PUBLIC REVIEW DRAFT

Town of Montague Hazard Mitigation Plan

Adopted by the Montague Select Board on
xx, xx

Prepared by

Montague Hazard Mitigation Committee

and

Franklin Regional Council of Governments
12 Olive Street, Suite 2
Greenfield, MA 01301
(413) 774-3167
www.frcog.org

This project was funded by grants received from the Massachusetts Municipal Vulnerability Preparedness (MVP) Program, Massachusetts Emergency Management Agency (MEMA) and the Federal Emergency Management Agency (FEMA).

Acknowledgements

Montague Multi-Hazard Mitigation Plan Update Committee

Christopher Bonnett, Montague Police Department
Gary Dion, Montague Center Water Department
David Hansen, Montague Center Fire Department
Walter Ramsey, Montague Planning Department
Daniel Wasiuk, Montague Board of Health
John Zellmann, Montague Emergency Management & Turners Fall Fire Department

Franklin Regional Council of Governments

Peggy Sloan, Director of Planning & Development
Kimberly Noake MacPhee, P.G., CFM, Land Use & Natural Resources Program Manager
Alyssa Larose, Senior Land Use & Natural Resources Planner
Xander Sylvain, Emergency Preparedness Program Assistant
Helena Farrell, Land Use & Natural Resources Planner
Ryan Clary, Senior GIS Specialist

The Montague Select Board offers thanks to the Massachusetts Emergency Management Agency (MEMA) for developing the 2018 Massachusetts Hazard Mitigation and Climate Adaptation Plan, which served as a template and important resource for the development of the 2020 Montague Multi-Hazard Mitigation Plan.

Contents

1 PLANNING PROCESS

1.1 INTRODUCTION

The Federal Emergency Management Agency (FEMA) and the Massachusetts Emergency Management Agency (MEMA) define Hazard Mitigation as any sustained action taken to reduce or eliminate long- term risk to people and property from natural hazards such as flooding, storms, high winds, hurricanes, wildfires, earthquakes, etc. Mitigation efforts undertaken by communities will help to minimize damages to buildings and infrastructure, such as water supplies, sewers, and utility transmission lines, as well as natural, cultural and historic resources.

Planning efforts, like the one undertaken by the Town of Montague, make mitigation a proactive process. Pre-disaster planning emphasizes actions that can be taken before a natural disaster occurs. Future property damage and loss of life can be reduced or prevented by a mitigation program that addresses the unique geography, demography, economy, and land use of a community within the context of each of the specific potential natural hazards that may threaten a community.

Preparing, and updating a hazard mitigation plan every five years, can save the community money and facilitate post-disaster funding. Costly repairs or replacement of buildings and infrastructure, as well as the high cost of providing emergency services and rescue/recovery operations, can be avoided or significantly lessened if a community implements the mitigation measures detailed in the plan.

FEMA requires that a community adopt a pre-disaster mitigation plan as a condition for mitigation funding. For example, the Hazard Mitigation Grant Program (HMGP), the Flood Mitigation Assistance Program (FMA), and the Pre-Disaster Mitigation Program are programs with this requirement.

1.2 HAZARD MITIGATION COMMITTEE

Updating the Town of Montague's Hazard Mitigation plan involved a committee comprised of the following members:

- Christopher Bonnett, Montague Police Department
- Gary Dion, Montague Center Water Department
- David Hansen, Montague Center Fire Department

- Walter Ramsey, Montague Planning Department
- Daniel Wasiuk, Montague Board of Health
- John Zellmann, Montague Emergency Management & Turners Fall Fire Department

The Hazard Mitigation Planning process update for the Town included the following tasks:

- Hosting a Community Resilience Building (CRB) workshop with local and regional stakeholders who identified Montague's key natural and man-made hazard vulnerabilities and strengths and proposed actions to build infrastructural, social, and environmental resilience to climate change. The workshop led to the creation of a Municipal Vulnerability Preparedness (MVP) report and designation for Montague as an MVP community in 2018.
- Reviewing and incorporating existing plans and other information, including changes in development in the years since the Town's previous Hazard Mitigation planning process.
- Updating the natural hazards that may impact the community from the previous plan.
- Conducting a Vulnerability/Risk Assessment to identify the infrastructure and populations at the highest risk for being damaged by the identified natural hazards, particularly flooding.
- Identifying and assessing the policies, programs, and regulations the community is currently implementing to protect against future disaster damages.
- Identifying deficiencies in the current Hazard Mitigation strategies and establishing goals for updating, revising or adopting new strategies.
- Hosting a public forum on December 11, 2019 to present the final draft plan and receive feedback from stakeholders and the community at-large on the action plan.
- Adopting and implementing the final updated Hazard Mitigation Plan.

The key product of this Hazard Mitigation Plan Update process is the development of an Action Plan with a Prioritized Implementation Schedule.

Meetings

Meetings of the Hazard Mitigation Committee were held on the dates listed below. Agendas for these meetings are included in Appendix B. All meetings followed Massachusetts Open Meeting Law and were open to the public.

April 2018
Held a Community Resilience Building workshop as part of the Municipal Vulnerability Preparedness (MVP) designation process for Montague. The objectives of the workshop were

to:

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

MVP workshop findings have been integrated into the Montague Multi-Hazard Mitigation Plan update process and final plan.

May 15, 2019
Work group meeting included hazard mitigation planning overview, and completion of the hazard identification and risk assessment, including a review of the results of the Community Resilience Building workshop and review of the Critical Facilities and Infrastructure map.

June 19, 2019
Work group meeting to revise the risk assessment, update Local Profile and Planning Context and to begin updating the hazard profiles. Work group identified critical facilities in town, and made edits to their critical facilities and past hazard map.

July 24, 2019
Work group meeting to finalize the hazard profiles and problem statements and review existing mitigation strategies.

October 29, 2019
Work group meeting to review a draft action items and plan for a public forum to gather stakeholder and community feedback.

December 11, 2019
A public forum was held to elicit feedback on the draft mitigation strategies and plan. Maps and data were presented. A prioritization exercise was completed to determine the highest priority action items.

Agendas and sign-in sheets for each meeting can be found in Appendix B. While not all members of the Hazard Mitigation Committee were able to attend each meeting, all members collaborated on the plan and were updated on progress by fellow Committee members after meetings occurred.

1.3 PARTICIPATION BY STAKEHOLDERS

A variety of stakeholders were provided with an opportunity to be involved in the update of the Montague Hazard Mitigation Plan. The different categories of stakeholders that were involved, and the engagement activities that occurred, are described below.

Local and Regional Agencies Involved in Hazard Mitigation Activities

In April 2018, Montague held a Community Resiliency Building workshop as part of the Massachusett's Municipal Vulnerability Preparedness (MVP) designation program. The workshop was critical to enabling participants to think about and engage across different sectors. Town officials representing administration, public safety, public health, wastewater treatment, energy, council on aging, and planning, came together with regional and state representatives from the school district, regional housing authority, MA Department of Conservation and Recreation, and FirstLight Power Resources, to determine the most threatening hazards to the Town of Montague and to agree upon high priorities and actions to address them. The results of the workshop are documented in the Town of Montague's *MVP Resiliency Plan*, and were integrated into this Hazard Mitigation Plan update process. The Franklin Regional Council of Governments (FRCOG), the regional planning agency for Montague and all 26 towns in Franklin County, facilitated the workshop.

In addition to the MVP process, FRCOG regularly engages with the Town of Montague as part of its regional planning efforts, which include the following:

- Developing the Sustainable Franklin County Plan, which advocates for sustainable land use throughout the region and consideration of the impact of flooding and other natural hazards on development.

- Developing and implementing the Franklin County Comprehensive Economic Development Strategy, which includes goals and strategies to build the region's economic resilience.

- Developing the Franklin County Regional Transportation Plan, which includes a focus on sustainability and climate resilience, and implementing the Franklin County Transportation Improvement Program to complete transportation improvements in our region.

- FRCOG Emergency Preparedness Program staff work with four regional committees: the Mohawk Area Public Health Coalition, the Franklin County Regional Emergency Planning Committee, the Franklin County Emergency Communications System Oversight Committee, and the Western Mass. Health and Medical Coordinating Coalition. Working with these committees and with local governments, the FRCOG provides integrated planning and technical assistance to improve and enhance our communities' ability to prepare for, respond to, and recover from natural and man-made disasters.

All of these FRCOG initiatives consider the impact of natural hazards on the region and strategies for reducing their impact to people and property through hazard mitigation activities. The facilitation of the Montague Hazard Mitigation Plan by FRCOG ensured that information from these plans and initiatives were incorporated into the Hazard Mitigation Planning process.

Agencies that Have the Authority to Regulate Development

The Montague Planning Board is the primary Town agency responsible for regulating development in town. Feedback to the Planning Board was ensured through the participation of the Montague Town Planner on the Hazard Mitigation Committee. In addition, the Franklin Regional Council of Governments, as a regional planning authority, works with all agencies that regulate development in Montague, including the municipal entities listed above and state agencies, such as the Department of Conservation and Recreation and MassDOT. This regular involvement ensured that during the development of the Montague Hazard Mitigation Plan, the operational policies and any mitigation strategies or identified hazards from these entities were incorporated into the Hazard Mitigation Plan.

Participation by the Public, Businesses, and Neighboring Communities

The plan update and public meetings were advertised on the Town website, and were posted at the Town Hall and at other designated public notice buildings. A copy of the draft plan was available to the public at the Town Hall and on the Town website at www.montague-ma.gov/. A public forum was held on December 11, 2019 and provided an opportunity for the public and other stakeholders to provide input on the mitigation strategies and to prioritize action items. Stakeholder invitations were sent to Town boards, committees, and departments, and to all neighboring communities, inviting them to the public forum and to review the plan and provide comments. The public forum was advertised via a press release in the Montague Reporter and on the Town website. The final public Comment Period was held from December 11, 2019 through January 1, 2020. (See Appendix A, Public Participation Process, for copies of all press releases and stakeholder invitations emailed to solicit comments on the draft Plan). Comments were reviewed by the Committee and incorporated into the final plan as appropriate.

The Committee and FRCOG staff reviewed and incorporated the following existing plans, studies, reports and technical information, which are cited in footnotes throughout this plan:

- 2017 Montague Open Space and Recreation Plan
- 2018 Town of Montague MVP Resiliency Plan
- 2015 Montague Community Wildfire Protection Plan
- 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan
- Resilient MA Climate Change Clearinghouse for the Commonwealth
- Additional data sources cited in footnotes throughout this Plan

2 LOCAL PROFILE AND PLANNING CONTEXT

2.1 COMMUNITY SETTING

The Town of Montague is located in western Massachusetts, in central Franklin County. Montague is bordered by the Millers River and the towns of Gill and Erving on the north and northeast; Wendell on the east; and the towns of Leverett and Sunderland on the south. The Connecticut River and the towns of Deerfield and Greenfield form Montague's western boundary. The Deerfield River runs into the Connecticut River just south of Montague City.

Historical documentation has established that areas adjacent to the Connecticut, Millers and Deerfield Rivers, as well as the Montague Plains, hosted extensive Native American hunting and fishing activity. Until the late 17th century, large numbers of Native American people congregated at the falls on the Connecticut River, at the place then known as Peskeomskut, and at Millers Falls during the annual spring spawning runs of salmon and shad.

Europeans came to Montague in the early 18th century and settled in the area around Taylor Hill and Dry Hill in Montague Center, the oldest of the Town's five villages. These Colonial settlers farmed the excellent soils of the surrounding river lowlands. Lumbering was also a part of the economic base, with dams along the Sawmill River to power the mills.

Around the turn of the 19th century, with the construction of the Upper Locks and Canal in Turners Falls by Dutch capitalists, as well as improvements in roadways and bridges such as the Fifth Massachusetts Turnpike from Montague City to Millers Falls, and the Connecticut River Bridge, the Town of Montague began to expand beyond the village of Montague Center to Montague City and Millers Falls.

The railroad came to the Town of Montague in the 1850s. Millers Falls was the hub of both east-west and north-south routes. In 1865, John Alvah Crocker purchased the Upper Locks and Canal Co. and began the creation of Turners Falls as a planned industrial community. He built the power canal and dam on the Connecticut River and marketed both industrial and home sites in the village. Avenue A was laid out as a wide commercial street flanked by narrower streets designed to accommodate dense housing for mill workers. Development of Lake Pleasant as a spiritualist summer tent camp on the edge of the Montague Plains can also be attributed to the coming of the railroad.

Steady growth continued into the early 20th century, with the population of the Town reaching

7,925 in 1915. The Turners Falls Company began generating hydroelectric power in 1904 and went on to construct the Cabot Station hydroelectric plant in 1915, which is still in operation today. In 1936, the Town acquired and expanded the existing private airport on 185 acres on the north section of the Montague Plains, making it the largest airport in the state at the time.

With the decline of industry in the latter half of the 20th century and the advent of the automobile came the increase of residential/suburban growth, particularly in the villages of Turners Falls, Montague City, Montague Center and Millers Falls. Industrial development in the 1990s was concentrated in the Airport Industrial Park located between Turners Falls and Millers Falls.

The past forty years of history in Montague reflect the national trend of increasing public concern about the environment. In the 1970s, there were proposals to locate first a large-scale landfill, then a nuclear power facility on the 2,000-acre Montague Plains, one of the few remaining examples of an intact inland Pitch Pine-Scrub Oak forest in southern New England. The proposals met with strong local opposition and eventually were withdrawn.

Montague Center residents successfully advocated for protection of approximately 50 acres of floodplain meadow along the Sawmill River off North Street during the 1980s, and the town's farmers have been active participants in the state's Agricultural Preservation Restriction Program. Farming and forestry are still widely practiced in Montague, and the rivers that once provided power for industry continue to do so today while providing economic opportunities through recreational activities and tourism.

Population Characteristics

While population growth in Montague has been slow since the early 20th Century, it is still one of the largest towns in Franklin County, with a 2010 population of 8,437 residents (a 1% decrease since 2000). As of 2017, Montague's population is estimated to be 8,311 (a 1% decrease since 2010). Montague serves as a regional employment center for surrounding towns.

Environmental Justice Populations

The State of Massachusetts defines an environmental justice community if any of the following conditions are met:

- Block group whose annual median household income is equal to or less than 65 percent of the statewide median ($62,072 in 2010); or

- 25% or more of the residents identifying as minority; or
- 25% or more of the residents are foreign-born; or
- 25% or more of households having no one over the age of 14 who speaks English only or very well - Limited English Proficiency (LEP)

Based upon these criteria, the Franklin County towns with Environmental Justice populations are Greenfield, Montague and Orange. Sections of all three towns were categorized as such based on the low income criteria. In Montague, the EJ area is located in portions of Turners Falls, Montague City, and Millers Falls (See the Critical Facilities and Infrastructure Map). Some of the EJ areas overlap with the floodplain, or are adjacent to areas zoned industrial which may contain hazardous materials. In 2010, roughly 3,711 people, 44% of Montague's population, lived within the Environmental Justice area. Approximately 20% of the population within the EJ areas are children under the age of 18.

Current Development Trends

Most of Montague's housing is located in the five villages. The main streets in downtown Turners Falls feature three-story brick buildings with housing above and ground-floor commercial uses, mostly constructed between 1870 and 1890. Housing on side streets in the downtown is a combination of duplexes and multi-family buildings, both masonry and wood, built during the same period on very small lots. The "hill" section of Turners Falls is residential in character, with single-family homes on ¼- to ½-acre lots.

The village of Montague City runs along the Power Canal from Turners Falls to the Town's boundary with Greenfield, and is composed of a mix of single-family homes, duplexes, multi-family buildings and commercial and industrial uses, including Cabot Station, the former Farren Hospital (now an extended care facility) and medical offices.

Millers Falls is a small mill village, with a mix of densely-packed housing and commercial uses, as well as a freight rail yard. Lake Pleasant is a unique community on the edge of the Montague Plains. Wood residences were built on tent lots laid out in the 1870s, resulting in very tightly-clustered housing. The village is surrounded by Pitch Pine/Scrub Oak forest.

The village of Montague Center has a traditional village green, flanked by residences on ¼- to ¾-acre lots, with a few remaining commercial uses. Agricultural uses predominate to the west and south of Montague Center. The eastern section of town, bounded by the Central New England Railroad on the west, is heavily forested, with scattered residences on large lots.

The total land area of the Town of Montague is approximately 20,109 acres. Approximately 14,170 acres, or 70% of the total land area, are undeveloped forest. An estimated 7,752 acres, 39% of Montague's land area, are permanently protected from development through public and private ownership. There are approximately 3,049 acres in agricultural use (not including forestry), constituting 15% of the town's land base. Roughly 1,388 acres of farmland have been permanently protected for agriculture.[1]

National Flood Insurance Program Status

Montague is a participating member of the National Flood Insurance Program. Currently there are eight flood insurance policies in effect in Montague, for a total insurance value of $2,290,000. Two losses have been paid in Montague for a total of $1,208. The town does not have any repetitive loss properties. Montague's Flood Insurance Rate Maps (FIRM) were issued in 1979. FEMA is undertaking a project to update the FIRMs for Franklin County but this effort will take approximately 10 years.[2]

Roads and Highways

Montague's transportation system consists of three state highways, bridges, a network of town roads, two rail lines, a limited regional bus system, a small airport, and an on- and off-road bike network. Montague has a total of 135 miles of roadway. State Route 2, a major east-west route located just north of the Montague border, connects Montague with Greenfield and Route 91 to the west and Erving to the east. State Routes 63 and 47 are the major commuter roads connecting Montague to larger cultural and employment centers to the south.

Major town roads include Avenue A/Montague City Road, connecting Turners Falls and Montague City; Millers Falls Road, connecting Turners Falls and Millers Falls; Turners Falls Road connecting Montague Center and Turners Falls; and Greenfield Road, connecting Montague Center to Montague City. Like many towns in the Commonwealth, Montague is struggling to maintain its roads and bridges. Beginning in 2014, Greenfield Road underwent a comprehensive renovation, including drainage repair, bridge restoration, retaining wall replacement, and addition of "share the road" signs alerting motorists of cyclists. In 2016, MassDOT completed the Montague City Road Complete Street project, which included traffic calming, a safer bike path crossing, new ADA sidewalks, street trees, and bus pullouts.

[1] 2017 Montague Open Space and Recreation Plan.
[2] National Flood Insurance Program (NFIP) Statistics as of December 18, 2018.

After the update of the 2014 Montague Hazard Mitigation Plan, the Town received a Hazard Mitigation Grant to complete erosion control measures along Millers Falls Road, at a location adjacent to the Millers River. Erosion and unstable soils continue to be an issue along steep slopes adjacent to the roadway. A primary concern identified in the 2018 MVP workshop is flooding along Montague City Road from an adjacent stream. In 2018 the Town was awarded an MVP Action Grant to complete designs and engineering to mitigate flooding from the stream.

Montague participates in MassDOT's Complete Streets Program to improve the safety and accessibility of the transportation system for all roadway users. As components of participation, Montague has adopted a Complete Streets Policy and a Complete Streets Prioritization Plan that identifies 41 potential projects across Montague. In February, 2019, Montague was awarded a $311,000 Complete Streets Project Grant to implement four priority projects identified in the plan: improving sidewalk connections in Montague Center to the Bookmill; pedestrian and transit improvements at the intersection of Millers Falls Road, Unity Street, and High Street; bicycle and pedestrian improvements at Avenue A and First Street; and implementing bicycle accommodations along Avenue A and Montague City Road.

The town has many smaller roads, including several gravel roads in the eastern section of town that have been paved during the last five years. Gravel roads make up 19 miles, or 14% of Montague's roads.[3] The Town also needs to assess and inventory culverts in town to prioritize repairs and replacements. A culvert on Ferry Road is causing flooding and is need of replacement.

Bridges

Bridge maintenance is a major problem in Massachusetts, and Montague is no exception. Out of Montague's 18 bridges, several bridges in town are currently in need of repair, are being repaired or are closed. The Massachusetts Department of Transportation (MassDOT) is responsible for repair, replacement and maintenance of most of these structures.

The Greenfield Road Bridge over the B&M Railroad tracks was dismantled in 1999 and replaced with a bicycle and pedestrian bridge in 2017. A bridge over the Millers River connecting East Mineral Road to the Town of Erving was redesigned and reconstructed for use as a bicycle and pedestrian bridge in 2005, and will remain closed to vehicles. Major renovations on the Gill-Montague Bridge, which was constructed in 1937 and crosses the Connecticut River and Power Canal in Turners Falls, began in 2010, and were completed in 2014. The $40.1 million project

[3] 2017 MassDOT Road Inventory File.

ensures that the 700-foot long span remains a critical link for industry, commerce and public safety in Montague.

Repairs to the General Pierce Bridge over the confluence of the Connecticut and Deerfield Rivers on Montague's border with Greenfield, formerly listed as "structurally deficient" by MassDOT, was required before work on the Gill-Montague Bridge could begin. The bridge is listed on MassDOT's Capital Investment Plan for construction sometime between 2020 and 2024. This overhaul represents a main infrastructure priority for the town. The bridge is a critical emergency vehicle route. Recently, the weight limit on the bridge was reduced to the point where the Town must now drain the water out of a fire truck before driving it over the bridge. The bridge is also now only one lane. Traffic queues up on both sides of the bridge to wait to cross, presenting a significant challenge for emergency vehicles trying to get through.

Two bridges over the Sawmill River in Montague Center (South Street and Center Street) were recently limited to one lane traffic due to weight restrictions, and are vulnerable to flooding. The South Street Bridge is listed on the Transportation Improvement Program (TIP) for replacement in 2024, and the Town is seeking to add the Center Street Bridge to the TIP as well. A bridge near Chestnut Hill is scheduled for replacement in 2020 through the State's Small Bridge Program. Should any of the bridges in Montague fail before they can be repaired or replaced, first responders are concerned about being able to access parts of Town. In addition, the State has not issued passable weight limits for some of the smaller bridges in town, making it difficult for Town departments to know whether heavy-duty trucks can still use these bridges.

In the canal district of Turners Falls, located between the Connecticut River and power canal, only one bridge (out of eight bridges that access the district) is fully functional, posing a public safety access concern for this neighborhood. The district includes "The Patch" residential neighborhood, which abuts an area with a concentration of vacant industrial buildings and brownfields, where contamination is expected or confirmed. Several of the vacant buildings have been targets for arson in recent years.

Rail

The Pan Am Systems Main Freight line runs east-west across the Montague Plains, and the New England Central line runs north-south, parallel to Route 63. The lines intersect in Millers Falls. Currently, rail service in Montague is only for the transportation of freight. The closest access to passenger rail for Montague residents is at the JWO Transit Center in downtown Greenfield, where Amtrak's Vermonter service between Washington D.C. and St. Albans, VT currently stops twice daily. Increased passenger rail service between Greenfield and Springfield is expected to begin the fall of 2019.

Rail lines in Montague were identified as an area of concern during Montague's Municipal Vulnerability Preparedness (MVP) workshop. Workshop participants voiced concerns about a derailment in Millers Falls that could cause a hazardous spill, as well as ongoing issues with trains idling and causing air quality issues, which could be exacerbated with higher temperatures. A hazardous spill on the rail line as it passes through the Montague Plains would also pose a serious hazard to the Town's public water supply. Rail lines were also identified as a potential wildfire hazard, particularly in Lake Pleasant and the Montague Plains. Sparks from the trains have caused brushfires in the past. Old rail ties stacked along the sides of the tracks are vulnerable to catching fire and are very difficult to put out.

Air Transportation

The Turners Falls Municipal Airport is one of only two airports in Franklin County. It currently offers a 3,200-foot long, 75-foot wide runway that can accommodate small single-engine and multi-engine planes and small jets. It is a General Aviation airport, used for transportation, business, recreation, flight instruction and civil defense. Most of the current users of the airport are recreational flyers. Students and families of students from area independent boarding schools use the airport to travel between school and home. There are also some business-oriented travelers, and Pioneer Aviation, located adjacent to the airport, runs a flight school. Use of the airport has declined since its peak in the 1980s.

The current Airport Master Plan calls for an expansion of the runway and upgrades to various facilities. The first phase of the airport's runway expansion project is complete. During the permitting process for this project, areas of environmental sensitivity and archaeological concern on the airport property were identified. Any proposed reconstruction and expansion of the runway will need to take these environmental and archaeological factors into consideration so that the project avoids impacting these areas. In addition to its transportation function, the airport provides important habitat for grassland birds. It is also used for recreational purposes by birders, walkers, mountain bikers and model airplane enthusiasts.

Public Transportation

The Franklin Regional Transit Authority (FRTA) serves 40 towns in Franklin, Hampshire, Hampden, and Worcester counties. Four fixed routes currently serve the Town of Montague. According to the American Community Survey, roughly 11 percent of households in Montague do not have access to a vehicle, showing that transportation alternatives to the personal automobile need to be available to all residents.

Public Drinking Water Supply

The Town of Montague has three developed sources of municipal drinking water. There are two public wellfields located in the village of Montague Center. A single shallow well serves the village of Montague Center and is owned and operated by the Montague Center Water District, which services approximately 160 customers in the village center. The District provides an average annual daily amount of roughly 35,000 gallons to approximately 450 people. Approximately 15 years ago, the District, along with the Turners Falls Water Department and a land trust, purchase 16 acres of land that was to be sold for development, to help protect the drinking water supply.

The Turners Falls Water Department owns and operates two wells in the Tolan Farm well field with an approved withdrawal volume of approximately 1.04 million gallons per day (MGD). Water from the wells is piped to storage tanks with approximately 6.3 million gallons of capacity on top of Wills Hill. The new Hannegan Brook Well located near Lake Pleasant came online in 2014 and functions as a back-up water supply that can yield 1.44 MGD to meet future water demands. The Turners Falls Water Department supplies approximately 7,057 people with drinking water on a daily average, which includes residents and businesses in Turners Falls, Millers Falls, the industrial park, Montague City, and Lake Pleasant.

The Turners Falls and Montague Center wells are hydrologically connected. During drought or times of high demand, pumping the Tolan Farm wells drains the Montague Center well. There is a valve connecting the two systems that allows the Turners Falls Water Department to supply Montague Center when necessary. The Montague Center Water District is actively seeking grants to rehabilitate or replace the water tank. Exploring a larger interconnection with the Turners Falls Water Department may also be a possibility for providing a more secure back-up supply.

The third source of water is the Lake Pleasant Reservoir, which was the Town's main source of water until 1965. Lake Pleasant is owned by the Turners Falls Fire District. It covers 53 acres and has a storage capacity of approximately 150 million gallons. It is connected to Green Pond, a 15-acre reservoir that holds approximately 40 million gallons. The Turners Falls Fire District owns approximately 1,310 acres of land (MassGIS assessed acreage figure) in the watershed for Hannegan Brook, which feeds the reservoirs.

In 1994, the Department of Environmental Protection (DEP) downgraded the Lake Pleasant and

Green Pond reservoirs to an emergency water supply. Under current law, these sources cannot be brought back online for regular use unless the Water Department builds a filtration plant. The cost associated with this project is a significant issue for residents of the district and the town. Abandonment of Lake Pleasant and Green Pond as water supplies could make them available for swimming and other recreational uses. However, according to the DEP, Lake Pleasant is hydrologically connected to the new Hannegan Brook Well, and swimming will continue to be prohibited in the lake.[4] The Turners Falls Water Department has proposed to install a water line across the General Pierce Bridge to connect to the Greenfield water supply. This would provide both communities with back-up supply. The water line installation should be coordinated with the bridge reconstruction, which is currently scheduled to begin in 2020.

Sewer Service

Montague has a municipal wastewater treatment facility on Greenfield Road with a capacity of 1.83 million gallons per day of flow; 7,440 pounds Biological Oxygen Demand (BOD) per day and 6,000 pounds Total Suspended Solids (TSS) per day. Treated effluent is discharged to the Connecticut River; sludge is shipped out of town for disposal. The Town is exploring composting of sludge to reduce costs. The wastewater treatment plant on Greenfield Road has a back-up generator and is in the process of installing a solar PV array to reduce energy use at the facility.

With the exception of Millers Falls, which is served by the Town of Erving's wastewater treatment facility, all of the densely developed areas of town are served by the sewer system, including the remaining four village centers and the Airport Industrial Park off Millers Falls Road. Sewer service is also available at the old landfill off Turnpike Road, which has been identified as an area for future industrial development. The Riverside section of the Town of Gill is also serviced by the Montague facility.

Areas not served consist of rural areas of Montague Center, including Meadow Road, North Leverett Road and the Taylor Hill and Chestnut Hill areas, Route 47 and Route 63 south of Millers Falls, Dry Hill Road, and Turners Falls Road between Hatchery Road and the Cemetery, Greenfield Road south of Greenfield Cross Road, Hillside Road, Millers Falls Road between the Airport Industrial Park and Winthrop Street, Lake Pleasant and Green Pond Roads and Wendell Road.

Stormwater in an area on the "hill" section of Turners Falls is combined with the sewer collection system (Combined Sewer Overflow or CSOs). Stormwater from this area flows to the

[4] 2017 Montague Open Space and Recreation Plan.

wastewater treatment plant where it is treated along with sewage. During heavy rain events, overflow of the sewer system is captured and retained in several structures intended to reduce overflow into the Connecticut River. While these structures have been updated recently, increasing amounts of stormwater from more intense rain events may overwhelm these systems in the future.[5] MA DEP is currently assessing the Town's CSOs and will provide the Town with recommended steps to address the issue.

Emergency Shelters / Critical Facilities

The Turners Falls High School serves as both a town and regional emergency shelter. The school has back-up power generators, and the Town is studying the feasibility of implementing a solar powered micro-grid to provide additional resiliency to the school and the Public Safety Complex. Several needs for the regional shelter were identified during the 2018 MVP workshop, including improved radio communications within the building, developing a back-up water supply for the building, and improving the air conditioning system.

The Montague MVP Plan identified the Highway Department garage as a substandard structure inadequate for the current needs of the town. In 2018, Montague Town Meeting voted to construct a new garage, which will begin in 2019.

Natural Resources

Montague falls into two ecological regions, and two different watersheds. The western section of town is part of the Connecticut River Valley, which is distinguished from its surrounding uplands by milder climate, relatively rich floodplain soils, and level terrain with some higher outcropping ridges. The remainder of Montague falls within the Worcester-Monadnock Plateau, which includes the hilliest areas of central Massachusetts. The higher elevations and geology in this region result in generally cool and acidic soils and vegetation typical of northern New England. The northeast corner of Montague is part of the Millers River watershed.

Montague is rich in water resources, including rivers, streams, ponds, wetlands and aquifers. In addition to the Connecticut and Millers River, many perennial streams run through the Town. Major tributaries to the Connecticut, listed from north to south, include Randall Brook, Hatchery Brook, the Sawmill River and Cranberry Pond Brook. The Sawmill has several perennial tributaries, including Goddard Brook, Pond Brook, Spaulding Brook, Chestnut Hill Brook and Williams Brook. Hannegan Brook feeds Lake Pleasant and Green Pond. Lyons Brooks flows into

[5] Town of Montague MVP Resiliency Plan. June 2018.

the Millers River.

As previously noted, Montague has extensive forests, extending from the town's eastern boundary to Route 63, and encompassing approximately 2,000 acres of pitch pine/scrub oak forest on the Montague Plains in the center of town. Pitch pine/scrub oak communities are the most fire-prone vegetation types in New England, and significant evidence exists suggesting that fire was an important influencing factor on the vegetation of the Plains for many years before European settlement.

Cultural and Historic Resources

Cultural and historic resources help define the character of a community and reflect its past. These resources may be vulnerable to natural hazards due to their location in a potential hazard area, such as a river corridor, or because of old or unstable structures. Publicly owned cultural and historical resources include the Carnegie Public Library, Colle Opera House, Millers Falls Branch Library, Montague Center Library, and the Shea Theater. Montague has two historic districts and one historic site listed on the National Register of Historic Places. The Montague Center Historic District comprises 1,700 acres and 152 buildings in the traditional New England village center. The Turners Falls Historic District encompasses 1,300 acres of the village, including 250 buildings. An area of Millers Falls that includes 50 buildings was submitted for nomination as a National Register Historic District in early 2018, and is currently under review by the Massachusetts Historical Commission.

The Montague Book Mill, also known as the Alvah Stone Mill, is perched on the banks of the Sawmill River. Listed on the National Register of Historic Places, it was built as a grist mill in 1842. The property now houses a used book store, a café and gourmet restaurant, an antique shop, and artists' studio. Until the 1930s, Montague families would visit by horse and buggy to buy grain and flour from the mill. Two of the old millstones can still be seen in the Sawmill River.

As idyllic a setting as the Book Mill grounds are, and despite many updates that have been made to the structure, the property is vulnerable in that it lies in a flood plain and is subject to periodic flooding. The dam was breached by flood waters in the late 1980s and a minor flash flood in 1997 took most of remaining dam structure down river. A flood in 2005 finished off the dam, taking away the last remains of the structure. An attempt was made to rebuild the dam but those efforts were stymied by environmental concerns, including fish passage and siltation. While designation on the National Register of Historic Places is honorary in nature and does not provide any protective measures for the historic resources, designated sites may qualify for federal and state funding if damaged during a natural or manmade hazard.

Native American sacred sites along the Connecticut and Sawmill Rivers are at risk due to erosion along the banks of the rivers. FirstLight Power maintains an erosion control plan along the Connecticut River as required by the Federal Energy Regulatory Commission (FERC), and has repaired and maintained eroding riverbank and slopes at six Native American camp sites along the river since 2008 using bioengineering techniques, totaling 195 feet of non-adjacent sections. In 2009 similar bank stabilization work was completed on 1,000 linear in the vicinity of the Narrows on the Connecticut River.

2.2 IMPACTS OF CLIMATE CHANGE

Greater variation and extremes in temperature and weather due to climate change has already begun to impact Montague, and must be accounted for in planning for the mitigation of future hazard events. In 2017, the Commonwealth launched the Massachusetts Climate Change Clearinghouse (Resilient MA), an online gateway for policymakers, planners, and the public to identify and access climate data, maps, websites, tools, and documents on climate change adaptation and mitigation. The goal of Resilient MA is to support scientifically sound and cost-effective decision-making, and to enable users to plan and prepare for climate change impacts. Climate projections for Franklin County available through Resilient MA are summarized in this section. Additional information about the data and climate models is available on the resilient MA website: http://resilientma.org

Figure 2-1 identifies primary climate change impacts and how they interact with natural hazards assessed in the State Hazard Mitigation and Climate Adaptation Plan. Following is a summary of the three primary impacts of climate change on Franklin County and Montague: rising temperatures, changes in precipitation, and extreme weather. How these impacts affect individual hazards is discussed in more detail within Section 3: Hazard Identification and Risk Assessment.

Rising Temperatures

Average global temperatures have risen steadily in the last 50 years, and scientists warn that the trend will continue unless greenhouse gas emissions are significantly reduced. The nine warmest years on record all occurred in the last 20 years (2017, 2016, 2015, 2014, 2013, 2010, 2009, 2005, and 1998), according to the U.S. National Oceanographic and Atmospheric Administration (NOAA).

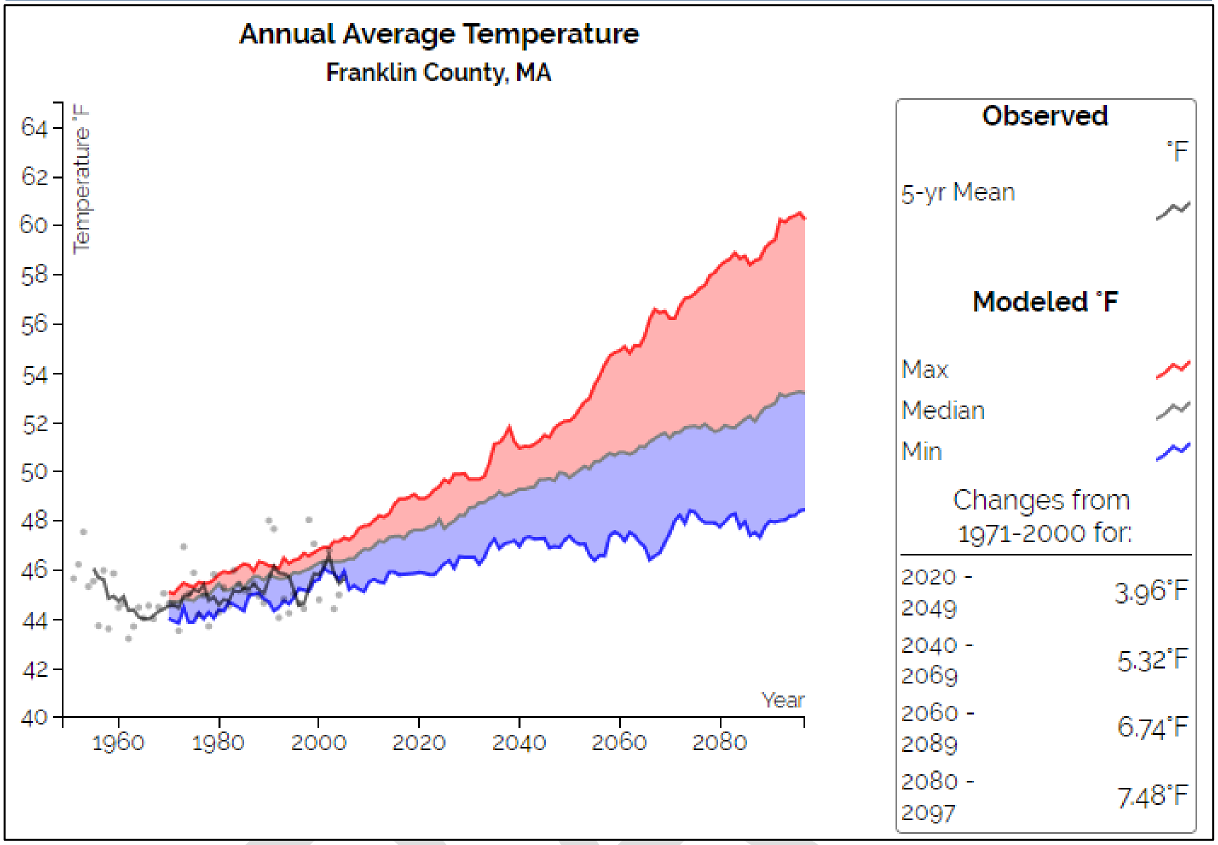
The average, maximum, and minimum temperatures in Franklin County are likely to increase significantly over the next century (resilient MA, 2018). Figure 2-2 displays the projected increase in annual temperature by mid-century and the end of this century, compared to the observed annual average temperature from 1971-2000. The average annual temperature is projected to increase from 45.3 degrees Fahrenheit (°F) to 50.6°F (5.32°F change) by mid-century, and to 52.8°F (7.48°F change) by the end of this century. The variation in the amount of change in temperature shown in Figure 2-2 is due to projections that assume different amounts of future GHG emissions, with greater change occurring under a higher emissions scenario, and less change occurring under a lower emissions scenario. For example, under a high emission scenario, the annual average temperature by the end of the century could be as high as 60°F.

Figure 2-1: Climate Change and Natural Hazard Interactions from the Massachusetts State Hazard Mitigation and Climate Adaptation Plan

Primary Climate Change Interaction	Natural Hazard	Other Climate Change Interactions	Representative Climate Change Impacts
Changes in Precipitation	Inland Flooding	Extreme Weather	Flash flooding, urban flooding, drainage system impacts (natural and human-made), lack of groundwater recharge, impacts to drinking water supply, public health impacts from mold and worsened indoor air quality, vector-borne diseases from stagnant water, episodic drought, changes in snow-rain ratios, changes in extent and duration of snow cover, degradation of stream channels and wetland
	Drought	Rising Temperatures, Extreme Weather	
	Landslide	Rising Temperatures, Extreme Weather	
Sea Level Rise	Coastal Flooding	Extreme Weather	Increase in tidal and coastal floods, storm surge, coastal erosion, marsh migration, inundation of coastal and marine ecosystems, loss and subsidence of wetlands
	Coastal Erosion	Changes in Precipitation, Extreme Precipitation	
	Tsunami	Rising Temperatures	
Rising Temperatures	Average/Extreme Temperatures	N/A	Shifting in seasons (longer summer, early spring, including earlier timing of spring peak flow), increase in length of growing season, increase of invasive species, ecosystem stress, energy brownouts from higher energy demands, more intense heat waves, public health impacts from high heat exposure and poor outdoor air quality, drying of streams and wetlands, eutrophication of lakes and ponds
	Wildfires	Changes in Precipitation	
	Invasive Species	Changes in Precipitation, Extreme Weather	
Extreme Weather	Hurricanes/Tropical Storms	Rising Temperatures, Changes in Precipitation	Increase in frequency and intensity of extreme weather events, resulting in greater damage to natural resources, property, and infrastructure, as well as increased potential for loss of life
	Severe Winter Storm / Nor'easter	Rising Temperatures, Changes in Precipitation	
	Tornadoes	Rising Temperatures, Changes in Precipitation	
	Other Severe Weather (Including Strong Wind and Extreme Precipitation)	Rising Temperatures, Changes in Precipitation	
Non-Climate-Influenced Hazards	Earthquake	Not Applicable	There is no established correlation between climate change and this hazard

Source: *Massachusetts State Hazard Mitigation and Climate Adaptation Plan*. September 2018

Figure 2-2: Projected Annual Average Temperature

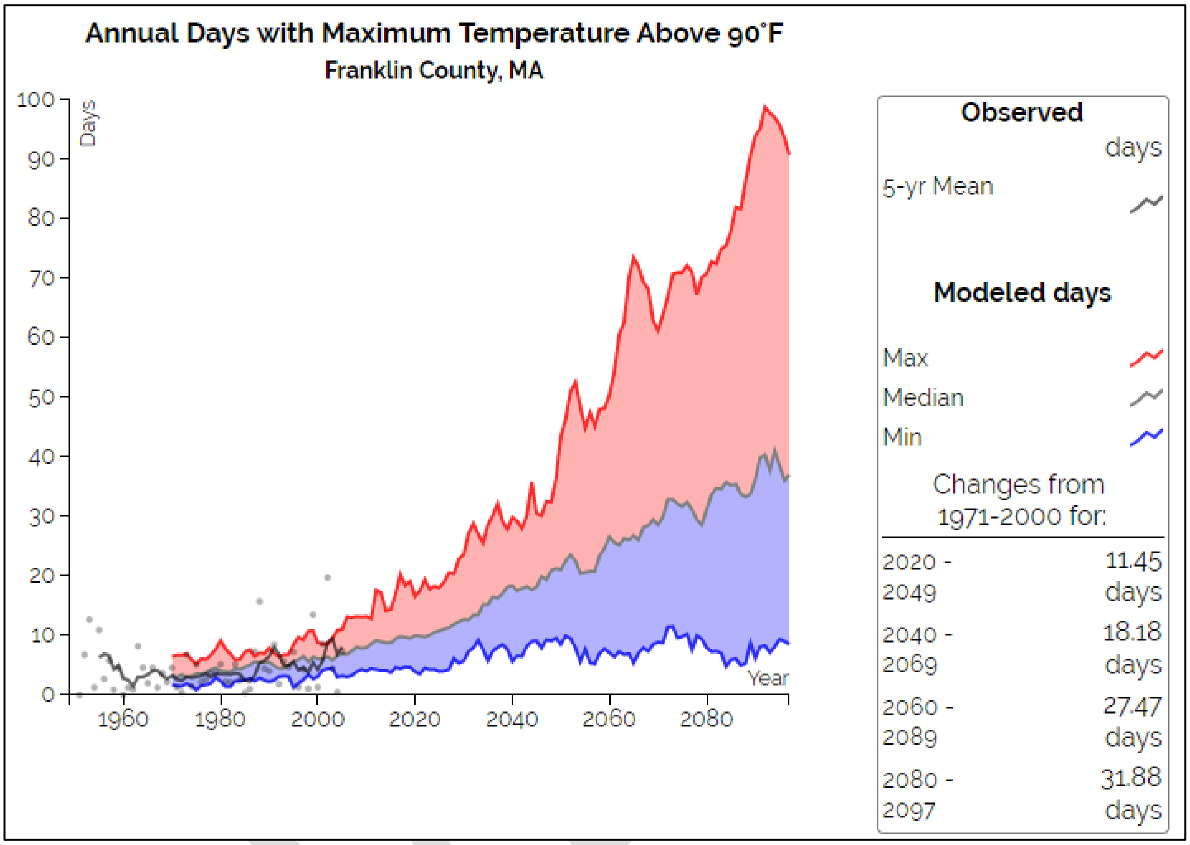


Source: Resilient MA, 2018

Winter temperatures are projected to increase at a greater rate than spring, summer, or fall. Currently Franklin County experiences an average of 169 days per year with a minimum temperature below freezing (32°F). The number of days per year with daily minimum temperatures below freezing is projected to decrease anywhere from 13 to 40 days by the 2050s, and by 15 to as many as 82 days (down to 87 days total) by the 2090s.

Although minimum temperatures are projected to increase at a greater rate than maximum temperatures in all seasons, significant increases in maximum temperatures are anticipated, particularly under a higher GHG emissions scenario. Figure 2-3 displays the projected increase in the number of days per year over 90°F. The number of days per year with daily maximum temperatures over 90°F is projected to increase by 18 days by the 2050s, and by 32 days by the end of the century (for a total of 36 days over 90°F), compared to the average observed range from 1971 to 2000 of 4 days per year. Under a high emissions scenario, however, there could be as many as 100 days with a maximum temperature above 90°F by the end of the century.

Figure 2-3: Projected Annual Days with a Maximum Temperature Above 90°F



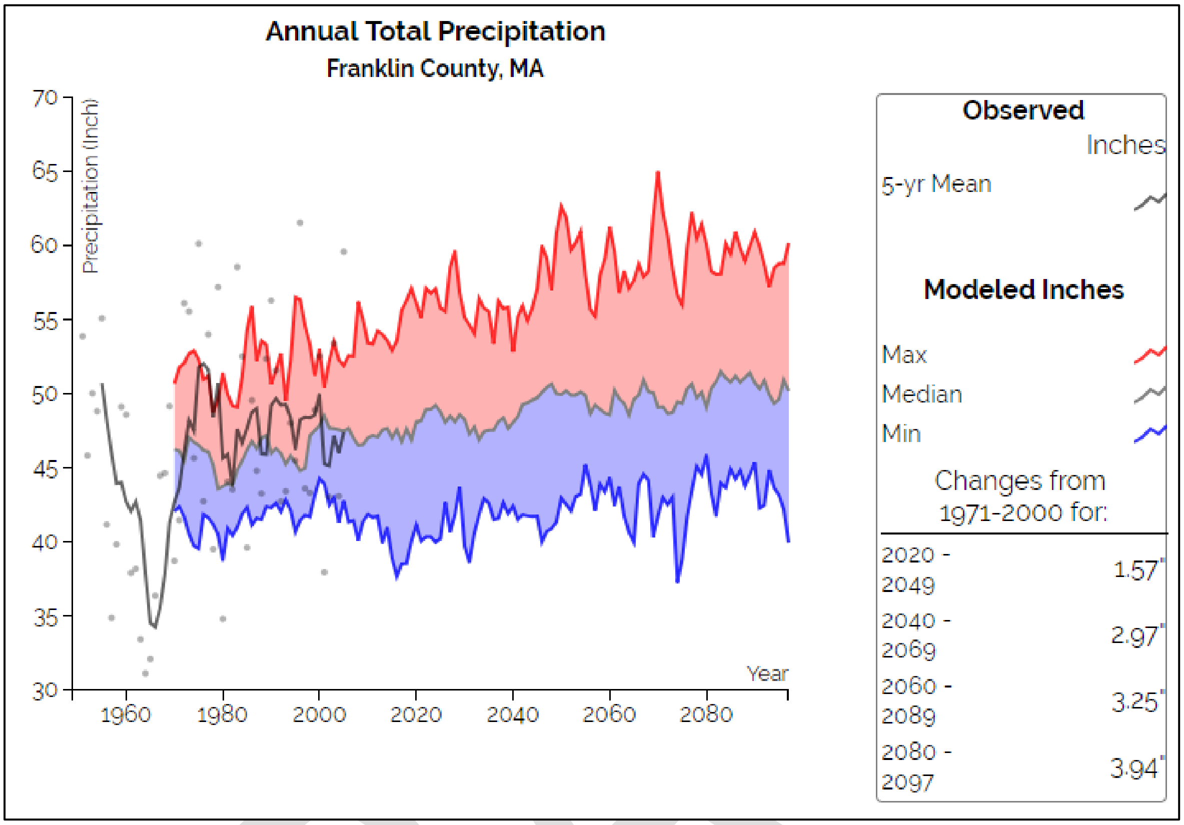
Source: Resilient MA, 2018

Changes in Precipitation

Changes in the amount, frequency, and timing of precipitation—including both rainfall and snowfall—are occurring across the globe as temperatures rise and other climate patterns shift in response. Precipitation is expected to increase over this century in Franklin County. Total annual precipitation is projected to increase by 3 inches by mid-century, and by 4 inches by the end of this century (see Figure 2-4). This will result in up to 52 inches of rain per year, compared to the 1971-2001 average annual precipitation rate of 48 inches per year in Franklin County. Precipitation during winter and spring is expected to increase, while precipitation during summer and fall is expected to decrease over this century. In general precipitation projections are more uncertain than temperature projections.[6]

[6] http://resilientma.org/datagrapher/?c=Temp/county/pcpn/ANN/25011/

Figure 2-4: Projected Annual Total Precipitation (Inches)



Source: Resilient MA, 2018

Extreme Weather

Climate change is expected to increase extreme weather events across the globe, as well as right here in Massachusetts. There is strong evidence that storms—from heavy downpours and blizzards to tropical cyclones and hurricanes—are becoming more intense and damaging, and can lead to devastating impacts for residents across the state. Climate change leads to extreme weather because of warmer air and ocean temperatures and changing air currents. Warmer air leads to more evaporation from large water bodies and holds more moisture, so when clouds release their precipitation, there is more of it. In addition, changes in atmospheric air currents like jet streams and ocean currents can cause changes in the intensity and duration of stormy weather.

In Franklin County, recent events such as Tropical Storm Irene in 2011, and the February tornado in Conway in 2018, are examples of extreme weather events that are projected to become more frequent occurrences due to climate change. While it is difficult to connect one storm to a changing climate, scientists point to the northeastern United States as one of the regions that is most vulnerable to an increase in extreme weather driven by climate change.

3 HAZARD IDENTIFICATION AND RISK ASSESSMENT

The following section includes a summary of disasters that have affected or could affect Montague. Historical research, conversations with local officials and emergency management personnel, available hazard mapping and other weather-related databases were used to develop this list.

The Hazard Mitigation Committee referred to the *Massachusetts State Hazard Mitigation and Climate Adaptation Plan* (September 2018) as a starting point for determining the relevant hazards in Montague. The table below illustrates a comparison between the relevant hazards in the State plan and in Montague's plan.

Table 3-1: Comparison of Hazards in the *Massachusetts State Hazard Mitigation and Climate Adaptation Plan, Montague Hazard Mitigation Plan, and Montague MVP Resiliency Plan*

Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2018)	Town of Montague Relevance	MVP Resiliency Plan Top Priority Hazard
 Inland Flooding	YES	Dam Failure
 Drought	YES	YES
 Landslide	YES	NO
 Coastal Flooding	NO	NO
 Coastal Erosion	NO	NO
 Tsunami	NO	NO

Table 3-1: Comparison of Hazards in the *Massachusetts State Hazard Mitigation and Climate Adaptation Plan, Montague Hazard Mitigation Plan, and Montague MVP Resiliency Plan*		
Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2018)	**Town of Montague Relevance**	**MVP Resiliency Plan Top Priority Hazard**
Average/Extreme Temperatures	YES	High Heat & Freezing
Wildfires	YES	YES
Invasive Species	YES	NO
Hurricanes/Tropical Storms	YES	Sever Weather Events – Snow, Wind, Ice, Rain
Severe Winter Storm	YES	Sever Weather Events – Snow, Wind, Ice, Rain
Tornadoes	YES	Sever Weather Events – Snow, Wind, Ice, Rain
Other Severe Weather	YES	Sever Weather Events – Snow, Wind, Ice, Rain
Earthquake	YES	NO

3.1 NATURAL HAZARD RISK ASSESSMENT METHODOLOGY

This chapter examines the hazards in the *Massachusetts State Hazard Mitigation and Climate Adaptation Plan* which are identified as likely to affect Montague. The analysis is organized into the following sections: Potential Effects of Climate Change, Hazard Description, Location, Extent, Previous Occurrences, Probability of Future Events, Impact, and Vulnerability. A description of each of these analysis categories is provided below.

Potential Effects of Climate Change

Climate change acts as a stressor and exacerbates natural hazards and a community's vulnerability to these hazards. The potential effects of climate change on each hazard, except earthquakes, are described to demonstrate the connections between traditional natural hazard analysis and climate change projections. This analysis aligns with three climate change categories (changes in precipitation, rising temperatures and extreme weather) included on the Commonwealth's resilient MA Climate Change Clearinghouse website.[7]

Hazard Description

The natural hazards identified for Montague are: severe winter storms, flooding (including dam failure), hurricanes/tropical storms, severe thunderstorms/tornados/microbursts, earthquakes, landslides, average/extreme temperatures, drought, and wildfire. Many of these hazards result in similar impacts to a community. For example, hurricanes, tornados and severe snowstorms may cause wind-related damage.

Location

Location refers to the geographic areas within the town that are affected by the hazard. Some hazards affect the entire town universally, while others apply to a specific portion of the town, such as a floodplain or area that is susceptible to wild fires. Classifications are based on the area that would potentially be affected by the hazard, on the following scale:

[7] http://www.resilientma.org/

Table 3-2: Location of Occurrence Rating Scale	
Classification	**Percentage of Town Impacted**
Large	More than 50% of the town affected
Medium	10 to 50% of the town affected
Isolated	Less than 10% of the town affected

Extent

Extent describes the strength or magnitude of a hazard. Where appropriate, extent is described using an established scientific scale or measurement system. Other descriptions of extent include water depth, wind speed, and duration.

Previous Occurrences

Previous hazard events that have occurred are described. Depending on the nature of the hazard, events listed may have occurred on a local, state-wide, or regional level.

Probability of Future Events

The likelihood of a future event for each natural hazard was classified according to the following scale:

Table 3-3: Probability of Occurrence Rating Scale	
Classification	**Probability of Future Events**
Very High	Events that occur at least once each 1-2 years (50%-100% probability in the next year)
High	Events that occur from once in 2 years to once in 4 years (25%-50% probability in the next year)
Moderate	Events that occur from once in 5 years to once in 50 years (2%-25% probability in the next year)
Low	Events that occur from once in 50 years to once in 100 years (1-2% probability in the next year)
Very Low	Events that occur less frequently than once in 100 years (less than 1% probability in the next year)

Impact

Impact refers to the effect that a hazard may have on the people and property in the community, based on the assessment of extent described previously. Impacts are classified according to the following scale:

Table 3-4: Impacts Rating Scale	
Classification	**Magnitude of Multiple Impacts**
Catastrophic	Multiple deaths and injuries possible. More than 50% of property in affected area damaged or destroyed. Complete shutdown of facilities for 30 days or more.
Critical	Multiple injuries possible. More than 25% of property in affected area damaged or destroyed. Complete shutdown of facilities for more than 1 week.
Limited	Minor injuries only. More than 10% of property in affected area damaged or destroyed. Complete shutdown of facilities for more than 1 day.
Minor	Very few injuries, if any. Only minor property damage and minimal disruption of quality of life. Temporary shutdown of facilities.

Vulnerability

Based on the above metrics, a hazard vulnerability rating was determined for each hazard. The hazard vulnerability ratings are based on a scale of 1 through 3 as follows:

1 – High risk
2 – Medium risk
3 – Low risk

Table 3-5 summarizes the work of the Committee to qualitatively categorize and determine the hazard vulnerability (risk to the town) of each hazard. The analysis and hazard vulnerability rating is based, in part, on local knowledge of past experiences with each type of hazard, review of available data, including climate change projections developed by the Commonwealth for Franklin County (resilientMA), and the work of the Committee during the development of the MVP Resiliency Plan and the update of this Multi-Hazard Mitigation Plan. The size and impacts of a natural hazard can be unpredictable. However, many of the mitigation strategies currently in place and many of those proposed for implementation can be applied to the expected natural hazards, regardless of their unpredictability.

Table 3-5: Hazard Identification and Risk Analysis

Type of Hazard	Location of Occurrence	Probability of Future Events	Impact	Overall Hazard Vulnerability Rating
Severe Winter Storms	Large	Very High	Limited	High
Extreme Temperatures	Large	Very High	Limited	High
Severe Thunderstorms / Wind / Microbursts	Isolated	Very High	Critical	High
Wildfires	Isolated	Very High	Catastrophic	High
Flooding (Annual/Flash Floods)	Isolated	Very High	Minor	Medium
Flooding (100/500-yr Event)	Large	Moderate	Limited	Medium
Hurricanes / Tropical Storms	Large	High	Minor	Medium
Earthquakes	Large	Very Low	Catastrophic	Medium
Landslides	Isolated	High	Limited	Medium
Invasive Species	Isolated	Very High	Limited	Medium
Tornadoes	Isolated	Moderate	Critical*	Medium
Dam Failure (other dams and beaver dams)	Isolated	Very Low	Catastrophic	Low
Drought	Medium	Moderate	Limited	Low

* The Committee noted during the risk assessment that the impacts of a tornado depends on where it occurs in town. If within the largely forested area east of Route 63, the impact would be minor; if one were to occur in one of the five villages, the impact could be critical.

The Committee developed problem statements and/or a list of key issues for each hazard to summarize the vulnerability of Montague's structures, systems, populations and other community assets identified as vulnerable to damage and loss from a hazard event. These problem statements were used to identify the Town's greatest vulnerabilities that will be addressed in the mitigation strategy (Section 4).

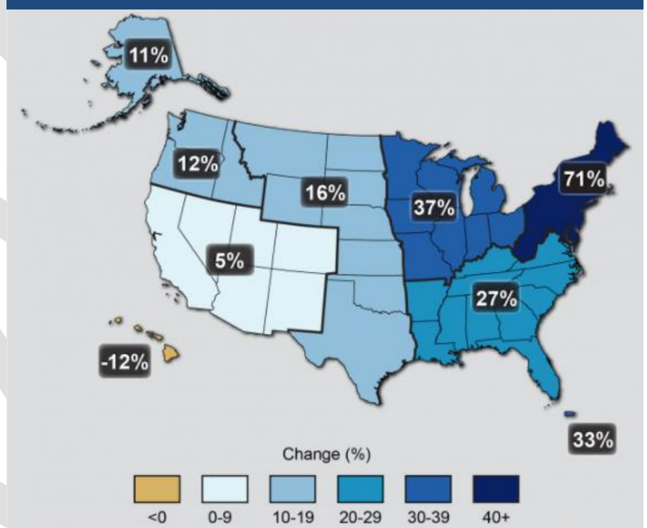
3.3 FLOODING

Potential Effects of Climate Change

In Massachusetts, annual precipitation amounts have increased at a rate of over 1 inch per decade since the late 1800s, and are projected to continue to increase largely due to more intense precipitation events. The Northeast has experienced a greater increase in extreme precipitation events than the rest of the U.S. in the past several decades (Figure 3-1). Although overall precipitation is expected to increase as the climate warms, it will occur more in heavy, short intervals, with a greater potential for dry, drought conditions in between.

Observed annual precipitation in Massachusetts for the last three decades was 47 inches. Total annual precipitation in Massachusetts is expected to increase between 2% to 13% by 2050, or by roughly 1 to 6 inches. In the Connecticut River Watershed, where most of the town is located, annual precipitation has averaged around 45 inches in recent decades. By 2050, the annual average could remain relatively the same (but occur in more heavy, short intervals) or increase by up to 16 inches a year. In general precipitation projections are more uncertain than temperature projections.[8]

Figure 3-1: Observed Change in Very Heavy Precipitation



The northeast has seen a greater increase in heavy precipitation events than the rest of the country. *Source: updated from Karl et al. 2009, Global Climate Change Impacts in the United States.*

An increase in stronger storms leads to more flooding and erosion. A shift to winter rains instead of snow will lead to more runoff, flooding, and greater storm damage along with less spring groundwater recharge. More frequent heavy precipitation events also lead to an increased risk for people who live along rivers or in their floodplains. Furthermore, residents who live outside the current flood zone could find themselves within it as the century progresses. Figure 3-2 shows potential effects of climate change on flooding from the Massachusetts State Hazard Mitigation and Climate Adaptation Plan.

---

[8] http://resilientma.org/datagrapher/?c=Temp/basin/pcpn/ANN/Connecticut/. Accessed June 13, 2019.

Figure 3-2: Effects of Climate Change on Flooding

Potential Effects of Climate Change		
	CHANGES IN PRECIPITATION ➔ MORE INTENSE AND FREQUENT DOWNPOURS	More intense downpours often lead to inland flooding as soils become saturated and stop absorbing more water, river flows rise, and urban stormwater systems become overwhelmed. Flooding may occur as a result of heavy rainfall, snowmelt or coastal flooding associated with high wind and storm surge.
	EXTREME WEATHER ➔ MORE FREQUENT SEVERE STORMS	Climate change is expected to result in an increased frequency of severe storm events. This would directly increase the frequency of flooding events, and could increase the chance that subsequent precipitation will cause flooding if water stages are still elevated.
	CHANGES IN PRECIPITATION ➔ EPISODIC DROUGHTS	Vegetated ground cover has been shown to significantly reduce runoff. If drought causes vegetation to die off, this flood-mitigating capacity is diminished.

Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Hazard Description

Nationally, inland flooding causes more damage annually than any other severe weather event (U.S. Climate Resilience Toolkit, 2017). Between 2007 and 2014, the average annual cost of flood damages in Massachusetts was more than $9.1 million (NOAA, 2014). Flooding is the result of moderate precipitation over several days, intense precipitation over a short period, or melting snowpack (U.S. Climate Resilience Toolkit, 2017). Developed, impervious areas can contribute to and exacerbate flooding by concentrating and channeling stormwater runoff into nearby waterbodies. Increases in precipitation and extreme storm events from climate change are already resulting in increased flooding. Common types of flooding are described in the following subsections.

Riverine Flooding

Riverine flooding often occurs after heavy rain. Areas with high slopes and minimal soil cover (such as found in many areas of Montague and Franklin County) are particularly susceptible to flash flooding caused by rapid runoff that occurs in heavy precipitation events and in combination with spring snowmelt, which can contribute to riverine flooding. Frozen ground conditions can also contribute to low rainfall infiltration and high runoff events that may result in riverine flooding. Some of the worst riverine flooding in Massachusetts' history occurred as a result of strong nor'easters and tropical storms in which snowmelt was not a factor. Tropical storms can produce very high rainfall rates and volumes of rain that can generate high runoff when soil infiltration rates are exceeded. Inland flooding in Massachusetts is forecast and classified by the National Weather Service's (NWS) Northeast River Forecast Center as minor, moderate, or severe based upon the types of impacts that occur. Minor flooding is considered a "nuisance only" degree of flooding that causes impacts such as road closures and flooding of recreational areas and farmland. Moderate flooding can involve land with structures becoming inundated. Major flooding is a widespread, life-threatening event. River forecasts are made at many locations in the state where there are United States Geological Survey (USGS) river gauges that have established flood elevations and levels corresponding to each of the degrees of flooding.

- Overbank flooding occurs when water in rivers and streams flows into the surrounding floodplain or into "any area of land susceptible to being inundated by floodwaters from any source," according to FEMA.

- Flash floods are characterized by "rapid and extreme flow of high water into a normally dry area, or a rapid rise in a stream or creek above a predetermined flood level," according to FEMA.

Fluvial Erosion

Fluvial erosion is the process in which the river undercuts a bank, usually on the outside bend of a meander, causing sloughing and collapse of the riverbank. Fluvial erosion can also include scouring and down-cutting of the stream bottom, which can be a problem around bridge piers and abutments. In hillier terrain where streams may lack a floodplain, such as in some areas of Montague, fluvial erosion may cause more property damage than inundation. Furthermore, fluvial erosion can often occur in areas that are not part of the 100- or 500-year floodplain.

Fluvial erosion hazard (FEH) zones are mapped areas along rivers and streams that are susceptible to bank erosion caused by flash flooding. Any area within a mapped FEH zone is considered susceptible to bank erosion during a single severe flood or after many years of slow channel migration. As noted above, while the areas of the FEH zones often overlap with areas mapped within the 100-year floodplain on Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMs) or Flood Hazard Boundary Maps (FHBMs), the FIRMs or FHBMs only show areas that are likely to be inundated by floodwaters that overtop the riverbanks during a severe flood. However, much flood-related property damage and injuries is the result of bank erosion that can undermine roads, bridges, building foundations and other infrastructure. Consequently, FEH zones are sometimes outside of the 100-year floodplain shown on FIRMs or FHBMs. FEH zones can be mapped using fluvial geomorphic assessment data as well as historic data on past flood events. Both the FIRMs and FEH maps should be used in concert to understand and avoid both inundation and erosion hazards, respectively.[9] Montague does not have mapped FEH zones.

[9] *Ammonoosuc River Fluvial Erosion Hazard Map for Littleton, NH*. Field Geology Services, 2010.

Urban Drainage Flooding

Urban drainage flooding is caused by increased water runoff due to urban development and drainage systems that are not capable of conveying high flows. Drainage systems are designed to remove surface water from developed areas as quickly as possible to prevent localized flooding on streets and other urban areas. They make use of a closed conveyance system that channels water away from an urban area to surrounding streams, bypassing natural processes of water infiltration into the ground, groundwater storage, and evapotranspiration (plant water uptake and respiration). Since drainage systems reduce the amount of time the surface water takes to reach surrounding streams, flooding can occur more quickly and reach greater depths than if there were no urban development at all. In urban areas, basement, roadway, and infrastructure flooding can result in significant damage due to poor or insufficient stormwater drainage.

Ground Failures

Flooding and flood-related erosion can result from various types of ground failures, which include mud floods and mudflows, and to a much lesser degree, subsidence, liquefaction, and fluvial erosion (discussed above).

Mud floods are floods that carry large amounts of sediment, which can at times exceed 50 percent of the mass of the flood, and often occur in drainage channels and adjacent to mountainous areas. Mudflows are a specific type of landslide that contains large amounts of water and can carry debris as large as boulders. Both mudflows and mud floods result from rain falling on exposed terrain, such as terrain impacted by wildfires or logging. Mud floods and mudflows can lead to large sediment deposits in drainage channels. In addition to causing damage, these events can exacerbate subsequent flooding by filling in rivers and streams.

Subsidence is the process where the ground surface is lowered from natural processes, such as consolidation of subsurface materials and movements in the Earth's crust, or from manmade activities, such as mining, inadequate fill after construction activity, and oil or water extraction. When ground subsides, it can lead to flooding by exposing low-lying areas to groundwater, tides, storm surges, and areas with a high likelihood of overbank flooding.

Liquefaction, or when water-laden sediment behaves like a liquid during an earthquake, can result in floods of saturated soil, debris, and water if it occurs on slopes. Floods from liquefaction are especially common near very steep slopes.

Ice Jam

An ice jam is an accumulation of ice that acts as a natural dam and restricts the flow of a body of water. There are two types of ice jams: a freeze-up jam and a breakup jam. A freeze-up jam usually occurs in early winter to midwinter during extremely cold weather when super-cooled water and ice formations extend to nearly the entire depth of the river channel. This type of jam can act as a dam and begin to back up the flowing water behind it. The second type, a breakup jam, forms as a result of the breakup of the ice cover at ice-out, causing large pieces of ice to move downstream, potentially piling up at culverts, around bridge abutments, and at curves in river channels. Breakup ice jams occur when warm temperatures and heavy rains cause rapid snowmelt. The melting snow, combined with the heavy rain, causes frozen rivers to swell. The rising water breaks the ice layers into large chunks, which float downstream and often pile up near narrow passages and obstructions (bridges and dams). Ice jams may build up to a thickness great enough to raise the water level and cause flooding upstream of the obstruction. The Ice Jam Database, maintained by the Ice Engineering Group at the U.S. Army Corps of Engineers (USACE) Cold Regions Research and Engineering Laboratory currently consists of more than 18,000 records from across the U.S.

Dam Failure

A dam is an artificial barrier that has the ability to impound water, wastewater, or any liquid-borne material for the purpose of storage or control of water. There are two primary types of dam failure: catastrophic failure, characterized by the sudden, rapid, and uncontrolled release of impounded water, or design failure, which occurs as a result of minor overflow events. Dam overtopping is caused by floods that exceed the capacity of the dam, and it can occur as a result of inadequate spillway design, settlement of the dam crest, blockage of spillways, and other factors. Overtopping accounts for 34 percent of all dam failures in the U.S.

There are a number of ways in which climate change could alter the flow behavior of a river, causing conditions to deviate from what the dam was designed to handle. For example, more extreme precipitation events could increase the frequency of intentional discharges. Many other climate impacts—including shifts in seasonal and geographic rainfall patterns—could also cause the flow behavior of rivers to deviate from previous hydrographs. When flows are greater than expected, spillway overflow events (often referred to as “design failures”) can occur. These overflows result in increased discharges downstream and increased flooding potential. Therefore, although climate change will not increase the probability of catastrophic dam failure, it may increase the probability of design failures. Impacts and Montague’s vulnerability to dam failure is discussed in more detail in the Dam Failure section of this plan.

Additional Causes of Flooding

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

Floodplains

Floodplains by nature are vulnerable to inland flooding. Floodplains are the low, flat, and periodically flooded lands adjacent to rivers, lakes, and oceans. These areas are subject to geomorphic (land-shaping) and hydrologic (water flow) processes. Floodplains may be broad, as when a river crosses an extensive flat landscape, or narrow, as when a river is confined in a canyon. These areas form a complex physical and biological system that not only supports a variety of natural resources, but also provides natural flood storage and erosion control. When a river is separated from its floodplain by levees and other flood control facilities, these natural benefits are lost, altered, or significantly reduced. When floodwaters recede after a flood event, they leave behind layers of rock and mud. These gradually build up to create a new floor of the floodplain. Floodplains generally contain unconsolidated sediments known as alluvium (accumulations of sand, gravel, loam, silt, and/or clay), often extending below the bed of the stream. These sediments provide a natural filtering system, with water percolating back into the ground and replenishing groundwater supplies.

Flooding is a natural and important part of wetland ecosystems that form along rivers and streams. Floodplains can support ecosystems that are rich in plant and animal species. Wetting the floodplain soil releases an immediate surge of nutrients from the rapid decomposition of organic matter that has accumulated over time. When this occurs, microscopic organisms thrive and larger species enter a rapid breeding cycle. Opportunistic feeders (particularly fish or birds) often utilize the increased food supply. The production of nutrients peaks and falls away quickly, but the surge of new growth that results endures for some time. Species growing in floodplains are markedly different from those that grow outside floodplains. For instance, riparian trees (trees that grow in floodplains) tend to be very tolerant of root disturbance and grow quickly in comparison to non-riparian trees.

Location

A floodplain is the relatively flat, lowland area adjacent to a river, lake or stream. Floodplains serve an important function, acting like large “sponges” to absorb and slowly release floodwaters back to surface waters and groundwater. Over time, sediments that are deposited in floodplains develop into fertile, productive farmland like that found in the Connecticut River valley. In the past, floodplain areas were also often seen as prime locations for development. Industries were located on the banks of rivers for access to hydropower. Residential and commercial development occurred in floodplains because of their scenic qualities and proximity to the water, and because these areas were easier to develop than the hilly, rocky terrain characteristic of many towns in the county. Although periodic flooding of a floodplain area is a natural occurrence, past and current development and alteration of these areas can result in flooding that is a costly and frequent hazard.

In Montague, 1,454 acres, 7% of the total land area, is in the floodplain, including approximately 14 acres of developed residential land. As noted previously, the Montague Book Mill, listed on the National Register of Historic Places, is located in the floodplain along the Sawmill River. Additionally, there are several historically significant Native American sacred sites in the vulnerable wetlands areas along the Connecticut and Millers Rivers.

In addition to the 100-year floodplain, areas upstream from major rivers play an important role in flood mitigation. Upland areas and the small tributary streams that drain them are particularly vulnerable to impacts from development, which can increase the amount of flooding downstream. These areas are critical for absorbing, infiltrating, and slowing the flow of stormwater. When these areas are left in a natural vegetated state (forested or forested floodplain), they act as “green infrastructure,” providing flood storage and mitigation through natural processes.

Fragmentation and development in upland areas, including roads which commonly were built along stream and river corridors, can alter this natural process and result in increased amounts of stormwater runoff into streams. For example, the channels of many of these streams were altered centuries ago as a result of widespread deforestation for agriculture and lumber. The many small mills that used to dot the landscape built dams on the streams to generate power. Many of these streams are still unstable and flashy during storm events, generating high volumes of runoff and transporting sediment to the lower, flatter reaches of the watershed. Montague has experienced the damaging effects of past alterations to the Sawmill River during flash flood events.

In addition, stressors to forests such as drought, extreme weather, and invasive species, can result in the loss of forest cover in upland areas. In particular, cold-water streams shaded by dense hemlock stands are particularly vulnerable due to the hemlock woolly adelgid that is causing widespread mortality of these trees in the region.

There are several areas in Montague identified by the Committee that experience localized and/or chronic flooding. Key areas of concern include:

<u>Main Street</u>

The Sawmill River has hopped its bank and is now undercutting the road in an area on Main

Street. The Town could pursue funds to continue bio-engineering work in this area. However, a short-term solution is needed to stabilize the riverbank.

Montague City Road

The MVP workshop participants shared that Montague City Road is experiencing frequent flooding from an adjacent stream. Annual flooding in the area between Montague City Road and the power canal had already been occurring, possibly due to beaver activity nearby and seepage from the canal. In 2018 the Town successfully applied for an MVP Action Grant to fund design and engineering along the road to mitigate flooding from the stream. The Town intends to pursue additional MVP funds to complete the project.

Hillcrest School Building

The Hillcrest school building in Turners Falls experiences flooding approximately every five to ten years due to frozen dry wells. In 2009 flooding caused 12 to 18 inches of water to accumulate in the heating tunnels of the building. Members of the school facility staff, Fire Department, Department of Public Works, and the Water Department assisted with flood containment and clean up efforts. A similar situation occurred again in 2019. Dry wells are the only form of drainage available in this location.

Ice Jams on the Sawmill River

Ice jams on the Sawmill River are an annual hazard in Montague, which cause flooding and threaten critical town infrastructure and land uses nearby.

Ice Jams on the Connecticut River

Historically ice jams were a common occurrence on the Connecticut River. During operation of the Vermont Yankee Nuclear Power Plant upstream in Vernon, VT, water from the river was used for cooling the fuel, and was then discharged back into the river. This increased water temperatures in the river, which resulted in less ice jams in recent years. However, with the closure of the plant in 2015, ice jams may become more common on the river again.

Town Roads, Bridges and Culverts

While the Town has replaced several culverts in recent years, many more remain in need of replacing. Montague also has many bridges throughout town that are in need of repair or replacement. According to participants of the MVP workshop, all but the new Gill-Montague Bridge are vulnerable. The bridges are a major access concern for first responders due to the risk of becoming impassable. The same is true for roads in town needing maintenance due to ongoing flooding and erosion issues. Specific areas of concern include:

- An undersized culvert on Ferry Road is causing flooding.
- Center Street and South Street bridges over the Sawmill River – these bridges have been reduced to one-lane traffic and are vulnerable to flooding. Repairs to these structures should be designed to accommodate floodplain capacity flows as identified in the Sawmill River Restoration Plan. The South Street bridge is scheduled for replacement in 2024 through the Transportation Improvement Program (TIP); the Town is working on adding the Center Street bridge to the TIP for replacement as well.
- Millers Falls Road – The Town received a Hazard Mitigation Grant to complete erosion control measures, however, erosion, steep slopes, and unstable soils continue to be an issue.
- A bridge on Chestnut Hill Road is in need of replacement. It is scheduled for replacement in 2020 with funding from the State's Small Bridge Program.

<u>Dam Failure</u>

There are five High Hazard and five Low Hazard dams on the Deerfield River. A catastrophic failure of any one High Hazard dam would likely result in the cascading failure of all the downstream dams and cause widespread flooding of downstream areas. Dams on the Connecticut River, both within town boundaries and upstream in Vermont and New Hampshire, have the potential for catastrophic flood impacts. A failure of either the dam or dike at the Northfield Mountain Pump Storage Facility in Erving would also cause catastrophic flooding in Montague. Additionally, there are dams on the Sawmill River where dam failures could release sufficient floodwaters upstream to inundate major portions of town, including densely settled village areas, critical infrastructure, and sections of roads that serve as evacuation routes.

<u>Beaver Dams</u>

Human-beaver conflict continues to be a problem in Montague. A pond created by a beaver dam in 2010 made it difficult for utility workers to replace high-tension wires standing in water. Flooding of roads and private property as well as elevated groundwater levels due to an increase in beaver dams is common. During heavy rains high ground water seeps up through basements. Recent construction of beaver dams in the Burnham's Field area has been contributing to annual flooding between Montague City Road and the power canal. A concrete basin on Meadow Road is plugged periodically by beaver activity near the Sunderland town line where the bank of the Connecticut River was built up to avoid losing the road to erosion caused by river flooding. Failure of beaver dams in Montague or the neighboring town of Leverett pose a potential risk to lives, property, and town infrastructure. Identifying the exact locations of these beaver dams in Montague and Leverett and mapping the potential inundation areas associated with them is needed to understand and manage the flood risk posed by beavers.

Landslides and Erosion

Steep slopes and unstable soils on the edges of Montague Plains near roads and along the Connecticut and Millers Rivers were recognized as a concern for landslide and erosion potential during the MVP workshop, and are discussed in more detail in the Landslide section of this plan.

Extent

The principal factors affecting the strength and magnitude of flood damage are flood depth and velocity. The deeper and faster that flood flows become, the more damage they can cause. Shallow flooding with high velocities can cause as much damage as deep flooding with slow velocity. This is especially true when a channel migrates over a broad floodplain, redirecting high-velocity flows and transporting debris and sediment.

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

Floods can be classified as one of two types: flash floods and general floods.

Flash Floods

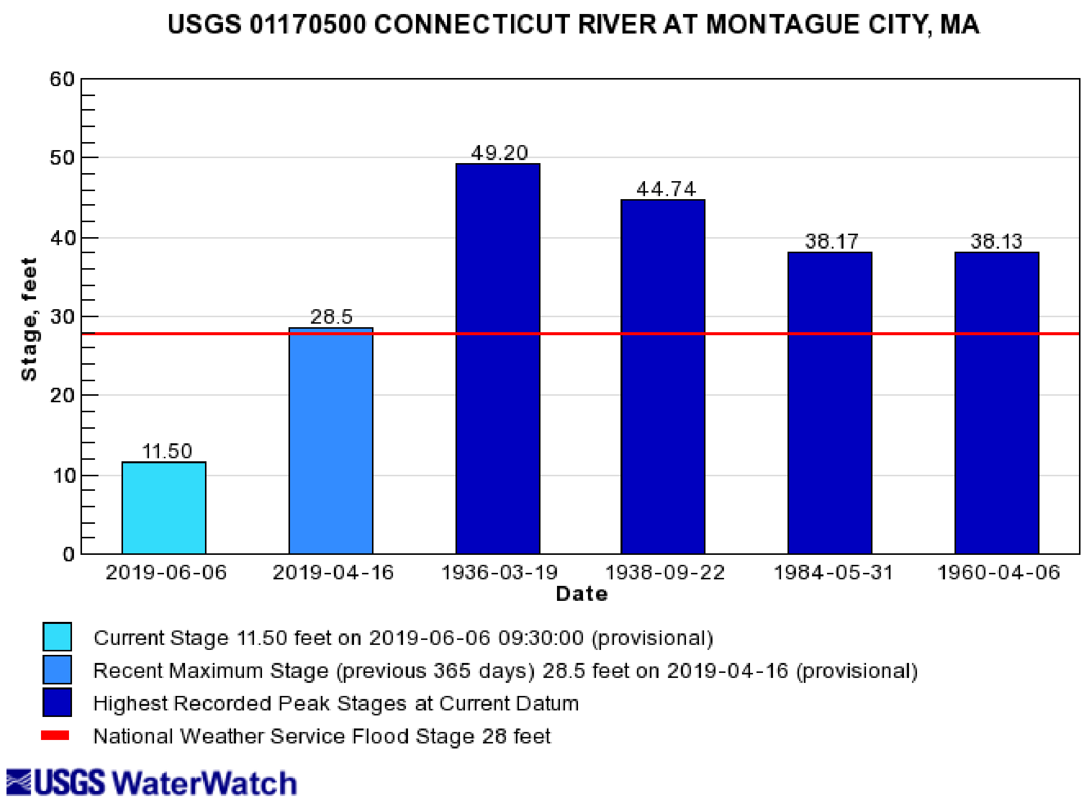
Flash floods are the product of heavy, localized precipitation in a short time period over a given location. Flash flooding events typically occur within minutes or hours after a period of heavy precipitation, after a dam or levee failure, or from a sudden release of water from an ice jam. Most often, flash flooding is the result of a slow-moving thunderstorm or the heavy rains from a hurricane. In rural areas, flash flooding often occurs when small streams spill over their banks. However, in urbanized areas, flash flooding is often the result of clogged storm drains (leaves and other debris) and the higher amount of impervious surface area (roadways, parking lots, roof tops).

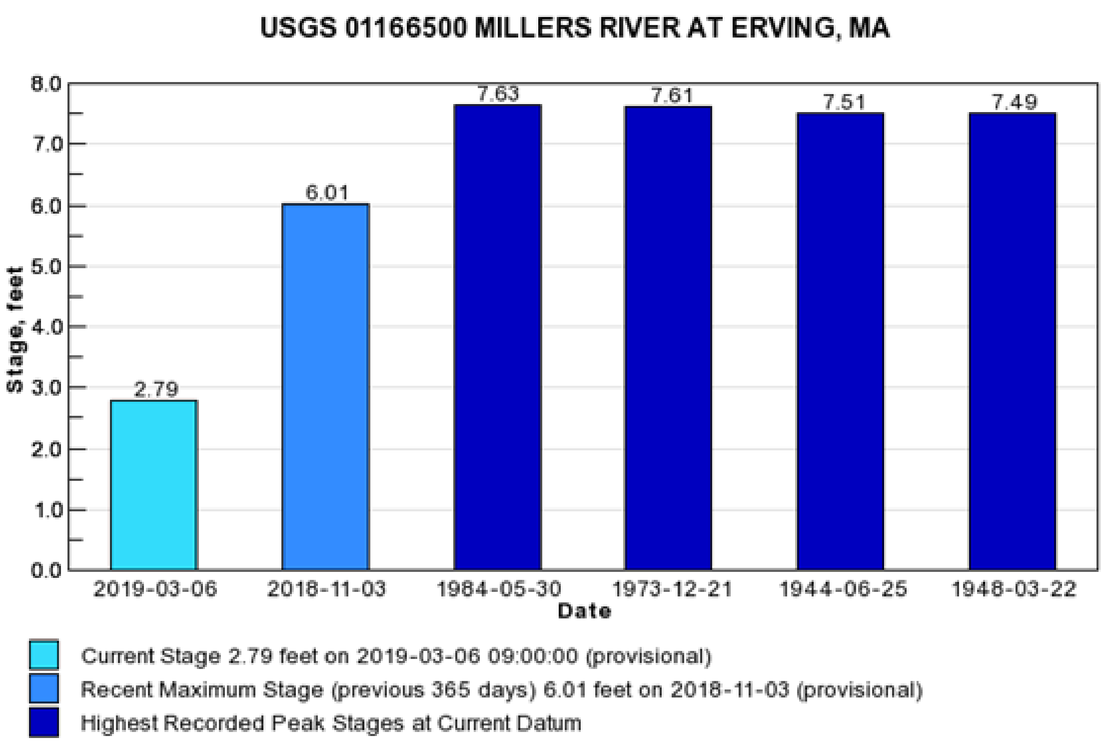
General Floods

General flooding may last for several days or weeks and are caused by precipitation over a longer time period in a particular river basin. Excessive precipitation within a watershed of a stream or river can result in flooding particularly when development in the floodplain has obstructed the natural flow of the water and/or decreased the natural ability of the groundcover to absorb and retain surface water runoff (e.g., the loss of wetlands and the higher amounts of impervious surface area in urban areas).

Flood flows in Massachusetts are measured at numerous USGS stream gauges. The gauges operate routinely, but particular care is taken to measure flows during flood events to calibrate the stage-discharge relationships at each location and to document actual flood conditions. In the aftermath of a flood event, the USGS will typically determine the recurrence interval of the event using data from a gauge's period of historical record. Figure 3-3 shows the four highest recorded peak flooding events on the Connecticut River in Montague City and the Millers River in Erving, as well as the highest flow event in the last 365 days.

Figure 3-3: Highest Recorded Flood Events on the Connecticut and Millers Rivers





Source: USGS WaterWatch https://waterwatch.usgs.gov/index.php?id=wwchart_ftc&site_no=01170500

The 100-Year Flood

The 100-year flood is the flood that has a 1 percent chance of being equaled or exceeded each year. The 100-year flood is the standard used by most federal and state agencies. For example, it is used by the National Flood Insurance Program (NFIP) to guide floodplain management and determine the need for flood insurance.

The extent of flooding associated with a 1 percent annual probability of occurrence (the base flood or 100-year flood) is called the 100-year floodplain, which is used as the regulatory boundary by many agencies. Also referred to as the Special Flood Hazard Area (SFHA), this boundary is a convenient tool for assessing vulnerability and risk in flood-prone communities. Many communities have maps that show the extent and likely depth of flooding for the base flood. This extent generally includes both the stream channel and the flood fringe, which is the stream-adjacent area that will be inundated during a 100-year (or 1 percent annual chance) flood event but does not effectively convey floodwaters.

The 500-Year Flood

The term “500-year flood” is the flood that has a 0.2 percent chance of being equaled or exceeded each year. Flood insurance is not required by the Federal Government in the 500-year floodplain, but could be required by individual lenders.

Secondary Hazards

The most problematic secondary hazards for flooding are fluvial erosion, river bank erosion, and landslides affecting infrastructure and other assets (e.g., agricultural fields) built within historic floodplains. Without the space required along river corridors for natural physical adjustment, such changes in rivers after flood events can be more harmful than the actual flooding. For instance, fluvial erosion attributed to Hurricane Irene caused an excess of $23 million in damages along Route 2. The impacts from these secondary hazards are especially prevalent in the upper courses of rivers with steep gradients, where floodwaters may pass quickly and without much damage, but scour the banks, edging buildings, and structures closer to the river channel or cause them to fall in. Landslides can occur following flood events when high flows oversaturate soils on steep slopes, causing them to fail.

These secondary hazards also affect infrastructure. Roadways and bridges are impacted when floods undermine or wash out supporting structures. Railroad tracks may be impacted, potentially causing a train derailment, which could result in the release of hazardous materials into the environment and nearby waterways. Dams may fail or be damaged, compounding the flood hazard for downstream communities. Failure of wastewater treatment plants from overflow or overtopping of hazardous material tanks and the dislodging of hazardous waste containers can occur during floods as well, releasing untreated wastewater or hazardous materials directly into storm sewers, rivers, or the ocean. Flooding can also impact public water supplies and the power grid.

Previous Occurrences

The average annual precipitation for Montague and surrounding areas in western Massachusetts is 48 inches. Between 1996 and 2017, 17 flash floods have been reported in Franklin County (Table 3-6), resulting in $3,245,000 in property damages.

Table 3-6: Previous Occurrences of Flash Floods in Franklin County			
Year	**# of Flash Flood Events**	**Annual Property Damage**	**Annual Crop Damage**
1996	4	$1,800,000	$0
1998	1	$75,000	$0
2000	1	$0	$0
2003	1	$10,000	$0
2004	1	$10,000	$0
2005	3	$1,235,000	$0
2013	3	$65,000	$0
2014	2	$50,000	$0
2017	1	$0	$0
Total	**17**	**$3,245,000**	**$0**

Source: National Oceanic and Atmospheric Administration (NOAA) Storm Events Database: https://www.ncdc.noaa.gov/stormevents/

From 1996 to 2018, 44 flood events were reported in Franklin County, resulting in total property damages worth $25,582,000 (Table 3-7). The bulk of these damages ($22,275,000) were from Tropical Storm Irene in August, 2011. Montague did not suffer major flooding from Tropical Storm Irene. The most severe impacts from Irene were experienced in the western portion of Franklin County.

Table 3-7: Previous Occurrences of Floods in Franklin County			
Year	**# of Flood Events**	**Annual Property Damage**	**Annual Crop Damage**
1996	7	$0	$0
1998	3	$0	$0
2001	1	$0	$0
2004	1	$0	$0
2005	2	$2,600,000	$0

Table 3-7: Previous Occurrences of Floods in Franklin County

2007	1	$250,000	$0
2008	3	$38,000	$0
2010	1	$150,000	$0
2011	8	$22,375,000	$0
2012	2	$0	$0
2015	10	$31,000	$0
2017	1	$1,000	$0
2018	4	$137,000	$0
Total	**44**	**$25,582,000**	**$0**

Source: National Oceanic and Atmospheric Administration (NOAA) Storm Events Database: https://www.ncdc.noaa.gov/stormevents/

Table 3-8 displays flood events in Montague since 1993 and reported damages. In total, 19 flood events were reported during this timeframe.

Table 3-8: Flooding Events in Montague Since 1993

Date	**Location**	**Type**	**Recorded Property Damages**
March 31 1993	Connecticut River	Flood	$0
April 4 1993	Connecticut River	Flood	$0
April 17 1993	Connecticut River	Flood	$0
April 8 1994	Connecticut River	Flood	$0
April 14 1994	Connecticut River	Flood	$0
circa 1996	Franklin County Technical School	Runoff	Unknown
June 13 1996	Sawmill River, Spaulding Brook	Flash Flood	$1,800,000
Jan 9 1998	Connecticut River	Flood	$0
March 30 1998	Connecticut River	Flood	$0
April 1 1998	Connecticut River	Flood	$0
April 22 1998	Connecticut River	Flood	$0
April 1 2004	Connecticut River	Flood	not available
Oct 8 2005	Region-wide	Flood	$4,200,000
Oct 15 2005	State-wide	Flood	$6,000,000
April 2007	Connecticut River	Flood	$0
2009	Hillcrest School Building	Failed dry well	Approx. $400 (school staff labor)
Sept 18 2012	Federal Street, Millers Falls	Drainage-driven flooding	$0
Aug 11 2015	Turners Falls Rd near Hatchery Road	Drainage-driven flooding	$0
Aug 15 2015	Route 63, Millers Falls	Drainage-driven flooding	$0
Aug 3 2018	Avenues A&C, Turners Falls	Drainage-driven flooding	$5,000

Source: National Oceanic and Atmospheric Administration (NOAA) Storm Events Database: https://www.ncdc.noaa.gov/stormevents/

The Town of Montague experienced severe flooding following a "microburst" rainstorm in June 1996. Six inches of rain fell in less than an hour, resulting in the worst flooding in 100 years of records on the Sawmill River and causing flooding along Goddard Brook, Chestnut Hill Brook, Spaulding Brook and Cranberry Pond Brook that washed out sections of Dry Hill Road, Chestnut Hill Road, Spaulding Brook Road and Old Sunderland Road. Sections of Center Street and South Street were impassible; and material from a local junk dealer located in or near the floodplain was widely distributed through the village. The Massachusetts Emergency Management Agency declared the Town a disaster area. A site survey was conducted by the National Weather Service on June 14th. More than 30 miles of roadway in southern Montague and Leverett were destroyed. The National Guard was dispatched to make temporary repairs to roads where detours were not possible, and the Town eventually received grant money from the state for permanent repairs. Numerous homes and businesses experienced some degree of flood damage. This event has been estimated as at least a 100-year event for southern Montague and a 500-year event for the Sawmill River and Spaulding Brook. The Massachusetts Emergency Management Agency has estimated damage from this flood at close to $2 million. Local residents who have lived in the area for many years said this was the worst flooding they had witnessed since the Great New England Hurricane of 1938. A few thought that it exceeded even that historical flood event.

In September 1999, all of Franklin County was declared a disaster area due to flooding from Tropical Storm Floyd. Floods in July and October of 2005 caused major damage countywide. Flooding during the Columbus Day holiday in 2005 saw the Connecticut River rise to 35.04 feet, more than 7 feet above flood stage, at Montague City, according to press reports at the time. Federal disaster relief funds were distributed to one Montague household, but the town saw damage from the flood waters. There was flooding on Millers Falls Road near Highland Cemetery and part of Wendell Road was washed out because the culvert beneath the road was washed away, according to press reports. Parts of Montague Center near the Sunderland border were flooded, as well. In April 2007, minor flooding occurred along the main stem of the Connecticut River through Montague. A crest of 30.3 feet was recorded (flood stage is 28 feet).

On August 3, 2018, flooding from heavy rain forced manhole covers off their settings on Avenue A near Food City Plaza in Turners Falls, and made the road impassable. Griswold Street and Avenue C in Turners Falls were also flooded and impassable. $5,000 in property damages were reported for this event.

Probability of Future Events

Based on previous occurrences, the frequency of occurrence of flash flooding events in Montague is "very high," with events occurring every 1-2 years. Montague's probability of experiencing flooding that inundates the 100 to 500 year floodplain is "moderate," with a 2% - 25% chance of occurring in a given year. Flooding frequencies for the various floodplains in Montague are defined by FEMA as the following:

- 10-year floodplain – 10 percent chance of flooding in any given year
- 25-year floodplain – 2.5 percent chance of flooding in any given year
- 100-year floodplain – 1 percent chance of flooding in any given year
- 500-year floodplain – 0.2 percent chance of flooding in any given year

Of all the regions in the United States, the Northeast has seen the most dramatic increase in the intensity of rainfall events. The U.S. National Climate Assessment reports that between 1958 and 2010, the Northeast saw more than a 70% increase in the amount of precipitation falling in very heavy events (defined as the heaviest 1% of all daily events). Climate projections for Massachusetts, developed by the University of Massachusetts, suggest that the frequency of high-intensity rainfall events will continue to trend upward, and the result will be an increased risk of flooding. Specifically, the annual frequency of downpours releasing more than two inches of rain per day in Massachusetts may climb from less than 1 day per year to approximately 0.9-1.5 days by 2100. Events which release over one inch during a day could climb to as high as 8-11 days per year by 2100. A single intense downpour can cause flooding and widespread damage to property and critical infrastructure. While the coastal areas in Massachusetts will experience the greatest increase in high-intensity rainfall days, some level of increase will occur in every area of Massachusetts, including Montague.[10]

Impact

Flooding can cause a wide range of issues, from minor nuisance roadway flooding and basement flooding to major impacts such as roadway closures. Specific damages associated with flooding events include the following primary concerns:

- Blockages of roadways or bridges vital to travel and emergency response
- Breaching of dams
- Damaged or destroyed buildings and vehicles

[10] ResilientMA: Climate Change Clearing House for the Commonwealth: http://resilientma.org/changes/changes-in-precipitation. Accessed December 13, 2018.

- Uprooted trees causing power and utility outages
- Drowning, especially people trapped in cars
- Contamination of drinking water
- Dispersion of hazardous materials
- Interruption of communications and/or transportation systems, including train derailments

The impact of a flood event in Montague could be minor, for annual flooding, or limited during a larger storm event, with more than 10% of property in the affected area damaged or destroyed, and possible shutdown of facilities (roads, bridges, critical facilities) for more than one day.

Vulnerability

Society

The impact of flooding on life, health, and safety is dependent upon several factors, including the severity of the event and whether or not adequate warning time is provided to residents. Populations living in or near floodplain areas may be impacted during a flood event. People traveling in flooded areas and those living in urban areas with poor stormwater drainage may be exposed to floodwater. People may also be impacted when transportation infrastructure is compromised from flooding.

In Montague, 1,454 acres, 7% of the total land area, is in the floodplain, including approximately 14 acres of developed residential land. According to 2005 MassGIS Land Use data there are 17 dwelling units located in the floodplain in Montague (Table 3-9). Using this number and Montague's estimated average household size, it is estimated that 37 people, or 0.4% of Montague's total population, reside in the floodplain.

Table 3-9: Estimated Montague Population Exposed to a 1 Percent Flood Event				
Total Population	**# of Dwelling Units in Flood Hazard Area**	**Average # of People Per Household**	**Estimated Population in Flood Hazard Area**	**% of Total Population in Flood Hazard Area**
8,311	17	2.2	37	0.4%

Source: 2013-2017 American Community Survey Five-Year Estimates; 2005 MassGIS Land Use data.

Vulnerable Populations

Of the population exposed, the most vulnerable include people with low socioeconomic status, people over the age of 65, young children, people with medical needs, and those with low

English language fluency. For example, people with low socioeconomic status are more vulnerable because they are likely to consider the economic impacts of evacuation when deciding whether or not to evacuate. The population over the age of 65 is also more vulnerable because some of these individuals are more likely to seek or need medical attention because they may have more difficulty evacuating or the medical facility may be flooded. Those who have low English language fluency may not receive or understand the warnings to evacuate. Vulnerable populations may also be less likely to have adequate resources to recover from the loss of their homes and jobs.

Table 3-10 estimates the number of vulnerable populations and households in Montague. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of Montague residents during a flood event.

Table 3-10: Estimated Vulnerable Populations in Montague

Vulnerable Population Category	Number	Percent of Total Population*
Population Age 65 Years and Over	1,745	21%
Population with a Disability	1,477	18%
Population who Speak English Less than "Very Well"	522	6%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	1,307	35%
Householder Age 65 Years and Over Living Alone	465	12%
Households Without Access to a Vehicle	408	11%

*Total population = 8,311; Total households = 3,786Note: Individuals and households may be counted under multiple categories.

Source: U.S. Census American Community Survey 2013-2017 Five-Year Estimates.

Populations that live or work in proximity to facilities that use or store toxic substances are at greater risk of exposure to these substances during a flood event. There are several Hazardous Facilities in Montague where hazardous chemicals are stored (See Table 3-41 in Manmade Hazards Section). Montague Water Pollution Control Facility is located within the Dam Inundation Zone and at the edge of the Connecticut River 100-year floodplain.

In the canal district of Turners Falls, there is a concentration of vacant industrial buildings and brownfields, where contamination is expected or confirmed, located between the Connecticut River and power canal and adjacent to dense neighborhoods. Several of the vacant buildings have been targets for arson in recent years. “The Patch” neighborhood abuts this area and is vulnerable to releases of toxic chemicals from flooding or fire. In addition, the Keith Street apartments and Winslow Wentworth House public housing are within close proximity to the area, as well as many multi-family homes on Canal Street. Only one bridge (out of eight bridges that access the canal district) is fully functional, posing a public safety access concern for this neighborhood.

In addition to chemicals stored in place, hazardous materials are routinely transported through town on common routes, including Avenue A, Millers Falls Road, Montague City Road, Turners Falls Road, and the freight rail lines. There are many locations where these vehicular transportation routes and freight rail lines either cross over and/or travel along the rivers in town, placing the populations living within close proximity to the road and railroad at higher risk to a hazardous material spill in conjunction with riverine flooding.

Health Impacts

The total number of injuries and casualties resulting from typical riverine flooding is generally limited due to advance weather forecasting, blockades, and warnings. The historical record from 1996 to 2018 indicates that there have been no fatalities or injuries associated with flooding or flash flooding events in Montague. However, flooding can result in direct mortality to individuals in the flood zone. This hazard is particularly dangerous because even a relatively low-level flood can be more hazardous than many residents realize. For example, while 6 inches of moving water can cause adults to fall, 1 foot to 2 feet of water can sweep cars away. Downed powerlines, sharp objects in the water, or fast-moving debris that may be moving in or near the water all present an immediate danger to individuals in the flood zone.

Events that cause loss of electricity and flooding in basements, where heating systems are typically located in Massachusetts homes, increase the risk of carbon monoxide poisoning. Carbon monoxide results from improper location and operation of cooking and heating devices (grills, stoves), damaged chimneys, or generators. According to the U.S. Environmental Protection Agency (EPA), floodwater often contains a wide range of infectious organisms from raw sewage. These organisms include intestinal bacteria, MRSA (methicillin-resistant staphylococcus aureus), strains of hepatitis, and agents of typhoid, paratyphoid, and tetanus (OSHA, 2005). Floodwaters may also contain agricultural or industrial chemicals and hazardous materials swept away from containment areas.

Individuals who evacuate and move to crowded shelters to escape the storm may face the additional risk of contagious disease; however, seeking shelter from storm events when advised is considered far safer than remaining in threatened areas. Individuals with pre-existing health conditions are also at risk if flood events (or related evacuations) render them unable to access medical support. Flooded streets and roadblocks can also make it difficult for emergency vehicles to respond to calls for service, particularly in rural areas.

Flood events can also have significant impacts after the initial event has passed. For example, flooded areas that do not drain properly can become breeding grounds for mosquitos, which can transmit vector-borne diseases. Exposure to mosquitos may also increase if individuals are outside of their homes for longer than usual as a result of power outages or other flood-related conditions. Finally, the growth of mold inside buildings is often widespread after a flood. Investigations following Hurricane Katrina and Superstorm Sandy found mold in the walls of many water-damaged homes and buildings. Mold can result in allergic reactions and can exacerbate existing respiratory diseases, including asthma (CDC, 2004). Property damage and displacement of homes and businesses can lead to loss of livelihood and long-term mental stress for those facing relocation. Individuals may develop post-traumatic stress, anxiety, and depression following major flooding events (Neria et al., 2008).

<u>Economic Impacts</u>

Economic losses due to a flood include, but are not limited to, damages to buildings (and their contents) and infrastructure, agricultural losses, business interruptions (including loss of wages), impacts on tourism, and impacts on the tax base. Flooding can also cause extensive damage to public utilities and disruptions to the delivery of services. Loss of power and communications may occur, and drinking water and wastewater treatment facilities may be temporarily out of operation. Flooding can shut down major roadways and disrupt public transit systems, making it difficult or impossible for people to get to work. Floodwaters can wash out sections of roadway and bridges, and the removal and disposal of debris can also be an enormous cost during the recovery phase of a flood event. Agricultural impacts range from crop and infrastructure damage to loss of livestock. Extreme precipitation events may result in crop failure, inability to harvest, rot, and increases in crop pests and disease. In addition to having a detrimental effect on water quality and soil health and stability, these impacts can result in increased reliance on crop insurance claims.

Damages to buildings can affect a community’s economy and tax base; the following section includes an analysis of buildings in Montague that are vulnerable to flooding and their associated value.

Infrastructure

Buildings, infrastructure, and other elements of the built environment are vulnerable to inland flooding. At the site scale, buildings that are not elevated or flood-proofed and those located within the floodplain are highly vulnerable to inland flooding. These buildings are likely to become increasingly vulnerable as riverine flooding increases due to climate change (resilient MA, 2018). At a neighborhood to regional scale, highly developed areas and areas with high impervious surface coverage may be most vulnerable to flooding. Even moderate development that results in as little as 3 percent impervious cover can lead to flashier flows and river degradation, including channel deepening, widening, and instability (Vietz and Hawley, 2016).

Additionally, changes in precipitation will threaten key infrastructure assets with flood and water damage. Climate change has the potential to impact public and private services and business operations. Damage associated with flooding to business facilities, large manufacturing areas in river valleys, energy delivery and transmission, and transportation systems has economic implications for business owners as well as the state's economy in general (resilient MA, 2018). Flooding can cause direct damage to Town-owned facilities and result in roadblocks and inaccessible streets that impact the ability of public safety and emergency vehicles to respond to calls for service. The 2018 MVP workshop indicated that the Town Hall in Turners Falls is vulnerable to flooding.

Table 3-11 shows the amount of commercial, industrial, and public/institutional land uses located in town and within the floodplain.

Table 3-11: Acres of Commercial, Industrial, and Public/Institutional Land Use Within the Flood Hazard Area in Montague

Land Use	Total acres in Town	Acres in Flood Hazard Area	% of total acres in Flood Hazard Area
Commercial	98	5	5%
Industrial	75	3	4%
Public/Institutional	142	6	4%

Source: 2005 MassGIS Land Use data.

2019 assessed building values were collected from the Montague Assessors Office for significant structures partially or completely located in the floodplain in Montague (Table 3-12).

Table 3-12: Total Building Value in Flood Hazard Area			
Structure	**Building Structure Value**	**Other Value**	**Total Building Value**
Water Pollution Control Facility	$3,813,400	$199,400	$4,012,800
Unity Park Field House	$98,300	$64,600	$163,900
Former Southworth Paper Company	$739,200	$94,500	$833,700
Montague Book Mill	$282,400	$46,200	$328,600
Total	**$4,933,300**	**$404,700**	**$5,339,000**

Source: 2019 Montague Assessors data.

NFIP data are useful for determining the location of areas vulnerable to flood and severe storm hazards. Table 3-13 summarizes the NFIP policies, claims, repetitive loss (RL) properties, and severe repetitive loss (SRL) properties in Montague associated with all flood events as of December 2018. A RL property is a property for which two or more flood insurance claims of more than $1,000 have been paid by the NFIP within any 10-year period since 1978. A SRL property is defined as one that "has incurred flood-related damage for which 4 or more separate claims payments have been paid under flood insurance coverage, with the amount of each claim payment exceeding $5,000 and with cumulative amount of such claims payments exceeding $20,000; or for which at least 2 separate claims payments have been made with the cumulative amount of such claims exceeding the reported value of the property" (FEMA). Montague currently has eight policies in force, $1,208 in losses have been paid and there are no repetitive loss properties in town.

Table 3-13: NFIP Policies, Claims, and Repetitive Loss Statistics for Montague						
Number of Housing Units (2017 Estimates)	**Number of Policies in Force**	**Percent of Housing Units**	**Total Insurance in Force**	**Number of Paid Losses**	**Total Losses Paid**	**Number of Repetitive Loss Properties**
4,077	8	0.2%	$2,290,000	2	$1,208	0

Source: National Flood Insurance Program (NFIP), FEMA Region I; U.S. Census Bureau 2013-2017 American Community Survey Five-Year Estimates.

Many dams within the Commonwealth have aged past their design life. As a result, they are less resilient to hazards such as inland flooding and extreme precipitation, and may not provide adequate safety following these disasters. These structures, if impacted by disasters, can affect human health, safety, and economic activity due to increased flooding and loss of infrastructure functions. These dams require termination or restoration to improve their infrastructure and better equip them to withstand the hazards that the Commonwealth will face due to climate change.

As already stated, climate change impacts, including increased frequency of extreme weather events, are expected to raise the risk of damage to transportation systems, energy-related facilities, communication systems, a wide range of structures and buildings, solid and hazardous waste facilities, and water supply and wastewater management systems. A majority of the infrastructure in Massachusetts and throughout the country has been sited and designed based on historic weather and flooding patterns. As a result, infrastructure and facilities may lack the capacity to handle greater volumes of water or the required elevation to reduce vulnerability to flooding. Examples of climate change impacts to sectors of the built environment are summarized below.

<u>Agriculture</u>
Inland flooding is likely to impact the agricultural sector. Increased river flooding is likely to cause soil erosion, soil loss, and crop damage (resilient MA, 2018). In addition, wetter springs may delay planting of crops, resulting in reduced yields.

<u>Energy</u>
Flooding can increase bank erosion and also undermine buried energy infrastructure, such as underground power, gas, and cable infrastructure. Basement flooding can destroy electrical panels and furnaces. This can result in releases of oil and hazardous wastes to floodwaters. Inland flooding can also disrupt delivery of liquid fuels.

<u>Public Health</u>
The impacts to the built environment extend into other sectors. For example, flooding may increase the vulnerability of commercial and residential buildings to toxic mold buildup, leading to health risks, as described in the Populations section of the inland flooding hazard profile. Inland flooding may also lead to contamination of well water and contamination from septic systems (DPH, 2014).

<u>Public Safety</u>
Flash flooding can have a significant impact on public safety. Fast-moving water can sweep up debris, hazardous objects, and vehicles, and carry them toward people and property. Flooding can impact the ability of emergency response personnel to reach stranded or injured people. Drownings may also occur as people attempt to drive through flooded streets or escape to higher ground.

Transportation
Heavy precipitation events may damage roads, bridges, and energy facilities, leading to disruptions in transportation and utility services (resilient MA, 2018). Roads may experience greater ponding, which will further impact transportation. If alternative routes are not available, damage to roads and bridges may dramatically affect commerce and public health and safety.

Water Infrastructure
Stormwater drainage systems and culverts that are not sized to accommodate larger storms are likely to experience flood damage as extreme precipitation events increase (resilient MA, 2018). Both culverts that are currently undersized and culverts that are appropriately sized may be overwhelmed by larger storms. Gravity-fed water and wastewater infrastructure that is located in low lying areas near rivers and reservoirs may experience increased risks. Combined sewer overflows may increase with climate change, resulting in water quality degradation and public health risks (resilient MA, 2018).

Environment
Flooding is part of the natural cycle of a balanced environment. However, severe flood events can also result in substantial damage to the environment and natural resources, particularly in areas where human development has interfered with natural flood-related processes. As described earlier in this section, severe weather events are expected to become more frequent as a result of climate change; therefore, flooding that exceeds the adaptive capacity of natural systems may occur more often.

One common environmental effect of flooding is riverbank and soil erosion. Riverbank erosion occurs when high, fast water flows scour the edges of the river, transporting sediment downstream and reshaping the ecosystem. In addition to changing the habitat around the riverbank, this process also results in the deposition of sediment once water velocities slow. This deposition can clog riverbeds and streams, disrupting the water supply to downstream habitats. Soil erosion occurs whenever floodwaters loosen particles of topsoil and then transport them downstream, where they may be redeposited somewhere else or flushed into the ocean. Flooding can also influence soil conditions in areas where floodwaters pool for long periods of time, as continued soil submersion can cause oxygen depletion in the soil, reducing the soil quality and potentially limiting future crop production.

Flooding can also affect the health and well-being of wildlife. Animals can be directly swept away by flooding or lose their habitats to prolonged inundation. Floodwaters can also impact habitats nearby or downstream of agricultural operations by dispersing waste, pollutants, and nutrients from fertilizers. While some of these substances, particularly organic matter and nutrients, can actually increase the fertility of downstream soils, they can also result in severe impacts to aquatic habitats, such as eutrophication.

Vulnerability Summary

Based on the above analysis, Montague has a "Medium" vulnerability to flooding. The following problem statements summarize Montague's areas of greatest concern regarding the flood hazard.

Flood Hazard Problem Statements
• Bridges in town serve as important access and evacuation routes but are badly in need of repair. The General Pierce Bridge connecting Montague with Greenfield is a high priority as it is a primary emergency route. Only one of the eight bridges accessing the canal district and "The Patch" neighborhood in Turners Falls is fully functional, posing a public safety concern. Evacuating residents may be difficult in the event that any or all of these compromised bridges are impacted by flooding and have to be closed during an emergency.
• The Center Street and South Street Bridges in Montague Center are vulnerable to flooding and have been restricted to one-way traffic. Repairs should incorporate design improvements to accommodate the floodplain flows as identified in the Sawmill River Restoration Plan.
• Several Hazardous Facilities in Town, including the historic mill buildings and power canal in Turners Falls, and the Montague Water Pollution Control Facility in Montague City are located at the edges of the 100-year floodplain and within the High Hazard Dam Inundation area.
• Montague City Road is experiencing frequent flooding from a stream located adjacent to the road. Design and engineering is in process to mitigate the flooding, and the Town plans to apply for construction funding to complete the project.
• The Hillcrest School building experiences flooding approximately every five to ten years.
• Though the Combined Sewer Overflow's have recently been upgraded, they need to be maintained and monitored continually. Studying and implementing strategies to reduce the amount of stormwater entering the system would help reduce the risk of overflow events occurring. MA DEP is assessing the CSOs and will provide recommendations to the Town.
• Bank stabilization is needed on the Sawmill River near Main Street where erosion is undercutting the road. Continued progress on implementing additional erosion control measures identified in the Sawmill River Restoration Plan could mitigate flooding in this

area.
• Erosion on steep slopes and poor, unstable soils is occurring along the Connecticut and Millers Rivers, on Millers Falls Road, and on the edges of Montague Plains near roads.
• Culvert maintenance is continuously needed across town and is done so on an annual basis. The town needs to prioritize and continue culvert upgrades and replacements.
• The Historic Mill District Canal may be leaking into building foundations, and decaying buildings could compromise the structural integrity of the canal. Failure of the canal could flood Montague City Road, an important access and evacuation route.
• While the chance is low, a dam failure at the Northfield Mountain pump storage facility or any of the High Hazard dams on the Deerfield or Connecticut Rivers could result in catastrophic flooding to parts of Montague.

3.4 SEVERE SNOWSTORMS / ICE STORMS

Potential Effects of Climate Change

Climate projections for Massachusetts indicate that in future decades, winter precipitation could increase annually by as much as 0.4-3.9 inches (an increase of 4-35%), but by the end of the century most of this precipitation is likely to fall as rain instead of snow. There are many human and environmental impacts that could result from this change including reduced snow cover for winter recreation and tourism, less spring snow melt to replenish aquifers and lower spring river flows for aquatic ecosystems. Figure 3-4 show potential effects of climate change on severe winter storms from the Massachusetts State Hazard Mitigation and Climate Adaptation Plan.

Figure 3-4: Effects of Climate Change on Severe Winter Storms

Potential Effects of Climate Change	
EXTREME WEATHER AND RISING TEMPERATURES ➔ INCREASED SNOWFALL	Increased sea surface temperature in the Atlantic Ocean will cause air moving north over the ocean to hold more moisture. As a result, when these fronts meet cold air systems moving from the north, an even greater amount of snow than normal can be anticipated to fall on Massachusetts.
RISING TEMPERATURES ➔ CHANGING CIRCULATION PATTERNS AND WARMING OCEANS	Research has found that increasing water temperatures and reduced sea ice extent in the Arctic are producing atmospheric circulation patterns that favor the development of winter storms in the eastern U.S. Global warming is increasing the severity of winter storms because warming ocean water allows additional moisture to flow into the storm, which fuels the storm to greater intensity.
EXTREME WEATHER ➔ INCREASE IN FREQUENCY AND INTENSITY	There is evidence suggesting that nor'easters along the Atlantic coast are increasing in frequency and intensity. Future nor'easters may become more concentrated in the coldest winter months when atmospheric temperatures are still low enough to result in snowfall rather than rain.

Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Hazard Description

Severe winter storms include ice storms, nor'easters, heavy snow, blowing snow, and other extreme forms of winter precipitation. A blizzard is a winter snowstorm with sustained or frequent wind gusts to 35 mph or more, accompanied by falling or blowing snow that reduces visibility to or below a quarter of a mile (NWS, 2018). These conditions must be the predominant condition over a 3-hour period. Extremely cold temperatures are often associated with blizzard conditions, but are not a formal part of the definition. However, the hazard created by the combination of snow, wind, and low visibility increases significantly with temperatures below 20ºF. A severe blizzard is categorized as having temperatures near or below 10°F, winds exceeding 45 mph, and visibility reduced by snow to near zero.

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

Ice Storms

Ice storm conditions are defined by liquid rain falling and freezing on contact with cold objects, creating ice buildups of one-fourth of an inch or more. These can cause severe damage. An ice storm warning, which is now included in the criteria for a winter storm warning, is issued when a half inch or more of accretion of freezing rain is expected. This may lead to dangerous walking or driving conditions and the pulling down of power lines and trees.

Ice pellets are another form of freezing precipitation, formed when snowflakes melt into raindrops as they pass through a thin layer of warmer air. The raindrops then refreeze into particles of ice when they fall into a layer of subfreezing air near the surface of the earth. Finally, sleet occurs when raindrops fall into subfreezing air thick enough that the raindrops refreeze into ice before hitting the ground. The difference between sleet and hail is that sleet is a wintertime phenomenon whereas hail falls from convective clouds (usually thunderstorms), often during the warm spring and summer months.

Nor'easters

A nor'easter is a storm that occurs along the East Coast of North America with winds from the northeast (NWS, n.d.). A nor'easter is characterized by a large counter-clockwise wind circulation around a low-pressure center that often results in heavy snow, high winds, and rain. A nor'easter gets its name from its continuously strong northeasterly winds blowing in from the ocean ahead of the storm and over the coastal areas.

Nor'easters are among winter's most ferocious storms. These winter weather events are notorious for producing heavy snow, rain, and oversized waves that crash onto Atlantic beaches, often causing beach erosion and structural damage. These storms occur most often in late fall and early winter. The storm radius is often as much as 100 miles, and nor'easters often sit stationary for several days, affecting multiple tide cycles and causing extended heavy precipitation. Sustained wind speeds of 20 to 40 mph are common during a nor'easter, with short-term wind speeds gusting up to 50 to 60 mph. Nor'easters are commonly accompanied with a storm surge equal to or greater than 2.0 feet.

Nor'easters begin as strong areas of low pressure either in the Gulf of Mexico or off the East Coast in the Atlantic Ocean. The low will then either move up the East Coast into New England and the Atlantic provinces of Canada, or out to sea. The level of damage in a strong hurricane is often more severe than a nor'easter, but historically Massachusetts has suffered more damage from nor'easters because of the greater frequency of these coastal storms (one or two per year). The comparison of hurricanes to nor'easters reveals that the duration of high surge and winds in a hurricane is 6 to 12 hours, while a nor'easter's duration can be from 12 hours to 3 days.

Severe winter storms can pose a significant risk to property and human life. The rain, freezing rain, ice, snow, cold temperatures and wind associated with these storms can cause the following hazards:

- Disrupted power and phone service
- Unsafe roadways and increased traffic accidents
- Infrastructure and other property are also at risk from severe winter storms and the associated flooding that can occur following heavy snow melt
- Tree damage and fallen branches that cause utility line damage and roadway blockages
- Damage to telecommunications structures
- Reduced ability of emergency officials to respond promptly to medical emergencies or fires
- Elderly are affected by extreme weather

Location

Although the entire Commonwealth may be considered at risk to the hazard of severe winter storms, higher snow accumulations appear to be prevalent at higher elevations in Western and Central Massachusetts, and along the coast where snowfall can be enhanced by additional ocean moisture. Ice storms occur most frequently in the higher-elevation portions of Western and Central Massachusetts. Inland areas, especially those in floodplains, are also at risk for flooding and wind damage.

The entire town of Montague is susceptible to severe snowstorms and ice storms. Because these storms occur regionally, they impact the entire town. As a result, the location of occurrence is "large," with over 50 percent of land area affected.

Extent

Since 2005, the Regional Snowfall Index (RSI) has become the descriptor of choice for measuring winter events that impact the eastern two-thirds of the U.S. The RSI ranks snowstorm impacts on a scale system from 1 to 5 as depicted in Table 3-13. The RSI is similar to the Fujita scale for tornadoes or the Saffir-Simpson scale for hurricanes, except that it includes an additional variable: population. The RSI is based on the spatial extent of the storm, the amount of snowfall, and population.

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

Table 3-13: Regional Snowfall Index Categories

Category	RSI Value	Description
1	1—3	Notable
2	2.5—3.99	Significant
3	4—5.99	Major
4	6—9.99	Crippling
5	10.0+	Extreme

Source: NOAA National Climatic Data Center

Prior to the use of the RSI, the Northeast Snowfall Impact Scale (NESIS), developed by Paul Kocin of The Weather Channel and Louis Uccellini of the National Weather Service, was used to characterize and rank high-impact northeast snowstorms with large areas of 10-inch snowfall accumulations and greater. In contrast to the RSI, which is a regional index, NESIS is a quasi-national index that is calibrated to Northeast snowstorms. NESIS has five categories, as shown in Table 3-14.

Table 3-14: Northeast Snowfall Impact Scale Categories		
Category	**NESIS Value**	**Description**
1	1—2.499	Notable
2	2.5—3.99	Significant
3	4—5.99	Major
4	6—9.99	Crippling
5	10.0+	Extreme

Source: NOAA National Climatic Data Center

Previous Occurrences

New England generally experiences at least one or two severe winter storms each year with varying degrees of severity. Severe winter storms typically occur during January and February; however, they can occur from late September through late April. According to NOAA's National Climatic Data Center, there have been 80 heavy snow events in Franklin County since 1996, resulting in $15,440,000 in damages; 29 winter storm events since 2002, resulting in $1,170,000 in damages; and two ice storms have resulted in damages of $3,150,000.

In December 2008, a major ice storm impacted the northeast. The hardest hit areas in southern New England were the Monadnock region of southwest New Hampshire, the Worcester Hills in central Massachusetts, and the east slopes of the Berkshires in western Massachusetts. Anywhere from half an inch to an inch of ice built up on many exposed surfaces. Combined with breezy conditions, the ice downed numerous trees, branches, and power lines which resulted in widespread power outages. More than 300,000 customers were reportedly without power in Massachusetts and an additional 300,000 were without power in the state of New Hampshire.

Damage to the infrastructure in Massachusetts and New Hampshire amounted to roughly 80 million dollars. This amount does not include damage to private property. The extent of the damage and number of people affected prompted the governors of both Massachusetts and New Hampshire to request federal assistance. FEMA approved both requests. President Bush issued a Major Disaster Declaration for Public Assistance for seven Massachusetts counties and all of New Hampshire.

Based on data available from the National Oceanic and Atmospheric Administration, there are 210 winter storms since 1900 that have registered on the RSI scale. Of these, approximately 18 storms resulted in snow falls in all or parts of Franklin County of at least 10 inches. These storms are listed in Table 3-15, in order of their RSI severity.

Table 3-15: High-Impact Snowstorms in Franklin County, 1958 - 2018			
Date	RSI Value	RSI Category	RSI Classification
2/22/1969	34.0	5	Extreme
3/12/1993	22.1	5	Extreme
1/6/1996	21.7	5	Extreme
2/5/1978	18.4	5	Extreme
2/23/2010	17.8	4	Crippling
2/15/2003	14.7	4	Crippling
1/29/1966	12.3	4	Crippling
3/12/2017	10.7	4	Crippling
2/27/1947	10.6	4	Crippling
12/25/1969	10.1	4	Crippling
12/4/2003	9.4	3	Major
2/8/2013	9.2	3	Major
2/2/1961	8.3	3	Major
2/10/1983	7.9	3	Major
2/14/1958	7.9	3	Major
2/12/2007	6.9	3	Major
3/2/1960	6.9	3	Major
1/25/2015	6.2	3	Major

Source: https://www.ncdc.noaa.gov/snow-and-ice/rsi/societal-impacts

In Montague's rural areas, many households that lose power during winter storms also lose access to their wells and are without a potable drinking water source. A snow storm in February 2010 caused widespread power outages in Millers Falls and Montague Center, in some areas lasting up to three days. The Turners Falls High School was opened as a shelter for residents during this time. During the winter of 2010/2011, large snow loads on roofs were a concern, and caused the roof of a barn in town to collapse. North Leverett Road was identified by the Committee as an area experiencing frequent vehicle accidents in the winter due to icy conditions.

Probability of Future Events

Based upon the availability of records for Franklin County, the likelihood that a severe winter storm will hit Montague in any given year is "Very High," or a 50% to 100% probability in any given year.

Increased sea surface temperature in the Atlantic Ocean will cause air moving north over this ocean to hold more moisture. As a result, when these fronts meet cold air systems moving from the north, an even greater amount of snow than normal can be anticipated to fall on Massachusetts. Climate projections for Massachusetts indicate that in future decades, winter precipitation could increase annually by as much as 0.4-3.9 inches (an increase of 4-35%), but by the end of the century most of this precipitation is likely to fall as rain instead of snow. There are many human and environmental impacts that could result from this change including reduced snow cover for winter recreation and tourism, less spring snow melt to replenish aquifers and lower spring river flows for aquatic ecosystems.

Impact

The phrase "severe winter storm" encapsulates several types of natural hazards, including snowfall, wind, ice, sleet, and freezing rain hazards. Additional natural hazards that can occur as a result of winter storms include sudden and severe drops in temperature. Winter storms can also result in flooding and the destabilization of hillsides as snow or ice melts and begins to run off. The storms can also result in significant structural damage from wind and snow load as well as human injuries and economic and infrastructure impacts.

The impact of severe winter storms in Montague is "limited," with more than 10 percent of property in the affected area damaged and complete shutdown of facilities for more than 1 day possible.

Vulnerability

Society

According to the NOAA National Severe Storms Laboratory, every year, winter weather indirectly and deceptively kills hundreds of people in the U.S., primarily from automobile accidents, overexertion, and exposure. Winter storms are often accompanied by strong winds that create blizzard conditions with blinding wind-driven snow, drifting snow, and extreme cold temperatures with dangerous wind chill. These events are considered deceptive killers because most deaths and other impacts or losses are indirectly related to the storm. Injuries and deaths may occur due to traffic accidents on icy roads, heart attacks while shoveling snow, or hypothermia from prolonged exposure to cold.

Heavy snow can immobilize a region and paralyze a community, shutting down air and rail transportation, stopping the flow of supplies, and disrupting medical and emergency services. Accumulations of snow can cause buildings to collapse and knock down trees and power lines. In rural areas, homes and farms may be isolated for days, and unprotected livestock may perish. In the mountains, heavy snow can lead to avalanches.

The impact of a severe winter storm on life, health, and safety is dependent upon several factors, including the severity of the event and whether or not adequate warning time was provided to residents. Residents may be displaced or require temporary to long-term sheltering. In addition, downed trees, damaged buildings, and debris carried by high winds can lead to injury or loss of life. The entire population of Montague is exposed to severe winter weather events.

<u>Vulnerable Populations</u>

Vulnerable populations include the elderly living alone, who are susceptible to winter hazards due to their increased risk of injury and death from falls, overexertion, and/or hypothermia from attempts to clear snow and ice, or injury and death related to power failures. In addition, severe winter weather events can reduce the ability of these populations to access emergency services. People with low socioeconomic status are more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on the net economic impact on their families. Residents with low incomes may not have access to housing or their housing may be less able to withstand cold temperatures (e.g., homes with poor insulation and heating supply).

The population over the age of 65, individuals with disabilities, and people with mobility limitations or who lack transportation are also more vulnerable because they are more likely to seek or need medical attention, which may not be available due to isolation during a winter storm event. These individuals are also more vulnerable because they may have more difficulty if evacuation becomes necessary. People with limited mobility risk becoming isolated or “snowbound” if they are unable to remove snow from their homes. Rural populations may become isolated by downed trees, blocked roadways, and power outages. Residents relying on private wells could lose access to fresh drinking water and indoor plumbing during a power outage.

Table 3-16 estimates the number of vulnerable populations and households in Montague. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of Montague residents during a severe winter storm event.

Table 3-16: Estimated Vulnerable Populations in Montague		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	1,745	21%
Population with a Disability	1,477	18%
Population who Speak English Less than "Very Well"	522	6%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	1,307	35%
Householder Age 65 Years and Over Living Alone	465	12%
Households Without Access to a Vehicle	408	11%

*Total population = 8,311; Total households = 3,786
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2013-2017 Five-Year Estimates.

Montague MVP workshop participants identified the safety and well-being of vulnerable populations as a concern and challenge in town. Specific concerns include:

- Community Action’s preschool in the Patch neighborhood is vulnerable if evacuation is required, given the limited access to the neighborhood.
- Currently, children living within 1.5 miles of the elementary school are not provided bus transportation to school. Children walking to school in the winter can be exposed to extreme weather. The conditions of sidewalks and crossings are also a concern.
- The homeless population has less access to information about impending hazards, and in some cases may not want to be contacted or stay in shelters.
- Non-English speaking residents in Turners Falls and Millers Falls have tight-knit communities that help each other during emergencies. However, Town officials have limited capacity to communicate with non-English speaking residents.

Health Impacts

Cold weather, which is a component of a severe winter storm, increases the risk of hypothermia and frostbite. Exposure to cold conditions can also exacerbate pre-existing respiratory and cardiovascular conditions. In addition to temperature-related dangers, however, severe winter storms also present other potential health impacts. For example, individuals may use generators in their homes if the power goes out or may use the heat system in their cars if they become trapped by snow. Without proper ventilation, both of these activities can result in carbon monoxide buildup that can be fatal. Loss of power can also lead to hypothermia. After Hurricane Sandy, the number of cases of cold exposure in New York City was three times greater than the same time period in previous years.[11] Driving during severe snow and ice conditions can also be very dangerous, as roads become slick and drivers can lose control of their vehicle. During and after winter storms, roads may be littered with debris, presenting a danger to drivers. Health impacts on people include the inability to travel to receive needed medical services and isolation in their homes. Additionally, natural gas-fueled furnaces, water heaters, and clothes dryers, and even automobile exhaust pipes, may become blocked by snow and ice, which can lead to carbon monoxide poisoning.

<u>Economic Impacts</u>

The entire building stock inventory in Montague is exposed to the severe winter weather hazard. In general, structural impacts include damage to roofs and building frames rather than building content. Heavy accumulations of ice can bring down trees, electrical wires, telephone poles and lines, and communication towers. Communication and power networks can be disrupted for days while utility companies work to repair the extensive damage.

Even small accumulations of ice may cause extreme hazards to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces. A specific area that is vulnerable to the winter storm hazard is the floodplain. Snow and ice melt can cause both riverine and urban flooding. The cost of snow and ice removal and repair of roads from the freeze/thaw process can drain local financial resources. The potential secondary impacts from winter storms, including loss of utilities, interruption of transportation corridors, loss of business functions, and loss of income for many individuals during business closures, also impact the local economy.

Similar to hurricanes and tropical storms, nor'easter events can greatly impact the economy, with impacts that include the loss of business functions (e.g., tourism and recreation), damage to inventories or infrastructure (the supply of fuel), relocation costs, wage losses, and rental losses due to the repair or replacement of buildings.

Infrastructure

All infrastructure and other elements of the built environment in Montague are exposed to the severe winter weather hazard. Potential structural damage to the facilities themselves may include damage to roofs and building frames. These facilities may not be fully operational if workers are unable to travel to ensure continuity of operations prior and after a severe winter

[11] Fink, 2012

event. Disruptions to key public services such as electricity, transportation, schools, and health care may become more common.[12] Table 3-17 identifies the assessed value of all residential, open space, commercial, and industrial land uses in Town, and the losses that would result from 1%, 5%, and 10% damage to this inventory as a result of a severe winter storm.

Table 3-17: Estimated Potential Loss by Tax Classification

Tax Classification	Total Assessed Value FY2019	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$594,091,351	$5,940,914	$29,704,568	$59,409,135
Open Space	$0	$0	$0	$0
Commercial	$35,125,445	$351,254	$1,756,272	$3,512,545
Industrial	$160,768,052	$1,607,681	$8,038,403	$16,076,805
Total	**$789,984,848**	**$7,899,848**	**$39,499,242**	**$78,998,485**

Source: Massachusetts Department of Revenue - Division of Local Services, Municipal Databank/Local Aid Section.

<ins>Agriculture</ins>

Severe winter weather can lead to flooding in low-lying agricultural areas. Ice that accumulates on branches in orchards and forests can cause branches to break, while the combination of ice and wind can fell trees. Storms that occur in spring can delay planting schedules. Frost that occurs after warmer periods in spring can cause cold weather dieback and damage new growth.

<ins>Energy</ins>

Severe weather can cause power outages from trees that fall during heavy snow and strong wind events. Severe ice events can take down transmission and distribution lines. The severe weather can impair a utility's ability to rapidly repair and recover the system.

<ins>Public Health</ins>

Severe winter weather presents many health hazards, as previously described in the discussion of the severe winter storm/nor'easter hazard profile. Severe winter storms and events with extended power outages may overburden hospitals and emergency shelters.

<ins>Public Safety</ins>

Public safety buildings may experience direct loss (damage) from downed trees, heavy snowfall, and high winds. Full functionality of critical facilities, such as police, fire and medical facilities, is essential for response during and after a winter storm event. Because power interruptions can

[12] Resilient MA 2018

occur, backup power is recommended for critical facilities and infrastructure. The ability of emergency responders to respond to calls may be impaired by heavy snowfall, icy roads, and downed trees.

<u>Transportation</u>

Other infrastructure elements at risk for this hazard include roadways, which can be obstructed by snow and ice accumulation or by windblown debris. Additionally, over time, roadways can be damaged from the application of salt and the thermal expansion and contraction from alternating freezing and warming conditions. Other types of infrastructure, including rail, aviation, port, and waterway infrastructure (if temperatures are cold enough to cause widespread freezing), can be impacted by winter storm conditions.

<u>Water Infrastructure</u>

Water infrastructure that is exposed to winter conditions may freeze or be damaged by ice.

Environment

Although winter storms are a natural part of the Massachusetts climate, and native ecosystems and species are well adapted to these events, changes in the frequency or severity of winter storms could increase their environmental impacts. Environmental impacts of severe winter storms can include direct mortality of individual plants and animals and felling of trees, which can damage the physical structure of the ecosystem. Similarly, if large numbers of plants or animals die as the result of a storm, their lack of availability can impact the food supply for animals in the same food web. If many trees fall or die within a small area, they can release large amounts of carbon as they decay. This unexpected release can cause further imbalance in the local ecosystem. The flooding that results when snow and ice melt can also cause extensive environmental impacts. Nor'easters can cause impacts that are similar to those of hurricanes and tropical storms and flooding. These impacts can include direct damage to species and ecosystems, habitat destruction, and the distribution of contaminants and hazardous materials throughout the environment.

Vulnerability Summary

Based on the above assessment, Montague faces a "high" vulnerability from severe snow storms and ice storms. Severe Winter Storms / Ice Storms occur frequently in Montague. However, the severity of impact is limited, as Montague is well-prepared for dealing with the impacts of winter storms. The following problem statements summarize Montague's areas of greatest concern regarding severe winter storms.

Severe Winter Storm Hazard Problem Statements
• Children walking to school in the winter are vulnerable to hazardous weather conditions and extreme cold. Routes are steep and sidewalks are not always cleared of snow, forcing children to walk in the roadway.
• Community Action's pre-school in the Patch neighborhood could be vulnerable if a hazard required evacuation, given limited access to the neighborhood.
• The Town needs additional capabilities to identify elders who need oxygen and other specialized medical equipment or support services during emergencies.
• Homeless and transient people in town are difficult to reach in the event of an emergency.
• The Town lacks capacity to communicate with Non-English speaking populations during emergencies.
• Emergency Communication Systems need to be enhanced with radio and cell towers in the eastern and southeastern part of town. The radio communication system at Turners Falls High School needs improvements, including the installation of repeaters.
• Turners Falls High School, which serves as the regional shelter, needs improved infrastructure for back-up power and water.

3.5 HURRICANES / TROPICAL STORMS

Potential Effects of Climate Change

A 2017 U.S. Climate Science Special Report noted that there has been an upward trend in North Atlantic hurricane activity since 1970. The report forecasts that future hurricanes formed in the North Atlantic will drop more rain and may have higher wind speeds. This is because a warmer atmosphere will hold more water, and hurricanes are efficient at wringing water out of the atmosphere and dumping it on land. When extreme storms like Tropical Storm Irene travel over inland areas, they may release large quantities of precipitation and cause rivers to overtop their banks. Irene dumped more than 10 inches of rain in western Massachusetts. Buildings floated downriver in Shelburne Falls, flooded highways were closed, and 400,000 utility customers lost power (resilient MA, 2018). Figure 3-5 displays the potential effects of climate change on hurricanes and tropical storms from the Massachusetts State Hazard Mitigation and Climate Adaptation Plan.

Figure 3-5: Effects of Climate Change on Hurricanes and Tropical Storms

Potential Effects of Climate Change	
EXTREME WEATHER AND RISING TEMPERATURES ➔ LARGER, STRONGER STORMS	As warmer oceans provide more energy for storms, both past events and models of future conditions suggest that the intensity of tropical storms and hurricanes will increase.
CHANGES IN PRECIPITATION ➔ INCREASED RAINFALL RATES	Warmer air can hold more water vapor, which means the rate of rainfall will increase. One study found that hurricane rainfall rates were projected to rise 7 percent for every degree Celsius increase in tropical sea surface temperature.

Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Hazard Description

Hurricanes can range from as small as 50 miles across to as much as 500 miles across; Hurricane Allen in 1980 took up the entire Gulf of Mexico. There are generally two source regions for storms that have the potential to strike New England: (1) off the Cape Verde Islands near the west coast of Africa, and (2) in the Bahamas. The Cape Verde storms tend to be very large in diameter, since they have a week or more to traverse the Atlantic Ocean and grow. The Bahamas storms tend to be smaller, but they can also be just as powerful, and their effects can reach New England in only a day or two.

Tropical systems customarily come from a southerly direction and when they accelerate up the

East Coast of the U.S., most take on a distinct appearance that is different from a typical hurricane. Instead of having a perfectly concentric storm with heavy rain blowing from one direction, then the calm eye, then the heavy rain blowing from the opposite direction, our storms (as viewed from satellite and radar) take on an almost winter-storm-like appearance. Although rain is often limited in the areas south and east of the track of the storm, these areas can experience the worst winds and storm surge. Dangerous flooding occurs most often to the north and west of the track of the storm. An additional threat associated with a tropical system making landfall is the possibility of tornado generation. Tornadoes would generally occur in the outer bands to the north and east of the storm, a few hours to as much as 15 hours prior to landfall.

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

Tropical Storms

A tropical storm system is characterized by a low-pressure center and numerous thunderstorms that produce strong winds and heavy rain (winds are at a lower speed than hurricane-force winds, thus gaining its status as a tropical storm versus a hurricane). Tropical storms strengthen when water evaporated from the ocean is released as the saturated air rises, resulting in condensation of water vapor contained in the moist air. They are fueled by a different heat mechanism than other cyclonic windstorms, such as nor'easters and polar lows. The characteristic that separates tropical cyclones from other cyclonic systems is that at any height in the atmosphere, the center of a tropical cyclone will be warmer than its surroundings—a phenomenon called "warm core" storm systems.

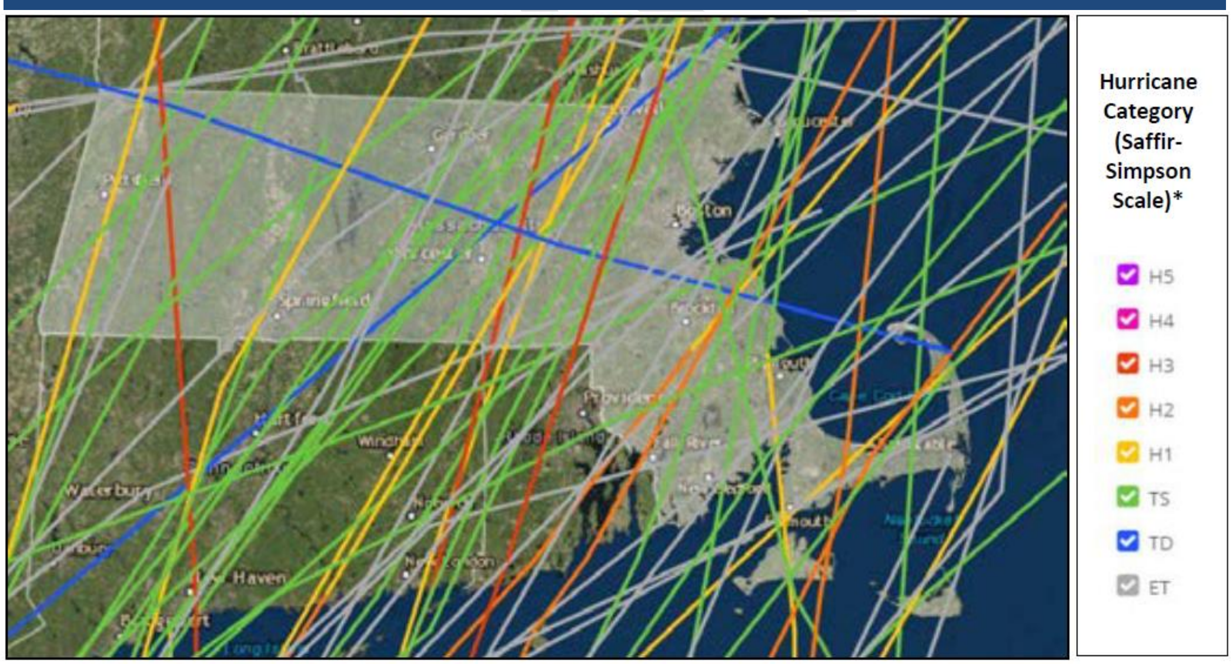
The term "tropical" refers both to the geographical origin of these systems, which usually form in tropical regions of the globe, and to their formation in maritime tropical air masses. The term "cyclone" refers to such storms' cyclonic nature, with counterclockwise wind flow in the Northern Hemisphere and clockwise wind flow in the Southern Hemisphere.

Location

Because of the hazard's regional nature, all of Montague is at risk from hurricanes and tropical storms, with a "large" location of occurrence with over 50 percent of land area affected. Ridge tops are more susceptible to wind damage. Inland areas, especially those in floodplains, are also at risk for flooding from heavy rain and wind damage. The majority of the damage following hurricanes and tropical storms often results from residual wind damage and inland flooding, as was demonstrated during recent tropical storms.

NOAA's Historical Hurricane Tracks tool is a public interactive mapping application that displays Atlantic Basin and East-Central Pacific Basin tropical cyclone data. This interactive tool tracks tropical cyclones from 1842 to 2017. According to this resource, over the time frame tracked, 63 events categorized as an extra-tropical storm or higher occurred within 65 nautical miles of Massachusetts. The tracks of these storms are shown in Figure 3-6. As this figure shows, the paths of these storms vary across the Commonwealth, but are more likely to occur toward the coast.

Figure 3-6: Historical Hurricane Paths within 65 Miles of Massachusetts



Source: NOAA, n.d. * TS=Tropical Storm, TD=Tropical Depression

Extent

Hurricanes are measured according to the Saffir-Simpson scale, which categorizes or rates hurricanes from 1 (minimal) to 5 (catastrophic) based on their intensity. This is used to give an estimate of the potential property damage and flooding expected from a hurricane landfall. Wind speed is the determining factor in the scale. All winds are assessed using the U.S. 1-minute average, meaning the highest wind that is sustained for 1 minute. The Saffir-Simpson Scale described in Table 3-19 gives an overview of the wind speeds and range of damage caused by different hurricane categories.

Table 3-19: 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 is severe; there are extensive glass failures; and entire buildings could fail.
Additional Classifications		
Tropical Storm	39-73	NA
Tropical Depression	< 38	NA

Source: NOAA, n.d. Note: mph = miles per hour, NA = not applicable

Tropical storms and tropical depressions, while generally less dangerous than hurricanes, can be deadly. The winds of tropical depressions and tropical storms are usually not the greatest threat; rather, the rains, flooding, and severe weather associated with the tropical storms are what customarily cause more significant problems. Serious power outages can also be associated with these types of events. After Hurricane Irene passed through the region as a tropical storm in late August 2011, many areas of the Commonwealth were without power for more than 5 days.

While tropical storms can produce extremely powerful winds and torrential rain, they are also able to produce high waves, damaging storm surge, and tornadoes. They develop over large bodies of warm water and lose their strength if they move over land due to increased surface friction and loss of the warm ocean as an energy source. Heavy rains associated with a tropical storm, however, can produce significant flooding inland, and storm surges can produce extensive coastal flooding up to 25 miles from the coastline.

One measure of the size of a tropical cyclone is determined by measuring the distance from its center of circulation to its outermost closed isobar. If the radius is less than 2 degrees of latitude, or 138 miles, then the cyclone is “very small.” A radius between 3 and 6 degrees of latitude, or 207 to 420 miles, is considered “average-sized.” “Very large” tropical cyclones have a radius of greater than 8 degrees, or 552 miles.

Previous Occurrences

According to NOAA’s Historical Hurricane Tracker tool, 63 hurricane or tropical storm events have occurred in the vicinity of Massachusetts between 1842 and 2016. The Commonwealth was impacted by tropical storms Jose and Phillipe in 2017. Therefore, there is an average of one storm every other year or 0.5 storms per year. Storms severe enough to receive FEMA disaster declarations, however, are far rarer, occurring every 9 years on average. The Commonwealth has not been impacted by any Category 4 or 5 hurricanes; however, Category 3 storms have historically caused widespread flooding. Winds have caused sufficient damage to impair the ability of individuals to remain in their homes.

In Massachusetts, major hurricanes occurred in 1904, 1938, 1954, 1955, 1960, 1976, 1985, 1991 and 2010. The Great New England Hurricane of 1938, a Category 3 hurricane which occurred on September 21, 1938, was one of the most destructive and powerful storms ever to strike Southern New England. Sustained hurricane force winds occurred throughout most of Southern New England. Extensive damage occurred to roofs, trees and crops. Widespread power outages occurred, which in some areas lasted several weeks. Rainfall from this hurricane resulted in severe river flooding across sections of Massachusetts and Connecticut. The combined effects from a frontal system several days earlier and the hurricane produced rainfall of 10 to 17 inches across most of the Connecticut River Valley. This resulted in some of the worst flooding ever recorded in this area. The most recent hurricane to make landfall in Franklin County was Hurricane Bob, a weak category 2 hurricane, which made landfall in New England in August 1991. In Franklin County, Hurricane Bob caused roughly $5,555,556 in property and crop damages. No hurricane has tracked directly through the Town of Montague.

Historic data for hurricane and tropical storm events indicate one hurricane and 17 tropical storms have been recorded in Franklin County. Hurricane Bob in 1991 caused over $5.5 million in property damage in the county, and over $500,000 in crop damage. In 2011, Tropical Storm Irene caused over $26 million in property damage in Franklin County, mostly from flooding impacts.

Probability of Future Events

A 2017 U.S. Climate Science Special Report noted that there has been an upward trend in North Atlantic hurricane activity since 1970. The report forecasts that future hurricanes formed in the North Atlantic will drop more rain and may have higher wind speeds. This is because a warmer atmosphere will hold more water, and hurricanes are efficient at wringing water out of the atmosphere and dumping it on land.[13]

Montague's location in western Massachusetts reduces the risk of extremely high winds that are associated with hurricanes, although it can experience some high wind events. Based upon past occurrences, Montague has a "high" probability, or a 25% to 50% chance, of experiencing a hurricane or tropical storm event in a given year.

Impact

The impact of hurricanes and tropical storms in Montague is typically "minor," with only minor property damage and temporary shutdown of facilities.

Vulnerability

The entire town would be vulnerable to the impact of a hurricane or tropical storm. Areas prone to flooding are particularly vulnerable. Additionally high winds could impact the town's communication and energy infrastructure.

Society

<u>Vulnerable Populations</u>

Populations that live or work in proximity to facilities that use or store toxic substances are at greater risk of exposure to these substances during a flood event. In Montague, the canal district of Turners Falls has a concentration of vacant industrial buildings and brownfields, where contamination is expected or confirmed, located between the Connecticut River and

---

[13] ResilientMA: Climate Change Clearing House for the Commonwealth: http://resilientma.org/changes/extreme-weather. Accessed January 11, 2019.

power canal and adjacent to dense neighborhoods. Several of the vacant buildings have been targets for arson in recent years. "The Patch" neighborhood abuts this area and is vulnerable to releases of toxic chemicals from flooding. Only one bridge (out of eight bridges that access the canal district) is fully functional, posing a public safety access concern for this neighborhood.

In addition to chemicals stored in place, hazardous materials are routinely transported through town on common routes, including Avenue A, Millers Falls Road, Montague City Road, Turners Falls Road, and the freight rail lines. There are many locations where these vehicular transportation routes and freight rail lines either cross over and/or travel along the rivers in town, placing the populations living within close proximity to the road and railroad at higher risk to a hazardous material spill in conjunction with flooding from a hurricane or tropical storm.

Among the exposed populations, the most vulnerable include people with low socioeconomic status, people over the age of 65, people with medical needs, and those with low English language fluency. For example, people with low socioeconomic status are likely to consider the economic impacts of evacuation when deciding whether or not to evacuate. Individuals with medical needs may have trouble evacuating and accessing needed medical care while displaced. Those who have low English language fluency may not receive or understand the warnings to evacuate. During and after an event, rescue workers and utility workers are vulnerable to impacts from high water, swift currents, rescues, and submerged debris. Vulnerable populations may also be less likely to have adequate resources to recover from the loss of their homes and jobs or to relocate from a damaged neighborhood.

Table 3-20 estimates the number of vulnerable populations and households in Montague. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of Montague residents during a hurricane or tropical storm event.

Table 3-20: Estimated Vulnerable Populations in Montague		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	1,745	21%
Population with a Disability	1,477	18%
Population who Speak English Less than "Very Well"	522	6%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	1,307	35%
Householder Age 65 Years and Over Living Alone	465	12%
Households Without Access to a Vehicle	408	11%
Households Living in a Home Built Prior to 1970	2,894	71%
Households Living in a Mobile Home	67	2%

*Total population =8,311; Total households = 3,786
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2013-2017 Five-Year Estimates.

The Committee also noted the age of buildings and homes in Montague as a concern. An estimated 2,894 housing units in town were built prior to State building codes went into effect. In particular, buildings in the downtown areas of Turners Falls and Millers Falls may be vulnerable to damage from wind. A number of buildings have suffered from deferred maintenance, and both downtowns have areas designated as Slum and Blighted, according to guidelines established by the Massachusetts Department of Housing and Community Development (DHCD).

Montague MVP workshop participants identified the safety and well-being of vulnerable populations as a concern and challenge in town. Specific concerns include:

- Community Action's preschool in the Patch neighborhood is vulnerable if evacuation is required, given the limited access to the neighborhood.
- Currently, children living within 1.5 miles of the elementary school are not provided bus transportation to school. Children walking to school can be exposed to extreme weather. The conditions of sidewalks and crossings are also a concern.
- The homeless population has less access to information about impending hazards, and in some cases may not want to be contacted or stay in shelters.

- Non-English speaking residents in Turners Falls and Millers Falls have tight-knit communities that help each other during emergencies. However, Town officials have limited capacity to communicate with non-English speaking residents.

Health Impacts

The health impacts from hurricanes and tropical storms can generally be separated into impacts from flooding and impacts from wind. The potential health impacts of flooding are extensive, and are discussed in detail in the Flooding section. In general, some of the most serious flooding-related health threats include floodwaters sweeping away individuals or cars, downed power lines, and exposure to hazards in the water, including dangerous animals or infectious organisms. Contact with contaminated floodwaters can cause gastrointestinal illness.

Wind-related health threats associated with hurricanes are most commonly caused by projectiles propelled by the storm's winds. Wind- and water-caused damage to residential structures can also increase the risk of threat impacts by leaving residents more exposed to the elements. Hurricanes that occur later in the year also increase the risk of hypothermia.

Economic Impacts

In addition to the human costs that extreme storms deliver when they permanently or temporarily displace people, the repair and reconstruction costs after storm damage can be enormous for homeowners and businesses. When bridges and culverts have been washed away and roads damaged, municipal and state agencies must secure the resources for expensive recovery projects in limited municipal budgets and from Federal disaster grant programs that are increasingly over-subscribed. Electrical grid, power plants and wastewater infrastructure repair costs are all expected to increase in the future.[14]

Infrastructure

Residential and commercial buildings built along rivers may be vulnerable to severe damage. Potential structural damage to the facilities themselves may include damage to roofs and building frames. These facilities may not be fully operational if workers are unable to travel to ensure continuity of operations prior and after a severe winter event. Table 3-21 identifies the assessed value of all residential, open space, commercial, and industrial land uses in Town, and the losses that would result from 1%, 5%, and 10% damage to this inventory as a result of a hurricane or tropical storm.

[14] ResilientMA: Climate Change Clearing House for the Commonwealth: http://resilientma.org/changes/extreme-weather. Accessed January 29, 2019.

Table 3-21: Estimated Potential Loss by Tax Classification				
Tax Classification	**Total Assessed Value FY2019**	**1% Damage Loss Estimate**	**5% Damage Loss Estimate**	**10% Damage Loss Estimate**
Residential	$594,091,351	$5,940,914	$29,704,568	$59,409,135
Open Space	$0	$0	$0	$0
Commercial	$35,125,445	$351,254	$1,756,272	$3,512,545
Industrial	$160,768,052	$1,607,681	$8,038,403	$16,076,805
Total	**$789,984,848**	**$7,899,848**	**$39,499,242**	**$78,998,485**

Source: Massachusetts Department of Revenue - Division of Local Services, Municipal Databank/Local Aid Section.

<u>Energy</u>

Hurricanes and tropical storms often result in power outages and contact with damaged power lines during and after a storm, which may result in electrocution.

<u>Public Health</u>

Combined sewer overflows associated with heavy rainfall can release contaminants, chemicals, and pathogens directly into the environment and into water systems. If a mass outbreak of waterborne illness were to occur, hospitals and medical providers may lack the capacity to treat patients.

<u>Public Safety</u>

Critical infrastructure, including local and state-owned police and fire stations, other public safety buildings, and facilities that serve as emergency operation centers may experience direct loss (damage) during a hurricane or tropical storm. Emergency responders may also be exposed to hazardous situations when responding to calls. Road blockages caused by downed trees may impair travel.

<u>Transportation</u>

Some roads and bridges are also considered critical infrastructure, particularly those providing ingress and egress and allowing emergency vehicles access to those in need. Costly damage to roads, bridges, and rail networks may occur as a result of hurricanes.[15]

<u>Water and Wastewater Infrastructure</u>

Wastewater treatment centers may face elevated risks of damage and destruction from hurricanes (resilient MA, 2018). Heavy rains can lead to contamination of well water and can

[15] Resilient MA 2018.

release contaminants from septic systems (DPH, 2014). Heavy rainfall can also overburden stormwater systems, drinking water supplies, and sewage systems.

Environment

The environmental impacts of hurricanes and tropical storms are similar to those described for other hazards, including flooding, severe winter storms and other severe weather events. As described for human health, environmental impacts can generally be divided into short-term direct impacts and long-term impacts. As the storm is occurring, flooding may disrupt normal ecosystem function and wind may fell trees and other vegetation. Additionally, wind-borne or waterborne detritus can cause mortality to animals if they are struck or transported to a non-suitable habitat.

In the longer term, impacts to natural resources and the environment as a result of hurricanes and tropical storms are generally related to changes in the physical structure of ecosystems. For example, flooding may cause scour in riverbeds and erode riverbanks, modifying the river ecosystem and depositing the scoured sediment in another location. Similarly, trees that fall during the storm may represent lost habitat for local species, or they may decompose and provide nutrients for the growth of new vegetation. If the storm spreads pollutants into natural ecosystems, contamination can disrupt food and water supplies, causing widespread and long-term population impacts on species in the area.

Vulnerability Summary

Based on the above analysis, Montague faces a medium vulnerability from hurricanes and tropical storms. The following problem statements summarize Montague's greatest areas of concern regarding hurricanes and tropical storms.

Hurricane / Tropical Storm Hazard Problem Statements
• Community Action's pre-school in the Patch neighborhood could be vulnerable if a hazard required evacuation, given limited access to the neighborhood.
• The Town needs additional capabilities to identify elders who need oxygen and other specialized medical equipment or support services during emergencies.
• Homeless and transient people in town are difficult to reach in the event of an emergency.
• The Town lacks capacity to communicate with Non-English speaking populations during emergencies.
• Emergency Communication Systems need to be enhanced with radio and cell towers in the eastern and southeastern part of town. The radio communication system at Turners Falls High School needs improvements, including the installation of repeaters.
• Turners Falls High School, which serves as the regional shelter, needs improved infrastructure for back-up power and water and air conditioning.
• Bridges in town serve as important access and evacuation routes but are badly in need of repair. The General Pierce Bridge connecting Montague with Greenfield is a high priority as it is a primary emergency route and secondary evacuation route. Only one of the eight bridges accessing the canal district and "The Patch" neighborhood in Turners Falls is fully functional, posing a public safety concern. Evacuating residents may be difficult in the event that any or all of these compromised bridges are impacted by flooding and have to be closed during an emergency.
• Several Hazardous Facilities in Town, including the historic mill buildings and power canal in Turners Falls, and the Montague Water Pollution Control Facility in Montague City are located at the edges of the 100-year floodplain and within the High Hazard Dam Inundation area. Multi-family homes, public housing, and the "Patch" neighborhood are located within close proximity to these facilities.
• The age and condition of buildings and homes in Montague is a concern. An estimated 2,894 housing units in town were built prior to State building codes went into effect. Areas of Turners Falls and Millers Falls are designated Slum and Blighted.

3.6 SEVERE THUNDERSTORMS / WIND / MICROBURSTS

Potential Effects of Climate Change

Climate change is expected to increase extreme weather events across the globe and in Massachusetts. Climate change leads to extreme weather because of warmer air and ocean temperatures and changing air currents. Warmer air leads to more evaporation from large water bodies and holds more moisture, so when clouds release their precipitation, there is more of it. In addition, changes in atmospheric air currents like jet streams and ocean currents can cause changes in the intensity and duration of stormy weather. While it is difficult to connect one storm to a changing climate, scientists point to the northeastern United States as one of the regions that is most vulnerable to an increase in extreme weather driven by climate change.[16]

Figure 3-6: Effects of Climate Change on Severe Thunderstorms, Wind, and Microbursts

Potential Effects of Climate Change		
	EXTREME WEATHER AND CHANGES IN PRECIPITATION ➔ MORE INTENSE AND FREQUENT THUNDERSTORMS AND DOWNPOURS	The Northeast has already experienced a larger increase in the intensity of rainfall events than any other region in the United States in the last fifty years, and this trend is expected to continue.

Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Hazard Description

A thunderstorm is a storm originating in a cumulonimbus cloud. Cumulonimbus clouds produce lightning, which locally heats the air to 50,000 degrees Celsius, which in turn produces an audible shock wave, known as thunder. Frequently during thunderstorm events, heavy rain and gusty winds are present. Less frequently, hail is present, which can become very large in size. Tornadoes can also be generated during these events. According to the National Weather Service, a thunderstorm is classified as "severe" when it produces damaging wind gusts in excess of 58 mph (50 knots), hail that is 1 inch in diameter or larger (quarter size), or a tornado.

Every thunderstorm has an updraft (rising air) and a downdraft (sinking air). Sometimes strong downdrafts known as downbursts can cause tremendous wind damage that is similar to that of

[16] ResilientMA: Climate Change Clearing House for the Commonwealth: http://resilientma.org/changes/extreme-weather. Accessed January 29, 2019.

a tornado. A small (less than 2.5 mile path) downburst is known as a “microburst” and a larger downburst is called a “macro-burst.” An organized, fast-moving line of microbursts traveling across large areas is known as a “derecho.” These occasionally occur in Massachusetts. Winds exceeding 100 mph have been measured from downbursts in Massachusetts.

Wind is air in motion relative to surface of the earth. For non-tropical events over land, the NWS issues a Wind Advisory (sustained winds of 31 to 39 mph for at least 1 hour or any gusts 46 to 57 mph) or a High Wind Warning (sustained winds 40+ mph or any gusts 58+ mph). For non-tropical events over water, the NWS issues a small craft advisory (sustained winds 25-33 knots), a gale warning (sustained winds 34-47 knots), a storm warning (sustained winds 48 to 63 knots), or a hurricane force wind warning (sustained winds 64+ knots). For tropical systems, the NWS issues a tropical storm warning for any areas (inland or coastal) that are expecting sustained winds from 39 to 73 mph. A hurricane warning is issued for any areas (inland or coastal) that are expecting sustained winds of 74 mph. Effects from high winds can include downed trees and/or power lines and damage to roofs, windows, and other structural components. High winds can cause scattered power outages. High winds are also a hazard for aircraft.

Location

Severe thunderstorms, wind and microbursts are typically isolated events in Montague, affecting less than 10% of the town.

Extent

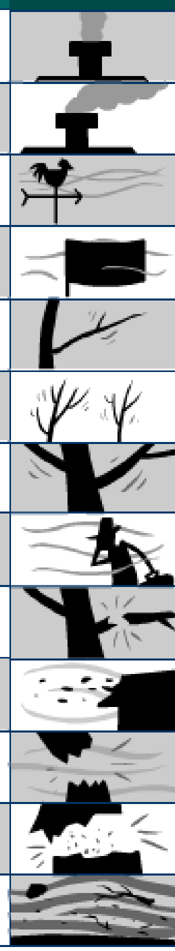
An average thunderstorm is 15 miles across and lasts 30 minutes; severe thunderstorms can be much larger and longer. The severity of thunderstorms can vary widely, from commonplace and short-term events to large-scale storms that result in direct damage and flooding. Thunderstorms can cause hail, wind, and flooding, with widespread flooding the most common characteristic that leads to a storm being declared a disaster. The severity of flooding varies widely based both on characteristics of the storm itself and the region in which it occurs. Lightning can occasionally also present a severe hazard. Southern New England typically experiences 10 to 15 days per year with severe thunderstorms.

Microbursts are typically less than three miles across. They can last anywhere from a few seconds to several minutes. Microbursts cause damaging winds up to 170 miles per hour in strength and can be accompanied by precipitation.

Montague is susceptible to high winds from several types of weather events: before and after frontal systems, hurricanes and tropical storms, severe thunderstorms and tornadoes, and nor'easters. Sometimes, wind gusts of only 40 to 45 mph can cause scattered power outages from downed trees and wires. This is especially true after periods of prolonged drought or excessive rainfall, since both are situations that can weaken the root systems and make them more susceptible to the winds' effects. Winds measuring less than 30 mph are not considered to be hazardous under most circumstances. Wind speeds in a hurricane are measured using the Saffir-Simpson scale. Another scale developed for measuring wind is the Beaufort wind scale (see Figure 3-7).

Figure 3-7: Beaufort Wind Scale

Beaufort number	Wind Speed (mph)	Seaman's term		Effects on Land
0	Under 1	Calm		Calm; smoke rises vertically.
1	1-3	Light Air		Smoke drift indicates wind direction; vanes do not move.
2	4-7	Light Breeze		Wind felt on face; leaves rustle; vanes begin to move.
3	8-12	Gentle Breeze		Leaves, small twigs in constant motion; light flags extended.
4	13-18	Moderate Breeze		Dust, leaves and loose paper raised up; small branches move.
5	19-24	Fresh Breeze		Small trees begin to sway.
6	25-31	Strong Breeze		Large branches of trees in motion; whistling heard in wires.
7	32-38	Moderate Gale		Whole trees in motion; resistance felt in walking against the wind.
8	39-46	Fresh Gale		Twigs and small branches broken off trees.
9	47-54	Strong Gale		Slight structural damage occurs; slate blown from roofs.
10	55-63	Whole Gale		Seldom experienced on land; trees broken; structural damage occurs.
11	64-72	Storm		Very rarely experienced on land; usually with widespread damage.
12	73 or higher	Hurricane Force		Violence and destruction.



Source: Developed in 1805 by Sir Francis Beaufort

Previous Occurrences

Since 1996, a total of 13 high wind events occurred in Franklin County (Table 3-21), causing a total of $288,000 in property damages. High winds are defined by the National Weather Service as sustained non-convective winds of 35 knots (40 mph) or greater lasting for 1 hour or longer, or gusts of 50 knots (58 mph) or greater for any duration. The probability of future high wind events is expected to increase as a result of climate projections for the state that suggest a greater occurrence of severe weather events in the future.

Table 3-21: High Wind Events in Franklin County			
Year	**# of High Wind Events**	**Annual Property Damage**	**Annual Crop Damage**
1996	2	$0	$0
1999	1	$0	$0
2003	2	$130,000	$0
2004	1	$30,000	$0
2005	1	$10,000	$0
2006	3	$68,000	$0
2011	1	$15,000	$0
2013	2	$35,000	$0
Total	**13**	**$288,000**	**$0**

Source: NOAA Storm Events Database: https://www.ncdc.noaa.gov/stormevents/

Thunderstorm winds are defined by the National Weather Service as winds arising from convection (occurring within 30 minutes of lightning being observed or detected) with speeds of at least 50 knots (58 mph), or winds of any speed (non-severe thunderstorm winds below 50 knots) producing a fatality, injury, or damage. Montague has experienced sixteen (16) thunderstorm wind events since 1994 (Table 3-22). These storms resulted in downed trees and wires and caused a total of $158,000 in property damage.

In June of 2008 a microburst caused downed power lines and several fallen trees. In September 2008, severe thunderstorms caused $8,000 in damages from downed trees and wires. A microburst on Dry Hill Road in 2009 caused extensive damage to the area. On May 26, 2010, strong thunderstorm winds caused damages throughout the Connecticut River Valley with numerous trees and wires down and widespread power outages. In Montague, a shelter was opened for victims as power outages lasted for up to 3 or 4 days in some areas of town. Many trees were knocked down, resulting in a three-week clean-up effort to clear roads. Behind the Montague Public Safety Complex, a microburst downed approximately 50 trees. The State knocked down damaged trees in the affected area after the storm, however, the town also had to clean up the area and cut down several more trees. Town crews worked for a week and half on storm clean up. The Town suffered more than $20,000 in damages and costs to clean up from the storm.

On July 30, 2019, the Montague Center area of town suffered damage from a microburst. The storm also impacted the neighboring town of Deerfield. According to the newspaper, Eversource reported 800 power outages from the storm. Nine roads in Montague Center were blocked with downed trees or wires. Town and utility crews worked overnight to clear the roads.[17] Red Fire Farm reported significant damage to crops and greenhouses. As of August 6, 2019, the farm estimates the crop damages from the storm to amount to $54,000.[18]

Table 3-22: Thunderstorm Wind Events in Montague				
Year	**# of Thunderstorm Wind Events**	**Annual Property Damage**	**Annual Crop Damage**	**Event Description**
1994	1	$0	$0	Downed trees
1997	1	$0	$0	
1998	1	$0	$0	
2001	1	$0	$0	Downed trees
2005	1	$5,000	$0	
2006	1	$25,000	$0	
2008	1	$8,000	$0	Downed trees and wires
2010	2	$35,000	$0	Downed trees and wires on Route 63 and Greenfield Road
2012	1	$1,000	$0	Large branches on Turners Falls Road were downed
2015	2	$30,000	$0	Downed trees and wires in multiple locations
2016	3	$45,000	$0	Downed trees and power lines in multiple locations
2017	1	$9,000	$0	Downed trees and wires on Swamp Road and North Leverett Road
2019	1	ND	$54,000	Microburst in Montague Center
Total	**17**	**$158,000**	**$54,000**	

Source: NOAA Storm Events Database: https://www.ncdc.noaa.gov/stormevents/; Red Fire Farm website: https://www.redfirefarm.com/about/microburst-cleanup-fundraiser/ accessed October 21, 2019.

Secondary hazards of thunderstorms and severe weather include lightning and hail. In Franklin

[17] "Microburst Wreaks Havoc in Deerfield, Montague," The Recorder newspaper, July 31, 2019.
[18] Red Fire Farm website: https://www.redfirefarm.com/about/microburst-cleanup-fundraiser/ Accessed October 21, 2019.

County, 22 lightning events since 1997 caused a total of $835,500 in property damages (Table 3-23). In Montague, in July 2018, lightning struck a house on K Street, resulting in a house fire and one injury. According to the Committee, the house had to be completely rebuilt. In August 2018, lightning caused a house fire near Route 63. Together these two events caused $13,000 in reported property damage, but as noted, actual damages were much higher.

Table 3-23: Lightning Events in Franklin County

Year	# of Lightning Events	Annual Property Damage	Annual Crop Damage
1997	1	$3,000	$0
2001	1	$20,000	$0
2002	1	$15,000	$0
2004	1	$35,000	$0
2005	1	$50,000	$0
2008	1	$10,000	$0
2010	2	$25,000	$0
2012	1	$500,000	$0
2013	4	$49,000	$0
2014	3	$93,000	$0
2018	6	$35,500	$0
Total	**22**	**$835,500**	**$0**

Source: NOAA Storm Events Database: https://www.ncdc.noaa.gov/stormevents/

A total of 42 hail events have been reported in Franklin County since 1998 (Table 3-24). Property damage was only recorded for one event, in the amount of $5,000. One hail event in 2008 resulted in $50,000 in crop damages. Pea to marble size hail fell in a swath from Colrain to Shelburne damaging apple and peach orchards. An estimated 45 acres of apples and two to three acres of peaches were damaged by the hail.

Table 3-24: Hail Events in Franklin County

Year	# of Hail Events	Annual Property Damage	Annual Crop Damage
1998	4	$0	$0
2000	1	$0	$0
2001	1	$0	$0
2003	1	$0	$0
2004	2	$0	$0
2005	3	$5,000	$0
2007	5	$0	$0
2008	7	$0	$50,000

2009	2	$0	$0
2010	4	$0	$0
2011	4	$0	$0
2012	1	$0	$0
2013	3	$0	$0
2017	3	$0	$0
2018	1	$0	$0
Total	**42**	**$5,000**	**$50,000**

Source: NOAA Storm Events Database: https://www.ncdc.noaa.gov/stormevents/

Probability of Future Events

According to the National Weather Service, Massachusetts experiences between 20 to 30 thunderstorm days each year. Based on past occurrences, there is a "very high" probability (50% - 100% chance) of a severe thunderstorm or winds affecting the town in a given year. Climate change is expected to increase the frequency and intensity of thunderstorms and other severe weather.

Impact

The entire town of Montague is vulnerable to high winds that can cause extensive damage. The U.S. is divided into four wind zones. States located in Wind Zone IV have experienced the greatest number of tornadoes and the strongest tornadoes. The Commonwealth is located within Wind Zone II, which includes wind speeds up to 180 mph. The entire Commonwealth is also located within the hurricane-susceptible region, and the western portion of the Commonwealth is located within the special wind region, in which wind-speed anomalies are present and additional consideration of the wind hazard is warranted. The entire town of Montague can experience the effect and impact from severe thunderstorms, microbursts, and hail. The magnitude of impact of a severe thunderstorm event can be "Critical," with more than 25% of property in the affected area damaged or destroyed.

Vulnerability

Society

The entire population of Montague is considered exposed to high-wind and thunderstorm events. Downed trees, damaged buildings, and debris carried by high winds can lead to injury or loss of life. Populations located outdoors are considered at risk and more vulnerable to many storm impacts, particularly lightning strikes, compared to those who are located inside. Moving to a lower risk location will decrease a person's vulnerability.

Vulnerable Populations

Socially vulnerable populations are most susceptible to severe weather based on a number of factors, including their physical and financial ability to react or respond during a hazard, and the location and construction quality of their housing. In general, vulnerable populations include people over the age of 65, the elderly living alone, people with low socioeconomic status, people with low English language fluency, people with limited mobility or a life-threatening illness, and people who lack transportation or are living in areas that are isolated from major roads. The isolation of these populations is a significant concern.

Table 3-25 estimates the number of vulnerable populations and households in Montague. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of Montague residents during a severe weather event.

Table 3-25: Estimated Vulnerable Populations in Montague		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	1,745	21%
Population with a Disability	1,477	18%
Population who Speak English Less than "Very Well"	522	6%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	1,307	35%
Householder Age 65 Years and Over Living Alone	465	12%
Households Without Access to a Vehicle	408	11%
Households Living in a Home Built Prior to 1970	2,894	71%
Households Living in a Mobile Home	67	2%

*Total population = 8,311; Total households = 3,786

Note: Individuals and households may be counted under multiple categories.

Source: U.S. Census American Community Survey 2013-2017 Five-Year Estimates.

The Committee also noted the age of buildings and homes in Montague as a concern. An estimated 2,894 housing units in town were built prior to State building codes went into effect. In particular, buildings in the downtown areas of Turners Falls and Millers Falls may be vulnerable to damage from wind. A number of buildings have suffered from deferred maintenance, and both downtowns have areas designated as Slum and Blighted, according to guidelines established by the Massachusetts Department of Housing and Community Development (DHCD).

Power outages can be life-threatening to those dependent on electricity for life support. Power outages may also result in inappropriate use of combustion heaters, cooking appliances and generators in indoor or poorly ventilated areas, leading to increased risks of carbon monoxide poisoning. People who work or engage in recreation outdoors are also vulnerable to severe weather.

Montague MVP workshop participants identified the safety and well-being of vulnerable populations as a concern and challenge in town. Specific concerns include:

- Community Action's preschool in the Patch neighborhood is vulnerable if evacuation is required, given the limited access to the neighborhood.
- Currently, children living within 1.5 miles of the elementary school are not provided bus transportation to school. Children walking to school can be exposed to extreme weather. The conditions of sidewalks and crossings are also a concern.
- The homeless population has less access to information about impending hazards, and in some cases may not want to be contacted or stay in shelters.
- Non-English speaking residents in Turners Falls and Millers Falls have tight-knit communities that help each other during emergencies. However, Town officials have limited capacity to communicate with non-English speaking residents.

<u>Health Impacts</u>

Both high winds and thunderstorms present potential safety impacts for individuals without access to shelter during these events. Extreme rainfall events can also affect raw water quality by increasing turbidity and bacteriological contaminants leading to gastrointestinal illness. Additionally, research has found that thunderstorms may cause the rate of emergency room visits for asthma to increase to 5 to 10 times the normal rate.[19] Much of this phenomenon is attributed to the stress and anxiety that many individuals, particularly children, experience during severe thunderstorms. The combination of wind, rain, and lightning from thunderstorms with pollen and mold spores can exacerbate asthma. The rapidly falling air temperatures characteristic of a thunderstorm as well as the production of nitrogen oxide gas during lightning

[19] (Andrews, 2012).

strikes have also both been correlated with asthma.

Economic Impacts

Wind storms and severe thunderstorms events may impact the economy, including direct building losses and the cost of repairing or replacing the damage caused to the building. Additional economic impacts may include loss of business functions, water supply system damage, inventory damage, relocation costs, wage losses, and rental losses due to the repair/replacement of buildings. Agricultural losses due to lightning and the resulting fires can be extensive. Lightning can be responsible for damage to buildings; can cause electrical, forest and/or wildfires; and can damage infrastructure, such as power transmission lines and communication towers.

Recovery and clean-up costs can also be costly, resulting in further economic impacts. Prolonged obstruction of major routes due to secondary hazards such as landslides, debris, or floodwaters can disrupt the shipment of goods and other commerce. Large, prolonged storms can have negative economic impacts on an entire region.

Because of differences in building construction, residential structures are generally more susceptible to wind damage than commercial and industrial structures. Wood and masonry buildings in general, regardless of their occupancy class, tend to experience more damage than concrete or steel buildings. Mobile homes are the most vulnerable to damage, even if tied down, and offer little protection to people inside.

Infrastructure

Damage to buildings is dependent upon several factors, including wind speed, storm duration, path of the storm track, and building construction. According to the Hazus wind model,[20] direct wind-induced damage (wind pressures and windborne debris) to buildings is dependent upon the performance of components and cladding, including the roof covering (shingles, tiles, membrane), roof sheathing (typically wood-frame construction only), windows, and doors, and is modeled as such. Structural wall failures can occur for masonry and wood-frame walls, and uplift of whole roof systems can occur due to failures at the roof/wall connections. Foundation failures (i.e., sliding, overturning, and uplift) can potentially take place in manufactured homes.

Massachusetts is divided into three design wind speeds for four risk categories, the limits of which are defined by the Massachusetts State Building Code (9th Edition). National wind data prepared by the American Society of Civil Engineers serve as the basis of these wind design

[20] https://www.fema.gov/hazus-mh-hurricane-wind-model

requirements ("Minimum Design Loads for Buildings and Other Structures," American Society of Civil Engineers ASCE-7). Generally speaking, structures should be designed to withstand the total wind load of their location. Montague falls within the 90 mph wind load zone. Refer to the State Building Code (9th Edition [780 CMR] Chapter 16 Structural Design, as amended by Massachusetts) for appropriate reference wind pressures, wind forces on roofs, and similar data.

All elements of the built environment are exposed to severe weather events such as high winds and thunderstorms. Table 3-26 identifies the assessed value of all residential, open space, commercial, and industrial land uses in Town, and the losses that would result from 1%, 5%, and 10% damage to this inventory as a result of high winds or a severe thunderstorm.

Table 3-26: Estimated Potential Loss by Tax Classification

Tax Classification	Total Assessed Value FY2019	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$594,091,351	$5,940,914	$29,704,568	$59,409,135
Open Space	$0	$0	$0	$0
Commercial	$35,125,445	$351,254	$1,756,272	$3,512,545
Industrial	$160,768,052	$1,607,681	$8,038,403	$16,076,805
Total	**$789,984,848**	**$7,899,848**	**$39,499,242**	**$78,998,485**

Source: Massachusetts Department of Revenue - Division of Local Services, Municipal Databank/Local Aid Section.

<u>Agriculture</u>

Forestry species and agricultural crops, equipment, and infrastructure may be directly impacted by high winds. Trees are also vulnerable to lightning strikes.

<u>Energy</u>

The most common problem associated with severe weather is loss of utilities. Severe windstorms causing downed trees can create serious impacts on power and aboveground communication lines. Downed power lines can cause blackouts, leaving large areas isolated. Loss of electricity and phone connections would leave certain populations isolated because residents would be unable to call for assistance. Additionally, the loss of power can impact heating or cooling provision to citizens (including the young and elderly, who are particularly vulnerable to temperature-related health impacts).

Utility infrastructure (power lines, gas lines, electrical systems) could suffer damage, and impacts can result in the loss of power, which can impact business operations. After an event, there is a risk of fire, electrocution, or an explosion.

<u>Public Safety</u>

Public safety facilities and equipment may experience a direct loss (damage) from high winds.

<u>Transportation</u>

Roads may become impassable due to flash or urban flooding, downed trees and power lines, or due to landslides caused by heavy, prolonged rains. Impacts to transportation lifelines affect both short-term (e.g., evacuation activities) and long-term (e.g., day-to-day commuting) transportation needs.

<u>Water & Wastewater Infrastructure</u>

The hail, wind, and flash flooding associated with thunderstorms and high winds can cause damage to water infrastructure. Flooding can overburden stormwater, drinking water, and wastewater systems. Water and sewer systems may not function if power is lost.

Environment

As described under other hazards, such as hurricanes and severe winter storms, high winds can defoliate forest canopies and cause structural changes within an ecosystem that can destabilize food webs and cause widespread repercussions. Direct damage to plant species can include uprooting or total destruction of trees and an increased threat of wildfire in areas of tree debris. High winds can also erode soils, which can damage both the ecosystem from which soil is removed as well as the system on which the sediment is ultimately deposited.

Environmental impacts of extreme precipitation events are discussed in depth in the Flooding section, and often include soil erosion, the growth of excess fungus or bacteria, and direct impacts to wildlife. For example, research by the Butterfly Conservation Foundation shows that above average rainfall events have prevented butterflies from successfully completing their mating rituals, causing population numbers to decline. Harmful algal blooms and associated neurotoxins can also be a secondary hazard of extreme precipitation events as well as heat. Public drinking water reservoirs may also be damaged by widespread winds uprooting watershed forests and creating serious water quality disturbances.

Vulnerability Summary

Based on the above assessment, Montague has a "High" vulnerability to severe thunderstorms and wind events. Thunderstorms are common in New England, and can impact property, crops, utilities and the population of Montague. Microbursts are less common, but can cause significant damage when they do occur. The cascade effects of severe storms include utility losses and transportation accidents and flooding. Particular areas of vulnerability include low-income and elderly populations, trailer homes, and infrastructure such as roadways and utilities that can be damaged by such storms and the low-lying areas that can be impacted by flooding. The following problem statements summarize Montague's areas of greatest concern regarding severe thunderstorms and wind events.

Severe Thunderstorm / Wind Hazard Problem Statements
• Children walking to school are vulnerable to thunderstorms and high wind events.
• Community Action's pre-school in the Patch neighborhood could be vulnerable if a hazard required evacuation, given limited access to the neighborhood.
• The Town needs additional capabilities to identify elders who need oxygen and other specialized medical equipment or support services during emergencies.
• Homeless and transient people in town are difficult to reach in the event of an emergency.
• The Town lacks capacity to communicate with Non-English speaking populations during emergencies.
• Emergency Communication Systems need to be enhanced with radio and cell towers in the eastern and southeastern part of town. The radio communication system at Turners Falls High School needs improvements, including the installation of repeaters.
• Turners Falls High School, which serves as the regional shelter, needs improved infrastructure for back-up water and power and air conditioning.
• Bridges in town serve as important access and evacuation routes but are badly in need of repair. The General Pierce Bridge connecting Montague with Greenfield is a high priority as it is a primary emergency route. Only one of the eight bridges accessing the canal district and "The Patch" neighborhood in Turners Falls is fully functional, posing a public safety concern. Evacuating residents may be difficult in the event that any or all of these compromised bridges are impacted by flooding and have to be closed during an emergency.
• The age and condition of buildings and homes in Montague is a concern. An estimated 2,894 housing units in town were built prior to State building codes went into effect. Areas of Turners Falls and Millers Falls are designated Slum and Blighted.
• Agricultural operations are susceptible to wind and hail damage.

3.7 TORNADOES

Potential Impacts of Climate Change

Climate change is expected to increase the frequency and intensity of severe weather, which can include tornadoes. However, tornadoes are too small to be simulated well by climate models. Therefore, specific predictions about how this hazard will change are not possible, given current technical limitations. As discussed in other sections in this Plan, the conditions that are conducive to tornadoes (which are also conducive to other weather phenomena, such as hurricanes and tropical storms) are expected to become more severe under global warming.

Figure 3-6: Impacts of Climate Change on Tornadoes

Potential Effects of Climate Change		
	EXTREME WEATHER ➔ INCREASE IN FREQUENCY AND INTENSITY OF SEVERE THUNDERSTORMS	Future environmental changes may result in an increase in the frequency and intensity of severe thunderstorms, which can include tornadoes. However, the resolution of current climate models is too coarse to accurately simulate tornado formation and the confidence on model details associated with this potential increase is low.

Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Hazard Description

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

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

Tornadoes can form from individual cells within severe thunderstorm squall lines. They can also form from an isolated supercell thunderstorm. They can be spawned by tropical cyclones or the remnants thereof, and weak tornadoes can even occur from little more than a rain shower if air is converging and spinning upward. Most tornadoes occur in the late afternoon and evening hours, when the heating is the greatest. The most common months for tornadoes to occur are June, July, and August, although the Conway, Massachusetts, tornado (2017) occurred in February.

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

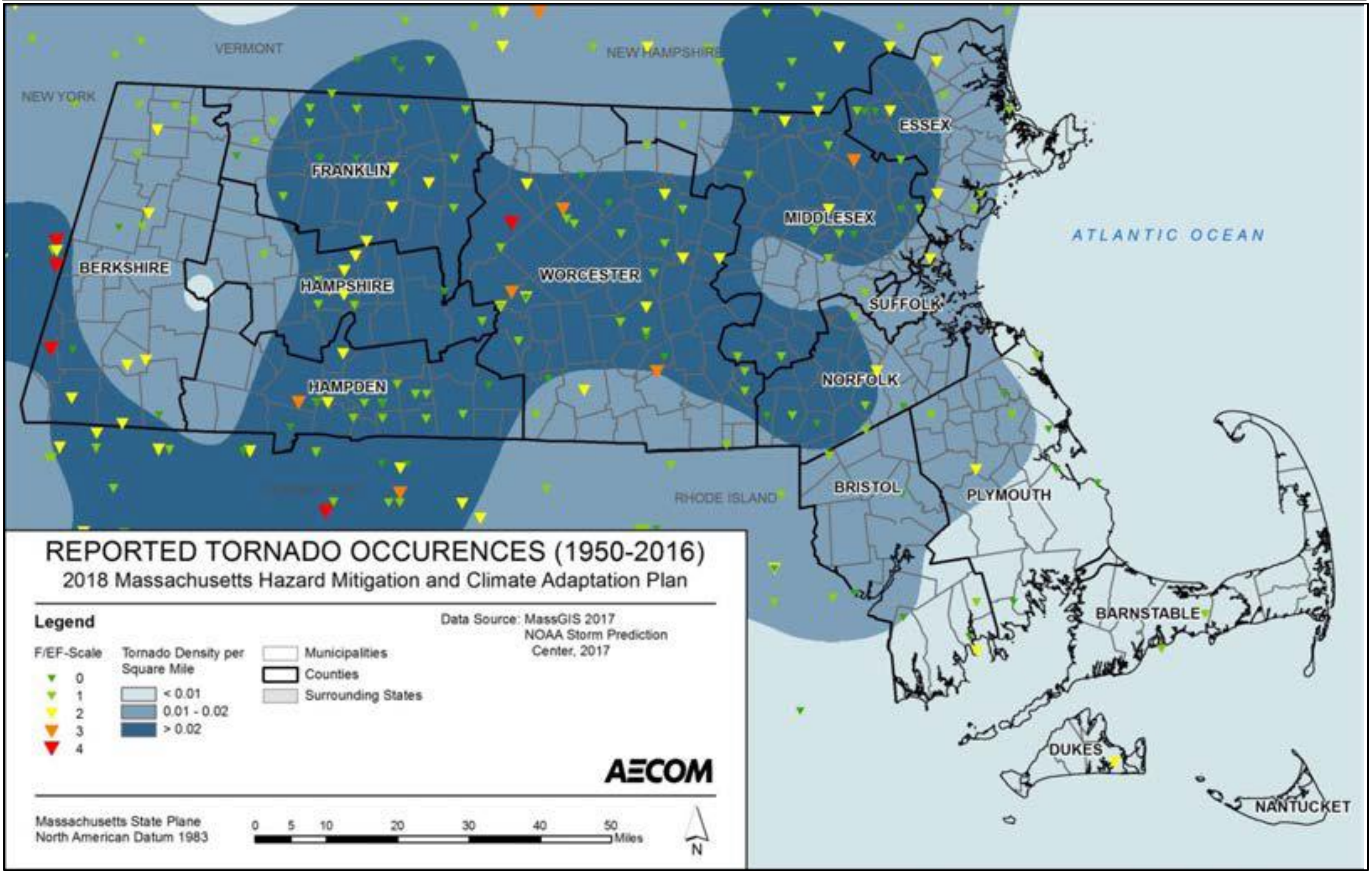
Location

Figure 3-7 illustrates the reported tornado occurrences, based on all-time initial touchdown locations across the Commonwealth as documented in the NOAA NCDC Storm Events Database. ArcGIS was used to calculate an average score per square mile. The analysis indicated that the area at greatest risk for a tornado touchdown runs from central to northeastern Massachusetts, and includes Montague and much of Franklin County. Tornadoes are rated as having an Area of Occurrence of "Isolated." If a tornado were to occur in Montague, it would likely impact less than 10% of the town.

Extent

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

Figure 3-7: Density of Reported Tornadoes per Square Mile



Source: NOAA Storm Prediction Center (SPC), as presented in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, September 2018.

Figure 3-8: Enhanced Fujita Scale & Guide to Tornado Severity

Scale	Wind Speed Estimate		Potential damage	Example of Damage
	mph	km/h		
EF0	65–85	105–137	Minor damage. Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over. Confirmed tornadoes with no reported damage (i.e., those that remain in open fields) are always rated EF0.	
EF1	86–110	138–177	Moderate damage. Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.	
EF2	111–135	178–217	Considerable damage. Roofs torn off from well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.	
EF3	136–165	218–266	Severe damage. Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations are badly damaged.	
EF4	166–200	267–322	Devastating damage. Well-constructed and whole frame houses completely leveled; some frame homes may be swept away; cars and other large objects thrown and small missiles generated.	
EF5	>200	>322	Incredible damage. Strong-framed, well-built houses leveled off foundations and swept away; steel-reinforced concrete structures are critically damaged; tall buildings collapse or have severe structural deformations; cars, trucks, and trains can be thrown approximately 1 mile (1.6 km).	

Source: Wikipedia: https://en.wikipedia.org/wiki/Enhanced_Fujita_scale

Previous Occurrences

Since the 1950s, there have been over twenty tornadoes in Franklin County. In the last two decades, five tornadoes have been reported in Franklin County, in the towns of Heath, Charlemont, Wendell, New Salem, and Conway (Table 3-27). The July 2006 tornado in Wendell also affected parts of Montague on the border with Wendell, knocking down trees on Wendell Road. The February 2017 tornado in the center of Conway was the most destructive, impacting forests and causing major property damage to several homes, barns, and a church that subsequently had to be torn down. Miraculously, no deaths or serious injuries were reported.

Table 3-27: Tornado Events in Franklin County				
Date	**Severity**	**Property Damage**	**Crop Damage**	**Event Narrative**
7/3/1997	F1	$50,000	$0	A tornado touched down just west of Number Nine Road in Heath and then skipped along a path which ended about a mile into northwest Colrain. Many large trees were uprooted or snapped at their mid levels. A silo was destroyed and part of the roof of an attached barn was peeled back. A hay tractor was flipped over with its wheels in the air. Doors to a garage were blown in and the roof was partially ripped off. The tornado affected mostly wooded terrain and did extensive tree damage when it passed through a state forest. The path width was up to 100 yards. There were no injuries.
7/3/1997	F1	$50,000	$0	A tornado touched down in the eastern part of Charlemont and travelled east causing damage to a campground. Fifteen trailers were damaged from falling trees and flying debris. Two of the trailers were severely damaged and one was destroyed with seven trees falling on top of it. Eyewitnesses reported rotation in the clouds and debris. The tornado then moved through the higher terrain of the Catamount State Forest. The path was discontinuous and ranged in width from 50 to 100 yards. The tornado path ended in the Copeland Hills section of Colrain. There were no direct injuries reported.
7/11/2006	F2	$200,000	$0	Brief F2 touchdown in Wendell and Montague
9/1/2013	EF0	$0	$0	A Massachusetts Department of Conservation and Recreation employee observed a waterspout on Quabbin Reservoir in New Salem, MA. He was able to snap two pictures of the storm, one showing a funnel and another showing the funnel extended down to the water. The waterspout was very short lived, never hit land, and did no damage and injured no people. Winds aloft were not conducive for tornadic

Table 3-27: Tornado Events in Franklin County				
Date	**Severity**	**Property Damage**	**Crop Damage**	**Event Narrative**
				development, but the environment was unstable and a surface front was moving through the region.
2/25/2017	EF1	$400,000	$0	This tornado touched down at 7:23 pm on Main Poland Road in western Conway, Massachusetts. The path width started at 50 yards, with a sharp gradient evident of damage versus no damage. Large sections of forest had thick pine trees snapped at mid-tree. Numerous power lines were downed along the path into downtown Conway. The path width grew, reaching a maximum width of 200 yards near the town hall. Several houses were severely damaged on Whately Road, southeast of the town hall. Roofs were blown off, and in one case the side walls of a house were missing with the interior of the house exposed. On Hill View Road a large barn collapsed. One injury occurred when a tree landed on a house on South Deerfield Road east of town. That was where the visible damage path ended.

Source: NOAA Storm Events Database: https://www.ncdc.noaa.gov/stormevents/

Probability of Future Events

As highlighted in the National Climate Assessment, tornado activity in the U.S. has become more variable, and increasingly so in the last 2 decades. While the number of days per year that tornadoes occur has decreased, the number of tornadoes on these days has increased. Climate models show projections that the frequency and intensity of severe thunderstorms (which include tornadoes, hail, and winds) will increase. Based on past occurrences, there is a "Moderate" probability (a 2% to 25% chance) of a tornado affecting the town in a given year.

Impact

Tornadoes are potentially the most dangerous of local storms, depending on where they touch down. A tornado in the forested area east of Route 63 in Montague would cause limited damage. If a major tornado were to strike in the populated areas of Montague, however, damage could be widespread. Fatalities could be high; many people could be displaced for an extended period of time; buildings could be damaged or destroyed; businesses could be forced to close for an extended period of time or even permanently; and routine services, such as telephone or power, could be disrupted. The severity of impact of a tornado event is "Critical," with more than 25% of property in the affected area damaged or destroyed.

Vulnerability

Society

The entire town of Montague has the potential for tornado formation, and is located in the area within Massachusetts described above as having higher-than-average tornado frequency. Residents of impacted areas may be displaced or require temporary to long-term shelter due to severe weather events. In addition, downed trees, damaged buildings, and debris carried by high winds can lead to injury or loss of life.

<u>Vulnerable Populations</u>

In general, vulnerable populations include people over the age of 65, people with low socioeconomic status, people with low English language fluency, people with compromised immune systems, and residents living in areas that are isolated from major roads. Power outages can be life-threatening to those who are dependent on electricity for life support and can result in increased risk of carbon monoxide poisoning. Individuals with limited communication capacity, such as those with limited internet or phone access, may not be aware of impending tornado warnings. The isolation of these populations is also a significant concern, as is the potential insufficiency of older or less stable housing to offer adequate shelter from tornadoes. Residents living in mobile homes are at increased risk to tornadoes.

An estimated 2,894 housing units in Montague, or 71% of all housing units in town, were built prior to the 1970s when the first building code went into effect in Massachusetts. An estimated 67 mobile homes are located in Montague, accounting for 2% of the total housing stock.[21] Table 3-28 estimates the number of vulnerable populations and households in Montague. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of Montague residents during a tornado event.

---

[21] U.S. Census Bureau 2013-2017 American Community Survey five-year estimates.

Table 3-28: Estimated Vulnerable Populations in Montague		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	1,745	21%
Population with a Disability	1,477	18%
Population who Speak English Less than "Very Well"	522	6%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	1,307	35%
Householder Age 65 Years and Over Living Alone	465	12%
Households Without Access to a Vehicle	408	11%
Households Living in a Home Built Prior to 1970	2,894	71%
Households Living in a Mobile Home	67	2%

*Total population =8,311; Total households = 3,786
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2013-2017 Five-Year Estimates.

Montague MVP workshop participants identified the safety and well-being of vulnerable populations as a concern and challenge in town. Specific concerns include:

- Community Action's preschool in the Patch neighborhood is vulnerable if evacuation is required, given the limited access to the neighborhood.
- Currently, children living within 1.5 miles of the elementary school are not provided bus transportation to school. Children walking to school can be exposed to extreme weather. The conditions of sidewalks and crossings are also a concern.
- The homeless population has less access to information about impending hazards, and in some cases may not want to be contacted or stay in shelters.
- Non-English speaking residents in Turners Falls and Millers Falls have tight-knit communities that help each other during emergencies. However, Town officials have limited capacity to communicate with non-English speaking residents.

Health Impacts

The primary health hazard associated with tornadoes is the threat of direct injury from flying debris or structural collapse as well as the potential for an individual to be lifted and dropped by the tornado's winds. After the storm has subsided, tornadoes can present unique challenges to search and rescue efforts because of the extensive and widespread distribution of debris. The distribution of hazardous materials, including asbestos-containing building materials, can present an acute health risk for personnel cleaning up after a tornado disaster and for residents in the area. The duration of exposure to contaminated material may be far longer if drinking water reservoir or groundwater aquifers are contaminated. According to the EPA, properly designed storage facilities for hazardous materials can reduce the risk of those materials being spread during a tornado. Many of the health impacts described for other types of storms, including lack of access to a hospital, carbon monoxide poisoning from generators, and mental health impacts from storm-related trauma, could also occur as a result of tornado activity.

Economic Impacts

Tornado events are typically localized; however, in those areas, economic impacts can be significant. Types of impacts may include loss of business functions, water supply system damage, damage to inventories, relocation costs, wage losses, and rental losses due to the repair or replacement of buildings. Recovery and clean-up costs can also be costly. The damage inflicted by historical tornadoes in Massachusetts varies widely, but the average damage per event is approximately $3.9 million.

Because of differences in building construction, residential structures are generally more susceptible to tornado damage than commercial and industrial structures. Wood and masonry buildings in general, regardless of their occupancy class, tend to experience more damage than concrete or steel buildings. Mobile homes are the most vulnerable to damage, even if tied down, and offer little protection to people inside.

Infrastructure

All critical facilities and infrastructure in Montague are exposed to tornado events. Table 3-29 identifies the assessed value of all residential, open space, commercial, and industrial land uses in Town, and the losses that would result from 1%, 5%, and 10% damage to this inventory as a result of a tornado.

Table 3-29: Estimated Potential Loss by Tax Classification				
Tax Classification	**Total Assessed Value FY2019**	**1% Damage Loss Estimate**	**5% Damage Loss Estimate**	**10% Damage Loss Estimate**
Residential	$594,091,351	$5,940,914	$29,704,568	$59,409,135
Open Space	$0	$0	$0	$0
Commercial	$35,125,445	$351,254	$1,756,272	$3,512,545
Industrial	$160,768,052	$1,607,681	$8,038,403	$16,076,805
Total	**$789,984,848**	**$7,899,848**	**$39,499,242**	**$78,998,485**

Source: Massachusetts Department of Revenue - Division of Local Services, Municipal Databank/Local Aid Section.

<u>Agriculture</u>

Forestry species and agricultural crops, equipment, and infrastructure may be directly impacted by tornadoes.

<u>Energy</u>

High winds could down power lines and poles adjacent to roads. Damage to above-ground transmission infrastructure can result in extended power outages.

<u>Public Safety</u>

Public safety facilities and equipment may experience direct loss (damage) from tornadoes. Shelters and other critical facilities that provide services for people whose property is uninhabitable following a tornado may experience overcrowding and inadequate capacity to provide shelter space and services.

<u>Transportation</u>

Incapacity and loss of roads and bridges are the primary transportation failures resulting from tornadoes, and these failures are primarily associated with secondary hazards, such as landslide events. Tornadoes can cause significant damage to trees and power lines, blocking roads with debris, incapacitating transportation, isolating populations, and disrupting ingress and egress. Of particular concern are bridges and roads providing access to isolated areas and to the elderly. Prolonged obstruction of major routes due to secondary hazards, such as landslides, debris, or floodwaters, can disrupt the shipment of goods and other commerce. If the tornado is strong enough to transport large debris or knock out infrastructure, it can create serious impacts on power and aboveground communication lines.

<u>Water & Wastewater Infrastructure</u>

The hail, wind, debris, and flash flooding associated with tornadoes can cause damage to infrastructure, such as storage tanks, hydrants, residential pumping fixtures, and distribution systems. Water and wastewater utilities are also vulnerable to potential contamination due to chemical leaks from ruptured containers. Ruptured service lines in damaged buildings and broken hydrants can lead to loss of water and pressure.

Environment

Direct impacts may occur to flora and fauna small enough to be uprooted and transported by the tornado. Even if the winds are not sufficient to transport trees and other large plants, they may still uproot them, causing significant damage to the surrounding habitat. As felled trees decompose, the increased dry matter may increase the threat of wildfire in vegetated areas. Additionally, the loss of root systems increases the potential for soil erosion.

Disturbances created by blowdown events may also impact the biodiversity and composition of the forest ecosystem. Invasive plant species are often able to quickly capitalize on the resources (such as sunlight) available in disturbed and damaged ecosystems. This enables them to gain a foothold and establish quickly with less competition from native species. In addition to damaging existing ecosystems, material transported by tornadoes can also cause environmental havoc in surrounding areas. Particular challenges are presented by the possibility of asbestos-contaminated building materials or other hazardous waste being transported to natural areas or bodies of water, which could then become contaminated. Public drinking water reservoirs may also be damaged by widespread winds uprooting watershed forests and creating serious water quality disturbances.

Vulnerability Summary

Overall, Montague has a “Medium” vulnerability to tornadoes. Tornadoes are not common occurrences in Montague, but can cause significant damage when they do occur. The cascade effects of tornadoes include utility losses and transportation accidents and flooding. Losses associated with the flood hazard are discussed earlier in this section. Particular areas of vulnerability include low-income and elderly populations, homeless populations, non-English speaking populations, residents in mobile homes, and infrastructure such as roadways and utilities that can be damaged by such storms and the low-lying areas that can be impacted by flooding. The following problem statements summarize Montague’s areas of greatest concern regarding tornadoes.

Tornado Hazard Problem Statements
• The age and condition of buildings and homes in Montague is a concern. An estimated 67 mobile homes are located in Montague, and 2,894 housing units in town were built prior to State building codes went into effect. Areas of Turners Falls and Millers Falls are designated Slum and Blighted.
• Children walking to school are vulnerable to tornado events.
• Community Action's pre-school in the Patch neighborhood could be vulnerable if a hazard required evacuation, given limited access to the neighborhood.
• The Town needs additional capabilities to identify elders who need oxygen and other specialized medical equipment or support services during emergencies.
• Homeless and transient people in town are difficult to reach in the event of an emergency.
• The Town lacks capacity to communicate with Non-English speaking populations during emergencies.
• Emergency Communication Systems need to be enhanced with radio and cell towers in the eastern and southeastern part of town. The radio communication system at Turners Falls High School needs improvements, including the installation of repeaters.
• Turners Falls High School, which serves as the regional shelter, needs improved infrastructure for back-up water and power and air conditioning.
• Bridges in town serve as important access and evacuation routes but are badly in need of repair. The General Pierce Bridge connecting Montague with Greenfield is a high priority as it is a primary emergency route. Only one of the eight bridges accessing the canal district and "The Patch" neighborhood in Turners Falls is fully functional, posing a public safety concern. Evacuating residents may be difficult in the event that any or all of these compromised bridges are impacted by a tornado or flooding and have to be closed during an emergency.

3.8 WILDFIRE

Potential Impacts of Climate Change

Climate change has the potential to affect multiple elements of the wildfire system: fire behavior, ignitions, fire management, and vegetation fuels. Periods of hot, dry weather create the highest fire risk. Therefore, the predicted increase in average and extreme temperatures in the Commonwealth may intensify wildfire danger by warming and drying out vegetation. A recent study published in *the Proceedings of the National Academy of Sciences* found that climate change has likely been a significant contributor to the expansion of wildfires in the western U.S., which have nearly doubled in extent in the past three decades.[22] Another study found that the frequency of lightning strikes—an occasional cause of wildfires—could increase by approximately 12 percent for every degree Celsius of warming.[23] Finally, the year-round increase in temperatures is likely to expand the duration of the fire season.

Climate change is also interacting with existing stressors to forests, making them more vulnerable to wildfire. Drought, invasive species, and extreme weather events, all can lead to more dead, downed, or dying trees, increasing the fire load in a forest.

Figure 3-9: Impacts of Climate Change on Wildfires

Potential Effects of Climate Change		
	RISING TEMPERATURES AND CHANGES IN PRECIPITATION ➔ PROLONGED DROUGHT	Seasonal drought risk is projected to increase during summer and fall in the Northeast as higher temperatures lead to greater evaporation and earlier winter and spring snowmelt, coupled with more variable precipitation patterns. Drought and warmer temperatures may also heighten the risk of wildfire, by causing forested areas to dry out and become more flammable.
	RISING TEMPERATURES ➔ MORE FREQUENT LIGHTNING	Research has found that the frequency of lightning strikes – an occasional cause of wildfires – could increase by approximately 12 percent for every degree Celsius of warming.

Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Hazard Description

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

[22] Abatzoglou and Williams, 2016
[23] Romps et al., 2014

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

Fire Ecology and Wildfire Behavior

The "wildfire behavior triangle" reflects how three primary factors influence wildfire behavior: fuel, topography, and weather. Each point of the triangle represents one of the three factors, and arrows along the sides represent the interplay between the factors. For example, drier and warmer weather with low relative humidity combined with dense fuel loads and steeper slopes can result in dangerous to extreme fire behavior.

How a fire behaves primarily depends on the characteristics of available fuel, weather conditions, and terrain, as described below.

- Fuel:
  - Lighter fuels such as grasses, leaves, and needles quickly expel moisture and burn rapidly, while heavier fuels such as tree branches, logs, and trunks take longer to warm and ignite.
  - Snags and hazard trees, especially those that are diseased or dying, become receptive to ignition when influenced by environmental factors such as drought, low humidity, and warm temperatures.
- Weather:
  - Strong winds, especially wind events that persist for long periods or ones with significant sustained wind speeds, can exacerbate extreme fire conditions or accelerate the spread of wildfire.
  - Dry spring and summer conditions, or drought at any point of the year, increases fire risk. Similarly, the passage of a dry, cold front through the region can result in sudden wind speed increases and changes in wind direction.
  - Thunderstorms in Massachusetts are usually accompanied by rainfall; however, 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.
- Terrain:

- Topography of a region or a local area influences the amount and moisture of fuel.
- Barriers such as highways and lakes can affect the spread of fire.
- Elevation and slope of landforms can influence fire behavior because fire spreads more easily uphill compared to downhill.

The wildland-urban interface is the line, area, or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels. There are a number of reasons that the wildland-urban interface experiences an increased risk of wildfire damage. Access and fire suppression issues on private property in the wildland-urban interface can make protecting structures from wildfires difficult. This zone also faces increased risk because structures are built in densely wooded areas, so fires started on someone's property are more easily spread to the surrounding forest.

Fire is also used extensively as a land management tool to replicate natural fire cycles, and it has been used to accomplish both fire-dependent ecosystem restoration and hazard fuel mitigation objectives on federal, state, municipal, and private lands in Massachusetts since the 1980s. for example, over the past 20 years, the Massachusetts Division of Fisheries and Wildlife (MassWildlife) has used a combination of tree harvesting, shrub mowing, and prescribed burning to benefit rare species and to reduce the risk of a catastrophic wildfire in the Montague Plains Wildlife Management Area, a rare pitch pine-scrub oak forest in Montague. Approximately 880 acres have been treated since 2004 to restore woodland and shrubland habitats.[24]

In Massachusetts, the DCR Bureau of Forest Fire Control is the state agency responsible for protecting 3.5 million acres of state, public, and private wooded land and for providing aid, assistance, and advice to the Commonwealth's cities and towns. The Bureau coordinates efforts with a number of entities, including fire departments, local law enforcement agencies, the Commonwealth's county and statewide civil defense agencies, and mutual aid assistance organizations.

Bureau units respond to all fires that occur on state-owned forestland and are available to municipal fire departments for mutual assistance. Bureau firefighters are trained in the use of forestry tools, water pumps, brush breakers, and other motorized equipment, as well as in fire behavior and fire safety. Massachusetts also benefits from mutual aid agreements with other state and federal agencies. The Bureau is a member of the Northeastern Forest Fire Protection

[24] "Background information on Montague Plains Wildlife Management Area," MA Division of Fisheries and Wildlife, as published in the *2018 Montague Open Space and Recreation Plan*.

Commission, a commission organized in 1949 by the New England states, New York, and four eastern Canadian Provinces to provide resources and assistance in the event of large wildfires. Massachusetts DCR also has a long-standing cooperative agreement with the U.S. Department of Agriculture's Forest Service both for providing qualified wildfire-fighters for assistance throughout the U.S. and for receiving federal assistance within the Commonwealth. Improved coordination and management efforts seem to be reducing the average damage from wildfire events. According to the Bureau's website, in 1911, more than 34 acres were burned on average during each wildfire. As of 2017, that figure has been reduced to 1.17 acres.

Location

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. The SILVIS Lab at the University of Wisconsin-Madison Department of Forest Ecology and Management classifies exposure to wildlife hazard as "interface" or "intermix." Intermix communities are those where housing and vegetation intermingle and where the area includes more than 50 percent vegetation and has a housing density greater than one house per 16 hectares (approximately 6.5 acres). 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. These areas are shown in Figure 3-10. Inventoried assets (population, building stock, and critical facilities) were overlaid with these data to determine potential exposure and impacts related to this hazard.

The Northeast Wildfire Risk Assessment Geospatial Work Group completed a geospatial analysis of fire risk in the 20-state U.S. Forest Service Northeastern Area. The assessment is comprised of three components—fuels, wildland-urban interface, and topography (slope and aspect)—that are combined using a weighted overlay to identify wildfire-prone areas where hazard mitigation practices would be most effective. Figure 3-11 illustrates the areas identified for the Commonwealth.

Early detection of wildfires is a key part of the Bureau's overall effort. Early detection is achieved by trained Bureau observers who staff the statewide network of 42 operating fire towers. During periods of high fire danger, the Bureau conducts county-based fire patrols in forested areas. These patrols assist cities and towns in prevention efforts and allow for the quick deployment of mobile equipment for suppression of fires during their initial stage. Figure 3-12 displays the Bureau's fire control districts and fire towers in Massachusetts.

Montague has several areas of "intermix" and "interface" zones within town, and falls within the "High" wildfire risk area. The entire town of Montague, which is approximately 70% forested, is at risk for wildfire. Fire is a significant natural hazard on the Montague Plains due to the extremely flammable nature of the Pitch Pine-Scrub Oak vegetation. The Montague Plains is the largest inland Pitch-Pine Scrub Oak (PPSO) community in southern New England, and the only large remnant of this ecosystem in the Connecticut River Valley. PPSO barrens are vegetative communities occurring on deep, coarse, well-drained sands derived from glacial outwash. The sands are acidic, poor in nutrients and prone to drought. Pitch pine-scrub oak barrens are maintained by fire, which increases the rate of cycling of nutrients to the soil. Without disturbance by fire, tree-sized oaks and white pine can take over.

Periodic high-intensity wildfires on the Plains were common in the past, including the 1907 fire that destroyed 130 homes in Lake Pleasant, a 1,200-acre fire in 1937, a 1,000-acre fire in 1944, a 475-acre fire in 1957, and several 100-acre fires. Fire suppression efforts increased after these wildfires, and recent decades have seen more frequent, but smaller, wildfires. Between 1939 and 1985, these suppression efforts allowed large areas of young pitch pine to grow into an extensive closed canopy forest. Fire-intolerant species such as white pine began filling in underneath, and in 1999, a dense forest of mixed pitch pine and white pine covered most of the sandplain. The historical shrubland with scattered oak and pitch pine trees remained only in a few small areas that had never been plowed. Habitat quality for native, fire-adapted plant and wildlife species declined with these changes.

In 1999, the Commonwealth purchased nearly 1,500 acres creating the Montague Plains Wildlife Management Area (WMA). Recent years have seen the addition of another 175 acres, bringing the total area protected on and around this regionally important glacial sandplain to nearly 1,800 acres. Over the past 20 years, the Massachusetts Division of Fisheries and Wildlife (MassWildlife) has used a combination of tree harvesting, shrub mowing, and prescribed burning to benefit rare species and to reduce the risk of a catastrophic wildfire. MassWildlife has cooperative agreements with the Department of Conservation and Recreation and the Town of Montague Conservation Commission to restore sandplain habitats on their inholdings within the WMA, and works closely with local fire departments and the DCR Bureau of Fire Control to ensure that firefighters have adequate access in the event of a wildfire and are familiar with the changes in vegetation and fuels resulting from habitat management activities.[25]

[25] "Background information on Montague Plains Wildlife Management Area," MA Division of Fisheries and Wildlife, as published in the *2018 Montague Open Space and Recreation Plan*.

The village of Lake Pleasant, on the eastern edge of the Plains, is an area of particular concern with respect to danger from wildfire. A crown fire west of the village could spread quickly, resulting in devastating loss of property and possibly life. Other residential and commercial buildings to the north, northwest, west and southwest of the Plains on Millers Falls Road, Hillside Road and Turners Falls Road are somewhat less susceptible to a catastrophic fire, but are still at risk. Smoke-sensitive areas close to the Plains include major roads, the Turners Falls Airport, Turners Falls High School/Great Falls Middle School, Highland School Apartments (elderly low-income housing), Franklin County Technical School, and Green Pond Road and Federal Street in Millers Falls.

In 2015 Montague completed a Town-wide Wildfire Protection Plan that assessed and identified areas in town at risk to wildfire (see Figure 3-13). Twenty-one separate areas were assessed based on two criteria: the first criteria is labeled as "Risk" and refers to the relative amount of infrastructure and population that exists in a particular area that could be exposed to any particular hazard; the second criteria is "Threat" which refers to the relative probability of the hazard of wildfire impacting that area. These two criteria were rated at three levels, and then added to create a final score for each area.

The three levels of each criteria are from least to greatest, and are as follows:

Risk

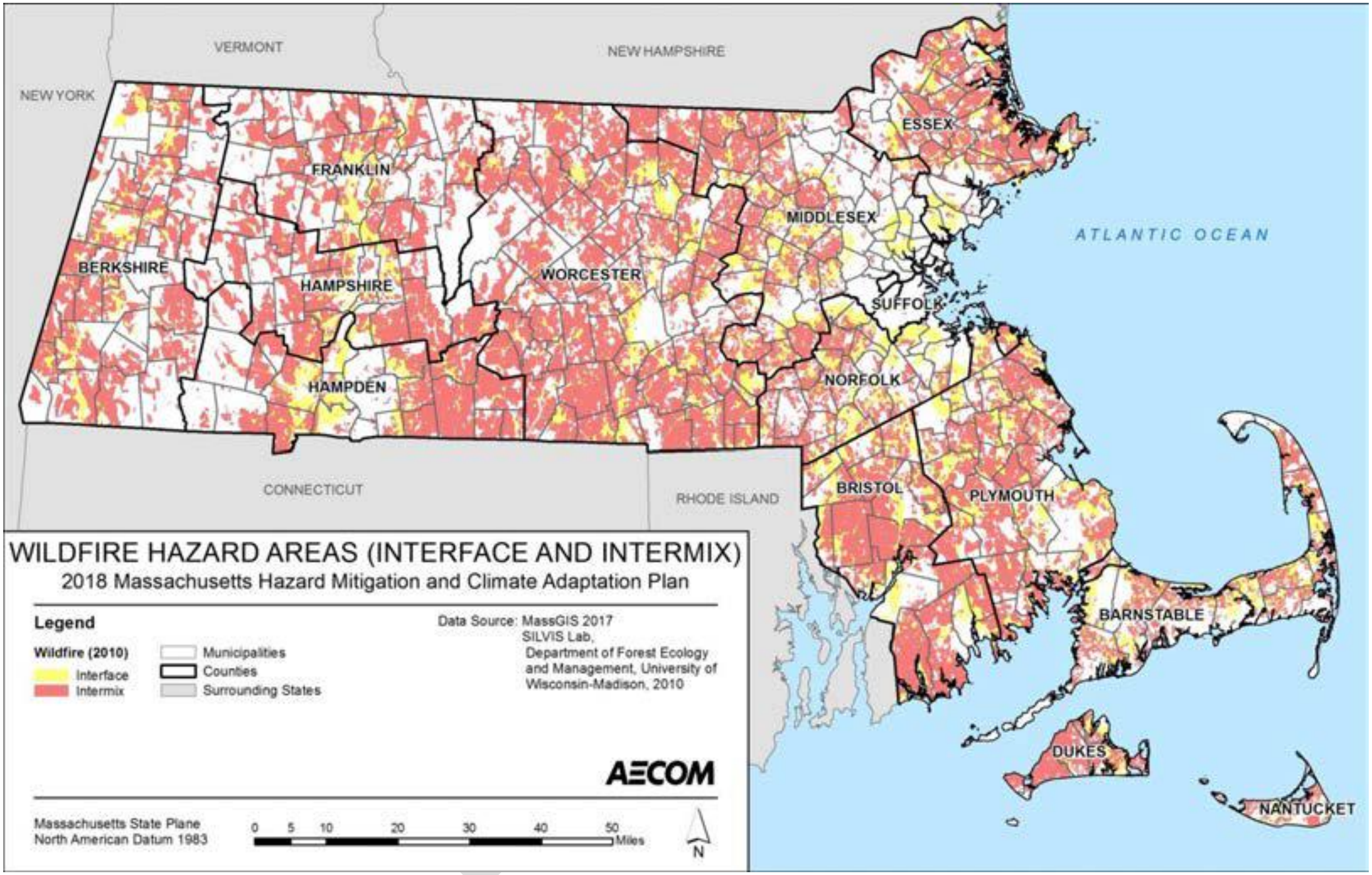
1) Sparsely Developed, extremely low population density
2) Single Family neighborhood, low population density
3) High population, employment, or student density: huge loss of life or critical infrastructure potential

Threat

1) Space is defensible, surrounded by hardwoods, outside of prevailing winds
2) On the edge of the pitch pine forest, within prevailing winds
3) In a pitch pine forest

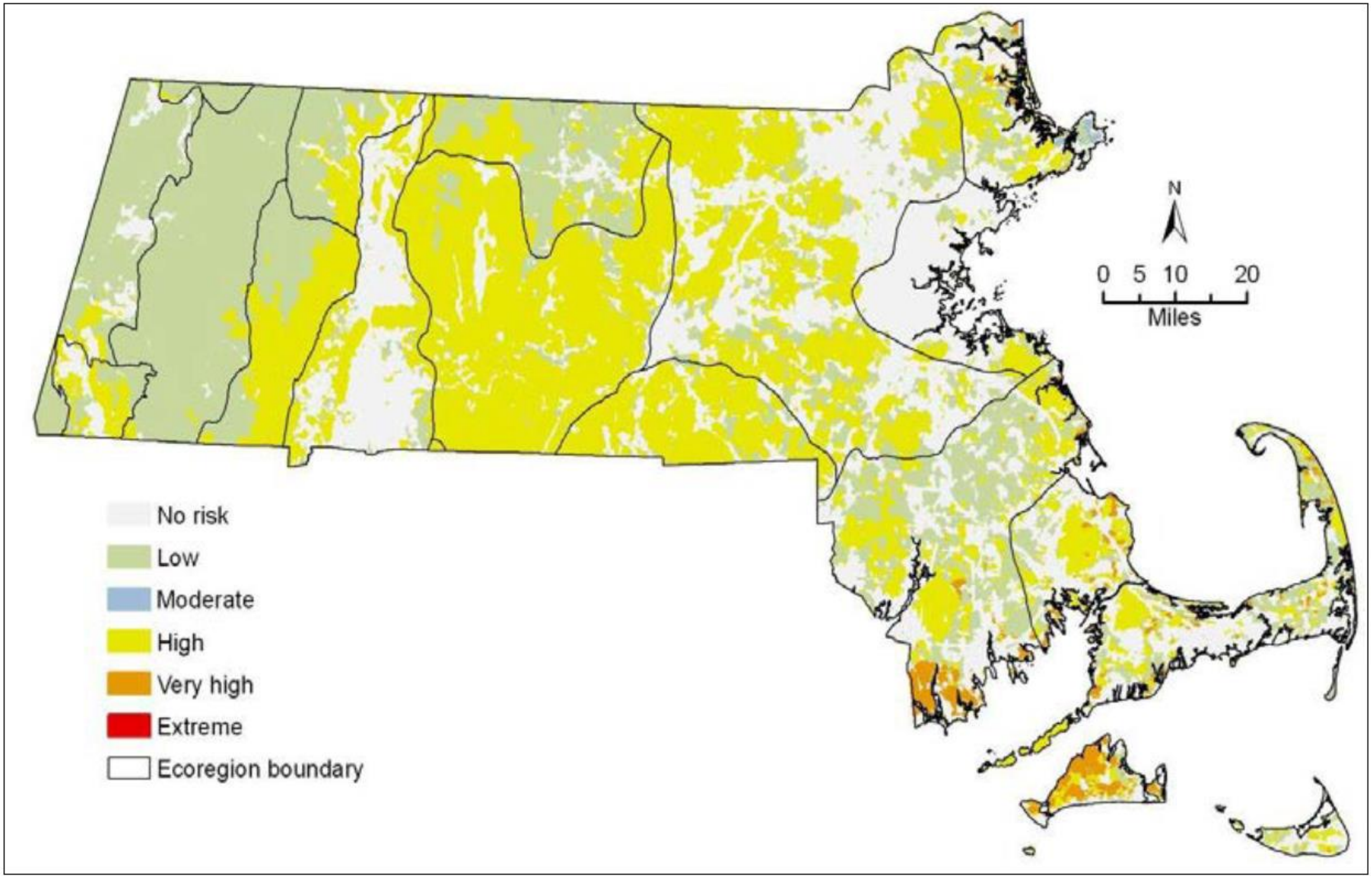
The areas at the highest risk for wildfire are Lake Pleasant Village, Turners Falls Water District Montague Center pump station, Turners Falls Road, Highland School Apartments, and power lines and other utilities. The wildfire plan identifies prioritized mitigation actions that have been carried forward in this Hazard Mitigation Plan update.

Figure 3-10: Wildland-Urban Interface and Intermix for the Commonwealth of Massachusetts



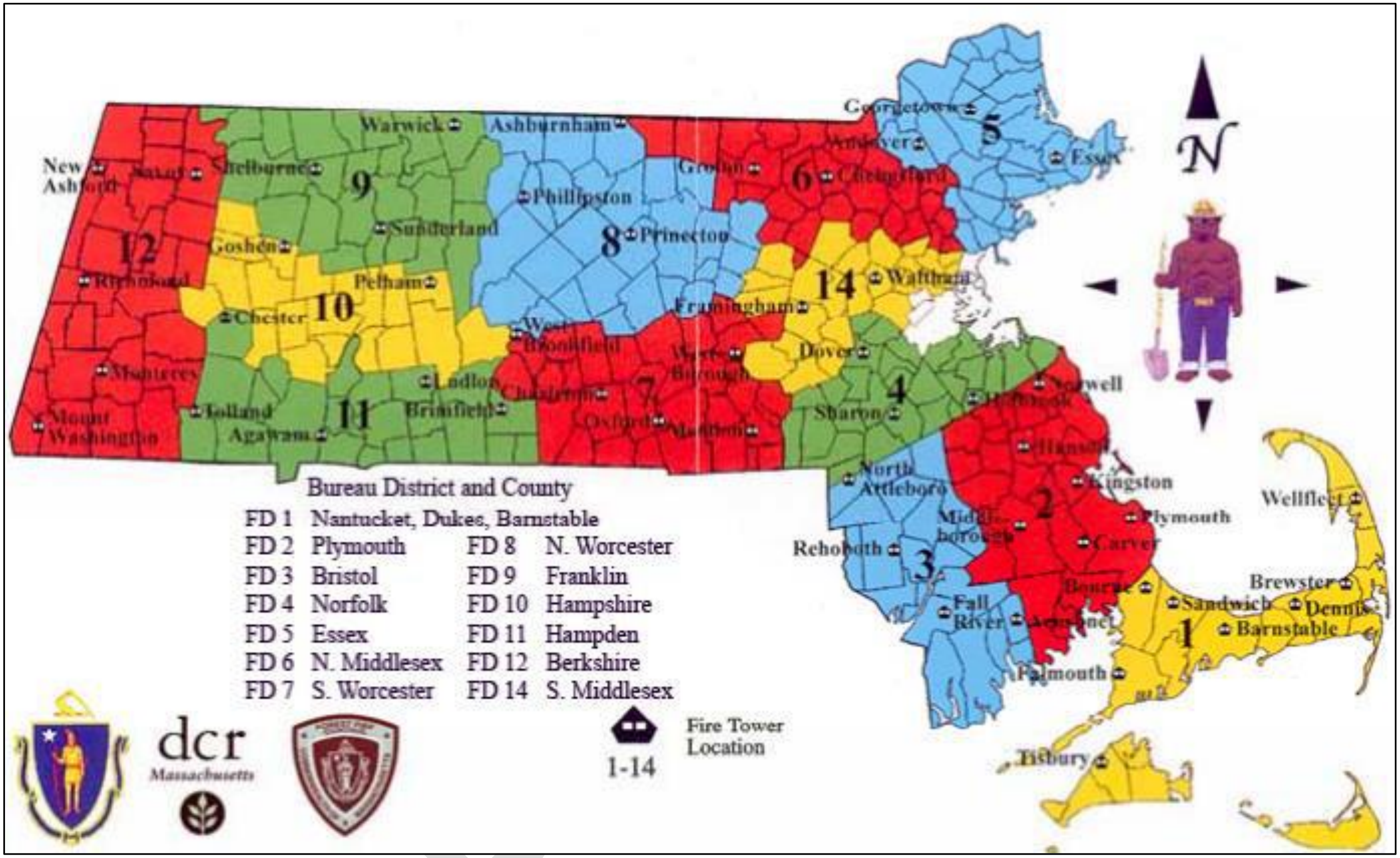
Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Figure 3-11: Wildfire Risk Areas for the Commonwealth of Massachusetts



Source: Northeast Wildfire Risk Assessment Geospatial Work Group, 2009, as presented in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, September 2018.

Figure 3-12: Massachusetts Bureau of Forest Fire Control Districts and Tower Network



Source: Massachusetts Department of Conservation and Recreation, Bureau of Forest Fire Control, 2018, as presented in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, September 2018.

Figure 3-13: Montague 2015 Community Wildfire Risk Assessment				
Risk	**Threat**	**Total**	**Site Location**	**Category**
3	3	6	Lake Pleasant Village	High density Residential
2	3	5	TF Water District Montague Center Pump Station	Critical Infrastructure
2	3	5	Turners Falls Road	Low Density Residential
3	2	5	Highland School Apartments	High density Residential
2	3	5	Power Lines+ Other utilities	Critical Infrastructure
2	2	4	Turners Falls Municipal Airport	Critical Infrastructure
3	1	4	Turners Falls High School	School
3	1	4	Franklin County Technical School	School
1	3	4	Bitzer Fish Hatchery	Low Density Employment
3	1	4	Montague Center North	High density Residential
2	2	4	Rte 63 North of Center Street	Low Density Residential
3	1	4	Millers Falls Village Center	High density Residential
1	3	4	Millers Falls Road	Low Density Residential
3	1	4	Airport Industrial Park + Trailer Park Area	High Density Employment
2	1	3	TF Water District Office and Reservoir	Critical Infrastructure
2	1	3	TF Water District Lake Pleasant Pump Station	Critical Infrastructure
2	1	3	Hillside Road	Low Density Residential
2	1	3	Randall Road	Low Density Residential
2	1	3	Bookmill Area	Low Density Employment
1	1	2	Lower Greenfield Road	Low Density Residential
1	1	2	East and West Mineral Roads	Low Density Residential

Source: *The Montague Community Wildfire Protection Plan: An Action Plan for Wildfire Mitigation in Montague, MA*. December 2015.

Extent

The National Wildfire Coordinating Group defines seven classes of wildfires:

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

Unfragmented and heavily forested areas of the state are vulnerable to wildfires, particularly during droughts. The greatest potential for significant damage to life and property from fire exists in areas designated as wildland-urban interface areas. A wildland-urban interface area defines the conditions where highly flammable vegetation is adjacent to developed areas. Fires can be classified by physical parameters such as their fireline intensity, or Byram's intensity, which is the rate of energy per unit length of the fire front (BTU [British thermal unit] per foot of fireline per second). Wildfires are also measured by their behavior, including total heat release during burnout of fuels (BTU per square foot) and whether they are crown-, ground-, or surface-burning fires. Following a fire event, the severity of the fire can be measured by the extent of mortality and survival of plant and animal life aboveground and belowground and by the loss of organic matter.[26]

If a fire breaks out and spreads rapidly, residents may need to evacuate within days or hours. A fire's peak burning period generally is between 1 p.m. and 6 p.m. Once a fire has started, fire alerting is reasonably rapid in most cases. The rapid spread of cellular and two-way radio communications in recent years has further contributed to a significant improvement in warning time.

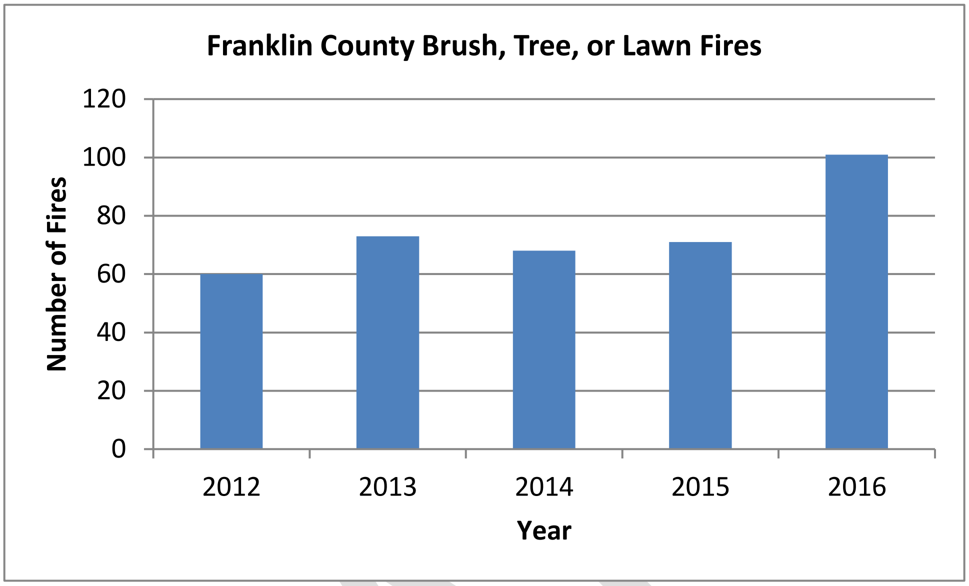
Previous Occurrences

In the last five years (2012 – 2016) Franklin County has averaged 75 brush, tree, or lawn fires a year, with the highest reported number of fires occurring in 2016 (Figure 3-14). During 2016,

[26] (NPS, n.d.).

Franklin County and Massachusetts experienced one of the worst droughts in the last 50 years.

Figure 3-14: Outdoor Vegetation Fires in Franklin County 2012 - 2016



Source: Massachusetts Fire Incident Reporting System County Profiles.

Montague has two independent fire districts: The Montague Center Fire District covers the southern section of town, encompassing the villages of Montague Center and Lake Pleasant, the southern 2/3 of the Montague Plains and most of the Town's rural areas. The Turners Falls Fire District is responsible for the northern section of town, including the villages of Turners Falls (including the Industrial Park), Montague City and Millers Falls, as well as the northern 1/3 of the Plains and the forested areas in the northeast section of Town.

Many brushfires are started on residential lots to clear grass, leaves, brush and other woody debris and become a problem when the homeowner can no longer control them. Lightning strikes, while relatively uncommon, are also a concern. In Montague, a large concern is the railroad which passes through heavily forested areas including the Montague Plains. In 2009, sparks from a passing train ignited dry brush in Montague Center; 8 acres burned before firefighters from 15 departments extinguished the blaze after 4 hours. Another brush fire in 2009 was started in Lake Pleasant by a passing train, and required assistance from neighboring towns to put out. In that instance, burning railroad ties had to be sprayed with fire-retardant foam. The Committee noted that numerous stockpiles of old railroad ties are now located along the tracks in town, and are a major fire concern. In June 2017, both Montague fire departments responded to a fire in Northfield where an estimate 1,500 ties were ignited next to the railroad tracks.[27]

---

[27] "Multiple towns respond to fire on railroad ties in Northfield." *The Recorder* newspaper, June 13, 2017.

Probability of Future Events

It is difficult to predict the likelihood of wildfires in a probabilistic manner because a number of factors affect fire potential and because some conditions (e.g., ongoing land use development patterns, location, and fuel sources) exert changing pressure on the wildland-urban interface zone. However, based on the frequency of past occurrences, Montague has a "Very High" probability (50% to 100% chance) that it will experience a wildfire in a given year.

Impact

Unfragmented and heavily forested areas of Montague are vulnerable to wildfires, particularly during droughts. The greatest potential for significant damage to life and property from fire exists in areas designated as wildland-urban interface areas. A wildland-urban interface area defines the conditions where highly flammable vegetation is adjacent to developed areas. In Montague, the impact from a wildfire could be "Catastrophic," with more than 50% of property in the affected area damaged or destroyed and multiple deaths or injuries possible.

Vulnerability

Society
As demonstrated by historical wildfire events, potential losses from wildfire include homes and businesses, and impacts to human health and the lives of residents and responders. The most vulnerable populations include emergency responders and those within a short distance of the interface between the built environment and the wildland environment.

<u>Vulnerable Populations</u>
All individuals whose homes or workplaces are located in wildfire hazard zones are exposed to this hazard, as wildfire behavior can be unpredictable and dynamic. However, 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. Landowners with pets or livestock may face additional challenges in evacuating if they cannot easily transport their animals. Outside of the area of immediate impact, sensitive populations, such as those with compromised immune systems or cardiovascular or respiratory diseases, can suffer health impacts from smoke inhalation. Individuals with asthma are more vulnerable to the poor air quality associated with wildfire. Finally, firefighters and first responders are vulnerable to this hazard if they are deployed to fight a fire in an area they would not otherwise be in.

Table 3-30 estimates the number of vulnerable populations and households in Montague. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of Montague residents during a wildfire event. In addition, the elderly, low-income residents of Highland School Apartments are vulnerable to impacts from wildfires.

Table 3-30: Estimated Vulnerable Populations in Montague		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	1,745	21%
Population with a Disability	1,477	18%
Population who Speak English Less than "Very Well"	522	6%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	1,307	35%
Householder Age 65 Years and Over Living Alone	465	12%
Households Without Access to a Vehicle	408	11%

*Total population = 8,311; Total households = 3,786

Note: Individuals and households may be counted under multiple categories.

Source: U.S. Census American Community Survey 2013-2017 Five-Year Estimates.

<u>Health Impacts</u>

Smoke and air pollution from wildfires can be a severe health hazard. Smoke generated by wildfire consists of visible and invisible emissions containing particulate matter (soot, tar, and minerals), gases (water vapor, carbon monoxide, carbon dioxide (CO2), and nitrogen oxides), and toxics (formaldehyde and benzene). Emissions from wildfires depend on the type of fuel, the moisture content of the fuel, the efficiency (or temperature) of combustion, and the weather. Other public health impacts associated with wildfire include difficulty in breathing, reactions to odor, and reduction in visibility. Due to the high prevalence of asthma in Massachusetts, there is a high incidence of emergency department visits when respiratory irritants like smoke envelop an area. Wildfires may also threaten the health and safety of those fighting the fires. First responders are exposed to dangers from the initial incident and the aftereffects of smoke inhalation and heat-related illness.

Economic Impacts

Wildfire events can have major economic impacts on a community, both from the initial loss of structures and the subsequent loss of revenue from destroyed businesses and a decrease in tourism. Individuals and families also face economic risk if their home is impacted by wildfire. The exposure of homes to this hazard is widespread. Additionally, wildfires can require thousands of taxpayer dollars in fire response efforts and can involve hundreds of operating hours on fire apparatus and thousands of man-hours from volunteer firefighters. There are also many direct and indirect costs to local businesses that excuse volunteers from work to fight these fires.

Infrastructure

For the purposes of this planning effort, all elements of the built environment located in the wildland interface and intermix areas are considered exposed to the wildfire hazard. Table 3-31 identifies the assessed value of all residential, open space, commercial, and industrial land uses in Town, and the losses that would result from 1%, 5%, and 10% damage to this inventory as a result of a wildfire.

Table 3-31: Estimated Potential Loss by Tax Classification

Tax Classification	Total Assessed Value FY2019	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$594,091,351	$5,940,914	$29,704,568	$59,409,135
Open Space	$0	$0	$0	$0
Commercial	$35,125,445	$351,254	$1,756,272	$3,512,545
Industrial	$160,768,052	$1,607,681	$8,038,403	$16,076,805
Total	**$789,984,848**	**$7,899,848**	**$39,499,242**	**$78,998,485**

Source: Massachusetts Department of Revenue - Division of Local Services, Municipal Databank/Local Aid Section.

The Fire Management Plan for the Montague Plains Wildlife Management Area (WMA) includes a vulnerability assessment of structures particularly susceptible to fire (see Figure 3-15). It identifies two fire-sensitive areas on the WMA itself, including a clubhouse building along Plains Road on the eastern side of the WMA. The clubhouse has since been moved to a location on Lake Pleasant Road, but is still vulnerable to wildfire. A new 1,600 square foot building was built in 2017. Defensible space is minimal behind the structure (to the east), but excellent on all other sides. A dense stand of pitch pine to the west of this structure puts it at considerable risk from wildfire. Electrical transmission lines are the other fire sensitive areas of the WMA. Most of the lines that cross the WMA have wooden poles which could be damaged or consumed by a wildfire, causing power outages in the region and electrical and structural hazards at the site. Only the largest power line, running northwest-southeast across the property has metal towers.

The plan also identified numerous fire sensitive areas off-site. The village of Lake Pleasant lies adjacent to the WMA to the southeast just across Lake Pleasant Road. A large, uninterrupted area of closed canopy pitch pine occurs west of the village of Lake Pleasant. Due to the arrangement and flammability of the fuels, a crown fire could sweep across the southern part of the WMA and into the village when winds are high and humidity is low. The village of Lake Pleasant has been affected by wildfires on several occasions in the past, and during at least one incident houses were destroyed.

There are a number of houses and other buildings adjacent to or near the boundary of the WMA to the north, northwest, west and southwest along Millers Falls Road, Hillside Road, and Turners Falls Road. While still at some risk of being affected by fires from the Montague Plain, these areas are at substantially less risk than the village of Lake Pleasant, because they occur at the bottom of slopes and are adjacent to mixed or hardwood forests (which do not support crown fires). A single residence lies in an inholding north of Plains Road at the western edge of the site. This residence is at particular risk to fire because it is surrounded by scrub oak thicket and pitch pine fuel types. The Fire Management Plan includes a variety of strategies designed to protect vulnerable structures from the risk of wildfire on the Plains. These strategies are outlined in greater detail in Section 4, Current Mitigation Strategies, of this plan.

<u>Agriculture</u>

While Massachusetts does not experience wildfires at the same magnitude as those in western states, wildfires do occur and are a threat to the agriculture sector. The forestry industry is especially vulnerable to wildfires. Barns, other wooden structures, and animals and equipment in these facilities are also susceptible to wildfires.

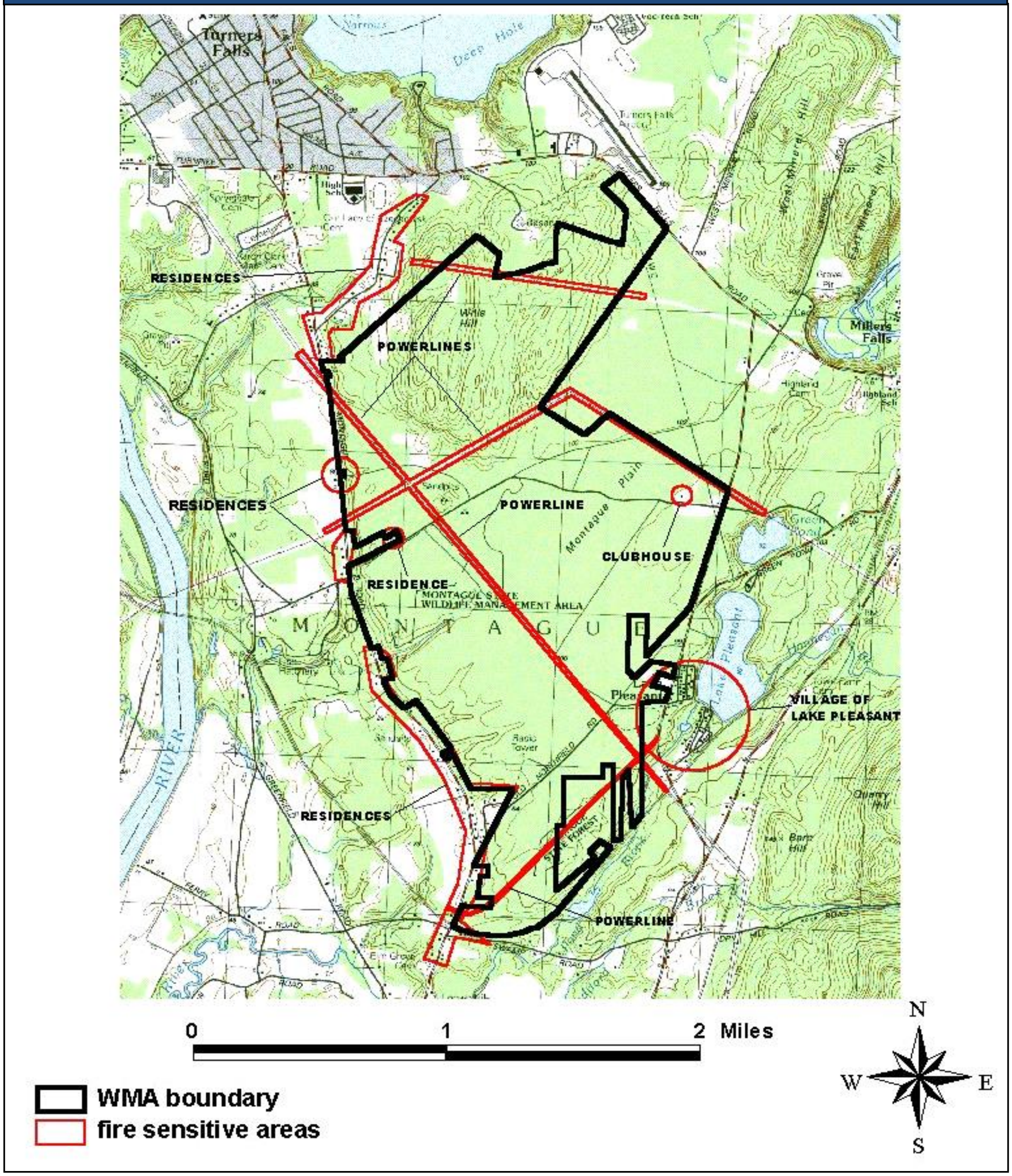
<u>Energy</u>

Distribution lines are subject to wildfire risk because most poles are made of wood and susceptible to burning. Transmission lines are at risk to faulting during wildfires, which can result in a broad area outage. In the event of a wildfire, pipelines could provide a source of fuel and lead to a catastrophic explosion.

<u>Public Health</u>

As discussed in the Populations section of the wildfire hazard profile, wildfires impact air quality and public health. Widespread air quality impairment can lead to overburdened hospitals.

Figure 3-15: Fire Sensitive Areas on/near Montague Plains Wildlife Management Area



Source: Fire Management Plan for the Montague Plains Wildlife Management Area

<u>Public Safety</u>

Wildfire is a threat to emergency responders and all infrastructure within the vicinity of a wildfire.

Transportation

Most road and railroads would be without damage except in the worst scenarios. However, fires can create conditions that block or prevent access, and they can isolate residents and emergency service providers. The wildfire hazard typically does not have a major direct impact on bridges, but wildfires can create conditions in which bridges are obstructed.

Water Infrastructure

In addition to potential direct losses to water infrastructure, wildfires may result in significant withdrawal of water supplies. Coupled with the increased likelihood that drought and wildfire will coincide under the future warmer temperatures associated with climate change, this withdrawal may result in regional water shortages and the need to identify new water sources.

Environment

Fire is a natural part of many ecosystems and serves important ecological purposes, including facilitating the nutrient cycling from dead and decaying matter, removing diseased plants and pests, and regenerating seeds or stimulating germination of certain plants. However, many wildfires, particularly man-made wildfires, can also have significant negative impacts on the environment. In addition to direct mortality, wildfires and the ash they generate can distort the flow of nutrients through an ecosystem, reducing the biodiversity that can be supported.

Frequent wildfires can eradicate native plant species and encourage the growth of fire-resistant invasive species. Some of these invasive species are highly flammable; therefore, their establishment in an area increases the risk of future wildfires. There are other possible feedback loops associated with this hazard. For example, every wildfire contributes to atmospheric CO_2 accumulation, thereby contributing to global warming and increasing the probability of future wildfires (as well as other hazards). There are also risks related to hazardous material releases during a wildfire. During wildfires, containers storing hazardous materials could rupture due to excessive heat and act as fuel for the fire, causing rapid spreading of the wildfire and escalating it to unmanageable levels. In addition, these materials could leak into surrounding areas, saturating soils and seeping into surface waters to cause severe and lasting environmental damage.

Vulnerability Summary

Based on the above assessment, Montague faces a “High” vulnerability from wildfire and brushfires. Existing and future mitigation efforts should continue to be developed and employed that will enable Montague to be prepared for these events when they occur. Wildfires can also cause utility disruption and air-quality problems. Particular areas of vulnerability include low-income and elderly populations, and residents living in the interface area adjacent to large areas of unfragmented forests. The following problem statements summarize the areas of greatest concern to Montague regarding wildfires.

Wildfire Hazard Problem Statements
• The Montague Plains is vulnerable to wildfire. Continued management for pine barren habitat and more fire hydrants are needed to effectively protect this area.
• The village of Lake Pleasant, residents and businesses along Turners Falls Road, residents of Highland School Apartments, the Montague Center pump station and power lines and utilities, are all vulnerable to wildfire.
• Sparks from trains travelling on the railroad tracks through the Montague Plains have caused brush fires in the past, and continue to be a concern. Stockpiles of old railroad ties along the tracks are a significant fire hazard.
• Dry Hill is vulnerable to wildfire and needs improved emergency access.
• Fire roads in the Montague Plains, Dry Hill, and Chestnut Hill sections of town are not maintained. Emergency access to these areas is a concern in the event of a wildfire.
• There is a lack of fire hydrants along Turners Falls Road, which is adjacent to the Montague Plains and includes numerous residences.

3.9 EARTHQUAKES

Potential Impacts of Climate Change

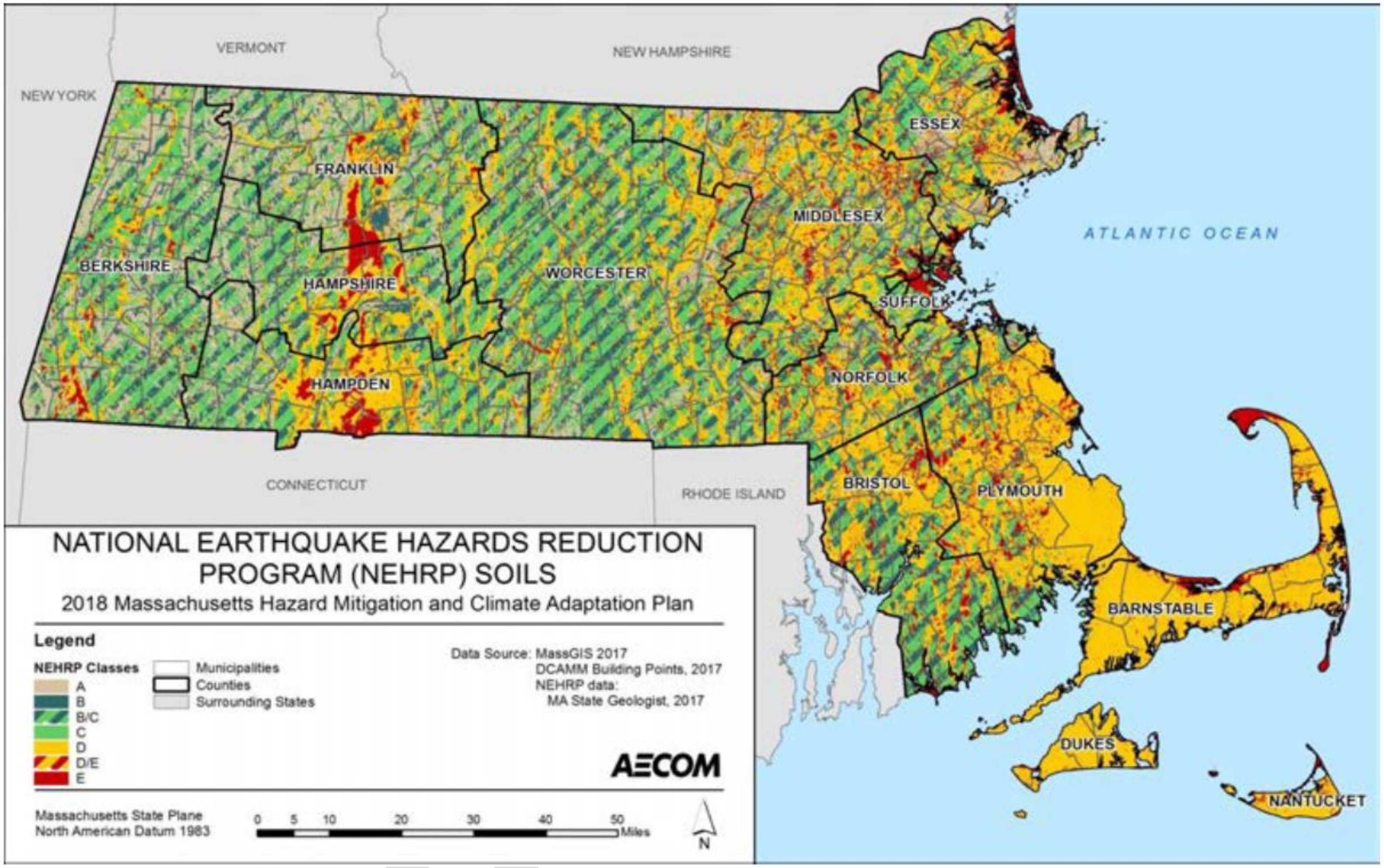
The State Hazard Mitigation and Climate Adaptation Plan does not identify any effects of climate change on the earthquake hazard in Massachusetts.

Hazard Description

An earthquake is the vibration of the Earth's surface that follows a release of energy in the Earth's crust. These earthquakes often occur along fault boundaries. As a result, areas that lie along fault boundaries—such as California, Alaska, and Japan—experience earthquakes more often than areas located within the interior portions of these plates. New England, on the other hand, experiences intraplate earthquakes because it is located deep within the interior of the North American plate. Scientists are still exploring the cause of intraplate earthquakes, and many believe these events occur along geological features that were created during ancient times and are now weaker than the surrounding areas.

Ground shaking is the primary cause of earthquake damage to man-made structures. This damage can be increased due to the fact that soft soils amplify ground shaking. A contributor to site amplification is the velocity at which the rock or soil transmits shear waves (S waves). The National Earthquake Hazards Reduction Program (NEHRP) developed five soil classifications, which are defined by their S-wave velocity, that impact the severity of an earthquake. The soil classification system ranges from A to E, where A represents hard rock that reduces ground motions from an earthquake and E represents soft soils that amplify and magnify ground shaking and increase building damage and losses. These soil types are shown in Figure 3-16.

Figure 3-16: National Earthquake Hazards Reduction Program Soil Types in Massachusetts



Note: This map should be viewed as a first-order approximation of the NEHRP soil classifications. They are not intended for site-specific engineering design or construction. The map is provided only as a guide for use in estimating potential damage from earthquakes. The maps do not guarantee or predict seismic risk or damage. However, the maps certainly provide a first step by highlighting areas that may warrant additional, site-specific investigation if high seismic risk coincides with critical facilities, utilities, or roadways.

Sources: Mabee and Duncan, 2017; Preliminary NEHRP Soil Classification Map of Massachusetts, as presented in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, September 2018.

Location

New England is located in the middle of the North American Plate. One edge of the North American Plate is along the West Coast where the plate is pushing against the Pacific Ocean Plate. The eastern edge of the North American Plate is located at the middle of the Atlantic Ocean, where the plate is spreading away from the European and African Plates. New England's earthquakes appear to be the result of the cracking of the crustal rocks due to compression as the North American Plate is being very slowly squeezed by the global plate movements. As a result, New England epicenters do not follow the major mapped faults of the region, nor are they confined to particular geologic structures or terrains. Because earthquakes have been detected all over New England, seismologists suspect that a strong earthquake could be centered anywhere in the region. Furthermore, the mapped geologic faults of New England currently do not provide any indications detailing specific locations where strong earthquakes are most likely to be centered.

In addition to earthquakes occurring within the Commonwealth, earthquakes in other parts of New England can impact widespread areas. This is due in part to the fact that earthquakes in the eastern U.S. are felt over a larger area than those in the western U.S. The difference between seismic shaking in the East versus the West is primarily due to the geologic structure and rock properties that allow seismic waves to travel farther without weakening.[28]

Because of the regional nature of the hazard, the entire town is susceptible to earthquakes, and the location of occurrence would be "large," with over 50% of the town affected.

Extent

The location of an earthquake is commonly described by the geographic position of its epicenter and by its focal depth. The focal depth of an earthquake is the depth from the surface to the region where the earthquake's energy originates (the focus). Earthquakes with focal depths up to about 43.5 miles are classified as shallow. Earthquakes with focal depths of 43.5 to 186 miles are classified as intermediate. The focus of deep earthquakes may reach depths of more than 435 miles. The focus of most earthquakes is concentrated in the upper 20 miles of the Earth's crust. The depth to the Earth's core is about 3,960 miles, so even the deepest earthquakes originate in relatively shallow parts of the Earth's interior. The epicenter of an earthquake is the point on the Earth's surface directly above the focus.

[28] (USGS, 2012).

Seismic waves are the vibrations from earthquakes that travel through the Earth and are recorded on instruments called seismographs. The magnitude or extent of an earthquake is a 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 sizes of earthquakes. The Richter scale is the most widely known scale for measuring earthquake magnitude. It has no upper limit and is not used to express 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.

The perceived severity of an earthquake is based on the observed effects of ground shaking on people, buildings, and natural features, and severity varies with location. Intensity is expressed by the Modified Mercalli Scale, which describes how strongly an earthquake was felt at a particular location. The Modified Mercalli Scale expresses the intensity of an earthquake's effects in a given locality in values ranging from I to XII. Seismic hazards are also expressed in terms of PGA, which is defined by USGS as "what is experienced by a particle on the ground" in terms of percent of acceleration force of gravity. More precisely, seismic hazards are described in terms of Spectral Acceleration, which is defined by USGS as "approximately what is experienced by a building, as modeled by a particle on a massless vertical rod having the same natural period of vibration as the building" in terms of percent of acceleration force of gravity (percent g). Tables 3-32 and 3-33 summarize the Richter scale magnitudes, Modified Mercali Intensity scale, and associated damage.

Table 3-32: Richter Scale Magnitudes and Effects

Magnitude	Effects
< 3.5	Generally not felt, but recorded.
3.5 - 5.4	Often felt, but rarely causes damage.
5.4 - 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 kilometers across where people live.
7.0 - 7.9	Major earthquake. Can cause serious damage over larger areas.
8 or >	Great earthquake. Can cause serious damage in areas several hundred kilometers across.

Source: US Federal Emergency Management Agency

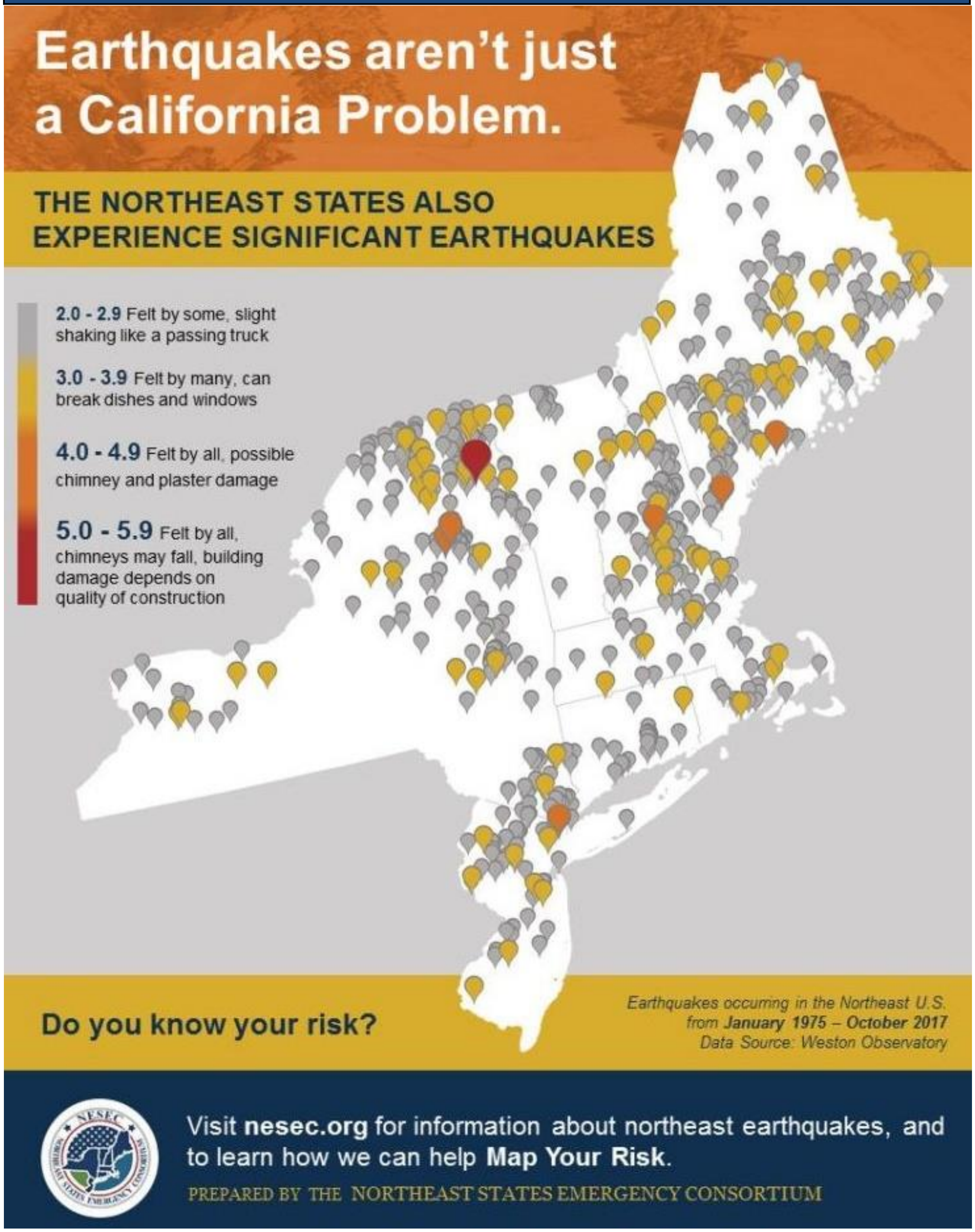
Table 3-33: Modified Mercalli Intensity Scale for and Effects			
Scale	**Intensity**	**Description of Effects**	**Corresponding Richter Scale Magnitude**
I	Instrumental	Detected only on seismographs.	
II	Feeble	Some people feel it.	< 4.2
III	Slight	Felt by people resting; like a truck rumbling by.	
IV	Moderate	Felt by people walking.	
V	Slightly Strong	Sleepers awake; church bells ring.	< 4.8
VI	Strong	Trees sway; suspended objects swing, objects fall off shelves.	< 5.4
VII	Very Strong	Mild alarm; walls crack; plaster falls.	< 6.1
VIII	Destructive	Moving cars uncontrollable; masonry fractures, poorly constructed buildings damaged.	
IX	Ruinous	Some houses collapse; ground cracks; pipes break open.	< 6.9
X	Disastrous	Ground cracks profusely; many buildings destroyed; liquefaction and landslides widespread.	< 7.3
XI	Very Disastrous	Most buildings and bridges collapse; roads, railways, pipes and cables destroyed; general triggering of other hazards.	< 8.1
XII	Catastrophic	Total destruction; trees fall; ground rises and falls in waves.	> 8.1

Source: US Federal Emergency Management Agency

Previous Occurrences

Although it is well documented that the zone of greatest seismic activity in the U.S. is along the Pacific Coast in Alaska and California, in the New England area, an average of six earthquakes are felt each year (Figure 3-17). Damaging earthquakes have taken place historically in New England (Table 3-34). According to the Weston Observatory Earthquake Catalog, 6,470 earthquakes have occurred in New England and adjacent areas. However, only 35 of these events were considered significant. The most recent earthquakes in the region that could have affected the Town of Montague are shown in Figure 3-17. There is no record of any damage to the Town of Montague as a result of these earthquakes.

Figure 3-17: Earthquakes Occurring in the Northeast from 1975 - 2017



Source: Northeast States Emergency Consortium (NESEC) http://nesec.org/earthquakes-hazards/.

Table 3-34: Northeast States Record of Historic Earthquakes			
State	**Years of Record**	**Number of Earthquakes**	**Years with Damaging Earthquakes**
Connecticut	1678 - 2016	115	1791
Maine	1766 - 2016	454	1973, 1904
Massachusetts	1668 - 2016	408	1727, 1755
New Hampshire	1638 - 2016	320	1638, 1940
Rhode Island	1766 - 2016	34	
Vermont	1843 - 2016	50	
New York	1737 - 2016	551	1737, 1929, 1944, 1983, 2002
Total Number of Earthquakes felt: 1,932			

Source: Northeast States Emergency Consortium website, http://nesec.org/earthquakes-hazards/

Probability of Future Events

Earthquakes cannot be predicted and may occur at any time. However, a 1994 report by the USGS, based on a meeting of experts at the Massachusetts Institute of Technology, provides an overall probability of occurrence. Earthquakes above magnitude 5.0 have the potential for causing damage near their epicenters, and larger magnitude earthquakes have the potential for causing damage over larger areas. This report found that the probability of a magnitude 5.0 or greater earthquake centered somewhere in New England in a 10-year period is about 10 percent to 15 percent. This probability rises to about 41 percent to 56 percent for a 50-year period. The last earthquake with a magnitude above 5.0 that was centered in New England took place in the Ossipee Mountains of New Hampshire in 1940. Based on past events, Montague has "Very Low" probability, or less than 1% chance in a given year, of being impacted by an earthquake.

Impact

Ground shaking from earthquakes can rupture gas mains and disrupt other utility service, damage buildings, bridges and roads, and trigger other hazardous events such as avalanches, flash floods (dam failure) and fires. Un-reinforced masonry buildings, buildings with foundations that rest on filled land or unconsolidated, unstable soil, and mobile homes not tied to their foundations are at risk during an earthquake. Massachusetts introduced earthquake design requirements into the building code in 1975 and improved building code for seismic reasons in the 1980s. However, these specifications apply only to new buildings or to extensively-modified existing buildings. Buildings, bridges, water supply lines, electrical power lines and facilities built before the 1980s may not have been designed to withstand the forces of an earthquake. The seismic standards have also been upgraded with the 1997 revision of the State Building Code. Liquefaction of the land near water could also lead to extensive destruction.

In Montague, roughly 71%, or 2,894 homes, were built prior to the 1975 earthquake design requirements. In addition, downtown Turners Falls, the most densely built section of town, is built on ledge. Although a major earthquake has not occurred in recent history in New England, if one were to occur it could cause significant damage to Montague's built environment and infrastructure, and cause multiple injuries or death among the population. Montague faces potentially "Catastrophic" impacts from earthquakes, with more than 50% of property damaged in the affected area.

Vulnerability

Society

The entire population of Montague is potentially exposed to direct and indirect impacts from earthquakes. 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. In addition, the time of day also exposes different sectors of the community to the hazard. There are many ways in which earthquakes could impact the lives of residents. Business interruptions could keep people from working, road closures could isolate populations, and loss of utilities could impact populations that suffered no direct damage from an event itself. People who reside or work in unreinforced masonry buildings are vulnerable to liquefaction.

<u>Vulnerable Populations</u>

The populations most vulnerable to an earthquake event include people over the age of 65 (21% of Montague's population) and those living below the poverty level (15.2% of Montague's population). These socially vulnerable populations are most susceptible, based on a number of factors, including their physical and financial ability to react or respond during a hazard, the location and construction quality of their housing, and the inability to be self-sustaining after an incident due to a limited ability to stockpile supplies. Residents living in homes built prior to the 1970s when the State building code first went into effect, and residents living in mobile homes, are also more vulnerable to earthquakes. An estimated 2,894 housing units in Montague, or 71% of all housing units in town, were built prior to the 1970s. An estimated 67 mobile homes are located in Montague, accounting for 2% of the total housing stock.[29]

[29] U.S. Census Bureau 2013-2017 American Community Survey five-year estimates.

Earthen dams and levees are highly susceptible to seismic events, and the impacts of their eventual failures can be considered secondary risks for earthquakes. Failure of the Turners Falls dam, canal, or the Northfield Mountain Pumped Storage Hydroelectric Facility upstream from Montague, are specific areas of concern for Montague and are discussed in more detail in the Dam Failure section.

Health Impacts

The most immediate health risk presented by the earthquake hazard is trauma-related injuries and fatalities, either from structural collapse, impacts from nonstructural items such as furniture, or the secondary effects of earthquakes, such as landslides and fires. Following a severe earthquake, health impacts related to transportation impediments and lack of access to hospitals may occur, as described for other hazards. If ground movement causes hazardous material (in storage areas or in pipelines) to enter the environment, additional health impacts could result, particularly if surface water, groundwater, or agricultural areas are contaminated.

Economic Impacts

Earthquakes also have impacts on the economy, including loss of business functions, damage to inventories, relocation costs, wage losses, and rental losses due to the repair or replacement of buildings. Lifeline-related losses include the direct repair cost for transportation and utility systems. Additionally, economic losses include the business interruption losses associated with the inability to operate a business due to the damage sustained during the earthquake as well as temporary living expenses for those displaced.

Infrastructure

All elements of the built environment in Montague are exposed to the earthquake hazard. Table 3-35 identifies the assessed value of all residential, open space, commercial, and industrial land uses in Town, and the losses that would result from 1%, 5%, and 10% damage to this inventory as a result of an earthquake.

Table 3-35: Estimated Potential Loss by Tax Classification				
Tax Classification	**Total Assessed Value FY2019**	**1% Damage Loss Estimate**	**5% Damage Loss Estimate**	**10% Damage Loss Estimate**
Residential	$594,091,351	$5,940,914	$29,704,568	$59,409,135
Open Space	$0	$0	$0	$0
Commercial	$35,125,445	$351,254	$1,756,272	$3,512,545
Industrial	$160,768,052	$1,607,681	$8,038,403	$16,076,805
Total	**$789,984,848**	**$7,899,848**	**$39,499,242**	**$78,998,485**

Source: Massachusetts Department of Revenue - Division of Local Services, Municipal Databank/Local Aid Section.

In addition to these direct impacts, there is increased risk associated with hazardous materials releases, which have the potential to occur during an earthquake from fixed facilities, transportation-related incidents (vehicle transportation), and pipeline distribution. These failures can lead to the release of materials to the surrounding environment, including potentially catastrophic discharges into the atmosphere or nearby waterways, and can disrupt services well beyond the primary area of impact.

Agriculture

Earthquakes can result in loss of crop yields, loss of livestock, and damage to barns, processing facilities, greenhouses, equipment, and other agricultural infrastructure. Earthquakes can be especially damaging to farms and forestry if they trigger a landslide.

Energy

Earthquakes can damage power plants, gas lines, liquid fuel storage infrastructure, transmission lines, utility poles, solar and wind infrastructure, and other elements of the energy sector. Damage to any components of the grid can result in widespread power outages.

Public Health

A significant earthquake may result in numerous injuries that could overburden hospitals.

Public Safety

Police stations, fire stations, and other public safety infrastructure can experience direct losses (damage) from earthquakes. The capability of the public safety sector is also vulnerable to damage caused by earthquakes to roads and the transportation sector.

Transportation
Earthquakes can impact many aspects of the transportation sector, including causing damage to roads, bridges, vehicles, and storage facilities and sheds. Damage to road networks and bridges can cause widespread disruption of services and impede disaster recovery and response.

Water and Wastewater Infrastructure
Due to their extensive networks of aboveground and belowground infrastructure—including pipelines, pump stations, tanks, administrative and laboratory buildings, reservoirs, chemical storage facilities, and treatment facilities—water and wastewater utilities are vulnerable to earthquakes. Additionally, sewer and water treatment facilities are often built on ground that is subject to liquefaction, increasing their vulnerability. Earthquakes can cause ruptures in storage and process tanks, breaks in pipelines, and building collapse, resulting in loss of water and loss of pressure, and contamination and disruption of drinking water services. Damage to wastewater infrastructure can lead to sewage backups and releases of untreated sewage into the environment.

Environment

Earthquakes can impact natural resources and the environment in a number of ways, both directly and through secondary impacts. For example, damage to gas pipes may cause explosions or leaks, which can discharge hazardous materials into the local environment or the watershed if rivers are contaminated. Fires that break out as a result of earthquakes can cause extensive damage to ecosystems, as described in the Wildfire section. Primary impacts of an earthquake vary widely based on strength and location. For example, if strong shaking occurs in a forest, trees may fall, resulting not only in environmental impacts but also potential economic impacts to the landowner or forestry businesses relying on that forest. If shaking occurs in a mountainous environment, cliffs may crumble and caves may collapse. Disrupting the physical foundation of the ecosystem can modify the species balance in that ecosystem and leave the area more vulnerable to the spread of invasive species.

Vulnerability Summary

Based on this analysis, Montague has a "Medium" vulnerability to earthquakes. The following problem statements summarize Montague's areas of greatest concern regarding earthquakes.

Earthquake Hazard Problem Statements
• The village of Turners Falls is built on ledge and is particularly vulnerable to the impacts of an earthquake.
• Roughly 71% of Montague's housing was constructed prior to the 1970's, when seismic standards were first required in Massachusetts.
• An earthquake could cause hazardous material releases from facilities and from vehicles on transportation routes damaged by an earthquake.
• Several bridges in town serve as important access and evacuation routes, and all but the new Gill-Montague Bridge are badly in need of repair. Evacuating residents may be difficult in the event that any or all of these bridges are impacted by an earthquake and have to be closed.
• The Farren Care Facility needs to shelter in place due to medical needs of patients. In the event that Farren must evacuate, existing emergency plans may not be sufficient for ensuring adequate ambulances and communication with town officials and first responders to evacuate patients safely and effectively during a hazard.
• The Town lacks capacity to reach Non-English speaking populations during emergencies.
• The Patch Neighborhood is vulnerable if an earthquake required evacuation, given limited access to the neighborhood.
• Turners Falls High School, which serves as the regional shelter, needs improved infrastructure for back-up water and power and A/C.

3.10 DAM FAILURE

Potential Impacts of Climate Change

The State Hazard Mitigation and Climate Adaptation Plan does not identify any effects of climate change on the dam failure hazard in Massachusetts.

Hazard Description

Dams and levees and their associated impoundments provide many benefits to a community, such as water supply, recreation, hydroelectric power generation, and flood control. However, they also pose a potential risk to lives and property. Dam or levee failure is not a common occurrence, but dams do represent a potentially disastrous hazard. When a dam or levee fails, the potential energy of the stored water behind the dam is released rapidly. Most dam or levee failures occur when floodwaters above overtop and erode the material components of the dam. Often dam or levee breeches lead to catastrophic consequences as the water rushes in a torrent downstream, flooding an area engineers refer to as an “inundation area.” The number of casualties and the amount of property damage will depend upon the timing of the warning provided to downstream residents, the number of people living or working in the inundation area, and the number of structures in the inundation area.

Many dams in Massachusetts were built during the 19th Century without the benefit of modern engineering design and construction oversight. Dams of this age can fail because of structural problems due to age and/or lack of proper maintenance, as well as from structural damage caused by an earthquake or flooding.

The Massachusetts Department of Conservation and Recreation Office of Dam Safety is the agency responsible for regulating dams in the state (M.G.L. Chapter 253, Section 44 and the implementing regulations 302 CMR 10.00). The regulations apply to dams that are in excess of 6 feet in height (regardless of storage capacity) or have more than 15 acre feet of storage capacity (regardless of height). Dam safety regulations enacted in 2005 transferred significant responsibilities for dams from the State of Massachusetts to dam owners, including the responsibility to conduct dam inspections.

Location

Of particular concern to Montague are the High Hazard dams on the Deerfield and Connecticut

Rivers. These facilities are licensed by the Federal Energy Regulatory Commission (FERC), and include the Somerset Dam, the Harriman Dam, the Sherman Dam (all owned by Great River Hydro), the Fife Brook Dam and the Bear Swamp Upper Reservoir (both owned by Brookfield Power), the Moore Dam (owned by TransCanada), the Northfield Mountain Pumped Storage Facility and the Turners Falls Project (owned by FirstLight). All of these facilities are classified as High Hazard Dams. The Emergency Action Plans for these projects include a series of inundation maps for each dam which illustrate potential flooding conditions for downstream areas including portions of Montague adjacent to the Connecticut, Millers and Sawmill Rivers.

A catastrophic failure of any one of these High Hazard dams would likely result in the cascading failure of all the downstream dams (both High and Low Hazard dams), resulting in widespread flooding of downstream areas in a matter of hours. The Hazards and Infrastructure Map shows the extent of the inundation area if one or more of these dams were to fail. Inundation maps for the Harriman Dam failure indicate significant areas of Montague would be flooded, including a large area west of Montague City Road. Flood waters would also impact areas along the Connecticut River west of Montague Center and also rise up the Sawmill River to Greenfield Road. Under the worst-case scenario, floodwaters from a catastrophic failure of the Sherman Dam would reach the confluence of the Connecticut and Deerfield Rivers in 3.2 hours.

In 2010 the Franklin Regional Council of Governments (FRCOG) and the University of Massachusetts Transportation Center (UMTC) prepared a study that examined the impact of a Harriman Dam failure on the transportation network in the towns within the inundation zone as well as the county. Building upon this exercise, the FRCOG developed town-specific recommendations in the event of flooding caused by failure of the Harriman Dam. An analysis was conducted for each of the Towns located along the path of the flood including identification of critical facilities located within Town boundaries. The recommendations are intended to be used as a starting point for the development of specific emergency plans in each Town.

An analysis of the inundation area in Turners Falls found that the number of automobiles per household is less than one, indicating a potential need for additional evacuation assistance, such as buses, in the event of a dam failure. Additionally, the Farren Care Center, a 122 bed nursing home facility, is located in the inundation area and will need to be evacuated prior to a flood. Currently the evacuation plan for the facility calls for moving patients and staff to to other nursing homes throughout the region and state. Farren Care is part of an arrangement with over 270 nursing homes state-wide, through the Massachusetts Department of Public Health, that offer space for patients during an emergency. The Town recently conducted a drill with the facility to test the evacuation plans. The Montague Town Hall is located adjacent to the inundation area, and would benefit from the development of an emergency plan to ensure protection of vital records and documents in the event a flood reaches the building.

An additional flooding scenario is a failure of the power canal in Turners Falls, owned by FirstLight Power. According to the 2018 Emergency Action Plan for the canal, failure of the left bank of the canal impoundment would flood Montague City Road in a matter of minutes. There would be little to no warning time.

Of additional concern is the Moore Dam, owned by TransCanada and located on the Connecticut River in the towns of Littleton, New Hampshire, and Waterford, Vermont, approximately 166 miles upstream from the Turners Falls Dam. According to the Emergency Action Plan, flooding caused by a failure of the dam would reach Turners Falls within 24 hours. Under Probable Maximum Flood conditions, flood waters would inundate 1st and 2nd Streets and areas surrounding Unity Park in Turners Falls, the “Patch” neighborhood, and neighborhoods on both sides of Montague City Road in Montague City. Additionally sections of Greenfield Road would be inundated, along with sections of Meadow Road adjacent to the Sawmill River and the Connecticut River.

The Lake Wyola Dam is a High Hazard dam located in the Town of Shutesbury that could potentially impact Montague if it failed, releasing flood waters into the Sawmill River. Roads that would be impacted by a dam failure, according to the Emergency Action Plan, are North Leverett Road, Spaulding Brook Road, Main Street, Center Street, South Ferry Road, and Meadow Road. The EAP states that there would be less than a two foot increase in 500 year flood stage levels by the time the flood waters reach the Montague town line. The plan lists 22 home addresses in Montague that fall within the 500 year flood plain in the inundation area. The dam is owned by the Town of Shutesbury.

The 100-year flood plain in Montague includes approximately 27 acres of developed land in the town, including an estimated 14 acres of developed residential land. The area inundated by a catastrophic failure of one of the High Hazard dams would cover substantially more acreage. Emergency responders should review inundation areas presented in the Emergency Action Plans, and the findings and recommendations from the 2010 Harriman Dam study and Town Recommendations, and identify possible evacuation routes, since significant portions of Montague, Greenfield and neighboring communities such as Deerfield, including sections of Route 5/10, may be flooded. Montague City Road, a designated flood evacuation route, would also be inundated in the event of a major dam failure on the Deerfield or Connecticut River.

The Federal Energy Regulatory Commission is responsible for oversight of hydroelectric projects and regulates dams under its jurisdiction. In Montague, FERC oversees the Turners Falls Project, which consists of the following components:

- The Turners Falls Dam, consisting of the Gill and Montague spillways in the Connecticut River
- The Turners Falls Reservoir, which consists of the length of the Connecticut River upstream of the Turners Falls Dam to the base of the Vernon Dam in Vernon, Vermont.
- The Cabot Power Canal, a 11,600 foot long canal that discharges from the Turners Falls Reservoir near the eastern end of the dam and supplies water to two hydropower stations and other commercial and industrial users downstream
- A canal gatehouse at the head of the canal to regulate flow into the canal for up to 10.7 feet of head differential between maximum normal pond in the reservoir and the canal level
- Station Number 1 on the left bank of the Connecticut River and the right bank of the power canal
- Cabot Station at the downstream end of the canal
- A canal spillway located adjacent to Cabot Station.

The Cabot Spillway, Turners Falls #1 Dam, Turners Falls Dam, and the Turners Falls Canal Headgates are High Hazard Potential dams in Montague. Failure of any of these dams, as well as the canal itself, was identified as an area of concern during the MVP community workshop in 2018. The Patch neighborhood located between the canal and the Connecticut River, and the village of Montague City located downstream, are vulnerable to failure of these structures. FirstLight maintains a reverse call system for residents in these areas, however, participants at the MVP workshop noted that new residents may be unaware of the system and may not have signed up for the calls to alert them of a dam or canal failure.

The Lake Pleasant Dam is classified as a non-jurisdictional dam in Montague. The Turners Falls Fire District is the Owner and Caretaker of record for the Lake Pleasant dam, which was last inspected in November 2015 and was found to be in fair condition. The inspection report notes that the structural height of the dam is less than 6 feet, there is no threat to residential property in the event of a dam failure, and impacts to roads and the railroad from a dam failure would be minimal. As Lake Pleasant Dam is classified as non-jurisdictional, periodic inspections are not a regulatory requirement.[30]

Landowners on the northwest side of Montague City Road have experienced high groundwater and periodic flooding, which Town officials have attributed to seepage from the Turners Falls

[30] Communication with Turners Falls Fire District, 2019.

Power Canal and beaver activity in the area. In response to concerns expressed by the Town, the Federal Energy Regulatory Commission commissioned a review of the structural integrity of the canal's left embankment in 2000, which determined that the integrity of the canal was sound and that the elevated groundwater levels and periodic flooding are likely due to the growing beaver population. Human-beaver conflict continues to be a problem in Montague where a pond created by a beaver dam in 2010 made it difficult for utility workers to replace high-tension wires standing in water.

Extent

Often dam or levee breaches lead to catastrophic consequences as the water ultimately rushes in a torrent downstream flooding an area engineers refer to as an "inundation area." The number of casualties and the amount of property damage will depend upon the timing of the warning provided to downstream residents, the number of people living or working in the inundation area, and the number of structures in the inundation area.

Dams in Massachusetts are assessed according to their risk to life and property. The state has three hazard classifications for dams:

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

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

- Low Hazard Potential dams – 10 years
- Significant Hazard Potential dams – 5 years
- High Hazard Potential dams – 2 years

The time intervals represent the maximum time between inspections. More frequent inspections may be performed at the discretion of the state. As noted previously, dams and reservoirs licensed and subject to inspection by the Federal Energy Regulatory Commission

(FERC) are excluded from the provisions of the state regulations provided that all FERC-approved periodic inspection reports are provided to the DCR. FERC inspections of high and significant hazard projects are conducted on a yearly basis. All other dams are subject to the regulations unless exempted in writing by DCR.

Previous Occurrences

To date, there have been no known dam or levee failures in Montague.

Probability of Future Events

Currently the frequency of a dam failure is “Very Low” with a less than 1 percent chance of a dam failing in any given year.

Dams are designed partly based on assumptions about a river’s flow behavior, expressed as hydrographs. Changes in weather patterns can have significant effects on the hydrograph used for the design of a dam. If the hygrograph changes, it is conceivable that the dam can lose some or all of its designed margin of safety, also known as freeboard. If freeboard is reduced, dam operators may be forced to release increased volumes earlier in a storm cycle in order to maintain the required margins of safety. Such early releases of increased volumes can increase flood potential downstream.

Throughout the western United States, communities downstream of dams are already seeing increases in stream flows from earlier releases from dams. Dams are constructed with safety features known as “spillways.” Spillways are put in place on dams as a safety measure in the event of the reservoir filling too quickly. Spillway overflow events often referred to as “design failures,” result in increased discharges downstream and increased flooding potential. Although climate change will not increase the probability of catastrophic dam failure, it may increase the probability of design failures.

According to FirstLight staff at Northfield Mountain, the next Emergency Action Plan (EAP) and dam inundation maps for the facility will include an extreme weather scenario.

Impact

A dam failure in Montague, or upstream from Montague, is likely to have a catastrophic impact, with multiple deaths and injuries possible, more than 50% of property in the affected area damaged or destroyed, and a possible complete shutdown of facilities for 30 days or more.

Vulnerability

Dam failures, while rare, can destroy roads, structures, facilities, utilities, and impact the population of Montague. Existing and future mitigation efforts should continue to be developed and employed that will enable Montague to be prepared for these events when they occur. Particular areas of vulnerability include low-income and elderly populations, buildings in the floodplain or inundation areas, and infrastructure such as roadways and utilities that can be damaged by such events.

Society

<u>Vulnerable Populations</u>
The most vulnerable members of the population are those living or working within the floodplain or dam inundation areas, and in particular, those who would be unable to evacuate quickly, including people over the age of 65, households with young children under the age of 5, people with mobility limitations, people with low socioeconomic status, and people with low English fluency who may not understand emergency instructions provided in English.

In Montague, the Patch neighborhood between the power canal and the Connecticut River is particularly vulnerable in the event of a dam failure. Only one bridge (out of eight bridges that access the canal district) is fully functional, posing a public safety access concern for this neighborhood. Montague City and Millers Falls are also vulnerable to flooding from dam failure; Montague City would also be impacted from a failure of the power canal.

<u>Economic Impacts</u>
Economic impacts are not limited to assets in the inundation area, but may extend to infrastructure and resources that serve a much broader area. In addition to direct damage from dam failure, economic impacts include the amount of time required to repair or replace and reopen businesses, governmental and nonprofit agencies, and industrial facilities damaged by the dam failure.[31]

Infrastructure
Structures that lie in the inundation area of each of the dams in Montague are vulnerable to a

[31] *Assessing the Consequences of Dam Failure: A How-To Guide*. Federal Emergency Management Agency (FEMA). March 2012.
https://damsafety.org/sites/default/files/files/FEMA%20TM%20AssessingtheConsequencesofDamFailure%20March2012.pdf

dam failure. Buildings located within the floodplain are also vulnerable to dam failure in Montague. Table 3-12 in the Flooding section provides the 2019 assessed building values for significant structures partially or completely located in the floodplain in Montague. Together these buildings are valued at $5,339,000.

Environment

Examples of environmental impacts from a dam failure include:

- Pollution resulting from septic system failure, back-up of sewage systems, petroleum products, pesticides, herbicides, or solvents
- Pollution of the potable water supply or soils
- Exposure to mold or bacteria during cleanup
- Changes in land development patterns
- Changes in the configuration of streams or the floodplain
- Erosion, scour, and sedimentation
- Changes in downstream hydro-geomorphology
- Loss of wildlife habitat or biodiversity
- Degradation to wetlands
- Loss of topsoil or vegetative cover
- Loss of indigenous plants or animals[32]

Vulnerability Summary

Overall, Montague has a "Low" vulnerability from dam or levee failure.

---

[32] *Assessing the Consequences of Dam Failure: A How-To Guide*. Federal Emergency Management Agency (FEMA). March 2012.
https://damsafety.org/sites/default/files/files/FEMA%20TM%20AssessingtheConsequencesofDamFailure%20March2012.pdf

Dam Failure Hazard Problem Statements
• While the chance is low, a dam failure at Harriman Dam, Northfield Mountain Pumped Storage Facility, or any of the High Hazard dams on the Deerfield or Connecticut Rivers could trigger cascading failures on multiple other dams downstream, result in catastrophic flooding to many parts of Montague.
• Critical buildings and infrastructure, including the Town Hall, Farren Care Facility, Unity Park, Newton Street and Franklin Street in Millers Falls, and bridges, are located partially or wholly within the High Hazard dam inundation areas.
• Hazardous Facilities, including gas stations and the historic mill buildings and power canal in Turners Falls, as well as the Montague Water Pollution Control Facility in Montague City, are located partially or wholly within the High Hazard dam inundation areas.
• Failure of the Canal Dike could flood Montague City. New residents may be unaware of FirstLight's reverse call system to alert them of a dam or canal failure.
• The Community Action preschool in the Patch Neighborhood is located in the High Hazard dam inundation zone. The school and neighborhood is vulnerable if a dam failure required evacuation, given limited access to the neighborhood.
• The Town lacks capacity to reach Non-English speaking populations during emergencies.
• Homeless and transient people, who often camp near the rivers in town, may be difficult to reach in the event of an emergency.
• In the event that the Farren Care Facility must evacuate, available resources may not be sufficient for ensuring adequate ambulances and first responders to evacuate patients safely and effectively during a widespread hazard like dam failure, which would place a significant strain on emergency resources across the county.

3.11 DROUGHT

Potential Impacts of Climate Change

Although total annual precipitation is anticipated to increase over the next century, seasonal precipitation is predicted to include more severe and unpredictable dry spells. More rain falling over shorter time periods will reduce groundwater recharge, even in undeveloped areas, as the ground becomes saturated and unable to absorb the same amount of water if rainfall were spread out. The effects of this trend will be exacerbated by the projected reduction in snowpack, which can serve as a significant water source during the spring melt to buffer against sporadic precipitation. Also, the snowpack melt is occurring faster than normal, resulting not only in increased flooding but a reduced period in which the melt can recharge groundwater and the amount of water naturally available during the spring growing period.

Reduced recharge can in turn affect base flow in streams that are critical to sustain ecosystems during dry periods and groundwater-based water supply systems. Reservoir-based water supply systems will also need to be assessed to determine whether they can continue to meet projected demand by adjusting their operating rules to accommodate the projected changes in precipitation patterns and associated changes in hydrology. Finally, rising temperatures will also increase evaporation, exacerbating drought conditions.

Figure 3-18: Impacts of Climate Change on Drought

Potential Effects of Climate Change		
	RISING TEMPERATURES AND CHANGES IN PRECIPITATION ➔ PROLONGED DROUGHT	The frequency and intensity of droughts are projected to increase during summer and fall in the Northeast as higher temperatures lead to greater evaporation and earlier winter and spring snowmelt, and precipitation patterns become more variable and extreme.
	RISING TEMPERATURES AND CHANGES IN PRECIPITATION ➔ REDUCED SNOWPACK	Due to climate change, the proportion of precipitation falling as snow and the extent of time snowpack remains are both expected to decrease. This reduces the period during which snowmelt can recharge groundwater Supplies, bolster streamflow, and provide water for the growing period.

Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Hazard Description

Droughts can vary widely in duration, severity, and local impact. They may have widespread social and economic significance that requires the response of numerous parties, including water suppliers, firefighters, farmers, and residents. Droughts are often defined as periods of deficient precipitation. How this deficiency is experienced can depend on factors such as land use change, the existence of dams, and water supply withdrawals or diversions. For example, impervious surfaces associated with development can exacerbate the effects of drought due to decreased groundwater recharge.

Drought is a natural phenomenon, but its impacts are exacerbated by the volume and rate of water withdrawn from these natural systems over time as well as the reduction in infiltration from precipitation that is available to recharge these systems. Groundwater withdrawals for drinking water can reduce groundwater levels, impacting water supplies as well as base flow (flow of groundwater) in streams. A reduction in base flow is significant, especially in times of drought, as this is often the only source of water to the stream. In extreme situations, groundwater levels can fall below stream channel bottom, and groundwater becomes disconnected from the stream, resulting in a dry channel.

Natural infiltration is reduced by impervious cover (pavement, buildings) on the land surface and by the interruption of natural small-scale drainage patterns in the landscape caused by development and drainage infrastructure. Sewer collection systems can also reduce groundwater levels when groundwater infiltrates into them. This is a common problem for wastewater collection systems in Franklin County, where many of the existing pipes were put in place over 100 years ago. Also, when drains are connected to the sanitary system, groundwater and precipitation are transported to wastewater treatment plants where effluent is typically discharged to surface water bodies and not returned to the groundwater.

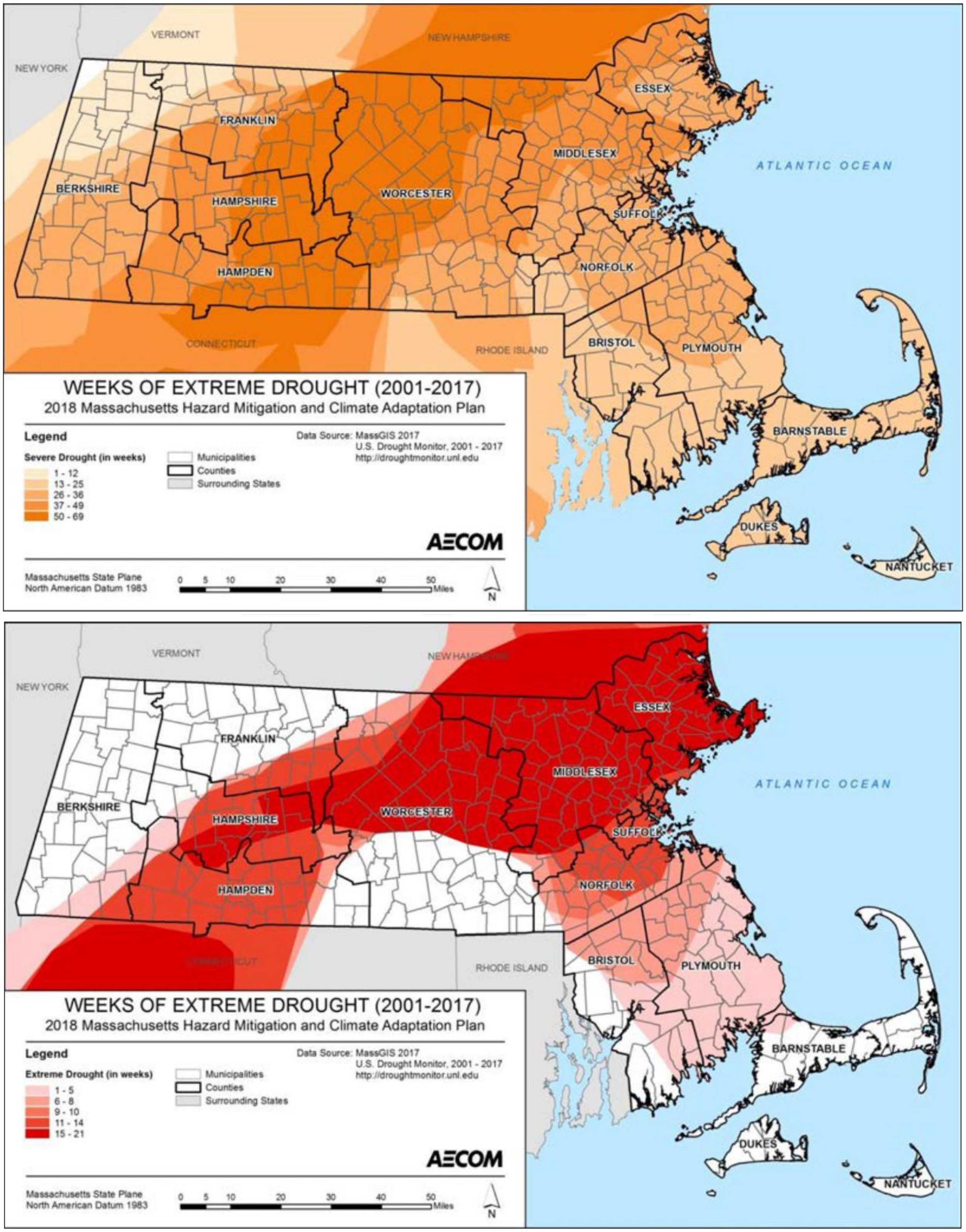
Highly urbanized areas with traditional stormwater drainage systems tend to result in higher peak flood levels during rainfall events and rapid decline of groundwater levels during periods of low precipitation. Thus, the hydrology in these areas becomes more extreme during floods and droughts.[33] The importance of increasing infiltration is widely recognized, and the implementation of nature-based solutions to help address this problem is discussed further in later portions of this plan.

Location

Montague falls on the edge of a region in Massachusetts that is more prone to severe and extreme drought based on the number of weeks these areas experienced drought conditions from 2001-2017 (Figure 3-19). In Montague, drought would mainly impact farmland and the Montague Plains, and would therefore have a "medium" location of occurrence, affecting between 10% to 50% of the town.

[33] ERG and Horsley Witten Group, 2017

Figure 3-19: Areas Experiencing Severe or Extreme Drought, 2001 - 2017



Source: U.S. Drought Monitor, 2017, as presented in the *2018 Massachusetts Hazard Mitigation and Climate Adaptation Plan.*

Extent

The severity of a drought would determine the scale of the event and would vary among town residents depending on whether the residents' water supply is derived from a private well or the public water system. The majority of residents in Montague are served by the public water supply systems. The remaining residents depend on private wells for water. Massachusetts' wells are permitted according to their ability to meet demand for 180 days at maximum capacity with no recharge; if these conditions extended beyond the thresholds that determine supply capacity the damage from a drought could be widespread due to depleted groundwater supplies.

The U.S. Drought Monitor categorizes drought on a D0-D4 scale as shown below.

Table 3-36: U.S. Drought Monitor		
Classification	**Category**	**Description**
D0	Abnormally Dry	Going into drought: short-term dryness slowing planting, growth of crops or pastures. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered
D1	Moderate Drought	Some damage to crops, pastures; streams, reservoirs, or wells low, some water shortages developing or imminent; voluntary water-use restrictions requested
D2	Severe Drought	Crop or pasture losses likely; water shortages common; water restrictions imposed
D3	Extreme Drought	Major crop/pasture losses; widespread water shortages or restrictions
D4	Exceptional Drought	Exceptional and widespread crop/pasture losses; shortages of water in reservoirs, streams, and wells creating water emergencies

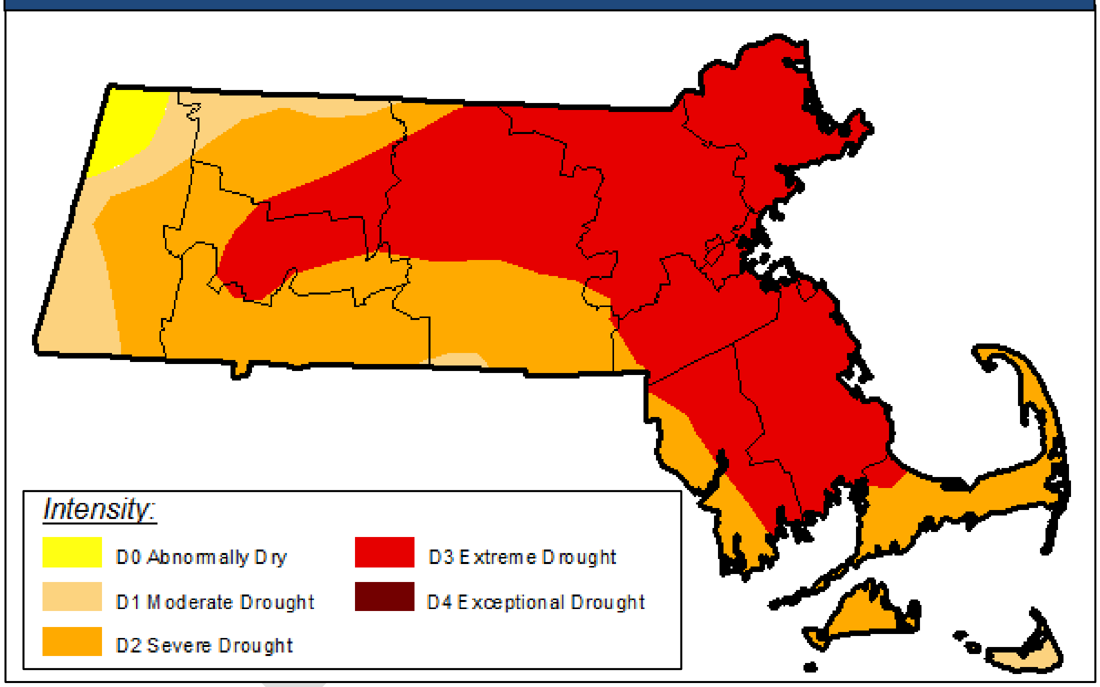
Previous Occurrences

In Massachusetts, six major droughts have occurred statewide since 1930. They range in severity and length, from three to eight years. In many of these droughts, water-supply systems were found to be inadequate.

Beginning in 1960 in western Massachusetts and in 1962 in eastern Massachusetts through 1969, Massachusetts experienced the most significant drought on record, according to the United States Geological Survey. The severity and duration of the drought caused significant impacts on both water supplies and agriculture. Although short or relatively minor droughts occurred over the next 50 years, the next long-term event began in March 2015, when Massachusetts began experiencing widespread abnormally dry conditions. In July 2016, based on a recommendation from the Drought Management Task Force (DMTF), the Secretary of EOEEA declared a Drought Watch for Central and Northeast Massachusetts and a Drought Advisory for Southeast Massachusetts and the Connecticut River Valley. Drought warnings were issued in five out of six drought regions of the state. Many experts stated that this drought was the worst in more than 50 years.

By September 2016, 78% of Franklin County was categorized as "severe drought" (D2) or higher, and 26% of the County was categorized as "extreme drought" (D3) (Figure 3-20).[34] By May 2017, the entire Commonwealth had returned to "normal" due to wetter-than-normal conditions in the spring of 2017.

Figure 3-20: Drought Conditions in Massachusetts on September 20, 2016



Source: U.S. Drought Monitor. https://droughtmonitor.unl.edu/

Drought was identified as an area of concern during the Montague Municipal Vulnerability Preparedness Community Building workshop in 2018. At the workshop it was noted that private wells have come close to running dry in the past and are vulnerable to prolonged dry periods.

[34] U.S. Drought Monitor, accessed February 13, 2019. https://droughtmonitor.unl.edu/Data/DataTables.aspx?state,MA

Probability of Future Events

According to the 2018 Massachusetts Hazard Mitigation and Climate Adaptation Plan, on a monthly basis over the 162-year period of record from 1850 to 2012, there is a 2% chance of being in a drought warning level. As noted previously, rising temperatures and changes in precipitation due to climate change could increase the frequency of episodic droughts, like the one experienced across the Commonwealth in the summer of 2016. In Montague, drought has a "Moderate" probability of future occurrence, or between a 2% and 25% chance of occurring in any given year.

Impact

Due to the water richness of western Massachusetts, Montague is unlikely to be adversely affected by anything other than a major, extended drought. The major impact to residents would be private wells running dry or being contaminated due to low water levels. Farmers could be impacted economically by the extended lack of water. Drought may increase the probability of a wildfire occurring. The prolonged lack of precipitation dries out soil and vegetation, which becomes increasingly prone to ignition as long as the drought persists. As a result, the impact of a drought would be "limited" with more than 10% of property damaged in the affected area and possible shut down of facilities for more than one day.

Firefighting capabilities could be compromised in a drought if aquifers, fire ponds, or rivers used for pumping water are low. During the MVP workshop, participants noted the need for more hydrants on the Montague Plains for fire suppression. The Turners Falls Water Department is also pursuing a back-up water supply connection with Greenfield over the General Pierce Bridge.

Vulnerability

The number and type of impacts increase with the persistence of a drought as the effect of the precipitation deficit cascades down parts of the watershed and associated natural and socioeconomic assets. For example, a precipitation deficiency may result in a rapid depletion of soil moisture that may be discernible relatively quickly to farmers. The impact of this same precipitation deficit may not affect hydroelectric power production, drinking water supply availability, or recreational uses for many months.

Society

The entire population of Montague is vulnerable to drought events. However, the vulnerability of populations to this hazard can vary significantly based on water supply sources and municipal water use policies.

Vulnerable Populations

Drought conditions can cause a shortage of water for human consumption and reduce local firefighting capabilities. Public water supplies (PWS) provide water for both of these services and may struggle to meet system demands while maintaining adequate pressure for fire suppression and meeting water quality standards. The Massachusetts Department of Environmental Protection (DEP) requires all PWS to maintain an emergency preparedness plan. The Montague Center Water Department serves residents and businesses in the village of Montague Center, and is interconnected with the Turners Falls Water Department, which can provide back-up water to the village. A water tank provides limited back-up supplies, but is in need of replacement or refurbishment. A more robust connection between the two water departments could be explored to provide greater redundancy within the systems. In addition, the Turners Falls Water Department is exploring installing a water main over the General Pierce bridge to connect with the City of Greenfield's water supply, which could also serve as a back-up supply. The Town has two interconnections with the Turners Falls Fire District, allowing for emergency short-term backup. Areas outside of Montague Center are served by private wells. Residential well owners are as vulnerable as their ability to find an alternate short- or long-term water supply (i.e. install a new well) or temporarily relocate in the event their well runs dry.

Health Impacts

With declining groundwater levels, residential well owners may experience dry wells or sediment in their water due to the more intense pumping required to pull water from the aquifer and to raise water from a deeper depth. Wells may also develop a concentration of pollutants, which may include nitrates and heavy metals (including uranium) depending on local geology. The loss of clean water for consumption and for sanitation may be a significant impact depending on the affected population's ability to quickly drill a deeper or a new well or to relocate to unaffected areas.

During a drought, dry soil and the increased prevalence of wildfires can increase the amount of irritants (such as pollen or smoke) in the air. Reduced air quality can have widespread deleterious health impacts, but is particularly significant to the health of individuals with pre-existing respiratory health conditions like asthma. Lowered water levels can also result in direct environmental health impacts, as the concentration of contaminants in swimmable bodies of water will increase when less water is present. Stagnant water bodies may develop and increase the prevalence of mosquito breeding, thus increasing the risk for vector-borne illnesses.

Economic Impacts
The economic impacts of drought can be substantial, and would primarily affect the agriculture, recreation and tourism, forestry, and energy sectors.

Infrastructure

Agriculture
Drier summers and intermittent droughts may strain irrigation water supplies, stress crops, and delay harvests. Insufficient irrigation will impact the availability of produce, which may result in higher demand than supply. This can drive up the price of local food. Farmers with wells that are dry are advised to contact the Massachusetts Department of Agricultural Resources to explore microloans through the Massachusetts Drought Emergency Loan Fund or to seek federal Economic Injury Disaster Loans.

Water and Wastewater Infrastructure
As noted already, drought affects both groundwater sources and smaller surface water reservoir supplies. Water supplies for drinking, agriculture, and water-dependent industries may be depleted by smaller winter snowpacks and drier summers anticipated due to climate change. Reduced precipitation during a drought means that water supplies are not replenished at a normal rate. This can lead to a reduction in groundwater levels and problems such as reduced pumping capacity or wells going dry. Shallow wells are more susceptible than deep wells. Suppliers may struggle to meet system demands while maintaining adequate water supply pressure for fire suppression requirements. Private well supplies may dry up and need to either be deepened or supplemented with water from outside sources.

Environment
Drought has a wide-ranging impact on a variety of natural systems. Some of those impacts can include the following:[35]

- Reduced water availability, specifically, but not limited to, habitat for aquatic species
- Decreased plant growth and productivity
- Increased wildfires
- Greater insect outbreaks
- Increased local species extinctions
- Lower stream flows and freshwater delivery to downstream estuarine habitats
- Increased potential for hypoxia (low oxygen) events
- Reduced forest productivity

[35] Clark et al., 2016

- Direct and indirect effects on goods and services provided by habitats (such as timber, carbon sequestration, recreation, and water quality from forests)
- Limited fish migration or breeding due to dry streambeds or fish mortality caused by dry streambeds

In addition to these direct natural resource impacts, a wildfire exacerbated by drought conditions could cause significant damage to Montague's environment as well as economic damage related to the loss of valuable natural resources.

Vulnerability Summary

Based on the above assessment, Montague has a vulnerability of "Low" from drought. While such a drought would require water saving measures to be implemented, there would be no foreseeable damage to structures or loss of life resulting from the hazard. The following problem statements summarize Montague's areas of greatest concern regarding droughts.

Drought Hazard Problem Statements
• Residents on private wells are vulnerable to drought.
• The Turners Falls Water Department is pursuing a connection with the City of Greenfield's water supply as a back-up water source.
• The Montague Center water supply is a shallow well and the holding tank is old and in need of replacement or refurbishment. A more robust interconnection with the Turners Falls Water Department could be explored.
• Drought exacerbates the risk of wildfire to which the Montague Plains, Dry Hill, and Lake Pleasant are vulnerable. More hydrants are needed on the Montague Plains.
• Turners Falls High School, which serves as the regional shelter, needs improved infrastructure for back-up water and power and air-conditioning.
• Farms in Montague that cannot draw water from the Connecticut River are vulnerable to crop losses from drought.

3.12 LANDSLIDES

Potential Impacts of Climate Change

According to the 2018 *Massachusetts State Hazard Mitigation and Climate Adaptation Plan*, slope saturation by water is already a primary cause of landslides in the Commonwealth. Regional climate change models suggest that New England will likely experience warmer, wetter winters in the future as well as more frequent and intense storms throughout the year. This increase in the frequency and severity of storm events could result in more frequent soil saturation conditions, which are conducive to an increased frequency of landslides. Additionally, an overall warming trend is likely to increase the frequency and duration of droughts and wildfire, both of which could reduce the extent of vegetation throughout the Commonwealth. The loss of the soil stability provided by vegetation could also increase the probability of landslides wherever these events occur.

Figure 3-21: Impacts of Climate Change on Landslides

Potential Effects of Climate Change	
CHANGES IN PRECIPITATION AND EXTREME WEATHER ➔ SLOPE SATURATION	Regional climate change models suggest that Massachusetts will likely experience more frequent and intense storms throughout the year. This change could result in more frequent soil saturation conditions, which are conducive to an increased frequency of landslides.
RISING TEMPERATURES ➔ REDUCED VEGETATION EXTENT	An increased frequency of drought events is likely to reduce the extent of vegetation throughout the Commonwealth. The loss of the soil stability provided by vegetation could also increase the probability of landslides wherever these events occur.

Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Hazard Description

The term landslide includes a wide range of ground movements, such as rock falls, deep failure of slopes, and shallow debris flows. The most common types of landslides in Massachusetts include translational debris slides, rotational slides, and debris flows. Most of these events are caused by a combination of unfavorable geologic conditions (silty clay or clay layers contained in glaciomarine, glaciolacustrine, or thick till deposits), steep slopes, and/or excessive wetness leading to excess pore pressures in the subsurface. Historical landslide data for the Commonwealth suggests that most landslides are preceded by two or more months of higher than normal precipitation, followed by a single, high-intensity rainfall of several inches or more.[36] This precipitation can cause slopes to become saturated.

Landslides associated with slope saturation occur predominantly in areas with steep slopes underlain by glacial till or bedrock. Bedrock is relatively impermeable relative to the unconsolidated material that overlies it. Similarly, glacial till is less permeable than the soil that forms above it. Thus, there is a permeability contrast between the overlying soil and the underlying, and less permeable, unweathered till and/or bedrock. Water accumulates on this less permeable layer, increasing the pore pressure at the interface. This interface becomes a plane of weakness. If conditions are favorable, failure will occur.[37]

Landslides are created by human activities as well, including deforestation, cultivation and construction, which destabilize already fragile slopes. Some human activities that could cause landslides include:

- vibrations from machinery or traffic;
- blasting;
- earthwork which alters the shape of a slope, or which imposes new loads on an existing slope;
- in shallow soils, the removal of deep-rooted vegetation that binds colluvium to bedrock; and
- construction, agricultural or forestry activities (logging) which change the amount of water which infiltrates the soil.

Location

In 2013, the Massachusetts Geological Survey prepared an updated map of potential landslide hazards for the Commonwealth (funded by FEMA's Hazard Mitigation Grant Program) to provide the public, local governments, and emergency management agencies with the location of areas where slope movements have occurred or may possibly occur in the future under conditions of prolonged moisture and high-intensity rainfall. This project was designed to provide statewide mapping and identification of landslide hazards that can be used for community level planning as well as prioritizing high-risk areas for mitigation.

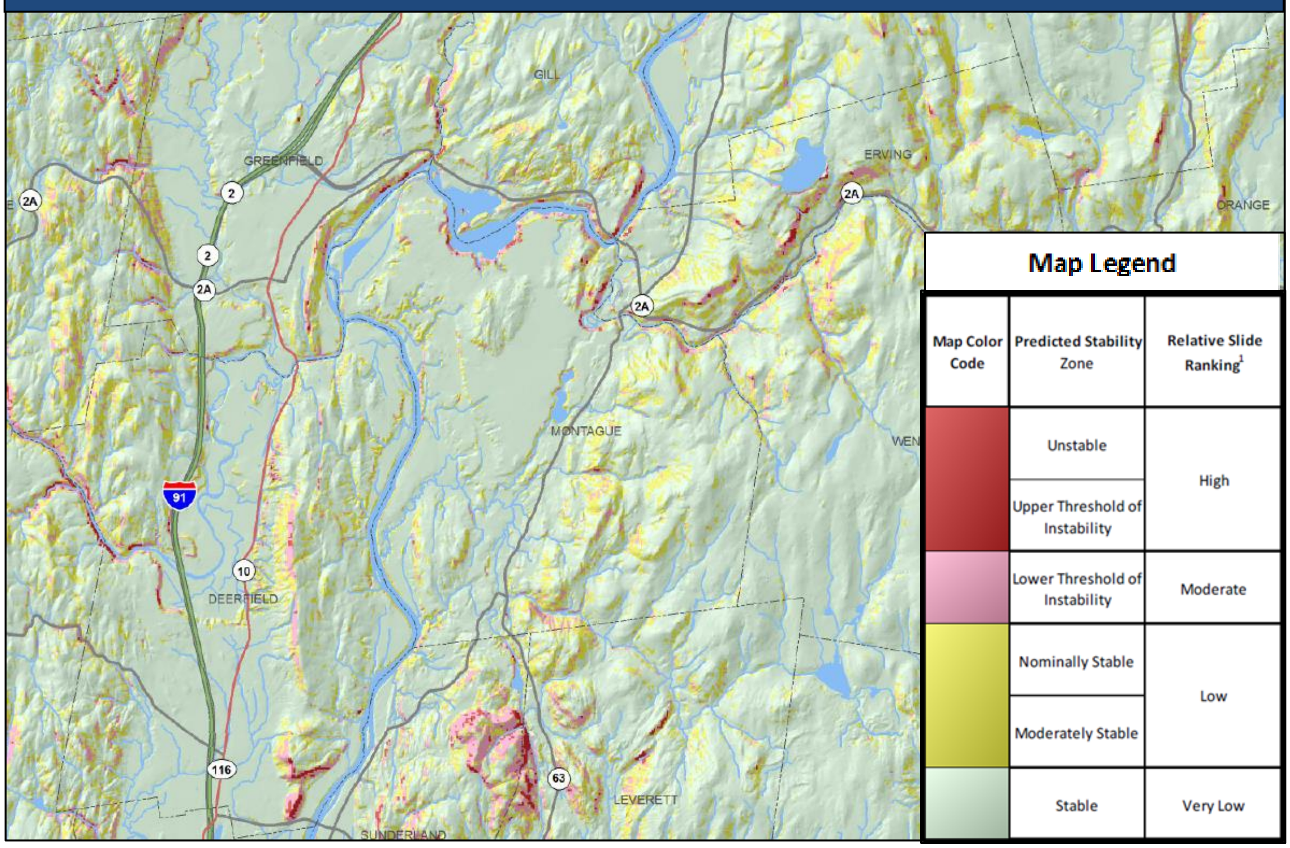
In Montague, unstable slopes are identified along the Connecticut River upstream of the Turners Falls dam, and along the Millers River. Smaller areas of unstable slopes are also identified on steep slopes near Montague Center and east of Route 63. These areas, as well as

[36] Mabee and Duncan, 2013
[37] Mabee, 2010

unstable soils along the edges of the Montague Plains, were discussed as areas of erosion and landslide concern during the 2018 MVP workshop. Erosion along the Millers River has threatened Millers Falls Road. The Town received a Hazard Mitigation Grant to address slope stabilization in this area, but it continually needs to be monitored. In addition, the Committee identified the steep riverbank behind Carlisle Avenue as a location that has experienced recent landslides. Currently the road is not threatened but the Town is monitoring the area. Flat land adjacent to low mountains in the Montague State Forest at the southeastern area of town could be vulnerable to landslides. Any destabilization of the mountains (major development removing vegetative cover, heavy rains following a wildfire) could cause a landslide with potentially devastating consequences.

Overall, landslide impacts are “isolated,” affecting less than 10% of the town.

Figure 3-22: Slope Stability Map for Montague and Surrounding Towns



Source: Massachusetts Geologic Survey and UMass Amherst, 2013

Extent

Natural variables that contribute to the overall extent of potential landslide activity in any particular area include soil properties, topographic position and slope, and historical incidence. Predicting a landslide is difficult. As a result, estimations of the potential severity of landslides are informed by previous occurrences as well as an examination of landslide susceptibility. Information about previous landslides can provide insight as to both where landslides may occur and what types of damage may result. It is important to note, however, that landslide susceptibility only identifies areas potentially affected and does not imply a time frame when a landslide might occur. The distribution of susceptibility in Montague is depicted on the Slope Stability Map, with areas of higher slope instability considered to also be more susceptible to the landslide hazard.

Previous Occurrences

No significant landslide events have been observed in Montague, however, smaller landslides occur frequently in town. Recent landslides have occurred behind Carlisle Avenue on the banks of the Connecticut River, as well as along Millers Falls Road on the banks of the Millers River.

After completion of the previous Hazard Mitigation Plan update, the Town applied for and was awarded a Hazard Mitigation Grant for the Millers Falls Road erosion control project. Erosion along a steep slope was threatening a segment of Millers Falls Road located across from Highland Cemetery, in between the Turners Falls Airport and the village of Millers Falls. The route is a main artery and evacuation route, and is the most direct route to access Millers Falls from the fire and police services based in Turners Falls. According to Town officials, the road was in imminent danger of washing out.

The project helped stabilize the slope and prevent future erosion and failure of the roadway. Neither the road nor the slope is within a floodplain, although the Millers River at the base of the slope is. Web-based aerial photographs of the area depict a large sediment delta in the river, which is indicative of severe erosion. A reconnaissance revealed that the slope has been actively failing, with fallen trees and scarps that have not yet weathered. Although most of the work conducted by the Town prior to the project had focused on management of drainage, there may be other factors contributing to the slope failure such as groundwater seepage and erosion of the toe of the slope at Millers River. While the project was successful in protecting the roadway, this area continues to experience erosion and needs constant monitoring from the town.

Cliffs along the Connecticut River at Barton’s Cove in Turners Falls are vulnerable to erosion from stormwater runoff coming from residential streets that dead end near the edge of the precipice. Residences close to the cliffs could be in danger if erosion continues. There are also negative consequences to the increased amount of salt and silt eroding into the Cove, including the possibility of increased eutrophication and loss of clean habitat for resident nesting bird populations. FirstLight Power maintains an erosion control plan along the Connecticut River as required by the Federal Energy Regulatory Commission (FERC), and has repaired and maintained eroding riverbank and slopes along the river since 2008 using bioengineering techniques, totaling over 1,000 feet. In 2009 bank stabilization work was completed in the vicinity of the Narrows on the Connecticut River.

Probability of Future Events

In general, landslides are most likely during periods of higher than average rainfall. The ground must be saturated prior to the onset of a major storm for a significant landslide to occur. Increasing heavy precipitation events will increase the risk of landslides in Montague. There is a "high" probability, or 25% to 50% chance, of a landslide happening in the next year.

Impact

Homes and infrastructure located on lots with significant slopes (i.e., 10% or greater), or that are located at the bottom of steep slopes, are at greater risk of impacts from landslides. The impact of a landslide in Montague is typically "limited," with a potential for more than 10% of property in the affected area being damaged or destroyed.

Vulnerability

Society

<u>Vulnerable Populations</u>
Populations who rely on potentially impacted roads for vital transportation needs are considered to be particularly vulnerable to this hazard. As noted previously, Millers Falls Road is an important evacuation and emergency route for the village of Millers Falls, and is susceptible to impacts from erosion and landslides along a portion of the road adjacent to the Millers River.

<u>Health Impacts</u>
People in landslide hazard zones are exposed to the risk of dying during a large-scale landslide; however, damage to infrastructure that impedes emergency access and access to health care is the largest health impact associated with this hazard. Mass movement events in the vicinity of major roads could deposit many tons of sediment and debris on top of the road. Restoring vehicular access is often a lengthy and expensive process.

Economic Impacts

A landslide's impact on the economy and estimated dollar losses are difficult to measure. Landslides can impose direct and indirect impacts on society. Direct costs include the actual damage sustained by buildings, property, and infrastructure. Indirect costs, such as clean-up costs, business interruption, loss of tax revenues, reduced property values, and loss of productivity are difficult to measure. Additionally, ground failure threatens transportation corridors, fuel and energy conduits, and communication lines

Infrastructure

Landslides can result in direct losses as well as indirect socioeconomic losses related to damaged infrastructure. Infrastructure located within areas shown as unstable on the Slope Stability Map should be considered to be exposed to the landslide hazard.

Agriculture

Landslides that affect farmland can result in significant loss of livelihood and long-term loss of productivity. Forests can also be significantly impacted by landslides.

Energy

The energy sector is vulnerable to damaged infrastructure associated with landslides. Transmission lines are generally elevated above steep slopes, but the towers supporting them can be subject to landslides. A landslide may cause a tower to collapse, bringing down the lines and causing a transmission fault. Transmission faults can cause extended and broad area outages.

Public Health

Landslides can result in injury and loss of life. Landslides can impact access to power and clean water and also increase exposure to vector-borne diseases.

Public Safety

Access to major roads is crucial to life safety after a disaster event and to response and recovery operations. The ability of emergency responders to reach people and property impacted by landslides can be impaired by roads that have been buried or washed out by landslides. The instability of areas where landslides have occurred can also limit the ability of emergency responders to reach survivors.

Transportation

Landslides can significantly impact roads and bridges. Landslides can block egress and ingress on roads, isolating neighborhoods and causing traffic problems and delays for public and private transportation. These impacts can result in economic losses for businesses. Mass movements can knock out bridge abutments or significantly weaken the soil supporting them, making them hazardous for use.

The possibility of a landslide in the vicinity of a highway or major road represents a significant economic vulnerability for the Town and State. For example, the damage to a 6-mile stretch of Route 2 caused by tropical storm Irene (2011), which included debris flows, four landslides, and fluvial erosion and undercutting of infrastructure, cost $23 million for initial repairs.

<u>Water and Wastewater Infrastructure</u>
Surface water bodies may become directly or indirectly contaminated by landslides. Landslides can block river and stream channels, which can result in upstream flooding and reduced downstream flow. This may impact the availability of drinking water. Water and wastewater infrastructure may be physically damaged by mass movements.

Environment
Landslides can affect a number of different facets of the environment, including the landscape itself, water quality, and habitat health. Following a landslide, soil and organic materials may enter streams, reducing the potability of the water and the quality of the aquatic habitat. Additionally, mass movements of sediment may result in the stripping of forest trees and soils, which in turn impacts the habitat quality of the animals that live in those forests. Flora in the area may struggle to re-establish following a significant landslide because of a lack of topsoil.

Vulnerability Summary
Based on the above assessment, Montague has a hazard index rating of “Medium” for landslides. The following problem statements summarize Montague’s areas of greatest concern regarding landslides.

Landslide Hazard Problem Statements
• Unstable soils, erosion, and steep slopes along the Connecticut and Millers Rivers, and in the south and eastern sections of town, are vulnerable to landslides. In particular, Carlisle Road and Millers Falls Road are vulnerable and need to be continually monitored.

3.13 EXTREME TEMPERATURES

Potential Impacts of Climate Change

Beyond the overall warming trend associated with global warming and climate change, Montague will experience increasing days of extreme heat in the future. Generally, extreme heat is considered to be over 90 degrees Fahrenheit (°F), because at temperatures above that threshold, heat-related illnesses and mortality show a marked increase. The average summer across the Commonwealth during the years between 1971 and 2000 included 4 days over 90°F. Climate scientists project that by mid-century, the state could have a climate that resembles that of southern states today, with between 10-28 days over 90°F. By the end of the century, extreme heat could occur between 13-56 days during summer, depending on how successful we are in reducing greenhouse gas emissions.[38]

Figure 3-23: Impacts of Climate Change on Extreme Temperatures

Potential Effects of Climate Change	
RISING TEMPERATURES ➔ HIGHER EXTREME TEMPERATURES	The average summer across the Massachusetts during the years between 1971 and 2000 included 4 days over 90°F (i.e. extreme heat days). Climate scientists project that by mid-century, the state could have a climate that resembles that of southern states today, with an additional 10-28 days over 90°F during summer. By the end of the century, extreme heat could occur between 13-56 days during summer.
RISING TEMPERATURES ➔ HIGHER AVERAGE TEMPERATURES	Compared to an annual 1971-2000 average temperature baseline of 47.6°F, annual average temperatures in Massachusetts are projected to increase by 3.8 to 10.8 degrees (likely range) by the end of the 21st century; slightly higher in western Massachusetts.

Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Hazard Description

There is no universal definition for extreme temperatures. The term is relative to the usual weather in the region based on climatic averages. Extreme heat for Massachusetts is usually defined as a period of three or more consecutive days above 90 degrees Fahrenheit (°F), but more generally as a prolonged period of excessively hot weather, which may be accompanied by high humidity. Extreme cold is also considered relative to the normal climatic lows in a region.

Massachusetts has four seasons with several defining factors, and temperature is one of the most significant. Extreme temperatures can be defined as those that are far outside the normal

[38] ResilientMA: Climate Change Clearing House for the Commonwealth: http://resilientma.org/changes/rising-temperatures. Accessed March 1, 2019.

ranges. The average highs and lows of the hottest and coolest months in Franklin County (using Greenfield data as a proxy) are provided in Table 3-37.

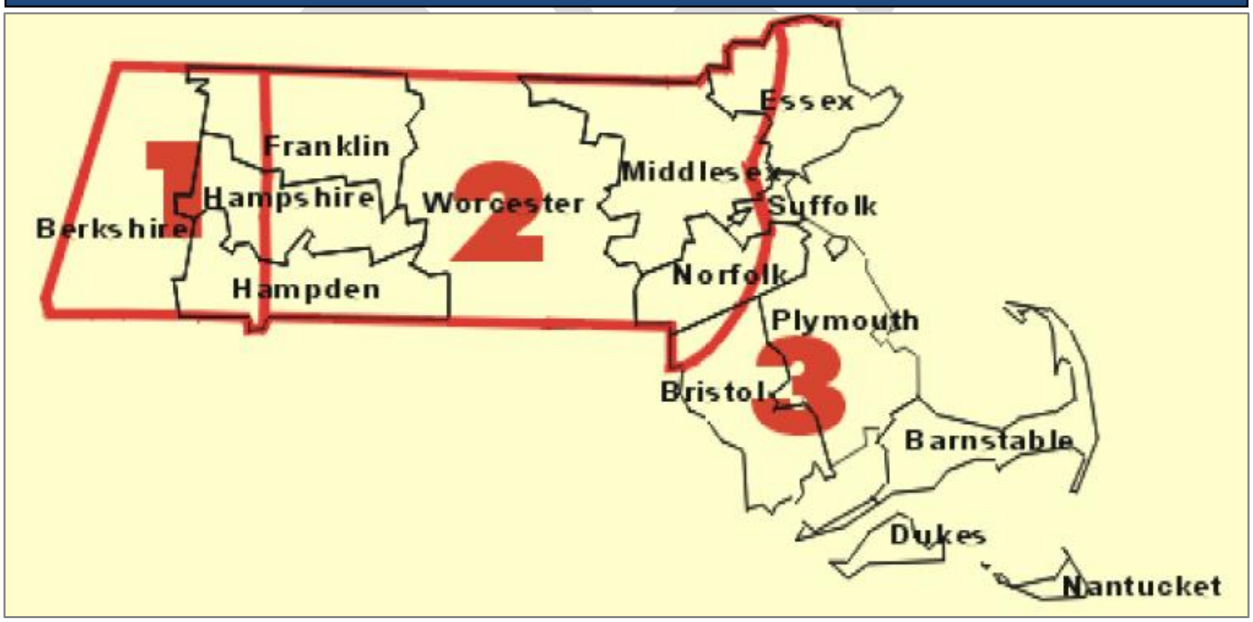
Table 3-37: Annual Average High and Low Temperatures (Greenfield)		
	July (Hottest Month)	**January (Coldest Month)**
Average High (°F)	81°	33°
Average Low (°F)	57°	12°

Note: Average temperatures are for the years 1981-2010.
Source: U.S. Climate Data.

Location

According to the NOAA, Massachusetts is made up of three climate divisions: Western, Central, and Coastal, as shown in Figure 3-24. Average annual temperatures vary slightly over the divisions, with annual average temperatures of around 46°F in the Western division (area labeled "1" in the figure), 49°F in the Central division (area labeled "2" in the figure) and 50°F in the Coastal division (area labeled "3" in the figure). Montague falls within the Central climate division.

Figure 3-24: Climate Divisions in Massachusetts



Source: NOAA, as presented in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, September 2018

Extreme temperature events occur more frequently and vary more in the inland regions of the State where temperatures are not moderated by the Atlantic Ocean. The severity of extreme heat impacts, however, is greater in densely developed urban areas like Boston than in suburban and rural areas, due to the urban "heat island" effect, described in more detail in the Impacts sub-section.

Extent

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

Figure 3-25: National Weather Service Wind Chill Chart

Temperature (°F)

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

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

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

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

Effective 11/01/01

Source: National Weather Service: https://www.weather.gov/safety/cold-wind-chill-chart

The NWS issues a Heat Advisory when the NWS Heat Index is forecast to reach 100 to 104°F for two or more hours. The NWS issues an Excessive Heat Warning if the Heat Index is forecast to reach 105°F or higher for two or more hours. The NWS Heat Index is based both on temperature and relative humidity, and describes a temperature equivalent to what a person would feel at a baseline humidity level. It is scaled to the ability of a person to lose heat to their environment. The relationship between these variables and the levels at which the NWS considers various health hazards to become relevant are shown in Figure 3-26. It is important to know that the heat index values are devised for shady, light wind conditions. Exposure to full sunshine can increase heat index values by up to 15°F. In addition, strong winds, particularly with very hot, dry air, can increase the risk of heat-related impacts.

Figure 3-26: National Weather Service Heat Index

NWS Heat Index — Temperature (°F)

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

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

Source: National Weather Service: https://www.weather.gov/safety/heat-index

Previous Occurrences

Since 1994, there have been 33 cold weather events within the Commonwealth, ranging from Cold/Wind Chill to Extreme Cold/Wind Chill events. Information on severe cold weather events in Montague and Franklin County was not available prior to 2015. However, detail on recent extreme events is provided below.

In February 2015, a series of snowstorms piled nearly 60 inches on the city of Boston in 3 weeks and caused recurrent blizzards across eastern Massachusetts. While Montague and western Massachusetts was not impacted as much from the snow, temperature gauges across the

Commonwealth measured extreme cold, with wind chills as low as -31°F. Wind chills as low as 28 below zero were recorded at the Orange Municipal Airport.

In February 2016, one cold weather event broke records throughout the state. Arctic high pressure brought strong northwest winds and extremely cold wind chills to southern New England. Wind chills as low as 38 below zero were reported in Orange.

According to the NOAA's Storm Events Database, there have been 43 warm weather events (ranging from Record Warmth/Heat to Excessive Heat events) since 1995 in Massachusetts. Excessive heat results from a combination of temperatures well above normal and high humidity. Whenever the heat index values meet or exceed locally or regionally established heat or excessive heat warning thresholds, an event is reported in the database. Information on excessive heat was not available for Montague or Franklin County prior to 2018.

In 2012, Massachusetts temperatures broke 27 heat records. Most of these records were broken between June 20 and June 22, 2012, during the first major heat wave of the summer to hit Massachusetts and the East Coast. In July 2013, a long period of hot and humid weather occurred throughout New England. One fatality occurred on July 6, when a postal worker collapsed as the Heat Index reached 100°F. In Franklin County, excessive heat was recorded for July 1, 2018, when a heat index of 107°F was observed at the Orange Municipal Airport from 1:00 PM to 5:00 PM.

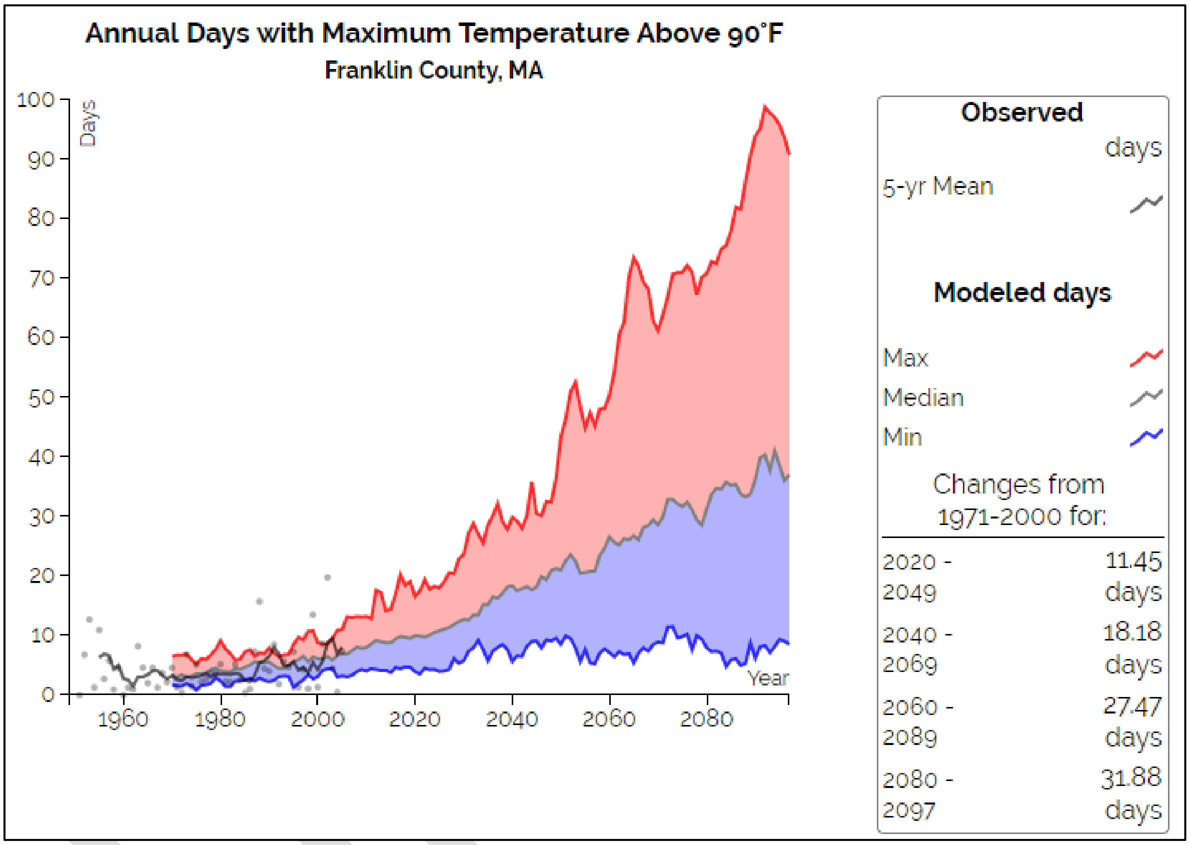
Probability of Future Events

There are a number of climatic phenomena that determine the number of extreme weather events in a specific year. However, there are significant long-term trends in the frequency of extreme hot and cold events. In the last decade, U.S. daily record high temperatures have occurred twice as often as record lows (as compared to a nearly 1:1 ratio in the 1950s). Models suggest that this ratio could climb to 20:1 by midcentury, if GHG emissions are not significantly reduced. The data support the trends of an increased frequency of extreme hot weather events and a decreased frequency of extreme cold weather events.

The average, maximum, and minimum temperatures in Franklin County are likely to increase significantly over the next century (resilient MA, 2018). This gradual change will put long-term stress on a variety of social and natural systems, and will exacerbate the influence of discrete events. Significant increases in maximum temperatures are anticipated, particularly under a higher GHG emissions scenario. Figure 3-27 displays the projected increase in the number of days per year over 90°F. The number of days per year with daily maximum temperatures over

90°F is projected to increase by 18 days by the 2050s, and by 32 days by the end of the century (for a total of 36 days over 90°F), compared to the average observed range from 1971 to 2000 of 4 days per year. Under a high emissions scenario, however, there could be as many as 100 days with a maximum temperature above 90°F by the end of the century.

Figure 3-27: Projected Annual Days with a Maximum Temperature Above 90°F



Source: resilient MA, 2018.

Impact

Extreme Cold

Extreme cold is a dangerous situation that can result in health emergencies for susceptible people, such as those without shelter or who are stranded or who live in homes that are poorly insulated or without heat. Extreme cold events are events when temperatures drop well below normal in an area. Extreme cold temperatures are characterized by the ambient air temperature dropping to approximately 0°F or below.

When winter temperatures drop significantly below normal, staying warm and safe can become a challenge. Extremely cold temperatures often accompany a winter storm, which may also cause power failures and icy roads. During cold months, carbon monoxide may be high in some areas because the colder weather makes it difficult for car emission control systems to operate effectively, and temperature inversions can trap the resulting pollutants closer to the ground.

Staying indoors as much as possible can help reduce the risk of car crashes and falls on the ice, but cold weather also can present hazards indoors. Many homes may be too cold, either due to a power failure or because the heating system is not adequate for the weather. Exposure to cold temperatures, whether indoors or outside, can cause other serious or life-threatening health problems. Power outages may also result in inappropriate use of combustion heaters, cooking appliances, and generators in indoor or poorly ventilated areas, leading to increased risk of carbon monoxide poisoning or fire.

Extreme Heat

A heat wave is defined as three or more days of temperatures of 90°F or above. A basic definition of a heat wave implies that it is an extended period of unusually high atmosphere-related heat stress, which causes temporary modifications in lifestyle and which may have adverse health consequences for the affected population. Heat waves cause more fatalities in the U.S. than the total of all other meteorological events combined.

Heat impacts can be particularly significant in urban areas. Buildings, roads, and other infrastructure replace open land and vegetation. Dark-colored asphalt and roofs also absorb more of the sun's energy. These changes cause urban areas to become warmer than the surrounding areas. This forms "islands" of higher temperatures, often referred to as "heat islands." The term "heat island" describes built-up areas that are hotter than nearby rural or shaded areas. Heat islands occur on the surface and in the atmosphere. On a hot, sunny day, the sun can heat dry, exposed urban surfaces to temperatures 50°F to 90°F hotter than the air. Heat islands can affect communities by increasing peak energy demand during the summer, air conditioning costs, air pollution and GHG emissions, heat-related illness and death, and water quality degradation.

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

Vulnerability
The entire town of Montague is vulnerable to extreme temperatures. Extreme temperature, both high heat and freezing temperatures, was identified as a top concern among participants in the 2018 MVP workshop. Elderly, low income, and homeless residents are particularly vulnerable to extreme temperatures and may lack air conditioning or safe ways to adequately heat their homes. Periods of extended high heat or extreme cold may strain the electrical grid and natural gas supply in town. Public health concerns related to extreme temperatures include poorer air quality and increased disease.

Society

<u>Vulnerable Populations</u>
According to the Centers for Disease Control and Prevention, populations most at risk to extreme cold and heat events include: (1) people over the age of 65, who are less able to withstand temperature extremes due to their age, health conditions, and limited mobility to access shelters; (2) infants and children under 5 years of age; (3) individuals with pre-existing medical conditions that impair heat tolerance (e.g., heart disease or kidney disease); (4) low-income individuals who cannot afford proper heating and cooling; (5) people with respiratory conditions, such as asthma or chronic obstructive pulmonary disease; and (6) the general public who may overexert themselves when working or exercising during extreme heat events or who may experience hypothermia during extreme cold events. Additionally, people who live alone—particularly the elderly and individuals with disabilities—are at higher risk of heat-related illness due to their isolation and potential reluctance to relocate to cooler environments.

An additional element of vulnerability to extreme temperature events is homelessness, as homeless individuals have a limited capacity to shelter from dangerous temperatures. Two homeless people died during an extreme cold event in January 2019 in Greenfield.

Table 3-38 estimates the number of vulnerable populations and households in Montague. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of Montague residents during an extreme temperature event.

Table 3-38: Estimated Vulnerable Populations in Montague		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	1,745	21%
Population with a Disability	1,477	18%
Population who Speak English Less than "Very Well"	522	6%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	1,307	35%
Householder Age 65 Years and Over Living Alone	465	12%
Households Without Access to a Vehicle	408	11%

*Total population = 8,311; Total households = 3,786
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2013-2017 Five-Year Estimates.

Montague MVP workshop participants identified the safety and well-being of vulnerable populations as a concern and challenge in town. Specific concerns include:

- Currently, children living within 1.5 miles of the elementary school are not provided bus transportation to school. Children walking to school can be exposed to extreme temperatures. The conditions of sidewalks and crossings are also a concern.
- Elders throughout town, particularly those living alone or who have no transportation, are highly vulnerable to hazards including extreme temperatures.
- The homeless population has less access to information about impending hazards, and in some cases may not want to be contacted or stay in shelters.
- Non-English speaking residents in Turners Falls and Millers Falls have tight-knit communities that help each other during emergencies. However, Town officials have limited capacity to communicate with non-English speaking residents.
- The village of Millers Falls was identified as vulnerable to air quality issues from trains idling at the train yard, which could be exacerbated with higher temperatures.

<u>Health Impacts</u>

When people are exposed to extreme heat, they can suffer from potentially deadly illnesses, such as heat exhaustion and heat stroke. Heat is the leading weather-related killer in the U.S., even though most heat-related deaths are preventable through outreach and intervention. A study of heat-related deaths across Massachusetts estimated that when the temperature rises above the 85th percentile (hot: 85-86°F), 90th percentile (very hot: 87-89°F) and 95th percentile (extremely hot: 89-92°F) there are between five and seven excess deaths per day in Massachusetts. These estimates were higher for communities with high percentages of African American residents and elderly residents on days exceeding the 85th percentile.[39] A 2013 study of heart disease patients in Worcester, MA, found that extreme heat (high temperature greater than the 95th percentile) in the 2 days before a heart attack resulted in an estimated 44 percent increase in mortality. Living in poverty appeared to increase this effect.[40] In 2015, researchers analyzed Medicare records for adults over the age of 65 who were living in New England from 2000 to 2008. They found that a rise in summer mean temperatures of 1°C resulted in a 1 percent rise in the mortality rate due to an increase in the number and intensity of heat events.[41]

Hot temperatures can contribute to deaths from heart attacks, strokes, other forms of cardiovascular disease, renal disease, and respiratory diseases such as asthma and chronic obstructive pulmonary disorder. Human bodies cool themselves primarily through sweating and through increasing blood flow to body surfaces. Heat events thus increase stress on cardiovascular, renal, and respiratory systems, and may lead to hospitalization or death in the elderly and those with pre-existing diseases.

Massachusetts has a very high prevalence of asthma: approximately 1 out of every 11 people in the state currently has asthma. In Massachusetts, poor air quality often accompanies heat events, as increased heat increases the conversion of ozone precursors in fossil fuel combustion emissions to ozone. Particulate pollution may also accompany hot weather, as the weather patterns that bring heat waves to the region may carry pollution from other areas of the continent. Poor air quality can negatively affect respiratory and cardiovascular systems, and can exacerbate asthma and trigger heart attacks.

The rate of hospital admissions for heat stress under existing conditions is shown in Figure 3-28. Between 2002 and 2012, the annual average age-adjusted rate of hospital admission for heat stress was highest in Plymouth and Suffolk Counties. Franklin County ranked among the second highest rate of 0.12-0.13 admissions per 10,000 people. As displayed in Figure 3-29, Franklin County experienced the highest annual average age-adjusted hospital admissions for heart attacks (4.29 to 4.17 per 10,000 people) during this period, along with Plymouth, Bristol, and Berkshire Counties. Hamden County had the highest annual average age emergency department visits due to asthma (see Figure 3-30), while Franklin County's rate was statistically

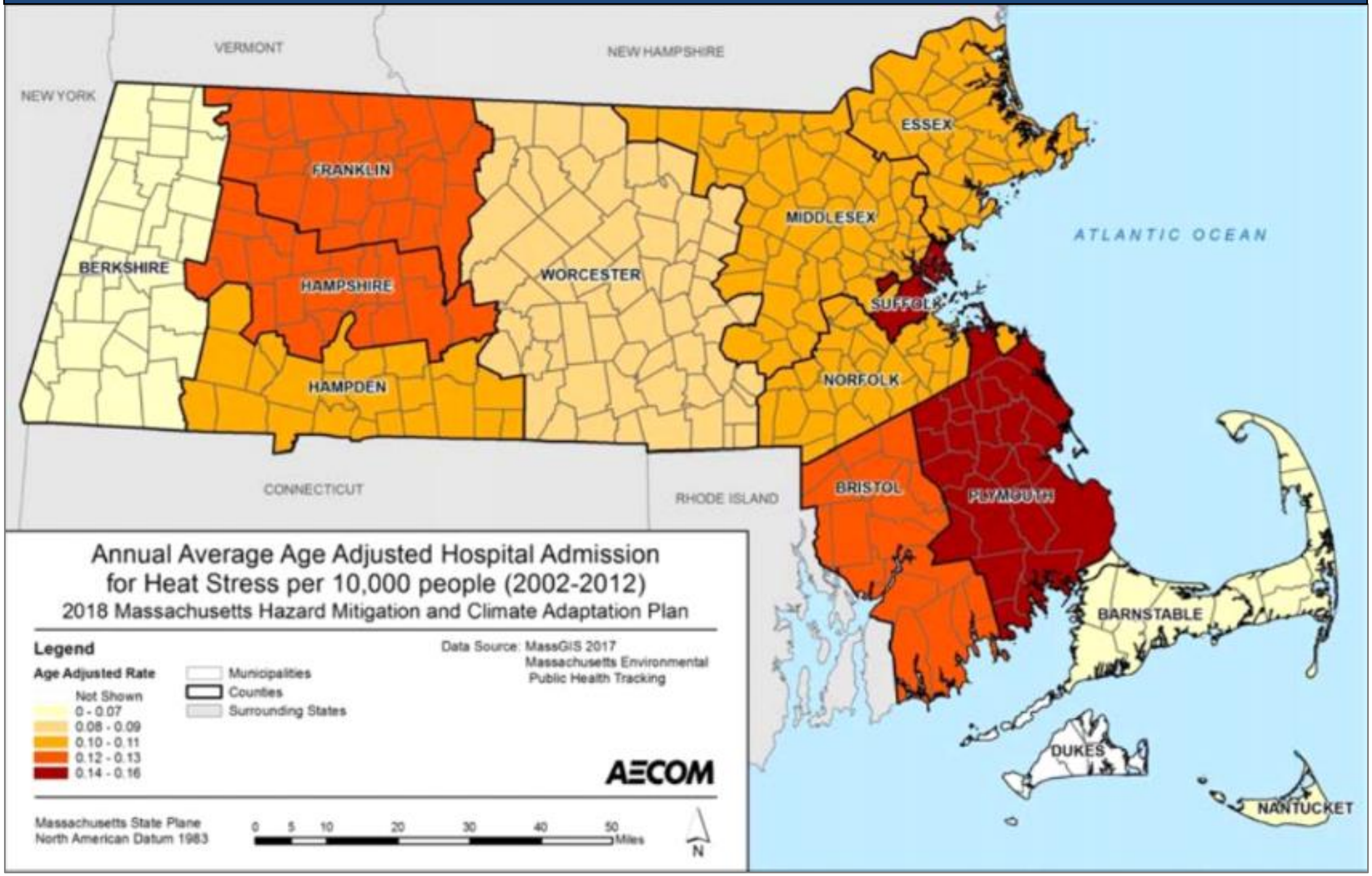
[39] Hattis et al., 2011)
[40] Madrigano et al., 2013
[41] (Shi et al., 2015).

significantly lower.

Some behaviors increase the risks of temperature-related impacts. These behaviors include voluntary actions, such as drinking alcohol or taking part in strenuous outdoor physical activities in extreme weather, but may also include necessary actions, such as taking prescribed medications that impair the body's ability to regulate its temperature or that inhibit perspiration.

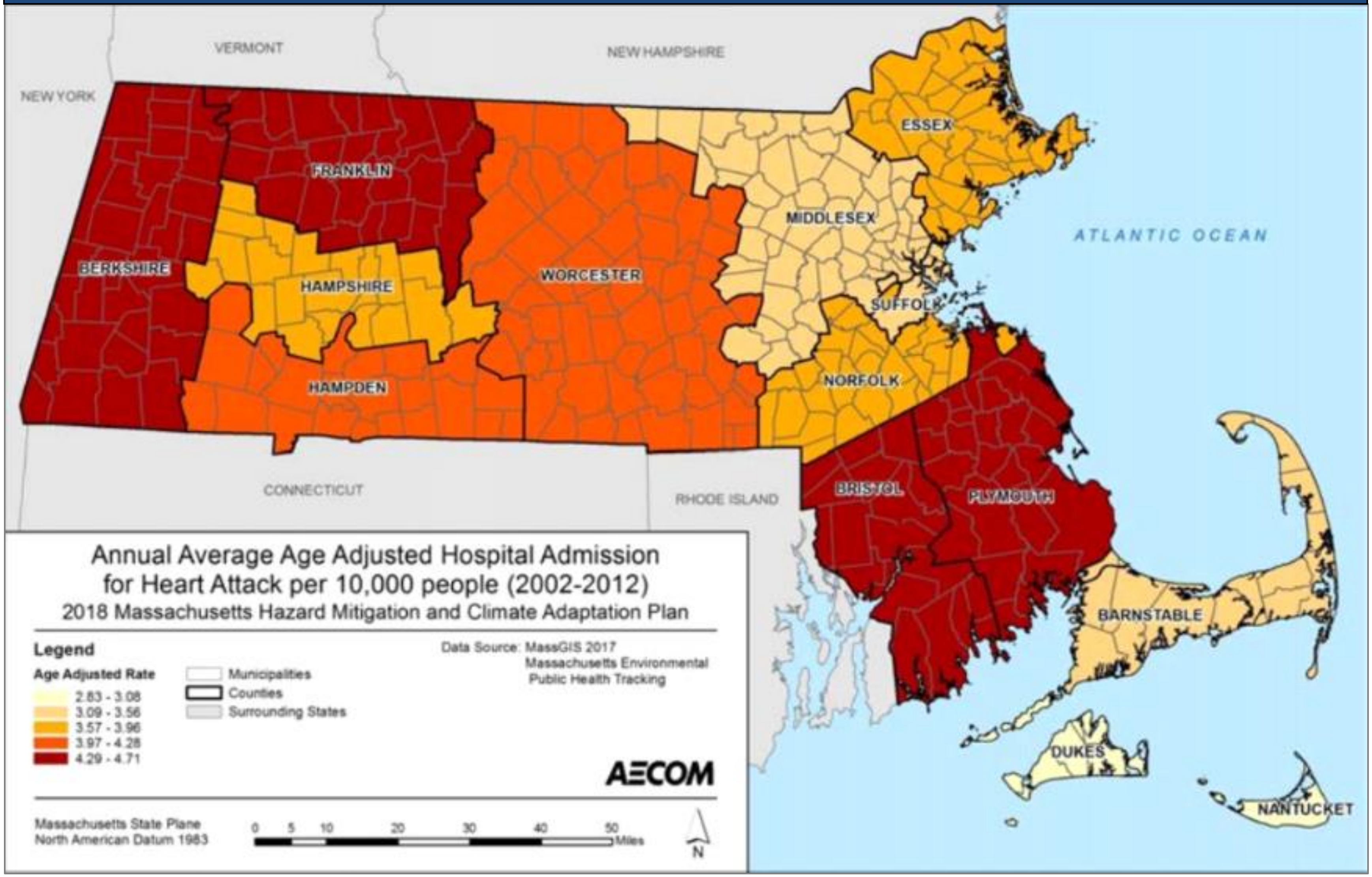
Cold-weather events can also have significant health impacts. The most immediate of these impacts are cold-related injuries, such as frostbite and hypothermia, which can become fatal if exposure to cold temperatures is prolonged. Similar to the impacts of hot weather that have already been described, cold weather can exacerbate pre-existing respiratory and cardiovascular conditions. Additionally, power outages that occur as a result of extreme temperature events can be immediately life-threatening to those dependent on electricity for life support or other medical needs. Isolation of these populations is a significant concern if extreme temperatures preclude their mobility or the functionality of systems they depend on. Power outages during cold weather may also result in inappropriate use of combustion heaters, cooking appliances, and generators in indoor or poorly ventilated areas, leading to increased risk of carbon monoxide poisoning or fires.

Figure 3-28: Rates of Heat Stress-Related Hospitalization by County



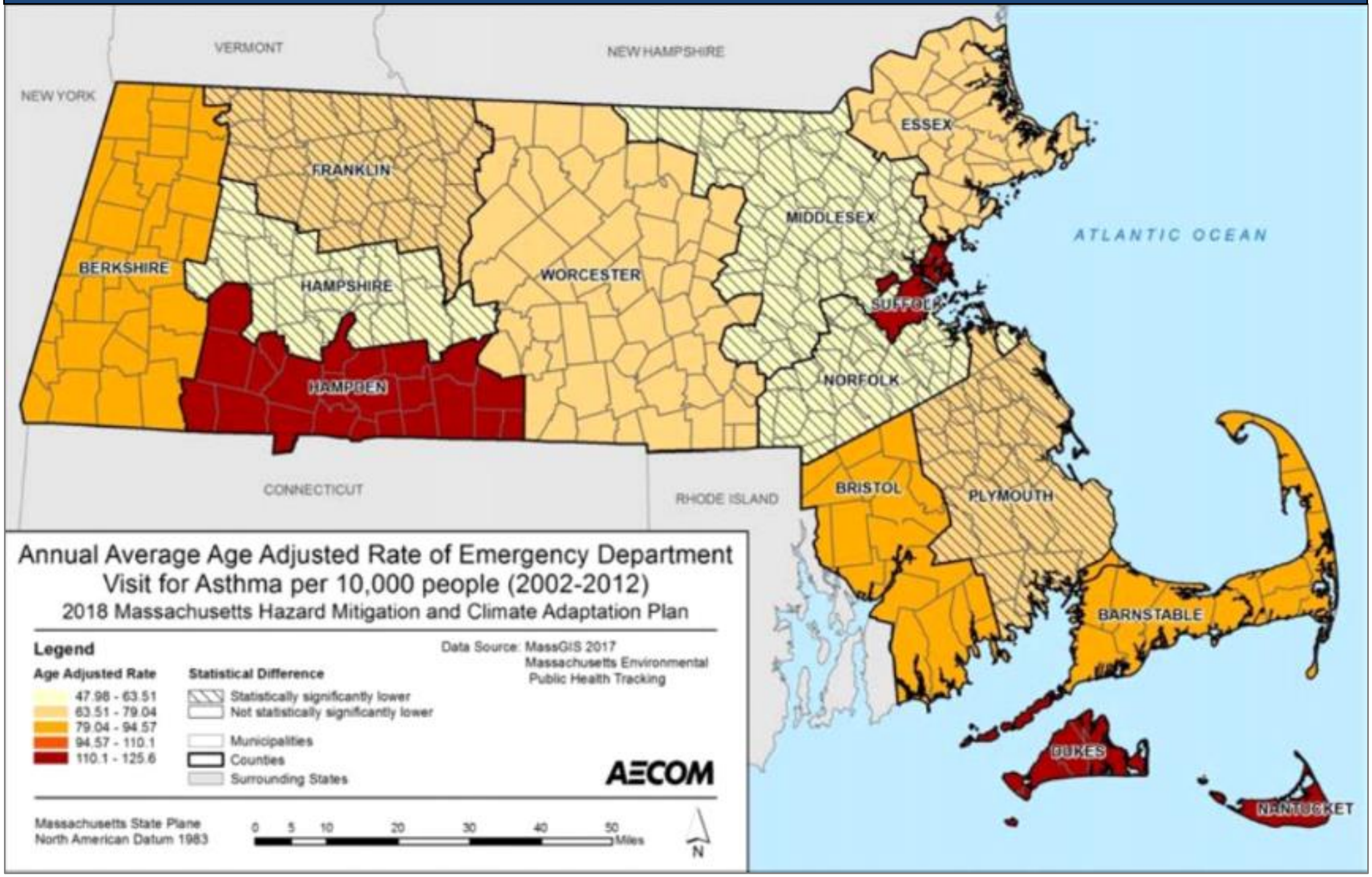
Source: Massachusetts Hazard Mitigation and Climate Adaptation Plan, September 2018.

Figure 3-29: Rates of Hospital Admissions for Heart Attacks by County



Source: Massachusetts Hazard Mitigation and Climate Adaptation Plan, September 2018.

Figure 3-30: Rates of Emergency Department Visits Due to Asthma by County



Source: Massachusetts Hazard Mitigation and Climate Adaptation Plan, September 2018.

Economic Impacts

Extreme temperature events also have impacts on the economy, including loss of business function and damage to and loss of inventory. Business owners may be faced with increased financial burdens due to unexpected building repairs (e.g., repairs for burst pipes), higher than normal utility bills, or business interruptions due to power failure (i.e., loss of electricity and telecommunications). Increased demand for water and electricity may result in shortages and a higher cost for these resources. Industries that rely on water for business (e.g., landscaping businesses) will also face significant impacts. There is a loss of productivity and income when the transportation sector is impacted and people and commodities cannot get to their intended destination. Businesses with employees that work outdoors (such as agricultural and construction companies) may have to reduce employees' exposure to the elements by reducing or shifting their hours to cooler or warmer periods of the day.

The agricultural industry is most directly at risk in terms of economic impact and damage due to extreme temperature and drought events. Extreme heat can result in drought and dry conditions, which directly impact livestock and crop production. Increasing average temperatures may make crops more susceptible to invasive species. Higher temperatures that result in greater concentrations of ozone negatively impact plants that are sensitive to ozone. Additionally, as described in the Environment sub-section, changing temperatures can impact the phenology.

Livestock are also impacted, as heat stress can make animals more vulnerable to disease, reduce their fertility, and decrease the rate of milk production. Additionally, scientists believe the use of parasiticides and other animal treatments may increase as the threat of invasive species and pests grows.

Infrastructure

All elements of the built environment are exposed to the extreme temperature hazard. The impacts of extreme heat on buildings include: increased thermal stresses on building materials, which leads to greater wear and tear and reduces a building's useful lifespan; increased air-conditioning demand to maintain a comfortable temperature; overheated heating, ventilation, and air-conditioning systems; and disruptions in service associated with power outages. Extreme cold can cause materials such as plastic to become less pliable, increasing the potential for these materials to break down during extreme cold events. In addition to the facility-specific impacts, extreme temperatures can impact critical infrastructure sectors of the built environment in a number of ways, which are summarized in the subsections that follow.

Agriculture

Above average, below average, and extreme temperatures are likely to impact crops—such as apples, peaches, and maple syrup—that rely on specific temperature regimes. Unseasonably warm temperatures in early spring that are followed by freezing temperatures can result in crop loss of fruit-bearing trees. Increasing heat stress days (above 90°F) may stress livestock and some crops. More pest pressure from insects, diseases and weeds may harm crops and cause farms to increase pesticide use. Farmers may have the opportunity to introduce new crops that are viable under warmer conditions and longer growing seasons; however, a transition such as this may be costly.[42]

Energy

In addition to increasing demand for heating and cooling, periods of both hot and cold weather can stress energy infrastructure. Electricity consumption during summer may reach three times the average consumption rate of the period between 1960 and 2000; more than 25 percent of this consumption may be attributable to climate change.[43] In addition to affecting consumption rates, high temperatures can also reduce the thermal efficiency of electricity generation.

Extended-duration extreme cold can lead to energy supply concerns, as the heating sector then demands a higher percentage of the natural gas pipeline capacity. When this occurs, New England transitions electricity generation from natural gas to oil and liquid natural gas. Limited on-site oil and liquid natural gas storage as well as refueling challenges may cause energy supply concerns if the events are colder and longer in duration.

Transportation

Extreme heat has potential impacts on the design and operation of the transportation system. Impacts on the design include the instability of materials, particularly pavement, exposed to high temperatures over longer periods of time, which can cause buckling and lead to increased failures.[44] High heat can cause pavement to soften and expand, creating ruts, potholes, and jarring, and placing additional stress on bridge joints. Extreme heat may cause heat stress in materials such as asphalt and increase the frequency of repairs and replacements. Roads are also vulnerable to rapid freeze and thaw cycles, which may cause damage to road surfaces. An increase in freeze and thaw cycles can also damage bridge expansion joints.[45]

Railroad tracks can expand in extreme heat, causing the track to "kink" and derail trains. Higher

[42] Resilient MA: http://resilientma.org/sectors/agriculture. Accessed March 4, 2019.
[43] EOEEA, 2011
[44] MassDOT, 2017
[45] Resilient MA: http://resilientma.org/sectors/transportation. Accessed March 4, 2019.

temperatures inside the enclosure-encased equipment, such as traffic control devices and signal control systems for rail service, may result in equipment failure. Rail operations will also be impacted when mandatory speed reductions are issued in areas where tracks have been exposed to high temperatures over many days, resulting in increased transit travel time and operating costs as well as a reduction in track capacity. Finally, extreme temperatures also discourage active modes of transportation, such as bicycling and walking. This will have a secondary impact on sustainable transportation objectives and public health.

Operations are vulnerable to heat waves and associated power outages that affect electrical power supply to rail operations and to supporting ancillary assets for highway operations, such as electronic signing. Increased heat also impacts transportation workers, the viability of vegetation in rights-of-way, and vehicle washing or maintenance schedules.[46] Hot weather increases the likelihood that cars may overheat during hot weather, and also increases the deterioration rate of tires.

Water Infrastructure

Extreme temperatures do not pose as great a threat to water infrastructure as flood-related hazards, but changes in temperature can impact water infrastructure. For example, extreme heat that drives increases in air-conditioning demand can trigger power outages that disrupt water and wastewater treatment.[47] Hotter temperatures will also likely result in increased outdoor water consumption. Combined with other climate impacts such as an increase in surface water evapotranspiration, changing precipitation patterns, and groundwater recharge rates, increased water demand may challenge the capacity of water supplies and providers. Extreme heat can damage aboveground infrastructure such as tanks, reservoirs, and pump stations. Warmer temperatures can also lead to corrosion, water main breaks, and inflow and infiltration into water supplies.[48] Extreme heat is likely to result in increased drought conditions, and this has significant implications for water infrastructure, as discussed in the Drought Section.

Extreme cold can freeze pipes, causing them to burst. This can then lead to flooding and mold inside buildings when frozen pipes thaw.

Environment

There are numerous ways in which changing temperatures will impact the natural environment.

[46] MassDOT, 2017
[47] Resilient MA: http://resilientma.org/sectors/water-resources. Accessed March 4, 2019.
[48] (Jha and Pathak, 2016).

Because the species that exist in a given area have adapted to survive within a specific temperature range, extreme temperature events can place significant stress both on individual species and the ecosystems in which they function. High-elevation spruce-fir forests, forested boreal swamp, and higher-elevation northern hardwoods are likely to be highly vulnerable to climate change. Higher summer temperatures will disrupt wetland hydrology. Paired with a higher incidence and severity of droughts, high temperatures and evapotranspiration rates could lead to habitat loss and wetlands drying out.[49] Individual extreme weather events usually have a limited long-term impact on natural systems, although unusual frost events occurring after plants begin to bloom in the spring can cause significant damage. However, the impact on natural resources of changing average temperatures and the changing frequency of extreme climate events is likely to be massive and widespread.

One significant impact of increasing temperatures may be the northern migration of plants and animals. Over time, shifting habitat may result in a geographic mismatch between the location of conservation land and the location of critical habitats and species the conserved land was designed to protect. One specific way in which average temperatures influence plant behavior is through changes in phenology, the pattern of seasonal life events in plants and animals. A recent study by the National Park Service found that of 276 parks studied, three-quarters are experiencing earlier spring conditions, as defined by the first greening of trees and first bloom of flowers, and half are experiencing an “extreme” early spring that exceeds 95% of historical conditions.[50] These changing seasonal cues can lead to ecological mismatches, as plants and animals that rely on each other for ecosystem services become “out of sync.” For example, migratory birds that rely on specific food sources at specific times may reach their destinations before or after the species they feed on arrive or are in season. Additionally, invasive species tend to have more flexible phenologies than their native counterparts; therefore, shifting seasons may increase the competitiveness of present and introduced invasive species.

Wild plants and animals are also migrating away from their current habitats in search of the cooler temperatures to which they are accustomed. This is particularly pertinent for ecosystems that (like many in the northeastern U.S.) lie on the border between two biome types. For example, an examination of the Green Mountains of Vermont found a 299- to 390-foot upslope shift in the boundary between northern hardwoods and boreal forests between 1964 and 2004.[51] Such a shift is hugely significant for the species that live in this ecosystem as well as for forestry companies or others who rely on the continued presence of these natural resources. Massachusetts ecosystems that are expected to be particularly vulnerable to

[49] (MCCS and DFW, 2010).
[50] (NPS, 2016).
[51] USGRP, 2014

warming temperatures include:

- Coldwater streams and fisheries
- Vernal pools
- Spruce-fir forests
- Northern hardwood (Maple-Beech-Birch) forests, which are economically important due to their role in sugar production
- Hemlock forests, particularly those with the hemlock wooly adelgid
- Urban forests, which will experience extra impacts due to the urban heat island effect

Additional impacts of warming temperatures include the increased survival and grazing damage of white-tailed deer, increased invasion rates of invasive plants, and increased survival and productivity of insect pests, which cause damage to forests.[52] As temperature increases, the length of the growing season will also increase.

Vulnerability Summary

Based on the above assessment, Montague has a "High" vulnerability to extreme temperatures. The following problem statements summarize Montague's areas of greatest concern regarding extreme temperatures.

[52] MCCS and DFW, 2010)

Extreme Temperature Hazard Problem Statements
• Higher temperatures exacerbate poor air quality caused by trains idling in the Millers Falls train yard.
• Extreme heat and cold may strain the electrical grid and Natural Gas supply. Montague would be first to lose access to Natural Gas if supplies run low.
• The Turners Falls High School boiler loses gas pressure and cannot operate during very cold temperatures, and the backup oil heating system can only run for one day. The school serves as a Regional Emergency Shelter and needs improved back-up power, water supplies, and air conditioning.
• Children walking to school are vulnerable to extreme temperatures, which can negatively impact their health and safety.
• Access to rivers, lakes and ponds for cooling off during high temperatures may lack sufficient designation and oversight by Town officials.
• Extreme heat exacerbates the wildfire risks that the Town faces: rail sparks on the Montague Plains, the Village of Lake Pleasant, Highland School Apartments, Turners Falls Road, and Dry Hill, are vulnerable to wildfire.
• Elderly and low-income residents are more vulnerable to extreme temperatures and may lack A/C or heating systems in their homes.
• Homeless and transient people in town may be difficult to reach if extreme temperatures put their health and safety at risk.
• The Town lacks capacity to reach Non-English speaking populations during emergencies.

3.14 INVASIVE SPECIES

Potential Impacts of Climate Change

A warming climate may place stress on colder-weather species while allowing non-native species accustomed to warmer climates to spread northward. This northward trend is already well documented, and is expected to accelerate in the future. Another way in which climate change may increase the frequency of natural species threat is through the possibility of climate refugees. As populations move to escape increasingly inhospitable climates, they are likely to bring along products, food, and livestock that could introduce novel (and potentially invasive) species to the areas in which they settle.

Extreme winter temperatures are also critical limiting factors for many forest pests, and warming is expected to increase their survival and lead to expansions and outbreaks. For example, in Massachusetts, it's likely that winter temperatures have been limiting the impact of hemlock wooly adelgid (Adelges tsugae), as many infested forest stands are surviving while in more southerly ranges there is near complete mortality from this pest. But the adelgid has already expanded its range with warming winter temperatures and is likely to have increased survival and higher reproductive rates in the northern portion of its range as temperatures warm, likely leading to more significant impacts on forests.[53]

Figure 3-31: Impacts of Climate Change on Invasive Species

Potential Effects of Climate Change		
	RISING TEMPERATURES ➔ WARMING CLIMATE	A warming climate may place stress on colder-weather species, while allowing non-native species accustomed to warmer climates to spread northward.
	RISING TEMPERATURES AND CHANGES IN PRECIPITATION ➔ ECOSYSTEM STRESS	Changes in precipitation and temperature combine to create new stresses for Massachusetts' unique ecosystems. For example, intense rainfall in urbanized areas can cause pollutants on roads and parking lots to get washed into nearby rivers and lakes, reducing habitat quality. As rainfall and snowfall patterns change, certain habitats and species that have specific physiological requirements may be affected. The stresses experienced by native ecosystems as a result of these changes may increase the chances of a successful invasion of non-native species.

Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Hazard Description

"Invasives" are species recently introduced to new ecosystems that cause or are likely to cause

[53] MassWildlife Climate Action Tool: http://climateactiontool.org/content/invasive-plants-and-animals. Accessed March 4, 2019.

significant harm to the environment, economy, or human health. Invasives compete with native plants and wildlife for resources, disrupt beneficial relationships, spread disease, cause direct mortality, and can significantly alter ecosystem function. Some of the more common invasives in Massachusetts may already be familiar - problematic invasive plants include purple loosestrife (Lythrum salicaria), Japanese barberry (Berberis thunbergi), glossy buckthorn (Frangula alnus), multiflora rose (Rosa multiflora), Japanese knotweed (Fallopia japonica), garlic mustard (Alliaria petiolata) and black locust (Robinia pseudoacacia). Invasive animals include forest pests such as the hemlock woolly adelgid (Adelgis tsugae), Asian longhorn beetle (Anoplophora glabripennis), and the emerald ash borer (Agrilus planipennis). The zebra mussel (Dreissena polymorpha) is a particularly detrimental aquatic invasive species that has recently been detected in Western Massachusetts.[54]

The Massachusetts Invasive Plant Advisory Group (MIPAG), a collaborative representing organizations and professionals concerned with the conservation of the Massachusetts landscape, is charged by the Massachusetts Executive Office of Energy and Environmental Affairs to provide recommendations to the Commonwealth to manage invasive species. MIPAG defines invasive plants as "non-native species that have spread into native or minimally managed plant systems in Massachusetts, causing economic or environmental harm by developing self- sustaining populations and becoming dominant and/or disruptive to those systems." These species have biological traits that provide them with competitive advantages over native species, particularly because in a new habitat they are not restricted by the biological controls of their native habitat. As a result, these invasive species can monopolize natural communities, displacing many native species and causing widespread economic and environmental damage. MIPAG recognized 69 plant species as "Invasive," "Likely Invasive," or "Potentially Invasive."

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

In 2000, Massachusetts passed an Aquatic Invasive Species Management Plan, making the

[54] MassWildlife Climate Action Tool: http://climateactiontool.org/content/invasive-plants-and-animals. Accessed March 4, 2019.

Commonwealth eligible for federal funds to support and implement the plan through the federal Aquatic Nuisance Prevention and Control Act. MassDEP is part of the Northeast Aquatic Nuisance Species Panel, which was established under the federal Aquatic Nuisance Species Task Force. This panel allows managers and researchers to exchange information and coordinate efforts on the management of aquatic invasive species. The Commonwealth also has several resources pertaining to terrestrial invasive species, such as the Massachusetts Introduced Pest Outreach Project, although a strategic management plan has not yet been prepared for these species.

Code of Massachusetts Regulation (CMR) 330 CMR 6.0(d) requires any seed mix containing restricted noxious weeds to specify the name and number per pound on the seed label. Regulation 339 CMR 9.0 restricts the transport of currant or gooseberry species in an attempt to prevent the spread of white pine blister rust. There are also a number of state laws pertaining to invasive species. Chapters 128, 130, and 132 of Part I of the General Laws of the state include language addressing water chestnuts, green crabs, the Asian longhorn beetle, and a number of other species. These laws also include language allowing orchards and gardens to be surveyed for invasive species and for quarantines to be put into effect at any time.

Identification and monitoring is an important element in mitigating impacts from invasive species. The Outsmart Invasive Species project is a collaboration between the University of Massachusetts Amherst, the Massachusetts Department of Conservation and Recreation (MA DCR) and the Center for Invasive Species and Ecosystem Health at the University of Georgia. The goal of the project is to strengthen ongoing invasive-species monitoring efforts in Massachusetts by enlisting help from citizens. The web- and smartphone-based approach enables volunteers to identify and collect data on invasive species in their own time, with little or no hands-on training. By taking advantage of the increasing number of people equipped with iPhone or digital camera/web technology, this approach will expand the scope of invasive-species monitoring, in an effort to help control outbreaks of new or emergent invasive species that threaten our environment.[55]

Location

The damage rendered by invasive species is significant. The massive scope of this hazard means that the entire Town of Montague may experience impacts from these species. Furthermore, the ability of invasive species to travel far distances (either via natural mechanisms or accidental human interference) allows these species to propagate rapidly over a large

[55] https://masswoods.org/outsmart. Accessed March 5, 2019.

geographic area. Similarly, in open freshwater ecosystems, invasive species can quickly spread once introduced, as there are generally no physical barriers to prevent establishment, outside of physiological tolerances, and multiple opportunities for transport to new locations (by boats, for example).

One of the immediate threats to Montague is the southern pine beetle that could imperil the Montague Plains. Japanese knotweed is present along the Sawmill River and the Connecticut River, and is resulting in streambank erosion. It is known for being less effective at erosion control along banks than the native plants that it crowds out.

Extent

Invasive species are a widespread problem in Massachusetts and throughout the country. The geographic extent of invasive species varies greatly depending on the species in question and other factors, including habitat and the range of the species. Some (such as the gypsy moth) are nearly controlled, whereas others, such as the zebra mussel, are currently adversely impacting ecosystems throughout the Commonwealth. Invasive species can be measured through monitoring and recording observances.

Previous Occurrences

The terrestrial and freshwater species listed on the MIPAG website as “Invasive” (last updated April 2016) are identified in Table 3-39. The table also includes details on the nature of the ecological and economic challenges presented by each species as well as information on where the species has been detected in Massachusetts. Twenty-five of the invasive species on the list have been observed in Montague since 2010.

Table 3-39: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Montague**
Acer platanoides L. (**Norway maple**)	A tree occurring in all regions of the state in upland and wetland habitats, and especially common in woodlands with colluvial soils. It grows in full sun to full shade. Escapes from cultivation; can form dense stands; out-competes native vegetation, including sugar maple; dispersed by water, wind and vehicles.	Y
Aegopodium podagraria L. (**Bishop's goutweed; bishop's weed; goutweed**)	A perennial herb occurring in all regions of the state in uplands and wetlands. Grows in full sun to full shade. Escapes from cultivation; spreads aggressively by roots; forms dense colonies in flood plains.	Y
Ailanthus altissima (P. Miller) Swingle (**Tree of heaven**)	This tree occurs in all regions of the state in upland, wetland, & coastal habitats. Grows in full sun to full shade. Spreads aggressively from root suckers, especially in disturbed areas.	Y
Alliaria petiolata (Bieb.) Cavara & Grande (**Garlic mustard**)	A biennial herb occuring in all regions of the state in uplands. Grows in full sun to full shade. Spreads aggressively by seed, especially in wooded areas.	Y
Berberis thunbergii DC. (**Japanese barberry**)	A shrub occuring in all regions of the state in open and wooded uplands and wetlands. Grows in full sun to full shade. Escaping from cultivation; spread by birds; forms dense stands.	Y
Cabomba caroliniana A.Gray (**Carolina fanwort; fanwort**)	A perennial herb occuring in all regions of the state in aquatic habitats. Common in the aquarium trade; chokes waterways.	N
Celastrus orbiculatus Thunb. (**Oriental bittersweet; Asian or Asiatic bittersweet**)	A perennial vine occuring in all regions of the state in uplands. Grows in full sun to partial shade. Escaping from cultivation; berries spread by birds and humans; overwhelms and kills vegetation.	Y
Cynanchum louiseae Kartesz & Gandhi (**Black swallow-wort, Louise's swallow-wort**)	A perennial vine occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to partial shade. Forms dense stands, out-competing native species: deadly to Monarch butterflies.	Y

Species (Common Name)	Notes on Occurrence and Impact	Observed in Montague
Elaeagnus umbellata Thunb. (**Autumn olive**)	A shrub occurring in uplands in all regions of the state. Grows in full sun. Escaping from cultivation; berries spread by birds; aggressive in open areas; has the ability to change soil.	Y
Euonymus alatus (Thunb.) Sieb. (**Winged euonymus; Burning bush**)	A shrub occurring in all regions of the state and capable of germinating prolifically in many different habitats. It grows in full sun to full shade. Escaping from cultivation and can form dense thickets and dominate the understory; seeds are dispersed by birds.	Y
Euphorbia esula L. (**Leafy spurge; wolf's milk**)	A perennial herb occurring in all regions of the state in grasslands and coastal habitats. Grows in full sun. An aggressive herbaceous perennial and a notable problem in western USA.	ND
Frangula alnus P. Mill. (**European buckthorn; glossy buckthorn**)	Shrub or tree occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Produces fruit throughout the growing season; grows in multiple habitats; forms thickets.	Y
Hesperis matronalis L. (**Dame's rocket**)	A biennial and perennial herb occurring in all regions of the state in upland and wetland habitats. Grows in full sun to full shade. Spreads by seed; can form dense stands, particularly in flood plains.	Y
Iris pseudacorus L. (**Yellow iris**)	A perennial herb occurring in all regions of the state in wetland habitats, primarily in flood plains. Grows in full sun to partial shade. Out-competes native plant communities.	Y
Lonicera japonica Thunb. (**Japanese honeysuckle**)	A perennial vine occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Rapidly growing, dense stands climb and overwhelm native vegetation; produces many seeds that are bird dispersed; more common in southeastern Massachusetts.	N
Lonicera morrowii A.Gray (**Morrow's honeysuckle**)	A shrub occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Part of a confusing hybrid complex of nonnative honeysuckles commonly planted and escaping from cultivation via bird dispersal.	Y
Lonicera x bella Zabel [*morrowii* x *tatarica*] (**Bell's honeysuckle**)	This shrub occurs in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Part of a confusing hybrid complex of nonnative honeysuckles commonly planted and escaping from cultivation via bird dispersal.	N
Lysimachia nummularia L. (**Creeping jenny; moneywort**)	A perennial herb occurring in all regions of the state in upland and wetland habitats. Grows in full sun to full shade. Escaping from cultivation; problematic in flood plains, forests and wetlands; forms dense mats.	Y

Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Montague**
Lythrum salicaria L. (**Purple loosestrife**)	A perennial herb or subshrub occurring in all regions of the state in upland and wetland habitats. Grows in full sun to partial shade. Escaping from cultivation; overtakes wetlands; high seed production and longevity.	Y
Myriophyllum heterophyllum Michx. (**Variable water-milfoil; Two-leaved water-milfoil**)	A perennial herb occurring in all regions of the state in aquatic habitats. Chokes waterways, spread by humans and possibly birds.	Y
Myriophyllum spicatum L. (**Eurasian or European water-milfoil; spike water-milfoil**)	A perennial herb found in all regions of the state in aquatic habitats. Chokes waterways, spread by humans and possibly birds.	Y
Phalaris arundinacea L. (**Reed canary-grass**)	This perennial grass occurs in all regions of the state in wetlands and open uplands. Grows in full sun to partial shade. Can form huge colonies and overwhelm wetlands; flourishes in disturbed areas; native and introduced strains; common in agricultural settings and in forage crops.	Y
Phragmites australis (Cav.) Trin. ex Steud. subsp. australis (**Common reed**)	A perennial grass (USDA lists as subshrub, shrub) found in all regions of the state. Grows in upland and wetland habitats in full sun to full shade. Overwhelms wetlands forming huge, dense stands; flourishes in disturbed areas; native and introduced strains.	Y
Polygonum cuspidatum Sieb. & Zucc. (**Japanese knotweed; Japanese or Mexican Bamboo**)	A perennial herbaceous subshrub or shrub occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade, but hardier in full sun. Spreads vegetatively and by seed; forms dense thickets.	Y
Polygonum perfoliatum L. (**Mile-a-minute vine or weed; Asiatic tearthumb**)	This annual herbaceous vine is currently known to exist in several counties in MA, and has also has been found in RI and CT. Habitats include streamside, fields, and road edges in full sun to partial shade. Highly aggressive; bird and human dispersed.	Y
Potamogeton crispus L. (**Crisped pondweed; curly pondweed**)	A perennial herb occurring in all regions of the state in aquatic habitats. Forms dense mats in the spring and persists vegetatively.	Y

Species (Common Name)	Notes on Occurrence and Impact	Observed in Montague
Ranunculus ficaria L. (**Lesser celandine; fig buttercup**)	A perennial herb occurring on stream banks, and in lowland and uplands woods in all regions of the state. Grows in full sun to full shade. Propagates vegetatively and by seed; forms dense stands especially in riparian woodlands; an ephemeral that outcompetes native spring wildflowers.	N
Rhamnus cathartica L. (**Common buckthorn**)	A shrub or tree occurring in all regions of the state in upland and wetland habitats.Grows in full sun to full shade. Produces fruit in fall; grows in multiple habitats; forms dense thickets.	Y
Robinia pseudoacacia L. (**Black locust**)	A tree that occurs in all regions of the state in upland habitats. Grows in full sun to full shade. While the species is native to central portions of Eastern North America, it is not indigenous to Massachusetts. It has been planted throughout the state since the 1700's and is now widely naturalized. It behaves as an invasive species in areas with sandy soils.	Y
Rosa multiflora Thunb. (**Multiflora rose**)	A perennial vine or shrub occurring in all regions of the state in upland, wetland and coastal habitats. Grows in full sun to full shade. Forms impenetrable thorny thickets that can overwhelm other vegetation; bird dispersed.	Y
Trapa natans L. (**Water-chestnut**)	An annual herb occurring in the western, central, and eastern regions of the state in aquatic habitats. Forms dense floating mats on water.	N

Source: Massachusetts Invasive Plant Advisory Group, https://www.massnrc.org/mipag/invasive.htm, and Franklin County Flora Group, 2019.

Although there are less clear-cut criteria for invasive fauna, there are a number of animals that have disrupted natural systems and inflicted economic damage on the Commonwealth, and may impact Montague (Table 3-40). One invasive species, the Zebra mussel, was first documented in Massachusetts in Laurel Lake in Erving and Warwick in 2009. Invasive fungi are also included in this table. Because of the rapidly evolving nature of the invasive species hazard, this list is not considered exhaustive.

Table 3-40: Invasive Animal and Fungi Species in Massachusetts	
Species (Common Name)	**Notes on Occurrence and Impact**
Terrestrial Species	
Lymantria dispar dispar (**Gypsy moth** (insect))	This species was imported to Massachusetts for silk production, but escaped captivity in the 1860s. It is now found throughout the Commonwealth and has spread to parts of the Midwest. This species is considered a serious defoliator of oaks and other forest and urban trees; however, biological controls have been fairly successful against it.
Ophiostoma ulmi, Ophiostoma himal-ulmi, Ophiostoma novo-ulmi (**Dutch elm disease** (fungus))	In the 1930s, this disease arrived in Cleveland, Ohio, on infected elm logs imported from Europe. A more virulent strain arrived in the 1940s. The American elm originally ranged in all states east of Rockies, and elms were once the nation's most popular urban street tree. However, the trees have now largely disappeared from both urban and forested landscapes. It is estimated that "Dutch" elm disease has killed more than 100 million trees.
Adelges tsugae (**Hemlock woolly adelgid** (insect))	This species was introduced accidentally around 1924 and is now found from Maine to Georgia, including all of Massachusetts. It has caused up to 90% mortality in eastern hemlock species, which are important for shading trout streams and provide habitat for about 90 species of birds and mammals. It has been documented in about one-third of Massachusetts cities and towns and threatens the state's extensive Eastern Hemlock groves.
Cryphonectria parasitica (**Chestnut blight** (fungus))	This fungus was first detected in New York City in 1904. By 1926, the disease had devastated chestnuts from Maine to Alabama. Chestnuts once made up one-fourth to one-half of eastern U.S. forests, and the tree was prized for its durable wood and as a food for humans, livestock, and wildlife. Today, only stump sprouts from killed trees remain.
Anoplophora glabripennis (**Asian long-horned beetle**)	This species was discovered in Worcester in 2008. The beetle rapidly infested trees in the area, resulting in the removal of nearly 30,000 infected or high-risk trees in just 3 years.

Cronartium ribicola (**White pine blister rust** (fungus))	This fungus is an aggressive and non-native pathogen that was introduced into eastern North America in 1909. Both the pine and plants in the Ribes genus (gooseberries and currants) must be present in order for the disease to complete its life cycle. The rust threatens any pines within a quarter-mile radius from infected Ribes.
Species (Common Name)	**Notes on Occurrence and Impact**
Aquatic Species	
Dreissena polymorpha (**Zebra mussel**)	The first documented occurrence of zebra mussels in a Massachusetts water body occurred in Laurel Lake in July 2009. Zebra mussels can significantly alter the ecology of a water body and attach themselves to boats hulls and propellers, dock pilings, water intake pipes and aquatic animals. They are voracious eaters that can filter up to a liter of water a day per individual. This consumption can deprive young fish of crucial nutrients.

Source: Chase et al., 1997; Pederson et al., 2005, CZM, 2013, 2014; Defenders of Wildlife; Gulf of Maine; EOEEA, 2013a, 2013b; as presented in the 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan.

Probability of Future Events

Because the presence of invasive species is ongoing rather than a series of discrete events, it is difficult to quantify the frequency of these occurrences. However, increased rates of global trade and travel have created many new pathways for the dispersion of exotic species. As a result, the frequency with which these threats have been introduced has increased significantly. Increased international trade in ornamental plants is particularly concerning because many of the invasive plants species in the U.S. were originally imported as ornamentals.

More generally, a warming climate may place stress on colder-weather species while allowing non-native species accustomed to warmer climates to spread northward. The impacts of invasive species and climate change is discussed in more detail below.

Impact

The impacts of invasive species may interact with those of climate change, magnifying the negative impacts of both threats. Furthermore, due to the very traits that make them successful at establishing in new environments, invasives may be favored by climate change. These traits include tolerance to a broad range of environmental conditions, ability to disperse or travel long distances, ability to compete efficiently for resources, greater ability to respond to changes in the environment with changes in physical characteristics (phenotypic plasticity), high reproductive rates, and shorter times to maturity.

To become an invasive species, the species must first be transported to a new region, colonize and become established, and then spread across the new landscape. Climate change may impact each stage of this process. Globally, climate change may increase the introduction of invasive species by changing transport patterns (if new shipping routes open up), or by increasing the survival of invasives during transport. New ornamental species may be introduced to Massachusetts to take advantage of an expanded growing season as temperatures warm. Aquatic invasives may survive in ships' ballast waters with warmer temperatures. Extreme weather events or altered circulation patterns due to climate change could also allow the dispersal of invasive species to new regions via transportation of seeds, larvae and small animals.

Species may shift their ranges north as the climate warms and be successful in regions they previously had not colonized. Invasives may also be able to spread more rapidly in response to climate change, given their high dispersal rates and fast generation times. These faster moving species may be at a competitive advantage if they can move into new areas before their native competitors.

Here in the Northeast, warming conditions may be particularly concerning for some invasives because species ranges in temperate regions are often limited by extreme cold temperatures or snowfall. There is concern that aquatic species, such as hydrilla (Hydrilla verticillata) and water hyacinth (Eichhornia crassipes), may be able to survive and overwinter in Massachusetts with increased temperatures and reduced snowfall. Nutria (Myocastor coypus), large, non-native, semi-aquatic rodents that are currently established in Maryland and Delaware, are likely to move north with warming temperatures - perhaps as far as Massachusetts.

Extreme winter temperatures are also critical limiting factors for many forest pests, and warming is expected to increase their survival and lead to expansions and outbreaks. For example, in Massachusetts, it’s likely that winter temperatures have been limiting the impact of hemlock wooly adelgid (Adelges tsugae), as many infested forest stands are surviving while in more southerly ranges there is near complete mortality from this pest. But the adelgid has already expanded its range with warming winter temperatures and is likely to have increased survival and higher reproductive rates in the northern portion of its range as temperatures warm, likely leading to more significant impacts on forests.

Invasive species are often able to thrive or take advantage of areas of high or fluctuating resource availability such as those found in disturbed environments. For example, for invasive plants, insect outbreaks or storms often free up space in the forest allowing light to penetrate and nutrients and moisture balances to change, allowing invasive plants to move in. Climate change is likely to create these types of opportunities through increased disturbances such as storms and floods, coastal erosion and sea level rise.

Invasives may also be better able to respond to changing environmental conditions that free up resources or create opportunities. For example, greater plasticity in response to their environment may allow some invasive plants to respond faster to increases in spring temperature than native plants. These invasives are able to leaf-out earlier in warmer years, taking up available space, nutrients, and sunlight, and achieving a competitive advantage against native species. Increased carbon dioxide in the atmosphere may also benefit some weedy plant species, allowing them to compete for other resources (like water) more effectively than their native counterparts.

Species roles may change as the climate changes, further complicating the management and policy response. As species ranges shift and existing inter-species relationships are broken, there is the potential that some species, including native species, may become pests because the interspecies interactions (e.g., predation, herbivory) that used to keep their population numbers in check are no longer functional.[56]

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

Vulnerability

Because plant and animal life is so abundant in Montague, the entire town is considered to be exposed to the invasive species hazard. Areas with high amounts of plant or animal life may be at higher risk of exposure to invasive species than less vegetated areas; however, invasive species can disrupt ecosystems of all kinds.

Society

The majority of invasive species do not have direct impacts on human well-being; however, as described in the following subsections, there are some health impacts associated with invasive

[56] This section excerpted from the MassWildlife Climate Action Tool: http://climateactiontool.org/content/invasive-plants-and-animals. Accessed March 5, 2019.

species.

Vulnerable Populations
Invasive species rarely result in direct impacts on humans, but sensitive people may be vulnerable to specific species that may be present in the state in the future. These include people with compromised immune systems, children under the age of 5, people over the age of 65, and pregnant women. Those who rely on natural systems for their livelihood or mental and emotional well-being are more likely to experience negative repercussions from the expansion of invasive species.

Health Impacts
Of particular concern to human health are species like the Asian tiger mosquito (Aedes albopic-tus). This invasive mosquito, originally from southeast and subtropical Asia has moved through the Eastern U.S. and has recently arrived in Massachusetts. Capable of spreading West Nile Virus, Equine Encephalitis, and numerous other tropical diseases, this aggressive mosquito is likely range-limited by cold winter temperatures, suitable landscape conditions (it prefers urban areas), and variation in moisture. As winter temperatures increase, the species is likely to become more prevalent in Massachusetts and throughout the Northeast, increasing the risk of serious illness for residents in summer months.[57]

Additional invasive species have negative impacts on human health. The Tree of Heaven (Ailanthus altissima)) produces powerful allelochemicals that prevent the reproduction of other species and can cause allergic reactions in humans. Similarly, due to its voracious consumption, the zebra mussel accumulates aquatic toxins, such as polychlorinated biphenyls or polyaromatic hydrocarbons, in their tissues at a rapid rate. When other organisms consume these mussels, the toxins can accumulate, resulting in potential human health impacts if humans consume these animals.

Loss of urban tree canopy from invasive species and pests can lead to higher summertime temperatures and greater vulnerability to extreme temperatures. Health impacts from extreme heat exposure is discussed in the Extreme Temperature section.

Economic Impacts
Economic impacts include the cost to control invasive species on public and private land. Individuals who are particularly vulnerable to the economic impacts of this hazard include all groups who depend on existing ecosystems in Montague for their economic success. This

---

[57] MassWildlife Climate Action Tool: http://climateactiontool.org/content/invasive-plants-and-animals. Accessed March 5, 2019.

includes all individuals working in forestry and agriculture-related fields, as well as those whose livelihoods depend on outdoor recreation activities such as hunting, hiking, or aquatic sports. Businesses catering to visitors who come to a town for outdoor recreation opportunities can also suffer from loss of business. Additionally, homeowners whose properties are adjacent to vegetated areas or waterbodies experiencing decline from an invasive species outbreak could experience decreases in property value.

Infrastructure

The entire town of Montague is considered exposed to this hazard; however, the built environment is not expected to be impacted by invasive species to the degree that the natural environment is. Buildings are not likely to be directly impacted by invasive species. Amenities such as outdoor recreational areas that depend on biodiversity and ecosystem health may be impacted by invasive species. Facilities that rely on biodiversity or the health of surrounding ecosystems, such as outdoor recreation areas or agricultural/forestry operations, could be more vulnerable to impacts from invasive species.

Agriculture

The agricultural sector is vulnerable to increased invasive species associated with increased temperatures. Approximately 15% of Montague's land base is in agricultural use. More pest pressure from insects, diseases, and weeds may harm crops and cause farms to increase pesticide use. In addition, floodwaters may spread invasive plants that are detrimental to crop yield and health. Agricultural and forestry operations that rely on the health of the ecosystem and specific species are likely to be vulnerable to invasive species.

Public Health

An increase in species not typically found in Massachusetts could expose populations to vector-borne disease. A major outbreak could exceed the capacity of hospitals and medical providers to care for patients.

Transportation

Water transportation may be subject to increased inspections, cleanings, and costs that result from the threat and spread of invasive species. Species such as zebra mussels can damage aquatic infrastructure and vessels.

Water Infrastructure

Water storage facilities may be impacted by zebra mussels. Invasive species may lead to reduced water quality, which has implications for the drinking water supplies and the cost of treatment.

Environment

Montague is 70% forested, and is therefore vulnerable to invasive species impacts to forests. Invasive plants can out-compete native vegetation through rapid growth and prolific seed production. Increased amounts of invasive plants can reduce plant diversity by dominating forests. When invasive plants dominate a forest, they can inhibit the regeneration of native trees and plants. This reduced regeneration further reduces the forest's ability to regenerate in a timely and sufficient manner following a disturbance event. In addition, invasive plants have been shown to provide less valuable wildlife habitat and food sources.

As discussed previously, the movement of a number of invasive insects and diseases has increased with global trade. Many of these insects and diseases have been found in New England, including the hemlock woolly adelgid, the Asian long-horned beetle, and beech bark disease. These organisms have no natural predators or controls and are significantly affecting our forests by changing species composition as trees susceptible to these agents are selectively killed.

Invasive species interact with other forest stressors, such as climate change, increasing their negative impact. Examples include:

- A combination of an earlier growing season, more frequent gaps in the forest canopy from wind and ice storms, and carbon dioxide fertilization will likely favor invasive plants over our native trees and forest vegetation.
- Preferential browse of native plants by larger deer populations may favor invasive species and inhibit the ability of a forest to regenerate after wind and ice storms.
- Warming temperatures favor some invasive plants, insects, and diseases, whose populations have historically been kept in check by the cold climate.
- Periods of drought weaken trees and can make them more susceptible to insects and diseases.[58]

Aquatic invasive species pose a particular threat to water bodies. In addition to threatening native species, they can degrade water quality and wildlife habitat. Impacts of aquatic invasive species include:

- Reduced diversity of native plants and animals
- Impairment of recreational uses, such as swimming, boating, and fishing

[58] Catanzaro, Paul, Anthony D'Amato, and Emily Silver Huff. *Increasing Forest Resiliency for an Uncertain Future*. University of Massachusetts Amherst, University of Vermont, USDA Forest Service. 2016

- Degradation of water quality
- Degradation of wildlife habitat
- Increased threats to public health and safety
- Diminished property values
- Local and complete extinction of rare and endangered species

Vulnerability Summary

Montague's overall hazard vulnerability rating for invasive species is "Medium." Below are the areas of greatest concern in Montague related to invasive species.

Invasive Species Hazard Problem Statements
• Japanese knotweed is growing along the Sawmill River, Connecticut River, and other streams in town. It is less effective at controlling erosion, leading to greater property loss, damage to infrastructure, and reduced water quality due to flooding.
• The Southern Pine Beetle threatens the Montague Plains, which consists of a unique, pine-scrub oak sandplain habitat.
• Other pests and pathogens could imperil the Montague Plains and the town's hardwood forests as temperatures warm.
• Agriculture and forestry in Montague rely on biodiverse ecosystems and are experiencing negative impacts due to invasive species. The scope of successfully controlling invasives long-term is often beyond the reach of what farmers and foresters can manage on their own.
• Warming temperatures favor some invasive plants, insects, and diseases, including those spread by ticks and mosquitos, whose populations have historically been kept in check by the cold climate
• Education and outreach is needed to increase local awareness around invasive species and equip residents with appropriate control measures.

3.15 OTHER HAZARDS

In addition to the hazards identified above, the Hazard Mitigation Team reviewed the full list of hazards listed in the Massachusetts Hazard Mitigation and Climate Adaptation Plan. Due to the location and context of the Town, coastal erosion, coastal flooding, and tsunamis were determined not to be a threat.

MANMADE HAZARDS

Most non-natural or manmade hazards fall into two general categories: intentional acts and accidental events, although these categories can overlap. Some of the hazards included in these two categories, as defined by MEMA, consist of intentional acts such as explosive devices, biological and radiological agents, arson and cyberterrorism and accidental events such as nuclear hazards, invasive species, infrastructure failure, industrial and transportation accidents. Accidental events can arise from human activities such as the manufacture, transportation, storage, and use of hazardous materials.

This plan does not address all manmade hazards that could affect Montague. A complete hazards vulnerability analysis was not within the scope of this update. For the purposes of this plan update, industrial transportation accidents, industrial accidents in a fixed facility, and cyber threats were evaluated.

Hazardous Materials General Description

Hazardous materials in various forms can cause death, serious injury, long-lasting health effects, and damage to buildings, homes, and other property. Many products containing hazardous chemicals are used and stored in homes routinely. These products are also shipped daily on the nation's highways, railroads, waterways, and pipelines. Chemical manufacturers are one source of hazardous materials, but there are many others, including service stations, hospitals, and hazardous materials waste sites. Hazardous materials come in the form of explosives, flammable and combustible substances, poisons, and radioactive materials. These substances are most often released as a result of transportation accidents or because of chemical accidents in plants.

A release may occur at a fixed facility or in transit. Communities with a large industrial base may be more inclined to experience a hazardous materials release due to the number of facilities that use such materials in their manufacturing process. Communities with several major roadways may be at a greater risk due to the number and frequency of trucks transporting hazardous materials.

Location and Extent

<u>Industrial Accidents – Transportation</u>

Franklin County transportation systems include road, rail, and air. Accessible and efficient freight transportation plays a vital function in the economy of the region. Most freight and goods being transported to and from Franklin County are by truck; however, a significant amount of freight that moves through the county is being hauled over the three main rail lines. Given that any freight shipped via air needs first to be trucked to an airport outside the region, air transportation is not being evaluated in this plan.

The major trucking corridors in Franklin County are Interstate 91, running north/south, and Route 2, running east/west. These two highways also represent the busiest travel corridors in the region for non-commercial traffic. According to the Franklin County Hazardous Material Emergency Plan (HMEP) , 12 or more trucks per hour travel through the region containing hazardous materials. While most of these vehicles are on Interstate 91, 2 trucks per hour carrying hazardous materials travel on Route 2 just north of Montague, and an average of 1 truck per hour carrying hazardous materials travels on Routes 63 and 47 in Montague. In addition, the HMEP notes that all roads in the county likely have vehicles carrying hazardous materials at varying intervals. Additionally, the Committee identified the following routes as hazardous transportation routes in Montague:

- Avenue A
- Industrial Boulevard
- Millers Falls Road
- Montague City Road
- Route 63
- Turners Falls Road

Safe and efficient transportation routes for trucks to and through the region are important to the region’s economy and to the safety of its citizens. The safer the transportation routes are, the less likely a transportation accident will occur.

Franklin County has two primary rail lines that carry hazardous materials to and through the county, both passing through Montague. The hazardous chemicals carried by rail through the county in 2013 were:

- Petroleum crude
- Liquefied petroleum
- Petroleum gases
- Sodium chlorate
- Sodium hydroxide
- Carbon dioxide
- Phenol molten
- Hydrochloric acid
- Acetone
- Methanol
- Air bag inflation
- chemicals
- Methyl methacrylate
- Alkylphenols
- Batteries, wet
- Adhesives
- Caustic alkali
- Helium, compressed
- Fire extinguisher
- chemicals
- Sulfuric acid
- Paint
- Gasoline
- Toluene
- Hydrogen peroxide

Industrial Accidents – Fixed Facilities

An accidental hazardous material release can occur wherever hazardous materials are manufactured, stored, transported, or used. Such releases can affect nearby populations and contaminate critical or sensitive environmental areas. Those facilities using, manufacturing, or storing toxic chemicals are required to report their locations and the quantities of the chemicals stored on-site to state and local governments. The Toxics Release Inventory (TRI) contains information about more than 650 toxic chemicals that are being used, manufactured, treated, transported, or released into the environment. Table 3-41 identifies facilities in Montague where toxic chemicals are stored, used, or where hazardous waste is generated.

Table 3-41: Massachusetts Toxics Users in Montague

Facility Name	Facility Location	Facility Type
Verizon MONTAGUE	26 Central Street	Tier II Facility (US EPA)
Verizon MILLERS FALLS	12 Crescent Street	Tier II Facility (US EPA)
Lightlife Foods; Inc	1 LightLife Way	Tier II Facility (US EPA)
Great Falls Aquaculture – Main Plant	One Australia Way & 24 Industrial Boulevard	Tier II Facility (US EPA)
Hillside Plastics, Inc.	262 Millers Falls Road	Tier II Facility (US EPA)
Charter NEX Films	18 Industrial Boulevard	Tier II Facility (US EPA)
Comcast – Montague Headend (Turners Falls)	33 Industrial Bloulevard	Tier II Facility (US EPA)
Dell Street Substation	9 Oak Street	Tier II Facility (US EPA)
Town of Montague Water Pollution Control Facility	34 Greenfield Road	Tier II Facility (US EPA)
Montague Substation	20 Farren Avenue	Tier II Facility (US EPA)
FirstLight Power Resources - Cabot Station	15 Cabot Street	Tier II Facility (US EPA)
Cabot Station	Montague City Road	Large Quantity Generator of EPA/RCRA-regulated Hazardous Waste
Verizon TURNERS FALLS	185 Avenue A	Tier II Facility (US EPA)

Table 3-41: Massachusetts Toxics Users in Montague		
Deerfield Packaging, Inc.	199 Industrial Boulevard	Tier II Facility (US EPA) Large Quantity Generator of MA-regulated Hazardous Waste
Hart & Cooley Inc. (Formally Selkirk/Heat Fab)	130 Industrial Blvd	Tier II Facility (US EPA) Large Quantity Toxic User
Judd Wire, Inc.	124 Turnpike Road	Tier II Facility (US EPA) Large Quantity Toxic User
Southworth Paper (closed)*	36 Canal St	Tier II Facility (US EPA) Large Quantity Toxic User
Walgreens	240 Avenue A	Large Quantity Generator of EPA/RCRA-regulated Hazardous Waste

* Southworth Paper is no longer in operation, but hazardous materials are still on site. MA DEP conducted a clean-up of the site, but additional decommissioning of the factory is needed.

Source: Massachusetts Executive Office of Energy and Environmental Affairs, Massachusetts Department of Environmental Protection, and U.S. EPA. https://mass-eoeea.maps.arcgis.com/apps/webappviewer/index.html?id=485fe2bea40f49d3944a58ed368a7b4d

As noted previously in this plan, blighted and abandoned properties in the canal district of Turners Falls are a hazardous materials concern for the town. Some of these properties have known or suspected contaminants, and have been targets of arson in the recent past. "The Patch" neighborhood abuts the canal district area and is vulnerable to releases of toxic chemicals from flooding or fire. In addition, the Keith Street apartments and Winslow Wentworth House public housing are within close proximity to the area, as well as many multi-family homes on Canal Street. Only one bridge (out of eight bridges that access the canal district) is fully functional, posing a public safety access concern for this neighborhood. Other blighted properties throughout town are a public health and safety concern as well.

In addition to the above facilities, many farmers store agricultural chemicals on their properties. Given that much farmland is located in or near floodplains and their adjacent water bodies, the potential for an accidental hazardous materials spill to impact water quality is present. This plan does not include an in-depth evaluation of hazardous materials as they relate to farming. In many cases, farmers do use and store pesticides, herbicides and fertilizers on their property. And in most cases, farmers are utilizing best management practices in the use and storage of agricultural chemicals and have undergone any required training and licensing if they are applying these chemicals to the land. Despite training and best management practices, an accidental release of hazardous materials can occur and potentially threaten human health and the environment. One approach that the Town could take to help prepare for a hazardous materials spill on a farm would be to become familiar with the types and quantities of chemicals stored on site at the larger farms. This would assist first responders in being adequately prepared to protect human health and prevent contamination of the environment in the event of a major spill or other accidental release of hazardous materials.

Hazardous facilities located outside of town boundaries can also be of concern to Montague. The Vermont Yankee nuclear power plant is located on the Connecticut River in Vernon, Vermont, near the Vermont/Massachusetts border. In January 2010, the facility notified the Vermont Department of Health that samples taken in November 2009 from a ground water monitoring well on site contained tritium. This finding signals an unintended release of radioactive material into the environment. Testing has shown that contaminated groundwater has leaked into the Connecticut River, though tritium levels in the river have remained below the lower limit of detection.[59]

On August 27, 2013, Entergy, then-owner of Vermont Yankee, announced that Vermont Yankee would cease operations at the end of 2014 for economic reasons. Vermont Yankee officially disconnected from the grid on December 29, 2014. The reactor was manually shut down without incident. Transfer of all Vermont Yankee spent fuel from the reactor to the spent fuel pool was completed on January 12, 2015. The transfer of all Vermont Yankee spent fuel to dry cask storage was completed on August 1, 2018. On December 6, 2018, the Vermont Public Utilities Commission (PUC) approved Entergy's sale of Vermont Yankee to subsidiaries of NorthStar Group Services, Inc., as a means of completing the decommissioning and site restoration on an accelerated schedule.[60]

More recently, the 2011 tsunami and earthquake in Japan that damaged a nuclear power plant demonstrates the potential vulnerability of these facilities to natural disasters, and the geographic extent that could be impacted by an accident. While Vermont Yankee is no longer in operation, the storage of spent fuel at the site still presents a potential risk. Montague officials should stay abreast of proper evacuation procedures in the event of an accident at the Vermont Yankee nuclear power plant.

Cyber Threats

A failure of networked computer systems could result in the interruption or disruption of town services (including public safety and other critical services), the disruption or interruption of the functioning of town departments, and the potential for loss or theft of important data (including financial information of the town and residents).

---

[59] Vermont Department of Health. http://healthvermont.gov/enviro/rad/vt_yankee.aspx

[60] Vermont Department of Public Service: https://publicservice.vermont.gov/content/nuclear_decommissioning_citizens_advisory_panel_ndcap/history. Accessed July 6, 2019.

There are many possible causes of a network failure, but most either happen because of damage to the physical network/computer system infrastructure or damage to the network in cyberspace. Physical damages are incidents that damage physical telecommunications infrastructure or server/computer hardware. Examples are a water main break above a server room, fire/lighting strike that destroys equipment, construction accident damaging buried fiber line, or power outage and other issues effecting the Internet Service Provider (ISP) that interrupts access to the internet to the town.

Damage to the cyber infrastructure can be malicious attacks or critical software errors that affect computer systems, from individual computers to the entire network. These virtual hazards can cause lack of access to the network, permanent data loss, permanent damage to computer hardware, and impact the ability to access programs or systems on the network. When incidents are malicious attacks, they can impact:

- Confidentiality: protecting a user's private information.
- Integrity: ensuring that data is protected and cannot be altered by unauthorized parties.
- Availability: keeping services running and giving administration access to key networks and controls.
- Damage: irreversible damage to the computer or network operating system or "bricking" and physical, real world damages, caused by tampering with networked safety systems.
- Confidence: confidence of stakeholders in the organization who was victim of the attack.

Motives for cyber-attacks can vary tremendously, ranging from the pursuit of financial gain—the primary motivation for what is commonly referred to as "cyber-crimes" is for profit, retribution, or vandalism. Other motivations include political or social aims. Hacktivism is the act of hacking, or breaking into a computer system, for a political or social purpose. Cyber espionage is the act of obtaining secrets without permission of the holder of the information, using methods on the Internet, networks, or individual computers. [61] These threats are not only external; many acts of cyber-crime happened from current or former employees who were given network access legitimately.

For Montague, the most likely cyber-threat effecting the town and town departments come from malware and social engineering. These crimes pray on the vulnerable and unprepared and every individual and organization that connects a device to the internet is a potential mark.

---

[61] NYC Hazard Mitigation, Cyber Threats, https://nychazardmitigation.com/hazard-specific/cyber-threats/what-is-the-hazard/

Social Engineering:

Social engineering involves obtaining confidential information from individuals through deceptive means by mail, email, over the phone, and increasingly through text messages.[62] These techniques are referred to as 'Phishing'.

Malware:

Malware, or malicious software, is any program or file that is harmful to a computer user. Types of malware can include computer viruses, worms, Trojan horses, and spyware. These malicious programs can perform a variety of different functions such as stealing, encrypting or deleting sensitive data, altering or hijacking core computing functions and monitoring users' computer activity without their permission. The most common way for malware to infect a town's network is through an employee opening an infected email attachment.

Previous Occurrences

Over the past few years a type of malware called ransomware has been targeted at local governments. Cyber-criminals will use social-engineering to infect a network, take control and block user access to that network, then request a ransom from the organization. Once the ransomware is on the network, it can be extremely expensive and time consuming to restore that network without paying the ransom. When the cost of the ransom is less than the cost of resorting the system, is when the cyber-criminals succeed.

The Montague Police Department was impacted by ransomware due to phishing attacks in 2017. The Police Department's network is well backed up and firewalled. The total loss, therefore, was 30 hours of labor rebooting the network and only 4 hours of data loss. In general, IT security practices are decentralized in Town, with no formal program or education for municipal employees.

In July 2019, school districts all across the United States were targeted by ransomware. Since 2013, there have been some 170 attacks against state and local governments and there is no sign that this trend is slowing. Unlike other hazards, cyber-threats are global. Cyber-criminals don't care where you are or how small your town is. Many cyber-crimes are not just lone criminals, they are more often than not committed by sophisticate criminal organizations and foreign governments who work around the clock looking to exploit small towns and big businesses alike.

The best way to prevent a cyber-attack is to follow best practices in cyber-security. Following

[62] Cybersecurity Precautions, MA Executive Office of Technology Services & Security, 2017

these best practices will greatly mitigate the likelihood a cyber-attack is successful. MA Executive Office of Technology Services and Security (EOTSS)[63] is the chief MA State program that can assist local governments with cyber-security. There are educational opportunities available throughout the region that aim to assist municipalities learn and implement these best practices.

Manmade Hazards Problem Statements
• The blighted mill properties along the canal in Turners Falls are vulnerable to extreme weather events and a range of Manmade hazards, including unabated hazardous materials exposure to air or water, leaching into the adjacent canal or river, or incineration in fire resulting from natural hazards and arson. Dense residential areas adjacent to the mills are vulnerable to exposure to hazardous materials.
• While the chance is low, a dam failure at Harriman Dam, or any of the High Hazard dams on the Deerfield or Connecticut Rivers or Northfield Mountain Pumped Storage Facility, could trigger cascading failures on multiple other dams downstream, resulting in catastrophic flooding in Montague, potentially including Critical Infrastructure, several Hazardous Facilities, and Hazardous Materials Routes and Rails.
• The Millers Falls rail yard is located adjacent to residences and businesses, and a derailment could cause a hazardous spill, affecting the community there.
• A hazardous spill on the rails through Montague Plains or through the Public Water Supply Protection Areas would pose a serious hazard to the aquifer, the Town's drinking water supply. A spill on the rails near the fish hatchery would put this resource at risk.
• Montague Center Water Department has a shallow well, which could be contaminated by a hazardous spill nearby. The water tank is also aging, which makes it more susceptible to hazards.
• Several bridges in town serve as important access and evacuation routes but are badly in need of repair. All but the new Gill-Montague Bridge are vulnerable to failure, which would be considered a Manmade hazard. Evacuating residents may be difficult in the event that any or all of these compromised bridges have to be closed during an emergency.
• Community Action School in the Patch Neighborhood could be vulnerable if a hazard required evacuation, given limited access to the neighborhood.
• Two schools on Industrial Boulevard, Franklin County Technical School and Ja'Duke Preschool, are within close proximity to facilities storing or using toxic materials, and have evacuation access vulnerabilities should a hazard cause closure of the dead end road.

[63] https://www.mass.gov/cybersecurity

Manmade Hazards Problem Statements
• Homeless and transient people, in town may be difficult to reach in the event of an emergency.
• The Town lacks capacity to reach Non-English speaking populations during emergencies.
• Emergency Communication Systems need to be enhanced with radio and cell towers in the eastern and southeastern part of town. The radio communication system at Turners Falls High School needs improvements, including the installation of repeaters.
• Cyber-attacks on local government is a growing threat. Keeping up with current best practices in cyber security can be challenging for a small community like Montague.
• Sparks from passing trains, as well as fires started by people, are a wildfire threat to the Montague Plains.

4 MITIGATION CAPABILITIES & STRATEGIES

4.1 NATURE-BASED SOLUTIONS FOR HAZARD MITIGATION & CLIMATE RESILIENCY

Nature-Based Solutions are actions that work with and enhance nature to help people adapt to socio-environmental challenges. They may include the conservation and restoration of natural systems, such as wetlands, forests, floodplains and rivers, to improve resiliency. NBS can be used across a watershed, a town, or on a particular site. NBS use natural systems, mimic natural processes, or work in tandem with engineering to address natural hazards like flooding, erosion and drought.

The 2018 Massachusetts Hazard Mitigation and Climate Adaptation Plan and the MVP program both place great emphasis on NBS, and multiple state and federal agencies fund projects that utilize NBS. For this plan, Low Impact Development (LID) and Green Infrastructure (GI) are included under the blanket term of NBS. Following are examples of how NBS can mitigate natural hazards and climate stressors, and protect natural resources and residents:

- Restoring and reconnecting streams to floodplains stores flood water, slows it down and reduces infrastructure damage downstream
- Designing culverts and bridges to accommodate fish and wildlife passage also makes those structures more resilient to flooding, allowing for larger volumes of water and debris to safely pass through
- Managing stormwater with small-scale infiltration techniques like rain gardens and vegetated swales recharges drinking water supplies, reduces stormwater runoff, and reduces mosquito habitat and incidents of vector-borne illness by eliminating standing pools of water following heavy rain events
- Planting trees in developed areas absorbs carbon dioxide, slows and infiltrates stormwater, and provides shade, reducing summertime heat, lowering energy costs for village residents and improving air quality by reducing smog and particulate matter
- Vegetated riparian buffers absorb and filter pollutants before they reach water sources, and reduce erosion and water velocity during high flow events

This update of the Montague Multi-Hazard Mitigation Plan incorporates Nature-Based Solutions into mitigation strategies where feasible.

4.2 EXISTING AUTHORITIES POLICIES, PROGRAMS, & RESOURCES

One of the steps of this Hazard Mitigation Plan update process is to evaluate all of the Town's existing policies and practices related to natural hazards and identify potential gaps in protection.

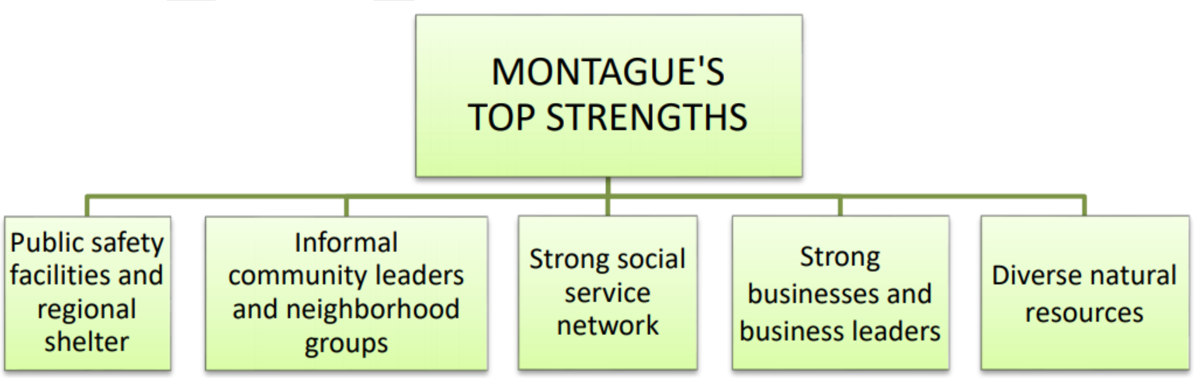
Montague has many of the no cost or low cost hazard mitigation capabilities in place. Land use zoning, subdivision regulations and an array of specific policies and regulations that include hazard mitigation best practices, such as limitations on development in floodplains, stormwater management, tree maintenance, etc. Montague has appropriate staff dedicated to hazard mitigation-related work for a community its size, including a Town Administrator, Town Planner, Building Inspector, Health Department, Emergency Management Director, a professionally run Highway Department, and a Tree Warden.

The Town also has very committed and dedicated volunteers who serve on Boards and Committees and in Volunteer positions. The Town collaborates closely with surrounding communities and is party to Mutual Aid agreements through MEMA. Montague is also a member community of the Franklin Regional Council of Governments, and participates in the Franklin County Regional Emergency Planning Committee (REPC).

Montague's Top Strengths and Assets

All Hazards

Participants at the 2018 MVP Community Resilience Building workshop identified strengths and assets that help keep their community resilient in the face of climate change and other challenges. They include:



- Public safety facilities and regional shelter: Workshop participants noted that important public facilities are located safely outside of floodplains, such as the Public Safety Complex on Turnpike Road. The Turners Falls High School, which serves as a regional shelter, is also outside of the floodplain.

- Informal community leaders and neighborhood groups: Participants said that there are a number of well-connected informal leaders in the community who could serve to help strengthen connections between Town officials and vulnerable or underserved populations. Neighborhood groups, also informal in nature, provide support to residents in the event of an emergency or severe weather, such as heavy snow, wind or rain.

- Strong social service network: Workshop participants expressed appreciation for social service organizations in Montague, including the regional housing authority that serves elders and low income people. They also said that relationships between social service providers and the Town are strong.

- Strong businesses and business leaders: Participants said that businesses and business leaders play an important role in the cohesiveness of the community. There are also good relationships between Town officials and business leaders, and participants stated that business leaders could play an important role in the event of an emergency or hazardous event.

- Diverse natural resources: This asset rounds out an impressive list of Montague's strengths and assets. The Montague Plains came up several times during the workshop as one of the community's greatest natural resources strengths**.**

Overview of Mitigation Strategies by Hazard

An overview of the general concepts underlying mitigation strategies for each of the hazards identified in this plan is as follows:

Flooding

The key factors in flooding are the water capacity of water bodies and waterways, the regulation of waterways by flood control structures, and the preservation of flood storage areas (like floodplains) and wetlands. As more land is developed, more flood storage is demanded of the town's water bodies and waterways. Floods on the Connecticut River and portions of its major tributaries that are prone to backwater effects are controlled by nine flood control reservoirs located upstream in Massachusetts, New Hampshire, and Vermont.

The Town of Montague has adopted several land use regulations that serve to limit or regulate development in floodplains, to manage stormwater runoff, and to protect groundwater and wetland resources, the latter of which often provide important flood storage capacity. These regulations are summarized in Table 4-1.

Infrastructure like dams and culverts are also in place to manage the flow of water. However, some of this infrastructure is aging and in need of replacement, or is undersized and incapable of handling heavier flows our region is experiencing due to climate change. The Town would like to inventory and evaluate culverts at road-stream crossings to prioritize upgrades.

Severe Snowstorms / Ice Storms

Winter storms can be especially challenging for emergency management personnel even though the duration and amount of expected amount of snowfall usually is forecasted. The Massachusetts Emergency Management Agency (MEMA) serves as the primary coordinating entity in the statewide management of all types of winter storms and monitors the National Weather Service (NWS) alerting systems during periods when winter storms are expected.

To the extent that some of the damages from a winter storm can be caused by flooding, flood protection mitigation measures also assist with severe snowstorms and ice storms. The Town has adopted the State Building Code, which ensures minimum snow load requirements for roofs on new buildings. There are no restrictions on development that are directly related to severe winter storms, however, there are some Subdivision Rules and Regulations that could pertain to severe winter storms, summarized in Table 4-1.

Severe snowstorms or ice storms can often result in a small or widespread loss of electrical service. Montague's critical facilities are equipped with back-up power. The Turners Falls High School, which serves as a regional shelter, is in need of improvements for back-up power and water. A study was recently completed that outlines options for a solar-powered micro-grid that could power the High School and Public Safety Complex during power outages.

Hurricanes and Tropical Storms

Hurricanes provide the most lead warning time of all identified hazards, because of the relative ease in predicting the storm's track and potential landfall. MEMA assumes "standby status" when a hurricane's location is 35 degrees North Latitude (Cape Hatteras) and "alert status" when the storm reaches 40 degrees North Latitude (Long Island). Even with significant warning, hurricanes cause significant damage – both due to flooding and severe wind.

The flooding associated with hurricanes can be a major source of damage to buildings, infrastructure and a potential threat to human lives. Flood protection measures can thus also be considered hurricane mitigation measures. The high winds that often accompany hurricanes can also damage buildings and infrastructure, similar to tornadoes and other strong wind events. For new or recently built structures, the primary protection against wind-related damage is construction according to the State Building Code, which addresses designing buildings to withstand high winds.

Severe Thunderstorms / Winds / Microbursts and Tornadoes

Most damage from tornadoes and severe thunderstorms come from high winds that can fell trees and electrical wires, generate hurtling debris and, possibly, hail. According to the Institute for Business and Home Safety, the wind speeds in most tornadoes are at or below design speeds that are used in current building codes, making strict adherence to building codes a primary mitigation strategy. In addition, current land development regulations, such as restrictions on the height and setbacks of telecommunications towers, can also help prevent wind damages.

Wildfires / Brushfires

Seventy percent of Montague is forested, including approximately 2,000 acres of rare pitch pine/scrub oak forest on the Montague Plains. A large portion of the Town is therefore at risk of fire. Wildfire and brushfire mitigation strategies involve educating people about how to prevent fires from starting, controlling burns within the town, as well as managing forests for fire prevention.

Over the past 20 years, the Massachusetts Division of Fisheries and Wildlife (MassWildlife) has used a combination of tree harvesting, shrub mowing, and prescribed burning to benefit rare species and to reduce the risk of a catastrophic wildfire on the Montague Plains Wildlife Management Area (WMA). MassWildlife has cooperative agreements with the Department of Conservation and Recreation and the Montague Conservation Commission to restore sandplain habitats on their inholdings within the WMA, and works closely with local fire departments and the DCR Bureau of Fire Control to ensure that firefighters have adequate access in the event of a wildfire and are familiar with the changes in vegetation and fuels resulting from habitat management activities. In addition, the Turners Falls Fire District actively manages more than 1,500 acres of forest in Montague. The 2015 Montague Community Wildfire Protection Plan outlines a number of mitigation strategies to protect Montague's built and natural environemtn from wildfire. These strategies are incorporated into Table 4-3: 2020 Montague Hazard Mitigation Prioritized Action Plan.

The Montague Fire Departments have ongoing educational program in the schools. Permits are required for the seasonal outdoor burning of leaves on residential property, generally permitted between January and early May. In Montague, Shelburne Fire Control issues these permits. Each permit is issued on a case-by-case situation according to several factors including where the property is located and any past problems with burning on that property. Specific burn permit guidelines are established by the state, such as the burning season and the time when a burn may begin on a given day.

Plans for new subdivisions are submitted to the appropriate Fire Department for review to ensure that fire trucks will have adequate access and that the water supply is adequate for fire-fighting purposes.

Earthquakes

Although there are five mapped seismological faults in Massachusetts, there is no discernible pattern of previous earthquakes along these faults nor is there a reliable way to predict future earthquakes along these faults or in any other areas of the state. Consequently, earthquakes are arguably the most difficult natural hazard for which to plan. Most buildings and structures in the state were constructed without specific earthquake resistant design features. In addition, earthquakes precipitate several potential devastating secondary effects such as building collapse, utility pipeline rupture, water contamination, and extended power outages. Therefore, many of the mitigation efforts for other natural hazards identified in this plan may be applicable during the Town's recovery from an earthquake.

Dam Failure

Dam failure is a highly infrequent occurrence, but a severe incident could prove catastrophic. In addition, dam failure most often coincides with flooding, so its impacts can be multiplied, as the additional water has nowhere to flow. The only mitigation measures currently in place are the state regulations governing the construction, inspection, and maintenance of dams. This is managed through the Office of Dam Safety at the Department of Conservation and Recreation. Owners of dams are responsible for hiring a qualified engineer to inspect their dams and report the results to the DCR. Owners of High Hazard Potential dams and certain Significant Hazard Potential dams are also required to prepare, maintain, and update Emergency Action Plans. Potential problems may arise if the ownership of a dam is unknown or contested. Additionally, the cost of hiring an engineer to inspect a dam or to prepare an Emergency Action Plan may be prohibitive for some owners.

In Montague, FirstLight Power Resources owns and operates the Turners Falls Dam and power canal, as well as the Northfield Mountain Pumped Storage facility in Erving. Great River Hydro owns and operates high-hazard dams upstream of Montague on the Deerfield and Connecticut Rivers. The Federal Energy Regulatory Commission (FERC) requires an Emergency Action Plan to be created for licensing of hydropower facilities. The primary purpose of an Emergency Action Plan is “to provide operating and mobilization and notification procedures to be followed in the case of an emergency” (such as a sudden release of water caused by a natural disaster or accident). The Plans include warning system information and inundation maps. FirstLight Power maintains a reverse call system for areas of Montague City that would be impacted by a failure of the power canal. Other areas of town that may be impacted from dam failures upstream of Montague would need to be notified by local authorities.

Drought

The Northeast is generally considered to be a moist region with ample rain and snow, but droughts are not uncommon. Widespread drought has occurred across the region as recently as 2016, and before that in the early 2000s, 1980s, and mid-1960s. More frequent and severe droughts are expected as climate change continues to increase temperatures, raise evaporation rates, and dry out soils - even in spite of more precipitation and heavier rainfall events.[64] The primary mitigation strategy currently in place is regulating uses within the aquifer recharge areas of the public water supply wells. Montague’s Water Supply Protection District regulates development within the aquifer recharge areas of the public drinking water supply wells, requiring larger lot sizes to provide for groundwater recharger, and protections to prevent contamination of the surface and groundwater resources.

The Montague Center Water District is interconnected with the Turners Falls Fire District, which could be used as a back-up water supply in times of drought. The Montague Center Water District is seeking funding to repair or replace its water tank to provide additional back-up supplies. The Turners Falls Fire District is exploring connections to the Greenfield Water Department for additional redundancy in times of drought.

Forest landowners in town can be encouraged to conserve and manage their forests for climate resiliency. Strategies for promoting a resilient forest include increasing the diversity of tree species and age of trees in a forest, and promoting trees not currently threatened by pests or diseases that will thrive in a warming climate.[65]

Extreme Temperatures

A primary mitigation measure for extreme temperatures is establishing and publicizing warming

[64] MassWildlife Climate Action Tool: https://climateactiontool.org/content/drought. Accessed March 8, 2019.
[65] Catanzaro, Paul, Anthony D’Amato, and Emily Silver Huff. *Increasing Forest Resiliency for an Uncertain Future*. University of Massachusetts Amherst, University of Vermont, USDA Forest Service. 2016

or cooling centers in anticipation of extreme temperature events. Getting the word out to vulnerable populations, especially the homeless and elderly, and providing transportation is particularly important but can be challenging. The Montague Senior Center serves as an unofficial warming center in the winter. Montague does not currently have a designated cooling center.

Planting and maintaining shade trees in villages and developed areas of towns can help mitigate extreme heat in these areas. Roofs and paving absorb and hold heat from the sun, making developed areas hotter during the summer than surrounding forested areas. Trees that shade these surfaces can significantly lower the temperature in a neighborhood, making it easier to be outside and reducing cooling costs for homeowners. A Tree Inventory for Turners Falls was completed in 2015, and the Subdivision Regulations currently require trees to be planted along new subdivision streets.

Invasive Species

The spread of invasive species is a serious concern as species ranges shift with a changing climate. People can also be a carrier of invasive plant species. Installing boot brushes at hiking entrances can help slow the spread of invasive species by removing seeds being carried in soil on hiking boots. Landowners can learn the top unwanted plants and look for them when out on their land, and work with neighbors to control invasive exotic plants.

Before implementing any forest management, landowners should be sure to inventory for invasive exotic species. They will need to be controlled before harvesting trees and allowing sunlight into the forest, which will trigger their growth and spread. Also, the timber harvester should be required to powerwash their machines before entering the woods. Financial assistance may be available to landowners through the USDA NRCS Environmental Quality Incentives Program (EQIP) to address invasive species.[66]

In addition, Montague can require only native, non-invasive species be used in new development and redevelopment.

All Hazards

The Turners Falls High School is a designated town and regional shelter. The building has back-up diesel generators; however, the shelter needs improved radio communications, back-up water, and air-conditioning. A feasibility study for a solar powered micro-grid was recently completed outlining options to further improve the school's back-up power generating capacity

---

[66] MassWildlife Climate Action Tool: https://climateactiontool.org/content/maintain-or-restore-soil-quality-limit-recreational-impacts. Accessed March 8, 2019.

and resiliency in the event of a widespread power outage. A regional sheltering plan that identifies regional shelter sites was completed for Franklin County with funds from the Western Region Homeland Security Advisory Council (WRHSAC). The Franklin County REPC is now working on operationalizing the plan by creating Shelter Management Teams and cost sharing agreements between towns. Montague officials should continue to participate in this process.

Primary and secondary evacuation routes are shown on the Critical Infrastructure map for Montague. The Town's reliance on bridges to access neighboring communities and primary evacuation routes is a vulnerability if one or more of these bridges are damaged or inaccessible.

A regional disaster debris management plan was created for Franklin County in 2015. The Franklin County REPC is currently working to verify the sites identified in the plan and complete agreements between towns for use of the regional sites. Towns may need to identify a site in their own town if regional agreements cannot be made.

Existing Mitigation Capabilities

The Town of Montague had numerous policies, plans, practices, programs and regulations in place, prior to the creation of this plan, that were serving to mitigate the impact of natural hazards in the Town of Montague. These various initiatives are summarized, described and assessed on the following pages and have been evaluated in the "Effectiveness" column.

Table 4-1: Existing Mitigation Capabilities

Strategy	Capability Type	Description	Hazards Mitigated	Effectiveness / Improvements
Floodplain Overlay District	Regulation - Zoning Bylaw	Overlay district to control development in the 100-year floodplain	Flooding	Partially Effective / 1979 floodplain maps are being updated. Revisit floodplain regulations once new maps are available.
Water Supply Protection District	Regulation – Zoning Bylaw	Regulates development and uses within the aquifer recharge areas of the public drinking water supply wells to prevent contamination of the surface and ground water resources	Flooding Drought Manmade Hazards	Partially Effective / Hannegan Brook well recharge area added to the district since the last plan; the Montague Center well needs an aquifer study to delineate the recharge area.
Minimum Lot Area	Regulation – Zoning Bylaw	Ranges from 0 in the Central Business district to 4 acres in the Agriculture – Forestry district; 2019 zoning amendments	Flooding Extreme Temperature	Effective at directing denser development to areas with infrastructure / Consider lot coverage

Table 4-1: Existing Mitigation Capabilities				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
		reduced minimum lot sizes in sewered districts & increased lot sizes in rural districts		maximums to limit impervious surfaces in appropriate districts
Earth Removal	Regulation - Zoning Bylaw	Requires a Special Permit unless less than 50 cubic yards in one year or part of an approved building permit. Performance bond required to ensure standards are met.	Flooding Landslides Drought	Effective
Parking Requirements	Regulation – Zoning Bylaw	Regulates amount and design of off-street parking; amended in 2019, allows for reduced parking requirement, off-site parking & reductions in parking for multi-use properties; design standards for parking lots require shade trees and encourage LID	Flooding Extreme Temperatures	Effective / Consider maximum parking requirements
Open Space Residential Development	Regulation - Zoning Bylaw	Requires 40% of the total lot area be preserved as Protected Open Space including agricultural or forested land. Provides a density bonus for protecting at least 60% as open space	Flooding Landslides Drought	Effective. Bylaw adopted in 2019. Utilize MA Smart Growth Toolkit model bylaw for possible future amendments[67]
Solar Energy Facilities	Regulation – Zoning Bylaw	Regulates ground-mounted solar installations larger than 2,000 square feet of panel surface area. Facilities are restricted to industrial zoning districts. Stormwater must be handled on-site. Retention of mature trees on the site equivalent to the amount of trees removed for the installation is required.	Flooding Landslides Drought Extreme Temperatures	Effective
Site Plan Review	Regulation – Zoning Bylaw	Applies to projects with the potential for significant impact on the character, infrastructure, and natural resources of the Town of Montague; Requires identification of areas subject to flooding and plans for stormwater management	All Hazards	Partially Effective. Clarify stormwater management plan submission requirement, in accordance with the Stormwater System Policy (see below)
Stormwater System Policy	Policy	Applies to projects requiring Site Plan Review; includes stormwater management standards	Flooding Drought Landslides Extreme	Partially Effective. Policy is incorporated into Subdivision Regulations / Reference policy in Site

[67] https://www.mass.gov/files/documents/2017/11/03/Open%20Space%20Design%20%28OSD%29-Natural%20Resource%20Protection%20Zoning%20%28NRPZ%29_0.pdf

Table 4-1: Existing Mitigation Capabilities				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
			Temperatures	Plan Review section of the Zoning Bylaw (see above) / Encourage adoption of the policy by the ZBA
Subdivision Regulations	Regulation – Subdivision Rules & Regulations	Dictates street, utility, and drainage design and construction	All Hazards	Effective. Subdivision Rules and Regulations were updated in 2017 to encourage LID site design and stormwater management techniques, stronger protection of natural features, and reduced roadway pavement widths
Industrial Park Development Standards	Regulation	Requires all drainage from new development to be accommodated on-site; drainage infrastructure must be designed to accommodate 125% of runoff from the 100-year storm.	Flooding Landslides	Effective
Participation in the National Flood Insurance Program	Program	As of 2018 there were eight (8) flood insurance policies in effect in Montague	Flooding	Partially Effective / Montague's floodplain maps are from 1979 – FEMA is in process of updating the maps
Montague Open Space and Recreation Plan	Plan	Inventories natural resources and identifies land protection priorities in the Town	Flooding Landslides Wildfire Drought Invasive Species	Effective / The plan was updated in 2017
Montague Comprehensive Plan	Plan	Provides a framework for guiding development in town	All Hazards	Partially Effective / The last comprehensive plan was completed in 1999. Consider creating a new comprehensive plan
State Building Code	Regulation	The Town of Montague has adopted the Massachusetts State Building Code, including the Stretch Energy Code	All Hazards	Effective for new construction & significant rehabilitation
National Pollutant Discharge Elimination System	Regulation – EPA Construction General Permit	Construction activities that disturb one acre or more are regulated under the NPDES stormwater program administered by the US EPA. Operators of regulated construction sites are required to develop and implement stormwater pollution prevention	Flooding Landslides	Effective to the extent of Compliance / Building Inspector should remind developers that this permit is required for projects disturbing more than one acre of land

Table 4-1: Existing Mitigation Capabilities

Strategy	Capability Type	Description	Hazards Mitigated	Effectiveness / Improvements
		plans and obtain a permit from the EPA.		
Emergency Shelters	Practice	The Turners Falls High School serves as a town and regional emergency shelter. The building has back-up diesel generators; a feasibility study for a solar-powered micro-grid is underway. The shelter needs improved radio communications, a back-up water supply, and improved air-conditioning	All Hazards	Partially Effective / Improve radio communications, back-up water supply, and air-conditioning at the school. Implement a micro-grid for increased resiliency
Underground Utilities	Practice	The Town requires all utilities to be placed underground for new subdivisions	Severe Snowstorms / Ice Storms Hurricanes / Tropical Storms Thunderstorms / Wind Events	Partially Effective / Encourage utility companies to underground existing utility lines in village centers and where repetitive outages occur.
Tree Maintenance	Practice	The Highway Department and electric company trim tree branches near overhead power lines	Severe Snowstorms / Ice Storms Hurricanes / Tropical Storms Thunderstorms / Wind Events	Effective
Trailer, Mobile Home, and Camper Regulations	Regulations – Zoning Bylaw	Mobile homes and campers may not be used as permanent residences, unless grandfathered under the bylaw	Hurricanes / Tropical Storms Thunderstorms / Wind Events	Partially Effective / Require that replacement mobile homes be tied down to reduce the damaging impacts of high winds
Fire Management Plan for Montague Plains WMA	Plan	Comprehensive plan for prevention and control of forest fires, including public education, observation and detection, fire fighting plans, use of prescribed fire and mechanical fuel reduction. Recommends actions that property owners in high-risk areas can take to prevent and reduce severity of forest fires.	Wildfire	Effective / Increase efforts to educate landowners in high risk areas about the danger of forest fire and what they can do to prevent it / Consider restrictions in Subdivision Regulations and Zoning Bylaws to reduce the danger of fire in high risk areas

Table 4-1: Existing Mitigation Capabilities

Strategy	Capability Type	Description	Hazards Mitigated	Effectiveness / Improvements
Community Wildfire Protection Plan	Plan	Action plan for town-wide wildfire mitigation.	Wildfire	Effective / Action items from the 2015 Wildfire Protection Plan are included in this Hazard Mitigation Plan update.
Burn Permits	Regulation	Residents are required to obtain permits for brush burning	Wildfire	Effective
Fire Safety Education	Practice	The Fire Departments have ongoing educational program in the schools.	Wildfire	Effective
Forestry Warden	Practice	The Town has a Forest Warden who has responsibility for addressing forest fires.	Wildfire	Effective
Forest Management	Practice	The Turners Falls Fire District actively manages more than 1,500 acres of forest in Montague; MassWildlife manages the Montague Plains for habitat restoration and fire suppression; Private land enrolled in Ch. 61 requires 10-year forest management plans	Wildfire Drought Invasive Species Flooding Landslides Thunderstorm / Wind Events Snowstorms / Ice Storms	Effective / Integrate climate change resiliency into management plans
FERC Regulation of Hydroelectric Facilities	Regulation	The Federal Energy Regulatory Commission oversees the operation and safety of hydroelectric projects	Dam Failure Flooding	Effective / Inform new residents in Montague City to sign up with FirstLight's emergency call system. Maintain the Mill District in Turners Falls and coordinate with property owners and FirstLight about redevelopment plans and the structural integrity of the canal
Permits for New Dam Construction	Regulation	State law requires a permit for the construction of any dam	Dam Failure Flooding	Effective
Dam Inspections	Regulation	Since 2004, State regulations place the responsibility of dam inspections on the owners of the dams, rather than the DCR. Owners of High Hazard Potential and certain Significant Hazard	Dam Failure Flooding	Not Effective / Adequate staff and resources should be given to DCR to ensure the inspection schedules are maintained. Inundation mapping is not

Table 4-1: Existing Mitigation Capabilities				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
		Potential dams are also responsible for preparing Emergency Action Plans.		available for all dams in town or in neighboring towns that could affect Montague. Incorporate Dam Safety into Development Review process
Erosion Control	Practice	The Town continues to implement erosion control measures along impacted Town roads	Flooding Landslides	Partially Effective / Continue to monitor areas of unstable slopes and implement erosion control measures as appropriate
Sawmill River Restoration Plan	Plan / Project	The Town has implemented bio-engineering techniques along the Sawmill River to address flooding and erosion	Flooding Landslides	Partially Effective / Continued implementation of recommendations in the plan is needed to address flooding and erosion; Center Street and South Street bridge replacements should incorporate plan recommendations
Warming and Cooling Centers	Practice	The Senior Center serves as an unofficial warming center in the winter. The Town does not have a designated cooling center.	Extreme Temperatures	Partially Effective / Official agreements should be developed for use of the Senior Center as a warming center. A cooling center should be designated, and the public informed about warming/cooling centers
Bridge and Culvert Repair / Replacement	Practice	The Highway Department maintains Town bridges and culverts.	Flooding	Partially Effective / Assess culverts and bridges and prioritize upgrades and replacements.
Combined Sewer Overflows (CSO) / Inflow and Infiltration (I&I) Mitigation	Practice	The Combined Sewer Overflows have recently been upgraded, but need to be maintained and monitored continually. Inflow and infiltration (I&I) of groundwater into sewer collection pipes in Miller Falls is overwhelming the Erving wastewater treatment plant.	Flooding Manmade Hazards	Partially Effective / Implement MA DEP recommendations for CSOs. Complete I&I mitigation measures identified for cracked pipes in Millers Falls.

4.3 HAZARD MITIGATION GOAL STATEMENTS AND ACTION PLAN

As part of the multi-hazard mitigation planning process undertaken by the Montague Multi-Hazard Mitigation Planning Committee, existing gaps in protection and possible deficiencies were identified and discussed. The Committee then developed general goal statements and mitigation action items that, when implemented, will help to reduce risks and future damages from multiple hazards. The goal statements, action items, Town department(s) responsible for implementation, and the proposed timeframe for implementation for each category of hazard are described below. It is important to note that the Town of Montague has limited capabilities and resources (especially staffing) to be able to expand and improve upon existing policies and programs when the town identifies a need for improvement.

Hazard Mitigation Goals

Based on the findings of the Risk Assessment, public outreach, and a review of previous town plans and reports, the Town of Montague has developed the following goals to serve as a framework for mitigating the hazards identified in this plan:

- To provide adequate shelter, water, food and basic first aid to displaced residents in the event of a natural disaster.
- To provide adequate notification and information regarding evacuation procedures, etc., to residents in the event of a natural disaster.
- To minimize the loss of life, damage to property, and the disruption of governmental services and general business activities due to natural hazards.

Prioritization of Hazards

The Committee examined the results of the Risk Assessment (see Section 3) and used the results to prioritize the identified hazards. The Committee evaluated the natural hazards that can impact the town based on probability of occurrence, severity of impacts, area of occurrence and preparedness. Those hazards receiving the highest Overall Hazard Vulnerability Rating were assigned the highest priority, as shown in Table 4-2.

Table 4-2: Montague Hazard Priority Level Rating		
Natural Hazard	**Overall Hazard Vulnerability Rating**	**Priority Level**
Severe Winter Storms	High Risk	High
Extreme Temperatures	High Risk	High
Severe Thunderstorms / Wind / Microbursts	High Risk	High
Wildfire	High Risk	High
Flooding (Annual / Flash Floods)	Medium Risk	Medium
Flooding (100/500 – Year Event)	Medium Risk	Medium
Hurricanes / Tropical Storms	Medium Risk	Medium
Earthquakes	Medium Risk	Medium
Landslides	Medium Risk	Medium
Invasive Species	Medium Risk	Medium
Tornadoes	Medium Risk	Medium
Dam Failure	Low Risk	Low
Drought	Low Risk	Low

Prioritization of Action Items

The Hazard Mitigation Committee identified several strategies that are currently being pursued, and other strategies that will require additional resources to implement. Strategies are based on previous experience, as well as the hazard identification and risk assessment in this plan.

Prioritization Methodology

The Montague Hazard Mitigation Planning Committee reviewed and prioritized a list of mitigation strategies using the following criteria:

- **Application to high priority or multiple hazards** – Strategies are given a higher priority if they assist in the mitigation of hazards identified as high priorities (Table 4-2) or apply to several natural hazards.

- **Time required for completion** – Projects that are faster to implement, either due to the nature of the permitting process or other regulatory procedures, or because of the time it takes to secure funding, are given higher priority.

- **Estimated benefit** – Strategies which would provide the highest degree of reduction in loss of property and life are given a higher priority. This estimate is based on the Hazard Identification and Risk Assessment Chapter, particularly with regard to how much of each hazard's impact would be mitigated.

- **Cost effectiveness** – In order to maximize the effect of mitigation efforts using limited funds, priority is given to low-cost strategies. For example, regular tree maintenance is a relatively low-cost operational strategy that can significantly reduce the length of time of power outages during a winter storm. Strategies that have identified potential funding streams, such as the Hazard Mitigation Grant Program, are also given higher priority.

The following categories are used to define the priority of each mitigation strategy:

- **Low** – Strategies that would not have a significant benefit to property or people, address only one or two hazards, or would require funding and time resources that are impractical.

- **Medium** – Strategies that would have some benefit to people and property and are somewhat cost effective at reducing damage to property and people.

- **High** – Strategies that provide mitigation of high priority hazards or multiple hazards and have a large benefit that warrants their cost and time to complete.

- **Very High** – extremely beneficial projects that will greatly contribute to mitigation of high priority and multiple hazards and the protection of people and property. These projects are also given a numeric ranking within the category.

Cost Estimates

Each of the following implementation strategies is provided with a cost estimate. Projects that already have secured funding are noted as such. Where precise financial estimates are not currently available, categories were used with the following assigned dollar ranges:

- **Low** – cost less than $25,000

- **Medium** – cost between $25,000 – $100,000

- **High** – cost over $100,000

Cost estimates take into account the following resources:

- Town staff time for grant application and administration (at a rate of $25 per hour)
- Consultant design and construction cost (based on estimates for projects obtained from town and general knowledge of previous work in town)
- Town staff time for construction, maintenance, and operation activities (at a rate of $25 per hour)

Project Timeline

The timeframe for implementation of the action items are listed in the Action Plan as Year 0-1, which is the first year following plan adoption, and subsequent years after plan adoption through the 5 year life of the plan (Year 2, Year 3, Year 4 and Year 5). The Committee recognized that many mitigation action items have a timeframe that is ongoing due to either funding constraints that delay complete implementation and/or the action item should be implemented each of the five years of the plan, if possible. Therefore, a category of Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate was added.

Even when the political will exists to implement the Action Items, the fact remains that Montague is a small town that relies heavily on a small number of paid staff, many of whom have multiple responsibilities, and a dedicated group of volunteers who serve on town boards. However, some Action Items, when implemented by Town staff and volunteers, result in a large benefit to the community for a relatively small cost.

For larger construction projects, the town has limited funds to hire consultants and engineers to assist them with implementation. For these projects, the Town may seek assistance through the Franklin Regional Council of Governments (FRCOG). However, the availability of FRCOG staff can be constrained by the availability of grant funding.

The 2020 Montague Multi-Hazard Mitigation Prioritized Action Plan is shown in Table 4-3. Potential funding sources for mitigation action items are listed when known. Other potential funding sources are listed in Table 5-1 of this plan. When Town funds are listed as a source to fund hazard mitigation projects or activities, either in part (match) or in full, these funds would be obtained from the town's "general fund".

Table 4-3: 2020 Montague Hazard Mitigation Prioritized Action Plan									
Action Type	Action Description	Hazards Addressed	Responsible Department / Board	Estimated Cost	Potential Funding Source	Estimated Timeframe	Benefits: Society (S) Infrastructure (I) Environment (E)	2014 Priority 2020 Priority	Status
Local Plans & Regulations	Convene an annual meeting of the Local Hazard Mitigation Committee to assess progress on implementing specified actions in the Local Multi-Hazard Mitigation Plan.	All Hazards	Emergency Management Director, Select Board	Low	Town / Volunteer Time	Year 1, 2, 3, 4, 5	S, I, E	High High	Modified from 2014 Plan. The Town completed the MVP planning process in 2018.
Education & Awareness / Local Plans & Regulations	Work with the REPC to develop a formal system for towns to record costs and property damages from hazard events. Encourage businesses and residents to report property damages, and farmers to report crop damages.	All Hazards	Hazard Mitigation Committee, Emergency Management Director, Public Works Superintendent, Fire Chiefs, Police Chief	Medium	Town, Volunteer Time, DLTA	Year 2	S, I, E	Medium Medium	Modified from 2014 Plan
Critical Facilities & Infrastructure	Evaluate municipal buildings and structures to determine if they are particularly vulnerable to earthquake damage and determine if any retrofitting measures could mitigate this vulnerability. Integrate measures into planned updates of buildings.	Earthquakes	Building Inspector, Public Works Superintendent	Low	Town	Year 2	S, I	Medium Medium	Carried over from 2014 Plan
Education & Awareness	Develop and disseminate emergency earthquake public information and instructions. Conduct earthquake drills in schools, businesses, special care facilities and other public gathering places.	Earthquakes	Emergency Management Director	Low	Town	Year 2	S	Medium Medium	Carried over from 2014 Plan
Critical Facilities & Infrastructure	Determine which shelters were built after 1975 and designate these as the appropriate shelter in the event of an earthquake.	Earthquake	Emergency Management Director	Low	Town	Year 0-1	S	High High	Carried over from 2014 Plan. TF High School was built in 1974
Local Plans & Regulations / Education & Awareness	Ensure Compliance with the Massachusetts State Building Code. Provide training to the Building Inspector, as needed, to ensure that all new construction complies with the appropriate seismic requirements of the State Building Code. Participate in trainings offered by FEMA's National Earthquake Technical Assistance Program (NETAP). NETAP is designed to help state, local, and tribal governments obtain the knowledge, tools, and support that they need to plan and implement effective earthquake mitigation strategies.	Earthquakes	Building Inspector, Emergency Management Director	Low	Town	Ongoing	S, I	High High	Carried over from 2014 Plan
Local Plans & Regulations	Encourage the Zoning Board of Appeals to adopt the Stormwater System Policy. Clarify that Site Plan Review requires submission of a stormwater management plan in accordance with the Stormwater System Policy.	Flooding Drought Landslides	Planning Board Zoning Board of Appeals	Low	Town	Year 0-1	I, E	Medium Medium	Modified from 2014 Plan

Table 4-3: 2020 Montague Hazard Mitigation Prioritized Action Plan									
Action Type	Action Description	Hazards Addressed	Responsible Department / Board	Estimated Cost	Potential Funding Source	Estimated Timeframe	Benefits: Society (S) Infrastructure (I) Environment (E)	2014 Priority / 2020 Priority	Status
Education & Awareness / Critical Facilities & Infrastructure	Encourage & implement forest stewardship practices that produce more stable, resilient, successional forested landscapes to reduce the risk of landslides, flooding, wildfire, drought, and invasive species.	Landslides Flooding Wildfire Drought Invasive Species	Conservation Commission, Planning & Conservation Department, Turners Falls Water Department, Fire Departments	Low – Medium	Town, Volunteer Time, MA DCR, NRCS	Ongoing	E	Medium / High / Medium	Modified from 2014 Plan
Critical Facilities & Infrastructure	Continue fuels mitigation and management in the Montague Plains, including prescribed fire and mechanical treatments to reduce wildfire potential in the most critical areas.	Wildfire	MassWildlife, MA DCR, Fire Departments	Medium	State	Ongoing	S, I, E	High / High	Carried over from 2014 Plan / included in 2015 Montague Wildfire Protection Plan
Critical Facilities & Infrastructure	Implement flood mitigation measures along Montague City Road, an important emergency and evacuation route in town.	Flooding	Highway Department Planning & Conservation Department Select Board Conservation Commission	High	MEMA MVP	Year 1	S, I, E	NA / High	New Action Item. The Town received an MVP Action Grant in 2018 to design flood mitigation measures. Funding is needed for implementation.
Local Plans & Regulations	Integrate regional landslide mapping into town land use regulations.	Landslides	Planning Board	Low	Town	Ongoing	S, I, E	Low / Low	Carried over from 2014 Plan / A Slope Stability Map of Massachusetts was created in 2013 by the MA Geological Survey
Education & Awareness	Educate homeowners about the risk of wildfires and brushfires and how to reduce the risk by adopting general fire safety techniques. In coordination with DCR, implement a Firewise program targeting the residents and businesses in the Urban-Interface zone; run 2-3 programs to demonstrate how to make a house safer in the event of a wildfire on the Montague Plains.	Wildfire	Fire Departments, MA DCR, MassWildlife	Low	Town MVP	Ongoing	S, I	High / High	Carried over from 2014 Plan/ included in 2015 Montague Wildfire Protection Plan & MVP Plan

Table 4-3: 2020 Montague Hazard Mitigation Prioritized Action Plan									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2014 Priority / 2020 Priority**	**Status**
Critical Facilities & Infrastructure	Implement safety infrastructure improvements on the Montague Plains including addition of hydrants and improving access roads and fire breaks; install a hydrant on Turners Falls Road; update Fire Department equipment for fighting a wildfire.	Wildfire	Turners Falls Water Department, Fire Departments, MassWildlife, Department of Public Works	High	MVP State	Year 2 and Ongoing	S, I, E	NA / High	New Action Item/ included in Montague Wildfire Protection Plan & MVP Plan
Education & Awareness	Conduct a tabletop exercise and educational trainings for first responders to improve the region's preparedness and response to a wildfire	Wildfire	Fire Departments, REPC, FRCOG, MA DCR, MassWildlife	Medium	MEMA WRHSAC	Year 3	S, I, E	Medium	New Action Item/ included in Montague Wildfire Protection Plan
Critical Facilities & Infrastructure	Work with utility companies to establish standards for an annual tree pruning program to reduce risk to infrastructure from severe storms.	Severe Winter Storms Hurricanes & Tropical Storms Severe Thunderstorms, Wind, & Microbursts Tornadoes	Hazard Mitigation Committee, Department of Public Works	Low	Town, Volunteer Time	Ongoing	S, I	Medium / Medium	Carried over from 2014 Plan / Eversource recently cleared trees around power lines in town
Education & Awareness	To decrease risk to population and buildings, disseminate information on how to prepare homes and other structures to withstand flooding and high winds.	Flooding Severe Winter Storms Hurricanes & Tropical Storms Severe Thunderstorms, Wind, & Microbursts Tornadoes	Hazard Mitigation Committee, Emergency Management Director, Director of Public Health	Low	Town	Ongoing	S	Medium / Medium	Carried over from 2014 Plan
Education & Awareness	Publicize home rehabilitation and weatherization resources to residents to upgrade older homes to better withstand hazard events; continue to address distressed, vacant and abandoned homes in town.	All Hazards	Board of Health, Planning & Conservation Department, Building Department, Franklin County Regional Housing & Redevelopment Authority (HRA), Community Action	High	CDBG AGO Mass Save	Ongoing	S, I	NA / Medium	New Action Item / Included in 2018 MVP Plan. HRA administers a housing rehabilitation program on behalf of Montague. Montague participates in the AGO's Abandoned Housing Initiative

Table 4-3: 2020 Montague Hazard Mitigation Prioritized Action Plan

Action Type	Action Description	Hazards Addressed	Responsible Department / Board	Estimated Cost	Potential Funding Source	Estimated Timeframe	Benefits: Society (S) Infrastructure (I) Environment (E)	2014 Priority	2020 Priority	Status
Local Plans & Regulations	Continue to participate in the Regional Emergency Planning Committee (REPC) to address procedures to deal with hazardous materials emergencies and encourage community awareness.	Manmade Hazards	Emergency Management Director, REPC	Low	Town	Ongoing	S, I, E	High	High	Modified from 2014 Plan
Local Plans & Regulations	Participate in tabletop exercises and trainings for hazardous material accidents.	Manmade Hazards	Emergency Management Director, Fire Department, Police Department, Department of Public Works, REPC	Low	MEMA WRHSAC	Ongoing	S, I, E	NA	High	New Action Item / The REPC and FRCOG offer hazardous material trainings and exercises annually
Local Plans & Regulations	Review evacuation procedures for emergency action plans of hazardous facilities including the Vermont Yankee nuclear power plant and the FERC-licensed hydroelectric dams and facilities on the Connecticut River.	Manmade Hazards	Emergency Management Director	Low	Town	Ongoing	S	High	High	Modified from 2014 Plan / The VT Yankee plant is no longer operational but spent nuclear fuel is stored onsite.
Local Plans & Regulations	Review and update the Floodplain District Overlay Zoning Bylaw once new floodplain maps are available. Special consideration should be given to further restricting or eliminating new development within the 100-year floodplain (1% chance flood event).	Flooding Hurricanes & Tropical Storms Severe Thunderstorms, Wind, & Microbursts	Planning and Conservation Department, Planning Board	Low	Town DLTA	Year 3	S, I, E	High	High	Carried over from 2014 Plan / The 1979 floodplain maps are being updated by FEMA
Local Plans & Regulations	Consider new land use regulations, including impervious surface limits, and local wetlands bylaw to further regulate development in floodplain, reduce runoff and minimize risk of localized flooding.	Flooding Hurricanes & Tropical Storms Severe Thunderstorms, Wind, & Microbursts	Planning and Conservation Department, Planning Board	Low	Town	Year 3	S, I, E	Medium	Medium	Carried over from 2014 Plan
Local Plans & Regulations	Consider becoming part of NFIP's Community Rating System.	Flooding Hurricanes & Tropical Storms Severe Thunderstorms, Wind, & Microbursts	Planning and Conservation Department, Select Board	Low	Town	Year 2	S, I, E	Medium	Low	Carried over from 2014 Plan
Education & Awareness	Provide property owners in flood prone areas information on the National Flood Insurance Program.	Flooding Hurricanes & Tropical Storms Severe Thunderstorms, Wind, & Microbursts	Hazard Mitigation Committee, Emergency Management Director, Planning and Conservation Department	Low	Town	Ongoing	S, I	Medium	Low	Carried over from 2014 Plan

Table 4-3: 2020 Montague Hazard Mitigation Prioritized Action Plan										
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2014 Priority**	**2020 Priority**	**Status**
Local Plans & Regulations	Once new floodplain maps are available, expand and update the Vulnerability Assessment for properties located within the 100-year floodplain (1% chance flood event), including information on crop damages if available.	Flooding Hurricanes & Tropical Storms Severe Thunderstorms, Wind, & Microbursts	Hazard Mitigation Committee, Planning and Conservation Department	Low	Town	Year 4	S, I	Medium	Medium	Modified from 2014 Plan
Local Plans & Regulations / Education & Awareness	Support local and regional watershed-wide open space protection efforts, particularly in floodplain areas or forested upland areas, with special attention to the Sawmill River Watershed.	Flooding Hurricanes & Tropical Storms Severe Thunderstorms, Wind, & Microbursts	Planning and Conservation Department, Planning Board, Select Board, Conservation Commission	Medium	Town, Volunteer Time	Ongoing	S, I, E	Medium	Medium	Ongoing from 2014 Plan / Approximately 39% of land in Montague is permanently protected. Between 2010 and 2017, an additional 523 acres were protected.
Critical Facilities & Infrastructure	Identify the locations of beaver dams in Montague and neighboring towns (Leverett) that pose a risk private property and town infrastructure if the dams were to fail. Work with the Franklin County REPC and neighboring towns to map potential inundation areas associated with beaver dams in and adjacent to Montague.	Dam Failure	Planning and Conservation Department	Low	Town	Ongoing	S, I, E	Low	Low	Carried over from 2014 Plan
Critical Facilities & Infrastructure / Local Plans & Regulations	Develop an annual program to assess and clear floodway ditches in the floodplain of overgrown vegetation and any other debris.	Flooding	Highway Department, Planning and Conservation Department, Select Board, Conservation Commission, FirstLight Power	Low	Town, Volunteer Time	Ongoing	I, E	Low	Low	Carried over from 2014 Plan
Critical Facilities & Infrastructure	Establish a micro-grid powered by solar PV between the High School and Public Safety Complex to provide emergency back-up power.	All Hazards	Planning and Conservation Department, Select Board, Emergency Management Director, School Committee	High	MVP MassCEC	Year 2	S, I, E	NA	High	New Action Item. Identified in 2018 MVP Plan

Table 4-3: 2020 Montague Hazard Mitigation Prioritized Action Plan										
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2014 Priority**	**2020 Priority**	**Status**
Critical Facilities & Infrastructure	Install more radio and cell phone towers in the eastern and southeastern part of town.	All Hazards	Emergency Management Director, Select Board, FRCOG	High	WRHSAC	Year 5	S, I	NA	High	New Action Item. Identified in 2018 MVP Plan; the Franklin County Emergency Communication System is in the process of transitioning to the State public safety radio system.
Critical Facilities & Infrastructure	Improve the radio communication system at the Turners Falls High School and install repeaters.	All Hazards	Emergency Management Director, Select Board, School Committee	High	Town	Year 3	S, I	NA	High	New Action Item. Identified in 2018 MVP Plan
Critical Facilities & Infrastructure	Rehabilitate the General Pierce Bridge, an important emergency and evacuation connection to Greenfield.	All Hazards	Select Board	High	Mass DOT	Year 1	S, I	NA	High	New Action Item. Identified in 2018 MVP Plan
Critical Facilities & Infrastructure	Improve the Canal District in Turners Falls and coordinate with property owners and FirstLight about redevelopment plans and the structural integrity of the canal.	Flooding Dam Failure Manmade Hazards	Planning and Conservation, Select Board, FirstLight	High	Town FirstLight	Ongoing	S, I, E	NA	High	New Action Item. Identified in 2018 MVP Plan
Critical Facilities & Infrastructure	Secure funding to complete abatement and demolition of abandoned and blighted mill properties on the Connecticut River such as Indeck, Railroad Salvage, and portions of Strathmore Mill.	Manmade Hazards	Planning and Conservation, Select Board	High	MassDevelopment FRCOG Brownfields Program	Ongoing	S, I, E	NA	High	New Action Item. Identified in 2018 MVP Plan. Montague receive $250,000 from MassDevelopment for abatement activities at Strathmore Mill.
Critical Facilities & Infrastructure	Secure funding to complete improvements along Montague City Road to mitigate flooding.	Flooding	Planning and Development, Highway Department, Select Board, Conservation Commission	High	MVP HMGP	Year 2	S, I, E	NA	High	New Action Item. Identified in 2018 MVP Plan

Table 4-3: 2020 Montague Hazard Mitigation Prioritized Action Plan									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2014 Priority / 2020 Priority**	**Status**
Critical Facilities & Infrastructure / Local Plans & Regulations	Evaluate repairs to the Center Street and South Street bridges over the Sawmill River, and incorporate design improvements to accommodate floodplain capacity flows as identified in the Sawmill River Restoration Plan	Flooding	Planning and Conservation, Highway Department, Conservation Commission, Select Board	High	Small Bridge Program MVP	Year 3	S, I, E	NA / High	New Action Item. Identified in 2018 MVP Plan
Critical Facilities & Infrastructure	Connect the irrigation well to the Turners Falls High School to be available as a back-up drinking water supply for sheltering.	All Hazards	Board of Health, School Committee	Medium	MVP	Year 4	S, I	NA / High	New Action Item. Identified in 2018 MVP Plan
Education & Awareness	Support the creation of additional neighborhood coalitions or networks, and strengthen connections with Town government or organizations. Conduct an educational program to encourage elders to register for assistance through TRIAD.	All Hazards	Police Department Hazard Mitigation Committee	Low	Volunteer Time	Ongoing	S	NA / High	New Action Item. Identified in 2018 MVP Plan
Local Plans & Regulations	Explore the creation of a communication plan to reach out to homeless populations regarding emergency information. Increase the Town's ability to communicate with residents in multiple languages. Compile a list of social services available including contacts and roles.	All Hazards	Police Department, Hazard Mitigation Committee, Emergency Management Director, Board of Health	Low	Volunteer Time Town	Year 3	S	NA / High	New Action Item. Identified in 2018 MVP Plan
Critical Facilities & Infrastructure	Maintain and improve sidewalks for all pedestrian routes to schools. Ensure that children have adequate and warm clothing for walking to school.	Severe Winter Storms Severe Thunderstorms, Wind, & Microbursts Extreme Temperature	Planning and Conservation, Highway Department, School Committee	Low - High	Chapter 90 Complete Streets Volunteer Time	Ongoing	S, I	NA / High	New Action Item. Identified in 2018 MVP Plan
Critical Facilities & Infrastructure	Implement recommended lining of failing sewer pipes in Millers Falls with “short sleeves” that will permanently seal the cracked sections to mitigate inflow and infiltration (I&I) of groundwater into the wastewater treatment system.	Flooding Manmade Hazards	Select Board Highway Department	High	Town MassWorks	Year 1	I, E	NA / High	New Action Item. A 2019 engineering study identified failing sections of pipes.
Critical Facilities & Infrastructure	Implement recommendations from MA DEP to address the Combined Sewer Overflows (CSOs)	Flooding Manmade Hazards	Select Board Highway Department Water Pollution Control Facility	High	MVP MassWorks	Year 4	S, I, E	NA / High	New Action Item.
Critical Facilities & Infrastructure	Map, assess, and prioritize culverts for repair or replacement. Design new or replacement culverts to withstand greater precipitation amounts due to climate change.	Flooding	Highway Department Planning and Conservation Department Conservation Commission FRCOG	Low	DLTA Community Compact	Year 2	S, I, E	NA / High	New Action Item.

Table 4-4: Montague Completed or Obsolete 2014 Hazard Mitigation Actions								
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**Priority in Past Plan**	**Current Status**
Local Plans & Regulations	Amend Town land use regulations to require construction of fire ponds and dry hydrants for new development in areas not served by public water supply to reduce the risk of fire hazards.	Wildfire	Planning & Conservation Department, Fire Departments	Low	Town	S,I,E	High	Complete. The Planning Board updated the Subdivision Regulations to require adequate water supply for fire suppression in new developments.
Critical Facilities & Infrastructure	Obtain a backup generator for the Sheffield school building.	All Hazards	Emergency Management Director	Medium	HMGP, Town	S	High	Completed. A back-up generator was purchased and installed at the school
Critical Facilities & Infrastructure	Purchase auxiliary power generators to ensure redundancy for EOC and other critical facilities.	All Hazards	Emergency Management Director, Planning & Conservation Department, REPC	Medium	HMGP, Town, volunteer time	S	High	Complete. Power generators were added since the 2014 Plan. See also new Action Item in Table 4-3 re: implementing a micro-grid for the EOC and other critical facilities.
Critical Facilities & Infrastructure	Work with the Franklin Regional Council of Governments on evaluating the project feasibility and design for mitigating slope erosion along a segment of Millers Falls Road. Apply for federal funding to implement the project if eligible.	Flooding Landslides	Planning and Conservation Department	High	HMGP	S, I, E	High	Complete. The Town applied for and was awarded HMGP funds for slope stabilization along Millers Falls Road, which was completed in 2016. The area continues to be monitored.
Local Plans & Regulations	Provide training to volunteer board members and the Building Inspector about the risk of landslides and mitigating the risk through the enforcement of existing land use regulations (zoning bylaws, subdivision regulations, building codes) that direct development to stable slopes and soils to reduce the risk of landslides. Reduce the risk of landslides at existing development by requiring that surface water and groundwater are properly managed as part of the permit process.	Landsides	Building Inspector, Conservation Commission, Planning Board, Zoning Board of Appeals	Low	Town, Volunteer Time	S, I, E	Medium	Complete. The Planning Board updated the Subdivision Regulations to more comprehensibly address stormwater, erosion, and reduce the threat of landslides from new development. See also new Action Item in Table 4-3 re: Stormwater Policy and Site Plan Review
Local Plans & Regulations	Enforce the State Building Code and provide training to the Building Inspector, as needed, to ensure new buildings are designed and constructed to reduce the risk of damage from high winds. Encourage the construction of new homes with basements or crawl spaces to provide shelter during a tornado, hurricane or other storm event with high winds.	Severe Winter Storms Hurricanes & Tropical Storms Severe Thunderstorms, Wind, & Microbursts Tornadoes	Building Inspector	Low	Town	S, I, E	High	Complete. The Building Code is enforced for new construction and significant rehabilitation. See new Action Item in Table 4-3 to address condition of older homes

Table 4-4: Montague Completed or Obsolete 2014 Hazard Mitigation Actions								
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**Priority in Past Plan**	**Current Status**
Local Plans & Regulations	Develop an evacuation plan and notification system in the event of a chemical spill in a fixed structure or in a transportation setting.	Manmade Hazards	Emergency Management Director	Medium	FEMA	S	High	Complete. Evacuation routes and communication plans are in place.
Local Plans & Regulations	As appropriate, consider adding flood prevention and mitigation to the Purpose Section of the Land Use regulations.	Flooding	Planning and Conservation Department, Planning Board	Low	Town	S, I, E	High	Complete. Flood prevention and mitigation measures were incorporated into land use regulation updates since the 2014 Plan.
Local Plans & Regulations	Conduct research to review changes in extent of the 100-year floodplain (1% chance flood event) of the Sawmill River since the NFIP study and mapping effort in 1982.	Flooding	Planning & Conservation, in cooperation with relevant state and federal agencies.		Massachusetts Division of Ecological Restoration Riverways Program, Town	E	Low	Obsolete. FEMA is updating the 100-year floodplain maps in Montague
Local Plans & Regulations	Amend the Special Permit regulations to include criteria to address flooding mitigation measures if the project is within the 100-year floodplain (1% chance flood event), or other flood-prone area.	Flooding Hurricanes & Tropical Storms Severe Thunderstorms, Wind, & Microbursts	Planning and Conservation Department, Planning Board, Conservation Commission	Low	Town	S, I, E	High	Redundant with existing floodplain regulations.
Critical Facilities & Infrastructure / Education & Awareness	In order to reduce the risk and potential loss of life from dam failure, prepare a map of dams and their potential inundation areas. Include all dams in the town and immediately upstream of the town's borders and the areas that are likely to be flooded in the event of a dam failure. Include those areas shown on the TransCanada Inundation Areas mapping for the Deerfield River projects and the Vernon Dam, as well as the Moore Dam and Lake Wyola Dam. Distribute map to public safety officials in Montague.	Dam Failure	Planning & Conservation (to oversee consultant)	Medium	Town	S, I, E	Low	Complete. Inundation maps are available for the Harriman Dam on the Deerfield River, the Moore Dam on the Connecticut River, the Northfield Mountain Pump Storage Facility, and the Turners Falls power canal dike.

5 PLAN ADOPTION AND MAINTENANCE

5.1 PLAN ADOPTION

The Franklin Regional Council of Governments (FRCOG) provided support to the Montague Multi-Hazard Mitigation Committee as they underwent the planning process. Town officials such as the Emergency Management Director and the Town Planner were invaluable resources to the FRCOG and provided background and policy information and municipal documents, which were crucial to facilitating completion of the plan.

When the preliminary draft of the Montague Multi-Hazard Mitigation Plan was completed, copies were disseminated to the Committee for comment and approval. The Committee was comprised of representatives of Town boards and departments who bear the responsibility for implementing the action items and recommendations of the completed plan (see the list of Committee members on the front cover).

Copies of the Final Review Draft of the Multi-Hazard Mitigation Plan for the Town of Montague were distributed to Town boards and officials, and to surrounding towns for review. Copies were made available at the Town Hall, and a copy of the plan was also posted on the Town website for public review. Once reviewed and approved by MEMA, the plan was sent to the Federal Emergency Management Agency (FEMA) for their approval. FEMA approved the plan on [enter date], and on [enter date], the Montague Board of Selectmen voted to adopt the plan (see Appendix C).

5.2 PLAN MAINTENANCE PROCESS

The implementation of the Montague Multi-Hazard Mitigation Plan will begin following its approval by MEMA and FEMA and formal adoption by the Montague Board of Selectmen. Specific Town departments and boards will be responsible for ensuring the development of policies, bylaw revisions, and programs as described in the Action Plan (Table 4-3). The Montague Multi-Hazard Mitigation Planning Committee will oversee the implementation of the plan.

Monitoring, Evaluating, and Updating the Plan

The measure of success of the Montague Multi-Hazard Mitigation Plan will be the number of identified mitigation strategies implemented. In order for the Town to become more disaster resilient and better equipped to respond to natural disasters, there must be a coordinated effort between elected officials, appointed bodies, Town employees, regional and state agencies involved in disaster mitigation, and the general public.

Implementation Schedule

Annual Meetings

The Montague Multi-Hazard Mitigation Planning Committee will meet on an annual basis and as needed (i.e., following a natural or other disaster) to monitor the progress of implementation, evaluate the success or failure of implemented recommendations, and brainstorm for strategies to remove obstacles to implementation. Following these discussions, it is anticipated that the Committee may decide to reassign the roles and responsibilities for implementing mitigation strategies to different Town departments and/or revise the goals and objectives contained in the plan. At a minimum, the Committee will review and update the plan every five years. The meetings of the Committee will be organized and facilitated by the Montague Town Planner and the Emergency Management Director.

Bi-Annual Progress Report

The Town Planner will prepare and distribute a biannual progress report in years two and four of the plan. Members of the Local Planning Committee will be polled on any changes or revisions to the plan that may be needed, progress and accomplishments for implementation, failure to achieve progress, and any new hazards or problem areas that have been identified. Success or failure to implement recommendations will be evaluated differently depending on the nature of the individual Action Items being addressed, but will include, at a minimum, an analysis of the following: 1) whether or not the item has been addressed within the specified time frame; 2) whether actions have been taken by the designated responsible parties; 3) what funding sources were utilized; 4) whether or not the desired outcome has been achieved; and 4) identified barriers to implementation. This information will be used to prepare the bi-annual progress report which may be attached as an addendum, as needed, to the local hazard mitigation plan. The progress report will be distributed to all of the local implementation group members and other interested local stakeholders. The Town Planner and the Committee will have primary responsibility for tracking progress and updating the plan.

Five-Year Update Preparation

During the fourth year after initial plan adoption, the Town Planner will convene the Committee to begin preparations for an update of the plan, which will be required by the end of year five in order to maintain approved plan status with FEMA. The team will use the information from the annual meetings and the biannual progress reports to identify the needs and priorities for the plan update.

Updated Local Hazard Mitigation Plan – Preparation and Adoption

FEMA's approval of this plan is valid for five years, by which time an updated plan must be approved by FEMA in order to maintain the town's approved plan status and its eligibility for FEMA mitigation grants. Because of the time required to secure a planning grant, prepare an updated plan, and complete the approval and adoption of an updated plan, the local Multi-Hazard Mitigation Planning Committee should begin the process by the end of Year 3. This will help the town avoid a lapse in its approved plan status and grant eligibility when the current plan expires.

The Committee may decide to undertake the update themselves, request assistance from the Franklin Regional Council of Governments, or hire another consultant. However the Committee decides to proceed, the group will need to review the current FEMA hazard mitigation plan guidelines for any changes. The updated Montague Multi-Hazard Mitigation Plan will be forwarded to MEMA and to FEMA for approval.

As is the case with many Franklin County towns, Montague's government relies on a few public servants filling many roles, upon citizen volunteers and upon limited budgets. As such, implementation of the recommendations of this plan could be a challenge to the Committee. As the Committee meets regularly to assess progress, it should strive to identify shortfalls in staffing and funding and other issues which may hinder Plan implementation. The Committee can seek technical assistance from the Franklin Regional Council of Governments to help alleviate some of the staffing shortfalls. The Committee can also seek assistance and funding from the sources listed in Table 5-1.

Table 5-1: Potential Funding Sources for Hazard Mitigation Plan Implementation				
Program	**Type of Assistance**	**Availability**	**Managing Agency**	**Funding Source**
National Flood Insurance Program	Pre-disaster insurance	Rolling	DCR	Property Owner, FEMA
Community Assistance Program	State funds to provide assistance to communities in complying with NFIP requirements	Annually	DCR	FEMA/NFIP
Community Rating System (Part of the NFIP)	Flood insurance discounts	Rolling	DCR	Property Owner
Flood Mitigation Assistance (FMA) Program	Cost share grants for pre-disaster planning & projects	Annual	MEMA	75% FEMA/ 25% non-federal
Hazard Mitigation Grant Program (HMGP)	Post-disaster cost-share Grants	Post Disaster	MEMA	75% FEMA/ 25% non-federal
Pre-Disaster Mitigation (PDM) Program	National, competitive grant program for projects & planning	Annual	MEMA	75% FEMA/ 25% non-federal
Small Business Administration Disaster Loans	Post- disaster loans to qualified applicants	Ongoing	MEMA	Small Business Administration
Public Assistance Program	Post-disaster aid to state and local governments	Post Disaster	MEMA	FEMA/ plus a non-federal share
Dam & Seawall Repair & Removal Program	Grant and loan funds for design, permitting, and construction of repair or removal of dams	Annual	EEA	Dam and Seawall Repair or Removal Fund
Emergency Management Performance Grant (EMPG)	Funding to assist local emergency management departments in building and maintaining an all-hazards emergency preparedness system, including planning; organizational support; equipment; training; and exercises	When funds are available	MEMA	
Volunteer Fire Assistance (VFA) Program	Grants and materials to towns with less than 10,000 population for technical, financial and other assistance for forest fire related purposes, including training, Class A foam, personal protective gear, forestry tools, and other fire suppression equipment	Annual	DCR	USDA Forest Service
Federal 604b Water Quality Management Planning Grant	Funding for assessment and planning that identifies water quality problems and provides preliminary designs for Best Management Practices to address the problems	Annual	MA DEP	EPA Clean Water Act

Table 5-1: Potential Funding Sources for Hazard Mitigation Plan Implementation				
Program	**Type of Assistance**	**Availability**	**Managing Agency**	**Funding Source**
Section 319 Nonpoint Source Competitive Grant Program	Provides grants for wide variety of activities related to non-point source pollution runoff mitigation	Annual	MassDEP	EPA
Economic Development Administration Grants and Investment	Provides grants for community construction projects, which can include mitigation activities	Rolling	FRCOG	U.S. Department of Commerce, EDA
Emergency Watershed Protection	A disaster recovery program made available in emergency situations when neither the state nor the local community is able to repair a damaged watershed	Post-Disaster	NRCS MA	USDA NRCS
Agricultural Management Assistance	Funding for producers to develop or improve sources of irrigation water supply, construct new or reorganize irrigation delivery systems on existing cropland to mitigate the risk of drought	Rolling	NRCS MA	USDA NRCS
Conservation Stewardship Program	Agricultural producers and forest landowners earn payments for actively managing, maintaining, and expanding conservation activities – like cover crops, rotational grazing, ecologically-based pest management, buffer strips, and pollinator and beneficial insect habitat – while maintaining active agricultural production	Rolling	NRCS MA	USDA NRCS
Environmental Quality Incentives Program (EQIP)	Provides technical and financial assistance to forestry & agricultural producers to plan and install conservation practices that address natural resource concerns including water quality degradation, water conservation, reducing greenhouse gases, improving wildlife habitat, controlling invasive plant species, and on-farm energy conservation and efficiency.	Rolling	NRCS MA	USDA NRCS
Agricultural Lands Conservation Program (ACEP)	Provides financial and technical assistance to help conserve agricultural lands and wetlands.	Rolling	NRCS MA	USDA NRCS
Forest Stewardship Program	Supports private landowners and municipalities to manage woodlands for timber, soil and water quality, wildlife and fish habitat, and recreation	Rolling	DCR / MA Woodlands Institute	USDA Forest Service

Table 5-1: Potential Funding Sources for Hazard Mitigation Plan Implementation				
Program	**Type of Assistance**	**Availability**	**Managing Agency**	**Funding Source**
Community Forest Stewardship Implementation Grants for Municipalities	Municipalities that manage a town forest or have water supply land currently enrolled in the Forest Stewardship Program apply for 75-25 matching reimbursement grants to implement their forest stewardship plan	Rolling as funding permits	DCR	USDA Forest Service
USDA Community Facilities Direct Loan & Grant	Provides grants and loans for infrastructure and public safety development and enhancement in rural areas	Annual	USDA Rural Development MA	USDA Rural Development
Transportation Improvement Program	Prioritized, multi-year listing of transportation projects in a region that are to receive Federal funding for implementation. Projects are limited to certain roadways and are constrained by available funding for each fiscal year. Any transportation project in Franklin County that is to receive federal funding must be listed on the TIP.	Rolling	Franklin County Transportation Planning Organization / FRCOG	80% Federal / 20% State
Chapter 90 Program	Funds maintaining, repairing, improving and constructing town and county ways and bridges which qualify under the State Aid Highway Guidelines	Annual	Mass DOT	State Transportation Bond
Culvert Replacement Municipal Assistance Grant	Funds replacement of undersized, perched, and/or degraded culverts located in an area of high ecological value with better designed crossings that meet improved structural and environmental design standards and flood resiliency criteria	Annual	MA Division of Ecological Restoration	State Appropriation
MassWorks Infrastructure Program	Funds for public infrastructure such as roadways, streetscapes, water, and sewer	Annual	EOHED	State Appropriation
Municipal Small Bridge Program	5 year program (FY17 – FY21) to assist cities and towns with replacing or preserving bridges with spans between 10' and 20'	Bi-Annual	MassDOT	State Appropriation
Municipal Vulnerability Preparedness (MVP) Planning and Action Grant Programs	Funding to support cities and towns to begin the process of planning for climate change resiliency and implement priority projects; projects proposing nature-based solutions that rely on green infrastructure or conservation and enhancement of natural systems to improve community resilience are given priority for implementation funding through the MVP Action Grant	Annual	EEA	State Appropriation

Table 5-1: Potential Funding Sources for Hazard Mitigation Plan Implementation				
Program	**Type of Assistance**	**Availability**	**Managing Agency**	**Funding Source**
Land and Water Conservation Fund Grant Program	Funding for municipalities for the acquisition of parkland, development of a new park, renovation of an existing park, development of trails in an existing conservation or recreation area, or the acquisition of conservation land	Annual	EEA	National Park Service
Drinking Water Supply Protection Grant	Provides financial assistance to public water systems and municipal water departments for the purchase of land in existing Department of Environmental Protection (DEP)-approved drinking water supply protection areas, or land in estimated protection areas of identified and planned future water supply wells or intakes	Annual	EEA	EEA
Landscape Partnership Grant	Funding for large-scale (min. 500 acres), joint conservation projects completed in partnership with federal, state, and local governments, and non-profits	Annual	EEA	EEA
Conservation Partnership Grant	Funds acquisition of conservation or recreation land by non-profit entities	Annual	EEA	EEA
LAND – Local Acquisitions for Natural Diversity	Funding for municipal conservation and agricultural commissions to acquire interests in land that will be used for conservation and passive recreation purposes	Annual	EEA	EEA
PARC - Parkland Acquisitions and Renovations for Communities	Funding for municipalities to acquire parkland, build a new park, or to renovate an existing park	Annual	EEA	EEA
Table Acronym Key: DCR = MA Department of Conservation & Recreation; FEMA = Federal Emergency Management Agency; MEMA = MA Emergency Management Agency; EEA = MA Executive Office of Energy & Environmental Affairs; USDA = U.S. Department of Agriculture; NRCS = Natural Resource Conservation Service; EDA = U.S. Economic Development Administration; EPA = U.S. Environmental Protection Agency; FRCOG = Franklin Regional Council of Governments; MassDOT = MA Department of Transportation; EOHED = MA Executive Office of Housing & Economic Development				

Incorporating the Plan into Existing Planning Mechanisms

Upon approval of the Montague Multi-Hazard Mitigation Plan by FEMA, the Committee will provide all interested parties and implementing departments with a copy of the plan, with emphasis on Table 4-3: 2020 Montague Hazard Mitigation Prioritized Action Plan. The Committee should also consider initiating a discussion with each department on how the plan can be integrated into that department's ongoing work. At a minimum, the plan should be distributed to and reviewed with the following entities:

- Fire Department
- Emergency Management Director
- Police Department
- Public Works / Highway Department
- Planning Board
- Zoning Board of Appeals
- Conservation Commission
- Franklin County Regional Emergency Planning Committee
- Building Inspector
- Select Board

Some possible planning mechanisms for incorporating the Montague Multi-Hazard Mitigation Plan into existing planning mechanisms to the fullest extent possible could include:

- Incorporation of relevant Hazard Mitigation and climate change information into the Open Space and Recreation Plan. There are opportunities to discuss findings of the hazard mitigation plan and incorporate them into the Environmental Inventory and Analysis section of the OSRP and to include appropriate action items from the hazard mitigation plan in the OSRP Action Plan.
- Any future development of master plans and scenic byway plans could incorporate relevant material from this plan into sections such as the Natural Resources section and any action plans.
- When the Final Draft Multi-Hazard Mitigation Plan for the Town of Montague is distributed to the Town boards for their review, a letter asking each board to endorse any action item that lists that board as a responsible party would help to encourage completion of action items.
- The Planning Board could include discussions of the Multi-Hazard Mitigation Plan Action Items in one meeting annually and assess progress. Current Subdivision Rules and

Regulations and Zoning Bylaws should be reviewed and revised by the Planning Board and Select Board based upon the recommendations of this plan. Technical assistance from the FRCOG may be available to assist in the modification of Montague's current Bylaws.

Continued Public Involvement

The Town of Montague is dedicated to continued public involvement in the hazard mitigation planning and review process. During all phases of plan maintenance, the public will have the opportunity to provide feedback. The 2020 Plan will be maintained and available for review on the Town website through 2025. Individuals will have an opportunity to submit comments for the Plan update at any time. Any public meetings of the Committee will be publicized. This will provide the public an opportunity to express their concerns, opinions, or ideas about any updates/changes that are proposed to the Plan.