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Town of Colrain Hazard Mitigation Plan

Adopted by the Colrain Select Board on xx, xx

Prepared by

Colrain Hazard Mitigation Plan Update Committee
(Local Planning Team)

and

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

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Kevin Fox, Town Coordinator
Kevin French, Emergency Management Director
Joe Kurdland, Board of Selectmen
Eileen Sauvageau, Board of Selectmen
Christopher Lannon, Police Chief
Robert Slowinski, Planning Board

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Peggy Sloan, Director of Planning & Development
Kimberly Noake MacPhee, Land Use & Natural Resources Program Manager
Alyssa Larose, Senior Land Use & Natural Resources Planner
Helena Farrell, Land Use & Natural Resources Planner
Allison Gage, Land Use & Natural Resources Planner
Alexander Sylvain, Emergency Preparedness Program Assistant
Ryan Clary, Senior GIS Specialist

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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 Colrain, 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 Colrain's Hazard Mitigation plan involved a committee comprised of the following members:

- Kevin Fox, Town Coordinator
- Kevin French, Emergency Management Director
- Joe Kurdland, Board of Selectmen
- Eileen Sauvageau, Board of Selectmen

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- Christopher Lannon, Police Chief
- Robert Slowinski, Planning Board

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 Colrain's key natural and man-made hazard vulnerabilities and strengths and proposed actions to build infrastructural, social, and environmental resilience to climate change. The Town identified the top four hazards, inventoried a shared list of strengths, and developed priority recommendations to help both towns advance their safety and resilience. This information is incorporated into the 2020 Hazard Mitigation Plan update.
- 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.
- 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 A. All meetings followed Massachusetts Open Meeting Law and were open to the public.

April 10, 2018
Held a Community Resilience Building workshop as part of the Municipal Vulnerability Preparedness (MVP) designation process for Colrain. 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 Colrain Hazard Mitigation Plan update process and final plan.

June 27, 2019
The Local Project Team (LPT) met and discussed the hazard mitigation plan update process and climate change and impacts on hazard events and the town, updating the hazard profiles and past events, and initial discussion of hazard identification and risk assessment, including a review of the results of the MVP Community Resilience Building workshop. The LPT also discussed the 2018 River Corridor Mapping and the relationship to flood hazard mitigation with Nicolas Miller from Field Geology Services.

October 24, 2019
The LPT continued discussed Colrain's risk to each hazard based on the location, extent, probability, and severity of hazards, reviewed the draft critical facilities & infrastructure map and environmental resources map and reviewed the status of the action items from the 2014 plan.

XXX 2020

XXXX 2020
A public review period for the draft plan was open from XXX through XXX. A Public Forum was held on XXXX 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 A. While not all members of the LPT 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 Colrain 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

On April 10, 2018, Colrain held a Community Resilience Building Workshop as part of the Massachusetts Municipal Vulnerability Preparedness (MVP) designation program. The workshop was critical to enabling participants to think about and engage across different sectors. Representatives and staff from the Fire Department, Emergency Services, Emergency Management Director, Highway Superintendent, Town Administrator, residents, and the Energy Committee all came together to determine the most threatening hazards to the Town and to agree upon high priorities and actions to address them. The results of the workshop are documented in the *Town of Colrain MVP Resiliency Plan*, and are integrated into this Hazard Mitigation Plan update. The Franklin Regional Council of Governments (FRCOG), the regional planning agency for Colrain and all 26 towns in Franklin County, facilitated the MVP workshop.

In addition to the MVP process, FRCOG regularly engages with the Town of Colrain 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 works to provide

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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 Colrain 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 Colrain Planning Board is the primary Town agency responsible for regulating development in town. Feedback to the Planning Board was ensured through the participation of a planning board member 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 Colrain, 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 Colrain 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 https://colrain-ma.gov/.

A public forum was held on XXXX and provided an opportunity for the public and other stakeholders to provide input on the mitigation strategies and to prioritize action items. Stakeholder letters 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 and subsequent comment period was advertised via a press release in the Greenfield Recorder and on the Town website. The final public Comment Period was held from XXXXX (See Appendix A, Public Participation Process, for copies of all press releases and stakeholder letters mailed to solicit comments on the draft Plan). Comments, if received, 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:

- Colrain Electronic Comprehensive Emergency Management Plan (eCEMP)
- 2015 Fluvial Geomorphic & Habitat Assessment for the East Branch North River Watershed
- 2017 Watershed-Based Plan to Maintain the Health and Improve the Resiliency of the Deerfield River Watershed
- 2018 Town of Colrain MVP Resiliency Plan
- 2018 River Corridor Mapping and Application in North River Watershede
- 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan
- 2019 A Framework for Resilience: Responding to Climate Change in the Deerfield River Watershed
- 2019 Using the Science of Fluvial Geomorphology to Develop River Corridor Management Tools to Protect the Health and Improve the Resiliency of the Deerfield Watershed
- Resilient MA Climate Change Clearinghouse for the Commonwealth
- Additional data sources cited in footnotes throughout this Plan

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2 LOCAL PROFILE AND PLANNING CONTEXT

2.1 COMMUNITY SETTING

Colrain is located at the foot of the Berkshire Hills between the towns of Leyden and Heath and Charlemont. The area's abundant fishing and woodland resources are believed to have made it attractive to Native Americans. The Mohawk Trail, a regional corridor for Native Americans, passes through Shelburne and Charlemont, Colrain's neighbors to the south.

Presbyterian Scotch Irish settled Colrain in the 1740s during the hardships of the French and Indian Wars. Settlement was initially on the southeastern uplands of the town and along the North River alluvial lands. Fort Morrison, Fort Lucas, South Fort Morris, and McDowell's Fort were constructed by the settlers to defend the new inhabitants. Several deadly Native American attacks occurred. A treaty ended the wars in 1763 and settlement proceeded rapidly due to good agricultural land, timber, and waterpower sites. The Town of Colrain was incorporated in 1761.

Over the next sixty years of development, the Town's land use patterns were established. Forests were cleared and farms were located on the good soils. Water powered mills were set up on the North and Green Rivers, and most of the brooks for sawmills, gristmills, and for manufacturing. Around the mills, the villages of Adamsville, Elm Grove, Foundry Village, Shattuckville, Griswoldville, and others were established. The villages were the local hubs with taverns, schools, churches, stores, and the residences of tradespeople. The Town's civic center was located at Colrain Center.

Agriculture determined the patterns of the landscape. Livestock had relatively high value and was the basis of farm wealth. In the early 19th century, Colrain was the second highest wool producing town in Franklin County, following Ashfield. Pastures were cleared on the hillsides to support sheep and cows. The forest cover was reduced to around 20 percent by the 1850s. Large quantities of cheese and butter were produced on the farms. Cultivated acres were devoted to corn, grain, and potato production. The elevations, soils and climate made the town very favorable for apple growing. In the 20th century, better transportation to markets encouraged egg, poultry, and milk production.

Manufacturing contributed to the development of the villages. Around 1814, Isaac Johnson and Warren Wing established the first cotton spinning mill in Franklin County at Shattuckville. Joseph Griswold established a cotton textile mill at Griswoldville in 1832 and another at Willis

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Place in 1865. As the century progressed, the mills expanded and attracted French Canadian and English mill worker families to live in mill owned housing. By 1837, two iron furnaces had been established, one at Foundry Village and the other at Willis Place, to cast iron products including wood stoves. The wood industries were important. There were sash and blind works in Elm Grove and Griswoldville, a furniture shop in Lyonsville, wagon shops, turning shops, box shop, cooper shop, and more than a dozen saw mills around town.

Emigration to Vermont, New York State, and the west began in the late 18th century. The population reached a peak of 2,016 around 1810 and slowly declined afterwards. The growth of manufacturing jobs offset the abandonment of some of the upland farms. The Shattuckville cotton mill closed in 1920. The population reached a low point of 1,391 around 1930. The Town's location away from railroads and interstate highways reduced economic opportunities and development.

Since the mid-20th century, land use patterns have been affected by the reduction in the number of farms and farm animals. Pastures have grown up into forests. Homes constructed outside of the villages for non-farming residents have reduced the agricultural focus of the countryside. Automobiles have increased the mobility of the residents and reduced their reliance on the local economy. The large cotton mills have closed and have recently been torn down, leaving BBA Nonwovens as the last fiber mill in town.

Colrain's significant historic resources are its agricultural and village land use patterns. The living history of productive fields, pastures and old farmsteads contributes to the Town's special character. Wood lots and extensive forests continue to support the local wood industries. The villages retain interesting 19th century buildings associated with the Town's personages and events. The architecture in this working landscape represents what the rest of New England once looked like.

In May 2019, MassGIS released a new land cover/land use dataset. This statewide dataset contains a combination of land cover mapping from 2016 aerial and satellite imagery, LiDAR and other data sources. Land use mapping is derived from standardized assessor parcel information for Massachusetts. This land cover/land use dataset does not conform to the classification schemes or polygon delineation of previous land use data from MassGIS (1951-1999; 2005) so comparisons of land use change over time can't be made using this current data.[1]

[1] https://docs.digital.mass.gov/dataset/massgis-data-2016-land-coverland-use

However, the 2016 land cover/land use dataset does reveal interesting information about Colrain that most residents probably already know. For example, most of the land cover is forests but the land use is primarily residential. According to 2016 MassGIS land cover data for the town presented in Table 2-1, the total land area of Colrain is approximately 28,599.8 acres with roughly 1.8 percent of those acres as developed open space. Forest comprises the largest land cover with 24,472 acres or 86 percent of all land in town. Agricultural uses including cultivated cropland, grassland, and pasture make up 2,757 acres or about 10 percent of total land cover in Colrain.

Table 2-1: Colrain 2016 MassGIS Land Cover and Land Use Data				
Total Acres = 28599.80				
Land Cover	**Acres**		**Land Use**	**Acres**
Bare Land	46.93		Agriculture	2686.86
Cultivated	587.08		Commercial	67.30
Deciduous Forest	9780.15		Forest	2636.89
Developed Open Space	508.72		Industrial	19.55
Evergreen Forest	14497.88		Mixed use, other	1614.19
Grassland	788.56		Mixed use, primarily residential	3686.21
Impervious	435.40		Open land	4081.85
Palustrine Aquatic Bed	9.74		Recreation	1916.74
Palustrine Emergent Wetland	97.73		Residential - multi-family	1370.18
Palustrine Forested Wetland	193.91		Residential - single family	4732.60
Palustrine Scrub/Shrub Wetland	9.74		Right-of-way	1208.63
Pasture/Hay	1381.55		Tax exempt	1810.99
Scrub/Shrub	78.68		Unknown	1387.88
Water	183.73		Water	206.93

Approximately 9 percent of the town is classified as agricultural land use, and 25 percent of the town is classified as residential land use. The residential land uses are typically on lots greater than a half-acre, which is not surprising given the lack of water and sewer infrastructure in town. Residential development is decentralized throughout the town and has occurred primarily along its scenic roadways. The area with the greatest residential density is found on Route 112 in and around Colrain Center. Although the town developed as a farming and industrial center, there are only a few commercial or industrial businesses located in the center of town. Less than 1 percent of the total area in town is comprised of commercial or industrial land uses.

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Population Characteristics

According to the 2010 U.S. Census, there are 1,671 residents (a 7.8% decrease since 2000, when the population was 1,813). As of 2017, Colrain's total population is estimated to be 1,631 (a 2% decrease since 2010).[2]

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 households having no one over the age of 14 who speaks English only or very well - Limited English Proficiency (LEP)

According to these criteria, the Town of Colrain does not currently have any environmental justice populations based on race, income, or language proficiency. Almost 100% of the Town's population is White with the next largest racial group identified as Black or African American at .7% of the total population. In terms of income, the annual median household income of Colrain is well above 65% of the State's annual median household income of $68,563. In addition, according to the latest U.S. Census's American Community Survey, there are no households that have Limited English Proficiency (LEP).

Current Development Trends

Since the mid-20th century, land use patterns have been affected by the reduction in the number of farms and farm animals. Pastures have grown up into forests. Homes constructed outside of the villages for non-farming residents have reduced the agricultural focus of the countryside. Automobiles have increased the mobility of the residents and reduced their reliance on the local economy. The large cotton mills have closed and have been torn down, leaving Barnhardt Manufacturing as the only remaining fiber mill in town, located in Griswoldville on Route 112. Yet many farms and orchards still remain and are an important part of the town's economy.

Colrain's significant historic resources are its agricultural and village land use patterns. The living history of productive fields, pastures and old farmsteads contributes to the town's special

[2] U.S. Census Bureau 2013-2017 American Community Survey 5-Year Estimates.

character. The Town of Colrain currently has the largest number of active dairy farms (nine) in the state of Massachusetts. Wood lots and extensive forests continue to support the local wood industries. Approximately 30% of the land area in Town is permanently protected from development as a result of being in state ownership or under conservation and agricultural preservation restrictions, and an additional estimated 45% is temporarily protected through enrollment in one or more of the state's Chapter 61, Chapter 61A or Chapter 61B tax abatement programs. The villages retain interesting 19th century buildings associated with the town's personages and events. The architecture in this working landscape represents what the rest of New England once looked like.

The Town of Colrain is divided into three types of zoning districts, which includes three Village Districts located along 112, and three Commercial-Industrial districts (See Town of Colrain Official Zoning Map). The Village Districts in Colrain are designed to encourage traditional mixed use land use and compact development patterns that reduce land and energy consumption, greenhouse gas emissions, and offer social and, economic benefits. Colrain Center retains its 19th century village appearance with a mix of institutional, civic, commercial, and residential buildings. However, inadequate wastewater infrastructure, historic buildings requiring expensive renovations, and limited land available for development or re-development due to constraints, such as being located in the 100-year floodplain and mapped River Corridor, are some of the challenges to development in Colrain.

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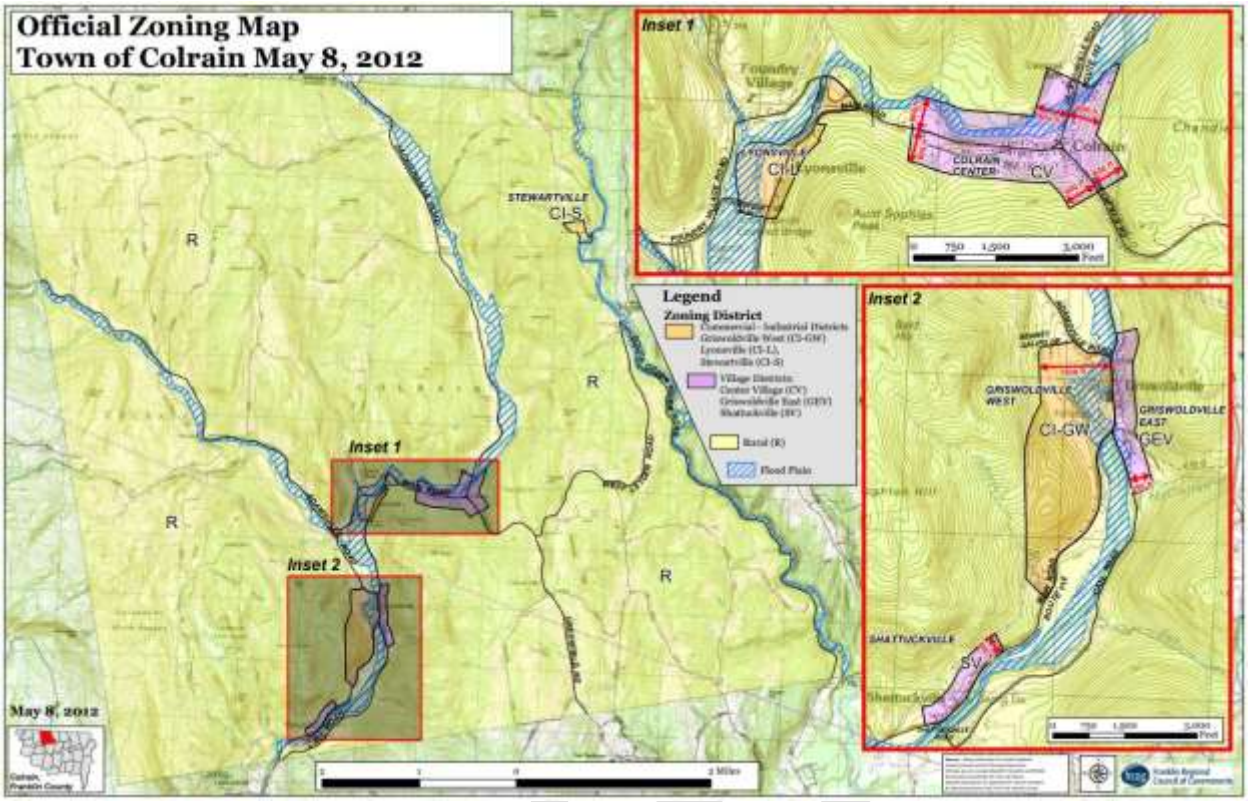

National Flood Insurance Program Status

Colrain is a participating member of the National Flood Insurance Program. Currently there are 6 flood insurance policies in effect in Colrain, for a total insurance value of $1,420,000. Two losses have been paid by claims totaling $10,992. Colrain does not have any repetitive loss properties. Colrain's Flood Insurance Rate Map (FIRM) is from 1980.[3]

Roads and Highways

The principal arteries running through Franklin County are the north/south running Interstate 91 and the east/west Route 2. The major artery running through Colrain is Route 112, a Federally-designated Scenic Byway. Route 112 connects Colrain with nearby towns in Vermont, a commercial center in Shelburne Falls to the south, and via Route 2, a regional employment center in Greenfield to the east. The closest access to I-91, Franklin County's major north/south route, is in Greenfield. About forty-seven miles or 48 percent of Colrain's roads are gravel. The town has a total of 99 miles of roads.

[3] National Flood Insurance Statistics for Franklin County as of December 18, 2018

Rail

There is no rail service in Colrain.

Public Transportation

There is no regular public transportation in Colrain. Transportation for the elderly and people with disabilities is provided by the Franklin Regional Transportation Authority (FRTA).

Public Drinking Water Supply

The Town of Colrain is served by four public water supply systems that are regulated by the Massachusetts Department of Environmental Protection: Foundry Acres Association on which there are 10 houses sharing a common well, Colrain Village Water Supply, Pine Hill Orchard, and Colrain Elementary School. These community water supplies serve a small number of the Town's residents. The remainder of the Town's population uses individual private wells for their drinking water supply.

Sewer Service

The Colrain Sewer District serves portions of the Village of Griswoldville. There is an industrial wastewater treatment facility located on the premises of a private firm, Barnhardt Manufacturing, that also serves as a municipal wastewater treatment plant for a small portion of Town. The District contains thirty-five homes but serves only about eighteen at this time. As things currently stand, should Barnhardt Manufacturing ever close down, the residences served by the Barnhardt wastewater treatment plant would be without sewer service. The landform that these homes are sited on is comprised of significant ledge and the siting of private septic systems would not be possible. Given the potential for these residences to be left without sewer options, the town is moving forward with a sewer study funded in part by a USDA grant in 2013.

The rest of the town is served by private septic systems.

Emergency Shelters

The Committee identified the Colrain Central School and the Community Church as the two shelters in town, although they acknowledged that the flooding from Irene called into question whether a third shelter, located at a higher elevation and away from the North River should be established. The Committee also noted that neither existing shelters has back-up generators, meaning that sheltering for long periods of time is not feasible. The Committee agreed an

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appropriate action item would be to seek an agreement with Pine Hill Orchard (a public water supply) to serve as an alternate shelter and to equip the Town Hall and/or Fire Department building with back-up generators. The Town has submitted a grant application to fund the purchase of two generators.

Natural Resources

Colrain's most noteworthy natural features are the East Branch North River, West Branch North River, North River and the extensive floodplains as well as hillside farmlands, and forested hills. Forests constitute the most abundant natural resource in the Town of Colrain. These forests, including many large tracts of uninhabited or roadless land, provide Colrain its rugged and rural character. According to the 2016 MassGIS Land Use data, Colrain has approximately 24,472 acres of forest land cover, comprising 86 percent of the Town's total land. Approximately 30% of the land in Colrain is permanently protected from development.[4] The Commonwealth of Massachusetts owns more than 2,700 acres of the forestland in Colrain, which is overseen by the Department of Conservation and Recreation. These forestlands include Catamount State Forest (1,339 acres in Colrain; 76 acres in Charlemont), and H.O. Cook State Forest (919 acres in Colrain; 915 acres in Heath). The Massachusetts Division of Fisheries and Wildlife (DFW) owns and manages the Catamount Wildlife Management Area (WMA) located in southwestern Colrain. Catamount WMA contains a total of 256 acres in two parcels, which abut Catamount State Forest. Large blocks of contiguous forestland are important resources for several reasons. Large blocks of forest provide clean water, air, and healthy wildlife populations. They represent an area with a low degree of fragmentation that can support wildlife species that require a certain amount of deep forest cover separate from people's daily activities. Forests help mitigate flooding by slowing and absorbing stormwater, and are critical in mitigating future climate change through sequestering and storing carbon.

Water Resources

Watersheds are the areas of land that drain to a single point along a stream or river. The Town of Colrain is located in the northeastern portion of the Deerfield River Watershed, an area that includes portions of the North and Green River subwatersheds, also known as Hydrologic Unit Code (HUC-12) watersheds.

The Green River watershed is located in southern Vermont and northwestern Massachusetts. It has a drainage area of 89.9 square miles and is comprised of numerous small streams, many of which originate in the uplands of eastern Colrain. The River itself originates in southern

[4] 2014 *Colrain Center Village Master Plan.*

Vermont and flows into Massachusetts in the Town of Colrain forming the Town's eastern border with the Town of Leyden. The Green River flows southeasterly through a steep narrow valley and, as it enters the City of Greenfield, its gradient lessens. The segment of the river from the Vermont-Massachusetts border to the Greenfield Wastewater Treatment Plant is considered as a Class B, cold-water fishery, with high quality water designations (Mass. DEP website).

The North River watershed is located in northwestern Massachusetts and southern Vermont, draining 94.2 square miles. The East Branch and the West Branch of the North River are the two main tributaries of the North River. The East Branch originates at Ryder Pond in Whitingham, Vermont and converges with the West Branch north of Griswoldville, in south-central Colrain. The West Branch also originates in the Town of Whitingham. Smaller streams, which are also part of the North River Watershed, include Foundry Brook, Taylor Brook, Tissdell Brook, Vincent Brook, and Roberts Brook. Forests dominate the upland slopes of the Watershed while the flood plain areas are mostly agricultural. The East and West Branch, as well as the North River from the confluence of the East and West Branches to Barnhardt Manufacturing, have all been designated as Class B, cold-water fisheries with high quality water. However, the 7.5 miles of the East Branch North River from the Vermont line to the confluence with the West Branch North River is listed as impaired for e.coli bacteria.[5]

The River Corridor has been mapped for the West Branch North River, East Branch North River and North River in Colrain using the scientific principles of fluvial geomorphology and a mapping protocol developed Field Geology Services. This mapping protocol was piloted in the North River HUC-12 watershed (2018) and the Green River HUC-12 watershed (2019).[6] The River Corridor is that area adjacent to a river where the river may erode, inundate and change position over time. Areas of high fluvial erosion hazard are identified along the river corridor, which is useful for climate change and flood mitigation planning and project development.

Table 2-3 shows the 2016 land cover and land use totals located within the mapped river corridor. As previously mentioned, the MassGIS land cover and land use data became available in May 2019. The committee identified the need to use this data in conjunction with the mapped river corridor data to update the vulnerability assessment for flooding and other hazards that create flooding. There was an Action Item created in Table 4-3 to address this need.

[5] 2016 Integrated List of Waters. MassDEP.

[6] Development of River Corridor Mapping Procedure with Initial Application in the North River Watershed, MA, prepared for Franklin Conservation District, Greenfield MA by Field Geology Services, 2018; River Corridor Toolkit, developed by the Franklin Regional Council of Governments, 2019.

Table 2-2: Colrain 2016 Land Cover and Land Use Data for the Delineated River Corridor				
Landcover	**Acres**		**Land Use**	**Acres**
Bare Land	18.25		Agriculture	195.20
Cultivated	229.68		Commercial	10.06
Deciduous Forest	282.34		Industrial	16.80
Developed Open Space	62.81		Mixed use, other	104.56
Evergreen Forest	65.67		Mixed use, primarily residential	38.53
Grassland	43.95		Open land	126.91
Impervious	55.53		Recreation	9.72
Palustrine Aquatic Bed	0.93		Residential - multi-family	84.31
Palustrine Emergent Wetland	14.20		Residential - single family	104.79
Palustrine Forested Wetland	47.45		Right-of-way	59.08
Palustrine Scrub/Shrub Wetland	0.04		Tax exempt	23.88
Pasture/Hay	80.65		Unknown	0.19
Scrub/Shrub	0.02		Water	119.45
Water	77.08			

Cultural and Historic Resources

The importance of integrating cultural resource and historic property considerations into hazard mitigation planning is demonstrated by disasters that have occurred in recent years, such as the Northridge earthquake in California, Hurricane Katrina in New Orleans, or floods in the Midwest. The effects of a disaster can be extensive—from human casualty to property and crop damage to the disruption of governmental, social, and economic activity. Often not measured, however, are the possibly devastating impacts of disasters on historic properties and cultural resources. Historic structures, artwork, monuments, family heirlooms, and historic documents are often irreplaceable, and may be lost forever in a disaster if not considered in the mitigation planning process. The loss of these resources is all the more painful and ironic considering how often residents rely on their presence after a disaster, to reinforce connections with neighbors and the larger community, and to seek comfort in the aftermath of a disaster.[7]

Historic properties and cultural resources can be important economic assets, often increasing property values and attracting businesses and tourists to a community. While preservation of historic and cultural assets can require funding, it can also stimulate economic development and revitalization. Hazard mitigation planning can help forecast and plan for the protection of

[7] Integrating Historic Property and Cultural Resource Considerations Into Hazard Mitigation Planning, State and Local Mitigation Planning How-To Guide, FEMA 386-6 / May 2005.

historic properties and cultural 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. The Committee verified that the significant cultural and/or historic resources listed in the latest version of the Colrain Comprehensive Emergency Management Plan (CEMP) are vulnerable to hazard events. Some of these structures house historic documents and cultural artifacts (Table 2-3).

Table 2-3: Colrain CEMP Cultural Resources

Resource Name	Resource Location	Resource Type	Materials Contained
Arthur Smith Covered Bridge	Lyonsville Road	Historical Structure	N/A
Colrain Community Church	306 Main Road	Historical Building	N/A
First Baptist Church	345 Foundry Village Road	Historical Building	N/A
Griswold Memorial Library	6 Main Road	Library	Archives, Historical Documents
Old Main Street Church	2 Main Street	Historical Building	N/A
The Wiliam Pitt House	4 Main Road	Historical Building	Museum, Artifacts
Town Common	Jacksonville Road and Main Road	Historical Landscape	N/A
Town Office	55 Main Road	Historical Building	Archives

Source: Colrain CEM Plan, Update 2012.

The Massachusetts Cultural Resource Information System (MACRIS) lists a total of 102 areas, buildings, burial grounds, objects, and structures of cultural and/or historic significance in Colrain. Designation on this list does not provide any protective measures for the historic resources but designated sites may qualify for federal and state funding if damaged during a natural or manmade hazard. MACRIS data are compiled from a variety of records and files maintained by the Massachusetts Historical Commission (MHC), including but not limited to, the Inventory of Historic Assets of the Commonwealth, National Register of Historic Places nominations, State Register of Historic Places listings, and local historic district study reports. An Action Item for this plan could include encouraging the Colrain Historic Commission to compile an inventory of the historic structures and landscapes and mapping all of the buildings and sites to make a determination as to which may be at most risk for flooding or other hazards.

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Community Facilities and Resources

It is important for communities to determine which areas or specific populations in their community may need special attention in times of an emergency. In addition to the infrastructure previously described, these facilities and resources are identified on the Critical Facilities and Infrastructure Map and Environmental Resources Maps at the end of Section 2.

Critical Facilities

A community's critical facilities include important municipal structures (i.e., town hall), emergency service structures (i.e., municipal public safety complex, shelters, and medical centers), and locations of populations that may need special assistance (i.e., nursing homes, day cares, schools, prisons) and major employers or other areas where there is a dense concentration of people. The Colrain CEM Plan identifies six critical facilities in Colrain. These include Barnhardt Manufacturing, Inc., Colrain Water District, Griswoldville Water District, Shelburne Falls Water District, Town Office, and the Colrain Highway Department. The critical facilities are shown on the Critical Facilities and Infrastructure Map at the end of Section 2.

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2.2 IMPACTS OF CLIMATE CHANGE

Greater variation and extremes in temperature and weather due to climate change has already begun to impact Colrain, 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 2-3 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: 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 2-4 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 2-4 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.

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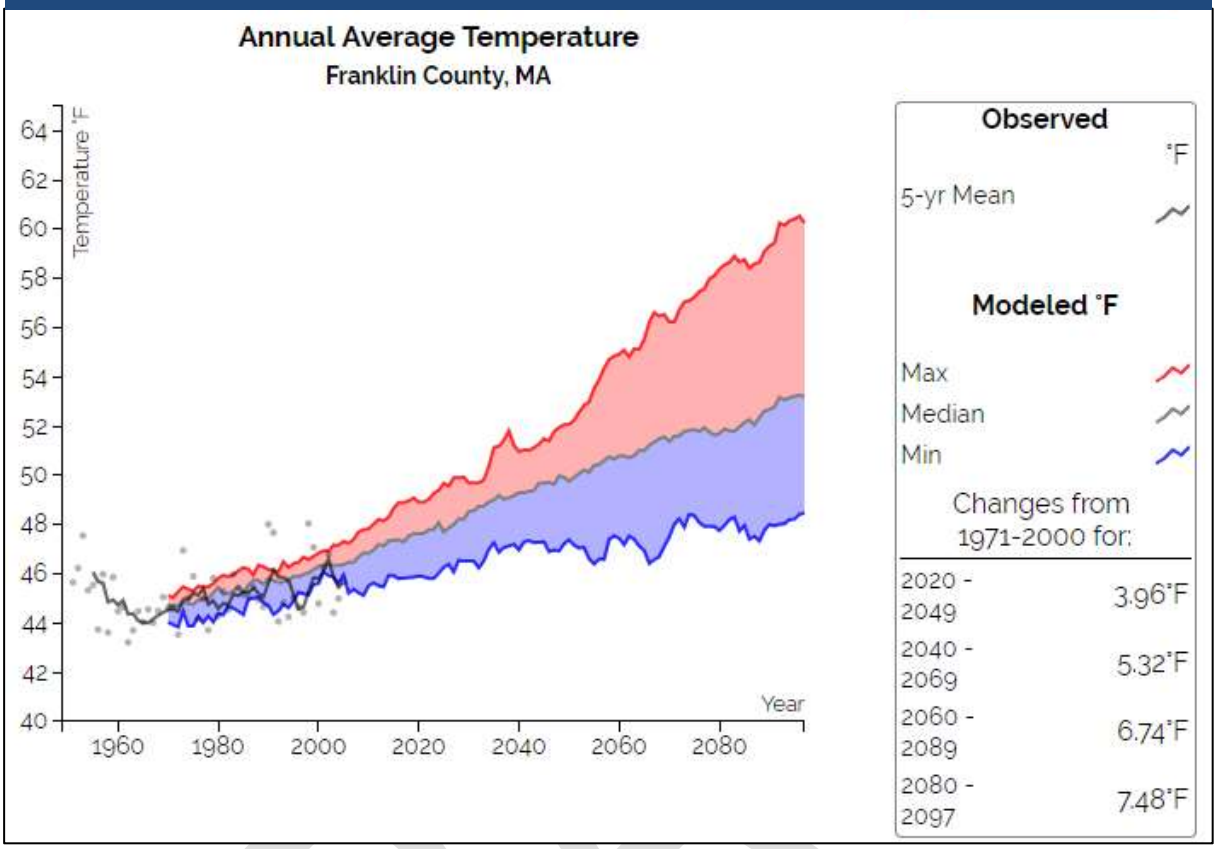
Figure 2-1: Climate Change and Natural Hazard Interactions from the Massachusetts State Hazard Mitigation and Climate Adaptation Plan

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

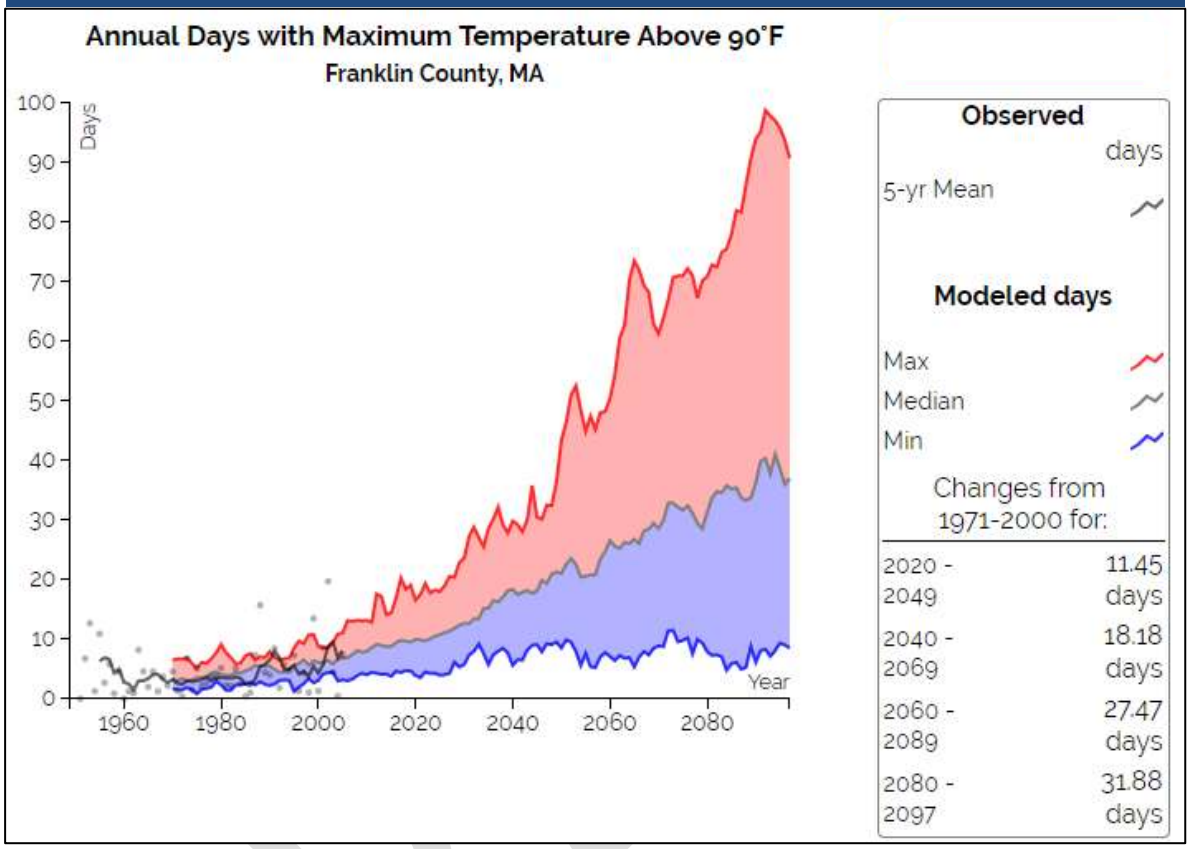


Source: Resilient MA, 2018

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. Figure 2-4 shows annual average temperatures in Franklin County rising to approximately 53° by the end of the century, an increase of nearly 7.5°.

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 2-5 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



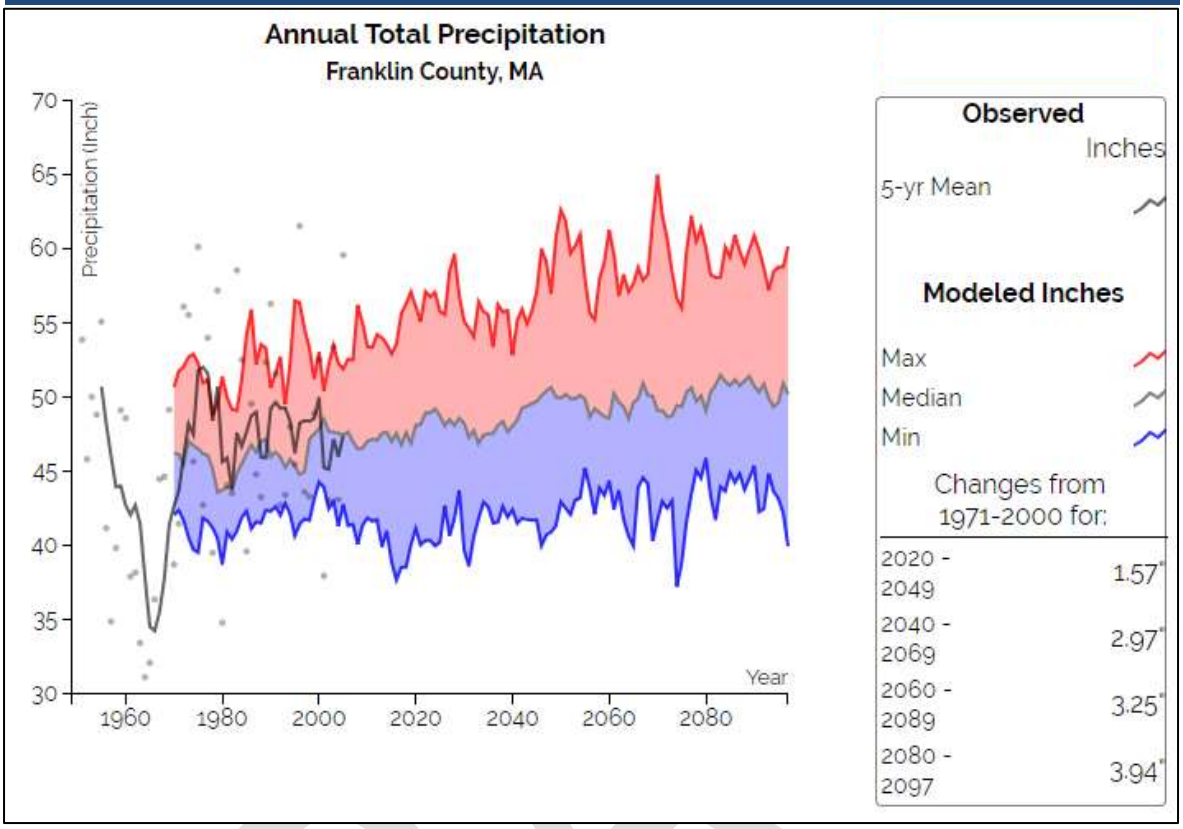
Source: Resilient MA, 2018

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 2-6). 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.[8]

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

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



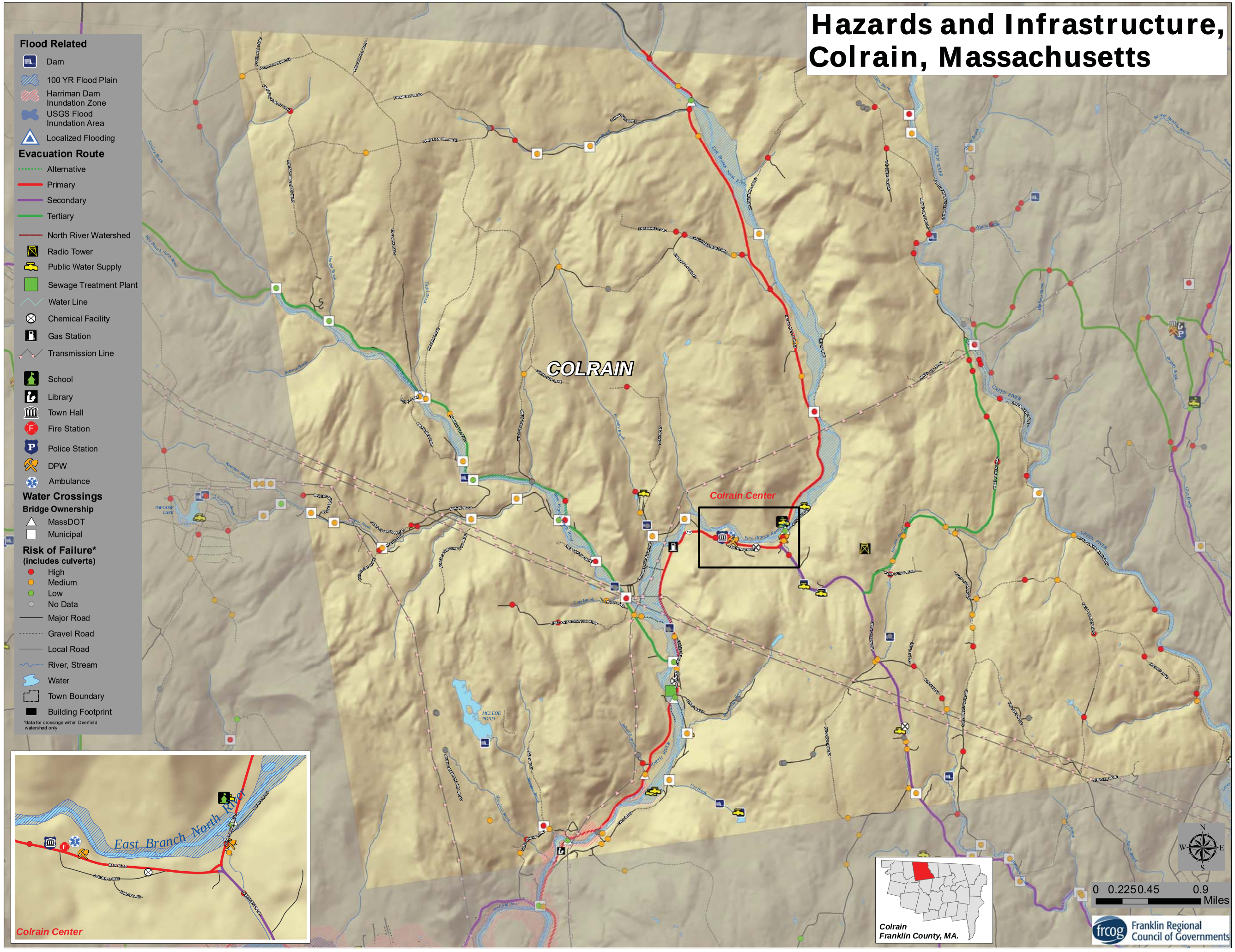
Source: Resilient MA, 2018

Extreme Weather

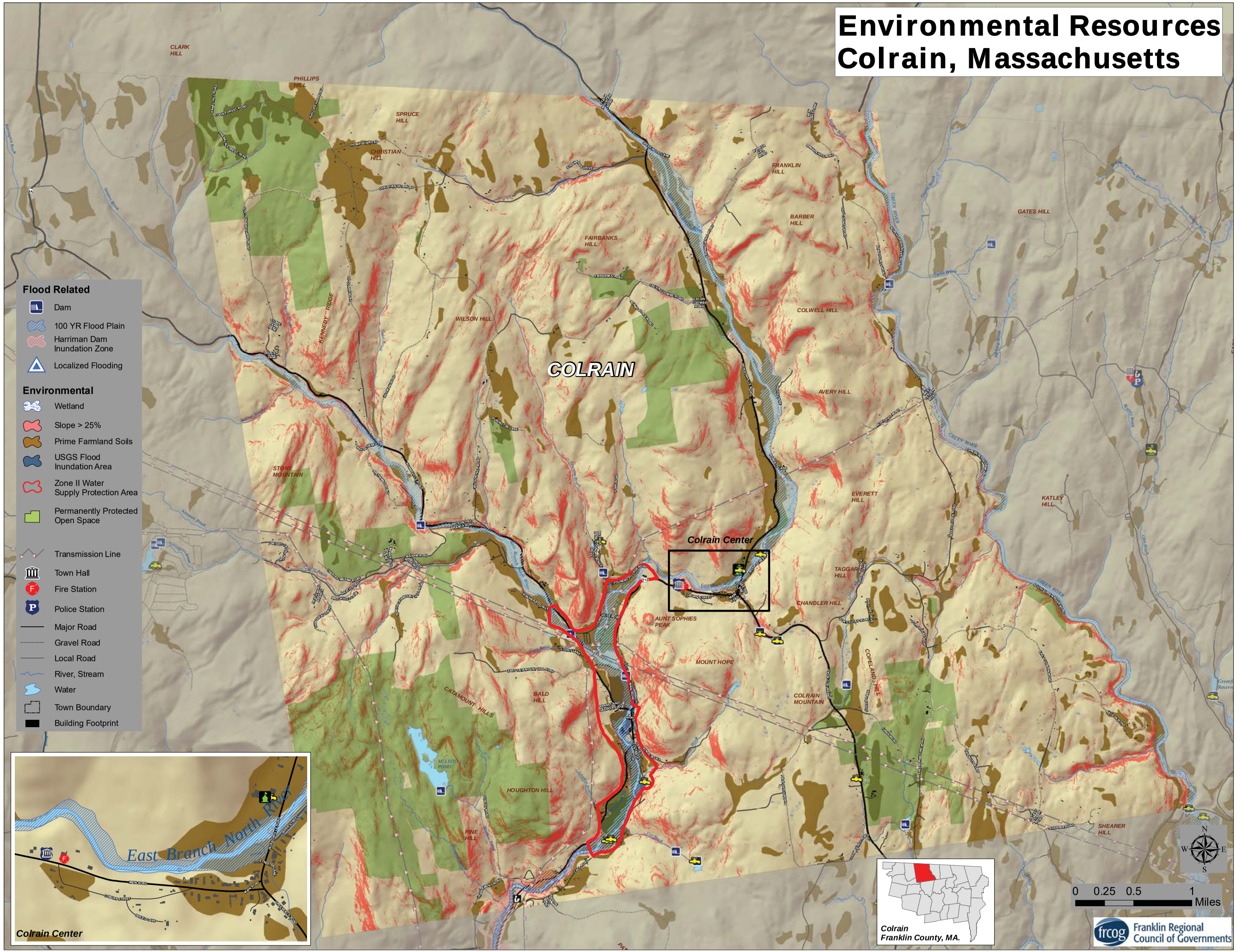
Climate change is expected to increase extreme weather events across the globe, as well as right here in Massachusetts. There is strong evidence that storms—from heavy downpours and blizzards to tropical cyclones and hurricanes—are becoming more intense and damaging, and can lead to devastating impacts 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.

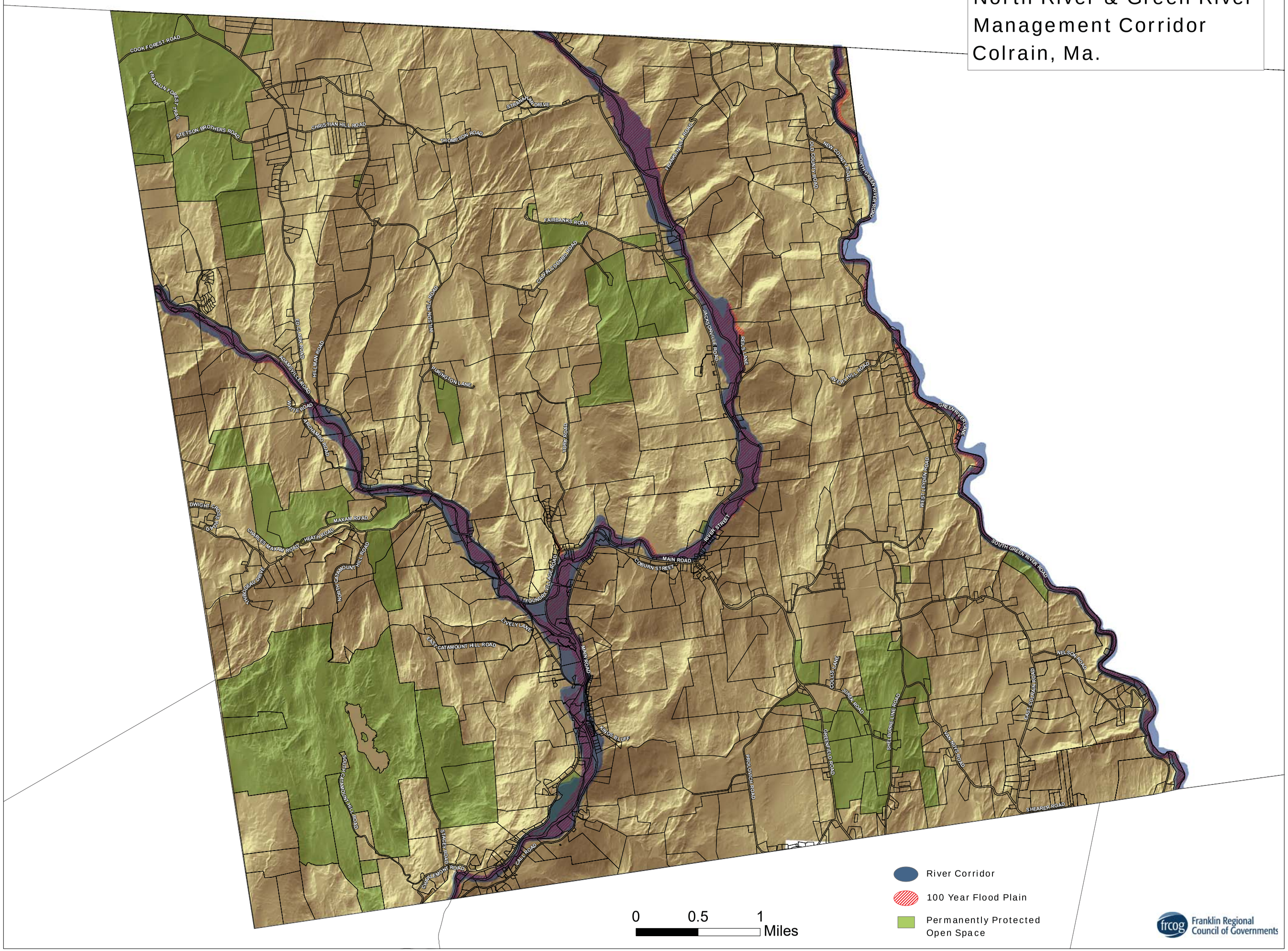
Hazards and Infrastructure, Colrain, Massachusetts



Environmental Resources
Colrain, Massachusetts



North River & Green River Management Corridor Colrain, Ma.



3 HAZARD IDENTIFICATION AND RISK ASSESSMENT

3.1 INTRODUCTION

The following section includes a summary of disasters that have affected or could affect Colrain. 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 Colrain. The table below illustrates a comparison between the relevant hazards in the State plan, in Colrain's Hazard Mitigation plan, and the Colrain Municipal Vulnerability (MVP) Plan.

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

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

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Table 3-1: Comparison of hazards in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, Colrain Hazard Mitigation Plan, and the MVP Resiliency Plan		
Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2018)	**Town of Colrain Relevance**	**MVP Resiliency Plan Top Priority Hazard**
Coastal Erosion	NO	NO
Tsunami	NO	NO
Average/Extreme Temperatures	YES	NO
Wildfires	YES	YES
Invasive Species	YES	NO
Hurricanes/Tropical Storms	YES	Flooding
Severe Winter Storm	YES	Winter storms, ice storms, ice jams
Tornadoes	YES	High Wind, Microbursts
Other Severe Weather	YES	High Wind, Microbursts

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Table 3-1: Comparison of hazards in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, Colrain Hazard Mitigation Plan, and the MVP Resiliency Plan		
Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2018)	**Town of Colrain Relevance**	**MVP Resiliency Plan Top Priority Hazard**
	YES	NO

3.2 NATURAL HAZARD RISK ASSESSMENT METHODOLOGY

This chapter examines the hazards in the *Massachusetts State Hazard Mitigation and Climate Adaptation Plan* that are identified as likely to affect Colrain. The analysis is organized into the following sections: 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.[9]

Hazard Description

The natural hazards identified for Colrain are: severe winter storms, flooding, tornado, dam failure, hurricanes/tropical storms, severe thunderstorms/wind/microbursts, extreme temperatures, earthquakes, landslides, drought, wildfire, and invasive species. 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 (Table 3-2) refers to the geographic areas within the planning area that are affected by the hazard. Some hazards affect the entire planning area universally, while others apply to a specific portion, 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:

[9] 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:

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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

The ranking is qualitative and is based, in part, on local knowledge of past experiences with each type of hazard, review of available data, and the work of the Committee. 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	Critical	1 – High Risk
Flooding	Medium	High	Limited	2 – Medium Risk

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Table 3-5: Hazard Identification and Risk Analysis				
Type of Hazard	**Location of Occurrence**	**Probability of Future Events**	**Impact**	**Overall Hazard Vulnerability Rating**
Tornadoes	Isolated	Moderate	Limited	3 – Low Risk
Dam Failure (other dams and beaver dams)	Isolated	Very Low	Minor	3 – Low Risk
Hurricanes / Tropical Storms	Medium	High	Limited	2 – Medium Risk
Severe Thunderstorms / Wind / Microbursts	Medium	High	Limited	2 – Medium Risk
Extreme Temperatures	Medium	High	Limited	2 – Medium Risk
Earthquakes	Isolated	Very Low	Minor	3 – Low Risk
Landslides	Medium	Moderate	Limited	2 – Medium Risk
Drought	Medium	Moderate	Limited	2 – Medium Risk
Wildfires	Isolated	Low	Minor	3 – Low Risk
Invasive Species	Medium	Very High	Limited	2 – Medium Risk

The Committee developed problem statements and/or a list of key issues for each hazard to summarize the vulnerability of Colrain'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).

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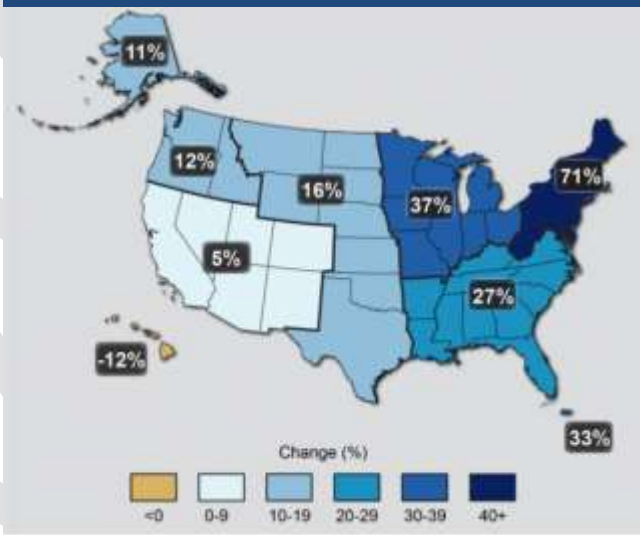
3.3 FLOODING

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 Millers River Watershed, 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 12 inches a year. In general precipitation projections are more uncertain than temperature projections.[10]

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.

[10] http://resilientma.org/datagrapher/?c=Temp/basin/pcpn/ANN/Millers/.

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 Colrain 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

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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.

There are a number of rivers, brooks, and streams in Colrain with the potential to cause localized flooding.

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 significant floodplain or are hydraulically disconnected from the floodplain, such as in many areas of Colrain, 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.[11] Fluvial

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

erosion hazard and River Corridor maps were prepared for the North River in Colrain, as part of the River Corridor Mapping Procedure that was applied to the North River in 2018.

Urban Drainage Flooding

Urban drainage flooding entails floods 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.

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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 because 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 Colrain’s vulnerability to dam failure is discussed in more detail in the Dam Failure section of this plan.

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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.

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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.

The 100-year floodplain in Colrain covers about 821 acres, or approximately three percent of the town, including an estimated thirty-three acres of developed residential land and eight acres of industrial use. There is less than an acre of public/institutional land use in the floodplain. Colrain's village center, although outside of the 100-year floodplain, runs adjacent to the North River and is vulnerable to flooding

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. Smaller streams, which are part of the North River Watershed, include Foundry Brook, Taylor Brook, Tissdell Brook, Vincent Brook, and Roberts Brook.

Colrain has worked to replace failing bridges and culverts throughout town that were identified in the last Hazard Mitigation Plan as vulnerable to flooding. For example, a culvert and bridge were replaced on Adamsville Road, and the bridge on Call Road was replaced that sustained serious damage after Hurricane Irene.[12] The old Highway Garage, which was inundated with four feet of floodwater after Hurricane Irene was also rebuilt with flood-doors and other flood resistant design features to mitigate future damages.[13] Although progress has been made, there are still some areas in town that may experience flooding and damaged infrastructure during severe weather.

Fragmentation and development in upland areas, including roads that 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.

[12] Bridge Assessment and Ranking, Town of Colrain, MA. BSC Group 2018
[13] https://www.recorder.com/Colrain-has-new-highway-garage-19040428

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.

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. Invasive plant species such as Japanese knotweed were described in the MVP workshop as causing riverbank erosion along both branches of the North River, especially along river corridors and in farm fields without buffers.

According to the 2016 *Fluvial Geomorphic and Habitat Assessment of the North River Watershed*, the 2014 *Hazard Mitigation Plan*, the 2018 *Development of River Corridor Mapping Procedure with Initial Application in the North River Watershed, MA*, and the 2017 *Watershed-Based Plan to Maintain the Health and Improve the Resiliency of the Deerfield River Watershed,* the following brooks and rivers in Colrain as susceptible to FEHs, ground failures, and/or flooding:

<u>Green River</u>

The entire section of the Green River that runs through Colrain is prone to flooding. Along south Green River Road, there are frequent landslides and slumping of land, which is caused by flooding. The 2017 *Watershed-Based Plan to Maintain the Health and Improve the Resiliency of the Deerfield River Watershed* found critical issues related to water quality, flood vulnerability, and upland tributary protection in the Green River HUC-12 watershed and determined that the watershed is a logical target for additional field assessments and development of restoration strategies to address water quality and flood-related hazards. Some of the report's high-priority action items specific to the Green River watershed are included in Section 4, Table 4-3: Colrain Hazard Mitigation Prioritized Action Plan.

<u>North River</u>

Riverbank erosion along both the East and West branches of the North River is increasing the surrounding area's vulnerability to the impacts of flooding. Large landslides, mudslides, and slumping are also a concern along much of the North River and its branches. The 2017 *Watershed-Based Plan to Maintain the Health and Improve the Resiliency of the Deerfield River Watershed* identified projects on several parcels in the watershed that could function as "attenuation assets" if climate resiliency measures (NBS construction projects) were undertaken to restore geomorphic functions, attenuate sediment load and retain and slow flood waters. Sediment buildup under bridges and around bridge abutments – a result in part

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of frequent flooding – is pushing the level of the North River and its branches higher. Also described in the 2017 report is a project that includes removal of excess sediment in and around the piers of the new Route 112 bridge and stabilization of the upstream mass failure adjacent to Barnhardt Manufacturing. High-priority action items specific to the North River mainstem and East Branch subwatersheds are included in the Prioritized Action Plan (Table 4-3). The North River flows alongside Colrain's village center where roads, bridges and culverts are vulnerable to high flood events. A key area of concern is the bridge near the Elementary School. Other critical facilities, including the Town's Highway Department, Fire Department, landfill, and salt shed, are located along a vulnerable stretch of land adjacent to the West Branch of the North River. Also, there are currently no shelters in town located outside of the floodplain.

Heath Road

The old stone culvert at Maxam and Heath Roads is too small to handle water flow and traps logs and other debris floating in the water.

Additionally, there are a number of streams in Colrain with the potential to cause localized flooding, including Foundry Brook, Taylor Brook, Tissdell Brook, Vincent Brook, and Roberts Brook.

Taylor Brook

Tributary confluences where significant sediment accumulation is occurring can cause channel migration, which can erode riverbanks and cause ground failures. The confluence of Taylor Brook and the West Branch of the North River is a site of significant sediment accumulation that could cause channel migration and threaten Adamsville Road across from the tributary mouth during a future large flood.[14]

Dam Failure

According to the 2014 Hazard Mitigation Plan, Colrain could be impacted if a dam failure were to occur at one of the dams in town or upstream on one of the Town's larger rivers. Colrain has five dams in town, four of which are identified as Significant Hazard, while the other is Low Hazard. The four significant hazard dams include: Colrain Lower Reservoir Dam, Colrain Upper Reservoir Dam, Kendall Company No.1 Dam, and Shelburne Falls Fire District Dam. Colrain's significant hazard dams were listed as in fair or satisfactory condition in the January 2011 information provided by the MA DCR Office of Dam Safety. Mcleod Pond Dam, Colrain's low hazard dam was listed as being in poor condition. Updated dam assessment reports and dam

[14] *Development of River Corridor Mapping Procedure with Initial Application in the North River Watershed, MA,* Field Geology Services, 2018

inundation area mapping should be sought for each dam so that the Town may better understand the potential risk that any of these dams pose to Colrain. There are two dams upstream in Vermont where a potential critical failure could impact Colrain: Jacksonville Pond and Gates Pond Dams. Also see the Dam Failure Section of this report.

Beaver Dam Failure

The Committee identified locations of beaver dams in Colrain, three of which are of particular concern, should the dam be breached. They include: 1) an impoundment on Jacksonville Roads, where fields are flooded due to the dam, 2) a three-acre impoundment on East Colrain Road, and 3) flooded farmland on Fort Lucas Road due to a beaver dam.

Based on these locations, flooding has a "Medium" area of occurrence in Colrain, with 10- 50% percent of the town affected.

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 Green River in Colrain, as well as the highest flow event in the last 365 days.

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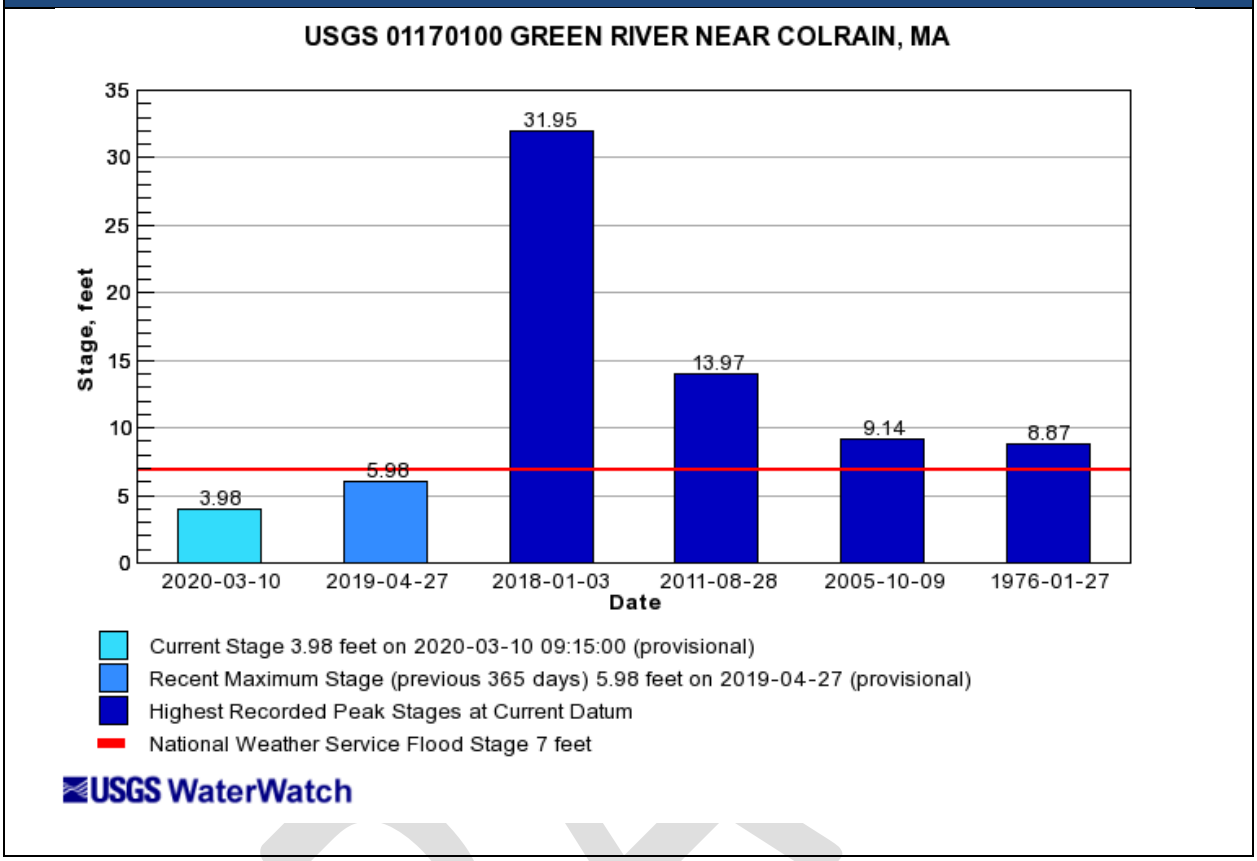
Figure 3-3: Highest Recorded Flood Events on the Green River Near Colrain



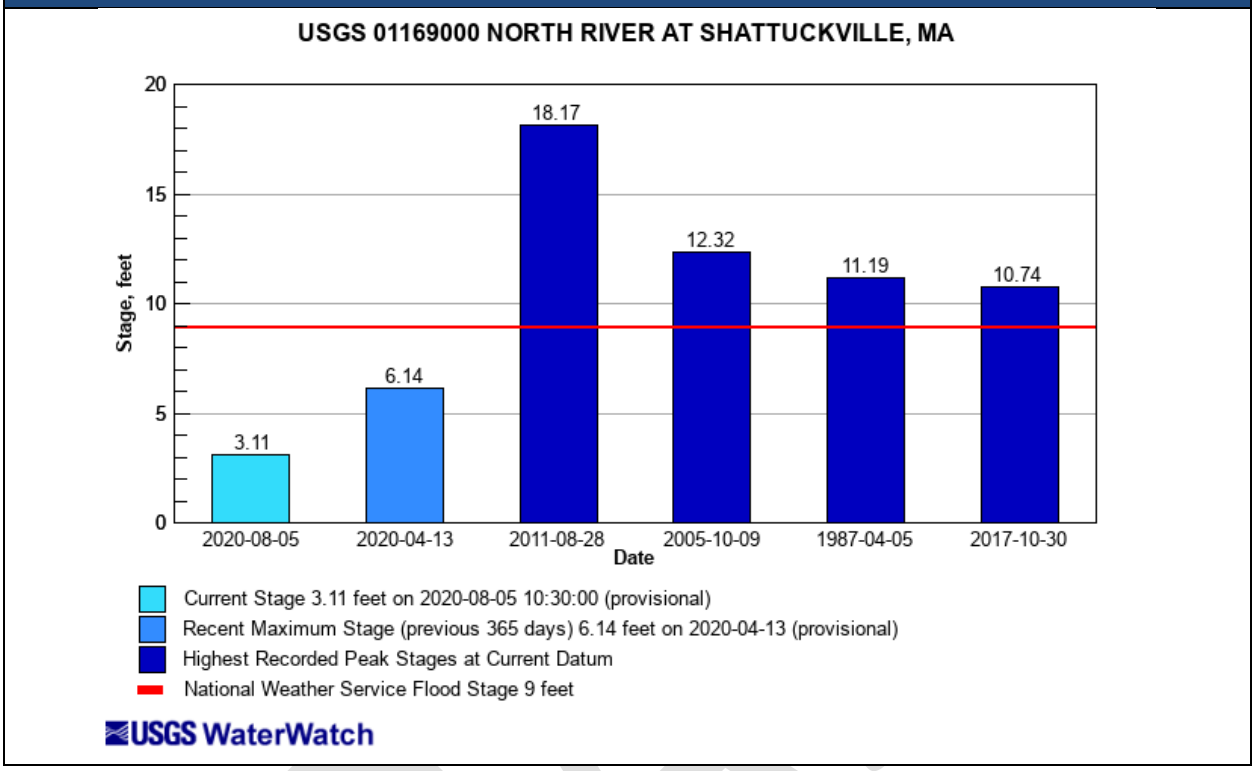
Source: USGS WaterWatch https://waterwatch.usgs.gov/index.php?id=wwchart_ftc&site_no=01166500

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.

Figure 3-4: Highest Recorded Flood Events on the North River at Shattuckville, MA



Source: USGS WaterWatch https://waterwatch.usgs.gov/?id=wwchart_ftc&site_no=01169000

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 purchases are 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. 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 Colrain 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.

In October 2005, rains from Tropical Storm Tammy and a subtropical depression caused severe flooding in New England, with Massachusetts sustaining $6.5 million in damages. A trailer park in Greenfield was destroyed, leaving 70 people homeless. Roads were washed out as more than 20 inches of rain fell on some areas of the region.

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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
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/

Tropical Storm Irene caused widespread flooding and damage in Colrain. Floodwaters overtook the wastewater treatment plant at Barnhardt Manufacturing, but the 250,000 gallon underground tanks were able to hold their contents and no spills occurred. Floodwaters also caused riverbank erosion, the toppling of many trees into the North River and its branches, and sediment debris and build-up.

In 2014 the Town of Colrain and the FRCOG submitted a FEMA Hazard Mitigation Grant Program application for a project identified as Colrain Route 112 Bank Stabilization. The project is located along the East Branch of the North River, along Route 112. The project area includes land on either side of Reil Lane, covering from approximately 100 Jacksonville Road to 140 Jacksonville Road. As of April 2019, the project is currently underway with the appropriate permitting processes.

The project area is extremely eroded due to the effects of high discharge events including Tropical Storm Irene. Two sections of river bank have been affected by erosion. The 75 foot downstream section is immediately downstream of Reil Lane Bridge and the upstream section is 370 feet upstream of the bridge and 300 feet long, where the river makes a sharp turn at the highway embankment. The erosion is close to the edge of the river and if left unchecked will eventually undermine the road, causing road closures. This road serves as a primary emergency

evacuation route for the Vermont Yankee Nuclear Power Plant located in Vernon, VT.

The project will include work on the entire riverbank and bed at the toe of the slope within the project area. The potential for upstream or downstream flooding or damage will not be affected as a result of this project. The channel bank full width will be maintained and not affect the river flow. Survey, design and project engineering will be performed by a qualified environmental engineering firm that will provide a set of final design and detailed construction plans to the Town. Specific site preparation and erosion control measures will be determined during the design phase and detailed on the construction plans.

Probability of Future Events

Based on previous occurrences, the frequency of occurrence of flooding events in Colrain is "High" and represents an event that occur from once in 2 years to once in 4 years (25%-50% probability in the next year). Flooding frequencies for the various floodplains in Colrain 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 Colrain.[15]

Impact

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

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
- 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 could be limited in Colrain, with minor injuries only, more than 10% of property in affected area damaged or destroyed, and complete shutdown of facilities for more than 1 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.

Of Colrain's total acreage, 820 acres lie within the 100-year floodplain. According to 2005 MassGIS Land Use data there are 28 dwellings located in the floodplain (Table 3-8). Using this number and Colrain's estimated average household size, it is estimated that 64 people, or 4% of Colrain's total population, reside in the floodplain.

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Table 3-8: Estimated Colrain 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**
1,631	28	2.28	64	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 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 3-9 estimates the number of vulnerable populations and households in Colrain. 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 Colrain residents during a flood event.

Table 3-9: Estimated Vulnerable Populations in Colrain		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	359	22%
Population with a Disability	184	11%
Population who Speak English Less than "Very Well"	44	3%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	201	28%
Householder Age 65 Years and Over Living Alone	99	14%
Households Without Access to a Vehicle	16	2%

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*Total population = 1,631; Total households = 714
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2013-2017 Five-Year Estimates.

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 Colrain. 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 power lines, 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).

Economic Impacts

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 Colrain 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.

Participants in the MVP workshop expressed concern about the future flooding impacts on undersized and failing culverts, bridges, and road infrastructure throughout the town and the Town's need for funding to monitor, repair, and replace infrastructure. The MVP report indicated a variety of projects that need funding support, including feasibility studies, design and construction for replacing the Fire Department facility and capping the landfill, gravel road repair, and other projects.

Table 3-10 shows the amount of commercial, industrial, and public/institutional land uses located in town and within the Flood Hazard Area in Colrain. Approximately 1.8 acres of commercial and .66 acres of public/institutional land uses lie within the floodplain, accounting for 16 percent of commercial land uses in town and 5 percent of public/institutional uses in town. There are roughly 20 acres of industrial land use in town, of which 8 is located in the floodplain.

Table 3-10: Acres of Commercial, Industrial, and Public/Institutional Land Use Within the Flood Hazard Area in Colrain

Land Use	Total acres in Town	Acres in Flood Hazard Area	% of total acres in Flood Hazard Area
Commercial	11	1.8	16%
Industrial	20	8	40%
Public/Institutional	13	.66	5%

Source: 2005 MassGIS Land Use data.

NFIP data are useful for determining the location of areas vulnerable to flood and severe storm hazards. Table 3-12 summarizes the NFIP policies, claims, repetitive loss (RL) properties, and severe repetitive loss (SRL) properties in Colrain 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). Colrain currently

has six policies in force, and two losses have been paid for a total of $10,992. There are no repetitive loss properties in town.

Table 3-11: NFIP Policies, Claims, and Repetitive Loss Statistics for Colrain						
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**
894	6	0.7%	$1,420,000	2	$10,992	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.

Public Health

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).

Public Safety

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

Flood Hazard Problem Statements
• Bridges and culverts throughout the town are vulnerable to flooding. In 2018, BSC Group completed a Bridge Assessment & Ranking report for 33 structures in the town and identified the top 10 priority list for maintenance, repairs or replacement. The Town does not have a comprehensive list or GIS mapping or condition information for the other drainage culverts that do not cross a perennial stream.
• Silt and debris has built up under bridges along both branches of the North River, which can undermine bridge abutments and puts the surrounding area at a greater risk of flooding.
• The riverbank is unstable on the East Branch of the North River near the Town salt shed, Fire Department, and Highway Department storage yard. The riverbank is also unstable along the North River near Route 112, which is an important emergency evacuation

Flood Hazard Problem Statements
route.
• There are currently no shelters that are located outside of the 100-year floodplain.
• Many of the Town's evacuation routes would be impacted by flooding, leaving residents stranded and limiting access by emergency responders.
• Some municipal buildings, businesses and homes need backup power.
• A plan is needed to assist elderly, special needs, and/or disabled residents during emergencies.
• Many residents live in isolated locations with unreliable cell service, which can decrease access to emergency services.
• Residents may not be enrolled in Colrain's emergency response system, Blackboard Connect, and enrollment needs to be promoted. Residents who live alone and who have not opted in to Blackboard connect are the most vulnerable, as they will not have reliable access to emergency information.
• Some of Colrain's residents rely on private wells, placing them at risk during prolonged power outages caused by flooding. Colrain does not yet have an emergency back-up supply of drinking water.
• The Shelburne Falls Fire District's public water supply wells are located in Colrain within the River Corridor and floodplain of the East Branch North River and are vulnerable to flooding and fluvial erosion hazards.
• Some homes throughout Colrain are still damaged from flooding during Hurricane Irene. Repeated flooding events will cause further structural damage.
• Beaver activity has created impoundments which, if breached, could impact Jacksonville Roads, East Colrain Road, and Fort Lucas Road with flooding.
• While the probability of a dam failure impacting Colrain is low, current Emergency Action Plans (EAP) and inundation mapping are needed for significant and high hazard dams in town and upstream. Once available, this information should be shared with Colrain town officials, EMD, and affected residents.
• Flooding has led to deposits of debris on farm fields. Additionally, farms along both branches of the North River do not have natural buffers and are prone to flooding.
• Invasive species, such as Japanese Knotweed, are spreading along the riverbanks and further contributing to riverbank erosion.
• Large sections of both branches of the North River, the North River and Green River are disconnected from their floodplains and flood storage areas.

Flood Hazard Problem Statements
• Approximately 53% of the roads in Colrain are constructed from gravel, which are prone to washouts during instances of heavy rain associated with thunderstorms.
• Funding is needed to implement project identified in existing climate change resilience studies to address riverbank stabilization, habitat restoration, and flood mitigation in Colrain. These include*: 2015 Fluvial Geomorphic and Habitat Assessment for the East Branch of the North River Watershed; 2018 Development of River Corridor Mapping Procedure with Initial Application in the North River Watershed, MA*; *2017 Watershed-Based Plan to Maintain the Health and Improve the Resiliency of the Deerfield River Watershed; 2019 Framework for Resilience; and the 2019 River Corridor Management Toolkit.*

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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 snowmelt to replenish aquifers and lower spring river flows for aquatic ecosystems. Figure 3-5 from the Massachusetts State Hazard Mitigation and Climate Adaptation Plan shows potential effects of climate change on severe winter storms.

Figure 3-5: 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 Colrain 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 3-12. 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 3-12: 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 3-13.

Table 3-13: 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

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Table 3-13: Northeast Snowfall Impact Scale Categories		
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. Tree damage, power outages, and closed roads from the 2008 ice storm were widespread in Colrain. Residents who rely upon forests for their livelihoods, including farmers who have maple sugaring operations, suffered losses due to this storm. Tree damage, power outages, and closed roads from the 2008 ice storm were widespread in Colrain.

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 3-14, in order of their RSI severity.

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Table 3-14: 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

The Hazard Mitigation Committee identified the following as storms that have impacted Colrain in recent history and are identified in Table 3-15.

Table 3-15: Recent Snow Events that Impacted Colrain			
Date	**Location**	**Type**	**Recorded Property Damages**
11/26/2014	Western Franklin	Heavy Snow	$35,000
10/27/2016	Western Franklin	Winter Weather	$200

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

Probability of Future Events

Based upon the availability of records for Franklin County and the information provided by the Hazard Mitigation Committee, the likelihood that a severe snow storm will hit Colrain in any given year is “Very High" and represents an event that occurs at least once each 1-2 years (50%-100% probability in the next 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

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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 snowmelt 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 an event would be "Critical," with multiple injuries possible, more than 25% of property in affected area damaged or destroyed, and complete shutdown of facilities for more than 1 week.

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

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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 Colrain is exposed to severe winter weather events.

Vulnerable Populations

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. Participants at the 2018 MVP workshop determined that these vulnerabilities are affecting the population on Colrain, and that severe winter storms are one of the top hazards impacting the town.

Table 3-16 estimates the number of vulnerable populations and households in Colrain. 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 Colrain residents during a severe winter storm event.

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Table 3-16: Estimated Vulnerable Populations in Colrain		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	359	22%
Population with a Disability	184	11%
Population who Speak English Less than "Very Well"	44	3%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	201	28%
Householder Age 65 Years and Over Living Alone	99	14%
Households Without Access to a Vehicle	16	2%

*Total population = 1,631; Total households = 714
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2013-2017 Five-Year Estimates.

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.[16] 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.

[16] Fink, Sheri. 2012. Hypothermia and Carbon Monoxide Poisoning Cases Soar in the City After Hurricane. New York Times. November 28.2012.

Economic Impacts

The entire building stock inventory in Colrain 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 Colrain are exposed to the severe winter weather hazards. 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. Disruptions to key public services such as electricity, transportation, schools, and health care may become more common.[17] 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 in Colrain

Tax Classification	Total Assessed Value FY2019	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$144,222,960	$1,442,230	$7,211,148	$14,422,296
Open Space	$0	$0	$0	$0

[17] Resilient MA 2018

Table 3-17: Estimated Potential Loss by Tax Classification in Colrain				
Tax Classification	**Total Assessed Value FY2019**	**1% Damage Loss Estimate**	**5% Damage Loss Estimate**	**10% Damage Loss Estimate**
Commercial	$4,955,687	$49,557	$247,784	$495,569
Industrial	$3,395,900	$33,959	$169,795	$339,590
Total	**$152,574,547**	**$1,525,745**	**$7,628,727**	**$15,257,455**

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

Agriculture

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.

Energy

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.

Public Health

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.

Public Safety

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 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.

Transportation

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,

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aviation, port, and waterway infrastructure (if temperatures are cold enough to cause widespread freezing), can be impacted by winter storm conditions.

Water Infrastructure

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, Colrain faces a "High" vulnerability from severe snowstorms and ice storms. Severe Winter Storms / Ice Storms occur frequently in Colrain. The following problem statements summarize Colrain's areas of greatest concern regarding severe winter storms.

Severe Winter Storm Hazard Problem Statements
• Severe winter storms and ice have the potential to impact the Town's evacuation routes.
• Severe winter storms and ice have the potential to cause long term power outages, and some municipal buildings, businesses and homes need backup power.
• Many Colrain residents rely on private wells for water, placing their water supply at risk during prolonged power outages caused by severe winter storms. Colrain does not yet have an emergency back-up supply of drinking water.
• Many residents live in isolated locations with unreliable cell service, which can decrease access to emergency services.

Severe Winter Storm Hazard Problem Statements
• Residents may not be enrolled in Colrain's emergency response system, Blackboard Connect. Residents who live alone and who have not opted in to Blackboard connect are the most vulnerable, as they will not have reliable access to emergency information.
• A plan is needed to assist elderly, special needs, and/or disabled residents during emergencies.
• Residents do not have access to regular, reliable public transportation.
• Low-income families may need heating assistance during periods of extreme cold.
• Destructive winds and ice associated with severe winter storms can cause widespread road closures by taking down trees and utility lines throughout town, further exacerbating communication and access to emergency services and information for residents already facing isolation.
• Severe winter storms can damage large swaths of forest, including forested areas managed for residents' livelihoods, such as sugar bush for maple syrup production, and stands for cordwood and lumber.

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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 3-6 from the Massachusetts State Hazard Mitigation and Climate Adaptation Plan displays the potential effects of climate change on hurricanes and tropical storms.

Figure 3-6: 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

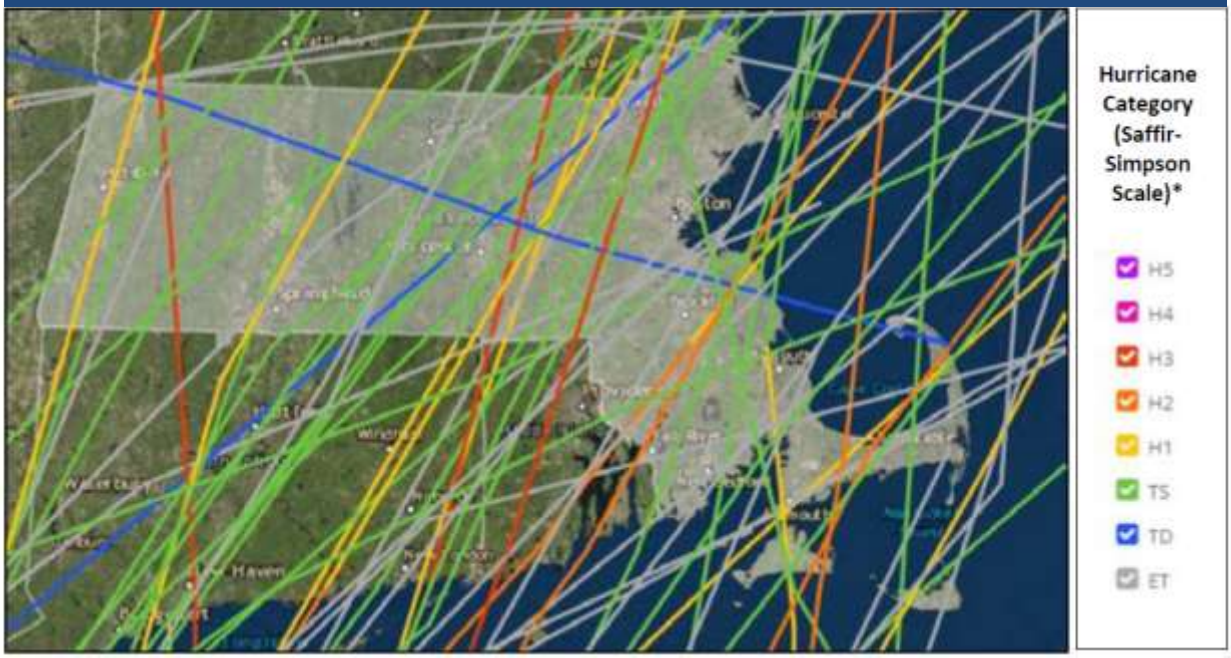
Hurricanes can range from as small as 50 miles across to as much as 500 miles across; Hurricane Allen in 1980 took up the entire Gulf of Mexico. There are generally two source regions for storms that have the potential to strike New England: (1) off the Cape Verde Islands near the west coast of Africa, 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.

Figure 3-7: Historical Hurricane Paths within 65 Miles of Massachusetts



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

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 Colrain is at risk from hurricanes and tropical storms, with a "medium" location of occurrence with 10 to 50% of the town 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 3-7. As this figure shows, the paths of these storms vary across the Commonwealth, but are more likely to occur toward the coast.

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 3-18 gives an overview of the wind speeds and range of damage caused by different hurricane categories.

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Table 3-18: 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 and 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 Colrain.

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

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atmosphere and dumping it on land.[18]

Colrain'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, Colrain has a "High" probability of future hurricanes, which are considered to be an event that occurs from once in 2 years to once in 4 years (25%-50% probability in the next year).

Impact

Considering the impacts of Tropical Storm Irene on Colrain during the Vulnerability Assessment revealed that the impact of a hurricane on the Town is "Limited", with minor injuries only, more than 10% of property in affected area damaged or destroyed, and complete shutdown of facilities for more than 1 day.

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 roads, communication and energy infrastructure.

Society

Vulnerable Populations

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 3-19 estimates the number of vulnerable populations and households in Colrain. 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 Colrain residents during a hurricane or tropical storm event.

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

Table 3-19: Estimated Vulnerable Populations in Colrain		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	359	22%
Population with a Disability	184	11%
Population who Speak English Less than "Very Well"	44	3%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	201	28%
Householder Age 65 Years and Over Living Alone	99	14%
Households Without Access to a Vehicle	16	2%

*Total population = 1,631; Total households = 714
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2013-2017 Five-Year Estimates.

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

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repair costs are all expected to increase in the future.[19]

Infrastructure

Residential and commercial buildings built along rivers may be vulnerable to severe damage from hurricanes and tropical storms and associated flooding and high wind. 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 3-20 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.

Table 3-20: Estimated Potential Loss by Tax Classification in Colrain

Tax Classification	Total Assessed Value FY2019	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$144,222,960	$1,442,230	$7,211,148	$14,422,296
Open Space	$0	$0	$0	$0
Commercial	$4,955,687	$49,557	$247,784	$495,569
Industrial	$3,395,900	$33,959	$169,795	$339,590
Total	**$152,574,547**	**$1,525,745**	**$7,628,727**	**$15,257,455**

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

Energy

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.

Public Health

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.

Public Safety

Critical infrastructure, including local and state-owned police and fire stations, other public

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

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.

Transportation

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.[20]

Water and Wastewater Infrastructure

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 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, Colrain faces a “Medium” vulnerability to hurricanes and tropical

[20] Resilient MA 2018.

storms. The Vulnerability Assessment revealed an occurrence could have limited impact the town, with minor injuries to citizens, and with more than 10% of property in affected area damaged or destroyed. The following problem statements summarize Colrain's greatest areas of concern regarding hurricanes and tropical storms.

Hurricane / Tropical Storm Hazard Problem Statements
• Heavy rain associated with hurricanes and tropical storms exacerbates the risk of flooding hazards and dam failures. ***See all FLOODING Hazard Problem Statements.***
• 51% of the housing stock in Colrain was built prior to building codes that require structures to withstand high winds, which makes some residents especially vulnerable to hurricanes and tropical storms. ***See all SEVERE THUNDERSTORM/WIND/MICROBURST and TORNADO Hazard Problem Statements.***
• Hurricanes and Tropical Storms can cause widespread road closures by taking down trees and utility lines, which has the potential to impact the Town's evacuation routes. The riverbank is unstable and vulnerable to flood hazards along the North River near Route 112, which is an important emergency evacuation route.
• Colrain's road salt shed, Fire Department, and landfill, as well as bridges and culverts throughout the town are vulnerable to the impacts of flooding associated with hurricanes and tropical storms.
• Colrain is vulnerable to power outages caused by hurricanes and tropical storms because the Town lacks backup power at some municipal buildings and an emergency drinking water supply.
• A number of challenges with communications infrastructure, including spotty cell phone and internet service, means residents may lack reliable access to emergency information during hazard events. Existing communication, isolation, and emergency services access challenges could be exacerbated by the impacts of hurricanes and tropical storms.
• Hurricanes and tropical storms can damage large swaths of forest, including forested areas managed for residents' livelihoods, such as sugar bush for maple syrup production, and stands for cordwood and lumber.

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.[21]

Figure 3-8: 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 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

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

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

The entire town of Colrain is at risk for severe thunderstorms, wind and microbursts. The Vulnerability Assessment determined that such a hazard would have a “Medium” location of occurrence in which the potential affected area could be as much as 10 to 50% 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.

Colrain 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

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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 3-9).

Figure 3-9: 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. Colrain has experienced twelve (12) thunderstorm wind events since 2006 (Table 3-22). These storms resulted in downed trees and wires and caused $262,500 in property damage. In one instance in 2013, a microburst tore through Colrain bringing down trees, wires, and a utility pole. In 2014, trees fell on several homes and cars during thunderstorm winds, causing $100,000 in damages.

Table 3-22: Thunderstorm Wind Events in Colrain				
Year	**# of Events**	**Annual Property Damage**	**Annual Crop Damage**	**Event Description**
2006	1	$10,000	$0	No details provided.
2007	1	$0	$0	Trees down. Route 112 closed as a result.
2010	1	$15,000	$0	Large trees on Main Street were downed by thunderstorm winds.
2013	3	$118,000	$0	On 6/17 a tree in Colrain was downed onto wires causing $3,000 in damage. On 6/30 State police reported winds gusting up to 40 mph downed trees and wires, blocking Foundry Village Road. Heavy rain had saturated the

Table 3-22: Thunderstorm Wind Events in Colrain				
Year	**# of Events**	**Annual Property Damage**	**Annual Crop Damage**	**Event Description**
				ground allowing for lighter winds downing trees causing $15,000 in damages. On 8/31 A microburst occurred in the southeastern portions of Leyden and Colrain, downing numerous trees and wires causing $100,000 in damages. Barton, Country Club, Bernardston, Plain, South Green River, Nelson, and Smead Hill Roads were all affected with a few trees that were downed onto houses. A utility pole was downed on Barton Road.
2014	3	$110,000	$0	On 7/2 a tree and wires on Route 112 South were downed and on 9/6 a tree on Jacksonville Road was downed by thunderstorm winds, each causing $5,000 in damages. On 10/8 numerous large trees and wires on York Road were downed by thunderstorm winds. Trees fell on several houses and cars causing $100,000 in damages.
2015	1	$5,000	$0	A tree and wires were downed onto a car on Calvin Coombs Road by thunderstorm winds.
2017	1	$2,500	$0	At 650 PM EST, a tree was brought down on power lines on Greenfield Road in Colrain. Also, a tree was brought down on West Leyden Road.
2018	1	$2,000	$0	A tree was reported down on wires on West Leyden Road in Colrain.
Total	**12**	**$262,500**	**$0**	

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

Secondary hazards of thunderstorms and severe weather include lightning and hail. In Franklin County, 22 lightning events since 1997 caused a total of $835,500 in property damages (Table 3-23).

Table 3-23: Lightning Events in Franklin County			
Year	**# of Lightning Events**	**Annual Property Damage**	**Annual Crop Damage**

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Table 3-23: Lightning Events in Franklin County			
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/

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In recent years, Colrain has also experienced several microbursts that caused substantial damage. In 2017 a microburst occurred near Roberts and Reil Lanes, which partially destroyed a barn that was under construction. The barn sustained structural damage and was moved off its foundation due to wind gusts that reached approximately 70 mph. Other recent microbursts affected property on Foundry Acres Drive and Adams Road, and left many residents in Colrain without power due to downed trees and damaged transformers.

The unfinished barn damaged during the 2017 microburst in Colrain. Source: The Greenfield Recorder.

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 "High" probability of a severe thunderstorm, wind, and microburst affecting Colrain in a given year, and these are considered events with the probability of occurring once in 2 years to once in 4 years (25%-50% probability in the next year). Climate change is expected to increase the frequency and intensity of thunderstorms and other severe weather.

Impact

The entire town of Colrain can experience the effect and impact from severe thunderstorms, microbursts, hail, and high winds that can cause extensive damage. The magnitude of impact of

severe thunderstorm-related events is likely "Limited," causing minor injuries only, more than 10% of property in affected area damaged or destroyed, and complete shutdown of facilities for more than 1 day.

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.

Vulnerability

Society

The entire population of Colrain 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 Colrain. 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 Colrain residents during a severe weather event.

Table 3-25: Estimated Vulnerable Populations in Colrain

Vulnerable Population Category	Number	Percent of Total Population*
Population Age 65 Years and Over	359	22%

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Table 3-25: Estimated Vulnerable Populations in Colrain		
Population with a Disability	184	11%
Population who Speak English Less than "Very Well"	44	3%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	201	28%
Householder Age 65 Years and Over Living Alone	99	14%
Households Without Access to a Vehicle	16	2%

*Total population = 1,631; Total households = 714
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2013-2017 Five-Year Estimates.

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.

Health Impacts

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.[22] 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 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.

[22] Andrews, L.W. 2012. How Thunderstorms Affect Health. Psychology Today. June 2, 2012. Https://www.psychologytoday.com/blog/minding-the-body/201206/how-thunderstorms-affect-health

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,[23] 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 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. Colrain 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

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

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 in Colrain

Tax Classification	Total Assessed Value FY2019	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$144,222,960	$1,442,230	$7,211,148	$14,422,296
Open Space	$0	$0	$0	$0
Commercial	$4,955,687	$49,557	$247,784	$495,569
Industrial	$3,395,900	$33,959	$169,795	$339,590
Total	**$152,574,547**	**$1,525,745**	**$7,628,727**	**$15,257,455**

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

Agriculture

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

Energy

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.

Public Safety

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

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Transportation

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.

Water & Wastewater Infrastructure

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, Colrain has a “Medium” vulnerability to severe thunderstorms and wind events. Thunderstorms are common in New England, and can impact property, crops, utilities and the population of Colrain. 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 Colrain’s areas of greatest concern regarding severe

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thunderstorms and wind events.

Severe Thunderstorm / Wind Hazard Problem Statements
• 51% of the housing stock in Colrain was built prior to building codes that require structures to withstand high winds, which makes some residents especially vulnerable to hurricanes and tropical storms. ***See all HURRICANE/TROPICAL STORM and TORNADO Hazard Problem Statements.***
• Heavy rain associated with severe thunderstorms contributes to the risk of flooding events and secondary flooding hazards. ***See all FLOOD Hazard Problem Statements.***
• Colrain is vulnerable to power outages caused by severe thunderstorms and the Town lacks backup power at municipal buildings and an emergency drinking water supply.
• Destructive winds associated with severe thunderstorms can cause widespread road closures by taking down trees and utility lines throughout town, impacting the Town's evacuation routes.
• A number of challenges with communications infrastructure, including spotty cell phone and internet service, means residents may lack reliable access to emergency information during hazard events. Existing communication, isolation, and emergency services access challenges could be exacerbated by severe thunderstorms and wind hazards.
• Many residents in Colrain live within or adjacent to forested areas. This increases the risk of impacts to the population from downed trees during wind hazards.
• Severe thunderstorms, wind, and microbursts can damage large swaths of forest, including forested areas managed for residents' livelihoods.

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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 (Figure 3-10). 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 3-10: 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

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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 3-11 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 Colrain and much of Franklin County. The Colrain Hazard Mitigation Committee rated tornadoes as having an "Isolated" Area of Occurrence. If a tornado were to occur in Colrain, less than 10% of the town would be affected.

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 3-12 provides guidance from NOAA about the impacts of a storm with each rating.

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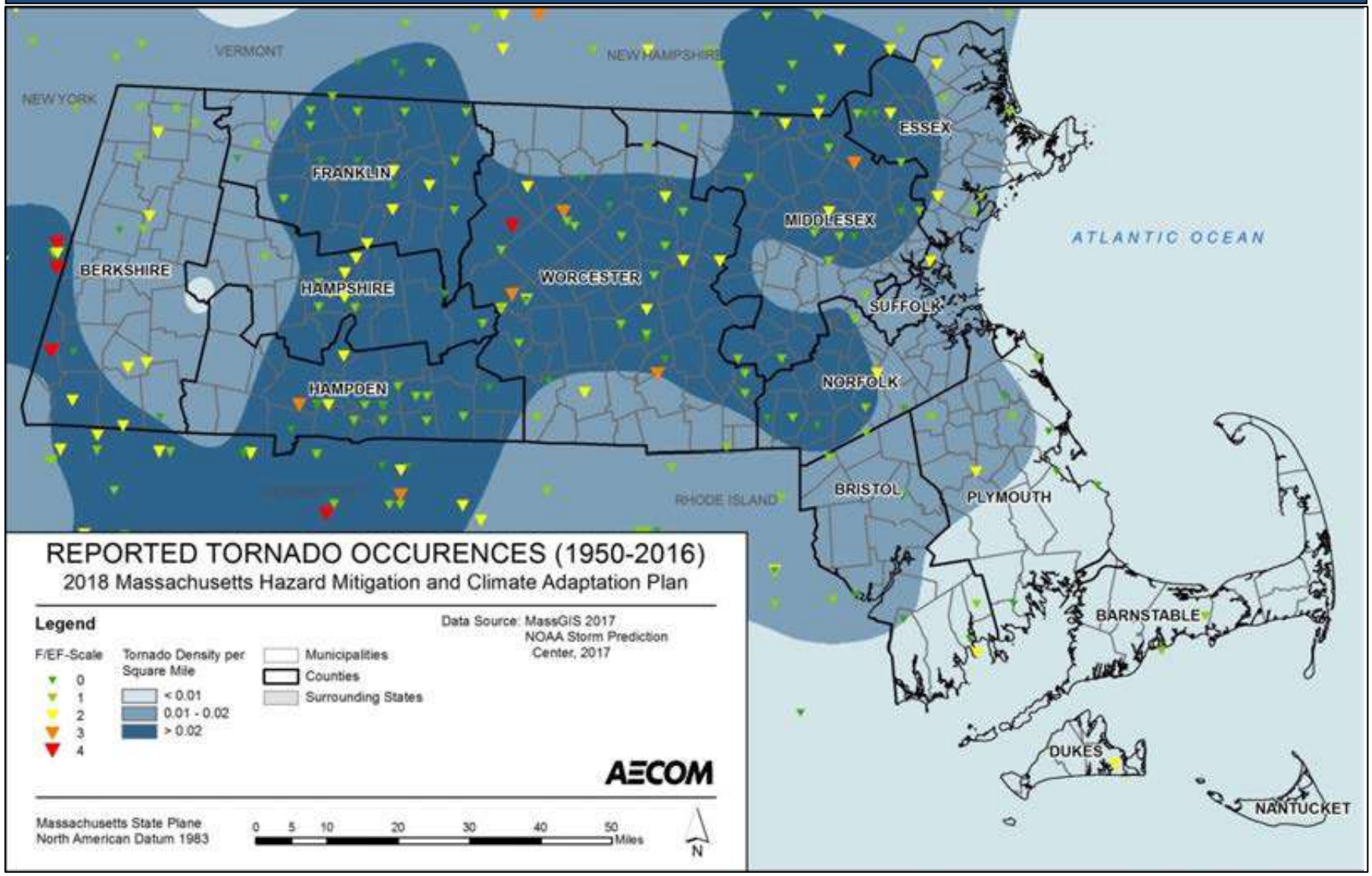
Figure 3-11: Density of Reported Tornadoes per Square Mile



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

Figure 3-12: 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

High wind speeds, hail, and debris generated by tornadoes can result in loss of life, downed trees and power lines, and damage to structures and other personal property (cars, etc.). 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 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. There have been no occurrences of a tornado in Colrain in recent years.

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
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

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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 two decades. While the number of days per year that tornadoes occur has decreased, the number of tornadoes on these days has increased. Climate models show projections that the frequency and intensity of severe thunderstorms (which include tornadoes, hail, and winds) will increase. Although Colrain has not had recent tornado occurrences, the Hazard Mitigation Committee determined that there is a "Moderate" probability, wherein a tornado event is likely to occur from once in 5 years to once in 50 years (2%-25% probability in the next year).

Impact

Tornadoes are potentially the most dangerous of local storms. If a major tornado were to strike in the populated areas of Corain, 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 likely "Limited" with more than 10% of property in the affected area damaged or destroyed.

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Vulnerability

Society

The entire town of Colrain 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.

Vulnerable Populations

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 455 housing units in Colrain, or 51% of all housing units in town, were built prior to the 1970s when the first building code went into effect in Massachusetts. An estimated 47 mobile homes are located in Colrain, accounting for 5 percent of the total housing stock.[24] Table 3-28 estimates the number of vulnerable populations and households in Colrain. 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 Colrain residents during a tornado event.

Table 3-28: Estimated Vulnerable Populations in Colrain

Vulnerable Population Category	Number	Percent of Total Population*
Population Age 65 Years and Over	359	22%
Population with a Disability	184	11%
Population who Speak English Less than "Very Well"	44	3%

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

Table 3-28: Estimated Vulnerable Populations in Colrain		
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	201	28%
Householder Age 65 Years and Over Living Alone	99	14%
Households Without Access to a Vehicle	16	2%

*Total population = 1,631; Total households = 714

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

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

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.

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Infrastructure

All critical facilities and infrastructure in Colrain 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 in Colrain				
Tax Classification	**Total Assessed Value FY2019**	**1% Damage Loss Estimate**	**5% Damage Loss Estimate**	**10% Damage Loss Estimate**
Residential	$144,222,960	$1,442,230	$7,211,148	$14,422,296
Open Space	$0	$0	$0	$0
Commercial	$4,955,687	$49,557	$247,784	$495,569
Industrial	$3,395,900	$33,959	$169,795	$339,590
Total	**$152,574,547**	**$1,525,745**	**$7,628,727**	**$15,257,455**

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

Agriculture

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

Energy

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

Public Safety

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.

Transportation

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

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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.

Water & Wastewater Infrastructure

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, Colrain has a “Low” vulnerability to tornadoes. Tornadoes are not common occurrences in Colrain, 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, 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 Colrain’s areas of greatest

concern regarding tornadoes.

Tornado Hazard Problem Statements
• 51% of the housing stock in Colrain was built prior to building codes that require structures to withstand high winds, which makes some residents especially vulnerable to hurricanes and tropical storms. ***See all SEVERE THUNDERSTORM/WIND/MICROBURST and TORNADO Hazard Problem Statements.***
• Colrain is vulnerable to power outages caused by tornados and the Town lacks backup power at municipal buildings and an emergency drinking water supply.
• Destructive winds associated with tornados can cause widespread road closures by taking down trees and utility lines throughout town, impacting the Town's evacuation routes.
• A number of challenges with communications infrastructure, including spotty cell phone and internet service, means residents may lack reliable access to emergency information during hazard events. Existing communication, isolation, and emergency services access challenges could be exacerbated by tornado hazards.
• Many residents in Colrain live within or adjacent to forested areas. This increases the risk of impacts to the population from downed trees during wind hazards.
• Tornados can damage large swaths of forest, including forested areas managed for residents' livelihoods.
• Residents, workers, and visitors working or recreating outdoors are susceptible to impacts from a tornado.

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3.8 WILDFIRE

Potential Impacts of Climate Change

Climate change has the potential to affect multiple elements of the wildfire system (Figure 3-13): 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.[25] 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.[26] 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 3-13: 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

[25] Abatzoglou, J.T. and Williams, A.P. 2016. Impact of anthropogenic climate change on wildfire across western US forests 2016 113 (42) 11770-11775; published ahead of print October 10, 2016, doi:10.1073/pnas.1607171113

[26] Romps, D.M. et al. 2014. Projected increase in lightning strikes in the United States due to global warming. Science. November 14, 2014. http://science.sciencemag.org/content/346/6211/851

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:

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- 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 16 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. 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 plains, 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.[27]

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.

[27] "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*.

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 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 3-14. Inventoried assets (population, building stock, and critical facilities) were overlaid with these data to determine potential exposure and impacts related to this hazard. Colrain has several areas of "intermix" zones within town.

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 3-15 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 3-17 displays the Bureau's fire control districts and fire towers in Massachusetts.

Colrain is heavily forested and therefore vulnerable to wildfires. Colrain mostly falls within the "High" wildfire risk area. The entire town, which is approximately 86% forested, is at risk for wildfire. However, if a wildfire were to occur, the location of occurrence would likely be "Isolated" with less than 10% of the town affected.

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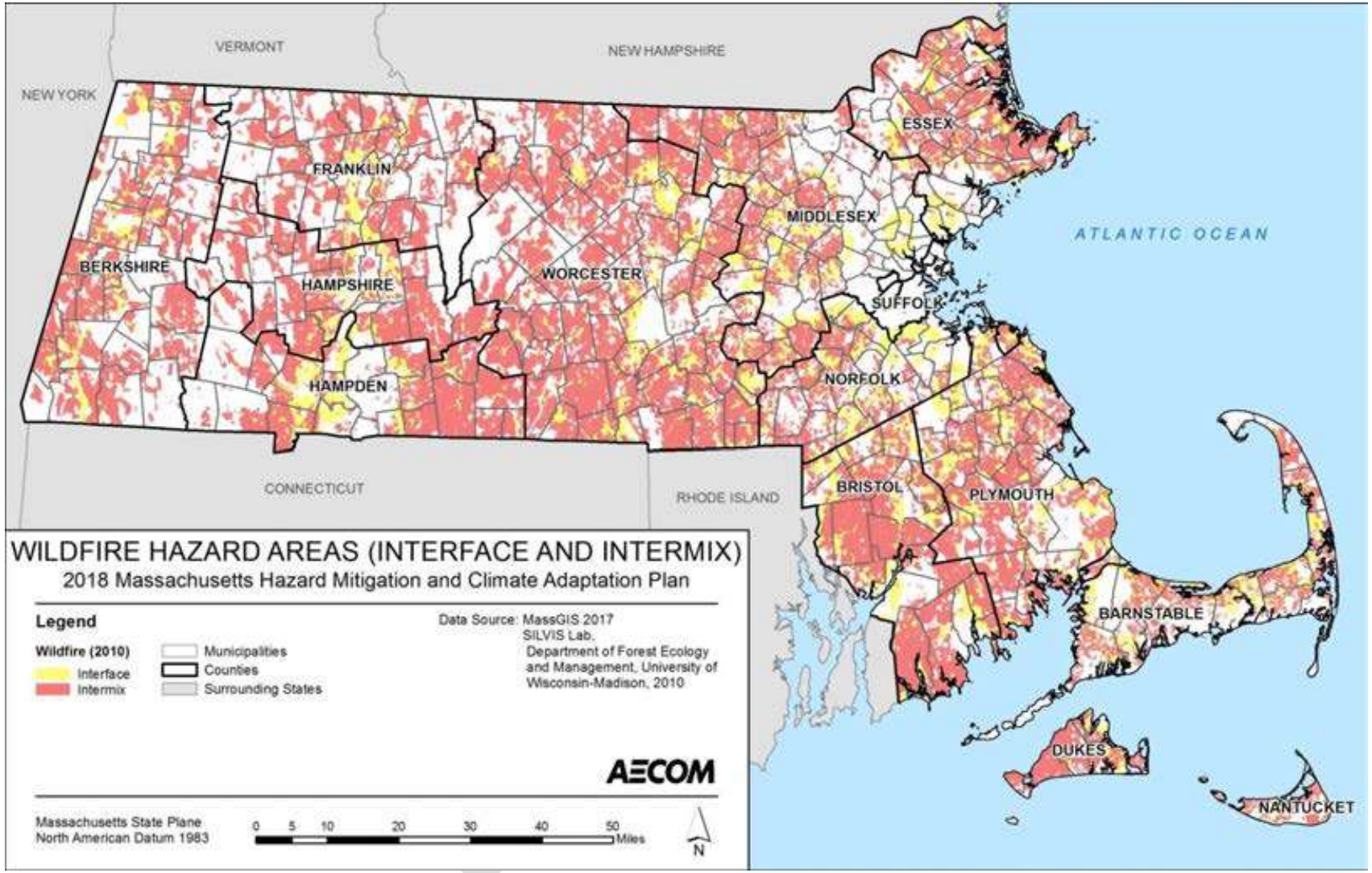
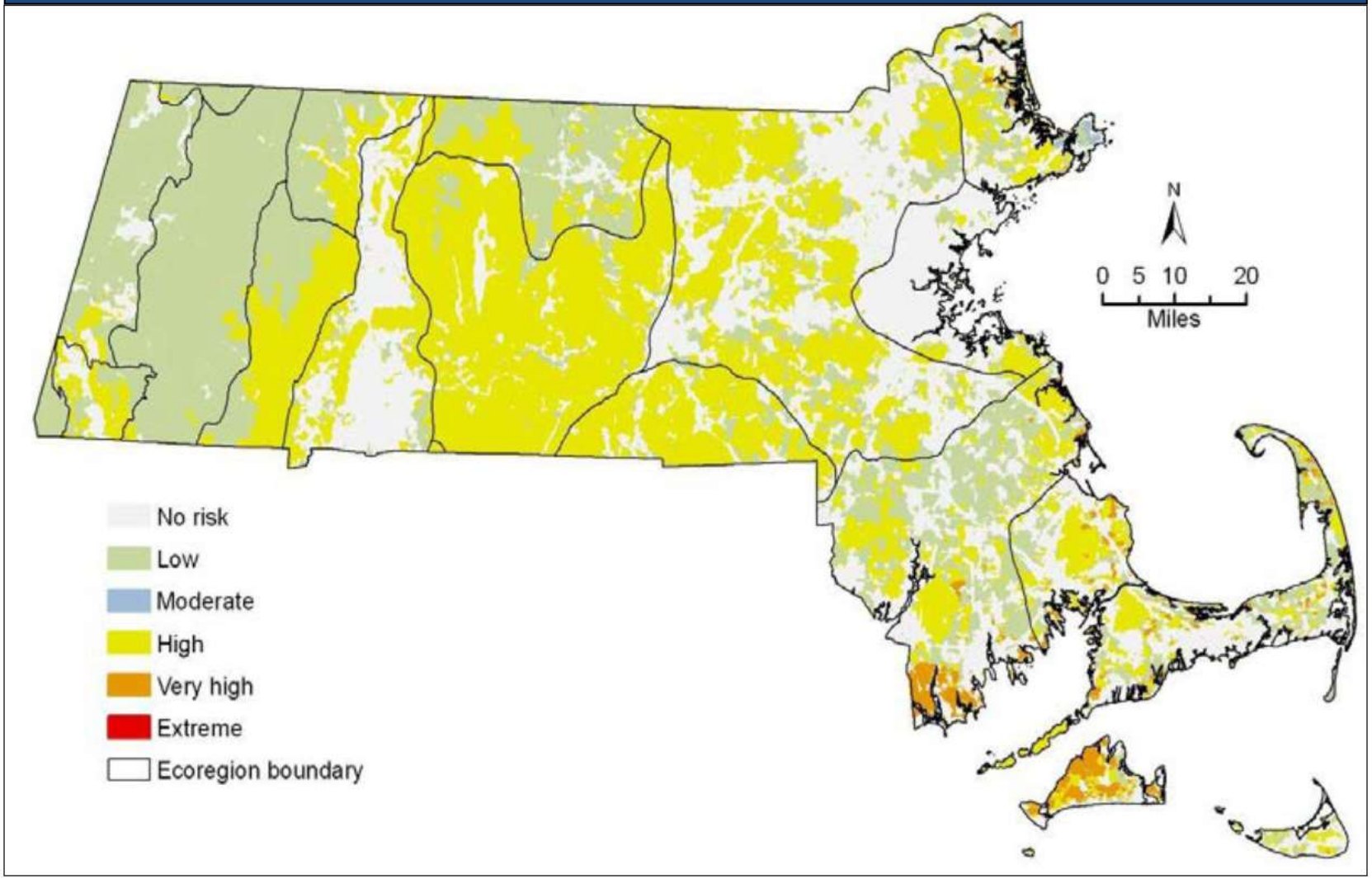
Figure 3-14: Wildland-Urban Interface and Intermix for the Commonwealth of Massachusetts



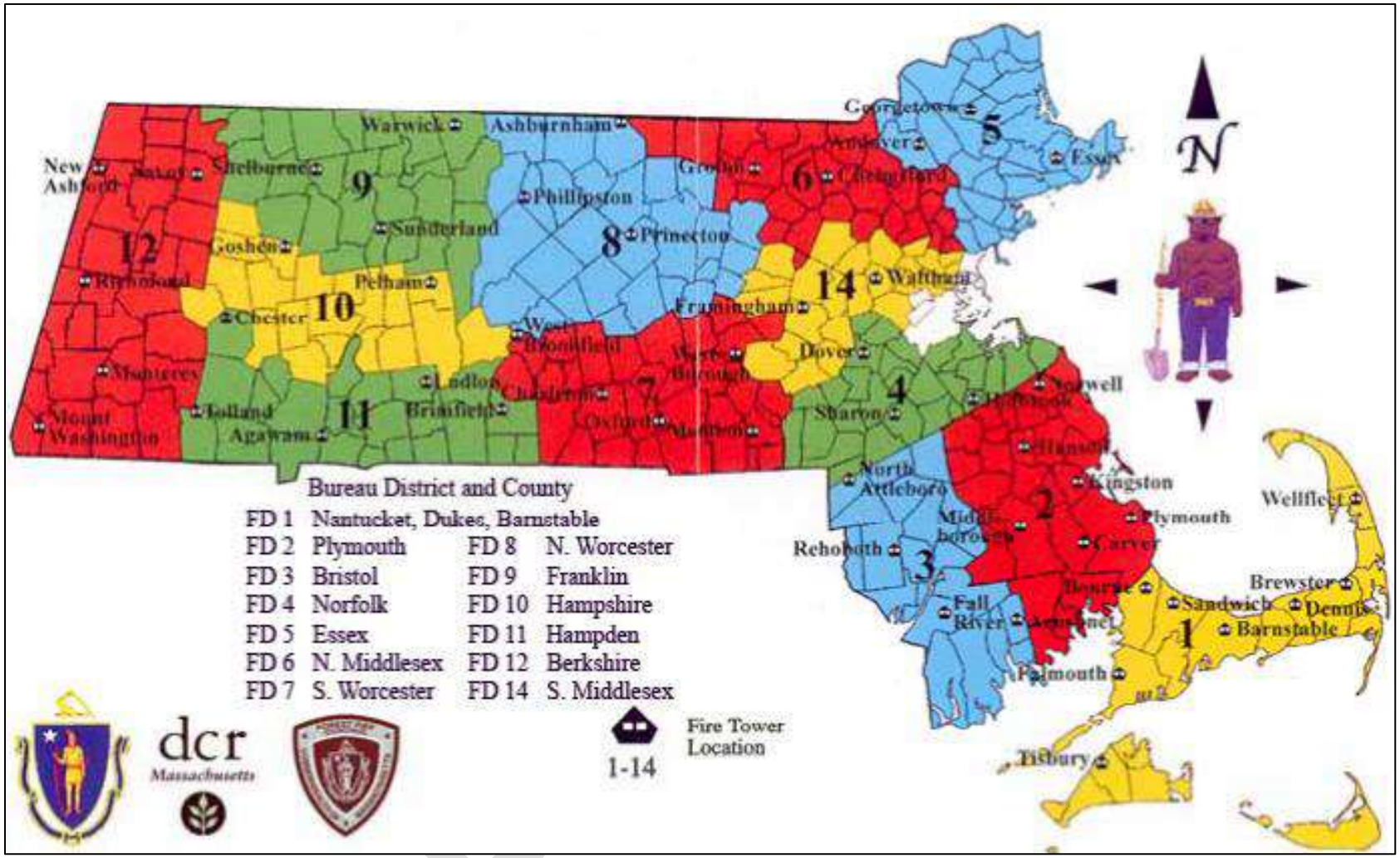
Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Figure 3-15: 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 3-16: 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.

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.[28]

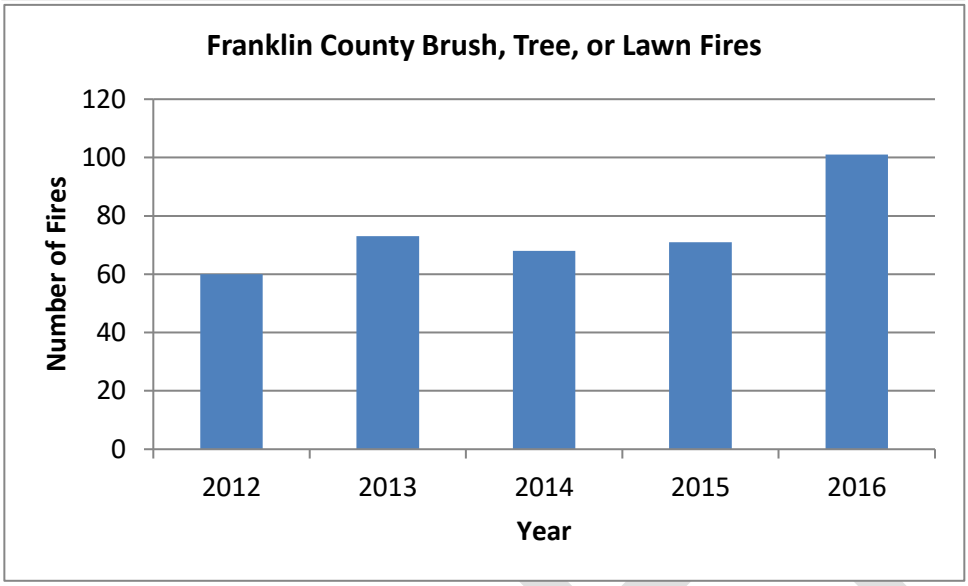
If a fire breaks out and spreads rapidly, residents may need to evacuate within days or hours. A fire's peak burning period generally is between 1 p.m. and 6 p.m. Once a fire has started, fire alerting is reasonably rapid in most cases. The rapid spread of cellular and two-way radio communications in 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 3-16). During 2016, Franklin County and Massachusetts experienced one of the worst droughts in the last 50 years.

[28]National Parks Service (NPS), compiled by George Wooten. n.d. Fire and fuels management: Definitions, ambiguous terminology and references. https://www.nps.gov/olym/learn/management/upload/fire-wildfire-definitions-2.pdf

Figure 3-17: Outdoor Vegetation Fires in Franklin County 2012 - 2016



Source: Massachusetts Fire Incident Reporting System County Profiles.

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, Colrain has a "Low" probability (1-2% chance) that it will experience a wildfire in a given year.

Impact

Unfragmented and heavily forested areas of Colrain 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. The greatest impact in Colrain from a wildfire is to the natural environment, which faces a "Minor" impact from wildfires, with very few injuries, if any, only minor property damage and minimal disruption of quality of life, and temporary shutdown of facilities.

Vulnerability

Society

As demonstrated by historical wildfire events, potential losses from wildfire include 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.

Vulnerable Populations

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 Colrain. 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 Colrain residents during a wildfire event.

Table 3-30: Estimated Vulnerable Populations in Colrain

Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	359	22%
Population with a Disability	184	11%
Population who Speak English Less than "Very Well"	44	3%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	201	28%
Householder Age 65 Years and Over Living Alone	99	14%
Households Without Access to a Vehicle	16	2%

*Total population = 1,631; Total households = 714

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

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

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Health Impacts

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 in Colrain

Tax Classification	Total Assessed Value FY2019	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$144,222,960	$1,442,230	$7,211,148	$14,422,296
Open Space	$0	$0	$0	$0
Commercial	$4,955,687	$49,557	$247,784	$495,569

Industrial	$3,395,900	$33,959	$169,795	$339,590
Total	**$152,574,547**	**$1,525,745**	**$7,628,727**	**$15,257,455**

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

Agriculture

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.

Energy

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.

Public Health

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.

Public Safety

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

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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, Colrain faces a "Low" vulnerability from wildfire and brushfires. While wildfires have caused minimal damage, injury and loss of life to date in Colrain, their potential to destroy property and cause injury or death exists. Existing and future mitigation efforts should continue to be developed and employed that will enable Colrain 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 Colrain regarding wildfires.

Wildfire Hazard Problem Statements
• Many residents in Colrain live within or adjacent to heavily forested areas. This increases the risk of impacts to the population from a wildfire.
• A drought would increase in the risk of wildfire in Colrain, and could make the forests in town more susceptible to damage from storms, pests and invasive species. ***See all DROUGHT Hazard Problem Statements.***

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Wildfire Hazard Problem Statements
• Some heavily forested areas of town, including the Catamount State Forest, are difficult for emergency responders to access. The roads in this area are State-owned and not well maintained.
• Colrain does not have an adequate supply of water for fire suppression in the Catamount State Forest. There is a need for fire hydrants and ponds in the State Forest.
• Colrain is vulnerable to power outages caused by wildfire, and the Town lacks backup power at municipal buildings and an emergency drinking water supply.
• Wildfire can cause widespread road closures throughout town, impacting the Town's evacuation routes.
• A number of challenges with communications infrastructure, including spotty cell phone and internet service, means residents may lack reliable access to emergency information during wildfire. Existing communication, isolation, and emergency services access challenges could be exacerbated by wildfire.
• Wildfires can damage large swaths of forest, including forested areas managed for residents' livelihoods.
• Residents, workers, and visitors working or recreating outdoors are vulnerable to wildfire.

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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 3-18.

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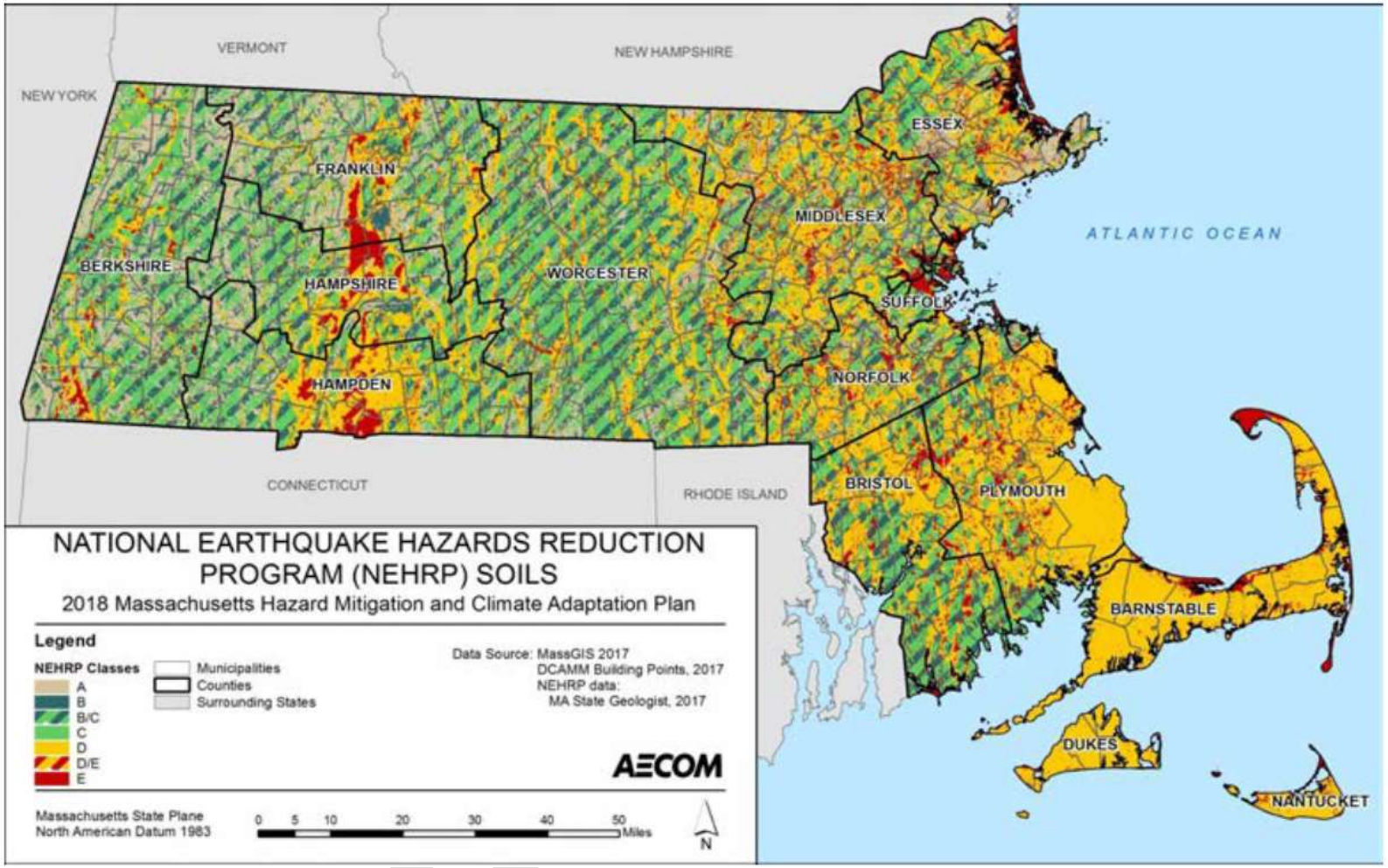
Figure 3-18: National Earthquake Hazards Reduction Program Soil Types in Massachusetts



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.[29]

Because of the regional nature of the hazard, the entire town is susceptible to earthquakes, and the location of occurrence would be "Isolated," with less than 10% 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.

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

[29] U.S. Geological Survey (USGS). 2012. New Evidence Shows Power of East Coast Earthquakes. Accessed May 6, 2013. http://www.usgs.gov/newsroom/article.asp?ID=3447

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

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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 3-19). 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 Colrain are shown in Figure 3-19. There is no record of any damage to the Town of Colrain as a result of these earthquakes.

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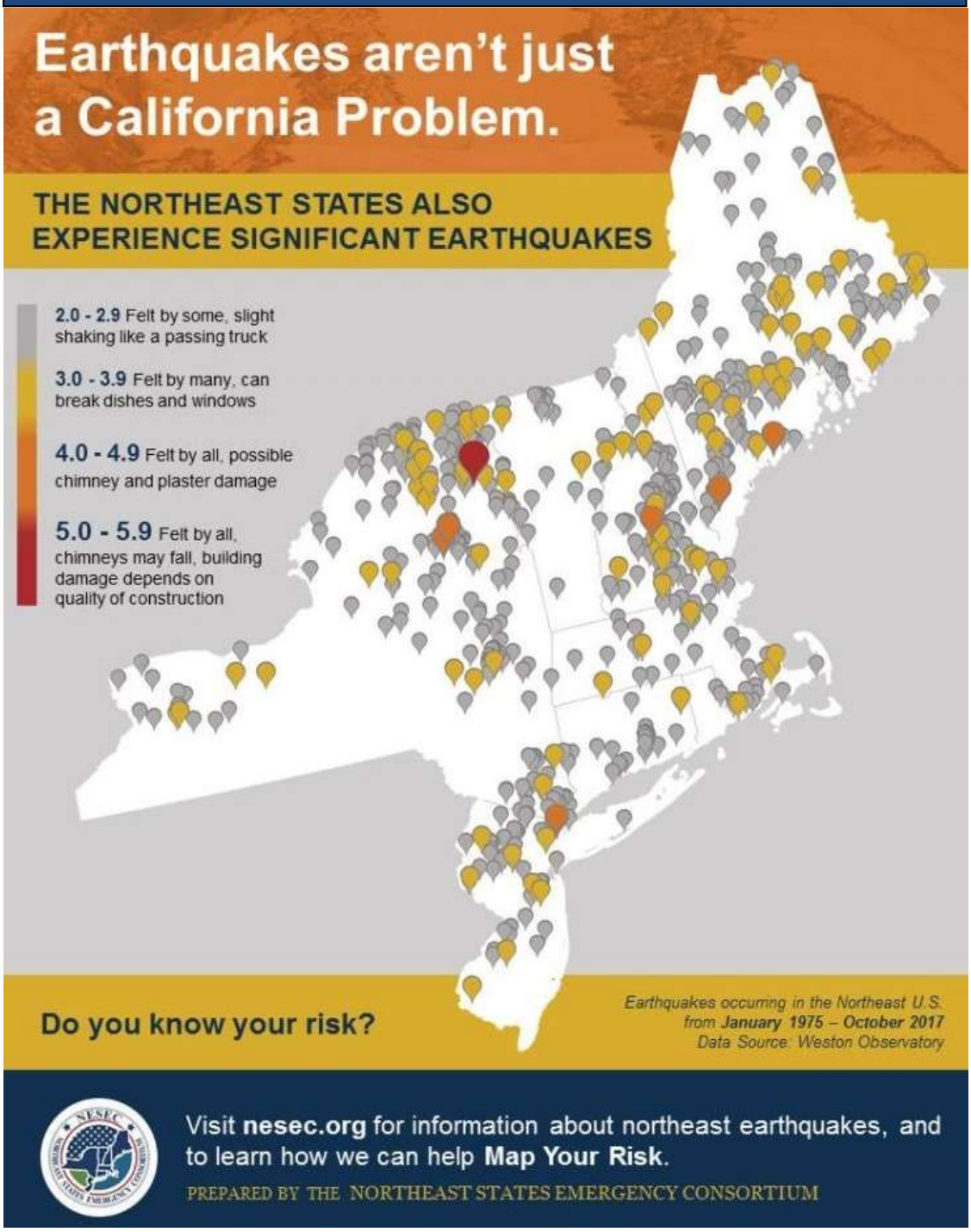
Figure 3-19: Earthquakes Occurring in the Northeast from 1975 - 2017



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, Colrain 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.

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Liquefaction of the land near water could also lead to extensive destruction.

Colrain faces potentially "Minor" impacts from earthquakes, with very few injuries, only minor property damage, minimal disruption of quality of life, and temporary shutdown of facilities.

Vulnerability

Society

The entire population of Colrain 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.

Vulnerable Populations

The populations most vulnerable to an earthquake event include people over the age of 65 (22% of Colrain's population) and those living below the poverty level (28% of Colrain's total households). 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 455 housing units in Colrain, or 51% of all housing units in town, were built prior to the 1970s when the first building code went into effect in Massachusetts. An estimated 47 mobile homes are located in Colrain, accounting for 5 percent of the total housing stock.[30]

Earthen dams and levees are highly susceptible to seismic events, and the impacts of their eventual failures can be considered secondary risks for earthquakes. There are four dams in Colrain with a "significant hazard" classification, including Colrain Lower Reservoir dam, that are vulnerable to the impacts of earthquakes. Dam failures were identified by Town officials as an area of concern during the Town's Municipal Vulnerability Preparedness Community Building Workshop in 2018. More detail can be found in the Dam Failure section. In the rare event that

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

an earthquake would trigger a dam failure at one of the upstream dams, Colrain's inundation areas would become flooded. Updated mapping of dam failure inundation areas would be helpful for informing evacuation planning, and Emergency Notification systems are needed between dam operator and the Town, so that people can evacuate in time.

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 Colrain 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 in Colrain

Tax Classification	Total Assessed Value FY2019	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$144,222,960	$1,442,230	$7,211,148	$14,422,296
Open Space	$0	$0	$0	$0
Commercial	$4,955,687	$49,557	$247,784	$495,569
Industrial	$3,395,900	$33,959	$169,795	$339,590
Total	**$152,574,547**	**$1,525,745**	**$7,628,727**	**$15,257,455**

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

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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, Colrain has a "Low" vulnerability to earthquakes. The following problem statements summarize Colrain's areas of greatest concern regarding earthquakes.

Earthquake Hazard Problem Statements
• 51% of the housing stock in Colrain was built prior to building codes that require structures to withstand earthquakes, which makes some residents especially vulnerable to earthquake impacts.
• Colrain is vulnerable to power outages caused by earthquakes and the Town lacks backup power at municipal buildings and an emergency drinking water supply.
• Earthquakes can cause widespread road damage and road closures, which would impact the Town's evacuation routes.
• A number of challenges with communications infrastructure, including spotty cell phone and internet service, means residents may lack reliable access to emergency information during hazard events. Existing communication, isolation, and emergency services access challenges could be exacerbated by an earthquake.
• The Town's shelters may be inaccessible or uninhabitable after an earthquake.

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

Colrain could be impacted if a dam failure were to occur at one of the dams in town or upstream on one of the Town's larger rivers. The Hazard Mitigation Committee determined that the location would be "Isolated" with less than 10% of the town affected.

Colrain has five dams in town, four of which are identified as Significant Hazard, while the other

is Low Hazard. The four significant hazard dams include: Colrain Lower Reservoir Dam, Colrain Upper Reservoir Dam, Kendall Company No.1 Dam, and Shelburne Falls Fire District Dam.

Colrain's Significant Hazard dams were listed as in fair or satisfactory condition in the January 2011 information provided by the MA DCR Office of Dam Safety (Table 3-36). Mcleod Pond Dam, Colrain's low hazard dam was listed as being in poor condition. However, the 2011 assessments are no longer current, and the Town may need to request updated dam inspection reports and assessments of the conditions of these dams that are required according to the inspection schedule shown on the next page. Updated dam assessment reports and dam inundation area mapping should be sought so that the Town may better understand the potential risk that its dams pose to Colrain.

Table 3-36: MA DCR Office of Dam Safety – Dam Information for Colrain

Dam Name	Hazard Code	Impoundment Name	River	Year Built	E10 - Overall Physical Condition of the Dam	Ownership Type	Primary Owner
Mcleod Pond Dam	Low	Mcleod Pond	Meadow Brook	1900	POOR - Significant structural, operational, and maintenance deficiencies are clearly recognized under normal loading conditions.	DCR - State Parks	Comm. of MA - DCR
Kendall Company No 1 Dam	Significant	North River	North River	1831	SATISFACTORY - Minor operational and maintenance deficiencies. Infrequent hydrologic events would probably result in deficiencies.	Private	Barnhardt Manufacturing Company
Shelburne Falls Fire District Dam	Significant	Shelburne Falls Reserv	Fox Brook	1910	SATISFACTORY - Minor operational and maintenance deficiencies. Infrequent hydrologic events would probably result in deficiencies.	Municipality or Political subdivision	Shelburne Falls Fire District
Colrain Lower Reservoir Dam	Significant	Lower Reservoir	Tributary of North River	1900	FAIR - Significant operational and maintenance deficiencies, no structural deficiencies. Potential deficiencies exist under unusual loading conditions that may realistically occur. Can be used when uncertainties exist as to critical parameters.	Municipality or Political subdivision	Colrain Fire District #1
Colrain Upper Reservoir Dam	Significant	Colrain Upper Reservoir	East Bk	1900		Municipality or Political subdivision	Colrain Fire District #1

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It is also important to consider and plan for the potential critical failure of dams upstream from Colrain. According to the 2014 Hazard Mitigation Plan, there are two dams in Vermont that could impact Colrain if they were breached: Jacksonville Pond and Gates Pond Dams. It is unknown what hazard rating these two dams merit. This information could be important for the Town's Emergency Management Director to determine.

The 2014 Hazard Mitigation Plan identified locations of beaver dams in Colrain, three of which are of particular concern, should the dam be breached. They include: 1) an impoundment on Jacksonville Roads, where fields are flooded due to the dam, 2) a three-acre impoundment on East Colrain Road, and 3) flooded farmland on Fort Lucas Road due to a beaver dam. UPDATE

As described in the Flooding section, there are some beaver dams in Colrain. Beaver dams can impound a significant amount of water, which can raise the risk of flooding. The locations of beaver activity and dams regulated by the Massachusetts Office of Dam Safety are shown on the maps that accompany this plan.

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:

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- 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

Colrain has not been affected by a dam breach since the Barnhardt Manufacturing dam on the North River was partially washed away during Tropical Storm Irene. The MVP workshop participants and LPT identified dam failure at a concern due to the flooding impacts that would result in town.

Probability of Future Events

Currently the frequency of dam failures 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 hydrograph 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.

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Impact

A dam failure impacting Colrain is likely to have a "Minor" impact, with very few injuries, if any, only minor property damage and minimal disruption of quality of life, and temporary shutdown of facilities.

Vulnerability

Dam failures, while rare, can destroy roads, structures, facilities, utilities, and impact the population of Colrain. Existing and future mitigation efforts should continue to be developed and employed that will enable Colrain 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

Vulnerable Populations

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.

Economic Impacts

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 Colrain are vulnerable to a dam failure. Buildings located within the floodplain are also vulnerable to dam failure in Colrain.

Environment

Examples of environmental impacts from a dam failure include:

[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

- 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

Due to the presence of significant hazard dams within the Town of Colrain and upstream, as well as several beaver dams in town, the Colrain faces "Low" vulnerability from dam or levee failure.

Dam Failure Hazard Problem Statements
• ***See all FLOODING Hazard Problem Statements.***
• The Town may be lacking essential information needed to prepare for dam failure hazard situations in town, including current dam inspection reports, updated EAPs and inundation area mapping from High, Significant, and Low Hazard dams where a breach or failure would impact the town.
• The Town may also need to coordinate emergency notification system upgrades and testing with dam operators where appropriate.
• Dam failure can be triggered by other natural disasters, including floods, hurricanes and tropical storms, and earthquakes, leading simultaneous hazard events.

[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

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 3-20: 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.

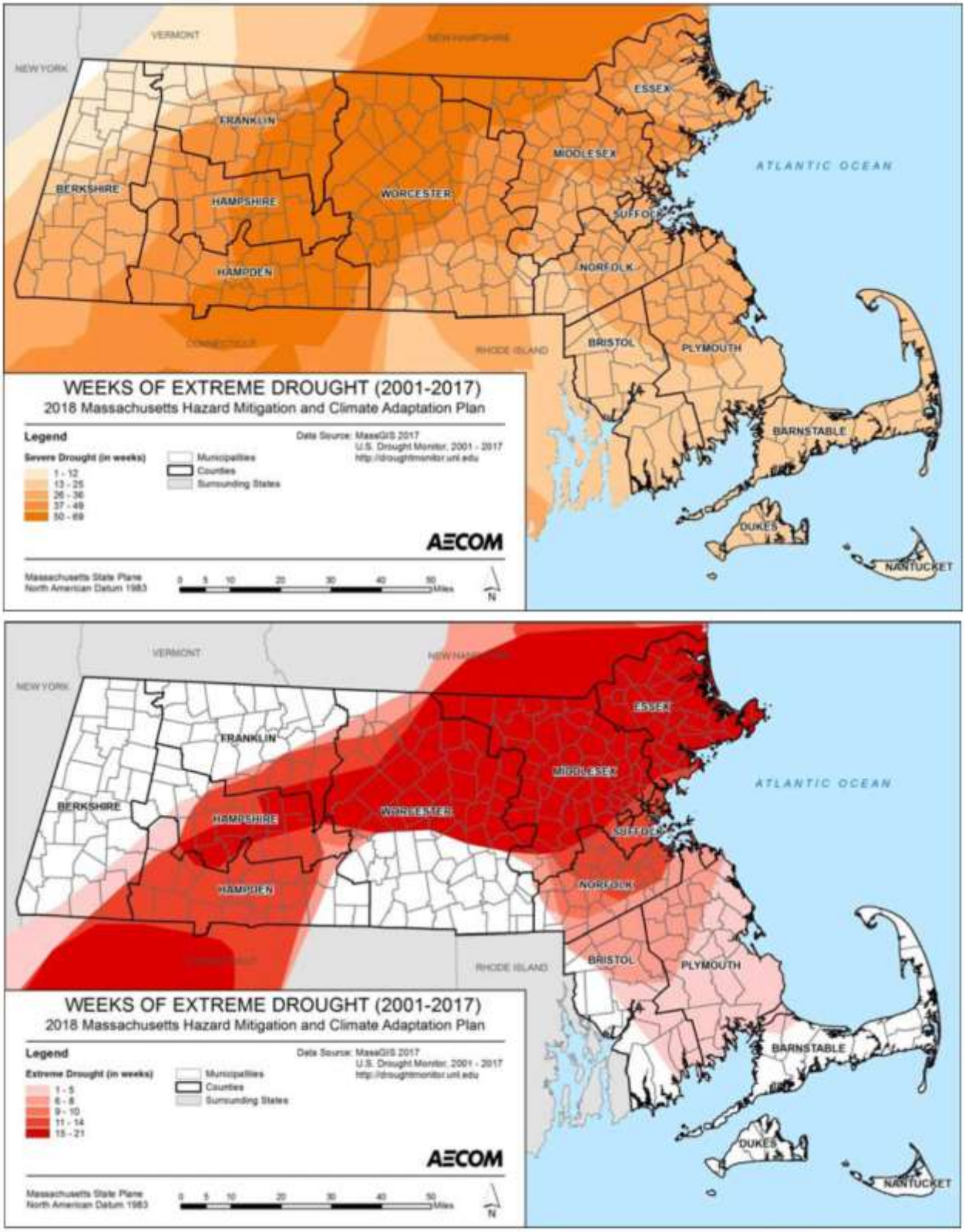
Highly urbanized areas with traditional stormwater drainage systems tend to result in higher peak flood levels during rainfall events and rapid decline of groundwater levels during periods of low precipitation. Thus, the hydrology in these areas becomes more extreme during floods and droughts.[33] The 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

Colrain falls just outside 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 3-21). Because of this hazard's regional nature, a drought would impact the entire town, resulting in a "Medium" location of occurrence, with 10 to 50 percent of total land area affected.

[33] ERG and Horsley Witten Group. 2017. Using Green Infrastructure to Improve Resilience in the Commonwealth of Massachusetts: Final Project Report.

Figure 3-21: 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 the type of private well serving town buildings, local businesses and Colrain resident, for example shallow wells in unconsolidated materials or deep, drilled bedrock wells. The majority of residents in Colrain are served by one of the four public water supplies in town, which draw water from wells located off of Route 112 near Call Road. 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 the depleted groundwater supplies. Verify w/ Committee.

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

Table 3-37: 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

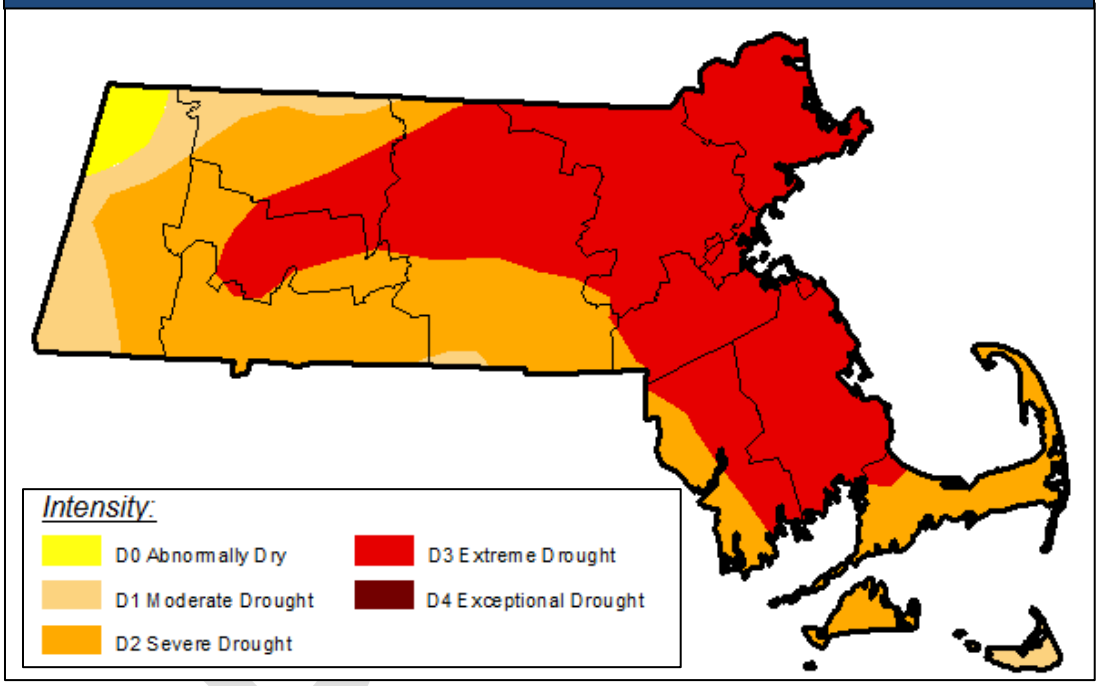
In Massachusetts, six major droughts have occurred statewide since 1930. They range in severity and length, from three to eight years. In many of these droughts, water-supply systems were found to be inadequate.

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 3-22).[34] By May 2017, the entire Commonwealth had returned to "normal" due to wetter-than-normal conditions in the spring of 2017.

Figure 3-22: Drought Conditions in Massachusetts on September 20, 2016



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

Drought and associated wildfires was identified as a natural hazard during the Colrain Municipal Vulnerability Preparedness Community Building workshop in 2018. At the workshop it was noted that private wells have run dry in the past and are vulnerable to prolonged dry periods. Colrain residents are also concerned about the increasing risk of experiencing a wildfire and diminished firefighting capacity in town during drought conditions.

[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 Colrain, drought has a "Moderate" probability of future occurrence, or between a 2 and 25 percent chance of occurring in any given year.

Impact

Due to the water richness of western Massachusetts, Colrain 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, as indicated in the 2018 MVP report, 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 percent of property in affected area damage or destroyed, and a complete shutdown of facilities for more than 1 day.

MVP workshop participants indicated that the drought impacts on firefighting is a concern at Catamount State Forest, where hydrants and other firefighting infrastructure may be insufficient, even in normal conditions. Firefighting capabilities town wide could be further compromised in a drought if aquifers, fire ponds, or rivers used for pumping water are low.

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 Colrain 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.

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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 Department of Health serves the Colrain Village Water Supply, Pine Hill Orchard, and Colrain Elementrary. However, the Town lacks an emergency backup drinking water supply. 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. The Town as well as homeowners and businesses are vulnerable during a drought if they are not able 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
- 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

[35] Clark, J.S. et al. 2016. The impacts of increasing drought on forest dynamics, structure, and biodiversity in the United States. Global Change Biology, 22, 2329–2352. Doi: 10.1111/gcb.13160.

conditions could cause significant damage to Colrain's environment as well as economic damage related to the loss of valuable natural resources.

Vulnerability Summary

Based on the above assessment, Colrain has a "Medium" vulnerability to 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 Colrain's areas of greatest concern regarding droughts.

Drought Hazard Problem Statements
• Firefighting capabilities may be compromised in a drought if aquifers, fire ponds, or rivers used for pumping water are low.
• Colrain's firefighting infrastructure may be insufficient, even in normal conditions. There is a need for fire hydrants and ponds at Catamount State Forest.
• Some of Colrain's residents are serviced by private wells that run the risk of going dry during prolonged drought.
• Most residents in Colrain live within or adjacent to heavily forested areas, making them susceptible to hazards affecting these areas.
• Periods of prolonged drought make Colrain's forests more vulnerable to wildfire.
• Some heavily forested areas of town, including the Catamount State Forest, are difficult for emergency responders to access. The roads in this area are State-owned and not well maintained. Fire hydrants and ponds are needed in Catamount State Forest.

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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 3-23: 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.

[36] Mabee, S.B., Duncan, C.C. 2013. Slope Stability Map of Massachusetts. Prepared for the Massachusetts Emergency Management Agency, the Federal Emergency Management Agency and the Massachusetts Department of Conservation and Recreation.

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.

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.

Colrain has areas in town with high and moderate landslide rankings. These areas are shown in Figure 3-24 and are mostly located along the hilly terrain distributed across the Town and the steep ridges that run north-south along both sides of Route 112 and the North River. There are also slopes running along ridges in the northwest section of town along the west branch of the North River with high and moderate landslide rankings. In general, due to the steep topography and soils in town, Colrain has a larger amount of unstable soils than other towns in Franklin County.

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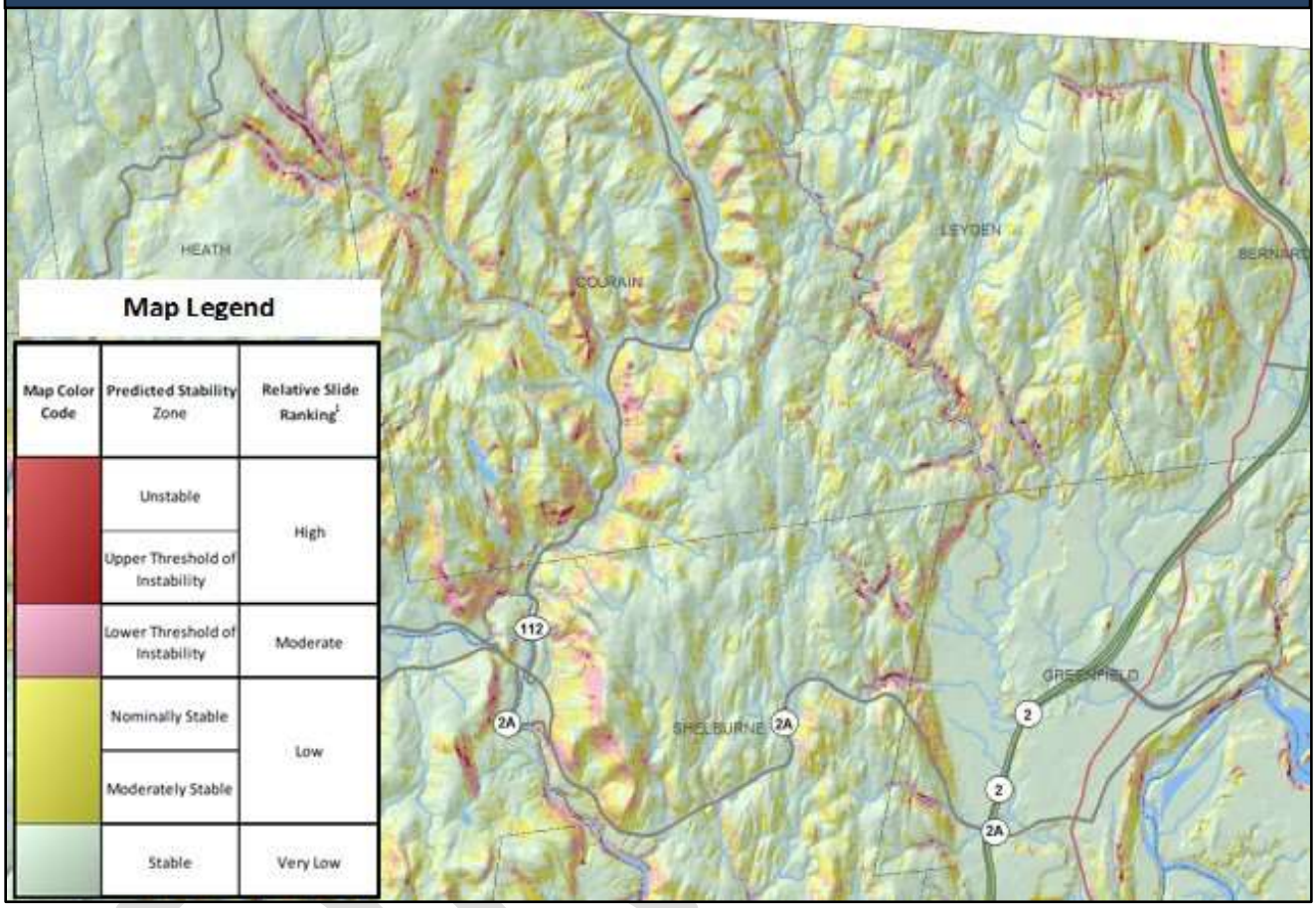
Colrain is also experiencing landslides along both branches of the North River, which are eroding the glacial soils along the riverbanks. See the Fooding Hazard section of this report.

Figure 3-24: Slope Stability Map, Colrain 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 Colrain 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 Colrain. However, the Committee feels the potential for landslides exist in several places throughout town due to existing natural conditions. Of greatest concern is erosion of the high banks of glacial deposits along the North River. This issue may be further exacerbated by the presence of Japanese knotweed, which is ineffective for erosion control. The uncapped town landfill is adjacent to a steep slope leading down to the West Branch of the North River and is vulnerable to a landslide event. The Committee also discussed an area in town across from the Branch Cemetery as being vulnerable to landslides due to multiple power lines situated on unstable soils. Due to these considerations, the potential area of occurrence is "Medium", with 10-50% of the town affected.

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 Colrain. There is a "Moderate" probability, or 2-25% chance, of a landslide happening in the next year.

Impact

Homes 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 Colrain would be "Limited" depending on where it occurs. More than 10% of property in the affected area could be damaged or destroyed.

Vulnerability

Society

Vulnerable Populations

Populations who rely on potentially impacted roads for vital transportation needs are considered to be particularly vulnerable to this hazard. In Colrain, many residents may be vulnerable to landslides due to the fact that many homes are built on property below steep slopes, and also because Colrain has limited alternative routes for accessing homes if Route 112 or other major roads were blocked by a landslide.

Health Impacts

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

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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. Route 112 and the Town's other major roadways could be impacted by a landslide due to their location below some of the unstable slope areas identified in the Slope Stability Map.

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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.

Water and Wastewater Infrastructure

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, Colrain has a hazard vulnerability rating of “Medium” for landslides. The following problem statements summarize Colrain’s areas of greatest concern regarding landslides.

Landslide Hazard Problem Statements
• The steep slopes in many areas of town are vulnerable to landslides, as identified on the Slope Stability Map. Residents who rely on potentially impacted roads for vital transportation needs are particularly vulnerable to this hazard.

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Landslide Hazard Problem Statements
• Structures and roads downslope of steep and unstable soils in other areas of town are at risk of damage due to landsides, as identified on the Slope Stability Map.
• Colrain's dependence on Route 112 as a primary transportation route places residents and emergency responders at risk if the road were impacted by a landslide.
• Colrain is vulnerable to power outages caused by landslides, and the Town lacks backup power at municipal buildings and an emergency drinking water supply.
• A number of challenges with communications infrastructure, including spotty cell phone and internet service, means residents may lack reliable access to emergency information after a landslide event. Existing communication, isolation, and emergency services access challenges could be exacerbated by landslides.
• Landslides can damage large swaths of forest, including forested areas managed for residents' livelihoods.
• Residents, workers, and visitors working or recreating outdoors are vulnerable to Landslides.

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3.13 EXTREME TEMPERATURES

Potential Impacts of Climate Change

Beyond the overall warming trend associated with global warming and climate change, Colrain 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.[37]

Figure 3-25: 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 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 3-38.

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

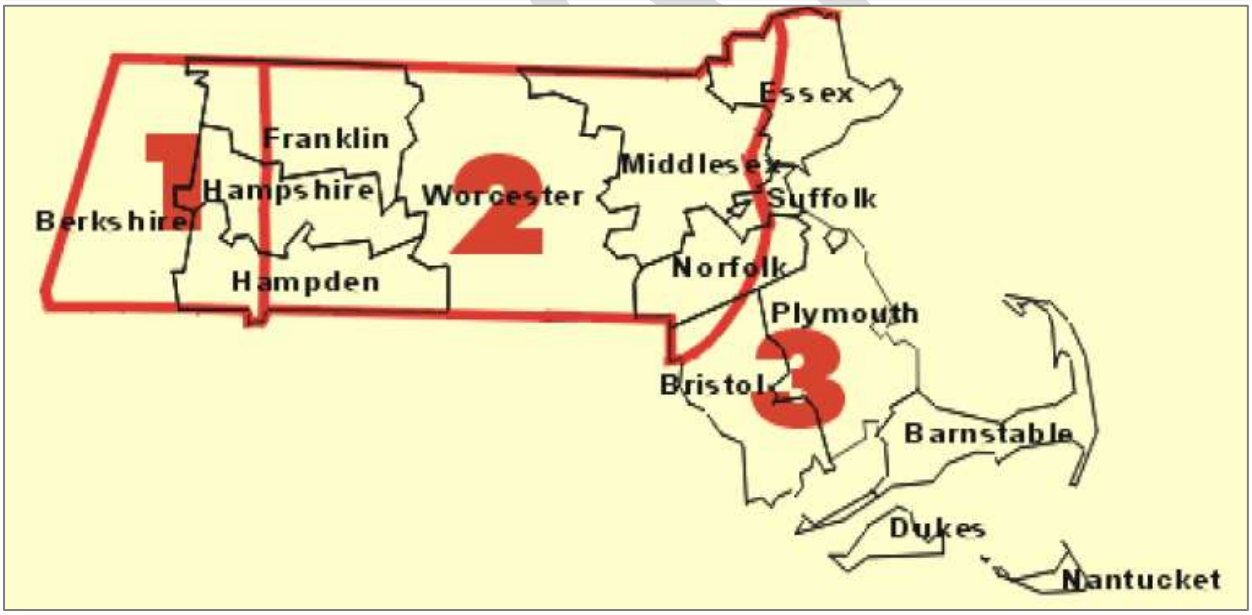
Table 3-38: Annual Average High and Low Temperatures (Greenfield)		
	July (Hottest Month)	**January (Coldest Month)**
Average High (°F)	81°	33°
Average Low (°F)	57°	12°

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 3-26. 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). Colrain falls on the boundary between the Western and the Central climate division. The Hazard Mitigation Committee felt that extreme temperature hazards would have a "Medium" location of occurrence and 10 to 50% of the town would be affected.

Figure 3-26: 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 3-27 shows the Wind Chill Temperature Index.

Figure 3-27: National Weather Service Wind Chill Chart

Wind (mph)	Temperature (°F)																	
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 3-28. 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 3-28: 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 Colrain 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 Colrain 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 Colrain 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.

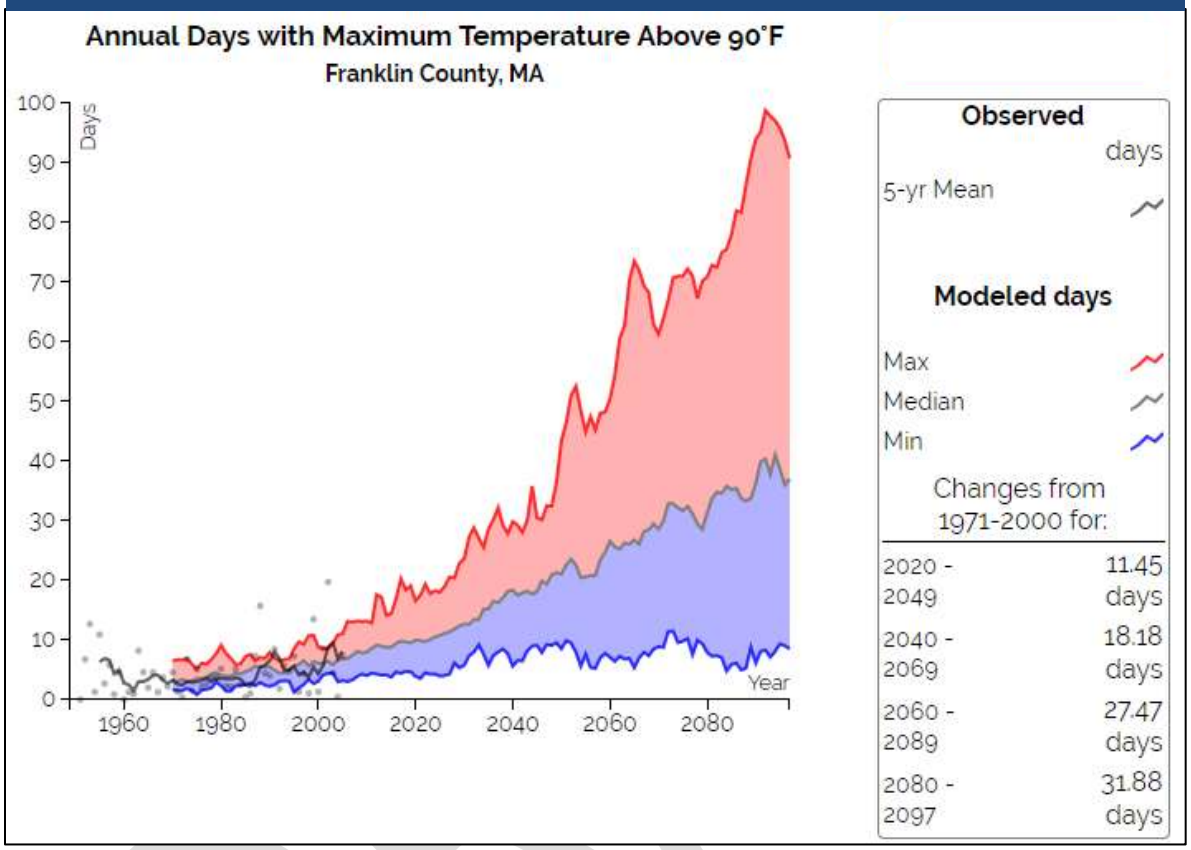
Probability of Future Events

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 3-30 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 3-29: Projected Annual Days with a Maximum Temperature Above 90°F



Source: resilient MA, 2018.

The Colrain Hazard Mitigation Committee determined that the probability of extreme temperatures affecting the town in the future is "High", or from once in 2 years to once in 4 years (25%-50% probability in the next year).

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 Colrain is vulnerable to extreme temperatures.

Society

Vulnerable Populations

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 from exposure to extreme cold in January 2019 in Greenfield.

Table 3-39 estimates the number of vulnerable populations and households in Colrain. 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 Colrain residents during an extreme temperature event.

Table 3-39: Estimated Vulnerable Populations in Colrain

Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	359	22%
Population with a Disability	184	11%
Population who Speak English Less than "Very Well"	44	3%
Vulnerable Household Category	**Number**	**Percent of Total Households***

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Table 3-39: Estimated Vulnerable Populations in Colrain		
Low Income Households (annual income less than $35,000)	201	28%
Householder Age 65 Years and Over Living Alone	99	14%
Households Without Access to a Vehicle	16	2%

*Total population = 1,631; Total households = 714
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2013-2017 Five-Year Estimates.

Health Impacts

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.[38] 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.[39] 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.[40]

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

[38] Hattis, D. et al. 2012. The Spatial Variability of Heat-Related Mortality in Massachusetts. Applied Geography. 33(2012) pg 45-52. http://wordpress.clarku.edu/yogneva/files/2012/04/Hattis-et-al-2011-The-spatial-variability-of-heat-related-mortality-in-Massachusetts.pdf
[39] Madrigano J, Mittleman MA, Baccarelli A, Goldberg R, Melly S, von Klot S, Schwartz J.Temperature, myocardial infarction, and mortality: effect modification by individual- and area-level characteristics. Epidemiology. 2013 May;24(3):439-46.
[40] Shi L. et al. 2015. Impacts of temperature and its variability on mortality in New England. Nature Climate Change. Volume 5. November 2015.

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 3-30. 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 3-31, 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 3-32), while Franklin County's rate was statistically 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.

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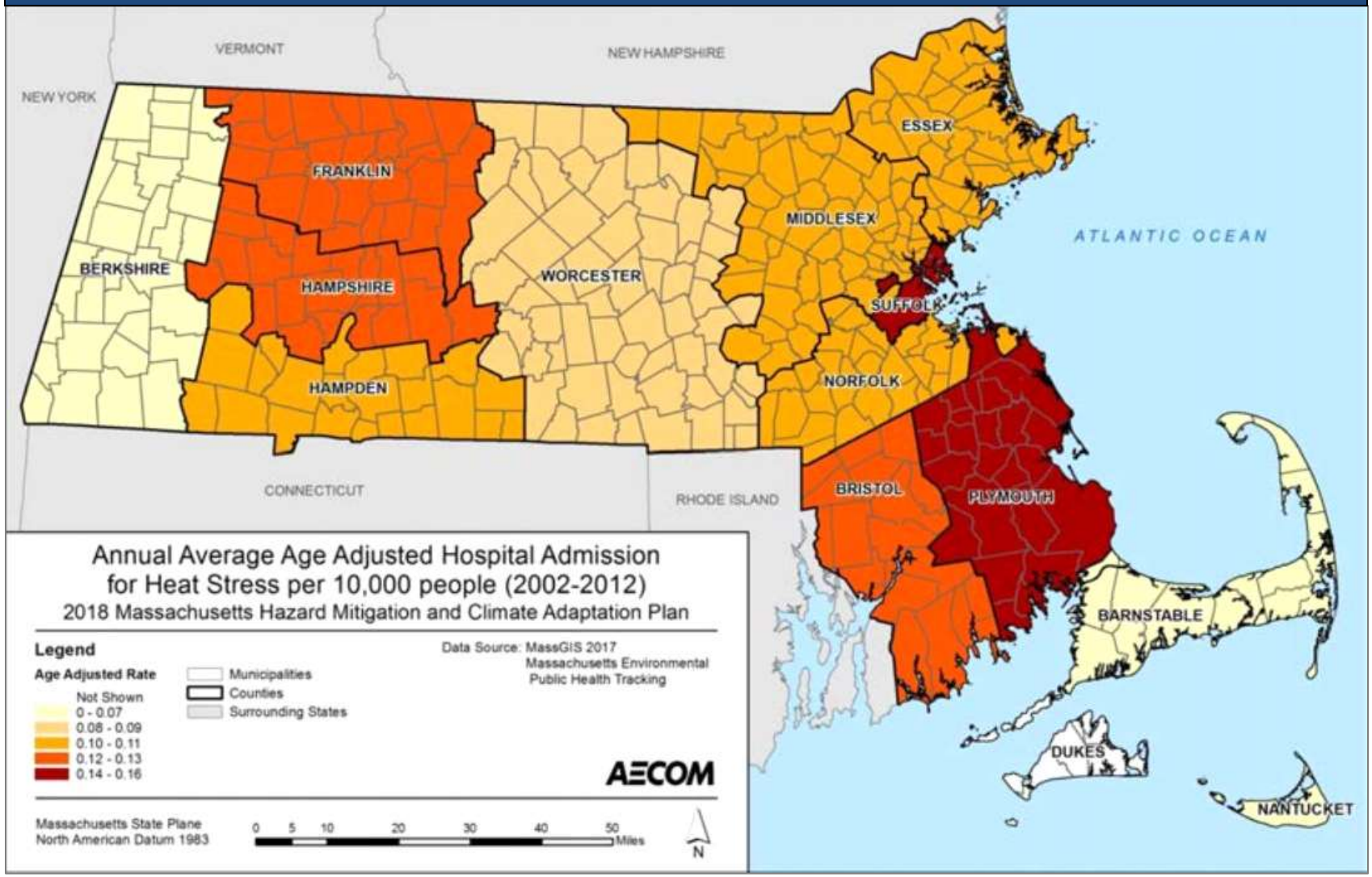
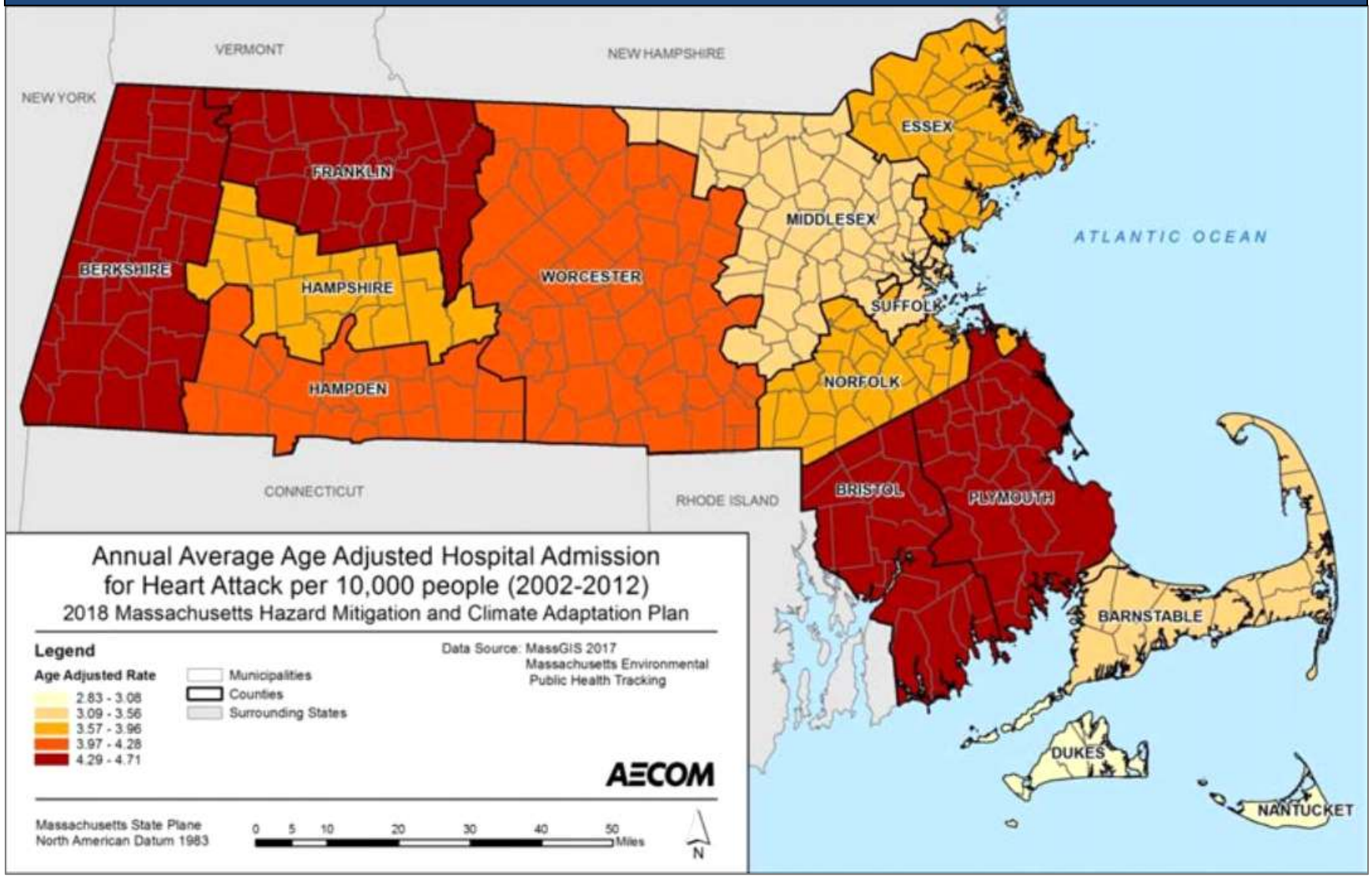
Figure 3-30: Rates of Heat Stress-Related Hospitalization by County



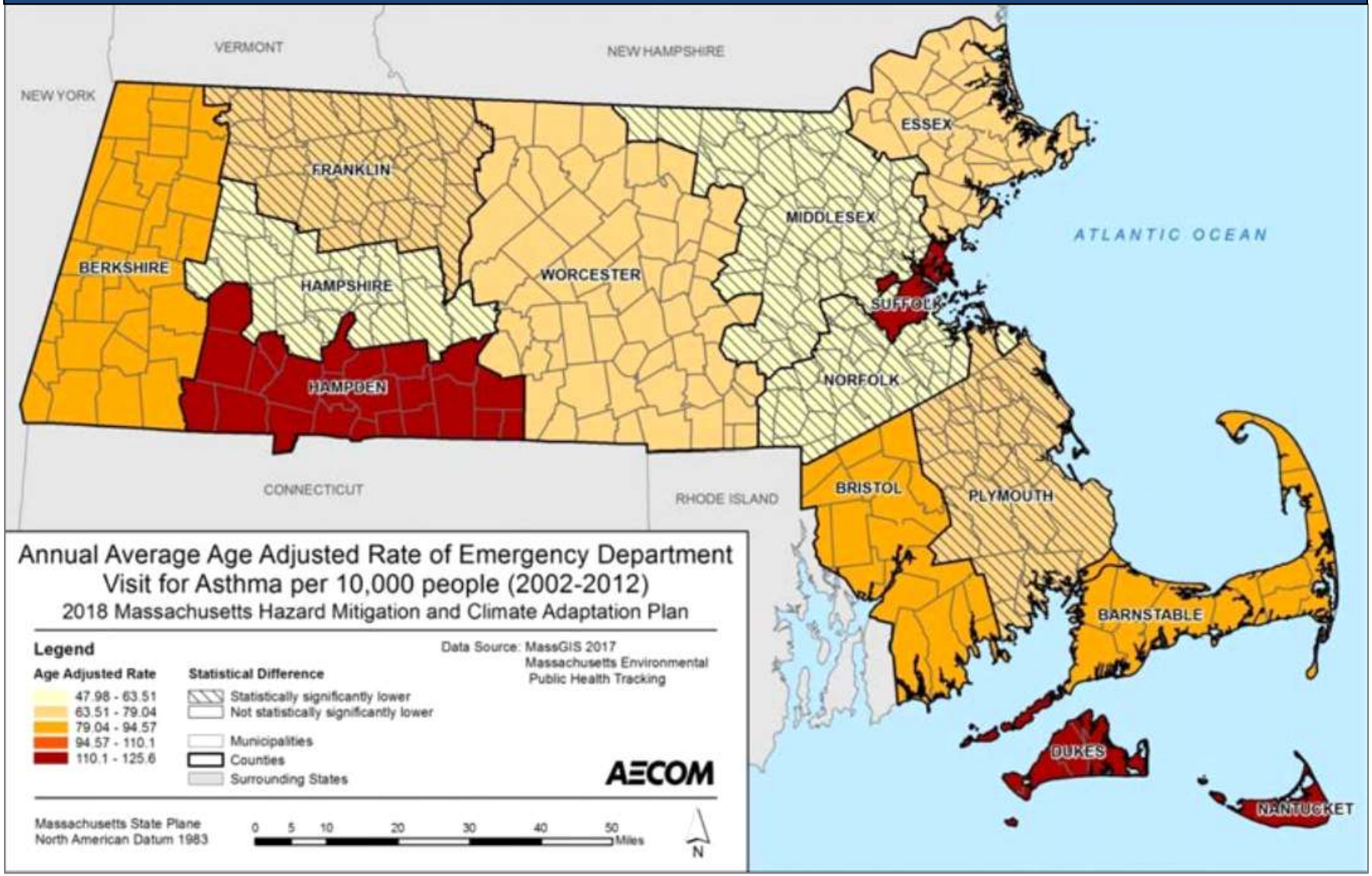
Source: Massachusetts Hazard Mitigation and Climate Adaptation Plan, September 2018.

Figure 3-31: Rates of Hospital Admissions for Heart Attacks by County



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

Figure 3-32: 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.[41]

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.[42] 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.[43] 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.[44]

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

[41] Resilient MA: http://resilientma.org/sectors/agriculture. Accessed March 4, 2019.
[42] Massachusetts Executive Office of Energy and Environmental Affairs and the Adaptation Advisory Committee (EOEEA). 2011. Massachusetts Climate Change Adaptation Report.
[43] Massachusetts Department of Transportation (MassDOT). 2017. Assessment of Extreme Temperature Impacts on MassDOT Assets
[44] 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.[45] 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.[46] 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. 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. Because the species that exist in a given area have adapted to survive within a specific

[45] Massachusetts Department of Transportation (MassDOT). 2017. Assessment of Extreme Temperature Impacts on MassDOT Assets

[46] Resilient MA: http://resilientma.org/sectors/water-resources. Accessed March 4, 2019.

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.[47] 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.[48] 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.[49] Such a shift is hugely significant for the species that live in this ecosystem as

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[47] Manomet Center for Conservation Sciences (MCCS) and Massachusetts Division of Fisheries and Wildlife (DFW). 2010. Climate Change and Massachusetts Fish and Wildlife: Volume 3 Habitat Management.

[48] National Park System (NPS). 2016. Project Brief: Phenology and Climate Change. https://www.nps.gov/subjects/climatechange/upload/2016-10-26-NPS-Phen-Project-Brief.pdf

[49] U.S. Global Change Research Program (USGCRP). 2014. Hatfield, J. et al., Ch. 6: Agri-culture. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., pp 150-174

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 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.[50] As temperature increases, the length of the growing season will also increase.

Vulnerability Summary

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

Extreme Temperature Hazard Problem Statements
• Elderly, disabled and low-income residents are more vulnerable to extreme temperatures and may lack A/C or adequate heating systems in their homes.
• A plan is needed to access and assist elderly, special needs, and/or disabled residents during emergencies.
• Low income families may need heating assistance during periods of extreme cold.
• Extreme cold temperatures combined with power outages, even short duration, can result in frozen and burst pipes for properties without back-up power.
• Extreme heat may worsen risk of wildfires and drought. ***See WILDFIRE and DROUGHT hazard problem statements.***

[50] Manomet Center for Conservation Sciences (MCCS) and Massachusetts Division of Fisheries and Wildlife (DFW). 2010. Climate Change and Massachusetts Fish and Wildlife: Volume 3 Habitat Management.

Extreme Temperature Hazard Problem Statements
• Extreme heat has the potential to cause long term power outages, or “brown outs”, and some municipal buildings, businesses and homes need backup power.
• Many Colrain residents rely on private wells for water, placing their water supply at risk during prolonged power outages caused by severe winter storms. Colrain does not yet have an emergency back-up supply of drinking water.
• Many residents live in isolated locations with unreliable cell service, which can decrease access to emergency services.
• Residents may not be enrolled in Colrain’s emergency response system, Blackboard Connect. Residents who live alone and who have not opted in to Blackboard connect are the most vulnerable, as they will not have reliable access to emergency information.
• Changing climate has resulted in an annual decrease in days below freezing, a trend that will progress over the next century. Fewer days below freezing and deep frosts occurring later in the season are some of the contributing factors for larger tic and mosquito populations and longer seasons for both. This increases risk to Colrain residents from insect borne diseases. Residents may not be familiar with how to deal with or prevent diseases associated with increasing average temperatures.

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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.[51]

Figure 3-33: 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 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

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

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.[52]

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 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

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

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.[53]

Location

The damage rendered by invasive species is significant. The massive scope of this hazard means that the entire Town of Colrain 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 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).

[53] https://masswoods.org/outsmart. Accessed March 5, 2019.

One of the immediate threats to Colrain is the Hemlock wooly adelgid, a small insect that attacks and kills Hemlocks, which has been sighted at several locations in nearby Wendell. The pest may spread unimpeded, leading to widespread hemlock mortality.[54]

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. As previously mentioned, Japanese knotweed is also of concern due to its ability to crowd out native species and erode riverbanks.

Previous Occurrences

The terrestrial and freshwater species listed on the MIPAG website as "Invasive" (last updated April 2016) are identified in Table 3-40. 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. Nineteen of the invasive species on the list have been observed in Colrain since 2010.

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[54] 2013 *Conway Open Space and Recreation Plan*

Table 3-40: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Colrain**
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.	N
Alliaria petiolata (Bieb.) Cavara & Grande (**Garlic mustard**)	A biennial herb occurring 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 occurring 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 occurring 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 occurring 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.	N
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

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Table 3-40: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Colrain**
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
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
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	Y

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Table 3-40: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Colrain**
	cultivation; overtakes wetlands; high seed production and longevity.	
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.	N
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.	N
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.	N
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	N

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Table 3-40: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Colrain**
	woodlands; an ephemeral that outcompetes native spring wildflowers.	
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.

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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 Colrain (Table 3-41). 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 3-41: 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.
Aquatic Species	

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Table 3-41: Invasive Animal and Fungi Species in Massachusetts	
Species (Common Name)	**Notes on Occurrence and Impact**
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.

The Colrain Hazard Mitigation Committee determined that there is a “Very High” probability of this hazard affecting the town in the future.

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.[55]

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 Colrain, the entire town is considered to be exposed to the invasive species hazard, which has the potential to cause "Limited" impacts. 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 species.

[55] This section excerpted from the MassWildlife Climate Action Tool: http://climateactiontool.org/content/invasive-plants-and-animals. Accessed March 5, 2019.

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 albopictus). 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.[56]

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 Colrain for their economic success. This 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.

[56] MassWildlife Climate Action Tool: http://climateactiontool.org/content/invasive-plants-and-animals. Accessed March 5, 2019.

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 Colrain 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.

<u>Agriculture</u>

The agricultural sector is vulnerable to increased invasive species associated with increased temperatures. 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.

<u>Public Health</u>

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.

<u>Transportation</u>

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.

<u>Water Infrastructure</u>

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

Colrain is 86% forested, and is therefore vulnerable to invasive species impacts to forests.

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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.[57]

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
- Degradation of water quality
- Degradation of wildlife habitat
- Increased threats to public health and safety
- Diminished property values

[57] 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

- Local and complete extinction of rare and endangered species

Vulnerability Summary

Based on the above assessment, Colrain has a "Medium" vulnerability to Invasive species. The following problem statements summarize Colrain's areas of greatest concern regarding invasive species.

Invasive Species Hazard Problem Statements
• Invasive species may reduce canopy coverage in forested areas and worsen the risk of extreme temperatures and wildfires in Colrain's forests, which make up approximately 86% of the town.
• Most residents in Colrain live within or adjacent to heavily forested areas, making them susceptible to invasive species hazards affecting these areas.
• Oriental bittersweet, Red Pine Scale, and the Emerald Ash Borer, threatens mature trees and wildlife habitat in Town, as well as pastures and forests across Colrain.
• Invasive species can severely damage large swaths of forest, including forested areas managed for residents' livelihoods. Farmers and landowners may lack information and support on programs and funding to protect their land and natural resources from the impacts of invasive species.
• Invasive species exacerbate stormwater flooding and erosion issues by dominating streambanks and altering the stability of river corridors. Japanese knotweed forms monocultures along stream and riverbanks in town, and is poor erosion control compared to native vegetation. Japanese knotweed is well established along the bank of the North River and may lead to road damage.
• A comprehensive inventory and assessment of invasive species in Colrain is needed to help prioritize mitigation efforts and choose the most effective strategies for controlling specific pests, plants or pathogens, in specific locations.
• Education and outreach is needed to increase local awareness around invasive species and equip residents with appropriate control measure.
• Changing climate has resulted in fewer days below freezing, a trend that will progress over the next century. Fewer days below freezing and deep frosts occurring later in the season are some of the contributing factors that has resulted in a climate more suitable for invasive insects and other pests that can carry non-native diseases.

3.15 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 Colrain. A complete hazards vulnerability analysis was not within the scope of this update. For the purposes of the 2020 plan, the Committee has evaluated non-natural hazards that are of an accidental nature. They include industrial transportation accidents and industrial accidents in a fixed facility. New to this plan update is a review of cyber security threats.

Hazard Definition

Hazardous materials in various forms can cause death, serious injury, long-lasting health effects, and damage to buildings, homes, and other property. Many products are 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 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 passing through.

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. 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. According to the Franklin County Hazardous Material Emergency Plan (HMEP), an estimated 12 or more trucks per hour travel through the region containing hazardous materials. Most of these trucks are on Interstate 91. However, approximately two vehicles per hour travel along Route 2, and up to one vehicle per hour travel along Route 112, which runs through Colrain. In addition, the HMEP notes that all roads in the county likely have vehicles carrying hazardous materials at varying intervals.

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

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- Paint
- Gasoline
- Toluene
- Hydrogen peroxide

The major portions of hazardous chemicals transported by highways are petroleum-based products such as gasoline and heating fuels. According to the HMEP, the following hazardous materials are regularly carried on Route 112:

- Gasoline
- Fuel oil
- Kerosene
- Liquefied Petroleum Gas (LPG)
- Propane

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 Franklin County Regional Emergency Planning Committee (REPC) 2018 List of Tier II Facilities includes those listed in Table 3-43 for Colrain. Facilities covered by the reporting requirements of the Federal Emergency Planning and Community Right-to-Know Act EPCRA) must submit annual Tier II reports to their Emergency Planning Committee (EPC), and Local Fire Department, and the State Emergency Response Commission (SERC).

Table 3-42: Facilities that Use Hazardous Materials

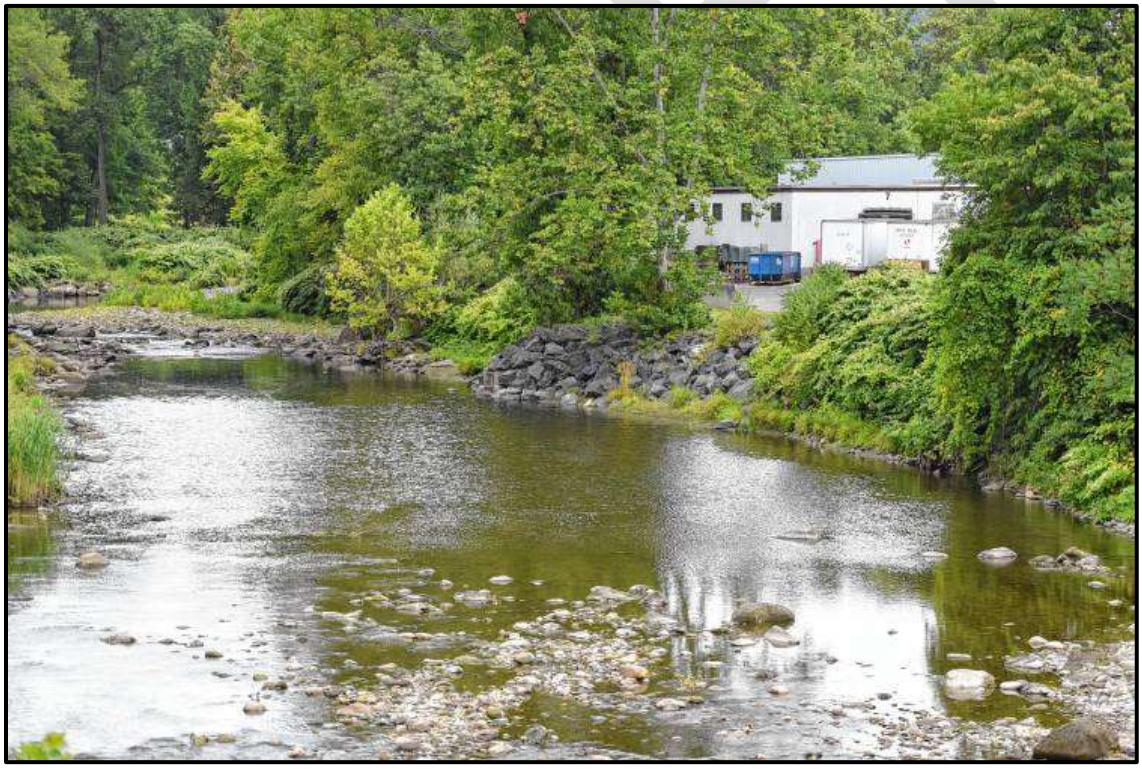
Facility Name	Facility Location
Barhardt Manufacturing	247 Main Road
Verizon Colrain Dial OFC (VZ – MA 828307)	26 Main Road/Rt 112

Colrain's 2018 MVP Plan indicates several manmade hazard vulnerabilities in the village center. These include the uncapped landfill and the Town's salt shed, which are adjacent to a steep site slope leading down to the West Branch of the North River. Additionally, many private septic systems in the village center are in failure and replacing the systems in their current locations is not possible. The Town could utilize the 2014 Colrain Center Village Master Plan and other

related studies to explore potential solutions to mitigate the risk of contamination from the more than 40 private septic systems that are a known concern.

Previous Occurrences

In September 2019, a sulfuric acid leak from the Barnhardt Manufacturing facility on the North River in Colrain resulted in thousands of dead fish in the river. The spill was mostly contained within a holding area, but enough acid made its way to the River to alter the water's chemistry and become an unsuitable habitat for many fish species. This is the second acid spill in the North River in recent decades. On September 3, 1999, a truck released 670 gallons of sulfuric acid into the North River in Colrain. MassWildlife found dead and dying fish up to 2.6 miles downstream of the spill. Fish species included trout, salmon, smallmouth bass, American eel, common shiner, dace, white sucker and darter. In 2003, Massachusetts settled with the responsible parties for $28,125.[58]



The site of the sulfuric acid leak in September 2019. Species of fish found dead by the Deerfield River Watershed Trout Unlimited included dace, bass, trout, and longnose suckers. Source: The Greenfield Recorder.

In addition to the above facilities, many farmers store agricultural chemicals on their properties. This plan does not include an in-depth evaluation of hazardous materials as they

[58] MA Department of Environmental Protection: https://www.mass.gov/service-details/more-nrd-settlements-massdep

relate to farming. In many cases, farmers do use and store pesticides, herbicides and fertilizers on their property. 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.

The Vermont Yankee nuclear power plant is located on the Connecticut River in Vernon, Vermont, near the Vermont/Massachusetts border and approximately 12 miles from Colrain. 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]

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).

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

[59] Vermont Department of Health. http://healthvermont.gov/enviro/rad/vt_yankee.aspx

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. [60] These threats are not only external; many acts of cyber-crime happened from current or former employees who were given network access legitimately.

For Colrain, 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.

<u>Social Engineering:</u>
Social engineering involves obtaining confidential information from individuals through deceptive means by mail, email, over the phone, and increasingly through text messages.[61] These techniques are referred to as 'Phishing'.

<u>Malware</u>
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

[60] NYC Hazard Mitigation, Cyber Threats, https://nychazardmitigation.com/hazard-specific/cyber-threats/what-is-the-hazard/
[61] Cybersecurity Precautions, MA Executive Office of Technology Services & Security, 2017

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.

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 sophisticated 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 these best practices will greatly mitigate the likelihood a cyber-attack is successful. MA Executive Office of Technology Services and Security (EOTSS)[62] 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.

Vulnerability Summary

The following problem statements summarize Colrain's areas of greatest concern regarding Manmade Hazards.

[62] https://www.mass.gov/cybersecurity

Manmade Hazard Problem Statements
• Colrain is vulnerable to a spill of hazardous materials and/or hazardous waste transported on Route 112.
• Several facilities in town store hazardous materials, including the Town's salt shed. There is also an uncapped landfill on a vulnerable site above the West Branch of the North River. These facilities and/or hazardous materials storage are in the 100-year floodplain. Therefore, the North River is susceptible to contamination.
• Cyber-attacks on local government is a growing threat. Keeping up with current best practices in cyber security can be challenging for a communities.
• More than 40 private septic systems are a known concern for failure in Colrain Center Village and replacing the systems in their current locations is not possible.

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3.16 VECTOR-BORNE DISEASES[63]

Hazard Profile

The Town of Colrain chose to include a discussion of the hazards posed by vector-borne disease in their community as part of this Plan update. Vector-borne disease is defined by the Centers for Disease Control (CDC) as illnesses in humans that are caused by contact (being bitten by) a vector such as mosquito, tick, or flea. Examples of mosquito-borne diseases include Chikungunya, Eastern Equine Encephalitis (EEE), Zika and West Nile Virus. Examples of tick-borne disease include Lyme disease, Anaplasmosis/Ehrlichiosis, Babesiosis and Powassan.

In the US in 2016, a total of 96,075 cases of vector-borne diseases were reported, 1,827 of which were reported in Massachusetts. The CDC indicates that cases of vector-borne diseases are substantially underreported. Tick-borne illnesses more than doubled between 2004 and 2016 and accounted for 77% of all vector-borne disease reports in the United States. Lyme disease accounted for 82% of all tick-borne cases, but cases of Spotted fever rickettsioses, Babesiosis and Anaplasmosis/Ehrlichiosis also increased. Between 2004 and 2016, nine vector-borne human diseases were reported for the first time from the United States and its territories. According to the CDC, vector-borne diseases have been difficult to prevent and control, and a Food and Drug Administration approved vaccine is only available for yellow fever virus. Insecticide resistance is widespread and is increasing.

The impacts of vector-borne diseases can be significant in a community and can affect residents' quality of life and ability to work. Other impacts of these diseases can include an increase in life-long morbidity and an increase in mortality.

Probability of Occurrence

According to the CDC, the geographic and seasonal distribution of vector populations and the diseases they can carry depends not only on the climate, but also on land use, socioeconomic and cultural factors, pest control, access to health care, and human responses to disease risk. Climate variability can result in vector/pathogen adaptation and shifts or expansions in their geographic ranges. Infectious disease transmission is sensitive to local, small-scale differences in weather, human modification of the landscape, the diversity of animal hosts and human behavior that affects vector/human contact.

[63] This section relies on a template prepared by the Berkshire Regional Planning Commission (BRPC) for towns in their region that are working to update local hazard mitigation plans. FRCOG updated available statistics for Massachusetts using information from MA DPH's website and for Franklin County (FRCOG Public Health Nurse and MAVEN).

Franklin County provides many and varied outdoor recreation opportunities for both residents and visitors, including hiking, swimming, mountain biking, and camping. Increased exposure to the outdoors, particularly to areas with heavy tree and forest cover, and areas with tall grass or standing water, significantly increase a person's exposure to vector-borne illnesses. Increases in average year-round temperature during the past few decades has also led to the over-wintering of ticks in Franklin County and across the Commonwealth. A lengthening warm season has also increased tick and mosquito populations significantly.

Location

The entire Town of Colrain is likely already impacted by vector-borne disease and is likely to be increasingly impacted. Exposure to any outdoor area with tall grasses, standing water, and trees increases risk. Residents and visitors can be exposed at home and in more commercial areas, although exposure in commercial areas is generally less likely.

Extent[64]

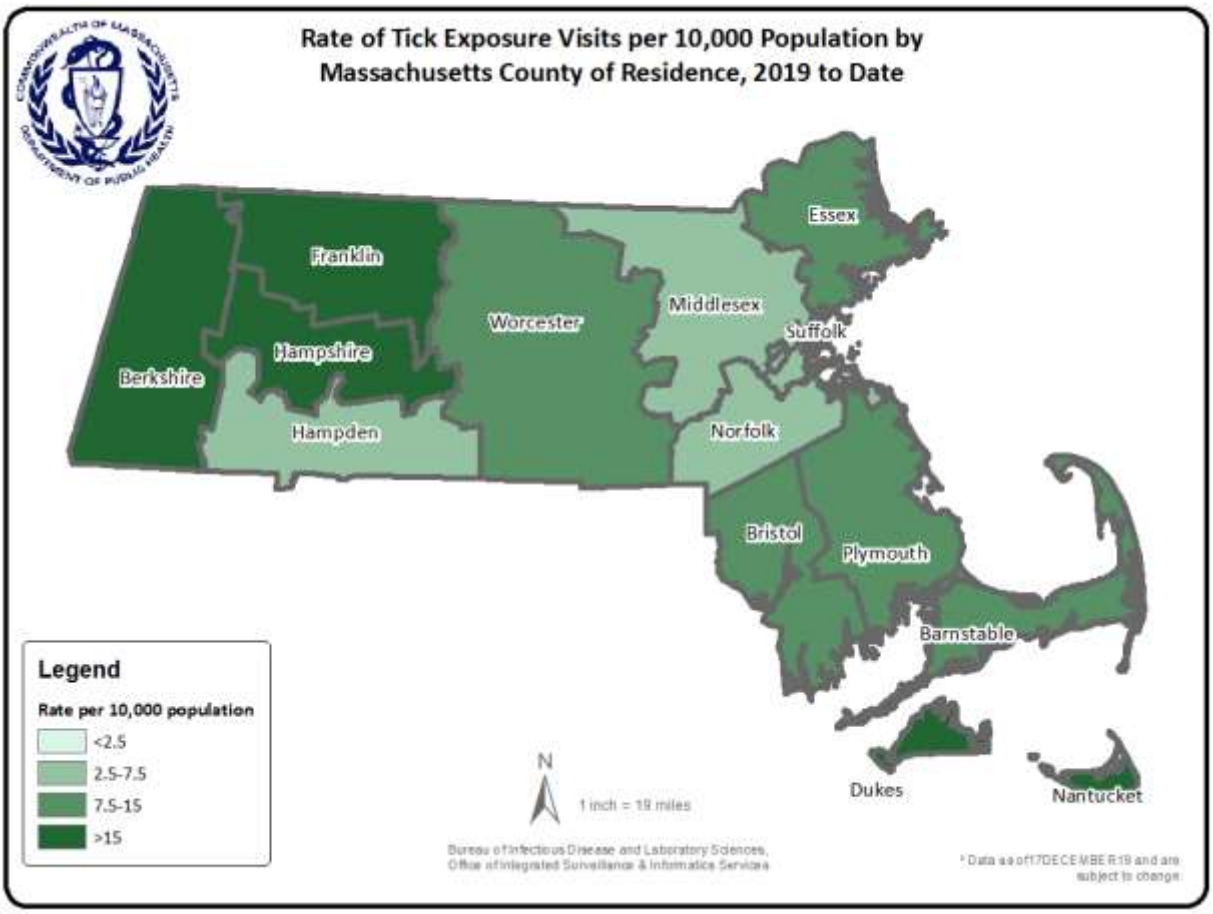
Tick-borne Illness

Massachusetts has seen cases of once non-existent or very rare tick-borne illnesses rise, including Anaplasmosis, Babesiosis, Lyme, Powassan, Spotted fever rickettsiosis and Tularemia. Tick activity and tick-borne diseases occur year-round in Massachusetts. Although tick activity is weather dependent, there are two peaks during the year; the first begins in March/April and lasts through August, and the second occurs in October-November. The majority of cases of tick-borne disease occur in June through August.

The map on the following page shows the rate, per 10,000 total population, of ED visits by patients who had a visit related to a tick exposure, by Massachusetts county of residence, 2019 to date. Although there are differences in the rate of patient visits, this shows that people are exposed to ticks throughout all of Massachusetts and should take recommended steps to reduce the chance of being bitten.[65]

[64] https://www.mass.gov/lists/tick-borne-disease-surveillance-summaries-and-data#monthly-tick-report-page- accessed March 19, 2020.

[65] https://www.mass.gov/info-details/monthly-tick-report-november-2019 accessed March 19, 2020.



The following information was downloaded from the website of the Massachusetts Department of Public Health.[66]

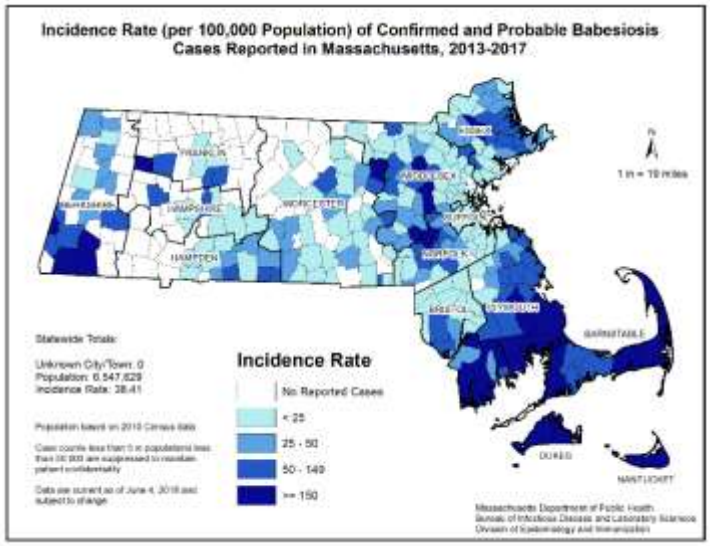
Babesiosis:

- 590 confirmed and probable cases of Babesiosis were reported in Massachusetts in 2017, a 13% increase from 2016. Overall, 1,677 suspect cases of Babesiosis were investigated.
- **2 confirmed cases in Franklin County**.
- Statewide, Babesiosis incidence increased from 7.9 to 9.0 cases per 100,000 residents. The incidence in Berkshire, Dukes, Hampden, Hampshire, Norfolk, Plymouth, Suffolk, and Worcester counties increased slightly. Counties with the highest incidence continued to be Barnstable, Dukes, and Nantucket.

[66] https://www.mass.gov/lists/tick-borne-disease-surveillance-summaries-and-data#lyme-disease-surveillance-data- accessed March 19, 2020.

- The majority of cases occurred in June, July and August, with only 35% of cases reporting awareness of a recent tick bite.

- People aged 60 years and older continue to be at greatest risk for clinical disease (59% of all patients identified with Babesiosis were 60 years or older) and 66% of all cases were male.



- 1,209 confirmed and probable cases of HGA were reported in Massachusetts in 2017, a 38% increase over 2016. Overall 2,473 suspect cases of HGA were investigated.

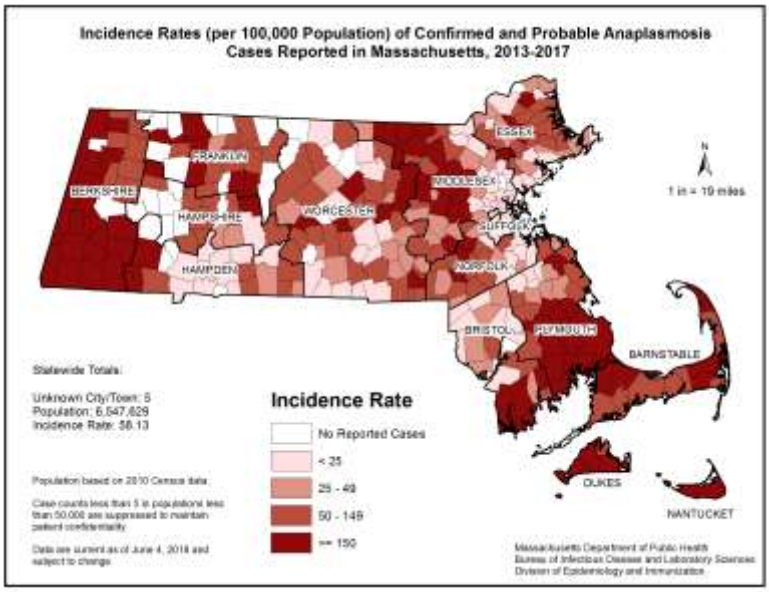
Human Granulocytic Anaplasmosis (HGA)

- Statewide, HGA incidence increased from 13.3 to 18.4 cases per 100,000 residents. The counties with the highest incidence are Barnstable, Berkshire, Dukes, **Franklin**, Nantucket and Plymouth. Berkshire County had the greatest change in incidence, from 66.3 to 133.4 cases per 100,000 residents.

- **27 confirmed cases in Franklin County**.

- The majority of cases occurred in May, June, and July, with only 45% of cases reporting awareness of a recent tick bite.

- People aged 60 years and over continue to be at greatest risk for clinical disease (56% of patients identified with HGA were 60 or over) and 64% of all cases were male.



- Nearly one out of three patients with HGA (29%) was hospitalized. The symptoms most commonly reported included fever (93%), malaise (72%), and muscle aches and pain (63%). There were three fatalities.

Lyme disease:

- 3,830 confirmed Lyme disease cases, and 1,770

probable cases, were reported in Massachusetts in 2014, which is a decrease of 1% from the number of confirmed and probable cases reported in 2013

- **50 confirmed cases in Franklin County in 2014**.
- The highest incidence rates were among children aged 5-9 years and adults aged 65-74 years.
- The majority of cases had onsets in June, July, and August.
- 66% of confirmed cases had a reported erythema migrans ("bulls-eye") rash.

The Franklin Regional Council of Governments' Cooperative Public Health Services (CPHS) Public Health Nurse supplied the following information for reported cases of vector-borne illnesses in 2019:[67]

- Lyme 92 suspect in 2019
  - In 2018, 76 suspect Lyme
  - In 2017, 86 suspect Lyme
- Babesiosis 1 (5 were reported but 4 were revoked-determined not to be Babesiosis)
- HGA Human Granulocytic Anaplasmosis (37 total reported, 11 confirmed, 14 suspect, 1 probable and 10 revoked)
- Erlichiosis 1 (6 reported: 1 probable, 5 revoked)
- No other tick-borne illnesses reported in 2019.

[67] Note: It is never clear if these trends actually represent an increase in infection/illness as small sample, underreporting is assumed, reporting of cases determined by clinical judgement. Virtually all of the reports that reach MAVEN are due to a laboratory result.

Mosquito-borne Illnesses[68]

West Nile Virus (WNV) and Eastern Equine Encephalitis (EEE or "Triple E") are viruses that occur in Massachusetts and can cause illness ranging from a mild fever to more serious disease like encephalitis or meningitis. There are other diseases spread by mosquitoes that people may be exposed to when traveling in other regions of the world. These include Zika virus, Dengue fever, and Chikungunya.

Eastern equine encephalitis (EEE) is a rare but serious disease caused by a virus that can affect people of all ages. EEE is generally spread to humans through the bite of a mosquito infected with the virus. EEE can cause severe illness and possibly lead to death in any age group; however, people under age 15 are at particular risk.[69]

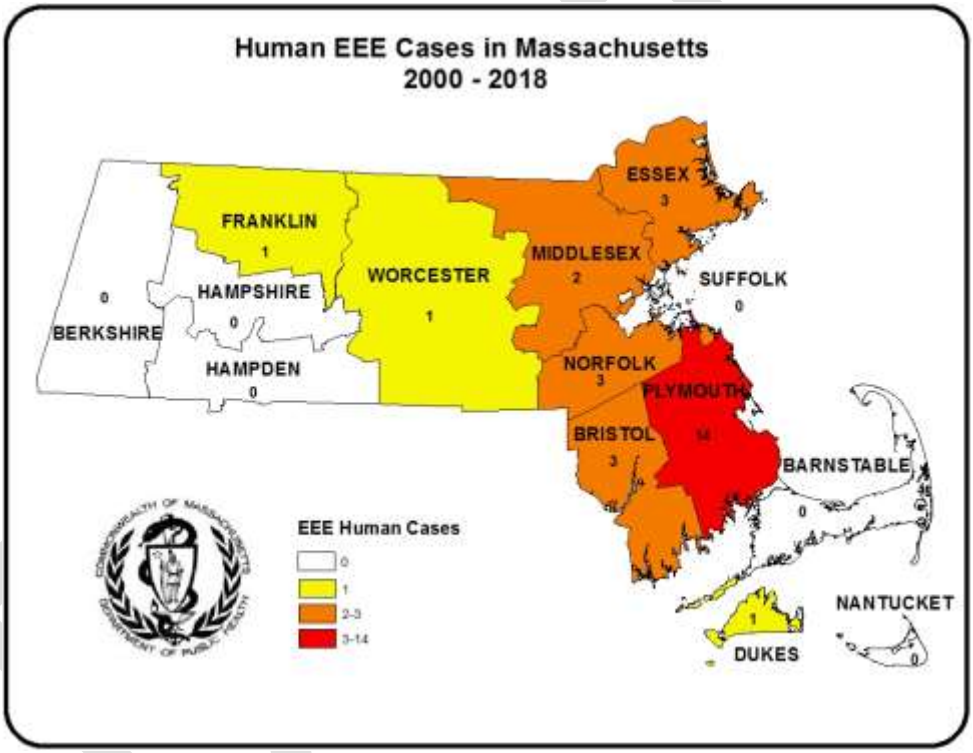
EEE has a 30-50% mortality and lifelong neurological disability among many survivors. The first symptoms of EEE are fever (often 103º to106ºF), stiff neck, headache, and lack of energy. These symptoms show up three to ten days after a bite from an infected mosquito. Inflammation and swelling of the brain, called encephalitis, is the most dangerous and frequent serious complication. The disease rapidly worsens and some patients may go into a coma within a week. There is no treatment for EEE. In Massachusetts, approximately half of the people identified with EEE have died from the infection. People who survive this disease will often be permanently disabled due to neurologic damage. Few people recover completely.

Historically, clusters of human cases have occurred over a period of two to three years, with a variable number of years between clusters. In the years between these case clusters or outbreaks, isolated cases can and do occur. Outbreaks of human EEE disease in Massachusetts occurred in 1938-39, 1955-56, 1972-74, 1982-84, 1990-92, and, 2004-06. Two cases of EEE

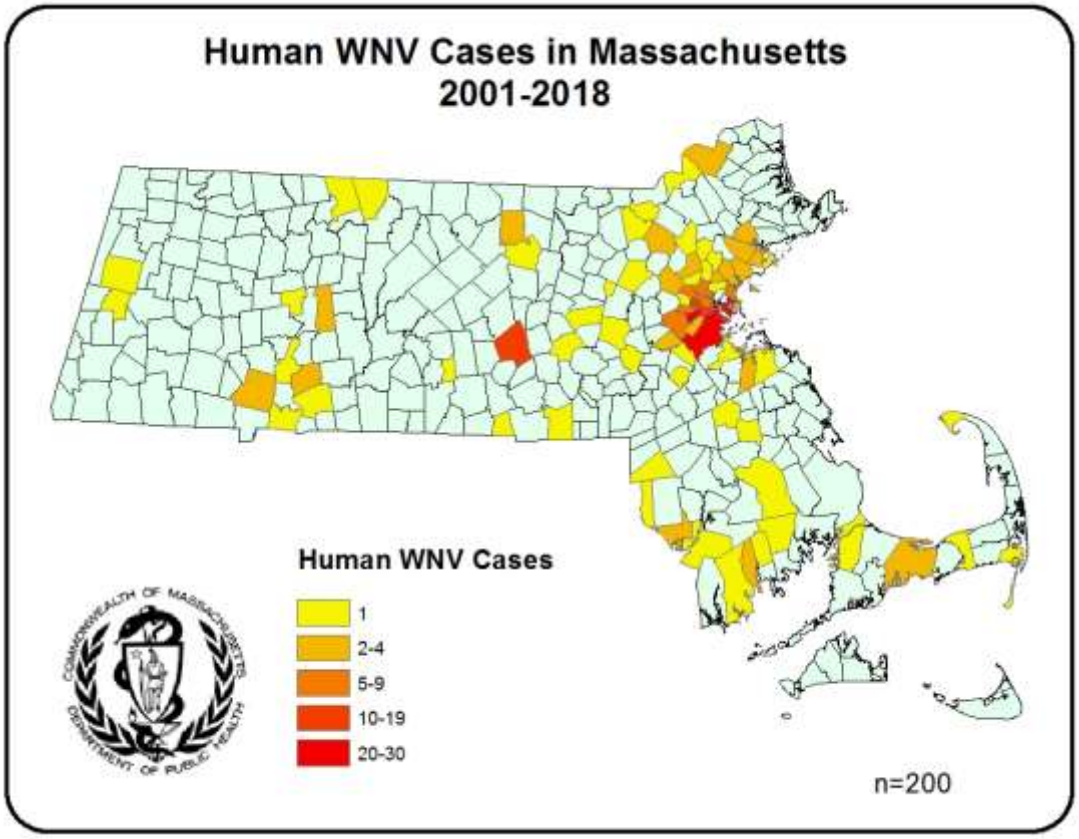
[68] https://www.mass.gov/mosquito-borne-diseases accessed March 20, 2020.
[69] https://www.mass.gov/guides/eee-in-massachusetts accessed March 20, 2020

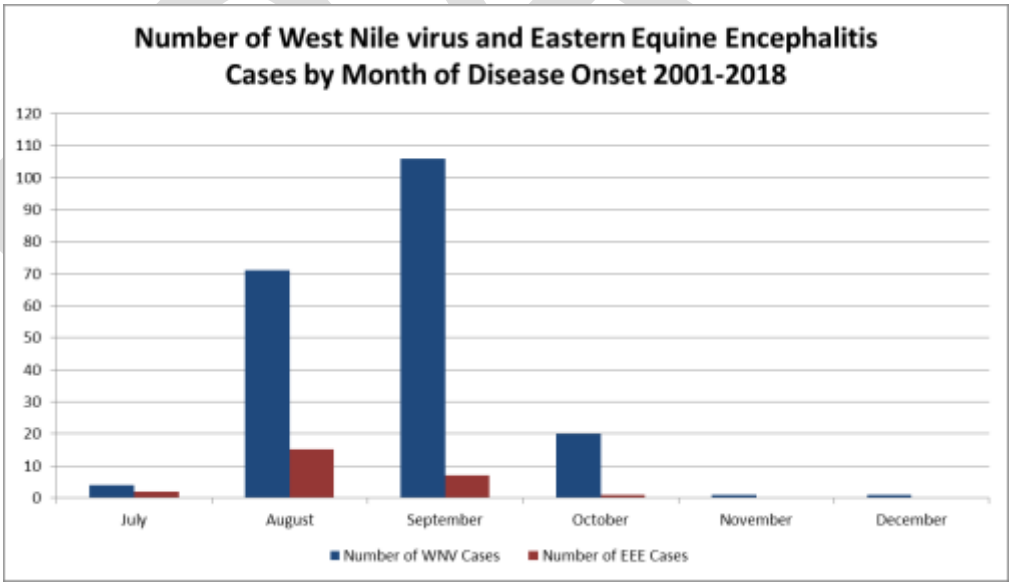
occurred in each of 2010 and 2011; one case each of these years occurred in visitors to Massachusetts. Seven human cases of EEE occurred in 2012, a single case in 2013 and no cases from 2014 - 2018.

The narrative above and the following figures are from the MA Department of Public Health's 2019 Arbovirus Surveillance and Response Plan.[70]



[70] https://www.mass.gov/lists/arbovirus-surveillance-plan-and-historical-data accessed March 20, 2020. Narrative copied from p. 1 of the report. Figures from pp. 24-26.





West Nile virus (WNV) first appeared in the United States in 1999. Since the initial outbreak in New York City, the virus has spread across the US from east to west. Following the identification of WNV in birds and mosquitoes in Massachusetts during the summer of 2000, MDPH arranged meetings between local, state, and federal officials, academicians, environmentalists and the

public to develop recommendations to adapt the arbovirus surveillance and response plan to include activities appropriate for WNV. Four workgroups addressed the issues of surveillance, risk reduction interventions, pesticide toxicity, and communication.

WNV infection may be asymptomatic in some people, but it leads to morbidity and mortality in others. WNV causes sporadic disease of humans, and occasionally significant outbreaks. Nationally, 2,554 human cases of WNV neuroinvasive disease (meningitis and encephalitis) and WNV fever were reported to the CDC in 2018. The majority of people who are infected with WNV (approximately 80%) will have no symptoms. A smaller proportion of people who become infected (~ 20%) will have symptoms such as fever, headache, body aches, nausea, vomiting, and sometimes swollen lymph glands. They may also develop a skin rash on the chest, stomach, and back. Less than 1% of people infected with WNV will develop severe illness, such as encephalitis or meningitis. The symptoms of severe illness can include high fever, headache, neck stiffness, stupor, disorientation, coma, tremors, convulsions, muscle weakness, vision loss, numbness, and paralysis. Persons older than 50 years of age have a higher risk of developing severe illness. In Massachusetts, there were at least 12 fatal WNV human cases identified between 2002 and 2018. All but three of these fatalities were in individuals 80 years of age or older; all of them were in individuals over 60.[71]

The number of EEE and WNV cases in Massachusetts in 2019 is shown below.[72]

2019 Arbovirus results summary

	Mosquito samples positive	Animals positive	Humans positive
WNV	87	0	3
EEE	428	9	12

LAST UPDATED November 14, 2019

Vulnerability Assessment

<u>Society</u>

Vector-borne illness has a significant impact on humans and on a community. These illnesses can significantly impact the health, long-term morbidity and mortality, and quality of life of Town residents and can reduce a person's ability to work or contribute to the community in other ways. In addition, pesticides and herbicides used to control vector populations can also negatively impact human health.

[71] https://www.mass.gov/lists/arbovirus-surveillance-plan-and-historical-data accessed March 20, 2020. pp.3-4.
[72] https://www.mass.gov/info-details/massachusetts-arbovirus-update accessed March 20, 2020.

Infrastructure
Vector-borne illnesses pose little threat to infrastructure and the built environment. Overtime, changes in development patterns may occur as people respond to the increase in disease carrying insects.

Natural Environment
Increases in vector-borne illnesses can increase the likelihood that a community needs to use chemical pesticides and herbicides to control vector populations. The increased use of these products and chemicals can negatively impact the natural environment, including vegetation, rivers and streams, and animal populations. Reducing populations of ticks and mosquitoes can reduce the food source for other dependent animal populations. Additionally, diseases carried by insects can affect wildlife. There is also the risk of people reacting to the threat of disease by altering the environment to not support vector habitat, which can severely damage the long-term health of ecosystems.

Economy
The economy is susceptible to the indirect impacts of vector-borne illnesses. If a community decides to engage in a pest-control program or another program to reduce vector populations, this can significantly affect their operating budget. Incorporation of any program to reduce vector populations in a community will likely cause tax increases within the municipality. Long-term, the more individuals in a population affected by vector-borne disease that results in life-long morbidity or mortality will reduce the overall economic participation and output of the population in a municipality. The can also be impacts on the outdoor recreation economy, which is a major revenue driver for Franklin County. People today choose to or may be advised by public health officials to avoid outdoor activities for fear of tick and mosquito bites.

Future Conditions
Continued changes to the climate, extreme precipitation events, issues with the control of stormwater, changes to animal and vector populations, and increases in insecticide resistance will lead to an ongoing and growing threat to individuals, governments and businesses. Local governments will need to invest in methods to reduce or prevent exposure to vector-borne diseases and should strongly consider methods that do not include the increased use of insecticides and herbicides. This may include methods such as promoting populations of bats, opossums and other animals that consume vectors of concern, increasing opportunities for residents to get ticks tested, reducing the cost and burden of tick testing and increasing the level of education and outreach to the public and health care practioners about current and new vector-borne illnesses so treatment can be expedited. Towns should implement educational programs for residents and visitors for bite-prevention and detection.

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Vector-borne Disease Problem Statements
• Climate change will increase the number of disease carrying vectors (ticks and mosquitoes) and increase demands on our public health system for symptom management and care for infected people.
• More and consistent outreach and education is needed to increase prevention and diagnosis of vector-borne diseases. The Massachusetts DPH website contains many good education and outreach materials as does the Franklin Regional Council of Governments' Cooperative Public Health Service program.
• Participating in mosquito control districts will reduce hazards and protect public health.
• Vector-borne disease can have a significant negative impact on public health and the local and regional outdoor recreation economy.
• Vector management strategies should strive to be protective of public health and, when feasible, use effective alternatives that are cost-effective and have minimum impacts on the natural environment.

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PREVENT
LYME
DISEASE!
• WEAR DEET REPELLENT
• CHECK FOR TICKS DAILY
• SHOWER SOON AFTER
BEING OUTDOORS
• TUCK PANTS INTO SOCKS
• CALL YOUR DOCTOR IF
YOU ARE BITTEN

3.17 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.

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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 Colrain Hazard Mitigation Plan incorporates Nature-Based Solutions into mitigation strategies where feasible.

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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.

Colrain has most of the no cost or low cost hazard mitigation capabilities in place, such as land use zoning, and other policies and regulations that include hazard mitigation best practices, such as limitations on development in floodplains, stormwater management, tree maintenance, etc. Colrain has appropriate staff dedicated to hazard mitigation-related work for a community its size, including a Town Administrator, Emergency Management Director, and a Highway Department. In addition to Town staff, Colrain has a volunteer Planning Board that reviews all proposed developments.

Colrain has some recommended plans in place, such as the 2018 *Community Resilience Building Municipal Vulnerability Plan* (MVP), the 2014 *Colrain Center Village Master Plan*, and a number of Fluvial Geomorphic and River Habitat studies, including the 2017 *Watershed-Based Plan to Maintain the Health and Improve the Resiliency of the Deerfield River Watershed*. However, both the Town's Comprehensive Master Plan and Open Space and Recreation Plan (OSRP) should be updated. The Town also has very committed and dedicated volunteers who serve on Boards and Committees and in other important volunteer positions, such as the Council on Aging and Energy Committee. The Town collaborates closely with surrounding communities and is party to Mutual Aid agreements through MEMA. Colrain is also a member community of the Franklin Regional Council of Governments, and participates in the Franklin County Regional Emergency Planning Committee (REPC).

Colrain's Top Strengths and Assets

All Hazards

Participants at the 2018 Colrain MVP Community Resilience Building workshop expressed pride in having a close-knot community in which residents look out for one another and help out their neighbors. Many families know each other and know the first responders and Town staff who help run the Towns. Participants cited several strengths and assets that help keep their communities resilient in the face of climate change and other challenges. They include:

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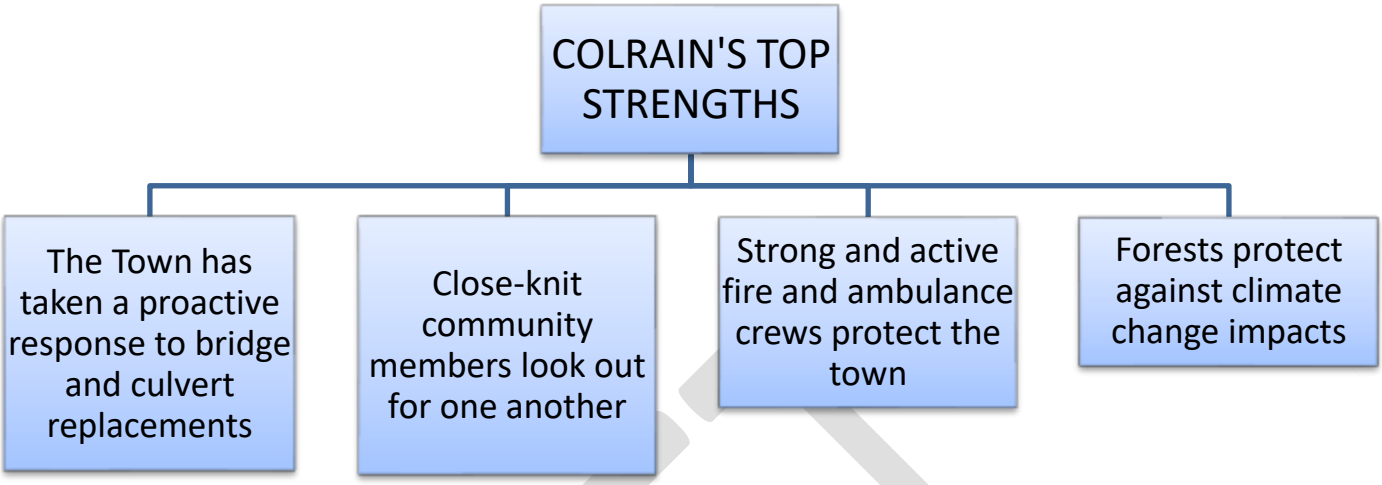
Figure 4-1: Colrain's Top Strengths



Infrastructural strengths and assets: Several bridges and culverts have been or are slated for repair or replacement, and the Town is pursuing additional funding for more repairs. Colrain's Fire, Police and EOC facilities are outside of the floodplain and are not vulnerable to flooding. Blackboard Connect serves to provide emergency information to Town residents who participate in the service.

Strength of Town Services: Colrain has a strong volunteer fire crew and a strong ambulance crew. The Town Administrator is knowledgeable and is actively pursuing funding on behalf of the Town.

Societal strengths and assets: People in Colrain are a close-knit community and most people know each other. People look out for one another.

Environmental strengths and assets: Much of Colrain is forested; forests are critical to resilience to climate change impacts including cleaning air and water, increasing stormwater infiltration and decreasing runoff, storing carbon and other important functions.

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. FEMA has identified no flood control structures within

the Town of Colrain.

The Town of Colrain 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.

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 other than driveway design requirements that could mitigate icing and facilitate snow removal, which are summarized in Table 4-1.

Severe snowstorms or ice storms can often result in a small or widespread loss of electrical service. Should a natural hazard cause a power outage, Colrain residents would be vulnerable to losing domestic heat and water supplies reliant on electricity.

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

Eighty-six percent of Colrain is forested, including 1,125 acres of state park in the Catamount State Forest and 1,620 acres of state park in the H.O. Cook State Forest. 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.

The Colrain Fire Department has several ongoing educational programs to educate residents on fire safety, including fire drills in the school and a junior firefighter program. In the last four years, the Fire Department has expanded its fire education program to seniors at the Colrain Community and Senior Center. The Colrain Fire Department is actively involved in teaching fire safety during Fire Prevention Week. 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.

There are currently no restrictions on development based on the need to mitigate wildfires.

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. Colrain Lower Reservoir Dam, Colrain Upper Reservoir Dam, Kendall Company No.1 Dam, and Shelburne Falls Fire District Dam are classified as significant hazard dams by the DCR Office of Dam Safety.

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.[73]

The impact of a drought would vary among Colrain residents depending on the type of well serving town buildings, local businesses and homes. Participants in the MVP workshop noted that private wells throughout town are vulnerable to drought and expressed concern about decreased water quality and quantity townwide. The Town could explore possible sources of backup water supply.

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.[74]

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[73] MassWildlife Climate Action Tool: https://climateactiontool.org/content/drought. Accessed March 8, 2019.
[74] Catanzaro, Paul, Anthony D'Amato, and Emily Silver Huff. *Increasing Forest Resiliency for an Uncertain Future*.

Extreme Temperatures

A primary mitigation measure for extreme temperatures is establishing and publicizing warming 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.

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.

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 can be encouraged to 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.[75]

All Hazards

Colrain's shelters are located within the floodplain, which represents a vulnerability in the event that the shelter is inundated by floodwaters and becomes unusable. Also, if Rte. 112 is impassable and residents can't access the shelter, a back-up is needed. Identifying shelters outside of the floodplain and obtain funding to equip them as needed was a high priority recommendation in the 2018 Municipal Vulnerability Plan.

A regional sheltering plan that identifies regional shelter sites was completed for Franklin

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University of Massachusetts Amherst, University of Vermont, USDA Forest Service. 2016

[75] MassWildlife Climate Action Tool: https://climateactiontool.org/content/maintain-or-restore-soil-quality-limit-recreational-impacts. Accessed March 8, 2019.

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. Colrain officials can participate in this process to ensure its residents have clear guidance on where to shelter during an emergency.

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 Colrain had numerous policies, plans, practices, programs and regulations in place that help to mitigate the impact of natural hazards in the town. 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	Hazard	Current Effectiveness / Improvements since 2014
Floodplain District	Regulation	Located within "Building Requirements" section – not a separate section Encroachments prohibited unless certified by a registered engineer will not result in increase in flood levels during base flood event Must meet State Building Code Mobile Homes prohibited in floodway	Flooding	Somewhat effective for regulating new development within the 100-year floodplain. Consider limiting new development within the 100-year floodplain. When the state issues their model bylaw in 2020 or 2021, use it to review and update Colrain's bylaw.
Impervious Cover	Regulation	Maximum lot coverage: 70% in Village Districts, 25% in Rural Districts, and	Flooding	Effective for limiting total impervious cover to reduce or minimize

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Table 4-1: Existing Mitigation Capabilities				
Strategy	**Capability Type**	**Description**	**Hazard**	**Current Effectiveness / Improvements since 2014**
		50% in Commercial/Industrial Districts		stormwater runoff.
OSRD/NRPZ	Regulation	Allowed by SPR Single family homes only Rural and Commercial/Industrial Districts. Not allowed in Villages Site plan must include: measures to prevent soil erosion, increased runoff, and flooding, and to manage stormwater; preliminary drainage calculations (definitive calculations to be included with definitive subdivision plan); Minimum size of 10 acres under single ownership Minimum of 35% protected open space, not including wetlands, floodplains, existing permanently protected open space, slopes greater than 25%, roadways or accessory uses Includes density bonus for protecting greater percentage of land, and for Agriculture or Forestry Management plans	Flooding, Erosion, Landslides	Effective.

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Table 4-1: Existing Mitigation Capabilities				
Strategy	**Capability Type**	**Description**	**Hazard**	**Current Effectiveness / Improvements since 2014**
Site Plan Review	Regulation	Site plan must include: • Surface drainage strategy that prevents increased drainage off-site or pollution; • Existing vegetation that will be left undisturbed and proposed landscape features, including the location and a description of screening, fencing and plantings using non-invasive species	Flooding, Invasive Species	Somewhat effective. Review criteria does not include specific stormwater/ drainage language.
Subdivision Regulations	Regulation	Design standards for roads include street grade regulations (six to ten percent maximum). Utilities (Electric and Phone): The Town requires all utilities for new subdivisions to be underground	Severe Winter Storms	Design standards are somewhat effective. Lack an Erosion/sediment Control element. Somewhat effective for ensuring that utility service is uninterrupted by severe storms in new areas of residential development.
Large Scale Ground-Mounted Solar Photovoltaic Installations	Regulation	Site plan requires locations of floodplains and inundation areas for moderate or high-hazard dams that would impact the project site; Requires stormwater and vegetation controls as part of O&M plan The facility shall be designed to minimize impacts to agricultural and environmentally sensitive land and to be compatible with continued agricultural	Flooding, Dam Failure	Effective.

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Table 4-1: Existing Mitigation Capabilities				
Strategy	**Capability Type**	**Description**	**Hazard**	**Current Effectiveness / Improvements since 2014**
		use of the land whenever possible Allows use of herbicides by licensed personnel only		
Stormwater Management	Regulation	Runoff and drainage must be treated on-site Rational Method or NRCS Method should be used Design for 25 year storm frequency Catch basins should be placed on sides of road Where a portion of a subdivision lies within an aquifer recharge area, storm drainage shall be directed, when appropriate, to retention basins in order to artificially recharge the groundwater Leaching catch basins may be required	Flooding	Effective
Vegetation Trees	Regulation	Subdivision regulations state that clearing or evacuating should not be started on any part of the street until the Tree Warden or other party designated by the Select Board has designated, in writing, those trees which are to remain in the tree belt. Such trees to be preserved shall be protected during construction by fenders or boxes, and their root systems shall be disturbed as little as possible.	Landslides	Somewhat effective. Does not specify the size of trees to be preserved. Requires street trees no more than 40 feet apart. If overhead wires, trees should be planted in front yards.

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Table 4-1: Existing Mitigation Capabilities				
Strategy	**Capability Type**	**Description**	**Hazard**	**Current Effectiveness / Improvements since 2014**
Town of Colrain Open Space and Recreation Plan	Plan	Inventories natural features and promotes natural resource preservation in the town, including areas in the flood plain; such as wetlands, aquifer recharge areas, farms and open space, rivers, streams and brooks.	Flooding, Invasive Species	The plan has expired. An updated and approved plan is effective in identifying sensitive resource areas, including flood plains and encourages forestland and farmland protection, which will help conserve the town's flood storage capacity.
Participation in the National Flood Insurance Program (NFIP)	Program	As of 2018, there were six homeowners with flood insurance policies.	Flooding	Effective, provided that the town remains enrolled in NFIP.
State Building Code	Regulation	The Town of Colrain has adopted the State Building Code	Earthquake, Fire, High Winds, Severe Winter Storms	Effective.
Zoning Bylaws	Regulation	Wireless Communications: Requires a Special Permit from the Planning Board. The setback distance from property lines shall be a minimum distance at least equal to the height of the wireless communication facility, plus twenty (20) feet and the distance from all dwellings shall be at least 500 feet.	Wind Related Hazards	Effective.

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Table 4-1: Existing Mitigation Capabilities				
Strategy	**Capability Type**	**Description**	**Hazard**	**Current Effectiveness / Improvements since 2014**
Zoning Bylaws	Regulation	Mobile Homes: Mobile homes occupied for more than thirty (30) days for housing or business purposes shall conform to all zoning and other regulations and requirements affecting permanent dwellings. In addition, mobile home parks are prohibited.	Wind Related Hazards	Effective.
Sheltering Plan	Plan	The Colrain Central School is the shelter identified for victims of hurricanes and tornados.	Wind Related Hazards	Somewhat effective. Ensure that identified shelters have sufficient back-up utility service in the event of primary power failure. Shelter is within the mapped River Corridor and possibly the floodplain.
Burning Permits	Regulation	Residents are permitted to obtain burn permits over the phone. State police personnel provide information on safe burn practices.	Wildfire	Effective.
Subdivision Review	Regulation	The Fire Department is involved in the review of subdivision plans.	Wildfire	Effective.
Public Education/Outreach	Program	The Fire Department has an ongoing educational program in the school.	Wildfire	Effective.

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Table 4-1: Existing Mitigation Capabilities				
Strategy	**Capability Type**	**Description**	**Hazard**	**Current Effectiveness / Improvements since 2014**
Blackboard Connect Emergency Notification System	Program	Colrain's emergency alert system allows town officials to contact residents in the event of large-scale accidents, natural hazards or public health emergencies.	All hazards	Effective. Continue to ensure that residents are signing up for the program and can be reached in the event of an emergency.
Municipal Vulnerability Preparedness Program	Plan	Colrain completed the MVP planning process and was designated an MVP Community.	All hazards	Effective.

4.3 HAZARD MITIGATION GOAL STATEMENTS AND ACTION PLAN

As part of the multi-hazard mitigation planning process undertaken by the Colrain 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 Colrain 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.

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Hazard Mitigation Goals

Based on the findings of the Risk Assessment, public outreach, and a review of previous town plans and reports, Colrain 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, and area of occurrence. The Committee also reviewed the Town's Existing Mitigation Strategies (Table 4-1) and the work completed since the 2014 plan (Table 4-4) to determine the Priority Level for each hazard.

The Committee developed problem statements and/or a list of key issues for each hazard to summarize the vulnerability of Colrain'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).

Table 4-2: Hazard Priority Level Rating

Natural Hazard	Overall Hazard Vulnerability Rating	Priority Level
Severe Winter Storms	High Risk	High
Flooding	Medium Risk	High
Hurricanes / Tropical Storms	Medium Risk	Medium

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Table 4-2: Hazard Priority Level Rating		
Natural Hazard	**Overall Hazard Vulnerability Rating**	**Priority Level**
Severe Thunderstorms / Wind / Microbursts	Medium Risk	High
Extreme Temperatures	Medium Risk	Medium
Landslides	Medium Risk	Medium
Drought	Medium Risk	Low
Invasive Species	Medium Risk	Low
Dam Failure	Low Risk	Low
Wildfires	Low Risk	Low
Tornadoes	Low Risk	Low
Earthquakes	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 the work of the Committee, as well as the hazard identification and risk assessment (Section 3) and the information in Tables 4-1, 4-2 and 4-4 of this plan.

Prioritization Methodology

The Colrain 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.

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- **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:

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- 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 Colrain 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 Colrain 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".

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Table 4-3: 2020 Colrain 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	Coordinate with VT Yankee and other affected towns to arrange periodic table-top drills to confirm that the Code Red System at the closed Vermont Yankee nuclear power plant will continue to be a reliable source of emergency information for the Town as the plant is decommissioned, and if not, determine how the Town will be notified in the event of emergencies at Vermont Yankee.	Manmade Hazards	VT Yankee, Town Administrator, Police Department, Select Board, Board of Health	Low	VT Yankee, Town, MEMA	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate	S	2014 High / 2020 High	Progress made and work is ongoing. Action description has been updated and carried over from 2014 plan. Colrain has implemented their own emergency alert system, Blackboard Connect and the townhas an agreement with Vermont Yankee to use their Code Red System for disseminating emergency information.
Critical Facilities & Infrastructure	Hire an engineering consultant to identify sources and necessary infrastructure and cost estimates for feasible options for a municipal emergency back-up drinking water supply.	Multiple Hazards	Emergency Management Director and Select Board; Colrain	Low - Medium	USDA, Community Development Block Grants, Economic Development Administration (EDA) Grants, MVP, MassDEP	Year 3	S, I	2014 Medium / 2020 Medium	Action description has been updated and carried over from 2014 plan. This has not yet been started due to lack of funding and staffing capacity. This Action Item was also identified in the 2018 MVP Plan.
Local Plans & Regulations	Identify and maintain a list of residents requiring additional assistance (special needs list) and update annually. Utilize existing emergency preparedness outreach materials on westernmaready.gov and other sources to disseminate information through the Town newsletter, the Town website, and at local events on what to include in a 'home survival kit,' how to prepare homes and other structures to withstand flooding and high winds, and the proper evacuation procedures to follow during a natural disaster as well as which local radio stations provide emergency information. Review materials annually and update as needed.	Multiple Hazards	Police Department, Fire Department, and Emergency Management Director	Low	Town	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate	S	2014 High / 2020 High	The list is updated annually and the Town conducts welfare checks on these individuals during states of emergency. The Town will expand its outreach to all residents as outlined in the action item.

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Table 4-3: 2020 Colrain 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	Hire consultant to conduct a feasibility study that includes an assessment of the current agreement with the Town of Colrain and Barnhardt regarding the Town's use of the Barnhardt sewer plant for residents in the Griswoldville area of town. Determine the Town's role/responsibility for providing sewer service to these homes in the event of Barnhardt closing. Assess any other areas of Town where there are concerns about the viability of sewage treatment (private or public). Evaluate feasible options and prepare cost estimates.	Multiple Hazards	Select Board, Board of Health, Conservation Commission	Medium	Town, USDA, EDA, MVP	Year 2	S, I, E	2014 Medium 2020 Medium	Action description has been updated and carried over from 2014 plan. This Action Item was also identified in the 2018 MVP Plan. This is a complicated issue involving many stakeholders. Some progress has been made and work is ongoing. The Town has conducted the 2014 Colrain Center Village Master Plan.
Critical Facilities & Infrastructure	Seek funding and technical assistance to close or dig out the existing, uncapped landfill, stabilize surrounding slopes and riverbanks adjacent to the West Branch of the North River, and to prepare the site for critically needed facilities and infrastructure upgrades, including a new Fire Department facility and community septic system.	Flooding, Hurricanes, Tropical Storms, Microbursts, Thunderstorms	Highway Department, Select Board	High	Town, HMGP, MVP	Years 2 - 3	S, I, E	2020 High	New Action Item. This Action Item was also identified in the 2018 MVP Plan.
Critical Facilities & Infrastructure	Seek funding to relocate the Town's road salt shed and Highway garage, which are vulnerable to flooding of the North River, and equip the reconstructed Highway Facilities with backup power.	Flooding, Hurricanes, Tropical Storms, Microbursts, Thunderstorms	Highway Department, Select Board	High	Town, HMGP, MVP	Year 0-1 with construction anticipated to be complete by Year 2	S, I	2014 High	Action description has been updated and carried over from 2014 plan. This Action Item was also identified in the 2018 MVP Plan.

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Table 4-3: 2020 Colrain 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	Hire consultant to help the town prioritize flood resiliency projects identified in previous fluvial geomorphic and river corridor mapping projects and other regional watershed resiliency studies. Prepare final designs, cost estimates and construction bid documents for high priority projects that provide flood resiliency and protect critical facilities (e.g., Town salt shed, Fire Department, and Highway Department storage yard), infrastructure (e.g., Rte.112 and numerous bridges), farms and homes. Previously identified projects include those that: ✓ Provide flood flow attenuation and storage (floodplain reconnection for both branches of the North River and mainstem North River and Green River; attenuation asset projects in upland watershed areas – chop & drop) ✓ Stabilize eroding river banks and landslide prone areas along these rivers ✓ Remove silt, cobbles, wood and other debris that have accumulated under and around bridges and culverts due to excessive sediment load and degraded fluvial geomorphic function of the rivers and streams in Colrain.	Flooding, Hurricanes/Tropical Storms, Landslides	Select Board	High	FEMA PDM, USDA NRCS, MassDEP 319 grant program, MVP	Years 2-4	S, I, E	2014 Medium _____ 2020 High	Several related Action Items have been consolidated, updated and carried over from the 2014 plan. Action Items were also identified in the 2018 MVP Plan.

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Table 4-3: 2020 Colrain 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	Develop a culvert management plan for stormwater culverts that do not cross a perennial stream. Conduct field work to document the location and condition of these structures and create an interactive GIS map of culverts. Use plan to prioritize upgrades and seek funding for construction for properly designed/sized culverts that are resilient to flooding and climate change. Seek funding to implement priority projects.	Flooding, Hurricanes, Tropical Storms, Microbursts, Thunderstorms	Highway Department	Medium	Town, MVP, Community Compact, HMGP, 3C funding through FRCOG	Year 2 for culvert inventory project. Years 3-5 for replacement	S, I, E	2014 High 2020 High	This Action Item was updated and carried over from the 2014 plan. This Action Item was identified in the 2018 MVP Plan. The Town does have a Bridge Assessment & Ranking Report prepared by BSC Group in 2018. The report provides information on 33 town owned structures (including some culverts) with 10 priority structures identified for preventative maintenance, repairs and possible replacement. The Town also has the High Risk Culvert mapping and assessment report for structures subject to the MA Stream Crossing Standards prepared by FRCOG that is based on the MassDOT/UMass Stream Crossing Explorer database.
Local Plans & Regulations	Update the Colrain Open Space and Recreation Plan (OSRP), which expired in 2009, to identify and prioritize areas in town that provide climate resiliency benefits as well as habitat, open space and recreation benefits. Leverage available grant funding for open space protection and recreation projects that include climate resiliency co-benefits.	Flooding, Landslide, Drought, Wildfire	Open Space Committee and the Select Board	Low	Town, District Local Technical Assistance	Year 2	S, I, E	2014 Medium 2020 Medium	Action Item is updated and carried over from 2014 plan. No progress to date due to other town priorities and staffing constraints.

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Table 4-3: 2020 Colrain 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	Collaborate with the Shelburne Falls Fire District to hire a consultant to finalize the conceptual designs, update the cost estimate and prepare bid documents for the project identified in 2015 to protect the wells from flooding from the East Branch North River. Evaluate the need and cost of elevating the wellheads about flood level.	Flooding	Select Board, Shelburne Falls Fire District	Medium	MVP, USDA, EDA	Year 2	S, I	2014 Medium --- 2020 Medium	Action Item updated and carried over from 2014 plan. Some progress has been made. This project was identified in the 2020 Shelburne Multi-Hazard Mitigation Plan. The project would primarily benefit the Towns of Buckland and Shelburne, though some Colrain residents are also part of this water district. Follow Buckland and Shelburne's progress towards siting a new public drinking water supply source, which would serve in addition, or to replace the vulnerable wellheads in Colrain.

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Table 4-3: 2020 Colrain 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	Purchase software, tablets and GPS devices to track critical infrastructure and structures vulnerable to climate change and natural hazards, including: dams, beaver dams, roads, bridges, culverts, roadside trees (adjacent to power lines), etc. Use software to store condition information and problem areas. Database will help the town prioritize replacements (culverts) and tree maintenance (pruning/removal) to reduce the risk to property and infrastructure hazard events. Use to maintain a list of areas where repetitive power outages occur. Track and ensure Town receives copies of dam Emergency Action Plans and Inspection Reports. Inventory areas along the North River, its branches, and other rivers, brooks, and streams in Town that are prone to ice buildup and ice jams, particularly along Green River Road, which is prone to ice jams.	Flooding, Severe Winter Storms, Hurricanes/ Tropical Storms, Tornadoes, Severe Thunderstorms/Wind/ Microbursts, Ice Jams, Landslides	Highway Department	Low-Medium	Town, MVP	Year 2	S, I, E	2014 High --- 2020 High	Related Action Items have been consolidated, updated and carried over from 2014 plan. Related Action Items were identified in the 2018 MVP Plan. Routine work is ongoing. The Highway Dept. conducts routine tree and culvert maintenance and monitors ice jams.
Critical Facilities & Infrastructure	Research pre- and post-disaster tracking systems for hazards and losses. Identify one appropriate for Colrain and purchase. Implement program, which will improve the Town's hazard mitigation planning and chances of qualifying for various grants. **This software could be the same as described in the previous Action Item**	Multiple Hazards	Emergency Management Director, Highway Superintendent	Low	Town, MVP	Year 2	S, I, E	High	New Action Item.

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Table 4-3: 2020 Colrain 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**
Public Education & Outreach	Work with the Franklin County Regional Housing and Redevelopment Authority to publicize the Community Development Block Grant (CDBG) funding for home rehabilitation for low to moderate income households to bring existing homes up to code and better withstand natural hazard events. Distribute information at the Town Hall, through the Town newsletter, at public events, and on the Town website.	Multiple Hazards	Select Board, Franklin County Regional Housing & Redevelopment Authority (HRA)	Low	Community Development Block Grants	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate	S, I	2014 High --- 2020 High	The Town has an agreement with the Franklin County Regional Housing and Redevelopment Authority (HRA) to run the program on a yearly basis when funding is available. Funding is not guaranteed for future years.
Local Plans & Regulations	To reduce the risk of flooding and fluvial erosion hazards and damage to infrastructure from high flow and flooding events in the North River, adopt a River Corridor Protection Zoning Overlay District.	Flooding, Hurricanes/ Tropical Storms, Severe Thunderstorms/Wind/ Microbursts, Landslides	Planning Board	Low	Municipal Vulnerability Preparedness (MVP) Action Grant, Town, District Local Technical Assistance (DLTA)	Year 3	S, I, E	Medium	New Action Item. The River Corridor for the North River was mapped in 2018. FRCOG has a model bylaw developed in 2016.
Local Plans & Regulations	Review and amend the Section 3.4 Flood Plain District of the Town's zoning bylaw using the new state Model Floodplain District Bylaw (will likely be available by 2021) to reduce the risk of flooding and damage to infrastructure and natural resources. Special consideration should be given to further restricting or limiting new development within the 100-year floodplain.	Flooding, Hurricanes/ Tropical Storms, Severe Thunderstorms/Wind/ Microbursts, Landslides	Planning Board	Low	MVP Action Grant, Town, DLTA	Year 3	S, I, E	Medium	New Action Item.
Local Plans & Regulations	To reduce the risk of flooding and damage to infrastructure and natural resources from uncontrolled stormwater runoff, review and update relevant sections of the Colrain Protective Zoning Bylaws and Subdivision Regulations to require or encourage the use of Nature-Based Solutions (NBS) for stormwater management for new development and redevelopment projects.	Flooding, Hurricanes/ Tropical Storms, Severe Thunderstorms/Wind/ Microbursts, Landslides	Planning Board	Low	MVP Action Grant, Town, DLTA	Year 4	S, I, E	Medium	Updated Action Item from 2014 plan. No progress made due to lack of funding and staff capacity and other priorities of the Planning Board.

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Table 4-3: 2020 Colrain 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	Conduct outreach to residents about the flood mitigation benefits of managing and protecting lands in the river corridor. Review corridor maps with residents at public meetings and incorporate the maps into Town plans, such as the Open Space & Recreation Plan.	Flooding, Hurricanes, Tropical Storms, Microbursts, Thunderstorms	Planning Board, Conservation Commission	Low	Town, MVP, DLTA	Years 1-5	S, I, E	Medium	New Action Item. This Action Item was identified in the 2018 MVP Plan. River Corridor mapping is discussed in this Hazard Mitigation Plan update and shown on the plan's maps.
Critical Facilities & Infrastructure	Update and expand the Vulnerability Assessment for properties located within the 100-year floodplain and mapped River Corridor, using Assessors' data and other available information.	Flooding, Hurricanes, Tropical Storms, Microbursts, Thunderstorms	Emergency Management Director, Assessors	Low	Town, MVP, DLTA	Year 3	S, I	Medium	New Action Item. The River Corridor was mapped in 2016.
Critical Facilities & Infrastructure	Compile an inventory of the historic structures and landscapes, using GPS coordinates, map all of the buildings and sites and compare to 100 year floodplain mapping and other known areas of flooding and fluvial erosion, such as the River Corridor. Hire a consultant to determine which structures may be at most risk for flooding and options for mitigating flood risks.	Flooding, Hurricanes, Tropical Storms, Microbursts, Thunderstorms	Colrain Historical Commission, Assessors	Low	Town, MVP, Mass Historic Commission	Year 4	I	Low	New Action Item. The River Corridor was mapped in 2016.
Public Education & Outreach	Contact the owners/operators of the Jacksonville Pond and Gates Pond Dams in Vermont and obtain any assessment, inundation mapping, and/or evacuation information for the dams. Agree upon a method for Colrain to receive any relevant updates on these dams in the future.	Dam Failure	Emergency Management Director	Low	Town	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate	S, I, E	2014 Medium 2020 Low	Action Item carried over from the 2014 plan. No progress to date.
Critical Facilities & Infrastructure	Secure and update the information on existing fire ponds in Catamount State Forest. Identify and report to DCR the need for more water supplies for fires suppression.	Wildfire	Fire Department, EMD	Low	Town	Year 2 and implemented in subsequent years (3-5)	S, I, E	Low	New Action Item. This Action Item was also identified in the 2018 MVP Plan.

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Table 4-3: 2020 Colrain 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	Implement forest stewardship practices that produce more climate resilient and stable, successional forested landscapes and which reduce the risk of fire hazards (such as the removal of slash and condition of access roads for fire fighting). Encourage (or require) Fire Department review of Forest Cutting Plans. Work with Town Counsel to develop local regulations to require Fire Department review and oversight of logging in town. Or, amend Conservation Commission's review procedures to include review by Fire Department.	Wildfire	Fire Department, Conservation Commission, Select Board, Town Counsel	Low	Town	Year 2 and implemented in subsequent years (3-5)	S, I, E	Medium	New Action Item. Need to contact DCR to get clarification on state law and review procedures.
Local Plans & Regulations	Identify possible locations in Colrain and/or neighboring towns that could serve as debris management sites.	All Hazards	EMD, Select Board, Conservation Commission	Low	Town, MVP	Year 2 and ongoing	S, I, E	High	New Action Item. Related Action Items identified in the 2018 MVP Plan. The Town has participated in the Franklin County Regional Emergency Planning Committee's (REPC) ongoing project to identify appropriate regional debris management locations.

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Table 4-4: Town of Colrain Complete 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 2014 Plan**	**Current Status**
Local Plans & Regulations	Examine current notification system including feasibility of Reverse 911. Develop a preliminary project proposal and cost estimate and implement plan.	Multiple Hazards	Town Administrator, Police Department, Select Board, Board of Health	Low	Town	S	High	Complete. The Town has Blackboard Connect to provide emergency information to Town residents who participate in the service.
Critical Facilities & Infrastructure	Seek funding to relocate and reconstruct the Town highway garage, which has been impacted by flooding of the North River.	Flooding	Select Board, Highway Department	High	Town, FEMA, USDA Rural Development	I	Medium	Complete. The new Colrain highway garage has been constructed.
Local Plans & Regulations	Collaborate with the Regional Emergency Planning Committee (REPC) to research appropriate vulnerability assessment models for facility and transportation hazardous materials accidents, collect relevant data, and populate model to further prioritize manmade hazard action items.	Manmade Hazards	Emergency Management Director, REPC, FRCOG	Low	Homeland Security, FEMA, FRCOG	S, I, E	High	Obsolete. The Town participates in the Franklin County Regional Emergency Planning Committee (REPC) table-top drills and those provided by Western Regional Homeland Security Council and FRCOG's Emergency Preparedness Program.
Local Plans & Regulations	Seek technical assistance to evaluate whether to join FEMA's Community Rating System based on information in this plan and available through FEMA.	Floods	Planning Board, Select Board, Conservation Commission	Low	Town, DCR Flood Hazard Management Program	S, I	Medium	Obsolete. It is not financially feasible for a small, rural town. No staff or administrative capacity for the program.
Education & Awareness	Educate residents through materials posted on the Town website, Town newsletter, and when issuing burn permits, about the risk of wildfire and brushfire and how to reduce this risk by adopting general fire safety techniques.	Wildfire	Fire Department, Shelburne Dispatch	Low	Town, Rural Fire Assistance	S, I, E	Low	Obsolete. This is done through Shelburne Control. The Fire Department maintains a link to burn permit information on its website.
Public Education & Outreach	Seek funding to 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, EMD, Select Board	Low	Town	S, I, E	Medium	Completed. Enforcement of the State Building Code is underway and ongoing. The Local Project Team determined that it is not necessary to include this as an Action Item in the 2020 Plan.

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5 PLAN ADOPTION AND MAINTENANCE

5.1 PLAN ADOPTION

The Franklin Regional Council of Governments (FRCOG) provided support to the Colrain Hazard Mitigation Committee as they underwent the planning process. Town officials such as the Emergency Management Director and the Town Administrator 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 Colrain 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 Hazard Mitigation Plan for the Town of Colrain were distributed to Town boards and officials, and to surrounding towns for review. Copies were made available at the Town Hall and the library, 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 Colrain Board of Selectmen voted to adopt the plan (see Appendix C).

5.2 PLAN MAINTENANCE PROCESS

The implementation of the Colrain Hazard Mitigation Plan will begin following its approval by MEMA and FEMA and formal adoption by the Colrain 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 Colrain Hazard Mitigation Planning Committee will oversee the implementation of the plan.

Monitoring, Evaluating, and Updating the Plan

The measure of success of the Colrain 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.

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Implementation Schedule

Annual Meetings

The Colrain Hazard Mitigation Planning Committee will meet on an annual basis or 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 Colrain Town Administrator and the Emergency Management Director.

Bi-Annual Progress Report

The Emergency Management Director 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 Emergency Management Director 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 Emergency Management Director 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

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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 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 Colrain Hazard Mitigation Plan will be forwarded to MEMA and to FEMA for approval.

As is the case with many Franklin County towns, Colrain’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.

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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

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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

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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

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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				

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Incorporating the Plan into Existing Planning Mechanisms

2014 Hazard Mitigation Plan

The Town of Colrain has taken steps to implement findings from the 2014 Hazard Mitigation Plan into the following policy, programmatic areas and plans: 2018 Colrain Municipal Vulnerability Preparedness (MVP) Resiliency Plan and the 2018 Development of River Corridor Mapping Procedure with Initial Application in the North River Watershed, MA project completed by the Franklin Conservation District.

2020 Hazard Mitigation Plan

Upon approval of the Colrain 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 Colrain 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/FCCIP
- Select Board

Some possible planning mechanisms for incorporating the Colrain 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. The Town could consider updating its OSRP, which has expired.

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- 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 Hazard Mitigation Plan for the Town of Colrain 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 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 EMD, 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 Colrain's current Bylaws.

Continued Public Involvement

The Town of Colrain 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.

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APPENDIX A Public Participation

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MEETING AGENDA

TOWN OF COLRAIN

MULTI-HAZARD MITIGATION PLAN UPDATE PROJECT

Project Facilitator: Franklin Regional Council of Governments

Town of Colrain

55 Main Road
Colrain, MA 01340

Thursday, June 27 2019

9:00 a.m. – 10:30 a.m.

1. Introductions
2. Overview of Project and Timeline
3. Overview of Hazards and Climate Change Stressors
4. Brief Review and Summary of MVP Process Findings
5. Discussion of River Corridors and Flood Hazard Mitigation (with map exercise) with Nic Miller, Field Geology Services
6. Schedule Next Meeting

Colrain Multi-Hazard Mitigation Plan Update
Project Meeting
June 27, 2019
Sign-in Sheet
Please Print Clearly

Name	Affiliation	Mailing Address/ Email	Phone Number
Kevin Fox	Town of Colrain	bos@colrain-ma.gov	413-624-6306
Joe Kurland	BOS	yosi@ganeydn.com	624-3204
Kimberly MacPhee	FRCOG	kmacphee@frcog.org	
Nicolas Miller	Field Geology Services	nicolas.miller1@gmail.com	207-491-4002
Chris Lannon	Colrain Police	Police@Colrain-ma.gov	624-3038
Kevin French	EMD	frenchhouse@yahoo.com	624-3294
Robert Slawinski	Planning Board	bobby2032@gmail.com	617-314-5127
Eileen Sauvageau	Selectboard	eileencabales@gmail.com	413-624-3294

MEETING AGENDA

TOWN OF COLRAIN

MULTI-HAZARD MITIGATION PLAN UPDATE PROJECT

Project Facilitator: Franklin Regional Council of Governments

Town of Colrain

55 Main Road
Colrain, MA 01340

Thursday, October 24, 2019

2:00 p.m. – 3:30 p.m.

1. Introductions
2. Discussion of Colrain's Risk to Each Hazard Based on the Location, Extent, Probability, and Severity of Hazards.
3. Review of Draft Critical Facilities & Infrastructure Map.
4. Review of Draft Environmental Resources Map.
5. Review of Action Items from 2014 Plan (to be distributed at the meeting).
6. Schedule Next Meeting

Colrain Multi-Hazard Mitigation Plan Update
Project Meeting
October 24, 2019
Sign-in Sheet
Please Print Clearly

Name	Affiliation	Mailing Address/ Email	Phone Number
Kimberly MacPhee		kmacphee@frcog.org	
Allison Gage		agage@frcog.org	
Robert Slajinski	Planning Board Chair	bobby2032@gmail.com	
Eileen Lauvageau		townclerk@colrain-ma.gov	
Kevin Fox		bos@colrain-ma.gov	

APPENDIX B Certificate of Adoption

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CERTIFICATE OF ADOPTION

Town of Colrain, **MASSACHUSETTS**

BOARD OF SELECTMEN

A RESOLUTION ADOPTING THE Town of Colrain

HAZARD MITIGATION PLAN

WHEREAS, the Town of Colrain established a Committee to prepare the 2020 Hazard Mitigation plan; and

WHEREAS, the Town of Colrain Hazard Mitigation Plan contains several potential future projects to mitigate potential impacts from natural hazards in the Town of Colrain, and

WHEREAS, a duly-noticed public meeting was held by the BOARD OF SELECTMEN on Date, and

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

NOW, THEREFORE BE IT RESOLVED that the Town of Colrain BOARD OF SELECTMEN adopts the 2020 Hazard Mitigation Plan, in accordance with M.G.L. Ch. 40.

ADOPTED AND SIGNED this Date.

Name(s)

Title(s)

Signature(s)

ATTEST

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