DRAFT

Town of Shutesbury Hazard Mitigation Plan

Adopted by the Shutesbury Select Board on , 2021
Approved by FEMA on , 2021

Prepared by
Shutesbury Hazard Mitigation Committee

and

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Contents

2 LOCAL PROFILE AND PLANNING CONTEXT

2.1 COMMUNITY SETTING

Shutesbury is located in western Massachusetts, in the hilly upland east of the Connecticut River and west of the Quabbin Reservoir between Wendell, Montague, Leverett, Amherst and Pelham. With an estimated population of 1,755[1] Shutesbury is a small, rural community situated in close proximity to major areas of commerce in Amherst, Deerfield, Montague, and Greenfield. Its landscape consists of narrow and broad river valleys, glacial ravines, ponds and brooks, historic villages, riverside dam remnants, farmhouses, open fields dirt roads, and large shade trees among large areas of contiguous forest and scenic vistas of wooded hillsides. Shutesbury's elevation—1,225 feet at the benchmark in the center of town and 1,305 feet at the highest point—distinguishes it as an insular area of steep terrain compared to surrounding towns, even some of its more hilly neighbors.

Prior to the 1700s, native settlement in Shutesbury was likely limited to small fishing and hunting camps along major waterbodies used by the Nipmuc, Pocumtuck, and Wabanaki Confederacy, who shared Shutesbury as territory.[2] The Town was founded in 1735 by a land grant for the purpose of providing a stopover along the trade and transportation route between Boston and Springfield/Hartford. In 1761 the Town was officially incorporated as Shutesbury, named in honor of a former Governor of the Massachusetts Bay Colony, Samuel Shute. Throughout the eighteenth and nineteenth centuries, high-flowing streams provided power and water for a variety of small mill and farming operations: early settlers built sawmills, gristmills, and a corn mill and by the mid-1800s. Ten water-powered sawmills were producing lumber, railroad ties, shingles, barrel staves, laths, and components for chairs and other wood products. During the period from 1723 to 1860, school districts were established, the northern end of Shutesbury was apportioned to Wendell, and land was purchased for a cemetery. The center of town built up throughout the 19th century, including a library and churches. In the first quarter of the 20th century, a large amount of land in Shutesbury was bought by the state's Metropolitan District Commission and the Town of Amherst for the creation of public drinking water supply the protection of the supply's watersheds.

After peaking at over 1,000 residents in 1820, Shutesbury's population fell to a low of around 200 in 1940. Then in the 30 years between 1970 and 2000 the population increased by 262

[1] U.S. Census Bureau 2015-2019 American Community Survey 5-Year Estimates.
[2] native-land.ca, accessed 11-6-2020

percent, up to 1,810 residents by the year 2000. This was facilitated by developments in transportation and communication, as well as the expansion of the University of Massachusetts. Similar to other towns in western Massachusetts, Shutesbury has witnessed a conversion from an agrarian lifestyle to a largely residential community whose residents commute elsewhere for their livelihood. Although a number of multi-generational families continue to live in town—engaged in forestry and agricultural activities—this percentage of the population has decreased over the past few decades.

Shutesbury has a Fiber-Optic-To-The-Home (FTTH) high-speed internet network owned by the Town. ShutesburyNET is operated under the telecom authority of Crocker Communications, which contracts with third parties for Network Operator, Internet Services Provider (ISP), and maintenance functions. ShutesburyNET ties into the internet via the Massachusetts Broadband Institute "last mile" network.

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.[3]

The 2016 land cover/land use dataset shown in Table 2-1 reveals the relationship between land use and land cover in Shutesbury. For example, most of the *land cover* is forests but the *land use* is primarily residential.

Table 2-1: Shutesbury 2016 MassGIS Land Cover and Land Use Data

Land Cover	Acres		Land Use	Acres
Bare Land	75		Agriculture	250
Cultivated	0		Commercial	38
Deciduous Forest	5,667		Forest	4,645
Developed Open Space	236		Industrial	4
Evergreen Forest	9,730		Mixed use, other	2
Grassland	231		Mixed use, primarily commercial	0
Impervious	241		Mixed use, primarily residential	0
Palustrine Aquatic Bed	9		Open land	2,391
Palustrine Emergent Wetland	8		Recreation	546
Palustrine Forested Wetland	533		Residential - multi-family	141

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

Table 2-1: Shutesbury 2016 MassGIS Land Cover and Land Use Data				
Land Cover	**Acres**		**Land Use**	**Acres**
Palustrine Scrub/Shrub Wetland	48		Residential - other	0
Pasture/Hay	73		Residential - single family	2,741
Scrub/Shrub	30		Right-of-way	150
Water	359		Tax exempt	6,240
			Unknown	83
			Water	105

According to the 2016 MassGIS data in Table 2-1, approximately 88.8 percent of Shutesbury's land cover is forest. Less than 2 percent of the town is classified as agricultural land use, and 16.6 percent of the town is classified as residential land use. Although the town developed as an industrial center, there are only a few commercial or industrial businesses located in town. Less than 1 percent of the total area in town is comprised of commercial or industrial land uses.

Population Characteristics

As of 2019, Shutesbury's total population is estimated to be 1,755 with 897 total households, 380 families, and a population density of 67 people per square mile.[4] The 2019 population figure represents a 0.03 percent increase since 2000.[5]

Environmental Justice Populations

The State of Massachusetts defines an environmental justice community as one that meets any of the following conditions:

- 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, Shutesbury does not currently have any environmental justice populations. Approximately 95 percent of the Town's population is white; the next largest racial/ethnic group is Latinx at .04 percent of the total population. The annual median household income of Shutesbury, $85,114 in 2019, is above 65 percent of the state's annual median household income of $68,563. And as of 2019, there are 13 households that have Limited English Proficiency (LEP).

[4] U.S. Census Bureau 2015-2019 American Community Survey 5-Year Estimates.
[5] U.S. Census Bureau 2000 Census

Current Development Trends

Major employment centers near Shutesbury include Greenfield, the Franklin County Seat (about 17 road miles), Amherst, home of UMass (10 miles), Northampton (18 miles), and Springfield (36 miles). The town's proximity to Amherst College and the University of Massachusetts has attracted residents who commute to these and the other colleges in the Five-College Area. Shutesbury's distance from other major employment centers and lack of direct access to major railroads or highways has limited growth and preserved many of the town's rural landscapes.

Shutesbury's zoning by-laws were completely revised in 2008 to encourage development along roadsides and in town center, and to discourage backlot development and low-density subdivision. The Town is divided into four main districts: Roadside Residential (RR), Town Center (TC), Lake Wyola District (LW), and Forest Conservation (FC). The bylaws contain many provisions designed to promoted and maintain open space. According to the bylaw's purpose section, the zoning bylaw's mechanisms are designed for the "protection of large contiguous tracts of forest land to maintain commercial forestry as a viable agricultural activity; the protection of water in the watersheds that supply drinking water to Amherst, Massachusetts, the Boston metropolitan area, and the Town of Shutesbury; the maintenance of a rural road system that includes many miles of unpaved roads; the protection of significant wildlife habitat in a healthy forest ecosystem; the allowance for mixed-use development in the Town Center area; the diversification of available housing types; greater affordability in housing; economic opportunities for residents including home-based businesses; and the clustering of residential development in compact settlements leaving large areas of open space undeveloped."[6]

According to information provided by the Franklin County Cooperative Inspection Program, between July 2010 and June 2020, seventeen (17) residential building permits for the construction of new, replacement, or accessory units were issued.

Table 2-2: New residential permits issued in Shutesbury per year, 2010-2019	
Year	# of building permits issued
2010	2
2011	4
2012	0
2013	3

[6] Shutesbury Planning Board, Town of Shutesbury Zoning Bylaw, 2008, p. 1

Table 2-2: New residential permits issued in Shutesbury per year, 2010-2019	
Year	# of building permits issued
2014	0
2015	1
2016	2
2017	2
2018	1
2019	1
2020	1
Total	**17**

FRCOG staff reviewed the addresses of the building permits and determined, based on information described below, that new development has occurred outside of known hazard areas such as floodplains. Ten of these residential permits were issued for houses on or proximate to Lake Wyola (one new home and nine replacement homes). There has not been any commercial development in the town in the last five years. However, the installation of ShutesburyNET, a fiber-optic high speed internet network, in 2019 may attract new in-home businesses.

According to 2005 MassGIS Land Use/Land Cover data, 233 acres lie within the 100-year floodplain in Shutesbury and twenty-seven (27) dwelling units are located in the floodplain. However, floodplains were drawn in Shutesbury's 1980 FIRM to include the lakes, ponds, and reservoirs (excluding the Quabbin Reservoir). Therefore, some portion of the 233 floodplain acres is actually open water, not floodplain. Newer Mass GIS land use/land cover data from 2016 indicate no change in the number of acres in the floodplain acres in Shutesbury or the number of dwelling units located within the floodplain. Franklin County does not have digital floodplain maps, significantly limiting flood hazard analysis. As noted below, FEMA is currently updating the floodplain maps for Shutesbury. Once the update is complete, a more accurate understanding of any recent development within the floodplain will be possible.

Because development in Shutesbury since the previously approved plan appears to be outside known hazard-prone areas, it is not expected to increase the town's overall vulnerability to flooding or other hazards. To assess and update the community's vulnerability to hazard events, the Committee completed an exercise to discuss the results of the Risk Assessment (see Section 3) and used the results to update the Overall Hazard Vulnerability Rating for each hazard. The ranking is qualitative and is based, in part, on local knowledge of past experiences with each type of hazard, the anticipated probability of occurrence, severity of impacts, and area of occurrence for each hazard given historical and climate change data, and a discussion of the type and location of current development trends and new development in Town, and other local knowledge.

National Flood Insurance Program Status

Shutesbury is a participating member of the National Flood Insurance Program. Currently there are two flood insurance policies in effect in Shutesbury, for a total insurance value of $525,000. No losses have been paid.

Shutesbury's floodplain map was last updated in 1980. In 2018, the Federal Emergency Management Agency (FEMA) initiated a 5-10 year process to update the floodplain maps for Franklin County towns, which will primarily involve using recent LiDAR topographic mapping and limited field surveys to create digital floodplain maps and correcting some anomalies in the 1980 maps (floodplains on the tops of hills) that may be revealed by the LiDAR mapping.

Infrastructure

Most of the infrastructure in Shutesbury consists of roads and bridges. Shutesbury's transportation infrastructure may prove problematic in the case of a natural disaster such as flooding, because some potential evacuation routes run alongside streams and rivers, and may be impassable.

Roads and Highways

The major artery running through town is Leverett Road, which connects Shutesbury with Leverett and Amherst to the west and Route 202 to the east. Shutesbury residents can travel north to Wendell, Montague, and Greenfield via Wendell and Montague Roads and south to Pelham, Amherst, and Belchertown via West Pelham and Pelham Hill Roads and Route 202. Route 202 runs between Springfield and points north. The closest access to I-91, Franklin County's major north/south route, is in South Deerfield. The town has a total of 39 miles of road, of which approximately sixteen miles are gravel.[7] Massachusetts DOT is responsible for 3.1 miles of road (on Route 202) and DCR for 5.1 miles of road (in the Quabbin Reservation and Shutesbury State Park) in Shutesbury; the Town maintains the remaining 31 percent.

Rail

There are no rail lines that run through Shutesbury.

Public Transportation

[7] FRCOG road data: "Miles of Town Maintained Roadway by surface type"

While the Franklin Regional Transit Authority (FRTA) and the Pioneer Valley Transit Authority (PVTA) provide active service to towns to the west, there are no regular transit services, paratransit, or demand-response service available to the town of Shutesbury.[8] A 2016 feasibility study for fixed-route transit concluded that though beneficial to residents, a route through Shutesbury and neighboring towns would not be financially sustainable.

Public Drinking Water Supply

The Town of Shutesbury does not have a municipal water or sewer system but public water supply wells do serve the Shutesbury Elementary School, Lake Wyola State Park, the Pine Brook Camp and Conference Center, the Shutesbury Athletic Club, and the Sirius Community. In general, Shutesbury residents on private wells and those serviced by public wells experience good-quality water but relatively low yields. The relatively low yields of bedrock aquifer wells mostly preclude the possibility of installing of new community water supplies. And although higher permeability and potential yields render stratified drift deposits better candidates for siting community water supply wells, their limited horizontal and vertical extents and the limited sizes of their recharge areas make this possibility unlikely as well. Up-to-date and effective regulations for new construction are necessary to assure that every household has an uncontaminated water supply in the future.[9]

Sewer Service

There is no municipal sewer service in Shutesbury, which means that everyone has a private septic system to maintain. Each household in town has its own private septic sewer system. There are no plans for a community sewage disposal system. The Town has discussed the construction of a small community wastewater treatment plant both town center and in the area of Lake Wyola to service the dense development of cottages and year-round houses around the lake that have shallow wells and are located on poor soils with a high water table. The Board of Health does a careful job of making sure new septic systems and wells are properly separated from one another.

Emergency Shelters

The 2014 Shutesbury electronic Comprehensive Emergency Management Plan (CEMP) CEMP outlines“an emergency management program for planning and response to potential emergency or disaster situations,” which includes emergency shelters to accommodate victims of disaster events.

The elementary school currently serves as the Town’s main emergency shelter; according to the

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[8] FRCOG, *2020 Franklin County Regional Transportation Plan*, 2019.

[9] Shutesbury Open Source and Recreation Plan, 2015

Emergency Management Director, the elementary school has a 100 kW back-up generator on-site that was installed in August 2012 and will power the entire school. However participants in the community workshop for the Municipal Vulnerability Plan expressed concern over the potential impact of using the shelter while school is in session and the subsequent safety implications for children.

In addition, the Town Hall and Fire Department are equipped with generators, and the Fire and Highway Departments with mini-splits that have good cooling capacity. The Turners Falls High School is identified in the eCEMP as a regional mass care shared facility.

Natural Resources

Shutesbury's landscape is largely composed of steep, heavily forested ridges that slope to the east in the eastern part of town, rolling, wooded hills and flats in the central and western parts of town, and abundant interspersed areas of forested and non-forested wetlands. Approximately 43 percent of Shutesbury is permanently protected from development. Much of this land and water is owned by the Massachusetts Department of Conservation and Recreation (DCR) for the protection of the Quabbin Reservoir drinking water supply. Additionally, DCR owns and manages the Lake Wyola State Park/Carroll A. Homes Recreation Area, the Great Pond portion of Lake Wyola, and the Shutesbury State Forest. These areas are open to the public for recreational use. In addition, the Shutesbury and Amherst Conservation Commissions manage conservation land in Shutesbury, which is also considered permanently protected from development.

Water Resources

Two public agencies have direct interests in maintaining the high quality of water in the Quabbin Reservoir and Atkins Reservoir. Large areas of town are owned and maintained as protected watersheds by the Division of Water Supply Protection of the Massachusetts Department of Conservation and Recreation (DCR) and the Town of Amherst. In addition to the reservoirs, there is one large lake (Lake Wyola), a number of ponds (including Ames Pond, Baker Pond, and Dudley Marsh), numerous beaver impoundments, and a number of streams in Shutesbury.

Watersheds and Surface Waters

Surface water in the western half of town drains to the west as part of the Connecticut River Watershed and is composed of the Adams Brook Sub-watershed, the Sawmill Brook Sub-watershed, and the Roaring Brook Sub-watershed, as well as a small section of Amethyst Brook that drains south into the Fort River in Amherst. This small section of Amethyst Brook is located in the south-central section of town just north of the border with Pelham and is tributary to a public water supply for the Town of Amherst, the Hawley Hill Intake (which is located in Pelham). The headwaters of Amethyst Brook contain both forested and non-forested wetlands. Surface water in the eastern half of town is drains to the southeast as part of the Chicopee River Watershed and is composed of the Swift River Sub-watershed. Within these sub-watersheds, the Sawmill River, Roaring Brook, Dean Brook, Nurse Brook, Adams Brook, the West Branch of the Swift River, Atherton Brook, Camel Brook, Cobb Brook and Amethyst Brook have been designated by the Division of Fisheries and Wildlife (MassWildlife) as cold-water fisheries and are considered to be high-quality trout streams.

Aquifers

An aquifer is an underground body of water that is typically found in layers of sand deposited during the glacial period. When it rains heavily, a large percentage of water infiltrates the soil, slowly migrating down to the saturated zone. The area between the saturated zone and the unsaturated zone is known as the water table of the aquifer. When more rain enters the aquifer than is taken out, the water table rises. The US Geological Survey (USGS) and the Office of Massachusetts Geographic Information Systems (MassGIS) have mapped subsurface conditions that support low to medium yield aquifers. According to the USGS and MassGIS there are low-to medium yield aquifers located in the vicinity of the following water bodies:

- Lake Wyola and Ames Pond;
- Dudleyville marsh;
- West Branch of the Swift River;
- Roaring Brook; and
- Dean Brook.

Low to moderate yield aquifers could provide enough water for a small community supply. It is estimated by DEP that low to medium yield aquifers can produce 0-50 gallons per minute (gpm).

Wetlands

The town's wetlands were inventoried by the U.S. Fish and Wildlife Service's National Wetlands Inventory (NWI) Program in the late 1970s. This survey identified the majority of large wetlands (greater than five acres) and therefore does not represent a comprehensive inventory of these valuable resources. Based on the NWI maps, there are over 600 acres of palustrine wetlands and roughly 400 acres of lacustrine wetlands in Shutesbury. The latter are associated with Lake Wyola, Dudley Marsh, the Atkins Reservoir, and the Quabbin Reservoir. Because of the town's rolling topography, most wetlands are connected by perennial or intermittent streams. Much of the rest is located along the headwaters of the aforementioned water bodies. Isolated wetlands (not connected to surface waters) represent a small percentage of Shutesbury's wetland acreage, although they are quite numerous.

Beaver Dams

Beaver activity has been increasing over the past decade. Several wetland areas have been flooded by beaver dam construction. As a result, their vegetation has changed from forested wetland to marshy habitat. Sometimes beaver activity is detrimental to property, causing problems for local land owners (e.g., flooding of wells, septic systems, lawns, out-buildings, and roadways). Affected individuals must contact the Board of Health and Conservation Commission for advice and permission to alleviate the beaver problem. Beaver dams will be discussed further in the dam failure section.

Forests

Shutesbury is almost entirely forested, which provides an abundance of timber and opportunities for recreation, wildlife habitat, the benefits of climate moderation, and the protection of water quality. The town's forests are mainly closed-canopied and middle-aged, having a diversity of species, but no diversity of horizontal or vertical structure. Evergreen forests of pine and hemlock dominate the lowland and riparian areas north and east of Atkins Reservoir; the areas along Dean Brook, Baker Brook, and Roaring Brook; the area northeast of the Dudleyville Marsh and eastward to South Brook; and the area southeast of Ames Pond. Deciduous forests dominate uplands and drier, south-facing slopes on the north-south trending ridge located in the center of town and along the Leverett Town line, just north of Leverett Road. The town is approximately 89 percent forested.

Large blocks of contiguous forestland, such as the Shutesbury State Forest, the Quabbin Reserve lands, and the large blocks between roads protected through the open space zoning bylaw are important resources for several reasons. First they represent an area with a low degree of fragmentation. Wildlife species that require a certain amount of deep forest cover separate from people's daily activities tend to migrate out of fragmenting landscapes. New frontage lots and subdivisions can often result in a widening of human activity, an increase in the populations of plants and animals that thrive alongside humans (i.e. raccoons and squirrels) and a reduction in the species that have larger home ranges and unique habitat needs. Large blocks of forest provide clean water, air, and healthy wildlife populations.

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.[10]

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 historic properties and cultural resources.

Cultural and historic resources help define the character of a community and reflect its past. Currently, there are no resources in Shutesbury that are listed on the National Register of Historic Places, though the state did place the shores of the Quabbin Reservoir on its mapped 1982 scenic landscape inventory. There are over 183 historic resources in town that are listed in the Massachusetts Cultural Resource Information System (MACRIS) database, and are of historic significance to the town. These sites 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. In Table 2-3, the 2014 CEMP OR Committee identified the following cultural and historic resources in Shutesbury.

Table 2-3: Shutesbury Cultural Resources

Resource Name	Resource Location	Resource Type	Materials Contained
Cemetery	Pratt Corner Rd	Cemetery	
Cemetery Commission/Carriage House	158 Leverett Rd	Cemetery; Historical building	
DCR State Park	94 Lakeview Rd	Historical building	
Historical Commission	3 West Pelham Rd	Historical building	Archives; artifacts
Jewish Cemetery of Amherst	218 Leverett Rd	Cemetery	
Locke's Village Cemetery	386 Lockes Pond Rd	Cemetery	
Shutesbury Congregational Church	Town Common Rd	Historical building	Archives
Spear Memorial Library	10 Cooleyville Rd	Library	
Town Hall	1 Cooleyville Rd	Historical building	Archives
Town Hall Annex	12 Wendell Rd	Historical building	Archives

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

2.2 IMPACTS OF CLIMATE CHANGE

Greater variation and extremes in temperature and weather due to climate change has already begun to impact Shutesbury, 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 within the district access climate data, maps, websites, tools, and documents on climate change adaptation and mitigation. The goal of Resilient MA is to support scientifically sound and cost-effective decision-making, and to enable users to plan and prepare for climate change impacts. Climate projections for Franklin County available through Resilient MA are summarized in this section. Additional information about the data and climate models is available on the resilient MA website: http://resilientma.org

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

Rising Temperatures

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

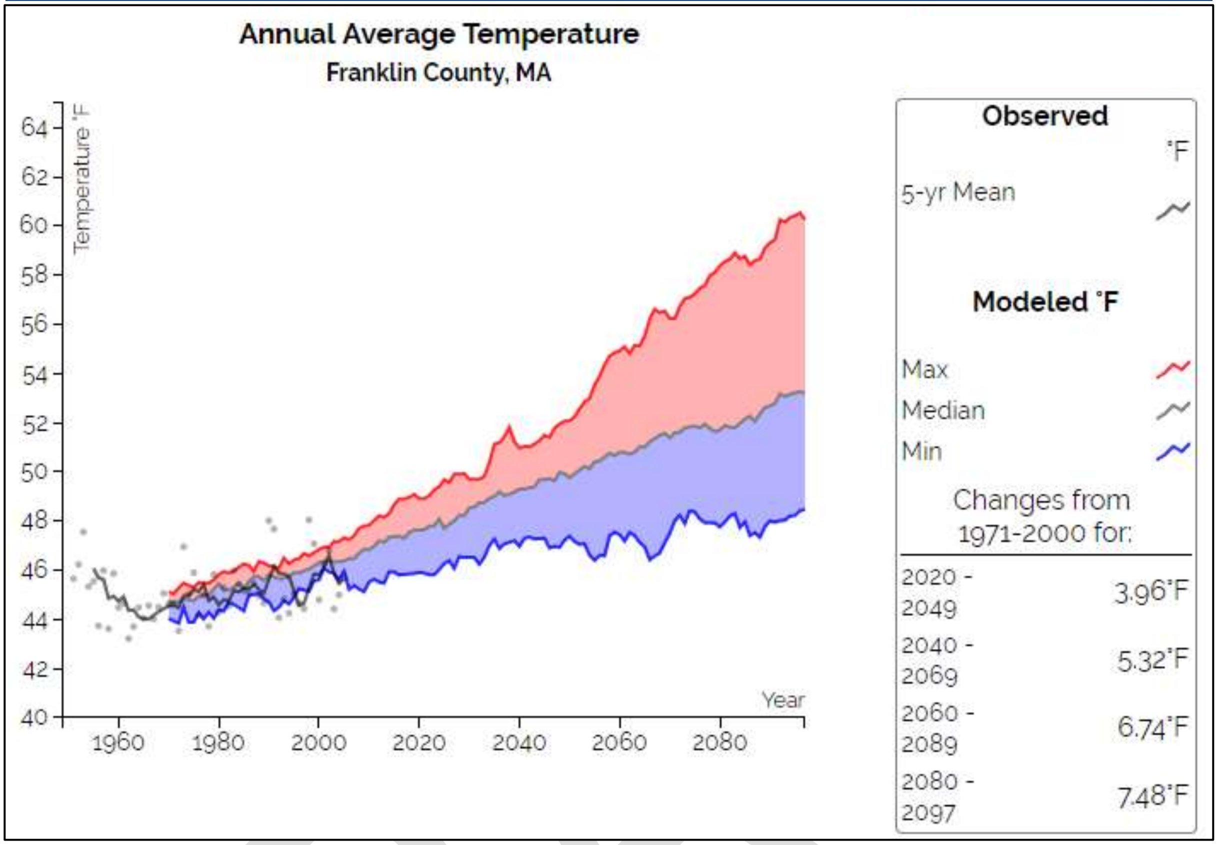
The average, maximum, and minimum temperatures in Franklin County are likely to increase significantly over the next century (resilient MA, 2018). Figure 2-2 displays the projected increase in annual temperature by mid-century and the end of this century, compared to the observed annual average temperature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

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

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

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

Figure 2-2: Projected Annual Average Temperature

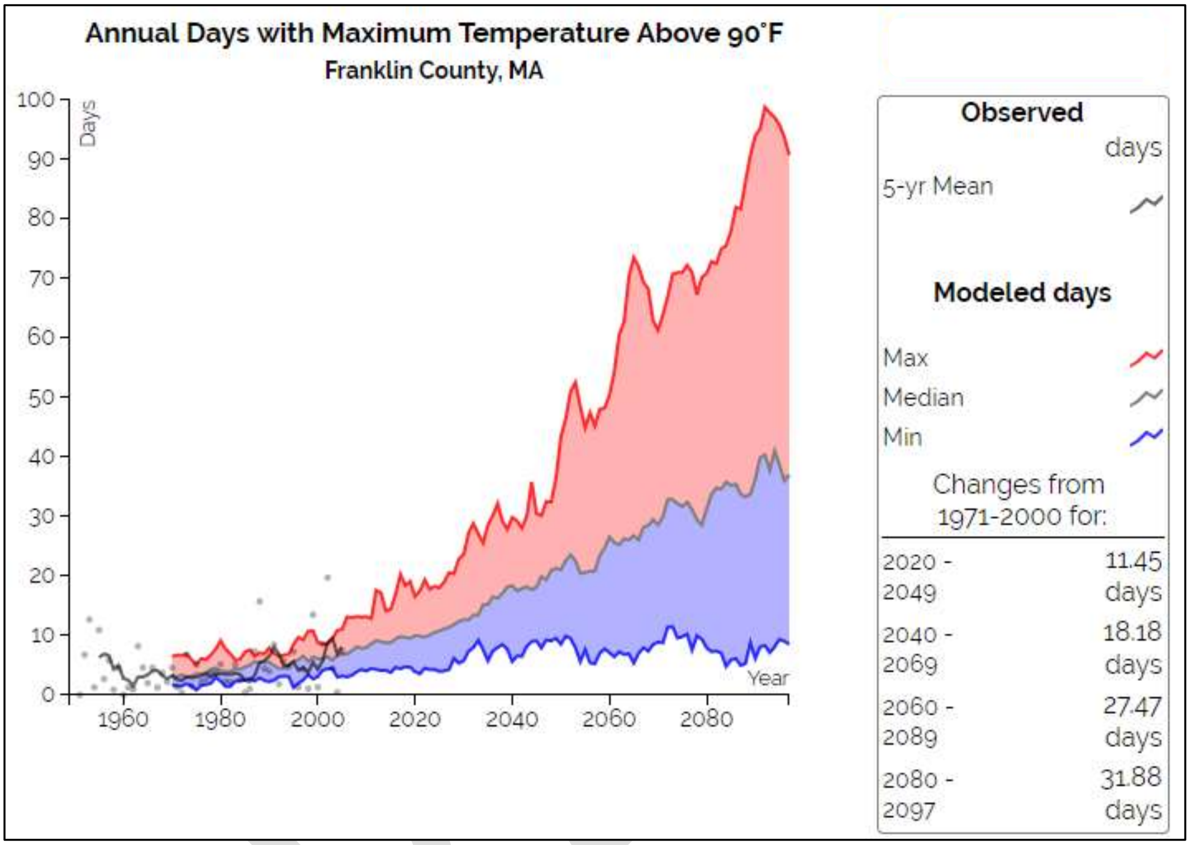


Source: Resilient MA, 2018

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

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

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



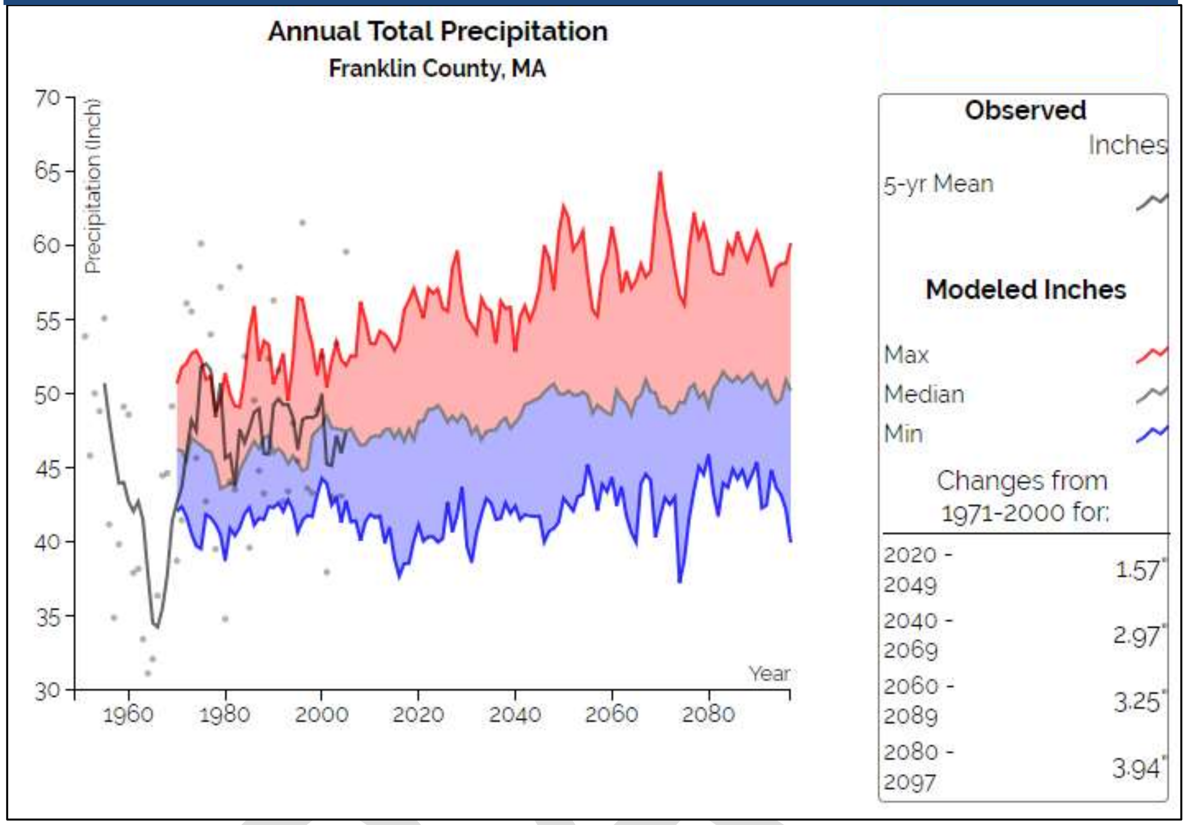
Source: Resilient MA, 2018

Changes in Precipitation

Changes in the amount, frequency, and timing of precipitation—including both rainfall and snowfall—are occurring across the globe as temperatures rise and other climate patterns shift in response. Precipitation is expected to increase over this century in Franklin County. Total annual precipitation is projected to increase by 3 inches by mid-century, and by 4 inches by the end of this century (see Figure 2-4). This will result in up to 52 inches of rain per year, compared to the 1971-2001 average annual precipitation rate of 48 inches per year in Franklin County. Precipitation during winter and spring is expected to increase, while precipitation during summer and fall is expected to decrease over this century. In general precipitation projections are more uncertain than temperature projections.[11]

[11] Resilient MA, 2018, http://resilientma.org/datagrapher/?c=Temp/county/pcpn/ANN/25011/

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



Source: Resilient MA, 2018

Extreme Weather

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

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

3 HAZARD IDENTIFICATION AND RISK ASSESSMENT

The following section includes a summary of disasters that have affected or could affect Shutesbury. 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 Shutesbury. The table below illustrates a comparison between the relevant hazards in the State plan and in Shutesbury's plan.

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

Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2018)	Town of Shutesbury Relevance	MVP Resiliency Plan Top Priority Hazard
	YES	YES
	YES	YES
	NO	NO
	NO	NO
	NO	NO

Table 3-1: Comparison of Hazards in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, Shutesbury Hazard Mitigation Plan, and Shutesbury MVP Resiliency Plan		
Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2018)	**Town of Shutesbury Relevance**	**MVP Resiliency Plan Top Priority Hazard**
 Tsunami	NO	NO
 Average/Extreme Temperatures	YES	YES
 Wildfires	YES	YES
 Invasive Species	YES	NO
 Hurricanes/Tropical Storms	YES	NO
 Severe Winter Storm	YES	YES
 Tornadoes	NO	NO
 Other Severe Weather	YES	YES
 Earthquake	NO	NO

3.1 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 Shutesbury. 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.

Hazard Description

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

Location

Location refers to the geographic areas within the 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:

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

Extent

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

Previous Occurrences

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

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

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

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

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

Vulnerability
Based on the above metrics, a hazard vulnerability rating was determined for each hazard. The

hazard vulnerability ratings are based on a scale of 1 through 3 as follows:

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

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. The hazards highlighted in Table 3-5 were also identified as high priority hazards during the 2020 Shutesbury MVP Workshop.

Table 3-5: Shutesbury Hazard Identification and Risk Analysis

Type of Hazard	Location of Occurrence	Probability of Future Events	Impact	Overall Hazard Vulnerability Rating
Severe Winter Storms				
Flooding				
Hurricanes / Tropical Storms				
Severe Thunderstorms / Wind / Microbursts				
Invasive Species				
Dam Failure				
Extreme Temperatures				
Drought				
Wildfires				
Tornadoes				
Earthquakes				

Table 3-5: Shutesbury Hazard Identification and Risk Analysis				
Type of Hazard	**Location of Occurrence**	**Probability of Future Events**	**Impact**	**Overall Hazard Vulnerability Rating**
Landslides				

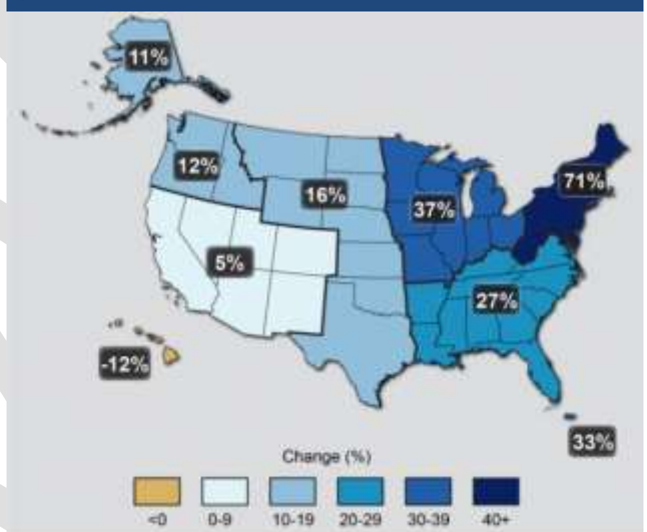
The Committee developed problem statements and/or a list of key issues for each hazard to summarize the vulnerability of Shutesbury's structures, systems, populations and other community assets identified as vulnerable to damage and loss from a hazard event. These problem statements were used to identify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

3.2 FLOODING

Potential Effects of Climate Change

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

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.*

Observed average annual precipitation in Massachusetts between 1971-2000 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.

The Climate Data Grapher tool on the resilientMA website contains down-scaled climate data for Franklin County (discussed in Section 2) and for the Connecticut River Watershed, which includes part of Shutesbury (Shutesbury is also in the Chicopee River Basin). Observed annual precipitation over the last several decades (1970-2005) is approximately 45 inches. By 2050, the model predicts that 41 inches per year would be the minimum annual precipitation; the median (middle value of the model predictions) could be 48 inches/year with a maximum of 60 inches per year. In general, precipitation projections are more uncertain than temperature projections. [12]

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

[12] Resilient MA, 2018, http://resilientma.org/datagrapher/?c=Temp/county/pcpn/ANN/Connecticut/

progresses. Figure 3-2 shows potential effects of climate change on flooding from the Massachusetts State Hazard Mitigation and Climate Adaptation Plan.

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

- Overbank flooding occurs when water in rivers and streams flows into the surrounding floodplain or into "any area of land susceptible to being inundated by floodwaters from any source," according to FEMA.
- Flash floods are characterized by "rapid and extreme flow of high water into a normally dry area, or a rapid rise in a stream or creek above a predetermined flood level," according to FEMA.

Fluvial Erosion

Fluvial erosion is the process in which the river undercuts a bank, usually on the outside bend of a meander, causing sloughing and collapse of the riverbank. Fluvial erosion can also include scouring and down-cutting of the stream bottom, which can be a problem around bridge piers and abutments. In hillier terrain where streams may lack a floodplain, 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.[13]

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

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 human made activities, such as mining, inadequate fill after construction activity, and oil or water extraction. When ground subsides, it can lead to flooding by exposing low-lying areas to groundwater, tides, storm surges, and areas with a high likelihood of overbank flooding.

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

Ice Jams

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

Dam Failure

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

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

The Massachusetts Emergency Management Agency (MEMA) identifies eight dams in Shutesbury. The Baker Reservoir Dam, Atkins Reservoir Dike, Horst Mill Pond Dam, and Ames Lower Pond and Ames Upper Pond Dams are all identified as having a low hazard or unrated.

The Dudleyville Pond Dam is ranked a significant hazard, and the Lake Wyola and Atkins Reservoir Dams are both considered high hazard dams. The Lake Wyola Advisory Committee is responsible for the inspection, care, and improvement of the Lake Wyola Dam. The Town of Amherst is responsible for the Atkins Reservoir Dam. The outflows of these two dams are located close to Shutesbury's western border with Leverett. Inundation mapping of these two locations show that a number of Leverett residents would be impacted by the failure of the Lake Wyola Dam, but not the Atkins Reservoir Dam. The Town of Leverett has created an evacuation plan for residents in the inundation zone, and has set up a Robocall list of these residents to quickly alert them in the event of a dam failure.

Impacts and Shutesbury's vulnerability to dam failure is discussed in more detail in the Dam Failure section of this plan.

Additional Causes of Flooding

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

Floodplains

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

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

Location

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

Franklin County has several major rivers and numerous tributaries which are susceptible to flood events. The major rivers in the region include the Connecticut, the Deerfield, and the Millers, none of which run through Shutesbury. There is a USGS gauges on the West Branch of the Swift River in Shutesbury.

Flooding poses a significant threat to life and public health and can cause severe property damage. In Shutesbury, the 100-year floodplain covers about 233 acres, or approximately 1.35 percent of the town, including an estimated 7.4 acres of developed residential land.[14] The Shutesbury Flood Insurance Rate Map (FIRM), dated June 18, 1980 identifies the Special Flood Hazard Areas in Shutesbury, also known as the 100-year floodplain, shown as Zones A and A1:

- Atkins Reservoir (A)
- West Branch of the Swift River from the Wendell border to its junction with Mount Mineral Road (limit of study) (A)
- Lake Wyola (A1)
- Dudley Marsh (A)

The National Flood Insurance Program has identified the following areas as 500-year floodplains

[14] 2005 MassGIS land use data.

(Zone B):

- Nurse Brook
- Unnamed tributary to Nurse Brook south of Atkins Reservoir
- Baker Reservoir, tributary north of reservoir, and area south of reservoir
- Tyler Brook
- Ames Pond
- South Brook
- Areas around Lake Wyola
- Forested wetland west of Ross Road
- Forested wetland northeast of Montague Road

Upland areas and the small tributary streams that drain them are particularly vulnerable to impacts from development, which can increase the amount of flooding downstream. These areas are critical for absorbing, infiltrating, and slowing the flow of stormwater. When these areas are left in a natural vegetated state (forested or forested floodplain), they act as "green infrastructure," providing flood storage and mitigation through natural processes.

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

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.

Town Roads, Bridges and Culverts

There are a number of areas throughout Shutesbury that are prone to localized flooding. The 2014 eCEMP and participants in the 2020 Municipal Vulnerability Preparedness Workshop identify that there are several gravel roads in Town with poor drainage that can quickly become impassible. NEED MORE DESCRIPTION OF PROBLEMS FOR THIS SECTION Roads identified as being particularly prone to flooding include:

- Roads along Lake Wyola

- Baker Road

Beaver Dams

Impoundments and landscape changes caused by beavers are occurring throughout Shutesbury. Specific areas where beaver activity is known and/or having an impact include XX. Beaver dams are also known to be forming wetlands throughout Shutesbury, and may be contaminating private wells. ?????? Regular monitoring of beaver dams and their condition is important for mitigating the risk of downstream flooding in case of a failure. Beaver dams in Shutesbury are further discussed in the dam failure section.

Based on these locations, flooding has a XX area of occurrence, with XX% 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.

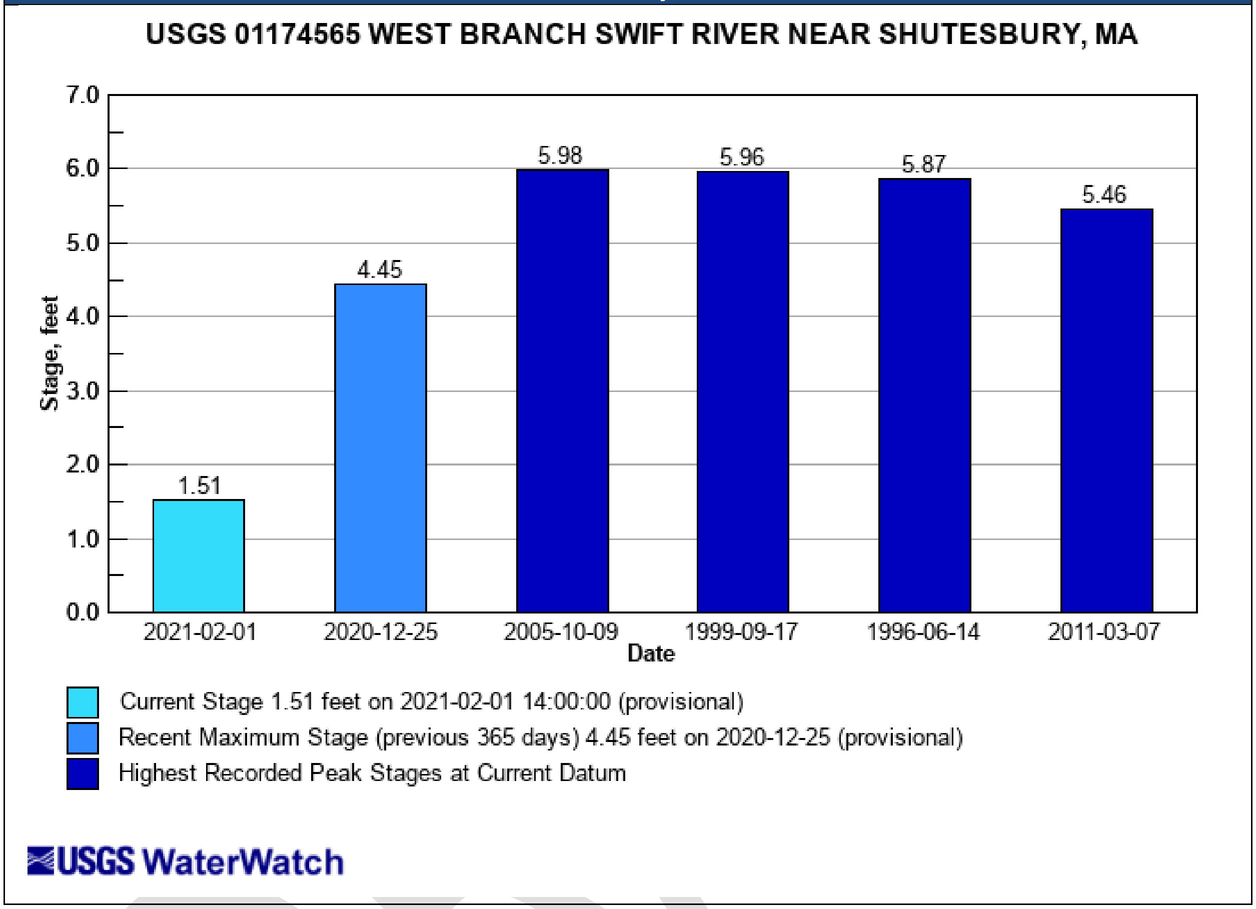
Most often, flash flooding is the result of a slow-moving thunderstorm or the heavy rains from a hurricane. In rural areas, flash flooding often occurs when small streams spill over their banks. However, in urbanized areas, flash flooding is often the result of clogged storm drains (leaves and other debris) and the higher amount of impervious surface area (roadways, parking lots, rooftops).

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 West Branch of the Swift River in Shutesbury, as well as the highest flow event in the last 365 days.

Figure 3-3: Highest Recorded Flood Events on the West Branch of the Swift River, Shutesbury, MA



Source: USGS WaterWatch https://waterwatch.usgs.gov/?id=wwchart_ftc&site_no=01174565

The 100-Year Flood

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

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

The 500-Year Flood

The term "500-year flood" is the flood that has a 0.2 percent chance of being equaled or exceeded each year. Flood insurance 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, riverbank erosion, and landslides affecting infrastructure and other assets (e.g., agricultural fields) built within historic floodplains. Without the space required along river corridors for natural physical adjustment, such changes in rivers after flood events can be more harmful than the actual flooding. For instance, fluvial erosion attributed to Hurricane Irene caused an excess of $23 million in damages along Route 2. The impacts from these secondary hazards are especially prevalent in the upper courses of rivers with steep gradients, where floodwaters may pass quickly and without much damage, but scour the banks, edging buildings, and structures closer to the river channel or cause them to fall in. Landslides can occur following flood events when high flows oversaturate soils on steep slopes, causing them to fail.

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

Previous Occurrences

The average annual precipitation for Shutesbury and surrounding areas in western Massachusetts is 48 inches. Between 1996 and 2020, 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.

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/

Table 3-8 is an inventory of five flood events with significant impacts to Shutesbury. This information was taken from NOAA data that is current through 2020. Event details describe extensive street flooding and impassibility, road washouts, and property damage.

Table 3-8: Flooding Events in Shutesbury			
Date	**Location**	**Type**	**Recorded Property Damages**
6/8/1996	Eastern FC	Flash Flood	Heavy rain accompanied thunderstorms in Franklin and Hampden Counties and roads were reported flooded in Erving, Deerfield, and Northfield. The Sawmill River and Roaring Brook went over their banks.
6/13/1996	Shutesbury, Leverett & Montague	Flash flood	Thunderstorms with torrential downpours produced a flash flood, which resulted in the worst flooding in 100 years of records on the Sawmill River. A reported 5-7 inches of rain drenched the Lake Wyola while the Town Center remained basically dry. More than 30 miles of roadway in the area were destroyed. Numerous homes and businesses experienced some degree of flood damage. Both Leverett and Shutesbury declared states of emergency.[15] The Massachusetts Emergency Management Agency has estimated damage from this flood at close to $2 million. Local residents who have lived in the area for many years said this was the worst flooding they had witnessed since the Great New England Hurricane of 1938. A few thought that it exceeded even that historical flood event.
9/17/1999	All Franklin County	Flood from Hurricane Floyd	Committee members estimated that damage from this storm totaled about $XX.
10/9/2005	All Franklin County	Flood from Tropical Storm Tammy	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. Shutesbury endured $XX worth of property damage and losses.
3/7/2011			Shutesbury received 2-5 inches of rain on top of melting snow, flooding tributaries. Cooleyville Road in Shutesbury was closed. Cushman Road, Boathill Road, and Route 63 at Depot Road in Leverett were closed due to flooding.
8/27/2011	Shutesbury	Flood from Tropical Storm Irene	Parts of Shutesbury lost power (though likely due to indirect causes) and a number of culvert failures washed roads out, namely Montague and Cooleyville Roads. The storm caused an estimated $XX in damage in Shutesbury.

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

[15] "FEMA rejects disaster bid," Daily Hampshire Gazette, June 21, 1996.

Generally, officials in Shutesbury reported that they were very lucky and were not impacted as hard as surrounding towns by Tropical Storm Irene. The Town experienced a limited power loss after the storm, but emergency response officials indicated that this was most likely a result of power company efforts to restore power to other towns that were more seriously impacted by the storm. Emergency response officials had management experience from dealing with the December 2008 ice storm and they monitored the situation throughout the storm. Water levels at the Wyola Dam were managed through multiple adjustments to the gates. The flow monitor of the West Branch of the Swift River peaked out at 1000 CFS, and officials estimated that Lake Wyola got about half of that amount. Trees were reported down around Town, including on Pratt Corner Road. The old stone culvert at the Baker Reservoir has a history of being over-capacity and was overrun during the tropical storm. As a result, the Baker Reservoir started overtopping the earthen retaining wall. The Camel Brook culvert on Cooleyville Road also washed out, which the Highway Department Superintendent reported occurred 8-10 times between 1999 and 2011, including two years in a row in 2010 and 2011. Because of this history, the culvert was replaced with a larger culvert in 2012 to address the ongoing flood concerns. The bridges on Cooleyville Road at the Shutesbury/New Salem Town Line were also replaced, due to advanced rot in the timbers and planking.

The big impact of the storm was the failure of a Montague Road culvert that caused the road to wash out. The culvert was later replaced with a larger one with a flat bottom and an arch at the top under difficult circumstances as the flooding from the storm continued. Mutual aid from the Town of Leverett was extremely helpful in addressing this problem. An emergency passage for 4-wheel drive vehicles only was cut through Carver Road due to 80 households being stranded until emergency access could be gained through Montague Road again.

Probability of Future Events

Based on previous occurrences, the frequency of occurrence of flooding events in Shutesbury is "XX," with a XX% percent probability in any given year. Flooding frequencies for the various floodplains in Shutesbury 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 Shutesbury.[16]

Impact

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

- Blockages of roadways or bridges vital to travel and emergency response
- Breaching of dams
- Damaged or destroyed buildings and vehicles
- 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 XX in Shutesbury, with more than XX% of property in the affected area damaged or destroyed, and possible shutdown of facilities (roads, bridges, critical facilities) for more than one week.

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

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

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.

According to the 1980 FEMA FIRM, 233 acres in Shutesbury lie within the 100-year floodplain. However, the 1980 map includes lakes, ponds, and reservoirs (excluding the Quabbin Reservoir). Therefore, some portion of the 233 floodplain acres is actually open water, not floodplain. According to 2005 MassGIS Land Use data there are 27 dwellings located in the floodplain (Table 3-9). This is confusing because there are only 7.4 acres in the floodplain. Explain that many of the dwellings may be around Lake Wyola, where parcel sizes could be smaller (this is totally speculation… need to verify first).Using this number and Shutesbury's estimated average household size, it is estimated that 64 people, or 3.6% of Shutesbury's total population, reside in the floodplain.

Table 3-9: Estimated Shutesbury 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
1,755	27	2.37	64	3.6%

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

Vulnerable Populations

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

Table 3-10 estimates the number of vulnerable populations and households in Shutesbury. 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 Shutesbury residents during a flood event.

Table 3-10: Estimated Vulnerable Populations in Shutesbury		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	329	19%
Population with a Disability	203	12%
Population who Speak English Less than "Very Well"	13	0.7%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	149	20%
Householder Age 65 Years and Over Living Alone	90	12%
Households Without Access to a Vehicle	35	5%

*Total population = 1,755; Total households = 740
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2015-2019 Five-Year Estimates.

Populations that live or work in proximity to facilities that use or store toxic substances are at greater risk of exposure to these substances during a flood event. According the 2014 CEMP, there are three hazardous facilities in Shutesbury where hazardous chemicals are stored (see table 3-41 Human made Hazards section).

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 2020 indicates that there have been no fatalities or injuries associated with flooding or flash flooding events in Shutesbury. However, flooding can result in direct mortality to individuals in the flood zone. This hazard is particularly dangerous because even a relatively low-level flood can be more hazardous than many residents realize. For example, while 6 inches of moving water can cause adults to fall, 1 foot to 2 feet of water can sweep cars away. Downed powerlines, sharp objects in the water, or fast-moving debris that may be moving in or near the water all present an immediate danger to individuals in the flood zone.

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

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

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

<u>Economic Impacts</u>

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

Damages to buildings can affect a community's economy and tax base; the following section includes an analysis of buildings in Shutesbury 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.

Table 3-11 shows the amount of commercial, industrial, and public/institutional land uses located in town and within the floodplain. No commercial, public/institutional, or industrial land uses lie within the floodplain.

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

Land Use	Total acres in Town	Acres in Flood Hazard Area	% of total acres in Flood Hazard Area
Commercial	2.9	0	0%
Industrial	9.6	0	0%
Public/Institutional	13.32	0	0%

Source: 2005 MassGIS Land Use data.

The average assessed values of the residential, commercial, and industrial land uses located within the floodplain are displayed in Table 3-12. The total average assessed value for these three land uses within the floodplain is $3,715,233. This is of concern because should a catastrophic flooding event befall Leverett, the assessed values of these structures and facilities would likely be significantly reduced, which in turn would impact the town's tax revenues.

Table 3-12: Average Assessed Value of Land Use in Flood Hazard Area, FY2021

Land Use	Total Acres in Town	Total Assessed Value	Average Assessed Value Per Acre	Acres in Flood Hazard Area	Average Assessed Value in Flood Hazard Area
Residential	424.6	$213,174,059	$502,059	7.4	$3,715,233
Commercial	2.9	$1,786,981	$616,200	0	$0
Industrial	9.6	$540,610	$56,314	0	$0

Source: Massachusetts Department of Revenue - Division of Local Services, Municipal Databank/Local Aid Section 2021; 2005 MassGIS Land Use data.

NFIP data are useful for determining the location of areas vulnerable to flood and severe storm hazards. Table 3-13 summarizes the NFIP policies, claims, repetitive loss (RL) properties, and severe repetitive loss (SRL) properties in Shutesbury 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).

As of December 2018 Shutesbury had two policies in force with a total insurance in force of $525,000 and no losses had been paid.

Table 3-13: NFIP Policies, Claims, and Repetitive Loss Statistics for Shutesbury						
Number of Housing Units (2019 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**
897	2	0.2%	$525,000	0	$0	0

Source: National Flood Insurance Program (NFIP), FEMA Region I 2018; U.S. Census Bureau 2015-2019 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).

The Locks Pond Road culvert located approximately 100 feet below the Lake Wyola Dam was identified as a primary culvert of concern. The culvert is in poor condition, and, if it fails, the road would wash out and potentially cause flooding of surrounding residences and infrastructure. Replacement of this culvert is slated to begin in spring or summer of 2021, and finish in the fall of 2021.

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

Flood Hazard Problem Statements
• Shutesbury's town bylaws and regulations do not directly address how development affects flooding or include requirements for mitigating floods. Areas where flooding could be addressed are Shutesbury's Subdivision Rules and Regulations, the Town's Development Impact Statement, and in Special Permitting for disturbing topsoil/topography.
• Many gravel roads throughout Town do not have proper drainage and are prone to flooding.

- Shutesbury's town bylaws and regulations do not directly address how development affects flooding or include requirements for mitigating floods. Areas where flooding could be addressed are Shutesbury's Subdivision Rules and Regulations, the Town's Development Impact Statement, and in Special Permitting for disturbing topsoil/topography.
- Chronic flooding occurs on XX Roads. Nature based solutions to increase flood resiliency are needed at these locations.
- There are a number of concerns over ice jams causing flooding and other damage, especially near XX Road.
- Beaver activity is present throughout Shutesbury, and is contributing to the development of wetlands and localized flooding.
- Many of Shutesbury's residents rely on private wells, placing them at risk during prolonged power outages caused by flooding. Flooding may also compromise water quality.
- Culvert and bridge maintenance is needed throughout town. Per the Town's Capital Plan, replacements, repairs, and upgrades have been prioritized at the following locations through FY '24: XX. Completion of the Locks Road Culvert …
- Shutesbury contains two *High Hazard Potential* dams: Atkin's Reservoir Dam and of the Lake Wyola Dam. While the chance is low, a catastrophic dam failure at the Lake Wyola dam would result in potentially very damaging flooding in Leverett.
- Vulnerable populations, including elderly and disabled residents, are more vulnerable in the event of an emergency due to lessened mobility or medical needs. Residents in Shutesbury are dispersed and some people may be difficult to reach in the event of an emergency.
- Many of the Town's evacuation routes would be impacted by flooding.
- Sheltering during an emergency may be difficult due to the lack of communication networks in Shutesbury and limited public knowledge of available sheltering options.

Hire an engineer to conduct a hydraulic analysis to provide prioritized recommendations for construction projects to mitigate damage from flood events in the following key areas of concern:

- Baker Road culvert;
- Wendell Road culvert north of Locks Pond Road;
- Ames Brook culvert on Wendell Road. FROM 2015 PLAN – STILL RELEVANT?

Implement a public education program for private well owners about proper construction methods and periodic inspections and testing to guard against contamination resulting from the infiltration of stormwater.

-

- **Conduct a field inventory of culverts and bridges** to rank and prioritize projects for increased flooding resiliency and storm-hardening, followed by design and implementation of priority re-sizing or replacement projects. Build on previous work in the Town's Hazard Mitigation Plan that identified top-priority culverts. Green infrastructure, Low-Impact Design, and other nature-based solutions will be integrated with hard-infrastructure improvements to establish approaches that will be robust in the face of natural hazards and climate-change scenarios.

- **Assess options for repairing or replacing the culvert downstream of the Lake Wyola Dam** to increase resilience of the dam and reduce the risk of flooding during heavy precipitation events. Explore funding options for implementation.

- **Update the Town's Master Plan** to address a full range of zoning-related climate change mitigation/adaptation issues, such as limiting development in high-hazard areas, incorporating green infrastructure in new development plans, and encouraging low-impact development practices.

- **Establish a regulatory review process for future developments** to address impervious cover and manage stormwater runoff. Review and update applicable Town regulations and bylaws to improve stormwater management and mitigate flooding risk.

- **Assess green infrastructure opportunities for stormwater management** to develop a list of specific priorities, assess feasibility and cost, rank priority projects in terms of climate resilience potential, and develop concept designs for key projects. Review Town regulations and update as necessary to support green infrastructure and low-impact development and encourage green infrastructure to be incorporated into all roadway projects. Focus on known problem areas for stormwater runoff, including Locks Pond Road and the Lake Wyola area. Assess opportunities to reduce runoff from private driveway to roadways, such as encouraging Green Infrastructure practices at private residences. Encourage stormwater harvesting and reuse practices on private and Town-owned properties.

- **Educate owners of private septic systems** about the importance of having systems pumped out and keeping them in good working condition in order to prevent risks to public health and the environment from systems that become overwhelmed during periods of heavy precipitation. Evaluate the possibility of developing a comprehensive Town-wide septic plan to uniformly address these concerns.

- **Explore options for enhanced and effective communication with residents.** Utilize the Town's recently installed broadband internet, and increase transparency and awareness in Town Make communications with residents more interactive. Pursue 100% enrollment in the Town announcement program (approximately 150 people are not enrolled). Assess communications alternatives that are not reliant on electricity the way that phone (VOIP) and internet systems in the community currently are.

- **Establish the elementary school as an emergency shelter.** Acquire necessary equipment and conduct policy review to plan for how best to safely shelter adults if school is still in session to identify potential safety issues regarding schoolchildren. Assess funding for AC and equipment.

- **Develop transportation planning for vulnerable populations during hazard events** to ensure that vulnerable groups, notably seniors, will be able to get to shelters, obtain food and medications, or receive emergency services. Focus should be on identifying vulnerable populations and providing aid during all types of climate-induced risks, such as extreme temperatures, increasingly intense storms which may make travel difficult, or flooding and storm events that may leave residents unprepared, stranded, or cut off from supplies.

- **Identify vulnerable populations and foster a communications network** in advance of a hazard event to facilitate communication efforts and outreach to those most in need of information and assistance. Focus should be on populations that may be more vulnerable to climate-induced risks, such as extreme temperatures, may lack appropriate shelter during increasingly intense storms, or that may be unprepared if stranded or cut off from supplies due to flooding or storm events. Evaluate communication or emergency alert methods that may not require internet access, as vulnerable populations, notably seniors, may not be connected to broadband service.

- **Hire one additional Highway Department staff** to increase the capacity of the department to respond to and mitigate hazardous conditions.

3.3 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 3-4 show potential effects of climate change on severe winter storms from the Massachusetts State Hazard Mitigation and Climate Adaptation Plan.

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

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

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

Hazard Description

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

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

Ice Storms

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

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

Nor’easters

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

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

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

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

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

Location

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

The entire town of Shutesbury 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 3-14. 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 3-14: 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 3-15.

Table 3-15: 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

Table 3-15: 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 86 heavy snow events in Franklin County since 1996, resulting in $15,447,000 in damages; 32 winter storm events since 2002, resulting in $1,170,000 in damages; and three ice storms since 2002 that have resulted in damages of $6,300,000.

In 2018, New England was hit by three Nor'easters within the first two weeks of March. The first was Winter Storm Riley which brought damaging winds, heavy snow and coastal flooding. Then, Winter Storm Quinn dumped heavy snow, taking down more trees and causing additional power outages on top of those caused by Riley. The third Nor'easter, called Winter Storm Skylar, occurred on March 11-13 and brought over a foot of snow in Massachusetts. With severe winter storms occurring soon after each other, there is little time to recover from one storm before needing to brace for the next. Utilites companies may have to work for weeks or months to restore power after mounting failures, leaving some customers without power for extended time periods. Snow storage and disposal becomes more challenging and expensive when designated snow storage areas fill up, forcing municipalities to pay for snow removal and hauling.

The severe winter storm that hit Franklin County on October 29, 2011 was a rare and historic nor'easter that brought very heavy snow to portions of southern New England and is sometimes referred to as the "Snowtober" storm. Snowfall accumulations of one to two feet were common in the Monadnocks, Berkshires, Connecticut Valley, and higher elevations in central Massachusetts. Snowfall rates reached 3 inches per hour for several hours during the storm. The accumulation of the heavy wet snow on trees that still had their leaves and on power lines resulted in widespread tree damage and power outages across many communities in central and western Massachusetts. At the peak, 665,000 customers in Massachusetts were without power. Seventy-seven shelters were opened and sheltered 2,000 residents across the state. A state of emergency was declared on October 29, officially ending on November 6. In Shutesbury, residents around Lake Wyola experienced power outages of a couple of days following the storm. Other affected areas included the lower west section of the Atkins

Reservoir, lower Pratt Corner Road, and January Hills Road. This storm resulted in reimbursements to Shutesbury of $1,232 from MEMA and $7,884.32 from FEMA in FY 2011.

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.

Ice covered trees and roads in Shutesbury after 2008 ice storm

Shutesbury was greatly impacted by the 2008 ice storm. All roads became impassable due to downed trees and power lines, and the town declared a state of emergency. Residents were without power for days, some for over a week after the storm. The Town used its newly established reverse call system to provide residents with information on the conditions in town. The Town Hall was set up as a shelter, and it is estimated that 75-100 residents visited the shelter during the emergency. The Town called in professional tree removal crews to help with the clean up. In addition, the Massachusetts Department of Conservation and Recreation and the Massachusetts National Guard sent help to Shutesbury. The storm cost the Town roughly $70,000 in overtime, gasoline, shelter expenses, and expenses for hiring the tree removal companies.[17] FEMA reimbursed the Town $64,535 in FY2009 for the December 2008 ice storm,

[17] "It was a heck of a week," Janice S. Gray. *Our Town: Tri-annual Community News.* Winter 2009.

and an additional $12,292 was received in FY 2011 and FY 2012 from MEMA for the storm.

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 3-16 in order of their RSI severity.

Table 3-16: High-Impact Snowstorms in Franklin County, 1958 - 2020

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

Probability of Future Events

Based upon the availability of records for Franklin County, the likelihood that a severe snow storm will hit Deerfield in any given year is “XX," or a XX to XX%probability in any given year.

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

Impact

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

The impact of an event would likely be XX, with more than XX% of property in the affected area damaged and complete shutdown of facilities for more than one 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 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 Shutesbury 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.

Table 3-17 estimates the number of vulnerable populations and households in Shutesbury. 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 Shutesbury residents during a severe winter storm event.

Table 3-17: Estimated Vulnerable Populations in Shutesbury		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	329	19%
Population with a Disability	203	12%
Population who Speak English Less than "Very Well"	13	0.7%
Vulnerable Household Category	**Number**	**Percent of Total Households***

Table 3-17: Estimated Vulnerable Populations in Shutesbury		
Low Income Households (annual income less than $35,000)	149	20%
Householder Age 65 Years and Over Living Alone	90	12%
Households Without Access to a Vehicle	35	5%

*Total population = 1,755; Total households = 740

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

Source: U.S. Census American Community Survey 2015-2019 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.[18] 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.

Economic Impacts

The entire building stock inventory in Shutesbury 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

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

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 Shutesbury are exposed to the severe winter weather hazard. Potential structural damage to the facilities themselves may include damage to roofs and building frames. These facilities may not be fully operational if workers are unable to travel to ensure continuity of operations prior and after a severe winter event. Disruptions to key public services such as electricity, transportation, schools, and health care may become more common.[19] Table 3-18 identifies the assessed value of all residential, open space, commercial, and industrial land uses in Shutesbury, and the losses that would result from 1%, 5%, and 10% damage to this inventory as a result of a severe winter storm.

Table 3-13: Estimated Potential Loss by Tax Classification

Tax Classification	Total Assessed Value FY2021	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$213,174,059	$2,131,740	$10,658,700	$21,317,400
Open Space	$0	$0	$0	$0
Commercial	$1,786,981	$17,870	$89,350	$178,700
Industrial	$540,610	$5,406	$27,030	$54,060
Total	$225,990,400	$2,259,904	$11,299,520	$22,599,040

Source: Massachusetts Department of Revenue - Division of Local Services, Municipal Databank/Local Aid Section, 2021.

Agriculture

Severe winter weather can lead to flooding in low-lying agricultural areas. Ice that accumulates

[19] Resilient MA 2018

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, 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, Shutesbury faces a XX vulnerability from severe snow storms and ice storms. Severe winter storms and ice storms occur frequently in Shutesbury. However, the severity of impact is XX [minor to limited], except for impact to population, which could be XX [critical]. The following problem statements summarize Shutesbury's areas of greatest concern regarding severe winter storms.

Severe Winter Storm Hazard Problem Statements
• Develop and maintain a list of areas where repetitive power outages occur. Meet with National Grid to discuss future potential opportunities to underground existing utility lines in priority locations on the list. Work with National Grid to identify funding sources and to develop funding applications as needed.
• Engage a structural engineer to inspect the roof of the elementary school to determine what additional repairs are required for it to be able to withstand the potential weight of snow loads from severe winter storms and then seek funding to complete the repairs.
• Identify priority areas for tree maintenance near utility lines in town and submit the list to National Grid for inclusion in its five-year action plan, which includes regular tree maintenance to reduce the number of limbs near overhead power lines, to reduce risk to infrastructure from severe winter storms. Meet bi-annually with the utility to ensure priority areas are included in the plan. THESE ARE FROM THE 2015 PLAN
• Strategies for safeguarding power lines and utilities infrastructure throughout Town need to be identified and evaluated. Eversource routinely removes trees, but the cutting program could be expanded to further mitigate hazards.
• Many of Shutesbury's residents rely on private wells, placing them at risk during prolonged power outages caused by severe winter storms.

• Many of the Town’s evacuation routes would be impacted by severe winter storms.
• Sheltering during an emergency may be difficult due to the lack of communication networks in Shutesbury and the limited number of sheltering options.
• Vulnerable populations, including elderly and disabled residents are more vulnerable in the event of an emergency due to lessened mobility or medical needs. Residents in Shutesbury are dispersed and some people may be difficult to reach in the event of an emergency.
• Shutesbury’s emergency communication system may not have up to date information, which may limit the number of residents who receive emergency information.
• New programming is needed to promote and increase household disaster preparedness town wide.

3.4 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 3-4 displays the potential effects of climate change on hurricanes and tropical storms from the Massachusetts State Hazard Mitigation and Climate Adaptation Plan.

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

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

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

Hazard Description

Hurricanes

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

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

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

Tropical Storms

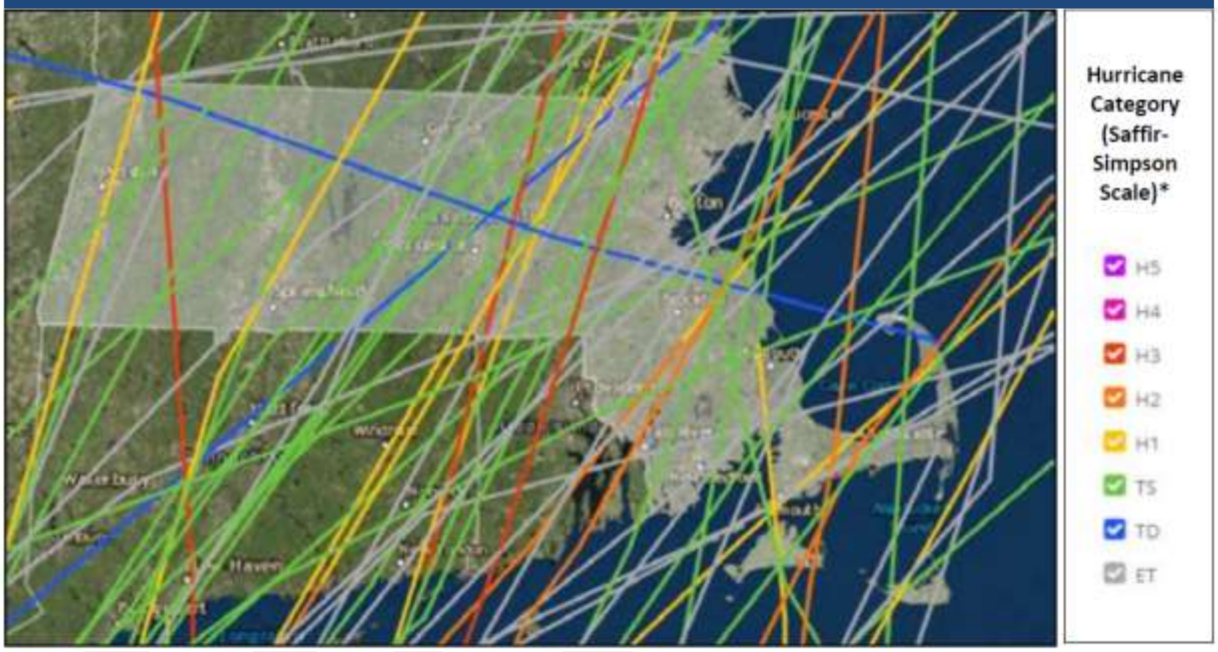
A tropical storm system is characterized by a low-pressure center and numerous thunderstorms that produce strong winds and heavy rain (winds are at a lower speed than hurricane-force winds, thus gaining its status as a tropical storm versus a hurricane). Tropical storms strengthen when water evaporated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

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

Location

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

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



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

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 2020. According to this resource, over the time frame tracked, 70 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 Figure 3-7 gives an overview of the wind speeds and range of damage caused by different hurricane categories.

Figure3-7: 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, 70 hurricane or tropical storm events occurred in the vicinity of Massachusetts between 1842 and 2020. The Commonwealth was impacted by tropical storms Jose and Phillipe in 2017. Therefore, there is an average of one storm every other 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 that 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. Category 1 storm Hurricane Gloria traveled directly through Shutesbury in 1985, and Tropical Storms Belle and Able moved over the northwest corner of Shutesbury in 1976.

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. (VERIFY) In 2011, Tropical Storm Irene caused over $26 million in property damage in Franklin County, mostly from flooding impacts.

Probability of Future Events

A 2017 U.S. Climate Science Special Report noted that there has been an upward trend in North Atlantic hurricane activity since 1970. The report forecasts that future hurricanes formed in the North Atlantic will drop more rain and may have higher wind speeds. This is because a warmer atmosphere will hold more water, and hurricanes are efficient at wringing water out of the atmosphere and dumping it on land.[20]

Shutesbury'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, especially at higher elevations. Therefore Shutesbury has a XX probability, or a XX chance, of experiencing a hurricane or tropical storm event in a given year.

Impact

While historically there have been no Hurricane events in Shutesbury, (IS THIS THE CASE? WHAT ABOUT HURRICANE GLORIA IMPACTS? the Vulnerability Assessment revealed an occurrence could XX impact the Town, with potential multiple injuries to citizens possible and with a potential of more than XX% of property damaged or destroyed.

Vulnerability

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

Society

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

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

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 Shutesbury. 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 Shutesbury residents during a hurricane or tropical storm event.

Table 3-14: Estimated Vulnerable Populations in Shutesbury		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	329	19%
Population with a Disability	203	12%
Population who Speak English Less than "Very Well"	13	0.7%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	149	20%
Householder Age 65 Years and Over Living Alone	90	12%
Households Without Access to a Vehicle	35	5%

*Total population = 1,755; Total households = 740
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2015-2019 Five-Year Estimates.

<u>Health Impacts</u>

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

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

Economic Impacts

In addition to the human costs that extreme storms deliver when they permanently or temporarily displace people, the repair and reconstruction costs after storm damage can be enormous for homeowners and businesses. When bridges and culverts have been washed away and roads damaged, municipal and state agencies must secure the resources for expensive recovery projects in limited municipal budgets and from Federal disaster grant programs that are increasingly over-subscribed. Electrical grid, power plants and wastewater infrastructure repair costs are all expected to increase in the future.[21]

Infrastructure

Hurricanes and tropical storms could XX impact the Town, with a potential of more than XX% of property in affected area damaged or destroyed. Residential and commercial buildings built along rivers may be vulnerable to severe damage. Potential structural damage to the facilities themselves may include damage to roofs and building frames. These facilities may not be fully operational if workers are unable to travel to ensure continuity of operations prior and after a severe winter event. Table 3-20 identifies the assessed value of all residential, open space, commercial, and industrial land uses in Shutesbury, 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 3-15: Estimated Potential Loss by Tax Classification

Tax Classification	Total Assessed Value FY2021	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$213,174,059	$2,131,740	$10,658,700	$21,317,400
Open Space	$0	$0	$0	$0
Commercial	$1,786,981	$17,870	$89,350	$178,700
Industrial	$540,610	$5,406	$27,030	$54,060
Total	$225,990,400	$2,259,904	$11,299,520	$22,599,040

Source: Massachusetts Department of Revenue - Division of Local Services, Municipal Databank/Local Aid Section, 2021.

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.

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

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 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.[22]

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

[22] Resilient MA 2018.

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, Shutesbury faces a "XX" vulnerability from hurricanes and tropical storms. While historically there have been no Hurricane events in Shutesbury, the Vulnerability Assessment revealed an occurrence could XX [critically] impact the Town. The following problem statements summarize Shutesbury's greatest areas of concern regarding hurricanes and tropical storms.

Hurricane / Tropical Storm Hazard Problem Statements
• **Pursue public facilities upgrades that would increase resiliency**, including repairs to the roofs of the Town Hall, Fire Department, and elementary school. Continue to pursue an MSBA grant for replacement of the roof at the elementary school.FROM MVP • Increase existing shelter capacity and capabilities, particularly in regard to storage space for supplies. FROM 2015 HMP • Most Shutesbury residents rely on private wells for water, placing them at risk during prolonged power outages.
• Strategies for safeguarding power lines and utilities infrastructure throughout Town need to be identified and evaluated. Eversource routinely removes trees, but the cutting program could be expanded to further mitigate hazards.
• Culvert and bridge maintenance is needed throughout town. Per the Town's Capital Plan, replacements, repairs, and upgrades have been prioritized at the following locations through FY '24: Dudleyville Road Bridge, Juggler Meadow Road culvert, Mill Yard Road bridge, Teawaddle Hill Road bridge, Millers Road Bridge, the Rattlesnake Gutter bridge, and the Shutesbury Road Culvert.
• Chronic flooding occurs on Route 63/Long Plain Road, Cushman Road, and Teawaddle Road. Nature based solutions to increase flood resiliency are needed at these locations. • Many of the Town's evacuation routes may be impacted by a hurricane or tropical storm. There are areas of Shutesbury where residents might become isolated if roads, bridges, or culverts were blocked or damaged by impacts of a hurricane or tropical

Hurricane / Tropical Storm Hazard Problem Statements
storm.
• Heavy rain and strong winds associated with hurricanes and tropical storms exacerbates the risk of flooding, dam failures, and severe wind hazards. Also see the flooding, dam failure, and severe thunderstorm, wind, or microburst hazard problem statements.
• Shutesbury's emergency communication system may not have up to date information, which may limit the number of residents who receive emergency information.
• Shutesbury's town bylaws and regulations do not directly address how development affects flooding or include requirements for mitigating floods. Areas where flooding could be addressed are Shutesbury's Subdivision Rules and Regulations, the towns Development Impact Statement, and in Special Permitting for disturbing topsoil/topography.
• New programming is needed to promote and increase household disaster preparedness town wide.
• Sheltering during an emergency may be difficult due to the lack of communication networks in Shutesbury and the limited number of sheltering options.
• Vulnerable populations, including elderly and disabled residents are more vulnerable in the event of an emergency due to lessened mobility or medical needs. Residents in Shutesbury are dispersed and some people may be difficult to reach in the event of an emergency.
• The REPC is working to identify options for regional and local debris management. The regional plan approved by MassDEP several years ago was never implemented because the communities that would serve as regional sites did not execute MOUs. The Town is being urged by MassDEP to select and provide disaster storage/disposal location(s).

3.5 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.[23]

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

[23] 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 Shutesbury is at risk for severe thunderstorms, wind and microbursts.

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.

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

Figure 3-9: 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 15 high wind events occurred in Franklin County (Table 3-21), causing a total of $303,000 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 3-16: 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
2018	1	$3,000	
2019	1	$12,000	
Total	**15**	**$303,000**	**$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. Though it has experienced many additional incidents of severe thunderstorm winds, Shutesbury has experienced six (6) NOAA-recorded thunderstorm wind events since 1994 (Table 3-22). These storms resulted in downed trees and wires and caused $35,000 in property damage.

Table 3-17: Thunderstorm Wind Events in Shutesbury				
Year	**# of Thunderstorm Wind Events**	**Annual Property Damage**	**Annual Crop Damage**	**Event Description**
1997	1	$0	$0	Trees and powerlines downed across Franklin County.
2008	1	$10,000	$0	Trees downed in Leverett and Shutesbury.
2014	1	$3,000	$0	Large limbs downed onto wires on West Pelham Road.
2015	1	$5,000	$0	A tree on West Pelham Road was downed by thunderstorm winds.
2016	1	$15,000	$0	Trees and wires on Route 202 downed by thunderstorm winds.
2017	1	$2,000	$0	Tree and wires down in front of the fire station.

Table 3-17: Thunderstorm Wind Events in Shutesbury				
Year	# of Thunderstorm Wind Events	Annual Property Damage	Annual Crop Damage	Event Description
Total	**6**	**$35,000**	**$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, 23 lightning events since 1997 caused a total of $835,500 in property damages (Table 3-23).

Table 3-18: Lightning Events in Franklin County			
Year	# of Lightning Events	Annual Property Damage	Annual Crop Damage
1997	1	$3,000	$0
2001	1	$20,000	$0
2002	1	$15,000	$0
2004	1	$35,000	$0
2005	1	$50,000	$0
2008	1	$10,000	$0
2010	2	$25,000	$0
2012	1	$500,000	$0
2013	4	$49,000	$0
2014	3	$93,000	$0
2018	6	$35,500	$0
2019	1	$0	$0
Total	**23**	**$835,500**	**$0**

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

A total of 45 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 3-19: 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
2020	3	$0	$0
Total	**45**	**$5,000**	**$50,000**

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

Probability of Future Events

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

Impact

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

Vulnerability

Society

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

Table 3-20: Estimated Vulnerable Populations in Shutesbury

Vulnerable Population Category	Number	Percent of Total Population*
Population Age 65 Years and Over	329	19%
Population with a Disability	203	12%
Population who Speak English Less than "Very Well"	13	0.7%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	149	20%
Householder Age 65 Years and Over Living Alone	90	12%
Households Without Access to a Vehicle	35	5%

*Total population = 1,755; Total households = 740

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

Source: U.S. Census American Community Survey 2015-2019 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.[24] 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. 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

[24] 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

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,[25] 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. Shutesbury falls within Wind Load Zone I. Refer to the State Building Code (9th Edition [780 CMR] Chapter 16 Structural Design, as amended by Massachusetts) for appropriate reference wind pressures, wind forces on roofs, and similar data.

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

Table 3-21: Estimated Potential Loss by Tax Classification

Tax Classification	Total Assessed Value FY2021	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$213,174,059	$2,131,740	$10,658,700	$21,317,400
Open Space	$0	$0	$0	$0
Commercial	$1,786,981	$17,870	$89,350	$178,700

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

Industrial	$540,610	$5,406	$27,030	$54,060
Total	$225,990,400	$2,259,904	$11,299,520	$22,599,040

Source: Massachusetts Department of Revenue - Division of Local Services, Municipal Databank/Local Aid Section, 2021.

<u>Agriculture</u>

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

<u>Energy</u>

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

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

<u>Public Safety</u>

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

<u>Transportation</u>

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

<u>Water & Wastewater Infrastructure</u>

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

Environment

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

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

Vulnerability Summary

Based on the above assessment, Shutesbury has a "XX" vulnerability to severe thunderstorms and wind events. Thunderstorms are common in New England, and can impact property, utilities and the population of Shutesbury. 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, 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 Shutesbury's areas of greatest concern regarding severe thunderstorms and wind events.

Severe Thunderstorm / Wind Hazard Problem Statements
• Although Shutesbury has an emergency communication system, there is a need to expand the system and increase subscription among residents. Education and outreach are needed to ensure that all residents are aware of emergency situations and have access to evacuation and sheltering instructions, including options for residents with specialized medical needs, and pet sheltering options.
• Shutesbury's emergency communication system may not have up to date information, which may limit the number of residents who receive emergency information. However, this system is dependent on residents self-reporting changes to their contact information.

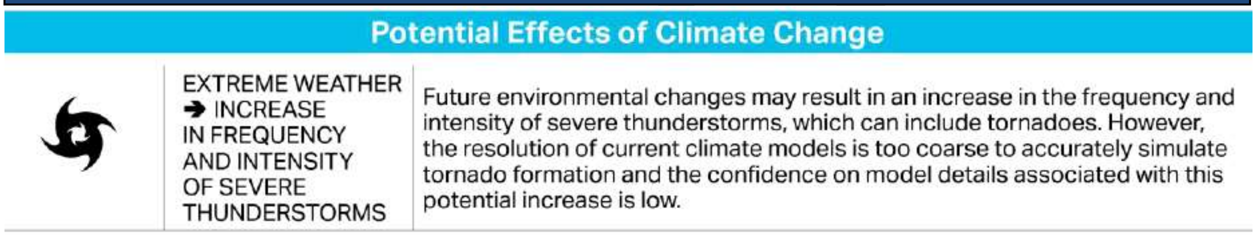
Severe Thunderstorm / Wind Hazard Problem Statements
• Strategies for safeguarding power lines and utilities infrastructure throughout Town need to be identified and evaluated. Eversource routinely removes trees, but the cutting program could be expanded to further mitigate hazards.
Remove trees from West Cemetery on Leverett Road that present a hazard in order to mitigate damage from a wind storm. To reduce the risk to property and infrastructure during high wind events, implement a general program to inspect Town trees annually so pruning or removal of hazardous trees/limbs can be done on a regular basis to reduce risks/hazards. Review Section 8.6.2.B, Common Driveways, of the town's zoning bylaws to determine if it is feasible to require utility lines be placed underground for all new development subject to the common driveway Bylaw To reduce risk to infrastructure from high wind events, integrate the use of brush mowing equipment into a regular system of tree maintenance and pruning that complements work the utility companies are already doing under their 5-year plan. Coordinate with local, state and regional agencies to implement the Franklin County Regional Debris Management Plan and identify a location(s) for the temporary storage of contaminated/hazardous debris. •

3.6 TORNADOES

Potential Impacts of Climate Change

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

Figure 3-10: 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 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.

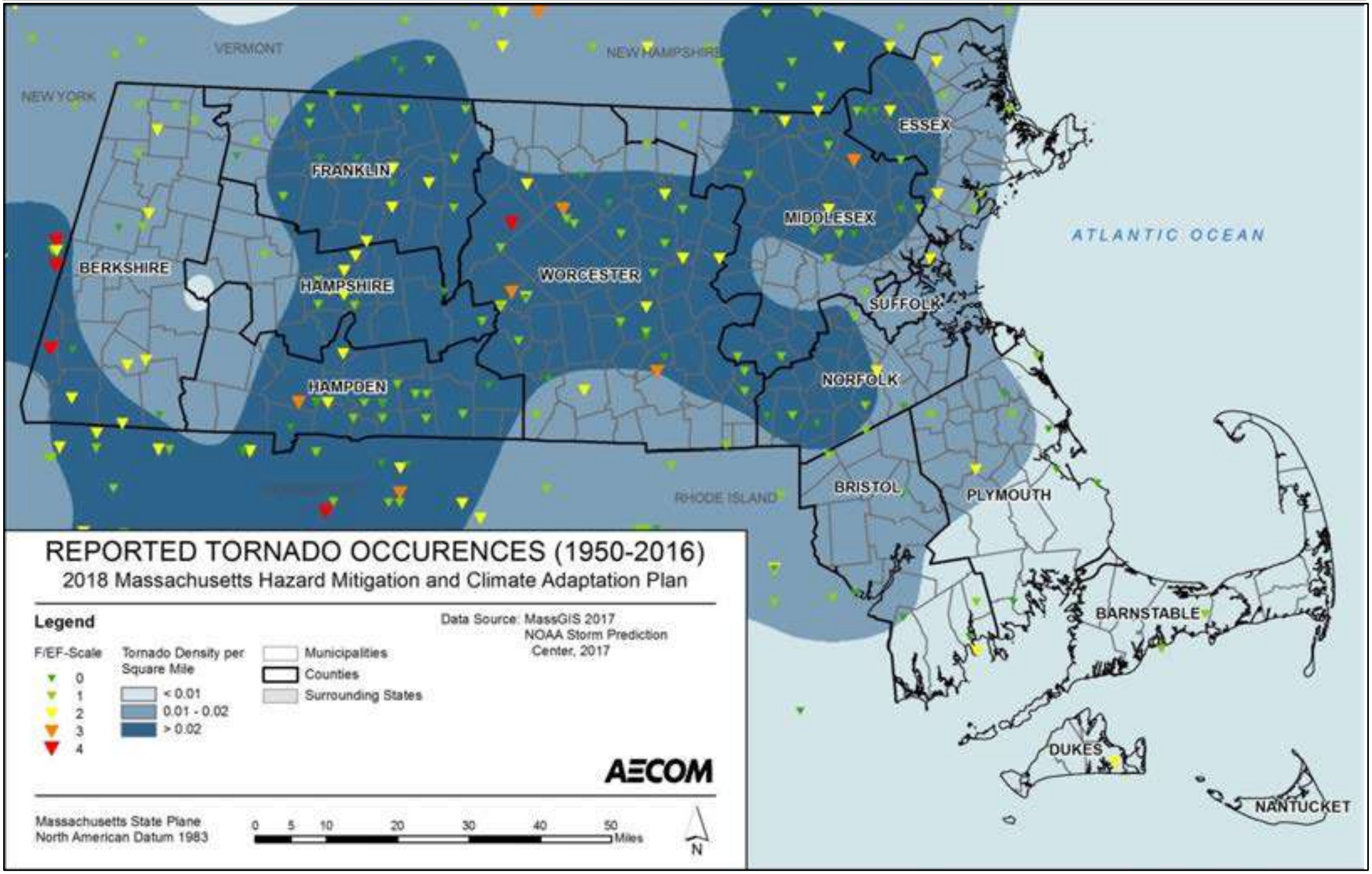
Location

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 Erving and much of Franklin County. Tornadoes are rated as having an Area of Occurrence of "XX." If a tornado were to occur in Shutesbury, it would likely impact less than 10% of the Town.

Extent

The NWS rates tornadoes using the Enhanced Fujita scale (EF scale), which does not directly measure wind speed but rather the amount of damage created. This scale derives 3-second gusts estimated at the point of damage based on the assignment of 1 out of 8 degrees of damage to a range of different structure types. These estimates vary with height and exposure. This method is considerably more sophisticated than the original Fujita scale, and it allows surveyors to create more precise assessments of tornado severity. Figure 3-12 provides guidance from NOAA about the impacts of a storm with each rating.

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

On June 1, 2011, thunderstorms forming ahead of a cold front across Southern New England organized into discrete supercells in an environment highly favorable for tornado formation. A tornado evaluated to be an EF-3 tornado entered Hampden County from the Berkshires, touched down in Westfield, and continued on a 38 mile long trek through West Springfield, Springfield, Wilbraham, Monson, Brimfield, and Sturbridge. This tornado was on the ground for an estimated 70 minutes. About two hours later, another supercell tracked just to the north of the storm track of the EF3 tornado. While its rotation was not as strong, it produced brief tornadoes in Wilbraham (EF1), North Brimfield (EF1), and Sturbridge (EF0). While the focus was on the tornadoes and their damage, damaging winds, large hail up to two inches in diameter, and some flash flooding also occurred across southern New England.

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.

Table 3-22: 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.

Table 3-22: Tornado Events in Franklin County				
Date	**Severity**	**Property Damage**	**Crop Damage**	**Event Narrative**
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 development, but the environment was unstable and a surface front was moving through the region.
2/25/2017	EF1	$400,000	$0	This tornado touched down at 7:23 pm on Main Poland Road in western Conway, Massachusetts. The path width started at 50 yards, with a sharp gradient evident of damage versus no damage. Large sections of forest had thick pine trees snapped at mid-tree. Numerous power lines were downed along the path into downtown Conway. The path width grew, reaching a maximum width of 200 yards near the town hall. Several houses were severely damaged on Whately Road, southeast of the town hall. Roofs were blown off, and in one case the side walls of a house were missing with the interior of the house exposed. On Hill View Road a large barn collapsed. One injury occurred when a tree landed on a house on South Deerfield Road east of town. That was where the visible damage path ended.

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

Probability of Future Events

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

Impact

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

Vulnerability

Society

The entire town of Shutesbury 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 293 housing units in Shutesbury, or 33 percent of all housing units in town, were built prior to the 1970s when the first building code went into effect in Massachusetts. An estimated 0 mobile homes are located in Shutesbury.[26] Table 3-28 estimates the number of vulnerable populations and households in Shutesbury. 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 Shutesbury residents during a tornado event.

[26] U.S. Census Bureau 2015-2019 American Community Survey five-year estimates.

Table 3-23: Estimated Vulnerable Populations in Shutesbury		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	329	19%
Population with a Disability	203	12%
Population who Speak English Less than "Very Well"	13	0.7%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	149	20%
Householder Age 65 Years and Over Living Alone	90	12%
Households Without Access to a Vehicle	35	5%

*Total population = 1,755; Total households = 740

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

Source: U.S. Census American Community Survey 2015-2019 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.

Infrastructure

All critical facilities and infrastructure in Shutesbury 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 3-24: Estimated Potential Loss by Tax Classification				
Tax Classification	**Total Assessed Value FY2021**	**1% Damage Loss Estimate**	**5% Damage Loss Estimate**	**10% Damage Loss Estimate**
Residential	$213,174,059	$2,131,740	$10,658,700	$21,317,400
Open Space	$0	$0	$0	$0
Commercial	$1,786,981	$17,870	$89,350	$178,700
Industrial	$540,610	$5,406	$27,030	$54,060
Total	$225,990,400	$2,259,904	$11,299,520	$22,599,040

Source: Massachusetts Department of Revenue - Division of Local Services, Municipal Databank/Local Aid Section, 2021.

<u>Agriculture</u>

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

<u>Energy</u>

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

<u>Public Safety</u>

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

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 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, Shutesbury has a "XX" vulnerability to tornadoes. Tornadoes are not common occurrences in Shutesbury, 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 Shutesbury's areas of greatest concern regarding tornadoes.

Tornado Hazard Problem Statements
• An estimated 44% of Shutesbury's housing stock was built prior to building codes that require structures to withstand high winds.
• Although Shutesbury has an emergency communication system, there is a need to expand the system and increase subscription among residents. Education and outreach are needed to ensure that all residents are aware of emergency situations and have access to evacuation and sheltering instructions, including options for residents with specialized medical needs, and pet sheltering options.
• Shutesbury's emergency communication system may not have up to date information, which may limit the number of residents who receive emergency information. However, this system is dependent on residents self-reporting changes to their contact information.
• Most Shutesbury residents rely on private wells for water, placing them at risk during prolonged power outages.
• Strategies for safeguarding power lines and utilities infrastructure throughout Town need to be identified and evaluated. Eversource routinely removes trees, but the cutting program could be expanded to further mitigate hazards.
• Many of the Town's evacuation routes may be impacted by a tornado. There are areas of the Town where residents might become isolated if roads, bridges, or culverts were blocked or damaged during a tornado.
• Existing communication infrastructure issues and vulnerabilities could be exacerbated due to a tornado.
• The REPC is working to identify options for regional and local debris management. The regional plan approved by MassDEP several years ago was never implemented because the communities that would serve as regional sites did not execute MOUs. The Town is being urged by MassDEP to select and provide disaster storage/disposal

location(s).

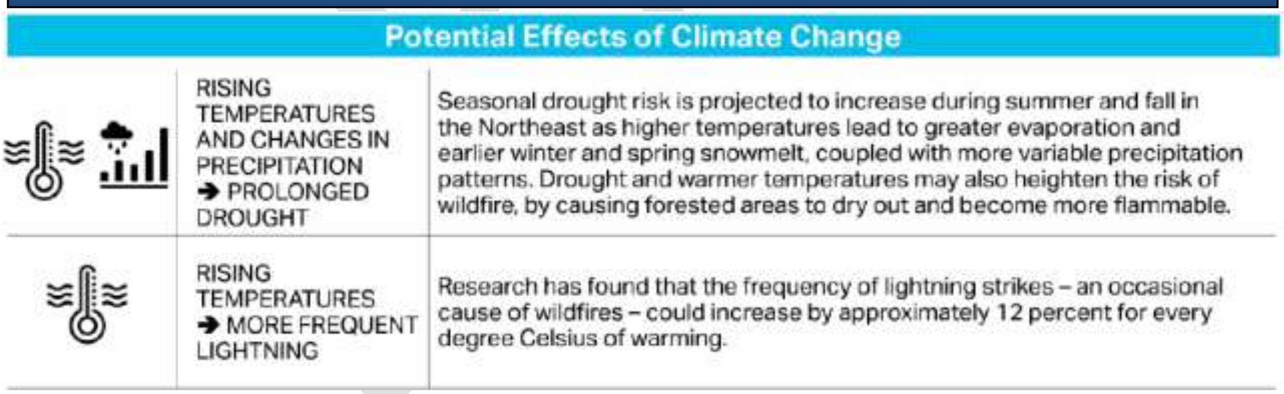
3.7 WILDFIRE

Potential Impacts of Climate Change

Climate change has the potential to affect multiple elements of the wildfire system: fire behavior, ignitions, fire management, and vegetation fuels. Periods of hot, dry weather create the highest fire risk. Therefore, the predicted increase in average and extreme temperatures in the Commonwealth may intensify wildfire danger by warming and drying out vegetation. A recent study published in *the Proceedings of the National Academy of Sciences* found that climate change has likely been a significant contributor to the expansion of wildfires in the western U.S., which have nearly doubled in extent in the past three decades.[27] 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.[28] 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

[27] 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

[28] 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:

- 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.[29]

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.

[29] "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.

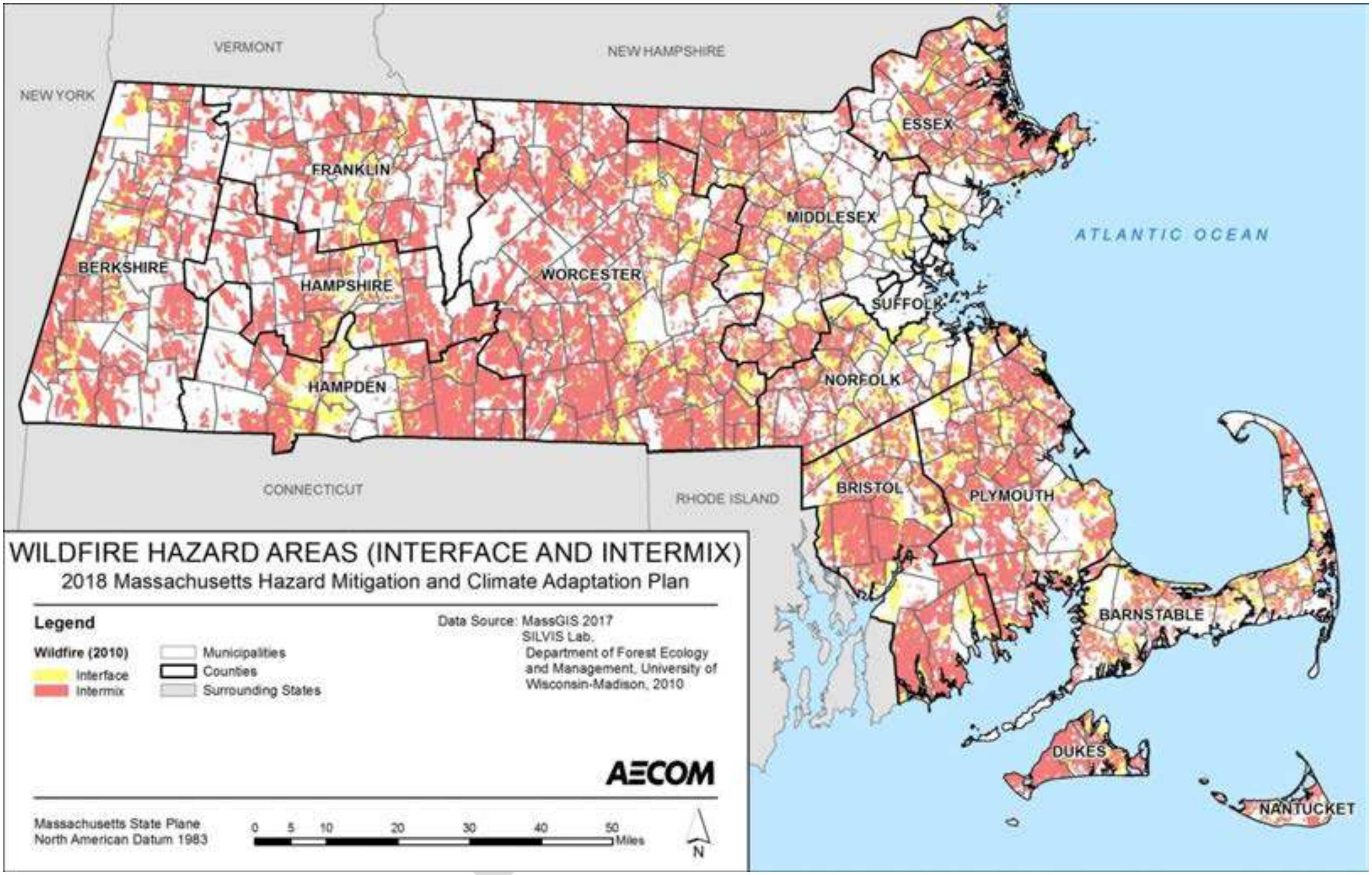
Location

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 3-15. Inventoried assets (population, building stock, and critical facilities) were overlaid with these data to determine potential exposure and impacts related to this hazard. Shutesbury 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 3-16 illustrates the areas identified for the Commonwealth. Shutesbury mostly falls within the "XX" wildfire risk area. The entire town of Shutesbury, which is approximately 89% forested, is at risk for wildfire.

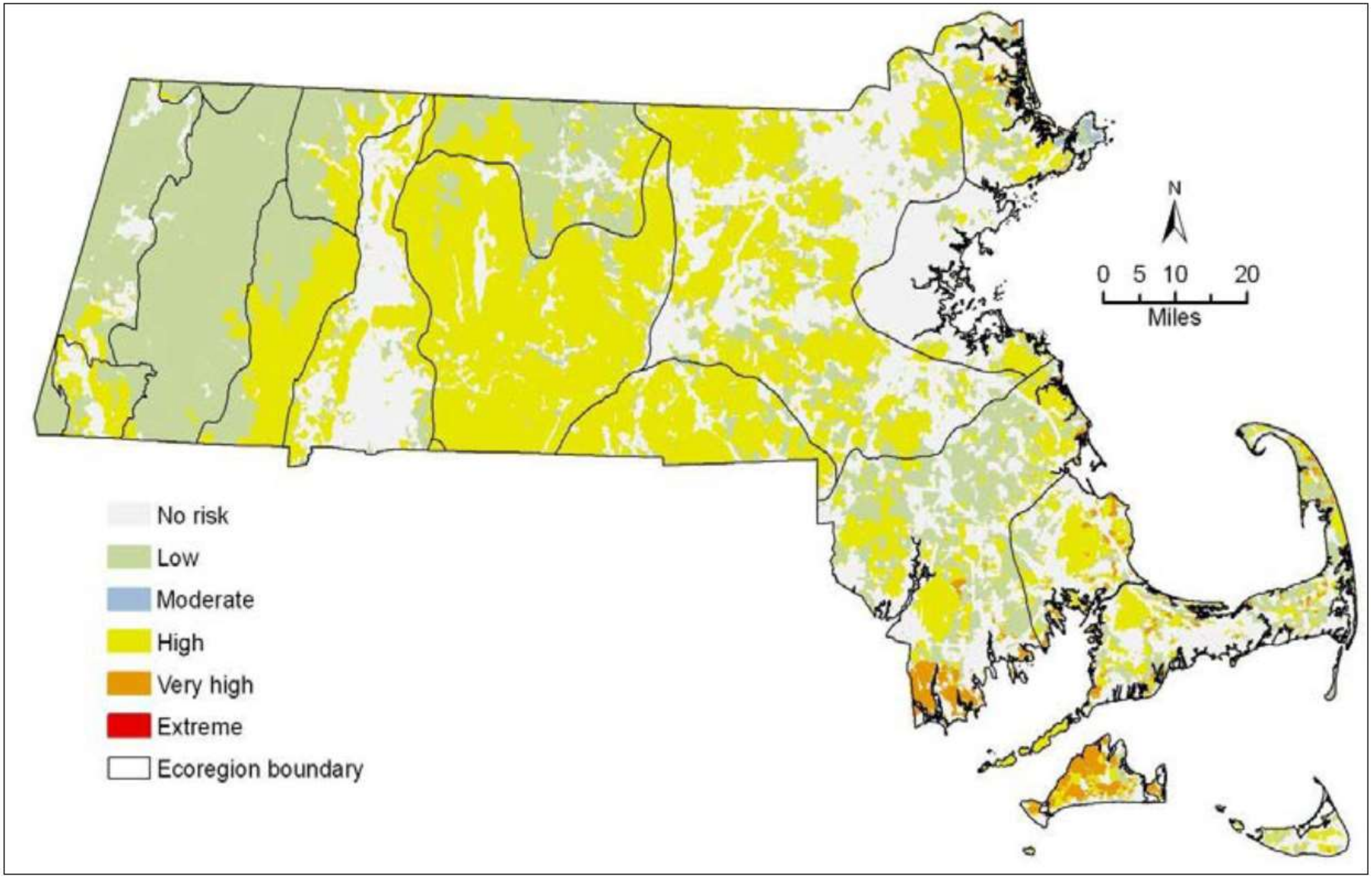
Early detection of wildfires is a key part of the Bureau’s overall effort. Early detection is achieved by trained Bureau observers who staff the statewide network of 42 operating fire towers. During periods of high fire danger, the Bureau conducts county-based fire patrols in forested areas. These patrols 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.

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



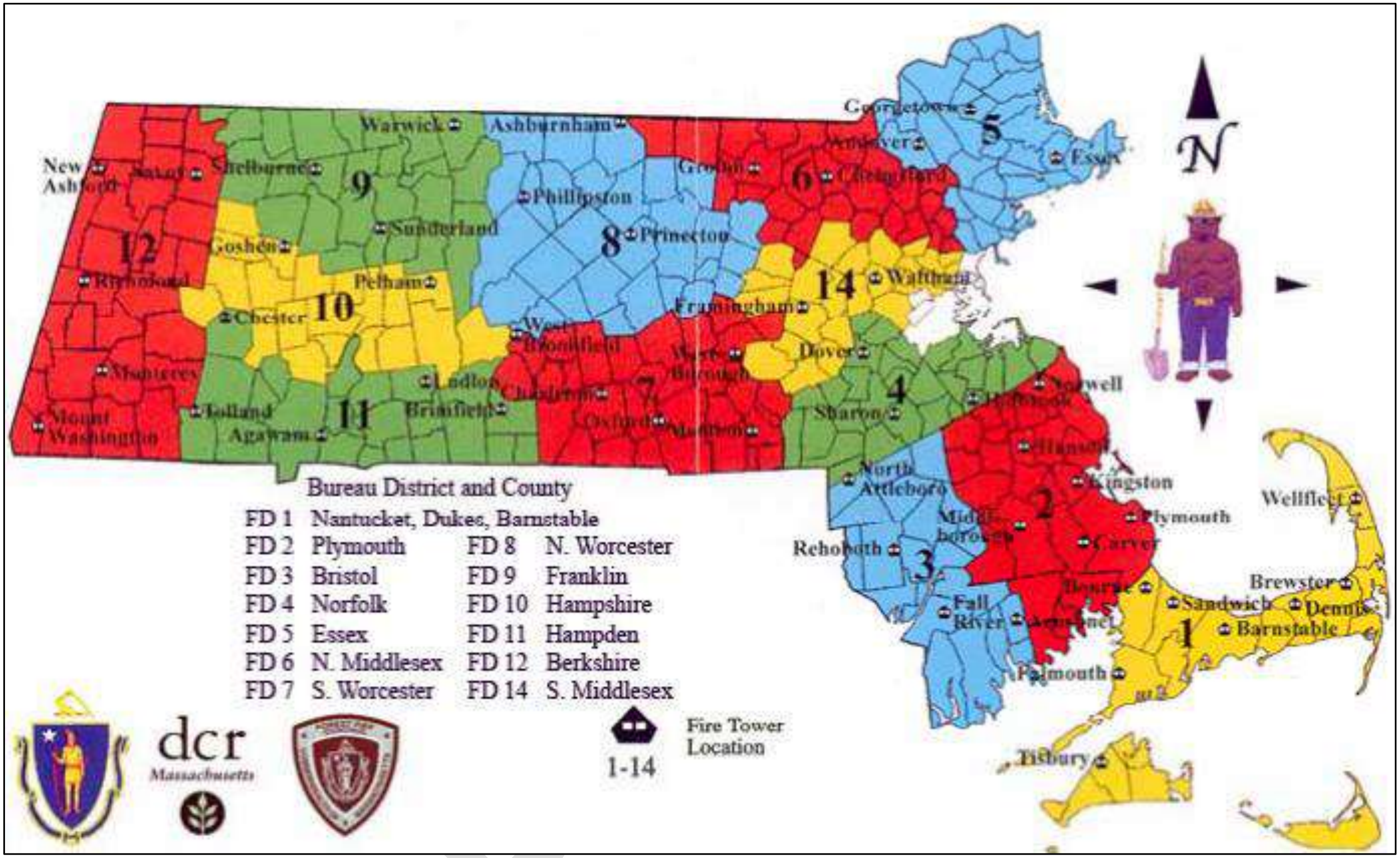
Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

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.[30]

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.

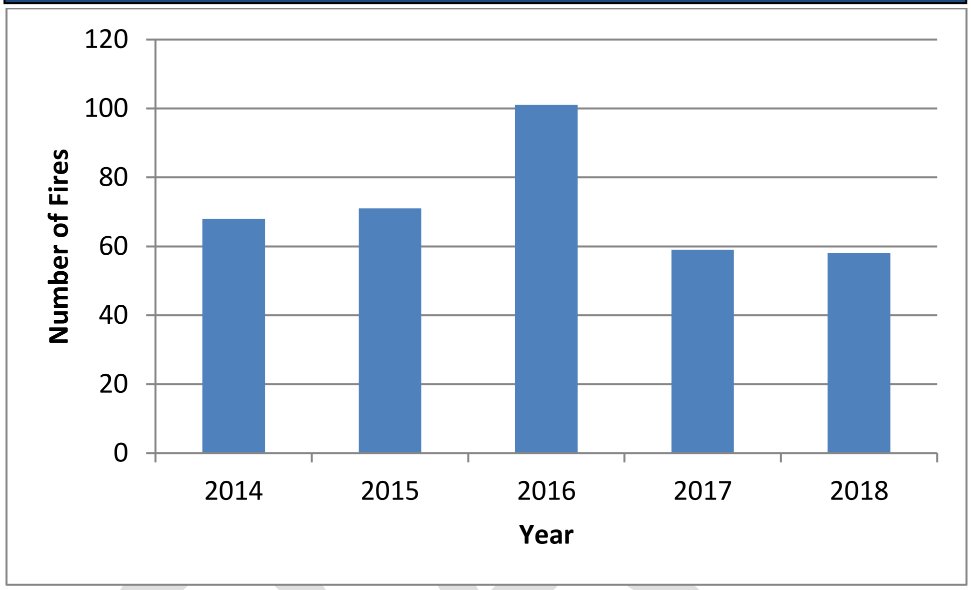
Shutesbury has approximately 15,397 acres of forests, comprising 89% of the Town's total land area, and is therefore at risk of fire. The largest tract of land that is uninterrupted by maintained/traveled roadways and is entirely in the town of Shutesbury is between 3,500 and 4,000 acres in northeast Shutesbury. This abuts other large tracts of land in New Salem and Wendell. This also abuts an area of 2,500 acres of state land that is separated by Cooleyville Road and Route 202 extending all the way to the shore of the Quabbin reservoir. Most of this area has very limited accessibility and has areas of very steep terrain and dense growth.

[30] 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

Previous Occurrences

In the last five years (2012 – 2016) Franklin County has averaged 71 brush, tree, or lawn fires a year, with the highest reported number of fires occurring in 2016 (Figure 3-18). During 2016, Franklin County and Massachusetts experienced one of the worst droughts in the last 50 years.

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



Source: Massachusetts Fire Incident Reporting System County Profiles.

Shutesbury is heavily forested and therefore vulnerable to wildfires. The largest brush fire in Shutesbury's history was reported by the Fire Chief to have burned approximately 50 acres in the Mt. Mineral area of Town in the early 1960s. In addition, there were a few other historical brush fires that were slightly smaller (40-45 acres) in an area behind the fire station and off of Pelham Hill Road (now mostly DCR property).

While wildfires have not been a significant problem in Shutesbury there is always a possibility that changing land use patterns and weather conditions will increase a community's vulnerability. For example, drought conditions can make forests and other open, vegetated areas more vulnerable to ignition.

Probability of Future Events

cONCERNS ABOUT working and non-working forests in Town ?? MANAGED VS NOT MANAGED with regard to the risk of wildfire. woody debris is often cleared VS LEFT IN PLACE?.

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, Shutesbury has a "XX" probability (X% to XX% chance) that it will experience a wildfire in a given year.

Impact

Unfragmented and heavily forested areas of Shutesbury 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 Shutesbury from a wildfire is to the natural environment, which faces a "XX" impact from wildfires, depending on the location of the outbreak and if the wildfire spreads.

The Town has experienced problems with maintaining adequate water storage for fire protection. IDENTIFIED AS A CONCERN IN MVP. DOES THIS APPLY TO FOREST FIRES? There are no hydrants in Shutesbury and the Town has no public water supply. As a result, the Fire Department sources its firefighting water solely from various surface water sources, including streams and ponds across Town. The Town's largest source of water for firefighting is Lake Wyola. In the 2020 MVP workshops, participants expressed concern over the lack of accessibility for the fire truck at the Lake, as there are only 3 to 4 points where the truck can access water due to development over the years. Workshop participants stated that changing precipitation patterns have already impacted the Town's water supply for firefighting, and expressed concern that this impact is expected to continue or worsen as a result of increased frequency and intensity of droughts. Workshop participants observed that shifting precipitation patterns impact certain water supplies more than others; for example, some water supplies are so drastically affected by a lack of rain in the summer they become unusable. Excessive weed growth in the summer has also impacted the supply of water for fire suppression.

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 Shutesbury. 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 Shutesbury residents during a wildfire event.

Table 3-25: Estimated Vulnerable Populations in Shutesbury		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	329	19%
Population with a Disability	203	12%
Population who Speak English Less than "Very Well"	13	0.7%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	149	20%
Householder Age 65 Years and Over Living Alone	90	12%
Households Without Access to a Vehicle	35	5%

*Total population = 1,755; Total households = 740

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

Source: U.S. Census American Community Survey 2015-2019 Five-Year Estimates.

<u>Health Impacts</u>

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

Economic Impacts

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

Infrastructure

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

Table 3-26: Estimated Potential Loss by Tax Classification				
Tax Classification	**Total Assessed Value FY2021**	**1% Damage Loss Estimate**	**5% Damage Loss Estimate**	**10% Damage Loss Estimate**
Residential	$213,174,059	$2,131,740	$10,658,700	$21,317,400
Open Space	$0	$0	$0	$0
Commercial	$1,786,981	$17,870	$89,350	$178,700
Industrial	$540,610	$5,406	$27,030	$54,060
Total	$225,990,400	$2,259,904	$11,299,520	$22,599,040

Source: Massachusetts Department of Revenue - Division of Local Services, Municipal Databank/Local Aid Section, 2021.

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 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, and input from the Fire Chief regarding concerns about climate change and droughts increasing the Town's vulnerability, Shutesbury faces a "XX" vulnerability from wildfire and brushfires. While wildfires have caused minimal damage, injury and loss of life to date in Shutesbury, 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 Shutesbury 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 Shutesbury regarding wildfires.

Wildfire Hazard Problem Statements
• Most residents in Shutesbury live within or adjacent to heavily forested areas in "intermix" and "interface" zones. This increases the risk of impacts to the population from a wildfire.
• Although Shutesbury has an emergency communication system, there is a need to expand the system and increase subscription among residents. Education and outreach are needed to ensure that all residents are aware of emergency situations and have access to evacuation and sheltering instructions, including options for residents with specialized medical needs, and pet sheltering options.
• Shutesbury's emergency communication system may not have up to date

Wildfire Hazard Problem Statements
information, which may limit the number of residents who receive emergency information. However, this system is dependent on residents self-reporting changes to their contact information.
• Most Shutesbury residents rely on private wells for water, placing them at risk during prolonged power outages that could occur due to a wildfire.
• There are locations in Shutesbury where water volume and/or pressure is low and would be insufficient for firefighting, especially during dry periods or drought. • Many towns in the region rely on volunteer fire departments and mutual aid to assist in firefighting. During dry spells or drought, firefighting resources in Shutesbury and surrounding towns could be strained if multiple wildfires break out at the same time. • There are several non-working forests in Shutesbury that do not have management plans for the removal of debris and may be vulnerable to wildfires. • Education materials should continue to be distributed to inform residents about brushfire and wildfire risks and to promote general fire safety practices. • Many of the Town's evacuation routes could be impacted by wildfire. • NEXT 3 ITEMS ARE FROM 2015 HMP
Assess and create water supply for fire prevention and identify methods for increasing storage capacity for fire prevention to mitigate impact to the built environment and forest resources.
Educate homeowners about general fire safety by publishing regular informational items on the Town website and in the community newsletter.
Attend a forum with DCR staff foresters for Town officials and private landowners to discuss forest management practices and forest cutting plans on State-owned and private forest lands.
• **Conduct a detailed vulnerability and risk assessment of surface water supplies used for firefighting** by the Fire Department or Emergency Management. Individual source ponds already identified as potential water sources should be inspected, physical problems noted, and possible solutions identified. Conduct a wildfire risk assessment to identify vulnerable areas and develop an action plan for the Fire Department. FROM MVP PLAN • **Establish a community education program on the risks of wildfire and** prevention measures that can be taken by residents.

3.8 EARTHQUAKES

Potential Impacts of Climate Change

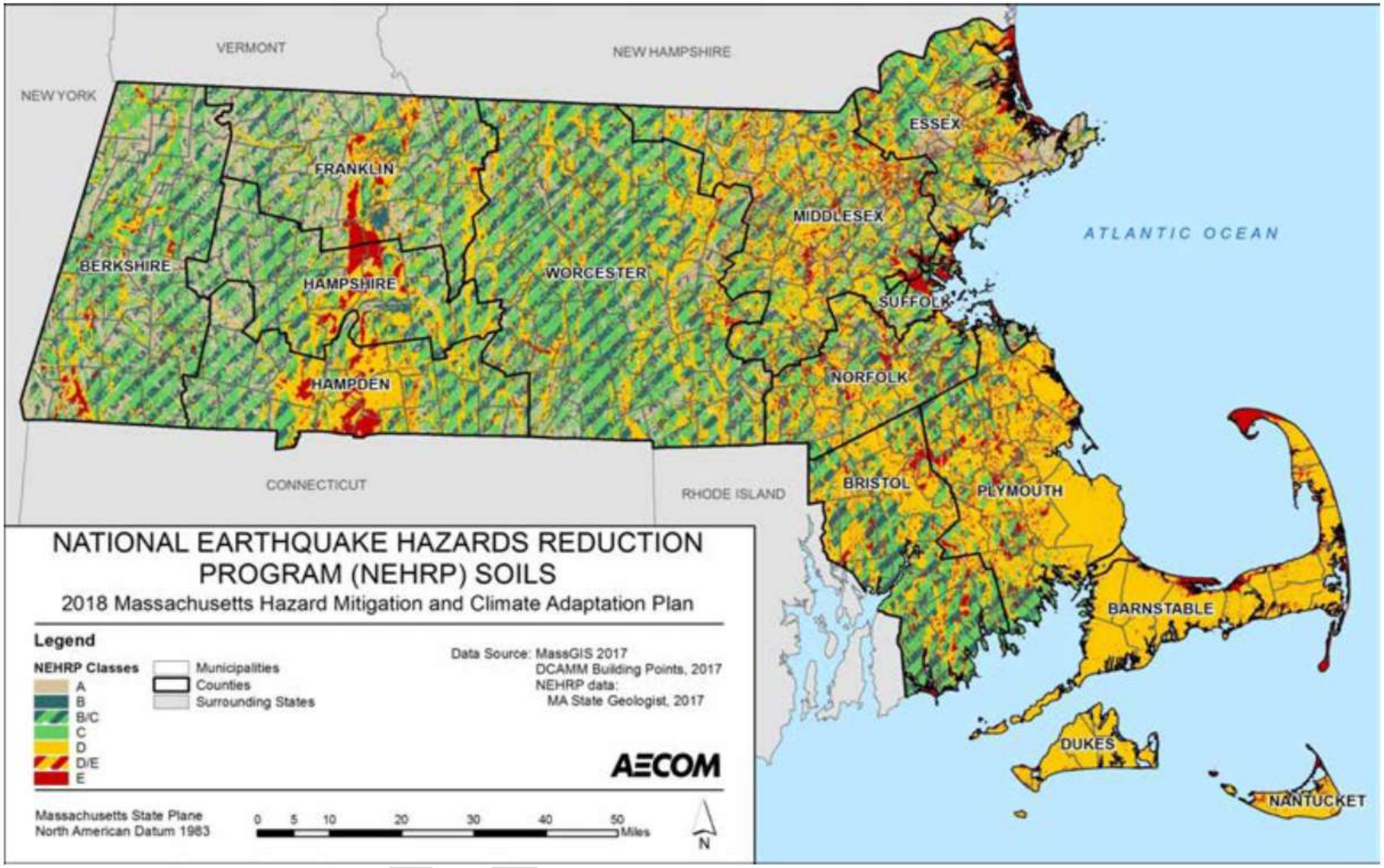
The State Hazard Mitigation and Climate Adaptation Plan does not identify any effects of climate change on the earthquake hazard in Massachusetts.

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 3-19.

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.[31]

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

[31] 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 3-27: Richter Scale Magnitudes and Effects

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

Source: US Federal Emergency Management Agency

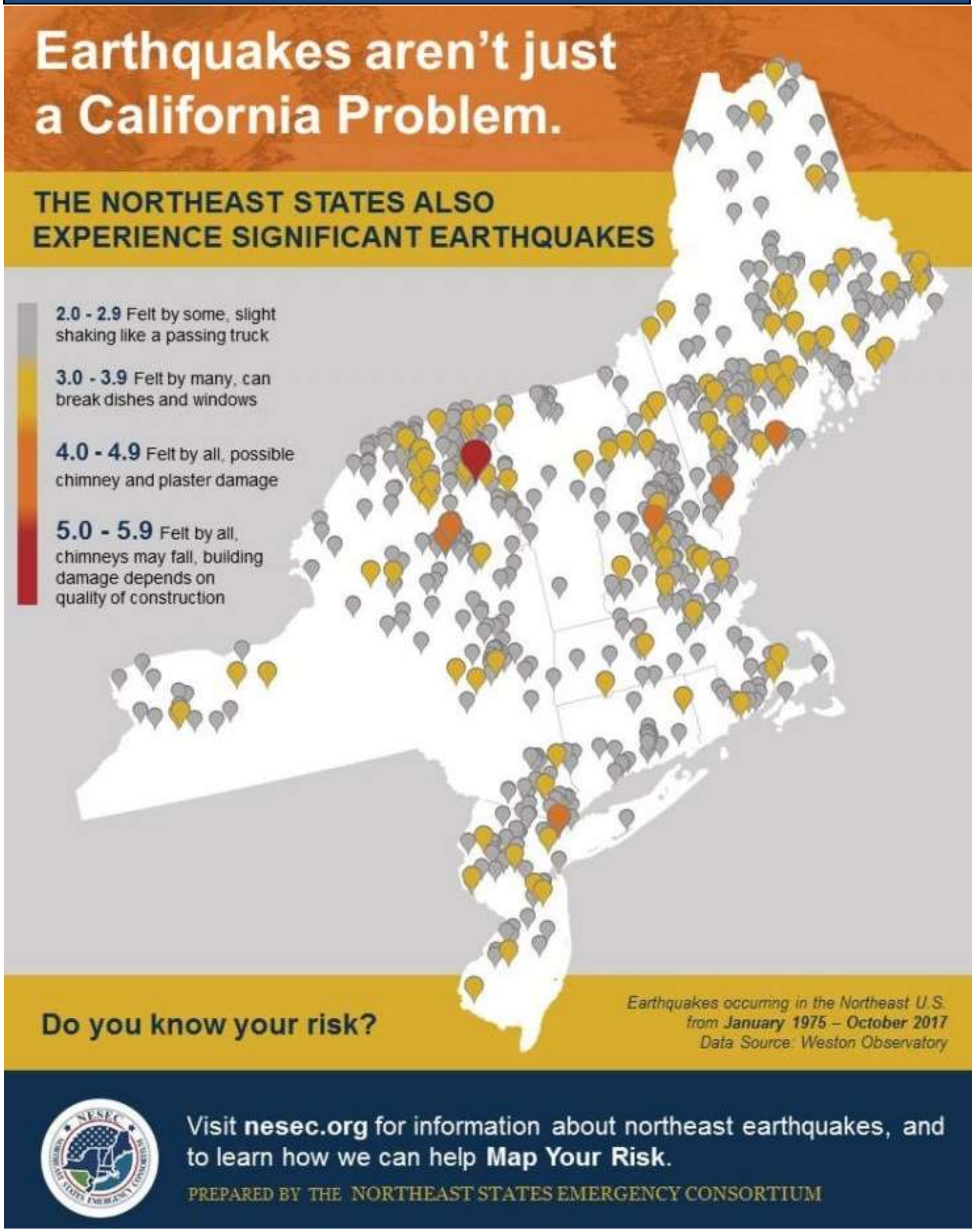
Table 3-28: Modified Mercalli Intensity Scale for and Effects			
Scale	**Intensity**	**Description of Effects**	**Corresponding Richter Scale Magnitude**
I	Instrumental	Detected only on seismographs.	
II	Feeble	Some people feel it.	< 4.2
III	Slight	Felt by people resting; like a truck rumbling by.	
IV	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 3-20). 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 Shutesbury are shown in Figure 3-20. There is no record of any damage to the Town of Shutesbury as a result of these earthquakes.

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



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

Table 3-29: 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, Shutesbury has "XX" probability, or a XX% chance in a given year, of being impacted by an earthquake.

Impact

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

Liquefaction of the land near water could also lead to extensive destruction. Because earthquakes are unlikely to occur in Shutesbury, the Committee ranked the potential impact of an event as "XX," with very few injuries and minimal disruption of quality of life.

Vulnerability

Society

The entire population of Shutesbury is potentially exposed to direct and indirect impacts from earthquakes. The degree of exposure depends on many factors, including the age and construction type of the structures where people live, work, and go to school; the soil type these buildings are constructed on; and the proximity of these building to the fault location. In addition, the time of day also exposes different sectors of the community to the hazard. There are many ways in which earthquakes could impact the lives of residents. Business interruptions could keep people from working, road closures could isolate populations, and loss of utilities could impact populations that suffered no direct damage from an event itself. People who reside or work in unreinforced masonry buildings are vulnerable to liquefaction.

<u>Vulnerable Populations</u>

The populations most vulnerable to an earthquake event include people over the age of 65 (26% of Shutesbury's population) and those living below the poverty level (19% of Shutesbury's population). These socially vulnerable populations are most susceptible, based on a number of factors, including their physical and financial ability to react or respond during a hazard, the location and construction quality of their housing, and the inability to be self-sustaining after an incident due to a limited ability to stockpile supplies. Residents living in homes built prior to the 1970s when the State building code first went into effect, and residents living in mobile homes, are also more vulnerable to earthquakes. An estimated 375 housing units in Shutesbury, or 44% of all housing units in town, were built prior to the 1970s. An estimated 19 mobile homes are located in Shutesbury, accounting for 2% of the total housing stock.[32]

Earthen dams and levees are highly susceptible to seismic events, and the impacts of their eventual failures can be considered secondary risks for earthquakes. As mentioned previously, there are two high hazard dams in Shutesbury (Atkin's Reservoir Dam and Lake Wyola Dam) upstream from Shutesbury. In the rare event that a compromise of any of these facility's dam should occur, residents would have to evacuate their homes.

<u>Health Impacts</u>

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

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 Shutesbury 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 3-30: Estimated Potential Loss by Tax Classification

Tax Classification	Total Assessed Value FY2021	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$213,174,059	$2,131,740	$10,658,700	$21,317,400
Open Space	$0	$0	$0	$0
Commercial	$1,786,981	$17,870	$89,350	$178,700
Industrial	$540,610	$5,406	$27,030	$54,060
Total	$225,990,400	$2,259,904	$11,299,520	$22,599,040

Source: Massachusetts Department of Revenue - Division of Local Services, Municipal Databank/Local Aid Section, 2021.

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

Earthquake Hazard Problem Statements
• Although Shutesbury has an emergency communication system, there is a need to expand the system and increase subscription among residents. Education and outreach are needed to ensure that all residents are aware of emergency situations and have access to evacuation and sheltering instructions, including options for residents with specialized medical needs, and pet sheltering options.
• Shutesbury's emergency communication system may not have up to date information, which may limit the number of residents who receive emergency information. However, this system is dependent on residents self-reporting changes to their contact information
• Most Shutesbury residents rely on private wells for water, placing them at risk during prolonged power outages.
• Many of the Town's evacuation routes may be impacted by an earthquake. There are areas of the Town where residents might become isolated if roads, bridges, or culverts were blocked or damaged during an earthquake.
• Existing communication infrastructure issues and vulnerabilities could be exacerbated by an earthquake.
• An estimated 44% of homes in Shutesbury were built prior to the first State building code in 1975, potentially making them more vulnerable to damages from earthquakes.

- The REPC is working to identify options for regional and local debris management. The regional plan approved by MassDEP several years ago was never implemented because the communities that would serve as regional sites did not execute MOUs. The Town is being urged by MassDEP to select and provide disaster storage/disposal location(s).
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3.9 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

The Massachusetts Emergency Management Agency (MEMA) identifies nine dams in Shutesbury of which the Dudleyville Pond Dam is a significant hazard and the Lake Wyola and Atkins Reservoir Dams are high hazard. The outflows of Lake Wyola and the Atkins Reservoir are located close to Shutesbury's western border with Leverett. Inundation mapping of these two locations show that a number of Leverett residents would be impacted by the failure of the

Lake Wyola Dam, but not the Atkins Reservoir Dam. The Town of Leverett has created an evacuation plan for residents in the inundation zone, and has set up a Robocall list of these residents to quickly alert them in the event of a dam failure.

XX ANY CONCERNS ABOUT BEAVER DAM FAILURES?

Extent

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

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

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

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

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

The time intervals represent the maximum time between inspections. More frequent inspections may be performed at the discretion of the state. As noted previously, dams and reservoirs licensed and subject to inspection by the Federal Energy Regulatory Commission (FERC) are excluded from the provisions of the state regulations provided that all FERC-approved periodic inspection reports are provided to the DCR. FERC inspections of high and significant hazard projects are conducted on a yearly basis. All other dams are subject to the regulations unless exempted in writing by DCR.

Previous Occurrences

To date, there have been no known dam or levee failures in Shutesbury. IS THIS STILL TRUE?

Probability of Future Events

Currently the probability of a dam failure is "XX" with a less than X% chance of a dam failing in any given year.

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

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

The health of the Lake Wyola Dam is monitored by the Lake Wyola Advisory Committee, who is responsible for the inspection, care, and improvement of the dam. The Town of Amherst is responsible for the Atkins Reservoir Dam.

Impact

A dam failure in Shutesbury is likely to have a "XX" impact. Residents along the Sawmill River in Leverett, along North Leverett Road and in North Leverett Village, will be be most impacted by a failure of the Lake Wyola Dam.

Vulnerability

Dam failures, while rare, can destroy roads, structures, facilities, utilities, and impact the population of Shutesbury. Existing and future mitigation efforts should continue to be developed and employed that will enable Shutesbury 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.[33]

Infrastructure
Structures that lie in the inundation area of each of the dams in Shutesbury are vulnerable to a dam failure. Buildings located within the floodplain are vulnerable to dam failure in Shutesbury. There are critical facilities in Shutesbury located either within the 100-year floodplain, in a dam inundation area, or in areas prone to localized flooding. Table 3-12 on page XX shows the value of replacing the structures and contents of buildings located in the flood hazard area of Shutesbury. In total, the structures and building contents are valued in excess of $4 million. It is evident that catastrophic flooding would cause significant economic, financial, and environmental damage.

Environment
Examples of environmental impacts from a dam failure include:

- Pollution resulting from septic system failure, back-up of sewage systems, petroleum products, pesticides, herbicides, or solvents
- Pollution of the potable water supply or soils
- Exposure to mold or bacteria during cleanup

[33] *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

- 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[34]

Vulnerability Summary

Due to the presence of High Hazard dams upstream from Shutesbury, and noted issues with beaver dams throughout Shutesbury, the Committee determined that the Town has a "XX" vulnerability from dam or levee failure.

Dam Failure Hazard Problem Statements
• While the chance is low, a catastrophic dam failure at a major facility upstream of Leverett would result in devastating flooding. A failure at the Lake Wyola Dam would result in a blockage on North Leverett Road and prevent some residents from evacuating.
• The REPC is working to identify options for regional and local debris management. The regional plan approved by MassDEP several years ago was never implemented because the communities that would serve as regional sites did not execute MOUs. The Town is being urged by MassDEP to select and provide disaster debris storage/disposal location(s).
• Emergency shelters may not be adequately staffed or supplied with water, food, and first aid supplies. There is a need to inventory the supplies currently available at local shelters.
• Beaver activity is occurring in proximity to residential settlements and municipal infrastructure. In some cases, beaver activity has led to the contamination of residential wells. Continued monitoring and risk assessment is needed to mitigate damage from a potential beaver dam failure.
• Although Shutesbury has an emergency communication system, there is a need to expand the system and increase subscription among residents. Education and

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

Dam Failure Hazard Problem Statements
outreach are needed to ensure that all residents are aware of emergency situations and have access to evacuation and sheltering instructions, including options for residents with specialized medical needs, and pet sheltering options.
• Shutesbury's emergency communication system may not have up to date information, which may limit the number of residents who receive emergency information.
• Many of the Town's evacuation routes may be impacted by flooding from dam failure. There are areas of the Town where residents might become isolated if roads, bridges, or culverts were blocked or damaged during a flood.
• Existing communication infrastructure issues and vulnerabilities could be exacerbated due to a dam failure. • **Coordinate with the Town of Amherst on inspections for the Atkins Reservoir Dam**. Consider climate change impacts, such as increased intensity and frequency of heavy precipitation events, when assessing the dam. FROM MVP •

3.10 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.

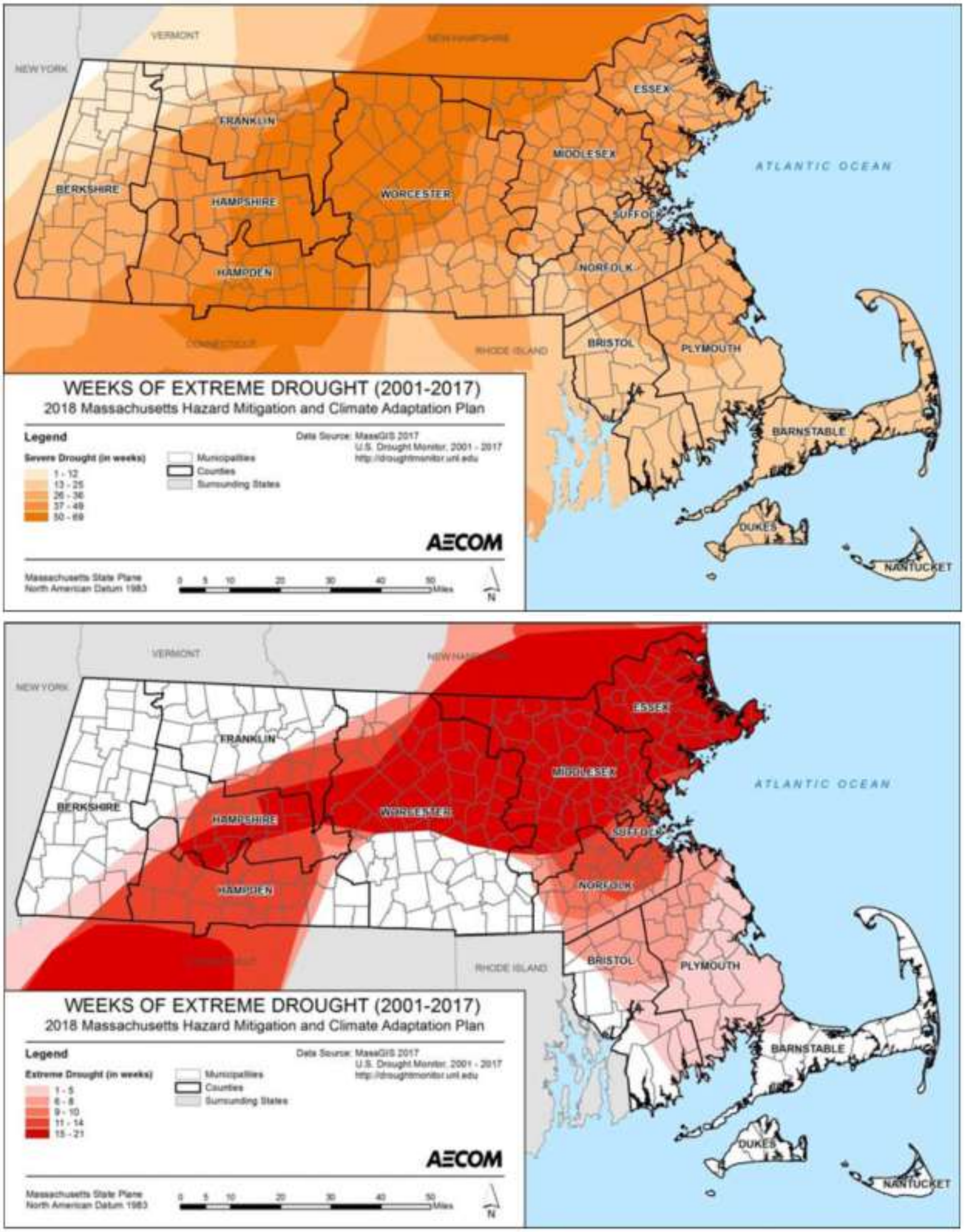
Highly urbanized areas with traditional stormwater drainage systems tend to result in higher peak flood levels during rainfall events and rapid decline of groundwater levels during periods of low precipitation. Thus, the hydrology in these areas becomes more extreme during floods and droughts.[35] The 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

Shutesbury falls in 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 3-22). Because of this hazard's regional nature, a drought would impact the entire town, resulting in a "XX" location of occurrence, or more than XX percent of total land area affected.

[35] 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, for 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 Shutesbury residents. For example, shallow wells in unconsolidated materials or deep, drilled bedrock wells. There is no municipal public water supply.

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

Table 3-31: 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

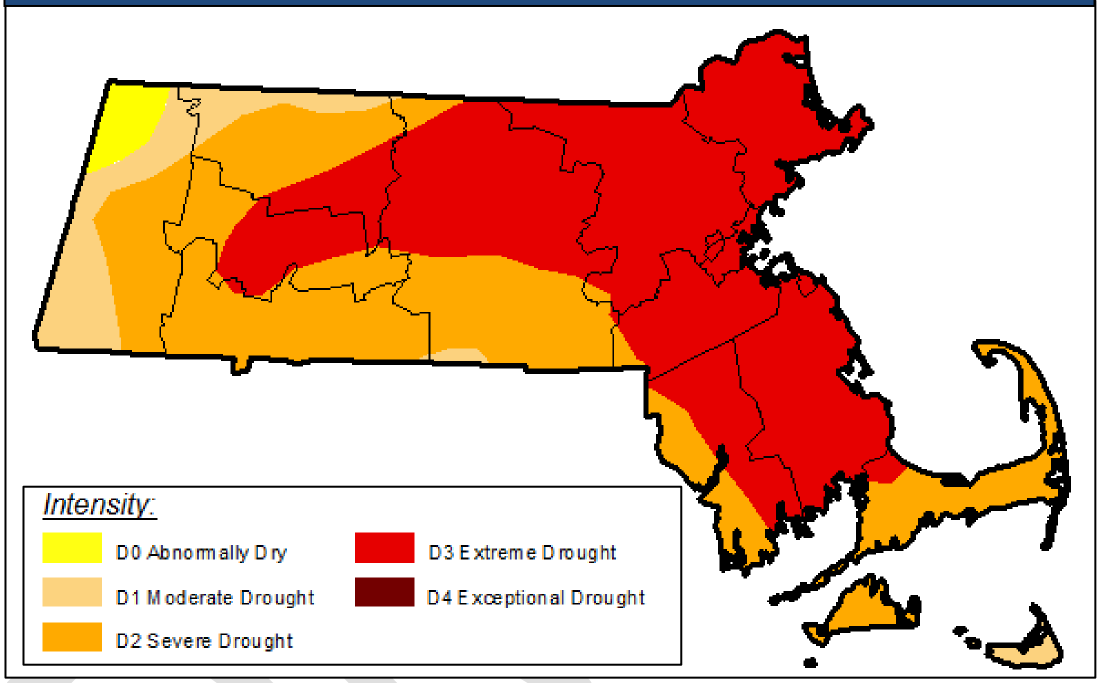
Previous Occurrences

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 3-23).[36] 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 was identified as an area of concern during the Shutesbury Municipal Vulnerability Preparedness Community Building workshop in spring of 2020. At the workshop it was noted that there has been an increase in well problems during dry summers, with an uptick in well drilling during these times. The Board of Health noted that wells in Town have had to be re-drilled, or deeper wells drilled in place of shallow wells.

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

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

one experienced across the Commonwealth in the summers of 2016, 2017, and 2020. In Shutesbury, drought has a "XX" probability of future occurrence, or between a XX% and xx% chance of occurring in any given year.

Impact

Due to the water richness of western Massachusetts, Shutesbury is unlikely to be adversely affected by anything other than a major, extended drought. The major impact to residents would be private wells running dry or being contaminated due to low water levels. Farmers could be impacted economically by crop failure due to 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 "XX" with more than XX% of property damaged or destroyed.

Firefighting capabilities could be compromised during a drought if aquifers, fire ponds, or rivers used for pumping water are low. MVP workshop participant Walter Tibbetts, Fire Chief, noted, fire risk from drought is a "double-edged sword," as drought simultaneously depletes water supplies available for firefighting. Other workshop participants expressed concern over the lack of accessibility for the fire truck at Lake Wyola, as there are only 3 to 4 points where the truck can access water due to development over the years

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

Vulnerable Populations

Drought conditions can cause a shortage of water for human consumption and reduce local firefighting capabilities. Public water supplies (PWS) provide water for both of these services and may struggle to meet system demands while maintaining adequate pressure for fire suppression and meeting water quality standards. The Massachusetts Department of Environmental Protection (DEP) requires all PWS to maintain an emergency preparedness plan. Shutesbury has public water supply systems that serve the Library, the Public Safety Complex (Emergency Operations Center, Police Department, Fire Department, and the Highway Department). However, there is no municipal public water supply in Shutesbury for residential use. Individual wells provide drinking water for residents and businesses in Shutesbury. 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.

<u>Health Impacts</u>

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.

<u>Economic Impacts</u>

The economic impacts of drought can be substantial, and would financially impact residents who need to re-drill wells. It can also affect the agriculture, recreation and tourism, forestry, and energy sectors.

Infrastructure

<u>Agriculture</u>

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:[37]

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

[37] 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.

Vulnerability Summary

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

Drought Hazard Problem Statements
• Most of Shutesbury's residents and businesses rely on individual wells for water, placing them at risk of water shortages during extended periods of drought.
• First responders may lack sufficient water infrastructure across town to fight wildfires; a vulnerability worsened by impacts of drought on local water supplies. An evaluation of artesian wells and surface water resources in Town should be completed to determine if they could be used as a backup supply.
• Shutesbury's forests make up 88% of the Town's land cover and are vulnerable to drought, which could also increase the risk to other hazards including wildfire and pests.
• Most residents in Shutesbury live within or adjacent to heavily forested areas, making them susceptible to hazards affecting these areas.
• Also see wildfire problem statements.
• **Assess wells providing water for key municipal facilities**, including the Town Hall, elementary school, and Fire Department, to ensure reliability of water supplies.
• **Assess additional options for stand pipes or underground storage tanks** for water supply for firefighting to reduce the Fire Department's reliance on surface water, which is vulnerable to the impacts of drought. Coordinate permitting efforts with other Town projects.
• **Continue efforts related to the Town's well monitoring program** to observe available water quantity for private wells across Town.
• **Conduct a feasibility assessment for dispersed municipal water supply** that would rely on multiple supply sources to provide public water and relieve some of the burden from residents' need to rely on and maintain private wells at every residence.
• **Establish a formal drought plan** to detail appropriate actions to be taken during times of extended drought, with particular attention to developing alternate water supply sources for farmers.
• **Conduct strategic planning to support the agricultural community** in the face of climate change. All of the identified hazards (heavy precipitation, drought, extreme temperatures, and extreme storm events) have the potential to significantly impact agricultural production, with

corresponding threats to livelihoods. Planning should include education on adapting agricultural practices to impacts of climate change, such as longer growing seasons, extended periods of drought, and changes in overall precipitation patterns. Educate farmers and gardeners on adaptation measures, including drought resistant crops.

-

3.11 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.[38] This precipitation can cause slopes to become saturated.

[38] 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

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.[39]

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:

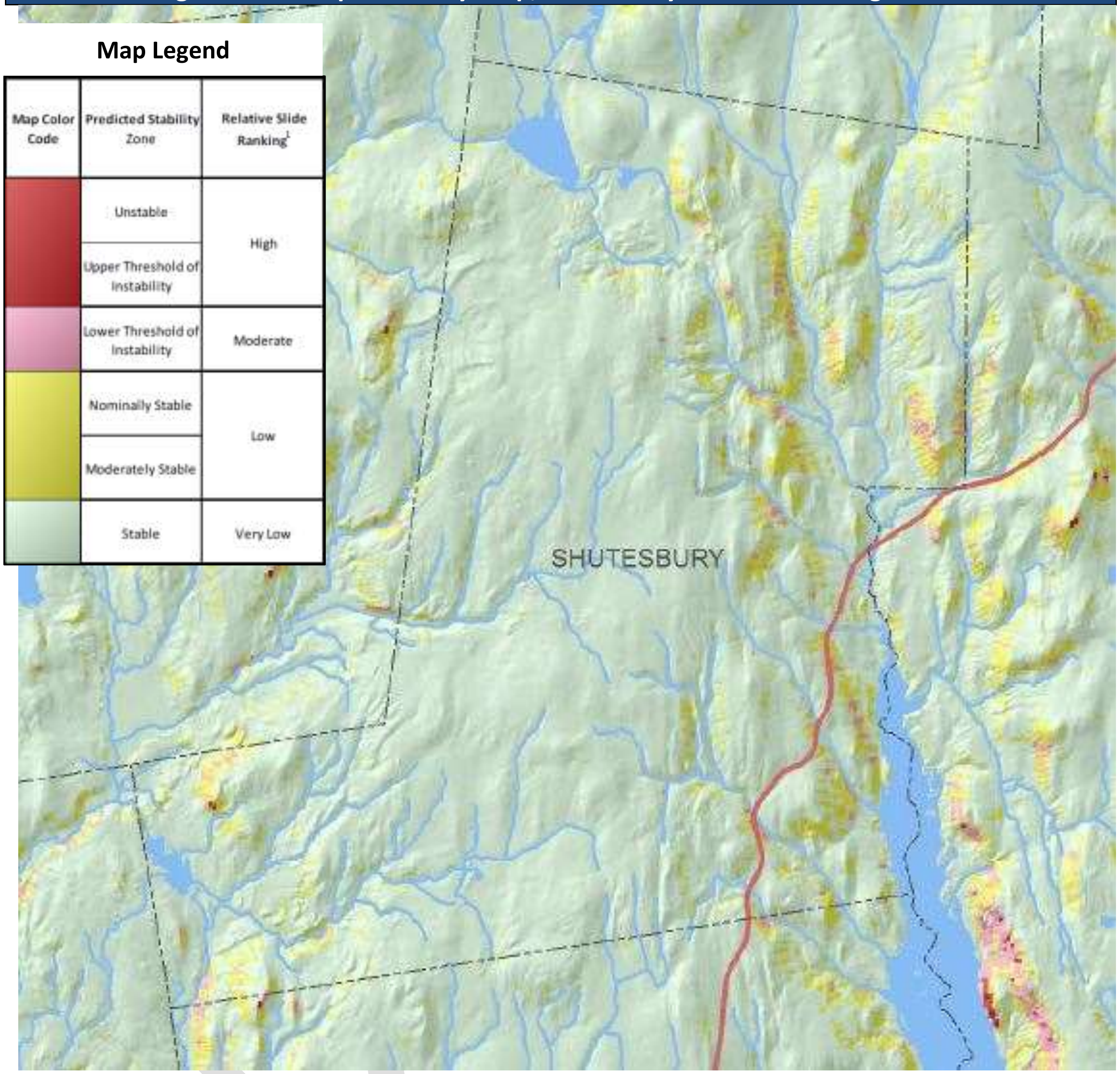
- vibrations from machinery or traffic;
- blasting;
- earthwork which alters the shape of a slope, or which imposes new loads on an existing slope;
- in shallow soils, the removal of deep-rooted vegetation that binds colluvium to bedrock; and
- construction, agricultural or forestry activities (logging)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

[39] 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

Figure 3-24: Slope Stability Map, Shutesbury and Surrounding Towns



Source: Massachusetts Geologic Survey and UMass Amherst, 2013

Shutesbury has a few areas in town with high and moderate landslide rankings. These areas are shown in Figure 3-25 and are mostly located along the eastern side of the ridges along Quabbin Reservoir and West Branch of the Swift River, as well as on the west sides of Poverty Mountain and the January Hills in southwest Shutesbury. In addition, steep sandy banks along dirt roads in town may be susceptible to landslides, particularly on Montague Road, Sand Hill Road, and dirt sections of Wendell Road.

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 Shutesbury 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 Shutesbury. However, the Committee evaluated the potential area of occurrence to be "XX" or less than XX% of the Town.

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 Shutesbury. There is a "XX" probability, or a XX% 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 Shutesbury would be "XX" with minimal property damage in the affected area.

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 Shutesbury, residents who live on Montague Road, Sand Hill Road, and dirt sections of Wendell Road because of the steep, sandy banks along these roads..

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 vehicular access is often a lengthy and expensive process.

Economic Impacts

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

Infrastructure

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

Agriculture

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

Energy

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

Public Health

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

Public Safety

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

Transportation

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

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

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, Shutesbury has a hazard index rating of "XX" for landslides. The following problem statements summarize Shutesbury's areas of greatest concern regarding landslides.

Landslide Hazard Problem Statements
• The steep slopes in the Quabbin Reservoir lands, the west sides of Poverty Mountain and the January Hills are vulnerable to landslides, as identified on the Slope Stability Map. In addition, steep sandy banks along dirt roads in town may be susceptible to landslides, particularly on Montague Road, Sand Hill Road, and dirt sections of Wendell Road.

• Shutesbury's emergency communication system may not have up to date information, which may limit the number of residents who receive emergency information. However, this system is dependent on residents self-reporting changes to their contact information.
• Vulnerable populations, including elderly and disabled residents are more vulnerable in the event of an emergency due to lessened mobility or medical needs
• The REPC is working to identify options for regional and local debris management. The regional plan approved by MassDEP several years ago was never implemented because the communities that would serve as regional sites did not execute MOUs. The Town is being urged by MassDEP to select and provide disaster storage/disposal location(s).

3.12 EXTREME TEMPERATURES

Potential Impacts of Climate Change

Beyond the overall warming trend associated with global warming and climate change, Shutesbury 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.[40]

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

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

Greenfield data as a proxy) are provided in Table 3-37.

Table 3-32: 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 3-27. 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). Shutesbury falls within the Central climate division.

Figure 3-26: Climate Divisions in Massachusetts

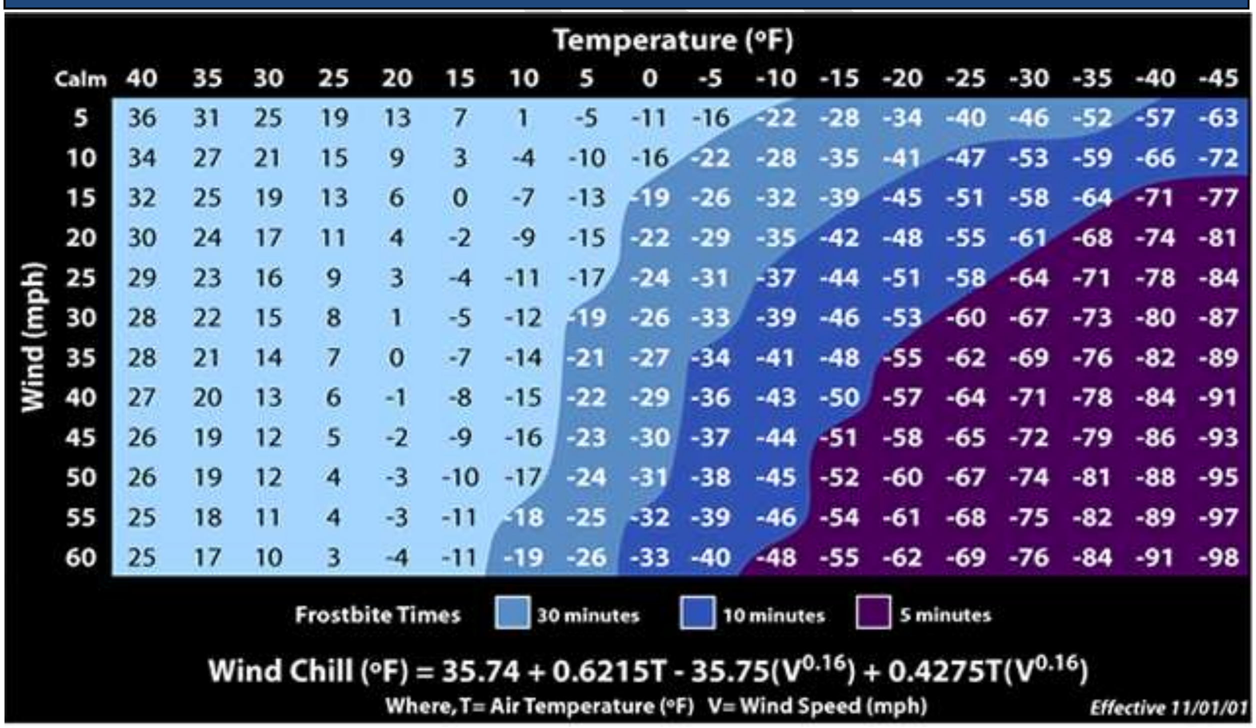
Source: NOAA, as presented in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, September 2018

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 3-28 shows the Wind Chill Temperature Index.

Figure 3-27: National Weather Service Wind Chill Chart



Wind (mph) \ Temperature (°F)	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
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 3-29. 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 1999, there have been 45 days within the Commonwealth recorded as Cold/Wind Chill to Extreme Cold/Wind Chill events.[41] Information on severe cold weather events in Shutesbury 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 Shutesbury and western

[41] NOAA Storm Events Database: https://www.ncdc.noaa.gov/stormevents/

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 days (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 Shutesbury 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.

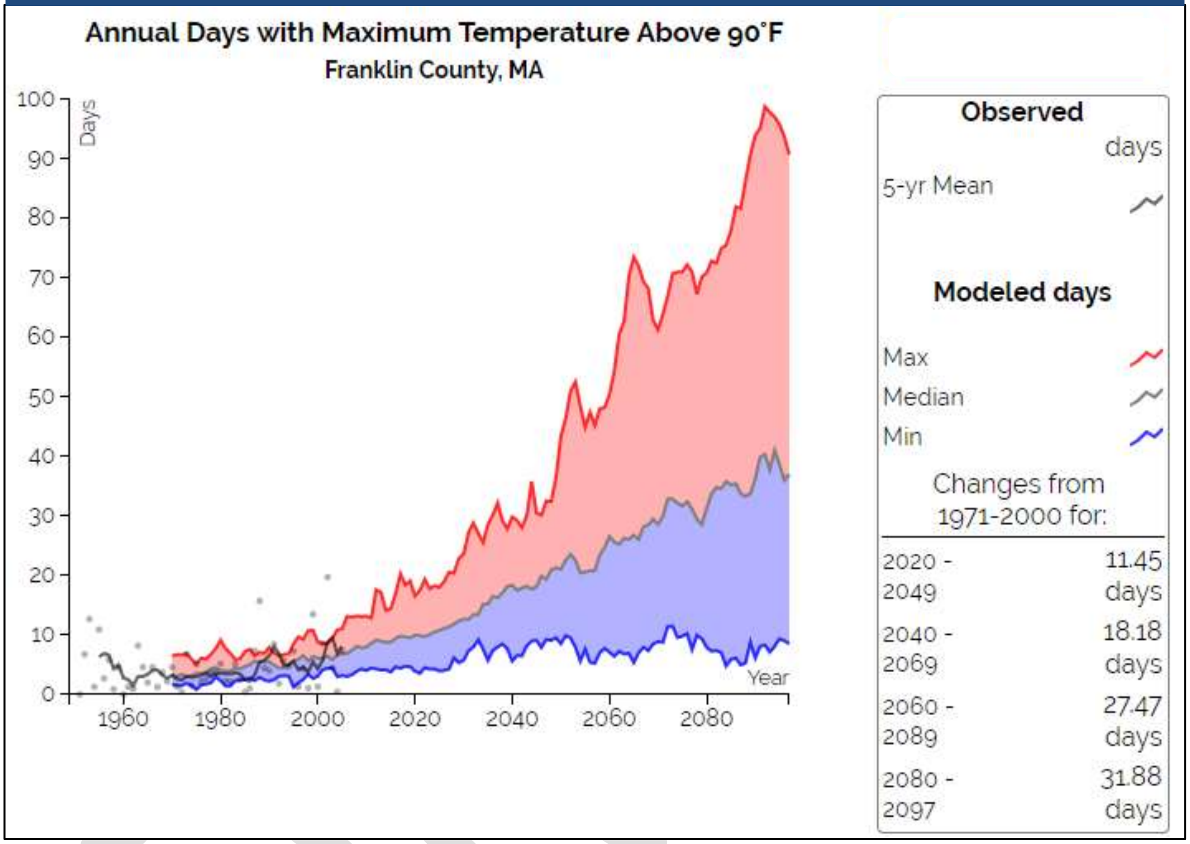
Probability of Future Events

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.

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 Shutesbury 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 3-38 estimates the number of vulnerable populations and households in Shutesbury. 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 Shutesbury residents during an extreme temperature event.

Table 3-33: Estimated Vulnerable Populations in Shutesbury		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	329	19%
Population with a Disability	203	12%
Population who Speak English Less than "Very Well"	13	0.7%
Vulnerable Household Category	**Number**	**Percent of Total Households***

Table 3-33: Estimated Vulnerable Populations in Shutesbury		
Low Income Households (annual income less than $35,000)	149	20%
Householder Age 65 Years and Over Living Alone	90	12%
Households Without Access to a Vehicle	35	5%

*Total population = 1,755; Total households = 740

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

Source: U.S. Census American Community Survey 2015-2019 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.[42] 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.[43] 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.[44]

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

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[42] 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

[43] 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.

[44] 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.

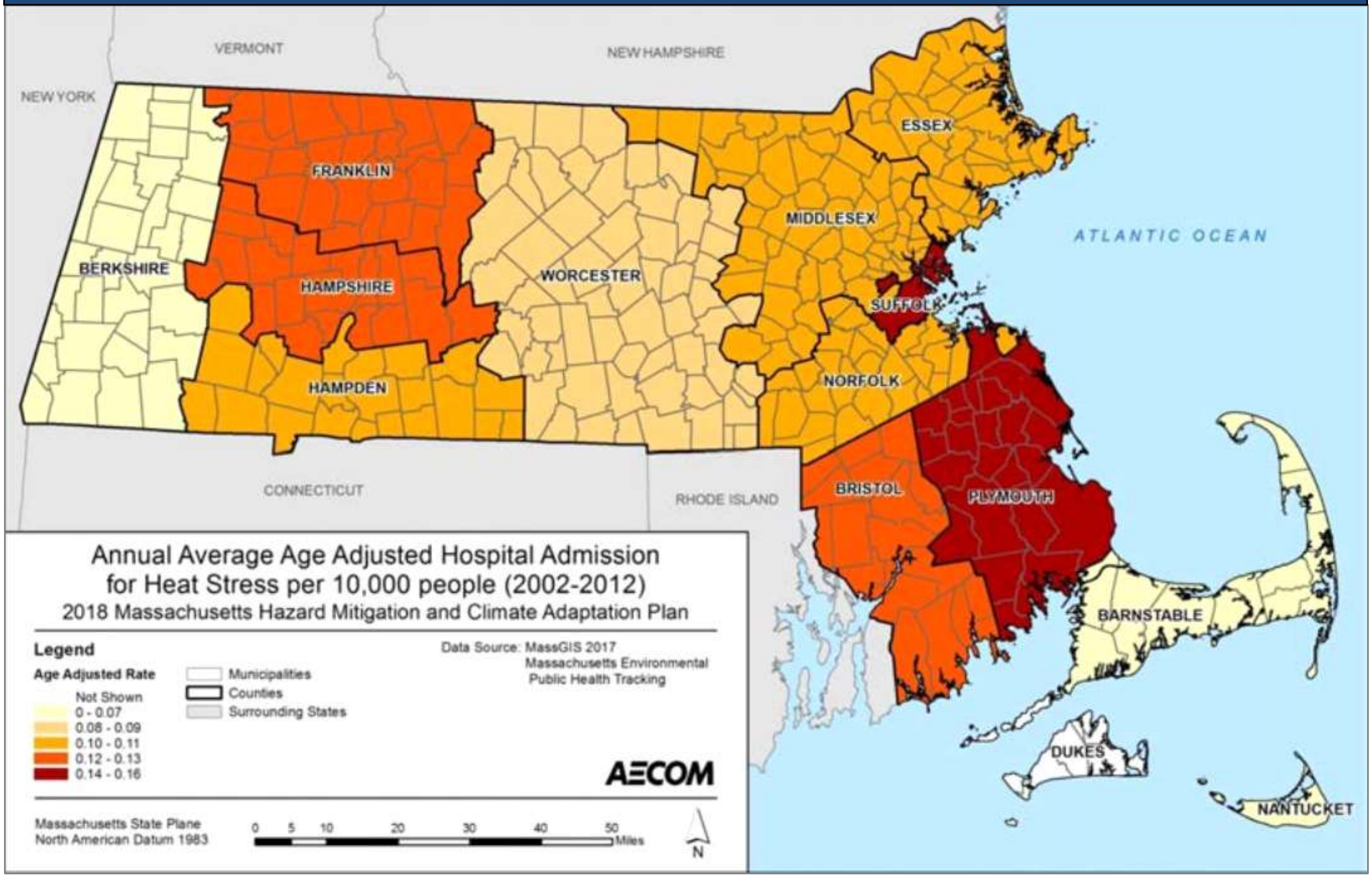
Massachusetts has a very high prevalence of asthma: approximately 1 out of every 11 people in the state currently has asthma. In Massachusetts, poor air quality often accompanies heat events, as increased heat increases the conversion of ozone precursors in fossil fuel combustion emissions to ozone. 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 3-31. 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 3-32, 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 3-33), 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.

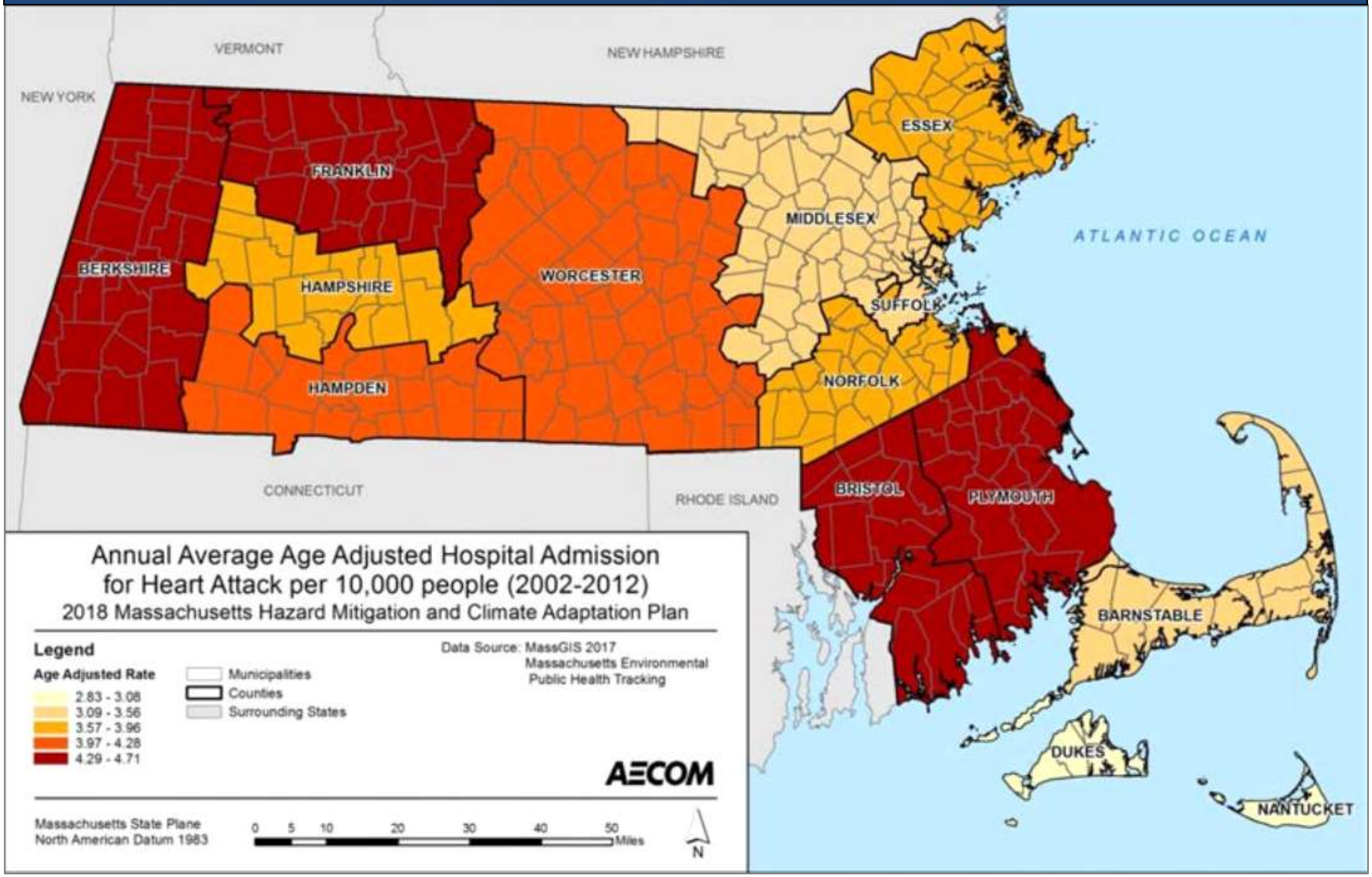
Cold-weather events can also have significant health impacts. The most immediate of these impacts are cold-related injuries, such as frostbite and hypothermia, which can become fatal if exposure to cold temperatures is prolonged. Similar to the impacts of hot weather that have already been described, 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.

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



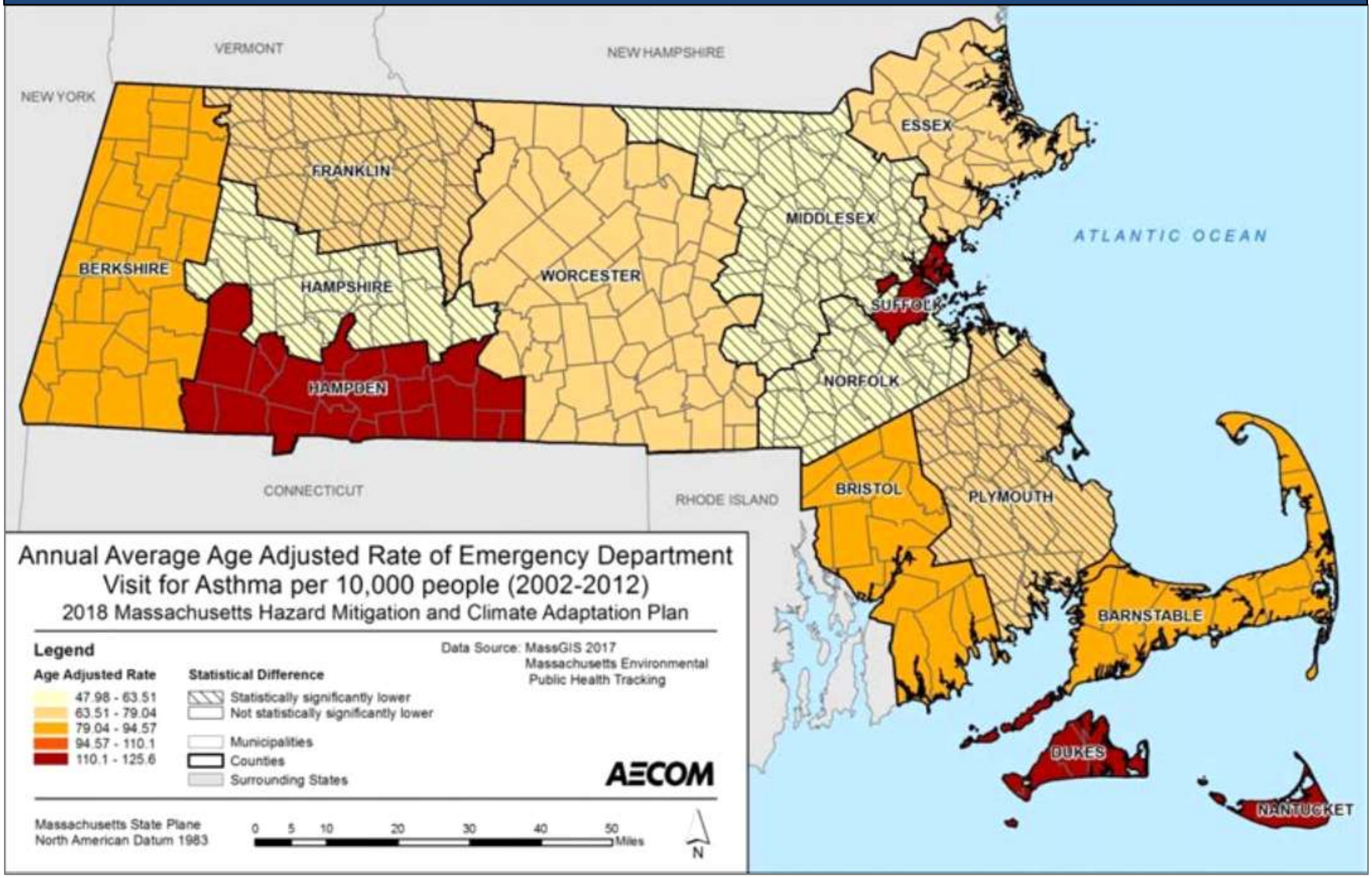
Source: Massachusetts Hazard Mitigation and Climate Adaptation Plan, September 2018.

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.[45]

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.[46] 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.[47] 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.[48]

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

[45] Resilient MA: http://resilientma.org/sectors/agriculture. Accessed March 4, 2019.
[46] Massachusetts Executive Office of Energy and Environmental Affairs and the Adaptation Advisory Committee (EOEEA). 2011. Massachusetts Climate Change Adaptation Report.
[47] Massachusetts Department of Transportation (MassDOT). 2017. Assessment of Extreme Temperature Impacts on MassDOT Assets
[48] 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.[49] Hot weather increases the likelihood that cars may overheat during hot weather, and also increases the deterioration rate of tires.

<u>Water Infrastructure</u>
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.[50] 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

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[49] Massachusetts Department of Transportation (MassDOT). 2017. Assessment of Extreme Temperature Impacts on MassDOT Assets
[50] 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.[51] 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.[52] 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.[53] Such a shift is hugely significant for the species that live in this ecosystem as

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[51] 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.
[52] 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
[53] 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.

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

Vulnerability Summary

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

Extreme Temperature Hazard Problem Statements
• Extreme cold temperatures combined with power outages, even short duration, can result in frozen and burst pipes for properties without back-up power.
• Residents may not be familiar with how to deal with or prevent diseases associated with increasing average temperatures (e.g., tick and mosquito borne diseases).
• Elderly, disabled and low-income residents are more vulnerable to extreme temperatures and may lack A/C or adequate heating systems in their homes.
• Extreme heat may worsen risk of wildfires and the availability of local water supplies for firefighting. Firefighters may already lack sufficient water volume, pressure, and/or infrastructure across town to fight wildfires. Also see wildfires problem statements.
• Extreme temperatures create a risk of "brown-outs" in the power grid, where

W. Yohe, Eds., pp 150-174

[54] 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
electricity supply may dip due to excess demand on the system and can affect vulnerable populations and municipal operations dependent on a consistent and uninterrupted power supply.
• 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 Shutesbury residents from insect borne diseases.
• Temperature swings in the winter months cause unpaved roads to become muddy, churned, and increasingly difficult to traverse. Improved drainage is needed on several roads in Shutesbury.
• **Establish a designated cooling center in Town** and ensure that it has adequate capacity and power requirements. Assess the feasibility of establishing the new library facility as a cooling center and identify related needs during the planning stages of development. Future plans for a separate police department facility may also provide an opportunity to establish it as a designated cooling center. • **Explore alternative measures for addressing extreme heat conditions at the elementary school**. Assess the feasibility of planning for school closures and remote learning on extreme temperature days. • **In the planning stages for the new Town library,** include provisions to have the facility serve as a community cooling shelter and explore options for incorporating a community meeting room. Assess the feasibility of including green energy features or an off-grid power supply to increase resilience of the facility. • **Install central air conditioning** in the Town's elementary school and regional schools to protect children from the impacts of increasing heat as seasonal weather patterns become more unpredictable and average temperatures and days over 90 degrees F increase. •

3.13 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.[55]

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

[55] 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.[56]

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

[56] 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.[57]

Location

The damage rendered by invasive species is significant. The massive scope of this hazard means that the entire town of Shutesbury 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,

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

for example).

One of the immediate threats to Shutesbury is the combination of the impacts of the Hemlock Woolly Adelgid and Hemlock Elongate Scale, small insects that colonize and kill hemlocks. Both pests may spread unimpeded, and together could cause widespread hemlock mortality.

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 species are nearly controlled, whereas others, such as the zebra mussel, are currently adversely impacting ecosystems throughout the Commonwealth. Invasive species can be measured through monitoring and recording observances.

Previous Occurrences

The terrestrial and freshwater species listed on the MIPAG website as "Invasive" (last updated April 2016) are identified in Table 3-39. The table also includes details on the nature of the ecological and economic challenges presented by each species as well as information on where the species has been detected in Massachusetts. Twenty-one of the invasive species on the list have been observed in Shutesbury since 2010.

Table 3-34: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Shutesbury**
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.	N
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

Table 3-34: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Shutesbury**
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.	N
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.	Y
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

Table 3-34: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Shutesbury**
	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.	Y
Phalaris arundinacea L. (**Reed canary-grass**)	This perennial grass occurs in all regions of the state in wetlands and open uplands. Grows in full sun to partial shade. Can form huge colonies and overwhelm wetlands; flourishes in disturbed areas; native and introduced strains; common in agricultural settings and in forage crops.	Y
Phragmites australis (Cav.) Trin. ex Steud. subsp. australis (**Common reed**)	A perennial grass (USDA lists as subshrub, shrub) found in all regions of the state. Grows in upland and wetland habitats in full sun to full shade. Overwhelms wetlands forming huge, dense stands; flourishes in disturbed areas; native and introduced strains.	Y
Fallopia japonica var. japonica (**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
Persicaria perfoliata (**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.	Y
Ficaria verna ssp. bulbilifer (**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

Table 3-34: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Shutesbury**
	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.

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 Shutesbury (Table 3-40). One invasive species, the Zebra mussel, was first documented in Massachusetts in Laurel Lake in Lee (Berkshire County, Housatonic River watershed) in 2009. Invasive fungi are also included in this table. Because of the rapidly evolving nature of the invasive species hazard, this list is not considered exhaustive.

Table 3-35: 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.

Table 3-35: Invasive Animal and Fungi Species in Massachusetts	
Species (Common Name)	**Notes on Occurrence and Impact**
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	
Dreissena polymorpha (**Zebra mussel**)	The first documented occurrence of zebra mussels in a Massachusetts water body occurred in Laurel Lake in July 2009. Zebra mussels can significantly alter the ecology of a water body and attach themselves to boats hulls and propellers, dock pilings, water intake pipes and aquatic animals. They are voracious eaters that can filter up to a liter of water a day per individual. This consumption can deprive young fish of crucial nutrients.

Source: Chase et al., 1997; Pederson et al., 2005, CZM, 2013, 2014; Defenders of Wildlife; Gulf of Maine; EOEEA, 2013a, 2013b; as presented in the 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan.

Probability of Future Events

Because the presence of invasive species is ongoing rather than a series of discrete events, it is difficult to quantify the frequency of these occurrences. However, increased rates of global trade and travel have created many new pathways for the dispersion of exotic species. As a result, the frequency with which these threats have been introduced has increased significantly. Increased international trade in ornamental plants is particularly concerning because many of the invasive plants species in the U.S. were originally imported as ornamentals.

More generally, a warming climate may place stress on colder-weather species while allowing non-native species accustomed to warmer climates to spread northward. The impacts of invasive species and climate change is discussed in more detail below.

Impact

The impacts of invasive species may interact with those of climate change, magnifying the negative impacts of both threats. Furthermore, due to the very traits that make them successful at establishing in new environments, invasives may be favored by climate change. These traits include tolerance to a broad range of environmental conditions, ability to disperse or travel long distances, ability to compete efficiently for resources, greater ability to respond to changes in the environment with changes in physical characteristics (phenotypic plasticity), high reproductive rates, and shorter times to maturity.

To become an invasive species, the species must first be transported to a new region, colonize and become established, and then spread across the new landscape. Climate change may impact each stage of this process. Globally, climate change may increase the introduction of invasive species by changing transport patterns (if new shipping routes open up), or by increasing the survival of invasives during transport. New ornamental species may be introduced to Massachusetts to take advantage of an expanded growing season as temperatures warm. Aquatic invasives may survive in ships' ballast waters with warmer temperatures. Extreme weather events or altered circulation patterns due to climate change could also allow the dispersal of invasive species to new regions via transportation of seeds, larvae, and small animals.

Species may shift their ranges north as the climate warms and be successful in regions they previously had not colonized. Invasives may also be able to spread more rapidly in response to climate change, given their high dispersal rates and fast generation times. These faster moving species may be at a competitive advantage if they can move into new areas before their native competitors.

Here in the Northeast, warming conditions may be particularly concerning for some invasives because species ranges in temperate regions are often limited by extreme cold temperatures or snowfall. There is concern that aquatic species, such as hydrilla (Hydrilla verticillata) and water hyacinth (Eichhornia crassipes), may be able to survive and overwinter in Massachusetts with increased temperatures and reduced snowfall. Nutria (Myocastor coypus), large, non-native, semi-aquatic rodents that are currently established in Maryland and Delaware, are likely to move north with warming temperatures - perhaps as far as Massachusetts.

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

Invasive species are often able to thrive or take advantage of areas of high or fluctuating resource availability such as those found in disturbed environments. For example, for invasive plants, insect outbreaks or storms often free up space in the forest allowing light to penetrate and nutrients and moisture balances to change, allowing invasive plants to move in. Climate change is likely to create these types of opportunities through increased disturbances such as storms and floods, coastal erosion and sea level rise.

Invasives may also be better able to respond to changing environmental conditions that free up resources or create opportunities. For example, greater plasticity in response to their environment may allow some invasive plants to respond faster to increases in spring temperature than native plants. These invasives are able to leaf-out earlier in warmer years, taking up available space, nutrients, and sunlight, and achieving a competitive advantage against native species. Increased carbon dioxide in the atmosphere may also benefit some weedy plant species, allowing them to compete for other resources (like water) more effectively than their native counterparts.

Species roles may change as the climate changes, further complicating the management and policy response. As species ranges shift and existing inter-species relationships are broken, there is the potential that some species, including native species, may become pests because the interspecies interactions (e.g., predation, herbivory) that used to keep their population numbers in check are no longer functional.[58]

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 Shutesbury, the entire town is considered to be exposed to the invasive species hazard. Areas with high amounts of plant or animal life may be at higher risk of exposure to invasive species than less vegetated areas; however, invasive species can disrupt ecosystems of all kinds.

Society

The majority of invasive species do not have direct impacts on human well-being; however, as described in the following subsections, there are some health impacts associated with invasive species.

[58] 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 ("ATM") (*Aedes albopictus*). This invasive mosquito, originally from southeast and subtropical Asia, arrived in Houston in 1985 via a container ship and quickly became established in warm-climate, Southern states. Since then, its range has recently expanded to Massachusetts, mainly due to an increase in minimum winter temperatures which allow its eggs to successfully survive until Spring. Capable of spreading diseases endemic to the Commonwealth, such as West Nile Virus and Eastern Equine Encephalitis (EEE), the ATM is also a known competent vector for tropical flaviviruses, including Zika virus, dengue, yellow fever, and chikungunya. Informal surveillance for the ATM by a nearby city found evidence of its presence and in 2019 it was detected in Brattleboro, VT - even further north than Shutesbury. This aggressive mosquito is likely range-limited by cold winter temperatures, suitable landscape conditions (it prefers urban areas and areas with standing water), 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.[59]

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.

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

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 Shutesbury 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. 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 Shutesbury is considered exposed to this hazard; however, the built environment is not expected to be impacted by invasive species to the degree that the natural environment is. Buildings are not likely to be directly impacted by invasive species. Amenities such as outdoor recreational areas that depend on biodiversity and ecosystem health may be impacted by invasive species. Facilities that rely on biodiversity or the health of surrounding ecosystems, such as outdoor recreation areas or agricultural/forestry operations, could be more vulnerable to impacts from invasive species.

Agriculture

The agricultural sector is vulnerable to increased invasive species associated with increased temperatures. More pest pressure from insects, diseases, and weeds may harm crops and cause farms to increase pesticide use. In addition, floodwaters may spread invasive plants that are detrimental to crop yield and health. Agricultural and forestry operations that rely on the health of the ecosystem and specific species are likely to be vulnerable to invasive species.

Public Health

An increase in species not typically found in Massachusetts could expose populations to vector-borne disease. A major outbreak could exceed the capacity of hospitals and medical providers to care for patients.

Transportation

Water transportation may be subject to increased inspections, cleanings, and costs that result from the threat and spread of invasive species. Species such as zebra mussels can damage aquatic infrastructure and vessels.

Water Infrastructure

Water storage facilities may be impacted by zebra mussels. Invasive species may lead to reduced water quality, which has implications for the drinking water supplies and the cost of treatment.

Environment
Shutesbury is 88% forested, and is therefore vulnerable to invasive species impacts to forests. Invasive plants can out-compete native vegetation through rapid growth and prolific seed production. Increased amounts of invasive plants can reduce plant diversity by dominating forests. When invasive plants dominate a forest, they can inhibit the regeneration of native trees and plants. This reduced regeneration further reduces the forest's ability to regenerate in a timely and sufficient manner following a disturbance event. In addition, invasive plants have been shown to provide less valuable wildlife habitat and food sources.

As discussed previously, the movement of a number of invasive insects and diseases has increased with global trade. Many of these insects and diseases have been found in New England, including the hemlock woolly adelgid, the Asian long-horned beetle, and beech bark disease. These organisms have no natural predators or controls and are significantly affecting our forests by changing species composition as trees susceptible to these agents are selectively killed.

Invasive species interact with other forest stressors, such as climate change, increasing their negative impact. Examples include:

- A combination of an earlier growing season, more frequent gaps in the forest canopy from wind and ice storms, and carbon dioxide fertilization will likely favor invasive plants over our native trees and forest vegetation.
- Preferential browse of native plants by larger deer populations may favor invasive species and inhibit the ability of a forest to regenerate after wind and ice storms.
- Warming temperatures favor some invasive plants, insects, and diseases, whose populations have historically been kept in check by the cold climate.
- Periods of drought weaken trees and can make them more susceptible to insects and diseases.[60]

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

[60] 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

- 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
- Local and complete extinction of rare and endangered species

Vulnerability Summary

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

Invasive Species Problem Statements
• The 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.
• Residents may not be familiar with how to deal with or prevent vector-borne diseases spread by insects drawn by warmer temperatures.
• Education and outreach is needed to increase local awareness around invasive species and equip residents with appropriate control measures.
• The hemlock wooly adelgid has caused extensive damage to hemlock trees throughout Shutesbury. Damaged trees may increase the Town's vulnerability to wildfires. Also see wildfire problem statements.
• Brushy Mountain is well maintained for invasives, but other non-working forests in Town are not and may be vulnerable to wildfires.
• **Assess additional mosquito/pest control options,** including establishment of buffers between developed and undeveloped areas, determination of future risks due to increase in type and quantity of pests/disease vectors due to climate change, and development of an education and outreach program. Evaluate alternative methods for pest management, such as biological controls, that do not involve chemical application. Coordinate with the Board of Health to increase educational opportunities/awareness relating to pests and disease control. Conduct research on the impacts of pest management options on the environment to inform Town bylaws.
• **Develop comprehensive invasive species management** from inventory stage through management planning and implementation to address existing invasive populations that threaten features such as open space or forests, both of which contribute to resiliency, as well as anticipate new invasives that are likely to move into the area as climates shift. Continue to manage the invasive plants in Town and explore alternative spraying options for Japanese knotweed. Assess biological control options for pests, including gypsy moths, and alternatives

to spraying for invasives.

- **Develop a comprehensive tree and forests management plan** to identify, remove, and replace problem trees, preserve intact forests, provide guidance and resources for gradually moving toward more climate-resilient trees and forest communities (e.g. species that will tolerate warmer temperatures), and develop guidelines to manage conversion of forest land (e.g. solar guidelines). Update the Town's Master Plan, zoning bylaws, and Planning Board policies accordingly.
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3.14 OTHER HAZARDS

In addition to the hazards identified above, the Committee 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 of Shutesbury, coastal erosion, coastal flooding, and tsunamis were determined not to be a threat. Human made hazards are not addressed in the State plan, but were addressed in the 2015 Shutesbury Hazard Mitigation Plan, and are considered a risk to the Town.

This plan does not address all human made hazards that could affect Shutesbury. A complete hazards vulnerability analysis was not within the scope of this update. For the purposes of the 2021 plan, the Committee discussed and updated the information from the 2015 Plan, where available, and discussed non-natural hazards that are of an accidental nature, including industrial transportation accidents and industrial accidents in a fixed facility. New to the 2021 plan is an evaluation of cyber-security, which has become a threat of greater concern in recent years.

3.14.1 VECTOR-BORNE DISEASES[61]

Hazard Profile

The Town of Shutesbury 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-

[61] This section relies heavily 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. Shutesbury requested that this section be added to their 2020 Hazard Mitigation Plan. FRCOG updated available statistics for Massachusetts using information from MA DPH's website and for Franklin County (FRCOG Public Health Nurse and MAVEN).

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.

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 Shutesbury 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

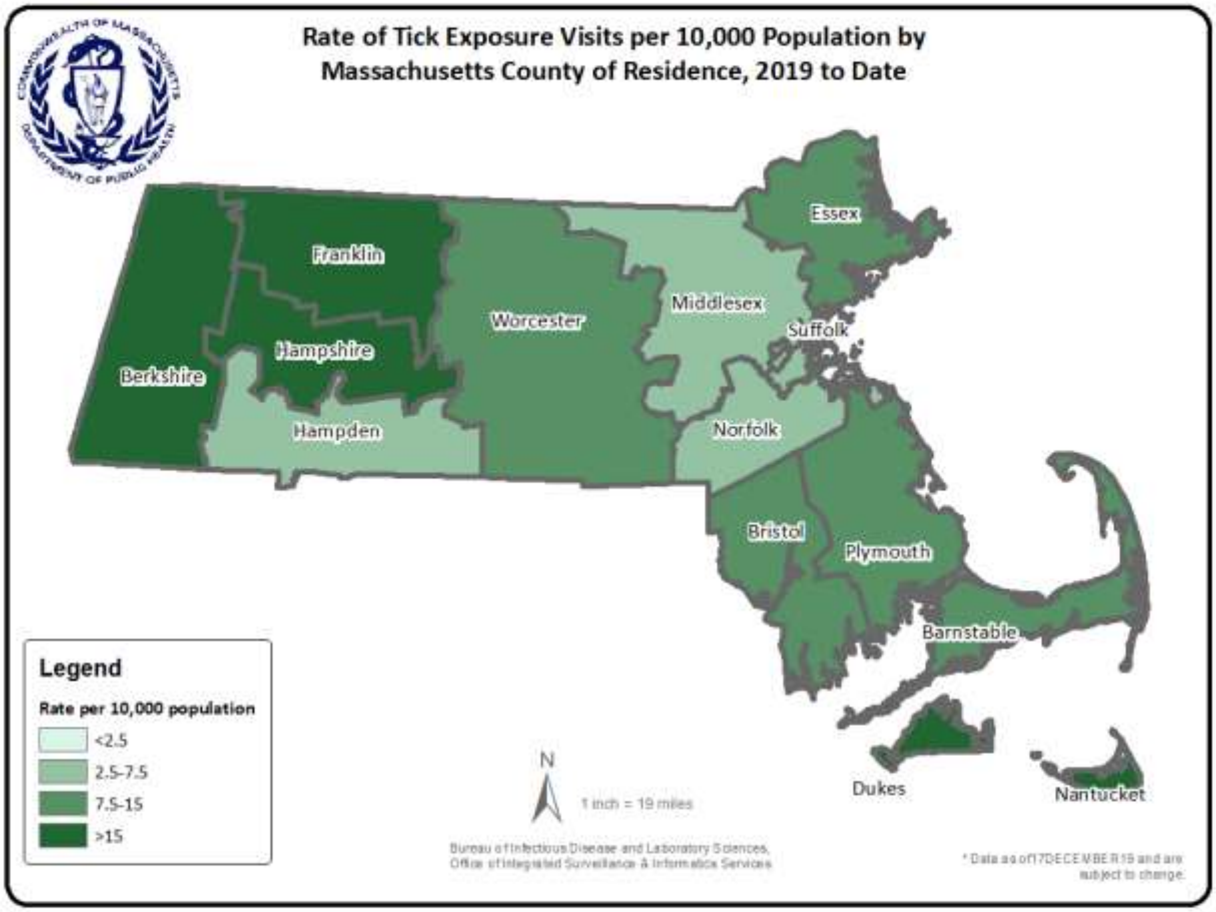
Tick-borne Illness[62]

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.[63]

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

[63] 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.[64]

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.

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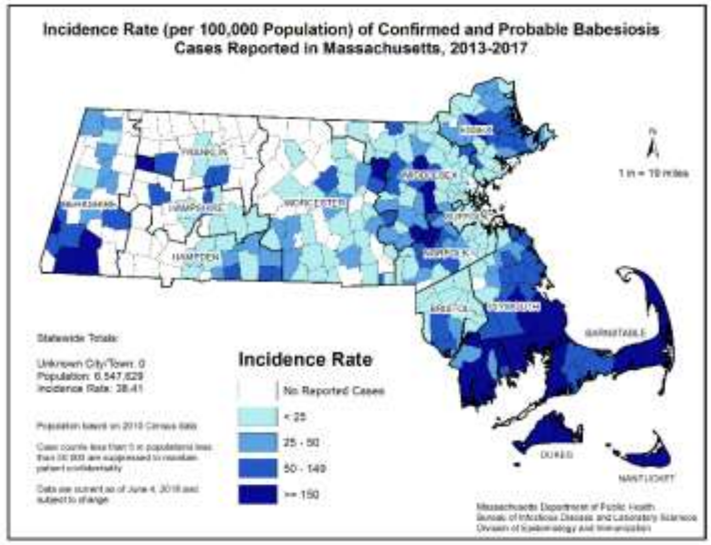
[64] https://www.mass.gov/lists/tick-borne-disease-surveillance-summaries-and-data#lyme-disease-surveillance-data- accessed March 19, 2020.

- 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.

<u>Human Granulocytic Anaplasmosis (HGA)</u>

- 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.

<u>Lyme disease</u>

- 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.

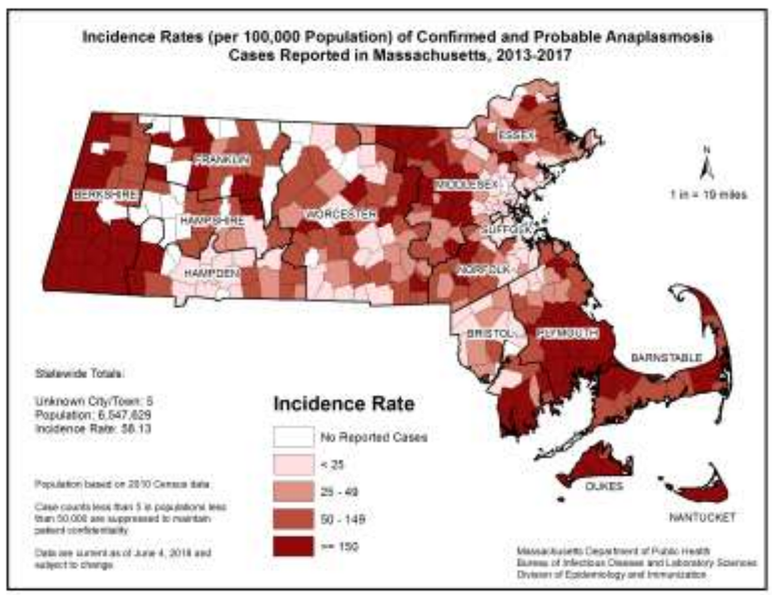
The Franklin Regional Council of Governments' Cooperative Public Health Services (CPHS) Public Health Nurse supplied the following information for reported cases of vector-borne illnesses in 2019:[65]

- In 2019, 92 suspect Lyme
- 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.

[65] 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[66]

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.[67]

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

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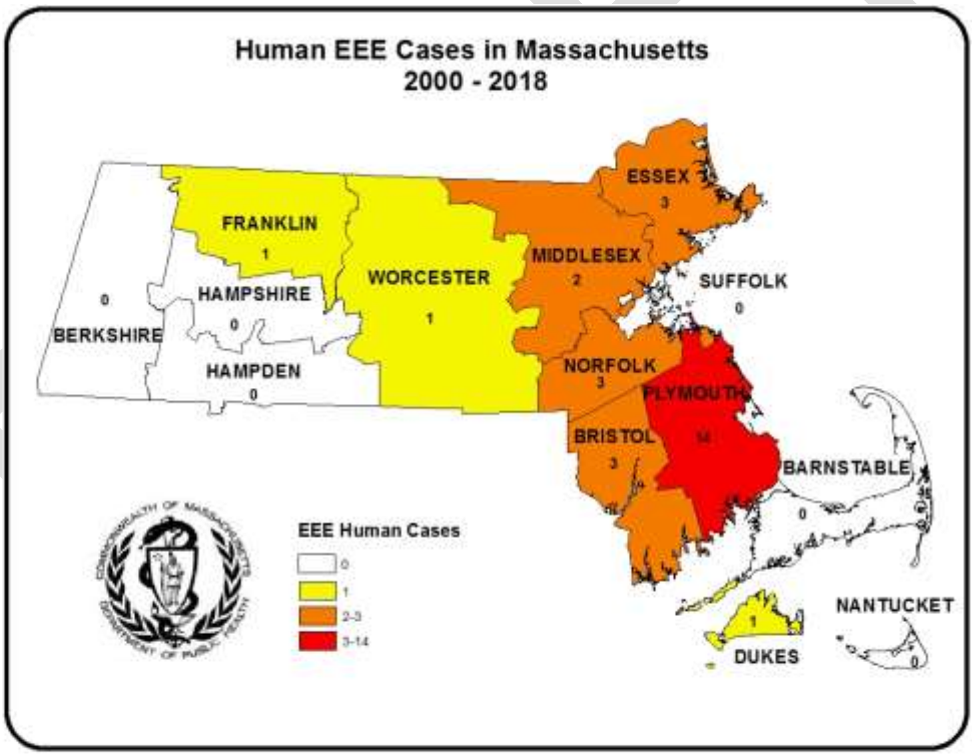
[66] https://www.mass.gov/mosquito-borne-diseases accessed March 20, 2020.

[67] https://www.mass.gov/guides/eee-in-massachusetts accessed March 20, 2020

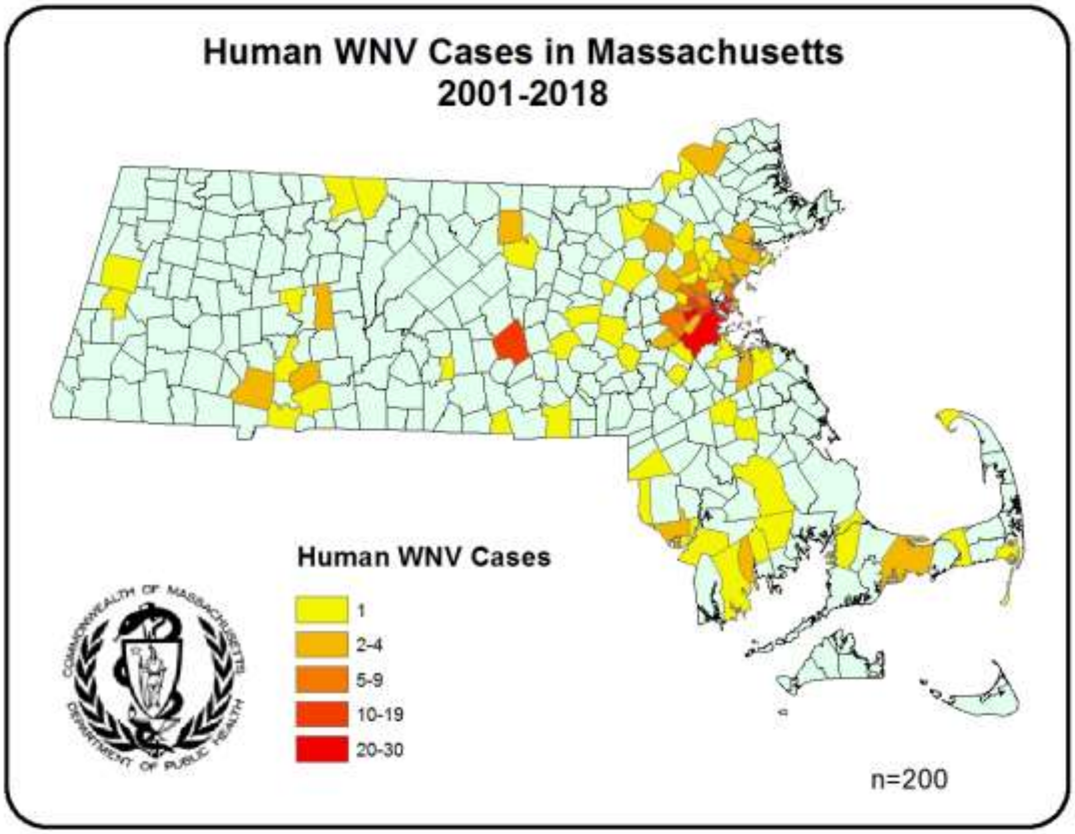
identified with EEE have died from the infection. People who survive this disease will often be permanently disabled due to neurologic damage. Few people recover completely.

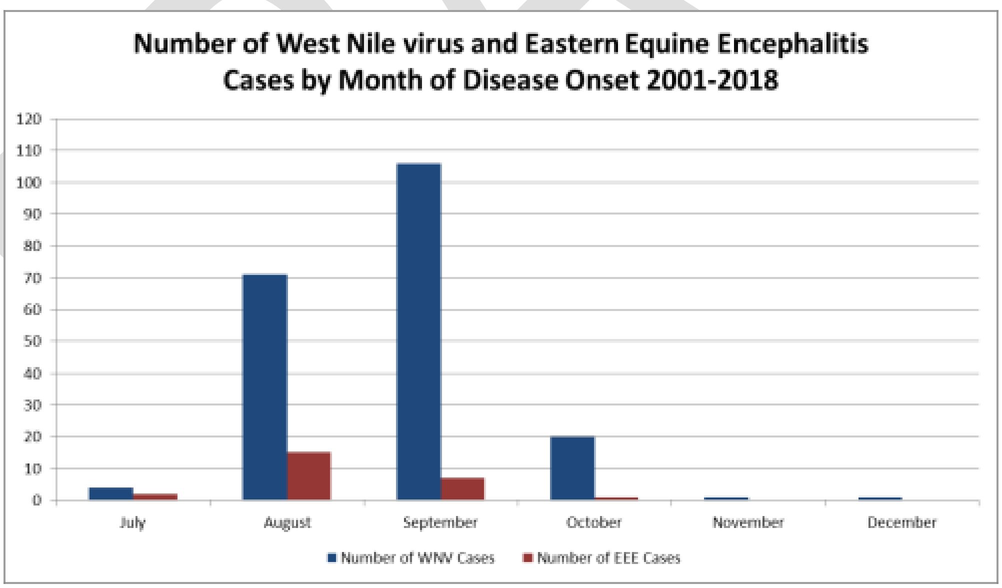
Historically, clusters of human cases have occurred over a period of two to three years, with a variable number of years between clusters. In the years between these case clusters or outbreaks, isolated cases can and do occur. Outbreaks of human EEE disease in Massachusetts occurred in 1938-39, 1955-56, 1972-74, 1982-84, 1990-92, and, 2004-06. Two cases of EEE 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.[68]



[68] 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.[69]

The number of EEE and WNV cases in Massachusetts in 2019 is shown below.[70]

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

Society

Vector-borne illness has a significant impact on humans and on a community. These illnesses

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

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.

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 practitioners about current and new vector-borne illnesses so treatment can be expedited. owns should implement educational programs for residents and visitors for bite-prevention and detection.

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. Shutesbury is not a member of the newly formed Pioneer Valley Mosquito Control District.
• 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.

3.14.2 HUMAN MADE HAZARDS

Hazard Description

Most non-natural or human made 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.

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.

Location and Extent

Industrial Accidents – Transportation

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,[71] approximately 13

[71] Franklin County Regional Emergency Planning Committee, Franklin County Hazardous Material Emergency Plan and Maps, 2006. Based on a one-time survey conducted in 2003.

trucks per hour traveling through the region contain hazardous materials. Most of these vehicles are on Interstate 91 and Route 2, neither of which do not pass through Shutesbury. An average of 1 truck per hour carrying hazardous materials travels on Route 202, but no residences are located on Route 202 in Shutesbury. In addition, the HMEP notes that all roads in the county likely have vehicles carrying hazardous materials at varying intervals.

Hazardous materials regularly carried on trucks that may pass through Shutesbury include:

- Gasoline
- Fuel oil
- Kerosene
- Liquified petroleum gas
- Propane
- Sodium aluminate
- Sulfuric acid
- NOS liquids 3082

Safe and efficient transportation routes for trucks to and through the region are important to the region's economy and to the safety of its citizens. The safer the transportation routes are, the less likely a transportation accident will occur.

Franklin County has two primary rail lines that carry hazardous materials to and through the county,neither of which passes through Shutesbury. The hazardous chemicals carried by rail through the county in 2013 were:

- Petroleum crude
- Liquefied petroleum
- Petroleum gases
- Sodium chlorate
- Sodium hydroxide
- Carbon dioxide
- Phenol molten
- Hydrochloric acid
- Acetone
- Methanol
- Air bag inflation
- chemicals
- Methyl methacrylate
- Alkylphenols
- Batteries, wet
- Adhesives
- Caustic alkali
- Helium, compressed
- Fire extinguisher
- chemicals
- Sulfuric acid
- Paint
- Gasoline
- Toluene
- Hydrogen peroxide

Industrial Accidents – Fixed Facilities

An accidental hazardous material release can occur wherever hazardous materials are manufactured, stored, transported, or used. Such releases can affect nearby populations and contaminate critical or sensitive environmental areas. Those facilities using, manufacturing, or storing toxic chemicals are required to report their locations and the quantities of the chemicals stored on-site to state and local governments.

The Toxics Release Inventory (TRI) tracks the management of over 650 toxic chemicals that pose a threat to human health and the environment. U.S. facilities in different industry sectors that manufacture, process, or otherwise use these chemicals in amounts above established levels must report how each chemical is managed through recycling, energy recovery, treatment, and environmental releases. *Note: a "release" of a chemical means that it is emitted to the air or water, or placed in some type of land disposal*. The information submitted by facilities to the EPA and states is compiled annually as the Toxics Release Inventory or TRI, and is stored in a publicly accessible database. TRI information helps support informed decision-making by industry, government, non-governmental organizations and the public. Note that TRI does not provide any safety or health information about these chemicals and compounds. TRI data, in conjunction with other information, can be used as a starting point in evaluating exposures that may result from industrial activities which involve toxic chemicals.[72]

It is important to note that inclusion on the TRI in no way indicates any issues with any of the sites, but rather is an inventory of those facilities meeting TRI reporting requirements. There are no facilities in Shutesbury listed in the TRI database.[73] Table 3-41 lists hazardous facilities in Shutesbury as identified in the Town's 2014 CEM Plan.

Table 3-36: Massachusetts Toxics Users in Shutesbury

Facility Name	Facility Location
National Grid Substation	491 Pratt Corner Road
Department of Public Works	59 Leverett Road
William W. Clark Excavating	22 Pratt Corner Road

Also worth consideration is that many farmers store agricultural chemicals on their properties. Given that much farmland is located in or near floodplains and their adjacent water bodies, the potential for an accidental hazardous materials spill to impact water quality is present. This plan does not include an in-depth evaluation of hazardous materials as they relate to farming. In many cases, farmers do use and store pesticides, herbicides and fertilizers on their property. And in most cases, farmers are utilizing best management practices in the use and storage of agricultural chemicals and have undergone any required training and licensing if they are applying these chemicals to the land. Despite training and best management practices, an accidental release of hazardous materials can occur and potentially threaten human health and

[72] https://www.epa.gov/enviro/tri-overview
[73] https://www.epa.gov/enviro/tri-search

the environment. One approach that the Town could take to help prepare for a hazardous materials spill on a farm would be to become familiar with the types and quantities of chemicals stored on site at the larger farms. This would assist first responders in being adequately prepared to protect human health and prevent contamination of the environment in the event of a major spill or other accidental release of hazardous materials.

Hazardous facilities located outside of town boundaries can also be of concern to Shutesbury. The Vermont Yankee nuclear power plant is located on the Connecticut River in Vernon, Vermont, near the Vermont/Massachusetts border. In January 2010, the facility notified the Vermont Department of Health that samples taken in November 2009 from a ground water monitoring well on site contained tritium. This finding signals an unintended release of radioactive material into the environment. Testing has shown that contaminated groundwater has leaked into the Connecticut River, though tritium levels in the river have remained below the lower limit of detection.[74]

On August 27, 2013, Entergy, then-owner of Vermont Yankee, announced that Vermont Yankee would cease operations at the end of 2014 for economic reasons. Vermont Yankee officially disconnected from the grid on December 29, 2014. The reactor was manually shut down without incident. Transfer of all Vermont Yankee spent fuel from the reactor to the spent fuel pool was completed on January 12, 2015. The transfer of all Vermont Yankee spent fuel to dry cask storage was completed on August 1, 2018. On December 6, 2018, the Vermont Public Utilities Commission (PUC) approved Entergy's sale of Vermont Yankee to subsidiaries of NorthStar Group Services, Inc., as a means of completing the decommissioning and site restoration on an accelerated schedule.[75]

The Yankee Atomic Electric Company (YAEC) stores spent nuclear fuel from the former Yankee Rowe nuclear facility, which operated for over three decades as a power generating facility until 1992. The plant was disassembled and officially decommissioned in 2007. However, spent fuel from the plant's operation is still stored on site adjacent to the Sherman Reservoir on the Deerfield River. The fuel is stored in Nuclear Regulatory Commission – approved dry canisters and casks made of steel and concrete, which are placed on a concrete pad on the site. The stored fuel is monitored 24 hours a day. The fuel storage site is within the inundation zone for the Harriman Dam, which is located approximately 6.5 miles upstream from the site. According

[74] Vermont Department of Health. http://healthvermont.gov/enviro/rad/vt_yankee.aspx
[75] Vermont Department of Public Service: https://publicservice.vermont.gov/content/nuclear_decommissioning_citizens_advisory_panel_ndcap/history. Accessed July 6, 2019.

to the YAEC's website, the type of container that the fuel is stored in has been tested to withstand submersion under 50 feet of water for 8 hours, among other safety tests.[76]

More recently, the 2011 tsunami and earthquake in Japan that damaged a nuclear power plant demonstrates the potential vulnerability of these facilities to natural disasters, and the geographic extent that could be impacted by an accident. While Vermont Yankee is no longer in operation, the storage of spent fuel at the site still presents a potential risk. The northern part of Shutesbury falls within 20 miles of the site. Shutesbury officials should stay abreast of proper evacuation procedures in the event of an accident at the Vermont Yankee nuclear power plant.

Cyber Threats

A failure of networked computer systems could result in the interruption or disruption of Town services (including public safety and other critical services), the disruption or interruption of the functioning of Town departments, and the potential for loss or theft of important data (including financial information of the Town and residents).

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).

Damage to the cyber infrastructure can be malicious attacks or critical software errors that affect computer systems, from individual computers to the entire network. These virtual hazards can cause lack of access to the network, permanent data loss, permanent damage to computer hardware, and impact the ability to access programs or systems on the network. When incidents are malicious attacks, they can impact:

- Confidentiality: protecting a user's private information.
- Integrity: ensuring that data is protected and cannot be altered by unauthorized parties.
- Availability: keeping services running and giving administration access to key networks and controls.
- Damage: irreversible damage to the computer or network operating system or "bricking" and physical, real world damages, caused by tampering with networked safety systems.

[76] Yankee Atomic Electric Company. http://www.yankeerowe.com/fuel_transportation.html.

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

For Shutesbury, the most likely cyber-threat affecting the Town and Town departments comes from malware and social engineering. These crimes prey on the vulnerable and unprepared and every individual and organization that connects a device to the internet is a potential mark.

Social Engineering

Social engineering involves obtaining confidential information from individuals through deceptive means by mail, email, over the phone, and increasingly through text messages.[78] These techniques are referred to as 'Phishing'.

Malware

Malware, or malicious software, is any program or file that is harmful to a computer user. Types of malware can include computer viruses, worms, Trojan horses, and spyware. These malicious programs can perform a variety of different functions such as stealing, encrypting or deleting sensitive data, altering or hijacking core computing functions and monitoring users' computer activity without their permission. The most common way for malware to infect a Town's network is through an employee opening an infected email attachment.

Previous Occurrences

Over the past few years a type of malware called ransomware has been targeted at local governments. Cyber-criminals will use social-engineering to infect a network, take control and block user access to that network, then request a ransom from the organization. Once the ransomware is on the network, it can be extremely expensive and time consuming to restore that network without paying the ransom. When the cost of the ransom is less than the cost of

[77] NYC Hazard Mitigation, Cyber Threats, https://nychazardmitigation.com/hazard-specific/cyber-threats/what-is-the-hazard/

[78] Cybersecurity Precautions, MA Executive Office of Technology Services & Security, 2017

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 sophisticate criminal organizations and foreign governments who work around the clock looking to exploit small towns and big businesses alike.

The best way to prevent a cyber-attack is to follow best practices in cyber-security. Following these best practices will greatly mitigate the likelihood a cyber-attack is successful. MA Executive Office of Technology Services and Security (EOTSS)[79] 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.

This assessment of human-made hazards is still just a preliminary assessment of Shutesbury's vulnerability to these hazards. The potential for these types of human made hazards to impact the town, its critical infrastructure and its residents is XX.

Human made Hazard Problem Statements
• Cyber-attacks on local government is a growing threat. Keeping up with current best practices in cyber security can be challenging for communities.
• Culvert and bridge maintenance is needed throughout town. Per the Town's Capital Plan, replacements, repairs, and upgrades have been prioritized at the following locations through FY '24: Dudleyville Road Bridge, Juggler Meadow Road culvert, Mill Yard Road bridge, Teawaddle Hill Road bridge, Millers Road Bridge, the Rattlesnake Gutter bridge, and the Shutesbury Road Culvert.
• Shutesbury is vulnerable to a spill of hazardous materials and/or hazardous waste at one of several facilities in town that use and store hazardous materials. These facilities and/or hazardous materials storage may be in the 100-year floodplain. •

79 https://www.mass.gov/cybersecurity