



WILLIAMSTOWN

MULTI-HAZARD MITIGATION PLAN UPDATE

Town of Williamstown, Massachusetts

June 2019



ACKNOWLEDGEMENTS

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The Town of Williamstown would like to thank the Williamstown Hazard Mitigation / Municipal Vulnerability Preparedness Committee (HM/MVP Committee), who served as the Advisory Committee for the Plan update, and who oversaw the planning process and completion of the plan update. The Berkshire Regional Planning Commission provided technical assistance to the HM/MVP Committee throughout the planning process.



OFFICE OF SELECT BOARD

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CERTIFICATE OF ADOPTION
TOWN OF WILLIAMSTOWN, MASSACHUSETTS
A RESOLUTION ADOPTING THE
WILLIAMSTOWN MULTI- HAZARD MITIGATION PLAN

WHEREAS, the Town of Williamstown authorized the Williamstown Hazard Mitigation and Municipal Vulnerability Committee to prepare the *Williamstown Multi-Hazard Mitigation Plan*; and

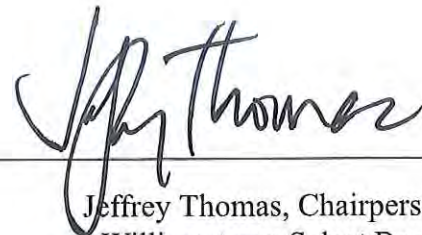
WHEREAS, the *Williamstown Multi-Hazard Mitigation Plan* contains several potential future projects to mitigate potential impacts from natural hazards in Williamstown, and

WHEREAS, a duly-noticed public meeting was held by the Williamstown Select Board on June 10, 2019, and

WHEREAS, the Williamstown Select Board authorizes responsible departments and/or agencies to execute their responsibilities demonstrated in the Plan, and

NOW, THEREFORE BE IT RESOLVED that the Williamstown Select Board adopts the *Williamstown Multi-Hazard Mitigation Plan*, in accordance with M.G.L. c. 40.

ADOPTED AND SIGNED June 10, 2019.



Jeffrey Thomas, Chairperson
Williamstown Select Board

TABLE OF CONTENTS

Section 1. Introduction and Background.....	1
Section 2. Planning Process.....	5
Section 3. Natural Hazard Risk Assessment	11
Section 4. Mitigation Strategies and Actions	123
Section 5. References.....	139
Appendices	141

SECTION 1. INTRODUCTION AND BACKGROUND

1.1. Purpose of the Williamstown Multi-Hazard Mitigation Plan

According to FEMA a hazard is defined as “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.” Hazard mitigation is defined as a “sustained action taken to reduce or eliminate the long-term risk to people and property from hazards and their effects.”

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 Multi-Hazard Plan is an update of the *Berkshire County Hazard Mitigation Plan*, dated November 5, 2012, a regional plan in which the Town of Williamstown was included with 18 other Berkshire County municipalities. Geographically this current plan update is a plan involving a single municipality, the Town of Williamstown, Massachusetts. During the development of this plan other hazard mitigation plans in the region were consulted, including the communities of Adams, Cheshire, Clarksburg, Lanesborough and New Ashford. The City of North Adams, the Town’s eastern neighbor, has not developed a Hazard Mitigation Plan. Additionally, the Municipal Vulnerability Preparedness (MVP) reports for the Towns of Adams and Lanesborough were consulted.

The Plan is designed to serve as a tool to help town officials identify hazard risks, assess the Town’s vulnerability to natural hazardous conditions, 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 region. This Plan should be used in conjunction with other local and regional plans, specifically other hazard mitigation plans and MVP reports, the Community Resilience Building Workshop Summary of Findings (product of Williamstown’s MVP project), and the Williamstown Comprehensive Emergency Management Plan (CEMP).

1.2. Background¹

The Town of Williamstown is located in northwestern Berkshire County, Massachusetts. The Town is bordered to the north by Pownal (VT), to the east by Clarksburg, North Adams, and Adams, to the south by New Ashford and Hancock, and to the west by Petersburg (NY) and Berlin (NY). Known as “The Village Beautiful,” the Town is approximately 47 square miles in size. The community sits in the fertile valley of the Hoosic River, including one major and two minor tributaries. The river valleys are surrounded by low mountains, with the Taconic Range along the Town’s western border and the Mount Greylock complex along the eastern border. The eastern mountain side of Mount Greylock, the state’s highest peak at 3,491 feet, and its associated peaks, drain into the Green River watershed. The mountains along the northern border are the southern reaches of the Green Mountains. The slopes of some mountainsides are steep, with some exceeding 15-25%. The Town has wide variability in elevation, ranging from a low elevation of 740 feet where the Hoosic River flows into Vermont to Mount Prospect of the Mount

¹ Main source for Background section unless otherwise noted: Town of Williamstown, 2016. *Williamstown’s Open Space and Recreation Plan, 2016 Revision*, Williamstown, MA.

Greylock complex at approximately 2,700 feet. Deep ravines cut by mountain streams are characteristic of the mountainsides on all sides of the town, visually demonstrated by the view of the Hopper from Route 7. According to a Build-out Study of Williamstown, land with slopes greater than 20% account for 55% of the total land area of Town. (Bachand, et al, NA)

Williamstown is a rural community, with the majority of land in an undeveloped state, with approximately 74% of the Town covered in forest and 13% in agricultural use or open fields. Residential land uses cover approximately 6% of the Town (MassGIS 2010). Development that does occur is located in the relatively flat and broad Hoosic River valley, with commercial development centralized in the downtown business sector and the Williams College campus. Residential development outside the Town Center is largely scattered along the major and rural roads. Refer to the topographic map in Figure 1.2.1.

Rural sprawl, a low-intensity, decentralized and scattered pattern of development, can consume open land, fragment forest and wildlife habitat in outlying areas and change the character of rural communities. Sprawl and a consumptive pattern of land development remains a problem in Berkshire County. Frontage lot, subdivision, and commercial strip development along major roads has continued to blur the boundaries between village and town centers and outlying rural areas. According to the Sustainable Berkshires Regional Plan, sprawling development patterns continue to slowly erode the very quality of life which makes the Berkshires a desirable place to live and visit. (BRPC, 2014)

In addition to the pattern of rural sprawl, new homes in the Berkshires are larger in size and being built on larger plots of land. Between 1950 and 1974 most residential units in the county were built on lots 0.25 - 0.50 acre. Since 1975 this trend changed significantly with many homes built on lots greater than five acres. Since 2000, 33% of the residential units built in Berkshire County have been built on lots greater than five acres. (BRPC, 2014) In Williamstown, the new single-family home development is the predominant development occurring outside of construction of institutional buildings by Williams College and the Clark Art Institute. New homes are generally being built along rural roadways.

According to a build-out analysis conducted by the University of Massachusetts, Amherst, approximately 13 building permits per year are issued by the Town of Williamstown during a five-year period, most consisting of residential construction or improvements (Bachand, et al, date unknown). However, building projects are also regularly conducted by Williams College. The build-out analysis found that 19% of Williamstown is free from building constraints and is available for development, consisting of 2,032 acres of residentially-zoned land and 15 acres of non-residentially-zoned land. Eighty one percent of the Town is not available because the land is already developed, is permanently protected (state and land trust ownership), or is constrained by being wetland resources or severely steep slopes of >20%. Land within the Town's Upland Conservation Overlay District was also considered unavailable for development due to the prohibition on residential development and other types of development limited solely to additions or accessory uses to existing facilities.

At the time of the 2010 U.S. Census, Williamstown had a population of 7,754 with 2,542 households. The population has decreased since the previous census in 2000, which recorded 8,424 residents. This trend is likely the result of declines in employment opportunities throughout the region, particularly in manufacturing. In addition to Town residents, approximately 2,000 undergraduate students are enrolled and live at Williams College. Census data shows a decreasing and aging population, with

decreasing percentages of people in the under 18 age categories and increasing percentages in the over 65 age categories.

The majority of total jobs in Williamstown are in service industries, the largest being educational and health services. The tourism sector, including creative economy institutions, also accounts for a significant portion of Williamstown's job mix. The Town's economy is diverse and includes a small agricultural and forestry presence, small business sector, art museums, large summer theater festival, tourist businesses such as lodging, restaurants, and shops, and health care industry. Williams College, which is the Town's largest employer, and is a significant source of jobs regionally, offers a range of job opportunities in food services, maintenance, office staff, administrative personnel, and highly specialized faculty. Some job losses in the healthcare industry have declined due to the partial closing of the North Adams Regional Hospital.

There are approximately 97 miles of roads in Williamstown, 52 of which are maintained by the Town, 21 of which are maintained by the MassDOT and 23 of which maintenance responsibilities lie with private owners or is unknown. According to MassGIS, there are 23 bridges and approximately 189 culverts in the Town, although the true number of culverts has not been verifiably quantified.

Figure 1.2.1. Topographical Map of Williamstown



SECTION 2. PLANNING PROCESS

2.1. Planning Committee

The Williamstown Community Development Department took the lead in developing the *Williamstown Multi-Hazard Mitigation Plan Update*, creating an advisory committee that consisted of municipal department heads, representatives from various town boards and committees, and representatives from the Mt. Greylock Regional School District, Williams College, Clark Art Institute, the Williamstown Fire Company, and other local stakeholders. Members of the Williamstown Hazard Mitigation / Municipal Vulnerability Preparedness Committee (HM/MVP Committee) are listed below in Table 2.1.1. Technical Assistance for the development of this plan were provided by the Berkshire Regional Planning Commission (BRPC).

Table 2.1.1. Williamstown Hazard Mitigation / Municipal Vulnerability Preparedness Committee

Name	Position
Henry Art	Williams College, Williamstown Conservation Commission
Sue Briggs	Chamber of Commerce
Joelle Brookner	Principal, Williamstown Elementary
Ryan Contenta	Building Commissioner
Kim Grady	Supt., Mt. Greylock School District
Andrew Groff	Director, Community Development Dept, Project Team Leader
Jason Hoch	Town Administrator; Workshop Project Team
Amy Jaschawitz	Planning Board
Kyle Johnson	Chief, Police Department
Timothy Kaiser	Director, Public Works
Jeff Kennedy	Board of Health Inspector
Tony King	Clark Art Institute
Jim Kolesar	President's Office, Williams College
Matthew Noyes	Clark Art Institute
Brian O'Grady	Director, Council on Aging
Craig Pedercini	Chief, Fire Department
Bill Powers	Clark Art Institute

The HM/MVP Committee formally began the planning process for the update of the hazard mitigation plan in January 2018, with funding from the Federal Emergency Management Agency (FEMA). The Town submitted its first draft plan for review to MEMA in February 2019. The HM/MVP Committee met three times, gathered and reviewed data on natural hazards that impact the Town, and reviewed the Mitigation Strategy and Action Plan from the expired Plan, noting areas that needed updating. Other planning documents and capital improvement plans relevant to hazard mitigation were reviewed and information incorporated as appropriate. These meetings were open to the public and complied with the Massachusetts Open Meeting Law.

During this same time period, with funding from the Massachusetts Executive Office of Energy and Environmental Affairs, the Town began to look more closely at natural hazards through the lens of climate change and began to develop strategies to become a more resilient community. The BRPC, a state certified Municipal Vulnerability Preparedness (MVP) provider, facilitated the planning process.

A central element of the MVP program is the planning and hosting of a Community Resilience Building Workshop, a day-long facilitated workshop attended by key officials and residents from a variety of disciplines and backgrounds. The HM/MVP Committee developed a list of stakeholders who would be valuable at such a workshop: those who would provide information and input from a variety of perspectives, including elected town officials, town department heads, first responders, business owners, farmers, and respected elders who had lived in Williamstown for a long time and/or had served on town boards in the past. Invitations to participate were sent from the Community Development Director's office.

On May 21, 2018 an all-day Community Resilience-Building Workshop was held at the Milne Public Library, attended by 27 town officials, residents and other stakeholders. The central objective of the workshop was to first review regional weather events from the past and climate change data and projections, then collect local data from attendees, and create a climate-related Natural Hazard Risk Matrix for the Town. As noted in the Workshop Agenda, the objectives for the day were to:

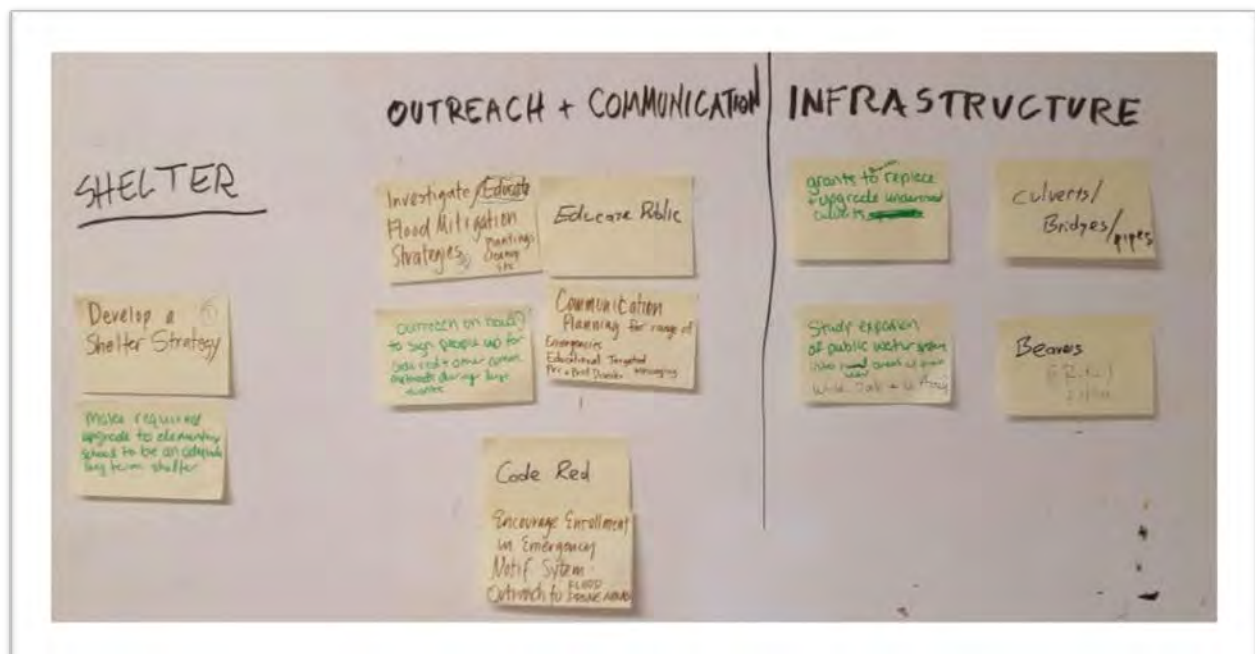
- Understand connections between ongoing issues, hazard, and local planning and actions in the Community; define top local natural and climate-related hazards of concern.
- Identify and map vulnerabilities and strengths to develop infrastructure, societal, and environmental risk profiles for the Community.
- Develop and prioritize actions that reduce vulnerabilities and reinforce strengths for your community – local organizations, academic institutions, businesses, private citizens, neighborhoods, and community groups.
- Identify opportunities to advance actions that further reduce the impact of hazards and increase resilience in the Community

The Workshop opened with a presentation about natural hazards that have been identified in the region and the Town, as determined by the HM/MVP Committee during their initial work to update the Town's Multi-Hazard Mitigation Plan. The presentation also provided background data on the observed changes in weather patterns in the region and future projections due to climate change. This presentation was tailored to provide a foundation upon which workshop participants could build. Posters were created to provide additional background data and offer potential mitigation ideas for consideration, such as low-impact development techniques. The posters were created in a scientific poster format.

After the presentation the Workshop followed the Community Resilience-Building Workshop format as described in the *Community Resilience Building Workshop Guide*. Participants were assigned to one of three small working groups, pre-assigned to provide a variety of perspectives and experiences at each table. At each table were handouts that would help to facilitate conversations, including a set of maps to help identify vulnerabilities. Participants were encouraged to write the areas of most concern on the maps. These maps edits were incorporated into a revised Critical Facilities and Areas of Concern Map. Each of the small working groups developed a Risk Matrix, identifying in their opinions the top four hazards that face the community, the Town's strengths and weaknesses in facing those hazards, and actions to lessen the impacts and build resiliency. The small groups convened at the end of the day to report their findings to the full group and, as a full group, to choose the highest priorities for action

On June 14, 2018 the Committee held an open public forum, inviting Town residents and other interested parties to learn about the Committee's work to date, hear the results of the Workshop and to solicit additional public input regarding the major findings. The forum opened with a viewing of informational posters developed as part of the Hazard Mitigation and MVP planning processes. A short presentation of findings followed the viewing, with the evening culminating in asking participants to rank the Actions that had been developed through the two planning processes. Participants at the forum ranked the Workshop's Top Priorities by marking the Top Three that they felt are the most pressing actions that the Town of Adams should pursue. The Top Actions that Received the most votes at the meeting revolved around three main themes: 1) Protect and Improve Infrastructure, 2) Enhance Public Outreach and Communications, and 3) Undertake Shelter Planning.

Fig. 2.1.1. Top Priorities from MVP Workshop



Source: HM/MVP Committee, 2018.

By focusing on multiple storm events and their impacts on infrastructure, business facilities and operations, neighborhoods and residents, Workshop attendees gained greater clarity on what lessons were learned from those experiences. More importantly, they gained insight into what procedures need to be improved, to make emergency preparedness and response, part of the fabric of the community. It was generally agreed that no single Town department had the resources to do all the strategic planning and implementation that is required. Attendees felt strongly that all community members, not just municipal boards and staff, needed to “take ownership” of emergency preparedness and response to hazards. Attendees felt that community ownership it was “doable” in this forward-thinking, tight-knit community. As a result of the MVP Workshop, the HM/MVP Committee was able to gather information and feedback from a more diverse set of voices, particularly residents’ perspectives on natural hazards and preparedness.

While many of the actions that emerged from the MVP Workshop mirrored those drafted by the HM/MVP Committee as part of its hazard mitigation planning process, workshop attendees prioritized the actions in a different way. The actions developed by the Committee through the hazard mitigation planning process prioritized municipal infrastructure needs while the actions developed through the MVP workshop raised a need for also prioritizing infrastructure needs but also voiced a need to increase outreach to residents about emergency communications and preparedness.

The Williams College community is an integral part of the greater Williamstown community, providing opportunities for students, faculty and local residents to become informed about and participate in discussions and actions on a wide variety of topics. On November 6, 2018 Williams College students held a public panel discussion about how climate change may be impacting Williamstown and what the Williams College community could do to help the Town become more resilient. Lauren Gaherty, the HM/MVP Committee's consultant, sat on the panel to report findings from the Town's hazard mitigation and MVP planning processes and to bring to the group a municipal government's perspective on addressing climate change. This panel discussion, which was broadcast on Williams College social media platforms, provided the opportunity to further engage and inform college students and faculty in the hazard mitigation planning process.

The HM/MVP Committee served as the core team in the development of this Multi-Hazard Mitigation Plan Update, reviewing hazard data generated by BRPC, commenting and editing draft report sections, evaluating the capacity, strengths and weaknesses of Town government, and drafting and prioritizing actions. The priority actions from both the Hazard Mitigation and MVP planning processes are reflected in the action plan offered in Section 4 of this report.

The *final Williamstown Multi-Hazard Mitigation Plan* is a compilation of data collected by BRPC, information gathered from the HM/MVP Committee during meetings, and interviews conducted with key stakeholders outside of working meetings. Interviews were specifically held with the Williamstown Council on Aging, Williams College and the Clark Art Institute. Updates on the findings of the Hazard Mitigation/ Municipal Vulnerability Preparedness planning processes and solicitation for feedback were given to the Williamstown Planning Board on January 8, 2019 and to the Williamstown Select Board on February 25, 2019, both meetings of which were publicly noticed and televised on community access television. Both boards were active participants in the HM/MVP planning process by sitting on the HM/MVP Committee and by having members attend the MVP Workshop. The Planning Board crafts land use policies and zoning amendments, and performs limited development permit review, including subdivisions, site plan reviews and Approval-Not-required projects. The Zoning Board of Appeals (ZBA), which reviews most development projects that proceed through the Special Permit process or requires a variance, was specifically invited to review the draft mitigation plan. The Director of Community Development, the Project Team Leader for the HM/MVP planning process, directly serves as staff to both the Planning Board and the ZBA. The Conservation Commission, which permits projects within wetland resource areas, including floodplain, participated in the HM/MVP process by sitting on the HM/MVP Committee and attending the MVP Workshop.

The draft *Williamstown Multi-Hazard Mitigation Plan* was offered for review and comment to Town residents and the general public February 25 through March 22, 2019. During this same period the Town issued direct invitations to the HM/MVP Committee members, Town boards and committees,

and to the neighboring Town of Pownal, VT, with which it has a close working relationship. The Town also issued a direct invitation to the neighboring Berkshire County communities of North Adams, Adams and Savoy through the informational channels of the Northern Berkshire Emergency Planning Committee; a second invitation was issued in person by Police Chief Johnson at a meeting of the REPC on March 21, 2019. Material involved in the public outreach and input process are found in Appendix C of this Plan.

Edits to the final Plan reflect comments provided by the HM/MVP Committee, local officials and citizens, MEMA and FEMA. Documentation of the Town's outreach program, including presentations and scientific posters used in public workshops and forums, are found in Appendix C of this Plan.

2.2. Coordination with Existing and Developing Planning Efforts

There are several documents and efforts that identify and address emergency and environmental concerns for Williamstown. The Town of Williamstown has a Comprehensive Emergency Management Plan (CEMP), which outlines an emergency management program for planning and response to potential emergency or disaster situations. The CEMP identifies and lists critical facilities and assigns responsibilities and functions, which will provide for the safety and welfare of its citizens against the threat of natural, technological, and national security emergencies and disasters. The plan addresses the Mitigation, Preparedness, Response and Recovery aspects of emergency management organizations, programs, protective actions, and specific hazards. Critical infrastructure and vulnerable populations were identified and verified using the CEMP and drawing on local first responder knowledge.

Regionally, Williamstown is an active member of the Northern Berkshire Regional Emergency Planning Committee (NBREPC), which is made up of nine towns in the northern Berkshire region. The NBREPC's priority is to minimize the risk to public safety, health and property through the development of a Regional Hazardous Materials Emergency Response Plan and a database of resources, equipment, and personnel that can be drawn on upon in an emergency. Although the primary responsibility of the NBREPC is to address hazardous materials, the organization has taken a broad emergency planning role that includes the full range of emergency and disaster planning and response.

More specifically this Multi-Hazard Mitigation Plan draws upon information found in the following plans:

- *Williamstown CEMP* (date unknown)
- *Williamstown, MA, Community Resilience Building Workshop Summary of Findings* (2018)
- *Williamstown's Open Space and Recreation Plan* (2016)
- *Berkshire County Hazard Mitigation Plan* (FEMA approved 2013)
- *Williamstown Master Plan*, (2002)
- *Williamstown Build-Out Analysis* (date unknown)
- Hazard Mitigation Plans of Adams, Clarksburg, Cheshire, New Ashford and Lanesborough
- *Massachusetts State Hazard Mitigation Plan* (FEMA approved 2013)
- *Massachusetts Climate Adaptation Plan*
- Pandemic Preparedness Plans (through Berkshire County Boards of Health Association [BCBOHA])
- *The Northern Berkshire Regional Shelter Plan* (developed through WRHSAC, CREPC and BCBOHA)
- Regional Evacuation Plans (developed through WRHSAC)

2.3. Plan Maintenance and Updates

The Williamstown Community Development Department is the steward of the *Williamstown Multi-Hazard Mitigation Plan of 2019*. The Town's expired Plan of 2012 was part of a regional, county-wide plan. Since that Plan was adopted there has not been an ongoing local process to guide hazard mitigation implementation for the Town of Williamstown. Such a process is needed over the next five years for the implementation of this Plan update and will be structured as described below.

After approval of the plan by FEMA, the HM/MVP Committee will continue to meet and function as the Hazard Mitigation Implementation Team, with the Community Development Director designated as the coordinator. Additional members could be added to the local implementation team from businesses, non-profits and institutions.

It has determined that the Plan should be reviewed and revised as appropriate every two years with the HM/MVP Committee. When the Plan is in its third or fourth year, the Community Development Department 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 Town will encourage public participation during the next five-year planning cycle. As updates and a review of the Plan are conducted by the Hazard Mitigation Implementation Team, these will be placed on the Town's web site and Town facebook pages, and any meetings of the Hazard Mitigation Implementation Team will be publicly noticed in accordance with Town and state open meeting laws.

SECTION 3. NATURAL HAZARD RISK ASSESSMENT

3.1. Identifying Hazards

As defined by FEMA, a natural hazard is a source of harm or difficulty created by a meteorological, environmental or geological event. Vulnerability is defined as the characteristics of community assets that make them susceptible to damage from a given hazard. A risk assessment is a produce or 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 Williamstown. The Town chose to investigate the 18 natural hazards that are identified and discussed in the *Commonwealth of Massachusetts State Hazard Mitigation Plan*. Two of the hazards, Coastal Hazards 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 other 16 hazards are grouped in nine categories that best fit their weather pattern and impact upon the Town (see Table 3.1.1.). The Town has added a natural hazard, that of beaver activity, to the list of hazards that are addressed in this plan.

To determine which natural hazards have the greatest potential to impact the town, the hazards were analyzed for their Area of Impact, Frequency of Occurrence and Severity. Refer to Table 3.1.2. for a matrix displaying the natural hazards and their ranking.

Table 3.1.1. Natural Hazards that Impact Williamstown

Hazard	Category
Flood (Including Ice Jam and Beaver Activity)	Flood
Dam Failure	Dam Failure
Hurricane / Tropical Storm	Hurricane
Nor'easter	Severe Winter Weather
Snow & Blizzard	Severe Winter Weather
Ice Storm	Severe Winter Weather
Thunderstorm	Severe Weather
High Winds	Severe Weather
Tornado	Severe Weather
Drought	Drought
Extreme Temperature	Severe Weather
Wildland Fire	Fire
Major Urban Fire	Fire
Earthquake	Earthquake
Landslide	Landslide
Coastal Hazards	Not Included
Tsunami	Not Included

Table 3.1.2. Hazards that have the greatest potential to impact Williamstown

Hazard	Area of Impact Rate	Frequency of Occurrence Rate	Magnitude / Severity Rate	Hazard Ranking
	1=small 2=medium 3=large	0 = Very low frequency 1 = Low 2 = Medium 3 = High Frequency	1=limited 2=significant 3=critical 4=catastrophic	
Flooding (include Ice Jam, Beaver Activity)	2	3	2	7
Severe Winter Event (Ice Storm, Blizzard, Nor’easter)	3	2	2	7
Severe Storms (High Wind, Tornado, Extreme Temperature)	3	2	2	7
Hurricane & Tropical Storms	3	2	2	7
Drought	3	1	1	5
Tornado	1	0	4	5
Earthquake	2	0	2	4
Urban & Wildfire	2	1	1	4
Dam Failure	1	0	2	3
Landslide	1	0	1	2
Area of Impact				
1=small	isolated to a specific area of town during one event			
2=medium	occurring in multiple areas across town during one event			
3=large	affecting a significant portion of town during one event			
Frequency of Occurrence				
0=Very low frequency	events that have not occurred in recorded history of the town, or that occur less than once in 1,000 years (less than 0.1% per year0			
1=Low frequency	events that occur from once in 100 years to once in 1,000 years (0.1% to 1% per year)			
2=Medium frequency	events that occur from once in 10 years to once in 100 years (1% to 10% per year)			
3=High frequency	events that occur more frequently than once in 10 years (greater than 10% per year)			
Magnitude/Severity				
1=limited	injuries and/or illnesses are treatable with first aid; minor” quality or life" loss; shutdown of critical facilities and services for 24 hours or less; property severely damaged < 10%			
2=significant	injuries and/or illnesses do not result in permanent disability; shutdown of several critical facilities and services for more than one week; property severely damaged < 25% and > 10%			
3=critical	injuries and/or illnesses result in permanent disability; complete shutdown of critical facilities for at least two weeks; property severely damaged < 50% and > 25%			
4=catastrophic	multiple deaths; complete shutdown of facilities for 30 days or more; property severely damaged> 50%			

Source: Table developed by BRPC 2005.

3.2. Flood Hazards

3.2.1. General Background

As noted in the Massachusetts SHMP, floods are among the most frequent and costly natural disasters in terms of human hardship and economic loss — 75% of federal disaster declarations are related to flooding. Property damage from flooding totals over \$5 billion in the United States each year. The high costs of flood response and reparations are the reason that the National Flood Insurance Program has been established. Flooding is the result of several types of natural hazards, the impacts of which can be exacerbated by development and local land-use practices, which is why it is so important that communities review and consider the effectiveness of their land use regulations and policies as part of their hazard mitigation planning process. (MEMA, 2013)

As part of this 2018 update, the Town of Williamstown has gathered the most updated and best available data, including historical occurrences, the severity and/or recurrence interval information where available, and potential trends into the future. This gathering of information also includes that provided by local data provided by emergency responders, public works staff, local officials, staff from Williams College and other institutions, business leaders and long-time residents. This update also looked at flood claims and repetitive losses in Williamstown. HAZUS has been utilized to aid in analyzing risk, potential losses, and damages. Taken together this information helps town officials and emergency management personnel gauge the scope of natural hazard events and assess their likelihood of reoccurring.

Common Types of Floods

The hazards that produce local or regional flooding in the region include hurricanes, tropical storms, heavy rain events, winter rain-on-snow, thunderstorms, and beaver activity. Storms coinciding with spring melt are historically common, with winter cycles of snow followed by rain becoming more common. Flash flood regimes are common in the region due to the hilly terrain and thin soil that supports headwater streams and rivers. Stream and riverine flooding often occurs after heavy rain events, filling steeply sloped stream channels that rapidly discharge into larger streams rivers. Naturally occurring accelerated runoff occurs when soils are not able to absorb rainfall such as when soils are already saturated or when the ground is frozen. (MEMA, 2013)

Man-made accelerated runoff occurs where development has created impervious surface areas, most particularly where runoff has been channeled and discharged into streams and rivers that are already swollen from natural runoff. Channeling and discharging runoff bypasses the natural processes whereby vegetated cover and uncompacted soils attenuate some portion of surface runoff through infiltration and uptake. Capturing, channeling and discharging runoff results in higher volumes of water reaching streams and river in an accelerated timeframe, causing greater stream and riverbank erosion, and higher debris and sediment loads.

Flooding of land also occurs when stream and river channels, bridge spans, culverts or drainage channels cannot accommodate the volume of water flowing through their system. Undersized culverts and bridge spans constrict flood waters, causing them to back up and flood properties upstream of the

constriction. The flooding associated with Christmas Brook at the Green River is an example of this type of flooding.

Urban flooding can occur when the amount of heavy snowmelt and/or rain events is too great to flow through storm drain systems. Backup and ponding of water can flood streets and properties, and manhole covers can be lifted out of position. Discharge of stormwater into rivers and streams can be blocked by floodwaters if the storm drain outlets themselves are under water, and in some instances stream/river water can flow back up into drainage systems and flood the urban areas served by the storm drain system. Flooding of some roadways can isolate homes and neighborhoods, and emergency response and evacuations routes can become impassable. (MEMA, 2013) The flooding in Water Street is due partially to a significant percentage of impervious surface area and outdated/undersized stormdrain systems and high storm flows in Christmas Brook.

Beaver activity can cause flooding in a variety of ways due to their instinct to create ponding and to react to flowing water. Damming streams and wetland outlets cause flooding that can expand areas of inundation upstream and outward, which can threaten the built environment. If the impoundment impacts a drinking water supply, it can threaten human health. Beavers can also cause flooding due to their propensity to block culverts, threatening not only the road crossing but possibly properties upstream. (MEMA, 2013)

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 in a typical year. It should be understood, however, that these measurements reflect statistical averages only; 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. A structure located within a the 100-year flood area on the NFIP maps has on average a 26% percent chance of suffering flood damage during the term of a 30-year mortgage. (MEMA, 2013). However, as noted in the FIRMs, the areas shown within the 100-year flood boundaries are for flood insurance only; they do not necessarily show all areas in a community subject to flooding.

Table 3.2.1. Recurrence Intervals and Probabilities of Occurances

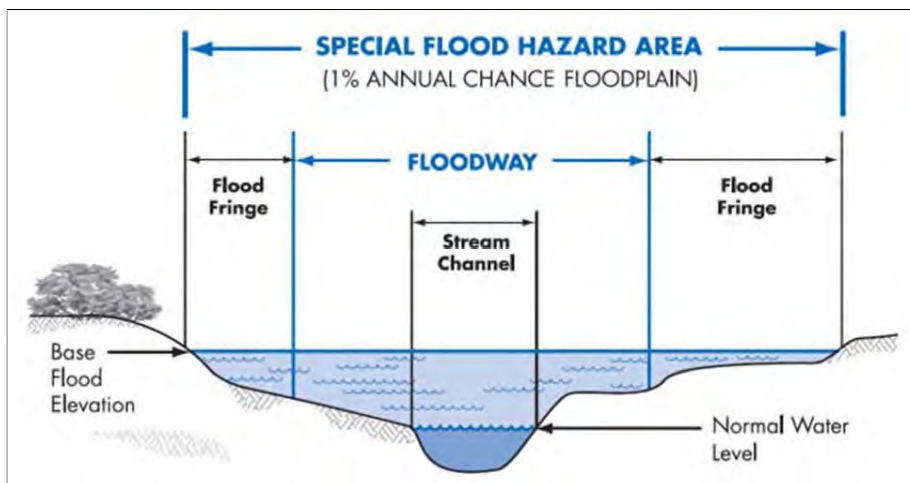
Recurrence interval,	Probability of occurrence	Percent chance of
500	1 in 500	0.2
100	1 in 100	1
50	1 in 50	2
25	1 in 25	4
10	1 in 10	10
5	1 in 5	20
2	1 in 2	50

Flood flows in Massachusetts are measured at numerous USGS stream gages, with two gages that reflect river flows in Williamstown. One gage is located on the Hoosic River in North Adams, 0.8 miles upstream of the Williamstown/North Adams municipal boundary (USGS #01332500). The second gage is located on the Green River in the town center (USGS #01333000), just upstream of the Main Street/Route 2 road crossing, and 0.7 miles upstream of the river's discharge into the Hoosic River. Typically, in the aftermath of a flood event, USGS will determine the recurrence interval of the event using data from the gage's period of historical record.

Floodplains and Wetlands

A floodplain or floodway is the area adjacent to a stream, river, or lake that becomes inundated during a flood. In the Berkshires these areas most often flood during spring melt and during high rain events, and inundation is often fairly common and expected, and are 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 deep channel. 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 the 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 are built in this floodway/floodplain area that constricts or impede flows, such as when roads cross this area and bridges and culverts are undersized. Figure 3.2.1. depicts the floodway and 100-year flood hazard areas of a floodplain. (MEMA, 2013)

Fig. 3.2.1. Flood-Prone Areas Typically Associated with Streams and Rivers



Source: (MEMA, 2013)

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. These are often important aquifers, the water drawn from them being filtered compared to the water in the stream, and can serve as sources of drinking water supplies. (MEMA, 2013) There are medium-yield and high-yield aquifers in soil layers flowing under the Hoosic River corridor, and there is a narrow aquifer flowing under Hemlock Brook (shown in yellow hatching on the Critical Facilities and Areas of Concern Maps in Appendix A). These aquifers are not currently sources of public drinking water wells.

Floodplains are among the most species-rich ecosystems in the world. The biodiversity of a natural floodplain is extraordinary, due to the mix of soils, hydrologic regimes and vegetated habitats that occupy these areas. Floodplains are the habitat that connects the truly aquatic ecosystems with the truly upland ecosystems, providing the habitats needed many aquatic-based and terrestrial-based wildlife. They have historically been converted to agricultural uses in New England due to their often fertile and deep soils and relatively level terrain. Further floodplain lands were developed as flowing waterways provided the power needed by industrial uses and the towns and cities that developed around them. (MEMA, 2013)

Human activity in floodplains frequently interferes with the natural function of floodplains. It can affect the distribution and timing of drainage, thereby increasing flood problems. Human development can create local flooding problems by altering or confining drainage channels. This increases flood potential in two ways: it reduces the stream's capacity to contain flows and it increases flow rates or velocities downstream during all stages of a flood event. Human activities can interface effectively with a floodplain if steps are taken to mitigate the activities' adverse impacts on floodplain functions. (MEMA, 2013). It is for these reasons that maintaining riverine floodplains in an undeveloped and natural state is so important to flood control. While some portions of the floodplain in Williamstown have historically

been cleared for farming and development, particularly areas along the Hoosic and Green Rivers, the majority of floodplains in the Town are currently undeveloped.

Secondary Hazards

In the Berkshire region rivers and streams tend to be dynamic systems, with stream channel and bank erosion common in both headwater streams and in the level, meandering floodplains of the Housatonic and Hoosic Rivers. Fluvial Erosion is the process where the river undercuts a bank, usually on the outside bend of a meander, causing sloughing and collapse of the riverbank. Fluvial erosion of stream and riverbanks can creep towards the built environment and threaten to undercut and wash away buildings, roads, and bridges. Many roads throughout the region follow streams and rivers, having been laid in the floodplain or carved along the slopes above the bank. Older homes, barns and other structures were also built in floodplain or just upgradient of stream channels in both rural and urban areas. Fluvial erosion can also scour and downcut stream and river channels, threatening bridge pilings and abutments. This type of erosion often occurs in areas that are not part of a designated floodplain. (MEMA, 2013)

Flood waters can increase the risk of the creation of and dislodging of ice dams during the winter months. Blocks of ice can develop in streams and rivers to create a physical barrier or dam that restricts flow, causing water to back up and overflow its banks. Large ice jam blocks that break away and flow downstream can damage culverts, bridges and roadways whose openings are too small to allow passage. (MEMA, 2013)

Electrical power outages can occur during flood storm events, particularly when storm events are accompanied by high winds, such as during hurricanes, tropical storms, thunderstorms and micro-bursts. Fortunately, most flooding in the Berkshire region is localized and have resulted in few wide spread outages in recent years, and where it occurs service has typically been restored within a few hours.

Landslides on steep slopes can occur when soils are saturated and give way to sloughing, often dislodging trees and boulders that were bound by the soil. The damage from Hurricane Irene in 2011 to Route 2 in the Florida/ Charlemont area was a combination of fluvial erosion from the Cold and Deerfield Rivers and a landslide on the upland slope of the road.

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). In addition to the 10 dams in Williamstown, the town is in the inundation area the Mount Williams Reservoir Dam in North Adams. A more thorough discussion of the Town of Williamstown's risks due to dam failure are discussed Section 3.6. of this plan.

Flooding of wastewater treatment facilities can not only inflict costly damages to buildings and other structures, it can cause the release of untreated effluent into receiving waters. Storm drain systems that direct high volumes of runoff into the sewer system during storm events can overwhelm the capacity of the receiving wastewater treatment facility, causing the release of untreated or undertreated effluent. (MEMA, 2013). This is true of the Hoosac Water Quality District treatment plant, a regional system that collects and treats wastewater from Clarksburg, North Adams and Williamstown. The centralized treatment facility for the system, which is located on Simonds Road in Williamstown, discharges into the Hoosic River northeast and downstream of the Town center. The facility has a history of being

overwhelmed during high spring flows and rain events because of significant infiltration and inflow (I&I) into the pipe delivery system. When the treatment facility is not able to handle the increases in flow, incompletely treated or untreated flows are discharged into the Hoosic River, increasing flood flow volumes at the treatment plant's discharge point and negatively impacting water quality due to increased bacterial and other contaminant concentrations. It is believed that the majority of I&I enters the system in North Adams, upstream of Williamstown. While Williamstown has taken steps to control I&I within its own system, the City of North Adams has been unable to seriously address I&I due to financial constraints.

Flooding of homes and businesses can impact human safety 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.

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.

Climate Change Impacts

Based on data gathered from the Northeast Climate Science Center (NCSC), based in UMass Amherst, the yearly precipitation total for Berkshire County has been experiencing a gradual rise over the last 70 years, rising from 40.1 inches in the 1960's to 48.6 inches in the 2000's. According to projections from the NCSC, the county is projected to experience an additional 3.55 inches by the 2050's and 4.72 inches by the 2090's. (NCSC, 2018)

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 NCSC predicts that annual increases of 3.3° to 7.0° F will occur in the Hoosic River Watershed by mid-century, with the greatest increases in the winter season. More mid-winter cold/thaw weather patterns 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.

Studies have also reported increases in precipitation in both developed and undeveloped watersheds across the northeast, with the increases being observed over a range of precipitation intensities, particularly in categories characterized as heavy and extreme storm events. These events are expected to increase both in number and in magnitude. Some scientists predict that the recurrence interval for

extreme storm and flood events will be significantly reduced. One study concluded that the 10-year storm may more realistically have a recurrence interval of 6 years, a 25-year storm may have a recurrence interval of 14 years and the 100-year storm may have a recurrence interval of 49-years. The same study predicts that if historic trends continue that flood magnitudes will increase, on average, by almost 17%. (Walter & Vogel, 2010)

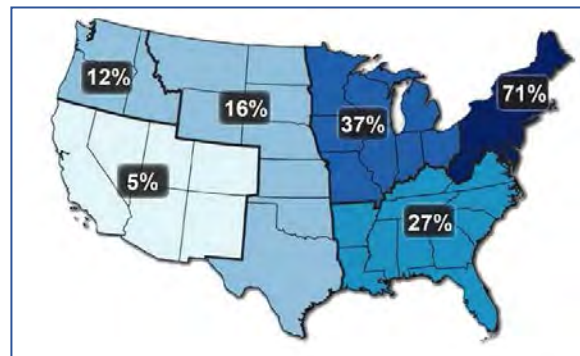
Data from at USGS streamflow gages across the northeast show a clear increase in flow since 1940, with an indication that a sharp “stepped” increase occurred in the 1970s. This is despite the fact that much of the land within many New England watershed has been reforested, and this type of land cover change would tend to reduce, rather than increase, flood peaks (Collins, 2008).

Climate change will likely alter how the region receives its precipitation, with an increase of it falling in the form of severe or heavy events. The observed amount of precipitation falling in very heavy events, defined as the heaviest one percent of all daily events, has increased 71% in the Northeast between 1958-2012.¹

The NCSC also predicts that in the Hoosic River Watershed there will an increase in the number of days with at least 1 inch of precipitation from 4.5 days in the 1960s, to 5.9 days in the 2000s to up to 8.3 days in 2050s and to up to 9.4 days in 2090s. (NCSC, 2018) Already observed in Massachusetts, the number of extreme precipitation events, those defined as more than two inches in one day, has increased since the the 1980s, with the greatest increase in the past decade (see Fig. 3.2.3)².

This trend has direct implications on the design of municipal infrastructure that can withstand extreme storm and flood events, indicating that all future designs must be based on them most updated precipitation and stream gauge information available. 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 increased flows that are predicted.

Fig. 3.2.2. Increase in Precipitation Falling in Top 1% Extreme Precipitation Events 1958-2012 Engineering



Source: NOAA, adapted from Karl, et al, 2009.

Fig. 3.2.3. Number of Extreme Precipitation Events of 2" or more in 1 Day



Source: <https://statesummaries.ncics.org/ma>

¹ NOAA - <https://toolkit.climate.gov/image/762>, adapted from Karl et al.

² <https://statesummaries.ncics.org/ma>

Already the engineering and regulatory sectors have recognized the increase in precipitation. The long-used TP-40 method for sizing stormdrain system has been replaced by NOAA Atlas 14 and other methods. As shown in Fig. 3.2.4, the design for a 24-hour 100-year storm event has been increased to accommodate a greater amount of water.

Fig. 3.2.4. Engineering Standard Changes

Change in 24-hour, 100-year Design Storms (inches)			
	NOAA TP-40	NOAA Atlas 14	Change
Boston	6.6	7.8	+1.2"
Worcester	6.5	7.6	+1.1"

It may be prudent, therefore, to slightly 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 slight increase in size may provide a large increase in capacity, and for very little increase 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 so that they can increase their holding capacity for extreme storm events with little incremental cost. The size of the engineered soil media, which is a costly component of the system, may remain the same size as current designs call for, 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 historic trends.

3.2.2. Hazard Profile

Location

Williamstown is located within the Hoosic River watershed. The Hoosic River enters Williamstown from North Adams on its eastern border, flowing through the northern section of the Town for 4.6 miles and into Vermont, after which the river eventually crosses into New York State and joins the Hudson River. The Hoosic River's major tributary in Williamstown is the Green River, whose main and secondary branches converge just north of Five Corners to flow north along Green River Road corridor (aka Route 43), through the center of the village, flow under Water Street and Main Street (aka Route 2) to join the Hoosic near the former railroad yards. Hemlock Brook is another tributary that flows north along the Route 7 corridor, joining the Hoosic River just downstream of the wastewater treatment plant. Flows in the Hoosic and Green Rivers reach their mean peak in the spring months at 300 cubic feet/second (CFS) and their mean low in early fall at 40 CFS.

The Town of Williamstown has relatively little floodplain areas. The floodplains of particular note are associated with the Hoosic and Green Rivers, particularly in the town center. The floodplain widens in the vicinity of the confluence of the Green River and Hoosic River as the rivers reach their valley bottoms. The main areas of flooding are typically along the Hoosic and Green Rivers, where flooding can occur during regular spring melt and during storms. Broad Brook is an area of concern, giving its steep slope, sediment transport and prominence of large boulders. The brook transports large amounts of sediment, cobbles and large boulders during storm events, where during higher flood events workers can hear large boulders being pushed downstream by flood waters and hitting the footings of the bridge. The sediment and debris transported by the brook fills the stream channel where it flows under Route 7, threatening to block water flow and cause extensive flooding of the area and the road. Local

workers have nicknamed the brook “the boulder field” at the Route 7 crossing. Historically heavy equipment was used in the stream to remove boulders and sediment, but this practice is now limited due to wetlands permitting, and it is unlikely that heavy equipment would fit under the bridge due to boulder/sediment buildup. Although MassDOT installed a bridge in the early 2000s designed to withstand the stress of such events, it is still an area of concern. During Tropical Storm Irene in 2011, water was splashing up against the bridge deck, but did not overtop it. It is believed that the cobble and boulder removal work done two years prior, under an emergency order, was the reason that the bridge did not overflow or become damaged. The location of major streams, rivers and floodplain areas, and areas of concern for flooding, can be seen in the topographic map in Section 1 and Figure 3.2.6. of this Plan.

Another area of concern is flooding along the Pan Am Rail corridor. Some area of the railroad track become inundated and there is concern that areas of the tracks could becoming undermined due to flooding from storms and beaver activity. The railroad does not communicate regularly with local officials and first responders despite requests to do so. The railroad does not share information on the types and volumes of hazardous materials being transported along the railroad line, making is difficult and potentially dangerous for local and regional emergency responders to plan to respond to a train derailment due to flooding or other causes.

Previous Occurrences

As part of gathering flood data for this updated Plan, data was gathered from the Massachusetts Hazard Mitigaion Plan of 2013 and from other sources for more recent data, including the National Weather Service, NOAA, and local sources. Between 1936 and 2017, four flood events equaling or exceeding the 1% annual chance flood have been documented the Berkshire County region: 1938, 1949, 1955 and 2011. The most recent flood event, Tropical Storm Irene in 2011, has been calculated to be at least a 1% chance (also referred to as a 100-year return interval) at the USGS stream gage in the Hoosic River in North Adams (USGS #01332500). This same event was calculated to be a 2%, or 50-year storm, at the Green River Gage (USGS #013333000).³ Refer to Table 3.2.2. for a list of flood events impacting the Berkshire County region. Those events that exceeded flood stage of nine feet at the Hoosic River USGS gage are bolded to provide a more local perspective of the event.

Table 3.2.2. Previous Flooding Occurrences in the Berkshire County region

Year	Description of Event
1936	Widespread flooding occurs along the northern Atlantic in March 1936. Widespread loss of life and infrastructure. Many flood stages are discharges highest of record at many USGS stream gages. ⁴
1938	Known as the Great New England Hurricane of 1938, with prolific rain event. This storm was considered a 1% annual chance flood event in several communities and is considered the flood of record for the Hoosic River Valley. ⁵ The former gage for this is located on the Hoosic River 3.5 miles upstream of Williamstown. The Hoosic River flooded downtown areas of densely-developed Adams and North Adams, with loss of life and extensive damage to buildings.

³ Bent, Gardner, USGS, personal email communication, 2-19-15.

⁴ Grover, Nathan C., 1937. *The Floods of March 1936, Part 1. New England Rivers*. USGS, Wash. DC.

⁵ Army Corps of Engineers, Flood Control Project, Technical Memorandum NO. 2-338 (June 1962)

	Williamstown suffered significant bridge damages and losses occurred, including the loss of the Wally Bridge on Main Street/Route 2.
Dec. 31, 1948 – Jan. 1, 1949	The New Year's Flood hit the Berkshire region with many of areas registering the flood as a 1% annual chance flood event; it was the flood of record for the current flood gage on the Hoosic River.
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 over between 2.5-5" of rain throughout the region and produced significant flooding throughout the region. Due to the significant amount of rain and the 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, however this and the unseasonable temperatures caused a rapid melting of the snow pack.
August 2003	Isolated thunderstorms developed that were slow moving and prolific rainmakers. These brought flooding to the area and caused the evacuation of the residents of the trailer park along Wahconah Falls Road in Dalton.
September 2004	The remnants from Hurricane Ivan brought 3-6" of rain. This, combined with saturated soils from previous storms, caused flooding throughout the region and caused damage to the spillway of the dam on Plunkett Reservoir in Hinsdale.
October 2005	A stationary cold front brought over 6" of rain and caused widespread flooding throughout the region; in Williamstown 3' of water flooded portions of The Spruces, leading to evacuations of residents; fortunately mobile homes were not flooded
November 2005	Widespread rainfall across the region of 1-1.5", which was 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" impact the area. Combined with frozen ground and snowmelt, this led to flooding across the region.
August 2008	A storm brought very heavy rainfall and resulted in flash flooding across parts of the region.
December 2008	A storm brought 1-4" of rain to the region, with some areas reporting ¼ to 1/3 of an inch an hour of freezing rain., before changing to snow. Moderate flooding and ponding occurred throughout the region.
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 which resulted in roads flooding.
October 2009	A low-pressure system moved across region bringing a 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 occurred producing 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. In Williamstown this event was a 1% annual chance flood event for the Hoosic River, and a 2% annual chance flood event for the Green River.
September 2011	Remnants of Tropical Storm Lee brought 4-9" of heavy rainfall to the region. Due to the saturated soils from Tropical Storm Irene, this rainfall lead to widespread minor to moderate flooding on rivers as well as small streams and creeks.
August 2012	Remnants from Hurricane Sandy brought thunderstorms developed repeatedly 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 brought wind and heavy rainfall caused flash flooding and road closures in areas; in Williamstown infrastructure damage occurred, Treadwell Hill Road crossing washed out, homes were damages on Petersburg Road, stream bank erosion was wide spread.
August 2013	Heavy rainfall repeatedly moved across the region causing more then 3 inches of rain in just a few hours resulting in streams and creeks to overflow their banks and resulting in 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 developed producing very heavy rain over a short period of time. This lead to some flash flooding and road closers, 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, which caused flash flooding in some areas. Many roads 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 heavy rainfall and flash flooding with 3-6" of rainfall occurring. The thunderstorms also caused a EF1 tornado in Dalton causing damage to trees and homes.
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.
January 2018	Severe rainfall and 50-degree temperatures followed several weeks of sub-zero record cold. Significant ice jams occurred on the Green River and Broad Brook; ice jam on Broad Brook at Pan Am Rail bridge caused disruption in rail traffic and flooding necessitated evacuation of workers at Steinerfilm were conducted by Williamstown first responders.

Source: BRPC 2018 (unless otherwise noted)

Bolded events are in the top 10 events that caused the Hoosic River to flow above flood stage at the North Adams USGS gage #01332500.

According to data from the USGS gauge #01332500 on the Hoosic River in North Adams, which provides data from 1941 to the present, there have been 37 times when the peak flow exceeded flood stage, which at this site is nine feet. Four events exceeded Major Flood Stage (13 feet): 1948/49, 1950, 2011, and 1976. The flood event of record, with the highest water level, was the New Year's Flood of 1948/49, with a peak level of almost 15 feet. In addition to these events, there are an additional 17 events that were near flood stage, being between 8.5-9.0 feet. Because this gage does not have data prior to 1941, it does not capture the two events listed in Table 3.2.2. 1936 and 1938; the Great Hurricane of 1938 was flood of record for that gage. Of the 37 flood exceedances, all but five events have occurred since 1975, and 14 have occurred since the beginning of 2000. Although this data only discusses historic peak flows, this coincides with the noticed "stepped" increase in stream flow in USGS stream gages beginning in the 1970s. The normal low water elevation for this Hoosic River site is four feet. See Table 3.2.3. for flood events above flood stage, listed according to peak water levels.

Comparing the dates of the 37 historic highest peak flows of the Green River to that of the Hoosic River (Tables 3.2.3., 3.2.4.), it can be seen that although many of the historic peak flows coincide and occur during the same event, there is a vast difference between the two. Whereas 86% of flood events in the Hoosic River occurred 1975 or later, only 70% of the highest peaks listed for the Green River occurred 1975 or later. It should be noted that the Hoosic and Green River watersheds are vastly different in size and level of development. The Green River has a watershed of 42.6 square miles and flows through steeply sloped ravines and narrow stream channels, with little floodplain acreage. The Hoosic River has a watershed of 126 square miles, including the 42.6 square miles of the Green River subwatershed. Although the Hoosic River watershed is also largely steeply sloped with relatively little floodplain acreage, the Hoosic River valley upstream of Williamstown is densely developed in North Adams and Adams, the river channel has been straightened in some areas, and it is encased in concrete in some areas (which alters flow the flow regime).

**Table 3.2.3. Historic Peak Level Crests at USGS
01332500 North Adams near Williamstown**

Peak Water Level (feet)	Date of Peak Occurrence
14.85	12/31/1948
13.85	11/26/1950
13.75	8/28/2011
13.02	8/10/1976
12.44	4/5/1987
12.35	10/8/2005
11.79	12/21/1973
10.87	3/22/1980
10.70	3/31/1987
10.59	3/13/1977
10.59	4/18/1982
10.25	1/19/1996
10.23	2/20/1981
10.14	4/16/2007
10.10	4/3/2005
9.82	5/30/1984
9.79	4/10/1980
9.73	12/12/2008
9.72	4/23/1969
9.57	3/29/2003
9.56	9/7/2011
9.56	4/1/2004
9.46	3/8/2008
9.45	12/17/2000
9.31	4/2/2004
9.26	3/18/1990
9.25	12/2/1996
9.22	6/15/1969
9.21	3/7/1979
9.18	10/20/1989
9.15	10/21/1995
9.12	9/18/2004
9.11	8/7/1990
9.08	3/7/2011
9.08	3/23/2010
9.04	4/23/1993

**Table 3.2.4. Historic Peak Water Level Crests at USGS # 01333000
Green River, Williamstown⁶**

Peak Water Level (feet)	Date of Peak Occurrence
7.5	12/31/1948
6.7	8/28/2011
6.4	3/13/1977
5.9	9/12/1960
5.7	12/21/1973
5.6	6/30/1976
5.3	10/24/2009
5.3	11/26/1950
5.2	1/18/2006
5.0	3/15/1986
5.0	3/31/1987
5.0	3/6/1979
4.9	6/15/1969
4.9	4/19/1983
4.9	5/30/1984
4.8	8/7/1990
4.8	10/26/2008
4.8	6/1/1952
4.7	8/8/1975
4.7	4/25/1968
4.7	2/2/1973
4.7	6/26/2000
4.7	4/2/1970
4.7	3/30/1993
4.6	7/13/1996
4.6	1/22/1959
4.6	3/22/1980
4.5	4/18/1982
4.5	12/7/1953
4.5	2/20/1981
4.5	12/2/1996
4.5	12/11/1952
4.4	12/21/1975
4.4	1/18/1999
4.4	5/6/1989
4.3	3/8/1995

⁶ https://nwis.waterdata.usgs.gov/ma/nwis/peak?site_no=01333000&agency_cd=USGS&format=html

Although the stream gages can provide a guide to the occurrence of flood events in Williamstown, the flood levels of the two rivers do not completely illustrate all the storm events that caused damages in the Town. The high-intensity, short-duration storm event that occurred on May 29, 2013 flooded properties, destroyed infrastructure and caused severe stream channel and land erosion. The Treadwell Hollow Road stream crossing was completely destroyed, with the culvert being washed out and deposited on land downstream of the site (Fig. 3.2.5., upper photo). Stream bank erosion and exposure of infrastructure

was widespread (Fig. 3.2.5., lower photo).

Small, isolated and often very localized storms such as this have occurred with seemingly more regularity across the Berkshires within the last 10 years, with severe damages incurred in similar storms in Adams, Pittsfield, Lee and Stockbridge.

Probability of Future Occurrences

Using the past as a guide, Williamstown can expect to continue to be impacted by floods. With six to eight flood events that approached or exceeded a 50-100-year interval in the Berkshire 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, and receive minor flooding at least once a year. In addition to this, the upward trend for increased precipitation, combined with existing development in or near floodplain areas, indicated 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.

Fig. 3.2.5. Treadwell Hollow Road crossing (upper photo); streambank and infrastructure damage Hemlock Brook



Source: Town of Williamstown, 2018.

Secondary Hazards

Severe flooding can threaten the functionality or structural integrity of dams. A more thorough discussion of the Town of Williamstown's risks due to dam failure are discussed Section 3.5 of this plan.

Flood waters and the debris that is moved or carried can damage or destroy bridges and the infrastructure attached to them. For instance, critical water, sewer, communication and gas lines can be attached to bridges, most notably the Wally Bridge on Main Street/Route 2 and the Moody Bridge on Route 7.

Flood waters can increase the risk of the creation of and dislodging of ice dams during the winter months. According to the Ice Jam Database, maintained by the Ice Engineering Group at the U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory (CRREL), there have been no ice jams in Williamstown. However, ice jams are known to occur along the Green River and Broad Brook. Figure 3.2.6. documents a flood event along the Green River, caused by an ice jam in the river upstream from Cable Mills. The flooding and movement of water and ice being was strong enough to lift and move a vehicle onto another one parked nearby.

Fig. 3.2.6. Ice Jam on Green River, Feb. 1982; ice movement strong enough to move cars



Source: Hank Art, Williams College.

The most recent ice jam event was in January 2018, when two inches of rain and an unusually warm weather of 50+ degrees Fahrenheit, which followed a period of prolonged and unusually cold weather, caused flooding from snow and ice melt across Berkshire County. In Williamstown an ice jam on Broad Brook caused redirection of flood waters. Within a few hours the driveway of Steinerfilm, which goes under the Pan Am railroad tracks, had flooded with more than five feet of water, trapping approximately 40 workers at the facility. A full evacuation was ordered and Town staff rescued the workers by loading them into the bed of a Town-owned ex-military vehicle equipped to drive through floodwaters.

This same weather pattern caused an ice jam in Kitchen Brook in the town of Cheshire, which subsequently flooded and deposited large chunks of ice on Route 8, a major north-south arterial road in the county. Ice jams caused flooding in several neighborhoods in dams. The same event caused the Town of Stockbridge to declare a local disaster due to concerns that a massive buildup of ice and rising flood water could damage the Route 7 bridge over the Housatonic River and/or the natural gas main pipeline that serves as the only gas supply to the neighboring town of Great Barrington (pop. ~7,000) (Zollshan, 2018).

Flood waters can overwhelm stormwater management systems and overwhelm sewer systems if Inflow and Infiltration (I&I) add water volume to the system. Inflow is water or sewage draining directly into the sewer line through a sewer connection and infiltration is the seepage of ground water into the sewer system through defects in sewer piping or into loose sewer connections. Water input into the sewer lines is increased during times of high surface runoff and soil saturation. This occurs with the Hoosic Water Quality District, the regional sewer system that serves Clarksburg, North Adams and Williamstown. The treatment facility and discharge point into the Hoosic River is located on Simonds Road in Williamstown. The wastewater treatment facility is overwhelmed and discharges untreated or improperly treated wastewater during times of high volume. A significant source of I&I has been identified in neighboring North Adams, where an old and deteriorating pipe system contributes water volumes into the sewer lines through old cross-connections with stormdrains, illicit sewer and stormdrain connections, and leaking pipes. While Williamstown has been addressing I&I in its system for several years, appropriating approximately \$180,000 per year to address infrastructure improvements. However, the I&I issue has gone largely unaddressed in North Adams, which is upstream of Williamstown. Projected increases in the number and severity of precipitation events due to climate change necessitates that the City identify, prioritize and repair sources of I&I.

Warning Time

The State Hazard Mitigation Plan states that, due to the sequential pattern of meteorological conditions needed to cause serious flooding, it is unusual for a flood to occur without warning. Notice of potential flood conditions for developing storm systems is generally available five days in advance, with warning times for floods between 24 and 48 hours ahead of time. Flash flooding can be less predictable, but potential hazard areas can be warned in advanced of potential flash flooding danger. NOAA's Northeast River Forecast Center provides flood warning for Massachusetts, relying on monitoring data from the USGS stream gage network, of which the closest is the gage on the Hoosic River in North Adams, just east and upstream of Williamstown. State agency staff monitor river, weather, and forecast conditions throughout the year. Notification of potential flooding is shared among state agency staff and the National Weather Service provides briefings to state and local emergency managers, as well as notifications to the public via the media and social networking. MEMA also distributes information regarding potential flooding to local Emergency Managers, the press, and the public. (MEMA, 2013)

The total number of injuries and casualties resulting from typical riverine flooding is generally limited based on advance weather forecasting, blockades, and warnings. Injuries and deaths generally are not anticipated if proper warning and precautions are in place. The exception is where the warning time is limited due to fast-developing events such as flash flooding from unpredicted severe thunderstorms or dam failures, or where earthquakes or landslides cause instantaneous earth movement. Populations without adequate warning of the event are highly vulnerable to this hazard. The historical record from 1993 to 2011 indicates there have only been two fatalities associated with a flood event in the state (occurring in May 2006) and five injuries associated with two flood events (occurring within two weeks of each other in March 2010). (MEMA, 2013).

Scientists predict that annual precipitation patterns are being altered, with a greater amount of rain falling in high-intensity bursts delivering two or more inches in a matter of hours. In Berkshire County these high-intensity storms are often very localized, effecting only a portion of the town or a particular subwatershed. The very localized impact area can be overlooked by regional weather forecasters

located in the Albany or Springfield area, and the short duration provides little time for town officials first responders to issue warnings. In Berkshire County flash floods can occur when bridges or culverts are washed out by severe flood events, particularly in steeply sloped areas. The May 2013 rain event, where more than two inches fell in 10 minutes is an example of the type of storm that can inflict severe damage in a short amount of time.

Exposure

Due to historic development patterns that occurred before the town's zoning and floodplain management regulations, there are several homes and businesses that are located within the floodplain. In addition, there are more properties that located along the Flood Insurance Rate Map (FIRM) delineated boundaries.

Development impacts, most particularly the removal of natural vegetation and addition of impervious surface area within a watershed or drainage area, increases the risk of accelerated high peak flows in waterways, which can lead to flooding, bank erosion and ban subsidence. The same development impacts within the floodplain affects the floodplains' ability to absorb, detain and store water during flood events.

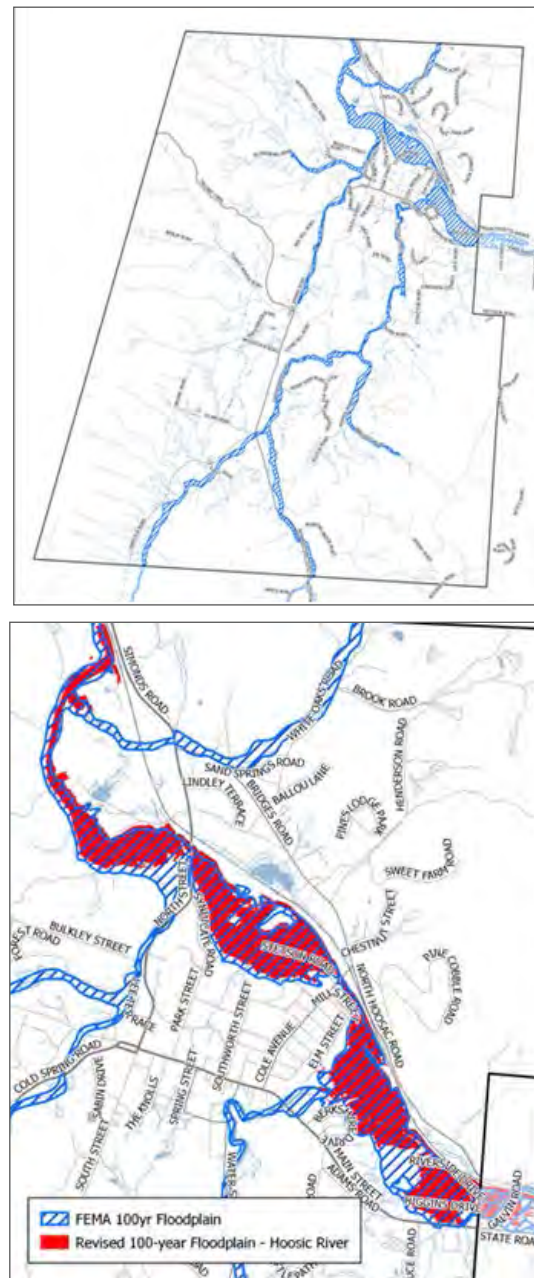
An analysis of the official FIRM flood hazard area maps of the early 1980s indicates that there is a total of 1,091 acres of 100-year floodplain within the town.

This amounts to 3.6% of the total town. Most floodplain areas in the town are associated with the Hoosic River and Green River and their tributaries as they flow into the rivers (refer to Fig. 3.2.7. and to Appendix A for floodplain area locations).

Based on additional analysis using 1989s FIRM data, 138.4 acres (12.7%) of the floodplain are developed. This leaves approximately 952 acres that are potentially developable under current zoning (Berkshire Regional Planning Commission, 2017). The town does have a floodplain bylaw, protecting zones A and A1-30 as shown on the FIRM.

After the extensive and severe flooding that occurred along the Hoosic River in Williamstown during T.S. Irene, the USGS and FEMA undertook efforts to recalculate a portion of the floodplain area of the river in North Adams and Williamstown. The revised boundary, published in 2014, should be considered

Fig. 3.2.7. 100-year Floodplain in Williamstown (FIRM 1980s top); Revised Hoosic River 100-year Floodplain Area (2014 lower)



Source: BRPC 2017.

more accurate and detailed because it incorporates more accurate mapping technology and field data gathered in the field after T.S. Irene occurred. Unfortunately, this revised floodplain area only covers the Hoosic River floodplain and does not include any of the river's tributaries. As can be seen in Fig. 3.2.7., the floodplain boundaries have been redefined and some lands east of the former Spruces Mobile Home Park and along the southern boundaries of the previous floodplain boundary have been removed. This likely results in fewer buildings being considered as being in floodplain areas.

Using assessor data, GIS data, and where available new floodplain data along the Hoosic River, it has been estimated that there are currently there are 16 commercial buildings (12.5% of commercial stock), 1 industrial building (20% of industrial stock) and 139 residential buildings (6.5% of residential stock) within the floodplain (Berkshire Regional Planning Commission, 2017). Residential buildings include only main buildings, not detached garages or other accessory structures.

Table 3.2.5. Number of Buildings in Floodplain in Williamstown

Buildings in the 100-year Floodplain in Williamstown							
Residential		Commercial		Industrial		Total	
No. Bldgs.	Percent Res. Bldgs.	No. Bldgs.	Percent Com. Bldgs.	No. Bldgs.	Percent Ind. Bldgs.	No. Bldgs.	Percent Total Bldgs.
139	6.5%	16	12.5%	1	20%	156	6.9%

Source: FIRM, Berkshire Regional Planning Commission, 2017

These figures are far lower than the number of buildings in the floodplain that were reported in the Town's former Hazard Mitigation Plan, which included building data from 2009. At that time the number of residential buildings in floodplain was calculated to be 375 in total, which included the homes in the Spruces Mobile Home Park. The newer estimate of 139 homes in the floodplain reflect the removal of approximately 225 homes from the Spruces, and a few others that are no longer in the 2014 floodplain boundary along the Hoosic River. Homes that continue to be considered as being in floodplain are located in floodplains along the Hoosic and Green Rivers, and along Hemlock, Buxton and Brood Brooks. Similarly, the number of commercial and industrial buildings has been recalculated and reduced since the 2009 data.

It should be noted that flooding of lands and properties can occur outside of floodplain areas during severe storm events, such as the storm event of May 30, 2013. This event flooded local streams, caused severe erosion in steeply sloped areas, and flooded properties and roads. Overwhelmed Buxton Brook flooded properties along Petersburg and Northwest Hill Roads, and completely destroyed the road crossing at Treadwell Hollow Road. See photo of the impacts in Figure 3.2.8.

Fig. 3.2.8. Intersection of Petersburg and Northwest Hill Roads, May 30, 2013.



Source: Town of Williamstown, 2018.

3.2.3. 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. Although data suggests that there are 156 properties in the flood plain in Williamstown, there are only 68 active flood insurance policies in Williamstown covering \$12,112,900 (MEMA, 2017). The town has had 24 flood insurance claims since 1978 for a total of \$152,891.34 (MEMA, 2017). This includes no repetitive flood loss properties. (MEMA, 2017). Locally it is known that the Spruces Mobile Home Park has suffered repeated flooding since its development in the 1960s and 1970s. Evacuation of residents from the park has occurred several times in recent decades, culminating in the devastating destruction and complete loss of the park after T.S. Irene in 2011. It is unsure why flood claims for the Park are not shown in MEMA's repetitive flood loss data.

Infrastructure and critical facilities that have been built in, over or under floodways are vulnerable to damage due to the power of high volumes of water and from the debris that those flows can carry or dislodge, or from the erosive and scouring power of floodwaters. Infrastructure from flood waters that are of most concern to the Town of Williamstown include sewer lines that are at risk from exposure and damage due to floodwaters, and culvert and bridges that are increasingly at risk due to higher flood volumes.

Population

Based on the population of 7,758 in Williamstown and the estimate that 6.5% of housing in the floodplain, it is expected that upwards of 504 residents may be impacted in a 1% flood event based on the percent of residential buildings in town in the floodplain. (Berkshire Regional Planning Commission, 2017) Using a second methodology, taking the number of 139 residential homes in the floodplain, with the average of 2.2 persons per household for Berkshire County⁷, the number of people impacted would be 306 residents.

⁷ ACS 2012-2016

The Spruces Mobile Home Park was previously the site of most concern and distress regarding flooding, with a history of evacuations, some of them mandatorily issued by Town officials. The park was constructed entirely within the floodplain during the 1950-70s, threatened by flooding from Paull Brook and from the Hoosic River. The Spruces was flooded and evacuated several times over the decades since construction. The Spruces was severely flooded by T.S. Irene in 2011, with 160 of the 225 mobile homes destroyed beyond repair. Underground utilities in 1/3 of the park were compromised beyond repair, rendering the park economically unviable. All residents from the 225 mobile homes were permanently displaced, a devastating loss of a close-knit community of largely low-income and elderly residents. The Town of Williamstown purchased the land and is in the process of creating a public park at the site. No homes or businesses will be constructed on the site, removing the Town's greatest risk of human injury or property damage.

Fig. 3.2.9. Flooding of The Spruces Aug. 28, 2011; water is approximately 5' in depth



Source: Town of Williamstown.

While The Spruces is no longer a risk to human injury or property damage due to flooding, the Sand Springs Road subdivision, also constructed in the 1950s, remains a flood hazard. White Oaks, Colonial Village and North Hoosic neighborhoods continue to be a flooding concern.

Of the population exposed, the most vulnerable populations typically include the economically disadvantaged and the population over the age of 65. Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on the net economic impact to their family. The population over the age of 65 is also more vulnerable because they are more likely to need medical or other special attention, which may not be available due to isolation during a flood event. They may also have more difficulty evacuating due to mobility issues. People with pets are also less likely to evacuate if they are not allowed to bring their pets with them (MEMA, 2013).

Severe Repetitive Loss Data

A severe repetitive loss is any insurable building for which two or more claims of more than \$1,000 were paid by the National Flood Insurance Program within any rolling ten-year period, since 1978 (FEMA, 2018). According to MEMA insurance data there has been no repetitive losses in Williamstown since 1978.

Critical Facilities

Williamstown does not currently have any critical communications or command center facilities within the floodplain. However, sewer lines run through floodplain areas associated with the Hoosic and Green

Rivers. There are also several public facilities that are located along the edge of the 100-year floodplain boundary, including the fire station, DPW, wastewater treatment plant and additional sewer lines.

There are approximately 97 miles of road in Williamstown, 7 of which travel through the 100-year floodplain area. Additionally, there are 23 bridges and more than 189 culverts. There are six bridges that are considered at risk to flooding due to having high scour scores in the MassDOT bridge database. These bridges include the Hemlock Brook and Cold Spring Road crossing, Green River and Blair Road crossing, Hoosic River and Simonds Road crossing, Green River and Main Street crossing, Hopper Brook and Hopper Road crossing and the Broad Brook and Sand Spring Road crossing. (MassDOT, 2018). All of these bridges are stable, however action is required to protect the exposed foundations from effects of additional erosion and corrosion. As discussed previously, the Route 7 Broad Brook crossing is a site of sediment, cobble and boulder deposition, causing an ongoing concern during flood events.

There are areas along the Hoosic and Green Rivers where sewer lines are located near the rivers and are at risk due to severe bank erosion that exposes pipes. The main sewer interceptor line that carries waste from Clarksburg and North Adams, located along the Hoosic River, has been exposed several times due to river bank erosion during severe flood events. Rip rap has been placed there several times, and the line has been moved away from the river. The Hoosac Water Quality District monitors the site in an ongoing basis.

One 18" sewer line has been exposed along the Green River. The exposure has caused the line to sink and could pull apart due to river bank movement. Rip rap has been added to the area to stabilize the bank, but the line is still at risk.

Economy

According to the State Hazard Mitigation Plan, economic losses due to a flood include, but are not limited to damage to buildings and infrastructure, agricultural losses, business interruption, and impacts on tourism, and the tax base. Damage to buildings can be estimated using the exposure analysis above. Other economic components such as loss of facility use, functional downtime, and social economic factors are less measurable with a high degree of certainty. (MEMA, 2013) In the downtown business area, commercial properties along Water Street, Meacham and Latham Streets, and along Christmas Brook experience periodic flooding. The Christmas Brook culvert improvement project recently completed by Williams College is expected to remedy this issue.

Flooding can 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. Flooded streets and roadblocks make it difficult for emergency vehicles to respond to calls for service. 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. Williamstown experiences repeated cycles of repair and replacement of infrastructure after flood events, only to have the work damaged during the next storm. Although the Town installs larger culverts where warranted during replacement of washed out or damaged structures, the ongoing repairs and replacements are a financial strain. Key recent upgrades include several culverts along Oblong Road and drainage improvements in the Gale Road area.

Damage to buildings can affect a community's economy and tax base. As part of this hazard mitigation plan update, the total loss of buildings and their content within the floodplain was calculated to

demonstrate the worst-case scenario of potential losses if a 1% chance flood event were to occur. This calculation took into consideration the value of all buildings within the floodplain, as determined with assessor records, and multiplied an additional percentage to represent the contents of the properties, totaling a potential loss of \$48 million. This represents complete destruction of buildings and contents within the floodplain. It should be noted that the floodplain boundaries used for this analysis include the newer 2014 floodplain boundaries delineated for the Hoosic River where available; for the rest of the Town the 1980s FIRM boundaries were used.

Table 3.2.6. Property Valuation within the 100-year Floodplain (\$ millions)

Residential Property	Residential Contents (50% Property Value)	Commercial Property	Commercial Contents (100% Property Value)	Industrial Property	Industrial Contents (125% Property Value)	Total Loss Estimate
\$31.8	\$15.9	\$3.2	\$3.2	\$0.050	\$0.063	\$54.25

Source: Berkshire Regional Planning Commission, 2017

Aside from damage to buildings, flooding could effect some portion of the businesses and public institutions in Williamstown that serve as major employers. As noted in Table 3.2.5., 12.5% of all commercial and 20% of industrial buildings in Williamstown are within the 100-year floodplain, including Steiner film, the workers of which had to be evacuated in January 2018 due to flooding of the driveway and only exit from the property.

Businesses located in Williamstown currently employ approximately 3,826 people, so up to 490 employees could be impacted in the event of a 1% chance of occurrence flood event, based on the percentage of commercial and industrial businesses in the floodplain (Berkshire Regional Planning Commission, 2017). Although not all employees are Williamstown residents, the economic repercussions of an economic shutdown would reverberate throughout the northern Berkshire County region. The Williams College athletic fields located along the Hoosic River chronically and repetitively flood during high flow events. Athletic competitions and games can draw large numbers of visitors and spectators to Williamstown, particularly if the game is against a rival or is during alumni events, and the cancellation of games or events can have economic repercussions that reverberate throughout the Williamstown and Northern Berkshire County region.

It should be noted that historical records indicate that total loss of buildings and content has not occurred in Williamstown outside of the loss of The Spruces in 2011 during T.S. Irene. It is more likely that flooding would result in partial damages or loss of a building and its content, as demonstrated through past flood insurance claims in Williamstown and the region. To determine a more likely scenario of damages from a 1% chance flood event, the HAZUS-MH modeling program was utilized (see following section). The HAZUS-MH model took into account and calculated not only the number of buildings within the floodplain, but also potential losses to agriculture, business interruption and other economic impacts.

HAZUS-MH

To further assess the Town's vulnerability to flood hazard, HAZUS-MH was run using a 1% chance flood event. HAZUS-MH is an extension to ArcGIS that allows for the modeling of storm events and calculates

the impact of the storm. HAZUS-MH delineates a floodplain differently than the current FEMA Floodplain maps by modeling where flooding may occur, rather than mapping that was conducted in the 1970's and 1980's. According to HAZUS, based on a 1% chance flood event, more commonly referred to as the 100-year flood event, up to 265 households and 606 individuals may seek shelter during a flood event (HAZUS-MH, 2017). It should be noted that The Spruces is included in the HAZUS-MH calculations, because manually removing this development from the model is not possible. Since The Spruces no longer exists, residential calculations under the HAZUS model are grossly overestimated. Current GIS mapping indicates that there are approximately 139 residential homes in the floodplain. For Williamstown the value of the HAZUS model is to identify potential damages to commercial and industrial properties.

Direct building losses are the estimated costs to repair or replace the damage caused to the building. Based on the HAZUS-MH analysis, the town could potentially experience a loss of \$72,770,000 during a 1% chance flood event. (Table 3.2.7). (HAZUS-MH, 2017) For more details about the impacts of a 1% chance storm event, see the full HAZUS-MH report in Appendix B.

Table 3.2.7. Damage Estimate from HAZUS (\$ millions)

	Residential Property	Residential Contents	Commercial Property	Commercial Contents	Industrial Property	Industrial Contents	Total Loss Estimate
Building Loss	\$29.5 (not applicable)	\$15.0 (not applicable)	\$7.04	\$16.9	\$0.5	\$1.1	\$72.5
Business Interruption	\$0.06 (not applicable)	NA	\$0.20	NA	0.01	NA	\$0.3

Source: HAZUS-MH, Berkshire Regional Planning Commission, 2017

Tropical Storm Irene – Profile of a Flood Event in Western Massachusetts

Tropical Storm Irene started out as an Atlantic hurricane that traveled up the eastern seaboard through North Carolina, the Mid-Atlantic states and inland New England August 26-28, 2011, impacting the Berkshires August 27-28.

The hardest hit areas were in Vermont, in the Hoosic River Watershed in Berkshire County and in the Deerfield River watershed in Franklin County. Vermont considers the storm the worst natural disaster since the floods of 1927. A total of 2260 road segments, 289 bridges, and 963 culverts were damaged, destroyed, or blown-out as a result. The total damage to infrastructure was estimated at between \$250 and \$300 million dollars, all for a state of just over 600,000 residents⁸

In Shelburne Falls, MA the Deerfield River was flowing at 38,000 cubic feet per second (cfs), well above the typical August flow of 800-1,000 cfs. The area received more than 8.5-10" over the course of two days. The Green River destroyed the Greenfield, MA dam and water pumping station. While the amount of rain in New England is less than more southern states received, the hilly and rocky terrain and the fact that the rain came atop soils already saturated were factors contributing to the severe flooding. Many streams and rivers were several feet above flood stage, flooding properties, washing out roads and forcing evacuations. The flood waters in the Hoosic River were the third highest recorded at the USGS gage installed in 1941.

Route 2 in Florida and Charlemont was severely damaged due to a combination of the wash out of the road by the river and heavy deposition of mud, trees and debris from a landslide caused by steep slopes and oversaturated soils. Several other major travel routes across Western Massachusetts were closed, including Rt. 91 in Deerfield (due to fear that a bridge over the Deerfield River was unsafe), Routes 20 and 23 in the southern hilltowns of Becket, Chester and Otis. The flood control chutes in North Adams were nearing the top with the highest water levels in recent memory (Fig. 3.2.12).

Fig. 3.2.10 Cold River Bridge Florida/Savoy



Source: BRPC 2018

Fig. 3.2.11. Hoosic River Levels during T.S. Irene 2011



⁸ (<http://www.georgetownclimate.org/resources/vermont-culvert-rebuilding-after-tropical-storm-irene>).

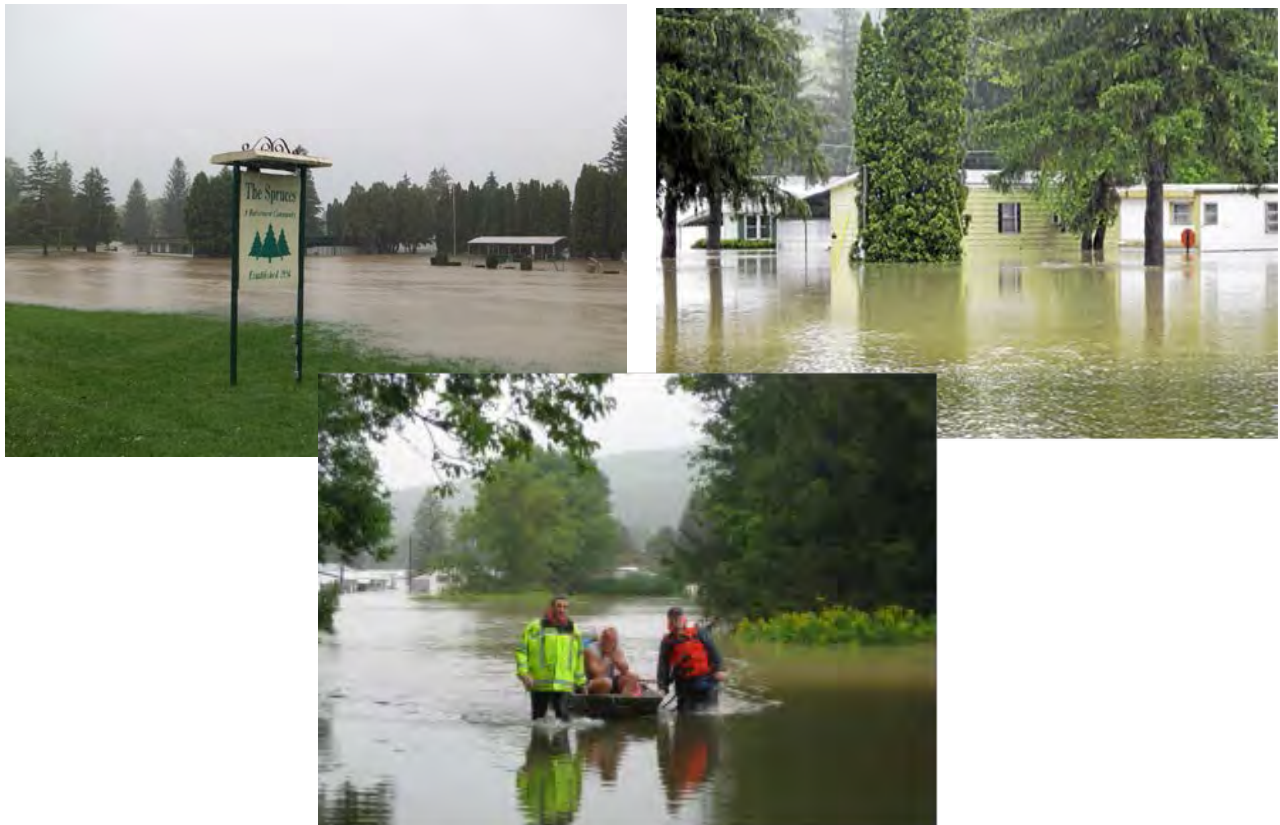
Farmers in the Deerfield watershed sustained heavy damage to crops, some losing their year's crop. Statewide almost 600,000 people were without power.⁹ Although deaths in New England are attributed to flooding from Tropical Storm Irene, there are no reported deaths in Berkshire County. The State of Massachusetts declared disasters for Berkshire and Franklin Counties.

The most devastating damages that occurred in Berkshire County are in Williamstown, where the storm was determined to be a 1% chance of occurrence storm. Water level in the Hoosic River in Williamstown rose from ~6' in depth to almost 14' in about seven hours. The Spruces Mobile Home Park was fully evacuated, and 75% of the homes were declared uninhabitable by the town building and health inspectors. Damage was so complete and widespread that the entire park was demolished and subsequently closed forever. More than 225 homes were lost. The Town of Williamstown, social service organizations and charities aided residents in relocating and, with FEMA funding, the site is being redeveloped into a public park.

Fig. 3.2.12. Flood Control Chutes in North Adams



Figs. 3.2.13. Flooding of The Spruces, Williamstown



⁹ http://www.masslive.com/news/index.ssf/2011/08/tropical_storm_irene_deluges_a.html

Christmas Brook – Profile of a Flood Improvement Project

Background

The Christmas Brook watershed is approximately 780 acres and includes the Williams College campus and associated college-owned stormwater drainage systems, where campus areas south of Latham Street flow into a series of closed drainage systems that are collected by a main trunk line, ultimately discharging into the Christmas Brook culvert. The Christmas Brook culvert is conveyed through underground culverts from Latham Street northeast to Water Street, where Christmas Brook discharges to the Green River. The Green River converges with the Hoosic River to the east of the campus. The culverted portion of Christmas Brook routinely floods in the area shown on Figure 3.2.13. due to undersized culvert and storm drainage capacity.

The purpose of the improvement project was to alleviate flooding in the area around Walden Street, the southern end of Spring Street, and Latham Street. The project approach was to restore the natural flood attenuation capability of Christmas Brook to the maximum extent feasible by stream and floodplain restoration in the upper reach of the stream. It was not feasible to daylight the culverted section of the brook due to existing development and land acquisition constraints, so the existing culvert was re-located and the capacity increased to convey the 100-year design storm.

As part of the project, a large subsurface detention system was constructed under the municipal parking lot at the end of Spring Street. This system mitigates stormwater flows from the west and reduces more localized flooding issues, flowing into the improved Christmas Brook drainage system. The total project cost was more than \$21 million, a cost that was largely borne by Williams College.

Fig. 3.2.13. Christmas Brook Flood Area

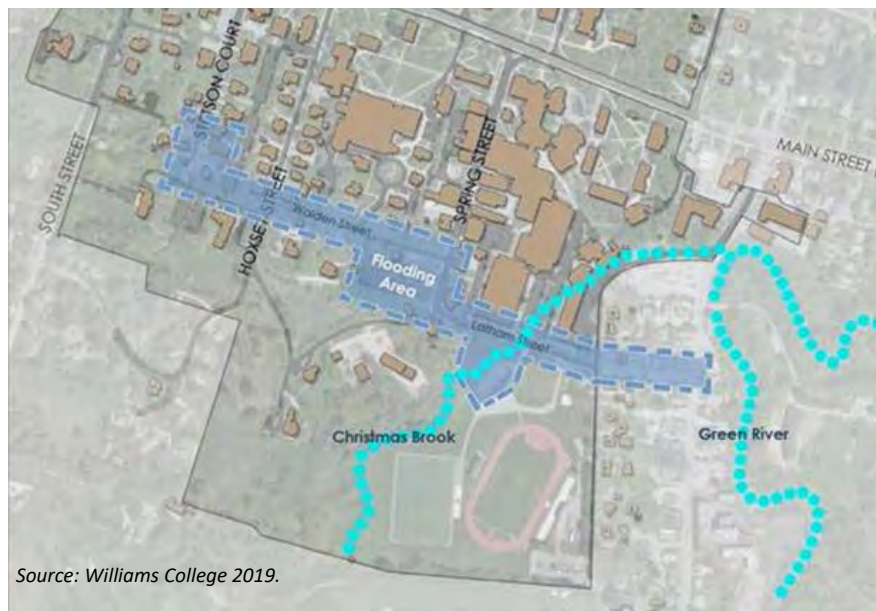


Fig. 3.2.14. Parking Lot Infiltration System being Installed



3.2.4. Existing Protections Against Increased Risk of Flooding

The Town of Williamstown has already numerous existing protections in place to help protect it from increasing the risk of future flooding, along with protections to alert vulnerable populations. Due to the prevalence of flooding as a risk of high concern, the Town has developed this detailed table of existing protections. Other natural hazards existing protections measures are described in less detail.

On June 25, 2018 the Massachusetts State NFIP Coordinator conducted a field visit that was attended by the Town Manager, Community Development Director and Public Works Director. A draft report that was generated by the NRIP Coordinator noted that the Town generally agrees with the floodplains as shown, and “Most Key” was that local bylaws do not allow for new construction in the floodplain. Also noted in the report was that the Town has invested in mitigation projects over the years, most notable the land acquisition of The Spruces for future public park land. The report did also note that the Town was not enrolled in the Community Rating System, and that the community has requested that the state conduct NFIP training for realtors in the area.

Table 3.2.8. Existing Protections

Type of Existing Protection	Description	Area Covered	Effectiveness	Improvements Needed
Town participates in the National Flood Insurance Program (NFIP)	Provides flood insurance for structures located within the floodplain	FEMA flood zones	Effective	None
Floodplain zoning district ordinance in place	Floodplain ordinance requires all development, including structural and nonstructural activities, be in compliance with state building code requirements for construction in floodplain	Covers FIRM zones Zone A, A1-30	Generally effective for new construction, but many older structures pre-date ordinance	None
Purchase of the land of the former Spruces Mobile Home Park	Floodplain land to be used for passive recreation; no new buildings permitted	The former Spruces Mobile Home Park	Effective	<i>None</i>
Building Code	The town enforces the state building code	Entire town	Effective	None
Zoning Bylaws	Upland Conservation Overlay District prohibits single family homes and severely restricts other development	Overlay district on elevations >1,350'	Effective	None

Zoning Bylaws	Stormwater regulations are in place for new construction, based on MA DEP's guidance, and encourages Low Impact Development to reduce surface runoff	Entire town	Effective	None
Zoning Bylaws	Subdivision zoning and regulations are protective to the point they restrict development.	Entire town	Effective	Future cluster zoning may allow careful development without being overly restrictive
Infrastructure Improvements	Annual appropriation directed to I&I improvements	Entire town	Effective	Finances continue to limit what can be done
Good working relationship with Williams College	Partners in infrastructure and emergency preparedness; example: Williams College completed the Christmas Brook improvement project to reduce flooding in the Town Center	Walden, Latham and Spring Streets	Believed to be Effective (completed 2018)	None at this time
Infrastructure Maintenance	Beaver activity is monitored and mitigation is undertaken on case-by-case basis	Entire town	Effective	None
USGS gages on Hoosic & Green Rivers	Monitoring to predict flood stages	Generally in town center	Effective in predicting safety procedures	None
Emergency communications systems	Regional school district and Town (Code Red) have communication systems in place	Residents who are enrolled	Effective	Pursue full enrollment
Emergency Preparedness	Generators in place at key critical facilities			

3.2.5. Actions

Since the Town of Williamstown's portion of the previous Hazard Mitigation Plan was completed in January 2011 (and formally adopted in 2012), the Town has had to respond to the flooding, evacuation, demolition and relocation of residents from The Spruces Mobile Home Park due to impacts of T.S. Irene in September 2011. As part of the initial response, the Town worked to shelter residents in various locations. The loss of The Spruces was the largest single loss of residential properties in Berkshire County in decades, if not centuries. As a result, the Town of Williamstown has focused on undertaking and completing The Spruces and the Water Street projects in the intervening years since the completion of the expired Plan. While these steps were necessary, and appropriate, during the next five years the Town should consider focusing some effort to reflect on Lessons Learned from responding to the impact of The Spruces. Participants in the MVP Planning Process stressed a need to take steps to improve emergency response communications, preparedness and response, with a special effort to reach vulnerable and transient populations and to develop adequate shelter plans.

As noted in this section of the updated Plan and during the MVP planning process, The Spruces has historically been Williamstown's area of most concern regarding flood risk and damages. Removal of the homes and residents from this property and permanently prohibiting construction of buildings there removes the risk of future injury to residents and loss of private property. The hard work that Town officials and social organizations undertook to secure the property and relocated residents will reap environmental and social benefits into the future. Additionally, the expansive reconstruction of the water and stormwater infrastructure in the Christmas Brook/Water Street area should address the chronic flooding of properties there. However, there remain several areas in Williamstown where structures and infrastructure continue to be at risk.

Narrative in regular text are from expired Hazard Mitigation Plan of 2012.

Narrative in italics are updates and new actions.

ACTION	BENEFITS AND UPDATES
Incorporate new FEMA 100-year floodplain data and maps into existing and future planning efforts.	More accurate data allows for a more accurate assessment of the flooding risk
Continue to strictly enforce 100-year floodplain bylaws and encourage the flood- proofing or relocation of existing structures in 100-year floodplain zones; continue to limit expansion of infrastructure in hazard-prone areas	Prohibit new construction to reduce future risk and protect existing structures

Insure the integrity of large beaver dams or breach them in a controlled manner	Reduce the risk of flooding and downstream transport of sediment and debris
<i>Develop a system to monitor beaver activity and resulting flooding along the railroad corridor and other locations in Town</i>	<i>Reduce the risk of railroad accidents, including potential hazardous materials spills; reduce risk of flooding of roads and properties and potential human health impacts due to beaver activity</i>
Determine which major transportation routes are in inundation areas for dams of High or Significant Hazard	Plan for evacuation routes and for redirecting of traffic during a failure
Continue to prioritize and improve stormwater management systems that are located in hazard prone areas or are undersized (<i>restated as a high priority action in the MVP Planning Process, coupled with a desire to seek grant funds to aid in implementation</i>)	Reduce the risk of localized flooding
Develop bylaws that require on-site containment of stormwater for new development	Reduce flooding downgradient and off-site; <i>existing bylaws are successful so no new bylaws have been developed since 2011</i>
Continue working on bylaw development requiring the use of low-impact development techniques, especially in flood-prone areas (as part of a comprehensive new stormwater bylaw)	Reduce or eliminate runoff from site and protect existing capacity of stormdrain systems in place downgradient; <i>existing bylaws are successful so no new bylaws have been developed since 2011</i>
Update an Emergency Action Plan (EAP) for Williamstown Reservoir Dam,	Improve response to potential dam failure; reduce potential damages and injury from dam failure; <i>EAP in place for Williamstown Reservoir</i>
Partner with and support the City of North Adams to develop an EAP for the Mt. Williams Reservoir	<i>Williamstown officials are pursuing this action</i>
Continue to have information available for landowners in hazard-prone areas that discuss hazard mitigation and preparedness (using Berkshire County Board of Health's brochures); utilize the Town website for publishing information.	Improve response of land owners when a disaster occurs
Develop and publicize local and regional evacuation routes and shelter locations; utilize the town website for publishing information.	Improve ability of local citizens to respond to emergency and disaster situations
Continue evaluating shelter capacity for Williamstown residents and determine each shelter's structural ability to withstand natural disaster events.	Determining shelter capacity and ability to withstand disasters will ensure a community can shelter its citizens during a disaster. <i>The construction of the new high school offers an opportunity for additional sheltering capacity</i>
Review local agreements for use of shared mass care shelters in the event of a disaster	Agreements to share shelters assists communities who do not have enough capacity to shelter their residents during a disaster

Determine ability of town governmental centers to withstand a variety of natural hazard events	Ensure ability to operate government functions and offer sheltering during disasters; <i>a permanent generator is in place at the new Mt. Greylock Regional High School; the Town Hall, Public Works facility, and Williamstown Elementary School are wired to accept portable generators, although hook up is cumbersome; full, permanent back up power should be installed at the WES for use as shelter</i>
Educate local officials to help them develop plans to protect critical documents and materials	Reduce future risk and confusion after a disaster; <i>lessons learned from Town response to T.S. Irene will translate into improved response in future – pre-planning pays dividends</i>
As necessary, update historic structures, businesses and critical facilities located in hazard-prone areas to withstand natural disasters, including 100-year floodplains and dam failure inundation areas; work with the MA NFIP to conduct a workshop for real estate brokers and landowners	Reduce risk of damage or loss of historic structures and community character; <i>the Town has requested a real estate broker training for the North County region</i>

3.3 Tropical Storm and Hurricane Hazards

3.3.1. General Background

A tropical storm system is characterized by a low-pressure center and numerous thunderstorms that produce strong winds and heavy rain. The term “tropical” refers both to the geographical origin of these systems, which usually form in tropical regions of the globe, and to their formation in maritime tropical air masses. Hurricanes begin as tropical storms over the warm moist waters of the Atlantic. 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. Tropical depressions, tropical storms, and hurricanes form over the warm, moist waters of the Atlantic, Caribbean, and Gulf of Mexico.

- A tropical depression is declared when there is a low-pressure center in the tropics with sustained winds of 25 to 33 mph.
- 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, it 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. (MEMA, 2013)

Tropical storms and tropical depressions, while generally less dangerous than hurricanes, can be deadly. The winds of tropical depressions/storms are usually not the greatest threat; rather, the rains, flooding, and severe weather associated with the tropical storms are what customarily cause more significant problems. Serious power outages can also be associated with these types of events. After the passing of Hurricane Irene through the region as a tropical storm in late August 2011, many areas of the Commonwealth were without power for in excess of 5 days. (MEMA, 2013) In Berkshire County, including the Town of Williamstown, it is the flooding rather than the winds that created the greatest risk to people and property, and inflict the greatest damages.

The official hurricane season runs from June 1st to November 30th. However, August, September, and the first half of October are when the storms most frequently occur for New England. 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, 2013)

The Saffir/Simpson scale categorizes or rates hurricanes from 1 (Minimal) to 5 (Catastrophic) based on their intensity. This scale 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, as storm surge values are highly dependent on the slope of the continental shelf and the shape of the

coastline, in the landfall region. All winds are using the U.S. 1-minute average, meaning the highest wind that is sustained for one minute. The Saffir/Simpson Scale described in Table 3.3.1. gives an overview of the wind speeds and range of damage caused by different hurricane categories. (MEMA, 2013)

Table 3.3.1. Saffir/Simpson Scale

Scale No. (Category)	Winds (mph)	Potential Damage
Tropical Depression	< 38	NA
Tropical Storm	39-73	NA
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.

3.3.2. Hazard Profile

Location

The entire area of Williamstown 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 flashy, steeply sloped stream channels that can become flooded, causing stream channel erosion.

NOAA's Historical Hurricane Tracks tool is a public interactive mapping application that displays Atlantic Basin and East-Central Pacific Basin tropical cyclone data. This interactive tool tracks tropical cyclones from 1842 to 2017. 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

The National Oceanic and Atmospheric Administration (NOAA) has been keeping records of hurricanes since 1842 (Table 3.3.2.). From 1842 to 2017, the community have had five (5) Tropical Depressions, five (5) Tropical Storms, one (1) Category 1 Hurricane and one (1) Category 2 Hurricane pass directly through the County. The following table lists these storms, and Fig. 3.3.1. shows the paths of these storms. According to NOAA records Williamstown has been in the direct track of a tropical storm only twice during this time (see Fig. 3.3.1.).

The effects of hurricanes and tropical storms however can impact areas outside of the direct path. During this same period, an additional thirty-eight (38) Tropical Depressions, eighty-six (86) Tropical Storms, fourteen (14) Category 1 Hurricanes and five (5) Category 2 Hurricanes have passed within 100 miles of the region. The effects of the 1938 hurricane and the 2011 T.S. Irene were the source of severe flooding and property damages throughout Williamstown, the Hoosic River Watershed and the Berkshire County region.

Table 3.3.2. 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

Source: NOAA, 1842-2017

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 historic storm of most note in Berkshire County is the New England Hurricane of 1938 (also known as 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. In general the majority of the storm damage was from storm surge and wind, but in Berkshire County the damages were mostly due to severe flooding. 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 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

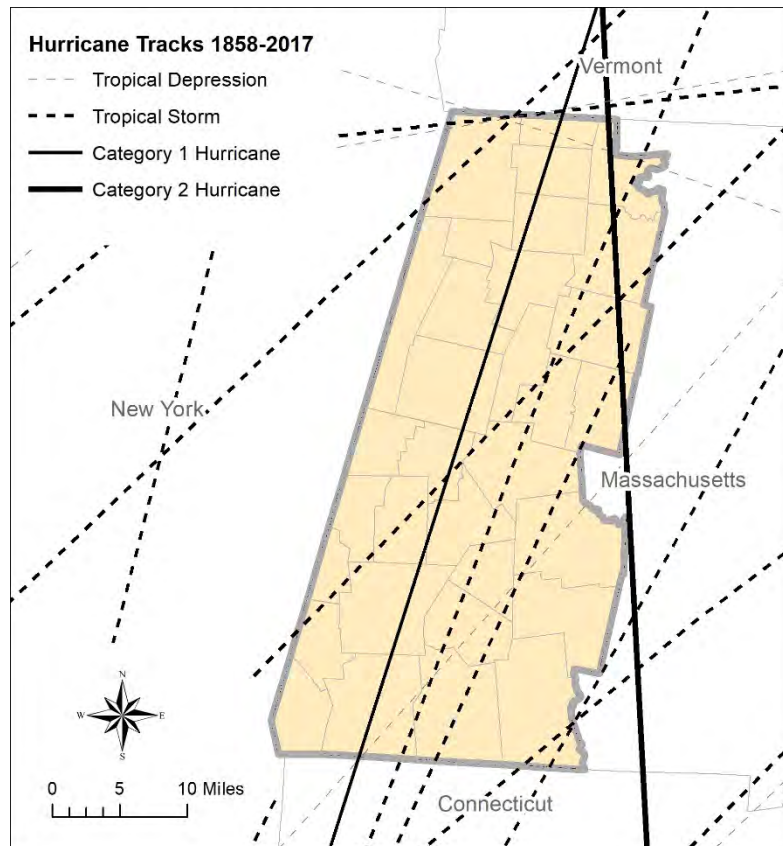
300 people were left homeless. The West Shaft Road bridge in North Adams was lost, as was the Wally Bridge in Williamstown.¹ The damages from this storm, following devastating flooding and damages from events in 1901, 1922, 1927 and 1936, and combined with that from a severe rain event in 1948, led to 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. Portions of The Spruces Mobile Home park in Williamstown were flooded under three feet of water, and residents were evacuated. 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)

Fig. 3.3.1. Tropical Depressions, Storms and Hurricanes Across Berkshire County



Source: BRPC 2017.

¹ Ennis, Tom, 2-11-04. "Before the Chutes, Hoosic Floods Raged," *iBerkshires.com*.

Locally T.S. Irene (DR-4028-MA) is the most memorable hurricane/tropical storm event in recent history due to the flooding that occurred in northern Berkshire and Franklin Counties in Massachusetts, and in southern Vermont. The path of the storm moved just east of Adams (see Fig. 3.3.2.) In Williamstown 225 mobile home households, many elderly and low income, permanently lost their homes in The Spruces due to destruction of homes and infrastructure (see Section 3.2. of this Plan for more details. 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.

Probability of Future Occurrences

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.

The NOAA Hurricane Research Division published a map showing the chance that a tropical storm or hurricane (of any intensity) will affect a given area during the hurricane season (June to November). This analysis was based on historical data from 1944 to 1999. Based on this analysis, the community has a 20-40% chance of a tropical storm or hurricane affecting the area each year. (MEMA, 2013)

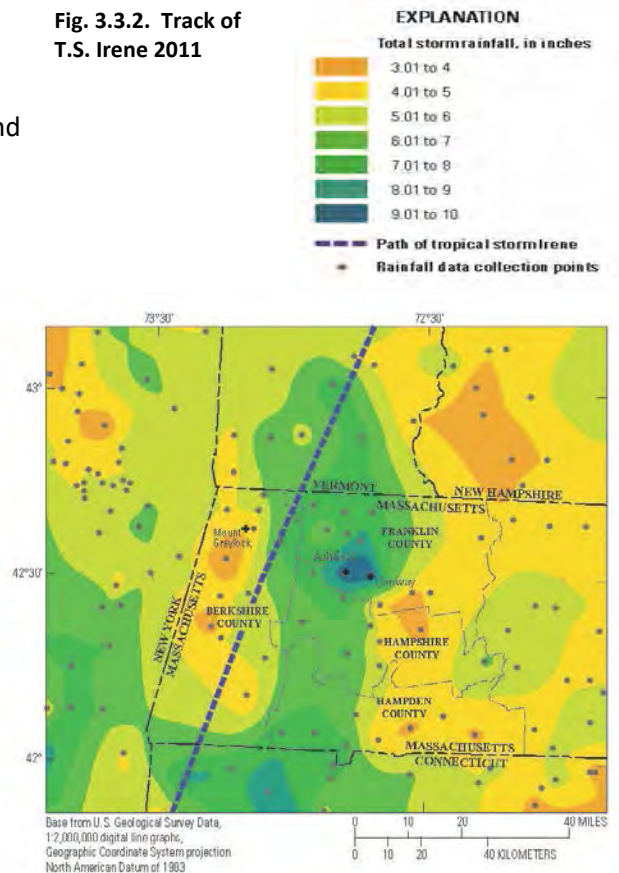
Severity

The severity of a hurricane is categorized by the Saffir-Simpson Hurricane Scale. 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.

Warning Time

Warning times for the majority of tropical storms and hurricanes are generally broadcast well in advance of landfall in New England. The National Weather Service 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

Fig. 3.3.2. Track of T.S. Irene 2011



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). In general, MEMA suggests that local and regional preparations should be complete by the time the storm is at the latitude of North Carolina. (MEMA, 2013)

Secondary Hazards

Precursor events or hazards that may exacerbate hurricane damage include heavy rains, winds, tornadoes, insufficient flood preparedness, and levee or dam breach or failure. Potential cascading events include loss of power and communications, health issues (mold, mildew); increased risk of fire hazards; hazardous materials, including waste byproducts; compromise of levee or dam; isolated islands of humanity; increased risk of landslides or other types of land movement; disruption to transportation; disruption of infrastructure functions; structural and property damage; debris distribution; and environmental impact. (MEMA, 2013) In Williamstown the loss of The Spruces Mobile Home Park resulted in permanent relocation and dispersion of a close-knit community.

Climate Change Impacts

The Northeast has been experiencing more frequent days with temperatures above 90°F, 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.

Exposure

To understand risk, the assets exposed to the hazard areas are identified. For the hurricane and tropical storm hazard MEMA has determined that the entire Commonwealth of Massachusetts is exposed to extensive winds and rains. (MEMA, 2013) Damages from a hurricane can be broken into two general categories of direct impacts: flooding and high winds. Flooding damage for Williamstown has been assessed and discussed in the flooding section of this plan and is not discussed here. For wind-based damage, the hurricane simulation model for Williamstown was run in HAZUS-MH, using a probabilistic 100-year (1% annual chance) storm using default HAZUS value. The 100-year storm was used to be comparable to the storm event used in the flooding model.

3.3.3. Vulnerability

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. Economically distressed,

elderly 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. HAZUS-MH was run to estimate the wind damage and the sheltering needs of Williamstown residents should a 100-year high wind event occur. This should be noted that this particular HAZUS-MH model calculated wind damages only – it does not calculate damages from flooding. The full report from the model is found in Appendix B. The HAZUS-MH model and results for flood events are found in Section 3.2. and correlate to the 1% annual chance or 100-year flood event, which may or may not be caused during a hurricane or tropical storm event.

According to HAZUS-MH, no residents may be displaced or require temporary to long-term sheltering due to wind damages. It should be noted that HAZUS-MH utilizes 2000 Census data, and therefore, the totals will vary slightly. However, as calculated by HAZUS-MH and reported in the flooding section of this plan, 583-606 residents could be displaced and seek shelter if the hurricane event resulted in a 100-year flooding event.

Critical Facilities

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. HAZUS-MH predicted that no critical facilities would be impacted by wind-related damages.

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. HAZUS-MH estimates the total building-related economic loss associated with each storm scenario (direct property damages and business interruption losses). The building related losses are broken into two categories: direct property damage losses and business interruption losses. The direct property damage losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the hurricane. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the hurricane.

Damage to buildings can impact a community's economy and tax base. HAZUS-MH analysis determined that there is \$163,370 of exposure due to the potential wind damage. The statistical data reports that some minor property damages could be sustained in three buildings within Williamstown, with the residential sector suffering all but a minor, less than 1% percentage of damages. No buildings would sustain moderate or severe damages. (HAZUS-MH, 2017)

Table 3.3.3. HAZUS-MH Results for Hurricane Winds (in dollars)

		Residential	Commercial	Industrial	Others	Total
Building Loss						
	Building	126,310	10	-	-	126,320
	Content	36,990	-	-	-	36,990
	Inventory	-	-	-	-	-
	Subtotal	163,300	10	-	-	163,310
Business Interruption						
	Income	-	-	-	-	-
	Relocation	60	-	-	-	60
	Rental Income	-	-	-	-	-
	Wage	-	-	-	-	-
	Subtotal	60	-	-	-	60
Total		163,360	10	-	-	163,370

Source: HAZUS-MH, 2017

HAZUS-MH also estimates the amount of debris that may be produced as a result of wind events. The debris produced is estimated to be approximately 177 tons, the vast majority (91%) of which would be tree debris. (HAZUS-MH, 2017) Because the estimated debris production does not include flooding, this is likely a conservative estimate and would likely be higher if multiple impacts occur, most particularly flood impacts.

3.3.4. Existing Protections

- Massachusetts Building Code dictates building construction in Williamstown, and the Town's Building Inspector strictly adheres to the Code.
- Regional School District and Town has emergency communications systems in place.

3.3.5. Actions

- Continue to enforce the Massachusetts Building Code.
- Continue to encourage all town residents and businesses to enroll in CodeRed.

3.4. Severe Weather Hazards: High Winds, Thunderstorms, Tornadoes, Extreme Temperatures

3.4.1. General Background

There are several severe weather events that impact the Berkshire County region and the Town of Williamstown, some of which occur suddenly and with little warning times. The severe weather hazards being discussed in this section of the plan are atmospheric in nature.

3.4.2. Severe Weather Hazard Profiles

Wind is air in motion relative to surface of the earth. Effects from high winds can include downed trees and/or power lines and damage to roofs, windows, etc. High winds can cause scattered power outages. Massachusetts is susceptible to high wind from several types of weather events: before and after frontal systems, hurricanes and tropical storms, severe thunderstorms and tornadoes, and Nor'easters. Winds measuring less than 30 mph are not considered to be hazardous under most circumstances. Sometimes, wind gusts of only 40 to 45 mph can cause scattered power outages from trees and wires being downed. This is especially true after periods of prolonged drought or excessive rainfall, since both are situations which can weaken the root systems and make them more susceptible to the winds' effects. (MEMA, 2013)

A thunderstorm is a storm with lightning and thunder produced by a cumulonimbus cloud, usually producing gusty winds, heavy rain, and sometimes hail. Frequently during thunderstorm events, heavy rain and gusty winds are present. Less frequently, hail is present, which can become very large. Tornadoes can also be generated during these events. (MEMA, 2013)

Rising, warm moist air is the foundation for thunderstorms. If this warm air is forced to rise and is channeled upward by hills or mountains, or areas where warm/cold or wet/dry air collide, it can become unstable and charged. Sometimes strong downdrafts of cool air, known as downbursts, can cause tremendous wind damage, similar to that of a tornado. A small (< 2.5-mile path) downburst is known as a "microburst." (MEMA, 2013)

Tornadoes are fierce phenomena which generate wind funnels of up to 200 mph or more, and occur in Massachusetts usually during June, July, and August. A tornado is a narrow, violently rotating column of air that extends from the base of a cumulonimbus cloud to the ground. The visible sign of a tornado is the dust and debris that are caught in the rotating column made up of water droplets. Tornadoes can form from individual cells within severe thunderstorm squall lines. They can form from an isolated super-cell thunderstorm. They can be spawned by tropical cyclones or even their remnants that are passing through. (MEMA, 2013) Tornadoes are the most violent of all atmospheric storms and are historically the deadliest of weather events in Berkshire County.

Massachusetts has four well-defined seasons. The seasons have several defining factors, with temperature one of the most significant. Extreme temperatures can be defined as those that are far outside the normal ranges. According to MEMA the average temperatures for Massachusetts are:

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

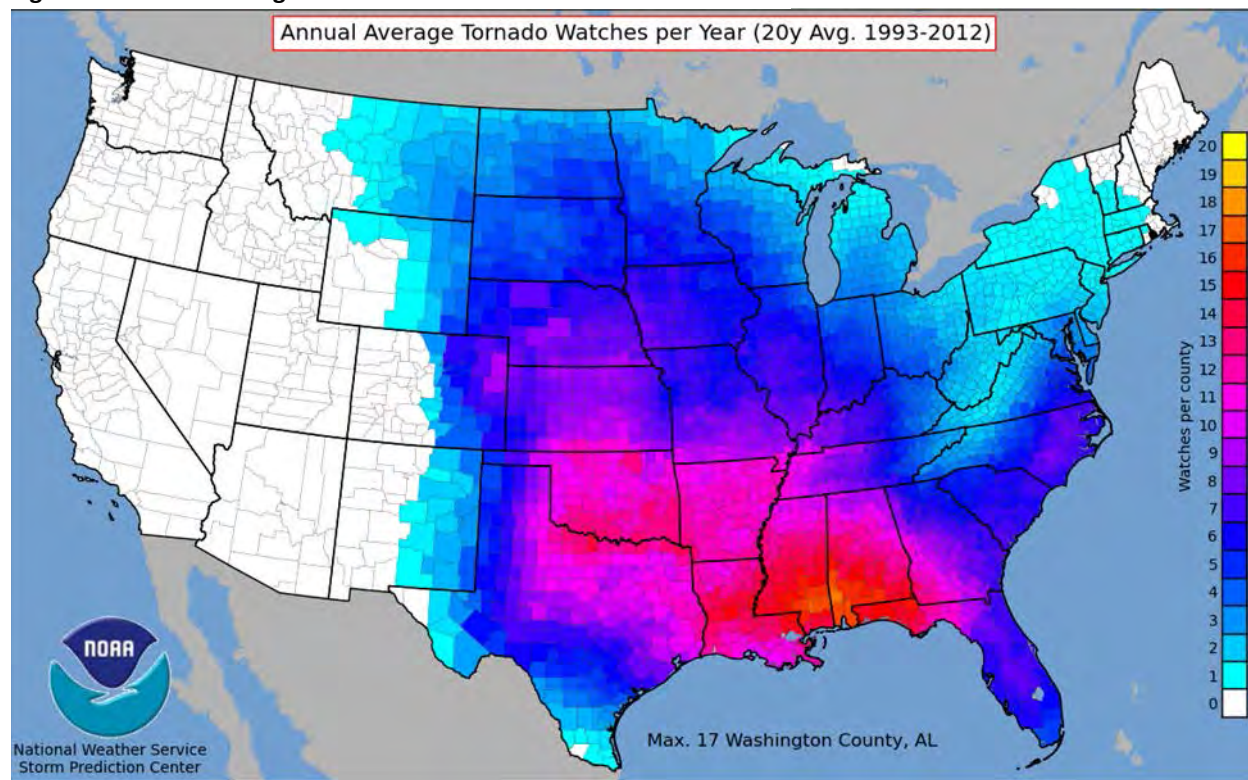
Extreme heat events impact the health of human beings, livestock and wildlife, and can impact the ability of people to function at home or work. Extreme cold is a dangerous situation that can result in health emergencies for susceptible people, such as those without shelter, who work outside or who are stranded or who live in homes that are poorly insulated or without heat.

Impacts from severe storm events can be as widespread as effecting all of the 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. In general, the high percentage of forest cover across Berkshire County, including most of Williamstown, tends to disrupt wind flows, although conversely trees can create high hazard conditions near buildings and utility lines. Areas of impact from tornados and microbursts are unpredictable.

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

The location of tornado impact is totally unpredictable. However, the county is located in a lower risk area with an average of 1 tornado watch per year (see Fig. 3.4.1.).

Fig. 3.4.1. Annual Average Tornado Watches



Source: National Weather Service Storm Prediction Center 2018

Secondary Hazards

The most significant secondary hazards associated with severe local storms are falling and uprooted trees and broken branches, downed power lines, and possible flooding and landslides. Rapidly melting snow combined with heavy rain can overwhelm both natural and man-made drainage systems, causing overflow and property destruction. (MEMA, 2013) Possible long-term power outages and closed transportation systems can threaten human health and disrupt businesses.

The Berkshires are currently a moderately temperate climate, but an increase in summer temperatures will create higher peak summer electricity demands for cooling, particularly with an increase in the number of air conditioning units being installed. Cooling degree days (CDD) are a measure of how much and for how long outside air temperature was higher than a specific base temperature. CDD are the difference between the average daily temperature and 65°F, which has been determined to be a temperature that does not typically call for use of indoor cooling systems. For example, if the temperature mean is 90°F, subtract 65 from the mean and the result is 25 cooling degree-days for that day. The number of CDDs for the summer season is 189 for in the Hoosic River Basin for the baseline years of 1971-2000. Summer CDDs are expected to increase by 94-237% (to 177-448 degree-days) by mid-century, and by 126-469% (to 238-886 degree-days) by end of century. (Northeast Climate Science Center, 2018). It is unknown how well prepared the electric grid is for the increased peak season and daily demand from ever more air conditioning units.

Previous Occurrences

According to the MA State Hazard Mitigation Plan, there have been several damaging severe storms that have included Berkshire County. Southern New England typically experiences 10 to 15 days per year with severe thunderstorms. An average thunderstorm is 15 miles across and lasts 30 minutes, although severe thunderstorms can be much larger and longer. (MEMA, 2013) Based on all sources researched, known severe weather events that have affected the region and were declared a FEMA disaster are identified in Table 3.4.1, which provides detailed information concerning the FEMA declarations for the Commonwealth. (MEMA, 2013)

Table 3.4.1. FEMA Severe Weather Event Declarations Including Berkshire County 1954 to Present

Incident Period	Description	Declaration Number
3/30/87 – 4/13-87	Severe storms and flooding; 8” in some areas of state with already high river conditions due to spring snowmelt	<i>DR-790</i>
10/7/05-10/16/05	Severe storms and flooding throughout Berkshire County the remnants of T.S. Tammy produced significant rain and flooding across western Massachusetts. It was reported that between 9-11” of rain fell. The state received over \$13 million in individual and public assistance.	<i>DR-1614</i>
4/15/07-4/25/07	Severe storms and flooding; 3-6” of wet snow, sleet, and rain to parts of western Mass. The storm was primarily a rain event due to warmer temperatures, but higher elevations experienced significant snow and	<i>DR-1701</i>

	ice accumulations. Mass received \$8 million in public assistance from FEMA.	
1/29/2011	Severe thunderstorms produced quarter- sized hail and damaging winds, knocking numerous trees and power lines in the affected areas, causing nearly \$100,000 in property damage.	EM-3343
10/29/11- 10/30/11	Severe storm and Nor'easter; at peak 665,000 residents state-wide without power; 2,000 people in shelters statewide. Snowfall accumulations of 1-2' were common in the Monadnocks, Berkshires, Connecticut Valley, and higher elevations in central Massachusetts. Up to 31 inches of snow was reported in Plainfield, MA. The accumulation of the heavy, wet snow on trees and power lines resulted in widespread tree damage and power outages across central and western Massachusetts. Six fatalities occurred during and in the aftermath of the storm.	DR-4051

Source: MEMA, 2013; BRPC 2017

The Storm Prediction Center maintains a severe weather database that contains information regarding hail, tornado, and damaging events. The damaging wind reports include data from 1996 to 2017. According to the Storm Prediction Center database, over the course of the last 20 years, the region has experienced 40 damaging wind events, with an annual frequency of two per year (NOAA, 2017). The events from the past 20 years caused over \$348,000 in property losses.

Microbursts occur throughout Berkshire County, downing trees, utility lines and sometimes causing damage to property. In the Berkshires microbursts are often very local in nature, effecting only a small area, and are often accompanied by heavy rainfall that can cause additional damage from flooding. However, because most microbursts effect small areas and damages are relatively limited, they are seldom listed by state or national agencies. According to local news media reports, several recent

Fig. 3.4.2. Microburst in Cheshire 7-18-16



Source: iBerkshires 7-18-16.

thunderstorm/microburst events have caused damages in the communities of Williamstown, North Adams, Adams, Cheshire, Lanesborough, Pittsfield, Lee, and Stockbridge.

On Sunday, June 1, 2016 an afternoon thunderstorm stalled for two hours over Lee and Stockbridge, flooding streets, basements and ground floors, including the ground floor of Stockbridge Town Hall. Stockbridge received almost 5" of rain while 4.5" fell at the Lee water treatment plant. Another inch of rain fell the next evening in another storm.¹ An event that struck Pittsfield and other central Berkshire communities in July 2011 caused extensive damage and was responsible for the death of a man in

¹ Lindsay, Dick, 6-1-16. "Weekend deluge swamps roads, homes in Stockbridge, Lee," *Berkshire Eagle*.

Hinsdale who was struck by a falling utility pole. WMECO called in 339 out-of-state work electric crews and 14 out-of-state tree crews to remove trees and repair damaged lines². Microbursts struck in Lanesborough twice, in 2001 and in 2004, knocking down trees and powerlines for several hours. A microburst struck Cheshire in 2016.

One known microburst, May 29, 2012, was documented as occurring in Hopkins Forest in northwestern Williamstown by Williams College. The event, with a 4:40 p.m. maximum wind speed of 84 miles per hour on the ridge, knocked down trees of various sizes and age, and created openings in the forest.

Fig. 3.4.3. Blowdown of Trees in Hopkins Forest May 2012



Source: Hank Art, Williams College, 2018.

² McKeever, Andy, 1-27-11. "Pittsfield Slammed by Surprise Microburst Storm," iBerkshires.

Typically, there are one to three tornadoes somewhere in southern New England per year, with Massachusetts experiencing an average of one tornado event annually between 1991 and 2010. Starting in 2007, tornadoes are rated based on the Enhanced Fujita Tornado Scale; prior to 2007 tornadoes were based on the Fujita Tornado Scale. Of the 18 tornadoes that have occurred in Berkshire County between 1950 and 2016, only one has occurred since 2007, an EF1 in July 2014 in Dalton (see Fig. 3.4.4.). Four tornadoes occurred during a single storm on July 3, 1997. These have resulted in over \$29 million in damage, seven deaths, and 60+ injuries. (NOAA, 2017).

The most memorable tornadoes in recent history occurred in West Stockbridge in August of 1973 (category F4) and in Great Barrington, Egremont, and Monterey in May of 1995 (category F4). In the West Stockbridge tornado four people died and 36 were injured, and in Great Barrington three people died and 24 were injured. The signs of the tornadoes destruction are still visible today in Great Barrington from Rt. 7. The hill to the east is scarred where the tornado uprooted and toppled trees – they lie scattered on the hillside like matchsticks.

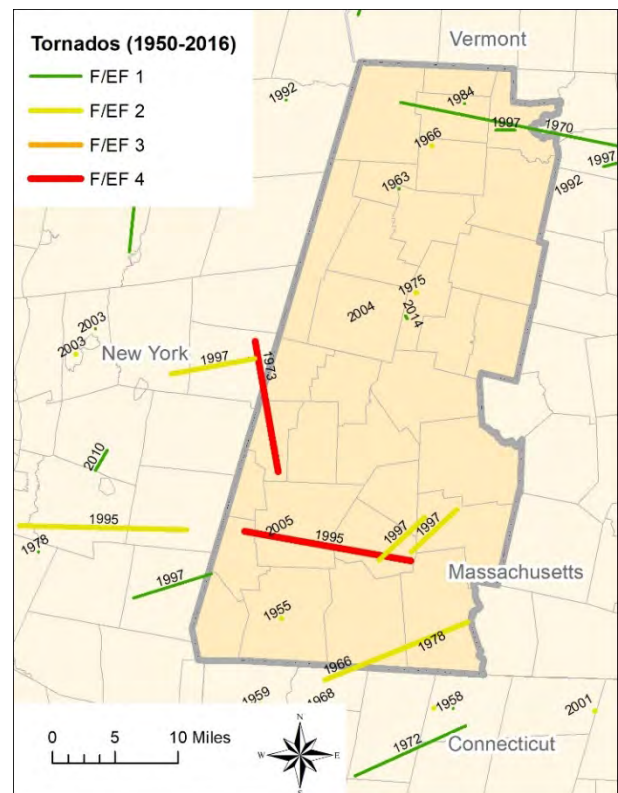
Most tornadoes occur in the late afternoon and evening hours, when the heating is the greatest. In Berkshire County the majority of tornadoes occur in the month of July and to a lesser degree in August, but tornadoes have hit the county as early as March (in Adams in 1966) and as late as October (in Cheshire in 1963). (MEMA, 2013)

Probability of Future Occurrences

Severe storms comprising 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 the maps generated the Berkshires is listed as a Special Wind Region within the Hurricane-susceptible Region of a Wind Zone II (up to 160 mph winds). See Fig. 3.4.5. Based on this historical data the Town of Williamstown 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 have been one fatality and 43 injuries as a result of lightning events from 1993 and 2012 in the Commonwealth (NCDC, 2012). Although thunderstorms with lightening may increase due to a more volatile atmosphere, the chance of death or injury is likely to remain low.

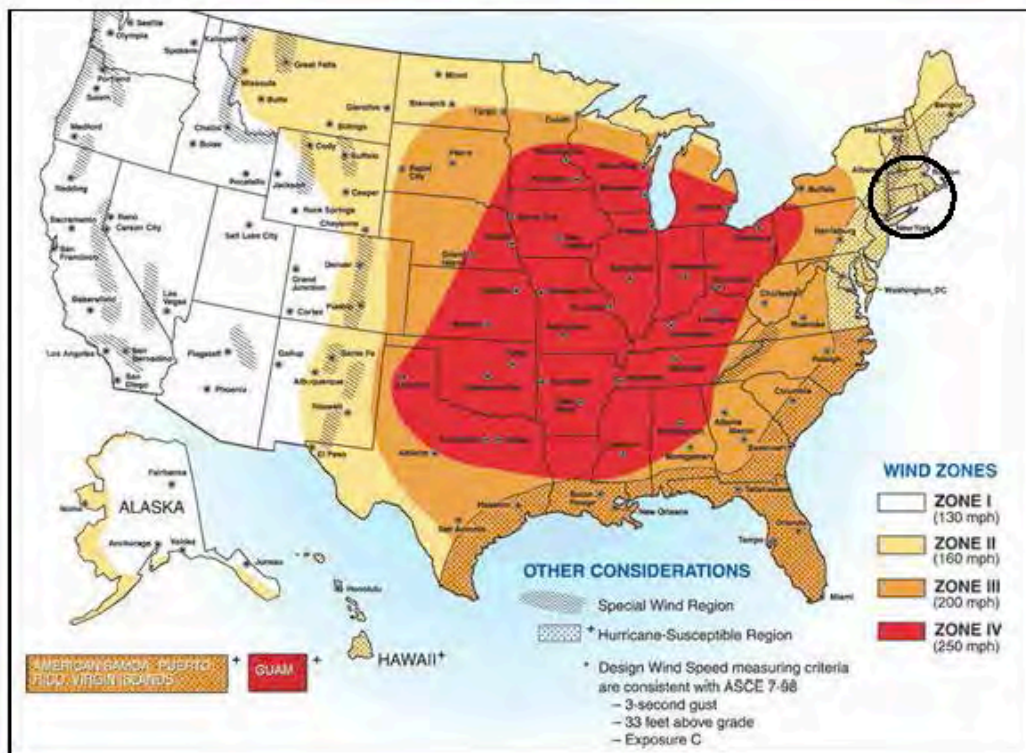
Fig. 3.4.4. Tornadoes in the Berkshire Region and their Severity



Source: Midwest Regional Climate Center, 2018

According to the National Climatic Data Center, since 1950, there have been 13 tornadoes that have touched down or moved in a path across Berkshire County. As shown in Fig. 3.4.4, there are several others that occurred in adjacent counties and states in the region. This averages to one tornado striking the county approximately every five years. Of these, only two have been of a severity of an EF4, which indicates that such a severe tornado has a statistical recurrence rate of one in every 33 years. (NOAA, 2017)

Fig. 3.4.5. Wind Zones in the U.S.



Source: MEMA 2013.

Since 2000, there have been 24 cold weather events within the Commonwealth, ranging from Cold/Wind Chill to Extreme Cold/Wind Chill events. Since 2000, there have been one warm weather event, Excessive Heat. Detailed information regarding most of these extreme temperature events was not available.

Extreme temperatures will continue throughout the entire county into the future. With global warming, the county should expect extreme temperatures regimes to be altered. It is projected that the region will experience 11 less days below 0°F. According to the Massachusetts Climate Change Projections for the Hoosic River Watershed, a high temperature of above 90°F occurred less than once per year during the baseline years of 1971-2000. By mid-century the number of days that the temperature will rise above 90°F will range from 4 to 17, and by the 2090s the number will increase to 6 to 50 days per year. By mid-century the number of days going above 95°F will increase from the baseline of zero days per year to a high of 5 days per year, and by the 2090s will increase to a high of 21 days per year. (Northeast Climate Science Center, 2018). If a heat wave lingers for several days in a row during the summer, the

evening temperatures will likely remain high, making it difficult for homes and other buildings to cool down before the start of the next hot day. People without access to air conditioning, especially those with medical issues, can suffer additional health effects or even death. The increased demand for electricity due to the use of air conditioning and fans will strain the electric grid, and possible cause brownouts or failures.

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 46 - 57 mph) or a High Wind Warning (sustained winds 40+ mph or any gusts 58+ mph). For tropical systems, the NWS issues a tropical storm warning for any areas that are expecting sustained winds 39 - 73 mph. A hurricane warning is issued for any areas that are 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 one inch in diameter or larger (quarter size), or a tornado (NWS, 2013).

Tornado damage severity is measured by the Enhanced Fujita Tornado Scale and it allows surveyors to create more precise assessments of tornado severity. Table 3.4.6. illustrates the EF-scale.

Table 3.4.6. Enhanced EF-Scale

EF Number	3-second gusts (mph)
0	65-85
1	86-110
2	111-135
3	136-165
4	166-200
5	Over 200

In the Berkshires, extreme cold temperatures are those that are well below zero for a sustained period of time, causing distress for vulnerable populations that are exposed to the temperatures when outside and straining home heating systems. The severity of extreme cold temperatures are generally measured through the Wind Chill Temperature Index. Wind Chill Temperature is the temperature that people and animals feel when 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 is cooled at a faster rate causing the skin's temperature to drop. (MEMA, 2013)

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 three hours, using only the sustained winds (not gusts). The NWS issues a Wind Chill Warning if the Wind Chill Index is forecast to fall to -25°F or colder for at least three hours 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, 2013)

The following are some of the lowest temperatures recorded in the Berkshire 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 present, showing Boston and three Berkshire County locations. (National Climatic Data Center, 2017)

- | | |
|-----------------------------|-----------------------|
| ▪ Boston, MA 102°F | ▪ Adams, MA 95°F |
| ▪ Great Barrington, MA 99°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°-104°F for two or more hours. The NWS issues an Excessive Heat Warning if the Heat Index is forecast to reach 105°F or more for two or more hours.

Warning Times

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 that severe criteria are observed. Some severe thunderstorm events may 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.

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) According to the Dalton Emergency Management Director, who monitors weather advisories, there was no tornado warning for the Town prior to the tornado that struck the town in 2014. The only warning issued was a severe weather warning, with possible high winds.

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, 2013)

The severe weather warnings issued for Berkshire County are generated out of the National Weather Service out of Albany NY, not from that in Boston. Also, 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. Also, given that the prevailing winds are 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.

Climate Change

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 that the probability for severe weather events increases 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.

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 made more vulnerable due to existing chronic medical conditions or lower economic status. Additional impacts pose serious threats to public health and safety of urban areas, rising sea levels, and decreases in natural biodiversity.

Exposure

Whereas risk from some hazards can be somewhat dependent on locating development and infrastructure in higher risk areas (i.e. 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.

Temperature extremes can occur throughout the entire region and the Town of Williamstown. Colder temperatures are more common in the higher elevations of the community, but the entire community is susceptible. Areas that are more prone to heat include the lower elevations in the downtown area and developments that are surrounded by parking lots. To understand risk, the assets exposed to the hazard areas are identified, and for the purposes of this plan the entire Town of Williamstown is considered to be at risk for all the severe weather hazards discussed in this section.

3.4.3. Vulnerability

Population

The following populations are more vulnerable to a severe wind storm or tornado (MEMA, 2013):

- communities without or having ineffective early warning systems;

- Elderly and functional needs populations are considered most vulnerable because they require extra time or outside assistance to seek shelter;
- those with a language barrier unable to following warning messages;
- those in mobile homes;
- people in automobiles at the time of a tornado.

Severe storm events such as wind and rain storm events can impact people across Berkshire County and the Town of Williamstown. Overall the greatest concern to human health from the hazards discussed in this section arise out of the potential for wide spread, long-term electricity outages, particularly during extreme temperature events that would make expose people susceptible to severe cold due to lack of heat and severe heat due to lack of fans or air conditioning. People with pre-existing illnesses who need electricity for oxygen, dialysis or other equipment, and those who need moderate temperatures and humidity to reduce stress on pulmonary or cardiac systems are more vulnerable to electricity outages. The elderly are typically more vulnerable due to chronic illness, and given the trend of an increasing elderly population, mitigation and preparing for electricity outages should be a high priority. The additional trend of helping seniors age in place could mean that elderly residents become isolated during severe weather events.

While residents in Williamstown have not experienced a prolonged power outage in recent memory, some residents in neighboring towns in the region were without electricity for days or weeks during the Ice Storm of 2008.

Massachusetts ranks 35th among states for frequency of tornadoes, 14th for the frequency of tornadoes per square mile, 21st for injuries, and 12th for cost of damage. (MEMA, 2013) On June 1, 2011, seven tornadoes traveled through the Connecticut River Valley. destroying large sections of Springfield and other towns in the region, killing three people, injuring 300 in Springfield alone, and leaving at least 500 people homeless. The F3 tornado traveled a 39-mile path from Westfield to Brimfield and Monson, the latter small towns of which suffered the greatest damages. With winds of up to 160 mph, it destroyed 1,400 homes and 78 businesses.³

According to available data tornadoes are the single deadliest natural hazard in Berkshire County in recent decades (other deadly hazards have historically been floods and dam failures). So far deaths have been relatively low because none of the stronger tornadoes were struck an area within one of the county's more densely populated areas such as a town center, village or subdivision. If a tornado where to strike a densely populated area it is likely that local and regional sheltering would be required.

Fig. 3.4.7. Path of the Great Barrington Tornado



³ <http://boston.cbslocal.com/2016/06/01/springfield-tornado-5-year-anniversary-3-killed-millions-damage/>

All residents in the Town of Williamstown are vulnerable to the health effects of extreme temperatures, with those who work outside directly at a greater risk. Others at greater risk are those individuals who have pre-existing medical conditions that impair their ability to regulate their body temperatures, or whose homes or work places are inadequately heated or cooled.

The NWS Wind Chill Temperature Index calculates how cold air feels on human skin, showing where temperature, wind speed and exposure time will cause frostbite to exposed human skin. Fig. 3.4.8. illustrates the relationship.

Vulnerable populations are the elderly and those with pre-existing health conditions such as cardiovascular disease, Type II diabetes and other chronic ailments are at higher risk of extreme heat events. Hot humid conditions have been found to make breathing more difficult for those suffering from impaired respiratory and pulmonary systems. Societal factors most associated with heat related health risks were a lack of air-conditioning, lower social economic status, socially isolated individuals and a higher percentage of elderly (DPH, 2014)

Based on the criteria for heat stress forecasts developed by the National Weather Service (NWS), watches or warnings are issued when thresholds of daytime high and nighttime low heat index (Hi) values are exceeded for at least two consecutive days (Fig. 3.4.9). That number provides a temperature that the body feels. It is important to know that the Heat Index values are devised for shady, light wind conditions. Exposure to full sunshine can increase heat index values by up to 15°F. In Boston more than 50 people die each year due to heat-related illnesses. (MEMA, 2013) When interviewed in 2016 about projected climate change impacts, local ambulance crews reported no increase in heat-related calls in recent years, but Pittsfield Fire Chief Czerwinski did note that his department and Berkshire Medical Center staff are coordinating more closely about when to open cooling centers in Pittsfield for vulnerable populations (BRPC & BCBOHA, 2016) .

Fig. 3.4.8. Wind Chill Temperature Index and Frostbite Risk

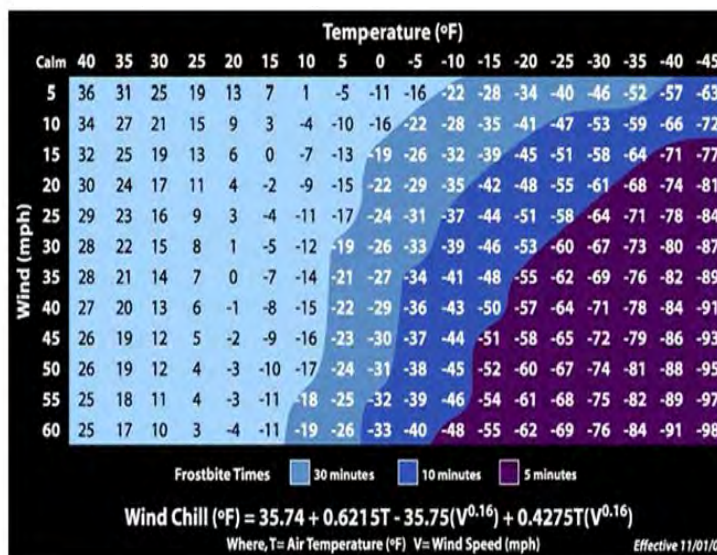


Fig. 3.4.9. Heat Index Chart and Human Health Impacts

TABLE 14-3. HEAT INDEX CHART																
Relative Humidity (%)	Temperature (°F)															
	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
	45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137
	50	81	83	85	88	91	95	99	103	108	113	118	124	131	137	
	55	81	84	86	89	93	97	101	106	112	117	124	130	137		
	60	82	84	88	91	95	100	105	110	116	123	129	137			
	65	82	85	89	93	98	103	108	114	121	128	136				
	70	83	86	90	95	100	105	112	119	126	134					
	75	84	88	92	97	103	109	116	124	132						
	80	84	89	94	100	106	113	121	129							
	85	85	90	96	102	110	117	126	135							
	90	86	91	98	105	113	122	131								
	95	86	93	100	108	117	127									
	100	87	95	103	112	121	132									
Category		Heat Index		Health Hazards												
Extreme Danger		130 °F + Higher		Heat Stroke or Sunstroke is likely with continued exposure.												
Danger		105 °F – 129 °F		Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.												
Extreme Caution		90 °F – 105 °F		Sunstroke, muscle cramps, and/or heat exhaustions possible with prolonged exposure and/or physical activity.												
Caution		80 °F – 90 °F		Fatigue possible with prolonged exposure and/or physical activity.												

Source: MEMA 2013

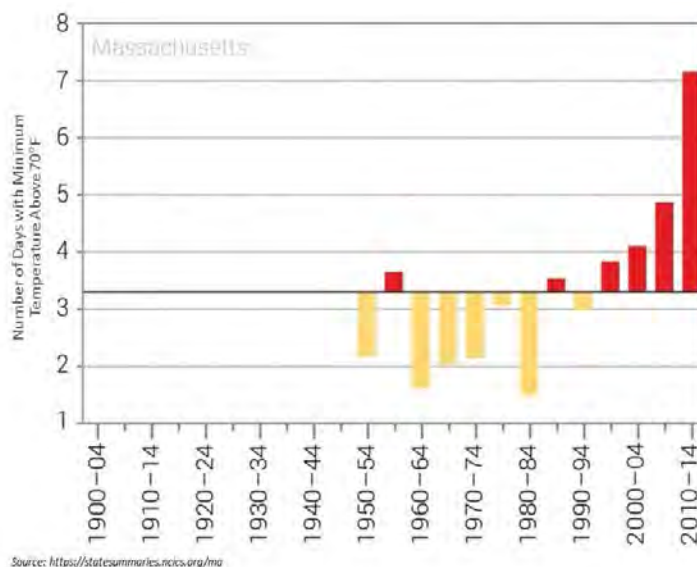
Nationally more than half of heat-related deaths occurred in homes where there was little or no air conditioning. Although the temperatures in the Berkshires do not equate to those in the southern portion of the country, the proportion of residents here without air conditioning is likely much higher than down south, indicating increased risk if the region were to experience a severe and prolonged heat wave. Air quality, which tends to be more degraded in urban areas, adds additional stress. Populations living in urban heat cores are more vulnerable to heat stress, particularly those without access to air conditioning and those with existing health conditions more susceptible. There are no urban core areas in Williamstown.

What may be more concerning is the trend for higher nighttime temperatures. Warm nights are those where the minimum temperature stays above 70°F. Since 1950 the number of warm nights in Massachusetts has steadily increased since the mid-1990s with the highest number since 1950 occurring between 2010 and 2014. Refer to Fig.3.4.10., where the dark horizontal line represents the long-term average.

Historically the cooler evening temperatures in the Berkshires has allowed residents to cool their body temperatures in the night air and to cool their homes by opening windows and using fans to bring in the cooler air. Warmer nighttime temperatures will make it increasingly difficult to cool homes that are not equipped with air conditioning.

Extreme heat temperatures and heat waves have historically been rare in Berkshire County, with temperatures that are cooler than the Hudson and Connecticut river valleys, ranging from 5°F cooler in the valley communities and 10°F cooler in the hilltowns. This is due largely to the slightly higher elevations of the Berkshires when compared to other regions in southern New England. Due to the rarity, this is a natural hazard for which communities and individuals are largely unprepared for. While most work places and increasingly more houses are being equipped with air conditioning, many residents across the county still rely on fans or inefficient window air conditioning units to cool their homes.

Fig. 3.4.10. Observed Number of Warm Nights in MA 1950-2014



According to the *Berkshire Communities for Climate Change* report, the Massachusetts Department of Public Health survey taken by local boards of health across the state, in which less than 20% of local boards reported dealing with heat waves. Thirteen of the 17 Berkshire towns that answered the survey reported not having taken any steps to plan for cooling centers. Local schools are often designated as an emergency shelters and in the western region only 38% of respondents reported having at least partially available air conditioning in their schools. (BCBOHA, 2016). In Williamstown, the Town Hall has been used as a cooling center and the Harper Senior Center recently had air conditioning installed to serve as a second cooling center.

Critical Facilities

All critical facilities in the Town of Williamstown are exposed to severe weather events such as high winds and thunderstorms and tornados. The most common problem associated with severe weather is 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 or urban flooding. (MEMA, 2013)

The Draft Lanesborough Hazard Mitigation Plan notes that electric power line infrastructure along the Route 7 corridor could pose a public safety risk in the event that the power lines come down during a severe wind or other event. In addition to the three-phase power the lines already carried, the power lines here carry electricity generated by the Berkshire Wind Cooperative wind turbine project, a 15-megawatt facility atop Brodie Mountain. The project owners are planning on adding two additional turbines for an additional 4.6 megawatts. This is an unusually high and dangerous amount of electricity, possibly able to melt asphalt if lines are broken. Several commercial solar projects have been proposed along the Route 7 corridor, and thus additional voltage may be added to the power lines along this portion of road if these are approved.

Route 7 is a major transportation artery in the region, serving as a main commercial route for Williamstown and a main link to the county's hospital in Pittsfield. Loss of this road could delay

emergency response and severely impact commercial and commuter movement. If a line went down anywhere on Route 7 between Bailey Road (South) to Prospect Street, there would be no way to divert traffic around it, short of sending them all over Summer Street or Old Cheshire Road, and then the all the way up Route 8 into North Adams and across Route 2 to Williamstown. Likewise, South bound traffic on Rt. 7 would have to go over Brodie Mountain Road into Hancock and out Routes 43, 22, and 20 in New Lebanon. Silver Street onto Ore Bed Road would have to be used for only emergency egress due to the fact that both are narrow dirt roads. These detours could be accentuated in the event of a region-wide disaster.

All critical facilities are exposed to the extreme temperatures hazards. Extreme cold temperature events can damage buildings and infrastructure through freezing/bursting pipes and freeze/thaw cycles. An exceptionally cold spell in February/March 2015 caused widespread freezing and destruction of water lines across central and northern Berkshire County. According to local public works staff, the frost line in the county generally extends four feet deep in communities located in the river valleys, depending on elevation and soil type. However, in 2015 the frost line reached lower depths, freezing water lines that buried 5-5.5 feet deep in many communities. Lenox, Pittsfield, Dalton, Adams and North Adams were quoted in local newspapers as responding to frozen and broken pipe across their respective communities. Aging, more brittle infrastructure was particularly vulnerable, with the City of North Adams reporting several damages that left residents without water for more than a week. Several local communities issued CodeRed advisories, including Dalton, Adams and North Adams.⁴

Extreme heat that occurs in the Berkshires generally does not impact buildings or other structures, but damages can be associated with overworking of HVAC systems, particularly those that are older or undersized. There is some concern that increased temperatures can reduce the 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 brown out 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.

Economic Vulnerability

Wind storms, thunderstorms, and tornado events may impact the economy, including loss of business function, water supply system damage, damage to inventory, relocation costs, wage loss, and rental loss due to the repair/replacement of buildings. Loss of key transportation routes may also occur. Agricultural losses can be devastating due to lightning and resulting fires. 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. (MEMA, 2013) Mobile homes are the most vulnerable to damage, even if tied down, and offer little protection to people inside. The total structural replacement cost value for residential buildings in the community is greater than \$509 million or approximately 62% of all occupancy classes. (Berkshire Regional Planning Commission, 2018).

⁴ Demers, Phil; Damon, Ed, 2015. "In Berkshires, frozen pipes still a risk – despite slight warmup", *Berkshire Eagle*, 3-9-15.

Many small businesses suffer disproportionately than larger industries – if small businesses cannot open the business than they may struggle to make payroll and other expenses – and the longer the closure the deeper the impacts.

3.4.4. Existing Protections

- The Town of Williamstown has backup generators for several critical facilities. Town Hall and the DPW facility have permanent generators and portable generators are available for drinking water well #1 and the elementary school, which is the Town's current local shelter. This building is in the town center and within walking distance to a majority of the population. The newly constructed Mt. Greylock Regional High School has permanent backup power and is being considered as an additional regional shelter site.
- Williams College, responsible for approximately 2,000 students, is prepared to be relatively self-sufficient if faced with a disaster. The college has developed shelter-in-place plans, established shelter and food emergency plans, and installed a two-megawatt emergency backup power generation system sufficient to provide electricity to house its student body and staff. Emergency drills are conducted periodically. Many of the major electric lines and cables are underground, reducing risk of damage during severe storm events. Communications systems to the outside world are in place, including mutual aid with other colleges for website functions.
- The Town of Williamstown and Williams College have established a close working relationship, having worked cooperatively on infrastructure and other community projects.
- Regarding electricity outages, town officials across Berkshire County have reported an improvement in response from the electric companies since the ice storm in 2008. Additionally, the electric utility companies have created special community liaison staff who work more directly with municipal first responders during emergency incidents.
- The Town of Williamstown is an active member of the Northern Berkshire Regional Emergency Planning Committee (NBREPC). This organization is a source of shared resources, first responder personnel and experience. Mutual aid agreements are in place.
- The Williamstown Elementary School has been designated as the Town of Williamstown's local shelter. Additionally, as a member of the Northern Berkshire Regional Emergency Planning Committee, the St. Elizabeth's of Hungary Parish has been established as a regional shelter if needed.
- CodeRed is utilized by emergency personnel when severe weather events are predicted; it is also utilized during and post-storm to inform residents of resulting road closures, power outages and other safety instructions.
- Cooling Centers are the Town Hall and the Harper Senior Center, which has a newly-installed air conditioning system.
- The Town of Williamstown adheres to the Massachusetts state building code, which as of 2018 was the Ninth Edition of the State Building Code. Part of that code requires buildings to withstand specific wind loads and adhere to energy efficiency standards. The Town is also a Green Community, which requires that new construction adhere to the state's Stretch Energy Code, requiring new buildings to more energy efficient and the building envelopes tighter than the state's

underlying code. The more heavily insulated building envelope will add in maintaining temperate interior temperatures against extreme exterior cold and heat. The MassSave Program offers free energy audits to residential and business customers who request the and, based on the results of the audits, offers financial incentives for building owners to become more energy efficient and better insulated.

3.4.5. Actions

- Continue strict adherence to MA building code and the Stretch Energy Code.
- Continue the partnership between the Town of Williamstown and Williams College to develop joint preparedness and response plans.
- Encourage cell phone users to enlist in the Town's CodeRed system.
- Develop a comprehensive shelter plan, one that includes a permanent generator at the elementary school and looks at the options available within the new regional high school.

3.5. Severe Winter Weather Hazards: Snow, Ice Storms, Blizzards and Nor'easters

3.5.1. General Background

Winter storms are the most common and most familiar of Massachusetts hazards which affect large geographical areas. The majority of blizzards and ice storms are viewed by people in the region as part of life in the Berkshires, an inconvenience and drain on municipal budgets. Residents and town staff expect to deal with several snow storms and a few Nor'easters each winter. However, periodically, a storm will occur which is a true disaster, and necessitates intense, large-scale emergency response.

Snow formation requires temperatures to be below freezing in all or most of the atmosphere from the surface up to cloud level. Generally, ten inches of snow will melt into one inch of water. Sometimes the snow-liquid ratio may be much higher – up to 20:1 or 30:1. This commonly happens when snow falls into a very cold air mass, with temperatures of 20 degrees or less at ground level. (MEMA, 2013)

A blizzard is a winter snowstorm with sustained or frequent wind gusts to 35 mph or more, accompanied by falling or blowing snow reducing visibility to or below a quarter-mile. These conditions must be the predominant condition over a three-hour period. Extremely cold temperatures are often associated with blizzard conditions, but are not a formal part of this definition. However, the hazard created by the combination of snow, wind, and low visibility increases significantly with temperatures below 20°F. 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, 2013)

A Nor'easter is typically a large counter-clockwise wind circulation around a low-pressure center often resulting in heavy snow, high winds, and rain. Strong areas of low pressure often form off the southern east coast of the U.S, moving northward with heavy moisture and colliding with cooler winter inland temperatures. Sustained wind speeds of 20-40 mph are common during a nor'easter, with short-term wind speeds gusting up to 50-60 mph or even to hurricane force winds. (MEMA, 2013) The main impacts of Nor'easters in the Berkshires is deep snow depths, high winds and reduced visibility, potentially resulting in the closing of schools, businesses, some governmental operations and public gatherings. Loss of electric power and possible closure of roads can occur during the more severe storms events.

Ice storm conditions are defined by liquid rain falling and freezing on contact with cold objects creating ice build-ups of ¼ inch or more that can cause severe damage. An ice storm warning, now included in the criteria for a winter storm warning, is for severe icing. This is issued when ½ -inch or more of accretion of freezing rain is expected. This may lead to dangerous walking or driving conditions and the pulling down of power lines and trees. (MEMA, 2013)

3.5.2. Hazard Profile

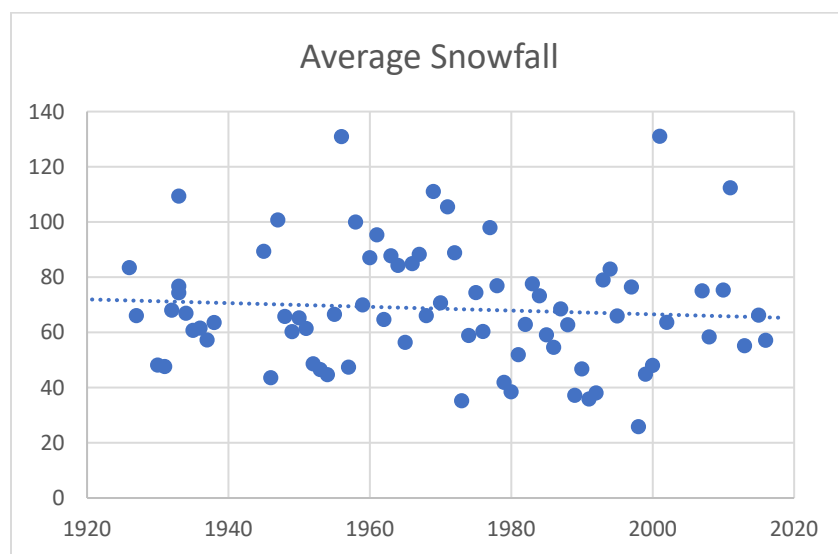
Location

Severe winter storm events generally occur across the entire area of Williamstown, although higher elevations above 1,000 feet have slightly higher snow depths.

Previous Occurrences

Figure 3.5.1. illustrates historic snowfall totals the region has received. Although the entire community is at risk, the higher terrains tend to receive higher snowfall amounts, and these same areas may receive snow when the lower elevations received mixed snow/rain or just rain. (National Climatic Data Center, 2017) In Williamstown the higher elevations 1,000 feet or more experience more severe snow and ice.

Figure 3.5.1. Average Snowfall in Berkshire County



The National Climatic Data

Center, a division of NOAA, reports statistics on severe winter storms from 1993 through 2017. 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 3.5.1. 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 the following sections. 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, non-flood-related severe storm events.

Table 3.5.2. Severe Winter Weather – Declared Disasters that included Berkshire County 1992-2017

Incident Period	Description	Declaration Number
12/11/92-12/13/92	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 approx. \$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.

Probability of Future Occurrences

Severe winter weather is a common occurrence each winter 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 are likely to continue to occur annually (MEMA, 2013). Williamstown'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 than 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 the town 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 than 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 and risk of roof failures.

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, 2013)

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 3.5.3. 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 2013.

Of the 12 recent winter storm disaster declarations that included Berkshire County (as listed in Table 2), 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 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 exacerbated by extremely cold temperatures in the days following the event.

While severe winter weather declarations have become more prominent in the 1990s, we do not believe that this reflects more severe weather conditions than the Berkshires experienced in the years 40+ years prior to the 1990s. Respected elders across Berkshire County comment that snow depths prior to the 1990s were consistently deeper than what currently occurs in the 2010s.

Warning Time

Meteorologists can often predict the likelihood of a severe winter storm. This can give several days of warning time. Schools and businesses usually have at least a 24-hour warning to monitor weather reports and start to plan closings. However, meteorologists cannot predict the exact time of onset or severity of the storm so decisions on closing schools, businesses or events are often made hours earlier. Some storms may come on more quickly and have only a few hours of warning time. (MEMA, 2013)

Secondary Hazards

Secondary impacts for winter events are similar to those experienced in other severe storm events such as high winds or flooding, but with the additional structural risk of damage from snow load, more widespread hazardous driving conditions and greater risk of hypothermia from power outages or shoveling. Prolonged extremely cold temperatures can also drive the frost line deeper into the ground, posing risks to piped infrastructure. The deeper frost line of 2015 was discussed in the previous section of this plan.

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 days with temperatures above 90°F, 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 5°F to 10°F increase in average ambient temperature with several more days of extreme heat during the summer. (MEMA, 2013)

Fig. 3.5.2. Opening Mohawk Trail in Florida MA with Shovels 1926



Source: Stan Brown, Florida, MA

Heating degree-days (HDD) are a measure of how much and for how long outside air temperature was lower than a specific base temperature, of which 65°F is often used. HDD are the difference between the average daily temperature and 65°F. For example, if the mean temperature is 30°F, we subtract the mean from 65 and the result is 30 HDD for that day. In the Hoosic River Basin the observed baseline (years 1971-2000) for the winter months was 3,953 HDD. By mid-century the number is projected to be reduced by 293 to 843 HDD, a 7-21% decrease. By end of century the HDD will be decreased by 450-119, a 450-1,129 decrease. (Northeast Climate Science Center, 2018) This decrease in HDD will result in a shift of energy demand, likely reducing demand during the winter months but causing an accompanying increase in summer demand.

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, 2013) Snow pack serves as insulation against prolonged severely cold temperatures, and a lack of snow cover during prolonged severe cold could result in deeper frost lines and damaged infrastructure.

Exposure

For the purposes of this plan, the entire Town of Williamstown is considered to be exposed to severe winter weather.

3.5.3. Vulnerability

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 fatalities may occur due to traffic accidents on icy roads, heart attacks while shoveling snow, or of hypothermia from prolonged exposure to cold. (MEMA, 2013)

Heavy snow can immobilize a region and paralyze a region, shutting down air and rail transportation, stopping the flow of supplies, and disrupting medical and emergency services. Accumulations of snow can collapse buildings and knock down trees and power lines. In rural areas, homes and farms may be isolated for days, and unprotected livestock may be lost. (MEMA, 2013)

The entire population of the community is exposed to the severe winter weather hazard, particularly those that work outside or whose job requires that they respond to the weather, such as shoveling, plowing or clearing snow from building roofs. The elderly are considered most susceptible due to their increased risk of injury and death from falls and overexertion and/or hypothermia from attempts to clear snow and ice, or related to power failures. Residents with low incomes may not have access to housing or their housing may be less able to withstand cold temperatures (e.g., homes with poor

insulation and heating supply). In addition, severe winter weather events can reduce the ability of these populations to access emergency services. Power outages can result in complete loss of heat for those who have electric heat or where electricity is required to run boilers or pellet stoves. Frozen water pipes could burst and threaten the home and the health of the residents who reside there. The ice storm of 2008 was the incident that created the longest power outages in the region in recent memory. Fortunately, although there was some ice on the higher elevations of the Taconic Range and along the southern flank of the Green Mountains, Williamstown did not experience severe ice damages or power outages.

Deep and heavy snow depths can weaken building roofs and threaten the structural integrity below them, injuring or killing people inside the building or those standing close to collapsing buildings. The weight of one foot of light fresh snow ranges from three pounds per square foot to 21 pounds per square foot for wet heavy snow.¹ Heavy snow loads in February/March 2015 caused the collapses of at least 210 buildings across the state.² Snow loads on buildings and homes with poorly insulated or vented attics are prone to melting and refreezing, causing the snow load to be heavier and making the roof more prone to ice dam damage. Educating building owners about improvements that could be done to protect roofs from snow load and ice dam damage would help to reduce risk from building collapse.

Critical Facilities

All critical facilities and infrastructure in the community are exposed to 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, but these facilities may not be fully operational due to workers unable to travel to ensure continuity of operations pre- and post-event. Fortunately many town critical workers live within a short driving distance and in neighboring communities, and public works and first responder staff levels seldom suffer. Because power interruption can occur, backup power is recommended for critical facilities and infrastructure. Fortunately the Town of Williamstown has generators in position to power governmental operations and to provide sheltering if needed. Williams College is relatively self-sufficient with its own power generating plan and sheltering plans in place. Long-term 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)

Economy

The entire general building stock inventory in the community is exposed and vulnerable 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. (MEMA, 2013)

¹ FEMA, 2013. *Risk Management Series, Snow Load Safety Guide, FEMA P-957*. Washington, DC.

² <https://www.bostonglobe.com/metro/2015/03/04/partial-roof-collapse-bayside-expo-center-dorchester-fire-officials-say/T3gLvWMMB7Jd7YszVABPDL/story.html>

Current modeling tools are not available to estimate specific losses for severe winter events. As an alternate approach, this plan considers a one percent damage of structures that could result from winter storm conditions. This one percent was used by the state in their 2013 State Hazard Mitigation Plan. Using assessor data from 2017, it is estimated that a severe winter event, likely one that would have heavy snow loads, could inflict a total of \$8.2 in building damages in Williamstown. Table 3.5.4. summarizes the potential damage that could result from winter storm conditions on the Town's total general building stock (structure only). These figures do not include financial losses suffered by businesses due reduced business hours or closures.

Table 3.5.4. Estimated Potential Loss Due to a Severe Winter Storm Event

Number of Buildings	Replacement Cost Value (Structure Only)	1% Loss
2,760	\$820,931,400	\$8,209,314

A specific area that is vulnerable to the winter storm hazard is the floodplain. Snow and ice melt and movement of ice jams can cause both riverine and urban 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.

The cost of snow and ice removal and repair of roads from the freeze/thaw process can drain municipal and state financial resources due to the cost of staff overtime, snow removal and wear on equipment. Rescheduling of schools and other municipal programs and meetings can also be costly. The potential secondary impacts from winter storms also impact the local economy including loss of utilities, interruption of transportation corridors, and loss of business operations and functions, as well as loss of wages for employees.

3.5.4. 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 Williamstown, Williams College and the Mt. Greylock Regional School District have good public communication systems that alert residents to school closings and other emergency conditions. Williamstown offers CodeRed emergency notification system to its residents, businesses and institutions; enrollment is prominently featured on the homepage of the Town's website.
- The Town of Williamstown 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 provide 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 the county was constructed before 1940, and 60% is pre-1960.³

3.5.5. Actions

- Develop a comprehensive sheltering plan that incorporates the elementary school and regional high school.
- Encourage homeowners to get energy audits and improve wall and attic insulation to buffer against short term power outages.
- Increase enrollment in Code Red.

³ BRPC, 2014. *Sustainable Berkshires, a Long-Range Plan for Berkshire County, Housing and Neighborhoods*. Pittsfield, MA

3.6. Dam Failure Hazards

3.6.1. General Background

A “dam” is an artificial barrier that has the ability to impound water, wastewater, or any liquid-borne material for the purpose of storage or control of water. 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, 2013)

The Massachusetts Department of Conservation and Recreation (DCR) Office of Dam Safety maintains an inventory of all the known dams in the state. A synopsis of this inventory is presented in the following pages. The BRPC has been unable to obtain an updated database from DCR for the 2018 plan, so the data has not changed since the 2005 plan unless updated information was known by the community on the removal or repair of dams. 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 classification for potential hazards pertain 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.

Table 3.6.1. 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

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 10 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 Plan 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.

3.6.2. Hazard Profile

Location

There are 11 public and privately-owned dams that could potentially inundate portions of Williamstown, 10 of which are located in the Town and one of which is located North Adams. These are listed in Table 3.6.2. and shown on the Critical Facilities and Areas of Concern Map in Appendix A.

These dams range in age, from the Williamstown Reservoir dam built in 1888 to the Harmond Pond dam built in 1957. The dams range in size from the Mount Williams Reservoir dam, with a normal impoundment capacity of 427 acre-feet (and maximum impoundment capacity of 791 acre-feet) to Taconic Park dam at Lindley Park normally impounding 1 acre-feet (Office of Dam Safety, 2004) Most of the dams are located on small streams and impound small water bodies, as indicated by their size class. Because of their size the owners are not required to have conducted an analysis to determine the severity or extent of flooding that would occur downstream if the dam were to fail or breach.

Table 3.6.2. Dams that could Inundate Areas in Williamstown

Dam Name	Year Completed	Location on stream/river	Owner	DCR Hazard Class	Size Class	Condition (as of 2004)
Bee Hill (breached)	1895	Flora Glen Brook	Town of Williamstown	Low	Non-Jurisdictional	Fair
Haley Pond	1929	Hemlock Brook	Private	Low	Small	Poor
Harmond Pond	1957	Sweet Brook	Private	Low	Intermediate	Not Available (NA)
Hoyt Pond	1904	Ford Glen Brook	Private	Low	Small	NA
Lower Hopkins Pond	1905	Ford Glen Brook	Private	Significant	Intermediate	Poor

Nichols Pond	1905	Buxton Brook	Private	Low	Small	NA
Taconic Park (Lindley Pk.)	NA	Hemlock Brook	Town of Williamstown	Low	Small	Fair
Williamstown Reservoir	1888	Trib. to Hoosic River	Town of Williamstown	High	Intermediate	Fair
Mount Williams Reservoir	1914	Paull Brook	City of North Adams	High	Large	Fair

Source: DCR Office of Dam Safety 2004

Severity

The U.S. Army Corps of Engineers developed the classification system shown in Table 3.6.3. for the hazard potential of dam failures to cause injury or loss of life, or to cause damages on property downstream of the dam. The system is designed to rat The Corps of Engineers hazard rating systems is based only on the potential consequences of a dam failure; it does not take into account the probability of such failures or the condition of the dam in question. (MEMA, 2013)

Table 3.6.3. Corps of Engineers Hazard Potential Classification

Hazard Category ^a	Direct Loss of Life ^b	Lifeline Losses ^c	Property Losses ^d	Environmental Losses ^e
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

- Categories are assigned to overall projects, not individual structures at a project.
- Loss of life potential is based on inundation mapping of area downstream of the project. Analyses of loss of life potential should take into account the population at risk, time of flood wave travel, and warning time.
- Indirect threats to life caused by the interruption of lifeline services due to project failure or operational disruption; for example, loss of critical medical facilities or access to them.
- Damage to project facilities and downstream property and indirect impact due to loss of project services, such as impact due to loss of a dam and navigation pool, or impact due to loss of water or power supply.
- Environmental impact downstream caused by the incremental flood wave produced by the project failure, beyond what would normally be expected for the magnitude flood event under which the failure occurs.

Source: MEMA, 2013.

Previous Occurrences

Historically, dam failure has had a low occurrence in Berkshire County. However, dams are one of the few natural hazards that are known to have taken human lives in Berkshire County.

- On April 20, 1886, the Mud Pond Dam in East Lee, MA, failed and heavily 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, during a two-day “cloudburst” Bassett Reservoir and Dean’s dams failed (Ennis, 2004). It is unclear if any injuries or deaths are attributed to the dam failures.
- On March 24, 1968, the 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, 2013)
- September 18, 2004 an incident occurred at the Plunkett Lake dam in Hinsdale. The first few weeks of September were unusually wet as the region received residual rain from three hurricanes. On September 18th, 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 Lake 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. This was largely due to culverts partially plugged by beavers. (BRPC, 2012)

Probability of Future Occurrences

Dam failure events are infrequent and usually coincide with events that cause them, such as earthquakes, landslides, excessive rainfall, and snowmelt. A factor to consider is that many of the dams within the region are more than 100 years old, 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. However, the probability of a dam failure is low in today’s regulatory and dam safety oversight environment.

Secondary Hazards

The failure of a dam that impounds a public drinking water supply could reduce or eliminate delivery of water to the public, such as that at the Mount Williams and Williamstown Reservoirs. Even if complete dewatering of the impoundment is not reached, the quality of the water may be impaired due to sediment disturbance and exposure of shoreline. Some public water supplies may be so impaired by sediment movement that they must be taken off line for years. This occurred at Windsor Reservoir, where the Dalton Fire & Water District had to remove the reservoir from use due to ongoing turbidity. The Town's reservoir is a backup supply to its groundwater wells, which limits this risk.

The sudden and potentially extreme volumes of water that are released during dam failures can impact 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. (MEMA, 2013) Upstream of the dam the former impoundment could become partially or completely dewatered, altering, and potentially destroying aquatic habitat. Loss of impoundments can also reduce fire-fighting capacity if the area lacks fire hydrants.

Climate Change Impacts

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. (MEMA, 2013)

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.

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, 2013)

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, 2013)

Exposure

There are two High Hazard dams, that at the Williamstown Reservoir and Mount Williams Reservoir, that could inundate portions of Williamstown. Both of these dams are on streams that flow into the

Hoosic River in the vicinity of the former Spruces Mobile Home Park. The permanent removal of homes from the park have eliminated the risk of flood damages to people and structures in Williamstown in this area. However, water releases down Paull Brook could flood or impact the airport and the Galvin Road neighborhood of North Adams.

3.6.3. Vulnerability

Population

All populations in a dam failure inundation zone would be exposed to the risk of a dam failure. The potential for loss of life is affected by the water volume release, 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. 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 or radio emergency warning system are highly vulnerable to this hazard. This population includes the elderly and young who may be unable to get themselves out of the inundation area. (MEMA, 2013)

A quantitative vulnerability assessment for property damages, injury or death could not be completed to estimate potential losses from most dams within Williamstown because inundation studies have not been conducted for most of them. The towns vulnerability to the dam failure hazard is discussed qualitatively below.

Critical Facilities

All critical facilities and transportation infrastructures in the dam failure inundation zone are vulnerable to damage. Flood waters may potentially cut off evacuation routes, limit emergency access, and destroy power lines and communication infrastructure. (MEMA, 2013) The inundation areas for the majority of dams in Williamstown are small unmapped, so it is not clear what, if any, critical facilities are within an inundation area for these dams. Route 2, a major east-west transportation route for northern Berkshire County, is in the inundation area for the Williamstown Reservoir dam, and is believed to be in the inundation area for the Mt. Williams Reservoir dam. At a minimum failure of either of these dams could temporarily close the route during the period of inundation, resulting in long detour routes and increased travel times. Damage to the road could result in long-term closure of the road.

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. As the inundation areas have not been mapped for most dams, it is unclear what economic impact would occur if the dams failed. The loss of Route 2 due to dam failure could severely impact businesses along the roadway in both Williamstown and North Adams, and would result in long detour routes and increased travel times for commercial and commuter movement. The economic impact of the road closure is unknown.

3.6.4. Existing Protections

- An Emergency Action Plan for the Williamstown Reservoir has been developed and is on file with the Williamstown Emergency Management Director.
- Williamstown has three groundwater wells for public drinking water; the reservoir is a backup supply, saved for back supply in the event of an extended power outage where diesel fuel for generators becomes unavailable.

3.6.5. Actions

- Determine which major transportation routes or other critical facilities are in inundation areas for High or Significant Hazard dams.
- Encourage and support the City of North Adams to inspect and develop an EAP for the Mt. Williams Reservoir; request a copy of the EAP once completed.

3.7. Drought Hazard

3.7.1. General Background

Drought is a period characterized by long durations of below normal precipitation. Drought occurs in virtually all climatic zones, yet its characteristics vary significantly from one region to another, since it is relative to the normal precipitation in that region. Direct impacts of drought include reduced water supply, crop yield, increased fire hazard, reduced water levels, and damage to wildlife and fish habitat.

The Massachusetts Executive Office of Energy and Environmental Affairs (EEA) and the Massachusetts Emergency Management Agency (MEMA) partnered to develop the *Massachusetts Drought Management Plan*, of which 2013 is the most updated version. The state's Drought Management Task Force, comprised of state and federal agencies, was created to assist in monitoring, coordinating and managing responses to droughts and recommends action to minimize impacts to public health, safety, the environment and agriculture (EEA, MEMA, 2013). The MA Department of Conservation Resources staff compile data from the agencies and develop monthly reports to track and summarize current water resource conditions.

In Massachusetts the determination of drought level is based on seven indices: Standardized Precipitation Index, Crop Moisture Index, Keetch-Byram Drought Index, Precipitation, Groundwater levels, Streamflow levels, and Index Reservoir levels. The Standardized Precipitation Index (SPI) reflects soil moisture and precipitation conditions, calculated monthly using Massachusetts Rainfall Database at the Department of Conservation and Recreation Office of Water Resources. SPI values are calculated for "look-back" periods of 1 month, 3 months, 6 months, and 12 months. (EEA, MEMA 2013)

The Crop Moisture Index (CMI) reflects short-term soil moisture conditions as used for agriculture to assess short-term crop water conditions and needs across major crop-producing regions. It is based on the concept of abnormal evapotranspiration deficit, calculated as the difference between computed actual evapotranspiration (ET) and computed potential evapotranspiration (i.e., expected or appropriate ET). Actual evapotranspiration is based on the temperature and precipitation that occurs during the week and computed soil moisture in both the topsoil and subsoil layers.

The Keetch-Byram Drought Index (KBDI) is designed specifically for fire potential assessment. It is a number representing the net effect of evapotranspiration and precipitation in producing cumulative moisture deficiency in deep duff and upper soil layers. It is a continuous index, relating to the flammability of organic material in the ground. The KBDI attempts to measure the amount of precipitation necessary to return the soil to full field capacity. The inputs for KBDI are weather station latitude, mean annual precipitation, maximum dry bulb temperature, and the last 24 hours of rainfall.

Determinations regarding the end of a drought or reduction of the drought level focus on two key drought indicators: precipitation and groundwater levels. These two factors have the greatest long-term impact on streamflow, water supply, reservoir levels, soil moisture and potential for forest fires. Precipitation is a key factor because it is the overall cause of improving conditions. Groundwater levels respond slowly to improving conditions, so they are good indicators of long-term recovery to normal conditions.

3.7.2. Hazard Profile

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 Williamstown is at risk of drought.

Williamstown draws its water from wells drilled into the Hoosic Valley Confined Aquifer. Located in sandy gravel deposits under the Hoosic and Green Rivers, it is confined by a thick layer of fine sand and glacial lake silts. The recharge areas for this aquifer are in the surrounding uplands to the northeast and northwest. These areas have been protected by the creation of a Water Resource Overlay Zoning District adopted at the May 1992 Town Meeting. The Sherman Springs Reservoir on the northern flank of Mount Williams provides emergency backup supply. The Town of Williamstown's water supply system is shown in Figure 3.7.1.

Previous Occurrences

Massachusetts is relatively water-rich, with few documented drought occurrences. According to the state's Hazard Mitigation Plan of 2013, the state has experienced multi-year droughts periods 1879-83, 1908-12, 1929-32, 1939-44, 1961-69 and 1980-83. There have been 13 documented droughts in the state between 1945 and 2002 (see Table 3.7.1.). (MEMA, 2013) The most severe drought occurred during the 1960s, due to both severity and extended duration.

Table 3.7.1. Estimated Droughts Based on the Mass. Standardized Precipitation Index

Year(s)	Duration (Months)	Estimated Drought Level
1924-1925	13	Warning
1930-1931	12	Emergency
1934-1935	15	Warning
1944	11	Watch
1949-1950	15	Watch
1957-1958	12	Warning
1964-1967	36	Emergency
1971	8	Watch
1980-1981	13	Watch
1985	7	Watch
1988-1989	11	Watch
1990-1991	9	Watch
2001-2002	13	Watch

Source: MEMA, 2013

Additional information indicates 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 began to be 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.¹ In general, the central portion of the state fared the worse and Berkshire County fared 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 3.7.2. and Fig. 3.7.2. and for the progression of the 2016-17 drought).

Water restrictions or bans are typically issued by the Water Department when flow in the Green River falls below 19 cubic feet per second for three days. The water level of the Green River is used purely as a guide, despite the fact that water flow in the river is separate from the water level in the deep, confined aquifer from which the Town draws its water. This aquifer is recharged from gravel deposits above 1,150 feet above sea level, and the Green River has no causal relationship to the level of the aquifer. A more accurate measurement of stress upon the aquifer is the drawdown level of the Town's three wells, which have remained remarkably consistent even during times of drought. According to a 1989 report to the Williamstown Planning Board from the Williams College Geology Department, the confined aquifer underlying the Hoosic River from which the Town draws its water has a theoretical minimum capacity of approximately 150 billion gallons.

When issuing restrictions or bans the Water Department send letters to all customers and posts the announcement on its website.

¹ MA Water Resources Commission, 2017. *Annual Report, Fiscal Year 2017*. Boston, MA.

Table 3.7.2. Drought Events and Levels 2001-2017

Year	Begin Date	End Date	Comment	Western	Drought Level by Regions				Cape & Islands
					CT River	Central	Northeast	Southeast	
	12/28/2001	1/31/2003							
2001	12/28/2001			Advisory	Advisory	Advisory	Advisory	Advisory	Advisory
2002			February 2002	Advisory	Watch	Watch	Watch	Advisory	Advisory
2002			March 2002	Watch	Watch	Watch	Watch	Watch	Watch
2002			April 2002	Watch	Watch	Watch	Watch	Watch	Watch
2002			May 2002	Watch	Watch	Watch	Watch	Watch	Watch
2002			June 2002	Advisory	Advisory	Advisory	Advisory	Advisory	Advisory
2002			July 2002	Advisory	Advisory	Advisory	Advisory	Advisory	Advisory
2002			August 2002	Advisory	Advisory	Advisory	Advisory	Watch	Watch
2002			September 2002	Advisory	Advisory	Advisory	Advisory	Watch	Watch
2002			October 2002	Advisory	Advisory	Advisory	Advisory	Advisory	Advisory
2002			December 2002	Normal	Normal	Normal	Normal	Normal	Advisory
2003		1/31/2003	As of January 31, 2003	Normal	Normal	Normal	Normal	Normal	Normal
	10/1/2007	3/18/2008							
2007	10/1/2007			Normal	Advisory	Advisory	Advisory	Advisory	Normal
2008		3/18/2008	As of March 18, 2008	Normal	Normal	Normal	Normal	Normal	Normal
	8/1/2010	11/19/2010							
2010	8/1/2010			Normal	Normal	Advisory	Advisory	Normal	Normal
2010			October 2010	Normal	Advisory	Advisory	Advisory	Normal	Normal
2010		11/19/2010	As of November 19, 2010	Normal	Normal	Normal	Normal	Normal	Normal
	10/1/2014	11/30/2014							
2014	10/1/2014			Normal	Normal	Normal	Normal	Advisory	Advisory
2014		11/30/2014	As of December 1, 2014	Normal	Normal	Normal	Normal	Normal	Normal
	7/1/2016	4/30/2017							
2016	7/1/2016		June 2016	Normal	Advisory	Watch	Watch	Advisory	Normal
2016			July 2016	Advisory	Watch	Warning	Warning	Watch	Advisory
2016			August 2016	Advisory	Watch	Warning	Warning	Warning	Watch
2016			September 2016	Watch	Warning	Warning	Warning	Warning	Watch
2016			October 2016	Warning	Warning	Warning	Warning	Warning	Advisory
2016			November 2016	Warning	Warning	Warning	Warning	Warning	Advisory
2016			December 2016	Warning	Warning	Warning	Watch	Warning	Advisory
2017			January 2017	Watch	Warning	Watch	Advisory	Warning	Advisory
2017			February 2017	Advisory	Watch	Advisory	Advisory	Watch	Advisory
2017			March 2017	Normal	Advisory	Advisory	Advisory	Advisory	Advisory

Source: <https://www.mass.gov/files/documents/2017/09/08/drought-status-history.pdf>

Fig. 3.7.2. Progression of the 2016-17 Drought



Source: MA Water Resources Commission, 2017.

Probability of Future Occurrences

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, 2013). The drought levels, recurrence interval and state estimated drought level nomenclature is found in Table 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.

Table 3.7.3. U.S. Drought Monitor Level and Comparable State Level Indices

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

Source: U.S. Drought Monitor; MA Drought Management Plan 2013.

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 (MEMA 2013)

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 the DEP 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.

Secondary Hazards

The secondary hazard most associated with drought is wildfire. For drought conditions to occur it is likely that soil moisture is limited or lacking, forest duff is dried out and standing vegetation is dry and possibly dead, providing the fuel needed for a wildfire. Given that Williamstown is 74% forested, and that forest lands are often located in steeply sloped and inaccessible areas, the risk of wildfire during drought conditions is a concern.

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, 2013) 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 conducted in 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.

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.²

Exposure

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

3.7.3. Vulnerability

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

Population

For the purposes of this plan update, the entire population of Williamstown is exposed and vulnerable to drought. Those residents who are served by the Williamstown Water Department are believed to be less vulnerable to drought due to the main supply being drawn from an extensive confined aquifer. A study by David Dethier from Williams College in 1989 described the extent and structure of the confined aquifer from which the Town draws its water. The estimate of total volume from the Williams study, characterized as "very conservative", is a minimum of 200,000,000 cubic feet (approximately 1.4 billion gallons). However, the Berkshire region has not suffered a severe, Emergency level drought since the 1960s and it is unclear how well the system could serve the demands of Williamstown during a prolonged drought.

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 in that section of the report.

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 that are in areas surrounded by forest or dry vegetation, such as water tanks, water pumps, sewer pumps and other infrastructure, could be more vulnerable to wildfire.

If a severe drought of long duration were to occur, the Water Department may need to provide some assistance to provide water to residents whose wells have gone dry. An emergency dispensing center may need to be created to serve this population.

² EEA, Adaptation Advisory Committee, 2011. *MA Climate Change Adaptation Report*, Boston, MA.

Economy

A severe, long-term drought could severely impact the operation of Williamstown's major employers, including Williams College and tourist-driven institutions and businesses.

Drought would also impact local farmers, causing crop and livestock losses. Data on the potential impacts to Williamstown's farmers is not directly available, but during the MVP Planning Process a local farmer described the economic impact of the recent drought. Although the drought it was limited in scope compared to other parts of the state, dry hay fields in Williamstown did not produce enough hay to provide livestock feed through the winter, forcing some local farmers had to go out of the area and buy hay. Because farming operations in the Berkshires survive on thin economic returns, the purchase of hay and other feed over a series of consecutive seasons could drive small operations out of business. Additionally dry standing vegetation in fields, such as hay or corn, could increase risk of wildfires and further impede economic survival.

3.7.4. Existing Protections

- The Town has bylaws in place that protect the aquifer and surface water supplies from inappropriate land uses.
- The Town's main drinking water well is drilled into an extensive confined aquifer, providing some protection from drought.
- The Williamstown Public Works Department and Williamstown CO₂ Lowering (COOL) Committee have partnered to conduct public outreach programs, which have resulted in reduce water consumption in the past decade.
- The Massachusetts DEP has broad jurisdiction to protect water supply and water quality.

3.7.5. Actions

- Expand water conservation efforts to continue to reduce water use on a Town wide level; encourage homeowners to install water conserving showerheads and other measures (free low-flow showerheads are given free during MassSave home energy audits).
- Consider protective measures for residents who have shallow wells or who are known to have water supply shortages in the past.
 - If water levels in the confined aquifer remain at safe levels during a drought, coordinate with local water haulers to draw from the Town's wells to provide water to impacted residences; provide water from the Town well system at public water filling stations.
 - Consider expanding water service to those who are already known to have water supply shortages in the past.

3.8. Fire Hazards

3.8.1. General Background

There are three basic fire hazard regions that are discussed as part of this risk assessment: Urban Fire, Wildland-urban, and Wildfire. A major urban fire or conflagration is a large destructive, often uncontrollable, fire that spreads substantial destruction. Over the past several years, structure fires in Massachusetts account for the majority of fire deaths, injuries, and property loss within the Commonwealth. In Massachusetts, 83% of building fires and 69% of fire deaths in 2010 took place in residential occupancies, with more fire deaths occurring in one-and two-family homes than in all other residential occupancies combined. People under the age of 5 and over the age of 55 have a much higher death rate than the average population, accounting for more than one-third of all deaths nationally.

A wildland-urban interface area defines the conditions where flammable vegetation is adjacent to developed areas. The wildland-urban interface is the line, area, or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels. In these areas, homes are built among densely wooded areas, so humans are more likely to start a fire that will easily spread to the surrounding forested areas with plentiful vegetative fuels. The wildland-urban interface is at risk for wildfires due to human caused fire ignitions, which are more common than natural causes such as lightning. (MEMA, 2013)

A wildfire can be defined as any non-structure fire that occurs in the vegetative wildland, including grass, shrub, leaf litter, and forested tree fuels. In general, wildfires in Massachusetts occurrence can be caused by human activity (prescribed burns or accidents) or natural events. Wildfires often begin unnoticed, but can spread quickly, igniting brush, trees, and homes. Because 95% of wildfires are started by negligent human behavior, such as smoking in forested areas or improperly extinguishing campfires, most are considered preventable. In 2011, approximately 8% of the outside and other fires were considered intentionally set, indicating that the vast majority are started by accident. Wildfires can result in the destruction of forests, brush, field crops, grasslands, and personal property. (MEMA, 2013)

The “wildfire behavior triangle” of weather, topography and fuel are the three primary factors that influence wildfire behavior (Fig. 3.8.1.). Of the three, weather is the most variable and least predictable¹. Climate change may influence future wildfire behavior due to changing weather and resulting forest 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, dying, or become receptive to ignition when influenced by environmental factors, such as drought, low humidity, and warm temperatures.

¹ <https://learn.weatherstem.com/modules/learn/lessons/121/12.html>. Source also of the triangle graphic.

- 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 drying 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.

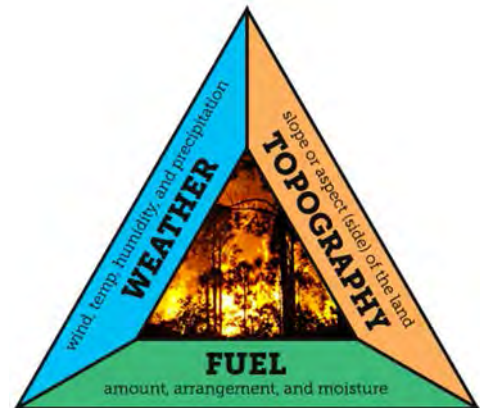
- Topography

- 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 (greater than any predicted by climate models), future areas burned are very likely to increase.
- Infestation from insects is also a 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 include smaller timber harvests, reduced access to affected recreational areas, and the destruction of cultural and economic resources and community infrastructure. (MEMA, 2013)

Figure 3.8.1. Fire Behavior Triangle



3.8.2. Hazard Profile

Location

The risk of urban fire is at a higher risk in the more densely developed Town center, which consists of a mix of institutional buildings and small commercial districts, interspersed and surrounded by residential neighborhoods. There are only a few areas in Williamstown where population exceeds five people per acre, and this area is largely Williams College student dorms. Fortunately, most of these buildings have sprinkler systems built into them. The map of Figure 3.8.2. illustrates population density using 2010 Census Blocks. This map can be used in conjunction with the map shown in Figure 3.8.4, to show where development and vegetation intersect.

Fig. 3.8.2. Population Density (2010 Census Blocks)

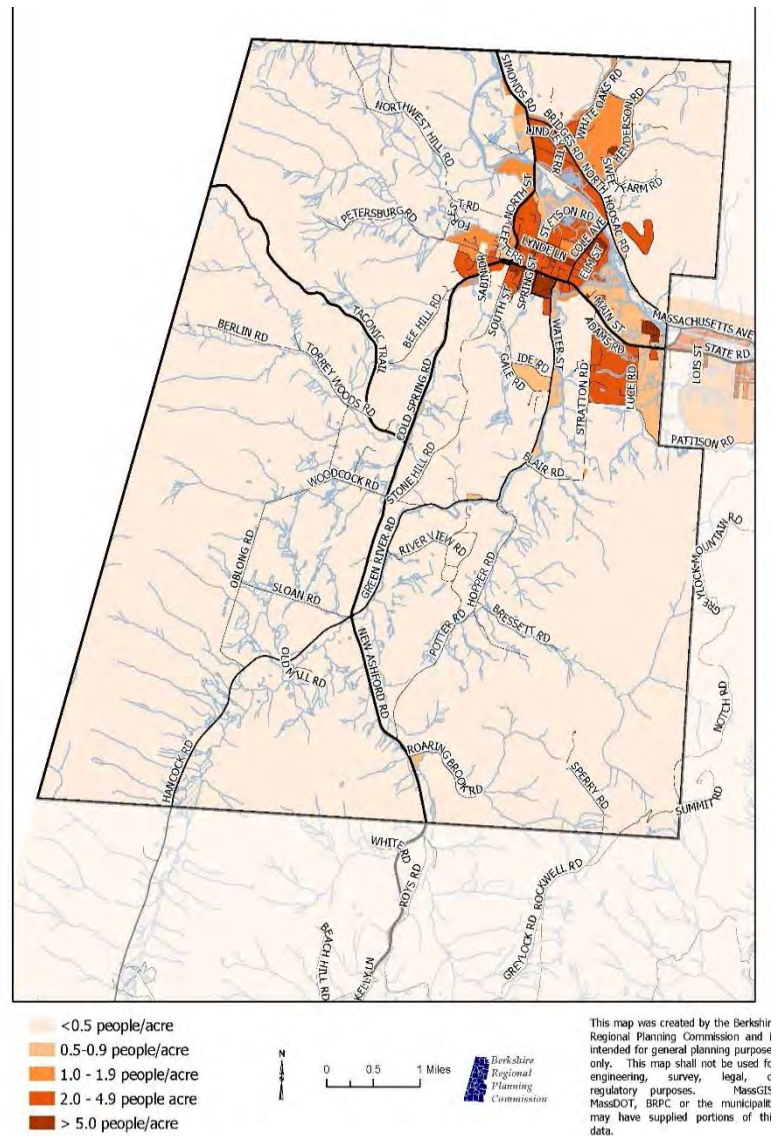
The majority of land in Williamstown is vulnerable to wildfire. Seventy-four percent of Williamstown is forested, with vast unfragmented forest blocks that lie in all four directions of the downtown center. There can be increased risks of fire due to human traffic in the state forests and other forest lands, and the risk of fire is higher in areas where overnight campers stay in lean-tos are located within the Mt. Greylock State Reservation. There are campgrounds within in the Greylock Reservation and camping is allowed on the Bullock Trust property on the Taconic Range. The steep slopes and limited road system within the surrounding forest lands increase the risk of a wildfire spreading due to difficulty in getting fire trucks and equipment to some remote areas.

Previous Occurrences

Based on the Department of Conservation & Recreation (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 burned annually 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, there were 901 fire incidents, combined urban and wildland, in Berkshire County during the years 2007-2016, and 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 (reported by Town of Lanesborough - not the 600 acres listed in the Massachusetts Fire Incident Reporting System). If these incidents were considered statistical outliers



Source: BRPC 2018.

and removed from the data, the average total burned acres during 2007-2016 would be 39 and the average wildland acres burned would be 19. Berkshire County fire officials have a good working relationship and respond rapidly through mutual aid and through a coordinated effort with the DCR.

In Williamstown, 18 incidents burned approximately three acres during 2007-2016, with an overall average of 0.3 acres per year. All of the incidents reported during this time period were wildfires, with no urban fire incidents. (MA Fire Incident Reporting System, 2017)

Probability of Future Occurrences

For the purpose of this plan, the probability of future occurrences is defined by the number of events over a specified period. The historical record 2007-2016 indicates that Williamstown has an extremely low average occurrence of urban or wildfires per year. Major urban fires are a low concern due to the lack of large urbanized areas where buildings are attached or closely adjacent to one another. Many commercial buildings have their own fire detection and suppression systems, but there are still a number of buildings with minimal or not fire protection because they have not been renovated to a level that requires fire protection upgrades. Risks continue to be mostly limited to structures, particularly homes, which as discussed earlier in this section pose the greater risks of injury and death.

Frequency

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 a number of variable factors affect 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. (MEMA, 2013) Due to the number of past incidents, the risk per year is low.

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. (MEMA, 2013)

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, probably due to spring burn season. However, wildfires can occur every month of the year. Drought, 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)

Table 3.8.1. Wildfires in Williamstown 2007-2016

Year	Number of Wildfires	Acres
2016	1	0
2015	7	0
2014	1	0
2013	2	0
2012	3	0
2011	1	1
2010	NA	NA
2009	0	0
2008	2	0
2007	1	2
Total	18	3

Source: MA Fire Incident Reporting System 2017.

Severity

Williamstown is not developed to a density that would provide fuel for a major urban fire. Single family detached houses in the most densely developed residential neighborhoods, in the historic town center area and in the more modern 1950s subdivisions, tend to be 20 feet or farther from each other, with farther distances between homes in later subdivisions. The greater potential for significant damage to property from fire in Williamstown exists in areas designated as wildland-urban interface areas. Building code requirements for fire alert systems and fire suppression systems in buildings where people live or work is a major factor in reducing the risk of a large conflagratory incident.

The risk of a severe wildfire consisting of 50 or 100 acres or more will depend on the wide spread availability of fuel and the accessibility of the site (access routes, steep slopes, etc.). The Clarksburg (242 acres) and Lanesborough (168 acres) wildfires are the most severe experienced in the region in recent decades. Both occurred in fairly inaccessible areas making fire control difficult.

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 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.

Secondary Hazards

Smoke and air pollution from wildfires can be a health hazard, especially for sensitive populations including children, the elderly, 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. (MEMA, 2013)

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 Williamstown that have been affected by secondary environmental impacts in recent memory.

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 in the Hoosic River Watershed,

where by mid-century the number of days that the temperature will rise above 90°F will range from 4 to 17, and by the 2090s the number will increase to 6 to 50 days per year. (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 in 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 of our 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)

Exposure

To understand risk, the assets exposed to the hazard areas are identified. For wildfire hazards identified as hazard areas include wildland-urban areas. The wildland-urban interface is the line, area, or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels. 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 Tract data, the Multi-Resolution 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 Williamstown for this hazard mitigation plan.

The SILVUS modeling tool has calculated that the Urban-wildland Interface, the area at greatest risk of urban-wildland fire occurrences, covers 14% of the town (shown in yellow in Figure 3.8.3.). The Intermix area, where wildlands and scattered development meet, is calculated as covering 19% of the Town (shown in tan), with most of the rest of the Town calculated as being Vegetated (66%, shown in green). The Interface area extends far beyond the developed core of the downtown area and denser suburbs. It also includes a large block of undeveloped land between Route 7 and Oblong Road, an area where road corridors are sparsely developed. Other large blocks of undeveloped lands are included in Interface and Intermix, and do not reflect accurate land uses and densities. The SILVUS model discrepancies may be attributed to delineation of census blocks, which in rural communities such Williamstown often extend widely and include large, sparsely populated and undeveloped acres of land.

Because the SILVUS model does not appear to reflect the true location of human habitation in Williamstown, this plan considered another data source to more accurately determine fire risk. To better understand the urban/wildland interface and the general forest types in Town, the analysis focused solely on land cover as mapped by the Multi-Resolution National Land Cover Database. This data and accompanying map shows more accurately the Interface and Intermix between existing development and forest, and shows what general types of forest surround the development, with the vast majority of Williamstown covered in deciduous forest. According to this data and illustrated in Figure 3.8.4., Williamstown is approximately 73% forested, with northern hardwoods comprising 89% of that forest and mixed forest comprising 7% of that forest. Conifer dominant forest, which poses a greater risk of wildfire, comprises only about 4% of the forest and is largely found on steeply sloped higher elevations. (Multi-Resolution Land Characteristics Consortium, 2011).

The ecosystems in Massachusetts that are most susceptible to wildfire hazard are pitch pine, scrub oak, and oak forests. These are the most flammable vegetative fuels. (MEMA, 2013) Williamstown does not

have any significant land coverage that include these ecosystems. However, the state forests are in general more vulnerable to wildfire due to increased human activity, particularly Mount Greylock State Reservation, the most heavily visited state park in the county.

Figure 3.8.3. Wildland-Urban Interface

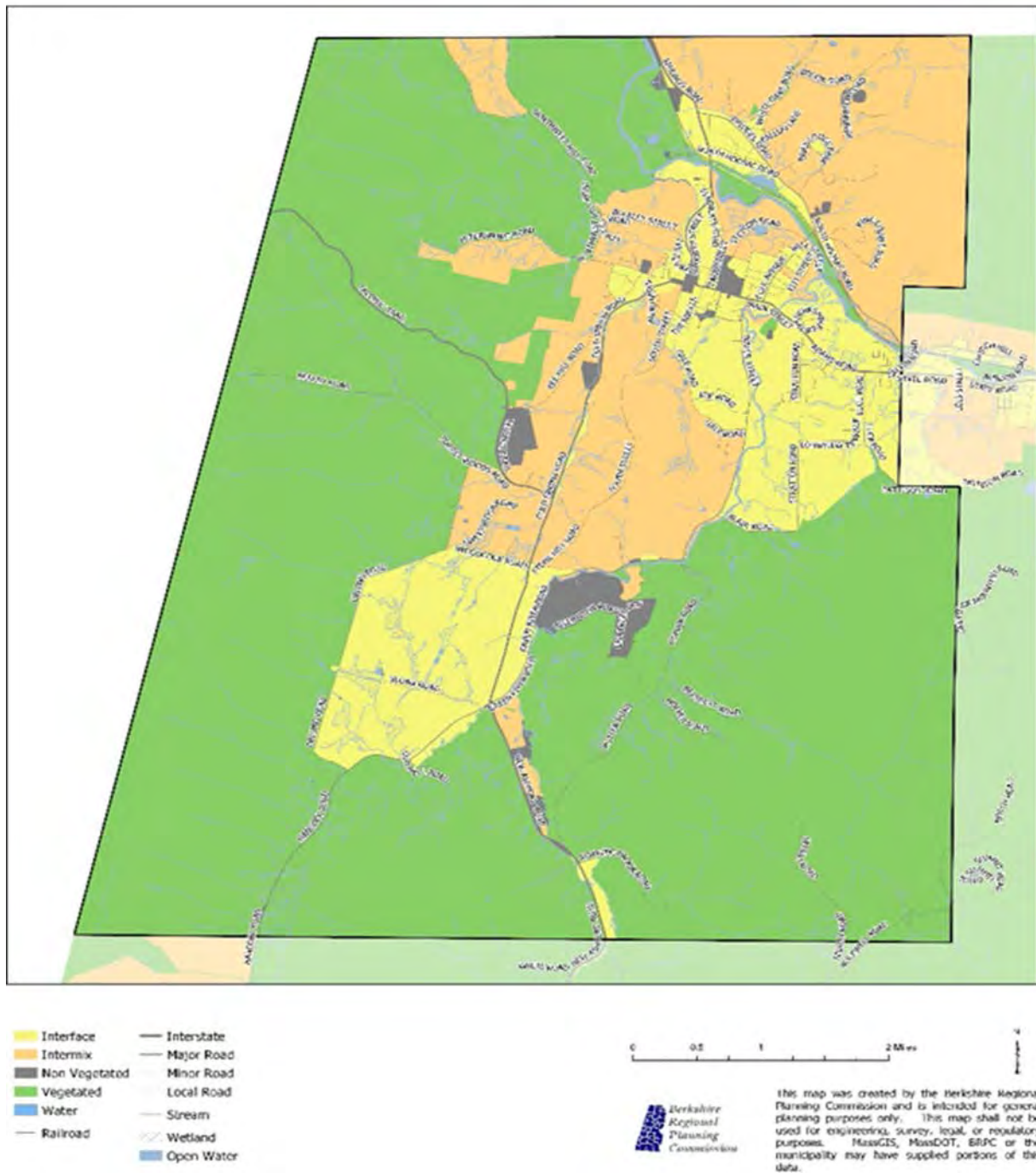
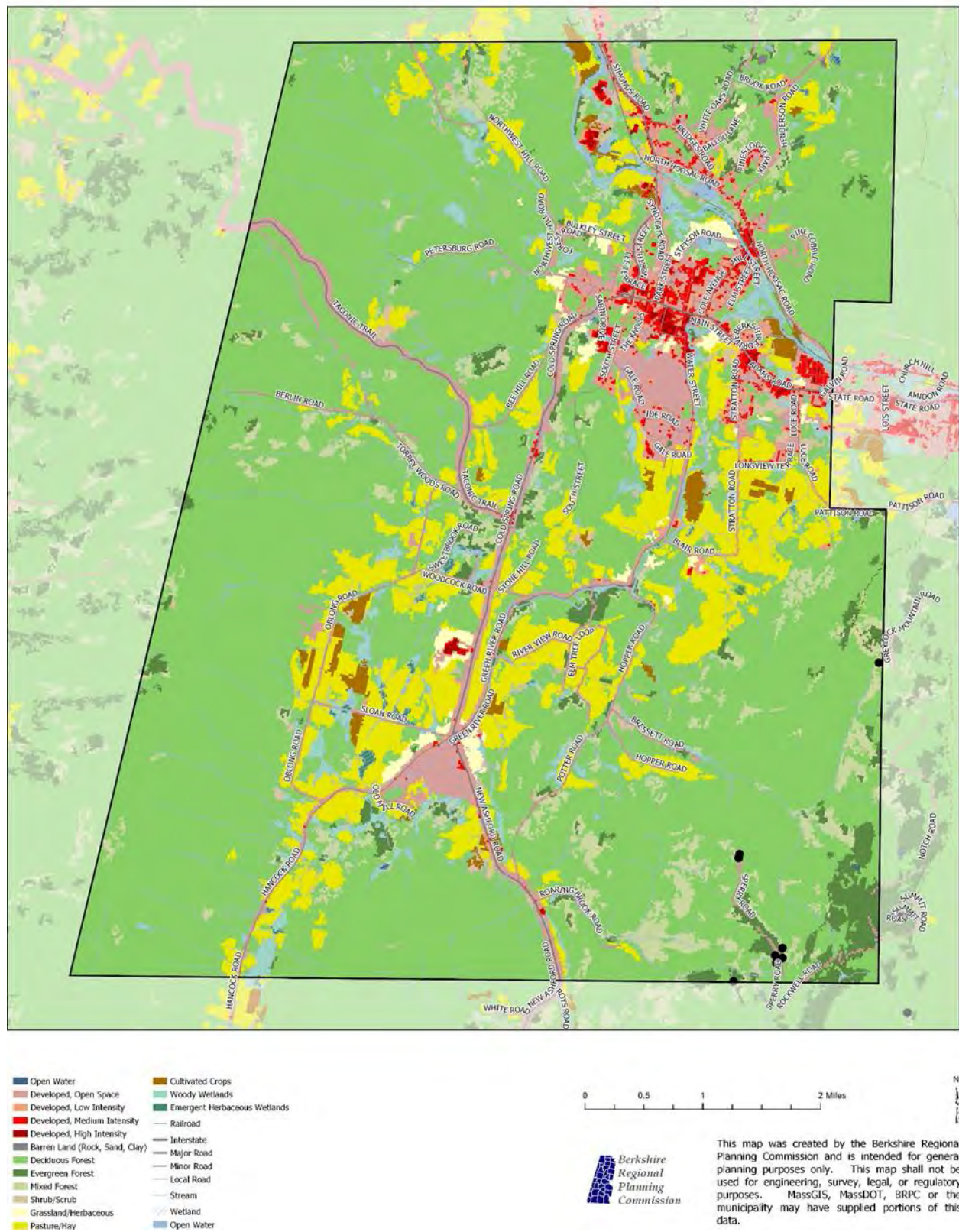


Fig. 3.8.4. National Land Cover Data Showing Forest and Development Patterns



3.8.3. Vulnerability

Population

Smoke and air pollution from wildfires can be a severe health hazard, especially for sensitive populations, including children, the elderly, 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 toxics (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, 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.

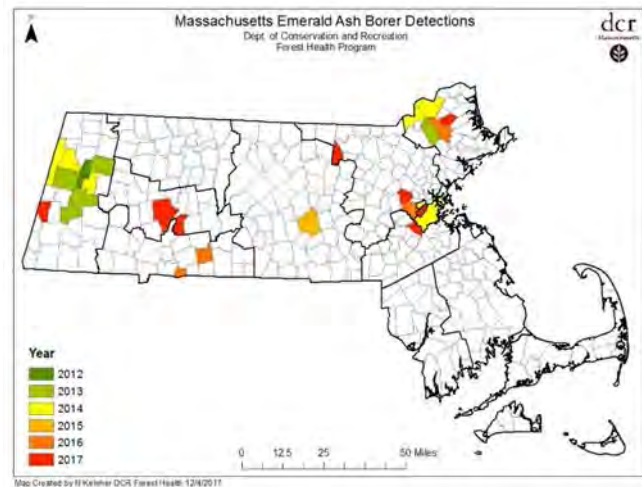
All Berkshire County communities are considered by the state, based on historic occurrences, to be at low risk of fire due to the number of fires that have occurred. This is most likely due to the low population density along the urban/woodland. The county's exception is the City of Pittsfield, which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

To estimate potential residential losses, a risk exposure analysis was conducted. Quantifying the number of homes at risk involved utilizing 2010 census and breaking it into the Interface and Intermix areas delineated from SILVUS. While the SILVUS model did not accurately reflect land cover, it was determined to be a good model for this analysis because it fairly accurately could estimate the number of residential units within those areas because it was based on Census data. Using this method it was determined that the Interface hazard area (shown in yellow in Fig. 3.8.3.) contains 1,650 housing units, and the Intermix hazard area (shown in tan) contains 690 housing units. (BRPC, 2018)

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 being lightly harvested, which can lead to a buildup of dry brush fuel. The ice storm of 2008, which impacted the higher elevations along the Berkshire Range, and to a lesser extent the Hoosac and Taconic 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, is leaving dead and dying snags, and in the long run is increasing fuel for wildfire. Although the lower elevations of the Hoosic River valley, including most of Williamstown, were largely unaffected by the ice storm, higher elevations on the east and western portion of the Town did experience some ice damage.

The presence of the Emerald Ash Borer, first found in Massachusetts in the town of Dalton in 2012 (shown in dark green on Fig. 3.8.5.), has quickly spread throughout central Berkshire County. This rapidly-spreading invasive insect quickly kills its host trees within a few years of settling in an area, leading to massive die-offs of all ash trees within an area. This will increase the amount of dead limbs, brush and standing dead trees throughout forests in the county. UMass Extension states that, as a component of Massachusetts forests, the highest percentages of ash are located in Berkshire County². Town officials in Williamstown are unaware of the Borer having arrived in Williamstown as this time. Other invasive insects such as the Hemlock Woolly Adelgid threaten healthy hemlock stands and the Asian Longhorn Beetle threatens ash, maples, elms, poplar and willow. The fire risk impacts of the ice storm and invasive insects are not well documented at this time. Town officials are not aware of any die offs at this time.

Fig. 3.8.5. Emerald Ash Borer Dispersal 2017



Critical Facilities

The vast majority of the critical facilities in Williamstown are located in areas of Town that are developed and have had some significant tree removal around the facility, reducing vulnerability to urban fires. In the event of wildfire, there would likely be little damage to the infrastructure and facilities located in the path of the fire. Most road and railroads would be without damage except in the worst scenarios. Fires can create conditions that block or prevent access and can isolate residents and emergency service providers. Power lines are the most at risk to wildfire because most poles are made of wood and susceptible to burning. In the event of a wildfire, pipelines could provide a source of fuel and lead to a catastrophic explosion. (MEMA, 2013)

Although the Williamstown Fire Station is not in an area of higher risk, the facility is outdated and has become too small to properly house the department's trucks, equipment and other vehicles. The existing facility was constructed in 1950, when trucks and equipment were smaller, limiting the type of trucks that the department can purchase. The building does not have personal space for volunteers to suit up or rest. The Fire District is in the process of conducting a feasibility study to determine the type of building needed and in spring 2018 purchased a property for the construction of a new station. Design and construction funds will need to be secured to advance the project.

Economy

Wildfire events can have major economic impacts on a community from the initial loss of structures and 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.

² <https://ag.umass.edu/landscape/fact-sheets/emerald-ash-borer>

To estimate the total potential loss of buildings in the community, the Interface and Intermix wildfire hazard areas were overlaid upon the assessor's parcel data. It was determined that \$620,161,700 is at risk of wildfire in the Interface area and \$311,533,800 is at risk of wildfire in the Intermix area. (BRPC 2018) It should be noted that these figures are assessor estimates and does not include market cost or replacement costs, nor do they include estimate of loss of building contents. These figures also do not include the major economic impacts on a community from the initial loss of structures and the subsequent loss of revenue from destroyed business, loss of employment and potential decrease in tourism.

3.8.4. Existing Protections

- Mutual Aid with other fire departments through the Berkshire County Fire Chiefs Association.
- The Fire Department strictly enforces burn permit system; it has also adopted the online county online permitting system to more easily monitor, permit and enforce private burning activities.
- Hydrants are located near developed areas, and the Fire Department has in recent years aggressively expanding the number of dry hydrant stations outside of the Town's water-served zones that draw from local water ways, such as the Green River and Hemlock Brook.
- The Town utilizes the CodeRed emergency communications systems.

3.8.5. Actions

- Support the Williamstown Fire District in its effort to construct a modern, right-sized fire station to house equipment, operations and fire fighter needs.
- Continue the strong bonds developed through local and regional mutual aid.
- Continue to recruit and train new fire department members, particularly those who work in Williamstown and can respond quickly to fire calls.
- Continue to maintain CodeRED emergency communications systems and encourage all residents to enroll into the system.

3.9. Landslide Hazards

3.9.1. General Background

The term landslide includes a wide range of ground movement, such as rock falls, deep failure of slopes, and shallow debris flows. Although gravity acting on an over steepened slope is the primary reason for a landslide, there are other contributing factors. According to the state hazard mitigation plan, slope saturation by water is a primary cause of landslides in the Commonwealth. This effect can be in the form of intense rainfall, snowmelt, changes in groundwater level, and water level changes along earth dams, and the banks of lakes, rivers, and reservoirs. Water added to a slope can not only add weight to the slope, which increases the driving force, but can increase the pore pressure in fractures and soil pores, which decreases the internal strength of the earth materials needed to resist the driving forces. (MEMA 2013)

Landslides in Massachusetts can be divided into four general groups, construction related, over steepened slopes caused by undercutting due to flooding or wave action, adverse geologic conditions, and slope saturation. Construction related failures occur predominantly in road cuts excavated into glacial till where topsoil has been placed on top of the till. This juxtaposition of materials with different permeability often causes a failure plane to develop along the interface between the two materials resulting in sliding following heavy rains. (MEMA 2013)

Undercutting of slopes during flooding events is a major cause of property damage. Streams erode the base of the slopes causing them to over steepen and eventually collapse. This is particularly problematic in unconsolidated glacial deposits, which covers the majority of the community. Adverse geologic conditions exist anywhere there are lacustrine or marine clay soils. Clays have relatively low strength, and when over steepened or exposed in excavations these areas often produce classic rotational landslides. (MEMA 2013)

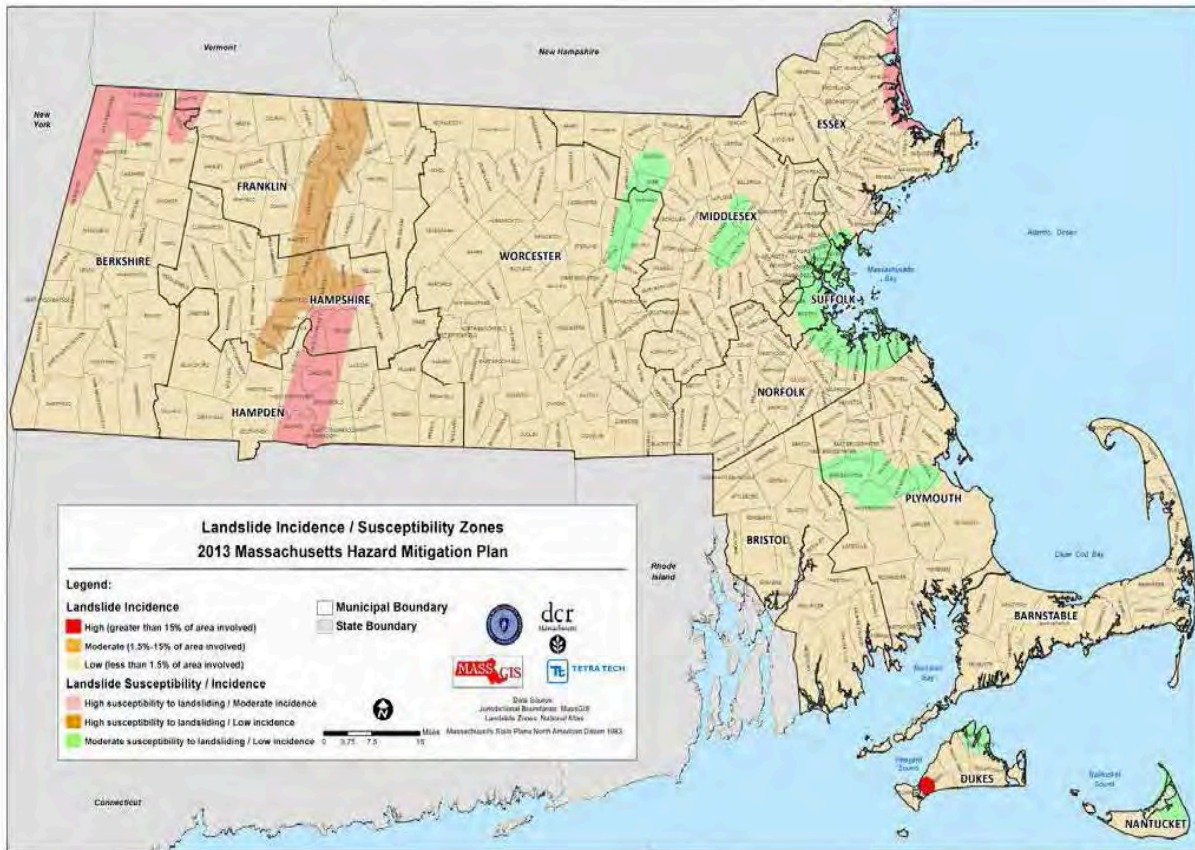
Another occurrence of landslides in Massachusetts results from slope saturation. This occurs following heavy rains and dominantly in areas with steep slopes underlain by glacial till or bedrock. Bedrock and glacial till soils are relatively impermeable relative to the unconsolidated material that overlies them. Water accumulates on these less permeable layers, increasing the pore pressure at the interface. This interface becomes a plane of weakness, and if conditions are favorable failure can occur. (MEMA 2013) Saturation was a leading cause of the landslide that occurred in Savoy at Route 2 during T.S. Irene in 2011.

3.9.2. Hazard Profile

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 Fig. 3.9.1 for locations). Most of Williamstown is included in this area.

Fig. 3.9.1 Landslide Incidence / Susceptibility Zones



Source: MEMA 2013

When referring to Fig. 3.9.1, 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 involved in landsliding, medium incidence means that 1.5-15% of an area has been involved, and low incidence means that 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 landsliding. (MEMA, 2013)

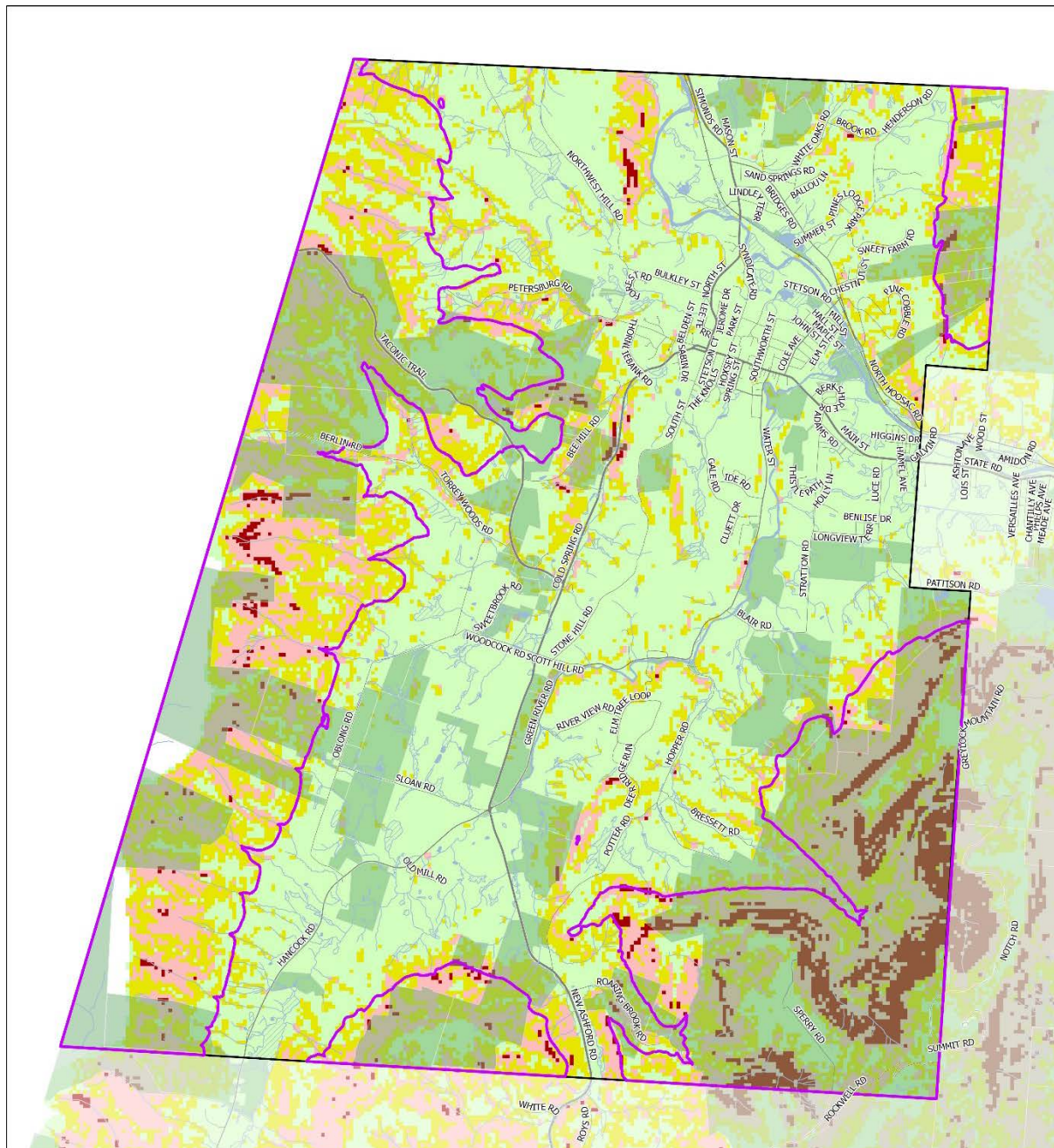
To investigate landslide risk more closely, data from the Slope Stability Map produced by the Massachusetts Geologic Survey was gathered. According to this model, areas with a Safety Rating of less than one is considered unstable, with lands categorized as Unstable and Moderately Unstable both having ratings of less than one. These categories are considered High Susceptibility Zones. Using this source as a guide, Williamstown has 995 acres of land categorized as Unstable (approximately 3% of

total land) and 4,663 acres as Moderately Unstable (approximately 15% of total land). These areas are shown on the map in Figure 3.9.2., with Unstable lands shown in dark red and Moderately Unstable lands shown in pink.

In Williamston the areas of Unstable lands are generally found on the steep slopes of the Mount Greylock series of peaks in the eastern portion of Town and on the steep slopes of the Taconic Range along the western border of the town. The greatest expanse of Unstable lands found in Williamstown are associated with Mount Greylock and Mount Prospect. Large bands of Unstable lands are found along the upper slopes of the Hopper, down through which flow Hopper and Money Brooks. In the Taconics, in the western portion of the town, swaths of Unstable lands are found along the deep ravines of the mountain streams, particularly that of Hemlock Brook and its tributaries, Sweet Brook and others. These streams flow down the eastern slopes of Berlin Mountain and Mount Raimier. Another area of Unstable land is along the slopes of Northwest Hill.

Other areas noted by Town officials that are prone to subsidence are on Scott Road, Pine Cobble Road, North Hoosac Road, Green River Road and Bee Hill Road (above Hemlock Brook).

Fig. 3.9.2 Slope Stability (using the Massachusetts Geologic Survey), with Upland Conservation District Boundaries. Protected open space lands are shown in darker green.



- Slope Stability**
- Unstable
 - Moderately Unstable
 - Low Stability
 - Stable
 - Upland Conservation Overlay Zoning District
 - Protected Open Space

0 0.5 1 2 Miles



This map was created by the Berkshire Regional Planning Commission and is intended for general planning purposes only. This map shall not be used for engineering, survey, legal, or regulatory purposes. MassGIS, MassDOT, BRPC or the municipality may have supplied portions of this data.

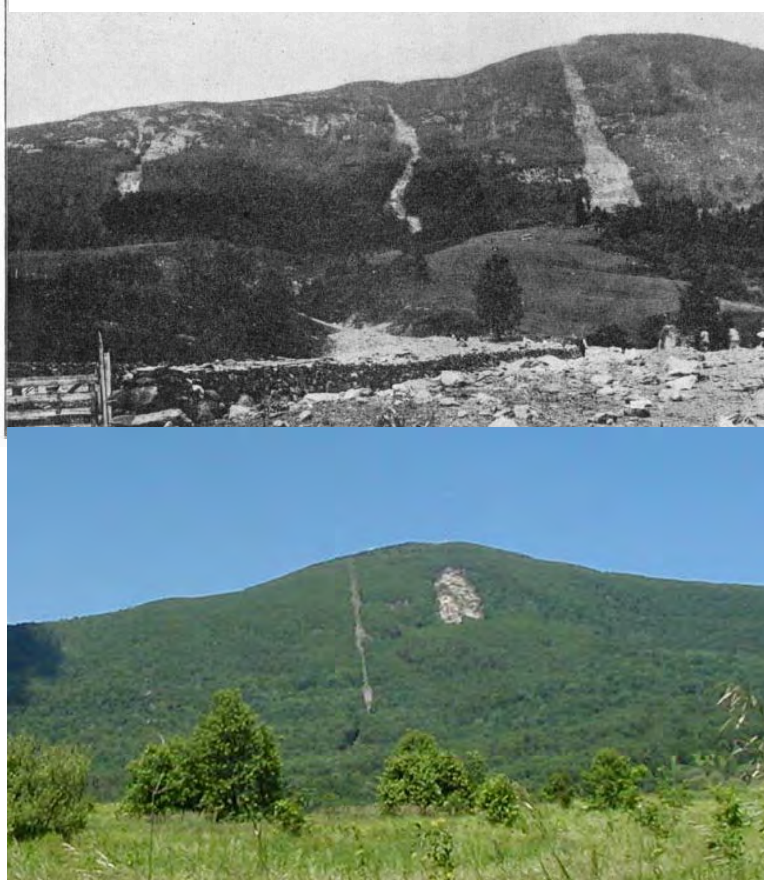
Previous Occurrences

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 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 Williamstown that can be presented in this report. 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 (Fig. 3.9.3 top photo). 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. The deforestation 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 (see Fig. 3.9.3. bottom).
- Early 2000s: Notable rock fall on Route 7 in New Ashford which closed a portion of the road for over a year. This is an example of the type of event that occurs throughout the region.
- August 2011: Hurricane Irene caused damage throughout portions of the Commonwealth, including a 5.8-mile section of Route 2 that was closed 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.

Fig. 3.9.3. Landslide scars on Mt. Greylock 1901 and 1990



Sources: Top - Mabee, Stephen B., Duncan, Christopher C. 2013. *Slope Stability Map of Mass.*, MA Geological Survey. Bottom – BRPC 1999.

Probability of Future Occurrences

Landslides are often triggered by other natural hazards such as earthquakes, heavy rain, floods, or wildfires, so landslide frequency is often related to the frequency of these other 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 landsliding 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)

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 T.S. Irene in 2011. The slide was 900 feet long and involved approximately 1.5 acres, with an average slope angle is 28 to 33°. The elevation difference from the top of the slide to the bottom was 460 feet, with an estimated volume of material moved being 5,000 cubic yards. Only the top 2 to 4 feet of soil material was displaced.

It is unknown what the severity of a landslide in the Unstable or Moderately Unstable areas of Williamstown would be due to the number of factors that lead to landsliding and to the low number of serious incidences that have occurred in the region.

Fig. 3.9.4. Landslide in Savoy August 2011



Source: Top: Mabee, Stephen B., Duncan, Christopher C. 2013. *Slope Stability Map of Mass.*, MA Geological Survey. Bottom: courtesy Stan Brown of Florida, MA

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 can 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. Assessing the geology, vegetation, and amount of predicted precipitation for an area can help in these predictions. 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)

Secondary Hazards

Landslides can cause several types of 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. Landslides also have the potential of destabilizing the foundation of structures, which may result in monetary loss for property owners. (Massachusetts Emergency Management Agency, 2013)

Landslides can severely alter the course of rivers and streams, erode banks and contribute large amounts of sediment and debris into waterways. Stream and river banks that are already prone to erosion or which are already undercut could become more unstable due to a large event. Landslide debris can block the flow of water under bridges and through culverts, threatening the structures themselves and 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.

Climate Change Impacts

With the latest regional models showing warmer and wetter winters for New England, climate change may impact storm patterns, increasing the probability of more frequent, intense storms with varying

duration. Increase in global temperature could affect the snowpack and its ability to hold and store water. 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 landslide occurrences. (MEMA, 2013)

In the Berkshires, the areas rated as being more prone to landslide incidence and susceptibility are undeveloped, forested steep slopes. Trees and other vegetation help to hold soil in place. Climate change is expected to impact forest species composition in a variety of ways, with cooler species such as sugar maples and hemlocks retreating northward and higher in elevation and invasive forest pests such as the emerald ash borer, wooly adelgid and Asian long-horned beetle increasing tree mortality of key 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.

Exposure

In general, as shown in Figure 3.9.2., most of the land in Williamstown is considered to be a low risk for landslides. Those areas categorized as Unstable or Moderately Unstable are at greatest risk of landsliding or subsidence. 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.

The majority land calculated as being located in High Susceptibility Zones in Williamstown is located within the Upland Conservation Overlay Zoning District: 904 acres (91%) of Unstable land and 3,632 acres (78%) of Moderately Unstable land is within this district. The purpose of this overlay district is to protect public health and safety; to protect persons and property against the hazards of floodwater inundation and unsuitable and unhealthy development of steep slopes and unsuitable soils. Single family dwellings and wind-generating energy facilities are not allowed in this district. All new development within the district is subject to the requirements of the Development Plan Review process, which is conducted by the Planning Board and involves review and comment from the Conservation Commission and Public Works Department. New development can be strictly conditioned or denied. The boundaries of this district area shown in purple in Figure 3.9.2.

The vast majority of Unstable lands are permanently protected from development because they are owned by the Commonwealth, by land trusts or by other organizations who maintain the lands for open space protection or recreation. All but 115 acres of Unstable lands are permanently protected in this way. However, although a large proportion of Moderately Unstable lands are also permanently protected, there remains 1,310 acres unprotected (approximately 28% unprotected). Expansion of urban and recreational developments up onto hillside areas could lead to more people being threatened by landslides each year.

3.9.3. Vulnerability

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 24 buildings in Williamstown are built on Unstable or Moderately Unstable land, all of which are residential buildings. To estimate the population vulnerable to the landslide

hazard, the approximate hazard areas were overlaid with the assessor parcel data to determine the impact. Based on the 24 houses in the Unstable or Moderately Unstable land, and the 2.16 people/household average in Williamstown, it can be calculated that approximately 52 people are risk due to potential landsliding.

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. (MEMA 2013) The 2013 state hazard mitigation plan notes that the estimated cost to address landslide problems to state highways alone was \$1 million during the years 1986, 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 T.S. Irene (2011) which included debris flows, four landslides, and fluvial erosion and undercutting of infrastructure cost \$23 million just for the 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 High Susceptibility Zones in Williamstown. There are, however, several road sections that travel through these areas. Most notable Cold Spring Road (Route 7) travels through a section Unstable and Moderately Unstable lands along Hemlock Brook. This road is a major regional arterial route, necessary for north-south travel for commuters, commercial traffic and emergency vehicles. The regional high school is located on this road. The loss of this route would require long detours and delays. Rock slides on Route 7 further south in New Ashford are prominent. The Taconic Trail (Route 2) travels through several miles of Moderately Unstable land, with a site just east of Petersburg Pass being categorized as Unstable. This route is a main route to communities in neighboring New York State. Other roads that has small areas of Unstable land are Green River Road along the Green River and Brook Road.

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 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. The 24 residential buildings located within the Unstable and Moderately Unstable areas have an assessed value of \$8,070,800. It should be noted that outside of a severe earthquake, the chances for widespread landsliding of all Unstable and Moderately Unstable lands within one event is very low.

3.9.4. Existing Protections

- Single family homes are not allowed in the Upland Conservation Overlay District.

- Development in the Upland Conservation Overlay District can only proceed by going through the Development Site Plan Review Process.
- Much of the land susceptible to landsliding is protected open space lands and are permanently protected from development due.

3.9.5. Actions

- Continue strictly regulating development with the Upland Conservation Overlay District.
- Support as appropriate permanent open space protection of lands that are categorized as High Susceptibility Zones.

3.10. Earthquake Hazards

3.10.1. General Background

An earthquake is the vibration, sometimes violent, of the earth's surface that follows a release of energy in the earth's crust due to fault fracture and movement. A fault is a fracture in the earth's crust along which two blocks of the crust have slipped with respect to each other. The cause of earthquakes in eastern North America is the forces moving the tectonic plates over the surface of the Earth. New England is located in the middle of the North American Plate. One edge of the North American plate is along the west coast where the plate is pushing against the Pacific Ocean plate. The eastern edge of the North American plate is at the middle of the Atlantic Ocean, where the plate is spreading away from the European and African plates. New England's earthquakes appear to be the result of the cracking of the crustal rocks due to compression as the North American plate is being very slowly squeezed by the global plate movements. (MEMA, 2013)

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. Table 1 summarizes Richter scale magnitudes and corresponding earthquake effects. Effects listed are more applicable at lower levels to California than to Massachusetts. 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 3.10.1. 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. Table 3.10.2. summarizes earthquake intensity as expressed by the Modified Mercalli Scale. (MEMA 2013)

Table 3.10.2. Modified Mercalli Scale

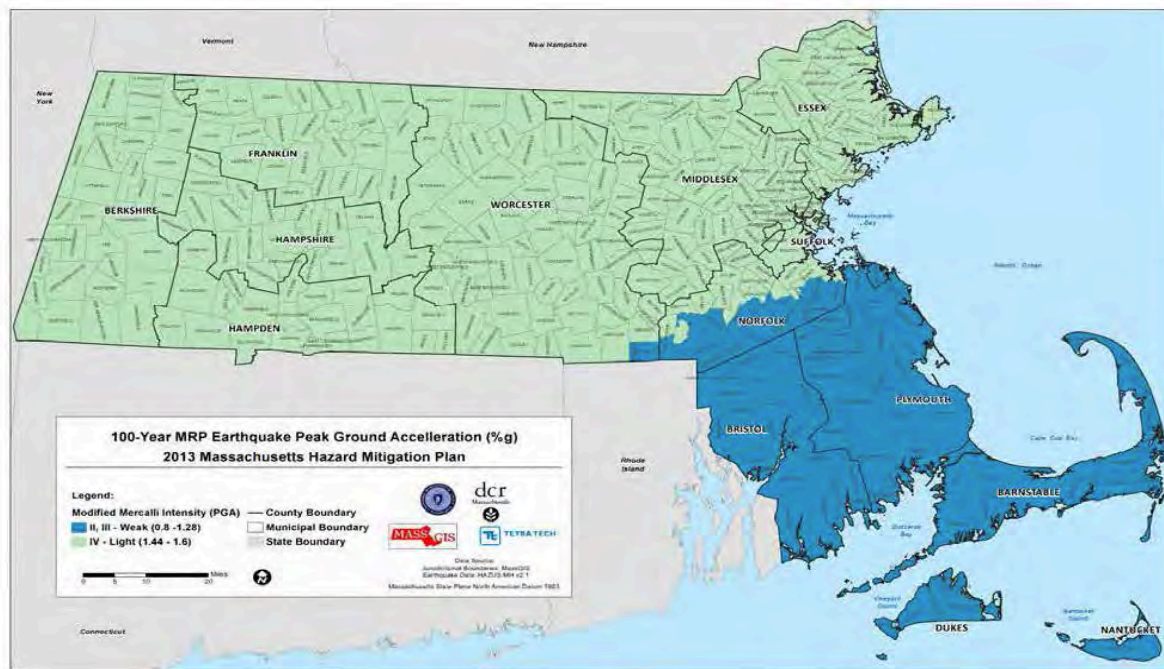
Mercalli Intensity	Description
I	Felt by very few people; barely noticeable.
II	Felt by few people, especially on upper floors.
III	Noticeable indoors, especially on upper floors, but may not be recognized as an earthquake.
IV	Felt by many indoors, few outdoors. May feel like passing truck.
V	Felt by 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). As shown in Figure 3.10.1. Berkshire County has a Mercalli Intensity of IV for a 100-year event, which is described as being light and as described in Table 3.10.2. as "felt my many indoors, few outdoors; may feel like passing truck."

According to MEMA'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.

Fig. 3.10.1. Peak Ground Acceleration Modified Mercalli Scale for a 100-year Mean Return Period



Source: MEMA 2013

3.10.2. Hazard Profile

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

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. This article was written after earthquakes were felt in the Boston area in 2011 and 2012.¹

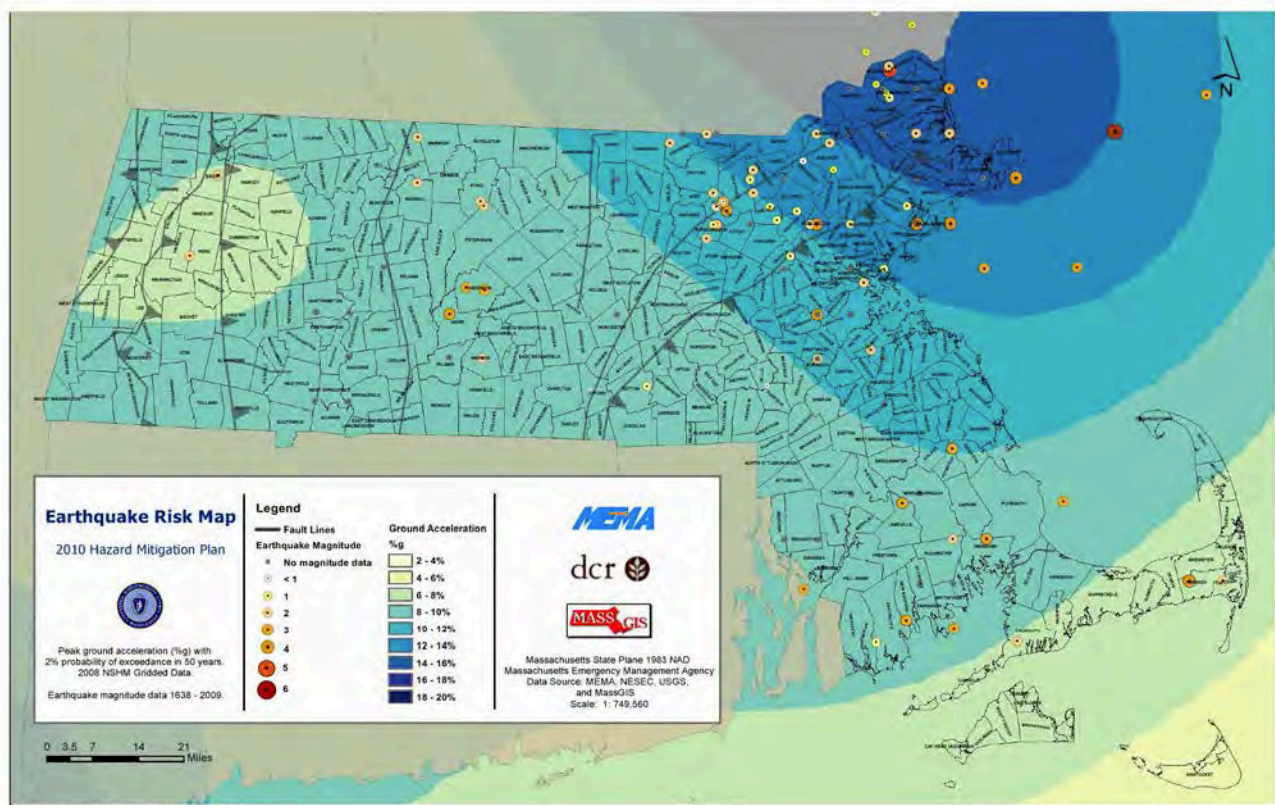
The largest earthquake since 1900 to strike Massachusetts was a magnitude 3.9 on the Richter Scale located east of the Quabbin Reservoir in 1994. According to the USGS, there have been two recent earthquakes with epicenters close to the Berkshires. A magnitude 3.3 on the Richter scale struck the area around Westfield, MA in 2000, a 2.2 magnitude struck Gardner in 2018 and a magnitude 1.9 struck

¹ Quintana, Olivia. 12-6-2016. *New England earthquakes happen more often than you think*, Boston Globe, Boston, MA.

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 only 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 Fig. 3.10.2.

Fig. 3.10.2 Earthquake Historic Occurrences and Risk



Source: MEMA 2013

Probability of Future Occurrences

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.

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 Fig. 1, 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)

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)

Secondary Hazards

Secondary hazard 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 for earthquakes. (MEMA, 2013) Damaged roadways could impede rescue efforts.

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)

Exposure

The entire town of Williamstown is 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)

3.10.3. Vulnerability

To assess the community's vulnerability to the earthquake hazard, probabilistic analyses were run in HAZUS for the 100-year mean return period (MRP) events. The HAZUS -MH model was used to estimate potential losses to these events. For this Plan update, a probabilistic assessment was conducted for the 100-year MRP using default settings in HAZUS-MH 4.0 to analyze the earthquake hazard for the community. The 100-year MRP event is an earthquake with a 1% chance that the mapped ground motion levels (PGA) will be exceeded in any given year with a magnitude 5.0 earthquake. This model estimates the total economic loss associated with each earthquake scenario, which includes building and lifeline-related losses (transportation and utility losses) based on the available inventory.

Population

The entire population of Williamstown 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)

According to the HAZUS-MH analysis, no injuries or casualties are estimated for the 100-year event and no sheltering is needed.

Critical Facilities

All critical facilities in the planning 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 an adjacent waterway. (MEMA, 2013)

Based on the HAZUS analysis for Williamstown, it is expected that there will be no damages associated with critical municipal facilities, transportation routes or utilities. There will be zero tons of debris to be handled.

Economy

Direct building losses are the estimated costs to repair or replace the damage caused to the building. HAZUS-MH estimates that 11 residential buildings may sustain slight damage and two residential buildings might sustain moderate damage during the computed earthquake event. HAZUS-MH estimated that Williamstown could experience \$250,000 in total building related losses across the town.

Table 3.10.3. HAZUS-MH Building-Related Economic Loss Estimates (dollars)

Economic Losses		Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	-	10,000	20,000	-	-	30,000
	Capital-Related	-	-	20,000	-	-	20,000
	Rental	-	10,000	10,000	-	-	20,000
	Relocation	-	10,000	10,000	-	10,000	30,000
	Subtotal	-	30,000	60,000	-	10,000	100,000
Capital Stock Losses							
	Structural	10,000	30,000	10,000	-	10,000	60,000
	Non-structural	20,000	40,000	20,000	-	10,000	90,000
	Content	-	-	-	-	-	-
	Inventory	-	-	-	-	-	-
	Subtotal	30,000	70,000	30,000	-	20,000	150,000
Total		30,000	100,000	90,000	-	30,000	250,000

Source: HAZUS-MH 2017.

3.10.4. Existing Protections

- The Town of Williamstown adheres to the Massachusetts Building Code.

3.10.5. Actions

- Continue strict enforcement of the Massachusetts Building Code.

SECTION 4. MITIGATION STRATEGIES AND ACTIONS

4.1 Major Findings

Several major findings of risk surfaced during the planning processes for the Williamstown Natural Hazard Mitigation Plan Update and the Municipal Vulnerability Preparedness (MVP) Project. The hazard of most concern voiced throughout both of these planning processes was that of flooding, although due recognition was given to increasing temperatures, drought and severe storm events. The complete destruction of the Spruces Mobile Home Park due to flooding in 2011, where all residents in this closely knit neighborhood lost their homes, still resonated in 2018. Members of the Williamstown Hazard Mitigation / Municipal Vulnerability Preparedness Committee (HM/MVP Committee) and attendees of the MVP Workshop raised the issue of repetitive flooding of roads in specific areas of the town and ongoing threats to public infrastructure, private properties and the railroad tracks. Flooding, along with snow and ice, were consistently the top hazards at each of the breakout tables at the MVP Workshop.

High priority actions for hazard mitigation revolve around assessing and prioritizing structural improvement projects to protect vulnerable bridges, culverts and water/sewer pipelines in town, particularly to enable them to withstand the impacts of more frequent and more severe storm events. High priorities also revolve around an improved community emergency preparedness program that proactively educates residents and businesses about emergency preparedness and communications so that all are informed of what to do and where to go in the event of a natural disaster.

Major Finding #1: The Most Serious Hazards in the Town of Williamstown

Williamstown's topography, that of relatively narrow valleys surrounded by steep slopes and deeply cut ravines, creates an environment that is conducive to quickly rising stream flows and severe erosion and scouring of stream channels. Development has historically been clustered in the low-lying areas, particularly surrounding the floodplains of the Hoosic and Green Rivers. Newer residential developments have crept up steeply sloped areas such as the White Oaks area of Town. There are relatively few wetlands to absorb flood waters.

- The complete destruction of the Spruces Mobile Home Park in 2011 displaced residents of all 225 housing units, making it the single greatest loss of residential property in Berkshire County since the great flood events of 1938 and 1948-49, and possibly since recorded history.
- Flood damages to municipal infrastructure have consistently incurred in a few key areas of the Town, particularly along eroding stream and river banks.
- A projected increase in the number and severity of high-volume rain storms are of concern due to the steeply sloped topography of the Town; the intense rain event of May 29, 2013 that caused flash flooding and damages infrastructure could serve as an example of the type of storm that may pose increased risk to the Town.
- Participants of the MVP Workshop held on May 21, 2018 identified 1) Flooding and 2) Snow & Ice as being the top two hazards that threaten the Town and its residents.

Major Finding #2: Vulnerability

- Flood water damages chronically threaten roads and municipal infrastructure:
 - Severe erosion of the bank of the Hoosic River in past severe storm events has exposed the main sewer interceptor line that delivers waste from North Adams into Williamstown; exposure threatens the integrity of the pipes.
 - Erosion of the bank of the Green River, near its discharge into the Hoosic River, has in past storms exposed the sewer pipe in this area; exposure has caused the pipeline to sink and pull apart.
 - Properties and infrastructure in the business/college section of Town, in the Water Street area, suffers from chronic flooding due to flows from Christmas Brook and from stormdrain systems; the expansive infrastructure improvements project recently completed by Williams College, which included underground pipe improvements and a runoff retention system under a parking lot, should reduce these risks.
 - Repeated flooding of homes or basements occur in the White Oaks, Colonial Village and North Hoosic neighborhoods.
 - Sand Springs Road is at risk from flooding and bank erosion of Broad Brook.
 - The Route 7 crossing and railroad tracks are at risk of flood damages from Broad Brook, with risk of damages not only from flood waters but also from movement of large boulders and transport of large amounts of sediment and cobbles; sediment/stone buildup under the Route 7 bridge reduces the capacity of the stream channel to pass floodwaters under the bridge.
 - Portable generators for the pumps for the drinking water system can be utilized where necessary.
 - The Hoosac Water Quality District's wastewater treatment plant continues to experience overflows during high flow events, primarily due to Inflow & Infiltration, much of which originates in North Adams.
- Populations deemed to be most vulnerable to natural hazards or disasters are the elderly, whose numbers are increasing, and transients staying in motels and inns to visit any of the Town's cultural or tourist institutions; while the Town offers the CodeRed emergency communications system to its residents, it is unknown of hotel and inn owners prescribe to this system, potentially leaving the transient population unaware of emergency announcements and directives.
- The Town does not have a clearly defined sheltering plan; the elementary school lacks a permanent backup power source; while the elementary and new high school are potential candidates, mutual aid agreements and protocols for opening and running a shelter at these buildings are not in place.
- The Williamstown Fire Station is outdated; it restricts the Fire District's ability to purchase and maintain modern equipment and properly provide needed services to fire fighters.
- Potential risk and impacts of a dam failure at Mount Williams Reservoir, owned by the City of North Adams, are unknown because an Emergency Action Plan has not been shared with Williamstown officials; it is unknown if an EAP has been prepared for the dam.

- The long-term impacts of forest pests such as the emerald ash borer and woolly adelgid are not yet fully known; accelerated numbers of dead and dying tree stands can increase the risk of fire; the Town's urban/suburban tree cover is aging with no plans for replacement of damaged or downed trees.
- The farming community is at risk from dry and drought conditions, with some farmers having to purchase hay during these times, threatening their economic viability.

4.2 Goals and Objectives

The overall Goals, Objectives and Actions within this plan were developed as local vulnerabilities were identified and concerns were being raised by the Williamstown HM/MVP Committee, through thoughtful input received during the MVP Workshop, and by residents who participated in the public input sessions held as part of the hazard mitigation and MVP planning processes. The Committee revisited and re-adopted the overall goal from the *Berkshire County Hazard Mitigation Plan (2012)*, finding it still relevant today.

Overall Goal:

Reduce the loss of life, property, and infrastructure, and environmental and cultural resources from natural disasters and improve the resiliency of the community to respond to shifting weather patterns and environmental impacts caused by climate change.

Major Objectives to meet the Goal and address the Major Findings:

The analysis of historic disaster data, projected changes in weather patterns due to climate change, and the concerns raised by local officials and residents were factors in the development of two Major Objectives in which to categorize a series of Actions:

1. Reduce the risk of flood damage.
2. Expand emergency communications and preparedness programs to increase public safety.

4.3. Local Capability Assessment

In addition to gathering data and information from the Williamstown HM/MVP Committee, interviews were held with key stakeholders to discuss current capabilities of the Town and key institutions to address natural hazard risks and vulnerability in Williamstown. Interviews were held with staff from the Town Manager's Office (including Emergency Management), Community Development Office (including Health and Building Inspections), and Public Safety and Public Works Departments, as well as with Williams College, Clark Art Institute, Mount Greylock Regional School District and the Council on Aging. Risk assessment, strength and weakness were discussed frankly and incorporated into this hazard mitigation plan to identify and prioritize existing protections and future actions. The existing protections have been described throughout the Risk Assessment sections of this plan. Additional findings on local capabilities are described herein.

During the MVP Workshop held in May 2018 residents highlighted the strengths of the Town of Williamstown, its first responder community, and the contributions of Williams College.

Infrastructure Strengths

- Water supply pumps and wellheads are protected
- Public water aquifer is extensive, and system has additional capacity to extend to new users
- Williams College is installing extensive new storm water management system in the downtown along Christmas Brook

Societal Strengths

- Community is proactive, cohesive and generally supportive of protection and enhancement efforts for benefit of all
- Mutual Aid during emergencies between Towns in region is excellent
- Williams College has its own shelter and evacuation plans
- Nursing and rehabilitation facilities are self-contained and have backup power
- Council on Aging maintains list of “vulnerable” seniors and has an outreach program to reach them; Senior Center is cooling/warming place
- Town has storm water bylaw, requiring on-site storage already
- Town has a functional Code Red system that can be enhanced/broadened
- Local Emergency Preparedness Committees are active in ongoing training of first responders

Environmental Strengths

- The Spruces Site Reuse Committee is actively working on a plan appropriate to floodplain location
- Extensive forest cover has cooling effect and provides rich habitat for a wide variety of plant and animal species
- Aquifer is extensive, and water is of good quality

Capability Self-Evaluation

As part of this Plan update, the Town of Williamstown conducted a self-evaluation of its hazard mitigation capabilities, reviewing its existing policies, programs, permitting and resources to monitor or reduce natural hazard impacts. As part of this effort key Town staff filled out the Capability Assessment Worksheet developed by FEMA and found in the *Local Mitigation Planning Handbook*. (FEMA, 2013) While the Town has many policies and regulations in place to address natural hazards and implement mitigation strategies, it was recognized that renewed focus on hazard mitigation should be considered more directly in all planning efforts. A summary of the self-evaluation includes:

Planning, Regulatory, Safe Growth Audit: The Town has a dated Master Plan (2002), an Economic Development Plan (2015), a current Open Space and Recreation Plan (2016) and a newly developed Municipal Vulnerability Preparedness Plan (2018). The Master Plan identifies flood hazards and calls for increased density and infill in the village center outside floodplain areas, but does not specifically discuss hazard mitigation strategies. The Open Space Plan quantifies the large proportion of permanently protected land in Williamstown and highlights the benefits of maintaining key ecosystems in their natural state, but does not specifically discuss how natural lands can serve as hazard mitigation strategies. The Vulnerability Preparedness Plan does specifically identify natural hazards and mitigation that the Town and other stakeholders can take to minimize risk.

The Town has zoning bylaws and site plan review procedures that are effective measures for reducing hazard impacts and these are enforced. A NFIP Community Assistance Contact Field Visit by Massachusetts State NFIP staff report from June 2018 finds that “Williamstown’s bylaws are in good order; no revisions are necessary at this time.” The Town specifically has a floodplain bylaw that regulates development in the floodplain, using the Flood Insurance Rate Map to delineate the bylaw boundaries. Stormwater management bylaws are in place for all new development and subdivisions to control runoff, including encouraging the use of Low Impact Development techniques and specifically referencing the use of Best Management Practices promoted in the most recent version of the Massachusetts Department of Environmental Protection Stormwater Manual. The Upland Conservation Overlay District, which regulates land higher than 1,300 in elevation, is intended to protect upland resources and restrict development that would negatively impact high gradient streams, increase runoff or destabilize steep slopes; the bylaw prohibits residential development and requires a special permit for any other development. Aquifer and drinking water overlay districts regulate development to protect water quality and supply. The Town strictly enforces the Massachusetts Wetlands Protection Act and state building code.

Administrative, Technical, Financial: Williamstown has a robust planning, administrative and enforcement staff for a community of its size in Berkshire County. Full-time staff include Town Management, Administration, Planning, Public Works, Public Health and Building Enforcement. Staff have in-house GIS Coordination, planning, grant writing and data information services. The Town does not have in-house civil engineering, but consults with and hires local firms when necessary. The Town employs or is eligible for all funding resources listed in the Capability Assessment Worksheet except that it does not demand impact fees and does not operate a stormwater utility, as these have not been determined as necessary given the pace of development and the level of protection offered by zoning and town bylaws.

Education, Outreach: The Town of Williamstown offers residents and businesses enrollment in Code Red. These programs are prominently posted in the Town website. Emergency planning and drills are held at the schools through coordination with the regional school district and local and state first responders. However, it is widely believed that outreach should be increased to better communicate and educate residents and business owners on how to prepare for emergency situations. This was discussed at Williamstown HM/MVP Committee meetings and echoed by residents in the Municipal Vulnerability Preparedness public planning process.

Mutual Aid Agreements and Coordination

In general, the first responder communities in the Berkshires coordinate and work well together during emergency situations. The Northern Berkshire region is somewhat isolated due to the Hoosac and Taconic mountain ranges, and the population of the area is relatively small compared to the rest of the state. As a result, local first responders tend to know each other. Formal mutual aid agreements are held by both fire and police, and Williamstown is an active member of the Northern Berkshire REPC.

Public Services in Williamstown

The working relationships between departments in Williamstown Town Government are close and cooperative, providing strong public services through shared goals and implementation. Staff in the Department of Public Works have a “can do” attitude of addressing immediate public safety issues and repairing or replacing damaged infrastructure proactively where possible. Public Health and Building Inspection Services ensure compliance with health and building codes to reduce risk to public health and

safety. All departments worked cooperatively to undertake the evacuation of residents from The Spruces in 2011, aid in sheltering and relocating them, and the subsequent FEMA-funded project to demolish and remove structures to create a permanent public park. In addition, Town staff have good working relationships with their facility colleagues at Williams College, each supporting the other where possible. One exceptional example is the Water Street project, where the college is funding an extensive infrastructure project that is intended to reduce flooding in this commercial district.

Responding to Natural Hazards and Disasters

Communication with all residents, especially seniors and other vulnerable populations, will be key to an effective response to a disaster, and although the Town's first responders feel they are prepared to act in an emergency situation, communication may not reach all residents equally. Although the Town offers CodeRed emergency communications system to all residents, Town officials do not know how many residents are enrolled, nor where gaps in enrollment may be. Those not enrolled will not know where the shelters are, or how or when to go there. The same would be true for warming or cooling centers during extreme temperature events.

Williamstown is a cultural destination, home to Williams College, the Berkshire Theater Festival, the Clark Art Institute and other attractions. As such, there is a large seasonal population, including college students, parents, second homeowners, theater and arts-loving tourists, hikers and campers. While Williams College is largely self-contained, having their own emergency plans and backup power sources to serve their students and faculty, other visitors would be unaware of how to receive emergency communications or seek shelter. Coordinating emergency communications and response amongst residents, tourist businesses and the presents a challenge for Williamstown's natural hazard response and sheltering strategy.

The Town has a Comprehensive Emergency Management Plan (CEMP), drafted by its previous Emergency Management Director. The CEMP goes beyond the MEMA-approved template in that it described in more detail what protocols should be undertaken during an emergency or disaster incident. However, the contact information in the CEMP needs to be updated to be truly effective in an emergency. It is anticipated that the updates will be completed once the new police station is in operation.

The establishment of a local, long-term shelter in Williamstown remains an outstanding issue for the Town. The Town is an active member of the Northern Berkshire REPC, which as a regional group has identified local and regional shelters. The Williamstown Elementary School has been identified as Williamstown's local shelter, but the Town does not have a formal agreement with the school for use of the building nor protocols in place to dictate when and how the building will open for sheltering. The elementary school has many pros, including being wired to accept a portable generator to power the kitchen, cafeteria and gym, and being within walking distance to a large segment of the population. The new Mt. Greylock Regional High School on Route 7 has the benefit of having permanent backup power to power the kitchen and other common areas, and has the added value of showers; the downside to this site as a shelter is its distance from any densely developed areas, requiring people to drive or be shuttled to the site. Other regional shelter sites are located in neighboring North Adams, also a drive away from population centers.

4.4 Prioritizing Actions

Although tornadoes have caused the most serious loss of life in Berkshire County in the last 50 years, their frequency, location and severity are unpredictable. Severe winter storms and ice storms are serious, annual, relatively predictable events that are viewed as part of life in the Berkshires. It is difficult to identify protection measures to mitigate the impacts of these events.

As has been demonstrated in this plan by previous occurrences, flooding can be the end result of several natural hazards, including heavy snowfall/spring melt, ice jams, heavy rains from severe thunderstorms and hurricanes, and beaver activity. Flooding can also occur due to failing infrastructure, such as deteriorated or undersized pipes, drainage systems, culverts, bridges and dams. Climate change and increased intensity of storms has limited the effectiveness of many stormwater drainage systems and road stream crossings because they are becoming undersized to handle storm flow volumes. Assessing, prioritizing and upgrading infrastructure throughout Williamstown is therefore the major focus of future mitigation planning and implementation.

The Williamstown HM/MVP Committee developed a natural hazard mitigation strategy based on personal and shared experiences, local and regional natural hazard data (both historical and projected future trends), and concerns voiced by residents and business owners during meetings, the MVP Workshop and public forums.

With all the above-mentioned information at hand, the HM/MVP Committee followed the prioritization method used in the development of actions for the *Berkshire Regional Natural Hazard Mitigation Plan*. Priority Levels were determined using three general criteria: 1) the level of potential severity of the hazard/disaster event 2) the level of concern for the hazard/disaster, as voiced by local officials, and 3) practicality of implementing each particular action. Although cost was considered as part of criteria #3, it was not a determining factor. Priority Levels were assigned as follows:

- High Priority: Actions that address hazards of greatest severity and concern in the region, as voiced by local officials and the Advisory Committee, and which should begin to be implemented immediately to avert or mitigate the impacts of future disasters.
- Medium Priority: Actions that address hazards of a lesser severity and concern, as voiced by local officials and the Advisory Committee, and which should be implemented as local capacity and funding becomes available.
- Low Priority: Actions recognized but of lesser importance than High and Medium Priority Actions, and which should be monitored for opportunities for future implementation.

As part of prioritization, the Williamstown HM/MVP Committee estimated the potential cost of implementing each of the actions identified. Estimated costs were determined using internal estimates by department staff, incorporating past experience with implementation of similar projects in Town or in the Berkshire County region. Costs include soft costs (engineering design, permitting, etc.), hard costs (construction and materials), and where appropriate staff time (including construction activities and project administration). Costs listed would be expected to be borne by responsible parties.

Detailed and current estimates were not generally available, so costs are summarized within the following ranges:

- High – over \$100,000
- Medium – between \$50,000 – \$100,000
- Low – less than \$50,000
- None – none needed

4.5 Williamstown Hazard Mitigation Actions

The Action Table listed herein is the culmination of the planning process undertaken by the Williamstown HM/MVP Committee, who was actively engaged in the Multi-Hazard Mitigation Plan Update and the Town's MVP Project. Improving the resiliency of the community to respond to projected climate change impacts should be considered during the planning and implementation of all actions. The Action Table that follows (Table 4.5.1.) includes many of the original actions that are ongoing from the Hazard Mitigation Plan of 2012 and a status of those actions. The Action Table also includes new actions that address concerns that have been identified as part of the planning processes of both the Hazard Mitigation Plan Update and the MVP Project.

The Critical Facilities Map that follows the Action Table illustrates the areas in Williamstown that are of most concern regarding natural hazard impacts.

Table 4.5.1. Action Table

OBJECTIVE #1: Reduce the risk of flood damage.

Original actions from 2012 Regional Hazard Mitigation Plan are in regular text.

Updates and newly formed actions are shown in italicized text.

Description of Action	Benefit	Responsible Parties	Timeframe / Priority	Resources / Funding	Estimated Cost	Update on Actions 2012-2018
Incorporate new FEMA 100-year floodplain data and maps into existing and future planning efforts	More accurate assessment of the flooding risk to properties and infrastructure	FEMA	4-6 years/ Medium	FEMA	Unknown	<i>USGS has updated a small section of the Hoosic River floodplain; rest of the town not done – FEMA has not prioritized Berkshire County for new flood maps</i>
Continue to strictly enforce 100-year floodplain bylaws and encourage flood-proofing or relocation of existing structures in 100-year floodplain zones	Reduce risk to people, property and infrastructure in floodplain	Town of Williamstown (Town)	Ongoing	NA	None	<i>The town continues to strictly enforce the floodplain bylaw</i>
Continue to limit the expansion of infrastructure in hazard-prone areas	Reduce the future risk of damages and emergency response	Town	Ongoing	NA	None	<i>The town continues to prohibit or limit the expansion into hazard-prone areas through zoning and other regulatory measures</i>
Insure the integrity of large beaver dams or breach them in a controlled manner	Reduce the risk of damages from flooding, sediment debris, public health	DPW, Cons Com, Div. Fish & Wildlife (F&W)	Ongoing	MSPCA, MA	Low-Medium	<i>The town has worked to ensure the integrity of beaver dams</i>

Continue to work with Fish & Wildlife to investigate permanent measures to minimize beaver impacts	Reduce the risk of flooding and possible public health impacts	Town, F&W	Ongoing	MA SPCA	None-Low	<i>Ongoing</i>
Determine which major transportation routes are in inundation areas for dams of High or Significant Hazard	Fact-based emergency preparedness for evacuations and traffic detours	Town, dam owners, MEMA	4-6 years/ Medium	NA	Low-Medium	<i>Williams Reservoir EAP in place; need to encourage and support North Adams in conducting inspection of and develop EAP for Mt. Williams Reservoir</i>
Continue to prioritize and improve stormwater management systems that are located in hazard prone areas or are inadequate	Reduce risk of flooding to people, property and infrastructure; ensure safe traffic movement	Town	4-6 years/ Medium	MA DEP, MA DOT	High	<i>Ongoing; Christmas Brook / Water Street improvements completed</i>
Develop bylaws that require on-site containment of stormwater for new development	Reduce risk of flooding and overwhelming existing drainage systems from new development runoff	Town, BRPC	4-6 years/ Medium	NA	None-Low	<i>Existing stormwater bylaws of 2011 successful in stormwater management</i>
Encourage low-impact development techniques, especially in flood-prone areas (as part of a comprehensive new stormwater bylaw)	Reduce risk of flooding and overwhelming existing drainage systems from new development runoff	Community Dev. Dept., Planning Board	4-6 years/ Medium	NA	None-Low (to Town); case-by-case costs to developers	<i>2011 bylaw encourages LID and refers to MA DEP Stormwater Manual</i>

Update an Emergency Action Plan (EAP) for Williamstown Reservoir Dam, and encourage the City of North Adams to develop an EAP for, and inspect the, Mt. Williams Reservoir	Protocols for inspections, delineate inundation areas, increased emergency preparedness and response	Town, City of North Adams, DCR	1-3 years/ High	NA	None-Low to Williams-town; unknown cost to N. Adams	<i>Williams Reservoir EAP updated and in place; need to encourage and support North Adams in conducting inspection of and develop EAP for Mt. Williams Reservoir</i>
Continue to have information available for landowners in hazard-prone areas that discuss hazard mitigation (using Berkshire County Board of Health's brochures); utilize the Town website for publishing information	Informed landowners can consider mitigation and emergency preparedness options to reduce risk	Town, BCBOHA, MEMA	4-6 years/ Medium	NA	None	<i>Spruces Mobile Home Park homes removed from floodplain; outreach to property owners continues to be needed</i>
As necessary, update historic structures, businesses and critical facilities located in hazard-prone areas, including 100-year floodplains and dam failure inundation areas	Enables the facilities owners to reduce their risk of damage and loss of operations	Town, Hist Commission, Chamber Commerce	4-6 years/ Medium	NA	Low	<i>Town has requested a training from MA NFIP for real estate brokers and property owners</i>
Install accessible dry hydrants in needed areas	Improved fire response	Fire District	1-3 years / High	NA	Medium	<i>Ongoing – new hydrants installed as funding allows.</i>
<i>Support the Hoosac Water Quality District's efforts to reduce I&I and other factors that overwhelm the system during severe precipitation events; support City of North Adams efforts to address I&I</i>	<i>Reduce discharge volumes during flood events; improve treatment and water quality; reduce risk of shut down of system from damages</i>	<i>Town, Hoosac WQD, City North Adams</i>	<i>4-6 / Medium</i>	<i>Town Funds; state funds</i>	<i>High</i>	<i>Williamstown directs funding annual to address I&I</i>

OBJECTIVE #2: Expand emergency communications and preparedness programs to increase public safety.

Description of Action	Benefit	Responsible Parties	Timeframe / Priority	Resources / Funding	Estimated Cost	Update on Actions 2012-2018
<i>Support the Williamstown Fire District's efforts to construct a modern fire station</i>	<i>Ability to purchase and house trucks and equipment needed for local and regional response; improved response to fires and other disaster incidents</i>	<i>Fire District, Town</i>	<i>3-4 years / High</i>	<i>Williamstown Fire District, Town, MA, Homeland Security</i>	<i>High</i>	<i>New Action</i>
Develop and publicize local and regional evacuation routes and shelter locations; utilize the town website for publishing information	Improved public emergency preparedness and response	Town, REPC, BCBOHA	4-6 years/ Medium	Homeland Security	None-Low	<i>HM/MVP Committee agrees increased public awareness needed</i>
Continue to fill communications gaps by adding new towers, using existing towers where possible; evaluate if new fire station can fill gap	Improve emergency communications	Town, WRHSAC, Fire District	4-6 years/ Medium	Homeland Security	High	<i>The WRHSAC has added / renovated towers to improve; Town working with Williams College to improve; new dedicated fiber system being developed as part of new police station design</i>
Continue evaluating shelter capacity for Williamstown residents and determine each shelter's structural ability to withstand natural disaster events; <i>this is a priority action identified by MVP planning process</i>	Ensure safe sheltering that meets needs of town and region	Town, School District, REPC,	4-6 years/ Medium	NA	Medium-High	<i>Regional shelter plan developed, but details not fully developed for local sheltering; permanent backup power source needed for Williamstown Elementary School to serve as shelter</i>

Review local agreements for use of shared mass care shelters in the event of a disaster	Ensure capacity to shelter residents in the North County region during a disaster	Municipalities, Shelters, SBREPC, MEMA	4-6 years/ Medium	NA	None	<i>Regional shelter plan for Northern Berkshire County has been developed – agreements need to be developed</i>
Determine ability of town governmental centers to withstand a variety of natural hazard events	Ensure town governmental operations continue during storm event or disaster	Town	4-6 years/ Medium	NA	Medium-High	<i>Military surplus generators ready for use; permanent generator needed for elementary school; permanent generator in place at new Mt. Greylock Regional</i>
Educate local officials to help them develop plans to protect critical documents and materials	Protect historical records and ensure ongoing governmental operations	Town	4-6 years / Medium	NA	Low	<i>Municipal data back-up system in place in cloud</i>
Improve record-keeping of local natural disasters and their impacts	Identify trends for improved mitigation options; improve chance for receipt of grant	Department Heads, Town	4-6 years/ Medium	NA	None	Not addressed
<i>Develop local shelter plan: formal agreements, protocols for opening & operating, public outreach to inform residents</i>	<i>Preparedness for potential sheltering</i>	<i>EMD, BCBOHA</i>	<i>1-3 years/ High</i>	<i>Capital Budget, grant funding</i>	Low-Medium	<i>New action</i>
<i>Designate and announce cooling/warming centers</i>	<i>Increased access for residents</i>	<i>EMD, BCBOHA, COA</i>	<i>1-3 years/ High</i>	<i>BCBOHA</i>	Low	<i>New action</i>
<i>Continue participation in Northern Berkshire Regional Emergency Planning Committee</i>	<i>Improved regional coordination for incident response</i>	<i>EMD/ REPC</i>	<i>Ongoing/ High</i>	<i>EMD, REPC, WRHSAC</i>	Low	<i>New action</i>

<i>Update eCEMP and paper copy of CEMP and distribute to key personnel</i>	<i>Improved regional coordination for incident response</i>	<i>EMD</i>	<i>Ongoing/High</i>	<i>EMD, REPC, WRHSAC</i>	<i>Low</i>	<i>New action</i>
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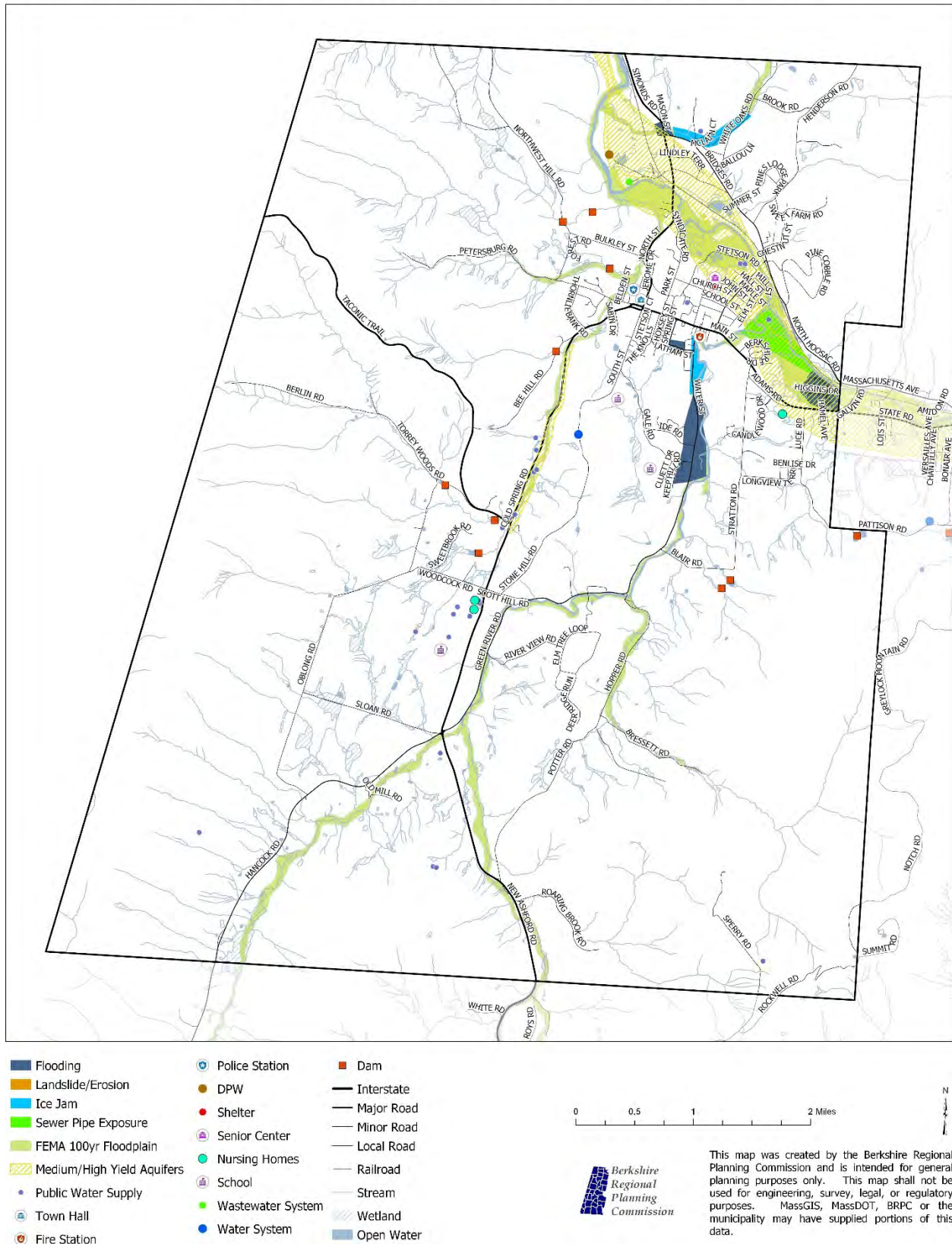
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APPENDIX A.
MAP OF CRITICAL FACILITIES AND AREAS OF CONCERN

Town of Williamstown - Critical Facilities and Areas of Concern



APPENDIX B.
HAZUS-MH REPORTS

Hazus-MH: Flood Global Risk Report

Region Name: Williamstown

Flood Scenario: Flood100

Print Date: Thursday, November 2, 2017

Disclaimer:

This version of Hazus utilizes 2010 Census Data.

Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific Flood. These results can be improved by using enhanced inventory data and flood hazard information.



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Table of Contents

Section	Page #
General Description of the Region	3
Building Inventory	
General Building Stock	4
Essential Facility Inventory	5
Flood Scenario Parameters	6
Building Damage	
General Building Stock	7
Essential Facilities Damage	9
Induced Flood Damage	10
Debris Generation	
Social Impact	10
Shelter Requirements	
Economic Loss	12
Building-Related Losses	
Appendix A: County Listing for the Region	15
Appendix B: Regional Population and Building Value Data	16



General Description of the Region

Hazus is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). The primary purpose of Hazus is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The flood loss estimates provided in this report were based on a region that included 1 county(ies) from the following state(s):

- Massachusetts

Note:

Appendix A contains a complete listing of the counties contained in the region .

The geographical size of the region is 47 square miles and contains 231 census blocks. The region contains over 3 thousand households and has a total population of 7,754 people (2010 Census Bureau data). The distribution of population by State and County for the study region is provided in Appendix B .

There are an estimated 3,015 buildings in the region with a total building replacement value (excluding contents) of 1,251 million dollars (2010 dollars). Approximately 88.92% of the buildings (and 74.91% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

Hazus estimates that there are 3,015 buildings in the region which have an aggregate total replacement value of 1,251 million (2014 dollars). Table 1 and Table 2 present the relative distribution of the value with respect to the general occupancies by Study Region and Scenario respectively. Appendix B provides a general distribution of the building value by State and County.

Table 1
Building Exposure by Occupancy Type for the Study Region

Occupancy	Exposure (\$1000)	Percent of Total
Residential	937,129	74.9%
Commercial	187,974	15.0%
Industrial	38,921	3.1%
Agricultural	5,325	0.4%
Religion	18,266	1.5%
Government	3,295	0.3%
Education	60,168	4.8%
Total	1,251,078	100.0%

Building Exposure by Occupancy Type for the Study Region
(\$1000's)

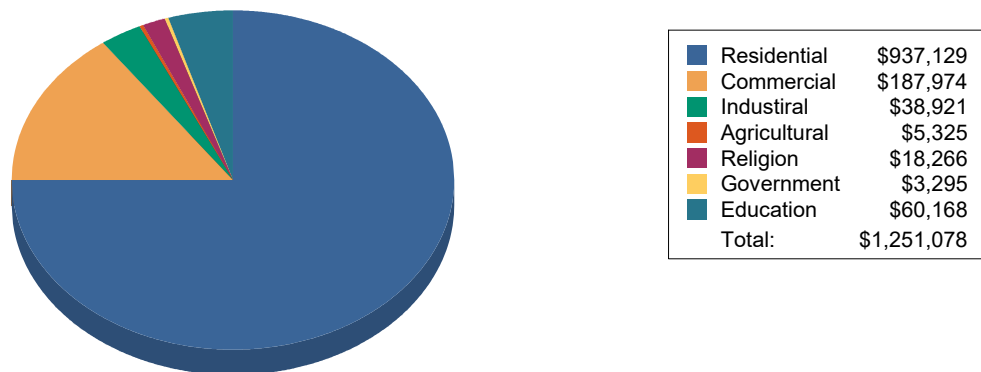
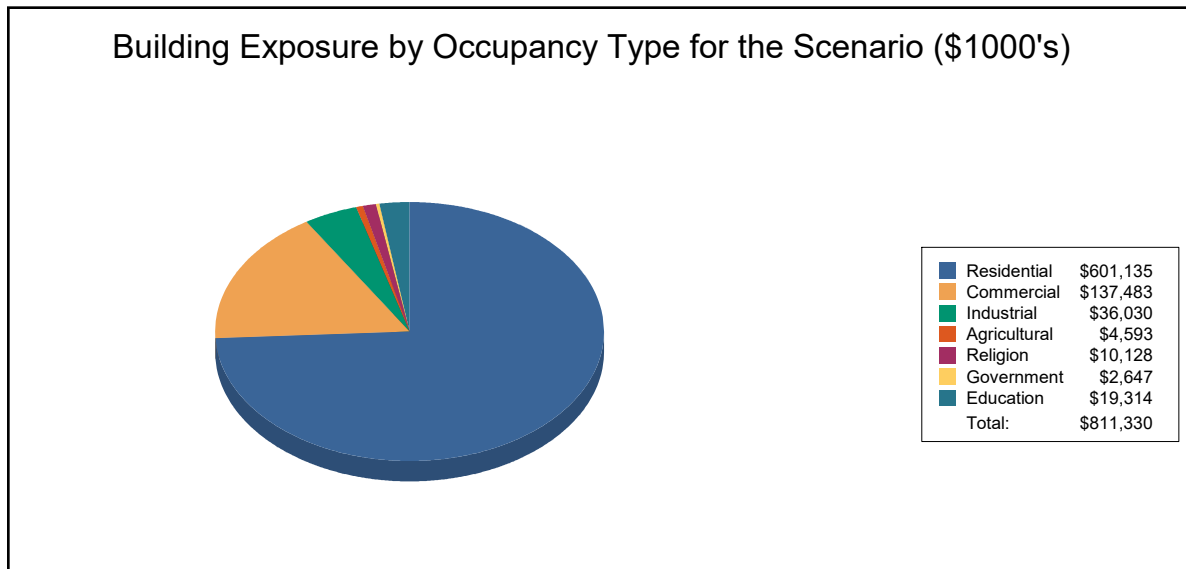


Table 2
Building Exposure by Occupancy Type for the Scenario

Occupancy	Exposure (\$1000)	Percent of Total
Residential	601,135	74.1%
Commercial	137,483	16.9%
Industrial	36,030	4.4%
Agricultural	4,593	0.6%
Religion	10,128	1.2%
Government	2,647	0.3%
Education	19,314	2.4%
Total	811,330	100.0%



Essential Facility Inventory

For essential facilities, there are no hospitals in the region with a total bed capacity of no beds.
There are 4 schools, 1 fire station, 1 police station and no emergency operation centers.

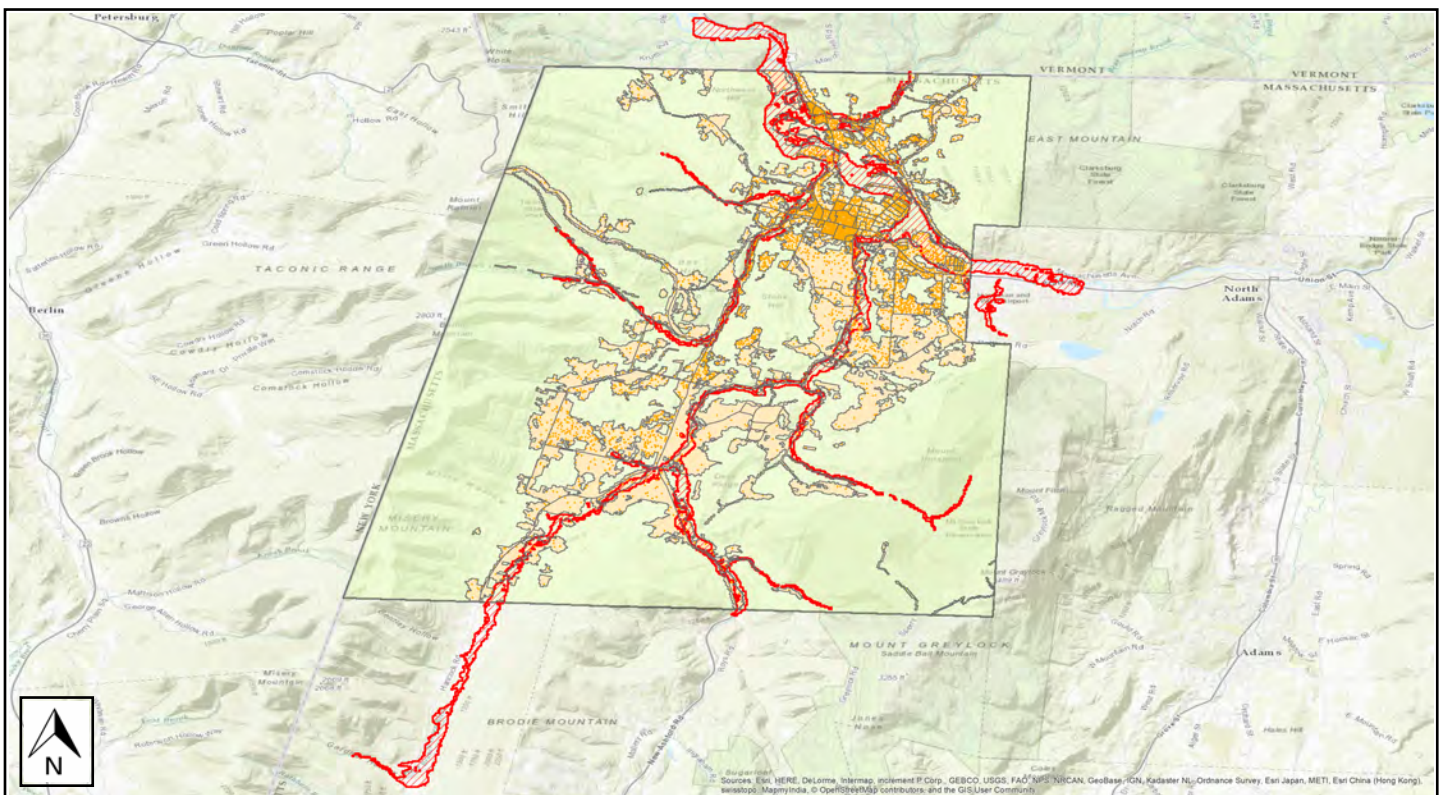
Flood Scenario Parameters

Hazus used the following set of information to define the flood parameters for the flood loss estimate provided in this report.

Study Region Name:	Williamstown
Scenario Name:	Flood100
Return Period Analyzed:	100
Analysis Options Analyzed:	No What-Ifs

Study Region Overview Map

Illustrating scenario flood extent, as well as exposed essential facilities and total exposure



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Building Damage

General Building Stock Damage

Hazus estimates that about 216 buildings will be at least moderately damaged. This is over 34% of the total number of buildings in the scenario. There are an estimated 98 buildings that will be completely destroyed. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the Hazus Flood Technical Manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 summarizes the expected damage by general building type.

Total Economic Loss (1 dot = \$300K) Overview Map

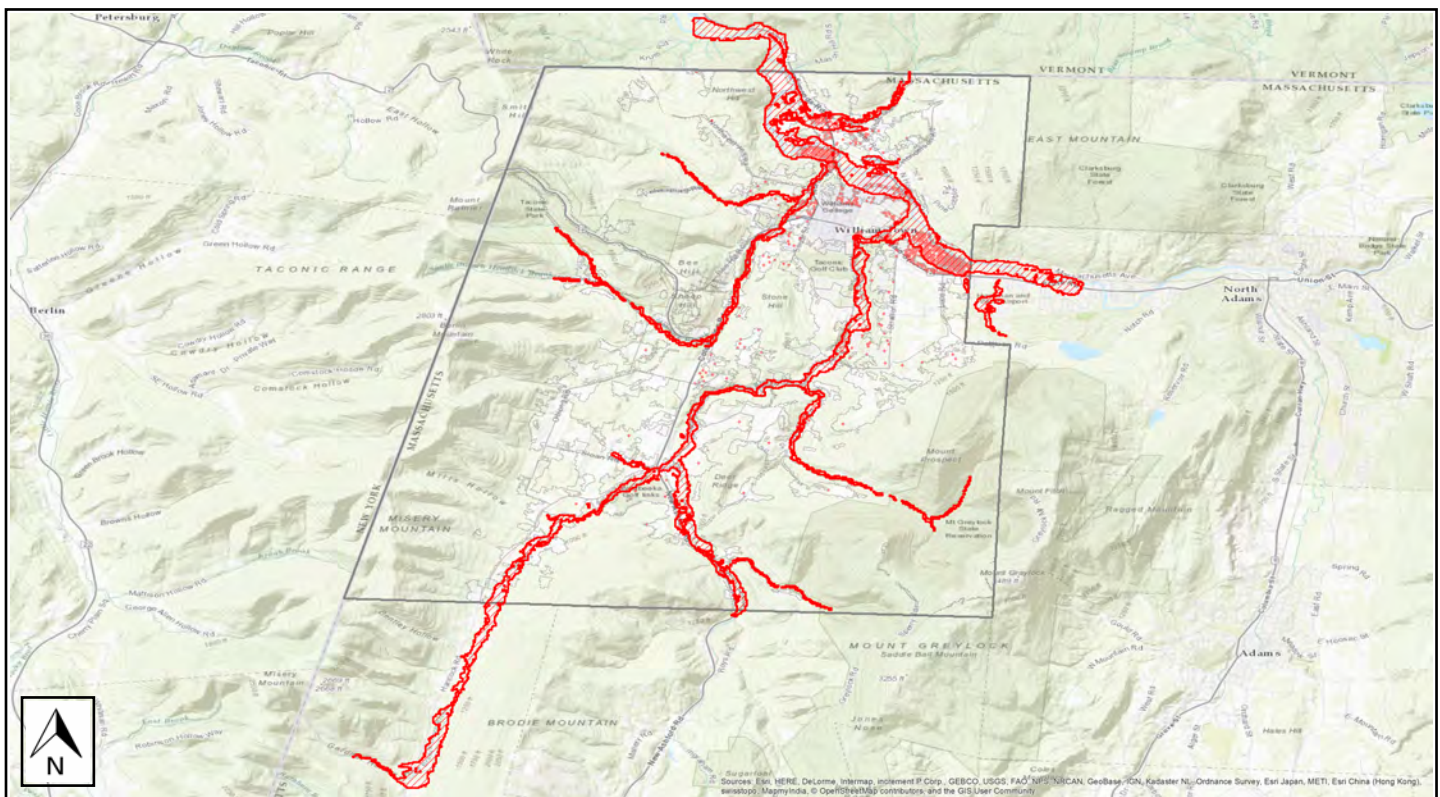


Table 3: Expected Building Damage by Occupancy

Occupancy	1-10		11-20		21-30		31-40		41-50		Substantially	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Commercial	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
Education	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Government	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Industrial	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Religion	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Residential	25	10.42	30	12.50	28	11.67	37	15.42	22	9.17	98	40.83
Total	25		31		28		37		22		98	

Counts By Damage Level

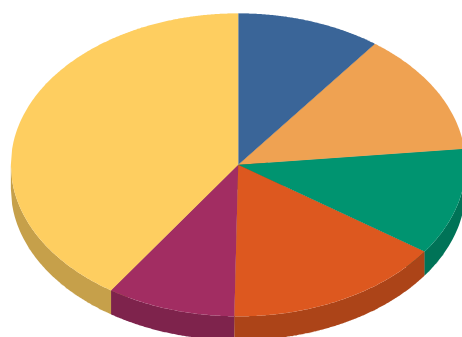


Table 4: Expected Building Damage by Building Type

Building Type	1-10		11-20		21-30		31-40		41-50		Substantially	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	0	0	0	0	0	0	0	0	0	0	0	0
ManufHousing	0	0	0	0	0	0	0	0	1	1	70	99
Masonry	1	100	0	0	0	0	0	0	0	0	0	0
Steel	0	0	1	100	0	0	0	0	0	0	0	0
Wood	24	14	30	18	28	17	37	22	21	13	28	17



FEMA

RiskMAP
Increasing Resilience Together

Essential Facility Damage

Before the flood analyzed in this scenario, the region had 0 hospital beds available for use. On the day of the scenario flood event, the model estimates that 0 hospital beds are available in the region.

Table 5: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		At Least Moderate	At Least Substantial	Loss of Use
Fire Stations	1	0	0	0
Hospitals	0	0	0	0
Police Stations	1	0	0	0
Schools	4	0	0	0

If this report displays all zeros or is blank, two possibilities can explain this.

- (1) None of your facilities were flooded. This can be checked by mapping the inventory data on the depth grid.
- (2) The analysis was not run. This can be tested by checking the run box on the Analysis Menu and seeing if a message box asks you to replace the existing results.



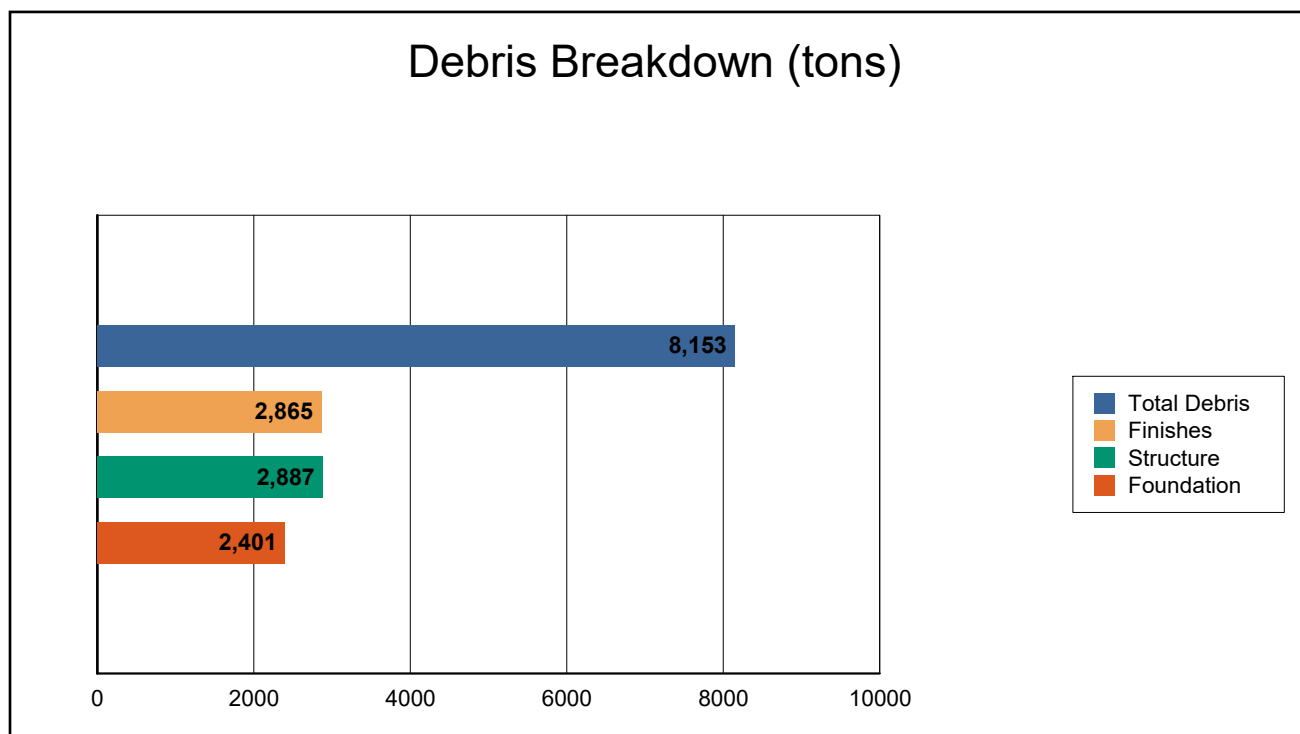
FEMA

RiskMAP
Increasing Resilience Together

Induced Flood Damage

Debris Generation

Hazus estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories: 1) Finishes (dry wall, insulation, etc.), 2) Structural (wood, brick, etc.) and 3) Foundations (concrete slab, concrete block, rebar, etc.). This distinction is made because of the different types of material handling equipment required to handle the debris.

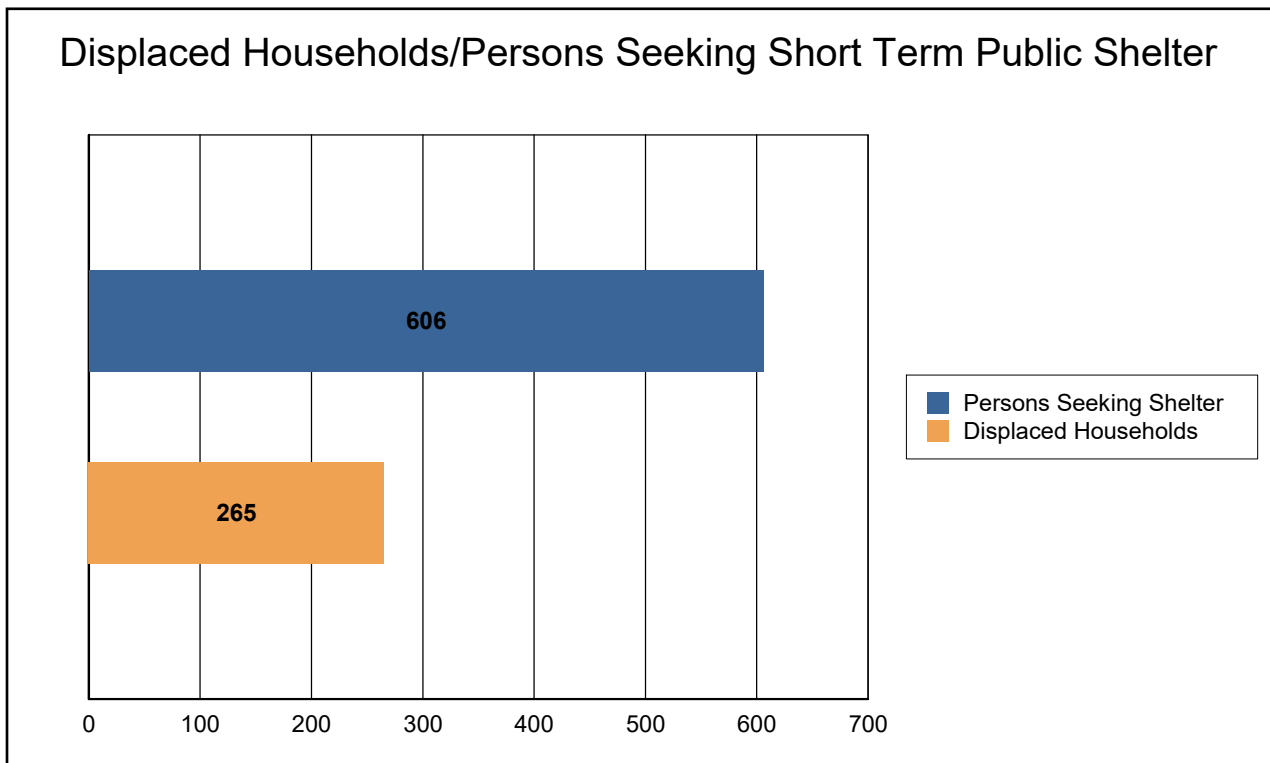


The model estimates that a total of 8,153 tons of debris will be generated. Of the total amount, Finishes comprises 35% of the total, Structure comprises 35% of the total. If the debris tonnage is converted into an estimated number of truckloads, it will require 326 truckloads (@25 tons/truck) to remove the debris generated by the flood.

Social Impact

Shelter Requirements

Hazus estimates the number of households that are expected to be displaced from their homes due to the flood and the associated potential evacuation. Hazus also estimates those displaced people that will require accommodations in temporary public shelters. The model estimates 265 households will be displaced due to the flood. Displacement includes households evacuated from within or very near to the inundated area. Of these, 606 people (out of a total population of 7,754) will seek temporary shelter in public shelters.



Economic Loss

The total economic loss estimated for the flood is 72.75 million dollars, which represents 8.97 % of the total replacement value of the scenario buildings.

Building-Related Losses

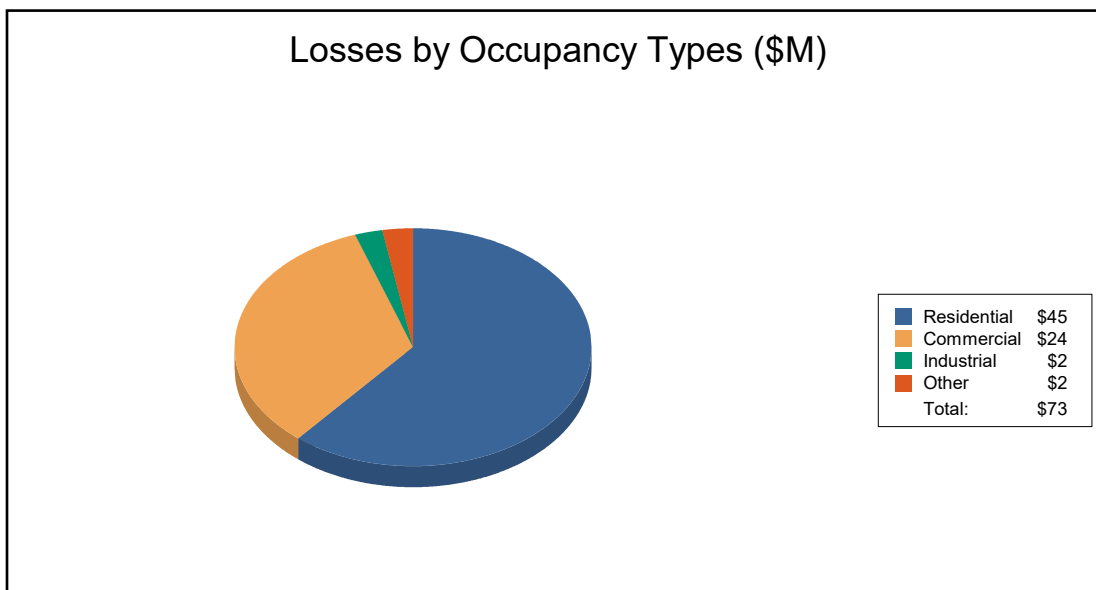
The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the flood. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the flood.

The total building-related losses were 72.44 million dollars. 0% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 61.25% of the total loss. Table 6 below provides a summary of the losses associated with the building damage.

Table 6: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Building Loss						
	Building	29.54	7.04	0.55	0.33	37.45
	Content	14.97	16.92	1.08	1.65	34.62
	Inventory	0.00	0.23	0.11	0.04	0.38
	Subtotal	44.50	24.19	1.73	2.03	72.44
Business Interruption						
	Income	0.00	0.10	0.00	0.00	0.10
	Relocation	0.04	0.02	0.00	0.00	0.06
	Rental Income	0.01	0.01	0.00	0.00	0.02
	Wage	0.01	0.09	0.00	0.03	0.13
	Subtotal	0.05	0.21	0.00	0.03	0.30
ALL	Total	44.56	24.40	1.73	2.06	72.75





Appendix A: County Listing for the Region

Massachusetts

- Berkshire



FEMA

Appendix B: Regional Population and Building Value Data

	Population	Building Value (thousands of dollars)		
		Residential	Non-Residential	Total
Massachusetts				
Berkshire	7,754	937,129	313,949	1,251,078
Total	7,754	937,129	313,949	1,251,078
Total Study Region	7,754	937,129	313,949	1,251,078

Hazus-MH: Hurricane Global Risk Report

Region Name: Williamstown

Hurricane Scenario: Probabilistic 100-year Return Period

Print Date: Thursday, November 2, 2017

Disclaimer:

*This version of Hazus utilizes 2010 Census Data.
Totals only reflect data for those census tracts/blocks included in the user's study region.*

The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific Hurricane. These results can be improved by using enhanced inventory data.

Table of Contents

Section	Page #
General Description of the Region	3
Building Inventory	4
General Building Stock	
Essential Facility Inventory	
Hurricane Scenario Parameters	5
Building Damage	6
General Building Stock	
Essential Facilities Damage	
Induced Hurricane Damage	8
Debris Generation	
Social Impact	8
Shelter Requirements	
Economic Loss	9
Building Losses	
Appendix A: County Listing for the Region	10
Appendix B: Regional Population and Building Value Data	11

General Description of the Region

Hazus is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of Hazus is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The hurricane loss estimates provided in this report are based on a region that includes 1 county(ies) from the following state(s):

- Massachusetts

Note:

Appendix A contains a complete listing of the counties contained in the region .

The geographical size of the region is 46.89 square miles and contains 2 census tracts. There are over 2 thousand households in the region and has a total population of 7,754 people (2010 Census Bureau data). The distribution of population by State and County is provided in Appendix B .

There are an estimated 3 thousand buildings in the region with a total building replacement value (excluding contents) of 1,251 million dollars (2014 dollars). Approximately 89% of the buildings (and 75% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

Hazus estimates that there are 3,015 buildings in the region which have an aggregate total replacement value of 1,251 million (2014 dollars). Table 1 presents the relative distribution of the value with respect to the general occupancies. Appendix B provides a general distribution of the building value by State and County.

Building Exposure by Occupancy Type

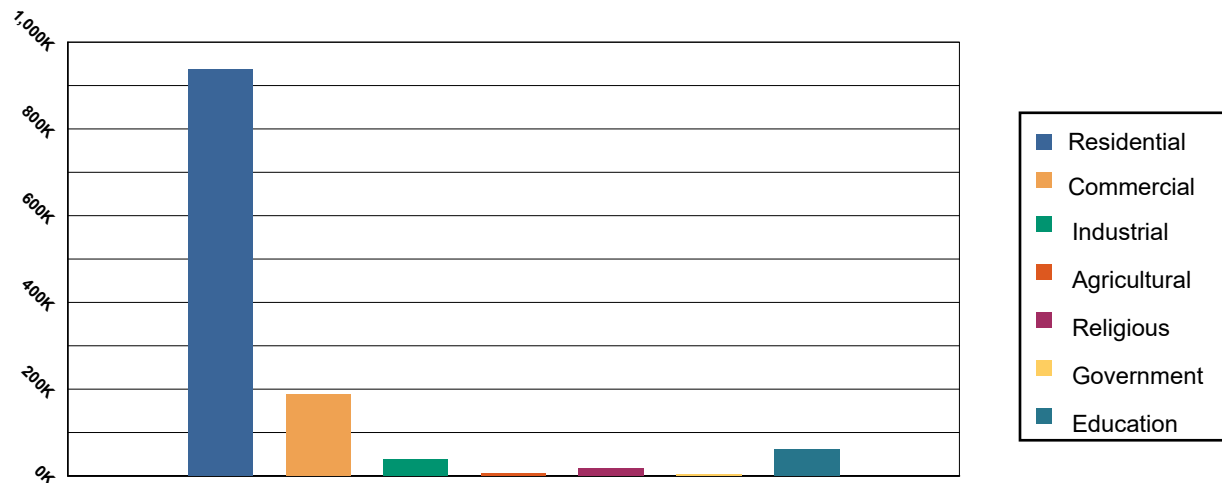


Table 1: Building Exposure by Occupancy Type

Occupancy	Exposure (\$1000)	Percent of Tot
Residential	937,129	74.91%
Commercial	187,974	15.02%
Industrial	38,921	3.11%
Agricultural	5,325	0.43%
Religious	18,266	1.46%
Government	3,295	0.26%
Education	60,168	4.81%
Total	1,251,078	100.00%

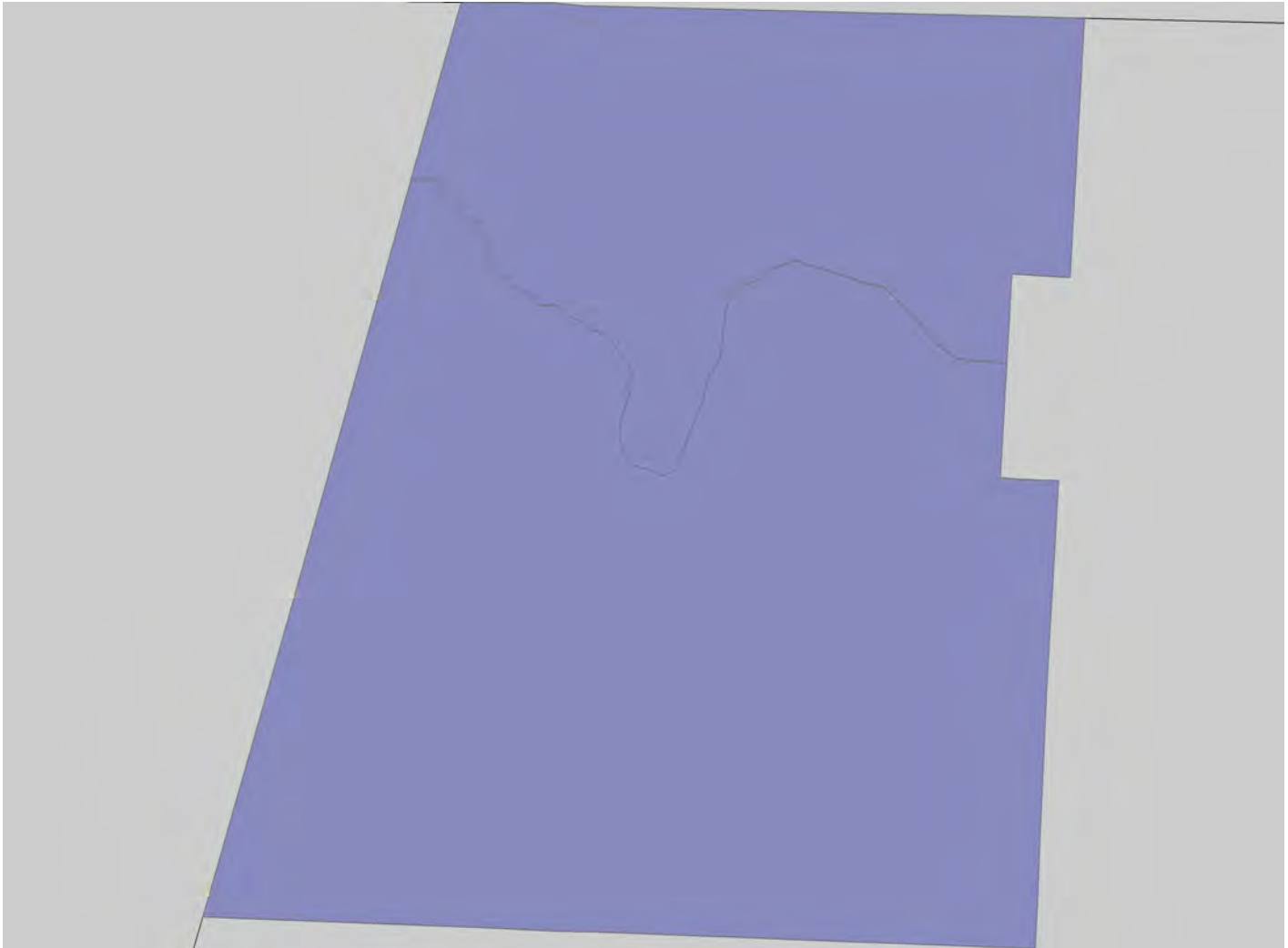
Essential Facility Inventory

For essential facilities, there are no hospitals in the region with a total bed capacity of no beds. There are 4 schools, 1 fire stations, 1 police stations and no emergency operation facilities.

Hurricane Scenario

Hazus used the following set of information to define the hurricane parameters for the hurricane loss estimate provided in this report.

Thematic Map with peak gust windfield and HU track



Scenario Name: Probabilistic

Type: Probabilistic

Building Damage

General Building Stock Damage

Hazus estimates that about 0 buildings will be at least moderately damaged. This is over 0% of the total number of buildings in the region. There are an estimated 0 buildings that will be completely destroyed. The definition of the 'damage states' is provided in Volume 1: Chapter 6 of the Hazus Hurricane technical manual. Table 2 below summarizes the expected damage by general occupancy for the buildings in the region. Table 3 summarizes the expected damage by general building type.

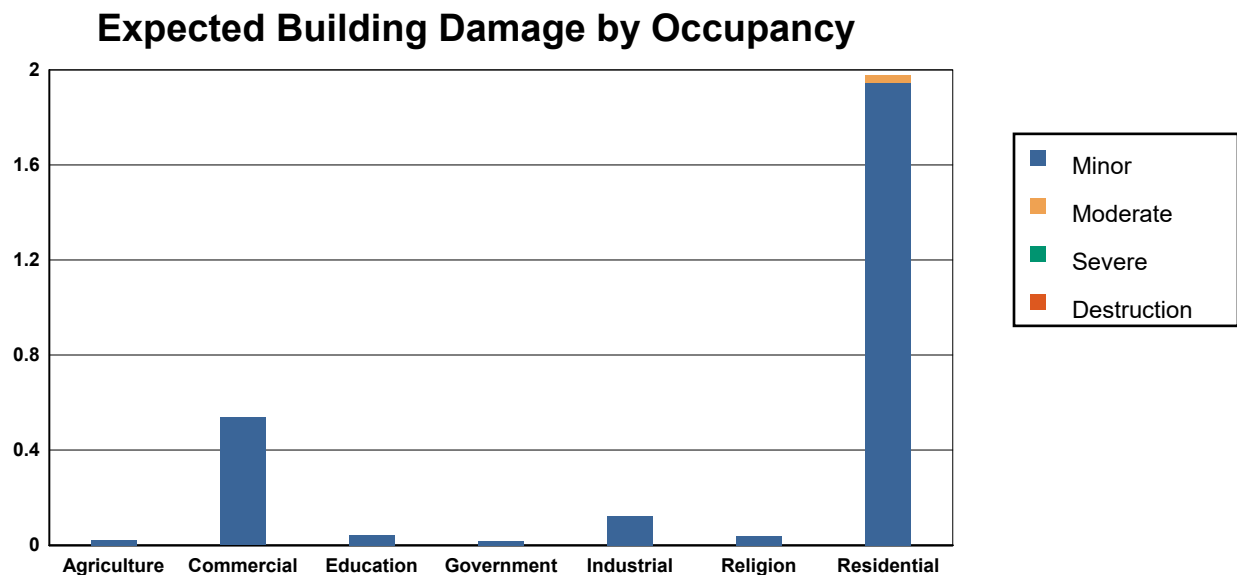


Table 2: Expected Building Damage by Occupancy : 100 - year Event

Occupancy	None		Minor		Moderate		Severe		Destruction	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	14	99.83	0	0.17	0	0.00	0	0.00	0	0.00
Commercial	228	99.77	1	0.23	0	0.00	0	0.00	0	0.00
Education	16	99.73	0	0.27	0	0.00	0	0.00	0	0.00
Government	6	99.71	0	0.29	0	0.00	0	0.00	0	0.00
Industrial	49	99.75	0	0.25	0	0.00	0	0.00	0	0.00
Religion	20	99.81	0	0.19	0	0.00	0	0.00	0	0.00
Residential	2,679	99.93	2	0.07	0	0.00	0	0.00	0	0.00
Total	3,012		3		0		0		0	

Table 3: Expected Building Damage by Building Type : 100 - year Event

Building Type	None		Minor		Moderate		Severe		Destruction	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	40	99.55	0	0.45	0	0.00	0	0.00	0	0.00
Masonry	184	99.64	1	0.35	0	0.01	0	0.00	0	0.00
MH	229	100.00	0	0.00	0	0.00	0	0.00	0	0.00
Steel	149	99.69	0	0.31	0	0.00	0	0.00	0	0.00
Wood	2,273	100.00	0	0.00	0	0.00	0	0.00	0	0.00

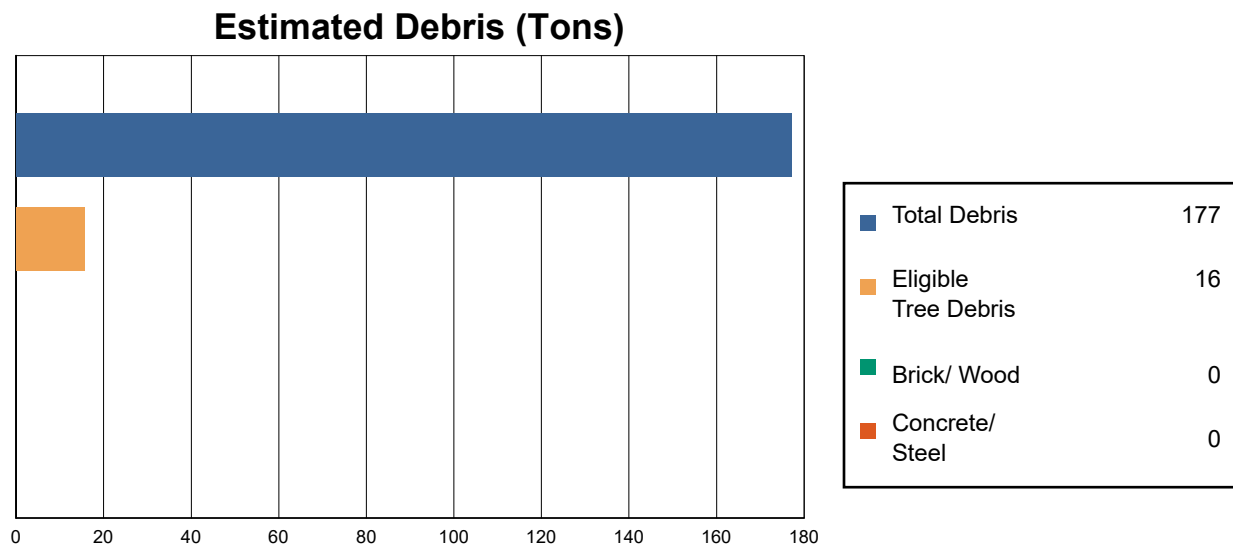
Before the hurricane, the region had no hospital beds available for use. On the day of the hurricane, the model estimates that 0 hospital beds (0%) are available for use by patients already in the hospital and those injured by the hurricane. After one week, none of the beds will be in service. By 30 days, none will be operational.

bioRxiv preprint doi: <https://doi.org/10.1101/2025.01.06.431105>; this version posted January 6, 2025. The copyright holder for this preprint (which was not certified by peer review) is the author/funder, who has granted bioRxiv a license to display the preprint in perpetuity. It is made available under aCC-BY-NC-ND 4.0 International license.

Classification	Total	# Facilities		
		Probability of at Least Moderate Damage > 50%	Probability of Complete Damage > 50%	Expected Loss of Use < 1 day
Fire Stations	1	0	0	1
Police Stations	1	0	0	1
Schools	4	0	0	4

Induced Hurricane Damage

Debris Generation

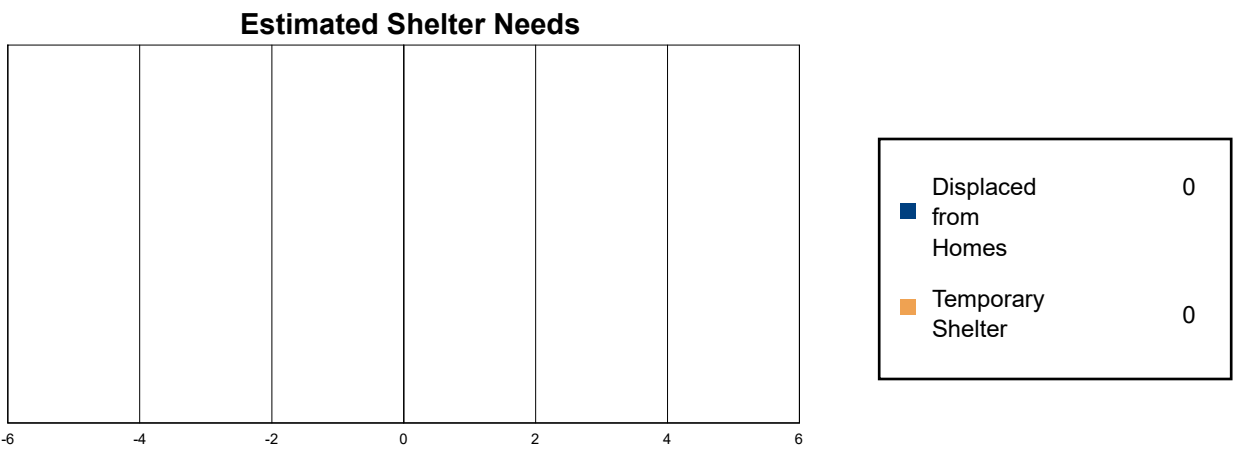


Hazus estimates the amount of debris that will be generated by the hurricane. The model breaks the debris into four general categories: a) Brick/Wood, b) Reinforced Concrete/Steel, c) Eligible Tree Debris, and d) Other Tree Debris. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 177 tons of debris will be generated. Of the total amount, 161 tons (91%) is Other Tree Debris. Of the remaining 16 tons, Brick/Wood comprises 0% of the total, Reinforced Concrete/Steel comprises of 0% of the total, with the remainder being Eligible Tree Debris. If the building debris tonnage is converted to an estimated number of truckloads, it will require 0 truckloads (@25 tons/truck) to remove the building debris generated by the hurricane. The number of Eligible Tree Debris truckloads will depend on how the 16 tons of Eligible Tree Debris are collected and processed. The volume of tree debris generally ranges from about 4 cubic yards per ton for chipped or compacted tree debris to about 10 cubic yards per ton for bulkier, uncompacted debris.

Social Impact

Shelter Requirement



Hazus estimates the number of households that are expected to be displaced from their homes due to the hurricane and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 0 households to be displaced due to the hurricane. Of these, 0 people (out of a total population of 7,754) will seek temporary shelter in public shelters.

Economic Loss

The total economic loss estimated for the hurricane is 0.2 million dollars, which represents 0.01 % of the total replacement value of the region's buildings.

Building-Related Losses

The building related losses are broken into two categories: direct property damage losses and business interruption losses. The direct property damage losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the hurricane. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the hurricane.

The total property damage losses were 0 million dollars. 0% of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 100% of the total loss. Table 5 below provides a summary of the losses associated with the building damage.

Total Loss by General Occupancy



Total Loss by Occupancy Type

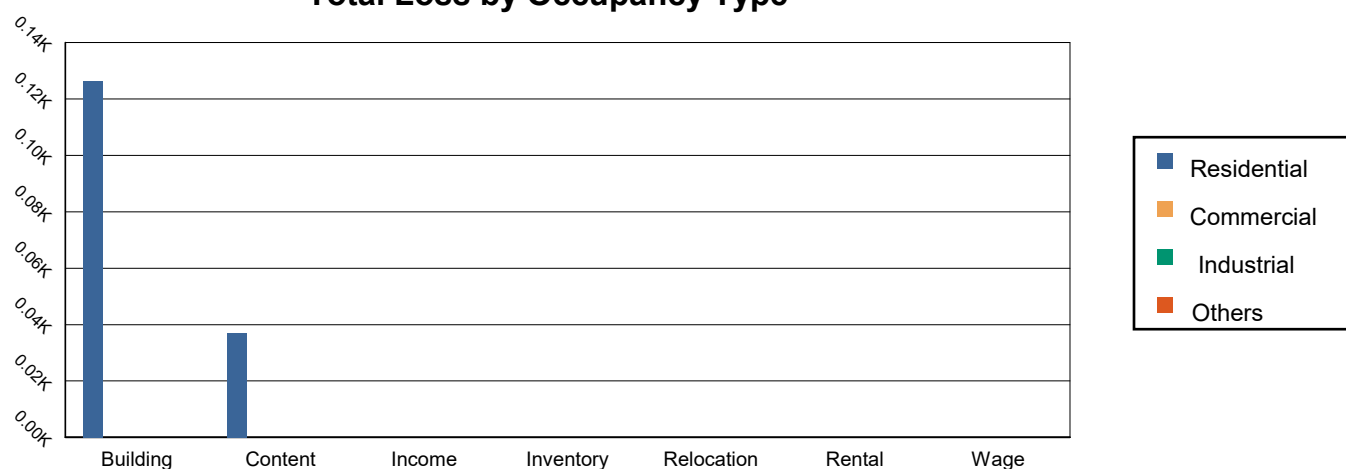


Table 5: Building-Related Economic Loss Estimates

(Thousands of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Property Damage						
	Building	126.31	0.01	0.00	0.00	126.32
	Content	36.99	0.00	0.00	0.00	36.99
	Inventory	0.00	0.00	0.00	0.00	0.00
	Subtotal	163.30	0.01	0.00	0.00	163.31
Business Interruption Loss						
	Income	0.00	0.00	0.00	0.00	0.00
	Relocation	0.06	0.00	0.00	0.00	0.06
	Rental	0.00	0.00	0.00	0.00	0.00
	Wage	0.00	0.00	0.00	0.00	0.00
	Subtotal	0.06	0.00	0.00	0.00	0.06
Total						
	Total	163.36	0.01	0.00	0.00	163.37

Appendix A: County Listing for the Region

Massachusetts

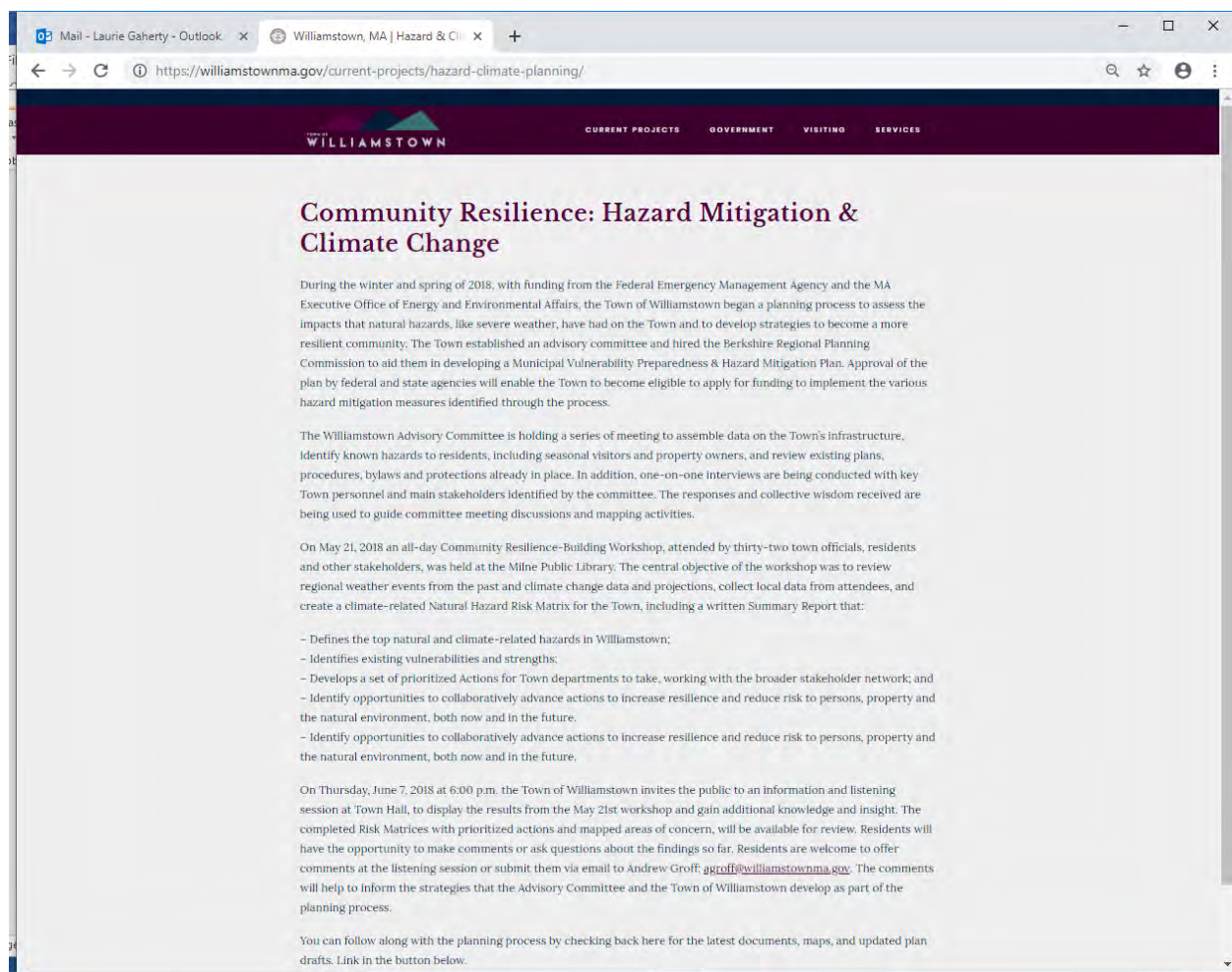
- Berkshire

Appendix B: Regional Population and Building Value Data

	Population	Building Value (thousands of dollars)		Total
		Residential	Non-Residential	
Massachusetts				
Berkshire	7,754	937,129	313,949	1,251,078
Total	7,754	937,129	313,949	1,251,078
Study Region Total	7,754	937,129	313,949	1,251,078

APPENDIX C.
PUBLIC OUTREACH, INVOLVEMENT AND INPUT

Town Website hosted this webpage about the Hazard Mitigation and Municipal Vulnerability Planning Process from May 2018 through February 2019



Municipal Vulnerability Preparedness Planning, Community Resilience-Building Workshop, May 21, 2018

The Town of Williamstown formed a Hazard Mitigation / Municipal Vulnerability Preparedness Committee to steer the process. Members of the Committee include municipal department heads and representatives from various town boards and committees from several disciplines, along with representatives of key community stakeholders such as Williams College, the Greylock Regional School District, Clark Art Institute and businesses. The goal of the Committee's work was to develop a set of Actions for addressing Priority Hazards, using the Community Resilience Building (CRB) Workshop process and methodology.

On May 21, 2018 an all-day CRB Workshop, attended by 27 town officials, residents and other stakeholders, was held at the Milne Public Library. The central objective of the workshop was to first review regional weather events from the past and climate change data and projections, then collect local data from attendees, and create a climate-related Natural Hazard Risk Matrix for the Town, including a written Summary Report that:

1. Defined the top natural and climate-related hazards in Williamstown;
2. Identified existing or future strengths and vulnerabilities;
3. Developed Prioritized Actions for Town departments to take, working with the broader stakeholder network; and
4. Identified opportunities to collaboratively advance actions to increase resilience and reduce risk to persons, property and the natural environment.

By focusing on multiple storm events and their impacts on infrastructure, business facilities and operations, neighborhoods and residents, CRB Workshop attendees gained greater clarity on what lessons were learned from those experiences. More importantly, they gained insight into what procedures need to be improved, to make emergency preparedness and response, part of the fabric of the community. It was generally agreed that no single Town department had the resources to do all the strategic planning and implementation that is required. Attendees felt strongly that all community members needed to "take ownership" of emergency preparedness and response to hazards and that it was "doable" in this forward-thinking, tight-knit community.

Workshop Participants Hard at Work



Natural Hazard Mitigation and Municipal Vulnerability Preparedness



Town of Williamstown
May 21, 2018

What is a Hazard Mitigation Plan?

A Mitigation Plan...

- Describes the natural hazards in a community
- Assesses the vulnerability of a community to the identified hazards
- Describes activities that can be done to mitigate the hazards before they occur
- Mitigation Plan is a REQUIREMENT to maintain eligibility for HMGP & PDM funds (Federal Disaster Mitigation Act of 2000)



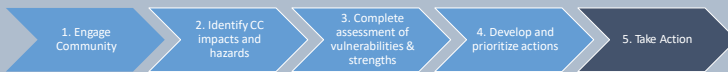
Municipal Vulnerability Preparedness Program 2017

Why MVP?

- Consider weather pattern observations and climate change projections
- MVP certified communities will have priority status for some state grant opportunities
- MVP grant funds may be more flexible than FEMA for local mitigation projects



State and local partnership to build resiliency to climate change



A Few Key Terms for Today

Natural Hazard – Source of harm or difficulty created by a meteorological, environmental or geological event

Risk – Potential for damage, loss, or other impacts created by the interaction of natural hazards with people, structures, facilities and systems that have value to the community

Vulnerability – Characteristics of people, structures, facilities and systems that make them susceptible to damage from a given hazard



Preparedness – Actions taken to plan, organize, equip, train and exercise to build and sustain the capabilities necessary to prevent, protect against, mitigate the effects of, respond to, and recover from those threats that pose the greatest risk

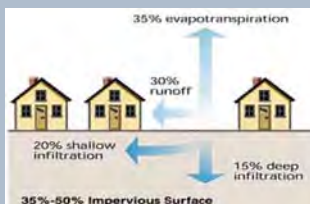
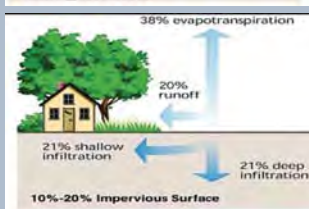
Mitigation – Sustained actions taken to reduce or eliminate long-term risk to life and property from hazards, the most done in order to reduce the impacts of a hazard

100-Year Flood Event – one that has a 1% annual chance of occurring, commonly called 100-yr flood event, this is statistical occurrence only – a town could experience two 100-yr flood events in a short period of time (or conversely not experience any within 100 years or more)

100-Year Floodplain – area of flooding associated with a 1% annual probability of occurrence; the boundary of the 100-yr floodplain is used by many agencies to assign flood risk, including FEMA and the National Flood Insurance Program

Changes in water patterns:

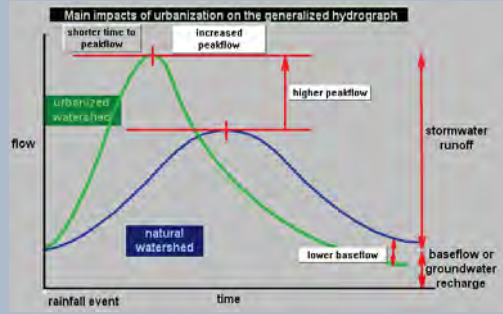
Impervious Surface = Increased Runoff



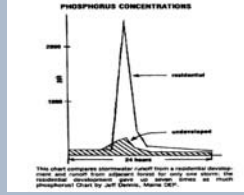
+ Piped runoff =



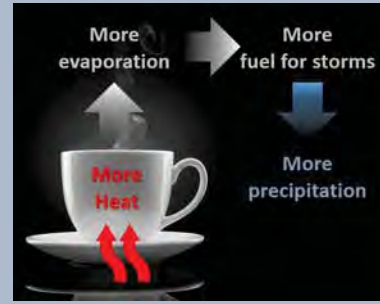
= Quicker, higher peak flow volumes



(And higher pollutant loads)



And Then There's Climate Change



Key Observed Climate Changes in MA



Temperature:



2.8°F since 1895 (7-10°F by 2100)
Berk. temp. up 1.7°F since 1960

Growing Season:



10 Days
Since 1950



Strong Storms:
(heaviest 1% of annual)



71%
Since 1958

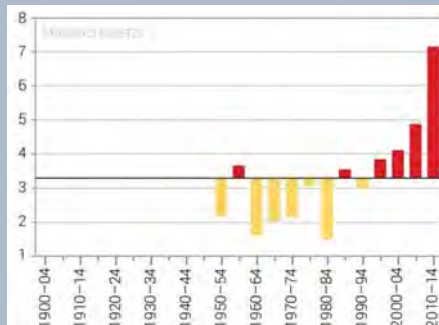


Extreme Heat Days in Hoosic Watershed

Current		Projected by Mid-Century (2050s)	Projected by End Century (2090s)
Days per year above 90°F	≤ 1	+ 4 - 17	+ 6 - 50
Days per year above 95°F	0	+ 0 - 5	+ <1 - 11
Degree Cooling Days		+ 4 - 16%	+ 35 - 460%

Observed Number of Warm Nights

- Number of Nights where minimum temp. > 70° F



Observed No. Extreme Precip. Events

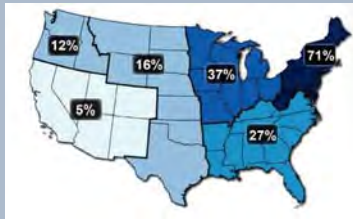
- Number of Events w/ Precipitation > 2" in 1 day*
- "Stepped Increase" in 1970-80s
- Increase of up to additional 1/5 day mid-century in Hoosic, with summer higher risk*



* Different sets of data



Photo: Ricci, NRCS



	NOAA TP-40	NOAA Atlas 14	Change
Boston	6.6	7.8	+1.2"
Worcester	6.5	7.6	+1.1"

FEMA 100-year flood, depth > 1 foot, at time building constructed

FEMA 100-year flood, depth < 1 foot, at time building constructed

Building constructed between 2005 and 2008, in location not designated as FEMA floodplain

Prior 100-year flood, depth > 1 foot

100-year flood, depth > 1 foot, from 2010 FEMA study

Building constructed between 2005 and 2008, now in regulated floodplain after 2010 FEMA re-study

[illegible]

Leave that floodplain open for the Big Event



Winter Weather Changes

Cycles of cold and warm will increase, alter risks

- **Warmer temps:** Less snow pack = altered water regimes and soil moisture
- **More rain-on-snow events =** Increased runoff, risk of winter floods
- **Less groundwater recharge =** lower baseflow in streams, rivers, reservoirs
- **Loss of snow insulation =** freeze/thaw = increased risk of frozen pipes, drains
- **Dryer spring soils**



Winter Weather Changes

Cycles of cold and warm will increase, alter risks

• Ice Risks:

- Ice jams
- Ice storms = potential loss of electricity



Ice Jams Jan. 2018 in Stockbridge, Cheshire

Ice Storm December 2008

- **Loss of electricity for 1+ million customers**
- **Some for more than 2 weeks**
- **FEMA obligates >\$32 million in Mass.**
 - State costs >\$7 million
 - Municipal costs >\$5 million
 - National Grid claims damages of >\$30 million
 - Small businesses without electricity "lose tens of millions of dollars"

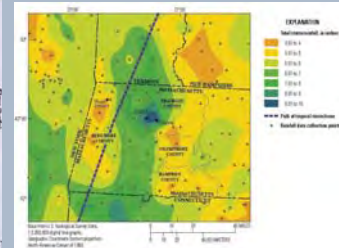


* MA Climate Change Action Plan

T.S. Irene 2011

- 500,000+ MA residents without electricity
- 6 out of 8 stream gages in Deerfield & Hoosic Rivers reach highest peaks of record
- Calculated as 100-year flood in Hoosic River in Adams
- Dubbed the "costliest Category 1 storm" (\$15.8 billion in damages)
- Fed. Disaster: FEMA \$5.6 million to MA households, \$30 million for MA public assistance
- Fed. Highways: \$46 million for roads and bridges, much of it for Rt 2

T.S. Irene and the Hoosic River





Adams had widespread flooding



Irene @ Rt. 2 and Shelburne Falls



Don't take Water for Granted

- Drought recurrence intervals may shorten
- Due to increased temp. and evaporation
- Lower groundwater recharge
- More water in summer/fall comes in extreme storm events with higher peak flows and more runoff
- Berkshires got off lightly this time



Natural Hazards Evaluated

Hazards Evaluated	
Flood	Tornado
Dam Failure	Extreme Temperature
Hurricane / Tropical Storm	Drought
Nor'easter	Wildland Fire
Snow & Blizzard	Major Urban Fire
Ice Storm	Earthquake
Thunderstorm	Landslide
High Winds	Ice Jam
Beaver Activity	

The Most Deadly Berkshire County Incidents

- **Hoosic River Floods**
 - 1938 -- Adams & North Adams -- 2 deaths, many injuries
- **Dam failures**
 - 1886 -- Mud Pond Dam -- Lee -- 7 deaths
 - 1901 -- Basset/Dean's Dam -- Adams -- 1 death
 - 1968 -- Lee Lake Dam -- Lee 2 deaths
- **Tornadoes**
 - 1973 -- W. Stockbridge -- 4 deaths, 36 injured
 - 1995 -- Great Barrington -- 3 killed, 24 injured



Outside of T.S. Irene –
What is the most injurious or
damaging incident that you
have had to respond to in
Williamstown or a neighboring
town?

Concerns around Williamstown

- Severe storms, some with little warning
- Steep, flashy streams with quick peak flood stages
- Cycles of bank erosion and damages, repair, and repeat damages



Concerns around Williamstown



Petersburg and Northwest Hill Rd., May 2013



Treadwell Hollow Rd., May 2013



Concerns around Williamstown



Ice Jams on Green River Feb. 1982



Concerns around Town



Ice Jams on Green River Feb. 1982

Assessing Vulnerability in Williamstown

- Approx. 3 miles of roadway travel through floodplain
- 156 Buildings in the Town are in the 100-yr floodplain (BRPC 2018)
 - 139 are residential homes, many along Green River, Hemlock, Buxton, Broad Brooks
 - Been 24 flood insurance claims in town 1978-2017 = ~\$153,000
 - No repetitive loss claims 1978-2017
 - 67 properties have active flood insurance policies = \$12 million

Buildings in the 100-year Floodplain

Residential		Commercial		Industrial		Total	
No. Bldgs.	Percent Res. Bldgs.	No. Bldgs.	Percent Com. Bldgs.	No. Bldgs.	Percent Ind. Bldgs.	No. Bldgs.	Percent Total Bldgs.
139	6.5%	16	12.5%	1	20%	156	7%

Assessing Vulnerability in Williamstown

- Potential damages in FIRM areas from 100-year flood (in millions)*

Residential Property	Res. Contents (50% Prop. Value)	Commercial Property	Com. Contents (100% Prop. Value)	Industrial Property	Ind. Contents (125% Prop. Value)	Total Loss Estimate
\$31.9	\$15.9	\$3.2	\$3.2	\$0.05	\$0.063	\$54.3

- HAZUS model est. \$72.4 million in losses**
- \$300,000 in business interruption
- Up to 256 households (~600 people) may seek shelter

• Sources: *BRPC, ** HAZUS

Are you Ready for Electricity Outages?

The energy sector's three major climate change concerns:

1. Flooding (increased precipitation, flooding)
2. Extreme events (hurricanes, snow, ice storms)
3. Increased temperature (demand surge, heat damage to distribution system)

One projection: household summer peak demands increase 3 fold from that of 1960-2000

Are you Ready for Electricity Outages?

▪ **Do you know where vulnerable populations are that need electricity?**

- Elderly (21% of town's pop. 65+ yrs*), disabled
- Medical needs like oxygen, dialysis

▪ **Do you know where to bring them for their needed services?**

▪ **Are you prepared to shelter residents in extreme cold and heat?**



* 2010 census

Where can we reasonably focus our Mitigation Efforts?

• Flooding is our prime target

- Several hazards result in flooding (hurricanes, thunderstorms, snow, ice jams, dam failure)
- Severe rain events cause localized flooding
- Predictable boundaries (but needs adjustment)
- Relative ease of implementing mitigation measures
- Focus of grant programs
- Local bylaws and zoning offer local control



Bronson Brook, Worthington



- 2- 10 foot box culverts washed out in 2003. Road was closed to all traffic.
- Culvert had a history of clogging with debris

Bronson Brook Post Irene



- A channel spanning tree located upstream of this culvert prior to the storm was mobilized and easily passed through this crossing.

- Road remained open and passable.



Examples of Mitigation Activities

• Structural Projects

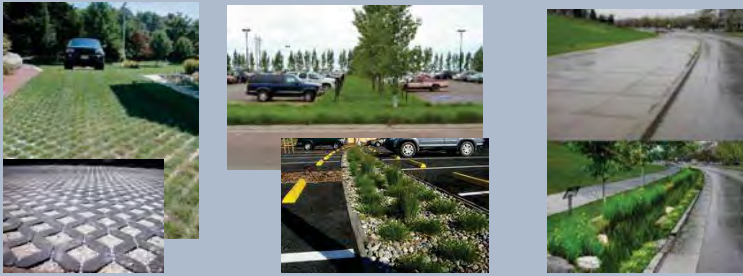
- Flood-proof, elevate or relocate buildings and infrastructure in floodplain or in flood zones
- Armor infrastructure on bridges
- Reduce road pavement widths (*narrowing 2 miles of road by 4' per lane can save \$500,000 in reconstruction*)
- Stream Crossing Standards = 1.2 X bank width
- Maintain and/or improve drainage systems
 - Can we disconnect or re-route the pipe?
 - Beaver deceivers



Examples of Mitigation Activities

• Structural Improvements – Disconnect the Pipe

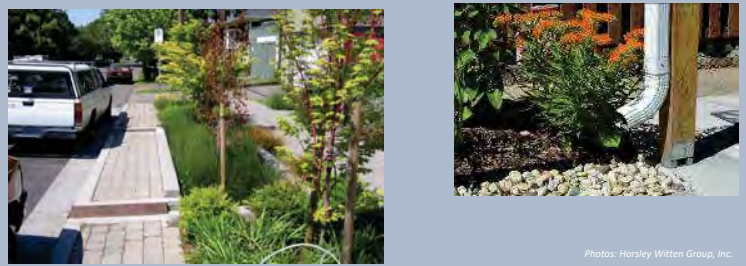
- Bioretention cells, swales, rain gardens, pervious pavers



Examples of Mitigation Activities

• Creative Development – Increase Infiltration

- Bioretention cells, swales, rain gardens



Photos: Horsley Witten Group, Inc.

Permeable Pavement

Redevelopment: Parking Lots, Walkways

- Higher initial cost (\$12/sf vs \$5-7/sf)
- Reduces the amount of land needed for stormwater management
- Can infiltrate as much as 70-80% of annual rainfall
- Can reduce salt use by as much as 75%



Examples of Mitigation Activities

• Maintain Natural Cover on Building Lots

- Minimize disturbance of natural vegetation and soils
- Maintain natural tree and shrub cover
 - A mature evergreen intercepts up to 4,000 gal. of water per year
 - A mature deciduous tree intercepts 500-2,000 gal/yr
- Natural cover especially important in water supply overlay district



Mitigation Policies

Guide Future Development –

- Strictly enforce floodplain bylaws
- Revisit zoning – does the town:
 - *Require that stormwater runoff be retained on site*
 - *Encourage or require max. allowable lot clearance*
 - *Encourage Low Impact Development techniques that infiltrate runoff*
 - *Restrict development on steep slopes*

Ongoing Monitoring

Incorporate New Data for Mitigation, Resilience, Adaptation

- Incorporate new floodplain data and boundaries when available
- Monitor data and climate change projections for infrastructure improvement projects



Now It's Your Turn

Identify the 4 Priority Hazards

- **Infrastructural**: municipal infrastructure, housing, utilities, commercial bldgs., municipal bldgs. and operations
- **Societal**: collective ability to respond – first responders, health services, goods and services
- **Environmental**: natural systems that protect, provide services or pose risk

[illegible]

Actions and Priorities

List and Prioritize Actions to Address your vulnerabilities

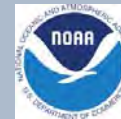
1. **Develop Your Actions**
2. **Prioritize them H-M-L and Time**
3. **Choose the Top 4 Priorities that your think are the greatest risks and should be addressed**
4. **Bring your Top 4 to the Full Group**

[illegible]

We Can Adapt

Snowshoe Hare (*Lepus americanus*)

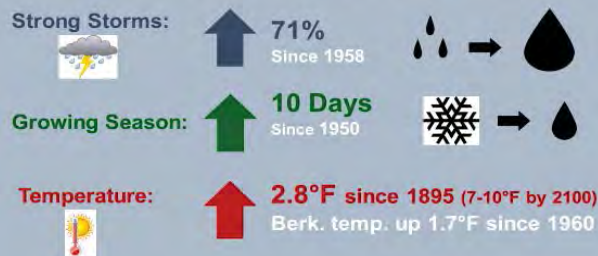
Centuries ago, even decades ago, there would likely be some snow cover in December to provide camouflage for this species.



CLIMATE CHANGE OBSERVATIONS

The Basics for the Berkshires

Key Observed Climate Changes in MA



Warmer Temperatures –

- More evaporation, less soil moisture, increased risk for fire, drought, human health risks (particularly for elderly, other vulnerable pops.)
- Greater temp. increases in winter
 - Less snow, but still cycles of freezing temperatures = infrastructure vulnerability
 - Rain-on-Snow = more overland winter flooding, ice jams
- Increased temps. = increased heat stress for people, livestock, wildlife
- Higher evening temps. = inability for people and homes to cool down and “catch up” to normal temps.
- Increased risk of thunderstorms and other severe rain events
- New and expanding pests: ticks, mosquitos, forest and crops
- Increased growing season
 - Pros: new farming opportunities
 - Cons: increased allergen season and increased potency

Observed Number of Warm Nights

- Number of Nights where min. temp. > 70° F



Precipitation Trends

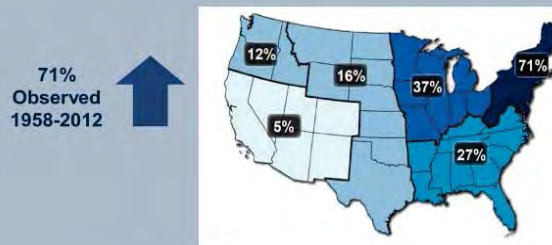
- Increase in Extreme Rain Events** = increased risks and damages to municipal infrastructure
- Engineering Standards** -- engineers now directed to use new data sets that include post-1970s precipitation data

Observed No. Extreme Precip. Events

- Number of Events w/ Precip. > 2" in 1 day

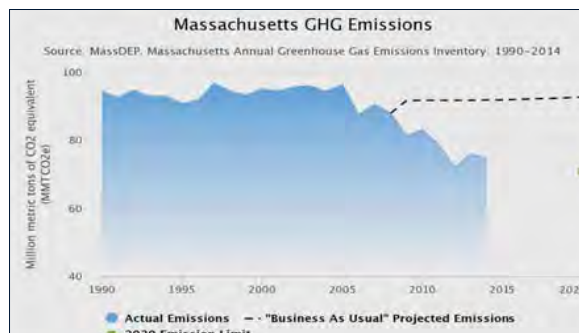


More Extreme Precipitation



MA Energy Reduction – Success

MA GHG Emissions dropped 21% while Gross State Product increased 70% in same time period



Severe Weather Bursts

- Steep slopes and severe rain bursts May 2013** = road flooding and culvert destruction.
- Severe stream and bank erosion** can occur, including sediment transport



A Last Thought

Pity the Snowshoe Hare
December 2012

Its instinct is to sit still when danger approaches, thinking it blends in with its surroundings .

Centuries ago, even decades ago, there would likely be some snow cover to provide camouflage for this species.

Humans have the ability to adapt, unlike our hare.



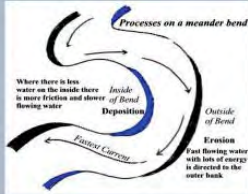
OPPORTUNITIES TO REDUCE RISK

Water Movement

Rivers Move – Give ‘em Room

Scour on the outside of meander bends.

Deposition on inside of bend



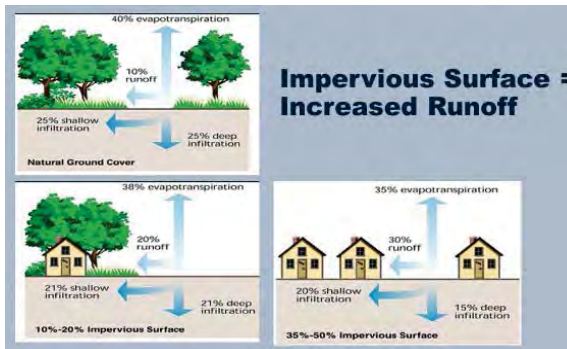
Above: Housatonic River at New Lenox Rd, Lenox



Right: Sediment deposition due to flood waters in floodplain area

Water Movement Altered

Impervious surfaces like buildings, road and parking lots = increased surface runoff and less ground infiltration

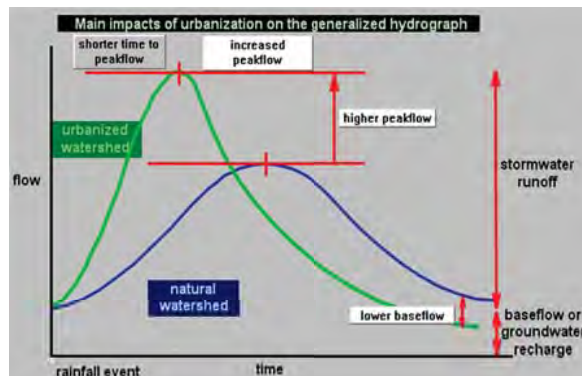


More Frequent Flood Impacts and Less Groundwater Recharge

Greater surface runoff leads to accelerated and higher peak stream and river flows = more severe flooding.

It can also lead to stream base flow and groundwater recharge.

This could lead to more frequent well failures, especially during drought conditions – see below.



Why Focus on Flood Risks?

- Flood events and recurrence intervals calculated (even if they need to be adjusted)
- Floodplain boundaries delineated (even if they need to be adjusted)
- Benefits of keeping development out of floodplains well documented
- Predicting large storm events and warning times are fairly reliable
- Mitigation techniques are feasible and benefits tangible
- Engineering standards can adapt – see below.

Change in 24-hour, 100-year Design Storms (inches)

	NOAA TP-40	NOAA Atlas 14	Change
Boston	6.6	7.8	+1.2"
Worcester	6.5	7.6	+1.1"

Bridges and Culvert Improvements



Bronson Brook, Worthington

Left:

- Box culvert washed out in 2003, closing road to all traffic.
- Had a history of clogging with debris.



Left:

- Post-T.S. Irene
- Channel-spanning tree was mobilized above this bridge, but passed through this upgraded design.
- Road remained open and passable

OPPORTUNITIES TO REDUCE RISK – LAND DEVELOPMENT TECHNIQUES

Land Use Policies

Guide Future Development

- Strictly enforce floodplain bylaws and wetlands protection to maintain flood storage resiliency
- Revisit zoning – does the town:
 - *Require that stormwater runoff be retained on site*
 - *Encourage Low Impact Development techniques that minimize land disturbance and maximizes the site's natural landscape*
 - *Concentrate development and maintain open natural landscapes for connectivity*
 - *Restrict development on steep slopes*

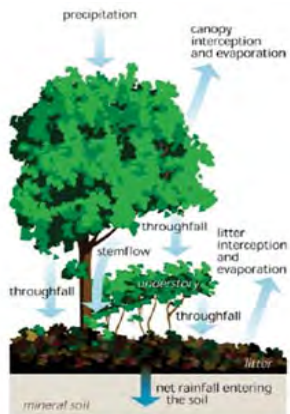
Incorporate New Data for Mitigation, Resilience, Adaptation

- Incorporate new floodplain boundaries when available – new floodplain data is available for the Hoosic River
- Monitor data and climate change projections

Develop Carefully

Maintain the Natural Landscape

- A mature deciduous tree intercepts 500-2,000 gallons of water per year.
- A mature evergreen intercepts up to 4,000 gallons / yr.
- Root systems of trees and understory hold soil in place.
- Natural cover is particularly important on steep slopes, such as those that surround the town center.



Disconnect the Pipe

- Reduce the amount of hard, impervious surface areas like homes, parking lots and buildings
- Capture the runoff that IS created rather than pipe it into a storm drain system – which discharges into the nearest waterway (accelerated, higher peak flows)



Left: Reduce pavement, capture runoff in rain gardens, bioretention cells



*Below:
Capture roof runoff in rain gardens*

Infiltrate More - Pervious Pavers and Pavement

Pavers allow infiltration while providing structure for cars



Pervious Pavement for Parking and Walkways

- Higher initial cost, but:
- Reduces land needed for retention ponds and other management
- Can infiltrate as much as 70-80% of rainfall
- Can reduce salt use by up to 75%
- Not for use where sand is applied in winter

Municipal Vulnerability Preparedness Public Forum, June 14, 2018

On Thursday, June 7, 2018 at 6:00 p.m. the Town of Williamstown invited the public to an Information & Listening session at Town Hall, to display the results from the May 21st workshop and to gain additional knowledge and insight from residents. An abbreviated version of the workshop presentation was given as an introduction to the topic and the scientific posters used in the workshop were again to provide information and inspire ideas. Attendees of the session were given the opportunity to make comments and ask questions about the findings. The attendees were asked to confirm by sticker-vote, which of the prioritized actions on the completed Risk Matrices and mapped areas of concern, were the most important to them. These additional votes and comments from residents helped to inform the strategies that the Committee and the Town of Williamstown adopt over the coming year.

Local Blog Post

The screenshot shows an email client window titled "Williamstown Looks at Threats from Climate - Message (HTML)". The email is from alerts@talkwalker.com and is dated Wednesday, June 06, 2018 2:44 AM. The subject is "[Talkwalker Alerts] Alert for Berkshire Regional Planning Commission".

The email content includes the Talkwalker Alerts logo and a "Tell a Friend" button. It states: "Latest News from our blog: 15 free hashtag tracking tools - from the experts. If you like our Alerts, please help us keep this service free by liking and following!".

Under the "News" section, there is one result titled "Thursday Session in Williamstown Looks at Threats from Climate". The text of the news item reads: "...of a grant from the commonwealth and advice from the **Berkshire Regional Planning Commission**. BRPC senior planner Lauren Gaherty will lead a discussion about the data that has been collected and the...". It includes a date "06/06/18 02:33", a location "United States", and a link to berkshires.com. There is also a "Tweet" button.

At the bottom of the email content, there are three buttons: "Delete Alert", "Manage Alerts", and "Create Alert". A footer note says: "if you like our Alerts, please help us keep this service free by liking and following!".

Thursday Session in Williamstown Looks at Threats from Climate Change

By Stephen Dravis *iBerkshires Staff*
02:33AM / Wednesday, June 06, 2018



Flash flooding in Williamstown four years ago cut through several roads and yards and displaced metal culverts on Treadwell Hollow Road. The town is one of several in the Berkshires using state grants to evaluate their vulnerability to natural events.

WILLIAMSTOWN, Mass. — You cannot really know where or when the next natural disaster is going to hit. But you can consider the possibilities and plan for the worst.

On Thursday at 6 p.m., Williamstown takes a step in that planning process when it holds a listening session for members of the public to consider the Municipal Vulnerability Plan the town is developing with the help of a grant from the commonwealth and advice from the Berkshire Regional Planning Commission.

BRPC senior planner Lauren Gaherty will lead a discussion about the data that has been collected and the threats that have been identified by a town-sponsored working group that last month held a daylong workshop.

Town Planner Andrew Groff this week explained that the MVP, a state initiative, will help Williamstown develop an updated Hazard Mitigation Plan, which he hopes to complete by later this year. "To qualify for [Federal Emergency Management Agency] grants, like the one we received for the Spruces, we have to maintain an up-to-date, FEMA-approved Hazard Mitigation Plan," Groff said.

Although the MVP is a separate document, it will help inform the more comprehensive Hazard Mitigation Plan. And the MVP alone will help the town qualify for other grants.

Williamstown is one of several communities in the Berkshires in various stages of the MVP process, Gaherty said on Tuesday.

Adams will have its public forum next Thursday, June 14, at Town Hall. Lanesborough and Monterey currently are in the middle of their processes. And Dalton, North Adams, Pittsfield, Sandisfield and Sheffield each were successful applicants in the second round of MVP grants. The state has also set up a "[climate change clearinghouse](#)" to gather data for planning ahead for severe conditions.

The more towns that go through the process, the more their findings can help inform the discussions in other towns, Gaherty said.

"We have some of the data we can pull and use for the next towns," she said. "But it really comes down to the local level: Where do you have flooding in your town. Every town experiences it slightly differently. It's really important to plan on the town level to help them to ... identify the risks and get grants or get things in the town meeting budgets for capital improvements and that sort of thing."

The threats to local communities are changing as the climate changes, and the data point to a combination of more frequent and severe weather events (rain storms, ice storms and the like) coupled with more frequent droughts.

"I think our big risks in Williamstown include ... these big temperature fluctuations in the wintertime," Groff said. "Look at the ice jams we had in the Green River. That's a big issue. The extremes are getting more extreme. In the wintertime, you have these rapid melts that are a problem. Or there's the possibility we could get more ice storms than snow storms, which would lead to more sustained power outages."

"But the biggest thing overall from a climate change risk perspective is a warmer atmosphere that can hold more moisture and create larger, quicker bursts in precipitation. We've seen it locally with the flash flooding that occurred in 2013. It was super localized, right along the Taconic range. One of the more nationally known stories is those poor folks in Ellicott City, Md., who got hammered with two 'thousand year' flash floods within two years of each other."

A weather event does not have to be a "named" storm or a catastrophic event like Tropical Storm Irene to cause significant damage. An event like the 2008 ice storm cost the state more than \$7 million and left more than 1 million Massachusetts residents without electricity, some for as much as two weeks.

"I think we need to think about how our rain patterns are evolving and how [Ellicott City] could happen to us, too," Groff said. "Luckily, our downtown is not in a narrow, tiny valley surrounded by streams. But we definitely have some streams that are susceptible to flash flooding."

The Thursday evening meeting will be a chance for residents to learn about some of the threats that have been identified and share information about potential problems that may not have been considered.

"We're going to basically report out what we heard in the workshop," Gaherty said. "There will be a short presentation to set the stage for the public about changing weather patterns, and we'll say, 'This is what people found in the workshop. These are the biggest changes that should be addressed.'"

"And then we'll ask, 'Did we get it right? Did we miss anything? What are your thoughts?' Basically, we're going to ask the public to weigh in."

MUNICIPAL VULNERABILITY PREPAREDNESS

TOP RECOMMENDED ACTIONS FOR HAZARD REDUCTION & PREPAREDNESS

INFRASTRUCTURE

Develop prioritized list of bridges, culverts, interceptor and other pipes

Seek grant funding to upgrade/replace undersized culverts, bridges and piping

Ongoing beaver monitoring and maintenance to prevent flooding

Study expansion of public water system into areas served by private wells (White Oak & Hoosic St.)

OUTREACH & COMMUNICATIONS

Develop Communications Strategy - Conduct public outreach on Code Red and other emergency-preparedness info at existing community events / venues to encourage awareness and full participation, esp. by seasonal residents

Develop public education program on flood mitigation and runoff reduction strategies – best management practices, low impact development, etc. Use Clark staff expertise, as appropriate.

SHELTERING

Develop a Shelter Strategy

Make required upgrades to Elementary School and/or High School to be a long-term shelter

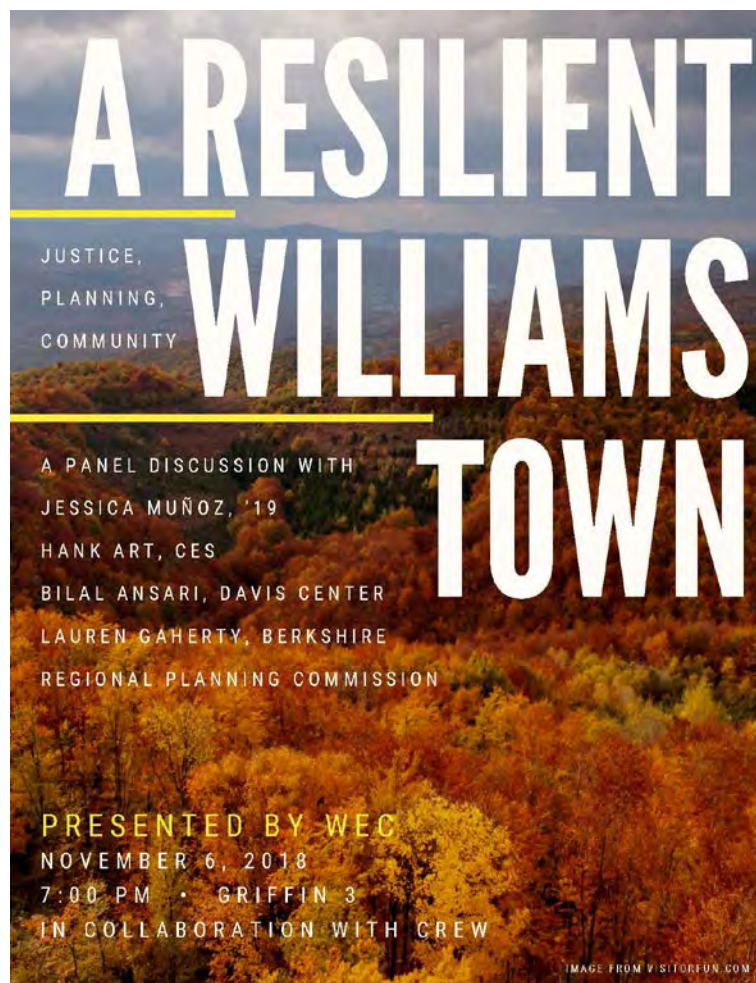
Features	Location	Ownership	V or S	FLOODING (INCLICE AM)	POWER OUTAGE	ICE/STORM	DROUGHT	PRIORITY	Time
Infrastructure								H M L	Short Long Ongoing
STREAM-CROSSING BRIDGES	Cole Ave & Hwy 7	STATE	V	Structural Condition of bridges structurally impacted by severe floodwaters and ice jamming				L	O
SEWAGE		TOWN	V	Develop an overall Sewer Strategy including "full" sewer facility				H	S
PUMPING STATIONS - BOTH WATER SUPPLY & SEWERS	Various	Water Dept & WSDOT	V	CONDUCT W DEPT - "Active Plan"				7	S
ROADS IN FLOODPLAIN	East Springs Rd & Elm Blvd	TOWN	V	Investigate/Refine Flood Mitigation Strategies, Encourage Voluntary structural to Emergency Services				H	S
COMMERCIAL CENTER FLOODING	Mechanics & Lakes WILLIAMS COLLS			Installation of multiple culverts, overpasses facilities and etc.				H	S
TREATMENT PLANT - LOW FLOW (DROUGHT)	Plant	HWQD	V	Extend Main Sewer to Object				L	O
RESIDENCES w/ SEWAGE WELLS (DROUGHT)	Various	PVT	V	Investigate Water Line Extension, New housing in areas served by Town water				L	O
CELL TOWER SPOTTY COVERAGE	Various	PVT/TOWN	V	Advocate with Carriers for cell service				L	O
POWER LINES	Various	PVT	V	Investigate serving lines in high risk areas?				L	O
TOWN WATER SUPPLY IS ADEQUATE/GOOD QUALITY	Various	TOWN	S						
RAILROAD - TRACK CONDITION & HAZ MATL TRANSPORT	Along Green Rd	RR & TOWN	V	Engage with RR to discuss Hazard Vulnerability Risk				M	L
Societal									
VULNERABLE POPULATIONS (Elderly, School age, Disabled, etc.)	Various	TOWN & PVT	V	TOWN WITH INCLUSION & COMMUNICATION STRATEGIES to include				H	O
EMERGENCY COMMUNICATIONS	Various	TOWN	V	Identify critical locations, Off-hours Messaging System improvement				M	O
TRANSIENT POPULATIONS - Persons, 2nd Homeowners, Seasonal, Tourists, etc.	Various	TOWN & PVT	V	Color grant from Home and Security or State to do				M	O
DISASTER PREPAREDNESS	Town-wide	TOWN	V	Voluntary Educational Programs, Train with Regional Response Team				M	O
LOSS OF BUSINESS REVENUE & POST DISASTER EFFECTS	Various	CHAMBER, TOWNS, INDUSTRY	V	Post Disaster Planning				M	O
SUPPLY WATER TO WELLS - WATER RES IN DROUGHT	Various	TOWN & PVT	V	Extend Main Sewer to Object, Low Impact Development, Educate on Residential Strategies to mitigate				M	L
COMMUNITY IS SUPPORTIVE	ALL		S						
HEALTH IMPACTS OF FLOODWATER & LONG FREEZE	Town-wide	TOWN & PVT	V	Educational Programs, Train with Regional Response Team				M	L
Environmental									
IMPACTS ON STORE FLOODING - WATER QUALITY, BANK EROSION, CREEP & SLIDING, ETC.	Various	TOWN, RR, PVT, INDUSTRY	V	Educational Programs, Mitigation Strategies				M	S
WETLANDS & POND SALTATION - LOSS OF FUNCTION	Various	as above	V	Update Wetland College Graduate Wetlands & Riparian Survey				M	S
POSSIBLE COVER - AGING & IN SITUATION - COOLING EFFECT	Various	as above	V	Rehabilitation/Regeneration program				M	S
FLOOD CLEANUP - HAZARDOUS MATERIAL & BODIES	Various	as above	V	Post Disaster Planning				M	O
DROUGHT - PESTILENCE & FIRE HAZARD INCREASE	Various	as above	V					M	O
BIODIVERSITY - LOSS OF VEG & TROPICAL ADRIAL IMPACTS	Various	ALL	V					M	O

Features	Location	Ownership	V or S	FLOODING	SNOW/ICE	DROUGHT	SEVERE WEATHER	PRIORITY	Time
Infrastructure								H M L	Short Long Ongoing
undersized culverts & bridges	various rural areas	Town/private	V	Chapter 90 highway funds to upgrade smaller culverts, grants to upgrade and replace larger culverts				H	L
road flooding	Hwy 7/bridges, road	Private	V	study options to fix bridge pond as leverage for fix to make improvements to location and bed				H	I
Vulnerable above-ground electricity utilities	Private	Private	V	advocate for areas to have utilities underground				M	O
Home Water Quality District (sewer)	HWQD	Joint	V	Continue to monitor				L	O
Public Water System	Town	Town/private	S	Study expansion of public water into Florence Street and other streets with deteriorating pipes or private				H	L
High School (outside of Downtown)	Town	School District	V/S	Make elementary school a proper shelter in case of inability to access high school				H	L
Societal									
Fire, General Volunteer and Doctor Shortages			V	community driven economic development				H	O
Overreach/Communication/Coordination w/ Community			V	Town Administrative focus on outreach/dispense ration from police station				H	S
Growing Senior Population living independently			V	Expansion of Council on Aging Resources				M	S
All Hazards Plan is Outdated			V	Update Plan				H	O
Arnold, Mill Streets, and Pines Lodge transient populations are underrepresented			V	Assign Bd of Selection members as neighborhood liaisons				M	O
Sheltering & Cooling Stations			V	Put generators in senior center and elementary school and put A/C in school				H	O
Environmental									
Ticks/Other Pests Moving North			V	Outreach concerning particular areas they are in, actual risk, and prevention such as tick traps				H	O
Food Supply During Disasters			V	Expansion of Council on Aging activities to identify vulnerable populations, monitoring				H	O
Ag production has decreased w/ changing seasons			V	Agricultural Cooperative strength/education on area future resources to farmers				M	O
Forest Management for fires			V	Fire Dept in conjunction with Hopkins Forest should study controlled burns				L	O
Shaded Walks in rural areas			V	Study expansion of public water to existing homes				H	L
Exit Line			V	general preparedness and all of the above will help during that type of event				L	L

Features	Location	Ownership	V or S	FLOODING	FIRE	SNOW/ICE	WIND	PRIORITY	Time
Infrastructure								H M L	Short Long Ongoing
Culverts/Bridges are undersized	Townwide	Town	V	Dread only think about future issue when updating				H	O
Sewer pipe in the Historic River / Green River	Townwide	Town	V	Work with DOT/HR/EF on permitting				M	O
Understand Storm Sewer System	Townwide	Town	V	Review system for issues, correct as found				M	O
Water Supply Pumps protected	Townwide	Town	S						
Flooded at Colonial Village	Colonial Village	Town/Townwide	V	Study/develop communication system				L	L
Reverses causing flooding along railroad at Bridges Pond	Bridges Pond	Town/Colonial	V	Close channel, trap (Maintenance)				H	O
Christmas Brook / Williams College new stormwater system	Christmas Brook	Williams	S					M	O
Gravel Roads opens at water crossings	Townwide	Town	V	Maintain/replace culverts as needed				M	L
Culverts in Broad Brook	Broad Brook	Town	V	Maintain as needed, work with state/federal agencies on permitting				M	O
Infrastructure (pipes) where they cross water is of concern	Townwide	Town	V	Plan and replace as needed				M	O
Societal									
Williams College has its own evacuation plans	Williams	Williams College	S					M	O
Volunteers are needed for the Fire Department	Townwide	Fire District	V	Make building on progress, provide equipment				H	O
Mutual Aid between surrounding towns	Townwide	Town/Fire District	S						
Working homes are well contained	Townwide	Private	S						
Connect the aging population a lot of vulnerable populations	Townwide	Connect us Aging	S						
On-site storage before for stormwater	Townwide	Town	S						
Lack of knowledge by public on problems	Townwide	Town/Townwide	V	Conduct public forums and educational campaigns as needed				H	S
People living in the floodplain	Townwide	Town/Townwide	V	Educate residents in floodplains				M	O
Reverses #1 (Radio Road)	Townwide	Town	S	Find/Replace Public				H	S
Environmental									
Not enough or diverse urban tree cover	Townwide	Town	V	Assess for more shade trees, encourage for more trees, provide plan and schedule grants for tree replacement				M	L
Forest Spruces	Town	Town	S						
Use Maximum condition of the railroad	Railroad	Railroad	V	Continue working with L&E to make continue training local responders				L	L
Reverses help and lack of fire a concern for forests	Townwide	State/Private	V	Promote forest management plans				L	L
Land subsidence along Scott Road	Scott Road	Private	V	Control water input of site				L	L

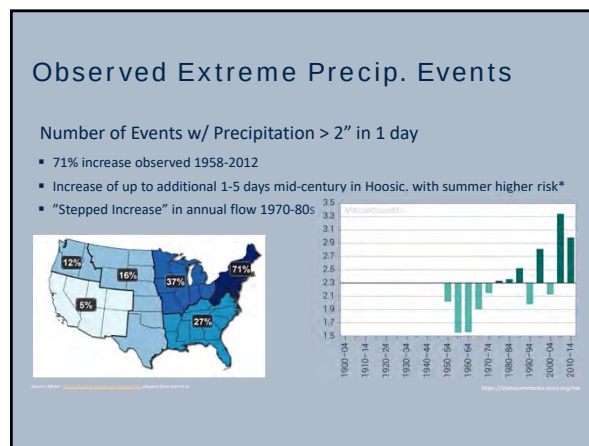
Participation in A Resilient Williamstown, Williams College Panel Discussion, November 6, 2018

On November 6, 2018 Williams College students held a public panel discussion about how climate change may be impacting Williamstown and what the Williams College community could do to help the Town become more resilient. Lauren Gaherty, the HM/MVP Committee's consultant, sat on the panel to report findings from the Town's hazard mitigation and MVP planning processes and to bring to the group a municipal government's perspective on addressing climate change. This panel discussion, which was broadcast on Williams College social media platforms, provided the opportunity to further engage and inform college students and faculty in the hazard mitigation planning process.

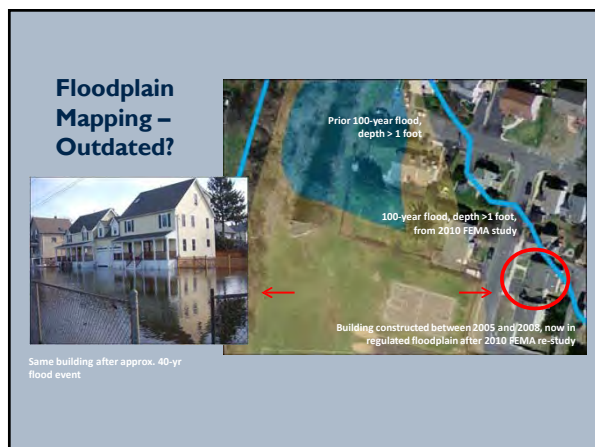




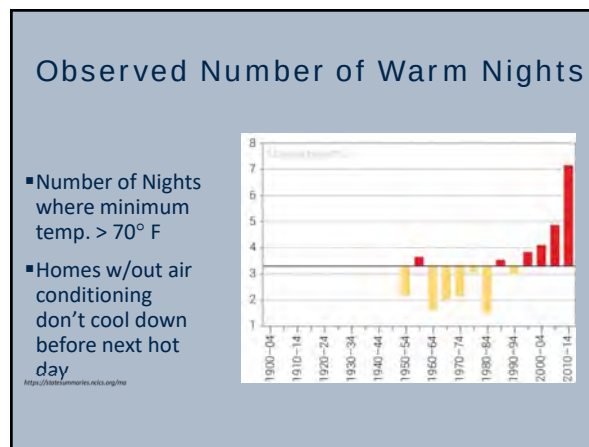
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Public Review of Draft Hazard Mitigation Plan February 25 – April 12, 2019

The draft Williamstown Multi-Hazard Mitigation Plan was offered for review and comment to Town residents and the general public February 25 through April 12, 2019. The announcement and a direct link were posted on the Town's news post webpage. During this same period the Town issued direct invitations to review and comment on the plan to the HM/MVP Committee members, Town boards and committees, and to the neighboring Town of Pownal, VT, with which it has a close working relationship.

