Town of West Stockbridge

Hazard Mitigation Plan

Town of West Stockbridge, Massachusetts

DRAFT October 29, 2021

Adopted Jan 18, 2022

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West Stockbridge Hazard Mitigation Plan
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Section 1
Introduction and Background

Purpose of the West Stockbridge Hazard Mitigation Plan

As defined by the Federal Emergency Management Agency (FEMA), a hazard is a "source of harm or difficulty created by meteorological, environmental, geological, or manmade phenomena" and hazard mitigation is "any sustained action taken to reduce or eliminate the long-term risk to life and property from hazards" (FEMA, 2013).

The Federal Disaster Mitigation Act of 2000 mandated that all localities prepare local hazard mitigation plans to be eligible for future FEMA funding from the newly established Pre-disaster Mitigation (PDM) grant program and for the existing post-disaster Hazard Mitigation Grant Program (HMGP), the latter of which is a mainstay of the FEMA grant programs.

This plan involves a single municipality, the Town of West Stockbridge, Massachusetts. During the development of this Plan, the West Stockbridge Comprehensive Emergency Management Plan, other hazard mitigation plans, sheltering plans and other relevant plans in the region were consulted.

The primary purpose for developing and executing a mitigation plan is for the community to "identify policies, actions, and tools that will reduce risk and possible future losses". This plan for the Town of West Stockbridge is no exception. It is designed to serve as a tool to help Town officials identify hazard risks, assess the Town's vulnerability to hazardous conditions, identify and consider measures that can be taken to minimize hazardous conditions, and develop an action plan that can reasonably be implemented to mitigate the impacts of hazards in the Town. A goal of this Plan is to use it in conjunction with other local and regional plans, other hazard mitigation plans, emergency preparedness plans developed in conjunction with the Southern Berkshire Emergency Planning Committee, and a soon-to-be drafted West Stockbridge Municipal Vulnerability Preparedness Plan, which the Town expects to apply for a grant to complete in fiscal year 2021.

Community Profile and Background

The Town of West Stockbridge has approximately 1,275 residents (per the 2020 U.S Census Bureau records) located in the south-central part of Berkshire County. West Stockbridge is bordered by Richmond to the north, Stockbridge to the east, and Great Barrington and Alford to the south and south-west respectively.

The town has a total area of 18.7 square miles (11,968± acres), of which 18.48 square miles is land and 0.22 square miles, or 1.18 %, is water. The town is located 11 miles south of Pittsfield, 37 miles southeast of Albany, New York, 52 miles west-northwest of Springfield, and 134 miles west of Boston.

In general, the center of West Stockbridge is a narrow, flat plain, left behind after the glacial retreat of 12,000 years ago. West Stockbridge is drained by the Williams River, which runs through the center of town. The river is fed by several marshy brooks and lakes, including Card Pond to the west, and Shaker Mill Pond and Mud Ponds to the north.

The town is bisected by Interstate 90, the Massachusetts Turnpike and has one of the two exits, the other being in the nearby town of Lee. Other state routes, Route 102 and Route 41 pass through town, with Routes 102 and 41 sharing a short stretch in downtown West Stockbridge. The town lies along a Berkshire Regional Transit Authority (BRTA) bus line, which provides service between Pittsfield and Great Barrington. Pittsfield is also the site of the nearest regional bus service, as well as regional Amtrak service. There are local airports in Pittsfield and Great Barrington, and the nearest national air service is located at Albany International Airport in New York.

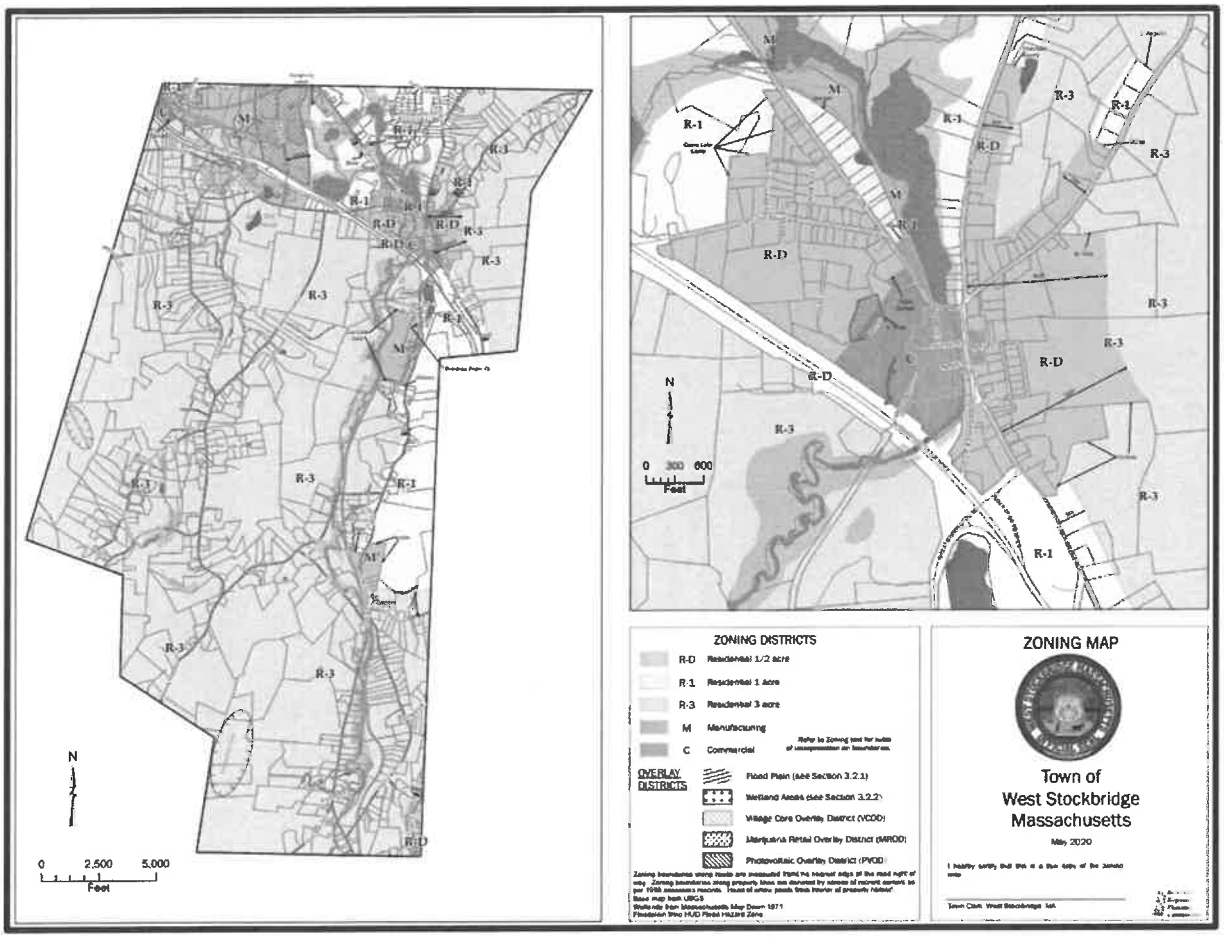


Figure 1.1 – West Stockbridge Zoning Map

Source: Town of West Stockbridge website

Development Patterns

This Hazard Mitigation Plan is the first such Plan for the Town of West Stockbridge. Construction and development in West Stockbridge, including commercial, industrial and residential construction, have followed traditional patterns. Development is regulated via the Town Zoning Bylaws, with Special Permit review by the Planning Board Zoning Board of Appeals. The Conservation Commission oversees development within the jurisdictional wetland areas.

Zoning Districts have not been changed. Industrial and Commercial development has generally been reuse of existing buildings and has generally followed the Route 41 & Route 102 corridor, which is zoned for Commercial (C), Manufacturing (M), and Residential (R-D & R-1), and Residential (R-1, R-2 and R-4) both north-east, south, and south-west of downtown (R-1 and R-3). All West Stockbridge Zoning Districts include mixed use. Residential construction and remodeling have occurred in traditional locations along existing roadways and in or near developed areas, primarily in the Residential 1 and 3 Acre (R-1 and R-3) Districts, which covers the majority of land in West Stockbridge. Since the development of the last Hazard Mitigation Plan, all new home and remodeling have gone through required permitting, as well conservation committee review and compliance. No new construction has occurred in the Floodplain Overlay District that would result in loss of floodplain area, as the Town strictly enforces its bylaws regarding development in the floodplain. The Town also enforces the Massachusetts Wetlands Protection Act, which limits construction that would impair wetlands functions, one of which is flood storage and control. The Town of West Stockbridge's infrastructure includes:

Water
Town water is supplied by groundwater wells. There are 227 town water customers.

Sewer
West Stockbridge operates a sewer treatment plant, with 157 service connections. Approximately 30% of Town residents are served by the public sewer system, with the remainder on private septic systems which are permitted through the Town Board of Health.

Schools
Children in West Stockbridge typically attend public schools in the Berkshire Hills Regional School District, whose schools are located in Great Barrington. There are no private schools and educational facilities located within West Stockbridge.

Town Roads
The West Stockbridge Highway Department maintains approximately 22.5 miles of paved roads, 12.5 miles of unpaved roads, 16 water-crossings (bridges and/or culverts), and has approximately 2.5 miles of roadway within the 100-year floodplain. The Town roadway infrastructure consists of primary and secondary roadways in addition to the local and private roadways in Town. Primary roads are: Stockbridge Road (State Rt. 102), State Line Road (State Rt. 102), Great Barrington Road (State Rt. 41), and Albany Road (State Rt. 41). Secondary roads are: Swamp Road, Lenox Road, and West Center Road.

Town-Owned Properties
The Town owns 25 parcels totaling approximately 520 acres, including more than 170 acres of nature and open space preservation. Town-owned buildings include Town Offices, Police Station, and Library at

21 State Line Road, one Fire Station and Town Garage, Sewer Treatment Plant, and Water Distribution System Plant.

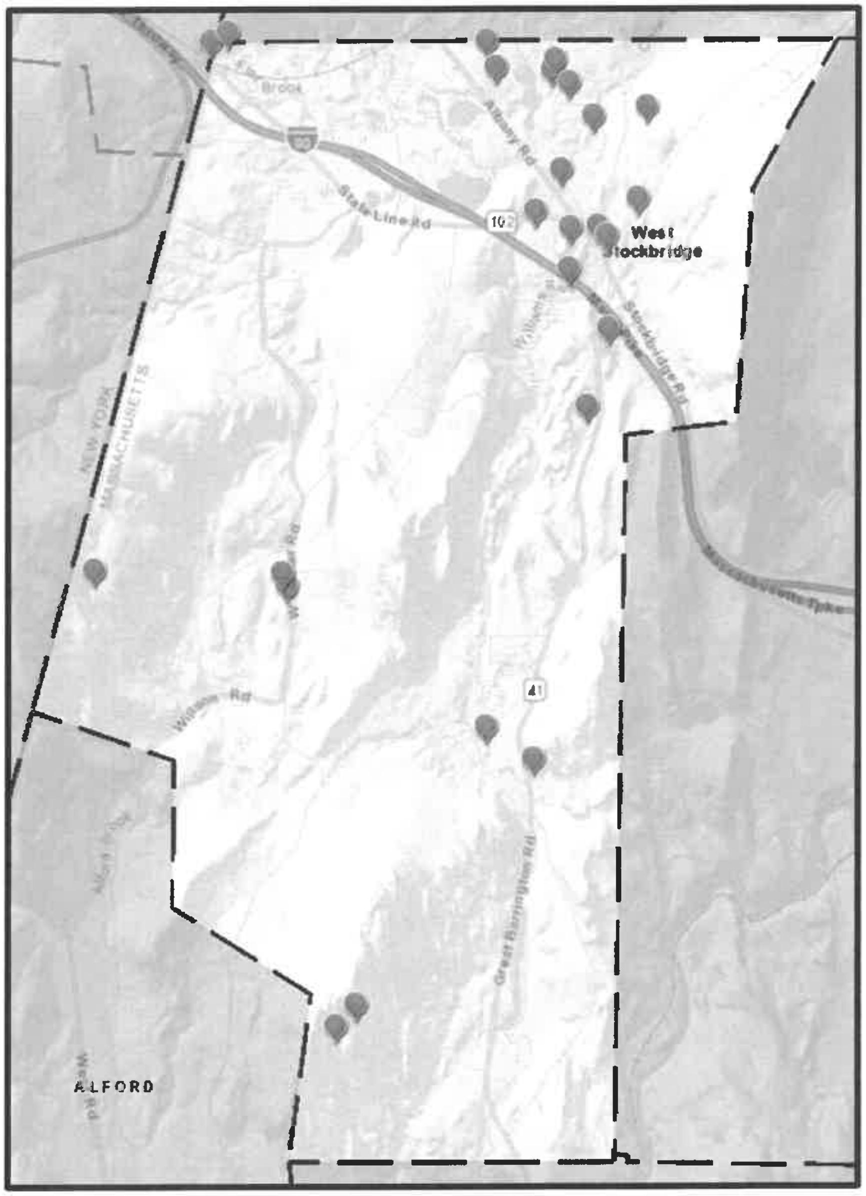


Figure 1.2 – West Stockbridge Town-Owned Properties
Source: MassGIS

Section 2
Planning Process

Planning Committee

The Town Administrator and DPW Director took the lead in convening an advisory committee to oversee the development of the West Stockbridge Hazard Mitigation Plan. This committee consisted of municipal department heads, first responders, representatives from various Town boards and committees, and residents. Members of the West Stockbridge Hazard Mitigation Advisory Committee are listed below, Table 2.1.

Table 2.1 – West Stockbridge Hazard Mitigation Advisory Committee
(As of October 2021; Founded July 2020)

Name	Position
Curt Wilton	DPW Director
Marc Portieri	Police Chief
Marie Ryan	Town Administrator
Steve Traver	Acting Fire Chief
John Masiero	Conservation Commissioner
Mark Webber	Resident

Committee Meetings were held on August 19, 2020, and October 13, 2021 to gather information and review documentation. The meetings were posted and open to the public, including stakeholders involved in hazard mitigation activities, neighboring communities and all others interested in being involved in the planning process, for participation. A draft of the Plan was also posted on the Town website for public review and comment. See the Appendix for evidence of meetings held.

Coordination with Existing and Developing Planning Efforts
The Town applied for was awarded a Hazard Mitigation Plan Grant from the Commonwealth from the FEMA HMGP 4372 Hazard Mitigation Grant Program in March 2020.

In addition to the planning efforts described above, this newly developed West Stockbridge Hazard Mitigation Plan draws and expands upon information found in the following plans and Town documents:

- West Stockbridge Master Plan
- West Stockbridge Zoning Bylaws
- West Stockbridge Town Code (General Bylaws)
- West Stockbridge Water Master Plan
- Dam Inspection Reports
- Housatonic Valley Association West Stockbridge Culvert Inspection Report
- West Stockbridge Comprehensive Emergency Management Plan

Incorporation with Other Planning Documents
The Town of West Stockbridge plans to implement findings from this 2021 Hazard Mitigation Plan into the following policy, programmatic areas and plans: General Town Bylaws, Master Plan, and Zoning Bylaws.

Plan Maintenance and Updates
The West Stockbridge Hazard Mitigation Plan is designed to be a working, living document. The West Stockbridge Town Administrator is the steward of the West Stockbridge Hazard Mitigation Plan of 2021.

Evaluation of the hazard mitigation plan in its entirety will be done on a five-year basis in accordance to the Disaster Mitigation Act of 2000, or if significant natural hazard disaster occurs. When the Plan is in its third or fourth year, the Town will begin the process of updating the Plan to ensure continuity and retain the Town's eligibility to apply for and receive FEMA and other relevant funding.

The Plan will be updated to meet changing conditions in the Town or in the region. Hazard mitigation measures that have been implemented will be analyzed for their effectiveness. This analysis may include site visits to appropriate locations where these measures have been implemented. Mitigation measures that have not been implemented will be reviewed to determine if they are still expected to minimize hazards if implemented, or if they are no longer viable options.

As with other planning projects undertaken in West Stockbridge, the public will be given the opportunity to review updates to the Plan and its proposed amendments in the future, and to submit comments. Public comments will be invited through notices place in the news media, at the Town's library, Senior Center, Town Hall and on the Town website. The Plan and its proposed amendments will be discussed at Select Board meetings, which are publicly noticed in accordance with public meeting laws, and televised and distributed through local cable access, thus providing wide-spread public exposure.

The West Stockbridge Planning Board is the primary town agency responsible for regulating development in the town. Feedback to the Planning Board was ensured through the participation of the Town Administrator on the local hazard planning team. In addition, Berkshire Regional Planning Commission (BRPC), the State-designated regional planning authority for West Stockbridge, works with all agencies that regulate development in its region, including municipal and state agencies, such as Department of Conservation and Recreation and MassDOT. This regular involvement ensured that during the development of the West Stockbridge Hazard Mitigation Plan, the operational policies and any mitigation strategies or identified hazards from these entities were incorporated.

Section 3

Natural Hazards Risk Assessment

Hazard Identification

As defined by FEMA, a hazard is an event or physical condition that has the potential to cause fatalities, injuries, property damage, infrastructure damage, agricultural loss, damage to the environment, interruption of business, or the types of harm or loss. Vulnerability is defined as the characteristics of community assets that make them susceptible to damage from a given hazard. A risk assessment is the process that collects information and assigns values to risks for the purpose of informing priorities, developing or comparing courses of action, and informing decision making (FEMA, 2013).

This section of the Plan discusses the natural hazards that have been determined to impact the Town of West Stockbridge.

State Hazards

The Massachusetts State Hazard Mitigation and Climate Adaptation Plan identifies the following 14 natural hazards that could have an impact or have a history of impacting communities in the Commonwealth of Massachusetts. These hazards are listed below:

- Inland Flooding
- Drought
- Landslide
- Coastal Flooding
- Coastal Erosion
- Tsunami
- Average/Extreme Temperatures
- Wildfires
- Invasive Species
- Hurricanes/Tropical Storms
- Severe Winter Storm
- Tornadoes
- Other Severe Weather
- Earthquake

Selection of Hazards that Affect West Stockbridge

As suggested under FEMA planning guidance, the Planning Team reviewed the full range of natural hazards identified in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan and identified natural hazards that could impact West Stockbridge in the future or that have impacted West Stockbridge in the past displayed in Table 3.1. Three of the hazards, Coastal Flooding, Coastal Erosion, and Tsunami, do not occur in the Town because it is a land-locked community within Berkshire County, approximately 140 miles from the Massachusetts coast and more than 100 miles from the Long Island Sound. The team members individually ranked the hazards, based on their own expertise and experience, and in addition to consulting data from Massachusetts State Hazard Plans and other resources, determined the following are the primary hazard issues for the Town: severe winter storms, inland flooding, other severe weather (high winds and thunderstorms), and invasive species.

Table 3.1 – Hazards with Greatest Potential to Impact West Stockbridge

Hazard	Area of Impact Rate: 1 = Small; 2 = Medium; 3 = Large	Frequency of Occurrence Rate: 0 = Very low frequency; 1 = Low; 2 = Medium; 3 = High frequency	Magnitude / Severity Rate: 1 = Limited; 2 = Significant; 3 = Critical; 4 = Catastrophic	Hazard Ranking (Cumulative Score)
Inland Flooding	1	1	1	3
Dams	1	0	1	2
Drought	1	0	1	2
Landslide	1	0	1	2
Average/Extreme Temperatures	1	0	1	2
Wildfires	1	0	1	2
Invasive Species	1	1	1	3
Hurricane/Tropical Storms	1	0	1	2
Severe Winter Storm	2	2	2	6
Tornadoes	1	0	1	2
Other Severe Weather (High Wind, Thunderstorm)	1	1	1	3
Earthquake	N/A	0	1	1

Climate Change
As discussed in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, climate change is now an additional lens through which natural hazards are assessed.

Four climate change categories have an impact on natural hazards:

1. **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 (MEMA, 2018).

2. **Sea Level Rise:** Climate change will drive rising sea levels, and rising seas will have wide-ranging impacts on communities, natural resources, and infrastructure along the Commonwealth's 1,519 tidal shoreline miles (MEMA, 2018).

3. **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 9 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) (MEMA, 2018).

4. **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 (MEMA, 2018).

Hazard Profiles

Inland Flooding

Overview

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). Inland 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 inland flooding (U.S. Climate Resilience Toolkit, 2017). Increases in precipitation and extreme storm events will result in increased inland flooding. Common types of inland flooding are described in the following subsections (Massachusetts Emergency Management Agency (MEMA), 2018).

Common Types of Floods

There are five common types of floods: riverine, urban drainage, ground failures, ice jam, and dam overtopping.

Riverine flooding often occurs after heavy rain. Areas of the state with high slopes and minimal soil cover (such as found in western Massachusetts) are particularly susceptible to flash flooding caused by rapid runoff that occurs in heavy precipitation events and in combination with spring snowmelt, which can contribute to riverine flooding. Frozen ground conditions can also contribute to low rainfall infiltration and high runoff events that may result in riverine flooding. Some of the worst riverine flooding in Massachusetts' history occurred 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 (MEMA, 2018).

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 (MEMA, 2018).

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." (MEMA, 2018). 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 (FEMA, 2011b)." (MEMA, 2018).

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 (MEMA, 2018).

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 (MEMA, 2018).

Subsidence is the process where the ground surface is lowered from natural processes, such as consolidation of subsurface materials and movements in the Earth's crust, or from manmade activities, such as mining, inadequate fill after construction activity, and oil or water extraction. When ground subsides, it can lead to flooding by exposing low-lying areas to groundwater, tides, storm surges, and areas with a high likelihood of overbank flooding (MEMA, 2018).

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 (MEMA, 2018).

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 downcutting 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 (MEMA, 2018).

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. (MEMA, 2018).

A dam is an artificial barrier that has the ability to impound water, wastewater, or any liquidborne 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. (MEMA, 2018). Further explanation of dam hazards is explained later, as a separate hazard category, in this section of the plan.

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 (MEMA, 2018).

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 (MEMA, 2018).

Measuring Floods

The frequency and severity of flooding are measured using a discharge probability, which is the probability that a certain river discharge (flow) level will be equaled or exceeded in a given year. The 100-year flood elevation or discharge of a stream or river has a 1% chance of occurring or being exceeded in any given year. In this case the statistical recurrence interval would be 100 years between the storm events that meet the 100-year discharge/flow. Such a storm, with a 1% chance of occurrence, is commonly called the 100-year storm. Similarly, the 50-year storm has a statistical recurrence interval of 50 years, and an annual flood is the greatest flood event expected to occur once in a typical year. It should be understood, however, that these measurements reflect statistical averages only using previously collected data, not projections due to climate change. Given these statistical averages, it is possible for two or more floods with a 100-year flood discharge to occur in a short time period.

The extent of the area of flooding associated with a 1% annual probability of occurrence (the base flood or 100-year flood), most commonly termed the 100-year floodplain area is a convenient tool for assessing vulnerability and risk in flood-prone communities. The 100-year flood boundary is used as the regulatory boundary by many agencies, including FEMA and MEMA. It is also the boundary used for most municipalities when regulating development within flood-prone areas. The FEMA Flood Insurance Rate Maps (FIRM) developed in the early 1980s for Berkshire County, typically serve as the regulatory boundaries for the National Flood Insurance Program (NFIP) and municipal floodplain zoning. However, as noted in the Flood Insurance Rate Maps, the areas shown within the 100-year flood boundaries are for flood insurance only; they do not necessarily reflect areas in a community prone to flooding.

Table 3.2 – Recurrence Intervals and Probabilities of Occurrences

Recurrence interval in years	Probability of occurrence in any given year	Chance of Reoccurrence in any given year
500	1 in 500	0.2
100	1 in 100	1
50	1 in 50	2
25	1 in 25	4
10	1 in 10	10
5	1 in 5	20
2	1 in 2	50

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. In the Berkshires, these areas most often flood during spring melt and during high rain events; inundation is often fairly common and expected, and equal to a 50% or 100% (annual) chance of recurrence. 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 (MEMA, 2018).

In general, flooding can be defined as a rising and overflowing of a body of water onto normally dry land. In some areas it is fairly easy to identify floodway floodplains due to terrain, soils, and vegetation. Floodplain forests and wetland ecosystems may occupy these areas, serving to buffer the impacts of floods by absorbing and storing water and tempering flowing waters. Backup of floodwaters occurs when structures built in a floodway/floodplain area constrict or impedes flows, such as when roads cross such an area or bridges and culverts are undersized. Figure 3.1 depicts the floodway and 100-year flood hazard areas of a floodplain (MEMA, 2013).

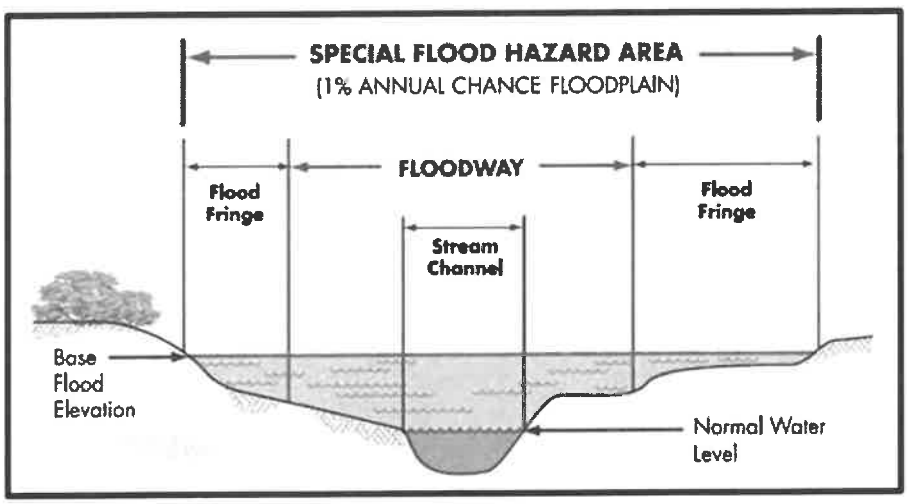


Figure 3.1 – Flood-Prone Areas Typically Associated with Streams and Rivers
Source: MEMA, 2013

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 (MEMA, 2018).

Location

Human development within historic floodplains has resulted in increased potential risks to public safety and infrastructure. Such development has occurred for centuries along rivers in Massachusetts, resulting in reduced natural flood storage capacity and increased exposure to flood risks. Inland flooding affects the majority of communities in the Commonwealth. Massachusetts has 27 regionally significant watershed areas. Two major river systems in the state are the Connecticut River and the Merrimack River. The Connecticut River flows south from the New Hampshire/Vermont state line through Massachusetts and Connecticut to Long Island Sound. Tributaries of the Connecticut River that are located in Massachusetts include the Deerfield, Millers, Chicopee, and Westfield Rivers. The Merrimack River flows south from the White Mountains of New Hampshire into northeast Massachusetts before discharging to the Atlantic Ocean. The Nashua and Shawsheen Rivers are tributaries of the Merrimack River in Massachusetts (MEMA, 2018).

As shown in Figure 3.2, West Stockbridge Flood Zone Map, the Town of West Stockbridge has significant floodplain areas spread across the Town, with approximately 1,050 acres of floodplain covering approximately 8.8% of the Town's total land mass. The floodplains of particular note are those in the Downtown District.

Previous Occurrences and Extent

Between 1938 and 2017, four flood events equaling or exceeding the 1% annual chance flood have been documented in the Berkshire County region, those being in 1938, 1949, 1955 and 2011. Not all these were documented to be a 1% chance storm for the Town of West Stockbridge, with the most recent flood event, Tropical Storm Irene in 2011 being determined to be a 1% chance flood event in northern Berkshire County and a 2% chance storm (50-year recurrence) according to the USGS Housatonic River stream gage in Great Barrington.

Table 3.3 – Previous Flooding Occurrences

Year	Description
1936	Widespread flooding occurs along the northern Atlantic in March 1936. Widespread loss of life and infrastructure. Many flood gauges are discharges of highest of record at many USGS stream gages, including Coltsville in Pittsfield.
1938	Large rain storm hit the area. This storm was considered a 1% annual chance flood event in several communities and a .2% annual chance flood event in Cheshire. The Hoosic River flooded downtown areas of densely-developed Adams and North Adams, with loss of life and extensive damage to buildings. Other communities were not as severely impacted.
Dec. 31, 1948 – Jan. 1, 1949	The New Year's Flood hit Berkshire County with many of areas registering the flood as a 1% annual chance flood event.
1955	Hurricanes Connie and Diane combined to flood many of the communities in the region and registering in 1% - 0.2% annual chance flood event (100-500-year flood event) (FEMA 1977-1991).
May 1984	A multi-day storm left up to 9" of rain throughout the region and 20" of rain in localized areas. This was reported as an 80-year flood for most of the area and higher where the rainfall was greater (USGS, 1989).

September 1999	The remnants from Hurricane Floyd brought between 2.5" - 5" of rain throughout the region and produced significant flooding. Due to the significant amount of rain and accompanying wind, there were numerous reports of trees down.
December 2000	A complex storm system brought 2 - 4" of rain with some areas receiving an inch an hour. The region had numerous reports of flooding.
March 2003	An area of low pressure brought 1" - 2" of rain, with unseasonable temperatures causing rapid melting of the snow pack.
August 2003	Isolated thunderstorms developed that were slow moving and prolific rainmakers, bringing flooding to the area.
September 2004	The remnants of Hurricane Ivan brought 3" - 6" of rain. This, combined with saturated soils from previous storms, caused flooding throughout the region and damaged the spillway of the Plunkett Reservoir dam in Hinsdale.
October 2005	A stationary cold front brought over 6" of rain and caused widespread flooding throughout the region. In Great Barrington, this was a 4%-10% chance flood (10-25 year recurrence).
November 2005	Widespread rainfall across the region of 1-1.5", preceded by 1-2 feet of snow, resulted in widespread minor flooding.
September 2007	Moderate to heavy rainfall occurred, which lead to localized flooding.
March 2008	Heavy rainfall ranging from 1" - 3" impacted the area, combined with frozen ground and snowmelt, caused flooding across the region.
August 2008	A storm brought very heavy rainfall resulting in flash flooding across parts of the region.
December 2008	A storm brought 1-4" of rain to the region, with some areas reporting 1/4 to 1/3" an hour of freezing rain., before changing to snow. Moderate flooding and ponding occurred throughout the region. In West Stockbridge, this was approximately a 10%-20% chance flood.
June 2009	Numerous slow-moving thunderstorms developed across the region, bringing very intense rainfalls and upwards of 6" of hail. This led to flash flooding in the region.
July 2009	Thunderstorms across the region caused heavy rainfall and flash flooding.
August 2009	An upper level disturbance moved across the region during the afternoon hours and triggered isolated thunderstorms resulted in roads flooding.
October 2009	A low-pressure system moved across region bringing widespread heavy rainfall to the area; 2-3" of rain was reported across the region.
March 2010	A storm brought heavy rainfall of 1.5-3" across the region, with roads closed due to flooding.
October 2010	The remnants from Tropical Storm Nicole brought 50-60 mph winds and 4-6" of rain resulting in urban flooding.
March 2011	Heavy rainfall, combined with runoff from snowmelt due to mild temperatures, resulted in flooding of rivers, streams, creeks, roads, and basements.
July 2011	Scattered strong to severe thunderstorms spread across the region resulting in small stream and urban flooding.
August 2011	Two distinct rounds of thunderstorms produced heavy rainfall and localized flooding of roads.
August 2011	Tropical Storm Irene tracked over the region bringing widespread flooding and damaging winds. Riverine and flash flooding resulted from an average of 3-6

	inches of rain and upwards of 9", within a 12-hour period. Widespread road closures occurred throughout the region. The storm is estimated to be a 1% chance storm on the Hoosic River in Williamstown, while in Great Barrington it was approximately a 4% chance flood (25-year recurrence).
September 2011	Remnants of Tropical Storm Lee dumped 4" - 9" of heavy rainfall on the region. Due to the saturated soils from Tropical Storm Irene, this rainfall lead to widespread minor to moderate flooding of rivers, as well as small streams and creeks. In West Stockbridge, this was approximately a 4% chance flood.
August 2012	Remnants from Hurricane Sandy brought repeated thunderstorms bringing heavy rains over areas of the region. Upwards of 4-5" of rain occurred and flash flooding caused the closure of numerous roads.
May 2013	Thunderstorms with wind and heavy rainfall caused flash flooding and road closures in areas.
August 2013	Heavy rainfall repeatedly moved across the region causing more than 3" of rain in a few hours causing streams and creeks to overflow their banks and flash flooding. Roads were closed as a result of the flooding and water rushed into some basements.
September 2013	Showers and thunderstorms tracked over the same locations and resulted in persistent heavy rain, flash flooding and road closures.
June 2014	Slow moving showers and thunderstorms producing very heavy rain over a short period of time, resulting in flash flooding and road closures, especially in urban and poor drainage areas.
June 2014	Showers and thunderstorms repeatedly passed over the same locations, leading to heavy rainfall and significant runoff, causing flash flooding in some areas. Many roads in the region were closed due to the flooding and some homes were affected by water as well.
July 2014	A cluster of strong to severe thunderstorms broke out causing 3"6" of rainfall and flash flooding.
May 2016	Bands of slow-moving showers and thunderstorms broke out over the region. Due to the slow movement of these thunderstorms, heavy rainfall repeatedly fell over the area resulting in flash flooding and some roads were temporarily closed.
August 2017	Widespread rain moved through the area resulting in isolated flash flooding.
August 2017	Severe thunderstorms developed resulting in flash flooding.

Source: NOAA, NWS, 2018

Table 3.4– Flood Stage Exceedances over Flood Stage at USGS Gage #01197500 in Great Barrington

Ranking (highest to lowest)	Height Above Flood Level (in feet)	Date of Occurrence
1	12.08	1-1-49
2	11.72	9-22-38
3	10.96	5-31-84
4	10.60	3-19-36
5	10.34	10-9-05
6	10.08	9-9-11
7	10.00	11-5-27
8	9.84	7-13-96

9	9.68	1-20-96
10	9.65	8-19-55
11	9.62	8-29-11
12	9.01	3-8-11

Source: NOAA, NWS, 2018

For many long term residents the multi-day storm in May 1984 that affected most of Southern Berkshire County had a particularly lasting effect, with many residents claiming that this was one of the worst storms in their memories of living in the Town.

Tropical Storm Irene (Aug. 28-29, 2001) was a 1% storm in the Hoosic River Watershed in northern Berkshire County, and while the Housatonic River at the Great Barrington gage indicates that it was above flood stage, it is listed as 11 out of the top 12 flood events at that site. The river was indeed at flood stage, with a gage level of 9.62' and a discharge of almost 7,000 cubic feet per second (cfs), far above the median discharge of 100-200 cfs for the same timeframe. However, the water levels resulting from Tropical Storm Lee, which followed on the heels of Irene on September 6th and 8th, were actually higher, with a peak of more than 10' and a discharge of 8,000 cfs at the Great Barrington gage. Interestingly, the October 2005 rain events created higher flood levels, peaking at 10.3' at the Great Barrington gage (USGS, NWS, 2018).

Impact

Severity

In general, the severity level of flood damage is affected by flood depth and flood velocity. The deeper and faster flood flows become, the more power they have and 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 (MEMA, 2013). However, flood damage to homes and buildings can occur even during shallow, low velocity flows that inundate the structure, its mechanical system and furnishings.

Flooding of homes and businesses can impact human safety and health if the area of inundation is not properly dried and restored. Wood framing can rot if not properly dried, compromising building structure and strength. Undetected populations of mold can establish and proliferate in carpets, duct work, wall board and almost any surface that is not properly dried and cleaned. Repeated inundation brings increased risks of both structural damage and mold. Vulnerable populations, such as those whose immune systems are compromised by chronic illness or asthma, are at higher risk of illness due to mold.

Climate Change Impacts

The scientific community is largely in agreement that climate change is altering the weather and precipitation patterns of the northeastern region of the U.S. The Intergovernmental Panel on Climate Change report of 2007 predicts temperature increases across the U.S., with the greatest increase in the northern states and during the winter months. The Northeast Climate Adaptation Science Center predicts that annual increases of 3.1 degrees to 6.7 degrees Fahrenheit will occur in the Housatonic River Watershed by mid- century, with the greatest increases in the winter season. More mid-winter cold/thaw weather pattern events could increase the risk of ice jams. Many studies agree that warmer late winter temperatures will result in more rain-on-snow storm events, leading to higher spring melt flows, which typically are already the highest flows of the year.

The NECSC also predicts that the region will see an increase in the number of days with at least 1 inch of precipitation from 4.5 days in the 1960s, to 5.1 days in the 2000s to 6.6 days in 2050s and 7.1 days in 2090s (Northeast Climate Science Center, 2018). The NOAA National Centers for Environmental Information provides a summary of observed climate changes for Massachusetts. According to this data, the number of extreme precipitation events, those defined as more than two inches in one day, has increased since the 1980s, with the greatest increase in the past decade.

These trends have direct implications on the design of municipal infrastructure to withstand extreme storm and flood events, indicating that all future designs must be based on the most updated precipitation and stream gauge information available, as well as climate change predictions. It is not unusual for stormwater management systems to be 50-100 years old, or older, and new infrastructure systems are being designed to have at least a 20-50-year lifespan. Thus, the vast infrastructure systems in place today will probably not accommodate the predicted increased flows.

It may be prudent, therefore, to overdesign the size of new stormwater management and flood control systems so that they have the capacity to accept the increase in flow or volume without failing. For many piped systems, such as culverts, drainage ditches and swales, the increase in size may provide a large increase in capacity for minimal increases in cost. If space is available, an increase in the capacity of retention/detention ponds may also be cost effective. Bioretention cells can be engineered to increase their holding capacity for extreme storm events with minor incremental costs. The size of the engineered soil media, which is a costly component of the management system, may remain the same size as required in current designs but a surface ponding area surrounding the central soil media is increased to serve as a holding pond.

Local public works superintendents are reporting an increase in road failures due to overwhelmed culverts, road washouts, eroding ditches, undercut road bases, and overtopped bridges. This information is not clearly documented, so it is not possible at this time to predict trends.

Probability

Using the past as a guide, West Stockbridge will continue to be impacted by floods. With six to eight flood events that approached or exceed a 50-100-year interval in the region in the last 100 years, we can assume that a flood event will impact the region every 12-15 years, if not more frequently due possibly to climate change, and result in minor flooding at least once a year. In addition to this, the increasing trend for increased precipitation, combined with existing development in or near floodplain areas, indicates that flooding will persist in some areas. Efforts to flood proof or relocate high-risk properties within the floodplain, along with efforts to prohibit or limit new development, will decrease the potential for expanded damage and losses. The Town's effort to control new sources of stormwater runoff and upgrade stormwater drainage systems should also help to alleviate flooding in certain areas, particularly road stream crossings.

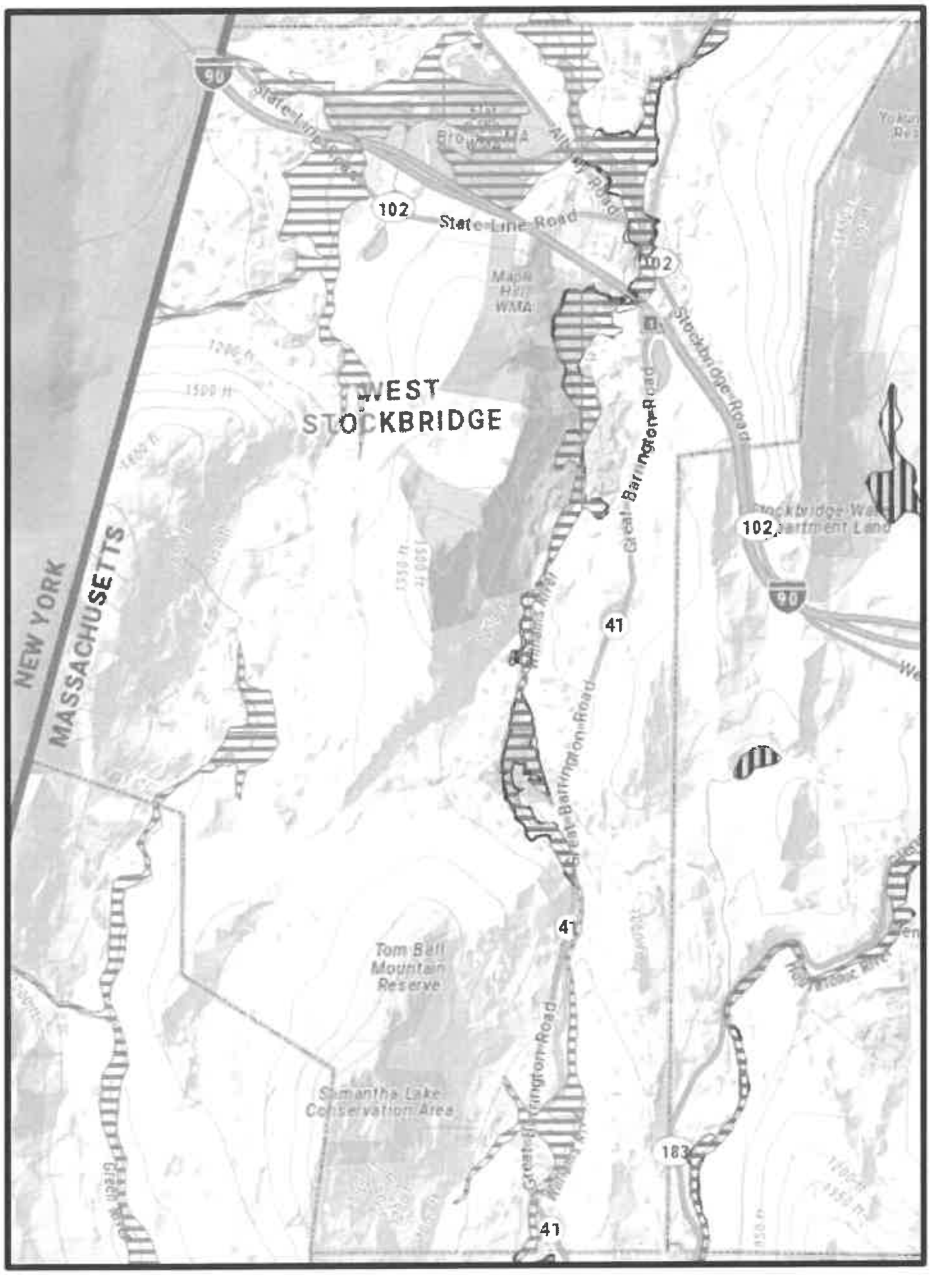


Figure 3.2 – West Stockbridge Flood Zone Map
Source: OLIVER

Secondary Hazards

The most problematic secondary hazards for flooding are fluvial erosion, river bank erosion, and landslides affecting infrastructure and other assets (e.g., agricultural fields) built within historic floodplains. Without the space required along river corridors for natural physical adjustment, such changes in rivers after flood events can be more harmful than the actual flooding. For instance, fluvial erosion attributed to Hurricane Irene caused an excess of $23 million in damages along Route 2. The impacts from these secondary hazards are especially prevalent in the upper courses of rivers with steep gradients, where floodwaters may pass quickly and without much damage, but scour the banks, edging buildings, and structures closer to the river channel or cause them to fall in. Landslides can occur following flood events when high flows oversaturate soils on steep slopes, causing them to fail. These secondary hazards also affect infrastructure. Roadways and bridges are impacted when floods undermine or wash out supporting structures. 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 (MEMA, 2018).

Dam failures, which are defined as uncontrolled releases of impounded water due to structural deficiencies in the dam, can occur due to heavy rain events and/or unusually high runoff events (MEMA, 2013). Severe flooding can threaten the functionality or structural integrity of dams. In addition to the Shaker Mill Pond Dam, the only High-Hazard Dam in West Stockbridge, the Town is in the inundation area for several other dams as shown on the attached map from the Massachusetts Office of Dam Safety (ODS) and listed in the following tables.

Table 3.5 – Dams Located within West Stockbridge Town Boundary

Dam Name	Water Body	Hazard Level (per MassODS)
Shaker Mill Pond Dam	Shaker Mill Pond/Williams River	High
Card Pond Dam	Card Pond	Low
Rose Lower Dam		N/A
Kingsmont Dam	Alford Brook	N/A
Alford Brook Club Dam	Alford Brook	N/A

Table 3.6 – Dams Located Outside Town Boundary, But with Potential to Impact Town Properties

Dam Name, TOWN	Water Body	Hazard Level (per MassODS)
Upper Root Reservoir LENOX	Upper Lenox Reservoir	High

Lower Root Reservoir LENOX	Lenox Reservoir	High
Richmond Iron Works Dam RICHMOND	Furnace Brook	N/A

Severe flooding can threaten the functionality of structural integrity of dams. In addition to the 5 registered dams in West Stockbridge, the Town is in the inundation area of dams located in adjacent Towns, most notably the Lenox Reservoirs.

Warning Time

Due to the sequential pattern of meteorological conditions needed to cause serious flooding, it is unusual for a flood to occur without warning. Flash flooding, which occurs when excessive water fills either normally dry creeks or river beds or dramatically increases the water surface elevation on currently flowing creeks and river, can be less predictable. However, potential hazard areas can be warned in advance of potential flash-flooding danger. Flooding is more likely to occur due to a rain storm when the soil is already wet and/or streams are already running high from recent previous rains. NOAA's Northeast River Forecast Center provides flood warnings for Massachusetts, relying on monitoring data from the USGS stream gauge network. Notice of potential flood conditions is generally available 5 days in advance. State agency staff also monitor river, weather, and forecast conditions throughout the year. Notification of potential flooding is shared among state agency staff, including the Massachusetts Emergency Management Agency (MEMA) and the Office of Dam Safety. The NWS provides briefings to state and local emergency managers and provides notification to the public via traditional media and social networking platforms. MEMA also distributes information regarding potential flooding to local emergency managers, the press, and the public (MEMA, 2018).

Increased drought frequency may also exacerbate the impacts of flood events, as droughts can cause vegetation that would otherwise have helped mitigate flooding to die off. Vegetated, undeveloped areas have been found to reduce runoff to less than 1 percent of total rainfall by increasing rainfall absorption (MEMA, 2018). These vegetated areas not only reduce the risk of downstream flooding but also increase the rate of groundwater recharge, which in turn increases an area's resilience to future drought events. Climate projections indicate that rainfall totals will increase overall and that more rain will fall in large rain events, which are the type of event that leads to flooding. By the end of this century (2080-2099), the annual number of days with precipitation over 1 inch is projected to increase by 1 to 4 days relative to the 1971-2000 average. Days with precipitation over 2 inches are expected to increase by 0 to 1 day, and days with precipitation over 4 inches are projected to increase by less than 1 day at the end of this century (MEMA, 2018).

Exposure and Vulnerability

People, property and infrastructure located in or near floodplains, near waterways where floodwaters are known to overflow their banks, or those located in areas of high groundwater tables are vulnerable to the impacts of flooding. Infrastructure and critical facilities built in, over or under floodways are vulnerable to damage due to the power of high volumes of water and from the debris those flows can carry or dislodge.

In West Stockbridge there are approximately 2.5 miles of Town roads that travel through the 100-year floodplain, which is approximately 7.14% of the Town's total number of road miles. Not all of these road sections flood equally – some function fine while others flood in less severe flood events than the 1% chance event.

In August 2021, The Housatonic Valley Association conducted a thorough study of all the road-stream crossings within the Town. The results of their study found the top five road stream crossings at risk for flooding were located on Great Barrington Road (2), Cobb Road, West Alford Road, and Baker Street. In addition, their study highlighted nine areas for the Town to prioritize: Wilson Road, Baker Street, Smith Road, West Alford Road (2), Cross Road, Great Barrington Road, Lenox Road, and West Center Road. Issues to suggested address for those areas included beaver issues, flooding issues, culvert size, erosion, and stormwater issues. The recommendations from this study have informed the mitigation actions for this section of the Plan.

NFIP Insured Structures

The Town does not have NFIP Insured Structures that have been repetitively damaged by floods. The Town does have a protocol for preparing vulnerable properties, which includes sand-bagging prior to expected high precipitation events like hurricanes.

Critical Facilities

The Town of West Stockbridge's Waste Treatment Plant is located just outside of the floodplain. According to MassDOT data, West Stockbridge has 15 bridges that cross water bodies, 5 of which are owned by the Town, and 10 of which are owned by the State. None of the Town-owned crossings are listed as structurally deficient by the State website.

Table 3.7 – List of Bridges in West Stockbridge

DOT Bridge Dept. Number (Name)	Road Name	Feature Crossed	Span Length (ft)	Year Built / Structurally Deficient?	Owner
W22011	State Line Road	Water – Flat Brook	4.90	1939 / No	MassDOT
W22015	Swamp Road	Water – Cone Brook	7.70	2002 / No	Town
W22012	Cone Hill Road	Water – Cone Brook	7.30	1939 / No	Town
W22008	State Route 41 – Albany Road	Water – Flat Brook	13.70	1900 / No	MassDOT
W22022	I-90 WB	State Route 102 – Albany Street	57.80	1957 / No	MassDOT
W22022	I-90 EB	State Route 102 – Albany Street	57.80	1957 / No	MassDOT
W22025	I-90	Water – Baldwin Brook	16.30	1957 / No	MassDOT

W22013	State Route 102 – State Line Road	Water – Brook	3.70	1939 / No	MassDOT
W22014	State Route 102 – State Line Road	Water – Baldwin Brook	3.70	1939 / No	MassDOT
W22023	Baker Street	I-90 EB	49.10	1957 / No	MassDOT
W22026	Baker Street	I-90 WB	35.10	1957 / No	MassDOT
W22016	State Route 102 – State Line Road	Cattle Pass	3.70	1939 / No	MassDOT
W22024	State Route 102 – Albany Street	I-90	90.00	1957 / No	MassDOT
W22018	I-90 EB	Moscow Road	36.80	1957 / No	MassDOT
W22018	I-90 WB	Moscow Road	36.80	1957 / No	MassDOT
W22019	I-90 EB	Water – Williams River	57.50	1957 / No	MassDOT
W22019	I-90 WB	Water – Williams River	57.50	1957 / No	MassDOT
W22020	State Route 41 – Great Barrington	I-90	50.90	1957 / No	MassDOT
W22002	Center Street	Water – Williams River	19.50	1992 / No	Town
W22007	State Route 41 / State Route 102 / Albany	Water – Williams River	22.10	2007 / No	MassDOT
W22017	I-90	Water – Stream to Card Pond	3.00	1957 / No	MassDOT
W22027	West Center Road	Water – Baldwin Brook	5.00	1920 / No	Town
W22005	East Alford Road	Water – Williams River	18.00	1996 / No	Town
W22004	State Route 41 – Great Barrington	Water – Williams River	23.50	2016 / No	MassDOT
W22001	State Route 41 – Great Barrington	Water – Williams River	14.90	1931 / No	MassDOT

Economy

According to the Massachusetts State Hazard Mitigation Plan, 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 the subway or commuter rail 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 (MEMA, 2018).

Damage to buildings can affect a community's economy and tax base. The total loss of buildings and their content within the floodplain has not been calculated for the worst-case scenario of potential losses if a 1% chance flood event were to occur. This represents complete destruction of all buildings and contents within the floodplain. It should be noted that historical records indicate that total loss of buildings and contents has never occurred in West Stockbridge, and is very rare in the region. It is more likely that flooding would result in partial damages or loss of a building and its contents, as demonstrated through past flood insurance claims in West Stockbridge and the region.

Actions

- Upgrade bridges noted as structurally deficient, in particular, Cone Hill Road Bridge and West Center Road Bridge
- Replace or upgrade culverts that are undersized and prone to flooding as reported from Town Road-Crossing Study conducted by The Housatonic Valley Association
- Upgrade Town-wide drainage conveyances
- Continue enforcement of flood management bylaws
- Plan and enact a Town stormwater management bylaw
- Continue to mow and maintain large beaver dams. Breach as needed
- Continue to prioritize roadway improvements
- Major transportation routes in inundation areas for dams of High or Significant Hazard have been determined.; Continue to update as necessary
- Encourage use of low-impact development techniques especially in flood-prone areas
- Conduct loss estimates for inundation areas
- Continue work to inform property owners in the floodplain about grant programs available to retrofit and/or flood proof structures

Dams

Overview

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. Dam failure is a catastrophic type of failure characterized by the sudden, rapid, and uncontrolled release of impounded water or the likelihood of such an uncontrolled release. Dams can fail for one or a combination of the following reasons:

- Overtopping caused by floods that exceed the capacity of the dam
- Deliberate acts of sabotage
- Structural failure of materials used in dam construction
- Movement and/or failure of the foundation supporting the dam
- Settlement and cracking of concrete or embankment dams
- Piping and internal erosion of soil in embankment dams
- Inadequate maintenance and upkeep (MEMA, 2018)

The Massachusetts Department of Conservation and Recreation (DCR) Office of Dam Safety maintains an inventory of all the known dams in the state. The dam regulations are governed by Massachusetts General Law chapter 253, § 44. The height of the dam is determined by the height of the dam at the maximum water storage elevation. The storage capacity of the dam is the volume of water contained in the impoundment at maximum water storage elevation. Size class may be determined by either storage or height, whichever gives the larger size classification.

The hazard classification pertains to potential loss of human life or property damage in the event of failure or improper operation of the dam or appurtenant works. Probable future development of the area downstream from the dam that would be affected by its failure shall be considered in determining the classification. Even dams which, theoretically, would pose little threat under normal circumstances can overspill or fail under the stress of a cataclysmic event such as an earthquake or sabotage.

Dam owners are legally responsible for having their dams inspected on a regular basis. High Hazard dams must be inspected every two years, Significant Hazard dams must be inspected every five years, and Low Hazard dams must be inspected every ten years. In addition, owners of High Hazard dams must develop Emergency Action Plans (EAPs) that outline the activities that would occur if the dam failed or appeared to be failing. Owners of Significant Hazard dams are strongly encouraged to also develop EAPs. The EAP would include a notification flow chart, list of response personnel and their responsibilities, a map of the inundation area that would be impacted, and a procedure for warning and evacuating residents in the inundation area. The EAP must be filed with local and state emergency agencies.

Factors that contribute to dam failure include design flaw, age, over-capacity stress, and lack of maintenance. Maintenance, or the lack thereof, is a serious concern for the community. By law, dam owners are responsible for the proper maintenance of their dams. If a dam were to fail and cause flooding downstream, the dam owner would be liable for damages and loss of life that were a result of the failure. Local officials are largely unaware of the age and condition of the dams within their communities.

Location

There are five public or privately-owned dams located throughout West Stockbridge. A summary of these dams and their hazard classification can be found in Table 3.8. The Town-owned Shaker Mill Pond Dam has significant potential for downstream impact if failure was to occur, and an Emergency Action Plan was completed in 2018.

Table 3.8 – Dams in West Stockbridge

Dam Name	Owner	Hazard Class	Size Class / Normal Impoundment	Condition	Location
Shaker Mill Pond Dam	Town	High	Intermediate / 119± acre-feet	Satisfactory	Shaker Mill Pond/Williams

Card Pond Dam	Town	Low	Unknown	Unknown	Card Pond
Rose Lower Dam	Gilligan	N/A	Unknown	Unknown	Red Rock Rd
Kingsmont Dam		N/A	Unknown	Unknown	Alford Brook
Alford Brook Club Dam	Alford Brook Club	N/A	Unknown	Unknown	Alford Brook

Table 3.9 – Dam Size Classification

Category	Storage (acre-feet)	Height (feet)
Small	>= 15 and <50	>= 6 and <15
Intermediate	>= 50 and <1000	>= 15 and <40
Large	>= 1000	>= 40

Table 3.10 – Dam Hazard Potential Classification

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

Previous Occurrences and Extent

Historically, dam failure has had a low occurrence in Berkshire County. However, it is one of the few natural hazards that have taken human lives in Berkshire County. The dam failure events of most note in Berkshire County are:

- April 20, 1886: the Mud Pond Dam in East Lee, MA, failed and heavy damaged or destroyed approximately 12 shops and industries along Greenwater Brook. This failure killed seven people. The cause of the failure was unknown (MEMA, 2013).
- August 19-20, 1901: Basset Reservoir and Dean's Dams fail after a two-day rain event, killing one person and damaging houses, businesses, roads and railroad tracks in Adams, North Adams (Ennis, 2004).
- March 24, 1968: Lee Lake Dam near East Lee, Massachusetts failed, destroying six homes, damaging 20 homes and one manufacturing plant. The failure caused two fatalities. The cause of the failure was unknown (MEMA, 2018).

While no dam failures have occurred in recent decades in the region, in September 2004 an incident occurred at the Plunkett Reservoir dam in Hinsdale. The first few weeks of September were unusually wet as the region received residual rain from three hurricanes. On September 18, 2004, after the effects of Hurricane Ivan dropped more than three inches of rain on the area in 24 hours, the flash boards at the Plunkett Reservoir dam gave way. The Emergency Management Director for Hinsdale calculated that approximately eight million gallons of water flooded the Housatonic River downstream of the lake, causing some minor flooding. There was no permanent damage or real estate damage, but the CSX rail line was undermined in the Hinsdale Flats area in Hinsdale. This was largely due to beaver activity, where culverts were partially plugged, and impeding and redirecting flood waters.

Impact

Severity

The U.S. Army Corps of Engineers developed the classification system shown in Table 3.11 for the hazard potential of dam failures. These classifications further explain the potential impacts of that dam failures could cause in West Stockbridge. The Corps of Engineers hazard rating system is based only on the potential consequences of a dam failure; it does not take into account the probability of such a failure (MEMA, 2018).

Table 3.11 – Corps of Engineers Hazard Potential Classification

Hazard Category	Direct Loss of Life	Lifeline Losses	Property Losses	Environmental Losses
Low	None (rural location, no permanent structures for human habitation)	No disruption of services (cosmetic or rapidly repairable damage)	Private agricultural lands, equipment, and isolated buildings	Minimal incremental damage
Significant	Rural location, only transient or day-use facilities	Disruption of essential facilities and access	Major public and private facilities	Major mitigation required
High	Certain (one or more) extensive residential, commercial, or industrial development)	Disruption of essential facilities and access	Extensive public and private facilities	Extensive mitigation cost or impossible to mitigate

Climate Change Impacts

According to MEMA, 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 severe rain events cause hydrographic 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. If the number of severe storms increases, or becomes the new norm, early releases of water will impact lands and waterways downstream more often.

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 may not increase the probability of catastrophic dam failure, it may increase the probability of design failures (MEMA, 2013).

If climate change results in a greater number of severe precipitation events and shortens recurrence intervals them, as is predicted, it will require dam operators to become more vigilant in monitoring precipitation and temperature patterns. Individual rain events, particularly if occurring during periods of saturated or frozen soils that cannot absorb rainfall, may require that dam operators open spillways, flashboards and other safety features more often, causing a greater number of high discharge events and possible flooding on properties downstream of the dam.

Probability

Dam failure events are infrequent and usually coincide with events that cause them, such as earthquakes, landslides, excessive rainfall, and snowmelt. However, additional factors to consider are that many of the dams within the region are more than 100 years, and some are approaching 200 years old, and many dam owners struggle to properly maintain their dams. There is a "residual risk" associated with dams. Residual risk is the risk that remains after safeguards have been implemented. For dams, the residual risk is associated with events beyond those that the facility was designed to withstand, such as more severe, more frequently occurring precipitation events. However, the probability of a full break dam failure is low in today's regulatory and dam safety oversight environment.

Secondary Hazards

The sudden and potentially extreme volumes of water that are released during dam failures can cause ecological damage both upstream and downstream of the dam. River channels downstream of the dam can experience severe scouring, banks can experience erosion and mass wasting, and boulders can become dislodged and move downstream by high and powerful water volumes. Trees and other vegetation can become uprooted and add to the debris moved by floodwaters, potentially clogging and threatening the integrity of culverts and bridges. Upstream of the dam the former impoundment could become partially or completely dewatered, altering, and potentially destroying aquatic habitat. If the impoundment behind the dam were a drinking water supply, the loss of stored water could threaten public health and the economy of the town (MEMA, 2018).

Other secondary impacts due to dam failure are potential human health impacts from inundation of private drinking water wells and septic systems. Flood waters typically carry higher bacterial counts than normal flows and these could flood directly into or seep through saturated groundwater into well shafts.

Additionally, floodwater could become more contaminated if water exchange occurs between wells and nearby septic systems.

Warning Time

Warning time for dam failure varies depending on the cause of the failure. In events of extreme precipitation or massive snowmelt, evacuations can be planned with sufficient time. In the event of a structural failure due to earthquake, there may be no warning time. A dam's structural type also affects warning time. Earthen dams do not tend to fail completely or instantaneously. Once a breach is initiated, discharging water erodes the breach until either the reservoir water is depleted, or the breach resists further erosion. Concrete gravity dams also tend to have a partial breach as one or more monolith sections are forced apart by escaping water. The time of breach formation ranges from a few minutes to a few hours (MEMA, 2018).

Dam owners are required to have established protocols for flood warning and response to imminent dam failure in the flood warning portion of its adopted emergency operations plan. These protocols are tied to the emergency action plans also created by the dam owners. These documents are customarily maintained as confidential information, although copies are required to be provided to the Commonwealth of Massachusetts for response purposes (MEMA, 2018). The estimated time of inundation from a Stockbridge Bowl dam failure would be 1-2 hours from the Bowl south to the Housatonic River.

Exposure and Vulnerability

Residents in the town are at risk from at least one dam located in West Stockbridge. Emergency Action Plans for the dams are on file with the Town on the Town website. Due to the sensitive nature of the contents of these plans, this Hazard Mitigation Plan will discuss in general terms the risks posed by these dams. A detailed risk assessment to quantify potential damages has not been conducted.

All populations in a dam failure inundation area would be exposed to the risk of a dam failure. The potential for loss of life is affected by the warning time, the capacity of dam owners and emergency personnel to alert the public and the capacity and number of evacuation routes available to populations living in areas of potential inundation.

Vulnerable populations are all populations downstream from dam failures that are incapable of escaping the area within the needed time frame. However, there is often limited warning time for a dam failure event. While dam failure is rare, when events do occur, they are frequently associated with other natural hazard events such as earthquakes, landslides, or severe weather, which limits their predictability and compounds the hazard. Populations without adequate warning of the event from a television, radio, siren or reverse 911 emergency warning system are highly vulnerable to this hazard. This population includes older and younger residents who may be unable to get themselves out of the inundation area (MEMA, 2018).

Conducting a detailed quantitative vulnerability assessment for property damages, injury or death due to dam failure was beyond the scope of the planning process for this Hazard Mitigation Plan. This type of information would be useful information but is not required to be calculated as part of Emergency Action Plans. The inundation maps are the basis for determining vulnerability. Rather, for the purposes of this planning process, the Town's vulnerability to the dam failure hazard is discussed qualitatively to provide a rough estimate of potential inundation.

Critical Facilities

Transportation infrastructure and bridges in the inundation area are vulnerable to damage. Flood waters may potentially cut off evacuation routes, limit emergency access, and destroy power or communication infrastructure. No municipal critical facility is located in the inundation area from the Shaker Mill Pond Dam.

Economy

Damage to buildings and infrastructure can impact a community's economy and tax base. Buildings and property located within or closest to the dam inundation areas have the greatest potential to experience the largest, most destructive surge of water. Summary of businesses/farms within the Shaker Mill Pond Dam inundation area can be found in the Emergency Action Plan on file with the Town.

Existing Protections

The Town has recently completed both a Phase 1 Dam Inspection (2020), which found the dam to be in "Satisfactory" condition, and an Emergency Action Plan was updated in 2018 for the Shaker Mill Pond Dam.

Actions

- Continue to inspect all dams at appropriate intervals
- Continue to maintain dams as necessary

Drought

Overview

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 (MEMA, 2018).

The National Drought Mitigation Center references five common, conceptual definitions of drought categorized by Wilhite and Glantz in 1985:

Meteorological drought is a measure of departure of precipitation from normal. It is defined solely on the degree of dryness. Due to climatic differences, what might be considered a drought in one location of the country may not be a drought in another location (MEMA, 2018).

Hydrological drought is associated with the effects of periods of precipitation (including snowfall) shortfalls on the surface or subsurface water supply, and occurs when these water supplies are below normal. This type of drought is related to the effects of precipitation shortfalls on stream flows and on reservoir and groundwater levels (MEMA, 2018).

Agricultural drought links various characteristics of meteorological (or hydrological) drought to agricultural impacts, such as precipitation shortages, differences between actual and potential evapotranspiration, soil water deficits, and reduced ground water or reservoir levels. It occurs when there is not enough water available for a particular crop to grow at a particular time. Agricultural drought is defined in terms of soil moisture deficiencies relative to the water demands of plant life, primarily crops (MEMA, 2018).

Socioeconomic drought is associated with the supply and demand of some economic good with elements of meteorological, hydrological, and agricultural drought. This differs from the aforementioned types of drought because its occurrence depends on the time and space processes of supply and demand to identify or classify droughts. The supply of many economic goods depends on the weather (e.g., water, forage, food grains, fish, and hydroelectric power) (MEMA, 2018).

Socioeconomic drought occurs when the demand for an economic good exceeds the supply as a result of a weather-related shortfall in the water supply. Ecological drought is an episodic deficit in water availability that drives ecosystems beyond thresholds of vulnerability, impacts ecosystem services, and triggers feedbacks in natural and/or human systems (MEMA, 2018).

There are also multiple operational definitions of drought. An operational definition attempts to quantitatively characterize the onset and end of droughts as well as the severity or levels during the drought (MEMA, 2018).

Location

For the purposes of tracking drought conditions across the Commonwealth, the state has been divided into six regions, with the Western Region being made up of Berkshire County. For the purposes of this Plan, the entire Town of West Stockbridge is at risk of drought. This includes residents and businesses.

Previous Occurrences and Extent

According to the state's Hazard Mitigation and Climate Adaptation Plan of 2018, The Commonwealth of Massachusetts has never received a Presidential Disaster Declaration for a drought-related disaster; however, the Commonwealth has experienced several substantial droughts over the past 100 years and has recorded events dating back to 1879 (MEMA, 2018). Table 3.12 displays the droughts that have occurred in the state since 1879 (MEMA, 2018).

Table 3.12 – Droughts in Massachusetts Based on Instrumental Records

Date	Area Affected	Recurrence	Remarks	Reference
1879-83	—	—		Kinnison (1931) as cited in USGS 1989
1908-12	—	—		Kinnison (1931) as cited in USGS 1989
1929-32	Statewide	10 to >50	Water-supply sources altered in 13 communities. Multistate.	USGS 1989
1939-44	Statewide	15 to >50	More severe in eastern and extreme western Massachusetts. Multistate.	USGS 1989
1957-59	Statewide	5 to 25	Record low water levels in observation wells, northeastern Massachusetts.	USGS 1989
1961-69	Statewide	35 to >50	Water-supply shortages common. Record drought. Multistate.	USGS 1989
1980-83	Statewide	10 to 30	Most severe in Ipswich and Taunton River basins; minimal effect in Nashua River basin. Multistate.	USGS 1989
1985-88	Housatonic River basin	25	Duration and severity as yet unknown. Streamflow showed mixed trends elsewhere.	USGS 1989
1995	—	—	Based on statewide average precipitation	DMP 2013
1998-1999	—	—	Based on statewide average precipitation	DMP 2013
Dec 2001-Jan 2003	Statewide	—	Level 2 drought (out of 4 levels) was reached statewide for several months	DCR 2017
Oct 2007-	9	—	Level 1 drought (out of 4 levels)	DCR 2017
Aug 2010-	13	—	Level 1 drought (out of 4 levels)	DCR 2017
Oct 2014-		—	Level 1 drought (out of 4 levels)	DCR 2017
Jul 2016-	Statewide	—	Level 3 drought (out of 4 levels)	DCR 2017

Notes: (1) "—" denotes data not available; (2) USGS 1989 determined dry periods from streamflow and precipitation records. Dry periods that exceeded a recurrence interval of 10 years were deemed droughts; (3) DMP 2013 analyzed precipitation data only and as a statewide average of stations; (4) DCR 2017 compiled data based on historical drought declarations by the State under the protocol in its 2013 Drought Management Plan. DCR = Department of Conservation and Recreation; USGS = United States Geological Survey.

Additional post-2013 data gathered shows that droughts occurred in the state 2007-08 and in 2010, although neither of these involved drought conditions in Berkshire County (Western Drought Region).

The most recent drought in Massachusetts occurred during a 10-month span in 2016-17. In July 2016 Advisory and Watch drought levels were issued for the eastern and central portions of the state, worsening in severity until the entire state was under a Drought Warning status for the months of November-December 2016. Water levels began to recover in February 2017, with the entire state determined to be back to normal water levels in May 2017. The Massachusetts Water Resources Commission stated that the drought was the worst since the state's Drought Management Plan was first issued in 2001, and the most severe since the 1960s drought of record. In general, the central portion of the state faired the worse and Berkshire County faired the best, with the county entering the drought later and emerging from the drought earlier than most of the rest of the state. Berkshire County was under a Watch status for two months and under a Warning status for three months during the height of the drought (see Table 3.13 for the progression of the 2016-17 drought). During this time the Mountain Water Systems issued a voluntary water restriction to its customers, limiting outdoor water use. The company's water supply was not in jeopardy, but the restriction was required of by the Massachusetts Department of Environmental Protection as a precaution (MEMA, 2013; MEMA 2018).

Table 3.13 – Evolution of 2016-2017 Drought

	Percent of Commonwealth at a Given Drought Level					
Time	None	D0 (Abnormally Dry) or above	D1 (Moderate Drought) or above	D2 (Severe Drought) or above	D3 (Extreme Drought) or above	D4 (Exceptional Drought)
September	0%	100%	98%	90%	52%	0%
December	1%	99%	98%	69%	36%	0%
May 2017	100%	0%	0%	0%	0%	0%
Source: U.S. Drought Monitor, 2017						

Source: MEMA, 2018

Impact

Severity

The severity of a drought depends on the degree of moisture deficiency, the duration, and the size and location of the affected area. The longer the duration of the drought and the larger the area impacted, the more severe the potential impacts. Droughts are not usually associated with immediate impacts on people or property, but they can have significant impacts on agriculture, which can impact the farming community of the region. As noted in the state Hazard Mitigation Plan, agriculture-related drought disasters are quite common, with 1/2 to 2/3 of the counties in the U.S. having been designated as disaster areas in each of the past several years. These designations make it possible for producers suffering losses to receive emergency loans. Such a disaster was declared in December 2010 for Berkshire County (USDA Designation # S3072).

When measuring the severity of droughts, analysts typically look at economic impacts on a planning area. Drought warnings, watches and advisories can be reduced based on: 1) normal levels of precipitation, and 2) groundwater levels within the "normal" range. In order to return to a normal status, groundwater levels must be in the normal range and/or one of two precipitation measures must be met. The precipitation measures are: 1) three months of precipitation that is cumulatively above normal, and 2) long-term cumulative precipitation above normal. The period for long-term cumulative precipitation ranges from 4 to 12 months, depending on the time of year. Precipitation falling during the fall and spring is ideal for groundwater recharge and, therefore, will result in the quickest return to normal conditions. Because the same levels of cumulative precipitation can differ in their abilities to reduce drought conditions, the decision to reduce a drought level will depend on the professional judgment of the Secretary of EEA with input from his agencies and the Drought Management Task Force (EEA, MEMA 2018).

MassDEP has the authority to declare water emergencies for communities facing public health or safety threats as a result of the status of their water supply systems, whether caused by drought conditions or for other reasons. The Department of Public Health (DPH) in conjunction with MassDEP monitors drinking water quality in communities.

According to the data at hand, the most severe droughts in Massachusetts occurred 1930-31 and 1964-67. Many local water managers and officials remember the drought years of the 1960s, where mandatory water bans were issued. Outside of this time period, most water restrictions in the region have been voluntary.

Climate Change Impacts

Changes in winter temperatures will lead to less snow pack and more rain-on-snow events, leading to more surface runoff and less groundwater recharge, leading to less stream and river base flows. Higher temperatures in warmer seasons can more severely impact the reduced base flows due to higher rates of evaporation of moisture from soil and lower groundwater and surface water inputs. According to the state's Climate Change Adaptation Report, a continued high greenhouse-gas-emission scenario could result in a 75% increase in the occurrence of drought conditions lasting 1-3 months.

Probability

An analysis of historical rainfall data indicated that, based on this index alone, between 1850 and 2012, the Commonwealth experienced drought emergency conditions in 1883, 1911, 1941, 1957, and 1965-1966. The 1965-1966 drought period is viewed as the most severe and longest duration drought to have occurred in Massachusetts. On a monthly basis, there is a 1% chance of the Commonwealth being in a drought Emergency. Drought Warning conditions not associated with drought Emergencies occurred in 1894, 1915, 1930, and 1985. On a monthly basis, there is a 2% chance of the state being in a drought Warning level. Drought Watch conditions not associated with higher levels of drought would have typically occurred in three to four years per decade between 1850 and 1950. The overall frequency of the Commonwealth being in a drought Watch is 8% each month (MEMA, 2018). The drought levels, recurrence interval and state estimated drought level nomenclature is found in Figure 3.3.

Berkshire County was determined to be in Warning drought conditions October 2016 through January 2017. Using the U.S. Drought Monitoring system, this type of drought event could be estimated to reoccur once per 10 to 50 years. Given that the duration was short and that the greatest severity was during the winter months, when water demand is less, water managers in Berkshire County did not suffer a severe threat to their supplies. The relatively low impact of this drought and of others in recent memory may lead water managers in the region towards a false sense of security.

MA Drought Levels	Names	Recurrence	Percentiles
Advisory	D0: Abnormally Dry	once per 3 to 5 years	21 to 30
Watch	D1: Moderate	once per 5 to 10 years	11 to 20
Warning	D2: Severe Drought	once per 10 to 20 years	6 to 10
Warning	D3: Extreme Drought	once per 20 to 50 years	3 to 5
Emergency	D4: Exceptional Drought	once per 50 to 100 years	0 to 2

Figure 3.3 – Mass. State Level and Comparable U.S. Drought Monitor Level Indices
Source: U.S. Drought Monitor; MA Drought Management Plan 2013.

Secondary Hazards

The secondary hazard most associated with drought is wildfire. A prolonged lack of precipitation dries out soil and vegetation, which becomes increasingly susceptible to ignition as the duration of the drought extends. A drought may increase the probability of a wildfire occurring (MEMA, 2018). See the Wildfire section for more information on this hazard in general and within the town of West Stockbridge.

Warning Time

Droughts are climatic patterns that occur over long periods of time. Drought levels advisories are issued at gradual levels to alert the public to conditions that, if continued, could result in more serious degrees of drought. Initial drought levels include Advisory and Watch levels. Voluntary water conservation efforts are advised during early stages of drought conditions and increasing conservation requirements are expected when Drought Warning and Emergency conditions develop. These higher levels of drought require months of dry conditions to be reached (MEMA, 2018). Therefore, according to state agencies, there is a lot of lead time as drought conditions progress.

Despite the long lead time to drought conditions, efforts to conserve water on the municipal, private and individual level should be encouraged and conducted on an ongoing basis. Efforts by water managers to identify and remedy leaks in the piping system that deliver water supplies should be given ongoing attention, and efforts to encourage customers to conserve water in the home and in commercial and industrial uses should be given additional attention. Water conservation efforts will reduce the demand on reservoir and groundwater supplies in the event that a multi-year Emergency Drought event, like that of the 1960s, recurs.

Exposure and Vulnerability

For the purposes of this Plan, the entire Town of West Stockbridge is at risk of exposure to drought. It is generally believed that residents that are on private wells may be more susceptible to drought, particularly those with shallow or point wells, but there is not definitive data to verify this belief.

To understand risk, this Plan considers the impact to population, critical facilities and the economy.

Population

For the purposes of this Plan, the entire population of West Stockbridge is exposed and vulnerable to drought. The Berkshire region has not suffered a severe, emergency level drought since the 1960s and it is unclear how well the water system could serve the demands of its customers during a severe drought emergency.

Due to the great expanses of state forest and wildlife lands in the region, which attract hikers and campers, and a tourist-based economy that brings additional people to the region in the summer, the risk of wildfire would increase during a severe drought. Drought would reduce the capacity of local firefighting efforts, hampering control of wildfire or urban fires. A more detailed discussion of wildfire and the Town's vulnerability is found within that section of this Plan.

Critical Facilities

Drought does not threaten the physical stability of critical facilities in the same manner as other hazards such as wind-based or flood-related events. Facilities and structures located outside the Town Center and in areas surrounded by forest or dry vegetation, such as water tanks, water pumps, and other infrastructure, could be more vulnerable to wildfire.

If a severe drought of long duration were to occur, the Town Water System may receive requests to provide water to residents whose wells have gone dry. An emergency dispensing center may need to be created to serve this population, as the infrastructure does not currently exist to do so.

Economy

A severe, long-term drought could impact the operation of West Stockbridge employers, particularly those that use water as part of the processes, as well as impact tourist and second homeowner visits should recreational lake levels drop severely.

Existing Protections

The Town does issue tips in the summer to its customers on conserving water. The Town does not provide any financial incentives to do so, however water usage by all customers is metered. Higher water prices may encourage increased conservation or reduced usage. The Town could partner with the MassDEP, Department of Energy Resources and the utilities to encourage residents and businesses to install water conservation measures, many of which are offered free of charge or with favorable financing.

The Massachusetts Department of Environmental Protection has broad jurisdiction to protect water supply and water quality. During a state of water emergency, MassDEP may issue orders to: (1) establish priorities for the distribution of any water or quantity of water use; (2) permit any person engaged in the operation of a water supply system to reduce or increase by a specified amount or to cease the distribution of that water; to distribute a specified amount of water to certain users as specified by the department; or to share any water with other water supply systems; (3) direct any person to reduce, by a specified volume, the withdrawal or use of any water; or to cease the withdrawal or use of any water; (4) require the implementation of specific water conservation measures; and, (5) mandate the denial, for the duration of the state of water emergency, of all applications for withdrawal permits within the areas of the Commonwealth to which the state of water emergency applies (EEA, MEMA, 2018).

Municipalities also have jurisdiction to control water supplies for protection of public health. Municipalities can adopt and implement bylaws to regulate public water supply pipes or to manage their prudential affairs and preserve peace and good order under their police powers, pursuant to G.L. c. 40, § 21, and c. 41, § 69B. Further, when MassDEP determines that an emergency exists in the case of a drought or disaster, a municipality may, following appropriate notice, regulate or otherwise restrain the use of water on public or private property (regardless of whether the supply source is public or private) pursuant to G.L. c. 40, § 41A (EEA, MEMA 2018).

Actions

- Work with MassSaves and other available water conservation programs to encourage residents to install water saving technologies; many of these devices are available at no or minimal expense.

Landslide

Overview

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. 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. Historical landslide data for the Commonwealth suggests that most landslides are preceded by 2 or more months of higher than normal precipitation, followed by a single, high-intensity rainfall of several inches or more (Mabee and Duncan, 2013). This precipitation can cause slopes to become saturated (MEMA, 2018).

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 (Mabee, 2010) (MEMA, 2018).

Occasionally, landslides occur as a result of geologic conditions and/or slope saturation. Adverse geologic conditions exist wherever there are lacustrine or marine clays, as clays have relatively low strength. These clays often formed in the deepest parts of the glacial lakes that existed in Massachusetts following the last glaciation. These lakes include Bascom, Hitchcock, Nashua, Sudbury, Concord, and Merrimack, among many other unnamed glacial lakes. The greater Boston area is also underlain by the Boston Blue Clay, a glaciomarine clay. The northeastern coast of Massachusetts is also underlain by marine clays. When oversteepened or exposed in excavations, these vulnerable areas often produce classic rotational landslides (MEMA, 2018).

Landslides can also be caused by external forces, including both undercutting (due to flooding or wave action) and construction. Undercutting of slopes during flooding or coastal storm events is a major cause of property damage. Streams and waves erode the base of the slopes, causing them to oversteepen and eventually collapse. This is particularly problematic in unconsolidated glacial deposits, which cover the majority of the Commonwealth. This type of failure occurs frequently in Cape Cod, Nantucket, Martha's Vineyard, Scituate, and Newbury, and along major river valleys (MEMA, 2018).

Construction-related failures occur predominantly in road cuts excavated into glacial till where topsoil has been placed on top of the till. Examples can be found along the Massachusetts Turnpike. Other construction-related failures occur in utility trenches excavated in materials that have very low cohesive strength and an associated high water table (usually within a few feet of the surface). This situation occurs in sandy deposits with very few fine sediments, and can occur in any part of the Commonwealth (MEMA, 2018).

Hazard Location

Thirty-six of the 50 U.S. states have moderate to highly severe landslide hazard areas. Within Massachusetts, there are a few areas that have a high susceptibility / moderate incidence occurrence to landslides, including areas within the Taconic and Hoosac Mountain Ranges of northern Berkshire

County (see Figure 3.4 for location). The Town of West Stockbridge is not included in any of these areas.

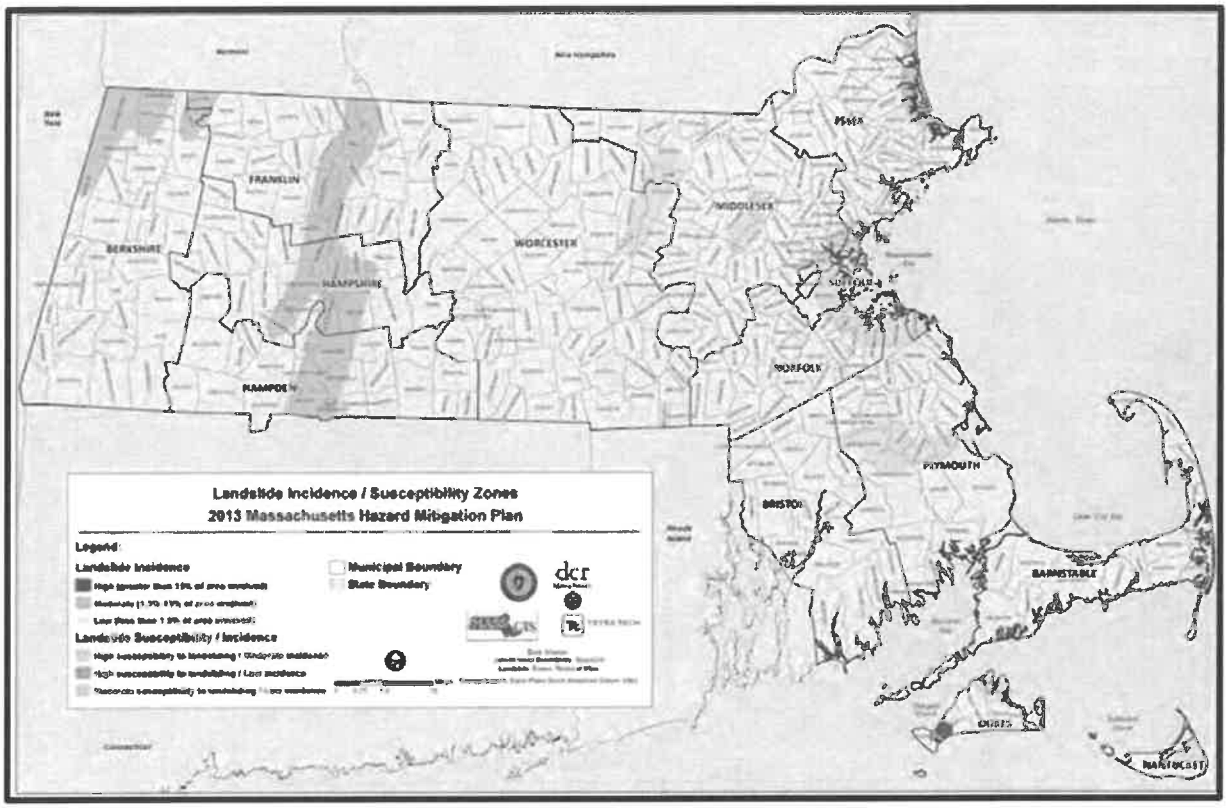


Figure 3.4 – Landslide Incidence
Source: MEMA, 2013

When referring to Figure 3.4, the definition of incidence and susceptibility are defined as such:

- Landslide incidence is the number of landslides that have occurred in a given geographic area. High incidence means greater than 15% of a given area has been affected by landslides; medium incidence means 1.5-15% of an area has been involved; and low incidence means less than 1.5% of an area has been involved.
- Landslide susceptibility is defined as the probable degree of response of geologic formations to natural or artificial cutting, to loading of slopes, or to unusually high precipitation. It can be assumed that unusually high precipitation or changes in existing conditions can initiate landslide movement in areas where rocks and soils have experienced numerous landslides in the past. Landslide susceptibility depends on slope angle and the geologic material underlying the slope. Landslide susceptibility only identifies areas potentially affected and does not imply a time frame when a landslide might occur. High, medium, and low susceptibility are delimited by the same percentages used for classifying the incidence of a landslide (MEMA,2013).

To investigate landslide risk more closely, data from the Slope Stability Map 2013, produced by the Massachusetts Geological Survey was reviewed.

The Slope Stability Map categorizes areas of Massachusetts into stability zones, and the categorization is correlated to the probability of instability in each zone. The probability of instability metric indicates how likely each area is to be unstable, based on the parameters used in the analysis. Thus, although specific landslide events cannot be predicted, this map shows where slope movements are most likely to occur after periods of high-intensity rainfall. According to the map, these unstable areas are located throughout the Commonwealth. However, the highest prevalence of unstable slopes is generally found in the western portion of the Commonwealth, including the area around Mount Greylock and the nearby portion of the Deerfield River, the U.S. Highway 20 corridor near Chester, as well as the main branches of the Westfield River (MEMA, 2018).

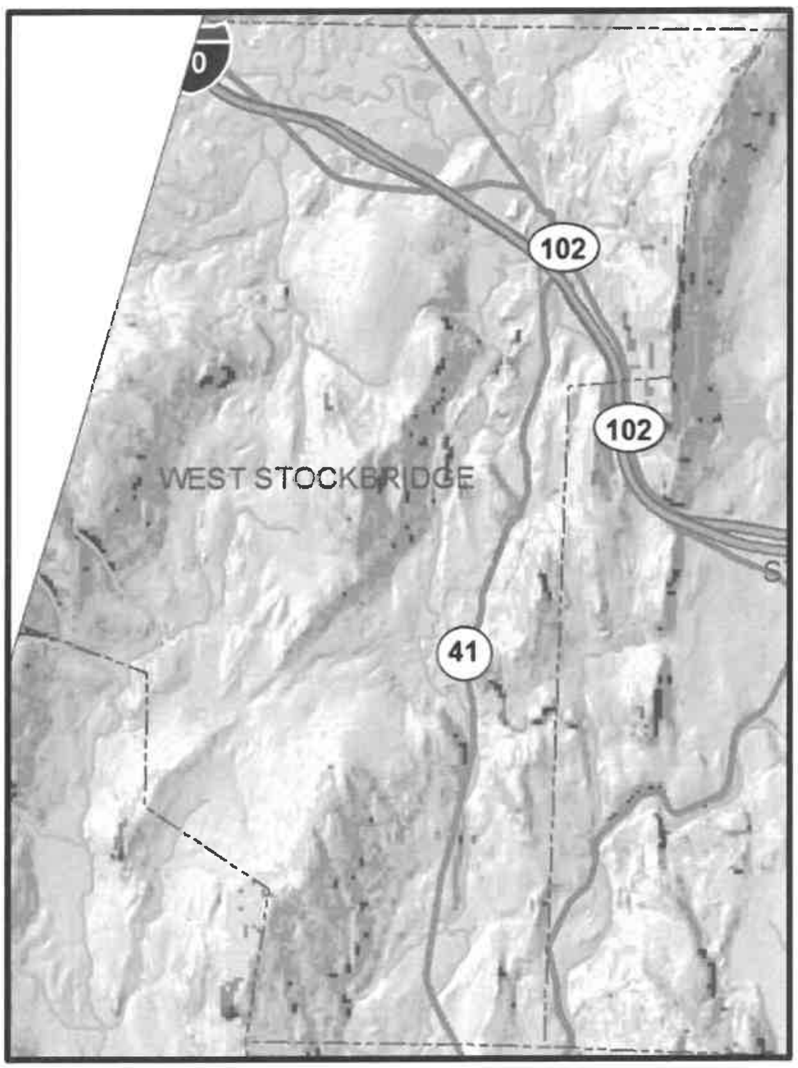


Figure 3.5 – Slope Stability Map of West Stockbridge
Source: Massachusetts Geological Society

Figure 3.5 is an excerpt of the Western region Massachusetts Slope Stability Map developed by the Massachusetts Geological Society, displaying the town of West Stockbridge. Figures 3.6 and 3.7 explain the color code and legend descriptions for the map.

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

Figure 3.6 – Slope Stability Map Color Legend

Source: Massachusetts Geological Society

[1]**Relative Slide Ranking** - This column designates the relative hazard ranking for the initiation of shallow slides on unmodified slopes.

[2]**Stability Index Range** - The stability index is a numerical representation of the relative hazard for shallow translational slope movement initiation based on the factors of safety computed at each point on a 9 meter (~30 foot) digital elevation model grid derived from the National Elevation Dataset. The stability index is a dimensionless number based on factors of safety generated by SINMAP that indicates the probability that a location is stable considering the most and least favorable parameters for stability input into the model. The breaks in the ranges of values for the stabilty index categories are the default values recommended by the program developers.

[3]**Factors of Safety** - The factor of safety is a dimensionless number computed by SINMAP using a modified version of the infinite slope equation that represents the ratio of the stabilizing forces that resist slope movement to destabilizing forces that drive slope movement (Pack et al., 2001). A FS>1 indicates a stable slope, a FS<1 indicates an unstable slope, and a FS=1 indicates the mariginally stable situation where the resisting forces and driving forces are in balance.

[4]**Probability of Instability** - This column shows the likelihood that the factor of safety computed within this map unit is less than one (FS<1, i.e., unstable) given the range of parameters used in the analysis. For example, a <50% probability of instability means that a location is more likely to be stable than unstable given the range of parameters used in the analysis.

[5]**Possible Influence of Stabilizing and Destabilizing Factors** - Stabilizing factors include increased soil strength, root strength, or improved drainage. Destabilizing factors include increased wetness or loading, or loss of root strength.

Pack, R. T., Tarboton, D. G. and Goodwin, C. N., 2001, Assessing terrain stability in a GIS using SINMAP, in 15th annual GIS conference, GIS 2001, Vancouver, British Columbia. February 19-22.

Figure 3.7 – Slope Stability Map Legend Descriptions

Source: Massachusetts Geological Society

According to this source, with red indicating higher instability, and pink indicating moderate instability, the areas most susceptible to landslides are in the higher elevations along the easterly and westerly edges of the Town border.

Previous Occurrences and Extent

Landslides commonly occur with other major natural disasters such as earthquakes and floods that exacerbate relief and reconstruction efforts. Rock slides occur along roadsides throughout the county where bedrock was blasted to make way for the road and there is little room between the road bed and the rock. Common examples are found on Route 2 near the Hairpin Turn in Clarksburg/Florida and Route 7 in New Ashford.

Many landslide events may have occurred in remote areas causing their existence or impact to go unnoticed. Therefore, this hazard profile likely does not identify all ground failure events that have impacted the Berkshires. While the region has had a few landslides of note, the data on them is very limited and there is nothing specific to West Stockbridge that can be presented in this report. Town officials confirm that no landslides are known to have occurred in the Town. Data taken from the state's hazard mitigation plan of 2013 notes these events that occurred in the Berkshire region.

- 1901: 11 landslides occurred along the east face of Mount Greylock after heavy rains. The mountain was designated in 1898 as the first Massachusetts State Reservation for conservation purposes, due largely to deforestation that occurred during private land ownership and which may have contributed to these landslide events.
- 1936: North Adams - one home was destroyed and six others evacuated during a slide in North Adams.
- 1990 – Following two days of heavy rain, a landslide estimated to be at least 1,000 feet long and 300 feet wide occurred in August on the eastern slope of Mt. Greylock, the state's highest peak. The landslide scar is still widely visible today.
- Early 2000s: Notable rock fall. This is an example of the type of event that occurs throughout the region.
- 2011: In August Tropical Storm Irene caused damage to a 5.8-mile section of Route 2 from South County Road in Florida to West Charlemont due to erosion and undercutting of the roadway, damage to retaining walls, debris flows, landslides, and bridge damage. The road was closed for an extended period of time.

Impact

Severity

To determine the extent of a landslide hazard, the affected areas need to be identified and the probability of the landslide occurring within some time period needs to be assessed. 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, even under ideal conditions (MEMA, 2013).

The most severe landslide to occur in the Berkshire region was the one that occurred along Route 2 in Savoy during Tropical Storm Irene in 2011. The slide was 900 feet long and covered approximately 1.5 acres, with an average slope angle is 28 to 33°. While the slide only displaced the top 2'-4' of soil materials, the estimated volume of moved material was 5,000 cubic yards.

It is unknown what the severity of a landslide in the Unstable or Moderately Unstable areas of West Stockbridge would be due to the number of factors that lead to landslides and to the extremely low number of serious incidences.

Climate Change Impacts

With the latest regional models showing warmer and wetter winters for New England, as well as more intense storms in the summer, storm patterns are expected to change with greater probabilities of more frequent, intense storms of varying duration. Increases in global temperature could affect the snowpack and its ability to hold and store water, as well as ground saturation and inability to hold additional water due to the increasing intensity of summer storms. Warming temperatures also could increase the occurrence and duration of droughts, which would increase the probability of wildfire, reducing the vegetation that helps to support steep slopes. All of these factors would increase the probability for more landslide occurrences (MEMA, 2013).

In the Berkshires, the areas rated as more susceptible to landslides s are undeveloped, forested steep slopes. Trees and other vegetation help hold soil in place. Climate change is expected to impact forest species composition in a variety of ways. Cooler tree species, such as sugar maples and hemlocks, are forecast to retreat northward and to higher elevations. Invasive forest pests, such as the emerald ash borer, wooly adelgid and Asian long-horned beetle, are forecast to expand their presence and increase the mortality rate of several and economically important key tree species. Hemlocks are a species that tend to be found in cool, steeply sloped ravines, and the dieback of this species could result in an increase in unstable slopes.

Probability

As landslides are often triggered by other natural hazards such as earthquakes, heavy rain, floods, or wildfires, their frequency is often related to the frequency of these hazards. 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 significant landslides to occur (MEMA, 2013).

For the purposes of this Plan, the probability of future occurrences is defined by the number of events over a specified period of time. There have been zero federally declared landslide disasters from 1954 to 2017 in Massachusetts. This time period includes the landslide in Savoy, which was included in a disaster declaration for a flooding/tropical storm. It is noted that the historical record may underestimate the true number of events that have taken place in the community because steep slopes are generally undeveloped and unmonitored for this type of event. Massachusetts state officials estimate that approximately one to three landslide events occur each year throughout the state (MEMA, 2013).

Secondary Hazards

Landslides can cause secondary effects, such as blocking access to roads, which can isolate residents and businesses and delay commercial, public, and private transportation. This could result in economic losses for businesses. Other potential problems resulting from landslides are power and communication failures, and destabilizing of structural foundations, which may result in monetary loss for property owners (MEMA, 2013).

Landslides can severely and permanently alter the course of rivers and streams, erode banks and deposit large amounts of sediment and debris into waterways. Stream and river banks already prone to erosion, or already undercut, could become more unstable due to a large landslide event. Landslide debris can block the flow of water under bridges and through culverts, threatening these structures themselves as well as transportation routes for miles downstream of the actual landslide event. If the landslide occurs during a flood event, debris could be widely distributed throughout the floodplain area.

Warning Time

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

- Springs, seeps, or saturated ground in areas that have not typically been wet before
- New cracks or unusual bulges in the ground, street pavements or sidewalks
- Soil moving away from foundations
- Ancillary structures such as decks and patios tilting and/or moving relative to the main house
- Tilting or cracking of concrete floors and foundations
- Broken water lines and other underground utilities
- Leaning telephone poles, trees, retaining walls or fences
- Offset fence lines
- Sunken or down-dropped road beds
- Rapid increase in creek water levels, possibly accompanied by increased turbidity (soil content)
- Sudden decrease in creek water levels though rain is still falling or just recently stopped
- Sticking doors and windows, and visible open spaces indicating jambs and frames out of plumb
- A faint rumbling sound that increases in volume as the landslide nears
- Unusual sounds, such as trees cracking or boulders knocking together (MEMA,2013)

Exposure and Vulnerability

Most of the developed areas within West Stockbridge are considered to be a low risk for landslides. Of the total land area of West Stockbridge, only a small percentage is modeled to be Unstable or Moderately Unstable. However, it should be recognized that landslides can occur throughout the Town during severe events, particularly earthquakes, and more commonly during high precipitation events during times of soil saturation.

Population

In general, the population exposed to higher risk landslide areas is considered to be vulnerable, including populations located downslope. Overlaying slope stability from the Massachusetts Geological Survey, it appears that very few buildings in West Stockbridge are located in moderate to highly unstable areas. Expansion of primarily second homeowner residential homes or deforestation of hillside areas could lead to more people and areas being threatened by landslides each year.

Critical Facilities

Several types of infrastructure are exposed to landslides, including buildings, transportation routes, bridges, water, sewer, and power lines. At this time all critical facilities, infrastructure, and transportation corridors located within the high incidence and high susceptibility hazard areas are considered vulnerable until more information becomes available. The 2013 state Hazard Mitigation Plan noted the estimated cost to address landslide problems to state highways alone was $1 million during the years 1986-90, and the expense to keep highways safe from landslides was $2 million. The cost associated with remediation work and cleanup of debris from only four landslide-related events during the October 2005 rain event was $2,300,000. The repair to a 6-mile stretch of Route 2 caused by Tropical Storm Irene (2011), which included debris flows, four landslides, fluvial erosion and undercutting of infrastructure, cost $23 million just for temporary repairs. Accordingly, landslides have a significant cost to taxpayers, yet this hazard is not well known because most earth movements occur during extreme rainstorms and it is the rain and associated flooding that receives the majority of the publicity (MEMA, 2013).

Based on the Slope Stability map, there are no critical municipal facility buildings within the Unstable or Moderately Unstable land areas in West Stockbridge.

Economy

In general, the built environment located in the high susceptibility zones (Unstable and Moderately Unstable) and the population, structures, and infrastructure located downslope are vulnerable to this hazard. In an attempt to estimate the general building stock vulnerable to this hazard, the associated building replacement values (buildings and contents) were determined by using the assessor's data. These values estimate the costs to repair or replace the damage caused to the building. These dollar value losses to the community's total building inventory replacement value would impact the local tax base and economy.

Existing Protections
Residents of the Town of West Stockbridge have voted to enable the Berkshire Scenic Mountain Act. Part of the purpose of the Act is to protect steeply sloped lands from erosion and waterways from the impacts of erosion. The Conservation Commission is the permitting authority for the Act. The Act is being reviewed for final approval by the Attorney General.

Since the majority of moderate to highly unstable areas in West Stockbridge are located within areas higher than 1,500 feet in elevation, and this acreage would be regulated under the Act, enforcing the Scenic Mountain Act regulations is appropriate to prevent future damage.

Actions

- Enforce timbering / clear cut regulations and other such land disturbing activities on slopes susceptible to erosion to avoid creating areas of bare ground subject to erosion and landslides.
- Provide the Building Commissioner, Planning Board, and Highway Department with the Slope Stability Map produced by Massachusetts Geologic Survey, for West Stockbridge.

Average/Extreme Temperatures

Overview

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 3 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 (MEMA, 2018).

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. (MEMA, 2018). According to MEMA, the average temperatures for Massachusetts are:

- Winter (Dec-Feb) Average = 22.5F
- Summer (June-Aug) Average = 65.8F

Extreme Cold
The extent (severity or magnitude) of extreme cold temperatures is generally measured through the Wind Chill Temperature Index. Wind Chill Temperature is the temperature that people and animals feel when they are outside, and it is based on the rate of heat loss from exposed skin by the effects of wind and cold. As the wind increases, the body loses heat at a faster rate, causing the skin's temperature to drop (MEMA, 2018).

The NWS issues a Wind Chill Advisory if the Wind Chill Index is forecast to dip to –15°F to – 24°F for at least 3 hours, based on sustained winds (not gusts). The NWS issues a Wind Chill Warning if the Wind Chill Index is forecast to fall to –25°F or colder for at least 3 hours. On November 1, 2001, the NWS implemented a Wind Chill Temperature Index designed to more accurately calculate how cold air feels on human skin. Figure 3.8 shows the Wind Chill Temperature Index (MEMA, 2018).

NWS Windchill Chart

Temperature (°F) / Wind (mph)

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

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

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

Where, T = Air Temperature (°F) V = Wind Speed (mph) *Effective 11/01/01*

Source: National Weather Service (NWS), Wind Chill Chart, 2018

Figure 3.8 – Wind Chill Temperature index

Source: MEMA, 2018

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 (MEMA, 2018).

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. Another hazard of extended cold temperatures in Massachusetts is saltwater freezing in coastal bays and harbors. Coastal freezing can interfere with the transportation of goods and people, and can also inhibit fishing and other industries that rely on boats (MEMA, 2018).

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 will 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 (MEMA, 2018).

Extreme Heat

The NWS issues a Heat Advisory when the NWS Heat Index is forecast to reach 100 to 104°F for 2 or more hours. The NWS issues an Excessive Heat Warning if the Heat Index is forecast to reach 105°F or higher for 2 or more hours. The NWS Heat Index is based both on temperature and relative humidity, and describes a temperature equivalent to what a person would feel at a baseline humidity level. It is scaled to the ability of a person to lose heat to their environment. The relationship between these variables and the levels at which the NWS considers various health hazards to become relevant are shown in Figure 3.9. 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. Also, strong winds, particularly with very hot, dry air, can increase the risk of heat-related impacts (MEMA, 2018).

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 (NWS), Heat Index, 2018

Figure 3.9 – Heat Index

Source: MEMA, 2018

A heat wave is defined as 3 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 (MEMA, 2018).

Heat waves cause more fatalities in the U.S. than the total of all other meteorological events combined. Since 1979, more than 9,000 Americans have died from heat-related ailments (EPA, 2016) (MEMA, 2018). Extreme heat events impact the health of human beings, livestock and wildlife, and can impact the ability of people to function at home or work.

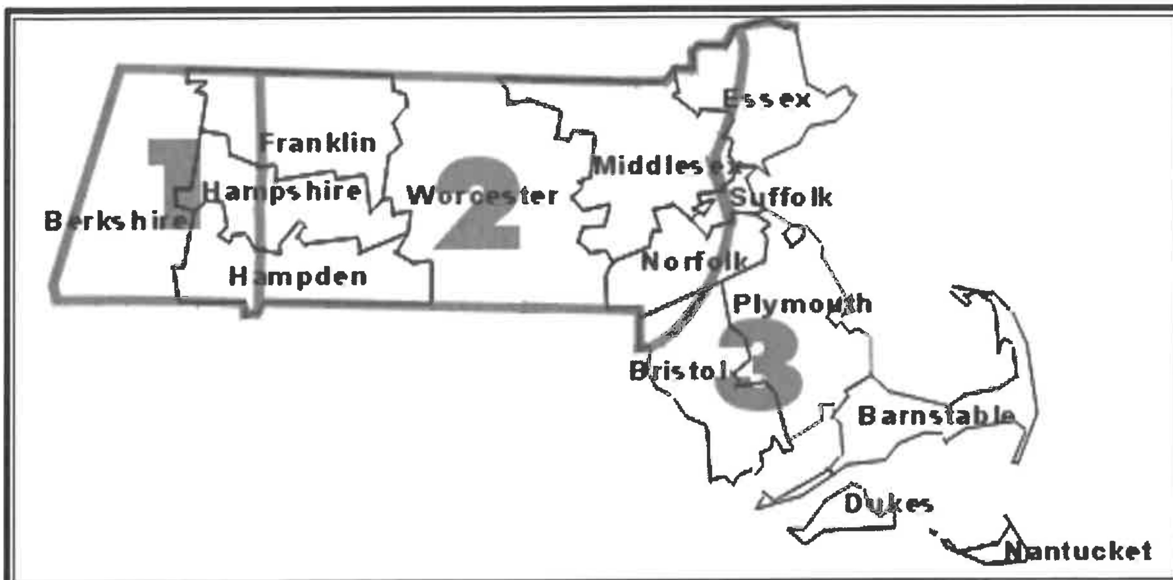
Heat impacts can be particularly significant in urban areas. Approximately half of the world's population lives in these heavily developed areas, with that number increasing to 74 percent in developed nations. As these urban areas develop and change, so does the landscape. Buildings, roads, and other infrastructure replace open land and vegetation. Surfaces that were once permeable and moist are now impermeable and dry. 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" (MEMA, 2018).

The term "heat island" describes built-up areas that are hotter than nearby rural or shaded areas. The annual mean air temperature of a city with more than 1 million people can be between 1.8°F and 5.4°F warmer than its surrounding areas. In the evening, the difference in air temperatures can be as high as 22°F. 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 (EPA, n.d) (MEMA, 2018).

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 (UCI, 2017) (MEMA, 2018).

Hazard Location

According to the NOAA, Massachusetts is made up of three climate divisions: Western, Central, and Coastal, as shown in Figure 3.10. 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) (MEMA, 2018). West Stockbridge is located in the Western division.



Source: NOAA, n.d.

Figure 3.10 – Climate Divisions of Massachusetts
Source: MEMA, 2018

Extreme temperature events occur more frequently and vary more in the inland regions where temperatures are not moderated by the Atlantic Ocean. The severity of extreme heat impacts is greater in densely developed urban areas like Boston than in suburban and rural areas (MEMA, 2018).

Previous Occurrences and Extent

Impact

Severity

In the Berkshires, extreme cold temperatures are those that are well below zero for a sustained period of time, causing distress for vulnerable populations exposed to such temperatures when outside and straining home heating systems. The severity of extreme cold temperatures is generally measured through the Wind Chill Temperature Index. Wind Chill Temperature is the temperature people and animals feel when outside and it is based on the rate of heat loss from exposed skin due to the effects of wind and cold. As the wind increases, the body is cooled at a faster rate causing the skin's temperature to drop faster.

The NWS issues a Wind Chill Advisory if the Wind Chill Index is forecast to dip to -15F to -24F for at least three hours, using only sustained winds (not gusts). The NWS issues a Wind Chill Warning if the Wind Chill Index is forecast to fall -25F or colder for at least three hours using only the sustained wind. In 2001 the NWS implemented a Wind Chill Temperature Index to more accurately calculate how cold air feels on human skin and to predict the threat of frostbite. According to the calculations, people can get frostbite in as little as 10 minutes when the temperature is -10 degrees and winds are 15 miles per hour (MEMA, 2018).

The following are some of the lowest temperatures recorded in the region for the period from 1895 to present (National Climatic Data Center, 2017).

- Lanesborough, MA –28°F
- Great Barrington, MA –27°F
- Stockbridge, MA –24°F
- Pittsfield, MA -19°F

Extreme heat temperatures are those that are 10°F or more above the average high temperature for the region and last for several hours. The following are some of the highest temperatures recorded for the period from 1895 to 2017, showing Boston and three Berkshire County locations (National Climatic Data Center, 2017).

- Boston, MA 102°F
- Great Barrington, MA 99°F
- Adams, MA 95°F
- Pittsfield, MA 95°F

It should be noted that temperature alone does not define the stress that heat can have on the human body – humidity plays a powerful role in human health impacts, particularly for those with pre-existing pulmonary or cardio-vascular conditions. The NWS issues a Heat Advisory when the Heat Index is forecast to reach 100-104F for two or more hours. The NWS issues an Excessive Heat Warning if the Heat Index is forecast to reach 105F or more for two or more hours. The heat index is the combination of the temperature and humidity.

Climate Change Impacts

Extreme temperatures are among the most dangerous impacts associated with climate change. Extreme heat is among the most harmful to public health and safety, particularly for populations more vulnerable due to existing chronic medical conditions or lower economic status. Increased changes in average temperatures pose negative impacts to public health and safety, particularly in urban areas; sea levels, and natural biodiversity.

Probability

In the years 2000-2017, there have been six extreme cold/wind chill weather events in Berkshire County and in the years 1998-2013 there were five heat events. Extreme temperatures will continue throughout the entire county. With climate change, the county should expect more extreme temperatures, both hot and cold. It is projected that the region will experience 11 less days below 0°F (Northeast Climate Science Center, 2018). According to the Massachusetts Climate Change Projections for the Housatonic River Watershed, a high temperature of above 90F currently only occurs once per year. By mid-century the number of days above 90F will range from 4 to 20, and by the 2090s the number will increase to 7 to 57 days per year. The number of days going above 95F will increase from the current 0 days per year to almost 6 days by mid-century and up to 27 days by the 2090s (MA Climate Change Projections for the Housatonic Watershed, 2018).

As is the case in many areas of the United States, extreme weather conditions were reported more frequently in 2015, 2016, 2017, and to date in 2018, with several of the hottest years on record occurring in the last four years. In July 2018, 68% of days (21) had above-normal daytime high and nighttime low temperatures, with a significant deviation of 4.3F recorded at a government observation station in Pittsfield, in the center of Berkshire County. At present, it is unknown if these higher temperatures are abnormalities, may be the new normal, or whether temperatures will continue to rise. It does appear the past few years have a trajectory of temperatures increasing faster than many climate scientists had projected, as evidenced by the MA Climate Change Projections for the Housatonic Watershed, 2018, cited above.

Secondary Hazards

The most significant secondary hazard associated with extreme temperatures is a severe weather event. Hot weather events are often associated with drought, as evaporation increases with temperature, and with wildfire, as high temperatures can cause vegetation to dry out and become more flammable. Warmer weather will also have an impact on invasive species. More commonly, heat events contribute to the formation of ground level ozone, a respiratory irritant that can exacerbate asthma and result in an increase in emergency department visits (MEMA, 2018).

Cold weather events are primarily associated with severe winter storms. The combination of cold weather with severe winter storm events is particularly dangerous because winter weather can knock out heat and power, increasing the vulnerability of populations sheltering from the cold. Loss of heat and power may also lead to carbon monoxide poisoning from inappropriate use of combustion-powered generators, heaters, and cooking appliances, and heavy snowfall may block vents for gas dryers and heaters. Similarly, prolonged extreme heat can cause power infrastructure to overheat or catch fire, leaving customers without power or the ability to operate air conditioning. Power failure leads to increased use of diesel generators for power and more wood stoves are used in extreme cold; in both situations, air pollution and health impacts increase (MEMA, 2018).

The Berkshires are currently a moderately temperate climate, but increases in summer temperatures will create higher peak summer electricity demands for cooling, including an increase in the number of air conditions units being installed. The current cooling degree days (CDD) with a base of 65°F for the summer season in the Housatonic River basin is 231 (for years 1971-2000). By mid-century the summer season CDD is projected to increase an additional 169-473, an increase of 73-205%, and by the 2090s the summer CDD is projected to increase an additional 239-931, an increase of 104-403%. (MA Climate Change Projects for Housatonic Watershed, 2018). It is unknown how well prepared the electric grid is for the increasing peak seasonal and daily demands.

Warning Time

Meteorologists can accurately forecast extreme temperature event development and the severity of the associated conditions with several days lead time. Excessive heat watches are issued when conditions are favorable for an excessive heat event in the next 24 to 72 hours. Excessive heat warning/advisories are issued when an excessive heat event is expected in the next 36 hours (MEMA, 2018).

Exposure and Vulnerability

Temperature extremes occur throughout the region and the Town of West Stockbridge. Colder temperatures are more common in the higher elevations of the community, the entire community is susceptible. Areas that are more prone to heat include the lower elevations in the Village Center areas. To understand risk, the assets exposed to the hazard areas are identified. The entire town of West Stockbridge is considered to be at risk for all the severe weather hazards discussed in this section.

Population

According to the Centers for Disease Control and Prevention, populations most at risk to extreme cold and heat events include the following: (1) people over the age of 65, who are less able to withstand temperatures 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 reluctance to relocate to cooler environments (MEMA, 2018).

Critical Facilities

All critical facilities are exposed to extreme temperatures hazards. Extreme cold temperature events can damage buildings and infrastructure through freezing/bursting pipes and freeze/thaw cycles. Town water mains are not believed to be in danger of freeze/thaw problems, but water connections to houses can be vulnerable during a hard winter.

Extreme heat events in the Berkshires generally do not impact buildings or other structures, but damages can be associated with overworking of HVAC systems, particularly those that are older or undersized. There are concerns that increased temperature events can reduce transmission capacity of electric power lines during summer heat waves, which is exactly the time when peak demand for electricity will be highest due to air conditioning. In general, the demand for electricity continues to rise, and the electric grid may have increasing difficulty meeting demand during the highest peak periods, leading to potential rolling brown outs or failures. Backup power sources will be all the more important for critical facilities, such as key public buildings (for continuity of operations) and cooling centers.

Economy

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. Even though most businesses will still be operational, they may be impacted aesthetically if extreme temperatures damage landscaping around their buildings. 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 (MEMA, 2018).

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. Higher temperatures that result in greater concentrations of ozone negatively impact plants that are sensitive to ozone (USGCRP, 2009). Additionally, as previously described, changing temperatures can impact the phenology (MEMA, 2018).

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 grows. Increased use of these treatments increases the risk of pesticides entering the food chain and could result in pesticide resistance, which could result in additional economic impacts on the agricultural industry (MEMA, 2018).

Actions

- No Actions necessary for this section of the plan

Wildfires

Overview

A wildfire can be defined as any non-structure fire that occurs in vegetative wildland that contains grass, shrub, leaf litter, and forested tree fuels. Wildfires in Massachusetts are caused by natural events, human activity, or prescribed fire. Wildfires often begin unnoticed but spread quickly, igniting brush, trees, and potentially homes (MEMA, 2018).

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 (MEMA, 2018).

Fire Ecology and Wildfire Behavior

In the "wildfire behavior triangle", weather, topography and fuel are the three primary factors that influence wildfire behavior. Of the three, weather is the most variable and least predictable. Climate change may influence future wildfire behavior due to changing weather and resulting fuel changes.

- 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, or become receptive to ignition when influenced by environmental factors, such as drought, low humidity, and warm temperatures.
- Weather:
  - Strong winds can exacerbate extreme fire conditions, especially wind events that persist for long periods, or ones with significant sustained wind speeds that quickly promote fire spread through the movement of embers or exposure within tree crowns.
  - Spring and summer months, many of which maintain drought-like conditions extending beyond normal season also can increase the normal fire season. Likewise, the passage of a dry, cold front through the region can result in sudden wind speed increases and change in wind direction affecting fire spread.
  - 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.
- Topography:
  - Topography of a region or a local area influences the amount and moisture of fuel.
  - Barriers such as highways and lakes can affect spread of fire.
  - Elevation and slope of landforms—fire spreads more easily uphill compared to downhill.
- Climate Change:
  - Without an increase in summer precipitation (currently greater than any predicted by climate models), future areas burned are very likely to increase.
  - Infestation from insects is of concern as it may affect forest health. Potential insect populations may increase with warmer temperatures. In addition, infested trees may increase fuel amount.
  - Tree species composition will change as species respond uniquely to a changing climate.
  - Wildfires cause both short-term and long-term losses. Short-term losses can include destruction of timber, wildlife habitat, scenic vistas, and watersheds. Long-term effects may include smaller timber harvests, reduced access to affected recreational areas, and the destruction of cultural and economic resources and community infrastructure (MEMA, 2013).

Hazard Location

The risk of large urban fires exists in few developed areas of West Stockbridge. The vast majority of buildings are found clustered in the Town center. The building stock is comprised of moderate to large sized homes in residential neighborhoods, many of which were built in the 19th and early 20th centuries, with a few subdivision enclaves and scattered large homes on larger lots.

The majority of land in Town is vulnerable to wildfire, as approximately 60% of West Stockbridge is forested.

Previous Occurrences and Extent

Based on the DCR Bureau of Forest Fire Control and Forestry records, in 1911, more than 34 acres were burned on average during each wildfire statewide. Since then, that figure has been reduced to 1.17 acres on average per wildfire incident statewide (MEMA, 2013). According to the Massachusetts Fire Incident Reporting System, wildfires reported to DCR in the past five years are generally trending downward. According to this system's reports, there were 901 fire incidents, combined urban and wildland, in Berkshire County during the years 2007-2016. Of these 411 (46% of total) occurred in the City of Pittsfield, the urban center of the region. This same data reports that a total of 832 acres were burned in the county during those 10 years, 631 (76%) of which are reported as acres of wildland burned. This indicates that over this 10-year span an average of 63 acres of wildland burned annually in Berkshire County. Of the 901 incidents, only 12 burned more than 10 acres and two of these burned more than 100 acres. It should be noted that during this same time period there were two large wildland fires in the county: 272 acres in Clarksburg near the Williamstown border in 2015 and 168 acres in Lanesborough in 2008. If these incidents were considered statistic outliers and removed from the data, the average totaled burned acres during 2007-2016 would be 39 and the average wildland acres burned would be 19. Berkshire County fire officials respond rapidly through mutual aid and through a coordinated effort with the DCR.

Impact

Severity

West Stockbridge is not developed to a density that would provide fuel for a major urban fire. Outside of mixed residential and commercial development along the Route 41 / Route 102 corridor, development in West Stockbridge consists largely of single-family homes built along rural roads. The greater potential for significant damage to property from fire in West Stockbridge exists in areas designated as wildland-urban interface areas and in the higher more forested areas.

Climate Change Impacts

While climate change is unlikely to change topography, it can alter the weather and fuel factors of wildfires. Climate scenarios project summer temperature increases between 3F and 9F and precipitation increases of up 5 inches (Northeast Climate Science Center, 2018). Hot dry spells create the highest fire risk, due to decreased soil moisture and increased evaporation and evapotranspiration. While in general annual precipitation has slightly increased Massachusetts in the past decades, the timing of snow and rainfall is changing. Less snowfall can lead to drier soils earlier in the spring and possible drought conditions in summer. More rain is falling in downpours, with higher rates of runoff and less soil infiltration. Such conditions would exacerbate summer drought and further promote high elevation wildfires where soil depths are generally thin. Climate change also may increase winds that spread fires. Faster fires are harder to contain, and thus are more likely to expand into residential neighborhoods (MEMA, 2013).

Probability

For the purpose of this Plan, the probability of future occurrences is defined by the number of events over a specified period. According to the 2019 West Stockbridge Annual Report, the Fire Department responded to 1 building fire and 2 brush/grass fires in 2019. Major urban fires are a low concern due to the lack of large urbanized areas where buildings are adjacent to one another. Many commercial buildings have their own fire detection and suppression systems. In the event of extremely dry conditions or drought, risk of fire in West Stockbridge includes mainly residential and forested areas.

It is difficult to predict the likelihood of urban fires and wildfires in a probabilistic manner, such as, "there will be a catastrophic wildfire once every X number of years." This is because the number of variable factors affecting the potential for a fire to occur and because some conditions (for example, ongoing land use development patterns, location, fuel sources, construction, etc.) exert increasing pressure on the wildfire and urban interface zone. Based on available data, urban fires and wildfires will continue to present a risk.

Differences in climate and building stock could play a factor in urban fires. It is likely that home fires related to heating occur more frequently in the northern areas of the U.S. Electrical distribution fires are likely to be more common in the northeast and south, where the building stocks are older, on average, than in the Midwest and West.

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. However, wildfires can occur every month of the year. Drought, lack of snow pack, and local weather conditions can expand the length of the fire season. The early and late shoulders of the fire season usually are associated with human-caused fires (MEMA, 2013).

Secondary Hazards

Smoke and air pollution from wildfires can be a health hazard, especially for sensitive populations including children, the older residents, and those with respiratory and cardiovascular diseases. Wildfire may also threaten the health and safety of those fighting the fires. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke.

Wildfires can generate a range of secondary environmental effects, which in some cases may cause more widespread and prolonged damage than the fire itself. Fires can cause direct economic losses in the reduction of harvestable timber and indirect economic losses in reduced tourism. Wildfires cause the contamination of reservoirs, destroy transmission lines, and contribute to flooding. They can strip slopes of vegetation, exposing them to greater amounts of runoff, which can in turn can weaken soils and cause failures on slopes. Major landslides can occur several years after a wildfire (MEMA, 2013). There are no areas in West Stockbridge that have been affected by these secondary hazards in recent memory.

Warning Time

Early warning for urban fires is none or minimal at best. Smoke detectors provide early warning of a fire; however, they do not guarantee an escape. Federal studies have shown in a typical fire, one has only about three minutes to evacuate safely before unsustainable conditions are encountered (MEMA, 2013).

Dry seasons and droughts are factors that greatly increase fire likelihood, and posting forest fire risk, issuing warnings and burn bans can reduce the risk of urban and urban-forest areas. 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 (MEMA, 2013). In Berkshire County, mutual aid response from neighboring towns is common, further reducing risks.

Exposure and Vulnerability

The ecosystems in Massachusetts most susceptible to wildfire hazard are pitch pine, scrub oak, and oak forests. These are the most flammable vegetative fuels (MEMA, 2013). West Stockbridge does not have significant land coverage that includes these ecosystems.

To understand risk, the assets exposed to the hazard areas are identified. For the wildfire hazard, areas identified as hazard areas include the wildland-urban areas. In its statewide hazard mitigation plan the Commonwealth utilized the SILVIS Lab, Department of Forest Ecology and Management at the University of Wisconsin to determine this risk. This method utilized census track data, the national land cover database and the protected areas database to determine risk.

This same method was utilized as part of the fire risk assessment analyses for the Town of West Stockbridge for this Hazard Mitigation Plan. However, upon examination of this data, the accuracy at the local level was questionable and raised more questions than it answered. For example, census blocks in some areas of the town include large blocks of undeveloped land and do not necessarily reflect the areas where homes are located within those blocks. The Interface area, as described previously, is the area being at greater risk of fire due to human-caused fire ignition.

A more accurate depiction to show location of development at risk of wildfire is the National Land Cover Data, which shows vegetative cover (including forest type), agricultural cover, and development according to density. This data is not based on census blocks, but on actual land use. The development in West Stockbridge is scattered along the roadways throughout the Town, with denser development occurring along Route 41/102, the main transportation route.

Population

Smoke and air pollution from wildfires can be a severe health hazard, especially for sensitive populations, including children, older residents, and those with respiratory and cardiovascular diseases. Smoke generated by wildfire consists of visible and invisible emissions that contain particulate matter (soot, tar, water vapor, and minerals), gases (carbon monoxide, carbon dioxide, nitrogen oxides), and toxins (formaldehyde, 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. Public health impacts associated with wildfire include difficulty in breathing, eye irritation, odor, and reduction in visibility. Wildfire may also threaten the health and safety of those fighting the fires. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke (MEMA, 2013). Residents in all areas of the town are vulnerable to these secondary hazards due to the amount of forest lands within the Town, and first responders throughout the region who respond to fires within their town or through mutual aid are vulnerable to direct and indirect dangers fighting fires.

All Berkshire County communities are considered by the state, based on historic occurrences, to be at low risk of fire due to the number of fires that have occurred. This is most likely due to the low population density along the urban/woodland interface. The county's exception is the City of Pittsfield, which is considered to be at medium risk.

Fires within the Town's forests are highly dependent on soil and vegetation moisture and amount of underbrush. Much of the forest in Berkshire County is lightly being harvested, which can lead to a buildup of dry brush fuel. The ice storm of 2008, which impacted the higher elevations along the Berkshire and Hoosac Ranges, damaged much of the timber stock by knocking down limbs and damaging crowns, which exposed areas of the trees and main trunks to the elements. As a result, this storm created a large amount of fallen debris in the forest, leaving dead and dying snags, and in the long run increasing fuel for wildfire.

Critical Facilities

West Stockbridge critical facilities such as the Town Offices, Fire Station, and Sewer Treatment Plant are not set deep into woodlands, but rather have lawn and parking areas surrounding the buildings. In the event of a large fire, most roads would be without damage except in the worst scenario, but the loss of electric pole and wires could cause power outages. Fires can create conditions that block or prevent access and can isolate residents and emergency service providers.

Economy

Wildfire events can have major economic impacts on a community from the initial loss of structures to the subsequent loss of revenue from destroyed business and decrease in tourism. Wildfires can cost thousands of taxpayer dollars to suppress and control and involve hundreds of operating hours on fire apparatus and thousands of volunteer man-hours from the volunteer firefighters. There are also many direct and indirect costs to local businesses that excuse volunteers from work to fight these fires.

Existing Protections

As of September 2020, the fire department had 1 paid Chief, and 14 volunteers compensated bi-annually via a stipend. The fire department issues burn permits January 15 – May 1st, but may shorten the burn season if conditions are too dry.

West Stockbridge does have sirens, but they are not currently in operation. The last testing was several years ago. The Town owns 3 fire engines, 1 Heavy Rescue vehicle, 2 pumpers (1000 gal/min), 1 SUV, 1 mini pumper rescue unit, and a rescue boat. Fire hydrants are located within areas serviced by the Town water system.

Actions

- Reactivate and test the existing siren warning system
- Continue to work with CSX Railroad to remove woody debris around tracks
- Continue to monitor and fight brush and other fires

Invasive Species

Overview

Invasive species are defined as non-native species that cause or are likely to cause harm to ecosystems, economies, and/or public health (NISC 2006). The focus of this section is on invasive terrestrial plants, as this is the most studied and managed typed of invasive; information for invasive aquatic flora and fauna (including marine species) is also provided when relevant (MEMA, 2018).

The Massachusetts Invasive Plant Advisory Group (MIPAG), a collaborative representing organizations and professionals concerned with the conservation of the Massachusetts landscape, is charged by EOEEA to provide recommendations to the Commonwealth to manage invasive 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" (MIPAG, n.d.). 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 (MEMA, 2018).

Hazard Location

The damage rendered by invasive species is significant. Experts estimate that about 3 million acres within the U.S. (an area twice the size of Delaware) are lost each year to invasive plants (Pulling Together, 1997, from Mass.gov "Invasive Plant Facts"). The massive scope of this hazard means that the entire Commonwealth experiences 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 and marine ecosystems, invasive species can quickly spread once introduced, as there are generally no physical barriers to prevent establishment, outside of physiological tolerances, and multiple opportunities for transport to new locations (by boats, for example) (MEMA, 2018).

For West Stockbridge, there are invasive species located in Card Pond and Shaker Mill Pond. In Card Pond, there is growth of Eurasian Watermilfoil (Myriophyllum spicatum) and Pondweeds (Potamogeton spp.). In the Shaker Mill Pond, there is growth of Eurasian Watermilfoil (Myriophyllum spicatum), Curlyleaf Pondweed (Potamogeton crispus), Waterweed (Elodea candensis), Pondweeds (Potamogeton spp.), Water Lilies (Nuphar/Nymphaea spp.), and Water Chestnut (Trapa natans).

Previous Occurrences and Extent

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 (MEMA, 2018).

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 (MEMA, 2018).

Impact

Severity

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. In marine environments, for example, the majority of invasive species are found on artificial substrates such as docks, oceanic platforms, boats, and ships (Mineur et al., 2012). Some (such as the gypsy moth) are nearly controlled, whereas others, such as the zebra mussel, are currently adversely impacting ecosystems throughout the Commonwealth. Invasive species can be measured through monitoring and recording observances (MEMA, 2018).

In West Stockbridge, there are active contracts with an outside agency, Sōlitude Lake Management, to conduct surveys of the invasive species at Card Pond and Shaker Mill Pond and carry out the necessary treatments for removal.

Climate Change Impacts

A warming climate may place stress on colder-weather species, while allowing non-native species accustomed to warmer climates to spread northward. Changes in precipitation and temperature combine to create new stresses for Massachusetts' unique ecosystems. For example, intense rainfaill 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 (MEMA, 2018).

Probability

As stated earlier, invasive species are a widespread issue in the Commonwealth of Massachusetts and West Stockbridge is no exception to such nuisance.

Secondary Hazards

Invasive species can trigger a wide-ranging cascade of lost ecosystem services. Additionally, they can reduce the resilience of ecosystems to future hazards by placing a constant stress on the system (MEMA, 2018).

Warning Time

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 (MEMA, 2018).

Exposure and Vulnerability

Because plant and animal life is so abundant throughout the Commonwealth, the entire area 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 urban areas; however, invasive species can disrupt ecosystems of all kinds (MEMA, 2018).

Population

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 (MEMA, 2018).

Economy
Invasive species are widely considered to be one of the most costly natural hazards in the U.S. A widely cited paper (Pimental et al., 2005) found that invasive species cost the U.S. more than $120 billion in damages every year. One study found that in 1 year alone, Massachusetts agencies spent more than $500,000 on the control of invasive aquatic species through direct efforts and cost-share assistance. This figure does not include the extensive control efforts undertaken by municipalities and private landowners, lost revenue due to decreased recreational opportunities, or decreases in property value due to infestations (Hsu, 2000) (MEMA, 2018).

Existing Protections
As stated earlier, the Town of West Stockbridge has active contracts with Sōlitude Lake Management to treat the invasive species which inhabit Card Pond and Shaker Mill Pond.

Actions

- Continue to monitor and inspect levels of invasive species with assistance from Sōlitude Lake Management or similar environmental agency

Hurricanes/Tropical Storms

Overview

Hurricanes
Hurricanes begin as tropical storms over the warm moist waters of the Atlantic Ocean, off the coast of West Africa, and over the Pacific Ocean near the equator. As the moisture evaporates, it rises until enormous amounts of heated, moist air are twisted high in the atmosphere. The winds begin to circle counterclockwise north of the equator or clockwise south of the equator. The center of the hurricane is called the eye (MEMA, 2018).

Tropical cyclones (tropical depressions, tropical storms, and hurricanes) form over the warm, moist waters of the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico (MEMA, 2018):

- A tropical depression is declared when there is a low-pressure center in the tropics with sustained winds of 25 to 33 mph (MEMA, 2018).
- A tropical storm is a named event defined as having sustained winds from 34 to 73 mph.
- If sustained winds reach 74 mph or greater, the storm becomes a hurricane. The Saffir-Simpson scale ranks hurricanes based on sustained wind speeds—from Category 1 (74 to 95 mph) to Category 5 (156 mph or more). Category 3, 4, and 5 hurricanes are considered "major" hurricanes. Hurricanes are categorized based on sustained winds; wind gusts associated with hurricanes may exceed the sustained winds and cause more severe localized damage (NOAA, n.d.[b]) (MEMA, 2018).

When water temperatures are at least 80°F, hurricanes can grow and thrive, generating enormous amounts of energy, which is released in the form of numerous thunderstorms, flooding, rainfall, and very damaging winds. The damaging winds help create a dangerous storm surge in which the water rises above the normal astronomical tide. In the lower latitudes, hurricanes tend to move from east to west. However, when a storm drifts further north, the westerly flow at the midlatitudes tends to cause the storm to curve toward the north and east. When this occurs, the storm may accelerate its forward speed. This is one of the reasons why some of the strongest hurricanes of record have reached New England (MEMA, 2018).

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 (MEMA, 2018).

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 incur the worst winds and storm surge. Dangerous flooding occurs most often to the north and west of the track of the storm. An additional threat associated with a tropical system making landfall is the possibility of tornado generation. Tornadoes would generally occur in the outer bands to the north and east of the storm, a few hours to as much as 15 hours prior to landfall (MEMA, 2018).

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 (MEMA, 2018).

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 (MEMA, 2018).

Hazard Location

The entire Town of West Stockbridge is vulnerable to hurricanes and tropical storms. The heavy rains often associated with tropical storms and hurricanes can result in flooding conditions, combined with high winds to create risks to people and property. Floodplain areas are especially at risk for flooding, as are steeply sloped stream channels that can become flooded causing severe stream channel erosion.

The National Oceanic and Atmospheric Administration (NOAA) Historical Hurricane Tracks tool is a public interactive mapping application that displays Atlantic Basin and East-Central Pacific Basin tropical cyclone data. This interactive tool tracks tropical cyclones from 1842 to 2017. Between 1842 and 2017, the region has experienced more than 240 tropical cyclone events. These events occurred within 100 miles of Berkshire County.

Previous Occurrences and Extent

NOAA has been keeping records of hurricanes since 1842 which is displayed in Table 3.14 below. From 1842 to 2017, five Tropical Depressions, five Tropical Storms, one Category 1 Hurricane and one Category 2 Hurricane pass directly through the County. Although none of these storms traveled directly through West Stockbridge, flooding and wind impacts were experienced to some degree.

Table 3.14 – Tropical Cyclonic Storms that Tracked Directly through Berkshire County

Name	Category	Date
Not Named	Tropical Depression	8/17/1867
Unnamed	Tropical Storm	9/19/1876
Unnamed	Tropical Depression	10/24/1878
Unnamed	Category 1 Hurricane	8/24/1893
Unnamed	Tropical Storm	8/29/1893
Unnamed	Tropical Depression	11/1/1899
Unnamed	Tropical Depression	9/30/1924
Unnamed	Category 2 Hurricane	9/21/1938
Able	Tropical Storm	9/1/1952
Gracie	Tropical Depression	10/1/1959
Doria	Tropical Storm	8/28/1971
Irene	Tropical Storm	8/28/2011

The effects of hurricanes and tropical storms however are often felt much farther away from the direct path. During this same period, an additional 38 Tropical Depressions, 86 Tropical Storms, 14 Category 1 Hurricanes and five Category 2 Hurricanes have passed within 100 miles of the region.

According to NOAA, tropical Storm season lasts from June 1 to November 30, and an average of 10 tropical storms develop along the eastern seaboard each year. On average, five of these 10 become hurricanes. In Berkshire County, Hurricanes and Tropical Storms are generally limited to the months of August, September, and October, with a few storms arriving in May, June, July, or November.

The most notable historic storm in Berkshire County is the New England Hurricane of 1938 (or Great New England Hurricane or Long Island Express or simply The Great Hurricane of 1938). The storm formed near the coast of Africa, becoming a Category 5 hurricane before making landfall as a Category 3 hurricane on Long Island on September 21. To date, this storm remains the most powerful, costliest, and deadliest hurricane in New England history. The majority of the storm damage was from storm surge and wind. Damage is estimated at $6 billion (2004 USD), making it among the most costly hurricanes to strike the U.S. mainland. It is estimated that if an identical hurricane struck today, it would cause $39.2 billion (2005 USD) in damage. The eye of the storm followed the Connecticut River north into Massachusetts, where the winds and flooding killed 99 people. In Springfield, the river rose to 6 to 10 feet above flood stage, causing significant damage. Up to six inches of rain fell across western Massachusetts, which when combined with over four inches that had fallen a few days earlier produced widespread flooding.

Locally the Great Hurricane of 1938 remains one of the most memorable historic storms, with almost seven inches of rain falling over a three-day period. The flooding from the Hoosic River caused severe damages in the northern Berkshire communities of Adams and North Adams.

According to an iBerkshires article highlighting the damages, two deaths occurred, many other people were injured, and 300 people were left homeless. The West Shaft Road bridge in North Adams was lost, as was the Wally Bridge in Williamstown. The damages from this storm, following devastating flooding and damages from events in 1901, 1922, 1927 and 1936, and combined with that from a severe rain event in 1948, led to the construction of the flood control chutes on the Hoosic River in Adams and North Adams.

Hurricane Gloria caused extensive damage along the east coast of the U.S. and heavy rains and flooding in western Massachusetts in 1985. This event resulted in a federal disaster declaration (FEMA DR-751). In October 2005 the remnants of Tropical Storm Tammy followed by a subtropical depression produced significant rain and flooding across western Massachusetts. It was reported that between nine and 11 inches of rain fell. The heavy rainfall washed out many roads in Hampshire and Franklin Counties. The Green River flooded a mobile home park in Greenfield, with at least 70 people left homeless. Following these events, the mobile home park was demolished, and the site was turned into a town park. Several people had to be evacuated from their homes. Localized flooding in Berkshire County was widespread, with several road washouts. This series of storms resulted in a federal disaster declaration (FEMA DR-1614) and Massachusetts received over $13 million in individual and public assistance (MEMA, 2013).

Tropical Storm Irene (August 27-29, 2011) produced significant amounts of rain, storm surge, inland and coastal flooding, and wind damage across southern New England and much of the east coast of the U.S. In Massachusetts, rainfall totals ranged between 0.03 inches (Nantucket Memorial Airport) to 9.92 inches (Conway, MA). Wind speeds in Massachusetts ranged between 46 and 67 mph. These heavy rains caused flooding throughout the Commonwealth and a presidential disaster was declared (FEMA DR-4028). The Commonwealth received over $31 million in individual and public assistance from FEMA. (MEMA, 2013)

Locally Tropical Storm Irene is the most memorable storm event in recent history due to the flooding that occurred in northern Berkshire and Franklin Counties in Massachusetts, and in southern Vermont. In Williamstown 225 mobile home households, many elderly and low income, permanently lost their homes in the Spruces Mobile Home Park. Extensive flooding in the Deerfield River watershed caused, among other damages, the closing of Route 2 in Florida/Charlemont (due to collapse of the road and a landslide) and damages to structures in Shelburne Falls. Flooding was experienced in West Stockbridge during this storm, but damages were must less extensive and no evacuations were conducted.

Impact

Severity

The severity of a hurricane is categorized by the Saffir-Simpson Hurricane Scale (shown in Figure 3.11). This scale categorizes or rates hurricanes from 1 (Minimal) to 5 (Catastrophic) based on their intensity. This is used to give an estimate of the potential property damage and flooding expected along the coast from a hurricane landfall. Wind speed is the determining factor in the scale. In Berkshire County flooding tends to be the impact of greatest concern because hurricane-force winds here occur less often. Historical data show that most tropical storms and hurricanes that hit landfall in New England are seldom of hurricane force, and of those most are a category 1 hurricane. The category hurricanes that stand out are those from 1938 and 1954.

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

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

Figure 3.11 – Saffir-Simpson Hurricane Scale
Source: MEMA, 2018

For tropical systems, the NWS issues a tropical storm warning for any areas that are expecting sustained winds of 39 – 73 mph. A hurricane warning is issued for any areas expecting sustained winds of 74+ mph. Effective 2010 the NWS modified the hail size criterion to classify a thunderstorm as 'severe' when it produces damaging wind gusts in excess of 58 mph, hail that is 1 inch in diameter or larger (quarter size), or a tornado (NWS, 2013).

Climate Change Impacts

The Northeast has been experiencing more frequent days with temperatures above 90F, increasing sea surface temperatures and sea levels, changes in precipitation patterns and amounts, and alterations in hydrological patterns. According to the Massachusetts Climate Change Adaptation Report, large storm events are becoming more frequent. Although there is still some level of uncertainty, research indicates the warming climate may double the frequency of Category 4 and 5 hurricanes by the end of the century, and decrease the frequency of less severe hurricane events. More frequent and intense storm events will cause an increase in damage to the built environment and could have devastating effects on the economy and environment. As stated earlier, cooler water temperatures along the Northeast Atlantic Ocean help to temper the strength of tropical storms, but if the ocean continues to warm, this tempering force could be lessened, leading to greater intensity of storms that make landfall in New England.

Probability

Based on past reported hurricane and tropical storm data, the region can expect a tropical depression, storm or hurricane to cross the region every 14.5 years. However, the community may also be impacted by a tropical event whose path is outside of the region every 0.75 years. Based on past storm events and given that the center of the county is approximately 85 miles to the Long Island Sound and 115 miles to Boston Harbor, the Berkshires will continue to be impacted by hurricanes and tropical storms.

Secondary Hazards

Precursor events or hazards that may exacerbate hurricane damage include heavy rains, winds, tornadoes, storm surge, insufficient flood preparedness, subsea infrastructure, and levee or dam breach or failure. Potential cascading events include health issues (mold and mildew); increased risk of fire hazards; hazardous materials, including waste byproducts; coastal erosion; compromise of levees or dams; isolated islands of humanity; increased risk of landslides or other types of land movement; disruptions to transportation; disruption of power transmission and infrastructure; structural and property damage; debris distribution; and environmental impacts (MEMA, 2018).

Warning Time

The NWS issues a hurricane warning when sustained winds of 74 mph or higher are expected in a specified area in association with a tropical, subtropical, or post-tropical cyclone. A warning is issued 36 hours in advance of the anticipated onset of tropical-storm-force winds. A hurricane watch is announced when sustained winds of 74 mph or higher are possible within the specified area in association with a tropical, subtropical, or post-tropical cyclone. A watch is issued 48 hours in advance of the anticipated onset of tropical-storm-force winds (NWS, 2013). Preparations should be complete by the time the storm is at the latitude of North Carolina. Outer bands containing squalls with heavy showers and wind gusts to tropical storm force can occur as much as 12 to 14 hours in advance of the eye, which can cause coastal flooding and may cut off exposed coastal roadways. The 1938 hurricane raced from Cape Hatteras to the Connecticut coast in 8 hours (MEMA, 2018).

Exposure and Vulnerability

To understand risk, the assets exposed to the hazard areas are identified. For the hurricane and tropical storm hazard, the entire Commonwealth of Massachusetts is exposed; more specifically, the Commonwealth is exposed to the wind and rains associated with these events. However, certain areas, types of building, and infrastructure are at greater risk than others, based on their proximity to the coast and/or manner of construction. Storm surge from a hurricane/tropical storm poses one of the greatest risks to residents and property. A FEMA Risk Analysis Team developed storm surge inundation grids for the Commonwealth in GIS format from the "maximum of maximums" outputs from the SLOSH model. These represent the worst-case storm surge scenarios for each hurricane category (Categories 1 through 4). To assess the Commonwealth's exposure to storm surge from hurricanes and tropical storms, a spatial analysis was conducted using the SLOSH model. The SLOSH boundaries do not account for any inland flash flooding (MEMA, 2018).

Berkshire County is landlocked, so no community in the region is at risk of storm surge. Damages from a hurricane can be broken into two general categories of direct impacts: flooding and high winds. Flooding damage for the Town of West Stockbridge has been assessed and discussed in the flooding section of this Plan and is not discussed here.

Population

High winds from tropical storms and hurricanes can knock down trees, limbs and electric lines, can damage buildings, and send debris flying, leading to injury or loss of life. Flooding often accompanies tropical storms and hurricanes. Economically distressed, older residents and other vulnerable populations are most susceptible, 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.

Critical Facilities

In past events in Berkshire County, critical facilities are mostly impacted during a hurricane by flooding, and these impacts are discussed in the flooding section of this Plan. Wind-related damages from downed trees, limbs, electricity lines, and communications systems would be at risk during high winds. There are very few areas where power lines are buried underground.

Economy

Hurricane/tropical storm events can greatly impact the economy, including loss of business function, damage to inventory, relocation costs, wage loss, and rental loss due to the repair/replacement of buildings.

Existing Protections

As described in this section, the main direct impacts from hurricanes and tropical storms result from flooding and/or high winds. Existing protections for flooding are described in the Flood Hazard Section of this Plan, including local bylaws and regulatory mechanisms, completed infrastructure improvements and emergency preparedness measures. Existing protections against wind damages include the Town's adherence to the Massachusetts Building Code, and more vigilant pruning of trees and limbs around electric power lines. West Stockbridge first responders and public works staff report that National Grid has become more proactive in tree trimming and more responsive to power outages in recent years.

Actions

- Have residents or seasonal residents self-identify their needs, such as the need for oxygen, to the Police and/or Fire Department may help to prevent problems during a disaster of any kind.
- Continue to open gate valves on Shaker Mill Pond to lower water through early warning protection
- Clean out / activate stormwater management systems to ensure free flow of water during heavy rain events.

Severe Winter Storm

Overview

Severe winter storms include ice storms, nor'easters, heavy snow, blowing snow, and other extreme forms of winter precipitation (MEMA, 2018).

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 (MEMA, 2018).

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 (MEMA, 2018).

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 (MEMA, 2018).

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 (MEMA, 2018).

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 (MEMA, 2018).

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 (MEMA, 2018).

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 (MEMA, 2018).

Hazard Location

Severe winter storm events generally occur across the entire area of West Stockbridge, although higher elevations have slightly higher snow depths.

Previous Occurrences and Extent

During this 24-year span, Berkshire County experienced 151 severe winter storms, an average of six per winter. This number varies each winter, ranging from one during 2006 to 18 during 2008. Snow and other winter precipitation occur very frequently across the entire region. Snowfall in the region can vary between 26 and 131 inches a year, however it averages around 65 inches a year, down from around 75 inches a year in 1920.

Another tracking system is the one- and three-day record snowfall totals. According to data from the Northeast States Consortium, 99% of the one-day record snowfall events in the region typically yield snow depths in the range of 12"-24", while the majority of three-day record snowfall events yield snow depths of 24"-36".

Table 3.15 – Record Snowfall Events and Snow Depths for Berkshire County

Record Snowfall Event	Snowfall 12" – 24"	Snowfall 24" – 36"
1-Day Record	99%	1%
3-Day Record	36%	64%

Source: Northeast States Emergency Consortium, 2010

Since 2000, two severe ice storm events have occurred in the region. The storms within that period occurred in December and January, but ice storms of lesser magnitudes may impact the region from October to April, and on at least an annual basis.

Based on all sources researched, known winter weather events that have affected Massachusetts and were declared a FEMA disaster are identified in Table 3.16. Of the 18 federally declared winter storm-related disaster declarations in Massachusetts between 1954 to 2018, Berkshire County has been included in 12 of those disasters. The number of disaster declarations for severe winter events in which

Berkshire County was included is more than double that of declarations for non-winter severe storm events.

Table 3.16 – Severe Winter Weather – Declared Disasters that included Berkshire County 1992-2017

Incident Period	Description	Declaration Number
12/11/92-1213/92	Nor'easter with snow 4'+ in higher elevations of Berkshires, with 48" reported in Becket, Peru and Becket; snow drifts of 12'+; 135,000 without power across the state	DR-975
3/13/93-3/17/93	High winds & heavy snow; generally 20-30" in Berkshires; blizzard conditions lasting 3-6 hrs afternoon of March 13.	EM-3103
1/7/96-1/8/96	Blizzard of 30+" in Berkshires, with strong to gale-force northeast winds; MEMA reported claims of approximately $32 million from 350 communities for snow removal	DR-1090
3/5/01-3/6/01	Heavy snow across eastern Berkshires to Worcester County; several roof collapses reported; $21 million from FEMA	EM-3165
2/17/03-2/18/03	Winter storm with snow of 12-24", with higher totals in eastern Berkshires to northern Worcester County; $28+ million from FEMA	EM-3175
12/6/03-12/7/03	Winter Storm with 1'-2' across state, with 36" in Peabody; $35 million from FEMA	EM-3191
1/22/05-1/23/05	Blizzard with heavy snow, winds and coastal flooding; highest snow falls in eastern Mass.; $49 million from FEMA	EM-3201
4/15/07-4/16/07	Severe Storm and Flooding; wet snow, sleet and rain added to snowmelt to cause flooding; higher elevations received heavy snow and ice; $8 million from FEMA	DR-1701
12/11/08-12/12/08	Major ice storm across eastern Berkshires & Worcester hills; at least ½" of ice accreted on exposed surfaces, downing trees, branches and power lines; 300,000+ customers without power in state, some for up to 3 wks.; $51+ million from FEMA	DR-1813
1/11/11-1/12/11	Nor'easter with up to 2' within 24 hrs.; $25+ million received from FEMA	DR-1959
10/29/11-10/30/11	Severe storm and Nor'easter with 1'-2' common; at peak 665,000 residents state-wide without power; 2,000 people in shelters statewide	DR-4051
2/8/13-2/9/13	Severe Winter Snowstorm and Flooding; $56+ million from FEMA	RE-4110

Source: FEMA, 2017

Impact

Severity

The magnitude or severity of a severe winter storm depends on several factors including a region's climatological susceptibility to snowstorms, snowfall amounts, snowfall rates, wind speeds, temperatures, visibility, storm duration, topography, time of occurrence during the day (e.g., weekday versus weekend), and time of season (MEMA, 2018).

NOAA's National Climatic Data Center (NCDC) is currently producing the Regional Snowfall Index (RSI) for significant snowstorms that impact the eastern two-thirds of the U.S. The RSI ranks snowstorm impacts on a scale from one to five, which is similar to the Fujita scale for tornadoes or the Saffir-Simpson scale for hurricanes. RSI is based on the spatial extent of the storm, the amount of snowfall, and the combination of the extent and snowfall totals with population. Data beginning in 1900 is used to give a historic perspective (MEMA 2013, NOAA 2018).

Table 3.17 – Regional Snowfall Index Ranking Categories

Category	Description	RSI-Value	Approximate Percent of Storms
1	Notable	1-3	1%
2	Significant	3-6	2%
3	Major	6-10	5%
4	Crippling	10-18	25%
5	Extreme	18+	54%

Source: MEMA, 2018

Of the 12 recent winter storm disaster declarations that included Berkshire County (as listed in Table 3.15), only two events were ranked as Extreme (EM-3103 in 1993 and DR-1090 in 1996), one was ranked Crippling (IM-3175 in 2003) and two were ranked as Major (EM-3191 in 2003 and DR-4110 in 2013). It should be noted that because population is used as a criteria, the storms that rank higher will be those that impact densely populated areas and regions such as Boston and other large cities and, as such, might not necessarily reflect the storms that impact lightly populated areas like the Berkshires. For example, one of the most famous storms in the Commonwealth in modern history was the Blizzard of '78, which dropped over two feet of snow in the Boston area during 65 mph winds that created enormous drifts and stranded hundreds of people on local highways. The storm hit the snow-weary city that was still digging out of a similar two-foot snowstorm 17 days earlier. Although the Berkshires received snow from this storm, the county was not listed in the declaration.

One of the most serious storms to impact communities in the Berkshires was the Ice Storm of December 11, 2008. The storm created widespread downed trees and power outages all across New York State, Massachusetts and New Hampshire. Over one million customers were without electricity, with 800,000 without power three days later and some without power weeks later. Living conditions were acerbated by extremely cold temperatures in the days following the event.

Climate Change Impacts

The climate of the region is changing and will continue to change over the course of this century. Since 1900, ambient air temperatures have increased by 0.5°F. This warming trend has been associated with other changes, such as more frequent day temperatures above 90F, reduced snowpack, and earlier snow melt and spring peak flows. By the end of the century, under the high emissions scenario of the Intergovernmental Panel on Climate Change, Massachusetts is expected to experience a 5F to 10F increase in average ambient temperatures with more days of extreme heat during the summer. Sea surface temperatures are expected to incase by 8F, which can influence precipitation temperature and dictate whether it falls as snow, ice or rain (MEMA, 2018).

Along with rising temperatures, it is expected that annual precipitation will increase by 14%, with a slight decrease in summer totals and a 30% increase in winter totals. Winter precipitation is predicted to more often be in the form of rain rather than snow. This change in precipitation will have significant effects on the amount of snow cover, winter recreation, spring snowmelt and peak stream flows, water supply, aquifer recharge, and water quality. The Commonwealth is located in an area where thresholds between snow and rain are sensitive and reductions in snow would be the largest. Snow is also predicted to fall later in the winter and cease falling earlier in the spring (MEMA, 2018).

Probability

Severe winter weather is a common occurrence each year in Massachusetts. According to the NOAA-NCDC storm database, over 200 winter storm events occurred in the Commonwealth between 2000 and 2012. Therefore, the subset of severe winter storms will likely continue to occur annually (MEMA, 2018). The Town of West Stockbridge's location in Western New England places it at a high-risk for winter storms. While the Town may not get the heavy snowfall associated with coastal storms, the severe storms that the county gets are added to the higher annual snowfall the county normally gets due to its slightly higher elevation then its neighboring counties in the Pioneer and Hudson River Valleys.

Using history as a guide for future severe winter storms, it can be assumed that West Stockbridge will be at risk for approximately six severe winter storms per winter. The highest risk of these storms occurs in January with significant risk also occurring in December through March. The region is getting less snowfall then previous years and can expect less snowfall in future years, however this does not mean the county will not experience years with high snowfall amounts (2010-11 had over 100 inches), but the trend indicates that the yearly snowfall total will continue to go down. It should be noted that although total snow depths may be reduced in the future, warmer winter temperatures will likely increase the number and severity of storms with heavy, wet snow, which can bring concerns for road travel, human injuries linked to shoveling, risk of roof failures and power outages.

Secondary Hazards

Structural damage (snow load); wind damage; impact to life safety; disruption of transportation routes; loss of productivity; municipal, business and societal economic impacts; loss of ability to evacuate; taxing first responder capabilities; service disruption (power, water, etc.); and communication disruption (MEMA, 2018).

Exposure and Vulnerability

All areas within the Town of West Stockbridge are exposed to severe winter storm events. Roads known to be particularly susceptible to snow drifts and high winds include West Center Road near Swamp Road, and Pixley Hill Road. Travel in these areas may be restricted during times of high winds and drifting.

Nor'easters share many characteristics with hurricane events. Both types of events can bring high winds and surge inundation that results in similar impacts on the population, structures, and the economy. For the purposes of the SHMCAP, the Hazus wind/surge model was used to estimate potential losses attributed to the February 1978 nor'easter, the most extensive nor'easter on record, with current (2010) population and built environment (MEMA, 2018).

Population

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 creating blizzard conditions with blinding wind-driven snow, drifting snow, and extreme cold temperatures with dangerous wind chill. They 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 (MEMA, 2018).

Heavy snow can immobilize a region and paralyze a city, 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 (MEMA, 2018).

In rural areas, homes and farms may be isolated for days, and unprotected livestock may be lost. In the mountains, heavy snow can lead to avalanches. Storms near the coast can cause coastal flooding and beach erosion as well as sink ships at sea. The impact of a nor'easter 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 (MEMA, 2018).

Critical Facilities

All critical facilities and infrastructure in West Stockbridge are exposed to the severe winter weather hazards. 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 interruption can occur, backup power is recommended for critical facilities and infrastructure. Infrastructure at risk for this hazard includes roadways that could be damaged due to the application of salt and intermittent freezing and warming conditions that can damage roads over time (MEMA, 2013).

A specific area that is vulnerable to the winter storm hazard is the floodplain. Snow and ice melt can cause riverine flooding. At-risk general building stock and infrastructure in floodplains are presented in the flood hazard profile (Section 3.2.). These risks can expect to increase as warmer winter temperatures results in more rain events.

Economy

The entire general building stock inventory in the Commonwealth 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. Communications and power can be disrupted for days while utility companies work to repair the extensive damage. Even small accumulations of ice may cause extreme hazards to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces. A specific area that is vulnerable to the winter storm hazard is the floodplain. Snow and ice melt can cause both riverine and urban flooding (MEMA, 2018).

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 (MEMA, 2018).

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. Hazus estimates the total economic loss associated with each storm scenario (direct building losses and business interruption losses). Direct building losses are the estimated costs to repair or replace the damage caused to a building (MEMA, 2018).

A Hazus analysis was conducted to determine the combination wind and surge impacts from the 1978 nor'easter event for the entire Commonwealth building stock. Because of differences in building construction, residential structures are generally more susceptible to wind damage than commercial and industrial structures. Wood and masonry buildings in general, regardless of their occupancy class, tend to experience more wind damage than concrete or steel buildings. Table 3.18 summarizes the estimated building loss (structure and contents). The total damage reflects the overall impact at an aggregate level. Note, according to the table, Berkshire County has zero estimated losses.

Table 3.18 – Estimated Building Loss from Hazus Wind and Storm Surge Analysis (Structure and Contents Replacement Cost Value) 1978 Nor'easter

County	Total (Wind and Surge)	Total Wind Only	Total Surge Only
Barnstable	$590,093,258	$194,949,258	$395,144,000
Berkshire	$0	$0	$0
Bristol	$204,625,675	$176,935,675	$27,690,000
Dukes	$53,040,437	$13,157,437	$39,883,000

Essex	$732,222,926	$64,446,927	$667,775,999
Franklin	$484,957	$484,957	$0
Hampden	$5,963,018	$5,963,018	$0
Hampshire	$1,897,908	$1,897,908	$0
Middlesex	$462,591,150	$221,504,150	$241,087,000
Nantucket	$24,544,131	$17,829,131	$6,715,000
Norfolk	$427,367,579	$231,024,579	$196,343,000
Plymouth	$555,012,866	$242,940,866	$312,072,000
Suffolk	$1,317,085,107	$134,302,106	$1,182,783,001
Worcester	$60,441,016	$60,441,016	$0
Total	**$4,435,370,028**	**$1,365,877,028**	**$3,069,493,000**

Source: MEMA, 2018

Existing Protections

Experiencing snow storms and severe winter weather are considered part of living in Berkshire County. Municipalities' budget money for snow plowing, sanding and overtime, and public works road crews plan equipment and materials purchases in preparation for the winter season. Capital improvements often consider new truck or plow equipment. Most snow and severe winter weather events are considered expensive nuisances, with only the most severe blizzard or Nor'easters that threaten human health due to closed transportation routes or services, or those that cause power outages, a cause for concern.

The Town of West Stockbridge follows the Massachusetts building code. In this building code, most of Berkshire County is in a zone that requires new construction to withstand 50 pounds per square foot (psf) of snow load, with a few south county towns having a rating of 40 psf. These are the strongest requirements in the state, with other parts of the state requiring strengths of 25-40 psf, depending on the location of the municipality. The snow load is an important consideration when building owners are considering installing solar panel on homes and businesses.

Properly insulated and sealed homes can maintain warm interior temperatures longer during a winter power outage than those with little or no insulation, reducing health risks to inhabitants sheltering in place and the risk of frozen pipes. Properly insulating and venting attics can help to reduce ice dam damage. The MassSave energy program offers free home audits and provides financial incentives for owners to seal and insulate the building envelopes. Berkshire Community Action Council provides further assistance by aiding low income residents' access fuel assistance and home improvement programs, including weatherization and energy-efficient furnaces and appliances. Being able to retrofit homes with little or no insulation is important as 40% of the building stock in Berkshire County was constructed before 1940, and 60% is pre-1960.

Actions

- Enforce snow load building code regulations
- Continue to encourage building owners to get energy audits and improve building efficiency to reduce human health risk due to extreme cold and power outages and reduce risk of building damage such as ice dams.
- Continue to encourage older residents, disabled, and those with medical issues to self-identify with the West Stockbridge Police Department as having special needs during emergency incidents.
- Develop and deploy education program to inform residents of their responsibilities, primarily for themselves and neighbors, during power outages and extreme winter weather events.
- Explore Reverse 9-1-1 for cell phone users and encourage residents to sign-up.

Tornadoes

Overview

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 (MEMA, 2018).

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 (MEMA, 2018).

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 (MEMA, 2018).

Most tornadoes occur in the late afternoon and evening hours, when the heating is the greatest. The most common months for tornadoes to occur are June, July, and August, although the Great Barrington, Massachusetts, tornado (1995) occurred in May and the Windsor Locks, Connecticut, tornado (1979) occurred in October (MEMA, 2018).

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 (MEMA, 2018).

Hazard Location

The U.S. experiences an average of 1,253 tornadoes per year, more tornadoes than any other country (NOAA, n.d.). Because Massachusetts experiences far fewer tornadoes than other parts of the country, residents may be less prepared to react to a tornado (MEMA, 2018).

Previous Occurrences and Extent

Known severe weather events that have affected Massachusetts and received FEMA disaster declarations are identified in Appendix B. Figure 3.12 illustrates the number of storm-related disasters per county. West Stockbridge, located in Berkshire County, has had four declared disasters according to the map. It should be noted that this count of severe weather events encompasses a number of natural hazards, including nor'easters, thunderstorms, hurricanes, and flooding. Although this means storm events may also be accounted for in other sections, the overall number of occurrences per county provides valuable insight into each county's exposure and is therefore restated here (MEMA, 2018).

Specific to West Stockbridge, there was one recorded severe tornado in 1974 which caused extreme damage including 3 deaths. There are two other reported tornadoes that were less severe with minor damage and no reported deaths.

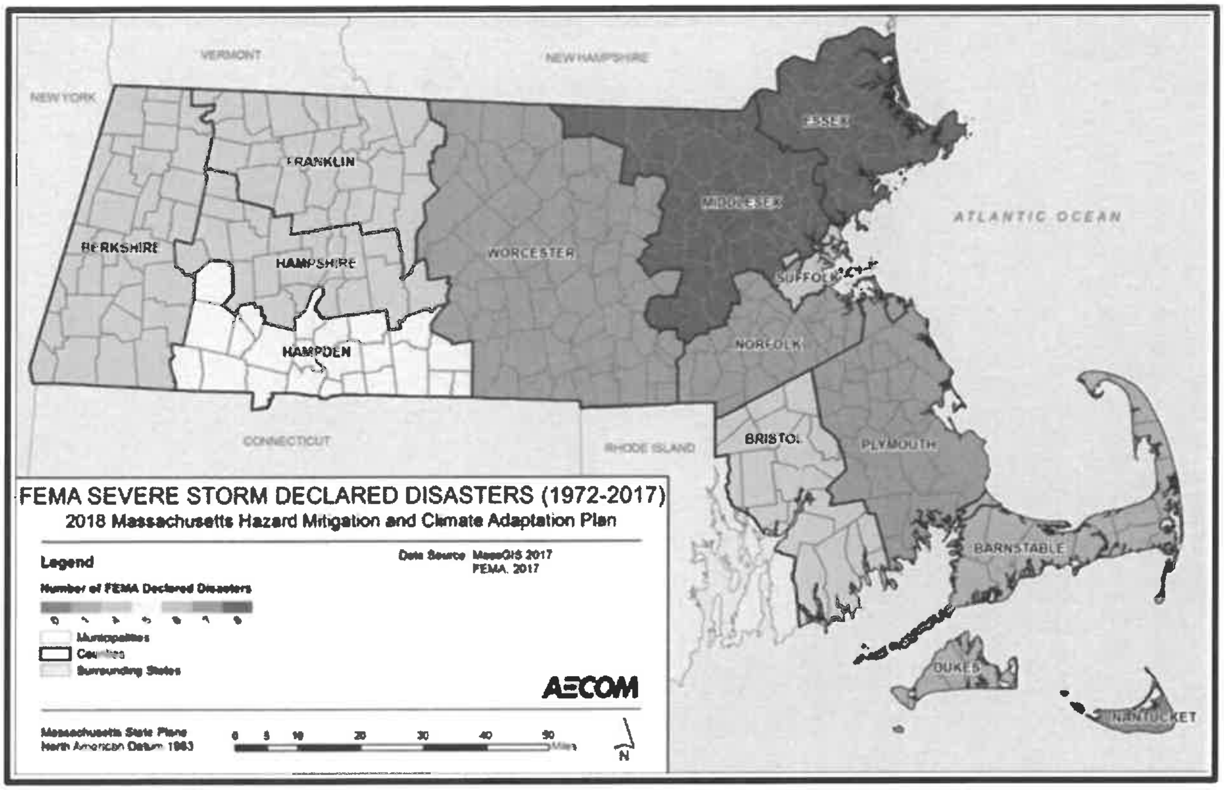


Figure 3.12 FEMA Severe Storm Declared Disasters by County in Massachusetts
Source: MEMA, 2018

Impact

Impacts from severe storm events can be widespread; affecting the entire northeast, such as a hurricane or nor'easter. Impacts can occur along narrow paths of Berkshire County where weather fronts collide and deliver high winds and rain or where tornado touchdowns have carved a path of destruction. Alternately impacts from these storms can be concentrated, such as when microbursts suddenly hit an area. Areas of impact from tornados and microbursts are unpredictable. The location of tornado impact is totally unpredictable. However, the county is in a lower risk area with an average of 1 tornado watch per year (see Figure 3.13).

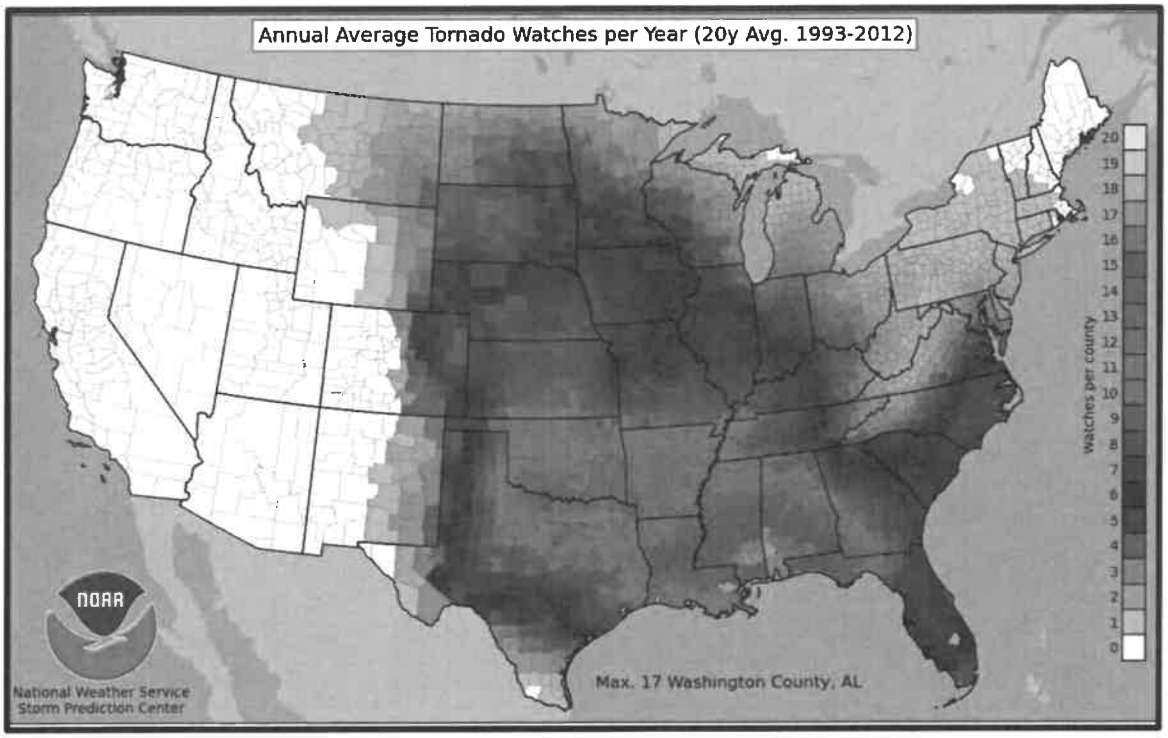


Figure 3.13 – Annual Average Tornado Watches Per Year
Source: MEMA, 2018

Severity
Tornadoes are potentially the most dangerous of local storms. If a major tornado were to strike in the populated areas of the Commonwealth, 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 (MEMA, 2018).

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 3.14 provides guidance from NOAA about the impacts of a storm with each rating (MEMA, 2018).

Scale	Wind speed		Relative frequency	Potential damage	
	mph	km/h			
EF0	65–85	105–137	53.5%	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	138–178	31.6%	Moderate damage. Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.	
EF2	111–135	179–218	10.7%	Considerable damage. Roofs torn off 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	219–266	3.4%	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 blown away some distance.	
EF4	166–200	267–322	0.7%	Extreme damage to near-total destruction. Well-constructed houses and whole frame houses completely leveled; cars thrown and small missiles generated.	
EF5	>200	>322	<0.1%	Massive Damage. Strong frame houses leveled off foundations and swept away; steel-reinforced concrete structures critically damaged; high-rise buildings have severe structural deformation. Incredible phenomena will occur.	

Source: Linn County EMA, n.d.
EF = Enhanced Fujita scale

Figure 3.14 – Guide to Tornado Severity
Source: MEMA, 2018

Probability

According to the National Climatic Data Center, since 1950 there have been 13 tornados that have touched down or moved in a path across Berkshire County. The most recent of these was in July 2014 when a tornado struck in Dalton. This averages to one tornado striking the county approximately every five years. Of these, only two have been of F4 severity, which indicates that such a severe tornado has a statistical recurrence rate of one in every 33 years (NOAA, 2017).

Secondary Hazards

The most significant secondary hazards associated with tornadoes are significant structural damage, power failures, falling and downed trees, and interruption of emergency services. Large hail commonly accompanies a tornado, and can damage cars and buildings as well as cause serious injuries for individuals without shelter. Heavy rain can overwhelm both natural and manmade drainage systems, causing overflow and further property destruction (MEMA, 2018).

Warning Time

Tornado watches and warnings are issued by the local NWS office. A tornado watch is released when tornadoes are possible in an area. A tornado warning means a tornado has been sighted or indicated by weather radar. The current average lead-time for tornado warnings is 13 minutes. Occasionally, tornadoes develop so rapidly, that little, if any, advance warning is possible (MEMA, 2013). No warning was the case in Dalton where, according to the Dalton Emergency Management Director, who monitors weather advisories, there was no tornado warning for the Town prior to the tornado striking the Greenridge area in 2014. The only warning issued was a severe weather warning, with possible high winds.

Exposure and Vulnerability

The entire region including the Town of West Stockbridge has the potential for tornado formation, although areas with higher-than-average tornado frequency face additional risk.

Population

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 (MEMA, 2018).

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 (MEMA, 2018).

Critical Facilities

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 (MEMA, 2018).

Economy

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 (MEMA, 2018).

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. High-rise buildings are also very vulnerable structures. Mobile homes are the most vulnerable to damage, even if tied down, and offer little protection to people inside (MEMA, 2018).

Actions

- Activate and use Town siren warning system

Other Severe Weather

Overview

Several frequent natural hazards in Massachusetts—particularly strong winds and extreme precipitation events—occur outside of notable storm events. This section discusses the nature and impacts of these hazards, as well as ways in which they are likely to respond to climate change (MEMA, 2018).

High Winds

Wind is air in motion relative to the 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 of 40 mph or more, or any gusts of 58 mph or more). For non-tropical events over water, the NWS issues a small craft advisory (sustained winds of 25 to 33 knots), a gale warning (sustained winds of 34 to 47 knots), a storm warning (sustained winds of 48 to 63 knots), or a hurricane-force wind warning (sustained winds 64 knots or more). 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 the boating, shipping, and aviation industry sectors. Tornadoes are analyzed separately in this section of the Plan and are not discussed further here (MEMA, 2018).

Thunderstorms

A thunderstorm is a storm originating in a cumulonimbus cloud. Cumulonimbus clouds produce lightning, which locally heats the air to 50,000 degrees Celsius, which in turn produces an audible shock wave, known as thunder. Frequently during thunderstorm events, heavy rain and gusty winds are present. Less frequently, hail is present, which can become very large in size. Tornadoes can also be generated during these events. A thunderstorm is classified as "severe" when it produces damaging wind gusts in excess of 58 mph (50 knots), hail that is 1 inch in diameter or larger (quarter size), or a tornado (NWS, 2013). Three basic components are required for a thunderstorm to form: moisture, rising unstable air, and a lifting mechanism. The sun heats the surface of the earth, which warms the air above it. If this warm surface air is forced to rise— by hills or mountains, or areas where warm/cold or wet/dry air bump together causing a rising motion—it will continue to rise as long as it weighs less and stays warmer than the air around it. As the warm surface air rises, it transfers heat from the surface of the earth to the upper levels of the atmosphere (the process of convection). The water vapor it contains begins to cool, releasing the heat, and the vapor condenses into a cloud. The cloud eventually grows upward into areas where the temperature is below freezing. Some of the water vapor turns to ice, and some of it turns into water droplets. Both have electrical charges. When a sufficient charge builds up, the energy is discharged in a bolt of lightning, which causes the sound waves we hear as thunder. An average thunderstorm is 15 miles across and lasts 30 minutes; severe thunderstorms can be much larger and longer. Southern New England typically experiences 10 to 15 days per year with severe thunderstorms (MEMA, 2018).

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 across large areas is known as a "derecho." These occasionally occur in Massachusetts. The strongest downburst recorded was a downburst in North Carolina of 175 mph. Winds exceeding 100 mph have been measured from downbursts in Massachusetts (MEMA, 2018).

Hazard Location

Previous Occurrences and Extent

Known severe weather events that have affected Massachusetts and received FEMA disaster declarations are identified in Appendix B. Figure 3.11 illustrates the number of storm-related disasters per county. West Stockbridge, located in Berkshire County, has had four declared disasters according to the map. It should be noted that this count of severe weather events encompasses a number of natural hazards, including nor'easters, thunderstorms, hurricanes, and flooding. Although this means storm events may also be accounted for in other sections, the overall number of occurrences per county provides valuable insight into each county's exposure and is therefore restated here (MEMA, 2018).

Impact

Impacts from severe storm events can be widespread; affecting the entire northeast, such as a hurricane or nor'easter. Impacts can occur along narrow paths of Berkshire County where weather fronts collide and deliver high winds and rain or where tornado touchdowns have carved a path of destruction. Alternately impacts from these storms can be concentrated, such as when microbursts suddenly hit an area. Areas of impact from tornados and microbursts are unpredictable.

Severe storms can occur anywhere in the Town of West Stockbridge. Thunderstorms affect relatively small areas, rather than large regions much like winter storms and hurricane events. The community is in an area that would experience between 15 and 20 thunderstorm days each year.

Severity

For non-tropical high wind events that occur over land, the National Weather Service (NWS) issues a Wind Advisory (sustained winds of 31 - 39 mph for at least one hour, or any gusts of 46 - 57 mph) or a High Wind Warning (sustained winds of 40+ mph or any gusts of 58+ mph). Effective 2010 the NWS modified the hail size criterion to classify a thunderstorm as 'severe' when it produces damaging wind gusts in excess of 58 mph, hail that is 1 inch in diameter or larger (quarter size), or a tornado (NWS, 2013).

Climate Change Impacts

Climate change presents a significant challenge for risk management associated with severe weather. The frequency of severe weather events has increased steadily over the last century. The number of weather-related disasters during the 1990s was four times that of the 1950s, and cost 14 times as much in economic losses. Historical data show the probability for severe weather events increasing in a warmer climate (MEMA, 2013). Warming ocean temperatures are a source of increased evaporation and resulting precipitation, and warmer air masses can create more volatile atmospheric conditions, particularly if they interact or collide with cooler air masses. Any severe storm event could have significant economic consequences.

Probability

Severe storms comprised of thunderstorms, high winds, and hail will continue to affect the community. While these events may occur during any month, they most likely will occur between May and August. FEMA has developed Wind Zones for the U.S. based on 100 years of hurricane data and 40 years of tornado data and, according to these maps, the Berkshires are listed as a Special Wind Region within the Hurricane-susceptible Region of a Wind Zone II (up to 160 mph winds). Based on this historical data the Town of West Stockbridge can expect to continue to experience at least the same number and severity of wind-related weather events into the future. Some scientists project that the number and severity of events will increase as a result of climate change.

Lightning strikes primarily occur during the summer months. According to NOAA, there has been 1 fatality and 43 injuries as a result of lightning events from 1993-2012 in the Commonwealth (NCDC, 2012) (MEMA, 2018). Although thunderstorms with lightening may increase due to a more volatile atmosphere, the chance of death or injury is likely to remain low.

Secondary Hazards

The most significant secondary hazards associated with severe thunderstorms and high winds include falling and downed trees and power lines. Heavy rain can overwhelm both natural and man-made drainage systems, causing overflows and property destruction. Thunderstorms can also cause floods and landslides, particularly when the soil on slopes becomes oversaturated and fails. Severe lightning can also spark fires, even when accompanied by heavy rains. Lightning can cause severe damage, injury, and death (MEMA, 2018). Possible long-term power outages and closed transportation systems can threaten human health and disrupt businesses.

Warning Time

Meteorologists can often predict the likelihood of a severe thunderstorm outbreaks with several days of lead time. However, they can only pin this down to portions of states and cannot predict the exact time of onset or severity of individual events. Other storms, such as a well-organized squall line, can yield lead times of up to an hour from the time a Severe Thunderstorm Warning is issued to the time severe criteria are observed. Some severe thunderstorm events develop quickly, with only a few minutes of advance warning times. Doppler radar and a dense network of spotters and amateur radio operators across the region have helped increase warning lead time across southern New England (MEMA, 2013). In Berkshire County, the hilly and sometimes steeply sloped terrain facilitates cumulonimbus cloud development, creating very localized thunderstorms. These can develop quickly and dissipate quickly, with damages caused by wind, rain and sometimes hail.

Severe weather warnings issued for Berkshire County are generated out of the National Weather Service in Albany, NY, not from NWS in Boston. Residents in most of Berkshire County rely on weather reports from Albany, NY television stations rather than from stations within the Commonwealth. This is because the county is listed as being in the Albany designated marketing area for cable and satellite companies. Given the prevailing winds from the west, Albany is often a good barometer for Berkshire weather. Fortunately, Albany TV stations include Berkshire County when they issue storm watches and warnings, and storm systems are easily tracked live online via the radar displays of all three major Albany television stations. Albany and local radio stations also issue warnings.

Exposure and Vulnerability

Whereas risks from some hazards can be dependent on locating development and infrastructure in higher risk areas, such as in floodplain areas, dam inundation areas or proximity to forest and grasslands, the hazards described in this section are less dependent on location. In some localized areas wind speeds can increase across wide expanses of open, unforested areas, such as pasture or crop lands, such as occur extensively in West Stockbridge.

Population

The entire population of the Commonwealth 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 (MEMA, 2018).

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 (MEMA, 2018).

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 (MEMA, 2018). 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 (MEMA, 2018). 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 (MEMA, 2018).

Critical Facilities

All critical facilities in the Town of West Stockbridge are exposed to severe weather events such as high winds, thunderstorms and tornados. The most common problems associated with severe weather are loss of electricity and possibly communications systems. Downed power lines can cause blackouts, leaving large areas isolated. Phone, water, and sewer systems may not function. Roads may become impassable due to flash flooding (MEMA, 2018).

Economic

Wind storms, thunderstorms, and tornado 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 (MEMA, 2018).

According to the NOAA's Technical Paper on Lightning Fatalities, Injuries, and Damage Reports in the U.S. from 1959 to 1994, monetary losses for lightning events range from less than $50 to greater than $5 million (the larger losses are associated with forest fires, with homes destroyed, and with crop loss).

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 (MEMA, 2018).

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 (MEMA, 2018).

Because of differences in building construction, residential structures are generally more susceptible to wind damage than commercial and industrial structures. Wood and masonry buildings in general, regardless of their occupancy class, tend to experience more damage than concrete or steel buildings. High-rise buildings are also very vulnerable structures. Mobile homes are the most vulnerable to damage, even if tied down, and offer little protection to people inside (MEMA, 2018).

Existing Protections
The Town of West Stockbridge adheres to the Massachusetts state building code. Part of this code requires buildings to withstand specific wind loads and adhere to energy efficiency standards. The MassSaves programs offers free energy audits to residential and business customers who request them and, based on the results of the audits, offers financial incentives for building owners to become more energy efficient and better insulated against severe temperatures.

Regarding electricity outages, officials across Berkshire County report improvements in electrical utilities responses since the ice storm of 2008. Additionally, the electric utility companies have created special community liaison staff who work more directly with municipal first responders during emergency incidents.

Actions

- Continue strict adherence to MA Building Code
- Encourage cell phone users to enlist in the Town's Reverse 9-1-1 system.
- Encourage the elderly, disabled, and those with medical issues to self-identify with the West Stockbridge Police Department as having special needs during emergency incidents.
- Develop and deploy education program to inform residents of their responsibilities, primarily for themselves and neighbors, during power outages and extreme weather events.

Earthquake

Overview

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 (MEMA, 2018).

Seismic waves are the vibrations from earthquakes that travel through the Earth. The magnitude or extent of an earthquake is a seismograph measured value of the amplitude of the seismic waves. The table below summarizes Richter scale magnitudes and corresponding earthquake effects. For example, earthquakes in the 2 to 2.5 range are typically felt in Massachusetts and throughout the eastern United States. Generally, earthquakes in the eastern U.S. are felt over a larger area than those in the western U.S. (MEMA, 2013).

Table 3.19 – Richter Scale

Richter Magnitude	Earthquake Effects
2.5 or less	Not felt or felt mildly near the epicenter, but can be recorded by seismographs
2.5 to 5.4	Often felt, but only causes minor damage
5.5 to 6.0	Slight damage to buildings and other structures
6.1 to 6.9	May cause a lot of damage in very populated areas
7.0 to 7.9	Major earthquake; serious damage
8.0 or greater	Great earthquake; can totally destroy communities near the epicenter

The intensity of an earthquake is based on the observed effects of ground shaking on people, buildings, and natural features, and varies with location. Intensity is expressed by the Modified Mercalli Scale; a subjective measure that describes how strongly an earthquake was felt at a particular location. The table below summarizes earthquake intensity as expressed by the Modified Mercalli Scale (MEMA, 2013).

Table 3.20 – Modified Mercalli Scale

Mercalli Intensity	Description
I	Felt by very few people; barely noticeable.
II	Felt by few people, especially on upper floors.
III	Noticeable indoors, especially on upper floors, but may not be recognized as an earthquake.
IV	Felt by many indoors, few outdoors. May feel like passing truck.
V	Felt by almost everyone, some people awakened. Small objects move, trees and poles may shake.
VI	Felt by everyone; people have trouble standing. Heavy furniture can move; plaster can fall off walls. Chimneys may be slightly damaged.
VII	People have difficulty standing. Drivers feel cars shaking. Some furniture breaks. Loose bricks fall from buildings. Damage is slight to moderate in well-built buildings; considerable in poorly built ones.
VIII	Buildings suffer slight damage if well-built, severe damage if poorly built. Some walls collapse.

IX	Considerable damage to structures; buildings shift off their foundations. The ground cracks. Landslides may occur.
X	Most buildings and their foundations are destroyed. Some bridges are destroyed. Dams are seriously damaged. Large landslides occur. Water is thrown on the banks of canals, rivers, lakes. The ground cracks in large areas.
XI	Most buildings collapse. Some bridges are destroyed. Large cracks appear in the ground. Underground pipelines are destroyed.
XII	Almost everything is destroyed. Objects are thrown into the air. The ground moves in waves or ripples. Large amounts of rock may move.

Seismic hazards are often expressed in terms of Peak Ground Acceleration (PGA) and Spectral Acceleration (SA). USGS defines PGA and SA as the following: 'PGA is what is experienced by a particle on the ground. Spectral Acceleration (SA) is approximately what is experienced by a building, as modeled by a particle mass on a massless vertical rod having the same natural period of vibration as the building. Both PGA and SA can be measured in g (the acceleration due to gravity) or expressed as a percent acceleration force of gravity (%g). PGA and SA hazard maps provide insight into location specific vulnerabilities. More specifically, a PGA earthquake measurement shows three things: the geographic area affected, the probability of an earthquake of each given level of severity, and the strength of ground movement (severity) expressed in terms of percent of acceleration force of gravity (%g) (MEMA, 2013).

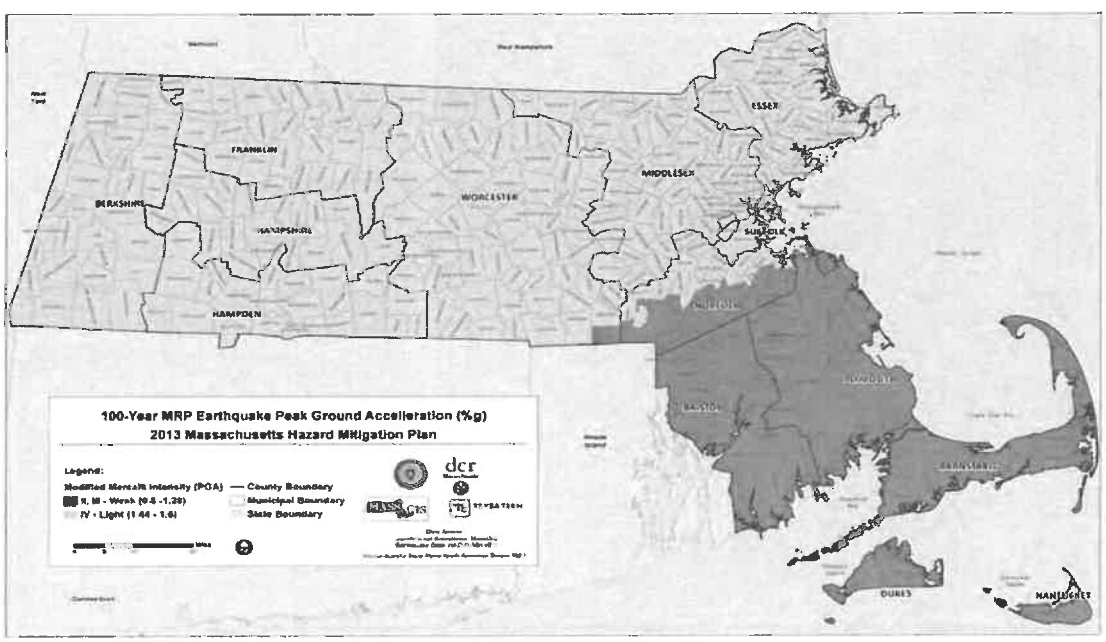


Figure 3.15 – Peak Ground Acceleration Modified Mercalli Scale for a 100-year Mean Return Period
Source: MEMA, 2013

According to the Massachusetts Emergency Management Agency's State Hazard Mitigation Plan, New England has not experienced a damaging earthquake since 1755, but numerous, less powerful earthquakes have been centered in Massachusetts and neighboring states. Seismologists state that a serious earthquake occurrence is possible. There are five normal faults in Massachusetts, three of these traverse portions of Berkshire County, but there is no discernable pattern of previous earthquakes along these fault lines. Earthquakes can occur without warning, can occur anywhere within the county, and may be followed by aftershocks. Most buildings and infrastructures in Massachusetts were constructed without specific earthquake resistant design features. Filled, sandy or clay soils are more vulnerable to earthquake pressures than other soils.

Hazard Location

New England's earthquakes to date have not aligned along mapped faults. 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 (MEMA, 2013).

Previous Occurrences and Extent

According to Alan Kafka, Director of Boston College's Weston Observatory, the most catastrophic earthquake to impact the state was the magnitude 6.0 event off Cape Ann in 1755. It was devastating and felt all over the Northeast. The largest earthquake since 1900 to strike Massachusetts was in 1994, a magnitude 3.9 on the Richter Scale, and located east of the Quabbin Reservoir. According to the USGS, there have been two recent earthquakes with epicenters close to the Berkshires. A magnitude 3.3 on the Richter scale struck the area around Westfield, MA in 2000 and a magnitude 1.9 struck the area around Northampton in 2012. To our west, a magnitude 3.1 struck in the Catskills region of New York in 2009 (USGS Earthquake Hazards Program 2017).

There are conflicting records reporting the occurrences of earthquakes in the Berkshires. According to the 2004 MA State Hazard Mitigation Plan, between 1668 and 1997 three earthquakes have occurred in the Berkshire region -- 1932, 1963 and 1982. The 1932 event occurred at Lake Garfield in Monterey, but the magnitude is unknown. The 1963 earthquake, which registered as 2.4 on the Richter Scale, is reported to have occurred in North Adams but with coordinates that indicate that it occurred in Savoy. The 1982 earthquake also occurred in North Adams and is registered at 2.0. (The Dewberry Company, 2004) However, the 2013 State Hazard Mitigation Plan indicates that only two earthquakes have occurred in the Berkshires, in Savoy and in the vicinity of the Hinsdale/Peru town border, both of which were in the magnitude of 2.0. The sites are show in Figure 3.16. All available the data indicates that an earthquake has not occurred in the West Stockbridge region of Berkshire County.

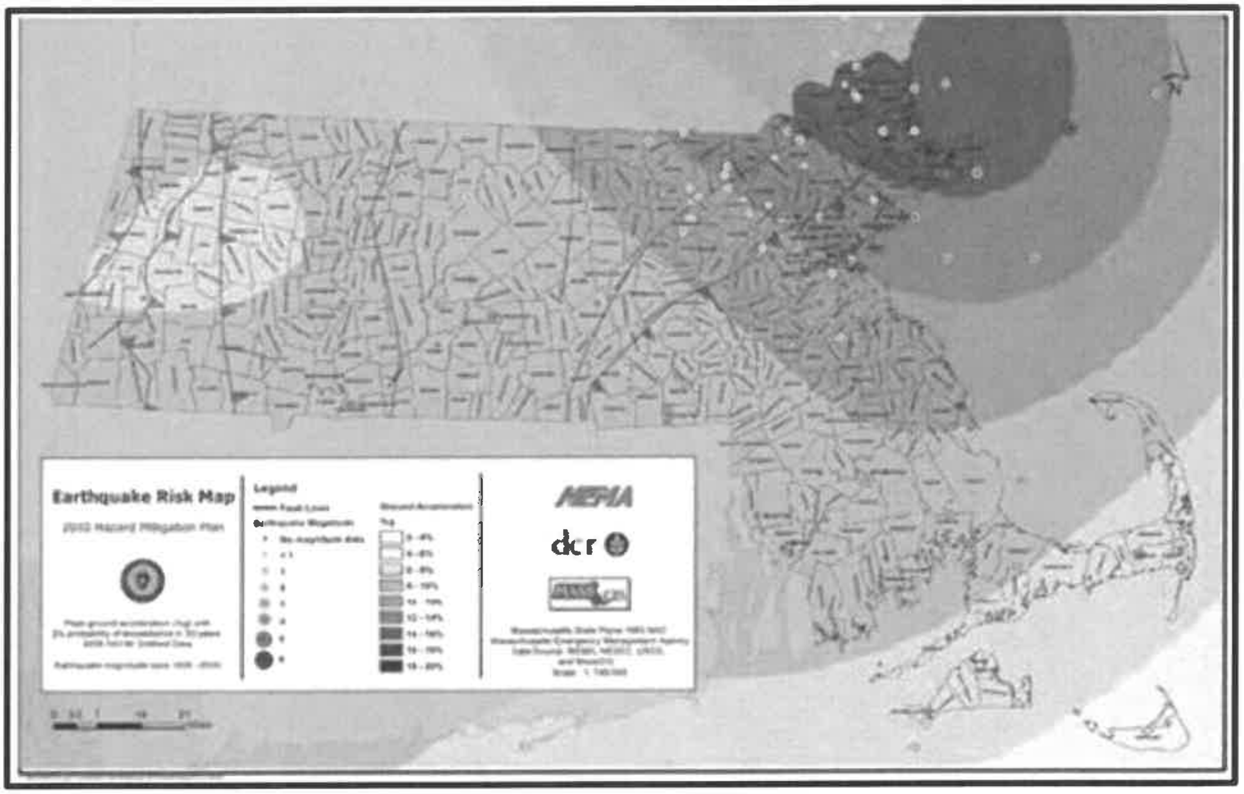


Figure 3.16 – Earthquake Historic Occurrences and Risk
Source: MEMA, 2013

Impact

Severity

The most commonly used method to quantify potential ground motion is in terms of peak ground acceleration (PGA), which measures the strength of a potential earthquake in terms of the greatest acceleration value of ground movement. The potential damage due to earthquake ground shaking increases as the acceleration of ground movement increases. For example, 100-year mean return period (MRP) event is an earthquake with a 1% chance that the mapped ground motion levels (PGA) will be exceeded in any given year. As shown in Figure 3.15, the 100-year earthquake event for Berkshire County is a Modified Mercalli Scale of IV (light impacts), felt by many indoors and a few outdoors, and may feel like passing truck. According to the MA State Hazard Mitigation Plan of 2013, the county could experience heavier impacts during the 500 and 1,000 MRP, with Modified Mercalli Scale ratings of V (moderate), felt by almost everyone, some people awakened, small objects move, and trees and poles may shake.

Because of this low frequency of occurrence and the relatively low levels of ground shaking that would be experienced, the community can be expected to have a low risk to earthquake damage as compared to other areas of the country. However, the impacts at the local level can vary based on types of construction, building density, soil type among other factors (MEMA, 2013).

Climate Change Impacts

The impacts of global climate change on earthquake probability are unknown. Some scientists feel that melting glaciers could induce tectonic activity. As ice melts and water runs off, tremendous amounts of weight are shifted on the earth's crust. As newly freed crust returns to its original, pre-glacier shape, it could cause seismic plates to slip and stimulate volcanic activity according to research into prehistoric earthquakes and volcanic activity. Secondary impacts of earthquakes could be magnified by climate change. Soils saturated by repetitive storms could be at higher risk of liquefaction during seismic activity due to the increased saturation. Dams storing increased volumes of water due to changes in the hydrograph could fail during seismic events. There are currently no models available to estimate these impacts (MEMA, 2013).

Probability

According to the state Hazard Mitigation Plan, earthquakes cannot be predicted and may occur any time of the day and any time of the year. Because the region's geologic faults zones do not correlate well to earthquake locations or aid in predication of occurrence, it is difficult to identify reasonably affordable mitigation measures. Based on the historic occurrences, which have been few and of limited severity, the community could be considered to be at a low risk for major earthquake damage in the future.

Secondary Hazards

Secondary hazards can occur to all forms of critical infrastructure and key resources as a result of earthquake. Earthquakes can cause large and sometimes disastrous landslides and mudslides. River valleys are vulnerable to slope failure, often as a result of loss of cohesion in clay-rich soils. Soil liquefaction occurs when water-saturated sands, silts or gravelly soils are shaken so violently that the individual grains lose contact with one another and float freely in the water, turning the ground into a pudding-like liquid. Building and road foundations lose load-bearing strength and may sink into what was previously solid ground. Unless properly secured, hazardous materials can be released, causing significant damage to the environment and people. Earthen dams and levees are highly susceptible to seismic events and the impacts of their eventual failures can be considered secondary risks of earthquakes (MEMA, 2013). Damages roadways could impede rescue efforts.

Warning Time

There is currently no reliable way to predict the day or month that an earthquake will occur at any given location. Research is being done with early-warning systems that use the low energy waves that precede major earthquake to issue an alert that earthquake shaking is about to be felt. These potential early warning systems can give up to approximately 40-60 seconds notice that earthquake shaking is about to be experienced, with shorter warning times for places closer to the earthquake epicenter. Although the warning time is very short, it could allow for immediate safety measures such as getting under a desk, stepping away from a hazardous material, or shutting down a computer system to prevent damage (MEMA, 2013).

Exposure and Vulnerability

For the purposes of this Plan, the entire town of West Stockbridge is considered to be at risk from earthquakes. However, some locations, building types, and infrastructure types are at greater risk than others are, due to the surrounding soils or their manner of construction (MEMA, 2013).

Population

The entire population of West Stockbridge is potentially exposed to direct and indirect impacts from earthquakes. The degree of exposure is dependent on many factors, including the age and construction type of the structures people live in, the soil type their homes are constructed on, their proximity to fault location, etc. The region's high percentage of older building stock could increase the risk of damage to some buildings. Business interruption could keep people from working, road closures could isolate populations, and loss of functions of utilities could impact populations that suffered no direct damage from an event itself (MEMA, 2013).

Critical Facilities

All critical facilities in the Plan's area are exposed to the earthquake hazard. Earthquakes losses can include structural and non-structural damage to buildings, loss of business function, damage to inventory, relocation costs, wage loss, and rental loss due to the repair/replacement of buildings. Roads that cross earthquake-prone soils have the potential to be significantly damaged during an earthquake event, potentially impacting commodity flows. Access to major roads is crucial to life and safety after a disaster event, as well as to response and recovery operations. In addition, 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. Facilities holding hazardous materials are of particular concern because of potential rupture and leaking into the surrounding area or adjacent waterways (MEMA, 2013).

Economy

Earthquakes also have impacts on the economy, including: loss of business function, damage to inventory, relocation costs, wage loss, and rental loss due to the repair/replacement of buildings. There is low risk that West Stockbridge will experience infrastructure or business losses and business due to earthquakes.

Existing Protections

The Town of West Stockbridge Building Commissioner uses and enforces the Massachusetts Building Code.

Actions

- Strict adherence to the state Building Code
- Strict adherence and enforcement of state storage regulations for hazardous materials.

Section 4
Mitigation Strategy

Existing Policies and Capabilities

As defined by FEMA, mitigation is sustained actions taken to reduce or eliminate long-term risk to life and property from hazards (FEMA, 2013). It is critical that the West Stockbridge Hazard Mitigation Plan not only identifies risks, but also assess the Town's vulnerability to those risks. To assess vulnerability, Town officials analyzed and considered risk data discussed in the previous section (Section 3, Risk Assessment), land use, population trends, location of critical facilities and transportation networks, and existing protection measures.

Land Use Planning and Zoning

As part of this Hazard Mitigation Plan, the Town of West Stockbridge conducted a self-evaluation of its existing policies, programs and resources that reduce hazard impacts and could be used to implement hazard mitigation activities. FEMA's Capability Assessment Worksheet, found within the Local Mitigation Planning Handbook (FEMA, 2013), was used as the evaluation tool for this exercise. The Town found that, in general, it already has in place many policies that serve as hazard mitigation strategies, including zoning and administrative tools to address hazards. Good communications exist between Town departments. However, the Town has few formal planning documents, including the Master Plan (from the 1970s, which is currently being updated) are outdated and do not consider natural hazard impacts. Although reviewed regularly, zoning bylaws have not been reviewed through the lens of natural hazard and climate change impacts.

As noted previously in this Plan, land within the 100-year floodplain covers a portion of land in West Stockbridge, including residential and commercial development. The Town has a floodplain zoning bylaw that requires that those who propose the erection of new structures and/or alteration or moving of existing structures must submit an application for a special permit to the Select Board that demonstrates that the construction, use or change of grade will not obstruct or divert the flood flow, reduce natural water storage or increase stormwater runoff. Subdivisions located partially or wholly within the Zone A of the Flood Insurance Rate Map shall take steps to avoid flood hazards.

Critical Resources and Facilities

A critical facility provides services and functions essential to a community, especially during and after a disaster, e.g. facilities housing incident command or emergency operations; medical facilities; schools and other buildings housing vulnerable populations; shelters; utility systems or power generating stations; transportation systems; and water and wastewater treatment plants. The West Stockbridge Wastewater Treatment is located just outside the 100-year floodplain, as well as critical emergency routes over Town roads and bridges.

Emergency Shelters

One alternative to mass sheltering is to promote sheltering in place, where residents weather the event in their own homes. When possible, sheltering in place can be preferable to moving residents to centrally-located shelters. This is especially important for residents who are located in areas that are remote and difficult to reach. This shelter option is also important for farmers and other independently-minded residents who are reluctant or refuse to leave their homes or their animals behind.

However, it is important to advocate sheltering in place only when the local residents are well-supplied with food, water and heat. Although some residents who live in remote areas have supplies and backup generators, their level of preparedness is varied, and even those who have purchased generators may not be properly educated on their use. If sheltering in place is determined to be a viable alternative to mass sheltering, the Town should conduct extensive outreach and education programs to ensure that residents are aware of how to properly and safely shelter in the event of an extended power outage or in the event that rescue teams cannot reach them.

The only time residents in West Stockbridge were advised to stay indoors was in August 2012, when a transformer recycling company in West Ghent, NY (approximately 10 miles west of southern Berkshire County) experienced a large commercial fire that sent a contaminated plume of smoke drifting across the region. Residents were advised to shelter in place and close their windows for one day as a precaution, particularly for those with respiratory illnesses. That alert was later cancelled when air currents shifted the plume's direction.

Business Risk

As noted in the Flood Risk Assessment Section of this Plan (Section 3.2), there are both residences and businesses located within the 100-year floodplain. Despite the risk, Town officials were not aware of any businesses that had suffered damages during the flood events.

West Stockbridge's Emergency Management

In West Stockbridge, two tiers of local emergency management are readily available: local fire and police response and the Southern Berkshire Regional Emergency Planning Committee (SBREPC) for southern regions of the Town as well as Richmond and Lenox ambulance services for the northerly regions of Town. For larger or more specific emergencies, state and federal assistance is available according to specific protocols.

Local emergency management planning and response and SBREPC are built upon the four components of emergency management: preparedness, mitigation, response, and recovery. Both formal and informal structures are focused on knowing what is needed and knowing how to get what's needed.

SBREPC is facilitated and assisted by Fairview Hospital's Emergency Management Director, as part of the hospital's community outreach support. This assistance is appreciated by local participants, many of whom are police or fire chiefs who do not have the individual resources or time to provide this coordination and depth of support. An example of this assistance is keeping a list of all communities' individual assets, available online by community. Monthly meetings provide ongoing education and updates; networking; and additional opportunities to know each member communities' resources and capabilities. All 911 calls are routed through a centralized call center, Berkshire Control, out of the Berkshire County Sheriff's Department in Pittsfield.

In West Stockbridge, Louis Oggiani is the Town's Emergency Management Director (EMD) and the Town's representative to SBREPC, thus fulfilling MEMA and FEMA's requirements that each town be part of a regional emergency planning committee (REPC).

SBREPC fulfills federal mandate and is fully credentialed by MEMA. Meeting monthly, it fulfills MEMA and FEMA requirements for training and specific exercises, such as hazard material transportation disaster training and related yearly exercises. SBREPC also provides training for other disasters and informal coordination for its members on matters which are beyond the coordination capacity of any single EMD. As a group, members of SBREPC coordinate and address sheltering, communications, and requirements for ambulance services, the importance of which the State recently recognized by funding a study to address gaps in these services. In addition, a representative of MEMA attends these meetings, providing more coordination and contact. Fairview Hospital's EMD is available to assist town's EMDs, as requested and her schedule allows.

While SBREPC may be viewed as an umbrella committee, each community has ultimate responsibility for its own emergency management planning and response. In West Stockbridge, the Emergency Management Director is in charge of the overall coordination, with the Select Board (the Town's Executive authority), of all resources needed to provide the required response. The Select Board has the authority to determine and issue an emergency declaration.

West Stockbridge uses a reverse 911 system to alert residents, second homeowners and businesses to impending disasters, as well as to stay in touch with them during a disaster. The system is tested regularly and people are encouraged frequently to update their contact numbers and how they wish to receive such information.

West Stockbridge's fire department is a volunteer department, led by a paid Fire Chief. As of August 2020, the fire department had 14 volunteers.

The fire department and the police department work extremely well together, with each having the lead on certain types of incidents and sharing responses on most others. The fire department takes the lead on fires; vehicular accidents involving personal injury or suspected personal injury; hazardous materials spills; fire alarms and carbon monoxide alarm activations; search and rescue; and medical calls. The police department has the lead on hazardous materials; matters of suspected or actual criminal activity; domestic and neighbor disturbances; and general safety, such as road safety. Both frequently respond to 911 calls, depending on available resources, and share a mutual focus on creating safety at the scene.

As is the case in most communities, West Stockbridge's fire department has informal mutual aid agreements with many surrounding communities. It is the Chief who makes the decision to call for mutual aid. That said, every volunteer has access to the priority list for mutual aid and can make that call if needed in the absence of a delegated fire department officer. Mutual aid is also relied on when the fire department is short on people, such as during a funeral or mutual aid exercises, with the responding town providing at least one vehicle and a crew to stand by at the fire station.

Berkshire County Sheriff's Control, (Berkshire Control), working with the Berkshire County Sheriff's Department and Berkshire County fire and police departments, is responsible for communications to and from fire departments; police departments; ambulance services; and all 911 dispatches. In West Stockbridge, all active firefighters are equipped with fire department pagers that receive Berkshire Control alerts and communications. Fire departments are in contact with Berkshire Control and ambulance services via 2- way radios. Berkshire Control is another resource for network, communications, and understanding the equipment and resources of individual fire departments.

Participation in NFIP and Floodplain Management

The existing protections in the Town of West Stockbridge are a combination of zoning, land use, and environmental regulations, infrastructure maintenance and drainage infrastructure improvement projects. Infrastructure maintenance generally addresses localized drainage clogging problems, while large scale capacity problems may require pipe replacement or invert elevation modifications. These more expensive projects are subject to the capital budget process and lack of funding is one of the biggest obstacles to completion of some of these.

West Stockbridge employs a number of practices to help minimize potential flooding and impacts from flooding, and to maintain existing drainage infrastructure. Such practices for town-wide mitigation measures include annual street sweeping, catch basin cleaning, and submission of a blanket Notice of Intent for roadway and drainage infrastructure along with frequent maintenance and repairs as needed.

Participation in the National Flood Insurance Program (NFIP)

West Stockbridge participates in the NFIP as of 12-2-20 the town has 36 policies in force as of July 5, 1982, covering just over $9 million in property value. FEMA maintains a database on flood insurance policies and claims. This database can be found on the FEMA website at: https://www.fema.gov/policy-claim-statistics-flood-insurance

The Town complies with the NFIP by enforcing floodplain regulations, maintaining up-to-date floodplain maps, and providing information to property owners and builders regarding floodplains and building requirements.

Floodplain District or Wetland Area Zoning Bylaw – Section 4.5 of the West Stockbridge Zoning bylaws states these areas are subject to restrictions set forth in Sections 6.4 and 6.5 of the Bylaws which specify the regulations to protect, preserve, and maintain the subject areas of land as well as regulations on work proposed for these areas including following the provisions of the Wetlands Protection Act, MGL c.131. §40.

Zoning regulations: The town is considering adopting a Stormwater bylaw.

Massachusetts Stormwater Policy: The Massachusetts Stormwater Policy is applied to developments within the jurisdiction of the Conservation Commission.

Existing Town-Wide Mitigation for Winter-Related Hazards

Standard plowing operations: The Highway Department provides standard snow plowing operations, including sidewalk plowing, to control the ice and snow accumulation for safety and environmental concerns including necessary maintenance for routine travel and emergency services.

The Town has a winter overnight parking ban which is issued by the Police Department to assist in the management of snow and ice removal by the Department of Public Works.

Section 5

Natural Hazard Mitigation Action Plan

Setting Goals

The Goal, Objectives and Actions within this Plan were developed as local vulnerabilities were being identified and concerns raised by the West Stockbridge Hazard Mitigation Advisory Committee and input received from local residents. The Advisory Committee adopted the following Goal:

Overall Goal: ***Protect the citizens, buildings and infrastructure, land, and cultural sites of West Stockbridge from any natural hazards and climate change.***

The analysis of historic disaster data and the concerns raised by emergency response were factors in the development of a series of "Major Findings" for the Town. These Major Findings list natural hazards that pose the greatest risks; highlighted what areas of West Stockbridge are most vulnerable to hazard/disaster impacts; and outlined priority actions. The summary of the Major Findings are as follows:

Major Finding #1: West Stockbridge's Most Serious Hazards

1. Severe Winter Storms
2. Flooding
3. Other Severe Weather (High winds and thunderstorms)

Major Finding #2: West Stockbridge's Vulnerability

1. Road-stream crossings at risk for failure with the shortest flood intervals as noted in The Housatonic Valley Association's Town of West Stockbridge Road-Stream Crossing Inventory

Major Objectives to meet the Goal and address Major Findings:

1. Repair/replace or upgrade culverts that are undersized and prone to flooding as well as bridges
2. Continue to enforce Town-wide Floodplain Bylaws
3. Reactivate, test, and use Town siren warning system, especially in extreme weather events

Prioritizing Actions

Although tornadoes have caused the most serious damages in Berkshire County in the last 50 years, their frequency, location and severity are unpredictable. Severe winter storms are serious, annual, relatively predictable events that are viewed as part of life in the Berkshires, although ice storms and rain-on-snow events are becoming more frequent and present different dangers. Flooding remains the natural hazard of most concern, being the end result of several natural hazards, including heavy snowfall/spring melt, ice jams, heavy rains from severe thunderstorms and hurricanes, and infrequently beaver activity. Flooding can also occur due to dam failure or poor stormwater management. Flooding is a natural hazard that can be mitigated, or lessened to some degree, through proper land use and structural improvements. Therefore, it is appropriate that flooding remain a major focus in future mitigation planning and implementation.

As part of the process of developing recommendations for new mitigation measures for this plan, the Town considered the issues related to new development, redevelopment, and infrastructure needs in order to limit future risks. Taking into consideration the Zoning and Bylaw changes adopted in recent years, and the Wetlands Act enforced by the Conservation Commission, the town determined that existing regulatory measures are taking good advantage of local Home Rule land use regulatory authority to minimize natural hazard impacts of development.

Table 5.4 demonstrates the prioritization of the Town's potential hazard mitigation measures. For each mitigation measure, the geographic extent of the potential benefiting area is identified as is an estimate of the overall benefit and cost of the measures. The benefits, costs, and overall priority were evaluated in terms of:

Table 5.1 Estimated Benefits Categories

Estimated Benefits	
High	Action will result in a significant reduction of hazard risk to people and/or property from a hazard event
Medium	Action will likely result in a moderate reduction of hazard risk to people and/or property from a hazard event
Low	Action will result in a low reduction of hazard risk to people and/or property from a hazard event

Table 5.2 Estimated Costs Categories

Estimated Costs	
High	Estimated costs greater than $100,000
Medium	Estimated costs between $10,000 to $100,000
Low	Estimated costs less than $10,000 and/or staff time

Table 5.3 Priority Categories

Priority	
High	Action very likely to have political and public support and necessary maintenance can occur following the project, and the costs seem reasonable considering likely benefits from the measure
Medium	Action may have political and public support and necessary maintenance has potential to occur following the project
Low	Not clear if action has political and public support and not certain that

	necessary maintenance can occur following the project

Geographic Coverage – Depending the mitigation action, it may be site specific, town-wide, or a specified area/location.

Lead Implementation – The designation of implementation responsibility was done based on a general knowledge of what each municipal department is responsible for. It is likely that most mitigation measures will require that several departments work together and assigning staff is the sole responsibility of the governing body of each community.

Time Frame – The time frame was based on a combination of the priority for that measure, the complexity of the measure and whether or not the measure is conceptual, in design, or already designed and awaiting funding. Because the time frame for this plan is five years, the timing for all mitigation measures has been kept within this framework. The identification of a likely time frame is not meant to constrain a community from taking advantage of funding opportunities as they arise.

Potential Funding Sources – This column attempts to identify the most likely sources of funding for a specific measure. The information on potential funding sources in this table is preliminary and varies depending on a number of factors. These factors include whether or not a mitigation measure has been studied, evaluated or designed, or if it is still in the conceptual stages. MEMA and DCR assisted MAPC in reviewing the potential eligibility requirements for hazard mitigation funding. Each grant program and agency has specific eligibility requirements that would need to be taken into consideration. In most instances, the measure will require a number of different funding sources. Identification of a potential funding source in this table does not guarantee that a project will be eligible for, or selected for funding. Upon adoption of this plan, the local team responsible for its implementation should begin to explore the funding sources in more detail. In addition, the best way to determine eligibility for a particular funding source is to review the project with a staff person at the funding agency. The following websites provide an overview of programs and funding sources.

Army Corps of Engineers (ACOE) – The website for the North Atlantic district office is: http://www.nae.usace.army.mil/. The ACOE provides assistance in a number of types of projects including shoreline/streambank protection, flood damage reduction, flood plain management services and planning services.

Massachusetts Emergency Management Agency (MEMA) – The grants page: https://www.mass.gov/hazard-mitigation-assistance-grant-programs describes the various Hazard Mitigation Assistance Programs.

Table 5.4 West Stockbridge Mitigation Measures Prioritization

Mitigation Action	Geographic Coverage	Estimated Benefit	Estimated Cost	Priority	Lead Implementation	Time Frame	Potential Funding Sources
Flood Mitigation							
Upgrade bridges noted as structurally deficient	Cone Hill Road Bridge	High	Low	Medium	Highway Dept.	3 years (Goal: 2024)	Town Appropriations
	West Center Road Bridge	High	Medium	Medium	Highway Dept.	5 years (Goal: 2026)	Small Bridge Grant
Replace or upgrade culverts that are undersized and prone to flooding as reported from Town Road-Crossing Study conducted by HVA	Town Wide	High	Medium	High	Highway Dept.	4-5 years (Goal: 2026)	Town Appropriations Grant Opportunities
Upgrade Town-wide drainage conveyances	Town Wide	High	Low	High	Highway Dept.	1-5 years (Goal: 2026)	Town Appropriations
Continue enforcement of flood management bylaws	Town Wide	High	Low	High	Building Insp. Planning/ Zoning Boards	5 years (Goal: 2026)	Operating Budget
Plan and enact a Town stormwater management bylaw	Town Wide	High	Low	Medium	Planning/ Zoning Boards Conservation Comm.	3-5 years (Goal: 2026)	Town Appropriations
Continue to mow and maintain large beaver dams. Breach as needed	Town Wide	Medium	Medium	Medium	Highway Dept.	2-3 years (Goal: 2024)	Operating Budget
Continue to prioritize roadway improvements	Town Wide	Medium	High	Medium	Highway Dept.	2-3 years (Goal: 2024)	Operating Budget Grant Opportunities
Major transportation routes	Town Wide	Medium	Low	Medium	Highway Dept.	2-3 years	Operating Budget

in inundation areas for dams of High or Significant Hazard have been determined.; Continue to update as necessary						**(Goal: 2024)**	
Encourage use of low-impact development techniques especially in flood-prone areas	**Town Wide**	**Medium**	**Low**	**Medium**	**Building Insp.** **Planning Board**	**2-3 years** **(Goal: 2024)**	**Town Appropriations**
Conduct loss estimates for inundation areas	**Town Wide**	**Medium**	**Medium**	**Medium**	**Building Insp.** **Highway Dept.**	**2-3 years** **(Goal: 2024)**	**Operating Budget**
Continue work to inform property owners in the floodplain about grant programs available to retrofit and/or flood proof structures	**Town Wide**	**Medium**	**Low**	**Medium**	**Building Insp.**	**2-3 years** **(Goal: 2024)**	**Operating Budget** **Grant Opportunities**
Mitigation Action	**Geographic Coverage**	**Estimated Benefit**	**Estimated Cost**	**Priority**	**Lead Implementation**	**Time Frame**	**Potential Funding Sources**
Dam Hazards Mitigation							
Continue to inspect all dams at appropriate intervals	**Town Wide**	**High**	**Medium**	**High**	**Highway Dept.**	**1-5 years** **(Goal: 2026)**	**Operating Budget**
Continue to maintain dams as necessary	**Town Wide**	**High**	**Low**	**Medium**	**Highway Dept.**	**1-5 years** **(Goal: 2026)**	**Operating Budget**
Mitigation Action	**Geographic Coverage**	**Estimated Benefit**	**Estimated Cost**	**Priority**	**Lead Implementation**	**Time Frame**	**Potential Funding Sources**
Drought Mitigation							
Work with MassSaves and other available water conservation programs to encourage residents to install water saving technologies; many of these devices are available at no or minimal expense.	**Town Wide**	**Medium**	**Low**	**Low**	**Water Dept.**	**5 years** **(Goal: 2026)**	**Grant Opportunities**

Mitigation Action	Geographic Coverage	Estimated Benefit	Estimated Cost	Priority	Lead Implementation	Time Frame	Potential Funding Sources
Landslide Hazards Mitigation							
Enforce timbering / clear cut regulations and other such land disturbing activities on slopes susceptible to erosion to avoid creating areas of bare ground subject to erosion and landslides.	**Town Wide**	**Medium**	**Low**	**Medium**	**Conservation Commission / Planning Board**	**3-4 years (Goal: 2025)**	**Operating Budget**
Provide the Building Commissioner, Planning Board, and Highway Department with the Slope Stability Map produced by Massachusetts Geologic Survey, for West Stockbridge.	**Town Wide**	**Medium**	**Low**	**Medium**	**Conservation Commission**	**3-4 years (Goal: 2025)**	**Operating Budget**
Mitigation Action	Geographic Coverage	Estimated Benefit	Estimated Cost	Priority	Lead Implementation	Time Frame	Potential Funding Sources
Fire Hazards Mitigation							
Reactivate and test the existing siren warning system	**Town Wide**	**Medium**	**Low**	**Medium**	**Police/Fire Depts.**	**1-2 years (Goal: 2023)**	**Operating Budget**
Continue to work with CSX Railroad to remove woody debris around tracks	**Railroad track areas**	**Medium**	**Medium**	**Medium**	**Highway Dept.**	**2-3 years (Goal: 2024)**	**Operating Budget**
Continue to monitor and fight brush and other fires	**Town Wide**	**Medium**	**Medium**	**Medium**	**Fire Dept.**	**5 years (Goal: 2026)**	**Operating Budget**
Mitigation Action	Geographic Coverage	Estimated Benefit	Estimated Cost	Priority	Lead Implementation	Time Frame	Potential Funding Sources
Invasive Species Mitigation							
Continue to monitor and inspect levels of invasive species with assistance from	**Card Pond and Shaker Mill Pond**	**Medium**	**Medium**	**Medium**	**Highway Dept. / Conservation Commission**	**3-5 years (Goal: 2026)**	**Town Appropriations Grant Opportunities**

Mitigation Action	Geographic Coverage	Estimated Benefit	Estimated Cost	Priority	Lead Implementation	Time Frame	Potential Funding Sources
Sōlitude Lake Management or similar environmental agency							
Mitigation Action	**Geographic Coverage**	**Estimated Benefit**	**Estimated Cost**	**Priority**	**Lead Implementation**	**Time Frame**	**Potential Funding Sources**
Hurricane & Tropical Storms Mitigation							
Have residents or seasonal residents self-identify their needs, such as the need for oxygen, to the Police and/or Fire Department may help to prevent problems during a disaster of any kind.	**Town Wide**	**Low**	**Low**	**Medium**	**Public**	**2-3 years (Goal: 2024)**	**Town Appropriations**
Continue to open gate valves on Shaker Mill Pond to lower water through early warning protection	**Shaker Mill Pond**	**High**	**Low**	**Medium**	**Highway Dept.**	**5 years (Goal: 2026)**	**Operating Budget**
Clean out / activate stormwater management systems to ensure free flow of water during heavy rain events.	**Town Wide**	**High**	**Medium**	**Medium**	**Highway Dept.**	**5 years (Goal: 2026)**	**Operating Budget**
Mitigation Action	**Geographic Coverage**	**Estimated Benefit**	**Estimated Cost**	**Priority**	**Lead Implementation**	**Time Frame**	**Potential Funding Sources**
Severe Winter Storm Mitigation							
Enforce snow load building code regulations	**Town Wide**	**Medium**	**Low**	**Low**	**Building Insp.**	**1-2 years (Goal: 2023)**	**Operating Budget**
Continue to encourage building owners to get energy audits and improve building efficiency to reduce human health risk due to extreme cold and power outages and reduce risk of	**Town Wide**	**Low**	**Low**	**Low**	**Building Insp.**	**5 years (Goal: 2026)**	**Grant Opportunities**

building damage such as ice dams.							
Continue to encourage older residents, disabled, and those with medical issues to self-identify with the West Stockbridge Police Department as having special needs during emergency incidents.	**Town Wide**	**High**	**Low**	**High**	**Public**	**1-2 years (Goal: 2023)**	**Town Appropriations**
Develop and deploy education program to inform residents of their responsibilities, primarily for themselves and neighbors, during power outages and extreme winter weather events.	**Town Wide**	**Medium**	**Low**	**Low**	**Private Utility Companies** **EMD**	**3-4 years (Goal: 2025)**	**Utility Company Sponsorship** **Grant Opportunities**
Explore Reverse 9-1-1 for cell phone users and encourage residents to sign-up.	**Town Wide**	**Medium**	**Low**	**Low**	**Police Dept. / EMD**		
Mitigation Action	**Geographic Coverage**	**Estimated Benefit**	**Estimated Cost**	**Priority**	**Lead Implementation**	**Time Frame**	**Potential Funding Sources**
Tornado Hazards Mitigation							
Activate and use Town siren warning system	**Town Wide**	**Medium**	**Low**	**Medium**	**Police/Fire Depts.**	**1-2 years (Goal: 2023)**	**Operating Budget**
Mitigation Action	**Geographic Coverage**	**Estimated Benefit**	**Estimated Cost**	**Priority**	**Lead Implementation**	**Time Frame**	**Potential Funding Sources**
Other Severe Weather Mitigation							
Continue strict adherence to MA Building Code	**Town Wide**	**High**	**Low**	**High**	**Building Insp.**	**5 years (Goal: 2026)**	**Operating Budget**
Encourage cell phone users to enlist in the Town's Reverse 9-1-1 system.	**Town Wide**	**High**	**Low**	**High**	**Public**	**1-2 years (Goal: 2023)**	**Town Appropriations**

Encourage the elderly, disabled, and those with medical issues to self-identify with the West Stockbridge Police Department as having special needs during emergency incidents.	**Town Wide**	**High**	**Low**	**High**	**Public**	**1-2 years (Goal: 2023)**	**Town Appropriations**
Develop and deploy education program to inform residents of their responsibilities, primarily for themselves and neighbors, during power outages and extreme weather events.	**Town Wide**	**Medium**	**Low**	**Low**	**Utility Companies** **EMD**	**3-4 years (Goal: 2024)**	**Grant Opportunities** **Private utility sponsorship**
Mitigation Action	**Geographic Coverage**	**Estimated Benefit**	**Estimated Cost**	**Priority**	**Lead Implementation**	**Time Frame**	**Potential Funding Sources**
Earthquake Mitigation							
Strict adherence to the state Building Code	**Town Wide**	**High**	**Low**	**High**	**Building Insp.**	**1-2 years (Goal: 2023)**	**Operating Budget**
Strict adherence and enforcement of state storage regulations for hazardous materials.	**Town Wide**	**High**	**Low**	**High**	**Fire Chief**	**1-2 years (Goal: 2023)**	**Operating Budget**
Mitigation Action	**Geographic Coverage**	**Estimated Benefit**	**Estimated Cost**	**Priority**	**Lead Implementation**	**Time Frame**	**Potential Funding Sources**
All Hazards Mitigation							
Assess modifications to Town Bylaws as needed regarding limiting the expansion of infrastructure in hazard-prone areas	**Town Wide**	**High**	**Low**	**Medium**	**Building Insp. Planning / Zoning Boards**	**2-3 years (Goal: 2024)**	**Town Appropriations**
Continue work to conduct local disaster response drills and feature them in local	**Town Wide**	**Medium**	**Medium**	**Medium**	**EMD** **Police/Fire**	**2-3 (Goal: 2024)**	**Operating Budget** **Grant Opportunities**

news media outlets					**Depts.**		
Continue to work with Southern Berkshire Regional Emergency Planning Committee to publicize local and regional evacuation routes and shelter locations	**Town Wide**	**Medium**	**Low**	**Medium**	**Highway Dept.** **EMD**	**3-4 years (Goal: 2025)**	**Operating Budget**
Continue work to develop formal and legally binding Mutual Aid Agreements for emergency response teams and DPWs	**Town Wide**	**Medium**	**Medium**	**Low**	**EMD**	**4-5 years (Goal: 2026)**	**Operating Budget**
Continue work to fill communications gaps by adding new towers where necessary, using existing towers and structure where possible	**Town Wide**	**Medium**	**High**	**Medium**	**Private Utility Companies** **EMD**	**3-5 years (Goal: 2026)**	**Operating Budget** **Grant Opportunities**
Continue work to increase local and regional emergency response training	**Town Wide**	**High**	**Medium**	**Medium**	**EMD**	**2-3 years (Goal: 2024)**	**Operating Budget** **Grant Opportunities**
Continue work to re-evaluate shelter capacity for West Stockbridge residents and determine each shelter's structural ability to withstand natural disaster events, including the Town Hall	**Town Wide**	**High**	**Medium**	**High**	**EMD**	**2-3 years (Goal: 2024)**	**Operating Budget** **Grant Opportunities**
Continue to expand and formalize local agreements for use of shared mass care shelters in the event of a disaster	**Town Wide**	**Medium**	**Low**	**Medium**	**EMD**	**3-4 years (Goal: 2025)**	**Operating Budget**

Continue to investigate option of shared regional shelters with neighboring communities	**Town Wide**	**Medium**	**Medium**	**Medium**	**EMD**	**3-4 years (Goal: 2025)**	**Operating Budget**
Continue to determine ability of town governmental centers to withstand a variety of natural hazard events	**Town Wide**	**Medium**	**Medium**	**Medium**	**Building Insp. EMD**	**3-4 years (Goal: 2025)**	**Operating Budget Grant Opportunities**
Continue to work to improve record keeping of local natural disasters and their impacts.	**Town Wide**	**Medium**	**Low**	**High**	**EMD**	**2-3 years (Goal: 2024)**	**Town Appropriations**
Continue work to educate local officials to help them develop plans to protect critical documents and materials	**Town Wide**	**Low**	**Low**	**Medium**	**EMD**	**3-4 years (Goal: 2025)**	**Operating Budget**
Work with West Stockbridge Historical Commission and identify historic structures, businesses, and critical facilities located in hazard-prone areas, including floodplains and dam failure inundation areas.	**Town Wide**	**Medium**	**Medium**	**Medium**	**Town Administrator/ EMD**	**2-3 years (Goal: 2024)**	**Operating Budget**
Provide workshops to help local historic properties and businesses to develop disaster mitigation plans for their facilities	**Town Wide**	**Medium**	**Medium**	**Medium**	**EMD**	**3-4 years (Goal: 2025)**	**Operating Budget Grant Opportunities**

The West Stockbridge Hazard Mitigation Plan 2021, including goals as outlined in here, will be utilized in future policy development, planning and zoning bylaws and changes, as well as with updates to other pertinent Town plans and/or developments of new plans. This plan will be posted on the Town Website and the Town Administrator, with assistance from the Town Public Works Superintendent and Emergency Management Director, will be responsible for ensuring the town planning efforts are consistent with the West Stockbridge Hazard Mitigation Plan 2021.

Section 6

References

Massachusetts State Hazard Mitigation Plan, October 2013

Massachusetts State Hazard Mitigation and Climate Adaptation Plan, September 2018

Slope Stability Map of Massachusetts, 2013, Massachusetts Geological Survey

Town of West Stockbridge Zoning Bylaws, 2020

Town of West Stockbridge Comprehensive Emergency Management Plan, 2021

Town of West Stockbridge Road-Stream Crossing Inventory, 2021, The Housatonic Valley Association

West Stockbridge Annual Report, 2019

West Stockbridge Annual Report, 2020

Certificate of Adoption
Select Board
Town of West Stockbridge, Massachusetts

A Resolution Adopting the
Town of West Stockbridge Hazard Mitigation Plan 2021

WHEREAS, the Town of West Stockbridge established a Committee to prepare the *Town of West Stockbridge Hazard Mitigation Plan 2021*; and

WHEREAS, the *Town of West Stockbridge Hazard Mitigation Plan 2021* contains several potential future projects to mitigate potential impacts from natural hazards in the Town of West Stockbridge, and

WHEREAS, duly-noticed public meetings were held by the LOCAL HAZARD MITIGATION ADVISORY Committee on August 19, 2020 and October 13, 2021.

WHEREAS, the Town of West Stockbridge authorizes responsible departments and/or agencies to execute their responsibilities demonstrated in the plan, and

NOW, THEREFORE BE IT RESOLVED that the Town of West Stockbridge Select Board adopts the *Town of West Stockbridge Hazard Mitigation Plan 2021*, in accordance with M.G.L. 40 §4 or the charter and bylaws of the Town of West Stockbridge.

ADOPTED AND SIGNED this Date, January 18, 2022

Select Board

Eric Shimelonis, Chairman

Roger Kavanagh, Select Board Member

Kathleen Keresey, Select Board Member