North Adams Hazard Mitigation and Climate Adaptation Plan

December 2020 [Draft]

City of North Adams

A RESOLUTION OF ADOPTING THE

the North Adams Hazard Mitigation and Climate Adaptation Plan

WHEREAS the City of North Adams recognizes the threat that natural hazards pose to people and property within the City of North Adams; and

WHEREAS the City of North Adams has prepared a hazard mitigation plan, hereby known as the North Adams Hazard Mitigation and Climate Adaptation Plan in accordance with the Disaster Mitigation Act of 2000; and

WHEREAS the North Adams Hazard Mitigation and Climate Adaptation Plan identifies mitigation goals and actions to reduce or eliminate long-term risk to people and property in the City of North Adams from the impacts of future hazards and disasters; and

WHEREAS a duly-noticed public comment period was held by the City of North Adams DATE to DATE, and

WHEREAS adoption by the North Adams City Council demonstrates their commitment to the hazard mitigation and achieving the goals outlined in the North Adams Hazard Mitigation and Climate Adaptation Plan.

NOW THEREFORE, BE IT RESOLVED BY THE CITY OF NORTH ADAMS, MASSACHUSETTS, THAT:

In accordance with M.G.L. c. 40. the North Adams City Council adopts the North Adams Hazard Mitigation and Climate Adaptation Plan.

ADOPTED by a vote of ____ in favor and ____ against, and ____ abstaining, this _____ day of

___________, ______.

Signature

Print Name

Title

ATTEST:

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CHAPTER 1: INTRODUCTION

Purpose

The purpose of hazard mitigation planning is to reduce or eliminate the need to respond to hazardous conditions that threaten human life and property. Hazard mitigation can be an action, activity, process, or physical project designed to reduce or eliminate the long-term risks from hazards.

The City of North Adams Hazard Mitigation and Climate Adaptation Plan (HMCAP) was prepared in order to meet the requirements of the Code of Federal Regulations, Title 44 CFR § 201.6 pertaining to local hazard mitigation plans. Title 44 CFR § 201.6(a)(1) states that "a local government must have a mitigation plan approved pursuant to this section in order to receive hazard mitigation project grants. A local government must have a mitigation plan approved pursuant to this section in order to apply for and receive mitigation project grants under all other mitigation grant programs." As the HMCAP will illustrate, the City's eligibility for FEMA's hazard mitigation grants is crucial. The North Adams HMCAP also benefited from the Municipal Vulnerability Preparedness (MVP) planning process, which enabled North Adams to integrate local effects of climate change into their hazard mitigation action plan.

The City of North Adams laid out the following mission statement for their hazard mitigation and climate adaptation planning process:

To identify risks and sustainable cost-effective actions to mitigate the impact of natural hazards in order to protect life, property and the environment in the City of North Adams.

In accordance with Title 44 CFR § 201.6 the local mitigation plan is the representation of the City's commitment to reduce risks from natural hazards, serving as a guide for decision makers as they commit resources to reducing the effects of natural hazards. Additionally, the HMP is meant to serve as the basis for the Commonwealth of Massachusetts to provide technical assistance and to prioritize project funding.

Background

Location

The City of North Adams is located in northern Berkshire County, Massachusetts. Settled in 1745, the Town was incorporated separately from Adams in 1878, and reincorporated as a City in 1895. Today, the City is bordered by the Town of Williamstown to the west, the Town of Adams to the south, the Town of Florida to the east, and the Town of Clarksburg to the north. Surrounded by the Green Mountain Range to the North, the Hoosac Range to the east, and Mount Greylock, the state's highest peak, to the southwest, the City is endowed with a dramatic landscape. The strong physical barriers created by the terrain has constricted development of the City to the valley floor, meaning residential and commercial development and transportation networks have historically been sandwiched into the valleys, which are relatively narrow. Elevation ranges from 2,963 feet on Mount Williams to 609 feet along the Hoosic River near the Williamstown/North Adams line. Slopes of 15 percent and greater account for approximately 20 percent of the land area, with relatively gentle terrain within the Hoosic River valley often exceeding slopes of 5 – 8 percent.

Due to the surrounding terrain, North Adams is positioned in one of the most risk-prone areas in Berkshire County. In addition to steep terrain, the City is situated at the confluence of the North and South Branches of the Hoosic River – meaning City residents are no stranger to flooding concerns. The location additionally leaves the City more vulnerable to landslides. While steep slopes remain largely undeveloped due to their lack of stable soils, development occurs at the foothills of these mountains, and disturbance could cause other issues such as dam failure. Landslide are likely to have a much higher probability of occurrence as climate change projections for the region call for increases in both the intensity and frequency of extreme precipitation events.

According to MassGIS land use data (2005), 78 percent of land within the City is forested or consists of wetlands. Residential land uses occupy 9 percent of the total land and tend to be concentrated within the downtown area. Commercial uses (approximately 2 percent of land area) are typically focused in the downtown area along the Route 2 and Route 8 corridors. Neighborhood density information was also derived using MassGIS land use dataset last updated in 2005. High density neighborhoods are identified as areas where housing is located on lots smaller than ¼ acre. Medium density neighborhoods are defined as areas where housing is located on ¼ to ½ acre lots. Low density neighborhoods are areas where housing is located on ½ o 1 acre lots. Lastly, very low-density neighborhoods are areas where housing is located on lots greater than 1 acre in size in very remote rural housing. Refer to Figure 3.3 for a map of land use and residential density for the City of North Adams.

Mitigation Planning

This is the City of North Adam's first hazard mitigation plan, and it is a single jurisdictional plan. The City of North Adams was not included in a regional hazard mitigation plan from 2012, however the Berkshire County Hazard Mitigation Plan provided a foundation and needed information for the North Adams Hazard Mitigation Plan.

CHAPTER 2: PLANNING PROCESS

44 CFR § 201.6(b) & 44 CFR § 201.6(c)(1)

Introduction

This chapter outlines the development of the City of North Adams HMCAP. It identifies who was involved in the process, how they were involved, and the methods of public participation that were employed. An open public involvement process during the drafting stage was essential to the development of the HMP. A discussion of how the community will continue public participation in the plan maintenance process (44 CFR § 201.6(c)(4)(iii)) will be discussed in Chapter 4.

The City retained the Berkshire Regional Planning Commission, a MVP Provider, to aid them in developing the Hazard Mitigation Plan and the MVP Plan. 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 as a key stakeholder tool. BRPC works with all local agencies to guide development in Berkshire County. The North Adams Hazard Mitigation Plan is a compilation of data collected by BRPC, information gathered from the planning committee during meetings, and interviews conducted with key stakeholders outside of working meetings.

The Plan reflects comments provided by participants and the public through the MVP planning process, the Hazard Mitigation Planning Committee, local officials and citizens, neighboring towns, and ultimately MEMA and FEMA.

Planning Meetings and Participation

44 CFR § 201.6(c)(1)

During the planning process there was opportunity for public comment and opportunity for neighboring communities, local and regional agencies or partners involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia and other private and non-profit interests to be involved in the planning process. Making the document available to the public for review meets requirements of 44 CFR § 201.6(b)(1), and solicitation of comment from neighboring towns meets requirements of 44 CFR § 201.6(b)(2), pertaining to involvement of regional partners in the planning process.

During the winter of 2019, North Adams began a joint planning process to create the City's first ever Hazard Mitigation Plan and to develop a MVP Plan. Grants from Federal Emergency Management Agency (FEMA) through the Massachusetts Emergency Management Agency (MEMA) and from the Massachusetts Executive Office of Energy and Environmental Affairs (EEA) made this comprehensive mitigation and climate change planning process feasible.

The City 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 including the Massachusetts College of Liberal Arts (MCLA) and the Hoosic River Revival (HRR), the local nonprofit with a mission to naturalize the now-armored Hoosic River. The committee members are listed in Table 2.1.

The Committee held a series of meetings to assemble data on the City's infrastructure, identify known hazards to residents, including seasonal visitors, and review existing plans, procedures, bylaws and protections already in place. On April 18th, 2019 an all-day Community Resilience-Building Workshop (CRB), attended by 29 City officials, residents, neighboring city representatives, emergency responders and others, was held at the St. Elizabeth of Hungary Parish City shelter. The CRB Workshop employs a unique community-driven process, based on scientific data but additionally enriched with local experience and dialogue, where participants identify top hazards, current challenges and strengths. Once these are identified, participants develop and prioritize actions to improve their community's resilience to natural and climate-related hazards, today and into the future. This community planning process is a major tool offered by the Massachusetts Municipal Vulnerability Preparedness Program, a state initiative to address climate change. The findings if this process informed this Hazard Mitigation Plan.

Table 2.1: Planning Committee Members

Name	Affiliation	Role
Canales, Michael	City of North Adams, Administrative Officer	Project Coordinator
Colonno, Dan	MCLA Campus Police	Core Team Member
Jusino, Amalio	NBREPC/NBEMS	Core Team Member
Anderson, Dave	First Congregational Church	Core Team Member
Lamb, Sandra	NACOA Director	Core Team Member
LaBonte, Lisa	City of North Adams: Housing	Core Team Member
Lescarbeau, Timothy	City of North Adams: DPW	Core Team Member
Hohn, Jennifer	Executive Director, North Adams Housing Auth.	Core Team Member
Wood, Jason	NAPD	Core Team Member
Meranti, Steve	NAFD	Core Team Member
Flaherty, Bob	North Adams Public Schools	Core Team Member
Moore, Michael	City of North Adams: Health Department	Core Team Member
Bushee, Mark	City of North Adams: Health Department	Core Team Member
Meranti, William	City of North Adams: Building Insp.	Core Team Member
Burnett, Carrie	North Adams Public Schools	Core Team Member
Massa, Caroline	BRPC	Lead Facilitator
Egan, Allison	BRPC	Facilitator
Maloy, Mark	BRPC	Facilitator
McDonough, Peg	BRPC	Facilitator
Feury, Zac	BRPC	Facilitator

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 lastly to create a climate-related Natural Hazard Risk Matrix for the City, including a written Summary Report that:

1. Defined top local natural and climate-related hazards of concern;
2. Identified existing and future strengthen and vulnerabilities;
3. Developed prioritized actions for the Community; and
4. Identified immediate opportunities to collaboratively advance actions to increase resilience.

Workshop participants are listed in Appendix B.

Categories of Concerns and Challenges from the CRB Workshop

Hoosic River & Flood Chutes

Looking across the Hoosic flood chutes at River Street between Holden Street and Marshall Street

The Hoosic River crosses through Massachusetts, Vermont, and New York. While the Hoosic can look like a small stream in the flood chutes that cut through the middle of North Adams, 720 square miles of land drain into the river[1], causing it to grow to a powerful flow of water rapidly. Schools, residential and commercial properties are located within and on the edges of the floodplain. Additionally, the Hoosic North Branch and the Hoosic South Branch converge in downtown North Adams at the old mill building where the City's major tourist destination, Mass MoCA, is housed.

The flood control chutes have prevented major flood events since their construction by the Army Corps of Engineers between 1950 and 1961, but the expected lifespan was 50 years and they have begun to fail. There an initiative, the Hoosic River Revival, to naturalize the river corridor and the flood control chutes themselves to improve habitat, reduce thermal pollution and enhance the aesthetics of the Hoosic River. However, there is a continued need to maintain the structural integrity of the chutes for protection of people, densely developed property and the economy.

Water & Sewer

The water and sewer systems in North Adams are aging infrastructure. The exact locations of pipes are unknown, and repair requires shutting down service to many of North Adams' residents. Those affected by the inadequacies of the water and sewer system in North Adams would like to see it mapped a monitored to better identify where problems occur, and smaller grids for shutdowns during repairs.

Dams, Reservoirs & Earthen Berms

Dam failure was of concern for North Adams. The City recently had inundation areas mapped to show what areas would be flooded in the case of dam failure. Large storms that breach dams or cause erosion could lead to such a disaster. Much of North Adams would be under water if the large reservoir dams failed as shown on the map.

North Adams uses dams to store water in reservoirs, as well as along the Hoosic River. Earthen berms are also used along the Hoosic River where the flood chutes do not provide protection. Earthen berms are a more natural form of flood mitigation, but they are subject to erosion if not properly engineered or maintained.

[1] *http://hoorwa.org/the-river/meet-the-hoosic/*

Stormwater & Street Flooding

There are particular problem areas for flooding in North Adams. The area around the MCLA campus is widely known for flooding issues. Flooding north of the Hoosic in downtown North Adams is also reported to be an issue. Some flooding comes from the stormwater systems themselves, throwing covers from the manholes as they overflow. Other issues are attributed to undersized culverts. Flooding is due to development in the floodplain, some areas simply flood as part of the natural ebb and flow of the river and tributaries. The City's next steps towards resilience should focus on increasing the capacity to handle the water as intense precipitation events increase in the Northeast.

Emergency Response and Communications

Emergency response is important to North Adams, as reflected in the Northern Berkshire Regional Emergency Management Committee 2015 award from FEMA for community preparedness. Even with their success, emergency responders see a lot of room for improvement. From backup energy sources, whether in the form of generators or alternative energy, to the need for communication infrastructure redundancy, MVP workshop participants expressed emergency preparedness needs for the community.

Emergency response is a daily activity in North Adams, and a new building to house operations is needed. Currently the North Adams fire department and police department share a building that is both in the natural floodplain of the Hoosic River if the flood chutes were not there and is also congested with traffic.

Bridges & Culverts

MVP workshop participants asked for upsized and maintained culverts and heightened bridges to keep up with the increased flow of water. Currently culverts at Ashland Street, State Street, and River Street cause street flooding. Maintenance of culverts is also needed Bridges over the Hoosic River on Route 2 are nearing the end of their lifespan. Additionally, bioswales and permeable surfaces were recommended during the workshop in order to mitigate some of the stormwater flowing into the system.

Insect-Borne Diseases

With increasing temperatures and rain, the concerns over insect populations have grown, particularly for those insects that carry and transmit diseases to humans such as Lyme's disease from ticks and West Nile form mosquitos. Residents want to avoid spraying harsh chemicals to control insects, but more research is needed on alternatives such as biological control with bats and other animals.

Social Resilience

North Adams is a city with complex social challenges as an urban community in a rural context. The EMS deals with frequent drug overdoses, leading the responders to worry about what would happen in a situation that might require sheltering a large population.

Populations are isolated in North Adams, those who cannot afford or are not licensed to drive are isolated due to a lack of public transportation. Where there is bus service, users are forced to wait outdoors for long periods of time in inclement weather including the Berkshire winters. North Adams wishes to improve public transportation in order to provide access and opportunity to its residents, as well as in order to be more prepared for mass evacuation needs.

Wildfire

While North Adams is densely developed downtown, dense forest covers most of North Adams and the surrounding towns. Additionally, the steep slopes have the potential to assist the spread of a forest fire if one occurred. Given the Appalachian Trail that cuts through North Adams, concerns are raised about hikers who may be neglectful with their campfires and propane stoves.

Railway

Communication with the railroad companies is a common barrier for communities when addressing issues with the railway. Residents have concerns over the materials transported through the City by the Pan Am Railway. A coordinated and drilled response to a potential accident may help reduce impact on the surrounding areas and mollify the fears of residents and emergency responders.

Housing

It is common for public housing to be in the floodplain and the most vulnerable locations, and North Adams is no exception. North Adams provides affordable housing in several buildings throughout the City. The elderly population living in public housing would have a difficult time in a potential evacuation, and the elderly and low-income residents would have an even harder time bouncing back from disaster. Evacuation could be needed in case of flood or landslide given the hillside location of some housing.

Aside from the concerns related to public housing, North Adams is beginning to see gentrification. MVP participants question is flood history is being revealed to new home buyers. Instead of selling these homes and putting people in harms way, it may be wiser to buy the properties out.

Public Comment on the Draft Plan

On May 28th, 2019 the City of North Adams presented workshop results to the public in coordination with the City Council meeting. A half hour before the City Council met, completed matrices were presented as posters for the public to review, make notes on, and identify what they saw as local priorities. Several residents attended the session before the City Council meeting, and many more learned about the community strengths, vulnerabilities, and proposed actions during a presentation and Q&A at the City Council meeting. All North Adams City Council meetings are televised to reach a wider and inclusive audience. Following the public session, an article was published in the local newspaper highlighting the integrated planning process.

Incorporation of Existing Information

44 CFR § 201.6(b)(3)

No plan should be created in a silo, particularly a hazard mitigation plan because of its applicability to land use, city services, and vulnerable people. The City of North Adams reviewed and incorporated existing plans, studies, reports and technical information into their hazard mitigation plan with the assistance of BRPC. This plan should be used in conjunction with other local and regional plans, specifically North Adams Vision 2020, which was simultaneously being reviewed and updated with the assistance of BRPC.

During the planning process existing studies, plans and guidance referenced include North Adams Vision 2030, the Comprehensive Plan for the City adopted in 2014, the Northern Berkshire District Forest Resource Management Plan, Emergency Action Plans for significant hazard dams, South Branch Hoosic River Conceptual Designs, A River Runs Through It: Reconnecting the North Branch of the Hoosic River and North Adams, and the MVP Workshop Summary of Findings. The MVP Planning process was vital in the formulation of this plan, for the prioritization of hazards and actions to mitigate exposure and vulnerabilities. The MVP Workshop Summary of Findings submitted in June of 2019 are integrated throughout this plan. All of these documents and additional resources discussed in meetings provided important insight into the value of natural resources in North Adams, as well as a long-term vision for the City, including a path forward for protecting the community's assets.

Other hazard mitigation plans in the region were consulted during the development of this plan, including the neighboring communities of Williamstown approved by FEMA Region I in June 2019, and Adams approved in May 2019.

Plan Structure

The next chapter of this plan will dive into the risk assessment, profiling each hazard with potential to affect the City of North Adams. After a general profile of the City's assets and vulnerabilities, each hazard analyzed includes a hazard profile and vulnerability assessment. Hazard profiles consist of likely severity, probability, geographic areas likely impacted, and historic data. The vulnerability Assessment includes hazard effects on people including vulnerable groups, the built environment including infrastructure, the natural environment, the economy, and future conditions to the extent reasonably foreseen in consideration of climate change.

Hazard Mitigation Goals

In developing this plan, the City of North Adams is taking action to reduce or avoid long-term vulnerabilities to the hazard identified in the following chapter. The following are the City's goals for this hazard mitigation plan:

1. To preserve the natural areas that provide hazard mitigation ecosystem services to the community.
2. To plan, design, and construct sustainable, cost-effective, and environmentally sound mitigation projects.
3. Protect lives, health, safety, and property of fulltime residents and seasonal visitors from the impacts of natural hazards.
4. To enhance communication and education of hazards for community residents, particularly those most vulnerable and isolated.
5. Identify the present and future risks that threaten life, property and environment in North Adams.
6. Protect critical facilities and essential public services from disruption during or after hazardous conditions.
7. Promote the hazard mitigation plan and involve stakeholders to enhance the local capacity to mitigate, prepare for, and respond to the impacts of natural hazards.
8. Integrate the risks and mitigation actions identified through this planning process into all plans for the City and region and ensure its consideration in all land use decisions.

CHAPTER 3: RISK ASSESSMENT

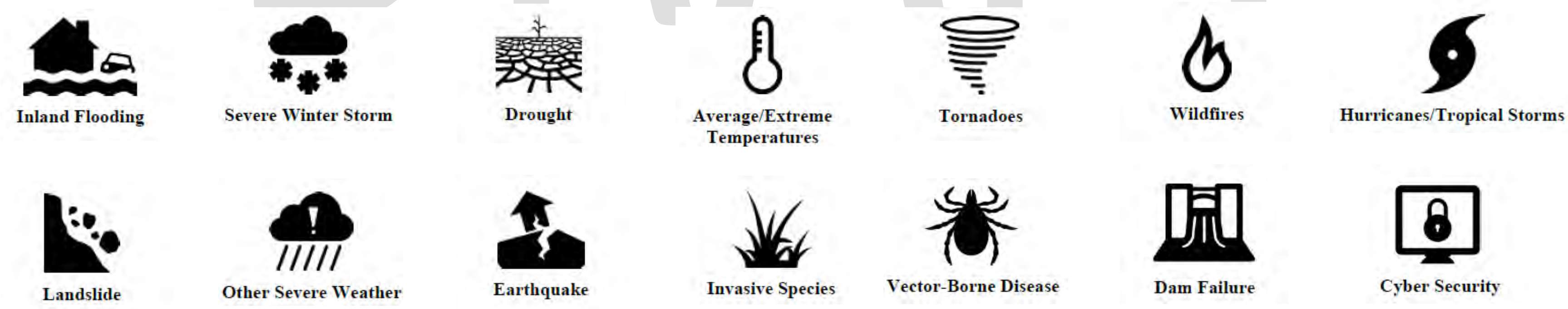
44 CFR § 201.6(c)(2)

FEMA Requirements

In accordance with 44 CFR § 201.6 (c)(2), this risk assessment provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. The risk assessment is an analysis of the hazards and risks facing the City of North Adams and contains detailed hazard profiles and loss estimates to serve as the scientific and technical basis for mitigation actions. This chapter also describes the decision-making and prioritization processes to demonstrate that the information analyzed in the risk assessment enabled the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards. This section also provides information on previous occurrences of hazard events and on the probability of future hazard events with consideration of climate change (44 CFR § 201.6(c)(2)(i).

Hazard Identification and Risk Assessment Processes

In order to identify potential hazards that can affect the City of North Adams several resources were utilized. While North Adams was not included in the 2012 Berkshire County Hazard Mitigation Plan, the City shares the hazards of the region, and therefore the 2012 plan served as a foundation to build from. The hazards identified in the 2012 plan were Flooding, Structurally Deficient Bridges over Waterways, Dam Failure, Wildfire, Snow, High Wind, and Other Natural hazards (i.e. severe storms and tornadoes). In order to build upon this list, the 2018 State Hazard Mitigation and Climate Adaptation Plan (SHMCAP) for the Commonwealth of Massachusetts was consulted and North Adams completed the Municipal Vulnerability Preparedness planning process. Accounting for the location, natural and built environments, history, and scientific studies of the area, it was determined that the City of North Adams must plan for the following hazards:



This plan also includes a section on Cyber Security hazards because this is a growing threat that could disable critical facilities and the essential services they provide to the community.

People

The United States Census Bureau 2018 Population Estimate for North Adams was 12,904 as of July 1, 2018, declining by almost a thousand people since the 2010 census. This is a far cry from the 24,200 residents purported to live in the City in 1900. The City first fell under 20,000 residents in the 1960 census, seeing a steady decline since, experiencing a 29 percent decrease between 1970 and 2010. Population decline is expected to continue, with a projected population of 12,655 in 2030 and 12,557 in 2035 (UMass Donahue Institute – Population Projections).

Across Berkshire County, the population is aging, and North Adams is no exception. The 2013-2017 ACS estimated about 19% of the North Adams population was over the age of 65, compared to an estimated 12% of the population in the City of Springfield, MA. The median age in North Adams is 43.1 years old.

Street Festival on Main Street

Common industries of employment noted in the American Community Survey (ACS) for 2013-2017 include educational services, health care, and social assistance employing 36.5% of the population, retail trade with 12.8% of the population, and arts, entertainment, recreation, accommodation and food services employing 12.2% of the population. The ACS estimated 17.8% of individuals were living below poverty levels.

While about 76% of the population drive alone to work, a notable 12% of the population walks to work, far exceeding the public transportation percentage of 2%. The median household income was $38,774.
When it comes to people in North Adams, daily visitors need to be factored in in addition to fulltime residents. Crowds visiting cultural attractions in North Adams bring in a new level of exposure and vulnerability to hazards.

Natural Environment

Hoosic River at MoCA

While no longer in its natural form in downtown North Adams, the Hoosic River runs through the City, two branches flowing east to west and from the south joining at the MassMoCA property. The River was historically much wider, and flooding was common as precipitation flowed from the higher elevations of surrounding mountains. The flood chutes today are designed with a slight angle to facilitate flow when water is low, and to move water through the City as quickly as possible. The flood chute design has severely damaged habitat and the ecological value of the Hoosic in North Adams. The river is feared more than cherished as a community asset. Organization such as the Hoosic River Revival are working to change that, and plans have been made to restore the Hoosic South Branch to its natural state with community access. Other waterways in North Adams include Hudson Brook joining the Hoosic in the northeast, Paull Brook flowing to Williamstown, and Notch Brook which joins the Hoosic next to the State Road bridge.

Surrounding the City are natural assets including Greylock State Reservation, with the tallest peak in Massachusetts, Windsor Lake, and Natural Bridge State Park. In addition to these destinations, North Adams has important wetland and forest habitat. Priority areas for conservation can be seen in the Figure 3.1 map.

The natural environment provides benefits to a community that are not always quantifiable. Ecosystem benefits such as clean air, carbon sequestration, clean water, wildlife habitat, water retention, wind and heat mitigation, increased real estate value and mental health. The natural environment stands to be damaged by a disaster. Disruptions that allow for a forest to restart the succession process can be very beneficial to the ecosystem. However, the environment can be severely damaged by pollutant contamination or other impacts of human development. On the same note a community may want to replace or restore trees and other assets of the natural environment that are part of the built environment for their ecosystem benefits.

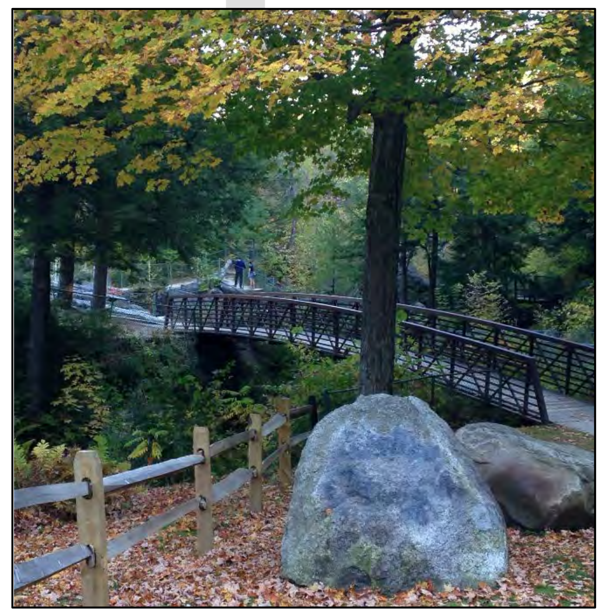


Figure 3.1: City of North Adams Environmental Concerns/Assets

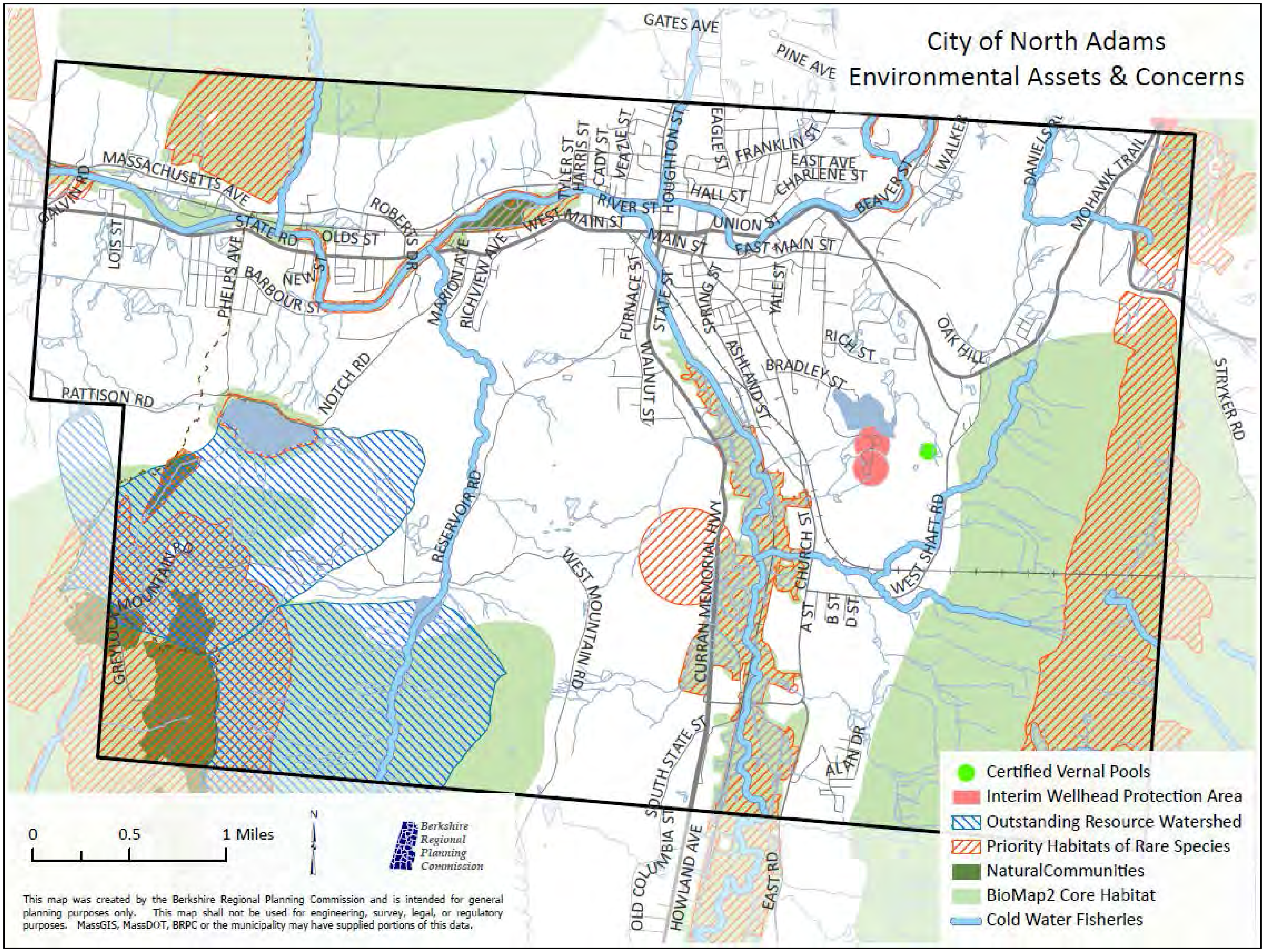
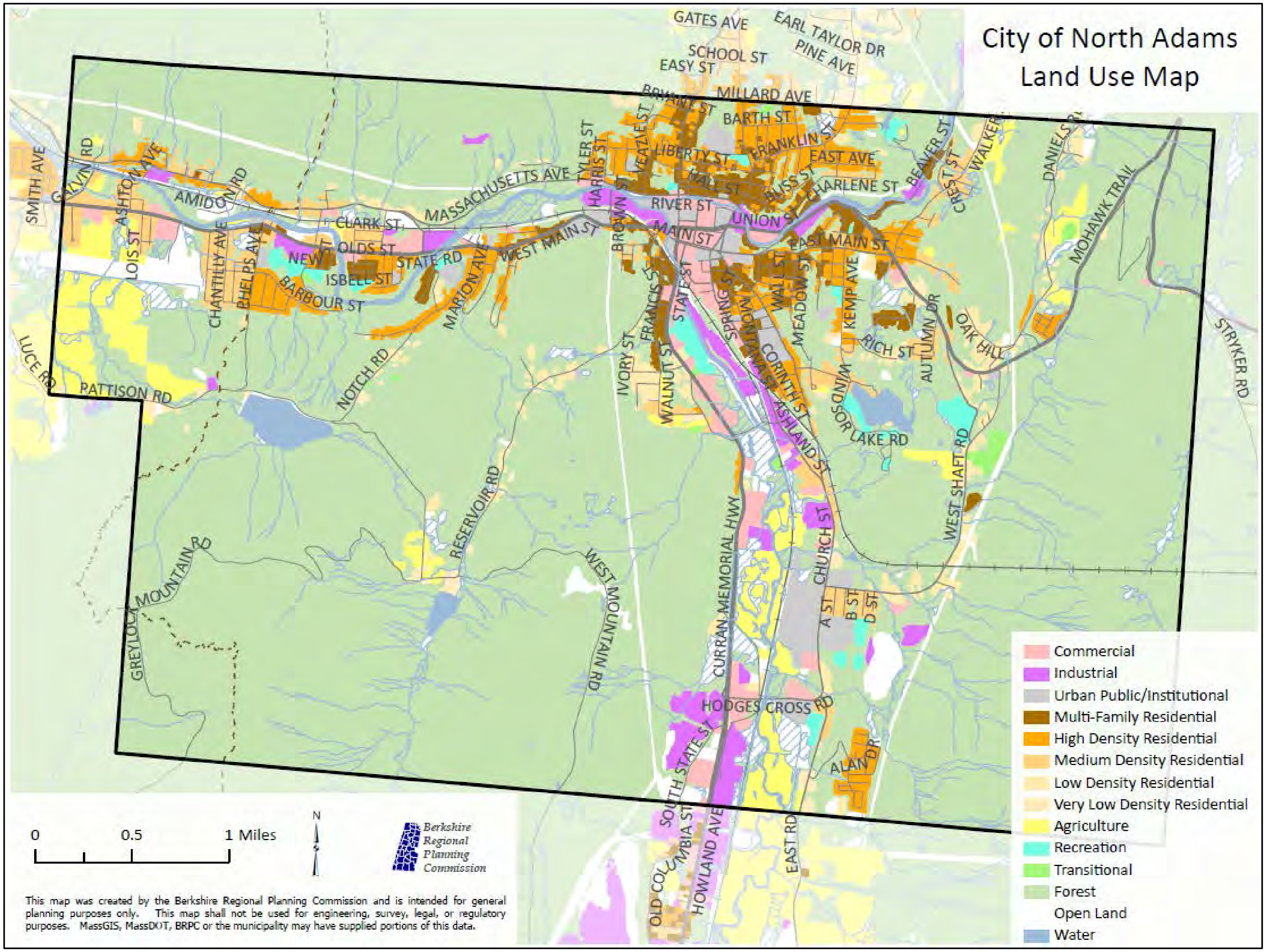


Figure 3.2: City of North Adams Land Use



Built Environment

Due to the common flooding of the Hoosic River in its natural form, historic settlers often chose to live in what is now known as Adams, just south of North Adams[2]. North Adams still retains many of its historic buildings, including old mills and commercial buildings. Development has concentrated along the Hoosic River, utilizing the flood plain for agriculture in colonial times and later harnessing the river flow energy for industrial uses beginning during the 19th and 20th centuries. Development is also severely restricted along the Hoosic River valley due to the steep slopes surrounding the City. The construction of the concrete flood control chutes through downtown to funnel the River through the City, further encouraged development within the floodplain, and historic floodway, of the Hoosic River.

44 CFR § 201.6 (c)(2)(ii)(C) asks that vulnerability in the risk assessment be addressed in terms of land uses and development trends within the community so that mitigation options can be considered in future land use decisions. North Adams is the second most metropolis place in Berkshire County with a thriving arts scene driven by the Massachusetts Museum of Modern Art (MASS MoCA). New investments in North Adams include hotels, adaptive reuse of abandoned mill buildings, a bike path and walkability improvements. Given these new developments, proactive hazard resilience planning is a matter of urgency to ensure people and assets are not placed in harm's way, and opportunities to integrate projects such as the bike path with Hoosic River hazard mitigation are not missed.

Critical facilities are the buildings and infrastructure hubs that are necessary for continued operation during a hazardous event. Table 3.1 shows North Adams's Critical Facilities and figure 3.4 provides a map of the critical facilities and areas of concern.

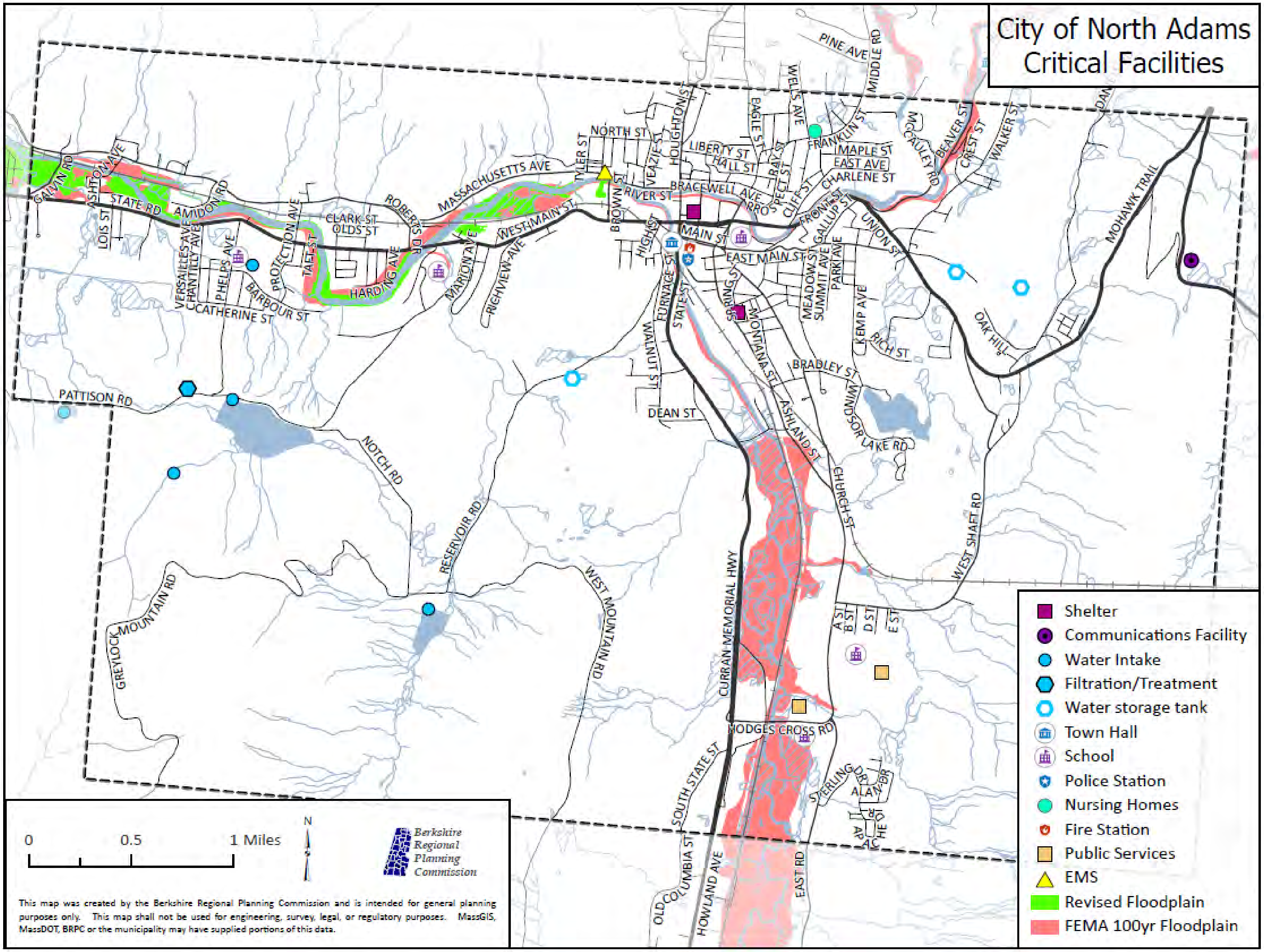
Table 3.1: North Adams Critical Facilities

Type	Name	Address (North Adams, MA 01247)
Emergency Operations Center	Department of Public Safety (Police & Fire)	10 Harris Street
Alternate Emergency Operations Center	Northern Berkshire EMS Building	40 American Legion Drive
City Offices	North Adams City Hall	10 Main Street
Public Utility	North Adams Public Services	59 Hodges Cross Road
	Water Treatment Facility	Reservoir Road
Shelter	North Adams Armory (Backup Shelter)	206 Ashland Street
	St. Elizabeth's Parish Center	70 Marshall Street
Back-Up Shelter Locations	City Yard	50 Hodges Cross Road
	Brayton Elementary School	20 Barbour Street
	Colegrove Park Elementary	24 Church Street

[2] *http://www.northadamshistory.org/history.htm*

	Drury Highschool	1130 Church Street
Medical Services	Hospital	77 Hospital Avenue
Housing for Vulnerable Populations	Riverview Apartments	150 Ashland Street
	St. Joseph's Court	85 Eagle Street
	North Adams Commons	175 Franklin Street
Communications Facility	Cell Tower	
	Verizon	

Figure 3.3: North Adams Critical Facilities and the Mapped Floodplain



Economy

Early establishment and growth of the City of North Adams was fueled by energy from the Hoosic River and lumber from the forests where the downtown stands today. Early industrialization including textile milling, blast furnace construction and shoemaking were all made possible with waterpower supplied by the Hoosic River, with these operations continuing up through the mid-19th century. During the mid-1870's, the 4.2-mile Hoosac Rail Tunnel was completed – marking the completion of the first major rock tunnel in the U.S. – and serving as a connection between Boston and upper New York State. Electronic manufacturing was prominent from 1930 up through the mid-1980's. Sprague Electric Company – the electronic component manufacturer serving as the City's industrial backbone, employing thousands of workers – closed in 1985. The closure of Sprague Electric represents a transitional moment for the City's economy – moving away from manufacturing-based production and toward cultural, educational, recreational and service-based industries. Today the economy is more diversified and moving towards a more cultural and tourism base, due to the growth of the Massachusetts College of Liberal Arts and the success and continuing expansion of MassMoCA, the country's largest museum of modern art. The success of MoCA has been a local magnate, drawing creative artists and innovative businesses to the area.

Prioritization

Table 3.2 illustrates the first step in the process of prioritizing hazard mitigation actions in addition to the profiling of local impacts during the risk assessment. The method of prioritization meets requirements of 44 CFR § 201.6(c)(3)(iii). Working through this table gave committee members the opportunity to quantify potential effects of hazards on North Adams. Hazards other than flooding are difficult to prioritize without this or a similar ranking system.

The next step of the prioritization process took place with a broader audience at the MVP Workshop and Public Listening Session. The MVP prioritization limits the number of hazards assessed and focused on prioritizing asset protection or mitigation actions. Therefore, both processes were needed for a comprehensive HMCAP. The tables resulting from the MVP planning process can be seen in Appendix B. There were three hazards that MVP workshop participants highlighted above the rest - flood, wind, and snow. Flooding concerns included rain, severe storms, fast runoff, and extreme precipitation. Snow hazards encompassed ice storms, snowstorms, and severe winter storms. The other top hazards discussed were fire, drought, landslide, extreme temperatures, and the railroad.

Table 3.2: Hazard Prioritization for the City of North Adams

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	
Dam Failure	**3**	**1**	**4**	**8**
Flooding (include Ice Jam, Beaver Activity)	**2**	**3**	**3**	**8**
Severe Winter Event (Ice Storm, Blizzard, Nor'easter)	**3**	**3**	**2**	**8**
Severe Storms (High Wind, Extreme Temperature)	**3**	**3**	**2**	**8**
Hurricane & Tropical Storms	**3**	**3**	**2**	**8**
Drought	**3**	**1**	**1**	**5**
Tornado	**2**	**2**	**2**	**6**
Earthquake	**3**	**1**	**1**	**5**
Urban & Wildfire	**1**	**2**	**1**	**4**
Landslide	**1**	**2**	**1**	**4**

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 (< 0.1% per year
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%

Hazard Profile

Inland flooding is the result of moderate precipitation over several days, intense precipitation over a short period, or melting snowpack (U.S. Climate Resilience Toolkit, 2017). Developed, impervious areas can contribute to inland flooding (U.S. Climate Resilience Toolkit, 2017). Common types of local or regional flooding are categorized as inland flooding including riverine, ground failures, ice jams, dam overtopping, beaver activity (tree removal, dam construction, and dam failure), levee failure, and urban drainage. Overbank flooding occurs when water in rivers and streams flows into the surrounding floodplain or into "any area of land susceptible to being inundated by floodwaters from any source." Flash floods are characterized by "rapid and extreme flow of high water into a normally dry area, or a rapid rise in a stream or creek above a predetermined flood level." (FEMA, 2011b as cited in MEMA & EOEEA, 2018[3]). The hazards that produce these flooding events in the region include hurricanes, tropical storms, heavy rain events, winter rain-on-snow, thunderstorms, and a recovering beaver population.

Likely 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.

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.

[3] *Massachusetts Emergency Management Agency & the Executive Office of Energy and Environmental Affairs developed the MA State Hazard Mitigation and Climate Adaptation Plan, 2018* https://www.mass.gov/service-details/massachusetts-integrated-state-hazard-mitigation-and-climate-adaptation-plan

Probability

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 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 floodplain 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). Increases in precipitation and extreme storm events will result in increased inland flooding.

Table 3.3: Recurrence Intervals and Probabilities of Occurances

Recurrence interval,	Probability of	Percent chance
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

Due to high slopes and minimal soil cover, Western Massachusetts is particularly susceptible to flash flooding caused by rapid runoff that occurs during heavy precipitation in combination with spring snowmelt. These conditions contribute to riverine flooding. Frozen ground conditions can also contribute to low rainfall infiltration and high runoff events that may result in riverine flooding (MEMA, 2018). Berkshire County has frozen ground conditions for more of the year than most of Massachusetts. There is a 90% likelihood that the temperature will reach 28° by October 22nd, with the potential ground freezing conditions lasting until May 20th of the following year (NOAA, 1988 as cited by UMASS Extension accessed on March 12th, 2019).

Geographic areas likely impacted

There are 3,254 acres that are within the 100-year floodplain in North Adams, which is 25% of the City. 58 acres of floodplain in North Adams are considered impervious, leading to more widespread flooding as water cannot infiltrate the ground. The geographic area most likely to flood are mapped in Figures 3.4 - 3.6. The FIRM floodplain boundaries of the Main Stem and North Branch Hoosic Rivers date back to the 1980s, but the boundaries of the Hoosic River downstream and flowing west out of the city center have been updated by the USGS after T. S. Irene of 2011. The floodplain of the Hoosic cuts through downtown North Adams from the south and east to west. There are particular problem areas for flooding in North Adams, though the natural floodplain has been drastically altered by the Army Corps constructed flood chutes. Maintenance or complete redesign of these flood chutes is needed to maintain the flood protection particularly in areas identified as vulnerable around the Mass MoCA and Willow Street. The area around the MCLA campus is widely known for flooding issues, particularly Ashland, Hodges Cross, Oak Hill streets. The MCLA townhouse basements flood, and runoff from Bradley Street flows down the MCLA Hoosac parking lot and into the Campus Center. Flooding north of the Hoosic in downtown North Adams is reported to be an issue. Flooding issues due to undersized culverts were reported by residents and City staff at Ashland Street, State Street, and River Street along the Hoosic River. The stormwater system is overwhelmed at Brown, Beaver, Houghton, and Galvin Streets as well as around The Porches, a local tourist destination.

Figure 3.4: Northwest City of North Adams Floodplain (FEMA 100-year floodplain FIRM data and USGS Post-Irene Updated Data)

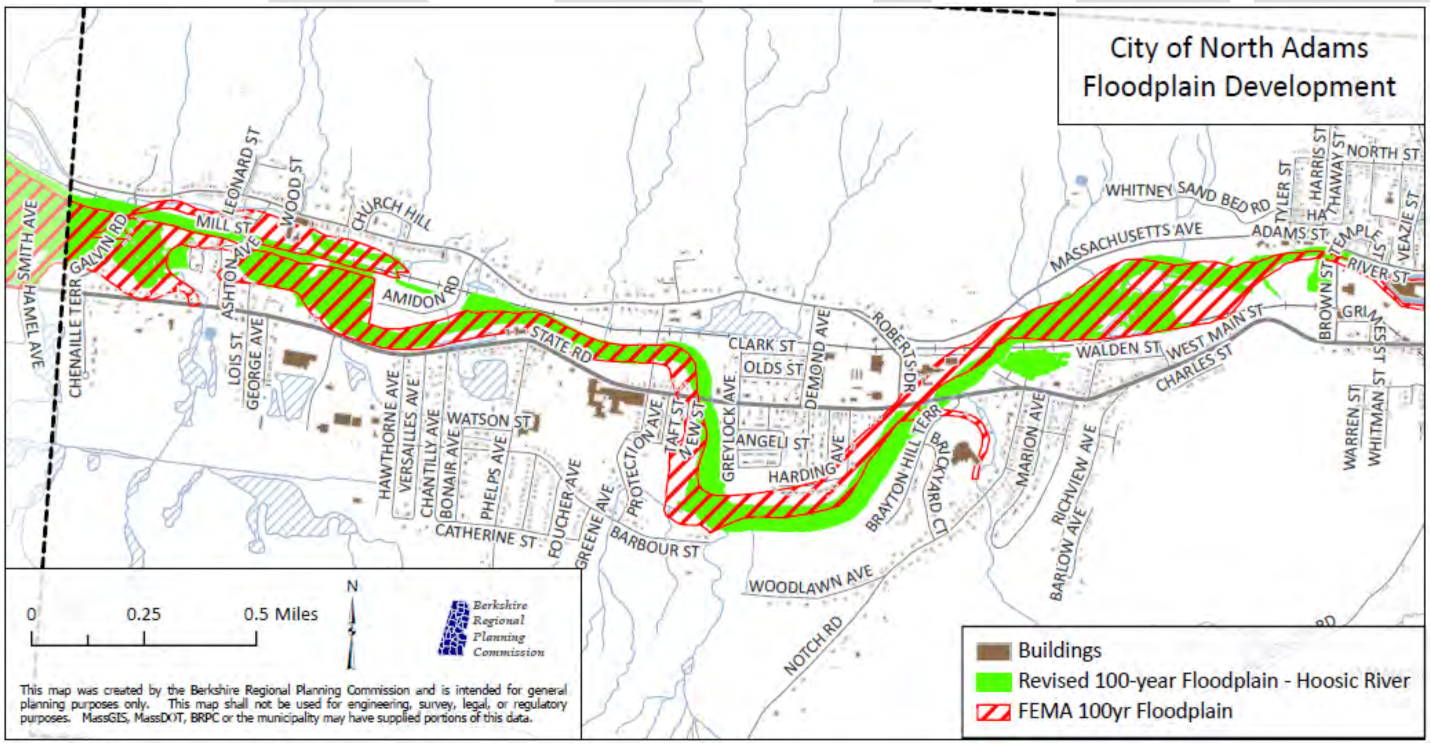


Figure 3.5: Northeast City of North Adams Floodplain (FEMA 100-year floodplain FIRM data)

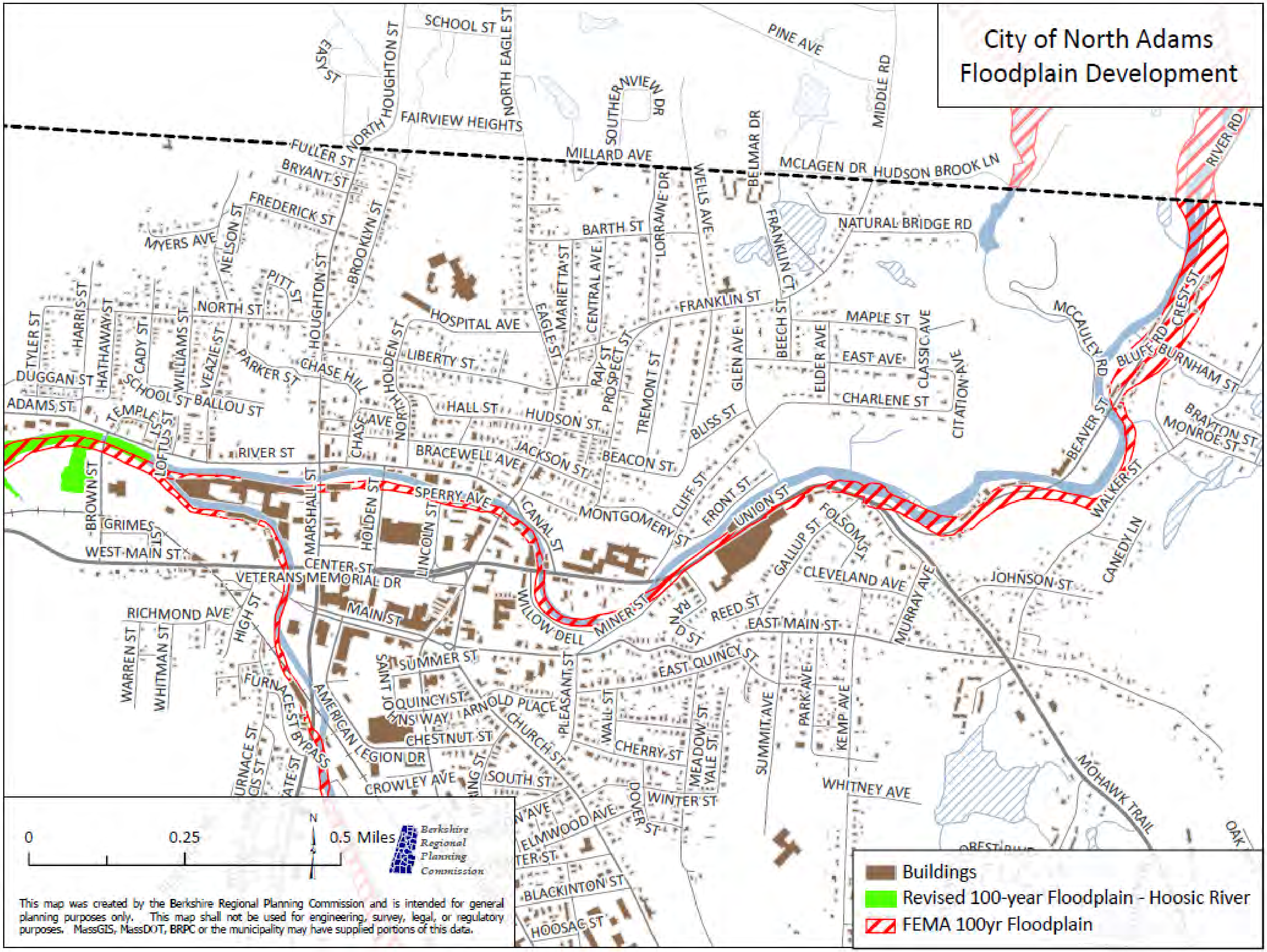
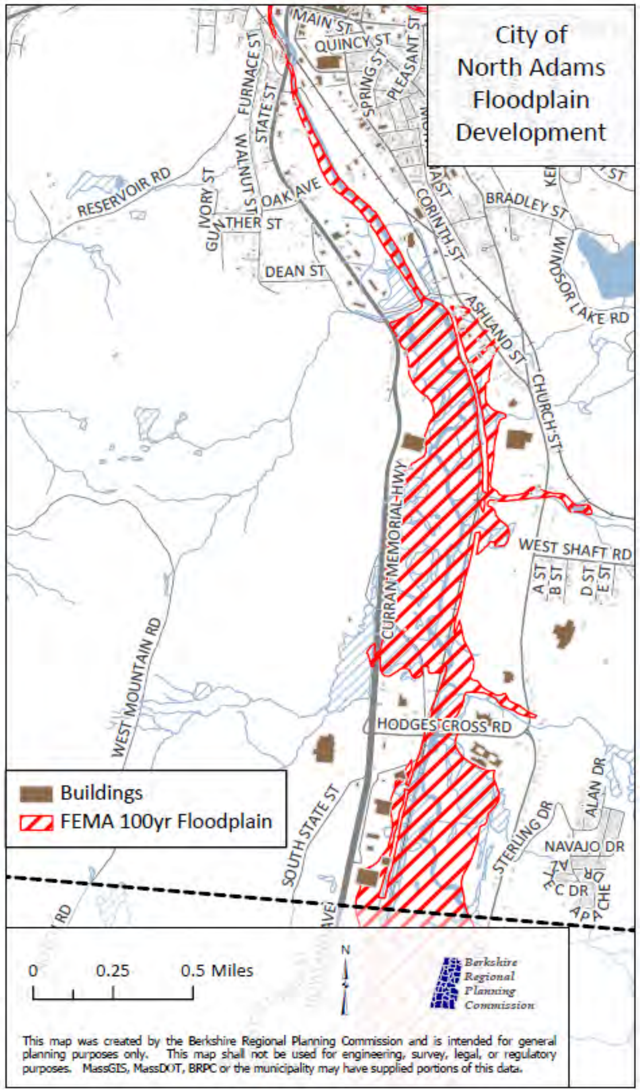


Figure 3.6: Southeast City of North Adams Floodplain



Historic data

Between 1936 and 2019, four flood events equaling or exceeding the 1% annual chance flood have been documented the Berkshire County region: 1938, 1948, 1955 and 2011. The most severe flood events to impact people and property in North Adams were 1938, 1948 and 1955 flood events. Peak flows and storm velocities in the Hoosic River during the storms of 1938 and 1948 were so high and strong that the waters flooded buildings and streets, washing away structures, automobiles and debris.

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. During this event the Phelps Avenue and Protection Avenue bridges were destroyed and the Petri Cleaning Store on Eagle Street collapsed into the river. Damage to houses in the Greylock section, Front Street, Brooklyn Street and Beaver Street was the worse. All pavement from Wood Street ended up at the Blackinton Mill. Damage in North Adams was put at $1.2 million. [4]

In addition to these events, there 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 Great Hurricane of 1938, which was one of the most devastating one experienced by the City. Of the 37 flood exceedances at the North Adams gauge, 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. Refer to Table 3.4. for a list of flood events impacting the region.

[4] *T. Ennis, Before the Chutes, Hoosic Floods Raged, iBerkshires 2-11-04.*

Table 3.4. 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.
1938	"The Great Hurricane of 1938" This storm was considered a 1% annual chance flood event in several. The Hoosic River flooded downtown areas of North Adams, with loss of life and extensive damage to buildings.
Dec. 31, 1948/ Jan. 1, 49	The New Year's Flood hit North Adams severely wiping out buildings along the Hoosic River and with many of areas registering the flood as a 1% annual chance flood event.
1955	Hurricanes Connie and Diane combined to flood many of the communities in the region and registering in 1% -0.2% annual chance flood event (100-500-year flood event) (FEMA 1977-1991).
May 1984	A multi-day storm left up to 9" of rain throughout the region and 20" of rain in localized areas. This was reported as an 80-year flood for most of the area and higher where the rainfall was greater (USGS, 1989).
September 1999	The remnants from Hurricane Floyd brought between 2.5-5" of rain and produced significant flooding throughout the region. Due to significant amounts 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 snowpack.
August 2003	Isolated thunderstorms developed that were slow moving and prolific rainmakers. Flooding led to the evacuation of Berkshire residents.
September 2004	The remnants from Hurricane Ivan brought 3-6" of rain. This, combined with previously saturated soils, caused flooding throughout the region.
October 2005	A stationary cold front brought over 6" of rain and caused widespread flooding throughout the region.
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 with intense rainfalls and up to 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 causing road 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	Heavy rainfall of 1.5-3" across the region closed roads 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 waterways, 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 with widespread flooding and damaging winds. Riverine and flash flooding resulted from 3-9 inches of rain within a 12-hour period. Widespread road closures occurred throughout the region. This event was a 1% annual chance flood event.
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 flooding on rivers as well as small streams and creeks.
August 2012	Remnants from Hurricane Sandy brought thunderstorms repeatedly bringing heavy rains over 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.
August 2013	Heavy rainfall repeatedly moved across the region with more than 3 inches of rain in just a few hours. Streams and creeks overflowed causing flash flooding. Roads were closed and water rushed into some basements.
September 2013	Showers and thunderstorms tracked over region 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 led 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 with heavy rainfall and significant runoff, causing flash flooding in some areas. Many roads were closed and some homes were affected.
July 2014	A cluster of strong to severe thunderstorms broke out causing heavy rainfall and flash flooding with 3-6" of rainfall occurring.

May 2016	Bands of slow-moving showers and thunderstorms broke out over the region. 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.

Table Source: BRPC 2018 (unless otherwise noted)

1948 Flood, River Street Package Store.
Credit Paul W. Marino

In response to the devastating floods of the 1930s and 1940s, the U.S. Army Core Engineers embarked upon a flood control project that encased the Hoosic River channel in concrete chutes in the North Adams city center. The chutes, constructed in the 1950s, are a three-sided structure, which encases the river on the bottom and up both river banks. Water flows in the concrete chutes varies, depending on the season and storm conditions. During low flows very little water flows through chutes, with much of the concrete bottom dry of any flow whatsoever. Flows increase during spring melt and storms events, with the chutes almost full during the severest storms, such as T. S. Irene in 2011.

The first section is along the North Branch of the Hoosic River. The structure begins at the Eclipse Mill Dam and continues downstream approximately 1.3 miles to the confluence with the South Branch of the Hoosic River. This section of the chute has a width between walls of 45 feet. The second section is along the South Branch of the Hoosic River. The structure begins adjacent to Joe Wolfe Field and continues approximately 0.8 miles to the confluence with the North Branch of the Hoosic River. This section of the chute has a width between walls that varies from 65 feet to 45 feet. After the confluence of the two branches, the flood control chute continues 1,200 feet downstream, with a width between walls of 110 feet. At the end of the chute, there is a full width parabolic apron and a depressed stilling basin to decrease flow velocities before returning to the existing river channel.[5]

[5] *Milone & MacBroom, Inc., 2010. Technical Memo, Hoosic River Flood Chute Naturalization Structural Assessment of Flood Control Chutes.*

Several repair projects have been conducted over the decades when concrete sections fail, but a comprehensive evaluation and rehabilitation program has not been undertaken. A section of the chutes near the Marshall Street bridge by Mass MoCA was damaged after a significant rainstorm in 2005. Repairs to that section were completed with a $500,000 federal funding earmark.6 As noted in an engineering study conducted by Milone & MacBroom in 2010, several sections of the concrete chutes are experiencing various degrees of degradation, weakening the integrity of the structures. Traverse, vertical and longitudinal cracks are present throughout the structures, as are spalls and exposed reinforcing steel. Wall panels are separating, some with notable groundwater seepage, and sinkholes are forming behind chute wall sections. More recently another section of the chutes near MoCA collapsed in April 2017, a serious concern given the close proximity of the collapse to the historic mill building.


Chute collapse near MoCA April 2017

In general, the chutes have functioned as designed. Local residents and officials note that the chutes have largely protected the land and properties along the concrete chutes, even during the most severe storm flooding events. The chutes were filled to the brim in some areas during T.S. Irene in 2011, a storm that was one of the most devastating flood events in recent decades. Maintaining the structural integrity of the chutes is paramount to protecting human life and property along the river corridor, particularly for those areas where residential and large industrial property directly abut the chutes.

Vulnerability Assessment

People

Approximately 92 residential buildings, including single family households and multifamily buildings, are located within the floodplain in North Adams. These residential buildings and the contents are worth almost $13 million. Another 63 mixed-use buildings, such as old mill building conversions, are in the floodplain, and most include apartments.

[6] *T. Daniels, 4-17-17, iBerkshires.com*

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

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

The total number of injuries and casualties resulting from typical riverine flooding is generally limited due to advance weather forecasting, blockades, and warnings. The historical record from 1993 to 2017 indicates that there have been two fatalities associated with flooding (occurring in May 2006) and five injuries associated with two flood events (occurring within 2 weeks of each other in March 2010). However, flooding can result in direct mortality to individuals in the flood zone. This hazard is particularly dangerous because even a relatively low-level flood can be more hazardous than many residents realize. For example, while 6 inches of moving water can cause adults to fall, 1 foot to 2 feet of water can sweep cars away. Downed powerlines, sharp objects in the water, or fast-moving debris that may be moving in or near the water all present an immediate danger to individuals in the flood zone. Events that cause loss of electricity and flooding in basements, which are where heating systems are typically located in Massachusetts homes, increase the risk of carbon monoxide poisoning. Carbon monoxide results from improper location and operation of cooking and heating devices (grills, stoves), damaged chimneys, or generators.

According to the U.S. Environmental Protection Agency (EPA), floodwater often contains a wide range of infectious organisms from raw sewage. These organisms include intestinal bacteria, MRSA (methicillin-resistant staphylococcus aureus), strains of hepatitis, and agents of typhoid, paratyphoid, and tetanus (OSHA, 2005). Floodwaters may also contain agricultural or industrial chemicals and hazardous materials swept away from containment areas. Individuals who evacuate and move to crowded shelters to escape the storm may face the additional risk of contagious disease; however, seeking shelter from storm events when advised is considered far safer than remaining in threatened areas. Individuals with pre-existing health conditions are also at risk if flood events (or related evacuations) render them unable to access medical support. Flooded streets and roadblocks can also make it difficult for emergency vehicles to respond to calls for service, particularly in rural areas. Flood events can also have significant impacts after the initial event has passed. For example, flooded areas that do not drain properly can become breeding grounds for mosquitos, which can transmit vector-borne diseases. Exposure to mosquitos may also increase if individuals are outside of their homes for longer than usual as a result of power outages or other flood-related conditions.

Finally, the growth of mold inside buildings is often widespread after a flood. Investigations following Hurricane Katrina and Superstorm Sandy found mold in the walls of many water-damaged homes and buildings. Mold can result in allergic reactions and can exacerbate existing respiratory diseases, including asthma (CDC, 2004). Property damage and displacement of homes and businesses can lead to loss of livelihood and long-term mental stress for those facing relocation. Individuals may develop post-traumatic stress, anxiety, and depression following major flooding events (Neria et al., 2008 as cited in MEMA & EOEEA, 2018)

Built Environment

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 widespread 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). Severe flooding can threaten the functionality or structural integrity of dams.

There is not a municipal wastewater treatment plant in North Adams because it is shared with and located in the neighboring Town of Williamstown. North Adams residents depend on both municipal sewer and septic systems. Septic systems can flood as can a wastewater treatment plant, contaminating the surrounding areas, posing health risks, and damaging the environment. A common effect of septic overflows due to flooding is nutrient overloads in nearby bodies of water that can kill native wildlife and vegetation.

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.

The FEMA FIRMs are out of date for all of Berkshire County, and therefore determining the number of buildings in the floodplain is impossible, particularly in areas as densely developed as North Adams along the Hoosic. The USGS did update the floodplain map for the stretch of the Hoosic from North Adams to Williamstown. When the floodplain data is overlaid with building footprints using ArcMap GIS, there are an approximate 92 residential buildings in floodplain in North Adams, along with 42 mixed use buildings, 21 commercial buildings, and 30 industrial buildings. Table 3.5 summarizes the number and types of buildings in the floodplain according to Effective FIRMs and USGS post-Irene updated data as well as the potential value of the building and building contents lost in a flood event. Value of contents for residential buildings is 50% of property value, mixed use is 75% of property value, commercial is 100% of property value, and industrial is 125% of property value.

Table 3.5: Estimated Number of Buildings in the Floodplain and Potential Value Lost in a Flood Event

Type	Total Buildings	Buildings in the Floodplain	Value of Building & Contents in the Floodplain
Residential	3942	92	$12,709,200
Mixed Use	63	42	$16,817,150
Commercial	313	21	$15,848,400
Industrial	33	30	$27,269,179
Total	**4351**	**185**	**$72,643,929**

The City of North Adams is a NFIP community. 44 CFR § 201.6(c)(2)(ii) requires all plans approved after October 1, 2008 must also address NFIP insured structures that have been repetitively damaged by floods. The City of North Adams has 1 repetitive loss property, which has applied for and received FEMA funding. The property is a modest residential home located on Galvin Road that is not located within the floodplain. It sustained damages in January 2005 ($1,969 claim) and during T.S. Irene in August 2011 (14,273 claim).

Natural Environment

Flooding has the potential to affect the natural environment in several ways. Flooding can spread contamination potentially harmful to people, the environment, and wildlife. In North Adams, the HA George & Sons Propane storage property and West Oil on Ashland Street are within the floodplain of the Hoosic River and could be potentially inundated.

Flooding can remove trees, other vegetation, rocks and soil causing erosion, high turbidity and the loss of community assets. Stormwater collects contaminants and sediment from roads and other surfaces and transports it into waterways if there is not a sufficient buffer to filter out the contaminants and sediment. Typically, there is no infrastructure in place to protect from nonpoint source pollution of this type.

Additionally, flooding can spread invasive species that damage forest health impacting native species and logging viability. Invasive Species will be discussed further in the Risk Assessment.

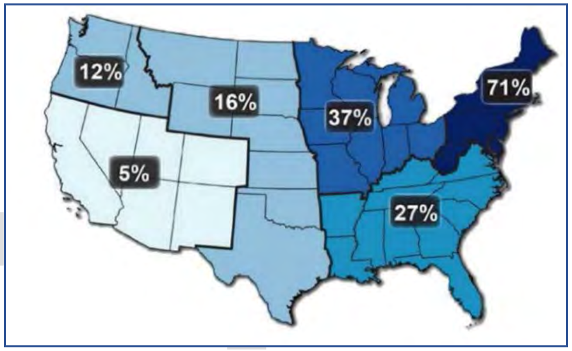
Economy

The impacts of flooding on the economy include the value of buildings and businesses potentially lost during a flood event, the loss of business revenue during the response and recovery period, economic loss due to an inability to commute to work or communicate, and the burden of paying for recovery and the rebuilding of infrastructure. In North Adams, the MassMoCA is a major economic driver locally. The museum is located at the convergence of north and south branches of the Hoosic, with aging flood chute panels between its foundation and potentially raging waters. The loss of this building would have devastating impacts on the North Adams economy.

Future Conditions

Based on data gathered from the Northeast Climate Science Center (NECSC), 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 NECSC, the county is projected to experience an additional 3.55 inches by the 2050's and 4.72 inches by the 2090's. (Northeast Climate Science Center, 2018)

Figure 3.7 Increase in Precipitation Falling in Top 1% Extreme Precipitation Events 1958-2012 Engineering



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

The scientific community agrees 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 ranging from 2.5-5.0° C (36-41° F) over the next 100 years across the U.S., with the greatest increase in the northern states and during the winter months. More mid-winter cold/thaw weather pattern events could increase the risk of ice jams. Many studies agree that warmer temperatures late in the 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 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.[7]

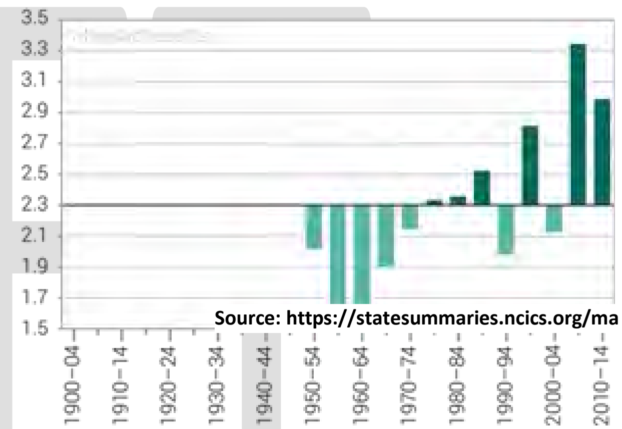
The NECSC also predicts that the Northeast will see an increase in the number of days with at least 1 inch of precipitation from 4.5 days in the 1960s, to 5.1 days in the 2000s to 6.6 days in 2050s and 7.1 days in 2090s. (Northeast Climate Science Center, 2018) Days with precipitation of more than 1 inch in the Hoosic River Watershed, as predicted in the Massachusetts Climate Change Projections report, is predicted to increase from the baseline of 5.9 days per year to 6.4 to 8.3 days by the 2050s, and to 6.5 to 9.4 days by the 2090s. The baseline reflects precipitation data 1971-2000. The upper scenario represents a 41% increase in these storms from the baseline by mid-century and a 60% increase by end of

[7] *NOAA - https://toolkit.climate.gov/image/762, adapted from Karl et al.*

century. Summer is currently season when there is the greatest chance for extreme precipitation events to occur, and summer is projected to continue to be the season of greatest chance and the season with the greatest increases in the number of days with extreme precipitation.

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 greastest increase in the past decade (see Fig. 3.9)[8].

Figure 3.8: Number of Extreme Precipitation Events of 2" or more in 1 Day



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

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 the most updated precipitation and stream gauge information available.

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.

[8] *https://statesummaries.ncics.org/ma*

Hazard Profile

Severe winter storms in North Adams typically include heavy snow, blizzards, nor'easters, and ice storms. 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 20ºF. A severe blizzard is categorized as having temperatures near or below 10 °F, winds exceeding 45 mph, and visibility reduced by snow to near zero (MEMA, 2013).

A Nor'easter is typically a large counterclockwise 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).

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)

Likely Severity

Periodically, a storm will occur which is a true disaster, and necessitates intense, large-scale emergency response. The main impacts of severe winter storms 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.

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)

The National Oceanic and Atmospheric Administration's (NOAA) 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. 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 3.6 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, only two events were ranked as Extreme (EM-3103 in 1993 and DR-1090 in 1996), one was ranked Crippling (IM-3175 in 2003) and two were ranked as Major (EM-3191 in 2003 and DR-4110 in 2013). It should be noted that because population is used as a criteria, the storms that rank higher will be those that impact densely populated areas and regions such as Boston and other large cities and, as such, might not necessarily reflect the storms that impact lightly populated areas like the Berkshires. For example, one of the most famous storms in the Commonwealth in modern history was the Blizzard of '78, which dropped over two feet of snow in the Boston area during 65 mph winds that created enormous drifts and stranded hundreds of people on local highways. The storm hit the snow-weary city that was still digging out of a similar two-foot snowstorm 17 days earlier. Although the Berkshires received snow from this storm, the county was not listed in the declaration.

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

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 that what currently occurs in the 2010s.

Probability

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 city staff expect to deal with several snow storms and a few Nor'easters each winter. 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). The City's location in Western New England places it at a high-risk for winter storms. The severe storms that the County gets are added to the higher annual snowfall the County normally has due to its slightly higher elevation relative to 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 City 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). 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, and risk of roof failures.

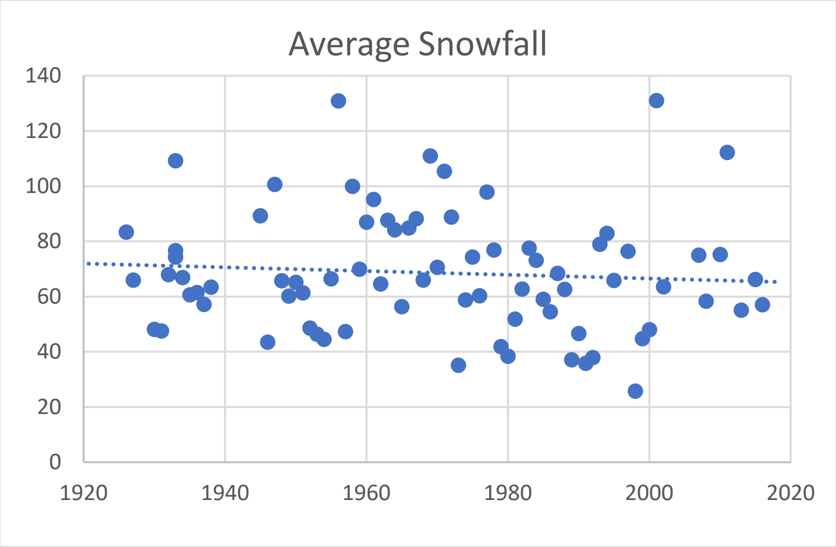
Geographic Areas Likely Impacted

Winter storms are the most common and most familiar of Massachusetts hazards which affect large geographical areas. Severe winter storm events generally occur across the entire area of North Adams, although higher elevations have slightly higher snow depths.

Historic Data

Figure 3.10 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). 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,

Figure 3.9: Average Snowfall in Berkshire County



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 3.7).

Table 3.7: 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 3.8: 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
03/13/93-03/17/93	High winds & heavy snow; generally 20-30” in Berkshires; blizzard conditions lasting 3-6 hrs afternoon of March 13.	EM-3103
01/07/96-01/08/96	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
03/05/01-03/06/01	Heavy snow across eastern Berkshires to Worcester County; several roof collapses reported; $21 million from FEMA	EM-3165
02/17/03-02/18/03	Winter storm with snow of 12-24”, with higher totals in eastern Berkshires to northern Worcester County; $28+ million from FEMA	EM-3175
12/06/03-12/07/03	Winter Storm with 1’-2’ across state, with 36” in Peabody; $35 million from FEMA	EM-3191
01/22/05-01/23/05	Blizzard with heavy snow, winds and coastal flooding; highest snow falls in eastern Mass.; $49 million from FEMA	EM-3201
04/15/07-04/16/07	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.; $49+ million from FEMA	DR-1813
01/11/11-01/12/11	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; $70+ million from FEMA statewide	DR-4051
02/08/13-02/09/13	Severe Winter Snowstorm and Flooding; $65+ million from FEMA statewide	DR-4110

Source: FEMA 2020.

Vulnerability Assessment

People

In rural areas such as North Adams, homes and farms may be isolated for days, and unprotected livestock may be lost. In the mountains, heavy snow can lead to avalanches. Residents may be displaced or require temporary to long-term sheltering. In addition, downed trees, damaged buildings, and debris carried by high winds can lead to injury or loss of life.

According to the NOAA National Severe Storms Laboratory, every year, winter weather indirectly and deceptively kills hundreds of people in the U.S., primarily from automobile accidents, overexertion, and exposure. Winter storms are often accompanied by strong winds creating blizzard conditions with blinding wind-driven snow, drifting snow, and extreme cold temperatures with dangerous wind chill. They are considered deceptive killers because most deaths and other impacts or losses are indirectly related to the storm. Injuries and deaths may occur due to traffic accidents on icy roads, heart attacks while shoveling snow, or hypothermia from prolonged exposure to cold (MEMA & EOEEA, 2018).

Vulnerable populations include the elderly living alone, who are susceptible to winter hazards due to their increased risk of injury and death from falls, overexertion, and/or hypothermia from attempts to clear snow and ice, or injury and death related to power failures. In addition, severe winter weather events can reduce the ability of these populations to access emergency services. People with low socioeconomic status are more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on the net economic impact on their families. Residents with low incomes may not have access to housing or their housing may be less able to withstand cold temperatures (e.g., homes with poor insulation and heating supply). The population over the age of 65, individuals with disabilities, and people with mobility limitations or who lack transportation are also more vulnerable because they are more likely to seek or need medical attention, which may not be available due to isolation during a flood event. These individuals are also more vulnerable because they may have more difficulty if evacuation becomes necessary. People with limited mobility risk becoming isolated or "snowbound" if they are unable to remove snow from their homes. Rural populations may become isolated by downed trees, blocked roadways, and power outages. The ability of emergency responders to respond to calls may be impaired by heavy snowfall, icy roads, and downed trees (MEMA & EOEEA, 2018).

Built Environment with Infrastructure and Systems

Severe winter storms can damage the built environment by collapsing roofs under the weight of snow, making roads impassable due to snow or ice, damaging roads by freezing or unintended damage due to snowplows, freezing and bursting pipes, downing trees and power lines, and the flooding damages that result from melting snow.

Natural environment

Winter storms are a natural part of the Massachusetts climate, and native ecosystems and species are well adapted to these events. However, changes in the frequency or severity of winter storms could increase their environmental impacts. Environmental impacts of severe winter storms can include direct mortality of individuals and felling of trees, which can damage the physical structure of the ecosystem. Similarly, if large numbers of plants or animals die as the result of a storm, their lack of availability can impact the food supply for animals in the same food web. If many trees fall within a small area, they can release large amounts of carbon as they decay. This unexpected release can cause further imbalance in the local ecosystem. The flooding that results when snow and ice melt can also cause extensive environmental impacts. Nor'easters can cause impacts that are similar to those of hurricanes and tropical storms, coastal flooding, and inland flooding. These impacts can include direct damage to species and ecosystems, habitat destruction, and the distribution of contaminants and hazardous materials throughout the environment (MEMA & EOEEA, 2018).

Economy

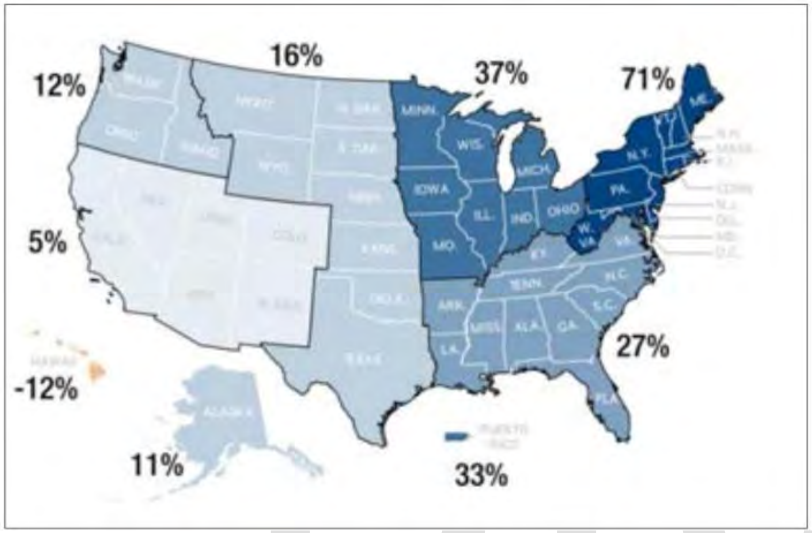
The cost of snow and ice removal and repair of roads from the freeze/thaw process can drain municipal and state financial resources due to the cost of staff overtime, snow removal and wear on equipment. Rescheduling of schools and other municipal programs and meetings can also be costly. The potential 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.

Severe winter weather can lead to flooding in low-lying agricultural areas. Ice that accumulates on branches in orchards and forests can cause branches to break, while the combination of ice and wind can fell trees. Storms that occur in spring can delay planting schedules. Frost that occurs after warmer periods in spring can cause cold weather dieback and damage new growth (MEMA & EOEEA, 2018).

Future Conditions

Increased sea surface temperature in the Atlantic Ocean will cause air moving north over this ocean to hold more moisture. As a result, when these fronts meet cold air systems moving from the north, an even greater amount of snow than normal can be anticipated to fall on Massachusetts. Although no one storm can be linked directly to climate change, the severity of rain and snow events has increased dramatically in recent years. As shown in Figure 3.11, the amount of precipitation released by storms in the Northeast has increased by 71 percent from the baseline level (recorded from 1901 to 1960) and present-day levels (measured from 2001 to 2012) (USGCRP, 2014 as cited in MEMA & EOEEA, 2018).Winter precipitation is predicted to more often be in the form of rain rather than snow.

Figure 3.10: Observed Changes in Heavy Precipitation



Source: NCA, 2014 as cited in MEMA & EOEEA 2018)

Droughts

Hazard Profile

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.

EEA and MEMA partnered to develop the *Massachusetts Drought Management Plan*, of which 2019 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, 2018). 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.

Likely 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.

Probability

As described below, Berkshire County is at lower risk of drought relative to the rest of the Commonwealth. However, that does not eliminate the hazard from potentially impacting the County and the City. The recorded historic patterns show near misses of severe drought conditions. Increases in temperature lead to faster evaporation of reservoirs, waterways, soils, and vegetation.

Geographic Areas Likely Impacted

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 City of North Adams is at risk of drought.

Historic Data

Massachusetts is relatively water-rich, with few documented drought occurrences. The most severe, state-wide droughts occurred in 1879-1883, 1908-1912, 1929-1932, 1939-1944, 1961-1969, 1980-1983, and 2016-2017. Several less-severe droughts occurred in 1999, 2001, 2002, 2007, 2008, 2010, and 2014. The nine-year drought from 1961-1969 is considered the drought of record. The longevity and severity of this drought forced public water suppliers to implement water-use restrictions, and numerous communities utilized emergency water supplies[9].

The most recent and significant drought in Massachusetts since the 1960s 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.[10]

Figure 3.11: Progression of the 2016-17 Drought

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

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[9] *https://www.mass.gov/doc/massachusetts-drought-management-plan/download*

[10] *MA Water Resources Commission, 2017. Annual Report, Fiscal Year 2017. Boston, MA.*

In general, the central portion of the state faired the worse and Berkshire County faired the best, with the county entering the drought later and emerging from the drought earlier than most of the rest of the state. Berkshire County was under a Watch status for two months and under a Warning status for three months during the height of the drought.

Vulnerability Assessment

People

The entire population of North Adams is exposed and vulnerable to drought. Those with access and functional needs and health impaired are at greatest direct risk. Residents and stakeholders who depend on water for their means of income, such as farming, would also be significantly impacted.

The Berkshire region has not suffered a severe, emergency level drought since the 1960s, and it is unclear how well North Adams would fair during a prolonged drought given changes in population, water use, and precipitation patterns.

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. A more detailed discussion of wildfire and the City's vulnerability is found in that section of the report.

Built Environment with Infrastructure and Systems

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. However, if drought led to wildfire across the entire Town, primarily private residential buildings, would be at risk. Additionally, as a result of wildfire, electrical and communication systems would be a significant risk. What water was remaining available would also be at risk of contamination.

Natural Environment

The natural environment is at greatest risk due to drought. Vegetation and wildlife would be challenged to find water to sustain life, and the vegetation and wildlife most sensitive to water availability would die off providing kindling for wildlife and leaving room for invasive species to dominant the landscape.

Drought has a wide-ranging impact on a variety of natural systems. Some of those impacts can include the following (Clark et al., 2016 as cited in MEMA & EOEEA, 2018):

- Reduced water availability, specifically, but not limited to, habitat for aquatic species
- Decreased plant growth and productivity
- Increased wildfires
- Greater insect outbreaks
- Increased local species extinctions
- Lower stream flows and freshwater delivery to downstream estuarine habitats
- Changes in the timing, magnitude, and strength of mixing (stratification) in coastal waters
- Increased potential for hypoxia (low oxygen) events
- Reduced forest productivity
- Direct and indirect effects on goods and services provided by habitats (such as timber, carbon sequestration, recreation, and water quality from forests)
- Limited fish migration or breeding due to dry streambeds or fish mortality caused by dry streambed/

In addition to these direct natural resource impacts, a wildfire exacerbated by drought conditions could cause significant damage to the Commonwealth's environment as well as economic damage related to the loss of valuable natural resources (MEMA & EOEEA, 2018).

Economy

The economic impacts of drought can be substantial, and would primarily affect the agriculture, recreation and tourism, forestry, and energy sectors. For example, drought can result in farmers not being able to plant crops or in the failure of planted crops (MEMA & EOEEA, 2018). Drier summers and intermittent droughts may strain irrigation water supplies, stress crops, and delay harvests (resilient MA, 2018). Droughts affect the ability of farmers to provide fresh produce to neighboring communities. Insufficient irrigation will impact the availability of produce, which may result in higher demand than supply. This can drive up the price of food, leading to economic stress on a broader portion of the economy.

In any season, a drought can also harm recreational companies that rely on water (e.g., ski areas, swimming pools, water parks, and river rafting companies) as well as landscape and nursery businesses because people will not invest in new plants if water is not available to sustain them. Social and environmental impacts are also significant, but data on the extent of damages is more challenging to collect. Although the impacts can be numerous and significant, dollar damage estimates are not tracked or available (MEMA & EOEEA, 2018).

Future Conditions

Changes in winter temperatures will lead to less snowpack 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.

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 the North Adams is 73.8% forested, the risk of wildfire during drought conditions is a concern.

Springfield Park Brush Fire in April 2017 during the Massachusetts 48-week drought

Photo Credit: Matthew Kudlate via Berkshire Eagle

Hazard Profile

Temperature is a fundamental measurement of describing climate, which is the prevailing weather patterns in a given area. Climate determines the types of plant and animal species that are able to survive in a region, and changes in climate will have significant impacts on the landscape because most species will not have the time to evolve and adapt over multiple generations to the new climate[11]. Scientists are still uncovering ways climate change will impact our lives both directly and indirectly.

Likely severity

Relative to the rest of the Commonwealth, the City of North Adams is protected from extreme heat by the higher elevation. Homes have been built to keep in warmth, and few have air conditioners. The environment and people have adapted to cooler conditions; however, extremes in cold and hot still can and will occur, particularly in the changing climate.

NOAA utilizes data to determine average temperature using land-based weather station measurements and by satellite measurements that cover the lowest level of the Earth's atmosphere. In moderate climate like in the Berkshires, the most severe impacts of the change in average temperature will be on our environmental composition, as well as on our vulnerable populations, particularly in urbanized areas like North Adams where there is some level of the Urban Heat Island (UHI) effect.

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

The NWS issues a Heat Advisory when the NWS Heat Index is forecast to reach 100 to 104°F for 2 or more hours. The NWS issues an Excessive Heat Warning if the Heat Index is forecast to reach 105°F or higher for 2 or more hours. The NWS Heat Index is based both on temperature and relative humidity and describes a temperature equivalent to what a person would feel at a baseline humidity level. It is scaled to the ability of a

[11] *https://www.epa.gov/climate-indicators/climate-change-indicators-us-and-global-temperature*

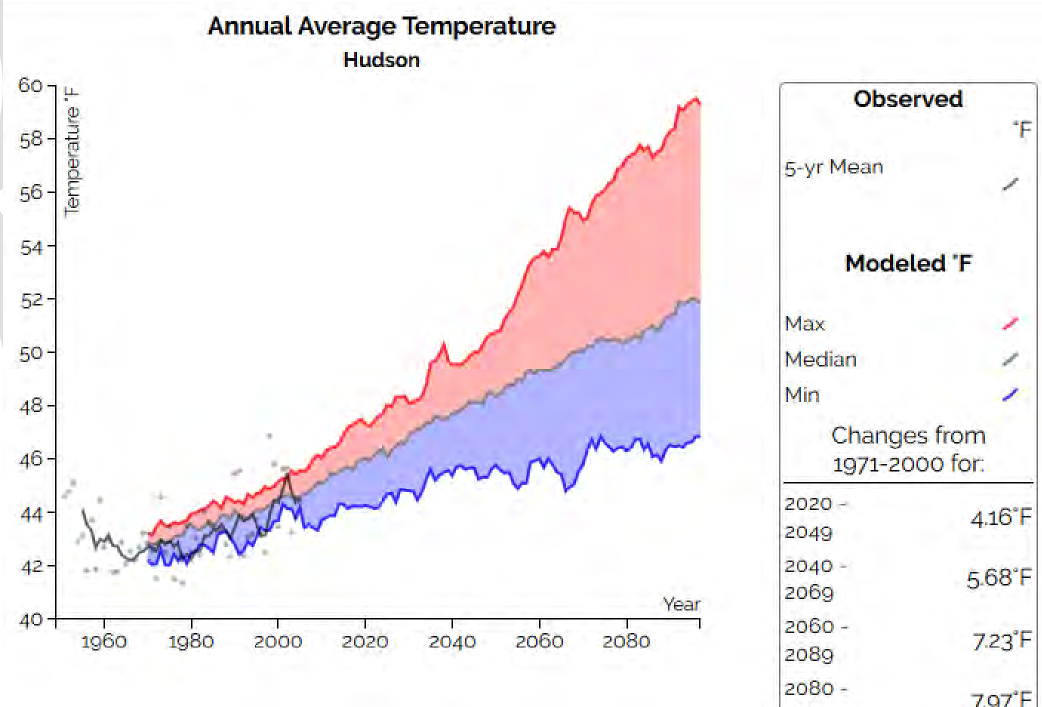
person to lose heat to their environment. It is important to know that the heat index values are devised for shady, light wind conditions. Exposure to full sunshine can increase heat index values by up to 15°F. Also, strong winds, particularly with very hot, dry air, can increase the risk of heat-related impacts.

Extreme heat temperatures are those that are 10°F or more above the average high temperature for the region and last for several hours. A heat wave is defined as 3 or more days of temperatures of 90°F or above. A basic definition of a heat wave implies that it is an extended period of unusually high atmosphere-related heat stress, which causes temporary modifications in lifestyle and which may have adverse health consequences for the affected population (MEMA & EOEEA, 2018).

Probability

The change in average temperatures has already affected North Adams. Figure 3.13 shows the observed and projected annual average temperature, increasing through the next century. In the next 30 years, North Adams, evaluated within the Hudson basin, will warm by an average of 4.16 degrees. According to extensive scientific study, the global changes in climate will lead to extreme temperatures as global weather patterns are altered. Figure 3.14 shows that North Adams has little experience with days over 90°F, but that will soon change as we see more days with dangerous levels of heat.

Figure 3.12: Observed and Projected Annual Average Temperature by Watershed Basin



Source: NECASC on Resilient MA, 2020

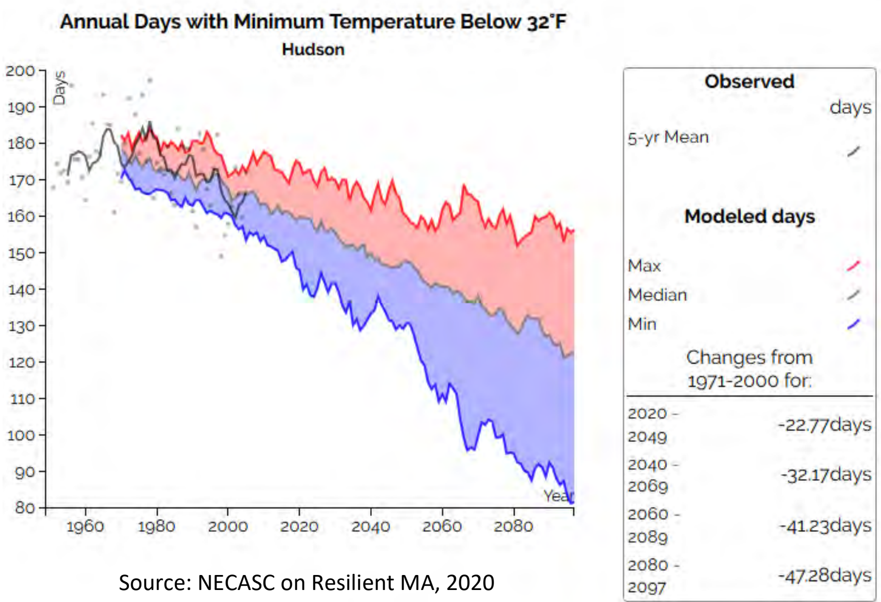
Geographic Areas Likely Impacted

All of North Adams is exposed to the impacts of extreme temperatures and the change in average temperature. Extreme temperature events occur more frequently and vary more in the inland regions where temperatures are not moderated by the Atlantic Ocean. This can have a particular impact on North Adams due to the UHI effect. UHI occurs were there are dark surfaces including pavement and building roofs that absorb heat, anthropogenic heat production such as air conditioners and cars, and a dearth of natural vegetation to provide a cooling effect through evapotranspiration or by providing shade.

Historic Data

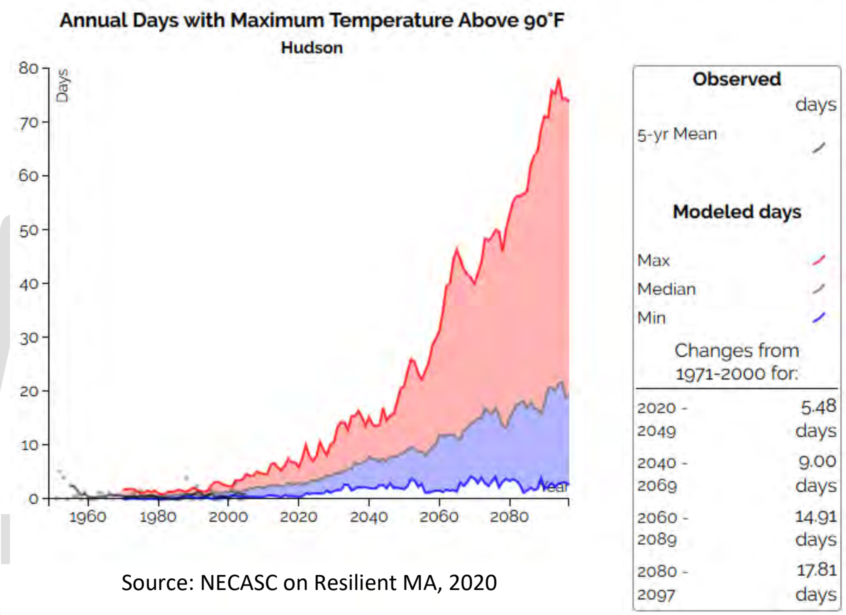
The world's five warmest years have all occurred since 2015 with nine of the 10 warmest years occurring since 2005, according to scientists from NOAA's National Centers for Environmental Information (NCEI)[12]. July is typically the hottest month of the year in North Adams with an average high temperature of 80°F. Since 2008, the hottest recorded July temperature in North Adams is 93.9°F, last occurring in 2018, and previously occurring in 2012, 2011, and 2010[13]. The lowest average temperature in North Adams occurs in January. Since 2008, the lowest recorded temperature for North Adams occurred in 2011 with temperatures at -19.8°F. The average low in January is 14°F.

Figure 3.14: Observed and Projected Days Below 32°F by Watershed Basin



Source: NECASC on Resilient MA, 2020

Figure 3.13: Observed and Projected Days Above 90°F by Watershed Basin



Source: NECASC on Resilient MA, 2020

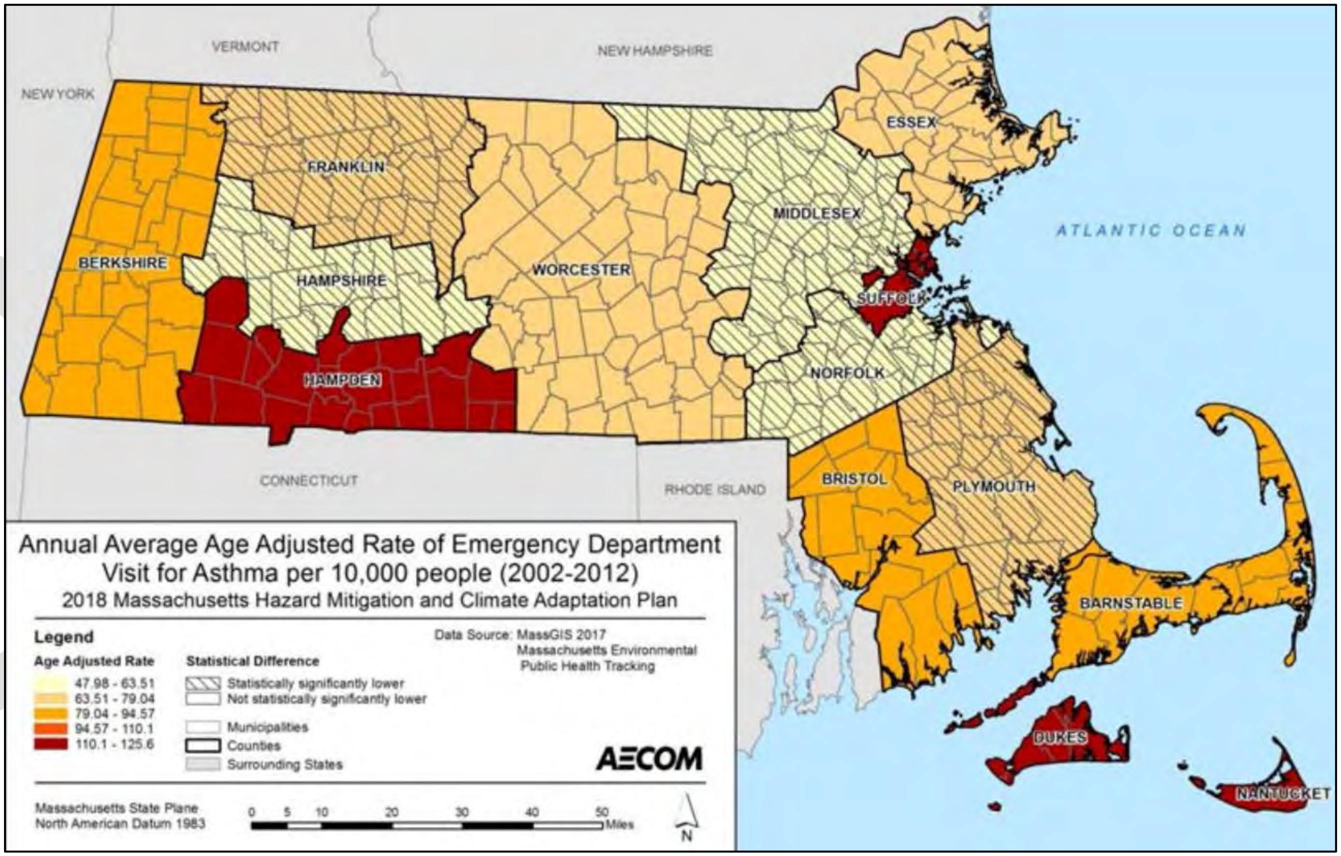
Figure 3.15 shows the decline in observed and projected days below freezing for North Adams. While some might see this as something to celebrate, there will be impacts on everything from natural cycles of snow melt and waterflow to the ability of insects such as ticks to survive and even reproduce at greater rates through the winter. Additional impacts will be discussed in the Vulnerability Assessment.

[12] *https://www.noaa.gov/news/2019-was-2nd-hottest-year-on-record-for-earth-say-noaa-nasa*

[13] *https://www.usclimatedata.com/climate/north-adams/massachusetts/united-states/usma0940/2018/7*

Vulnerability Assessment

Figure 3.15: Rates of Emergency Department Visits Due to Asthma by County



People

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

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. When people are exposed to extreme heat, they can suffer from potentially deadly illnesses, such as heat exhaustion and heat stroke. Heat is the leading weather-related killer in the U.S., even though most heat-related deaths are preventable through outreach and intervention (EPA, 2016). A study of heat-related deaths across Massachusetts estimated that when the temperature rises above the 85th percentile (hot: 85-86°F), 90th percentile (very hot: 87-89°F) and 95th percentile (extremely hot: 89-92°F) there are between five and seven excess deaths per day in Massachusetts.

These estimates were higher for communities with high percentages of African American residents and elderly residents on days exceeding the 85th percentile (Hattis et al., 2011). A 2013 study of heart disease patients in Worcester, MA, found that extreme heat (high temperature greater than the 95th percentile) in the 2 days before a heart attack resulted in an estimated 44 percent increase in mortality. Living in poverty appeared to increase this effect (Madrigano et al., 2013). In 2015, researchers analyzed Medicare records for adults over the age of 65 who were living in New England from 2000 to 2008. They found that a rise in summer mean temperatures of 1°C resulted in a 1 percent rise in the mortality rate due to an increase in the number and intensity of heat events (Shi et al., 2015). Hot temperatures can also contribute to deaths from respiratory conditions (including asthma), heart attacks, strokes, other forms of cardiovascular disease, renal disease, and respiratory diseases such as asthma and chronic obstructive pulmonary disorder. Human bodies cool themselves primarily through sweating and through increasing blood flow to body surfaces. Heat events thus increase stress on cardiovascular, renal, and respiratory systems, and may lead to hospitalization or death in the elderly and those with pre-existing diseases. Massachusetts has a very high prevalence of asthma: approximately 1 out of every 11 people in the state currently has asthma (Mass.gov, n.d.). In Massachusetts, poor air quality often accompanies heat events, as increased heat increases the conversion of ozone precursors in fossil fuel combustion emissions to ozone. Particulate pollution may also accompany hot weather, as the weather patterns that bring heat waves to the region may carry pollution from other areas of the continent. Poor air quality can negatively affect respiratory and cardiovascular systems and can exacerbate asthma and trigger heart attacks.

Built Environment

All elements of the built environment are exposed to the extreme temperature hazard, including state-owned critical facilities. The impacts of extreme heat on buildings include: increased thermal stresses on building materials, which leads to greater wear and tear and reduces a building's useful lifespan; increased air-conditioning demand to maintain a comfortable temperature; overheated heating, ventilation, and air-conditioning systems; and disruptions in service associated with power outages (resilient MA, 2018). Extreme cold can cause materials such as plastic to become less pliable, increasing the potential for these materials to break down during extreme cold events (resilient MA, 2018). In addition to the facility-specific impacts, extreme temperatures can impact critical infrastructure sectors of the built environment in a number of ways, which are summarized in the subsections that follow.

Extreme cold temperature events can damage buildings through freezing or bursting pipes and freeze and thaw cycles. Additionally, manufactured buildings (trailers and mobile homes) and antiquated or poorly constructed facilities may not be able to withstand extreme temperatures. The heavy snowfall and ice storms associated with extreme cold temperature events can also cause power interruptions. Backup power is recommended for critical facilities and infrastructure.

Extreme heat has potential impacts on the design and operation of the transportation system. Impacts on the design include the instability of materials, particularly pavement, exposed to high temperatures over longer periods of time, which can cause buckling and lead to increased failures (MassDOT, 2017). High heat can cause pavement to soften and expand, creating ruts, potholes, and jarring, and placing additional stress on bridge joints. Extreme heat may cause heat stress in materials such as asphalt and increase the frequency of repairs and replacements (resilient MA, 2018). Railroad tracks can expand in extreme heat, causing the track to “kink” and derail trains. Higher temperatures inside the enclosure-encased equipment, such as traffic control devices and signal control systems for rail service, may result in equipment failure (MEMA & EOEEA, 2018). The PanAm railroad cuts through the City of North Adams and the chance of a train carrying unknown chemicals being derailed is of concern to stakeholders.

Natural Environment

There are numerous ways in which changing temperatures will impact the natural environment. Because the species that exist in a given area have adapted to survive within a specific temperature range, extreme temperature events can place significant stress both on individual species and the ecosystems in which they function. High-elevation spruce-fir forests, forested boreal swamp, and higher-elevation northern hardwoods are likely to be highly vulnerable to climate change (MCCS and DFW, 2010). Higher summer temperatures will disrupt wetland hydrology. Paired with a higher incidence and severity of droughts, high temperatures and evapotranspiration rates could lead to habitat loss and wetlands drying out (MCCS and DFW, 2010). Individual extreme weather events usually have a limited long-term impact on natural systems, although unusual frost events occurring after plants begin to bloom in the spring can cause significant damage. However, the impact on natural resources of changing average temperatures and the changing frequency of extreme climate events is likely to be massive and widespread. Climate change is anticipated to be the second-greatest contributor to this biodiversity crisis, which is predicted to change global land use. One significant impact of increasing temperatures may be the northern migration of plants and animals. Over time, shifting habitat may result in a geographic mismatch between the location of conservation land and the location of critical habitats and species the conserved land was designed to protect. Between 1999 and 2018 (fiscal years), the Commonwealth spent more than $395 million on the acquisition of more than 143,033 acres of land and has managed this land under the assumption of a stable climate. As species respond to climate change, they will likely continue to shift their ranges or change their phenologies to track optimal conditions (MCCS and DFW, 2010). As a result, climate change will have significant impacts on traditional methods of wildlife and habitat management, including land conservation and mitigation of non-climate stressors (MCCS and DFW, 2010). Changing temperatures, particularly increasing temperatures, will also have a major impact on the sustainability of our waterways and the connectivity of aquatic habitats (i.e., entire portions of major rivers will dry up, limiting fish passage down the rivers). Additional impacts of warming temperatures include the increased survival and grazing damage of white-tailed deer, increased invasion rates of invasive plants, and increased survival and productivity of insect pests, which cause damage to forests (MCCS and DFW, 2010). As temperature increases, the length of the growing season will also increase. Since the 1960s, the growing season in Massachusetts increased by approximately 10 days (CAT, n.d. as cited in MEMA & EOEEA, 2018).

Climate change is also likely to result in a shift in the timing and durations of various seasons. This change will likely have repercussions on the life cycles of both flora and fauna within the Commonwealth. While there could be economic benefits from a lengthened growing season, a lengthened season also carries a number of risks. The probability of frost damage will increase, as the earlier arrival of warm temperatures may cause many trees and flowers to blossom prematurely only to experience a subsequent frost. Additionally, pests and diseases may also have a greater impact in a drier world, as they will begin feeding and breeding earlier in the year (Land Trust Alliance, n.d. as cited in MEMA & EOEEA, 2018).

Economy 44 CFR § 201.6(c)(2)(i)(B)

The agricultural industry is most directly at risk in terms of economic impact and damage due to extreme temperature and drought events. Extreme heat can result in drought and dry conditions, which directly impact livestock and crop production. Increasing average temperatures may make crops more susceptible to invasive species (see Section 4.3.3 for additional information). Higher temperatures that result in greater concentrations of ozone negatively impact plants that are sensitive to ozone (USGCRP, 2009). Additionally, as previously described, changing temperatures can impact the phenology.

Above average, below average, and extreme temperatures are likely to impact crops—such as apples, cranberries, and maple syrup—that rely on specific temperature regimes (resilient MA, 2018). Unseasonably warm temperatures in early spring that are followed by freezing temperatures can result in crop loss of fruit-bearing trees. Farmers may have the opportunity to introduce new crops that are viable under warmer conditions and longer growing seasons; however, a transition such as this may be costly (resilient MA, 2018 as cited in MEMA & EOEEA, 2018).

Livestock are also impacted, as heat stress can make animals more vulnerable to disease, reduce their fertility, and decrease the rate of milk production. Additionally, scientists believe the use of parasiticides and other animal treatments may increase as the threat of invasive species grows. Increased use of these treatments increases the risk of pesticides entering the food chain and could result in pesticide resistance, which could result in additional economic impacts on the agricultural industry (MEMA & EOEEA, 2018).

Future Conditions

Temperature changes will be gradual over the years. However, for the extremes, meteorologists can accurately forecast event development and the severity of the associated conditions with several days lead time. High, low, and average temperatures in Massachusetts are all likely to increase significantly over the next century as a result of climate change. This gradual change will put long-term stress on a variety of social and natural systems and will exacerbate the influence of discrete events (MEMA & EOEEA, 2018).

Tornadoes/High Wind

Hazard Profile

Likely Severity

Tornadoes are potentially the most dangerous of local storms. If a major tornado were to strike damage could be significant, particularly if there is a home or other facility in its path. Many people could be displaced for an extended period of time; buildings could be damaged or destroyed; businesses could be forced to close for an extended period of time or even permanently; and routine services, such as telephone or power, could be disrupted.

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

Probability

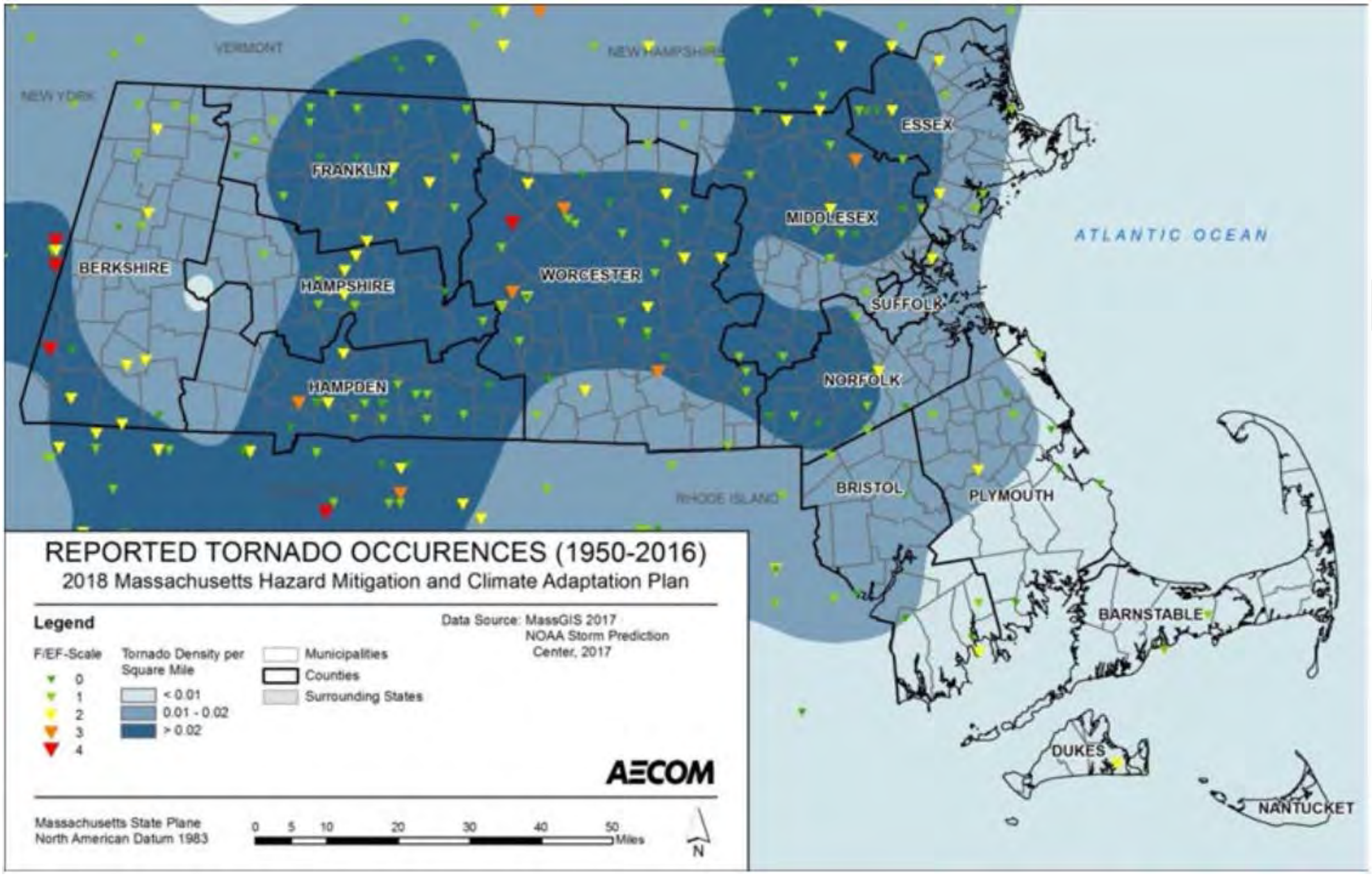
The location of tornado impact is totally unpredictable. Tornadoes are fierce phenomena which generate wind funnels of up to 200 MPH or more, and occur in Massachusetts usually during June, July, and August. Worcester County, and areas just to its west have been dubbed the "tornado alley" of the state, as the majority of significant tornadoes in Massachusetts weather history have occurred in that region (BRPC, 2012).

From 1950 to 2017, the Commonwealth experienced 171 tornadoes, or an average annual occurrence of 2.6 tornado events per year. In the last 20 years, the average frequency of these events has been 1.7 events per year (NOAA, 2018). Massachusetts experienced an average of 1.4 tornadoes per 10,000 square feet annually between 1991 and 2010, less than half of the national average of 3.5 tornadoes per 10,000 square feet per year (NOAA, n.d. as cited in MEMA & EOEEA, 2018).

Geographic Areas Likely Impacted

While the area impacted by a tornado will be limited at the time of the event, anywhere in North Adams is susceptible. Figure 3.15 is show tornadoes reported in Massachusetts.

Figure 3.16: Density of Reported Tornadoes per Square Mile



Historic Data

The National Climatic Data Center reports data on tornado events and does so as far back as 1950. Of the 18 tornados that have occurred in Berkshire County between 1950 and 2018, only one has occurred since 2007, an EF1 in July 2014 in Dalton. Four tornados 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 tornados 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 tornado's 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 (MEMA & EOEEA, 2018).

Vulnerability Assessment

People

In general, vulnerable populations include people over the age of 65, people with low socioeconomic status, people with low English language fluency, people with compromised immune systems, and residents living in areas that are isolated from major roads. Power outages can be life-threatening to those who are dependent on electricity for life support and can result in increased risk of carbon monoxide poisoning. Individuals with limited communication capacity, such as those with limited internet or phone access, may not be aware of impending tornado warnings. The isolation of these populations is also a significant concern, as is the potential insufficiency of older or less stable housing to offer adequate shelter from tornadoes (MEMA & EOEEA, 2018).

Built Environment

All critical facilities and infrastructure are exposed to tornado events. High winds could down power lines and poles adjacent to roads (resilient MA, 2018). Damage to aboveground transmission infrastructure can result in extended power outages. Incapacity and loss of roads and bridges are the primary transportation failures resulting from tornadoes, and these failures are primarily associated with secondary hazards, such as landslide events. Tornadoes can cause significant damage to trees and power lines, blocking roads with debris, incapacitating transportation, isolating populations, and disrupting ingress and egress. Of particular concern are bridges and roads providing access to isolated areas and to the elderly (MEMA & EOEEA, 2018). The hail, wind, debris, and flash flooding associated with tornadoes can cause damage to infrastructure, such as storage tanks, hydrants, residential pumping fixtures, and distribution systems. This can result in loss of service or reduced pressure throughout the system (EPA, 2015). Water and wastewater utilities are also vulnerable to potential contamination due to chemical leaks from ruptured containers. Ruptured service lines in damaged buildings and broken hydrants can lead to loss of water and pressure (EPA, 2015 as cited in MEMA & EOEEA, 2018).

Natural environment

Direct impacts may occur to flora and fauna small enough to be uprooted and transported by the tornado. Even if the winds are not sufficient to transport trees and other large plants, they may still uproot them, causing significant damage to the surrounding habitat. As felled trees decompose, the increased dry matter may increase the threat of wildfire in vegetated areas. Additionally, the loss of root systems increases the potential for soil erosion. Disturbances created by blowdown events may also impact the biodiversity and composition of the forest ecosystem. Invasive plant species are often able to quickly capitalize on the resources (such as sunlight) available in disturbed and damaged ecosystems. This enables them to gain a foothold and establish quickly with less competition from native species. In addition to damaging existing ecosystems, material transported by tornadoes can also cause environmental havoc in surrounding areas. Particular challenges are presented by the possibility of asbestos-contaminated building materials or other hazardous waste being transported to natural areas or bodies of water, which could then become contaminated. Public drinking water reservoirs may also be damaged by widespread winds uprooting watershed forests and creating serious water quality disturbances.

Economy

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

Future Conditions

As highlighted in the National Climate Assessment, tornado activity in the U.S. has become more variable, and increasingly so in the last 2 decades. While the number of days per year that tornadoes occur has decreased, the number of tornadoes on these days has increased. Climate models show projections that the frequency and intensity of severe thunderstorms (which include tornadoes, hail, and winds) will increase (USGCRP, 2017 as cited in MEMA & EOEEA, 2018).

Hazard Profile

The term landslide includes a wide range of ground movements, such as rock falls, deep failure of slopes, and shallow debris flows. The most common types of landslides in Massachusetts include translational debris slides, rotational slides, and debris flows. Most of these events are caused by a combination of unfavorable geologic conditions (silty clay or clay layers contained in glaciomarine, glaciolacustrine, or thick till deposits), steep slopes, and/or excessive wetness leading to excess pore pressures in the subsurface (MEMA & EOEEA, 2018).

Likely Severity

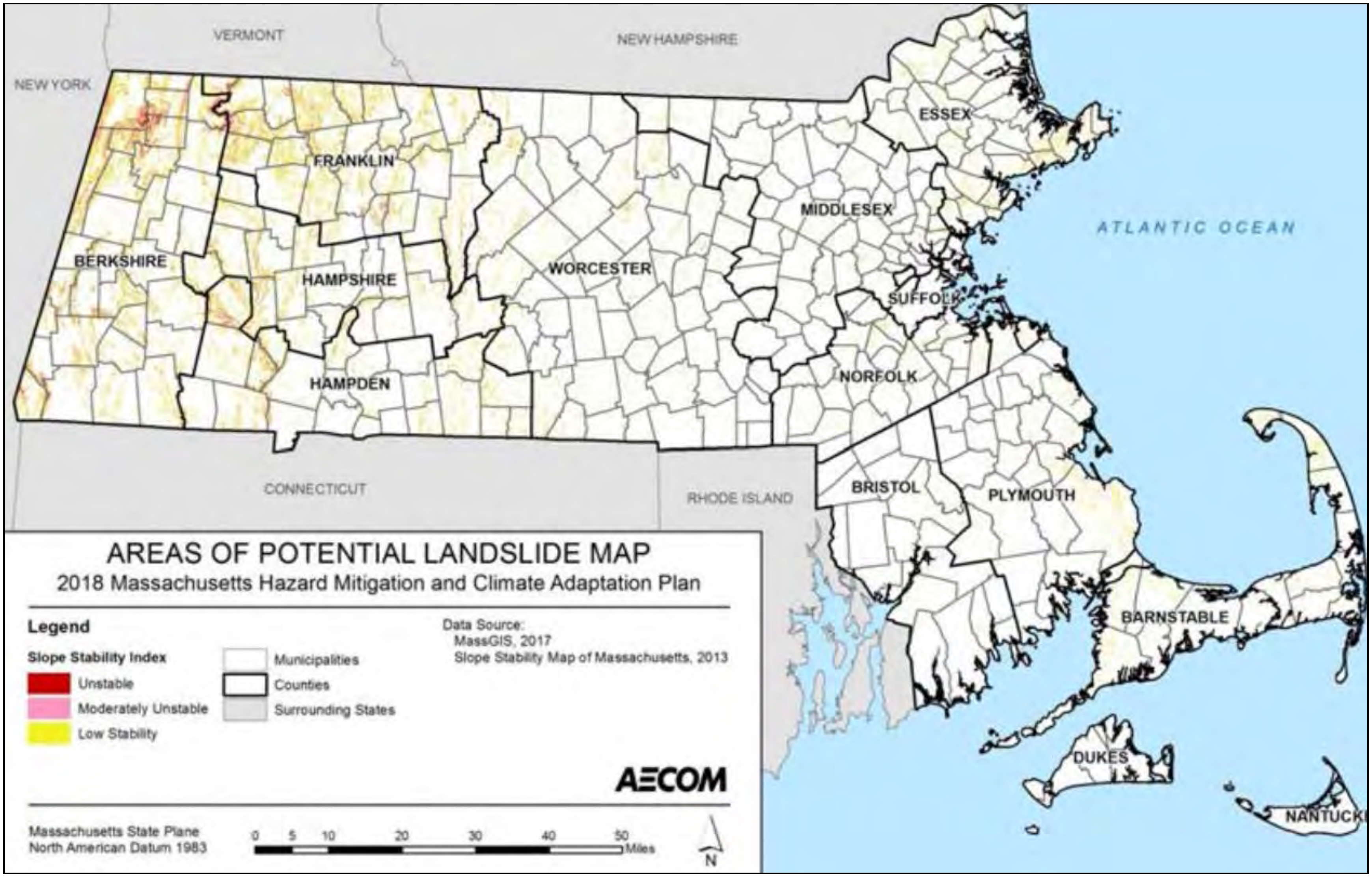
Natural variables that contribute to the overall extent of potential landslide activity in any particular area include soil properties, topographic position and slope, and historical incidence. Predicting a landslide is difficult, even under ideal conditions (MEMA & EOEEA, 2018). Estimations of the potential severity of landslides are informed by previous occurrences as well as an examination of landslide susceptibility. Information about previous landslides provide insight as to both where landslides may occur and what types of damage may result. It is important to note, however, that landslide susceptibility only identifies areas potentially affected and does not imply a time frame when a landslide might occur (MEMA & EOEEA, 2018).

Probability

For the purposes of this HMCAP, the probability of future occurrences is defined by the number of events over a specified period of time. Looking at the recent record, from 1996 to 2012, there were eight noteworthy events that triggered one or more slides in the Commonwealth. However, because many landslides are minor and occur unobserved in remote areas, the true number of landslide events is probably higher. Based on conversations with the Massachusetts Department of Transportation (MassDOT), it is estimated that about 30 or more landslide events occurred in the period between 1986 and 2006 (Hourani, 2006). This roughly equates to one to three landslide events each year.

The probability of instability metric indicates how likely each area is to be unstable. In 2013, the Massachusetts Geological Survey prepared an updated map of potential landslide hazards for the Commonwealth (funded by FEMA's Hazard Mitigation Grant Program) to provide the public, local governments, and emergency management agencies with the location of areas where slope movements have occurred or may possibly occur in the future under conditions of prolonged moisture and high-intensity rainfall (MEMA & EOEEA, 2018). The statewide results of this study are shown in Figure 3.17 and a more detailed results for North Adams are shown in Figure 3.18 with corresponding map legend.

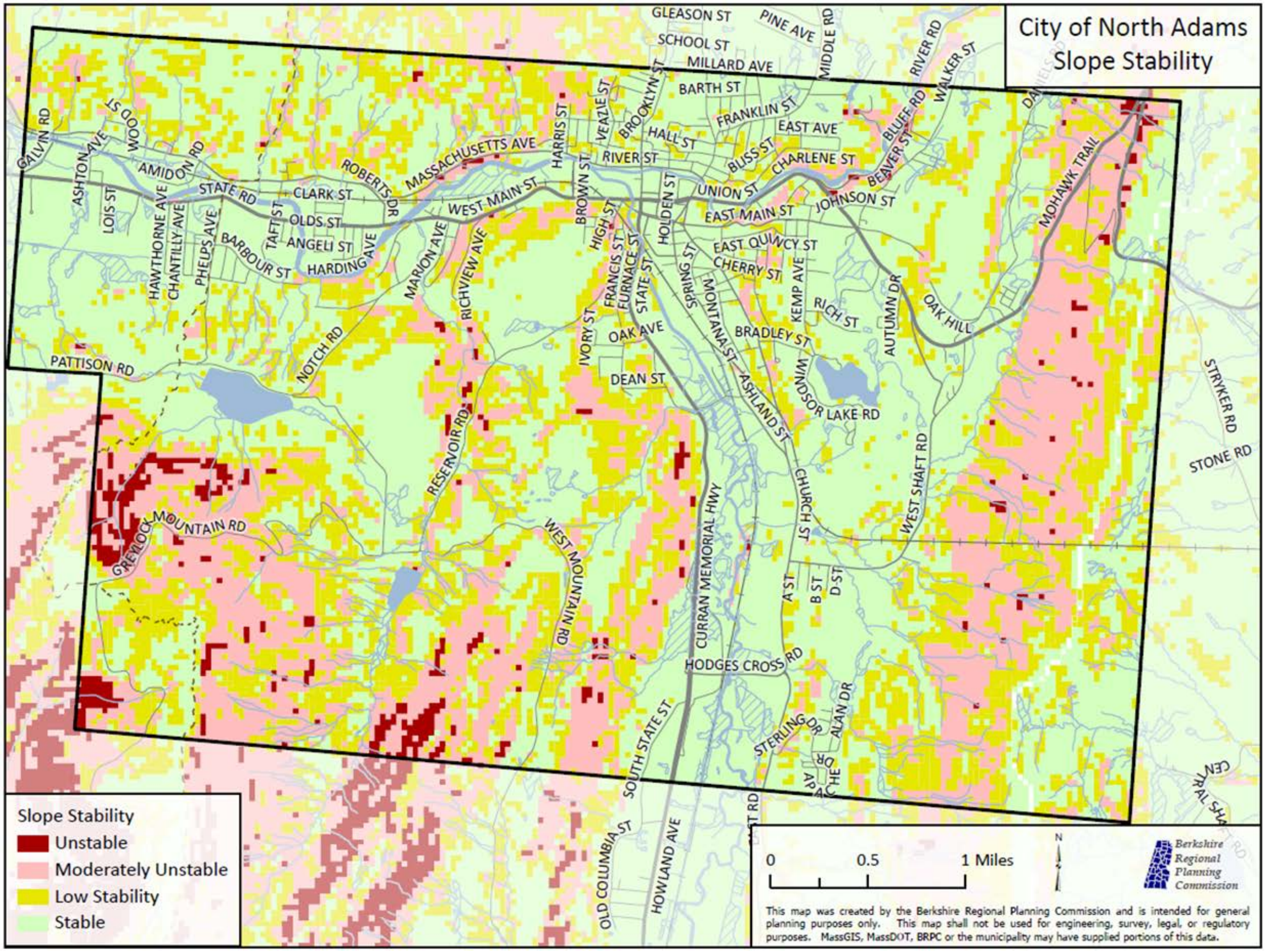
Figure 3.17: Slope Stability Map



[1]**Relative Slide Ranking—**This column designates the relative hazard ranking for the initiation of shallow slides on unmodified slopes. [2]**Stability Index Range—**The stability index is a numerical representation of the relative hazard for shallow translational slope movement initiation based on the factors of safety computed at each point on a 9-meter (~30-foot) digital elevation model grid derived from the National Elevation Dataset. The stability index is a dimensionless number based on factors of safety generated by SINMAP that indicates the probability that a location is stable, considering the most and least favorable parameters for stability input into the model. The breaks in the ranges of values for the stability index categories are the default values recommended by the program developers. [3]**Factors of Safety—**The factor of safety is a dimensionless number computed by SINMAP using a modified version of the infinite slope equation that represents the ratio of the stabilizing forces that resist slope movement to destabilizing forces that drive slope movement (Pack et al., 2001 as cited in MEMA & EOEEA, 2018). A FS>1 indicates a stable slope, a FS<1 indicates an unstable slope, and a FS=1 indicates the marginally stable situation where the resisting forces and driving forces are in balance. [4]**Probability of Instability—**This column shows the likelihood that the factor of safety computed within this map unit is less than one (FS<1, i.e., unstable) given the range of parameters used in the analysis. For example, a <50% probability of instability means that a location is more likely to be stable than unstable given the range of parameters used in the analysis. [5]**Possible Influence of Stabilizing and Destabilizing Factors—**Stabilizing factors include increased soil strength, root strength, or improved drainage. Destabilizing factors include increased wetness or loading, or loss of root strength (Massachusetts Geologic Survey and UMass Amherst, 2013; Pack et al., 2001 as cited in MEMA & EOEEA, 2018).

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

Figure 3.18: City of North Adams Slope Stability/ Landslide Susceptibility Map



Generally accepted warning signs for landslide activity include the following (MEMA & EOEEA, 2018):

- Springs, seeps, or saturated ground in previously dry areas
- New cracks or unusual bulges in the ground
- 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 waterlines 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 even though rain is still falling or has just recently stopped
- Sticking doors and windows, and visible open spaces indicating jambs and frames out of plumb
- A faint rumbling that increases in volume as the landslide nears
- Unusual sounds, such as trees cracking or boulders knocking together

Geographic Areas Likely Impacted

Although specific landslide events cannot be predicted like a storm, a slope stability map shows where slope movements are most likely to occur after periods of high-intensity rainfall. Unstable areas are located throughout the Commonwealth. However, the highest prevalence of unstable slopes is generally found in the western portion of the Commonwealth, including the area around Mount Greylock where North Adams is located, and the nearby portion of the Deerfield River, the U.S. Highway 20 corridor near Chester, as well as the main branches of the Westfield River (MEMA & EOEEA, 2018). Figure 3.17 shows the areas in North Adams that are at risk of landslide. The areas of unstable and moderately unstable slopes does overlap with residential development in North Adams, though it is primarily located within the Mount Greylock State Reservation protected land.

Landslides associated with slope saturation occur predominantly in areas with steep slopes underlain by glacial till or bedrock. Bedrock is relatively impermeable relative to the unconsolidated material that overlies it. Similarly, glacial till is less permeable than the soil that forms above it. Thus, there is a permeability contrast between the overlying soil and the underlying, and less permeable, unweathered till and/or bedrock. Water accumulates on this less permeable layer, increasing the pore pressure at the interface. This interface becomes a plane of weakness. If conditions are favorable, failure will occur (Mabee, 2010 as cited in MEMA & EOEEA, 2018). Occasionally, landslides occur as a result of geologic conditions and/or slope saturation. Adverse geologic conditions exist wherever there are lacustrine or marine clays, as clays have relatively low strength. These clays often formed in the deepest parts of the glacial lakes that existed in Massachusetts following the last glaciation. Landslides can also be caused by external forces, including both undercutting (due to flooding) and construction. Construction-related failures occur predominantly in road cuts excavated into glacial till where topsoil has been placed on top of the till. Examples can be found along the Massachusetts Turnpike. Other construction-related failures occur in utility trenches excavated in materials that have very low cohesive strength and an associated high-water table (usually within a few feet of the surface). This situation occurs in sandy deposits with very few fine sediments and can occur in any part of the Commonwealth (MEMA & EOEEA, 2018).

Historic Data

Historical landslide data for the Commonwealth suggests that most landslides are preceded by 2 or more months of higher than normal precipitation, followed by a single, high-intensity rainfall of several inches or more (Mabee and Duncan, 2013). This precipitation can cause slopes to become saturated. In Massachusetts, landslides tend to be more isolated in size and pose threats to high traffic roads and structures that support tourism, and general transportation. Landslides commonly occur shortly after other major natural disasters, such as earthquakes and floods, which can exacerbate relief and reconstruction efforts. Many landslide events may have occurred in remote areas, causing their existence or impact to go unnoticed. Expanded development and other land uses may contribute to the increased number of landslide incidences and/or the increased number of reported events in the recent record (MEMA & EOEEA, 2018).

The most severe landslide to occur in the Berkshire region occurred along Route 2 in Savoy during T.S. Irene in 2011. The slide was 900 feet long, 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 (BRPC, 2012). The landslide has a significant impact on North Adams because Route 2 is a major transportation route to and from North Adams.

Vulnerability Assessment

People

Populations who rely on potentially impacted roads for vital transportation needs are considered to be particularly vulnerable to this hazard. The number of lives endangered by the landslide hazard is increasing due to the state's growing population and the fact that many homes are built on property atop or below bluffs or on steep slopes subject to mass movement. People in landslide hazard zones are exposed to the risk of dying during a large-scale landslide; however, damage to infrastructure that impedes emergency access and access to health care is the largest health impact associated with this hazard. Mass movement events in the vicinity of major roads could deposit many tons of sediment and debris on top of the road. Restoring vehicular access is often a lengthy and expensive process. Additionally, landslides can result in injury and loss of life. Landslides can impact access to power and clean water and increase exposure to vector-borne diseases.

Built Environment

There are nine buildings located within areas identified as unstable slopes, primarily residential buildings. 184 buildings are in areas designated as moderately unstable, including the previously mentioned nine in unstable areas. Loss of these buildings could result in loss of life. There would also be significant issues with access of roads and neighborhoods.

Landslides can result in direct losses as well as indirect socioeconomic losses related to damaged infrastructure. Infrastructure located within areas shown as unstable on the Slope Stability Map should be considered to be exposed to the landslide hazard. Highly vulnerable areas include mountain roads and transportation infrastructure, both because of their exposure to this hazard and the fact that there may be limited transportation alternatives if this infrastructure becomes unusable. Mass movements can knock out bridge abutments or significantly weaken the soil supporting them, making them hazardous for use. Access to major roads is crucial to life safety after a disaster event and to response and recovery operations. The ability of emergency responders to reach people and property impacted by landslides can be impaired by roads that have been buried or washed out by landslides. The instability of areas where landslides have occurred can also limit the ability of emergency responders to reach survivors.

The energy sector is vulnerable to damaged infrastructure associated with landslides. Transmission lines are generally elevated above steep slopes, but the towers supporting them can be subject to landslides. A landslide may cause a tower to collapse, bringing down the lines and causing a transmission fault. Transmission faults can cause extended and broad area outages (MEMA & EOEEA, 2018).

Surface water bodies may become directly or indirectly contaminated by landslides. Landslides can reduce the flow of streams and rivers, which can result in upstream flooding and reduced downstream flow. This may impact the availability of drinking water (MEMA & EOEEA, 2018).

Natural Environment

Landslides can affect a number of different facets of the environment, including the landscape itself, water quality, and habitat health. Following a landslide, soil and organic materials may enter streams, reducing the potability of the water and the quality of the aquatic habitat. Additionally, mass movements of sediment may result in the stripping of forests, which in turn impacts the habitat quality of the animals that live in those forests (Geertsema and Vaugeouis, 2008 as cited in MEMA & EOEEA, 2018). Flora in the area may struggle to re-establish following a significant landslide because of a lack of topsoil.

Economy

Direct costs of landslide include the actual damage sustained by buildings, property, and infrastructure. Indirect costs, such as clean-up costs, business interruption, loss of tax revenues, reduced property values, and loss of productivity are difficult to measure. Additionally, ground failure threatens transportation corridors, fuel and energy conduits, and communication lines (USGS, 2003 as cited in MEMA & EOEEA, 2018). Landslides that affect farmland can result in significant loss of livelihood and long-term loss of productivity. Forests can also be significantly impacted by landslides.

Future Conditions

Increased precipitation, severe weather events and other effects of climate change affecting the region may lead to a higher likelihood for landslides as soil and vegetative cover are impacted. In a steep sloped and densely developed municipality like North Adams, special attention should be paid to the risk of landslide when making development decisions.

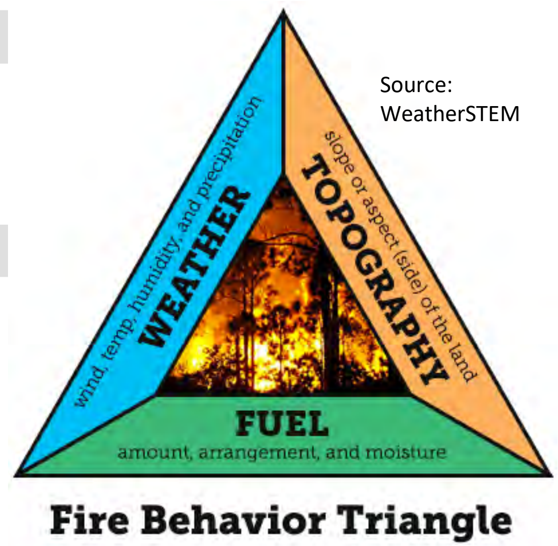
Hazard Profile

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

Likely severity

North Adams has a well-equipped Fire Department that would coordinate with the Commonwealth's Bureau of Forest Fire Control and Forestry and local Fire District Warden. Given the ability to respond, and limited ideal fuel for a large-scale forest fire, North Adams is at low risk of forest fire relative to other hazards. Small brush fires are a much more common occurrence.

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



Source: WeatherSTEM

Fuel:

- Lighter fuels such as grasses, leaves, and needles quickly expel moisture and burn rapidly, while heavier fuels such as tree branches, logs, and trunks take longer to warm and ignite.
- Snags and hazard trees, especially those that are diseased or dying, become receptive to ignition when influenced by environmental factors such as drought, low humidity, and warm temperatures.

Weather:

- Strong winds, especially wind events that persist for long periods or ones with significant sustained wind speeds, can exacerbate extreme fire conditions or accelerate the spread of wildfire.

- Dry spring and summer conditions, or drought at any point of the year, increases fire risk. Similarly, the passage of a dry, cold front through the region can result in sudden wind speed increases and changes in wind direction.
- Thunderstorms in Massachusetts are usually accompanied by rainfall; however, during periods of drought, lightning from thunderstorm cells can result in fire ignition. Thunderstorms with little or no rainfall are rare in New England but have occurred.

Terrain

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

Probability

It is difficult to predict the likelihood of wildfires in a probabilistic manner because a number of factors affect fire potential and because some conditions (e.g., ongoing land use development patterns, location, and fuel sources) exert changing pressure on the wildland-urban interface zone. However, based on the frequency of past occurrences, interested parties should anticipate at least one notable wildfire in the Commonwealth each year, making the probably of North Adams being impacted extremely low.

Geographic Areas Likely Impacted

North Adams is vulnerable to fire across the municipality. Fire risk and associated damages increases where there is a mix of development and forested land. While the risk of fire is relatively low for North Adams compared to the Commonwealth, there is some hazard still posed by wildfire. Given increasing temperature and evaporation, drought and forest fire concerns are growing. A brush fire in neighboring Clarksburg State Forest in 2015 is suspected to have started with an Appalachian Trail hiker's campfire[14]. Mount Williams Reservoir was used by responders to put out the fire. The Mount Williams Reservoir is susceptible to depletion during drought as it was notably low in the 1950s, indicating that back sources and fire ponds are needed in the region.

The ecosystems that are most susceptible to the wildfire hazard are pitch pine, scrub oak, and oak forests, as these areas contain the most flammable vegetative fuels. Other portions of the Commonwealth are also susceptible to wildfire, particularly at the urban-wildland interface, shown in Figure 4-57 . The SILVIS Lab at the University of Wisconsin-Madison Department of Forest Ecology and Management classifies exposure to wildlife hazard as "interface" or "intermix." Intermix communities are those where housing and vegetation intermingle and where the area includes more than 50 percent vegetation and has a housing density greater than one house per 16 hectares (approximately 6.5 acres). Interface

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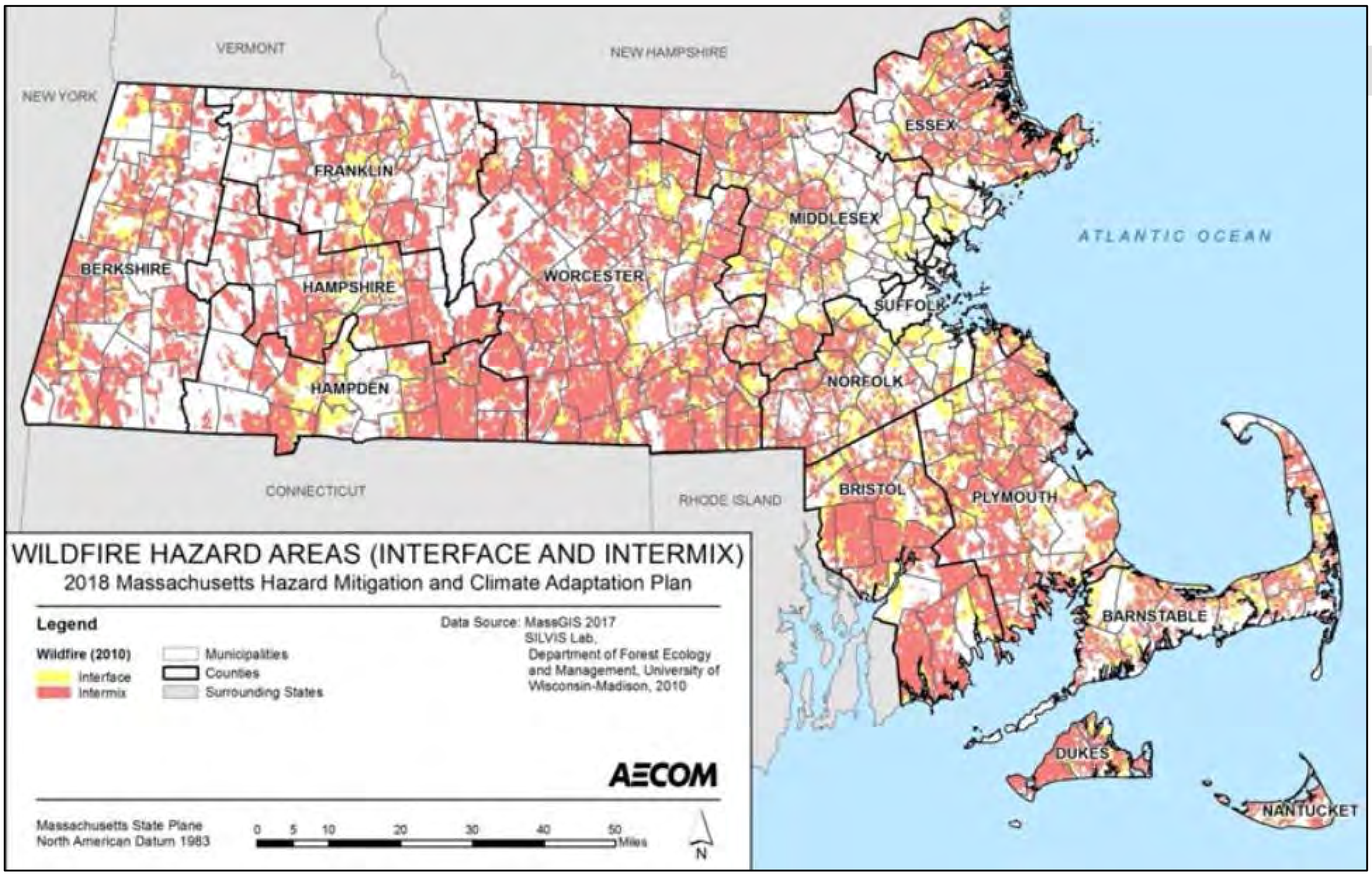
[14] *https://www.berkshireeagle.com/stories/clarksburg-state-forest-brush-fire-successfully-knocked-down,326542#top-carousel*

communities are defined as those in the vicinity of contiguous vegetation, with more than one house per 40 acres and less than 50 percent vegetation, and within 1.5 miles of an area of more than 500 hectares (approximately 202 acres) that is more than 75 percent vegetated. These areas are shown in Figure 4-57. Inventoried assets (population, building stock, and critical facilities) were overlaid with these data to determine potential exposure and impacts related to this hazard. Figure 3.19 shows the results of a geospatial analysis of fire risk by the Northeast Wildfire Risk Assessment Geospatial Work Group.

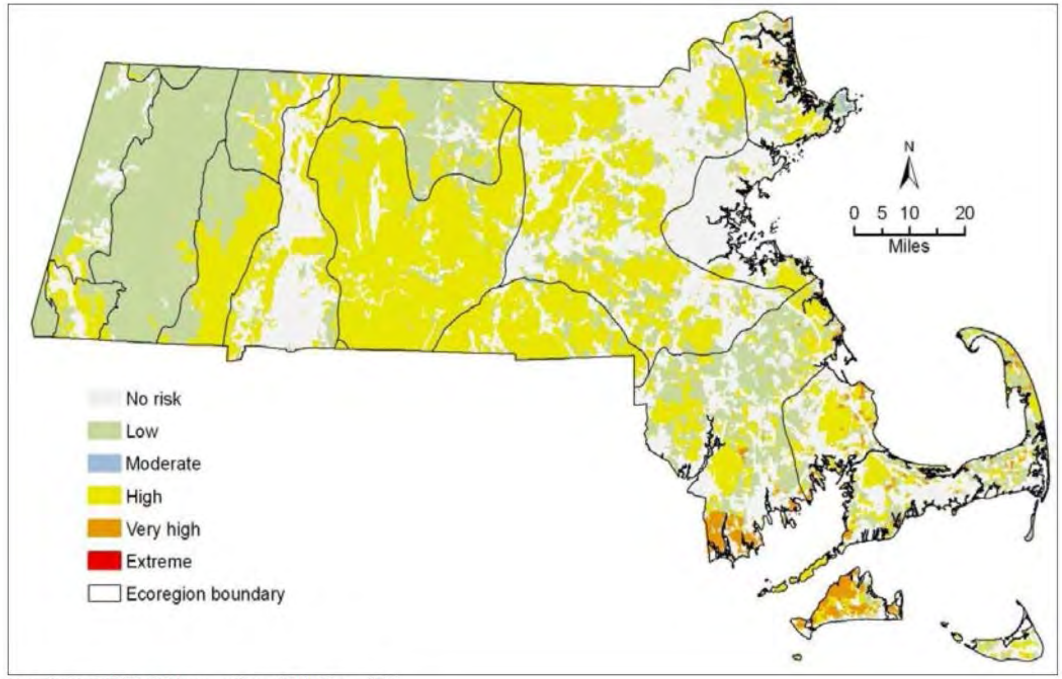
Figure 3.19: Wildland-Urban Interface and Intermix for the Commonwealth of Massachusetts



Historic Data

The wildfire season in Massachusetts usually begins in late March and typically culminates in early June, corresponding with the driest live fuel moisture periods of the year. April is historically the month in which wildfire danger is the highest. Drought, snowpack level, and local weather conditions can impact the length of the fire season (MEMA & EOEEA, 2018).

Figure 3.20: Wildfire Risk Areas for the Commonwealth of Massachusetts



Source: Northeast Wildfire Risk Assessment Geospatial Work Group, 2009

Based on the DCR Bureau of Forest Fire Control and Forestry records, in 1911, more than 34 acres were burned on average during each wildfire statewide. Since then, that figure has been reduced to 1.17 acres 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: 168 acres in Lanesborough in 2008 and 272 acres in Clarksburg near the Williamstown border in 2015. If these incidents were considered statistic outliers and removed from the data, the average totaled burned acres during 2007-2016 would be 39 and the average wildland acres burned would be 19. Berkshire County fire officials respond rapidly through mutual aid and through a coordinated effort with the DCR.

2015 Clarksburg State Forest Fire fought with North Adams Mount Williams reservoir.

Vulnerability Assessment

People

As demonstrated by historical wildfire events, potential losses from wildfire include human health and the lives of residents and responders. The most vulnerable populations include emergency responders and those within a short distance of the interface between the built environment and the wildland environment. In 2018 MEMA and EOEEA estimated the population vulnerable to the wildfire hazard by overlaying the interface and intermix hazard areas with the 2010 U.S. Census population data. The Census blocks identified as interface or intermix were used to calculate the estimated population exposed to the wildfire hazard. Interface or intermix areas are those where buildings intermingle with forest. In Berkshire County 131,219 persons were in Wildlife Hazard Areas. 55,486 in Interface areas, and 39,171 in Intermix areas.

There may be a higher risk posed to the population that lives along the Pan Am railroad tracks where sparks have been noted by residents as the train rides along the tracks. All individuals whose homes or workplaces are located in wildfire hazard zones are exposed to this hazard, as wildfire behavior can be unpredictable and dynamic. However, the most vulnerable members of this population are those who would be unable to evacuate quickly, including those over the age of 65, households with young children under the age of 5, people with mobility limitations, and people with low socioeconomic status. Landowners with pets or livestock may face additional challenges in evacuating if they cannot easily transport their animals. Outside of the area of immediate impact, sensitive populations, such as those with compromised immune systems or cardiovascular or respiratory diseases, can suffer health impacts from smoke inhalation. Individuals with asthma are more vulnerable to the poor air quality associated with wildfire. Finally, firefighters and first responders are vulnerable to this hazard if they are deployed to fight a fire in an area they would not otherwise be in.

Smoke and air pollution from wildfires can be a severe health hazard. Smoke generated by wildfire consists of visible and invisible emissions containing particulate matter (soot, tar, and minerals), gases (water vapor, carbon monoxide, carbon dioxide (CO_2), and nitrogen oxides), and toxics (formaldehyde and benzene). Emissions from wildfires depend on the type of fuel, the moisture content of the fuel, the efficiency (or temperature) of combustion, and the weather. Other public health impacts associated with wildfire include difficulty in breathing, reactions to odor, and reduction in visibility. Due to the high prevalence of asthma in Massachusetts, there is a high incidence of emergency department visits when respiratory irritants like smoke envelop an area. Wildfires may also threaten the health and safety of those fighting the fires. First responders are exposed to dangers from the initial incident and the aftereffects of smoke inhalation and heat-related illness.

Built Environment

All buildings and other facilities are vulnerable to wildfire through direct impacts of burning or indirect through cut off from utilities. If any portion of a communications or and electrical systems were impacted by wildfire it would impact a portion or the entire system.

Drinking water for North Adams would also be at risk of contamination. Most roads would be without damage except in the worst scenarios. However, fires can create conditions that block or prevent access, and they can isolate residents and emergency service providers. The wildfire hazard typically does not have a major direct impact on bridges, but wildfires can create conditions in which bridges are obstructed as well (MEMA & EOEEA, 2018).

Natural environment

Fire is a natural part of many ecosystems and serves important ecological purposes, including facilitating the nutrient cycling from dead and decaying matter, removing diseased plants and pests, and regenerating seeds or stimulating germination of certain plants. However, many wildfires, particularly man-made wildfires, can also have significant negative impacts on the environment. In addition to direct mortality, wildfires and the ash they generate can distort the flow of nutrients through an ecosystem, reducing the biodiversity that can be supported. Frequent wildfires can eradicate native plant species and encourage the growth of fire-resistant invasive species. Some of these invasive species are highly flammable; therefore, their establishment in an area increases the risk of future wildfires. There are other possible feedback loops associated with this hazard. For example, every wildfire contributes to atmospheric CO_2 accumulation, thereby contributing to global warming and increasing the probability of future wildfires (as well as other hazards). There are also risks related to hazardous material releases during a wildfire. During wildfires, containers storing hazardous materials could rupture due to excessive heat and act as fuel for the fire, causing rapid spreading of the wildfire and escalating it to unmanageable levels. In addition, these materials could leak into surrounding areas, saturating soils and seeping into surface waters to cause severe and lasting environmental damage (MEMA & EOEEA, 2018).

Economy

Wildfire events can have major economic impacts on a community, both from the initial loss of structures and the subsequent loss of revenue from destroyed businesses and a decrease in tourism. Individuals and families also face economic risk if their home is impacted by wildfire. The exposure of homes to this hazard is widespread. Additionally, wildfires can require thousands of taxpayer dollars in fire response efforts and can involve hundreds of operating hours on fire apparatus and thousands of man-hours from volunteer firefighters. There are also many direct and indirect costs to local businesses that excuse volunteers from work to fight these fires (MEMA & EOEEA, 2018).

Future Conditions

While climate change is unlikely to change topography, it can alter the weather and fuel factors of wildfires. Climate scenarios project summer temperature increases between 3°F and 9°F and precipitation increases of up 5 inches (Northeast Climate Science Center, 2018). Hot dry spells create the highest fire risk, due to decreased soil moisture and increased evaporation and evapotranspiration. While in general annual precipitation has slightly increased Massachusetts in the past decades, the timing of snow and rainfall is changing. Less snowfall can lead to drier soils earlier in the spring and possible drought conditions in summer. More 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).

- Without an increase in summer precipitation (greater than any predicted by climate models), future areas burned is 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 and 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)

Hazard Profile

Likely Severity

Tropical cyclones (tropical depressions, tropical storms, and hurricanes) form over the warm, moist waters of the Atlantic Ocean, Caribbean Sea, 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, the storm becomes a hurricane. The Saffir-Simpson scale ranks hurricanes based on sustained wind speeds—from Category 1 (74 to 95 mph) to Category 5 (156 mph or more). Category 3, 4, and 5 hurricanes are considered "major" hurricanes. Hurricanes are categorized based on sustained winds; wind gusts associated with hurricanes may exceed the sustained winds and cause more severe localized damage (NOAA, n.d.[b]).

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

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 (BRPC, 2012).

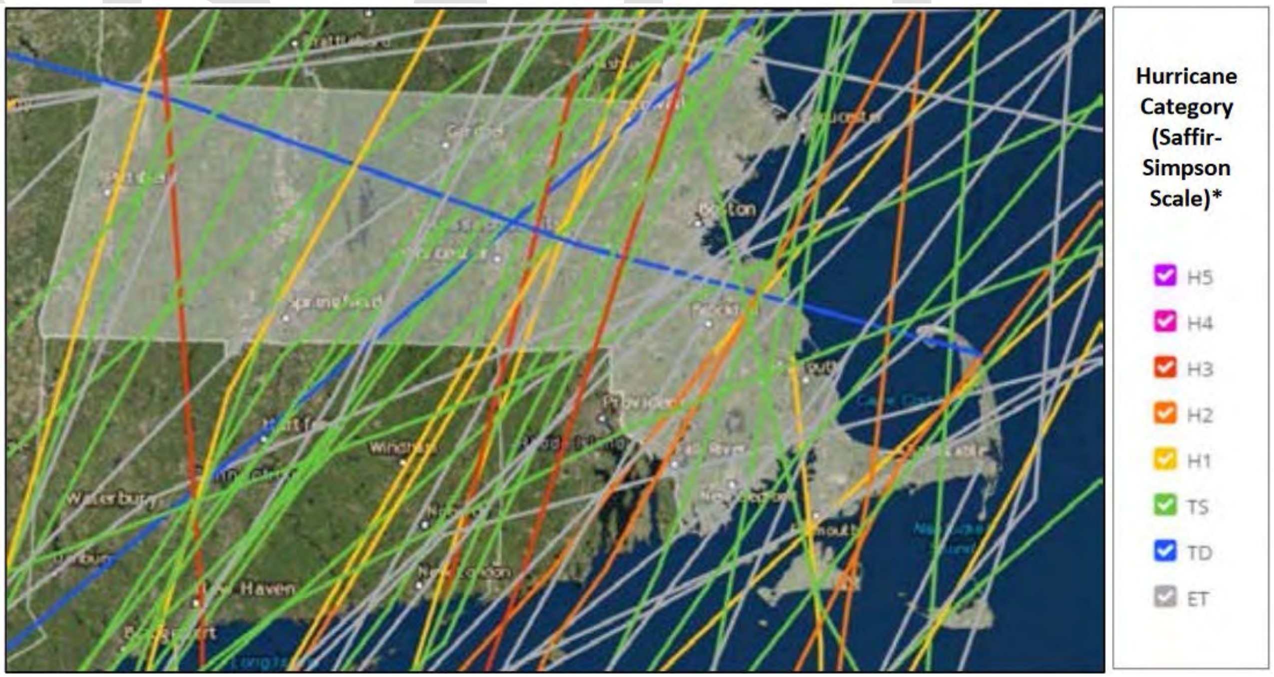
Probability

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

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).

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

Figure 3.21: Historical Hurricane Paths within 65 miles of Massachusetts



Source: NOAA, n.d. as cited in MEMA & EOEEA, 2018 (*TS= Tropical Storm, TD = Tropical Depression)

Geographic Areas Likely Impacted

The entire Commonwealth is vulnerable to hurricanes and tropical storms, depending on each storm's track. Inland areas, especially those in floodplains, near waterways, or isolated in the hills and mountains are at risk for flooding from heavy rain and wind damage. The majority of the damage following hurricanes and tropical storms often results from residual wind damage and inland flooding, as was demonstrated during recent tropical storms. Historic storm tracks can be seen in the NOAA graphic, figure 3.20. The graphic shows tracks that have cut through North Adams, and Hurricane Irene is still a vivid memory for residents of North Adams.

Historic Data

The National Oceanic and Atmospheric Administration (NOAA) has been keeping records of hurricanes since 1842 (Table 3.9). From 1842 to 2018, there have been five (5) Tropical Depressions, five (5) Tropical Storms, one (1) Category 1 Hurricane and one (1) Category 2 Hurricane pass directly through Berkshire County. 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 North Adams. In the Berkshires, two deaths occurred, many other people were injured, and 300 people were left homeless. The West Shaft Road bridge in North Adams was lost, as was the Wally Bridge in Williamstown. The damages from this storm, following devastating flooding and damages from events in 1901, 1922, 1927 and 1936, and combined with that from a severe rain event in 1948, led to the construction of the flood control chutes on the Hoosic River in Adams and North Adams.

Table 3.9: Tropical Depressions, Storms, and Hurricanes Traveling Across 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

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 9 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. Localized flooding in Berkshire County was widespread, with several road washouts. This series of storms resulted in a federal disaster declaration (FEMA DR-1614) and Massachusetts received over $13 million in individual and public assistance. (MEMA, 2013)

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

Locally, TS Irene (DR-4028-MA) is the most memorable storm event in recent history due to the flooding that occurred in northern Berkshire and Franklin Counties in Massachusetts, and in southern Vermont. In Williamstown 225 mobile home households, many elderly and low income, permanently lost their homes in the Spruces Mobile Home Park. Extensive flooding in the Deerfield River watershed caused, among other damages, the closing of Route 2 in Florida/Charlemont (due to collapse of the road and a landslide) and damages to structures in Shelburne Falls.

Vulnerability Assessment

People

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 several factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Populations that live or work in proximity to facilities that use or store toxic substances are at greater risk of exposure to these substances during a flood event such as near the railroad tracks, town garage, or transfer station.

The most vulnerable include people with low socioeconomic status, people over the age of 65, people with medical needs, and those with low English language fluency. For example, people with low socioeconomic status are likely to consider the economic impacts of evacuation when deciding whether to evacuate. Individuals with medical needs may have trouble evacuating and accessing needed medical care while displaced. Those who have low English language fluency may not receive or understand the warnings to evacuate. Findings reveal that human behavior contributes to flood fatality occurrences. For example, people between the ages of 10 and 29 and over 60 years of age are found to be more vulnerable to floods. During and after an event, rescue workers and utility workers are vulnerable to impacts from high water, swift currents, rescues, and submerged debris. Vulnerable populations may also be less likely to have adequate resources to recover from the loss of their homes and jobs or to relocate from a damaged neighborhood (MEMA & EOEEA, 2018).

Built Environment

Hurricanes and tropical storms can destroy homes with wind, flooding, or even fire that results from the destructive forces of the storm. 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. Local and state-owned police and fire stations, other public safety buildings, and facilities that serve as emergency operation centers may experience direct loss (damage) during a hurricane or tropical storm. Emergency responders may also be exposed to hazardous situations when responding to calls. Road blockages caused by downed trees may impair travel.

Heavy rains can lead to contamination of well water and can release contaminants from septic systems (DPH, 2014 as cited in MEMA & EOEEA, 2018). Additionally, hurricanes and tropical storms often result in power outages and contact with damaged power lines during and after a storm, which may result in electrocution.

Natural Environment

The environmental impacts of hurricanes and tropical storms are similar to those described for other hazards, including inland flooding, severe winter storms and other severe weather events. As the storm is occurring, flooding may disrupt normal ecosystem function and wind may fell trees and other vegetation. Additionally, wind-borne or waterborne detritus can cause mortality to animals if they are struck or transported to a non-suitable habitat. In the longer term, impacts to natural resources and the environment as a result of hurricanes and tropical storms are generally related to changes in the physical structure of ecosystems. For example, flooding may cause scour in riverbeds, modifying the river ecosystem and depositing the scoured sediment in another location. Similarly, trees that fall during the storm may represent lost habitat for local species, or they may decompose and provide nutrients for the growth of new vegetation. If the storm spreads pollutants into natural ecosystems, contamination can disrupt food and water supplies, causing widespread and long-term population impacts on species in the area.

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. Due to the wind and water damage, and transportation issues that result, the impact to the economy can potentially be very high.

Future conditions

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.

Hazard Profile

Other severe weather captures the natural hazardous events that occur outside of notable storm events, but still can cause significant damages. These events primarily include high winds and thunderstorms. The City of North Adams has experienced numerous thunderstorms and high wind events including microbursts. Wind is air in motion relative to the surface of the earth. A thunderstorm is a storm originating in a cumulonimbus cloud. Cumulonimbus clouds produce lightning, which locally heats the air to 50,000 degrees Celsius, which in turn produces an audible shock wave, known as thunder. Frequently during thunderstorm events, heavy rain and gusty winds are present. Less frequently, hail is present, which can become very large in size. Tornadoes can also be generated during these events (MEMA & EOEEA, 2018).

Likely Severity

High Winds

Effects from high winds can include downed trees and/or power lines and damage to roofs, windows, and other structural components. High winds can cause scattered power outages. Massachusetts is susceptible to high winds from several types of weather events: before and after frontal systems, hurricanes and tropical storms, severe thunderstorms and tornadoes, and nor'easters. Sometimes, wind gusts of only 40 to 45 mph can cause scattered power outages from downed trees and wires. This is especially true after periods of prolonged drought or excessive rainfall, since both are situations that can weaken the root systems and make them more susceptible to the winds' effects. Winds measuring less than 30 mph are not considered to be hazardous under most circumstances. Wind speeds are measured using the Beaufort wind scale shown in table 3.10.

Thunderstorms

A thunderstorm is classified as "severe" when it produces damaging wind gusts in excess of 58 mph (50 knots), hail that is 1 inch in diameter or larger (quarter size), or a tornado (NWS, 2013). The severity of thunderstorms can vary widely, from commonplace and short-term events to large-scale storms that result in direct damage and flooding. Widespread flooding is the most common characteristic that leads to a storm being declared a disaster. The severity of flooding varies widely based both on characteristics of the storm itself and the region in which it occurs. Lightning can occasionally also present a severe hazard (MEMA & EOEEA, 2018).

Table 3.10: Beaufort Wind Scale – Effects on Land

Force	Wind (Knots)	WMO Classification	Appearance of Wind Effects On Land
0	Less than 1	Calm	Calm, smoke rises vertically
1	1-3	Light Air	Smoke drift indicates wind direction, still wind vanes
2	4-6	Light Breeze	Wind felt on face, leaves rustle, vanes begin to move
3	7-10	Gentle Breeze	Leaves and small twigs constantly moving, light flags extended
4	11-16	Moderate Breeze	Dust, leaves, and loose paper lifted, small tree branches move
5	17-21	Fresh Breeze	Small trees in leaf begin to sway
6	22-27	Strong Breeze	Larger tree branches moving, whistling in wires
7	28-33	Near Gale	Whole trees moving, resistance felt walking against wind
8	34-40	Gale	Twigs breaking off trees, generally impedes progress
9	41-47	Strong Gale	Slight structural damage occurs, slate blows off roofs
10	48-55	Storm	Seldom experienced on land, trees broken or uprooted, "considerable structural damage"
11	56-63	Violent Storm	
12	64+	Hurricane	

Source: NOAA Storm Prediction Center. Developed in 1805 by Sir Francis Beaufort
ft = feet; WMO = World Meteorological Organization

Probability

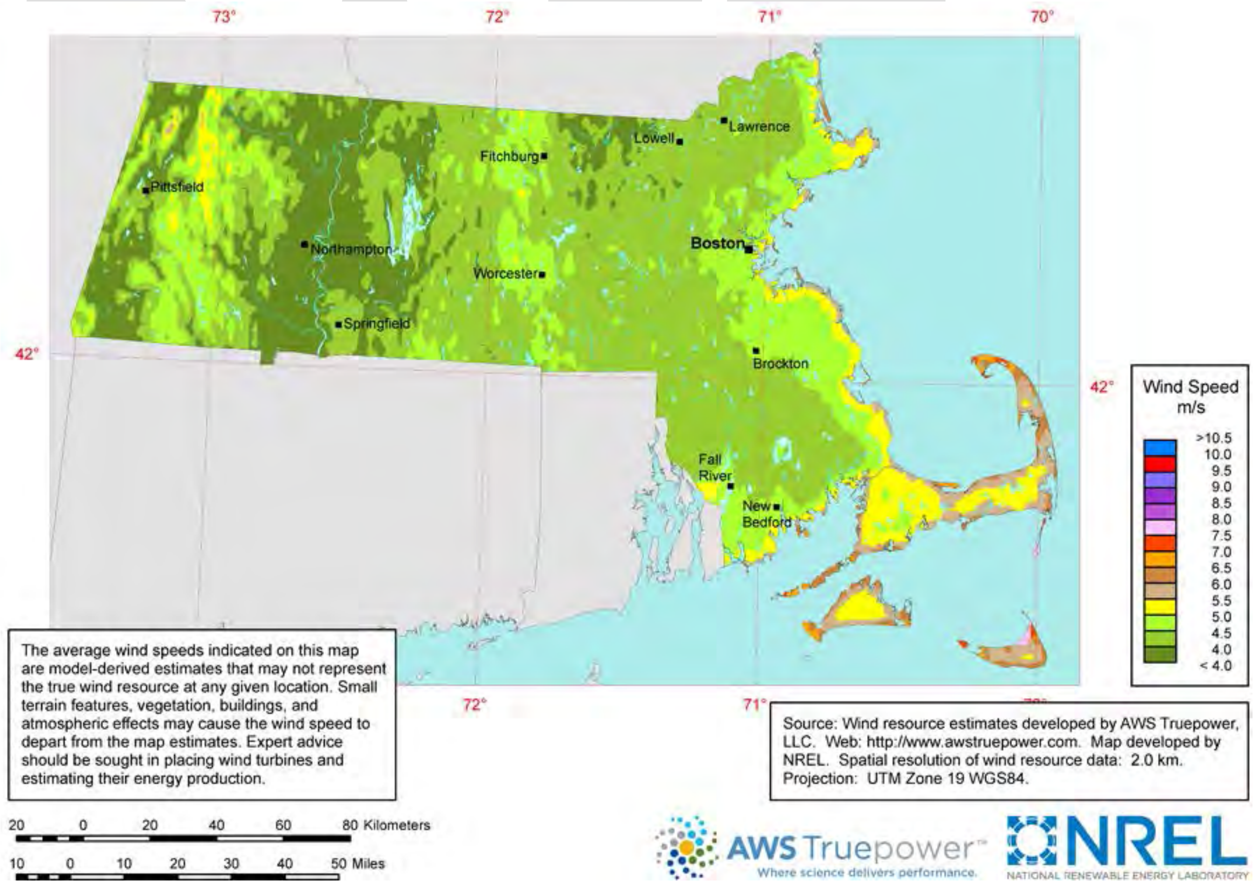
High Winds

Over the last 10 years (between January 1, 2008, and December 31, 2017), a total of 435 high wind events occurred in Massachusetts on 124 days, and an annual average of 43.5 events occurred per year. High winds are defined by NWS 10-1605 as sustained non-convective winds of 35 knots (40 mph) or greater lasting for 1 hour or longer, or gusts of 50 knots (58 mph) or greater for any duration (NCDC, 2018). However, many of these events may have occurred as a result of the same weather system, so this count may overestimate the frequency of this hazard. The probability of future high wind events is expected to increase as a result of climate projections for the state that suggest a greater occurrence of severe weather events in the future.

Thunderstorms

Three basic components are required for a thunderstorm to form: moisture, rising unstable air, and a lifting mechanism. The sun heats the surface of the earth, which warms the air above it. If this warm surface air is forced to rise—by hills or mountains, or areas where warm/cold or wet/dry air bump together causing a rising motion—it will continue to rise as long as it weighs less and stays warmer than the air around it. As the warm surface air rises, it transfers heat from the surface of the earth to the upper levels of the atmosphere (the process of convection). The water vapor it contains begins to cool, releasing the heat, and the vapor condenses into a cloud. The cloud eventually grows upward into areas where the temperature is below freezing. Some of the water vapor turns to ice, and some of it turns into water droplets. Both have electrical charges. When a sufficient charge builds up, the energy is discharged in a bolt of lightning, which causes the sound waves we hear as thunder. An average thunderstorm is 15 miles across and lasts 30 minutes; severe thunderstorms can be much larger and longer. Southern New England typically experiences 10 to 15 days per year with severe thunderstorms (MEMA & EOEEA, 2018).

Figure 3.22: Massachusetts Average Annual Wind Speed at 30 m



Geographic Areas Likely Impacted

High Winds

The entire City is vulnerable to high winds that can cause extensive damage. The heavily developed portions of North Adams are primarily in the valley and protected from high winds, but this quickly changes in the higher elevations.

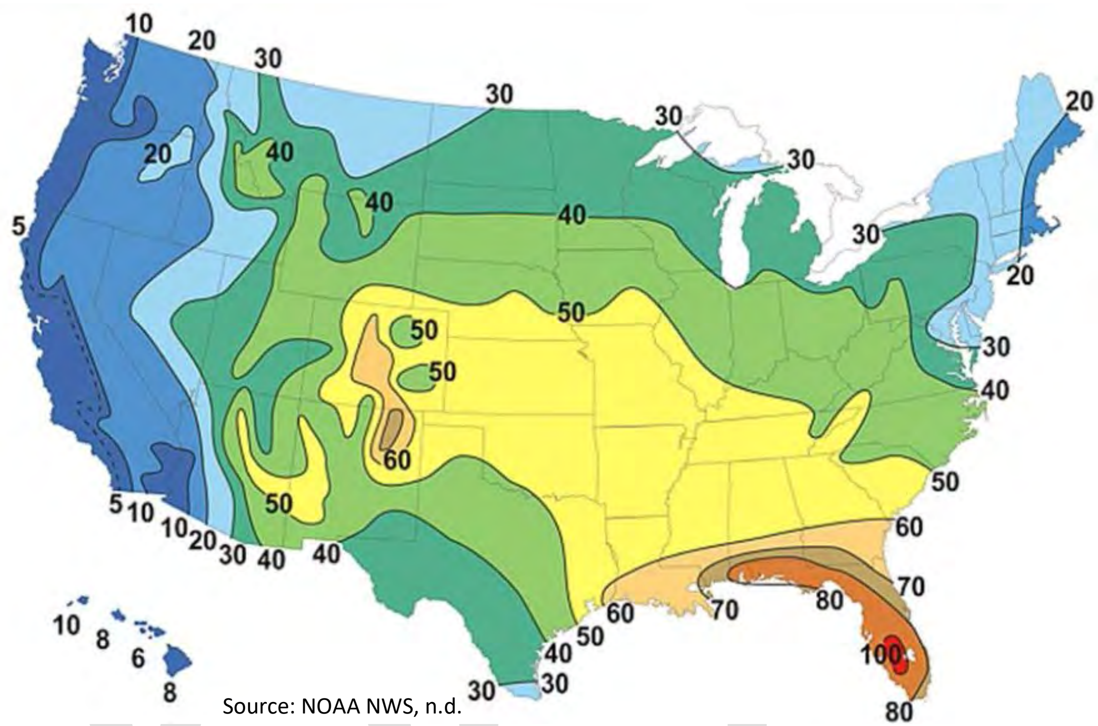
Thunderstorms

Even more so than high wind, thunderstorms have the potential of impacting all North Adams. Microbursts can also occur anywhere associated with thunderstorms.

Historic Data

It is difficult to define the number of other severe weather events experienced by North Adams each year. Figure 3.21 shows number of annual thunderstorm days across the United States. Massachusetts experiences 20 to 30 thunderstorm days each year.

Figure 3.23: Annual Average Number of Thunderstorm Days in the U.S.



Source: NOAA NWS, n.d.

Vulnerability Assessment

People

The entire population of the Commonwealth is considered exposed to high-wind and thunderstorm events. Downed trees, damaged buildings, and debris carried by high winds can lead to injury or loss of life.

Socially vulnerable populations are most susceptible to severe weather based on a number of factors, including their physical and financial ability to react or respond during a hazard, and the location and construction quality of their housing. In general, vulnerable populations include people over the age of 65, the elderly living alone, people with low socioeconomic status, people with low English language fluency, people with limited mobility or a life- threatening illness, and people who lack transportation or are living in areas that are isolated from major roads. The isolation of these populations is a significant concern. Power outages can be life-threatening to those dependent on electricity for life support. Power outages may also result in inappropriate use of combustion heaters, cooking appliances and generators in indoor or poorly ventilated areas, leading to increased risks of carbon monoxide poisoning. People who work or engage in recreation outdoors are also vulnerable to severe weather.

Both high winds and thunderstorms present potential safety impacts for individuals without access to shelter during these events. Extreme rainfall events can also affect raw water quality by increasing turbidity and bacteriological contaminants leading to gastrointestinal illness. Additionally, research has found that thunderstorms may cause the rate of emergency room visits for asthma to increase to 5 to 10 times the normal rate (Andrews, 2012). Much of this phenomenon is attributed to the stress and anxiety that many individuals, particularly children, experience during severe thunderstorms. The combination of wind, rain, and lightning from thunderstorms with pollen and mold spores can exacerbate asthma (UG, 2017). The rapidly falling air temperatures characteristic of a thunderstorm as well as the production of nitrogen oxide gas during lightning strikes have also both been correlated with asthma (MA SHMCAP, 2018).

Built Environment

All elements of the built environment are exposed to severe weather events such as high winds and thunderstorms. Damage to buildings is dependent upon several factors, including wind speed, storm duration, path of the storm track, and building construction. According to the Hazus wind model, direct wind-induced damage (wind pressures and windborne debris) to buildings is dependent upon the performance of components and cladding, including the roof covering (shingles, tiles, membrane), roof sheathing (typically wood-frame construction only), windows, and doors, and is modeled as such. Structural wall failures can occur for masonry and wood-frame walls, and uplift of whole roof systems can occur due to failures at the roof/wall connections. Foundation failures (i.e., sliding, overturning, and uplift) can potentially take place in manufactured homes (MEMA & EOEEA, 2018).

The most common problem associated with severe weather is loss of utilities. Severe windstorms causing downed trees can create serious impacts on power and aboveground communication lines. High winds caused one of the 24 NERC-reported electric transmission outages between 1992 and 2009, resulting in disruption of service to 225,000 electric customers in the Commonwealth (DOE, n.d.). During this period, lightning caused nearly 25,000 disruptions (DOE, n.d.). Downed power lines can cause blackouts, leaving large areas isolated. Loss of electricity and phone connections would leave certain populations isolated because residents would be unable to call for assistance. Additionally, the loss of power can impact heating or cooling provision to citizens (including the young and elderly, who are particularly vulnerable to temperature-related health impacts). Utility infrastructure (power lines, gas lines, electrical systems) could suffer damage, and impacts can result in the loss of power, which can impact business operations. After an event, there is a risk of fire, electrocution, or an explosion.

Public safety facilities and equipment may experience a direct loss (damage) from high winds. Roads may become impassable due to flash or urban flooding, or due to landslides caused by heavy, prolonged rains. Impacts to transportation lifelines affect both short-term (e.g., evacuation activities) and long-term (e.g., day-to-day commuting) transportation needs. The hail, wind, and flash flooding associated with thunderstorms and high winds can cause damage to water infrastructure. Flooding can overburden stormwater, drinking water, and wastewater systems. Water and sewer systems may not function if power is lost (MEMA & EOEEA, 2018).

Natural Environment

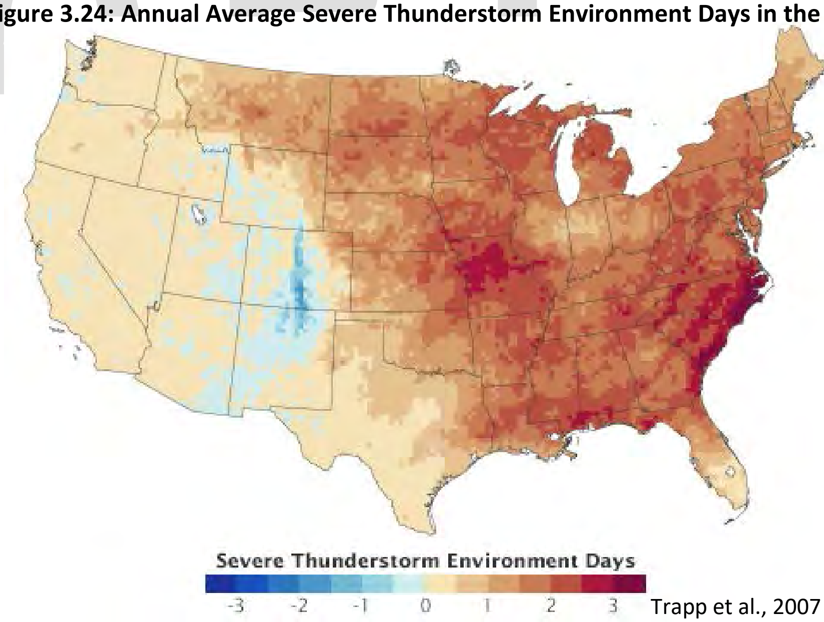
As described under other hazards, such as hurricanes and nor'easters, high winds can defoliate forest canopies and cause structural changes within an ecosystem that can destabilize food webs and cause widespread repercussions. Direct damage to plant species can include uprooting or total destruction of trees and an increased threat of wildfire in areas of tree debris. High winds can also erode soils, which can damage both the ecosystem from which soil is removed as well as the system on which the sediment is ultimately deposited. Environmental impacts of extreme precipitation events are discussed in depth in Section 4.1.1 and often include soil erosion, the growth of excess fungus or bacteria, and direct impacts to wildlife. For example, research by the Butterfly Conservation Foundation shows that above-average rainfall events have prevented butterflies from successfully completing their mating rituals, causing population numbers to decline. Harmful algal blooms and associated neurotoxins can also be a secondary hazard of extreme precipitation events as well as heat. Public drinking water reservoirs may also be damaged by widespread winds uprooting watershed forests and creating serious water quality disturbances (MEMA & EOEEA, 2018).

Economy

Agricultural losses due to lightning and the resulting fires can be extensive. Forestry species and agricultural crops, equipment, and infrastructure may be directly impacted by high winds. Trees are also vulnerable to lightning strikes.

According to the NOAA's Technical Paper on Lightning Fatalities, Injuries, and Damage Reports in the U.S. from 1959 to 1994, monetary losses for lightning events range from less than $50 to greater than $5 million (the larger losses are associated with forest fires, with homes destroyed, and with crop loss) (NOAA, 1997). Lightning can be responsible for damage to buildings; can cause electrical, forest and/or wildfires; and can damage infrastructure, such as power transmission lines and communication towers (MEMA & EOEEA, 2018).

Figure 3.24: Annual Average Severe Thunderstorm Environment Days in the U.S.



Trapp et al., 2007

Future Conditions

Research into the impact of climate change on severe storms such as thunderstorms has looked at the impact of the increased convective available potential energy (CAPE) on frequency and intensity of storms, and a decrease in wind shear as the Artic warms. Some studies show no change in the number of storms, but an increase in intensity due to more energy and evaporated moisture available to fuel storms. Other studies have shown an increase in the number and intensity of storms because the increase in CAPE compensated for a decrease in wind shear[15]. We can expect greater impacts of severe storms in the region while the exact changes are still being determined.

[15] *https://earthobservatory.nasa.gov/features/ClimateStorms*

Hazard Profile

Likely Severity

The City of North Adams chose to examine the hazard of both plant and animal invasive species. Invasive species are defined as non-native species that cause or are likely to cause harm to ecosystems, economies, and/or public health (NISC 2006).

The damage rendered by invasive species is significant. The Massachusetts Invasive Plant Advisory Group (MIPAG), a collaborative representing organizations and professionals concerned with the conservation of the Massachusetts landscape, is charged by EOEEA to provide recommendations to the Commonwealth to manage invasive species of plants. MIPAG defines invasive plants as "non-native species that have spread into native or minimally managed plant systems in Massachusetts, causing economic or environmental harm by developing self-sustaining populations and becoming dominant and/or disruptive to those systems" (MIPAG, n.d.). These species have biological traits that provide them with competitive advantages over native species, particularly because in a new habitat they are not restricted by the biological controls of their native habitat. As a result, these invasive species can monopolize natural communities, displacing many native species and causing widespread economic and environmental damage (MEMA & EOEEA, 2018).

Invasive species are a widespread problem in Massachusetts and throughout the country. The geographic extent of invasive species varies greatly depending on the species in question and other factors, including habitat and the range of the species (MEMA & EOEEA, 2018).

Probability

Increased rates of global trade and travel have created many new pathways for the dispersion of exotic species. As a result, the frequency with which these threats have been introduced has increased significantly. Increased international trade in ornamental plants is particularly concerning because many of the invasive plants species in the U.S. were originally imported as ornamentals.

Geographic Areas Likely Impacted

Experts estimate that about 3 million acres within the U.S. (an area twice the size of Delaware) are lost each year to invasive plants (Pulling Together, 1997, from Mass.gov “Invasive Plant Facts”). The massive scope of this hazard means that the entire Commonwealth experiences impacts from these species. Furthermore, the ability of invasive species to travel far distances (either via natural mechanisms or accidental human interference) allows these species to propagate rapidly over a large geographic area. Similarly, in open freshwater and marine ecosystems, invasive species can quickly spread once introduced, as there are generally no physical barriers to prevent establishment, outside of physiological tolerances, and multiple opportunities for transport to new locations (by boats, for example).

Invasive insects are a significant threat, particularly to trees and everything that depends on those trees from wildlife to people.

Historic Data

Invasive species are a human-caused hazard, often spread when shipping goods between continents, forest products are transported, or people plant nonnative species on their properties for their aesthetic value. Because the presence of invasive species is ongoing rather than a series of discrete events, it is difficult to quantify the frequency of these occurrences.

The terrestrial, freshwater, and marine species listed on the MIPAG website as "Invasive" (last updated April 2016) are listed in Table 3.11. The table also includes details on the nature of the ecological and economic challenges presented by each species as well as information on when and where the species was first detected in Massachusetts (MEMA & EOEEA, 2018).

Table 3.11. Invasive Plants in Massachusetts

Species	Common name	Notes
Terrestrial/Freshwater		
Acer platanoides	Norway maple	A tree occurring in all regions of the state in upland and wetland habitats, and especially common in woodlands with colluvial soils. It grows in full sun to full shade. Escapes from cultivation; can form dense stands; outcompetes native vegetation, including sugar maples; dispersed by wind, water, and vehicles.
Acer pseudoplatanus	Sycamore maple	A tree occurring mostly in southeastern counties of Massachusetts, primarily in woodlands and especially near the coast. It grows in full sun to partial shade. Escapes from cultivation inland as well as along the coast; salt-spray tolerant; dispersed by wind, water, and vehicles.
Aegopodium podagraria	Bishop’s goutweed, bishop’s weed; goutweed	A perennial herb occurring in all regions of the state in uplands and wetlands. Grows in full sun to full shade. Escapes from cultivation; spreads aggressively by roots; forms dense colonies in floodplains.
Ailanthus altissima	Tree of Heaven	This tree occurs in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Spreads aggressively from root suckers, especially in disturbed areas.
Alliaria petiolata	Garlic mustard	A biennial herb occurring in all regions of the state in uplands. Grows in full sun to full shade. Spreads aggressively by seed, especially in wooded areas.
Berberis thunbergii	Japanese barberry	A shrub occurring in all regions of the state in open and wooded uplands and wetlands. Grows in full sun to full shade. Escapes from cultivation; spread by birds; forms dense stands.
Cabomba caroliniana	Carolina fanwort; fanwort	A perennial herb occurring in all regions of the state in aquatic habitats. Common in the aquarium trade; chokes waterways.
Celastrus orbiculatus	Oriental bittersweet; Asian or Asiatic bittersweet	A perennial vine occurring in all regions of the state in uplands. Grows in full sun to partial shade. Escapes from cultivation; berries spread by birds and humans; overwhelms and kills vegetation.
Cynanchum louiseae	Black swallow-wort; Louise’s swallow-wort	A perennial vine occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to partial shade. Forms dense stands, outcompeting native species: deadly to Monarch butterflies.
Elaeagnus umbellata	Autumn olive	A shrub occurring in uplands in all regions of the state. Grows in full sun. Escapes from cultivation; berries spread by birds; aggressive in open areas; has the ability to change soil.
Euonymus alatus	Winged euonymus, burning bush	A shrub occurring in all regions of the state and capable of germinating prolifically in many different habitats. It grows in full sun to full shade. Escapes from cultivation and can form dense thickets and dominate the understory; seeds are dispersed by birds.
Euphorbia esula	Leafy spurge; wolf's milk	A perennial herb occurring in all regions of the state in grasslands and coastal habitats. Grows in full sun. An aggressive herbaceous perennial and a notable problem in the western U.S..

Species	Common name	Notes
Frangula alnus	European buckthorn, glossy buckthorn	Shrub or tree occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Produces fruit throughout the growing season; grows in multiple habitats; forms thickets.
Glaucium flavum	Sea or horned poppy, yellow hornpoppy	A biennial and perennial herb occurring in southeastern MA in coastal habitats. Grows in full sun. Seeds float; spreads along rocky beaches; primarily Cape Cod and Islands.
Hesperis matronalis	Dame's rocket	A biennial and perennial herb occurring in all regions of the state in upland and wetland habitats. Grows in full sun to full shade. Spreads by seed; can form dense stands, particularly in floodplains.
Iris pseudacorus	Yellow iris	A perennial herb occurring in all regions of the state in wetland habitats, primarily in floodplains. Grows in full sun to partial shade. Outcompetes native plant communities.
Lepidium latifolium	Broad-leaved pepperweed, tall pepperweed	A perennial herb occurring in eastern and southeastern regions of the state in coastal habitats. Grows in full sun. Primarily coastal at upper edge of wetlands; also found in disturbed areas; salt tolerant.
Lonicera japonica	Japanese honeysuckle	A perennial vine occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Rapidly growing, dense stands climb and overwhelm native vegetation; produces many seeds that are dispersed by birds; more common in southeastern Massachusetts.
Lonicera morrowii	Morrow's honeysuckle	A shrub occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Part of a confusing hybrid complex of non-native honeysuckles commonly planted and escaping from cultivation via bird dispersal.
Lonicera x bella [morrowii x tatarica]	Bell's honeysuckle	This shrub occurs in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Part of a confusing hybrid complex of non-native honeysuckles commonly planted and escaping from cultivation via bird dispersal.
Lysimachia nummularia	Creeping jenny, moneywort	A perennial herb occurring in all regions of the state in upland and wetland habitats. Grows in full sun to full shade. Escaping from cultivation; problematic in floodplains, forests and wetlands; forms dense mats.
Lythrum salicaria	Purple loosestrife	A perennial herb or subshrub occurring in all regions of the state in upland and wetland habitats. Grows in full sun to partial shade. Escaping from cultivation; overtakes wetlands; high seed production and longevity.
Myriophyllum heterophyllum	Variable water-milfoil; two-leaved water-milfoil	A perennial herb occurring in all regions of the state in aquatic habitats. Chokes waterways, spread by humans and possibly birds.
Myriophyllum spicatum	Eurasian or European water-milfoil; spike water- milfoil	A perennial herb found in all regions of the state in aquatic habitats. Chokes waterways, spread by humans and possibly birds.
Phalaris arundinacea	Reed canary-grass	This perennial grass occurs in all regions of the state in wetlands and open uplands. Grows in full sun to partial shade. Can form huge colonies and overwhelm wetlands; flourishes in disturbed areas; native and introduced strains; common in agricultural settings and in forage crops.

Species	Common name	Notes
Phragmites australis	Common reed	A perennial grass (USDA lists as subshrub, shrub) found in all regions of the state. Grows in upland and wetland habitats in full sun to full shade. Overwhelms wetlands forming huge, dense stands; flourishes in disturbed areas; native and introduced strains.
Polygonum cuspidatum / Fallopia japonica	Japanese knotweed; Japanese or Mexican bamboo	A perennial herbaceous subshrub or shrub occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade, but hardier in full sun. Spreads vegetatively and by seed; forms dense thickets.
Polygonum perfoliatum	Mile-a-minute vine or weed; Asiatic tearthumb	This annual herbaceous vine is currently known to exist in several counties in MA, and has also has been found in RI and CT. Habitats include streamsides, fields, and road edges in full sun to partial shade. Highly aggressive; bird and human dispersed.
Potamogeton crispus	Crisped pondweed, curly pondweed	A perennial herb occurring in all regions of the state in aquatic habitats. Forms dense mats in the spring and persists vegetatively.
Ranunculus ficaria	Lesser celandine; fig buttercup	A perennial herb occurring on stream banks, and in lowland and uplands woods in all regions of the state. Grows in full sun to full shade. Propagates vegetatively and by seed; forms dense stands, especially in riparian woodlands; an ephemeral that outcompetes native spring wildflowers.
Rhamnus cathartica	Common buckthorn	A shrub or tree occurring in all regions of the state in upland and wetland habitats. Grows in full sun to full shade. Produces fruit in fall; grows in multiple habitats; forms dense thickets.
Robinia pseudoacacia	Black locust	A tree that occurs in all regions of the state in upland habitats. Grows in full sun to full shade. While the species is native to central portions of Eastern North America, it is not indigenous to MA. It has been planted throughout the state since the 1700s and is now widely naturalized. It behaves as an invasive species in areas with sandy soils.
Rosa multiflora	Multiflora rose	A perennial vine or shrub occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Forms impenetrable thorny thickets that can overwhelm other vegetation; bird dispersed.
Salix atrocinerea/Salix cinerea	Rusty Willow/Large Gray Willow complex	A large shrub or small tree most commonly found in the eastern and southeastern areas of the state, with new occurrences being reported further west. Primarily found on pond shores but is also known from other wetland types and rarely uplands. Forms dense stands and can outcompete native species along the shores of coastal plain ponds.
Trapa natans	Water chestnut	An annual herb occurring in the western, central, and eastern regions of the state in aquatic habitats. Forms dense floating mats on water.

Table 3.12: Current Invasive and Nuisance Insect Threats to North Adams Forests

Insect	Origin	Host Trees	DCR-Management Approach
Gypsy Moth	Introduced	Oaks, other deciduous species	Discovered in 1869, current management relies on natural population controls- naturally abundant virus and fungus populations regulate gypsy moth population cycles.
Winter Moth	Introduced	Maples, oaks, other deciduous trees (fruit)	Identified in Massachusetts in 2003, it was introduced to Canada in the 1930s. The biocontrol species, Cyzenis albicans, has been released and successfully established to manage winter moth populations in eastern mass.
Hemlock Woolly Adelgid	Introduced	Eastern hemlock	Discovered in 1989, two biocontrol species, Psedudoscymnus tsugae and Laricobius nigrinus, have been released in MA to limited establishment success.
Southern Pine Beetle	Native	Pitch pine	Population densities monitored through annual trapping. The impacts of climate change could significantly alter southern pine beetle generation periods and devastate pitch pine stands.
Emerald Ash Borer	Introduced	All ash species	Discovered in 2012, three biocontrol species, Tetrastichus planipennisi, Spathius galinae, and Oobius agrili, were successfully released in MA. Continued releases are planned.
White Pine Needlecast	Native	Eastern white pines	White pine defoliation is being monitored across the state. Needlecast has been identified to be caused by multiple fungal pathogens; the most prevalent agent in Massachusetts is Lecanosticta acicola.

Source: https://www.mass.gov/service-details/current-forest-health-threats

The Emerald Ash Borer was first discovered in Massachusetts in Dalton, south of North Adams. The Emerald Ash Borer can kill ash trees quickly by drilling holes through the trunks. Communities across the region are responding to the loss of Ash trees on their properties and along powerlines that are vulnerable to falling ash trees.

Emerald Ash Borer.

Vulnerability Assessment

People

Invasive species rarely result in direct impacts on humans, but sensitive people may be vulnerable to specific species that may be present in the state in the future. These include people with compromised immune systems, children under the age of 5, people over the age of 65, and pregnant women. Those who rely on natural systems for their livelihood or mental and emotional well-being are more likely to experience negative repercussions from the expansion of invasive species.

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

Built Environment

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

Invasive species may lead to reduced water quality, which has implications for the drinking water supplies and the cost of treatment.

Natural Environment

An analysis of threats to endangered and threatened species in the U.S. indicates that invasive species are implicated in the decline of 42 percent of the endangered and threatened species. In 18 percent of the cases, invasive species were listed as the primary cause of the species being threatened, whereas in 24 percent of the cases they were identified as a contributing factor (Somers, 2016). A 1998 study found that competition or predation by alien species is the second most significant threat to biodiversity, only surpassed by direct habitat destruction or degradation (Wilcove et al., 1998). This indicates that invasive species present a significant threat to the environment and natural resources in the Commonwealth. Aquatic invasive species pose a particular threat to water bodies. In addition to threatening native species, they can degrade water quality and wildlife habitat. Impacts of aquatic invasive species include:

- Reduced diversity of native plants and animals
- Impairment of recreational uses, such as swimming, boating, and fishing
- Degradation of water quality
- Degradation of wildlife habitat
- Increased threats to public health and safety
- Diminished property values
- Declines in fin and shellfish populations
- Loss of coastal infrastructure due to the habits of fouling and boring organisms
- Local and complete extinction of rare and endangered species (EOEEA, 2002 as cited by MEMA & EOEEA, 2018)

Economy

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

Invasive species are widely considered to be one of the costliest natural hazards in the U.S. A widely cited paper (Pimental et al., 2005) found that invasive species cost the U.S. more than $120 billion in damages every year. One study found that in 1 year alone, Massachusetts agencies spent more than $500,000 on the control of invasive aquatic species through direct efforts and cost-share assistance. This figure does not include the extensive control efforts undertaken by municipalities and private landowners, lost revenue due to decreased recreational opportunities, or decreases in property value due to infestations (Hsu,2000). Individuals who are particularly vulnerable to the economic impacts of this hazard would include all groups who depend on existing ecosystems in the Commonwealth for their economic success. This includes all individuals working in agriculture-related fields, as well as those whose livelihoods depend on outdoor recreation activities such as hunting, hiking, or aquatic sports. Additionally, homeowners whose properties are adjacent to vegetated areas could experience property damage in a number of ways. For example, the roots of the Tree of Heaven (Ailanthus altissima) plant are aggressive enough that they can damage both sewer systems and house foundations up to 50 to 90 feet from the parent tree (MEMA & EOEEA, 2018).

Future Conditions

Temperature, concentration of CO_2 in the atmosphere, frequency and intensity of hazardous events, atmospheric concentration of CO_2, and available nutrients are key factors in determining species survival. It is likely that climate change will alter all of these variables. As a result, climate change is likely to stress native ecosystems and increase the chances of a successful invasion. Additionally, some research suggests that elevated atmospheric CO_2 concentrations could reduce the ability of ecosystems to recover after a major disturbance, such as a flood or fire event. As a result, invasive species—which are often able to establish more rapidly following a disturbance—could have an increased probability of successful establishment or expansion. Other climate change impacts that could increase the severity of the invasive species hazard include the following (Bryan and Bradley, 2016; Mineur et al., 2012; Schwartz, 2014; Sorte,2014; Stachowicz et al., 2002 as cited in MEMA & EOEEA, 2018):

- Elevated atmospheric CO2 levels could increase some organisms' photosynthetic rates, improving the competitive advantage of those species.
- Changes in atmospheric conditions could decrease the transpiration rates of some plans, increasing the amount of moisture in the underlying soil. Species that could most effectively capitalize on this increase in available water would become more competitive.
- Fossil fuel combustion can result in widespread nitrogen deposition, which tends to favor fast-growing plant species. In some regions, these species are primarily invasive, so continued use of fossil fuels could make conditions more favorable for these species.
- As the growing season shifts to earlier in the year, several invasive species (including garlic mustard, barberry, buckthorn, and honeysuckle) have proven more able to capitalize by beginning to flower earlier, which allows them to outcompete later-blooming plants for available resources. Species whose flowering times do not respond to elevated temperatures have decreased in abundance.
- Some research has found that forests pests (which tend to be ectotherms, drawing their body heat from environmental sources) will flourish under warming temperatures. As a result, the population sizes of defoliating insects and bark beetles are likely to increase.
- Warmer winter temperatures also mean that fewer pests will be killed off over the winter season, allowing populations to grow beyond previous limits.
- There are many environmental changes possible in the aquatic environment that can impact the introduction, spread, and establishment of aquatic species, including increased water temperature, decreased oxygen concentration, and change in pH. For example, increases in winter water temperatures could facilitate year-round establishment of species that currently cannot overwinter in New England (Sorte, 2014 as cited in MEMA & EOEEA, 2018).

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

Hazard Profile

Likely severity

The City of North Adams chose to examine the hazard of vector-borne diseases in their community. Vector-borne disease are defined by the CDC as illnesses in humans derived from a vector, including mosquitoes, ticks, and fleas that spread pathogens. Examples of mosquito-borne diseases include Chikungunya, Eastern Equine Encephalitis (EEE), Zika, and the West Nile Virus. Examples of tick-borne diseases include Lyme Disease, Anaplasmosis/Ehrlichiosis, Babesiosis, and Powassan.

The damage rendered by vector-borne diseases can be significant in a community, and can drastically affect quality of life, ability to work, loss of specific bodily functions, increase life-long morbidity and increase mortality.

Probability

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

The Berkshires provide outdoor recreation opportunities for both residents and visitors, including hiking, swimming, mountain biking, and camping. Increased exposure to the outdoors, particularly to areas with heavy tree and forest cover, and areas with tall grass or standing water, significantly increase a person's exposure to vector-borne illnesses. Increases in average year-round temperature during the past few decades has also led to the over-wintering of ticks in Berkshire County, and a lengthening warm season, among other characteristics of the Berkshire environment, has increased tick and mosquito populations significantly. Cases of Lyme in Berkshire County have increased by [fill in with Berk data]. Additionally, Massachusetts has seen cases of once non-existent or very rare tick borne illnesses rise, including Anaplasmosis/Ehrlichiosis (848 cases in 2016, can be fatal), Babesiosis (518 cases in 2016, significantly higher than any other state, can be fatal), Lyme (198 cases in 2016), Powassan (5 cases in 2016, fatality rate is 10%), Spotted fever rickettsiosis (8 cases in 2016, 20% untreated cases are fatal), and Tularemia (5 cases in 2016).

Geographic Areas Likely Impacted

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

Historic Data

In the United States in 2016, a total of 96,075 cases were reported, 1,827 of which were reported in the state of Massachusetts. In Berkshire County, [drop in local data and data source]. The CDC indicates that cases of vector-borne diseases are substantially underreported. Tickborne illnesses more than doubled between 2004 and 2016 and accounted for 77% of all vector-borne disease reports in the United States. Lyme disease accounted for 82% of all tickborne cases, but spotted fever rickettsioses, babesiosis, and anaplasmosis/ehrlichiosis cases also increased. During the years of 2004 to 2016, nine vector-borne human diseases were reported for the first time from the United States and US territories. According to the CDC, vector-borne diseases have been difficult to prevent and control, and a Food and Drug Administration (FDA) approved vaccine is only available for yellow fever virus. Insecticide resistance is widespread and is increasing.

Vulnerability Assessment

People

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

Built Environment

Vector-borne illnesses pose little threat to the built environment in a community. Overtime we may see changes in development as people respond to the increase in disease carrying insects.

Natural Environment

Increases in vector-borne illnesses can increase the likelihood that a community needs to use chemical pesticides and herbicides to control vector populations. The increased use of these products and chemicals can significantly affect the natural environment, including vegetation and other animal populations. Reducing populations of ticks and mosquitos can reduce the food source for other dependent animal populations. Additionally, diseases carried by insects can affect wildlife as they do humans. There is also the risk of people reacting to the threat of disease by altering the environment to not support habitat, severely damaging long-term ecosystem health.

Economy

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

Future Conditions

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

References:

CDC May 1, 2018 https://www.cdc.gov/ncezid/dvbd/vital-signs/2016-data.html
CDC September 9, 2019 https://www.cdc.gov/climateandhealth/effects/vectors.htm
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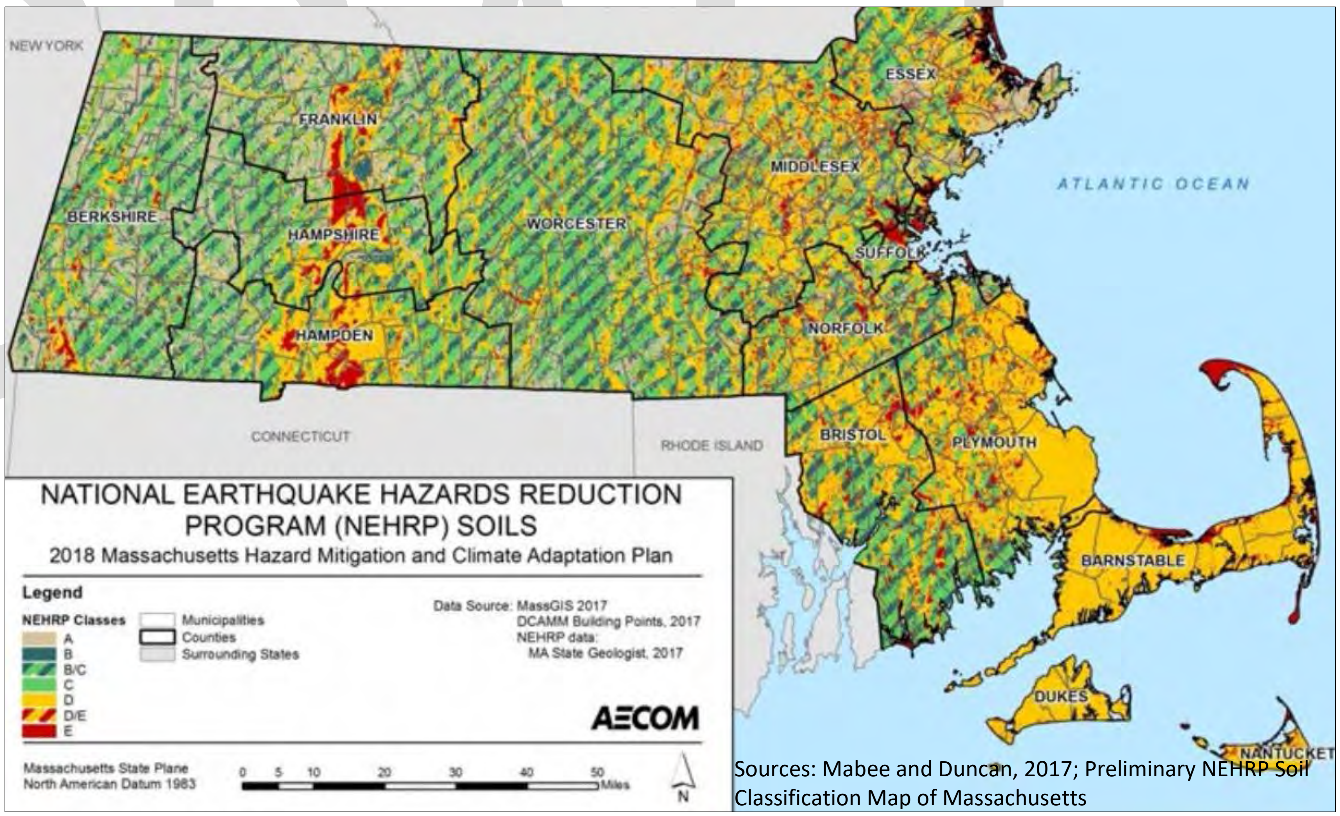
CDC December 13, 2018 https://www.cdc.gov/tularemia/diagnosistreatment/index.html
CDC 2020 https://wwwn.cdc.gov/nndss/conditions/spotted-fever-rickettsiosis/case-definition/2020/
CDC July 17, 2019 https://www.cdc.gov/powassan/index.html
Dept. of Health, Rhode Island https://health.ri.gov/diseases/ticks/?parm=26
New York State Dept. of Health https://www.health.ny.gov/diseases/communicable/ehrlichiosis/fact_sheet.htm

Hazard Profile

An earthquake is the vibration of the Earth's surface that follows a release of energy in the Earth's crust. These earthquakes often occur along fault boundaries. As a result, areas that lie along fault boundaries—such as California, Alaska, and Japan—experience earthquakes more often than areas located within the interior portions of these plates, including North Adams (MEMA & EOEEA, 2018).

Likely severity

Figure 3.25: NEHRP Soil Types in Massachusetts



Sources: Mabee and Duncan, 2017; Preliminary NEHRP Soil Classification Map of Massachusetts

Ground shaking is the primary cause of earthquake damage to man-made structures. This damage can be increased due to the fact that soft soils amplify ground shaking. A contributor to site amplification is the velocity at which the rock or soil transmits shear waves (S waves). The National Earthquake Hazards Reduction Program (NEHRP) developed five soil classifications, which are defined by their S-wave velocity, that impact the severity of an earthquake. The soil classification system ranges from A to E, where A represents hard rock that reduces ground motions from an earthquake and E represents soft soils that amplify and magnify ground shaking and increase building damage and losses. These soil types are shown in Figure 3.22. Soil types A, B, C, and D are reflected in the HAZUS analysis that generated the exposure and vulnerability results later in the section (MEMA & EOEEA, 2018).

The location of an earthquake is commonly described by the geographic position of its epicenter and by its focal depth. The focal depth of an earthquake is the depth from the surface to the region where the earthquake's energy originates (the focus). Earthquakes with focal depths up to about 43.5 miles are classified as shallow. Earthquakes with focal depths of 43.5 to 186 miles are classified as intermediate. The focus of deep earthquakes may reach depths of more than 435 miles. The focus of most earthquakes is concentrated in the upper 20 miles of the Earth's crust. The depth to the Earth's core is about 3,960 miles, so even the deepest earthquakes originate in relatively shallow parts of the Earth's interior. The epicenter of an earthquake is the point on the Earth's surface directly above the focus. Seismic waves are the vibrations from earthquakes that travel through the Earth and are recorded on instruments called seismographs. The magnitude or extent of an earthquake is a seismograph-measured value of the amplitude of the seismic waves. The Richter magnitude scale (Richter scale) was developed in 1932 as a mathematical device to compare the sizes of earthquakes. The Richter scale is the most widely known scale for measuring earthquake magnitude. It has no upper limit and is not used to express damage. An earthquake in a densely populated area, which results in many deaths and considerable damage, can have the same magnitude as an earthquake in a remote area that causes no damage. The perceived severity of an earthquake is based on the observed effects of ground shaking on people, buildings, and natural features, and severity varies with location. Intensity is expressed by the Modified Mercalli Scale, which describes how strongly an earthquake was felt at a particular location. The Modified Mercalli Scale expresses the intensity of an earthquake's effects in a given locality in values ranging from I to XII. Seismic hazards are also expressed in terms of PGA, which is defined by USGS as "what is experienced by a particle on the ground" in terms of percent of acceleration force of gravity. More precisely, seismic hazards are described in terms of Spectral Acceleration, which is defined by USGS as "approximately what is experienced by a building, as modeled by a particle on a massless vertical rod having the same natural period of vibration as the building" in terms of percent of acceleration force of gravity (percent g).

Because of the low frequency of earthquake occurrence and the relatively low levels of ground shaking that are usually experienced, the entirety of the Commonwealth and the City of North Adams can be expected to have a low to moderate risk to earthquake damage as compared to other areas of the country. However, impacts at the local level can vary based on types of construction, building density, and soil type, among other factors (MEMA & EOEEA, 2018).

Probability

New England experiences intraplate earthquakes because it is located deep within the interior of the North American plate. Scientists are still exploring the cause of intraplate earthquakes, and many believe these events occur along geological features that were created during ancient times and are now weaker than the surrounding areas (MEMA & EOEEA, 2018).

A 1994 report by the USGS, based on a meeting of experts at the Massachusetts Institute of Technology, provides an overall probability of occurrence. Earthquakes above about magnitude 5.0 have the potential for causing damage near their epicenters, and larger magnitude earthquakes have the potential for causing damage over larger areas. This report found that the probability of a magnitude 5.0 or greater earthquake centered somewhere in New England in a 10-year period is about 10 percent to 15 percent. This probability rises to about 41 percent to 56 percent for a 50-year period. The last earthquake with a magnitude above 5.0 that was centered in New England took place in the Ossipee Mountains of New Hampshire in 1940 (MEMA & EOEEA, 2018).

Geographic Areas Likely Impacted

New England is located in the middle of the North American Plate. One edge of the North American Plate is along the West Coast where the plate is pushing against the Pacific Ocean Plate. The eastern edge of the North American Plate is located at the middle of the Atlantic Ocean, where the plate is spreading away from the European and African Plates. New England's earthquakes appear to be the result of the cracking of the crustal rocks due to compression as the North American Plate is being very slowly squeezed by the global plate movements. As a result, New England epicenters do not follow the major mapped faults of the region, nor are they confined to particular geologic structures or terrains. Because earthquakes have been detected all over New England, seismologists suspect that a strong earthquake could be centered anywhere in the region. Furthermore, the mapped geologic faults of New England currently do not provide any indications detailing specific locations where strong earthquakes are most likely to be centered. Instead, a probabilistic assessment conducted through a Level 2 analysis in Hazus (using a moment magnitude value of 5) provides information about where in Massachusetts impacts would be felt from earthquakes of various severities. For this plan, an assessment was conducted for the 100-, 500-, 1,000-, and 2,500-year mean return periods. The results of that analysis are discussed later in this section (MEMA & EOEEA, 2018).

Historic Data

In some places in New England, including locations in Massachusetts, small earthquakes seem to occur with some regularity. For example, since 1985 there has been a small earthquake approximately every 2.5 years within a few miles of Littleton, Massachusetts. It is not clear why some localities experience such clustering of earthquakes, but a possibility suggested by John Ebel of Boston College's Weston Observatory is that these clusters occur where strong earthquakes were centered in the prehistoric past. The clusters may indicate locations where there is an increased likelihood of future earthquake activity (MEMA & EOEEA, 2018).

Although it is well documented that the zone of greatest seismic activity in the U.S. is along the Pacific Coast in Alaska and California, in the New England area, an average of six earthquakes are felt each year. Damaging earthquakes have taken place historically in New England. According to the Weston Observatory Earthquake Catalog, 6,470 earthquakes have occurred in New England and adjacent areas. However, only 35 of these events were considered significant (MEMA & EOEEA, 2018).

Vulnerability Assessment

People

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

The populations most vulnerable to an earthquake event include people over the age of 65 and those living below the poverty level. These socially vulnerable populations are most susceptible, based on a number of factors, including their physical and financial ability to react or respond during a hazard, the location and construction quality of their housing, and the inability to be self-sustaining after an incident due to a limited ability to stockpile supplies.

Hazus performed for the State Hazard Mitigation and Climate Adaptation Plan estimates the number of people that may be injured or killed by an earthquake depending on the time of day the event occurs. Estimates are provided for three times of day representing periods when different sectors of the community are at their peak: peak residential occupancy at 2:00 a.m.; peak educational, commercial, and industrial occupancy at 2:00 p.m.; and peak commuter traffic at 5:00 p.m. Table 3.13 shows the number of injuries and casualties expected for events of varying severity, occurring at various times of the day.

Table 3.13: Estimated Number of Injuries, Causalities and Sheltering Needs in Berkshire County

Severity	***100-Year MRP***			***500-Year MRP***			***1,000-Year MRP***			***2,500-Year MRP***		
Time	**2am**	**2pm**	**5pm**	**2am**	**2pm**	**5pm**	**2am**	**2pm**	**5pm**	**2am**	**2pm**	**5pm**
Injuries	0	0	0	4	6	4	9	13	10	22	35	25
Hospitalization	0	0	0	0	1	1	1	2	1	3	6	5
Casualties	0	0	0	0	0	0	0	0	0	1	1	1
Displaced Households	0			21			51			143		
Short-Term Sheltering Needs	0			12			29			82		

Source: SCMCAP, 2018 HAZUS

MRP= Mean Return Period

Built Environment

All elements of the built environment in the planning area are exposed to the earthquake hazard. In addition to direct impacts, there is increased risk associated with hazardous materials releases, which have the potential to occur during an earthquake from fixed facilities, transportation-related incidents (vehicle transportation), and pipeline distribution. These failures can lead to the release of materials to the surrounding environment, including potentially catastrophic discharges into the atmosphere or nearby waterways, and can disrupt services well beyond the primary area of impact (MEMA & EOEEA, 2018).

Earthquakes can damage power plants, gas lines, liquid fuel storage infrastructure, transmission lines, utilities poles, solar and wind infrastructure, and other elements of the energy sector. Damage to any components of the grid can result in widespread power outages (MEMA & EOEEA, 2018). Damage to road networks and bridges can cause widespread disruption of services and impede disaster recovery and response (MEMA & EOEEA, 2018).

Earthquakes can also cause large and sometimes disastrous landslides and wildfires. Soil liquefaction is a secondary hazard unique to earthquakes that 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. Liquefaction may occur along the shorelines of rivers and lakes and can also happen in low-lying areas away from water bodies but where the underlying groundwater is near the Earth's surface. 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 & EOEEA, 2018).

Natural Environment

Earthquakes can impact natural resources and the environment in a number of ways, both directly and through secondary impacts. For example, damage to gas pipes may cause explosions or leaks, which can discharge hazardous materials into the local environment or the watershed if rivers are contaminated. Fires that break out as a result of earthquakes can cause extensive damage to ecosystems, as described in Section 4.3.2. Primary impacts of an earthquake vary widely based on strength and location. For example, if strong shaking occurs in a forest, trees may fall, resulting not only in environmental impacts but also potential economic impacts to any industries relying on that forest. If shaking occurs in a mountainous environment, cliffs may crumble, and caves may collapse. Disrupting the physical foundation of the ecosystem can modify the species balance in that ecosystem and leave the area more vulnerable to the spread of invasive species (MEMA & EOEEA, 2018).

Economy

Earthquakes also have impacts on the economy, including loss of business functions, damage to inventories, relocation costs, wage losses, and rental losses due to the repair or replacement of buildings. The business interruption losses are the losses associated with the inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses of those people displaced from their homes because of the earthquake.

Additionally, earthquakes can result in loss of crop yields, loss of livestock, and damage to barns, processing facilities, greenhouses, equipment, and other agricultural infrastructure. Earthquakes can be especially damaging to farms and forestry if they trigger a landslide (MEMA & EOEEA, 2018).

Future Conditions

Earthquakes cannot be predicted and may occur at any time. Peak Ground Acceleration (PGA) maps are used as tools to determine the likelihood that an earthquake of a given Modified Mercalli Intensity may be exceeded over a period of time, but they are not useful for predicting the occurrence of individual events. Therefore, geospatial information about the expected frequency of earthquakes throughout Massachusetts is not available. Unlike previous hazards analyzed in this plan, there is little evidence to show that earthquakes are connected to climate change (MEMA & EOEEA, 2018). However, there are some theories that earthquakes may be associated with a thawing Earth as the temperature increases.

Hazard Profile

Likely severity

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. 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. See table 3.14.

Table 3.14: 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

The classification for potential hazard shall be in accordance with table 3.15. The Hazard Potential Classification rating pertains to potential loss of human life or property damage in the event of failure or improper operation of the dam or appurtenant works. The hazard potential classification for a dam has no relationship to the current structural integrity, operational status, flood routing capability, or safety condition of the dam or its appurtenances[16]. Poor condition indicates a dam that presents a significant risk to public safety due to deficiencies such as significant seepage, erosion or sink holes, cracking of structural elements, or vegetation undermining the structural stability of the dam.

[16] *https://www.mass.gov/files/documents/2017/10/30/302cmr10.pdf*

Table 3.15: Dam Hazard Potential Classification

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

Probable future development of the area downstream from the dam that would be affected by its failure shall be considered in determining the classification. Even dams which, theoretically, would pose little threat under normal circumstances can overspill or fail under the stress of a cataclysmic event such as an earthquake or sabotage.

Dam owners are legally responsible for having their dams inspected on a regular basis. High hazard dams must be inspected every two years, Significant Hazard dams must be inspected every five years, and Low Hazard dams must be inspected every 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 local residents in the inundation area. The EAP must be filed with local and state emergency agencies (BRPC, 2012).

Probability

Factors that contribute to dam failure include design flaw, age, over-capacity stress and lack of maintenance (BRPC, 2012). Maintenance, or the lack thereof, is a serious concern for many Berkshire communities. 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. As a result of difficulty in getting information on private dams, local officials are largely unaware of the age and condition of the dams within their communities (BRPC, 2012).

There are two primary types of dam failure: catastrophic failure, characterized by the sudden, rapid, and uncontrolled release of impounded water, or design failure, which occurs as a result of minor overflow events. Dam overtopping is caused by floods that exceed the capacity of the dam, and it can occur as a result of inadequate spillway design, settlement of the dam crest, blockage of spillways, and other factors. Overtopping accounts for 34 percent of all dam failures in the U.S.

There are a number of ways in which climate change could alter the flow behavior of a river, causing conditions to deviate from what the dam was designed to handle. For example, more extreme precipitation events could increase the frequency of intentional discharges. Many other climate impacts—including shifts in seasonal and geographic rainfall patterns—could also cause the flow behavior of rivers to deviate from previous hydrographs. When flows are greater than expected, spillway overflow events (often referred to as “design failures”) can occur. These overflows result in increased discharges downstream and increased flooding potential. Therefore, although climate change will not increase the probability of catastrophic dam failure, it may increase the probability of design failures (MEMA & EOEEA, 2018).

Figure 3.26: North Adams Dams & Dams of Concern

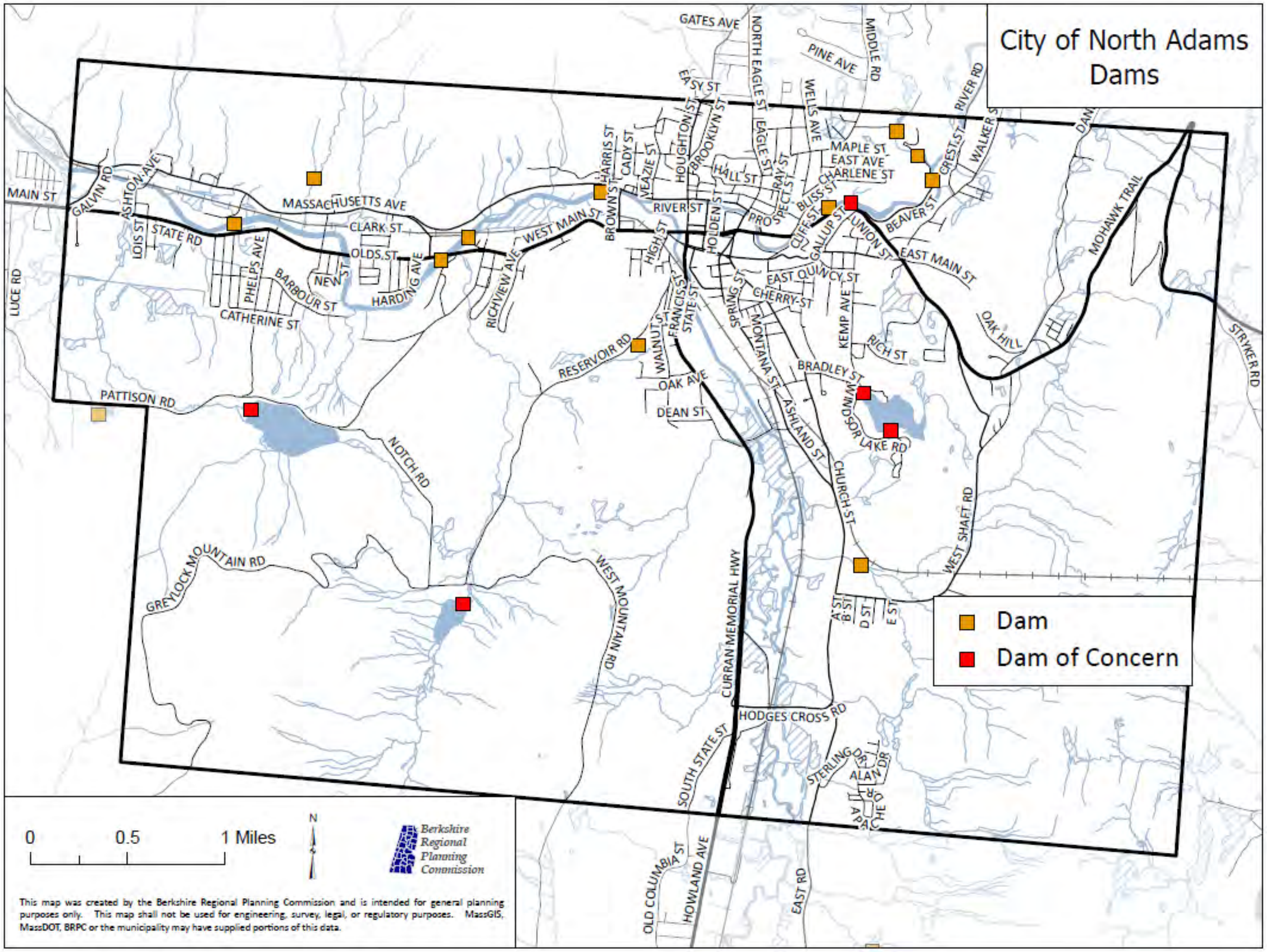


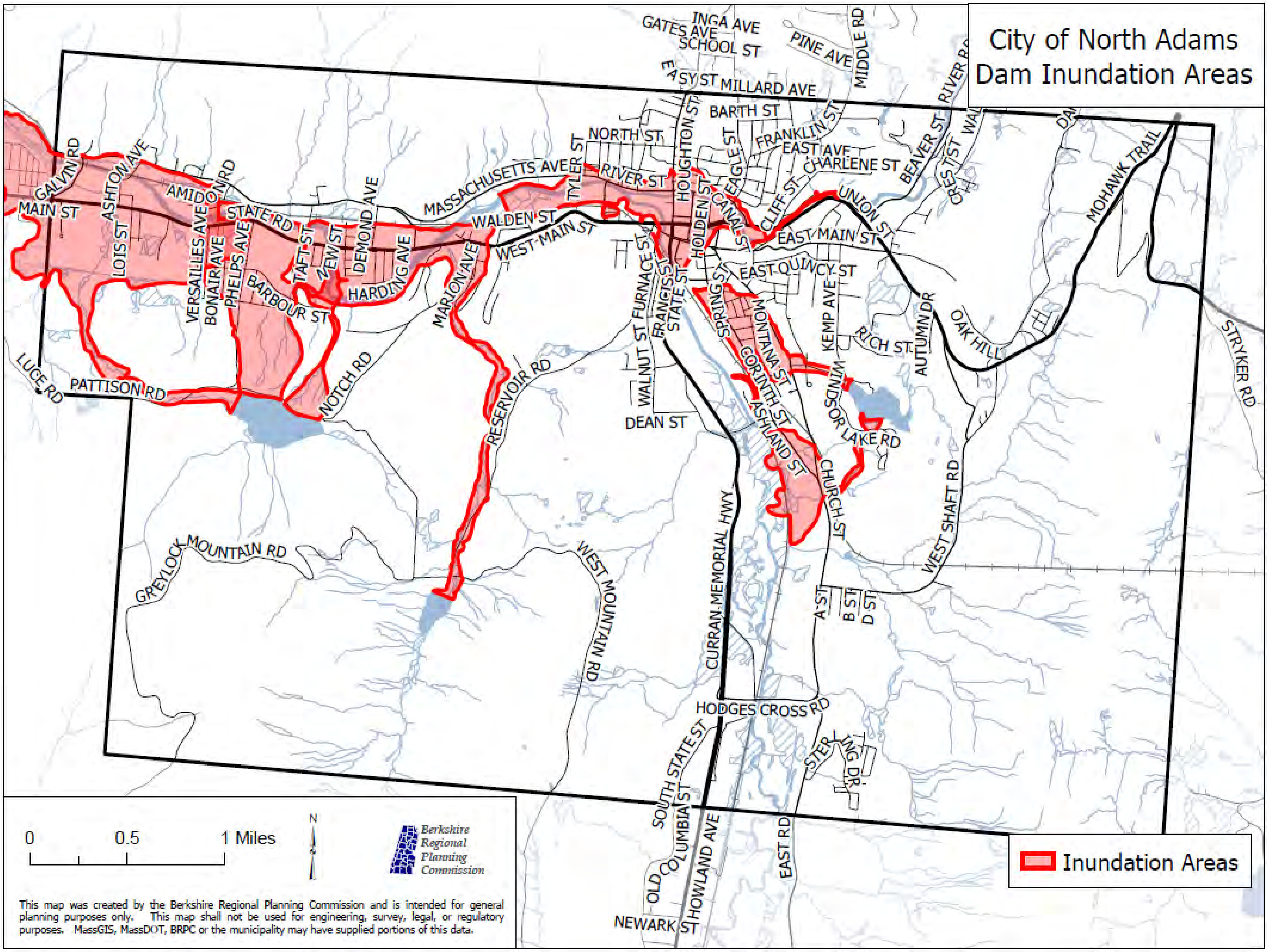
Figure 3.26: shows dam location areas in the City of North Adams. Table 3.16 provides a summary of severity, probability and location for dams located in the City of North Adams. Figure 3.27: Provides a map of dam failure inundation areas based on contracted engineering studies and

The DCR Office of Dam Safety lists 12 dams in the City of North Adams as shown in Table 3.16. Information was last acquired from the Massachusetts Office of Dam Safety in 2004. Inspection status was updated for City-owned dams.

Table 3.16: Dam Hazard Status for North Adams

Name	Hazard Code	Size Class	Inspection Condition	Owner	Water Source	Impounded Waterbody
Beaver Mills Dam	Low	Small	Fair	Eric Rudd / Cire Corporation	N. Branch Hoosac River	Mill Pond
Eclipse Dam	Significant	Intermediate	Fair	City Of North Adams	N. Branch Hoosic River	N. Branch Hoosic River
Hoosic Mills Weir	Low	Small	Good	City Of North Adams	N. Branch Hoosic River	Mill Pond
Hudson Brook Dam	Low	Intermediate	Fair	Eric Rudd / Cire Corporation	Hudson Brook	Hudson Brook
Low Service Res. Dam	Low	Intermediate	Non-Jurisdictional	City Of North Adams	Off Stream	Lower Reservoir
Mount Williams Reservoir Dam	High	Large	Fair	City Of North Adams	Paull Brook	Mt.Williams Reservoir
Natural Bridge Dam	Significant	Intermediate	Good	MA DCR	Hudson Brook	Mill Pond
Notch Reservoir Dam	High	Large	Poor	City Of North Adams	Notch Brook	Notch Reservoir
Sherman Brook Dam	Low	Small		Consolidated Aluminum Co.	Sherman Brook	Sherman Brook
Tunnel Brook Dam	Significant	Small	Poor	Boston & Maine Corp	Tunnel Brook	Tunnel Brook Pond
Upper Reservoir Dam	Significant	Intermediate	Fair	City Of North Adams	Tr-Hoosic River	Upper Reservoir
Windsor Lake Dam	High	Intermediate	Poor	City Of North Adams	Tr-Hoosic River	Windsor Lake

Figure 3.27: City of North Adams Dam Inundation Areas



Historic Data

Historically, dam failure has had a low occurrence in Berkshire County. However, many of the dams within the region are more than 100 years old. The oldest municipally owned dam in North Adams, at the Windsor Lake Dam, was completed in 1883[17].

In September 2004 an incident occurred at the Plunkett Lake dam in nearby Hinsdale. The first few weeks of September were unusually wet as the region received residual rain from three hurricanes that devastated Florida and areas of its neighboring states. On September 18, 2004, after the effects of Hurricane Ivan dropped more than three inches of rain on the area in 24 hours, the flash boards at the Plunkett Lake dam gave way. The Emergency Management Director for Hinsdale calculated that approximately 8 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 beaver activity, where culverts were partially plugged; impeding and redirecting flood waters (BRPC, 2012).

Vulnerability Assessment

People

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 severity of the dam failure, the warning time, the capacity of dam owners and emergency personnel to alert the public and the capacity and number of evacuation routes available to populations living in areas of potential inundation. Vulnerable populations are all populations downstream from dam failures that are incapable of escaping the area within the needed time frame. There is often limited warning time for a dam failure event. While dam failure is rare, when events do occur, they are frequently associated with other natural hazard events such as earthquakes, landslides, or severe weather, which limits their predictability and compounds the hazard. Populations without adequate warning of the event from a television, radio or phone emergency warning system are highly vulnerable to this hazard. This population includes the elderly, young, and large groups of people who may be unable to get themselves out of the inundation area. (Massachusetts Emergency Management Agency, 2013)

[17] *USACE 2018 National Inventory of Dams (NID) released in January 2019, accessed at https://nid-test.sec.usace.army.mil/ords/f?p=105:1::::::*

Built Environment

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. (Massachusetts Emergency Management Agency, 2013)

Natural environment

A dam failure would cause significant destruction to the natural environment. Before the dam changed the volume and area of water that would flow downstream of the dam, only vegetation able to withstand inundation would grow where the water flowed or saturated soils. Dam failure would likely cause the accumulation of downed trees downstream including at culverts and bridges leading to further damage.

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.

Future Conditions

According to MEMA, dams are designed partly based on assumptions about a river's flow behavior, expressed as hydrographs. Changes in weather patterns can have significant effects on the hydrograph used for the design of a dam. If severe rain events cause hydrographic changes, it is conceivable that the dam can lose some or all of its designed margin of safety, also known as freeboard. If freeboard is reduced, dam operators may be forced to release increased volumes earlier in a storm cycle in order to maintain the required margins of safety. If the number of severe storms increases, or becomes the new norm, early releases of water will impact lands and waterways downstream more often.

Dams are constructed with safety features such as spillways and lower level outlets to allow release of additional water discharges. 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. (Massachusetts Emergency Management Agency, 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.

Hazard Profile

Likely Severity

The City of North Adams chose to examine the hazard of cybersecurity. Cybersecurity is defined as the defending of computers, servers, mobile devices, electronic systems, networks, and data from malicious attacks. The term can be divided into a few common categories, including: Network security, Application security, Information security, Operational security, Disaster recovery and business continuity and End-user education (Kaspersky 2020).

The damage rendered by cybersecurity can be significant. Municipalities may see their entire system compromised by cyber-attacks and may need to expend significant financial resources to recover from an attack.

Probability

Increased computer usage, internet access and improved programming skills by the public, including potential hackers, all lead to an increase in the probability of a cyber-attack. The frequency of attacks impacting the government has increased over the last few years, leading to a higher probability that any one entity will be attacked. In 2018, government was the 7th most targeted industry for cybercrime and experienced 8% of the total attacks. Nation-state sponsored groups are the most likely to target this sector. These groups are likely to use, sell, or deliver compromised information to their respective governments, typically for economic or political gain (IBM 2019). The most likely reason for attacks on a community like North Adams is for ransom or to access personal information about residents.

As computers and connectivity become more pervasive in our lives, the number of vulnerabilities increases. Over the last three years, more than 42,000 vulnerabilities within software programs have been publicly disclosed. Vulnerabilities have increased over 5400% in the last five years (IBM 2019). These vulnerabilities provide more ways that criminals can access computer networks and compromise systems.

Geographic Areas Likely Impacted

The City of North Adams in its entirety is likely to be impacted. City facilities are more likely to be targeted for cybercrime, however all residents are also at risk. In addition, the electrical grid and telecommunications network throughout North Adams are at risk of attacks and could result in large sections of the City being without power or communications.

Historic Data

Cyberattacks are a human-caused hazard, often spread by users who have inadvertently allowed access to their systems. Over the last 3 years, more than 11.7 billion records and over 11 Terabytes of data were leaked or stolen in publicly disclosed incidents. These compromised records contain information such as social security numbers, addresses, phone numbers, banking/payment card information, and passport data. In some cases, health data may also be stolen (IBM 2019).

Locally, at least two municipalities in the county and numerous municipalities in the state have been attacked with Ransomware. These attacks have cost the communities anywhere from tens of thousands of dollars to millions of dollars in ransom and countless hours restoring their systems and improving their resilience to a future attack. Luckily, little, if any, personal data was taken, but the impact on the municipalities ability to function was severely limited for some time.

Vulnerability Assessment

People

Cyberattacks rarely have direct impacts on humans, however the disruption they cause will impact people. Personal identifiable information that may be stolen can cause disruption to people's lives, impacting their finances, security, and future. Cyber-attacks that impact the utilities may cause potential harm to those who rely on electricity for life support, heat, and water. Hospitals and medical facilities utilizing networked monitoring systems are vulnerable to hacking. Services provided by a municipality such as those necessary for purchasing a home can be put on hold as well.

Built Environment

Cyberattacks on the built environment may result in the loss of power, communications and equipment failure in government offices. Attacks on the utilities would likely result in temporary loss of service, however utilities can also be attacked where the systems are taken control of and purposely overloaded, damaging the physical infrastructure, which will result in a costlier recovery and a longer recovery time.

Government computer equipment can also be damaged or locked, preventing the use of that equipment unless a ransom is paid. This equipment can be replaced, but the data on the computers may not be recoverable, resulting in the loss of data unless the computers have been properly backed up.

Natural Environment

Cyberattacks pose a threat to the natural environment as well. Systems such as wastewater or drinking water treatment plants are vulnerable to ransomware. One study at Georgia Institute of Technology simulated a hacker gaining access to a water treatment plant and overdosing the system with chlorine. Hackers could also control pumps, valves, or many other parts of the system if they are connected to the internet (Toon, 2017).

Economy

The economy is most susceptible to the threat of cyberattacks due to the loss of utilities and computers causing a reduction in economic output. The power outage in 2003 that impacted most of the Northeast was a result of a cyber-attack. This outage caused an estimated $6 billion in economic damages over 2 days (IRMI 2020). The US government estimates that malicious cyber activity costs the US economy between $57 billion and $109 billion in 2016 (White House 2018). In addition, local government need to invest in cyber security or to respond to a cyber-attack will result in higher taxes within that municipality.

Future Conditions

Continued expansion and connectivity of cyber assets will lead to a continued and growing threat to businesses, governments and individuals. Local governments will need to invest in cyber security to help mitigate the future risk of a cyber-attack. This will include upgrading computer systems, deploying security protections such as firewalls, and training users on identifying malicious activity and emails. Governments will also need to utilize professional computer staff or consultants to assist in protecting their assets and the data of their constituents.

References:

Kaspersky 2020 https://usa.kaspersky.com/resource-center/definitions/what-is-cyber-security

IRMI 2020 https://www.irmi.com/articles/expert-commentary/cyber-attack-critical-infrastructure

IBM 2019 https://www.ibm.com/security/data-breach/threat-intelligence

Toon 2017 https://rh.gatech.edu/news/587359/simulated-ransomware-attack-shows-vulnerability-industrial-controls

White House 2018 https://www.whitehouse.gov/wp-content/uploads/2018/03/The-Cost-of-Malicious-Cyber-Activity-to-the-U.S.-Economy.pdf

CHAPTER 4: MITIGATION STRATEGY

44 CFR § 201.6(c)(3-5)

The Mitigation Strategy lays out how the City of North Adams intends to reduce potential losses identified in the Risk Assessment chapter. The goals and objectives of North Adams guide the selection of actions to mitigate and reduce potential losses. A prioritized list of cost-effective, environmentally sound, and technically feasible mitigation actions is the product of reviewing benefits and costs of each proposed project.

The most pressing issue needing mitigation in North Adams is flooding. The aging stormwater infrastructure leaves North Adams vulnerable to heavy precipitation events. The concrete flood chutes are at the end of their design life and the integrity of the structures is compromised. Failure of the City's Hoosic River flood chutes or dams would be catastrophic. The naturalization and restoration of the Hoosic River is desired by many stakeholders, to create a community asset and effective nature-based infrastructure. However, the flood chutes need to be replaced and strengthened where existing development will not allow for the naturalization of the Hoosic River.

There are many examples that the City can now look towards for inspiration and feasible ideas in reclaiming the Hoosic. Considering the characteristics of the Hoosic, the Lsar in Munich, Germany is a great example of a river being restored as a community asset and improved flood mitigation. In the limited space available, natural landscaping provides a buffer between built and natural environments. The historic built environment is in a precarious location in North Adams, but there are options for softening the barriers between it and the Hoosic River.

Hoosic River in concrete flood chutes. Looking upstream (eastward) towards MoCA at confluence of Main Stem and North Branch

In its current state the Hoosic River is a vulnerability. Its potential is to be accessible by the public, beautification for the city, integrated flood mitigation, and a draw for visitors. In order to move progress forward on the Hoosic River, the City needs significant coordination from multiple state and federal agencies with jurisdiction over the land, water, and protected species.

The City of North Adams is fortunate in having natural mitigative infrastructure in their preserved and retained forests and wetlands. The undeveloped land serves as important green infrastructure performing ecosystem services including stormwater management, flood control and reduction, soil stabilization, wind mitigation, water filtration, and drought prevention amongst other benefits not easily quantified. There are many tools available for calculating ecosystem services such as FEMA's Ecosystem Service Benefits Calculator[18]. One study by the Trust for Public Land found that for every $1 invested through the Land and Water Conservation Fund, there was a return on that investment of $4 from the value of natural goods and services[19]. In the City of North Adams, the natural features and facilities are managed and maintained for their services to the community by the City and regional partners. Other natural systems in North Adams have been so severely altered and paved over that they no longer provide the full spectrum of services possible. Namely, the flood chutes that cut through the city are in dire need of replacement with a system that employs a better meshing of green and grey infrastructure.

North Adams rests in the valley below their dams and reservoirs. Regular monitoring and maintenance of the dams is required. To be better prepared for flooding from dam or flood chute failure, there needs to be enhanced community education and emergency response preparedness. The City also wishes to prioritize digitally mapping drinking water, sewer, and stormwater lines for better monitoring and replacement where necessary. While this is North Adams first hazard mitigation plan and therefore will not have completed mitigation actions, the City has several initiatives completed and underway to improve local resilience. Since 1981 the City of North Adams has participated in the National Flood Insurance Program to provide insurance for structures located in the floodplain. The City has also established zoning ordinances that regulate and mitigate the potential flooding impacts of development. Two overlay districts, Floodway District (Section 9.2) and Floodplain District (Section 9.3) regulate development within these areas with the purposes of protecting human life and property, assuring the continuation of natural flow patterns and providing adequate safe floodwater storage capacity to protect against the hazards of flood

[18] *https://www.fema.gov/media-library/assets/documents/110202*

[19] *http://cloud.tpl.org/pubs/benefits-LWCF-ROI%20Report-11-2010.pdf*

inundation. Additionally, in 2016 the City established Environmental Performance Standards that must be met by project developers applying for Special Permits. Under this ordinance, medium- and large-sized development project proposals must submit an Environmental and Community Impact Analysis, which clearly and methodically assesses the relationship of the proposed use and/or development to the natural and man-made environment of North Adams. In the analysis developers must identify potential impacts of the project, such as surface runoff (especially peak runoff) that could lead to increased surface and groundwater flooding, changes in soil that could lead to erosion and sedimentation, and demands on the public water supply. The analysis must be prepared by an interdisciplinary team of professionals qualified, experienced, and, where applicable, licensed, in their fields.

The City monitors and makes needed repairs to the concrete flood chutes that encase the Hoosic River. Due to limited resources, large repair projects often occur when the chutes fail or are in imminent risk of failure. After decades of deferred maintenance, work during the past several years has been undertaken to proactively map and evaluate the underground water, sewer and stormwater drainage systems. Work to repair leaks and broken pipes have been done as resources allow. If there is an emergency, the City utilizes a reserves 911 system and CodeRED to alert residents of the hazardous conditions.

There were more than 80 action items developed through the City's natural hazard and climate change planning processes. These actions emerged through the parallel and complementary planning processes conducted as part of the Community Resilience Building Workshop and the Hazard Mitigation Plan. While any of these individual items are important actions that could lead directly or indirectly to improved community-wide resilience, not all reach to the specific level of being included in a FEMA hazard mitigation document. In practicality, including all 80 actions seemed to dilute the importance of key actions that should be prioritized and pursued to meet the requirements set forth in 44 CFR § 201.6(c)(3-5). As a result, the Mitigation Action Plan outlined in Table 4.1 lists the actions that are most relevant to addressing natural hazards and disasters that could impact the City of North Adams and its residents and meets the requirements set forth by FEMA.

This does not diminish the importance of the actions not listed herein. For example, several key priority actions were identified that involve increasing the capacity of local public health officials, first responders and the Northern Berkshire Regional Emergency Planning Committee (REPC) to develop emergency preparedness plans and improve the emergency response infrastructure. These include wider public outreach, improving and expanding emergency communications, and acquiring equipment and supplies. The REPCs of Berkshire County are the region's first response teams and are invaluable resources that should be wholeheartedly supported through local, regional, state and federal efforts. This plan refers to and supports the actions proposed by the REPCs, including efforts to obtain grants and other financial means to meet their goals and responsibilities. It also supports complementary but herein unlisted actions developed as part of the CRB Workshop and the accompanying North Adams Municipal Vulnerability Plan.

The mitigation projects listed in table 4.1 fall within the primary *Categories of Actions*:

- Local plans and regulations
- Structural projects
- Natural systems protection
- Education programs
- Preparedness and response actions

The column containing *Description of Action* is the brief summary of the mitigation action the community has identified to reduce their vulnerability to a hazard or more broadly increase resilience. The Benefit column will explain what the action mitigates or how it to increase resilience.

The column containing *Cost* was estimated and categorized as follows:

High: Over $100,000
Medium: Between $50,000 - $100,000
Low: Less than $50,000
N/A: For some projects, cost is not applicable

Implementation Responsibility will reflect ownership and/or jurisdiction of a facility or action that will be mitigated or otherwise receive funding for improved resilience.

Priority of a project is determined by factors including conditions due to climate change or disaster events and recovery priorities; local resources, community needs, and capabilities; State or Federal policies and funding resources; hazard impacts identified in the risk assessment; development patterns that could influence the effects of hazards; and partners that have come to the table. *Timeframe* is listed at Short, Long, and Ongoing to reflect the timeframe identified for projects through the MVP Community Resilience Building process. A project that has been identified as short term is one that can and needs to be implemented immediately. These projects are likely to pass a benefit-cost analysis, have the political and community support necessary, and are practicable. Long term projects still require multiple steps before implementation, including studies, engineering, and gaining community support. Ongoing projects are those that may be implemented immediately but will require constant investment of resources for maintenance or other project requirements such as education.

Resources and Funding listed for each action are known potential technical assistance, materials and funding for the type of project identified.

Table 4.1 provides a roadmap for North Adams to increase resiliency and will be updated with the new plan in five years.

Table 4.1: Mitigation Action Plan - North Adams

Category of Action	Description of Action	Benefit	Cost	Implementation Responsibility	Timeframe / Priority	Resources / Funding
Local plans and regulations	Review zoning for ways to increase smart growth patterns and use of stormwater BMPs (pervious pavement, rain gardens, bioswales, etc).	Reduce flooding caused by stormwater runoff.	Medium	Planning Board, Mayor's Office	Short / High	City funding, EOEEA
Local plans and regulations; needed for structural project; natural systems protection	Conduct hydrologic and hydraulic / engineering study to assess structural integrity of the concrete chutes and to determine if Hoosic River Revival (HRR) plans to naturalize chutes is feasible and protective.	Provide flood protection for the property in the Hoosic River floodplain, improve aquatic habitat and reduce thermal pollution.	High	Mayor's Office, Public Services, HRR	Short / High	City funding, FEMA, DER, EOEEA
Natural systems protection	Implement HRR plan for South Branch of Hoosic River, including natural and green features to help absorb flooding and improve habitat.	Reduce the risk of flooding to properties located in Hoosic floodplain; improve habitat.	High	Mayor's Office, Public Services, HRR	Long / Medium	City funding, FEMA, DER, EOEEA
Local plans and regulations	Identify potential funding for maintaining/repairing the concrete chutes.	Maintain flood chutes to ensure flood protection.	High	Public Services	Short / High	City funding, EOEAA
Local plans and regulations	Increase the frequency of maintenance for flood chutes and berms, with focus on problem areas such as Versailles Ave., Hodges Cross Rd.	Maintain flood chutes to ensure flood protection for adjacent properties and neighborhoods.	Medium	Public Services	Short / High	City funding, EOEAA

Category of Action	Description of Action	Benefit	Cost	Implementation Responsibility	Timeframe / Priority	Resources / Funding
Local plans and regulations; natural systems protection	Work with Mass. Div. of Fisheries & Wildlife (DFW) to solve issues involving work on the chutes and along the river in Wood Turtle habitat.	Maintain flood chutes and berms to continue providing flood protection; maintain habitat for rare species.	Low	Public Services, Conservation Commission, MA DFW	Short / High	City funding, FEMA
Structure and infrastructure projects	Create retention basin for Hoosic River.	Provide flood protection for properties located in the Hoosic River floodplain.	High	Public Services, Town of Clarksburg	Short / High	Municipal funding, FEMA, EOEAA
Natural systems protection	Utilize the closed middle section of Barbour Street for public space that function as green infrastructure and sophisticated flood prevention, possibly part of the Rail Trail plan.	Reduce risk of flooding from heavy rain events to slow, detain, retain, and absorb stormwater using nature-based solutions (NBS).	Medium	Mayor's Office, Parks & Recreation, Public Services,	Long / Low	City funding, FEMA, EOEEA
Structure and infrastructure projects	Redesign and rebuild flood mitigation around Mass MoCA and Willow Street.	Provide flood protection for properties.	High	Public Services	Short / High	City funding, FEMA, DER, EEA
Structure and infrastructure projects; natural systems protection	Rebuild State Road, utilizing natural based solutions/green infrastructure where possible.	Reduce risk of flooding in the Hoosic River floodplain and prevent further erosion of bank and riparian habitat.	High	Public Services	Short / High	City funding, FEMA, EOEEA
Local plans and regulations	Evaluate and replace if needed bridges over Hoosic River along Route 2 east of New Street and on West Main Street; considerations should be made for temporary alternative route.	Ensure Route 2 continues to function as a principal arterial road; create alternative route and redundant route.	High	MA Dept. of Transportation (MassDOT), Public Services	Short / High	City funding, FEMA

Category of Action	Description of Action	Benefit	Cost	Implementation Responsibility	Timeframe / Priority	Resources / Funding
Structure and infrastructure projects	Continue maintenance and inspections of new bridge on State Street near City Hall.	Reduce the risk of critical roadway failure.	Medium	Public Services, MassDOT	Ongoing / Low	City funding
Structure and infrastructure projects	Purchase temporary bridges to prevent populations from being cut off during storms.	Reduce the risk of physical / social isolation during an emergency.	High	Public Services	Short / Low	City funding, FEMA
Local plans and regulations	Improve efforts to clear debris and increase maintenance of stream crossings, culverts and stormwater drainage systems.	Reduce the risk of road and property damage; increase connectivity of aquatic passage.	Medium	Public Services	Ongoing / High	City funding, DER, EOEEA
Structure and infrastructure projects	Assess, prioritize, and replace culverts, increasing size whenever appropriate; focus on Ashland, State, and River Streets to reduce street flooding.	Reduce the risk of property and road flood damages from heavy rain events.	High	Public Services	Ongoing / High	City funding, FEMA, DER, EOEEA
Structure and infrastructure projects;	Increase use of permeable pavement, bioswales and rain gardens in new development and when repairing/upgrading culverts.	Increased infiltration/reduced stormwater runoff reduces flooding.	High	Public Services	Short / High	City funding, DER, EOEEA
Local plans and regulations	Request update to the FIRM maps and reevaluate floodplain boundaries.	Reduce the risk of developing in the floodplain and loss of life or property.	Medium	Mayor's Office, Planning Board	Short / High	FEMA

Category of Action	Description of Action	Benefit	Cost	Implementation Responsibility	Timeframe / Priority	Resources / Funding
Local plans and regulations	Yearly inspections and increased maintenance, debris clearing and monitoring to prevent risk of failure at the dams.	Safeguard against potential flooding and detect structural damage/deterioration to prevent risk of failure.	Medium	Public Services	Ongoing / High	City funding
Local plans and regulations; Structure and infrastructure projects	Survey, engineer and redesign stormwater drainage and water and sewer systems; digitize records and improve systems mapping.	Mitigate non-point source pollutions; mitigate flooding hazard from heavy rain events and reduce infiltration & inflow.	High	Public Services; Water & Sewer, Hoosic Water Quality District (HWQD)	Short / High	City funding, FEMA, DER, EOEEA
Local plans and regulations	Conduct studies to determine course of action to stabilize banks where erosion has exposed the sewer interceptor line that crosses that Hoosic River in west North Adams.	Ensure integrity of sewer interceptor line for desired function.	Medium	HWQD, Public Services,	Short / High	City funding, FEMA
Structure and infrastructure projects	Replace water and sewer lines where necessary.	Continue potable water and sewer service.	High	Public Services, Water & Sewer, HWQD	Ongoing / High	City funding, FEMA
Local plans and regulations	Analyze if energy production by dams is economically viable and will fund maintenance.	Potential revenue source for maintaining dam infrastructure.	Medium	Mayor's Office, Public Services	Short / Low	City funding, DOER
Local plans and regulations	Conduct study to see if Old Sprague dam should be removed to prevent flooding.	Reduce the risk of flooding to properties located near Old Sprague dam.	Medium	Public Services	Short / Medium	City of North Adams, FEMA

Category of Action	Description of Action	Benefit	Cost	Implementation Responsibility	Timeframe / Priority	Resources / Funding
Structure and infrastructure projects	Fund city public services dept. for infrastructure improvements to address storm drain capacity at Church Street, Brown Street, Beaver Street, Houghton Street, Galvin Street, and near the Porches.	Mitigate non-point source pollution. Mitigate flooding hazard from heavy rain events.	High	Public Services, Mayor's Office, City Council	Short / High	City funding, EOEEA
Structure and infrastructure projects	Design and implement retention/infiltration system to mitigate flooding on MCLA campus; focus on Bradley Street, parking and Towers.	Reduce the risk of flooding of properties due to stormwater runoff.	High	Public Services, MCLA	Long / Medium	City funding, FEMA, EOEEA
Local plans and regulations	Hire a beaver trapper; streamline the process for removal.	Reduce flooding of property due beaver activity.	Low	Public Services, Animal Control, Mass. DFW	Short / High	City funding, EOEEA
Local plans and regulations	Review and update emergency plans; add redundancy for the Mt. Williams Reservoir if needed.	Reduce the risk of insufficient water resources during emergency events and/or drought(s).	Medium	Emergency Management	Short / Medium	City funding, FEMA
Local plans and regulations	Support Northern Berkshire Regional Planning Committee (REPC) emergency planning and response efforts, building on its experience and success.	Improved emergency planning and response reduces impacts to people and property.	Low	EM, Regional REPC	Ongoing / Medium	City funding
Local plans and regulations	Contract tree removal around critical infrastructure where utility company is not maintaining.	Reduce the risk of debris damaging critical infrastructure such as power lines / utility poles.	Medium	Public Services; National Grid	Ongoing / Medium	City funding

Category of Action	Description of Action	Benefit	Cost	Implementation Responsibility	Timeframe / Priority	Resources / Funding
Local plans and regulations / Structural and infrastructure projects	Support emergency communications improvements; add back-up receivers at the hospital, new wireless tower at MCLA, access Greylock Tower, use reverse 911 and social media to advertise CodeRED.	Bolster existing communication systems and add redundancy; increase public awareness of emergency preparedness.	High	Emergency Management (EM), National Grid, MA Dept. of Conservation & Recreation (DCR); MCLA; ATT/Verizon	Long / Medium	City funding, FEMA
Local plans and regulations	Maintain protection for the electric substation located adjacent to the Hoosic River.	Continue providing critical functions and electricity.	Medium	EM, National Grid	Ongoing / Low	City funding
Local plans and regulations; Structure and infrastructure projects	Establish criteria for creation of new Emergency Operations Center so that Ambulance access will not be threatened in severe storm events; pursue design and construction funding for new site.	Ensure emergency access for all residents and ensure adequate facilities for emergency management personnel.	Medium	EM, REPC	Short / High	City funding, FEMA
Structure and infrastructure projects	Repair and replace roofing and siding for the Riverview and Greylock public housing.	Reduce risk of damage from hazardous weather to public housing facilities.	High	City Housing Authority	Short / Low	City funding, FEMA
Local plans and regulations; natural systems protection	Improve forest management to remove buildup of debris and underbrush while maintaining healthy forest soils and ecosystem.	Reduce the risk of wildfire while maintaining/improving carbon sequestration.	Medium	Public Services, Fire Dept., DCR Forest Services	Short / High	City funding, FEMA, EOEEA
Local plans and regulations	Protect the HA George Propane storage facility on Ashland Street.	Reduce risk of hazardous materials incident.	Medium	EM, HA George	Short / Low	City funding

Category of Action	Description of Action	Benefit	Cost	Implementation Responsibility	Timeframe / Priority	Resources / Funding
Local plans and regulations;	Create maps for primary and alternative routes; avoid roads that flood; commune routes to public (possible signage); training/education with follow-up site visits for business owners; focus on vulnerable populations: College, Ashland (seniors, disabled), City Housing near the railroad and flood areas that will need evacuating in an emergency.	Protect lives by creating evacuation routes for emergency events.	High	EM, REPC, MCLA, COA, Housing Authority	Short / Medium	City funding, FEMA, EOEEA
Local plans and regulations	Improve communications with Pan Am Railways to be better able to respond to issue(s) with hazardous materials transported by railway.	Mitigate potential harm from a potential spill of hazardous materials being transportation via rail to or through the area.	Low	Mayor's Office, EM, Fire Dept., REPC, Pan Am	Ongoing / Medium	City funding, Pan Am
Local plans and regulations	Create maps and rate each section of the railroad for access and type of equipment that can go there; coordinate with Pan Am to maintain improve tracks to minimize damage risk.	Ensure preparedness for incidents of rail accidents.	Medium	Mayor's Office, EM, Fire Dept., REPC, Pan Am	Short / Low	City funding
Local plans and regulations	Establish a swift water rescue team.	Expand REPC capacity to respond to flood or aquatic rescues.	High	Emergency Management, Fire Department	Short / High	City funding, FEMA

CHAPTER 5: PLAN ADOPTION

44 CFR § 201.6(c)(5)

This plan received official approval pending adoption from FEMA on ______________ and was formally adopted by the City Council of North Adams on ___________. The Plan received final approval from FEMA on ___. These documents are displayed in the front of the Plan.

CHAPTER 6: PLAN MAINTENANCE

44 CFR § 201.6(c)(4)

44 CFR § 201.6(c)(4) asks for a section of the HMCAP to describe the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle, process by which North Adams will incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvement plans, when appropriate, and how the community will continue public participation in the plan maintenance process (44 CFR § 201.6(c)(4)(iii)).

Plan Review and Updates

§201.6(c)(4)(i) (iii)

The City of North Adams will officially review needed updates for the plan on an annual basis. Specifically the Hazard Mitigation Planning Committee, stakeholders, and partners will maintain and update the mitigation action tables, complete site visits and produce reports of completed or initiated mitigation actions to incorporate into the next plan revision, research and document new disaster information, and participate in resiliency- and mitigation-related initiatives available to the region.

Annual review is scheduled to occur during the Capital Assets Group meeting in October beginning in 2020. Under the leadership of the City Manager the committee will track updates based on completed mitigation actions, new development, changing problem areas, and input from public involvement. As needed on an annual basis, these updates will be shared with BRPC, which maintains county-wide GIS data.

In reaching out the residents and neighbors of North Adams, the Hazard Mitigation Planning Committee began building a network of interested residents that can enhance the next update. While the Hazard Mitigation Plan must be updated every five years, North Adams will begin the process of organizing and identifying funding for the plan update every 3.5 years.

Integration in Future Planning

§201.6(c)(4)(ii)

This HMCAP will be used in all future planning efforts in the City including comprehensive plan updates, transportation plans, and zoning changes.

The final adopted HMCAP will be made publicly available on the City of North Adams and BRPC websites for reference and comment. Any regional plans developed by BRPC or the Commonwealth should refer to the publicly available North Adams Hazard Mitigation and Climate Adaptation Plan to ensure consistency with the vision for community resilience to hazards.

APPENDICES:

APPENDIX A: PLANNING MEETING DOCUMENTATION

February 7, 2019 Meeting Sign-In Sheet

North Adams [illegible] 2/7/2019

Sign In

#	Name	Affiliation/Title	Email	Phone
1	Tim Lescarbeau	Com of Public Services	Tlescarbeau@northadams-ma.gov	
2	Mike Canales	Admin - NA	mcanales@northadams-ma.gov	672-0011
3	Mark Bashaw	Health	mbashaw@northadams-ma.gov	
4	Michael Moore	Health Director	mmoore@northadams-ma.gov	
5	Bill Meranti	Inspection	Bmeranti@northadams-ma.gov	652-1528
6	Steve Meranti	NAFD / Chief	smeranti@northadams-ma.gov	413 652-[illegible]
7	Michael Cozzaglio	NAFD / Chief	mcozzaglio@northadams-ma.gov	413 652-[illegible]
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February 21, 2019 & March 14, 2019 Meeting Sign-In Sheet

North Adams HMP/MVP Meeting **Sign In** 2.21.2019

#	Name	Affiliation/Title	Email	Phone	
1	Michael Canales	City of North Adams	mcanales@northadams-ma.gov	672-0011	3/14/19
2	Dan Colonno	MCLA	d.colonno@mcla.edu	662-5284	
3	Amalia Jusino	NBEMS	ajusino@northadamsambulance.com	822-8668	3/14/19
4	David Anderson	NAFD Chaplain	davezone66@hotmail.com	652 4179	
5	Sandra Lamb	NACPA Director	spitzerctr@yahoo.com	662-3125	
6	Lisa LaBonte	N.A. Housing Authority	lisa@northadamsha.com	663-5379	3/14/19
7	Tim Lescarbeau	City Of North Adams	Tlescarbeau@northadams-ma.gov	662-3000 X 3235	3/14/19
8	Jennifer Hohn	Executive Director / NAHA	jen@northadamsha.com	663-5379	
9	[illegible]	Lieutenant - North Adams PD	[illegible]@northadams-ma.gov	413-664-4944 [illegible]	
10	Steve Merant	Chief North Adams Fire Dept	smerant@northadams-ma.gov	413-662-3103	3/14/19
11	Bob Flaherty	North Adams Public Schools	rflaherty@napsk12.org	413-776-1262	
12	Michael Moore	NA Health Dept	mmoore@northadams-ma.gov	662-3232	3/14/19
13	Mark R Bushee	NA Health/Inspection Services	mBushee@northadams-MA.gov	662-3000 x 3020	3/14/19
14	William Meranti	City of North Adams	bmeranti@northAdams-MA.gov	662-3000	
15	Carrie Burnett	Business Director	cburnett@napsk12.org	413-464-2930	3/14/19
16					

North Adams Municipal Vulnerability Preparedness (MVP) and Hazard Mitigation Planning
Committee Meeting
3/14/2019

Agenda

1pm Review and make notes on the facilities map and complete hazards assessment worksheet

1:30pm Discuss outreach strategy

1. Brainstorm outreach activities
   Determine public outreach objectives and schedule
2. Identify appropriate outreach methods
3. Develop clear and consistent messages that align with community values
4. Evaluate and incorporate feedback from outreach activities
5. Provide an opportunity for public review of the final draft plan
6. Document the outreach

2pm Decide MVP workshop date(s) and location

2:15pm Solidify invitee list

Sign In 3/14/19

#	Name	Affiliation/Title	Email	Phone
1	Jason LaForest	North Adams City Council Hoosic River Revival	jlaforest@northadams-ma.gov jlaforest@hoosicriverrevival.org	413-663-4587
2				

North Adams Municipal Vulnerability Preparedness (MVP) and Hazard Mitigation Planning Committee Meeting

4/04/2019

Agenda

1pm Questions on the MVP workshop, goals

1:30pm Review Invite List

2pm Confirm the space is available, food arranged for, maps needed, other materials set

April 4, 2019 Meeting Sign-In Sheet

4/4/2019

Sign In

#	Name	Affiliation/Title	Email	Phone
1	Tim Lescarbeau	City of NA Public Services	TLescarbeau@northadams-ma.gov	662-3000 x 3235
2	Bob Flaherty	N.A. Public Schools	rflaherty@napsk12.org	413-770 1262
3	Kevin Hempstead	Council on Aging	KLHNYY27@yahoo.com	413-329-3634
4	Michael Moore	City of NA Health Dept	mmoore@northadams-ma.gov	662-3000 x3020
5	Lisa LaBonte	North Adams Housing	lisa@northadamsha.com	663-5379
6	Amalio Jusino	NBEMS/REPC	ajusino@northadamsambulance.com	822-8669
7	William Morandi	City of North Adams	bmorandi@NorthAdamsMA.gov	652-1528
8	Michael Canales	City	mcanales@northadams-ma.gov	672-0011
9	Jason LaForest	Hoosic River Revival	jlaforest@hoosicriverrevival.org	663-4587
10	Steve Meranti	NAFD / Chief	smeranti@northadams-ma.gov	652-9084
11				

North Adams Hazard Mitigation 2/5/2020

Sign In

#	Name	Affiliation/Title	Email	Phone
1	Steve Meranti	NAFD / Chief	smeranti@northadams-ma.gov	413-662-3103
2	Michael Canales	City of North Adams	mcanales@northadams-MA.gov	413-672-0011
3	Jason LaForest	City Council / Hoosic River Revival	jlaforest@hoosicriverrevival.org	663-4587
4	Kevin Hempstead	COA - City of NA	KLHNYY27@yahoo.com	413-329-3634
5	Michael Moore	Health Director City of NA	mmoore@northadams-ma.gov	662-3000 x3020
6	Albert Zoito	North Adams Police Dept.	AZoito@northadams-ma.gov	(413) 664-4944 ext #1
7	Bob Flaherty	N/A PSK Facilities	flahertybob@yahoo.com	413-770-1262
8				

APPENDIX B: PUBLIC PARTICIPATION DOCUMENTATION

North Adams MVP CRB Workshop Participants – 4/18/19

North Adams Municipal Vulnerability Preparedness and Hazard Mitigation Planning Workshop — **Sign In** — **4/18/2019**

#	Name	Affiliation/Title	Email	Phone
1	BoB ALLARD	ALLSAINTSEPISCOPAL & MRC TEAM LEADER	ALLARDROBERT91@GMIAL	4662294? 6652180?
2	Nick GRIFFIN	NORTH ADAMS HOUSING AUTHORITY	MAINTENANCE@NORTHADAMSHA.com	(413) 663-5379
3	Michael Moore	HEALTH DIRECTOR CITY OF N. ADAMS	MMoore@northadams-ma.gov	413-662-3000 x3020
4	Joseph Charon	NBEMS | NB REPC	jcharon@northadamsambulance.com	413-329-0137
5	JASON LAFOREST	NORTH ADAMS CITY COUNCIL HOOSIC RIVER REVIVAL	jlaforest@northadams-ma.gov jlaforest@hoosicriverrevival.org	(413) 663-4587
6	Steve Meranti	North Adams Fire / Chief	smeranti@northadams-ma.gov	413-652-9004
7	Michael Cozzaglio	north Adams Police	mcozzaglio@northadams-ma.gov	413652-3334
8	AlBERT ZOITO	NORTH ADAMS Police	AZoiTo@NORTHADAMS-MA.gov	413 664-4944
9	Laura Sherman	Northern Berkshire EMS	lsherman@northadamsambulance.com	413.664.6680
10	Jeffrey Kennedy	Billsville BoH	jkennedy@williamstown.ma.gov	413-458-9344
11	CARL McKinney	Town of Clarksburg	clarksburgta111@yahoo.com	413-663-8250
12	DAVID MAISONNEUVE	SAVOY VFD	damais@aol.com	413-464-5697
13	Dan Colonno	MCLA POLICE	d.colonno@MCLA.edu	4136655254
14	Amalio Jusino	NBEMS Asst. Chief	ajusino@northadamsambulance.com	413-822-8669
15	Angela Swistak	NB Transport Director of paratransit	aswistak@northadamsambulance.com	413-822-4545
16	Michael Canales	NA	mccanales@northadams-ma.gov	413 672-0011

North Adams Municipal Vulnerability Preparedness and Hazard Mitigation Planning Workshop

Sign In

4/18/2019

17	Francis Morandi	NOBARC (HAM RADIO)	NOLDO@BCN.NET	413 6639359 2879275
18	Brice George	H.A George	bricegeorge@Gmail.com	4136630652
19	MaryAnn King	NAPD	mking@northadams-ma.gov	413 884 9036
20	Brad Furlon	HWQD	bfurlon@hoosacwaterqualitydistrict.com	413-884-4192
21	Nick Mantello	NAFD	Nicholas.J.Mantello@Gmail.com	413-663-0270
22	Kevin Hempstead	CUFC	KLHHYX276 yahoo.com	413-329-3634
23	Sharon Burke	SMI Adams	sharon.burke@muralstech.com	413-743-6251
24	William Morandi	City of North Adams		413-652-1528
25	Tom Bernard	CITY OF N.A.	mayorbernard@northadams-ma.gov	662-3000
26	Jasonwood	NAPD	Jwood@northadams-ma.gov	662-3436
27	Barbara Malkas	NAPS	bmalkas@napsk12.org	776-1458
28	Kyle George	H.A George	Kylegeorge22@gmail.com	413-446-9742
29	Paul Markland	City of N.A.	Pmarkland@North Adams-MA.Gov	413 652-3162
30				
31				
32				
33				

May 25, 2019 Public Listening Session Sign-In Sheet

North Adams Municipal Vulnerability Preparedness Public Forum

May 28, 2019

Name	Affiliation(s)
Tim Lescarbeau	City of N. Adams
Bob Allard	NBREPC, MRC, CERT, HAMRADIO
Robert W. Smith	140 Pleasant St. - Resident
Bryan K. Sapienza	113 Pleasant St. - Resident, Public Arts Commission
WAYNE WILKINSON	NORTH ADAMS CITY COUNCIL
JOSHUA MORAN	NORTH ADAMS CITY COUNCIL
Eric Buddington	"
Keith Bona	NA Council

Please sign in and use the stickers to vote for priorities.

APPRENIX C: REQUEST FOR COMMENT FROM REGIONAL PARTNERS AND JURISDICTIONS

The request for comment from regional partners and jurisdictions is currently being sent.

APPENDIX D: COMPLETED MITIGATION ACTIONS

In future updates to this plan, this section will contain completed mitigation actions from the Action Mitigation Plan table. This plan currently does not contain completed actions because this is the City's first Hazard Mitigation Plan document