Worcester County Flooding Events

NOAA's National Centers for Environmental Information Storm Events Database provides information on previous flood events for Worcester County, which includes the City of Fitchburg. A disaster declaration is a statement made by a community when the needs required by a disaster or emergency is beyond the capabilities of that community. Ten disaster declarations were made in Worcester County due to flooding between 2000 and 2019, as can be seen in Table 4-5 on the next page.

Table 4-5. Previous Federal Disaster Declarations - Flooding

Disaster Name and Date of Event	Disaster Number	Type of FEMA Assistance	Counties Under Declaration
Severe Storms and Flooding March 5-April 16, 2001	DR-1364	None	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
Flooding April 1-30, 2004	DR-1512	Individual & Households Program	Essex, Middlesex, Norfolk, Suffolk, Worcester
Severe Storms and Flooding October 7-16, 2005	DR-1614	Public Assistance; Individual & Households Program	All 14 Massachusetts Counties
Severe Winter Storm and Flooding December 11-18, 2008	DR-1813	Public Assistance	All 14 Massachusetts Counties
Severe Storm and Flooding March 12-April 26, 2010	DR-1895	Public Assistance; Individual & Households Program	Bristol, Essex, Middlesex, Suffolk, Norfolk, Plymouth, Worcester
Severe Winter Storm, Snowstorm, and Flooding February 8-9, 2013	DR-4110	Public Assistance	All 14 Massachusetts Counties
Severe Winter Storm, Snowstorm, and Flooding January 26-28, 2015	DR-4214	Public Assistance	Barnstable, Bristol, Dukes, Essex, Middlesex, Nantucket, Norfolk, Plymouth, Suffolk, Worcester

(FEMA, 2019d)

4.2.3 GIS Flooding Exposure Analysis

Hazard location and extent of riverine flooding was determined using the current effective FEMA Flood Insurance Rate Map (FIRM) data for Fitchburg, dated 1991. For purposes of this exposure analysis, the following special flood hazard areas as identified in the City of Fitchburg's current FIRMs were included:

- Flood Zone A – 1% Annual Chance Flood Hazard
- Flood Zone X – 0.2% Annual Chance Flood Hazard

The City's existing tax parcel and property value data were used to estimate the number of parcels (developed and undeveloped) and buildings located in identified hazard areas along with their respective assessed values. The parcel data set provides information about the parcel size, land use type, and assessed value among other characteristics. The parcel data was also classified into various land use types based on the Massachusetts Department of Revenue's Property Type Classification Code for Fiscal Year 2019.

To determine the vulnerability of each parcel and building, a GIS overlay analysis was conducted in which flood hazard extent zones were overlaid with the parcel data and existing building footprint data.

To calculate the exposure of parcels and buildings to flood hazards, parcels with buildings that are located completely or partially within recognized hazard zones were identified using the ArcGIS overlay analysis (i.e. select by location using the intersect function). The number of parcels and buildings for each land use category was then totaled, along with the value of buildings and real estate properties associated with those parcels. These figures provide a strong indication of current hazard vulnerability, as well as potential future vulnerability as it relates to vacant and potentially developable parcels.

Flooding Vulnerability Assessment

A flood exposure analysis was conducted for critical facilities and vulnerable populations throughout the municipality utilizing MassGIS data, FEMA flood maps, and information gathered from the municipality. Table 4-6 below displays critical facilities in Fitchburg that are located within either the 100-year or 500-year FEMA flood zone and Table 4-7 shows the Census Blocks in Fitchburg that contain a high concentration of vulnerable populations.

Table 4-6. Critical Facilities Located within the FEMA Flood Zone

Facility	Address	100-Year Flood Zone	500-Year Flood Zone
Verizon Switching Facility MA873207	676 Main Street		X
Guild of St. Agnes - Fitchburg Preschool/School	62 Dover Street		X
MOC Child Care and Head Start Services	133 Prichard Street		X
Montachusett Regional YMCA Preschool / Kindergarten	55 Wallace Avenue		X
Sawmill Pond Dam	N/A	X	
Greenes Pond Dam	N/A	X	
Mill Pond #1 Dam	N/A	X	
James Pond Dam	N/A	X	
Arden Mill Dam	N/A	X	
Swimming Pool Dam	N/A	X	
North Nashua River Mill #4 Dam	N/A	X	
North Nashua River Mill #9 Dam	N/A	X	
North Nashua River Mill #6 Dam	N/A	X	
Fitchburg Gas & Electric Dam	N/A	X	
Putnams Pond Dam	N/A	X	
Falulah Reservoir Dam	N/A	X	
Trotting Park or Coolidge Park Dam	N/A	X	
Wastewater Treatment Plant Dam	N/A	X	
Electric Station Dam	N/A	X	
McTaggarts Pond Dam	N/A		X
Department of Public Works	301 Broad Street	X	
Electric Substation	Sawyer Passway		X
Emergency Shelter	14 Wallace Avenue	X	

Facility	Address	100-Year Flood Zone	500-Year Flood Zone
Fitchburg Blueberry Lane Landfill	41 Blueberry Lane	X	X
Fitchburg City Hall	166 Boulder Drive	X	
Fitchburg District Courthouse	100 Elm Street	X	
Fitchburg Law Library	84 Elm Street	X	
Fitchburg Public Library	610 Main Street	X	
Pelletier's Building Supply Co	133 Water Street	X	
Market Basket	130 Water Street	X	
CVS Pharmacy	96 Water Street	X	
CVS Pharmacy	436 John Fitch Highway	X	
Gas Station Sunoco	240 Lunenburg Street	X	
Gas Station	376 River Street	X	
Gas Station and Johnny's Service Station	339 River Street	X	
Gas Station and Montvori Oil Corp	2 Boulder Drive		X
DRS Technologies	166 Boulder Drive	X	
British American Club	1 Simonds Road	X	
Midtown Beef Co	87 Water Street	X	
Seaboard Folding Box Corp.	35 Daniels Street	X	
Mocron Products Inc.	25 Sawyer Passway	X	
Matthews Realty Trust	314 John Fitch Highway	X	
Central Plaza Shopping Center	130 Water Street	X	
Commercial Street Realty Trust	40 Commercial Street	X	
Jiffy Lube	541 John Fitch Highway	X	
Verizon Switching Facility MA873207	676 Main Street	X	
Fitchburg- East Wastewater Treatment Facility	24 Lanides Lane	X	
Independent Cleaners	1 Wallace Road		X
Simonds International Corp.	139 Intervale Road		X
Penske	210 Airport Road		X
Coolidge Park	Pearl Street at John Fitch Highway		X
Arrhythmia Research Technology	24 Sawyer Passway	X	
Hazardous Material Site - Solar Farms	115 Sawyer Passway		X
Foster Insurance Agency	321 Lunenburg Street		X
Central Steam Plant	465 Westminster Street		X
Former Vogue Wall Coverings	68 Airport Road		X
Homeless Shelter	356B Broad Street #4		X
CareWell Urgent Care	380 John Fitch Highway	X	
MOC's Child Care & Head Start School	63 Fairmount Street		X
North Central Charter Essential School	1 Oak Hill Road, Suite 100	X	
Wallace Tower	54 Wallace Avenue		X

Facility	Address	100-Year Flood Zone	500-Year Flood Zone
Christ Church Religious Center	569 Main Street	X	
Masjid Baitul Zikr Religious Center	370 Main Street		X
Horizon Christian Fellowship Religious Center	356 Broad Street		X
New Life Spanish Christian Church Religious Center	63 Fairmount Street		X
Sewer Pump Station	75 Sawyer Passway	X	
Train Station MBTA Commuter Rail	100 Main Street		X
First Student Bus	203 Airport Road		X
Fitchburg Municipal Airport	567 Crawford Street		X
Underground Storage Tank	401 Princeton Road	X	
Underground Storage Tank	0 Lanides Lane	X	
Underground Storage Tank	301 Broad Street	X	
Underground Storage Tank	1200 Main Street	X	
Underground Storage Tank	222 Lunenburg Street	X	
Underground Storage Tank	166 Boulder Drive	X	
Underground Storage Tank	356 River Street	X	
Underground Storage Tank	133 Water Street	X	
Underground Storage Tank	236 Lunenburg Street	X	
Underground Storage Tank	91 Laurel Street	X	
Underground Storage Tank	347 River Street	X	
Underground Storage Tank	0 Nursery Lane	X	
Underground Storage Tank	240 Lunenburg Street	X	
Underground Storage Tank	370 John Fitch Highway	X	
Underground Storage Tank	339 River Street	X	
Underground Storage Tank	23 Woodbury Avenue	X	
Underground Storage Tank	232 Airport Road		X
Underground Storage Tank	402 Broad Street		X
Underground Storage Tank	232 Falulah Road		X
Underground Storage Tank	0 Intervale Road		X
Underground Storage Tank	1022 Main Street		X
Underground Storage Tank	237 Lunenburg Street		X
Underground Storage Tank	16 Benson Street		X
Underground Storage Tank	676 Main Street		X
Underground Storage Tank	68 Airport Road		X
Underground Storage Tank	210 Falulah Road		X
Underground Storage Tank	88 Benson Street		X
Underground Storage Tank	64 Main Street		X
Underground Storage Tank	203 Airport Road		X
Water Storage Tank	909 Rindge Road	X	

Out of 265 critical facilities in Fitchburg, 100 are located in 100-year or 500-year flood zone (Table 4-7). Some of the critical facilities include locations with vulnerable populations, hazardous material sites, gas stations, and underground storage tanks. It is important to protect these facilities from flooding that could threaten public health and cause water quality and contamination issues downstream if hazardous sites were to leach or erode.

Table 4-7. Vulnerable Populations and Environmental Justice Community Located within the FEMA Flood Zone

Census Block Number	Vulnerable Population	Total Area (acres)	Area in 100 Year Flood Plain	Percent in 100 Year Flood Plain	Area in 500 Year Flood Plain	Percent in 500 Year Flood Plain
250277101001000	Minor*	4.4	0.05	1.06	0.11	2.42
250277101001003	Minor*	3.0	0.67	22.25	0.51	16.95
250277101001005	Elderly	3.7	0.75	20.48	0.50	13.63
250277101001053	Minor*	2.2	0	0.00	0.31	14.21
250277101002007	Minor*	2.9	0	0.00	1.64	55.59
250277101002008	Minor* and Elderly	1.7	0	0.00	1.72	100
250277101002009	Minor*	1.8	0	0.00	1.19	67.39
250277101002011	Minor*	1.3	0	0.00	0.33	25.42
250277101003000	Minor*	19.7	8.26	41.90	2.36	11.96
250277101003012	Minor*	21.9	7.01	31.95	4.99	22.75
250277101004000	Minor*	2.5	0.01	0.24	0.05	2.04
250277102006002	Minor*	208.8	3.82	1.83	2.75	1.32
250277103001008	Minor*	2.5	0.01	0.25	0.07	2.62
250277103001009	Minor*	17.3	11.31	65.19	2.27	13.08
250277103001019	Minor*	464.0	27.92	6.02	6.93	1.49
250277103001030	Minor*	4.0	0	0.00	0.02	0.59
250277103002006	Minor*	12.7	4.32	34.02	2.85	22.46
250277103002007	Minor*	4.8	0.01	0.17	0	0.00
250277103002024	Minor*	58.4	5.80	9.94	2.97	5.08
250277103002030	Elderly	3.1	0.00	0.00	0.05	1.71
250277103002033	Minor*	6.2	0.66	10.64	0.46	7.34
250277103002034	Minor*	1.3	0.15	11.59	0.81	62.11
250277103002036	Elderly	1.4	0.00	0.00	0	0.01
250277103002073	Elderly	17.7	0.76	4.31	0.45	2.54
250277105002000	Elderly	6.8	6.34	93.84	0.39	5.71
250277105002006	Minor*	3.0	0.53	17.97	1.16	39.26
250277106001001	Minor*	3.0	0	0.00	0.45	15.06
250277106001002	Minor*	6.9	4.61	67.09	0.41	5.92
250277106001018	Minor*	6.9	0	0.00	0.00	0.00

Census Block Number	Vulnerable Population	Total Area (acres)	Area in 100 Year Flood Plain	Percent in 100 Year Flood Plain	Area in 500 Year Flood Plain	Percent in 500 Year Flood Plain
250277106003007	Minor*	13.7	4.34	31.72	2.01	14.71
250277106003008	Minor*	2.4	0	0.00	0.004	0.17
250277106003010	Minor*	9.6	0	0.00	0.01	0.14
250277106005003	Minor*	11.7	0.72	6.18	2.03	17.38
250277106005010	Minor*	4.6	0.40	8.59	1.13	24.43
250277107001000	Minor*	5.1	0.00	0.00	0.04	0.80
250277107002002	Minor*	1.0	0	0.35	0.36	36.05
250277107002005	Elderly	1.5	0.09	6.15	1.12	76.37
250277107002014	Minor*	0.8	0.01	1.60	0.02	2.93
250277107002030	Elderly	0.3	0	0.00	0.004	1.28
250277107002031	Minor*	1.9	0	0.12	0.14	7.67
250277107002035	Minor*	4.5	3.77	84.06	0.71	15.88
250277108001000	Minor*	82.4	0.25	0.31	0.01	0.01
250277108003014	Minor*	2.0	0.00	0.05	0.34	17.28
250277108003019	Minor*	9.8	6.48	66.14	0.57	5.85
250277108003033	Minor*	11.6	6.40	55.21	1.30	11.19
250277110001009	Elderly	16.0	10.55	65.88	1.86	11.59
250277110001010	Elderly	0.7	0.45	63.84	0.25	34.96
250277110001011	Minor*	1.8	0	0.00	0.01	0.62
250277111001007	Elderly	24.2	0.60	2.46	1.37	5.67
250277111001009	Elderly	2.1	0.05	2.22	0.01	0.29
250277111001011	Minor*	7.5	0.94	12.55	0.86	11.38
250277111001017	Elderly	20.0	0.99	4.92	0.80	3.97
250277111001023	Minor*	2.3	0.00	0.00	0.07	2.85
250277111002010	Minor*	434.5	2.19	0.50	0.48	0.11
250277111002011	Minor*	1059.2	9.07	0.86	0.75	0.07
250277111002020	Elderly	865.0	10.52	1.22	3.21	0.37
250277111002032	Elderly	6.2	3.48	55.94	0.30	4.78
250277111002036	Minor* and Elderly	10.5	0.62	5.95	0.34	3.28
0189937	MI	415	98	24	65	16
0189938	M	646	254	39	114	18
0189939	MI	114	17	15	8	7
0189940	M	82	0.01	0.01	0.05	0.07
0189955	MI	74	1	1	1	2
0189956	MI	59	7	12	3	4
0189957	M	99	7	7	2	2
0189959	MIE**	123	18	14	26	21

Census Block Number	Vulnerable Population	Total Area (acres)	Area in 100 Year Flood Plain	Percent in 100 Year Flood Plain	Area in 500 Year Flood Plain	Percent in 500 Year Flood Plain
0189961	M	115	18	16	7	6
0189963	MI	281	28	10	17	6
0189965	MI	62	15	24	11	17
0189966	MI	81	35	44	12	14
0189968	M	209	0.25	0.12	0.01	0.01
0189970	MI	208	22	11	5	2
0189972	M	164	20	12	3	2
0189974	MI	40	0	0	0.06	0.15

**Minor is a person under the age of full legal responsibility.*
***MIE stands for M=minority, I=Income, E=English isolation*

During the CRB Workshop, stakeholders discussed concern for residents who may experience social isolation, including elderly residents and children. 58 Census Blocks in Fitchburg with a higher concentration of youth or seniors and 16 Census Blocks with a higher concentration of Environmental Justice Communities are located partially within a FEMA flood zone.

Flood Exposure Tables

The results of the vulnerability assessment conducted for Fitchburg's existing community assets are summarized on the following pages. These include an exposure table for natural hazards with geographically defined risk areas (FIRM zones). Table 4-8 and 4-9 below show the detailed exposure of buildings in 100-year flood zones and in 500-year flood zones by parcel type. The value of all buildings and their exposure to flooding within the FIRM zones is also listed. A total of 784 parcels are in both the 100- and 500-year flood zone (Table 4-8, 4-9). Overall, 15% of Fitchburg's total property is at risk to flooding. An analysis of developable vacant parcels has shown that 854 parcels remain undeveloped, with 98 of them, or 19% of the total, located in flood zones.

Table 4-8. Exposure of Parcels in 100 Year Flood Zones by Land Use Type

Land Use Type	Total Number of Parcels	Total Area of Parcels (acres)	Number of Parcels in the Flood Zone	Area of Parcels in the Flood Zone (acres)	Percentage of Parcels in the Flood Zone	Property Value in the Flood Zone
Residential	9326	6137	141	161	2	$21,637,900
Commercial	598	999	148	203	20	$51,417,600
Industrial	139	734	49	371	50	$29,644,200
Institutional	62	1060	20	588	55	$127,207,600
Agricultural	1	44	N/A	N/A	N/A	N/A
Recreation & Open Space	3	10	2	10	99	$3,207,600
Total	**10,129**	**8987**	**360**	**1334**	**14**	**$233,114,900**

Table 4-9. Exposure of Parcels in 500 Year Flood Zones by Land Use Type

Land Use Type	Total Number of Parcels	Total Area of Parcels (acres)	Number of Parcels in the Flood Zone	Area of Parcels in the Flood Zone (acres)	Percentage of Parcels in the Flood Zone	Property Value in the Flood Zone
Residential	9,326	6,137	211	172	2.8	$30,023,900
Commercial	598	999	135	237	23	$52,110,200
Industrial	139	734	61	430	58	$36,458,400
Institutional	62	1060	15	544	51	$88,536,500
Agricultural	1	44	N/A	N/A	N/A	N/A
Recreation & Open Space	3	10	2	10	99	$3,207,600
Total	**10,129**	**8,987**	**424**	**1395**	**15**	**$210,336,600**

There are 360 parcels with 1,334 acres in the 100-year floodplain. In contrast, there were 303 structures totaling 876.54 acres documented in 2015 (MRPC, 2015). Building and parcel data are not comparable and therefore these cannot be used to infer if flood vulnerability has increased since the 2015 plan. However, 20% of developable, vacant parcels are in the 100-year floodplain and 19% are in the 500-year floodplain (please see Tables 4-10 and 4-11). Therefore, future flood vulnerability in Fitchburg could increase without proactive action to mitigate future flood risk. In addition, one recently developed parcel (Garden Remedies) is partially located in the 100- and 500-year flood zone, which may indicate a slight increase in flood vulnerability (Table 4-12). Several planned developments are also in the flood zones (Table 4-12).

To further resiliency in the City, a flood exposure analysis was completed on all vacant, developable parcels. The analysis was conducted utilizing MassGIS data, FEMA flood maps, and information from the City. The result of this analysis identifies future flooding that could occur on these parcels if they were to be developed. Undeveloped parcels in Fitchburg are summarized in Tables 4-10 and 4-11.

Table 4-10. Exposure of Developable, Vacant Land to the 100-Year Flood Zone

Land Use Type	Total Number of Parcels	Total Area of Parcels (acres)	Number of Parcels in Flood Zone	Area of Parcels in the Flood Zone (acres)	Percentage of the Parcels in the Flood Zone
Residential	571	1,770	22	268	15
Commercial	31	16	9	5	34
Industrial	23	50	6	23	45
Government	212	2,012	47	370	18
Agricultural	N/A	N/A	N/A	N/A	N/A
Open Space	17	466	2	195	42
Total	**40**	**4315**	**86**	**862**	**20**

Table 4-11. Exposure of Developable, Vacant Land to the 500-Year Flood Zone

Land Use Type	Total Number of Parcels	Total Area of Parcels (acres)	Number of Parcels in Flood Zone	Area of Parcels in the Flood Zone (acres)	Percentage of the Parcels in the Flood Zone
Residential	571	1,770	30	256	14
Commercial	31	16	11	5	31
Industrial	23	50	12	26	51
Government	212	2,012	43	359	18
Agricultural	N/A	N/A	N/A	N/A	N/A
Open Space	17	466	2	195	42
Total	854	4315	98	840	19

The output of the ArcGIS overlay analysis showed all vacant, developable parcels that intersected with a flood zone. The number of parcels was totaled for each land use type within each of the FEMA Flood Zones. While 4315 acres of land in Fitchburg are vacant and developable, 20% of that land is located within the 100-year flood zone and an additional 19% in the 500-year flood zone. It is recommended that, as the City expands development, additional analysis be conducted on these parcels to reduce future damage from flooding.

Recent and planned development (Table 3-6) were overlaid with FEMA flood zone maps to determine their vulnerability to flooding. Parcels were categorized by development type. The exposure of potential development within each land use type was documented by the area and percentage of parcels that overlap with a flood zone. Five of the potential developments are in the 100-year flood zone. Two additional potential developments are located on parcels in the 500-year flood zone. Please refer to Tables 4-12 and 4-13 below.

Table 4-12. Recent* and Planned Development in the 100-Year FEMA Flood Zone

Development Name	Development Address	Land Use Type	Total Area of Parcels (acres)	Area of Parcels in the Flood Zone (acres)	Percentage of the Parcels in the Flood Zone
Garden Remedies*	307 Airport Rd.	Industrial	8.0	1.6	20
The Hub Craft	25 Newport St.	Industrial	5.1	1.1	21
Fitchburg Sandpit Site	0 Airport Road	Government	21.7	4.5	21
Apical, LLC	431 Westminster St.	Industrial	9.2	3.7	41
Wastewater Treatment Adaptive Reuse	230 Princeton Road	Government	16.3	7.7	47
Blue Collar Botany	644 River St.	Industrial	2.65	1.3	50
Total			62.9	19.9	32

Table 4-13. Recent* and Planned Development in the 500-Year FEMA Flood Zone

Development Name	Development Address	Land Use Type	Total Area of Parcels (acres)	Area of Parcels in the Flood Zone (acres)	Percentage of the Parcels in the Flood Zone
Garden Remedies*	307 Airport Rd.	Industrial	8.0	5.5	68
Harper Furniture	10 Main St., Summer St.	Commercial	0.2	0.2	100
The Hub Craft	25 Newport St.	Industrial	5.1	4.0	79
Fitchburg Sandpit Site	0 Airport Road	Government	21.7	6.8	31
A Cannabis Grower to Be Named Later	310 Broad St.	Industrial	0.5	0.3	57
Apical, LLC	431 Westminster St.	Industrial	9.2	0.5	6
Wastewater Treatment Adaptive Reuse	230 Princeton Road	Government	16.3	1.4	9
Blue Collar Botany	644 River St.	Industrial	2.7	0.9	32
Total			63.6	19.6	31

4.2.4 Dams and Dam Failure

Dam failure is defined as a collapse of an impounding structure resulting in an uncontrolled release of impounded water from a dam (DCR, 2017a). There are two types of dam failures that can occur. Catastrophic failure occurs when there is a sudden, rapid, uncontrolled release of impounded failure. The second type is design failure, which occurs as a result of minor overflow events. Dam overtopping occurs when floods exceed the capacity of the dam, which can be due to inadequate spillway design or other outside factors such as settlement of the dam crest or back of spillways. Thirty-four percent of all dam failures that occur in the United States are a result of overtopping (EEA and EOPSS, 2018). Many dam failures in the United States have been secondary results of other disasters. The prominent causes include earthquakes, landslides, extreme storms, massive snowmelt, equipment malfunction, structural damage, foundation failures, and sabotage (MEMA and DCR, 2013). Dam failures during flood events are of concern in Massachusetts, given the high density of dams constructed in the 19th century (MEMA and DCR, 2013).

Climate change may indirectly affect dam breaches for a variety of reasons. Dams are typically designed based on historic water flows and known hydrology. Climate change projections indicate that the frequency, intensity, and amount of precipitation will increase in New England. Increased precipitation may push dams over capacity. Therefore, dams will have to be monitored for safety. There are several mechanisms in place to manage increases in water, such as slowly releasing water. It is advised that these events are monitored as they can add additional stress on the dam infrastructure.

Dam failure can cause property damage, injuries, and potentially fatalities. These impacts can be at least partially mitigated through advance warning to communities impacted by a dam failure. In addition, the breach may result in erosion on the rivers and stream banks that are inundated. Dam failure is classified as a low frequency event in the City. As defined by the 2013 Massachusetts State Hazard

Mitigation Plan, a very low frequency hazard may occur less frequently than once in 100 years (less than a 1% chance per year). A dam failure can still present a high level of risk, which is indicated through a dam's classification. These classifications are defined by DCR as:

> *High:* Dams located where failure or mis-operation will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highway(s) or railroad(s).
>
> *Significant:* Dams located where failure or mis-operation may cause loss of life and damage home(s), industrial or commercial facilities, secondary highway(s) or railroad(s), or cause interruption of use or service or relatively important facilities.
>
> *Low:* Dams located where failure or mis-operation may cause minimal property damage to others. Loss of life is not expected.

As of February 2017, all dams classified as high hazard potential or significant hazard potential were required to have an Emergency Action Plan (EAP) (DCR, 2019a). This plan must be updated annually and submitted to the Commissioner and the Massachusetts Emergency Management Agency. The plan should also be retained by the dam owner and the City in which the dam is located. Guidelines and a template were established by the Office of Dam Safety to ensure that all EAPs follow the proper format.

According to City officials and the Massachusetts Department of Conservation and Recreation's (DCR) Office of Dam Safety, there are 31 dams in Fitchburg. Information related to these dams is summarized in Table 4-14. The City is currently pursuing the removal of McTaggarts Dam. Scott reservoir is still used for drinking water purposes. Fitchburg residents and municipal staff have proposed removing the Overlook Reservoir Dam. Parkhill Park and Trotting Park/Coolidge Park dams have been removed.

Table 4-14. Inventory of Dams in Fitchburg or Owned by Fitchburg

Dam Name	Location	Dam Owner	Hazard Potential Classification
Arden Mills Dam	Fitchburg	Arden Mills, LLC c/o Global Property Development Corp.	Low
Arden-Duck Mill Dam	Fitchburg	Arden Mills, LLC c/o Global Property Development Corp.	Low
Electric Station Dam	Fitchburg	Fitchburg Gas & Electric Light Co.	Low
Falulah Reservoir Dam	Fitchburg	Fitchburg	Significant
Greene's Pond Dam	Fitchburg	Fitchburg, Dept. of Public Works	Significant
James Pond Dam	Fitchburg	No. 1 Mill Warehouse, LLC	Significant
Kimball Rd. Dam	Fitchburg	Unknown	N/A
Lovell Reservoir Dam	Fitchburg	Fitchburg, Division of Water Supply	High
Lovell Reservoir Dike	Fitchburg	Fitchburg, Division of Water Supply	High
Lower Spring Pond Dam	Fitchburg	Unknown	N/A
Marshal Reservoir Dam	Fitchburg	Fitchburg	N/A
McTaggarts Pond Dam	Fitchburg	Fitchburg	Significant
Mill Pond #1 Dam	Fitchburg	Munksjo Paper Inc.	Significant
Mirror Lake Dam	Fitchburg	Fitchburg, Parks Department	Significant

Nichols Pond Dam	Fitchburg	Unknown	N/A
Nichols St. Dam	Fitchburg	Thomas E. Donnelly	N/A
North Nashua River Mill #4 Dam	Fitchburg	Munksjo Paper Inc.	Low
North Nashua River Mill #6 Dam	Fitchburg	Fitchburg	N/A
North Nashua River Mill #9 Dam	Fitchburg	291 Westminster Street, LLC	Low
Overlook Reservoir Dam	Fitchburg	Fitchburg	High
Overlook Reservoir Dike	Fitchburg	Fitchburg	High
Putnams Pond Dam	Fitchburg	Fitchburg	N/A
Saima Pond Dam	Fitchburg	Finnish American Club of Saima	N/A
Scott Reservoir Dam	Fitchburg	Fitchburg, Division of Water Supply	High
Snows Mill Pond Dam	Fitchburg	Caraustar Fitchburg Paperboard	High
Swimming Pool Dam	Fitchburg	Unknown	N/A
Upper Sawmill Pond Dam	Fitchburg	Fitchburg	Significant
Upper Spring Pond Dam	Fitchburg	Unknown	N/A
Wastewater Treatment Plant Dam	Fitchburg	Fitchburg	Low
Weyerhauser Dam	Fitchburg	Unknown	N/A
Dams Located Outside of Fitchburg			
Ashby Reservoir Dam	Ashby	Fitchburg	Significant
Bickford Pond Dam	Hubbardston	Fitchburg	High
Bickford Pond Dike	Hubbardston	Fitchburg	High
Fitchburg Reservoir North Dam	Ashby	Fitchburg, Division of Water Supply	Low
Fitchburg Reservoir South Dam	Ashby	Fitchburg, Division of Water Supply	Low
Fitchburg Reservoir South Dike	Ashby	Fitchburg, Division of Water Supply	Low
Mare Meadow Reservoir Dam	Hubbardston	Fitchburg	High
Meetinghouse Pond Reservoir Dam	Westminster	Fitchburg, Division of Water Supply	Significant
Smith Pond Dam	Westminster	Fitchburg	N/A
Wachusett Lake Dam	Westminster	Fitchburg, Division of Water Supply	Significant
Wyman Pond Compensating Reservoir Dam	Westminster	Fitchburg, DPW	High

(US Army Corps of Engineers, 2020)

4.2.5 Flooding and Climate Change

Fitchburg's average annual precipitation is 47.9 inches (NEIC, 2019). Extreme rain and snow events are becoming increasingly common and severe, particularly in the Northeast region of the country (Figure 4-4). Large rain or snow events that happened once a year in the middle of the 20th century now occur approximately every nine months. Additionally, the largest annual events now generate 10% more rain than in 1948. Regionally, New England has experienced the greatest increase in the frequency of extreme rain and snow events. These events now occur 85% more frequently than they did 60 years ago (Madsen and Willcox, 2012).

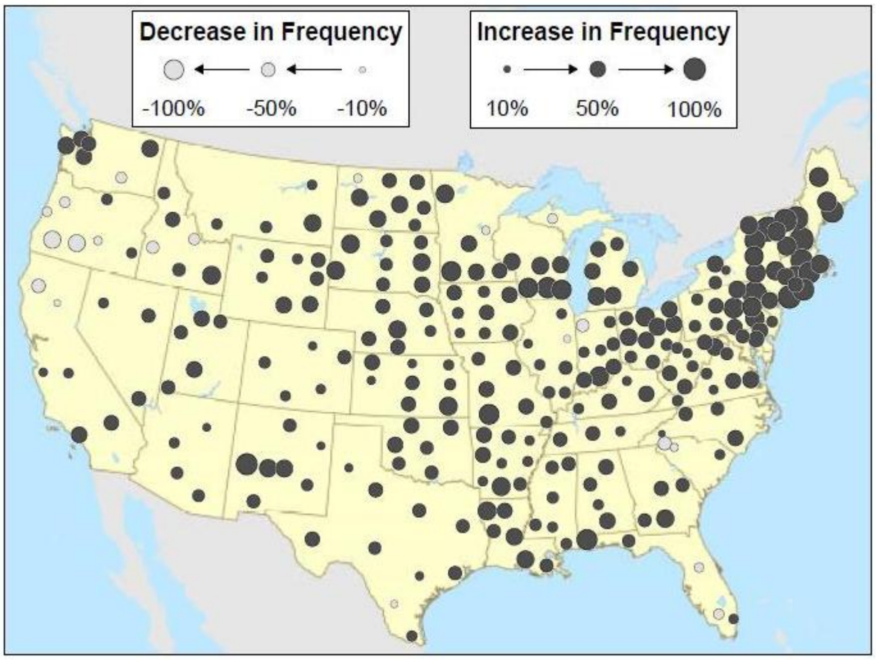


Figure 4-4. Changes in Frequency of Extreme Downpours
(Madsen and Willcox, 2012)

4.3 Wind Related Hazards

High winds can occur during hurricanes, tropical storms, tornadoes, nor'easters, and thunderstorms. The entire City of Fitchburg is vulnerable to the impacts of high wind. Wind may down trees and power lines. High wind and storm events can cause property damage and hazardous driving conditions. While Fitchburg's current 100-year wind speed is 110 mph, climate change will likely increase events and severity (ASCE, 2017).

The planning process identified vulnerabilities related to potential storm damage to power and phone wires from overhanging trees that have not been trimmed by the electric utilities (Unitil) or the phone or cable companies. The utilities' tree maintenance program should be upgraded to reduce the risk associated with tree damage to utility lines. High winds and heavy snow loads caused significant power line damage in Fitchburg during a nor'easter in 2018. Falling trees and branches can also block traffic and emergency routes. This is a regional issue that affects cities and towns beyond Fitchburg.

During Fitchburg's MVP Workshop in March 2020, attendees discussed the impact of past storms on power systems and service disruption. In 2016, a storm led to a downed power line which resulted in the loss of power at a wastewater pumping station. The gas for the generator at the same pumping station caught on fire and eliminated backup power. Workers were able to bypass the pumping station and Eversource was able to get the pumps back online. However, backup power to the area impacted was cut off for an estimated four hours.

Fitchburg does have reliable communications towers that house equipment for the Police and several other City departments. City officials stated that their communications systems may be at risk during flooding and high wind events. The development of emergency communication plans for vulnerable populations should be developed, that includes an inventory of current resources and an identification of additional needs.

NOAA's National Centers for Environmental Information offers thunderstorm wind, high wind, and strong wind data for Worcester County. Between 2000 and 2019, 248 wind entries were uploaded into the database and 135 were related to thunderstorms. Other wind events were related to coastal storms, low pressure cells, rains, and other hazard events. During this time period, there was one death, seven injuries, and nearly $4.7 million worth of damages. Winds ranged from 39 to 65 miles per hour.

4.3.1 Severe Storms and Thunderstorms

Thunderstorms are typically less severe than other hazard events discussed in this section. However, thunderstorms can cause local damage and are a city-wide risk in Fitchburg. The entire city area is equally susceptible to impacts from thunderstorms, which can include lightning, strong winds, heavy rain, hail, and sometimes tornados. Thunderstorms typically last for about 30 minutes and can generate winds of up to 60 mph. Winds associated with thunderstorms can knock down trees, resulting in power outages and blocked evacuation and transportation routes. Extreme rain during thunderstorms can cause inland flooding around waterbodies or due to surcharged drainage systems. During periods of drought, lightning from thunderstorm cells can result in fire ignition. Thunderstorms with little or no rainfall are rare in New England but have occurred (EEA and EOPSS, 2018). Thunderstorms are considered high frequency events in Fitchburg. As defined by the 2013 Massachusetts State Hazard Mitigation Plan, this hazard may occur more frequently than once in 5 years (a greater than 20% chance per year).

NOAA's National Centers for Environmental Information offers thunderstorm and hail data for Worcester County (NOAA, 2019a). Between 2000 and 2019, 135 thunderstorm events caused $3.2 million in property damages in Worcester County. Five injuries and one death were reported. Out of the 135 events, Fitchburg was severely affected by 10 storms. Up to $180,000 worth of property damage was reported, but no deaths or injuries occurred. All the major thunderstorm events that affected Fitchburg caused downed trees and powerlines, leading to roadblocks and power outages in parts of the City.
Between 2000 and 2019, there were 80 hail events that caused $125,000 in property damage. No deaths or injuries were reported. The size of hail typically ranges from 0.75" up to 2" (NOAA, 2019a).

4.3.2 Hurricanes and Tropical Storms

Tropical cyclones (including tropical depressions, tropical storms, and hurricanes) form over the warm waters of the Atlantic, Caribbean, and Gulf of Mexico. A tropical storm is defined as having sustained winds from 39 to 73 mph. If sustained winds exceed 73 mph, it is categorized a hurricane. The Saffir-Simpson scale ranks hurricanes based on sustained wind speeds from Category 1 (74 to 95 mph) to Category 5 (156 mph or more). Category 3, 4, and 5 hurricanes are considered "Major" hurricanes. Wind gusts associated with hurricanes may exceed the sustained winds and cause more severe localized damage (MEMA and DCR, 2013). The Saffir/Simpson scale (Table 4-15) categorizes or rates hurricanes from 1 (minimal) to 5 (catastrophic) based on their intensity. This is used to provide 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, as storm surge values are highly dependent on context (EEA and EOPSS, 2018).

Table 4-15. Saffir/Simpson Scale

Scale No. (Category)	Winds (mph)	Potential Damage
1	74 – 95	Minimal: damage is primarily to shrubbery and trees, mobile homes, and some signs. No real damage is done to structures.
2	96 – 110	Moderate: some trees topple, some roof coverings are damaged, and major damage is done to mobile homes.
3	111 – 130	Extensive: large trees topple, some structural damage is done to roofs, mobile homes are destroyed, and structural damage is done to small homes and utility buildings.
4	131 – 155	Extreme: extensive damage is done to roofs, windows, and doors; roof systems on small buildings completely fail; and some curtain walls fail.
5	> 155	Catastrophic: roof damage is considerable and widespread, window and door damage are severe, there are extensive glass failures, and entire buildings could fail.

MEMA and DCR, 2013, page 325 (table originally created by NOAA)

The official hurricane season runs from June 1 to November 30. However, storms are more likely to occur in New England during August, September, and October (MEMA and DCR, 2013). When hurricanes and tropical storms occur, they will impact the entire planning area. Vulnerable populations and all existing and future buildings, including critical facilities, are at risk to hurricane and tropical storm hazards. Hurricane events have a large spatial extent and could potentially affect the entire City of Fitchburg. Impacts include water damage to buildings from building envelope failure, business interruption, loss of communications, and power failure. Flooding is a major concern, as slow-moving hurricanes can discharge tremendous amounts of rain on an area. Figure 4-5 shows the impacts of extreme events on the State. Hurricanes are a city-wide hazard in Fitchburg and are considered a medium frequency event. As defined by the 2013 Massachusetts State Hazard Mitigation Plan, this hazard can occur between once in 5 years to once in 50 years (a 2% to 20% chance per year).

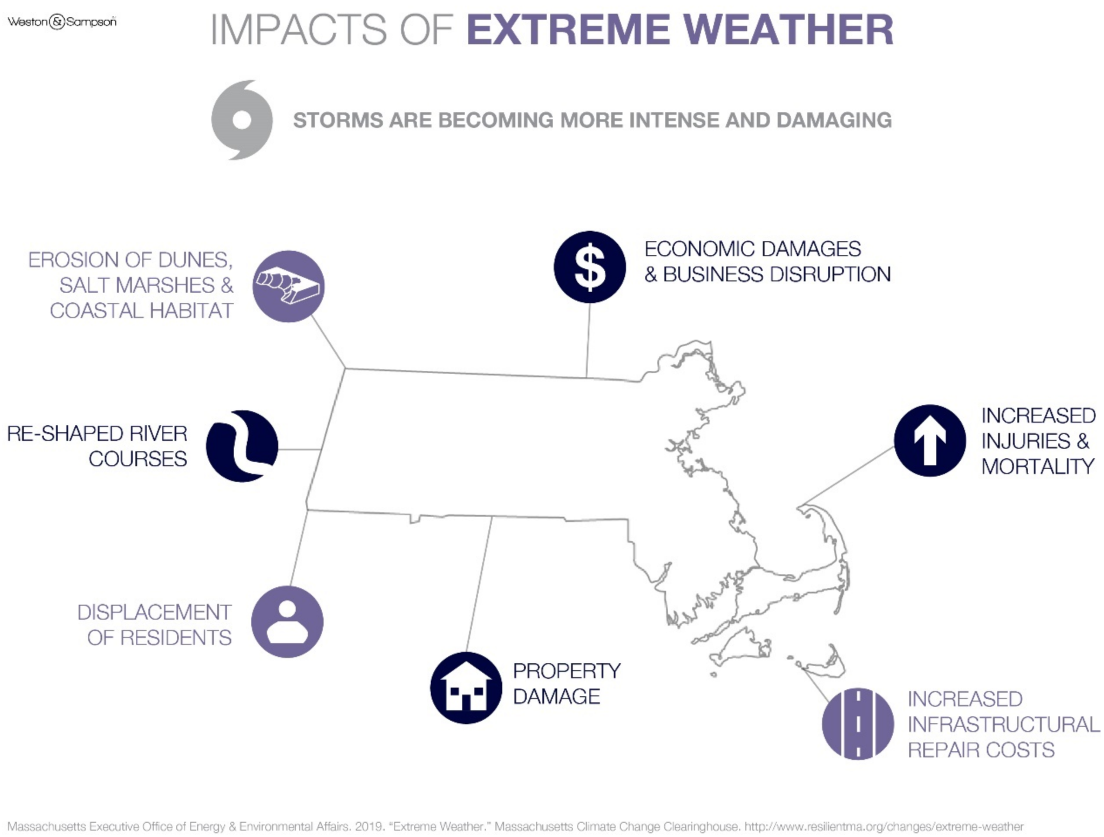


Figure 4-5. Impacts of extreme events and stronger storms on the State of Massachusetts

The region has been impacted by hurricanes throughout its history, starting with the Great Colonial Hurricane of 1635. Massachusetts experienced 11 hurricanes and one named tropical storm between 1851 and 2012. This includes six category 1 hurricanes, two category 2 hurricanes, and three category 3 hurricanes (Blake et al., 2011). Worcester County faced three major Tropical Storms in the last 10 years. During the August 2011 Tropical Storm, the Automated Surface Observing System at Fitchburg Municipal Airport (KFIT) recorded sustained wind speeds of 29 knots (33 mph) and gusts to 40 knots (46 mph). Hurricanes that have occurred in the region since 1938 are listed in Table 4-16.

Table 4-16. Hurricane Records for Eastern Massachusetts, 1938 to 2019

Hurricane/Tropical Storms Event	Date
Great New England Hurricane*	September 21, 1938
Great Atlantic Hurricane*	September 14-15, 1944
Hurricane Doug	September 11-12, 1950
Hurricane Carol*	August 31, 1954
Hurricane Edna*	September 11, 1954
Hurricane Diane	August 17-19, 1955
Hurricane Donna	September 12, 1960
Hurricane Gloria	September 27, 1985
Hurricane Bob	August 19, 1991
Hurricane Grace	October 31, 1991

Hurricane/Tropical Storms Event	Date
Hurricane Floyd	September 1999
Hurricane Katrina	September 13, 2005
Tropical Storm Hanna	September 6, 2008
Hurricane Bill	August 22, 2009
Tropical Storm - Hurricane Earl	September 4, 2010
Tropical Storm Irene	August 28, 2011
Hurricane Sandy	October 29-30, 2012
Tropical Storm-Hurricane Arthur	July 4, 2014
Tropical Storm Hermine	September 5, 2016
Tropical Storm Jose	September 20, 2017
Hurricane Florence	September 18, 2018
Tropical Storm Dorian	September 7, 2019

** Category 3* *National Oceanic and Atmospheric Administration (NOAA, 2019a)*

Hurricane damage in Fitchburg was estimated using a hurricane modeling software. Hazus Multi-Hazard (Hazus) is a GIS model developed by FEMA to estimate losses in a defined area due to a specified natural hazard. The Hazus hurricane model allows users to input specific parameters in order to model a defined hurricane magnitude, which is based on wind speed. The largest hurricane ever witnessed in Massachusetts was a Category 3 hurricane, which occurred in 1954. For the purpose of this analysis, in order to estimate potential damage, both a Category 2 and a Category 4 hurricane were modeled. Although there have been no recorded Category 4 hurricanes in Massachusetts, the storm was modeled to show the impact that could occur from an extreme scenario. A Category 4 hurricane could potentially occur in the future due to climate change.

In Massachusetts, the return period for a Category 2 hurricane is approximately 0.01 percent, and for a Category 4 hurricane it is approximately 0.005 percent. Hazus models hurricanes based upon their return period. Therefore, a Category 2 was modeled as a 100-year hurricane and a Category 4 was modeled as a 500-year hurricane. To model each of these hurricanes, the study region was defined. The City of Fitchburg was outlined by the Census Tracts in the City, and the probabilistic scenario was used. This scenario considers the impact of thousands of storms that have a multitude of tracks and intensities. The output shows the potential impact that could occur in Fitchburg if either a Category 2 or a Category 4 hurricane passed by. Hazus is based on 2010 Census data and 2014 dollars. The tables below show the estimated damage from both a Category 2 and a Category 4 hurricane in the City.

Table 4-17. Category 2 Hurricane Damage

Land Use Type	Total Number of Buildings	Total Number of Buildings Damaged[1]	Percent of Buildings Damaged[1]	Total Value of Building Damage[2]
Residential	10,661	109	1.03	$10,955.61
Commercial	929	10	1.04	$249.94
Industrial	318	3	1.13	$122.64
Others	200	2	3.83	$73.19
TOTAL	**12,108**	**124**	**8.06**	**$11,401.38**

[1]Includes Slight, Moderate, Extensive, and Complete Damage
[2]Includes Building, Content and Inventory

Table 4-18. Category 4 Hurricane Damage

Land Use Type	Total Number of Buildings	Total Number of Buildings Damaged[1]	Percent of Buildings Damaged[1]	Total Value of Building Damage[2]
Residential	10,659	1066	10%	$52,899.12
Commercial	930	71	7%	$2,301.78
Industrial	317	24	1%	$2,472.48
Others	201	16	30%	$847.96
TOTAL	12,108	1,177	48%	**$58,521.34**

[1]Includes Slight, Moderate, Extensive, and Complete Damage
[2]Includes Building, Content and Inventory

In addition to infrastructural damage, Hazus also calculates the potential societal impact, property damage, and business interruption loss. A full Hazus risk report for each hurricane category can be found in Appendix B.

4.3.3 Tornados

A tornado is a narrow, rotating column of air that extends from the base of a cloud to the ground. Tornadoes are the most violent of all atmospheric storms (EEA and EOPSS, 2018). According to the 2018 SHMCAP, the following are common factors in tornado formation:

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

Tornadoes can be spawned by tropical cyclones or the remnants thereof, and weak tornadoes can even form from little more than a rain shower if air is converging and spinning upward. The most common months for tornadoes to occur are June, July, and August. There are exceptions: The 1995 Great Barrington, Massachusetts tornado occurred in May; and the 1979 Windsor Locks, Connecticut tornado occurred in October (EEA and EOPSS, 2018).

The Fujita Tornado Scale measures tornado severity through estimated wind speed and damage. The National Weather Service began using the Enhanced Fujita-scale (EF-scale) in 2007, which led to increasingly accurate estimates of tornado severity. Table 4-19 provides more detailed information on the EF Scale.

Table 4-19. Enhanced Fujita Scale

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

(MEMA and DCR, 2013, p.416)

Massachusetts experiences an average of 1.7 tornadoes per year. The most tornado-prone areas of the State are the central counties. In 2018 there were three EF1 tornados that touched down in Worchester County causing damage to the surrounding areas. On June 23rd, 2015, a tornado with maximum winds estimated at 75 mph, wreaked havoc near the Wachusett Mountain which is close to Fitchburg. Tornadoes are comparatively rare in eastern Massachusetts, although Worcester County is considered an at-risk location (EEA and EOPSS, 2018). There have been 33 recorded tornadoes in Worcester County since 1950 (NOAA, 2019a). Table 4-20 below provides additional information. The most devastating tornado in Massachusetts in the history of recorded weather occurred in Worcester County in 1953, it killed 90 people, injured more than 1,200, and caused more than $250 million in damages (NOAA, 2019a) (not adjusted for inflation).

Table 4-20. Tornado Records for Worcester County, 1950-2019

Date	Fujita	Fatalities	Injuries	Property Damage
6/9/1953	F4	90	1228	$250,000,000
10/24/1955	F1	0	0	$2,500
6/1/1956	F1	0	14	$25,000
11/21/1956	F2	0	0	$2,500,000
6/19/1957	F1	0	0	$25,000
7/5/1957	F2	0	0	$2,500
7/11/1958	F1	0	0	$250
7/16/1958	F1	0	1	$2,500
7/29/1958	F1	0	0	$2,500
10/12/1962	F2	0	0	$25,000
5/20/1963	F2	0	0	$25,000
8/31/1966	F2	0	0	$0
7/17/1968	F1	0	0	$2,500
5/29/1969	F1	0	0	$2,500
10/3/1970	F3	0	0	$250,000
7/1/1971	F1	0	2	$25,000
11/7/1971	F1	0	0	$2,500
8/9/1972	F2	0	1	$25,000
5/3/1976	F1	0	0	$2,500

Date	Fujita	Fatalities	Injuries	Property Damage
8/10/1979	F2	2	2	$2,500,000
6/22/1981	F3	0	3	$25,000
8/8/1986	F1	0	0	$2,500
7/10/1989	F1	0	0	$250,000
8/10/1990	F0	0	0	$30
6/17/2001	F1	0	0	$25,000
7/23/2002	F1	0	0	$50,000
7/19/2007	EF0	0	0	$0
6/1/2011	EF3	0	0	$0
8/31/2014	EF0	0	0	$100,000
6/23/2015	EF0	0	0	$25,000
7/26/2018	EF1	0	0	$25,000
8/4/2018	EF1	0	1	$5,000,000
10/23/2018	EF1	0	0	$0
Total		92	1,252	$260,922,780

(NOAA, 2019a)

There have been no recorded tornadoes in the city. If a tornado were to occur in Fitchburg, damages would depend on the track of the tornado and would be most likely be high due to the prevalence of older construction and the density of development that exist. Structures built before current building codes may be more vulnerable. Evacuation, sheltering, debris clearance, distribution of food and other supplies, search and rescue, and emergency fire and medical services may be required. Critical evacuation and transportation routes may be impassable due to downed trees and debris, and recovery efforts may be complicated by power outages.

Tornado events in Fitchburg are a very low frequency event and the entire city area is equally susceptible. As defined by the 2013 Massachusetts State Hazard Mitigation Plan, this hazard may occur less than once in 100 years (a less-than 1% chance per year). Tornados are difficult to simulate well in climate models because of their small size. However, it is predicted that the frequency of tornados in eastern Massachusetts will rise in the future due to climate change.

4.3.4 Nor'easters

A nor'easter is characterized by large counterclockwise wind circulation around a low-pressure center that often results in heavy snow, high winds, waves, and rain along the East Coast of North America. The term nor'easter refers to their strong northeasterly winds blowing in from the ocean. The storm radius is often as much as 100 miles and sustained wind speeds of 20 to 40 mph are common, with short-term gusts of up to 50 to 60 mph. Nor'easters are commonly accompanied by a storm surge equal to or greater than two feet. High surge and winds during a hurricane can last from 6 to 12 hours, while these conditions during a nor'easter can last from 12 hours to three days (EEA and EOPSS, 2018). These winter weather events are among the season's most ferocious storms, often causing beach erosion, flooding, and structural damage (EEA and EOPSS, 2018). Due to its inland location, Fitchburg is not subject to the coastal hazards often associated with nor'easters. The City of Fitchburg is vulnerable to high winds, snow, and extreme rain during nor'easters. These impacts can lead to property damage, downed trees, power service disruptions, surcharged drainage systems, and localized flooding. These conditions can impact evacuation and transportation routes and complicate emergency response efforts. Some of the historic events described in the "Flood-Related Hazards" section of this report was preceded by nor'easters, including the 1991 "Perfect Storm." The Blizzard of '78 was a particularly notable storm. More recently, winter storms in 2015 and 2018 caused significant snowfall amounts.

Nor'easters generally occur on at least an annual basis, typically in late fall and early winter. Some years bring up to four nor'easter events. Nor'easters in Fitchburg are high frequency events. As defined by the 2013 Massachusetts State Hazard Mitigation Plan, this hazard may occur more frequently than once in 5 years (a greater than 20% chance per year).

4.3.5 Climate Change and Severe Storms

There is evidence suggesting that nor'easters along the Atlantic coast are increasing in frequency and intensity. Future nor'easters may become more concentrated during the coldest winter months when atmospheric temperatures are still low enough to result in snowfall rather than rain (EEA and EOPSS, 2018).

4.4 Winter Storms

Winter storm events are atmospheric in nature and can impact the entire planning area. All current and future buildings and populations are at risk of winter storms, which have a variety of potential impacts. Fitchburg's hilly topography magnifies winter storms impacts. Heavy snow loads may cause roofs and trees to collapse, leading to structural damage. Deaths and injury are also possible impacts. Additional impacts can include road closures, power outages, business interruption, business losses (i.e. due to road closures), hazardous driving conditions, frozen pipes, fires due to improper heating, and second-hand health impacts caused by shoveling (such as a heart attack). Public safety issues are also a concern, as streets and sidewalks can become difficult to pass. This issue may be especially difficult for vulnerable populations such as elderly people who may have trouble crossing at intersections due to large accumulations of snow. Impassable streets can also complicate emergency response efforts during an extreme event.

Winter storms are a potential town-wide hazard in Fitchburg. These events can include wind, heavy snow, blizzards, and ice storms. Blizzards and ice storms in Massachusetts can range from an inconvenience, to extreme events that cause significant impacts and require a large-scale, coordinated response.

Table 4-21. Previous Federal Disaster Declarations – Winter Weather

Disaster Name and Date of Event	Disaster Number	Type of Assistance	Counties Under Declaration
Snowstorm March 05, 2001 - March 07, 2001	EM-3165	FEMA Public Assistance	Middlesex, Essex, Norfolk, Worcester, Hampshire, Franklin, Berkshire
Snowstorm December 6-7, 2003	EM-3191	FEMA Public Assistance	Middlesex, Essex, Suffolk, Norfolk, Bristol, Plymouth, Barnstable, Worcester, Hampshire, Hampden, Franklin, Berkshire

Disaster Name and Date of Event	Disaster Number	Type of Assistance	Counties Under Declaration
Snowstorm January 22 - 23, 2005	EM-3201	FEMA Public Assistance	All 14 Massachusetts Counties
Severe Winter Storm and Flooding December 11-18, 2008	DR-1813	FEMA Public Assistance; FEMA Hazard Mitigation Grant Program	All 14 Massachusetts Counties
Severe Winter Storm December 11-18, 2008	EM-3296	None	Middlesex, Essex, Suffolk, Bristol, Worcester, Hampshire, Hampden, Franklin, Berkshire
Severe Winter Storm, Snowstorm, and Flooding February 8-9, 2013	DR-4110	FEMA Public Assistance	All 14 Massachusetts Counties
Severe Winter Storm, Snowstorm, and Flooding January 26-28, 2015	DR-4214	FEMA Public Assistance	Barnstable, Bristol, Dukes, Essex, Middlesex, Nantucket, Norfolk, Plymouth, Suffolk, Worcester
Severe Winter Storm and Snowstorm March 13-14, 2018	DR-4379	FEMA Public Assistance	Essex, Middlesex, Norfolk, Suffolk, Worcester

(FEMA, 2019d)

4.4.1 Heavy Snow and Blizzards

A blizzard is a winter snowstorm with sustained wind or frequent wind gusts of 35 mph or more, accompanied by falling or blowing snow that reduces visibility to or below a quarter of a mile. 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 criteria. 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 (EEA and EOPSS, 2018).

Winter storms pose multiple risks, including wind, ice, and heavy snow. The National Weather Service defines “heavy snow” as snowfall accumulating to 4" or more in 12 hours or less; or snowfall accumulating to 6" or more in 24 hours or less (NOAA and National Weather Service, 2019). Winter storms can be combined with the nor’easters discussed previously in the “Wind-Related Hazards” section.

Figure 4-6. Fitchburg after heavy snow.
(Source: Wx1box - National Weather Service Boston/Norton Amateur Radio Skywarn Group Facebook Page)

There have been 41 winter storm entries between 2000 and 2019 totaling $1.5 million of storm damage in Worcester County (NOAA, 2019a). Two of the entries were categorized as a blizzard. No injuries or deaths were reported. The "Blizzard of 1978" is a well-known winter storm that deposited more than three feet of snow and led to multi-day closures of roads, businesses, and schools. Winter weather and heavy snow also have caused significant damages (totaling up to $1.3 million) in Worcester County between 2000 and 2019 (NOAA, 2019a).

The City provides standard snow plowing operations and clearing snow has not posed any significant challenges. However, city officials acknowledged that due to steep areas, icing conditions can occur throughout the city, making travel difficult. The spring thaw, with freezing conditions, is particularly difficult in these hilly areas.

Blizzards are classified as high frequency events in Fitchburg. As defined by the 2013 Massachusetts State Hazard Mitigation Plan, this hazard can occur more than once in five years (a greater than 20% chance of occurring each year).

4.4.2 Ice Storms

Ice storm conditions are defined by liquid rain falling and freezing on contact with cold objects creating ice build-ups of ¼ inch or more that can cause severe damage. An ice storm warning, now included in the criterion for a winter storm warning, is for severe icing. This is issued when ½ inch or more of accretion of freezing rain is expected. This may lead to dangerous walking or driving conditions and the weighing down of power lines and trees. Icy roads can also complicate emergency response efforts during an extreme event. There were four ice storms in Worcester County between 2000 to 2019, during which $23 million worth of property damage came from just one ice storm on 12/11/2008. Up to six tenths of an inch of ice accumulated on exposed surfaces across southern Worcester County. Trees, large limbs, and wires were downed in Worcester, Auburn, Charlton, Grafton, Oxford, Worcester, and Shrewsbury. Several trees landed on houses and one landed on a boat (NOAA, 2019a). Cities and towns were without power for days and school were canceled due to power outages.

Ice storms are classified as medium frequency events in Fitchburg and the entire city area is equally susceptible. As defined by the 2013 Massachusetts State Hazard Mitigation Plan, this hazard can occur between once in five years and once in 50 years (a 2% to 20% chance of occurring each year).

Sleet occurs when raindrops fall into subfreezing air thick enough that the raindrops refreeze into ice before hitting the ground. Sleet differs from hail. Sleet is a wintertime phenomenon, while hail usually falls during thunderstorms in the spring and summer (MEMA and DCR, 2013).

4.5 Geological Hazards

Geologic hazards can include earthquakes, landslides, sinkholes, and subsidence. City officials did not identify any local areas that were previously recorded as being vulnerable to geologic hazards.

4.5.1 Earthquakes

An earthquake is the vibration, sometimes violent, of the earth's surface that follows a release of energy in the earth's crust due to fault fracture and movement. The magnitude or extent of an earthquake is a seismograph-measured value of the amplitude of the seismic waves. The Richter Magnitude Scale (Richter Scale) was developed in 1932 as a mathematical device to compare the size of earthquakes. The Richter Scale is the most widely known scale that measures earthquake magnitude. It has no upper limit and is not a direct indication of damage. An earthquake in a densely populated area, which results in many deaths and considerable damage, can have the same magnitude as an earthquake in a remote area that causes no damage. Table 4-22 summarizes Richter Scale magnitudes and corresponding earthquake effects (MEMA and DCR, 2013).

Table 4-22. Richter Scale and Effects

Richter Magnitudes	Earthquake Effects
Less than 3.5	Generally, not felt, but recorded
3.5- 5.4	Often felt, but rarely causes damage
Under 6.0	At most slight damage to well-designed buildings. Can cause major damage to poorly constructed buildings over small regions.
6.1-6.9	Can be destructive in areas up to about 100 km across where people live.
7.0- 7.9	Major earthquake. Can cause serious damage over larger areas.
8 or greater	Great earthquake. Can cause serious damage in areas several hundred meters across.

(Louie, 1996)

Earthquakes occur occasionally in New England compared to other parts of the country and are often so small that they are not felt. The first recorded earthquake was noted by the Plymouth Pilgrims and other early settlers in 1638. Of the over 5,000 earthquakes recorded in the Northeast Earthquake Catalog through 2008, 1,530 occurred within the boundaries of the six New England States, with 366 earthquakes recorded for Massachusetts between 1627 and 2008. Historically, moderately damaging earthquakes strike somewhere in the region every few decades, and smaller earthquakes are felt approximately twice per year (MEMA and DCR, 2013). A summary of historic earthquakes in Massachusetts is included in Table 4-23 below.

Table 4-23. Historical Earthquakes in Massachusetts and Surrounding Area, 1727-2020

Location	Date	Magnitude
MA - Cape Ann	11/10/1727	5
MA - Cape Ann	12/29/1727	NA
MA - Cape Ann	2/10/1728	NA
MA - Cape Ann	3/30/1729	NA
MA - Cape Ann	12/9/1729	NA
MA - Cape Ann	2/20/1730	NA
MA - Cape Ann	3/9/1730	NA
MA - Boston	6/24/1741	NA
MA - Cape Ann	6/14/1744	4.7
MA - Salem	7/1/1744	NA
MA - Off Cape Ann	11/18/1755	6

Location	Date	Magnitude
MA - Off Cape Cod	11/23/1755	NA
MA - Boston	3/12/1761	4.6
MA - Off Cape Cod	2/2/1766	NA
MA - Offshore	1/2/1785	5.4
MA - Wareham/Taunton	12/25/1800	NA
MA - Woburn	10/5/1817	4.3
MA - Marblehead	8/25/1846	4.3
MA - Brewster	8/8/1847	4.2
MA - Boxford	5/12/1880	NA
MA - Newbury	11/7/1907	NA
MA - Wareham	4/25/1924	NA
MA - Cape Ann	1/7/1925	4
MA - Nantucket	10/25/1965	NA
MA - Boston	12/27/1974	2.3
MA - Nantucket	4/12/2012	4.5
MA – Newburyport	2/20/2013	2.3
MA – Freetown	1/9/2014	2.0
MA – Bliss Corner	2/11/2014	2.2
MA – off Northshore	8/18/2014	2.0
MA – Rockport Coast	6/1/2016	2.2
MA – Nantucket	8/18/2018	2.4
MA – Templeton	12/21/2018	2.1
MA – Gardner	12/23/2018	2.2
MA – Rockport	4/27/2019	2.1
MA – North Plymouth	12/3/2019	2.1

(USGS, 2020)

Ground shaking or ground motion is the primary cause of earthquake damage to man-made structures. Ground motion from earthquakes is amplified by soft soils and reduced by hard rock. Ground motion is measured by maximum peak horizontal acceleration expressed as a percentage of gravity (%g). Peak ground acceleration in the State ranges from 10 %g to 20 %g, with a 2% probability of exceedance in 50 years.

A serious earthquake in Massachusetts is possible. Fitchburg is located in an area with a PGA of 12%g with a 2% probability of exceedance in 50 years (Figure 4-7). This is the fourth highest zone in the state with two reported earthquakes of magnitude 3 in the past. However, none of the earthquakes have their epicenter recorded in Fitchburg. Thus, Fitchburg is a moderate area of earthquake risk. Although new construction under the most recent building codes generally will be built to seismic standards, much of the development in the city pre-dates the current building code. These events can strike without warning and can have a devastating impact on infrastructure and buildings constructed prior to earthquake resistant design considerations. It can be assumed that all existing and future buildings and populations are at risk to an earthquake hazard. If an earthquake occurs, the entire region, not just the City, would face significant challenges.

Impacts from earthquakes can range from slight to moderate building damage, to catastrophic damage and fatalities, depending on the severity of the earthquake event. Events may cause minor damage such as cracked plaster and chimneys, or broken windows, or major damage resulting in building collapse. Based on the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, the degree of exposure "depends on many factors, including the age and construction type of the structures where people live, work, and go to school; the soil type these buildings are constructed on; and the proximity of these building to the fault location." Furthermore, the time of day exposes different sectors of the community to the hazard. Earthquakes can lead to business interruptions, loss of utilities and road closures which may isolate populations. People who reside or work in unreinforced masonry buildings are vulnerable to liquefaction (liquefaction is the phenomenon that occurs when the strength and stiffness of a soil is reduced by earthquake). Earthquakes often trigger fires and the water distribution system may be disrupted, thus posing a risk for public health and safety.

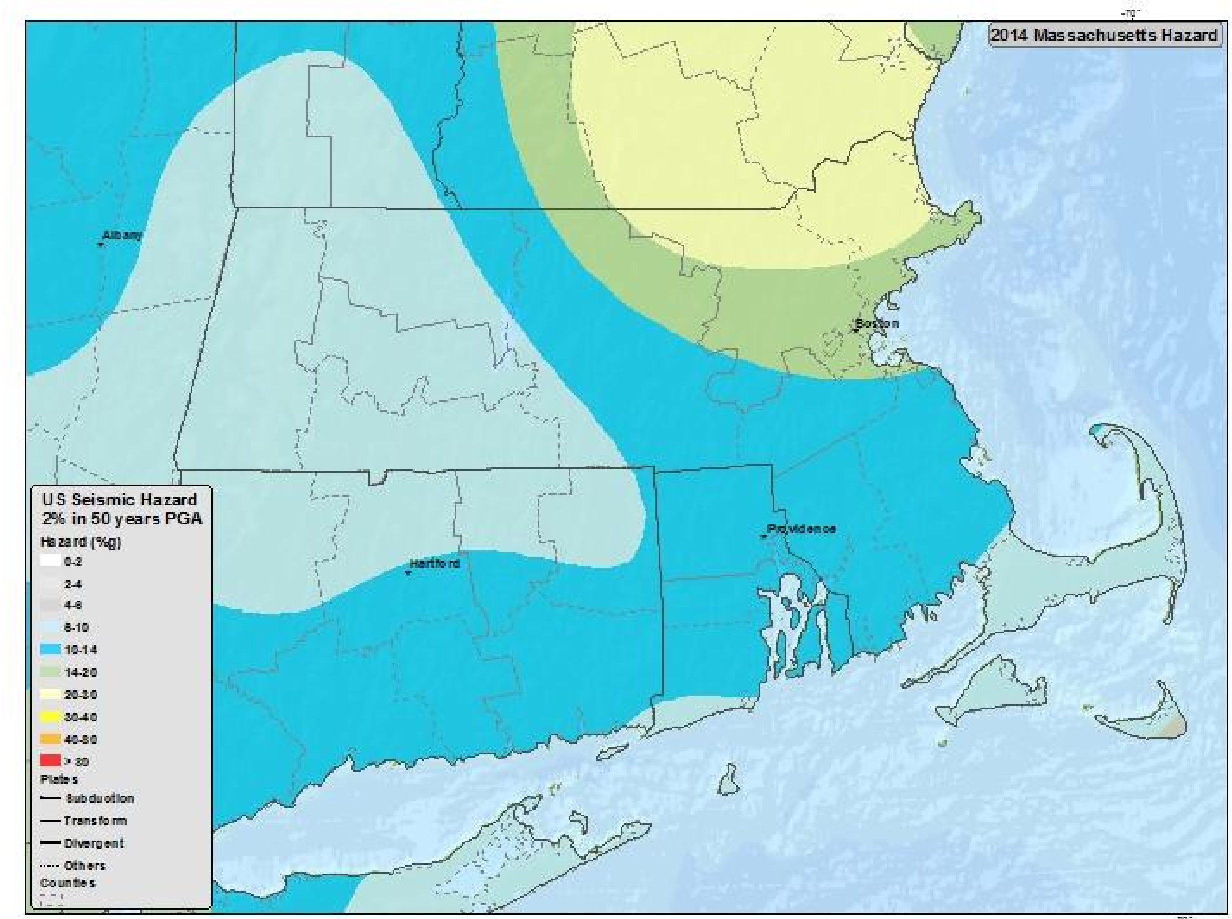


Figure 4-7. 2014 Seismic Hazard Map- Massachusetts
(USGS)

Potential earthquake damage was modeled for Fitchburg using Hazus. The Hazus earthquake model allows users to input specific parameters in order to model a defined earthquake magnitude, with the epicenter located at the center of the municipality. In this analysis, two earthquakes were modeled: a magnitude 5.0 and a magnitude 7.0 earthquake. While large earthquakes are rare in Massachusetts, there was a magnitude 5.0 earthquake recorded in 1963. The tables below show the estimated damage from both a magnitude 5.0 and a magnitude 7.0 earthquake in the municipality. In addition to the infrastructural damage, Hazus also calculated the potential social impact, property damage, and business interruption loss. A full Hazus risk response report for each earthquake category can be found in Appendix B.

Table 4-24. Estimated Infrastructural Damage in Fitchburg from Magnitude 5 Earthquake

Land Use Type	Total Number of Buildings	Total Number of Buildings Damaged	Percent of Buildings Damaged	Total Value of Building Damage[1]
Residential	10,658	5232	49%	$174,000,000
Commercial	930	720	77%	$170,000,000
Industrial	317	248	78%	$103,000,000
Others	198	130	65%	$93,000,000
TOTAL	**12,103**	**6330**	**52%**	**$ 756,000,000**

[1]Includes Slight, Moderate, Extensive, and Complete Damage
[2]Includes Building, Content and Inventory

Table 4-25. Estimated Infrastructural Damage in Fitchburg from Magnitude 7 Earthquake

Land Use Type	Total Number of Buildings	Total Number of Buildings Damaged	Percent of Buildings Damaged	Total Value of Building Damage[1] (millions of dollars)
Residential	10658	10,621	99%	$2,989.3136
Commercial	930	929	99%	$1,065.8684
Industrial	317	316	99%	$637.5407
Others	198	196	99%	$586.8761
TOTAL	**12,103**	**12,062**	**99%**	**$ 5,279.9680**

[1]Includes Slight, Moderate, Extensive, and Complete Damage
[2]Includes Building, Content and Inventory

Earthquakes are classified as a low frequency event in Fitchburg. As defined by the 2013 State Hazard Mitigation Plan, these events occur from once in 50 years to once in 100 years, or 1% to 2% per year. According to the 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan, the probability of a magnitude 5.0 or greater earthquake centered in New England is about 10-15% in a 10-year period.

4.5.2 Landslides

Landslides include a wide range of ground movement, such as rock falls, deep failure of slopes, and shallow debris flows. Although gravity acting on an over steepened slope is the primary reason for a landslide, there are other contributing factors. These contributing factors can include erosion by rivers or ocean waves over steepened slopes, rock and soil slopes weakened through saturation by snowmelt or heavy rains, earthquake-created stresses that make weak slopes fail, excess weight from accumulation of rain or snow, and stockpiling of rock or ore from waste piles or man-made structures (USGS, 2019).

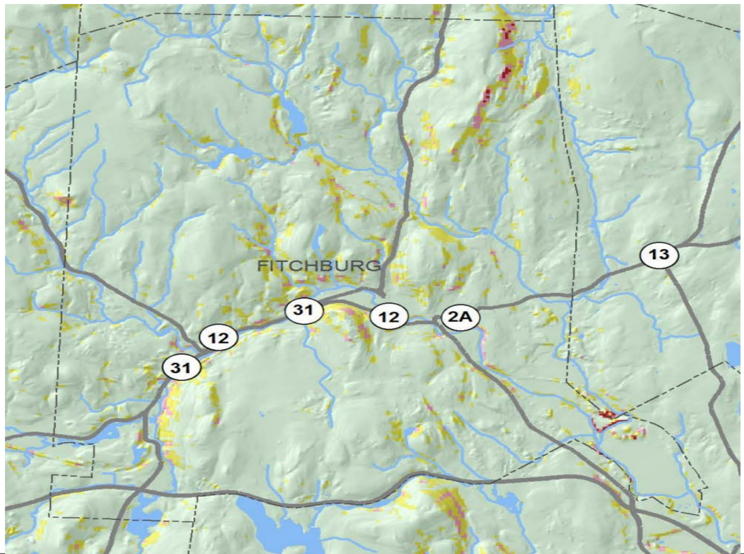
Landslides occur throughout the United States, causing an estimated $1 billion in damages and 25-50 deaths each year. Any area composed of very weak or fractured materials resting on a steep slope will likely experience landslides. Although the physical cause of many landslides cannot be removed, geologic investigations, good engineering practices, and effective enforcement of land-use management regulations can reduce landslide hazards (USGS, 2019). Landslides can damage buildings and infrastructure and cause sedimentation of water bodies. Landslide intensity can be measured in terms of destructiveness, as demonstrated by Table 4-26 below.

Table 4-26. Landslide Volume and Velocity

Estimate Volume (m^3)	Expected Landslide Velocity		
	Fast moving (rock fall)	Rapid moving (debris flow)	Slow moving (slide)
<0.001	Slight intensity	--	--
<0.5	Medium intensity	--	--
>0.5	High intensity	---	--
<500	High intensity	Slight intensity	--
500-10,000	High intensity	Medium intensity	Slight intensity
10,000 – 50,000	Very high intensity	High intensity	Medium intensity
>500,000	--	Very high intensity	High intensity
>>500,000	--	--	Very high intensity

(Cardinali et al., 2002)

Fitchburg is classified as stable and therefore having a low risk for landslides (Fig. 4-8). No significant landslides have been recorded for Fitchburg or Worcester County (Appendix B of EEA and EOPSS, 2018). Rather, local officials indicate that there are occasionally localized issues of erosion during construction as a result of development, or as a result of clearing vegetation. Landslides are classified as low frequency events in Fitchburg. According to the 2013 State Hazard Mitigation Plan, these events occur from once in 50 years to once in 100 years, or 1% to 2% per year.



Map Color Code	Predicted Stability Zone	Relative Slide Ranking[1]	Stability Index Range[2]	Factor of Safety (FS)[3]	Probability of Instability[4]	Predicted Stability With Parameter Ranges Used in Analysis	Possible Influence of Stabilizing or Destabilizing Factors[5]
	Unstable	High	0	Maximum FS<1	100%	Range cannot model stability	Stabilizing factors required for stability
	Upper Threshold of Instability		0 - 0.5	>50% of FS1	>50%	Optimistic half of range required for stability	Stabilizing factors may be responsible for stability
	Lower Threshold of Instability	Moderate	0.5 - 1	≥50% of FS>1	<50%	Pessimistic half of range required for instability	Destabilizing factors are not required for instability
	Nominally Stable	Low	1 - 1.25	Minimum FS=1	_	Cannot model instability with most conservative parameters specified	Minor destabilizing factors could lead to instability
	Moderately Stable		1.25 - 1.5	Minimum FS=1.25	_	Cannot model instability with most conservative parameters specified	Moderate destabilizing factors are required for instability
	Stable	Very Low	>1.5	Minimum FS=1.5	_	Cannot model instability with most conservative parameters specified	Significant destabilizing factors are required for instability

Figure 4-8. Slope Stability Map of Massachusetts focusing on Fitchburg
(Source: The Massachusetts Geological Survey, 2013)

4.6 Fire Related Hazards

Fitchburg is more likely to experience a brushfire compared to a wildfire (or a fire with a large impact area). Wildfires and brushfires can occur in the vegetative wildland, including grass, shrub, leaf litter, and forested tree fuels. Fires can be caused by natural events, human activity or in an intentional controlled manner, as in the case of prescribed fire (MEMA and DCR, 2013, 252). The State Hazard Mitigation and Climate Adaptation Plan (EEA and EOPPS, 2018) states:

> *"The ecosystems that are most susceptible to the wildfire hazard are pitch pine, scrub oak, and oak forests, as these areas contain the most flammable vegetative fuels. Other portions of the Commonwealth are also susceptible to wildfire, particularly at the urban-wildland interface…. Interface communities are defined as those in the vicinity of contiguous vegetation, with more than one house per 40 acres and less than 50 percent vegetation, and within 1.5 miles of an area of more than 500 hectares (approximately 202 acres) that is more than 75 percent vegetated."*

Brush fires are classified as medium frequency events in Fitchburg and occur frequently in the City (Fig. 4-9). As defined by the 2013 State Hazard Mitigation Plan, these events occur between once in five years to once in 50 years (a 2% to 20% chance of occurring per year). Fire risk is influenced by fuel (the type of material), terrain and weather. Strong winds can exacerbate extreme fire conditions, especially wind events that persist for long periods, or ones with significant sustained wind speeds that quickly promote fire spread through the movement of embers or exposure within tree crowns. Fires can spread quickly into developed areas.

Brush fires can lead to property damage and injury. The areas of Fitchburg most vulnerable to brush fire are primarily heavily wooded areas, such as the green spaces within and directly adjacent to downtown, such as Rollstone Hill and the City Forest area. The fire department has equipment and resources to respond to fires in these and other areas. Fitchburg had 458 fire incidents in 2017, out of which 406 were structure fires. The fire incidents caused one civilian death and two injuries. The number of fire incidents decreased to 428 (359 structure fires) in 2018, but four civilian injuries were reported. As described by the core team members, in 1940 Fitchburg experienced a large fire that caused significant property damages.

Brushfires can lead to death and property damage. All homes or workplaces located in brush fire hazard zones are exposed to this hazard. The most vulnerable members of this population are those who would be unable to evacuate quickly, including those over the age of 65, households with young children under the age of 5, people with mobility limitations, and people with low socioeconomic status (EEA and EOPSS, 2018). Secondary effects from brush fire include contamination of reservoirs, destroyed power, gas, water, broadband, and oil transmission lines. Brush fires can also contribute to flooding as they strip slopes of vegetation, thereby exposing them to greater amounts of runoff which may cause soil erosion and ultimately the chance of flooding. Additionally, subsequent rains can worsen erosion because brush fires burn ground vegetation and ground cover.

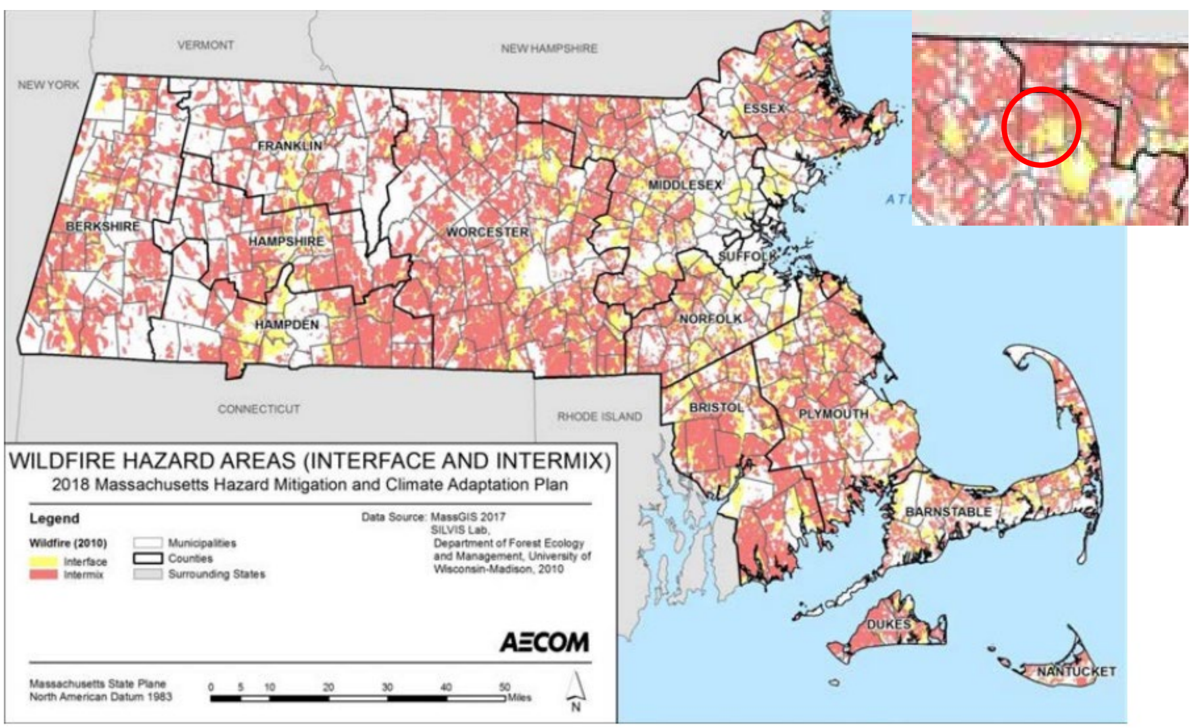


Figure 4-9. Wildfire related hazard areas in Massachusetts, Fitchburg is outlined in red.
Source: (EEA and EOPSS, 2018)

4.7 Extreme Temperatures

Massachusetts has four clearly defined seasons. Extreme temperatures are considered outliers, or temperatures that fall outside the typical range for each season. Extreme temperatures can last from an afternoon to a few days. Day and nighttime temperatures also play a role when considering the effect of temperature. For example, when the temperature does not cool off at night during an extreme heat wave, the risk of heat related illnesses is intensified. During extreme cold, pipes may freeze and burst in many buildings with unreinforced masonry.

4.7.1 Extreme Cold

Extremely cold temperatures are measured using the Wind Chill Temperature Index provided by the National Weather Service (NWS). The updated index was implemented in 2001 and helps explain the impact of cold temperatures on unexposed skin. Figure 4-10 below provides more information. Extreme temperatures are considered a City-wide hazard in Fitchburg and generally last from an afternoon to a few days. Extremely cold temperatures can create dangerous conditions for homeless populations, stranded travelers, and residents without sufficient insulation or heat. The homeless, the elderly, and people with disabilities are often most vulnerable. In Fitchburg, 14% of the population is over 65 years old and 15% of the population has a disability (US Census Bureau, 2018). Cold weather events can also have significant health impacts such as frostbite and hypothermia. Furthermore, power outages during cold weather may result in inappropriate use of combustion heaters, cooking appliances, and generators in poorly ventilated areas, which can lead to increased risk of carbon monoxide poisoning.

NOAA's National Centers for Environmental Information Storm Events Database provides data for extreme cold events. Between 2000 and 2019, Worcester County experienced seven extreme cold and will chill events, which caused no deaths, injuries, or property damage.

Temperature (°F)

Wind (mph)	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
Calm																		
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

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 4-10. Windchill Temperature Index and Frostbite Risk
(NOAA, n.d.)

4.7.2 Extreme Heat

Increased temperatures will impact all locations within Fitchburg. Extreme heat is when the maximum temperature reaches above 90°F during the day. Projected heat days and heat waves can have an increased impact in densely settled urban areas. These can become "heat islands" as dark asphalt and roofs store the heat from the sun. Impacts from heat stress can exacerbate pre-existing respiratory and cardiovascular conditions.

The City of Fitchburg does not collect data on heat occurrences. July is the hottest month in Fitchburg and average temperature is July is around 81°F (NEIC, 2019). NOAA's National Centers for Environmental Information Storm Events Database provides data on excessive heat. Between 2000 and 2019, Worcester County experienced three extreme heat days, which did not result in injury or property damage. An event in 2013 did result in a fatality. Extreme temperatures are classified as medium frequency events. As defined by the 2013 State Hazard Mitigation Plan, these events occur from once in 5 years to once in 50 years, or 2% to 20% per year. According to the 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan, between four and five heat waves (3 or more consecutive days of 90°+F temperatures) occur annually in Massachusetts.

The NWS issues a Heat Advisory when the Heat Index (Figure 4-11) is forecast to reach 100-104˚ F for two or more hours (NOAA, n.d.). The NWS issues an Excessive Heat Warning if the Heat Index is forecast to reach 105˚+F for two or more hours. Heat waves cause more fatalities in the U.S. than the total of all other meteorological events combined. From 1979-2012, excessive heat exposure caused in excess of 8,000 deaths in the United States (MEMA and DCR, 2013). During this period, more people in this country died from extreme heat than from hurricanes, lightning, tornadoes, floods, and earthquakes combined.

Relative Humidity (%)	Temperature (ºF)															
	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										

Category	Heat Index	Health Hazards
Extreme Danger	130 °F – Higher	Heat Stroke or Sunstroke is likely with continued exposure.
Danger	105 °F – 129 °F	Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.
Extreme Caution	90 °F – 105 °F	Sunstroke, muscle cramps, and/or heat exhaustions possible with prolonged exposure and/or physical activity.

Figure 4-11. Heat Index Chart
(NOAA, n.d.)

Because most heat-related deaths occur during the summer, people should be aware of who is at greatest risk and what actions can be taken to prevent a heat-related illness or death. According to the Centers for Disease Control and Prevention, the populations most vulnerable to extreme heat impacts include the following:

- People over the age of 65.
- Children under the age of five.
- Individuals with pre-existing medical conditions that impair heat tolerance.
- Individuals without proper cooling.
- Individuals with respiratory conditions.
- Individuals that overexert themselves during extreme heat events.

Homeless people are increasingly vulnerable to extreme heat. The capacity of homeless shelters is typically limited. In Fitchburg, children under five years old make up 22% of the population, and 14% are over 65 years old. However, even young, and healthy individuals can succumb to heat if they participate in strenuous physical activities during hot weather. Some behaviors also put people at greater risk, including drinking alcohol, taking part in strenuous outdoor physical activities in hot weather, and taking medications that impair the body's ability to regulate its temperature or that inhibit perspiration (MEMA and DCR, 2013; ACS 2014-2018).

Based on Figure 4-12 below, compiled by the Massachusetts Department of Public Health Bureau of Environmental Health (MA DPH, 2019), Fitchburg has a population density of 1478 people per square mile. The total number of population vulnerability measures in each Census Tract (2010) varies between 2 and 3. These population vulnerability measures include: low income, low English proficiency, non-white (Hispanic and non-Hispanic ethnicities), and elderly residents.

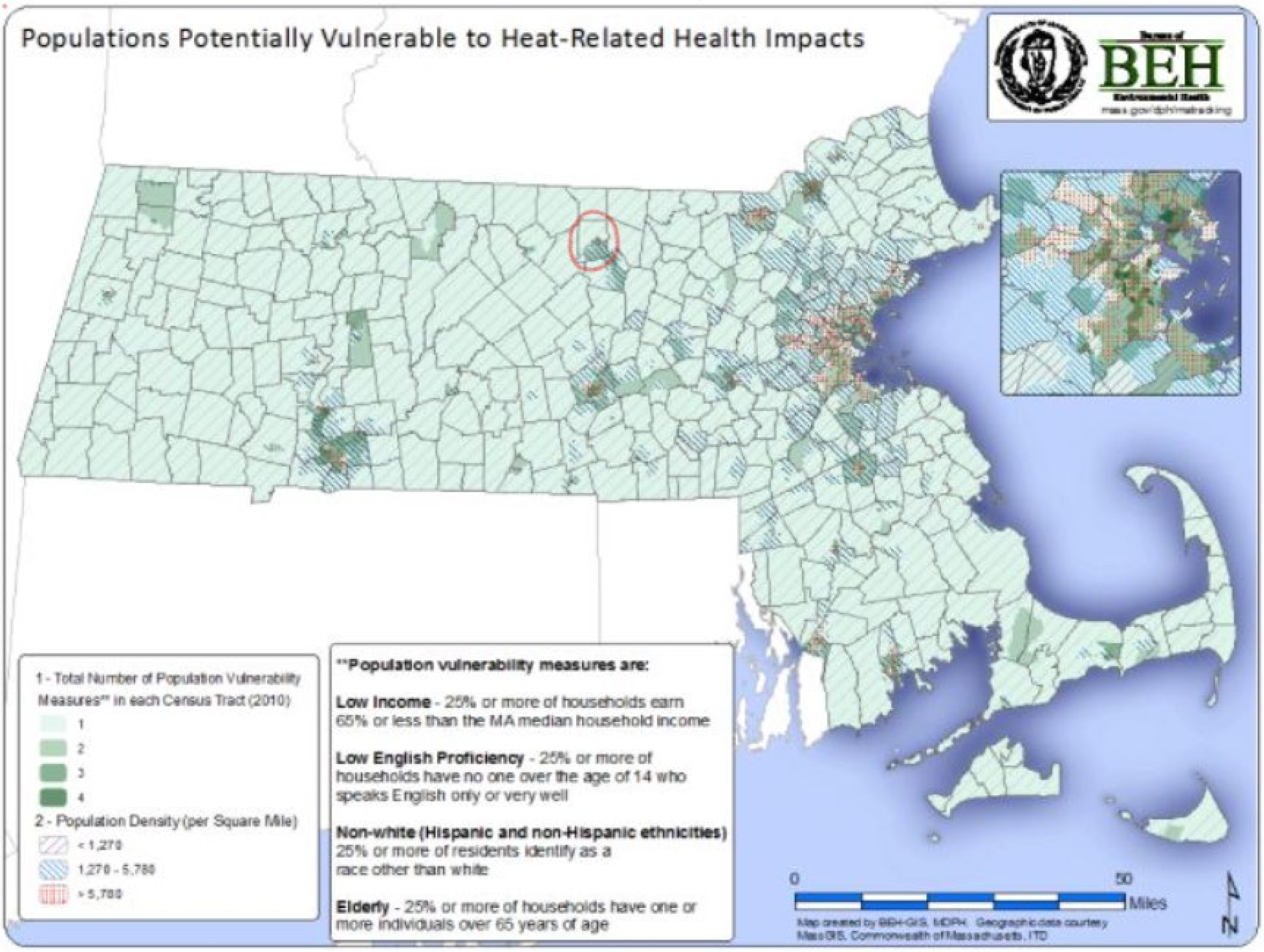


Figure 4-12. Populations Potentially Vulnerable to Heat Related Health Impacts
(Massachusetts Department of Public Health, Bureau of Environmental Health, 2019)

4.7.3 Climate Change Impacts: Extreme Temperatures

Between 1961 and 1990, Boston experienced an average of one day per year in excess of 100°F. That could increase to six days per year by 2070, and 24 days per year by 2099. Under these conditions, by the end of the century, Massachusetts's climate could more closely resemble that of Maryland or the Carolinas (refer to Figure 4-13 below). These changes in temperature would also have a detrimental impact on air quality and public health concerns, including asthma and other respiratory conditions (Frumhoff et al., 2007). Increased temperatures can lead to a longer growing season, which in turn leads to a longer pollen season. Warmer weather can also support the migration of invasive species and lead to an increase in vector-borne diseases. Increasing temperatures can also worsen air pollution, which can lead to negative health impacts such as respiratory problems.

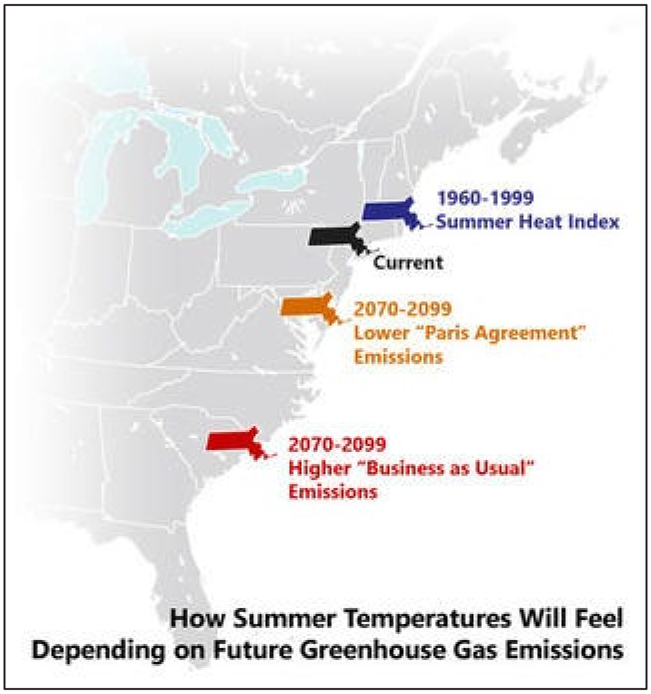


Figure 4-13. Massachusetts Extreme Heat Scenarios.
(Frumhoff et al., 2007)

4.8 Drought

Drought is an extended period of deficient precipitation and occurs in virtually all climatic zones. Since each region has a different baseline precipitation amount, the characteristics of drought vary significantly from one region to another. Agriculture, the water supply, aquatic ecosystems, wildlife, and the economy are vulnerable to the impacts of drought (EEA and EOPSS, 2018).

Although Massachusetts is relatively small, it has a number of distinct regions that experience significantly different weather patterns and varying impacts from changes in precipitation. In accordance with the Massachusetts Drought Management Plan, the Drought Management Task Force provides recommendations to the Secretary of Energy & Environmental Affairs about the location and severity of drought in the Commonwealth. The Drought Management Plan (2019) divides the state into seven regions: Western, Central, Connecticut River Valley, Northeast, Southeast, Cape, and Islands. Fitchburg is located within the central region (EEA and MEMA, 2019).

According to the updated Drought Management Plan (2019) there are five levels of drought to characterize drought severity.

- Level 0 – Normal,
- Level 1 - Mild Drought,
- Level 2 - Significant Drought,
- Level 3 - Critical Drought, and
- Level 4 – Emergency Drought,

The drought levels are based on the severity of drought conditions and their impacts on natural resources and public water supplies.

Although the City of Fitchburg experienced water supply restrictions in 2015, the City usually has adequate water supply. The drinking water supply system was built to support the paper mill industry, which was a significant water user. Since the mills are no longer in operation, there is typically abundant water supply in Fitchburg.

The Drought Management Plan specifies agency response and interagency coordination and communication based on various drought levels. During normal conditions, data are routinely collected and distributed. There is additional data collection during an advisory, and increased assessment and proactive education during a watch. Water restrictions might be appropriate at the watch or warning stage, depending on the capacity of each individual water supply system. A warning level indicates a severe situation and the possibility that a drought emergency may be necessary. A drought emergency is one in which use of emergency supplies become necessary, or in which the Governor may exercise his authority to require mandatory water restrictions (EEA and MEMA, 2019).

A variety of drought indices are available to assess the various impacts of dry conditions. The Commonwealth uses a multi-index system to determine the severity of a drought or extended period of dry conditions. A determination of drought level is based on seven indices:

1. Standardized Precipitation Index
2. Precipitation (percent of normal)
3. Crop Moisture Index
4. Keetch-Byram Drought Index (KBDI)
5. Groundwater levels
6. Stream flow levels
7. Index Reservoir levels

In the updated Drought Management Plan, the Drought Management Trask Force has eliminated the precipitation index that is based on percent of normal precipitation.

Drought level is determined monthly, based on the number of indices that have reached a certain level. A majority of the indices would need to be triggered in a region in order for a drought designation to move to a more severe level. Drought levels are declared on a regional basis for each of the six regions in Massachusetts. Drought levels may also be made county by county, or be watershed specific. The end of a drought is determined by precipitation and groundwater levels, since these have the greatest long-term impact on streamflow, water supply, reservoir levels, soil moisture and potential for forest fires (EEA and MEMA, 2013).

Worcester county had 13 drought periods from 2000 to 2019, according to the National Center for Environmental Information. Six of these events were declared Extreme Droughts by The U.S. Drought Monitor (NOAA, 2019a). Figure 4-14 illustrates statewide drought levels in Massachusetts from 1850 to 2012, using the Standardized Precipitation Index (SPI). Table 4-27 below summarizes a history of Massachusetts droughts between 1879 and 2017.

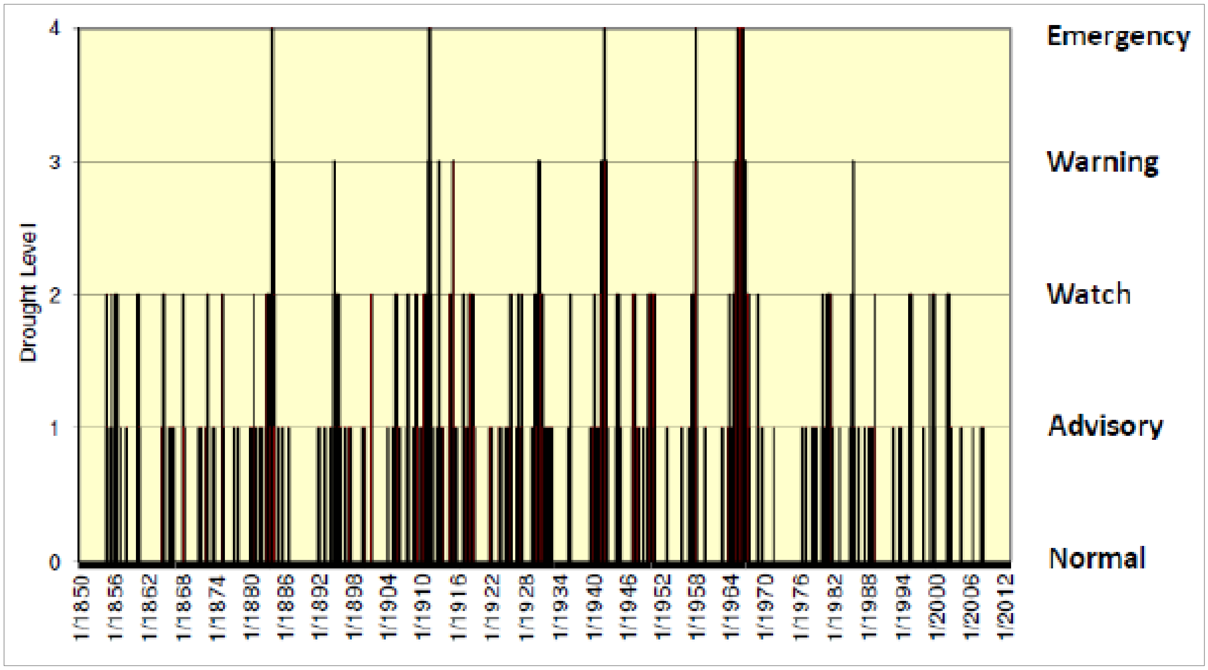


Figure 4-14 Statewide Drought Levels Using SPI Thresholds, 1850 to 2012.

Source: EEA and MEMA, 2013, page 37.

Table 4-27. Droughts in Massachusetts Based on Instrumental Records

Date	Area Affected	Recurrence Interval (years)	Remarks
1879 to 1883	–	–	–
1908 to 1912	–	–	–
1929 to 1932	Statewide	10 to >50	Water-supply sources altered in 13 communities. Multistate.
1939 to 1944	Statewide	15 to >50	More severe in eastern and extreme western Massachusetts. Multistate.
1957 to 1959	Statewide	5 to 25	Record low water levels in observation wells, northeastern Massachusetts.
1961 to 1969	Statewide	35 to >50	Water-supply shortages common. Record drought. Multistate.

Date	Area Affected	Recurrence Interval (years)	Remarks
1980 to 1983	Statewide	10 to 30	Most severe in Ipswich and Taunton River basins; minimal effect in Nashua River basin. Multistate.
1985 to 1988	Housatonic River Basin	25	Duration and severity unknown. Streamflow showed mixed trends elsewhere.
1995	–	–	Based on statewide average precipitation.
1998 to 1999	–	–	Based on statewide average precipitation.
2001 to 2003	Statewide	–	Level 2 drought (out of 4 levels) was reached statewide for several months.
2007 to 2008	Statewide except West and Cape and Islands regions	–	Level 1 drought (out of 4 levels)
2010	Connecticut River Valley, Central and Northeast regions	–	Level 1 drought (out of 4 levels)
2014	Southeast and Cape and Islands regions	–	Level 1 drought (out of 4 levels)
2016-2017	Statewide	–	Level 3 drought (out of 4 levels).

(EEA and EOPSS, 2018, page 4-45)

Drought Watches not associated with higher levels of drought generally would have occurred three to four times per decade between 1850 and 1950. The Drought Emergency declarations dominated the 1960s. There were no Drought Watches, or more severe drought conditions, in the 1970s. In the 1980s, there was a lengthy Drought Watch level of precipitation between 1980 and 1981, followed by a Drought Warning in 1985. A frequency of Drought Watches at a rate of three years per decade resumed in the 1990s (1995, 1998, 1999). In the 2000s, Drought Watches occurred in 2001 and 2002. The overall frequency of being in a Drought Watch is eight percent on a monthly basis over the 162-year period of record (EEA and MEMA, 2019). There were six Drought Watches in Massachusetts in 2002, five Drought Watches in 2016, and two drought watches in 2017 (DCR, 2017b). Figure 4-15 presents an example of drought conditions in the six drought regions.

Drought is a potential city-wide hazard in Fitchburg. As noted previously, temperature is projected to increase and may lead to exacerbated drought conditions especially in summer and fall months. Droughts can also increase fire risk: fires can be caused by lightning, and a 2014 study found that the frequency of lightning strikes could increase by more than 10% for every degree Celsius of warming (EEA and EOPSS, 2018). During Fitchburg's CRB Workshop in February 2020, workshop participants discussed the connections between multiple hazards and their potential impact on the City. One example given was the potential for a severe drought to increase the risk of brush fires.

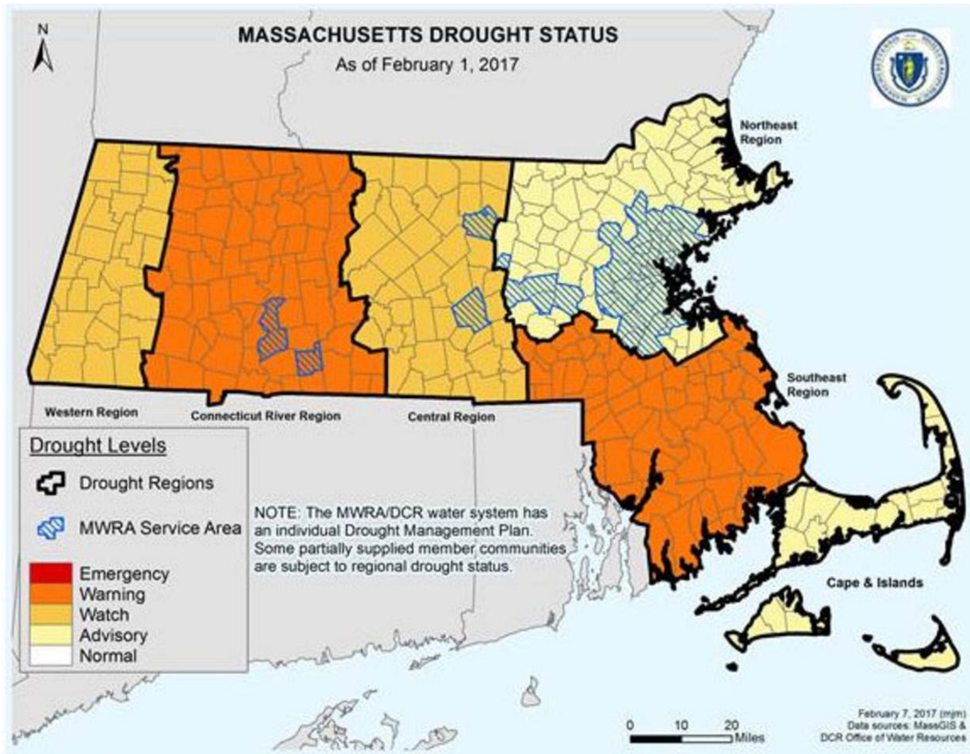


Figure 4-15. Massachusetts Drought Status, February 2017
(DCR, 2017b)

A long-term drought could lead to impacts to Fitchburg's wetlands and streams, North Nashua River and several drinking water reservoirs. Commercial, municipal, and residential water conservation is important during times of drought or low water levels. In a drought emergency affecting the water supply, water use restrictions would be implemented in Fitchburg, which could result in loss of landscaped areas and business revenues depending on the length of the water use restriction.

Droughts are classified as a low frequency natural hazard event. As defined by the 2013 Massachusetts State Hazard Mitigation Plan, these events can occur between once in 50 years to once in 100 years (a 1% to 2% chance of occurring per year).

4.8.1 Drought and Climate Change

Under climate change, drought conditions will be exacerbated with projected increasing air temperatures and changes in precipitation. Between 1970 and 2000, the median number of consecutive dry fall days in Massachusetts was 11.4 days. This is in comparison to a projected median of 13.5 consecutive days by the end of the century (EEA, 2018a). the same report also mentions that the occurrence of droughts lasting 1 to 3 months could go up by as much as 75% over existing conditions by the end of the century, under the high emissions scenario in the Northeastern States.

5.0 EXISTING MITIGATION MEASURES

The City of Fitchburg is already undertaking measures to mitigate local hazards. Chapter 5 documents the City's current operations and discusses potential improvements. FEMA's *Local Mitigation Planning Handbook* categorizes hazard mitigation measures into four types, as displayed in Table 5-1 below (FEMA, 2013). As this chapter will demonstrate, Fitchburg uses many of these tools.

Table 5-1. FEMA's Types of Mitigation Actions

Measure	Action	Examples
Local Plans and Regulations	These actions include government authorities, policies, or codes that influence the way land and buildings are developed and built.	• 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	These actions involve modifying existing structures and infrastructure to protect them from a hazard or remove them from a hazard area. This could apply to public or private structures as well as critical facilities and infrastructure. This type of action also involves projects to construct manmade structures to reduce the impact of hazards.	• Acquisitions and elevations of structures in flood prone areas • Utility undergrounding • Structural retrofits • Floodwalls and retaining walls • Detention and retention structures • Culverts • Safe rooms
Natural Systems Protection	These are actions that minimize damage and losses and preserve or restore the functions of natural systems.	• Sediment and erosion control • Stream corridor restoration • Forest management • Conservation easements • Wetland restoration and preservation
Education and Awareness Programs	These are actions to inform and educate citizens, elected officials, and property owners about hazards and potential mitigation strategies. A greater understanding and awareness of hazards and risk among local officials, stakeholders, and the public is more likely to lead to direct actions.	• Radio or television spots • Websites with maps and information • Real estate disclosure for properties in the floodplain • Presentations to school groups or neighborhood organizations • Mailings to residents in hazard-prone areas.

Measure	Action	Examples
		• Participation in the National Weather Service's StormReady community preparedness program • Participation in Firewise Communities through the National Fire Protection Association's community preparedness program

(*FEMA*, 2013)

There are numerous existing natural hazard mitigation measures already in place in Fitchburg. These were identified through feedback from the Core Team, CRB Workshop participants, interviews with local experts, and additional research by the project team. The hazard mitigation measures outlined below are organized by hazard type, including multi-hazards, floods, dam mitigation, wind, winter weather, drought, fire, extreme temperatures, and geologic hazards. The City is also involved in sustainability measures that offer public co-benefits that include improved pedestrian and cycling conditions.

5.1 Existing Multi-Hazard Mitigation Measures

Montachusett Emergency Response Committee – Under the Emergency Planning and Community Right to Know Act of 1986, communities are required to establish Emergency Planning Committees to develop a response plan for chemical emergencies. Fitchburg is a part of a regional emergency response committee, which includes Fitchburg, Leominster, and Lunenburg. In accordance with this legislation, the City of Fitchburg has identified locations where hazardous materials are stored, used, and transported.

Fitchburg Emergency Management is the lead department, but other representatives are invited to attend such as the Board of Health, Fire Department, and Mayor's Office.

Comprehensive Emergency Management Plan (CEMP)
Fitchburg has a CEMP that was last updated in 2014. The plan could be updated with new contact information and moved online. Every community in Massachusetts is required to have a Comprehensive Emergency Management Plan. This plan addresses mitigation, preparedness, response and recovery from a variety of natural and man-made emergencies. Included in this plan is important information regarding flooding, hurricanes, tornadoes, dam failures, earthquakes, and winter storms.

List of Critical Facilities – The list of critical facilities was updated during this planning process. The Montachusett Regional Planning Commission offers an interactive mapping application to update critical infrastructure.

Recommended Improvements

Continue to update materials and communicate with regional partners.

Update CEMP.

Use MRPC software to simulate real time evacuation scenarios to mitigate hazards to the public.

Regional Support from Surrounding Communities – Fitchburg has provided and received additional support from surrounding communities. The support is informally structured. The Fitchburg Emergency Management Director maintains contact with surrounding communities.	Formalize or document support systems to retain institutional knowledge and increase transparency in case of an emergency when additional support from other departments and municipalities may be needed.
FEMA Deployment – FEMA can deploy vehicles in the case of an emergency.	None at this time.
Salvation Army Emergency Assistance and Disaster Services – Assistance is offered by Salvation Army Emergency Assistance for families and individuals experiencing financial hardships, including food, clothing, and utility/heating assistance. Additionally, Service Units volunteers act as first responders and assist those impacted by fires, flood and other disasters using mobile kitchen truck, as part of the Salvation Army Disaster Services.	None at this time.
Certified Emergency Response Team (CERT) – A team of trained volunteers organized by the Fire Department who can be called upon to assist and respond during emergencies.	Expand the number of volunteers.
Waschusett Medical Reserve Corp – A non-profit organization providing medical care, counseling, and other social services in north Worcester County.	None at this time.
Emergency Management Training – The Emergency Manager has attended Texas A&M "TEEX" emergency management training.	Expand training for more municipal staff.
CodeRED – The City of Fitchburg has the CodeRED system, which provides City officials the ability to deliver messages to targeted areas or the entire City quickly through a reverse calling system. Residents may update their CodeRED information on the City website.	Expand outreach to increase the number of residents receiving alerts.
Emergency Shelters – The Senior Center is the City's designated FEMA shelter. If needed, all schools could be used as a shelter, but the Memorial Middle School and Fitchburg State's Recreation Centers would be the likely be best. The City also has a large portable shelter. The Fitchburg Public Library may also be used as a warming and cooling facility.	Develop a shelter plan for pets. Upgrade Senior Center or find a new building to serve as a shelter. Expand outreach about location of emergency shelters.

Backup Generators – Every city building has backup emergency generators, including the Senior Center, City Hall, the schools, Fire Stations, and the Police Station. Smaller generators are available if needed for residential homes or command posts. The Fire Department and CERT have access to these. The Water Division also has one portable generator for pump stations.	Install backup generators at critical facilities, including private entities (gas stations and grocery stores)
Buried Utilities – Although not required, many new developments have installed underground utilities. Buried utilities are required for Assisted and Independent Living Facilities and within the Mill Conversion Overlay District. The Community Development Department and the City's electric provider, Until, would lead any changes related to burying utility lines.	None at this time.
Permits for Construction – Permits are required from the Building Department to ensure the building code and utility connections are properly made. Public Works requires permits to ensure safe excavation, sewer connections and other stormwater regulations are met. The Fire Department inspects certain aspects of all new construction for fire prevention safety.	Develop an online permitting system to increase cross departmental coordination, streamline the process, and set easier to understand expectations.
Multi-Department Review of Developments – Depending upon the type of development, extent of construction, and location, multiple departments, including the Planning Board, Building Department, Board of Health, Department of Public Works, Conservation Commission, the Fire Department, and Zoning Board of Appeals, may review site plans prior to approval.	Streamline the system and increase coordination between departments.
Massachusetts State Building Code – The Massachusetts State Building Code contains many detailed regulations regarding wind loads, earthquake resistant design, flood-proofing, and snow loads.	None at this time.
Open Space and Recreation Plan (OSRP) 2014-2021 –The City has a wealth of conservation areas and recreation spaces that help reduce urban heat island effect and provide flood storage, among other climate resilient co-benefits. The OSRP aims to maintain, promote use, and increase the number of these spaces.	Update the OSRP in the next few years with climate resilience and hazard mitigation in mind.
Zoning Ordinance–Chapter 181 of the City Code, Zoning regulates the land use of new and redeveloped parcels. Zoning allows, regulates, or guides landscaping, the siting of small energy systems, environmental performance, and safety standards for various land use types. Zoning can be used as a tool to promote affordable housing, proper communication facilities, and smart development. The Zoning Code includes a Floodplain Protection Overlay District and a Water Resource	The zoning is currently undergoing revision to include smart growth policies.

Protection Overlay District, which are further described in the following sections.

Consider incorporating climate resilience into the site plan review process through the completion of a climate resilience design guideline or scoring system.

Rules and Regulations for Special Permits & Site Plan Review – Procedures and guidelines set forth by the Planning Board corresponding to the Section 181.9397 Special Permits of the Zoning Ordinance. Special permits are required for construction of large residential, commercial, institutional, municipal, and industrial developments or expansions.

5.2 Existing City-Wide Mitigation for Flood Related Hazards

Fitchburg employs a number of practices to help minimize potential flooding, reduce impacts from flooding, and proactively maintain existing drainage infrastructure. Existing City-wide mitigation measures include the following.

Recommended Improvements

Continue participation in the National Flood Insurance Program to enable property owners to purchase insurance protection against flood losses. Increase outreach to property owners with the floodplain.

Participation in the NFIP – Fitchburg participates in the National Flood Insurance Program (NFIP) (FEMA, 2019c). The NFIP is a Federal program administered by FEMA enabling property owners in participating communities to purchase insurance as a protection against flood losses in exchange for State and community floodplain management regulations that reduce future flood damages. NFIP offers flood insurance to communities that comply with the minimum standards for floodplain management.

Fitchburg participates in the NFIP with 52 policies in force as of January 28th, 2020 (DCR, 2020). FEMA maintains a database on flood insurance policies and claims. This database can be found on the FEMA website.

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 building requirements.

NFIP uses a Community Rating System (CRS) to award communities that go beyond the minimum standards with lower flood insurance premiums for property owners. The incentives are awarded upon a credit system for various activities. Points are awarded to communities that prepare, adopt, implement, and update a comprehensive flood hazard mitigation plan using a standard planning process. As of May 2019, Fitchburg is not currently participating in the CRS Program (FEMA, 2019c).

Once the new FEMA FIRMs are finished, update regulations referencing the old map.

FEMA FIRMS – Flood Insurance Rate Maps (FIRMs) denote areas of the 100-year and 500-year floodplain, which is used for the NFIP and other regulatory controls. For example, the Building Inspector

and the Fitchburg Conservation Commission enforce a federal law requiring elevation above the 100-year flood level of new and substantially improved residential structures in the floodplain. These floodplains are also used in wetland protection and floodplain control regulation. Fitchburg's FEMA FIRMs were last updated in 1991. A more recent update was initiated in 2019 but was still in progress at the time of report writing.	Consider requiring regulatory controls out to the 500-year floodplain to account for climate change.
Street Sweeping – The Department of Public works is responsible for street sweeping, which occurs twice per year on all roads. Every spring, sweeping begins on the main lines of the city, followed by side streets on a ward-by-ward basis.	None at this time.
Stormwater System Maintenance– The Department of Public Works regularly clears debris from its catch basins, storm drains, and culverts across the City. Catch basins that regularly have more debris and manage more stormwater (like at the bottom of hills) are prioritized. The City rebuilt 40-50 catch basins in the last year. Road salt can cause erosion of catch basins. The City repaired two high priority culverts in the last five years to reduce flooding.	Map and inventory catch basins, culverts, and outfalls. Include stormwater systems in private housing developments, especially the detention basins that have been turned over to the City. Continue to upgrade and rehabilitate stormwater system using climate projections and green infrastructure where possible.
Stormwater – Sewer Separation Plan and Implementation – The Department of Public Works' Wastewater Division leads the separation of the combined sewer overflow system in coordination with the Street (Stormwater) Division. The Wastewater Division has a capital plan and is currently implementing design and construction projects. The City has a consent decree from Massachusetts Department of Environmental Protection to separate the system. There were 250 transfer areas to be fixed and 20-30 have been fixed within the last few years.	Incorporate climate projections in the stormwater system upgrades.
Maintenance of Public Water Bodies – Many community groups help clear debris and keep the waterways clean. The Department of Public Works complies with the Army Corp of Engineers Sediment and Debris Controls in flood protection areas. The City is also working on an erosion control project near the southern wastewater treatment plant and airport.	None at this time.
NPDES Phase II Stormwater Program or Municipal Separate Storm Sewer System (MS4) Permit– The City continues to implement an aggressive NPDES stormwater program that includes measures for public education and outreach, illicit discharge detection and elimination, construction and post-construction controls, and City-wide good housekeeping and stormwater maintenance procedures. The City continues to implement its NPDES Phase II	None at this time.

stormwater program, which includes public education programs. In addition, the City provides educational stormwater materials on the City website and annual mailings. The City also has a Stormwater Management Plan as part of their Small Municipal Separate Storm Sewer Systems (MS4) permit.

Massachusetts Stormwater Management Standards and Handbook – Massachusetts administers stormwater standards through provisions of the Wetlands Protection regulations, 310 CMR 10.00 for wetland notices of intent and surface water discharge permits. The local Conservation Commission and Planning Board regulates this at the local level. The Massachusetts Stormwater Handbook provides guidance on how to meet the regulations and manage stormwater pollution.

The Massachusetts Stormwater Handbook is currently being updated by MassDEP.

Stormwater Management Ordinance and Stormwater Management Rules and Regulations – Chapter 154, Stormwater Management of the City Code regulates non-stormwater discharge, connections, and obstructions in addition to stormwater management during and post construction. The corresponding Stormwater Management Rules and Regulations was recently updated in 2019 to conform with the requirements of the MS4 permit. The rules and regulations require proper planning, implementation, and maintenance of stormwater management and erosion control measures. It also establishes minimum requirements and procedures to control the adverse effects of increased post-development stormwater runoff and nonpoint source pollution associated with new development and redevelopment.

The stormwater standards currently reference the Massachusetts Stormwater Management Standards that are being reviewed and updated to incorporate climate resilience. Update fees and fines to appropriately cover expenses of program.

Floodplain Protection Overlay District (FPOD) – The City's FPOD (Section 181.81 of the Zoning Ordinance) is defined by the 100-year floodplain as designated by FEMA. The Floodplain Overlay District regulates certain activities within a flood zone enhancing federal/state laws. The Floodplain Overlay District is enforced by the Building Inspector (municipal staff) and regulated by Board of appeals.

Considering increased the FPOD to the 500-year floodplain to accommodate the anticipated impacts of climate change.

Massachusetts Wetlands Protection Act and Local Wetlands Protection – The Commonwealths' Wetlands Protection Act (Chapter 131, Section 40 MGL) regulates the protection of resource areas in and around wetlands, including land subject to flooding. This regulates development and activity within a 100-foot buffer around wetlands, and a 200-foot buffer around riverfront areas. The Wetlands Protection Act is locally enforced by the Conservation Commission and Department of Community Development. The City further regulates wetlands through the local Wetlands Protection Ordinance (Ch. 178) and the Wetlands Protection Rules and Regulations (2012).

The local Wetlands Protection Ordinance and corresponding Rules and Regulations could consider the incorporation of climate change.

Beaver Management – The City has outsourced help to install "beaver diverters" and water control devices to mitigate flooding caused by beaver dams. When necessary, beavers are removed from the site.	None at this time.
Grants – Several grants have been submitted in the last five years to improve flooding and the stormwater system including MassDEP 319 Grants; EPA Urban Waters; two Massachusetts Vulnerability Preparedness (MVP) Action Grants; several FEMA Flood Mitigation Grants for Columbia Avenue drainage, Shea Street culvert replacement, and Elizabeth St and Mountain Ave for erosion control, and Dam and Seawall Removal.	Continue to apply for grants to support the implementation of this plan.
City Assistance – The Fitchburg Fire Department assist in pumping out flooded basements or yards, but it is at a cost to the city.	Apply for flood mitigation related funding opportunities

5.3 Existing Dam Mitigation Measures	Recommended Improvements
Dam Rehabilitation and Removal – Fitchburg's long-term plan is to rehabilitate or remove aging dams throughout the city. The City is currently planning for the removal of McTaggart's Pond Dam. Overlook Dam is a priority for removal. Scott Reservoir Dam is part of the water supply system and needs a drain installed, among other improvements.	Appy for grants including the Dam and Seawall Grant and the MVP Action Grant to support these efforts.
Dam and Levee Maintenance – Fitchburg completes regular maintenance on dams and levees when finances are available. The City's MVP Planning grant provided funding to review the condition of the Nashua River Flood Reduction System and develop recommendations for future action.	Implement the findings of the current assessment of the Nashua River Flood Reduction System.
DCR Dam Safety Regulations and Inspections (2017) – All jurisdictional dams are subject to the Division of Conservation and Recreation's dam safety regulations (302 CMR 10.00). The dams must be inspected regularly, and reports filed with the DCR Office of Dam Safety.	Develop a new process for streamlining and completing inspections, possibly with the help of a consultant.
Permits Required for Construction – State law requires a permit for the construction of any dam.	None at this time.
Emergency Action Plans (2017) – DCR requires that all dams classified or reclassified as high hazard potential and significant hazard potential have an Emergency Action Plan. Through the MVP planning grant, Fitchburg received funding to develop an emergency action plan template.	Develop updated Emergency Action Plans using the template.

5.4 Existing City-Wide Mitigation for Wind-Related Hazards

Existing Mitigation	Recommended Improvements
Massachusetts State Building Code (Ninth Edition, 2018) – The City enforces the Massachusetts State Building Code whose provisions are generally adequate to protect against most wind damage. The code's provisions are the most cost-effective mitigation measure against tornados given the extremely low probability of occurrence. If a tornado were to occur, damages would depend on the track of the tornado and would most likely be high due to the prevalence of older construction and the density of development.	None at this time.
Tree Maintenance – The Tree Warden and Unitil maintain trees to reduce the risk of power outages and damage to powerlines during high wind events. Unitil increased maintenance after the 2008 ice storm. Information is shared between the City and Unitil regularly and during wind hazard events.	Expand maintenance program.

5.5 Existing City-Wide Mitigation for Winter-Related Hazards

Existing Mitigation	Recommended Improvements
Snow Removal Requirements in the General Ordinance – Ordinance Number 157-33 requires private property owners or tenants to clear snow from public sidewalks abutting their property (Snow and Ice Control Manual, City of Fitchburg, 2017).	None at this time.
Snow Plowing and De-icing Operations – The Public Works Department provides standard snow plowing operations on main arterials, including salting. Certain roads in the City are subject to ice build-up and require additional attention during cold weather, regardless of snowfall. The City scrapes ice off the pavement with a grader and keeps the area treated with salt. The City started experimenting with using only salt in some areas, instead of a combination of salt and sand, which required investing in new equipment.	Need proper training with new equipment and continued monitoring and improvements to salt and sand mixture pilot. Develop an efficient practice for tracking snow plowing operations.
Snow Emergency Parking Bans – The City places parking restrictions when a snow emergency is declared.	None at this time.
Fuel Assistance – Available to renters and homeowners meeting income guidelines through the New England Farm Workers' Council.	Expand programs to assist low-income households by providing fuel assistance.

5.6 Existing City-Wide Mitigation for Drought-Related Hazards

Existing Mitigation	Recommended Improvements
Water Resource Protection Overlay District (WRPOD) – The WRPOD regulates land uses to protect the surface water and groundwater used for drinking water supplies.	None at this time.

Land Acquisitions for Public Water Supply Protection – The City has an ongoing program of land acquisition for water supply, and an additional 318 acres of land were recently approved at public hearing for purchase.	Continue to purchase land and preserve natural resources through conservation restrictions.
Water Conservation – The Nashua River USGS stream flow gauge is used to determine if water use restrictions are necessary. Water restrictions have been used in the past (2015). The Water department has done outreach about water conservation on their website and provided giveaways (including low-flow showerheads and other devices) to encourage residents to follow water conservation guidelines. The City's water supply is adequate for the foreseeable future.	Add water restriction policies to the City website.

5.7 Existing City-Wide Mitigation for Fire-Related Hazards	Recommended Improvements
Open Burning Permits Required – The City allows controlled open burning of agricultural products (not construction or building materials) in accordance with state regulations from January 15 to May 1st. The Fitchburg Board of Health requires a permit.	None at this time.
Review of Construction – The Fire Department and Building Department review buildings for proper fire protection systems, alarms, and sprinklers.	None at this time.
Public Education – The Fire Department educates residents about home fire prevention through a variety of avenues, including the development and distribution of pamphlets.	Continue public education efforts and update materials, as necessary. Expand outreach into new forms.
Fire Department Services – There are currently two fire stations in Fitchburg, one which is staffed and one of which is used for storage. Additionally, the City has portable water pumps that are available for firefighting.	Need a new emergency response center.
Statewide Fire Mobilization Plan (Massachusetts Fire and EMS Mobilization Plan, 2018)– The state has a fire mobilization plan for brush fires, as well as a separate plan for Fitchburg's Fire District. Fitchburg is prepared to respond to brushfires smaller than five acres.	None at this time.
"Senior SAFE" program – Fitchburg received grant funding for the Senior SAFE Program, which aids in providing fire safety to seniors through the fire department. It also aims to improve safety in senior housing.	Look to secure other grants for continued outreach to vulnerable populations.

Brush Clearing - Brush clearing to provide access to Emergency Service vehicles	None at this time.

5.8 Existing City-Wide Mitigation for Extreme Temperature-Related Hazards	Recommended Improvements
Tree Maintenance by City – The City maintains street trees and numerous trees on public grounds, historic sites, conservation areas, park areas and cemeteries. The City has recently received a grant from the Greening the Gateways program to plant additional trees. There are some designated roads in Fitchburg where the Scenic Road Act applies, and tree removal must be approved by the Planning Board and Tree Warden after a public hearing. The City provides information on tree maintenance, planting, and removal on their website. Unitil, the area's electric provider, also complete preventive maintenance and education on planting tips and tree removal on their website.	Continue to plant trees in areas with less tree canopy.
Heating and Cooling Shelter – The Fitchburg Public Library can be used as a heating or cooling facility.	Explore other ways to provide refuge to the heat, such as splash pads or other shade features.

5.9 Existing City-Wide Mitigation for Geologic Hazards	Recommended Improvements
Massachusetts State Building Code – The State Building Code contains a section on designing for earthquake loads (780 CMR 1612.0). Section 1612.1 states that the purpose of these provisions is "to minimize the hazard to life to occupants of all buildings and non-building structures, to increase the expected performance of higher occupancy structures as compared to ordinary structures, and to improve the capability of essential facilities to function during and after an earthquake". This section goes on to state that due to the complexity of seismic design, the criteria presented are the minimum considered to be "prudent and economically justified" for the protection of life safety. The code also states that absolute safety and prevention of damage, even in an earthquake event with a reasonable probability of occurrence, is not economically achievable for most buildings. Section 1612.2.5 establishes seismic hazard exposure groups and assigns all buildings to one of these groups according to a Table 1612.2.5. Group II includes buildings which have a substantial public hazard due to occupancy or use and Group III are those buildings having essential facilities which are required for post-earthquake recovery, including fire, rescue and police stations, emergency rooms, power-generating facilities, and communications facilities.	None at this time.

5.10 Existing City-Wide Sustainability Measures

Existing City-Wide Sustainability Measures	Recommended Improvements
Complete Street Implementation Plan – The City has developed a list of priority project to encourage walking and biking, which will reduce greenhouse gases.	None at this time.
Green Communities Program – Fitchburg is a member of the Green Communities program. Fitchburg has received funding for energy conservation measures in buildings and streetlights.	None at this time.

5.11 Mitigation Capabilities and Local Capacity for Implementation

Under the Massachusetts system of "Home Rule," the City of Fitchburg is authorized to adopt and, from time to time amend, a number of local ordinances and regulations that support the City's capabilities to mitigate natural hazards. These include the Zoning Ordinance, Stormwater Ordinance, Subdivision and Site Plan Review Regulations, and Wetlands Ordinance. Local ordinances may be amended to improve the City's capabilities, and changes to most regulations simply require a public hearing and a vote of the authorized board or commission. The City of Fitchburg has recognized several existing mitigation measures that require implementation or improvements, and has the capacity based on these Home Rule powers within its local boards and departments to address them. The City also has the ability to expand on and improve the existing policies and programs listed above.

6.0 STATUS OF MITIGATION MEASURES FROM THE 2015 DRAFT PLAN

6.1 Implementation Progress on the Previous Plan

The City of Fitchburg has taken steps to integrate the 2015 Montachusett Region Natural Hazard Mitigation Plan Update into several planning mechanisms, including updates to the Emergency Action Plans for the dams owned by the City, and the Fire Department's Disaster Response plans created by the City's Emergency Management Director.

In addition, the City updated its stormwater ordinance (Ch. 154 of the City Code) in 2019 and created a companion Stormwater Rules & Regulations document to address requirements of the City's Municipal Separate Storm Sewer System (MS4) Permit from the US Environmental Protection Agency (EPA). The City also updated its zoning ordinance (Ch. 181 of the City Code) in 2020. The stormwater and zoning ordinance changes improve the City's ability to regulate water quality and reduce potential flooding associated with new and redevelopment. The City also participated in the process of updating Fitchburg's FEMA Flood Insurance Rate Maps (FIRM), which was led by the USGS, and will impact the Floodplain Protection Overlay District.

Additionally, the 2015 Montachusetts Regional Hazard Mitigation Plan listed several priority actions items specific to the City of Fitchburg. Fitchburg staff and Core Team members reviewed these previous mitigation measures for completion and to determine if the measures were still a priority. As indicated in Table 6-1, the City completed several mitigation measures. Some of the measures have become continual operation and maintenance and are captured in Chapter 5. Some actions were deferred because of the lack of funding or capacity. The measures that were not completed were evaluated with the Core Team. The decision on whether to remove or retain a particular measure was based on the members' assessment of continued relevance or effectiveness. Table 6-1 summarizes the status of the mitigation measures and their priority.

Table 6-1. Status of Mitigation Measures from the 2015 HMP

Description of Action	Implementation Responsibility	Carry forward?
Utilize interactive mapping application prepared by MRPC/CMRPC to update critical infrastructure and simulate real time evacuation scenarios to mitigate hazards to the public.	Emergency Management Director, Police Department mostly responsible for emergency evacuation plan.	Critical infrastructure list is up to date. Add simulation to next plan.
Increase awareness by educating property owners regarding actions that they can take to reduce risk to property by hosting an Open House at the Fire Department, develop and distribute Pamphlets on Fire Safety and Prevention (SAFE PROGRAM and SENIOR SAFE) and wildfire prevention.	Fire Department	Education completed and can be continued through the operation section of plan. Various forms of community engagement will be included in the next plan.
Develop storm related debris management plan to mitigate identified hazards.	Public Works, Board of Health	Include in next plan.

Table 6-1. Status of Mitigation Measures from the 2015 HMP

Description of Action	Implementation Responsibility	Carry forward?
Develop a priority list and possibly seek funding through the Hazard Mitigation Grant Program (HMGP) for the replacement of undersized culverts throughout the City to reduce or eliminate flooding risk.	Public Works	Include in next plan. Fixed two problem areas, but culverts are in need of repair.
Implement recommendations regarding natural hazard mitigation in existing planning documents, the five-year action plan of the Open Space and Recreation Plan, and the emergency evacuation plan.	Conservation Commission, City Council, Planning Board, Emergency Management Director, Fire Department, and Police Department	Include, and add Economic Development Strategic Plan to the list.
Develop a Mitigation Plan to provide access to water, information, shelter and food stores to people in remote locations of the City and integrate this information into community comprehensive plans.	Emergency Management Director	Include, need to document institutional knowledge of emergency response, especially to the ice storm in 2008.
Increase hazard education and risk awareness to public by updating and disseminating information on local Radio/TV Stations to educate the public and alert them of emergency information including shelter locations and other instructions related to natural hazards.	Emergency Management Director	Include, related to ideas that came out of the CRB Workshop.
Continue participation in the National Flood Insurance Program to enable property owners to purchase insurance protection against flood losses.	Conservation Commission, City Council	Remove, move to operation and maintenance section of plan.
Ensure that all identified shelters have sufficient back-up utility service in the event of a primary power failure to reduce or eliminate risk to human life.	Building Inspector, Emergency Management Director	Remove, all shelters do have a backup generator. However, add an action to add backup generators at other critical facilities.
Implement the standards in the Subdivision Rules and Regulations to require temporary and permanent erosion control measures to improve floodplain management.	Planning Board	Remove, erosion control is regulated by the Stormwater Management Regulations and floodplain management is regulated by the Conservation Commission and Planning Board. Move to

Table 6-1. Status of Mitigation Measures from the 2015 HMP

Description of Action	Implementation Responsibility	Carry forward?
		operation section and maintenance section of plan.
Pursue efforts to demolish vacant buildings to mitigate the potential of fire related hazard.	Building Department Program	Remove, no longer a top priority for this plan.
Develop a preliminary project proposal and cost estimate for updating current 911 system, including feasibility of Reverse 911 to reduce or eliminate the long-term risk to human life and property from hazards.	Emergency Management Director	Remove, the City has a Reverse911 system in place.
Install "beaver diverters" and water control devices to mitigate flooding caused by beaver dams.	Public Works	Remove, this has been addressed. Move to operation and maintenance section of plan.
Hire trapper for removal of beavers to mitigate flooding caused by beaver dams.	Public Works	Remove, this has been addressed. Move to operation and maintenance section of plan.

7.0 HAZARD MITIGATION AND CLIMATE ADAPTATION STRATEGY

7.1 Identification of Hazard Mitigation and Climate Adaptation Strategies

The City developed a list of priority hazard mitigation and climate adaptation strategies through a multi-faceted approach. Strategies were discussed and developed upon review of the:

- Community profile, including the City's strengths and vulnerabilities.
- Hazard and climate change risk assessment.
- Existing measures.
- Updates to the previous mitigation plan.
- Input from stakeholders.

Stakeholders were engaged through Core Team meetings, the CRB Workshop, and the virtual public listening sessions. The full list of action items from the CRB Workshop is available in Appendix C and was integrated into the final list of action items vetted by the Core Team. Table 7-1 below represents the City's high, medium, and low priority action items. Each of these action items was analyzed for its overall benefit, estimated cost, timeframe, and implementation responsibility, which informed prioritization. A description of each prioritization category is included below.

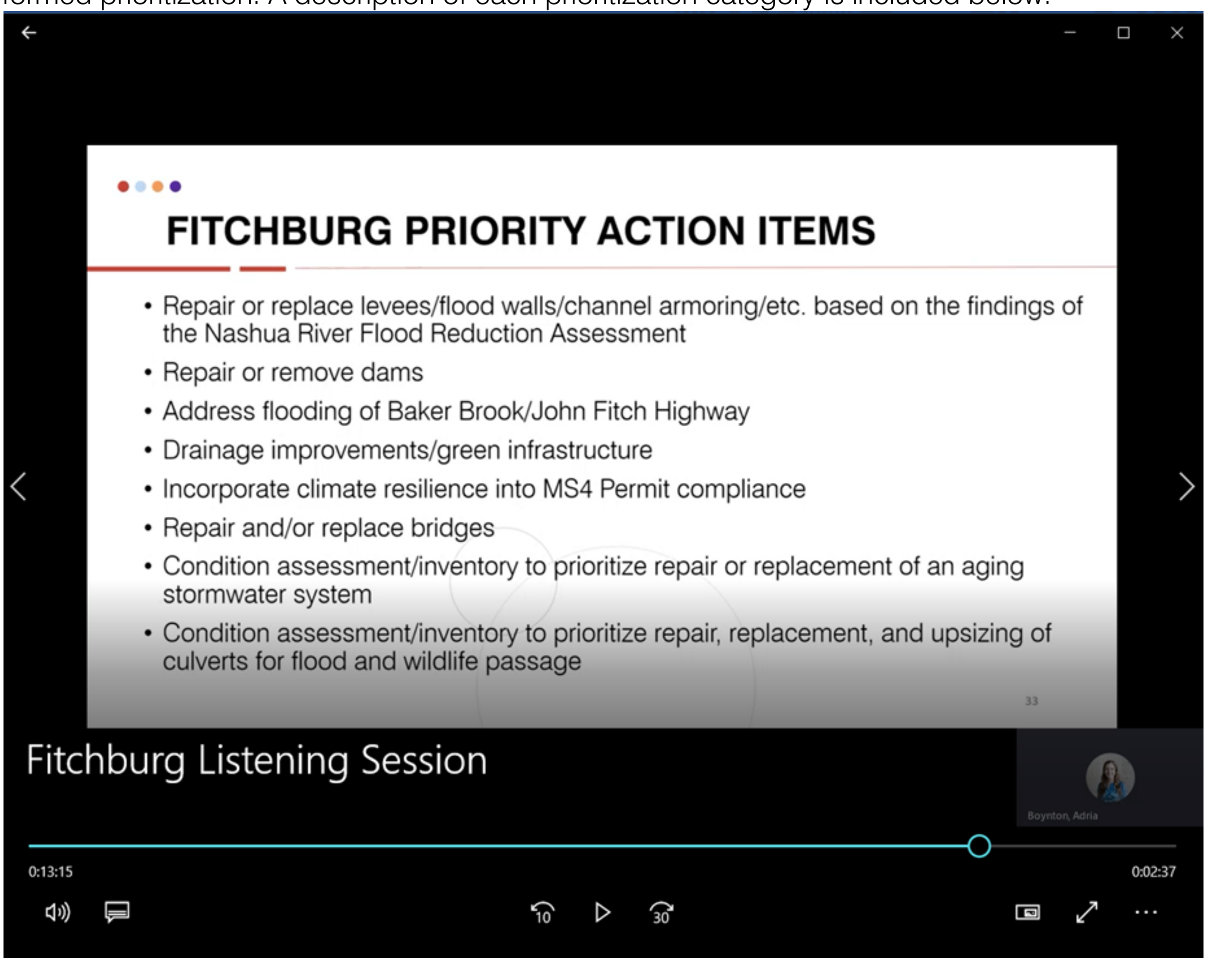


Figure 7-1 Some of the priority action items that were presented during Fitchburg's virtual Public Listening Session Webinar

Priority – Designation of high, medium, or low priority was based on overall potential benefits. A High Priority action is very likely to have political and public support and necessary maintenance can occur following the project. A medium priority action may have political and public support and necessary maintenance may have potential to occur following the project. A low priority action may not have political and public support for implementation or the necessary maintenance support following the project.

Mitigation Action – A brief description of each mitigation measure that was identified in this plan.

Implementation Responsibility – Most mitigation measures will require a multi-department approach where several City departments share responsibility. The designation of implementation responsibility in the table was assigned based on general knowledge of the responsibilities of each municipal department.

Implementation Timeframe – The timeframes represented below are assigned based on the length of time necessary to complete the project, the projected funding availability, and staff capacity. The timeframe is noted in years.

Approximate Implementation Cost – Approximate implementation costs are given for all mitigation measures. All cost data would need to be updated at the time of design and construction and is only provided as an estimate.

$: <$10,000	$$$$: $250,000-$500,000
$$: $10,000-$100,000	$$$$$: $500,000+
$$$: $100,000-$250,000	

Potential Funding Sources – Sources of potential funding for each action item are identified in Table 7-1 and summarized in Table 7-2. While acronyms are used in Table 7-1, the full names of potential funding sources can be found in Table 7-2. The "Potential Funding Sources" column in Table 7-1 lists the funding sources to which the priority project would be most competitive and therefore is not comprehensive. For example, a project may be eligible to apply for an MVP Action Grant, but it may not be competitive, and so the MVP Action grant is not listed. Please note that each grant source should also be reviewed prior to applying as granting agencies change eligibility criteria frequently and sometimes have very specific requirements. For example, the DER culvert replacement grant does not currently provide funding for all culvert replacements, but rather for a specific type. In addition, DER Priority Projects do not fund standalone dam removal projects but will remove dams as a part of a larger project. FEMA FMA Grants were not listed under potential funding sources at this time because projects must mitigate or eliminate flooding for a repetitive loss site. Fitchburg does not currently have the specific addresses of repetitive loss sites but does plan to request this information. FEMA HMPG grants were also not listed in Table 7-1 as this funding is only available after a disaster declaration occurs. FEMA FMA and HMPG grants, however, may be possible funding sources in certain circumstances. The City's General Fund is considered a default potential funding source, unless the City pursues additional funding. An additional description of municipal funding is available in Section 7.2.

Table 7-1. Priority Action Items

ID	Priority	Mitigation Action	Implementation Responsibility	Implementation Timeframe	Approximate Implementation Cost	Potential Funding Sources
A	H	Remove dams, especially McTaggart's Pond and Overlook Reservoir Dam.	DPW	McTaggart: 1-3 years. Other dams: 10+ years.	$$$$$	EEA Dam and Seawall Repair or Removal Program, MET
B	H	Assess dams for rehabilitation or removal, especially Green's Pond Dam and Putt's Pond Dam.	DPW	1-3 years.	$$$	EEA Dam and Seawall Repair or Removal Program, MET, MVP Action Grant
C	H	Rehabilitate dams, especially Scott Dam.	DPW	10+ years.	$$$$$	EEA Dam and Seawall Repair or Removal Program, MET, MVP Action Grant
D	H	Repair and/or replace bridges, especially Oak Hill Road Bridge, Rindge Road, First Street/Railroad Street (a rail bridge), and Westminster Hill Road Bridge.	MassDOT, DPW	Westminster Hill Road: 3-5 years Others: 10+ years.	$$$$$	Chapter 90 Program, Municipal Small Bridge Program
E	H	Repair or replace levees, flood walls, channel armoring, etc. based on the findings of the Nashua River Flood Reduction Assessment.	DPW	Immediate action, but completion take 10+ years.	$$$$$	EEA Dam and Seawall Repair or Removal Program, BRIC, DER Priority Projects
F	H	Conduct a condition assessment and	DPW	Assessment: 1-3 years.	Assessment: $$	BRIC, DER Culvert

Table 7-1. Priority Action Items

ID	Priority	Mitigation Action	Implementation Responsibility	Implementation Timeframe	Approximate Implementation Cost	Potential Funding Sources
		inventory to prioritize repair or replacement of an aging stormwater system and to eliminate combined sewer overflows.		Construction: 10+	Construction: $$$$$	Grant, MVP Action Grant, Sewer Enterprise Funds
G	H	Perform drainage improvements and incorporate green infrastructure where possible, especially on Pearl Hill Road and Main Street.	DPW	3-5 years.	$$$	MVP Action Grant, MET, 319 grants, 604b, CDBG, EPA Urban Waters, MassDEP MS4 Municipal Assistance, MassDEP SWMA Grants
H	H	Reduce stormwater flows into Baker Brook from John Fitch Highway by designing the roadway with complete street principles and address flooding of roadway.	DPW	1-3 years.	Design: $$$ Construction: $$$$$	Complete Streets Funding Program, MVP Action Grant, MassDOT TIP
I	H	Conduct a condition assessment and inventory to prioritize repair, replacement, and upsizing of culverts for flood and wildlife passage.	DPW	1-3 years.	Assessment: $$$ Culvert Design: $$$ Construction: $$$$	DER Culvert Grant, MVP Action Grant, BRIC
J	H	Continue efforts to reduce erosion along the North Nashua River riverbank to protect airport and wastewater treatment facility.	Wastewater, Airport	3-5 years.	$$$	MassDEP Restoration Grants, Sewer Enterprise Funds, MVP Action Grant, BRIC

Table 7-1. Priority Action Items

ID	Priority	Mitigation Action	Implementation Responsibility	Implementation Timeframe	Approximate Implementation Cost	Potential Funding Sources
K	H	Increase community awareness/participation in the Community Emergency Response Team (CERT).	Emergency Management	1-3 years.	$	CCP Grant
L	H	Upgrade Water Department's SCADA equipment.	DPW	<1 year.	$$$	Water Enterprise Funds
M	H	Develop an asset management plan with a condition assessment and inventory of old stone retaining walls to prioritize repair or replacement.	DPW	1-3 years.	$$	General Fund, Free cash appropriation
N	H	Plant more trees in areas with minimal urban tree canopy.	DPW	1-3 years.	$$	MVP Action Grant, Greening the Gateway Cities Program, Community Forest Grant Program
O	H	Develop emergency communication plans and improve awareness and community participation through Facebook, CodeRed, etc. Engage vulnerable residents in particular, which could include renters, seniors, youth, low-income households, and people experiencing homelessness.	Emergency Management, Fire Department, Police Department	1-3 years.	$	General Fund, Nonprofit Funding

Table 7-1. Priority Action Items

ID	Priority	Mitigation Action	Implementation Responsibility	Implementation Timeframe	Approximate Implementation Cost	Potential Funding Sources
P	H	Examine shelter capacity and accessibility, including for residents and animals, temporary emergency shelters and permanent shelters.	Emergency Management, Building Dept, DPW	1-3 years.	$	EMPG, BRIC
Q	H	Develop an emergency response plan to provide access to water, information, shelter, and food for people in remote locations. Document institutional knowledge on current response operations.	Emergency Management, Fire Department, Police Department	1-3 years.	$	CCP Grant
R	H	Increase hazard education and risk awareness to public by updating and disseminating information on Local Radio/TV Stations to educate the public and alert them of emergency information including shelter locations and other instructions related to natural hazards.	Emergency Management, Fire Department, Police Department	1-3 years.	$	General Fund, MVP Action Grant
S	H	Explore options of acquiring land and redesigning the large commercial parking lot with Low Impact Development Techniques to address flooding of Baker Brook.	DPW, Community Development, Private Property Owners	10+ years.	Land acquisition - $$$$$	LAND Grant, Land & Water Conservation Fund, MVP Action Grant, PARC, BRIC

Table 7-1. Priority Action Items

ID	Priority	Mitigation Action	Implementation Responsibility	Implementation Timeframe	Approximate Implementation Cost	Potential Funding Sources
T	H	Incorporate climate resilience into MS4 Permit compliance.	DPW	1-3 years.	$$	MS4 Municipal Assistance Grant, MVP Action Grant
U	M	Implement recommendations regarding climate adaptation and hazard mitigation in existing planning documents such as the Economic Development Strategy, Open Space and Recreation Plan, and Master Plan. Update plans with climate resilience considerations when appropriate.	Community Development	3-5 years.	$$	MVP Action Grant
V	M	Identify, prioritize, and acquire properties for flood and drought mitigation. Assist displaced residents.	DPW, Community Development	10+ years.	Identify: $ Purchase Land: $$$$$	Community Forest Grant, LAND Grant, Land & Water Conservation Fund, PARC, FMA
W	M	Acquire properties in water supply watershed areas to protect drinking water sources.	Water	5-10 years.	$$$$$	DWSP, Land and Water Conservation Fund
X	M	Relocate two of the emergency management facilities into larger buildings and away from the floodplain.	Emergency Management	5-10 years.	$$$$$	BRIC

Table 7-1. Priority Action Items

ID	Priority	Mitigation Action	Implementation Responsibility	Implementation Timeframe	Approximate Implementation Cost	Potential Funding Sources
Y	M	Upgrade municipal buildings with cooling, flood protection, and other resiliency measures, especially the Senior Center, Library, City Hall, Police Department, Fire Department, and DPW.	Emergency Management, Building Dept, DPW	3-5 years.	$$$$$	BRIC, MVP Action Grant
Z	M	Design and construct stormwater system upgrades at the DPW facility.	DPW	3-5 years.	$$	BRIC, MVP Action Grant, 319 grants, 604b, CDBG, EPA Urban Waters, MassDEP MS4 Municipal Assistance, MassDEP SWMA Grants
AA	M	Improve electricity redundancy at critical facilities, including shelters, grocery stores, and gas stations.	Emergency Management, Building Dept, DPW	3-5 years.	$$$$	General Fund, MVP Action Grant
BB	M	Increase emergency response training and develop clear policy and procedures, public education, etc.	Emergency Management, Fire Department, Police Department	1-3 years.	$	CCP Grant, EMPG
CC	M	Utilize interactive mapping application prepared by MRPC/CMRPC to simulate real time evacuation scenarios to	Emergency Management, Fire Department, Police Department	1-3 years.	$	General Fund

Table 7-1. Priority Action Items

ID	Priority	Mitigation Action	Implementation Responsibility	Implementation Timeframe	Approximate Implementation Cost	Potential Funding Sources
		mitigate hazards to the public.				
DD	M	Explore opportunities for additional flood storage at City-owned properties along the Nashua River, including parks such as Riverfront Park.	DPW, Community Development	3-5 years.	$$	Land & Water Conservation Fund, PARC, MVP Action Grant, Gateway City Parks Program
EE	L	Develop a long-term remediation assessment and maintenance plan of landfills.	DPW	1-3 years.	$$	EPA Brownfields Grant, Mass Development Brownfields Fund
FF	L	Develop a renewable energy master plan.	Unitil	5-10 years.	$$	DOER Grant, EEA Planning Assistance, Unitil
GG	L	Develop storm-related debris management plan to mitigate identified hazards.	Public Works, Board of Health	1-3 years.	$	General Fund

7.2 Potential Funding Sources

The identification of potential funding sources is preliminary and may vary depending on numerous factors. These factors include, but are not limited to, if a mitigation measure is conceptual or has been studied, evaluated, or designed. In most cases, the measure will require a combination of funding sources. The funding sources identified are not a guarantee that a specific project will be eligible for, or receive, funding. Upon adoption of this plan, the local representatives responsible for implementation should begin to explore potential funding sources in more detail.

Traditional funding sources within the City of Fitchburg, such as funding from the operating and capital budgets, may be able to cover some of the costs associated with the action items detailed in Table 7-1. The addition of a stormwater utility in Fitchburg could provide funding for many stormwater-related projects. State revolving funds and other no- or low-interest loans may also be of interest. There is a great variety of funding available for Massachusetts municipalities, both through the state and federal governments. A full list of funding opportunities can be found on the Community Grant Finder webpage. The Community Grant finder provides a streamlined interface where municipalities can easily learn about grant opportunities.

Table 7-1 in the previous section identifies potential funding sources for each action item. However, combining several action items into a single grant proposal may make an application more competitive, depending on the grant's criteria. Therefore, Table 7-2 below outlines more information on potential funding sources, to assist the City in matching grants with appropriate project types.

Table 7-2. Potential Funding Sources

Source	Grant	Description of Funding
Executive Office of Housing and Economic Development	MassWorks Infrastructure Program	Provides grants for public infrastructure projects that support and accelerate housing production, spur private development, and create jobs
HUD	HUD Community Development Block Grant Programs (CDBG)	To develop viable urban communities by providing decent housing and a suitable living environment, and expanding economic opportunities.
Department of Housing and Community Development (DHCD)	Massachusetts Downtown Initiative	Offers services and assistance to communities seeking help on how to revitalize their downtowns
FEMA	FEMA Hazard Mitigation Grant Program (HMGP)	Provides funding after a disaster to significantly reduce or permanently eliminate future risk to lives and property from natural hazards
FEMA	FEMA Building Resilient Infrastructure & Communities (BRIC)	Provides funds for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event, with a focus on infrastructure projects and "community lifelines." Replaced FEMA's Pre-Disaster Mitigation (PDM) Program.
EDA	Disaster Supplemental Funding	Funding available to communities impacted by natural disasters and flooding
MEMA	MEMA Citizen Corps Program (CCP) Grant	Supports local Community Emergency Response Teams (CERT) and Volunteers in Police Service (VIPS) in preparing for all-hazards. Can be used for planning activities, equipment, training, and exercises.
FEMA	Emergency Management Performance Grant (EMPG)	Supports local emergency management agencies in implementing the National Preparedness System and national Preparedness Goal of a secure and resilient nation. Funds projects related to logistics/distribution management planning, evacuation plan/annex, disaster

Table 7-2. Potential Funding Sources

Source	Grant	Description of Funding
		financial management, catastrophic disaster housing, resilient communities, and implementing community lifelines.
FEMA	FEMA Public Assistance (PA) Program	FEMA reimburses government agencies and nonprofits for disaster response and recovery costs, including debris removal, emergency protective measures, and repair of publicly owned facilities.
MA DOER	MA DOER Green Communities Designation and Grant Program	The designation allows communities to access grants for clean, affordable, and resilient energy projects
MA DEP	MA Electric Vehicle Incentive Program (MassEVIP) Fleets Incentives	Helps public entities acquire electric vehicles and install charging stations for their fleets
EPA	EPA Smart Growth Grants	Support activities that improve the quality of development and protect human health and the environment.
EPA	Healthy Communities Grant Program	Reduce environmental risk to protect and improve human health and the quality of life
MA DEP	Statewide Water Management Act (SWMA) Grant	Funds planning projects to identify implementation actions to improve ecological conditions, conservation projects and drought resiliency planning, and withdrawal mitigation projects that increase porosity and water quality.
US Forest Service	US Forest Service Community Forest Grant Program	Funding to acquire private forest land threatened by conversion and establish community forests
MA DER	MA DER Culvert Replacement Municipal Assistance Grant Program	Grant to replace undersized, perched, and/or degraded culverts located in an area of high ecological value
MA DEP	Federal Clean Water Act, 604b Grant Program: Water Quality Management Planning	Funds nonpoint source assessment and planning projects, including projects related to green infrastructure
MA DEP	Federal Clean Water Act, Section 319 Nonpoint Source	Implementation projects that address the prevention, control, and abatement of NPS pollution.

Table 7-2. Potential Funding Sources

Source	Grant	Description of Funding
	(NPS) Competitive Grants Program	
MA DEP	MassDEP Water Quality Monitoring Grant Program	Enhance MassDEP surface water quality assessment data by building or expanding capacity for bacteria monitoring data collection.
EEA	EEA Planning Assistance Grants	Funds zoning for sustainable housing production, regulations that reduce energy use and GHG emissions, and zoning that results in permanent land conservation.
EEA	Land Use Planning Grants	Supports efforts to plan, regulate, and act to conserve and develop land consistent with the Massachusetts' Sustainable Development Principles
EEA	Local Acquisitions for Natural Diversity (LAND) Grant Program	Helps cities and towns acquire land for conservation and passive recreation
NPS	Massachusetts Land and Water Conservation Fund Grant Program	Funding for the acquisition, development, creation and/or renovation of parks, trails, and conservation areas.
EEA	Municipal Vulnerability Preparedness (MVP) Action Grant	Provides support to implement climate change resiliency priority projects. Project types include planning, assessment and regulatory updates; nature-based solutions; and resilient redesigns and retrofits for critical facilities and infrastructure.
MassDEP	MassDEP Restoration Grants	Funding for restoration projects. Opportunities are announced as settlement funds become available.
MassDEP	MS4 Municipal Assistance Grant Program	Funds community efforts to meet the requirements of the 2016 MS4 permit and reduce stormwater pollution through partnerships
EEA	EEA Dam and Seawall Repair or Removal Program	Intended to promote public health, public safety, and ecological restoration.
MET	Massachusetts Environmental Trust (MET)	Grants to support projects that protect and restore natural resources, including dam removal.
DER	DER Priority Projects	Funds cranberry bog wetland restoration, streamflow restoration, and urban stream revitalization projects.
EPA	EPA Drinking Water State Revolving fund (DWSRF)	A federal-state partnership to help ensure safe drinking water and provide financial support to water systems.
MA DEP	MA DEP PFAS Treatment Grant	Supports designs for treatment of drinking water in PFAS-impacted communities.

Table 7-2. Potential Funding Sources

Source	Grant	Description of Funding
DEP	Drinking Water Supply Protection (DWSP) Grant Program	Financial assistance for protection of existing DEP-approved public drinking water supplies, protection of planned future public drinking water supplies, and protection of planned future public drinking water supplies.
EPA	EPA Brownfields Grant Funding Program	Funding for brownfields assessment, cleanup, revolving loans, environmental job training, technical assistance, training, and research.
MassDevelopment	MassDevelopment Brownfields Redevelopment Fund	Finances the environmental assessment and remediation of brownfield sites in Economically Distressed Areas (EDAs) of the Commonwealth.
DCR	Greening the Gateways Program	Tree planting program for the Massachusetts Gateway communities.
EEA	Gateway City Parks Program	This program funds the creation and restoration of parks and recreational facilities in underserved urban neighborhoods.
EEA	Parkland Acquisitions and Renovations for Communities (PARC) Grant Program	Assists municipalities in acquiring and developing land for park and outdoor recreation purposes. Can be used to acquire parkland, build a new park, or renovate an existing park.
MassTrails	MassTrails Grants	Grants to design, create, and maintain the diverse network of trails, trail systems, and trails experiences.
NFWF	National Fish and Wildlife Foundation Grants	Provides funding to projects that sustain, restore, and enhance the nation's fish, wildlife, plants, and habitats.
MA Department of Fire Services	Senior SAFE	Supports fire and life safety education for seniors
MA Department of Fire Services	Student Awareness of Fire Education (S.A.F.E.)	Grants for local fire departments to teach fire and life safety to schools
MassDOT	Chapter 90 Program	Reimbursable grants for capital improvements such as highway construction, preservation and improvement projects that extend the life of capital facilities.
MassDOT	Community Transit Grant Program	Funding to meet the transportation and mobility needs of seniors and people with disabilities
MassDOT	Complete Streets Funding Program	Technical assistance for creating a Complete Streets Prioritization Plan and construction funding for implementation
MassDOT	Municipal Small Bridge Program	Funding for small bridge replacement, preservation, and rehab projects

Table 7-2. Potential Funding Sources

Source	Grant	Description of Funding
MassDOT	State Transportation Improvement Program (STIP)	Funding for bicycle paths, bridges, roadways, sidewalks, and transit investments
USDA NRCS	Watershed and Flood Prevention Operations Program	Helps municipalities protect and restore watersheds
USDA NRCS	Emergency Watershed Protection Program	Funds to help communities quickly address serious and long-lasting damages to infrastructure and the land
USDA NRCS	Regional Conservation Partnership Program	NRCS seeks to co-invest with partners to implement projects that demonstrate innovative solutions

7.3 Regional Partnerships

Mitigating natural hazards is not confined to a local issue. The drainage systems that service communities are often complex systems of storm drains, roadway drainage infrastructure, pump stations, dams, and other facilities owned and operated by a wide variety of agencies, including the Massachusetts Department of Transportation (MassDOT) and the Department of Conservation and Recreation (DCR). The planning, construction, operation, and maintenance of these structures are integral to the hazard mitigation efforts of communities. These agencies are the City's regional partners in hazard mitigation efforts, and the City will also coordinate with the Montachusett Regional Planning Commission on locally relevant support and outreach.

The state agencies also operate with the same constraints as communities, including budgetary and staffing limitations. Similarly, to municipalities, these agencies must make decisions about numerous competing priorities. In order to implement many of the mitigation measures identified by the City of Fitchburg, all parties will need to work together towards a mutually beneficial solution.

8.0 PLAN ADOPTION AND MAINTENANCE

8.1 Plan Adoption

The City of Fitchburg 2020 HMP-MVP Plan was adopted by the City Council on *[ADD DATE]*. See Appendix E for documentation. The plan was approved by FEMA on [*ADD DATE*] for a five-year period that will expire on [*ADD DATE*].

8.2 Plan Implementation

The Core Team will use Table 7.1 as a guide for taking action to mitigate hazards and improve the City's climate resilience. The time frame, responsible department, and funding mechanisms in Table 7.2 layout out an implementation plan for the Core Team. The Core Team will be held accountable through the tracking mechanisms explained in the following sections. The HMP-MVP Plan will also inform future planning and budgeting processes.

8.3 Plan Maintenance

8.3.1 Tracking Progress and Updates

FEMA's initial approval of this plan is valid for five years. During that time, the City will need to continue to track progress, document hazards, and identify future mitigation efforts. This can be achieved through a combination of two methods:

1. Meetings: The Core Team, coordinated by the Department of Public Works, will meet once a quarter during regularly scheduled project meetings to monitor plan implementation. The Core Team will be amended as needed but will include representatives from the Department of Public Works, Police, Fire, the Building Commissioner, FEMA Coordinator, and others. These meetings will provide an opportunity for regular check-ins, identifying overlaps and capital planning needs related to hazard mitigation, and forward-looking discussions regarding next steps.

2. Surveys: The coordinator of Core Team will also prepare and distribute a survey every year. The survey will be made available to all Core Team members and any other interested local stakeholders. The questions in the survey will reference the tables of existing and proposed action items listed in the HMP-MVP Plan. The survey will assist in determining any necessary changes or revisions to the plan that may be needed. In addition, it will provide written documentation of status updates, accomplishments, and progress related to the action items listed in the HMP-MVP Plan. The surveys will also help document new hazards or problem areas that have been identified since the 2020 Plan. The information collected through the survey will be used to formulate an update and/or addendum to the plan.

8.3.2 Continuing Public Participation

The adopted plan will be posted on the City's website. The posting of the plan on the City's website will provide a mechanism for citizen feedback, such as an e-mail address for interested parties to send comments. The City will encourage local participation whenever possible during the next five-year planning and implementation cycle. The Core Team will incorporate engagement into the implementation of the priority action items. All updates to the plan, including implementation progress, will be placed on the City's website. All public meetings related to the HMP-MVP Plan will be publicly noticed in accordance with City and State open meeting laws.

8.3.3 Integration of the Plans with Other Planning Initiatives

Upon approval of the City of Fitchburg 2020 HMP-MVP Plan by FEMA, the Core Team will make the plan available to all interested parties and all departments with an implementation responsibility. The group will initiate a discussion with those various departments regarding how the plan can be integrated into their ongoing work. At a minimum, the plan will be reviewed and discussed with the following departments:

- Community Development
- Conservation Commission
- Police Department
- Fire Department
- Health Department
- Public Works Department
- Building and Zoning Department

Appropriate sections of the HMP-MVP Plan will be integrated into other plans, policies and documents as those are updated and renewed, including the writing of, or updates to, the City's Master Plan, Open Space Plan, Comprehensive Emergency Management Plan, and Capital Investment Program. Coordination with the Montachusett Regional Planning Commission, local organizations, businesses, watershed groups, and state agencies will be required for successful implementation and continued updating.

8.4 Process of Updating

By maintaining the 2020 HMP-MVP Plan, the City will have a competitive application when applying to FEMA for funding to update the plan. Once the resources have been secured to update the plan, the Core Team will need to determine whether to undertake the update itself or hire a consultant. If the Core Team decides to update the plan itself, the group will need to review the current FEMA hazard mitigation plan guidelines for any change in the requirements. The update to the City of Fitchburg 2020 HMP-MVP Plan will be forwarded to MEMA for review and to FEMA for ultimate approval. The Core Team will begin drafting the full update of the plan in four years. This will help the City avoid a lapse in its approved plan status and grant eligibility when the current plan expires at the end of year five.

9.0 LIST OF REFERENCES

American Society of Civil Engineers (ASCE).2018. ASCE 7 Hazard Tool. Fitchburg, Massachusetts. asce7hazardtool.online/.

Bingmaps https://www.bing.com/maps?q=city+of+fitchburg+ma&src=IE-SearchBox&FORM=IESR4A

Blake, Eric S.; Landsea, Christopher W.; and Gibney, Ethan J. 2011. *The Deadliest, Costliest, and Most Intense United States Tropical Cyclones from 1851 to 2010*. NOAA Technical Memorandum NWS NHC-6. National Weather Service, National Hurricane Center. https://www.nhc.noaa.gov/pdf/nws-nhc-6.pdf.

Cardinali, M, P. Reichenback, R. Guzzetti, F. Ardizzone, G. Antonini, M. Galli, M. Cacciano, M. Castellani, P. Salvati. 2002. A Geomorphological Approach to the Estimation of Landslide Hazards and Risks in Umbria, Central Italy. European Geophysical Society. Natural Hazards and Earth System Sciences. 2: 57-72. https://www.nat-hazards-earth-syst-sci.net/2/57/2002/nhess-2-57-2002.pdf.

City of Fitchburg. Complete Streets Policy. 2017. http://www.fitchburgpubliclibrary.org/DocumentCenter/View/1494/Complete-Streets-Fitchburg-Final-Draft?bidId=

City of Fitchburg. "Economic Development Strategic Plan", October 2018.

City of Fitchburg. "Open Space and Recreation Plan Update Fitchburg, Massachusetts 2014-2021"

City of Fitchburg. Current and Future Developments in Fitchburg. Shared by Mike O'Hara from the Community Development Office on 4/3/2020.

City of Fitchburg Website. "Brief History of Fitchburg". http://www.ci.fitchburg.ma.us/443/Brief-History-of-Fitchburg

City of Fitchburg. Stormwater Management Rules and Regulations; Chapter 154. 2019. https://www.fitchburgma.gov/DocumentCenter/View/4865/Fitchburg-Stormwater-Rules--Regulations-2019

City of Fitchburg. Snow and Ice Control Manual. Winter 2016- 2017. http://www.fitchburgma.gov/DocumentCenter/View/4867/Fitchburg-Snow--Ice-Manual-2016-2017?bidId=

City of Fitchburg. Wetlands Protection Ordinance Rules and Regulations; Chapter 178. 2012. http://www.fitchburgma.gov/DocumentCenter/View/602/Wetlands-Protection-Ordinance-Rules-and-Regulations-PDF?bidId=

City of Fitchburg. ZONING. Chapter 181. 2019 (latest amendments). http://www.ci.fitchburg.ma.us/DocumentCenter/View/2069/Fitchburg-Zoning-Ordinance

Commonwealth of Massachusetts, Massachusetts Emergency Management Agency (MEMA), and Massachusetts Executive Office of Energy & Environmental Affairs (EOEEA). "Massachusetts State Hazard Mitigation and Climate Adaptation Plan," September 2018b.

Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), and National Weather Service. "Storm Data Preparation." Operations and Services Performance, NWSPF 10-16., July 9, 2018a. nws.noaa.gov/directives/sym/pd01016005curr.pdf.

Edward J. Collins Jr. "Economic Trends Fitchburg, Massachusetts A City by the River" Center for Public Management at the University of Massachusetts, Boston February 2018

EPA, United States Environmental Protection Agency SDWIS. https://enviro.epa.gov.

Federal Emergency Management Agency (FEMA). 2020a. Hazard Mitigation Planning. https://www.fema.gov/hazard-mitigation-planning

Federal Emergency Management Agency (FEMA). 2020b.Grants. http://www.fema.gov/grants.

Federal Emergency Management Agency (FEMA). 2019a "Hazard Mitigation Grant Program." https://www.fema.gov/hazard-mitigation-grant-program.

Federal Emergency Management Agency (FEMA). 2019b. "Flood Zones," https://www.fema.gov/flood-zones.

Federal Emergency Management Agency (FEMA). 2019c. "NFIP Flood Insurance Manual Appendix F: Community Rating System," fema.gov/media-library-data/1559830308363-e690ed2aea6606fb81826904e4a7bd7f/app-f_crs_508_apr2019.pdf.

Federal Emergency Management Agency (FEMA). 2019d. "Disasters: Total Number of Declared Disasters," Accessed April 2020. fema.gov/disasters?field_dv2_state_territory_tribal_value_selective=MA&field_dv2_incident_type_tid=All&field_dv2_declaration_type_value=All&field_dv2_incident_begin_value%5Bvalue%5D%5Bmonth%5D=&field_dv2_incident_begin_value%5Bvalue%5D%5Byear%5D=&field_dv2_incident_end_value%5Bvalue%5D%5Bmonth%5D=&field_dv2_incident_end_value%5Bvalue%5D%5Byear%5D=.

Federal Emergency Management Agency (FEMA). 2019e. "Definitions: Repetitive Loss Structure.". fema.gov/national-flood-insurance-program/definitions.

Federal Emergency Management Agency (FEMA). 2019f "The National Flood Insurance Program." fema.gov/national-flood-insurance-program.

Federal Emergency Management Agency (FEMA). 2019g. "Repetitive Loss Properties."

Federal Emergency Management Agency (FEMA). 2013. "Local Mitigation Planning Handbook". https://www.fema.gov/media-library/assets/documents/31598?id=7209.

Federal Emergency Management Agency (FEMA). 1991. "Flood Map".

Frumhoff, Peter, James McCarthy, Jerry Melillo, Susanne Moser, and Donald Wuebbles. 2007. "Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions." Northeast Climate Impacts Assessment. Cambridge, MA: Union of Concerned Scientists.

General Laws of Massachusetts. Section 3A of Chapter 23A: "Economic development incentive program; establishment; definitions for Secs. 3A to 3G. Gateway municipality'". https://malegislature.gov/Laws/GeneralLaws/PartI/TitleII/Chapter23A/Section3A

General Laws of Massachusetts. Section 40 of Chapter 131: "Section 40: Removal, fill, dredging or altering of land bordering waters". https://malegislature.gov/Laws/GeneralLaws/PartI/TitleII/Chapter23A/Section3A

Kocin, P. J., and L. W. Uccellini, 2004: A snowfall impact scale derived from Northeast storm snowfall distributions. Bull. Amer. Meteor. Soc., 85, 177–194.

Louie, John. 1996. "What Is Richter Magnitude?" Nevada Seismological Laboratory.

Madsen, Travis, and Nathan Willcox. 2012._"When It Rains, It Pours: Global Warming and the Increase in Extreme Precipitation from 1948 to 2011." Environment America Research & Policy Center. environmentamerica.org/sites/environment/files/reports/When%20It%20Rains,%20It%20Pours%20vUS.pdf.

MassAudubon. 2020. Losing Ground Statistics. https://www.massaudubon.org/our-conservation-work/advocacy/shaping-the-future-of-your-community/publications-community-resources/losing-ground/statistics/town/fitchburg

Massachusetts Bay Transportation Authority https://mbta.com/schedules/CR-Fitchburg/line

Massachusetts Department of Conservation and Recreation (DCR).2020a "Community Information System: Repetitive Loss for the City of Fitchburg," Data as of September 2019.

Massachusetts Department of Conservation and Recreation (DCR). 2020b. "Emergency Action Plans." Office of Dam Safety. mass.gov/service-details/emergency-action-plans.

Massachusetts Department of Conservation and Recreation (DCR). "Inventory of Dams." 2020. https://docs.digital.mass.gov/dataset/massgis-data-dams

Massachusetts Department of Conservation and Recreation (DCR). "302 CMR 10.00: Dam Safety," February 10, 2017. mass.gov/files/documents/2017/10/30/302cmr10.pdf.

Massachusetts Department of Conservation and Recreation (DCR). 2017b. Recent Drought History. https://www.mass.gov/files/documents/2017/09/08/drought-status-history.pdf

Massachusetts Department of Conservation and Recreation (DCR). 2006. Fitchburg Reconnaissance Report from Massachusetts Heritage Landscape Inventory Program. http://www.ci.fitchburg.ma.us/DocumentCenter/View/482/An-Inventory-of-Fitchburgs-Historic-Landscapes-PDF

Massachusetts Department of Environmental Protection. 310 CMR 10.00: Wetlands Protection Act Regulations. 2017. https://www.mass.gov/regulations/310-CMR-1000-wetlands-protection-act-regulations

Massachusetts Department of Public Health (DPH), 2019. Populations Potentially Vulnerable to Heat-Related Impacts. Bureau of Environmental Health. Retrievable from https://nescaum-dataservices-assets.s3.amazonaws.com/MA-statewide-vuln-pop-map.JPG

Massachusetts Division of Fisheries and Wildlife. 2012. BioMap2 Conserving the Biodiversity of Massachusetts in a Changing World. http://maps.massgis.state.ma.us/dfg/biomap/pdf/town_core/Fitchburg.pdf

Massachusetts Executive Office of Energy & Environmental Affairs (EEA), and Adaptation Advisory Committee. "Massachusetts Climate Change Adaptation Report," September 2011.

Massachusetts Emergency Management Agency (MEMA), and Massachusetts Department of Conservation and Recreation (DCR).2013. "Commonwealth of Massachusetts State Hazard Mitigation Plan,"

Massachusetts Executive Office of Energy and Environmental Affairs (MA EOEEA) and Executive Office of Public Safety and Security (EOPSS). 2018. Massachusetts State Hazard Mitigation and Climate Adaptation Plan.

Massachusetts Executive Office of Energy and Environmental Affairs (EEA) and the Massachusetts Emergency Management Agency (MEMA). 2019. Massachusetts Drought Management Plan. https://www.mass.gov/doc/massachusetts-drought-management-plan/download.

Massachusetts Fire and EMS Mobilization Plan. 2018. https://www.mass.gov/doc/statewide-fire-mobilization-plan/download

Massachusetts Executive Office of Energy and Environmental Affairs (EEA) and the Massachusetts Emergency Management Agency (MEMA). 2019. Massachusetts Drought Management Plan. https://www.mass.gov/doc/massachusetts-drought-management-plan/download

Mass GIS. 2020. Standardized Assessor's Parcel Data. https://docs.digital.mass.gov/dataset/massgis-data-standardized-assessors-parcels.

MA State Building Code. Ninth Edition: 780. 2018. https://www.mass.gov/handbook/ninth-edition-of-the-ma-state-building-code-780

Montachusett Regional Planning Commission (MRPC); "Montachusett Region Natural Hazard Mitigation Plan 2015 Update"

National Oceanic and Atmospheric Administration (NOAA).2020a. "Observed Weather Reports: Annual Climate Report." National Weather Service Forecast Office: Boston, MA, January 8, w2.weather.gov/climate/index.php?wfo=box.

National Oceanic Atmospheric Administration (NOAA). 2019a National Oceanic Atmospheric Administration (NOAA).2019a. "Storm Events Database: Worcester County." National Centers for Environmental Information. https://www.ncdc.noaa.gov/stormevents/.

National Oceanic and Atmospheric Administration (NOAA). 2018. National Weather Service Forecast Office: Boston, MA. “Seasonal Climate Report.” https://w2.weather.gov/climate/index.php?wfo=box

National Oceanic and Atmospheric Administration. 2015. Atlas 14: Precipitation-Frequency Atlas of the United Sates. Volume 10 Version 2.0: Northeastern States.

National Oceanic and Atmospheric Administration (NOAA) and National Weather Service. 2019. “Heavy Snow.” Glossary. https://w1.weather.gov/glossary/index.php?word=heavy+snow.

National Oceanic and Atmospheric Administration (NOAA).n.d. Heat Index. https://www.weather.gov/bgm/heat

National Oceanic and Atmospheric Administration (NOAA).n.d. " Wind Chill Safety.” https://www.weather.gov/bou/windchill

Oliver: MassGIS Online Mapping Tool for Environmental justice community. http://maps.massgis.state.ma.us/map_ol/ej.php

Slope Stability Map of Massachusetts focusing on Fitchburg. The Massachusetts Geological Survey. 2013. https://mgs.geo.umass.edu/biblio/slope-stability-map-massachusetts

US Census Bureau QuickFacts U.S Department of Commerce ”QuickFacts: Fitchburg Town, Worcester County Massachusetts,” https://www.census.gov/quickfacts/fact/table/fitchburgcitymassachusetts,US/PST045219

USGS Current Conditions for the Nation. USGS 01094400 North Nashua River at Fitchburg, MA. https://waterdata.usgs.gov/nwis/uv?site_no=01094400

United States Geological Survey (USGS).2020. “Earthquake Hazards Program,” 2020. earthquake.usgs.gov/

United States Geological Survey (USGS). 2019. “Landslides 101.” https://www.usgs.gov/natural-hazards/landslide-hazards/science/landslides-101?qt-science_center_objects=0#qt-science_center_objects.

United States Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), and National Weather Service. 2018. “Storm Data Preparation.” Operations and Services Performance, NWSPF 10-16. nws.noaa.gov/directives/sym/pd01016005curr.pdf.

United States Weather Bureau. 1961. Technical Paper No. 40 (TP-40): Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years. https://www.nws.noaa.gov/oh/hdsc/PF_documents/TechnicalPaper_No40.pdf.

Vision2020 - Fitchburg's Comprehensive Master Plan. 1998. Land Use Section. http://www.fitchburgma.gov/DocumentCenter/View/125/Land-Use-Section-PDF