DRAFT

Northfield and Warwick Community Resilience Building and Hazard Mitigation Regional Plan

Adopted by the Northfield and Warwick Select Boards on xx, xx

Prepared by
Northfield and Warwick Core Teams
(Local Planning Team)

and

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This project was funded by a grant received from the Massachusetts Executive Office of Energy and Environmental Affairs' (EEA) Municipal Vulnerability Preparedness Program (MVP).

Acknowledgements

The Northfield and Warwick Select Boards thank the Northfield and Warwick Core Team (Local Planning Team) for their work on this project.

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The Northfield and Warwick Select Boards offer thanks to the Massachusetts Emergency Management Agency (MEMA) for developing the 2018 Massachusetts Hazard Mitigation and Climate Adaptation Plan, which served as a resource for this plan. Technical assistance was provided by staff of the Franklin Regional Council of Governments.

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1 PLANNING PROCESS

1.1 INTRODUCTION

The Federal Emergency Management Agency (FEMA) and the Massachusetts Emergency Management Agency (MEMA) define Hazard Mitigation as any sustained action taken to reduce or eliminate long-term risk to people and property from natural hazards such as flooding, storms, high winds, hurricanes, wildfires, earthquakes, etc. Mitigation efforts undertaken by communities will help to minimize damages to buildings and infrastructure, such as water supplies, sewers, and utility transmission lines, as well as natural, cultural and historic resources. The Massachusetts Executive Office of Energy and Environmental Affairs (EEA) supports climate change resiliency planning and implementation of priority projects through the Municipal Vulnerability Preparedness grant program (MVP). Communities who complete vulnerability assessments and develop action-oriented resiliency plans through the MVP planning process become certified as an MVP community and are eligible for MVP Action grant funding and other opportunities. Funding for planning work is awarded to communities by the State.

Planning efforts, like the one undertaken by Northfield and Warwick, make mitigation a proactive process. Pre-disaster planning emphasizes actions that can be taken before a natural disaster occurs. Future property damage and loss of life can be reduced or prevented by a mitigation program that addresses the unique geography, demography, economy, and land use of a community within the context of each of the specific potential natural hazards that may threaten a community. The combined Hazard Mitigation and Municipal Vulnerability Preparedness Regional plan assesses each community's vulnerabilities and strengths with regard to each natural hazard as well as its emergency preparedness and response capacities.

Preparing, and updating a hazard mitigation plan every five years, can save the community money and facilitate post-disaster funding. Costly repairs or replacement of buildings and infrastructure, as well as the high cost of providing emergency services and rescue/recovery operations, can be avoided or significantly lessened if a community implements the mitigation measures detailed in the plan.

FEMA requires that a community adopt a pre-disaster mitigation plan as a condition for mitigation funding. For example, the Hazard Mitigation Grant Program (HMGP), the Flood Mitigation Assistance Program (FMA), and the Pre-Disaster Mitigation Program are programs with this requirement.

1.2 CORE TEAMS

Producing the Northfield and Warwick Community Resilience Building and Hazard Mitigation Regional Plan involved core teams comprised of the following members:

- , Fire Chief
- , Emergency Management Director
- , Planning Board
- , Board of Selectmen
- , Town Administrator
- , Highway Foreman
- , Police Chief

The Planning process for the Towns included the following tasks:

- Public kick-off meetings held in February 2020 presented an overview of the planning process, key climate change impacts in the region, and initiated discussion of hazard impacts and priorities in each town.
- Reviewing and incorporating existing plans and other information including changes in development in the years since the Towns' previous Hazard Mitigation planning process;
- Updating the natural hazards that may impact the community from the previous plan;
- Conducting targeted stakeholder outreach to gather input into hazard impacts and actions;
- Hosting two, 2-hour, Community Resiliency Building virtual workshops in each town to identify the top hazards of concern, strengths and vulnerabilities, and actions to improve community resilience and mitigate future risk.
- Utilizing the results of the workshops to conduct a Vulnerability/Risk Assessment to identify the infrastructure and populations at the highest risk for being damaged by the identified natural hazards;
- Identifying and assessing the policies, programs, and regulations the community is currently implementing to protect against future disaster damages;
- Identifying deficiencies in the current Hazard Mitigation strategies and establishing goals for updating, revising or adopting new strategies;
- Hosting a public listening session to present the draft plan and gather any final public comment; and
- Adopting and implementing the final Community Resilience Building and Hazard Mitigation Regional Plan.

The key products of this planning process are the development of the Summary of Findings Report, an Action Plan with a Prioritized Implementation Schedule, a set of maps and matrices summarizing strengths and vulnerabilities of the Towns' infrastructure, societal, and natural resource risk profiles, and prioritized community actions that reduce or eliminate long term vulnerability to identified hazards and climate change.

Meetings

Meetings were held on the dates listed below. Agendas for these meetings are included in Appendix A. All meetings followed Massachusetts Open Meeting Law and were open to the public. Due to the COVID-19 pandemic, revisions to the public outreach process were made to accommodate a virtual approach to meetings and workshops.

February 10, 2020

Core Team meeting to review the project schedule and plan for the kick-off meetings and workshops.

February 24 and 27, 2020

Public kick-off meetings were held in each town (residents and stakeholders of both towns were invited to attend either meeting) to present the planning process, provide background on the MVP and Hazard Mitigation Planning programs, review key climate change data and impacts, and begin discussions of hazard impacts and priorities in each community.

May 5, 2020

Staff and Core Team members met virtually to discuss options for moving forward after the onset of the COVID-19 pandemic. A new outreach strategy included attendance by Staff at regularly scheduled Town board and committee meetings, both virtual and socially distanced in-person, to gather input for the plan.

Summer and Fall, 2020

Staff met with the Northfield Energy Committee, Northfield Planning Board, Northfield Selectboard, Warwick Board of Health, Warwick Planning Board, Warwick Conservation Commission, Warwick Energy and Building Committee, and Warwick Open Space Committee. Staff also has discussions with individual Town departments, including the Northfield Wastewater Treatment Plant, Northfield Memorial Library, Northfield Senior Center, and regional and community stakeholders such as Thomas Aquinas College and the Moody Center in Northfield.

January 27, 2021

Staff and Core Team members met virtually to review input from the summer and fall and plan for virtual Community Resilience Building workshops.

February 17 and March 3, 2021

Hosted two, 2-hour, virtual public workshops as part of the Municipal Vulnerability Preparedness (MVP) designation process for Northfield and Warwick. The objectives of the workshops were to:

- Review climate change data and impacts for the region
- Define the top natural and climate-related hazards of local concern
- Identify existing and future strengths and vulnerabilities in three categories: Infrastructure, Environment, and Society

MVP workshop findings have been integrated into the Northfield and Warwick Community Resilience Building and Hazard Mitigation Regional Plan.

March 8 and March 17, 2021

Hosted two, 2-hour, virtual public workshops as part of the Municipal Vulnerability Preparedness (MVP) designation process for Northfield and Warwick. The objectives of the second round of workshops were to:

- Identify actions to address vulnerabilities and/or build upon strengths in three categories: Infrastructure, Environment, and Society
- Prioritize action items to the extent possible

After the second workshops, staff created online action prioritization surveys that were then distributed to workshop participants, regional stakeholders, Town boards and departments, and publicized to residents. The online survey was also available on the town websites or FRCOG website. Survey results were used to help create the final draft action plan for review by the Core Team members.

April 6, 2021

Staff and Core Team members reviewed Table 2-2 Hazard Problem Statements, which included updates from the MVP workshops, and competed Table 3-5 Hazard Identification and Risk Analysis.

April 21, 2021

Staff and Core Team members met to review the draft Action Plan tables for each community and to finalize prioritization.

May 27, 2021
A public listening session was held virtually to present the key findings from the plan and priority actions. The listening session was publicized in local newspapers and on the Town websites. A public review period for the draft plan was open from _____, 2021 through ____, 2021 to illicit final public feedback.

Agendas and sign-in sheets for each meeting can be found in Appendix A. While not all members of the Core Team were able to attend each work group meeting, all members collaborated on the plan and were updated on progress by fellow team members after meetings occurred.

1.3 PARTICIPATION BY STAKEHOLDERS

A variety of stakeholders were provided with an opportunity to be involved in the update of the Northfield and Warwick Community Resilience Building and Hazard Mitigation Regional Plan. The different categories of stakeholders that were involved, and the engagement activities that occurred, are described below.

Local and Regional Agencies Involved in Community Resilience Building and Hazard Mitigation Planning Activities
In February and March 2021, Northfield and Warwick held a series of virtual Community Resiliency Building workshops. The workshops were part of the Massachusetts Municipal Vulnerability Preparedness (MVP) designation program. The workshops were critical to enabling participants to think about and engage across different sectors. The Fire Departments, Emergency Management Directors, Highway Superintendents, Town Administrators, members of the Planning Boards, Select Boards, Energy Committees, Conservation Commissions, and staff from Mount Grace Land Conservation Trust, Franklin Land Trust, FirstLight Power Resources, and the Moody Center, all came together to determine the most threatening hazards to the Towns of Northfield and Warwick and to agree upon high priorities and actions to address them.

In addition, targeted outreach to the MA Department of Conservation and Recreation Forest Fire Control and the Quabbin Food Connector was completed in between workshops. The results of the workshops are documented in the Northfield and Warwick Community Resilience Building and Hazard Mitigation Regional Plan. The Franklin Regional Council of Governments (FRCOG), the regional planning agency for Northfield, Warwick, and all 26 towns in Franklin

County, facilitated the MVP workshops.

In addition to the MVP process, FRCOG regularly engages with the Towns of Northfield and Warwick as part of its regional planning efforts, which include the following:

- Developing the Sustainable Franklin County Plan, which advocates for sustainable land use throughout the region and consideration of the impact of flooding and other natural hazards on development.

- Developing and implementing the Franklin County Comprehensive Economic Development Strategy, which includes goals and strategies to build the region's economic resilience.

- Developing the Franklin County Regional Transportation Plan, which includes a focus on sustainability and climate resilience, and implementing the Franklin County Transportation Improvement Program to complete transportation improvements in our region.

- FRCOG Emergency Preparedness Program staff work with four regional committees: the Mohawk Area Public Health Coalition, the Franklin County Regional Emergency Planning Committee, the Franklin County Emergency Communications System Oversight Committee, and the Western Mass. Health and Medical Coordinating Coalition. Working with these committees and with local governments, the FRCOG works to provide integrated planning and technical assistance to improve and enhance our communities' ability to prepare for, respond to, and recover from natural and manmade disasters.

All of these FRCOG initiatives consider the impact of natural hazards on the region and strategies for reducing their impact to people and property through hazard mitigation activities. The facilitation of the Northfield and Warwick Community Resilience Building and Hazard Mitigation Regional Plan by FRCOG ensured that information from these plans and initiatives were incorporated into the Planning process.

Agencies that Have the Authority to Regulate Development

The Select Board and Planning Board is the primary Town agency responsible for regulating development in town. Feedback to the Select Board and Planning Board was ensured through the participation of a select board person and planning board member on the Core Team and workshops. In addition, the Franklin Regional Council of Governments, as a regional planning authority, works with all agencies that regulate development in Northfield and Warwick, including the municipal entities listed above and state agencies, such as the Department of Conservation and Recreation and MassDOT. This regular involvement ensured that during the development of the Northfield and Warwick Community Resilience Building and Hazard Mitigation Regional Plan, the operational policies and any mitigation strategies or identified hazards from these entities were incorporated.

Participation by the Public, Businesses, and Neighboring Communities

The plan development and public meetings were advertised on the Towns' websites and were posted at the Town Halls and at other designated public notice buildings. A copy of the draft plan was available to the public at the Town Halls, and on the Town and FRCOG websites.

A public listening session on May 27, 2021 provided opportunities for the public and other stakeholders to provide input on the mitigation strategies and action items. Stakeholder letters were sent to Town boards, committees, and departments, and to all neighboring communities, inviting them to the public listening session and to review the plan and provide comments. The public forum and subsequent comment period was advertised via a press release in the Greenfield Recorder and on the Town and FRCOG websites. The final public Comment Period was held from [enter dates] (See Appendix A, Public Participation Process, for copies of all press releases and stakeholder letters mailed to solicit comments on the draft Plan). Comments, if received, were reviewed by the Core Teams and incorporated into the final plan, as appropriate.

The Core Teams and FRCOG staff reviewed and incorporated the following existing plans, studies, reports and technical information, which are cited in footnotes throughout this plan:

- 2013 Northfield Open Space and Recreation Plan
- 2020 Warwick Open Space and Recreation Plan
- 2014 Northfield Multi-Hazard Mitigation Plan
- 2015 Warwick Multi-Hazard Mitigation Plan
- 2019 River Corridor Toolkit
- 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan
- Resilient MA Climate Change Clearinghouse for the Commonwealth
- Additional data sources cited in footnotes throughout this Plan

2 LOCAL PROFILE AND PLANNING CONTEXT

2.1 COMMUNITY SETTING

Northfield and Warwick are neighboring towns located in north central Massachusetts, in the northeast corner of Franklin County, abutting Vermont and New Hampshire. Northfield borders Vernon, in Windham County, Vermont, and Hinsdale and Winchester, Cheshire County, New Hampshire. Warwick borders Winchester and Richmond, Cheshire County, New Hampshire. Northfield is one of the oldest towns along the Connecticut River and the only community to be located on both the east and west banks of the river.

Incorporated in 1723, Northfield attracted European settlers as early as 1673 to farm the fertile soils of the river basin. Homesteading and subsistence farming were predominant in Northfield in the 1700s, and farming grew to cover a large portion of the Town by the 19th Century. By the 20th Century, many farms consolidated, small mills were shut down in favor of larger businesses in adjoining towns, and the Town became known for its Protestant missionaries educated at the Northfield Seminary. The Northfield Seminary campus later became home to the Northfield Mount Hermon (NMH) School, which vacated the site in 2005 to consolidate facilities onto its Gill campus. The Northfield campus was purchased in 2010 and is now the second campus of Thomas Aquinas College.

Established in the 1760s, the Town of Warwick borders Northfield to the east. Warwick's steep, forested hills and high-gradient fast running streams provided waterpower for mills, especially wood manufacturing. The town's extensive forest resources attracted entrepreneurs interested in establishing tanneries and saw, box, glass, and brick mills. By mid-19th Century, most of the land in town had been cleared for agriculture. In 1845, some million board feet of timber were sent to the mills from Warwick, and farms produced modest quantities of field-crops for local consumption with most land devoted to unimproved pasture for raising livestock. However, Warwick's distance from commercial centers in the Connecticut River Valley and limited agricultural potential hampered commercial ventures. Population declined swiftly until the late Twentieth Century, when the automobile enabled people to move to rural areas like Warwick and commute to work in surrounding towns.

Vast acres of abandoned farmland characterized the Warwick landscape in the late 19th and early 20th Centuries. Much of this land was purchased by the State and is now reforested. Together, Warwick State Forest and Mount Grace State Forest comprise almost 12,000 acres or 49 percent of land in Warwick, and is an important open space asset.

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

According to the 2016 MassGIS land cover/land use data, the total land area of Northfield is 22,617 acres, and the total land area of Warwick is approximately 24,136 acres. Table 2-1 shows that forest is the largest type of land cover in both Northfield and Warwick. Including deciduous and evergreen forests, Northfield has approximately 16,731 acres of forest, which comprises 74 percent of its total cover. Warwick has about 21,302 acres of deciduous and evergreen forest, which comprises 88 percent of its total land cover. Open water and wetlands represent approximately 6 percent of the total land cover of both towns, with 1,388 acres in Northfield and 1,488 acres in Warwick. Northfield is nearly 1,460 acres (6.5 percent) cultivated land, which is the second largest land cover type and reflects the significant role of farming in the town. Cultivated land cover in Warwick is a mere 10.3 acres, signifying the lasting forest regeneration that occurred in town during the late 19th century and through the 20th century.

In Northfield, the primary land uses are residential, open land, agriculture, forest, and industrial. Warwick's highest land uses are forest and residential. Tax exempt is the largest land use category in both towns, which could represent a variety of educational, non-profit, religious, government, or other entities, including Northfield and Warwick State Forests.

Although both towns developed as farming and industrial communities, there are only a few commercial activities remaining in either town. In Northfield, commercial land use is 296.5 acres (1.3 percent) and industrial land use is 1,448 acres (6.4 percent) of the total acreage in town, whereas Warwick is 58.8 acres (.24 percent) commercial and 0 acres (0 percent) industrial land uses of total acreage in town.

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

Table 2-1: Northfield and Warwick 2016 MassGIS Land Cover and Land Use Data					
Northfield Total Acres = 22,617 and Warwick Total Acres = 24,136					
Land Cover	**Northfield** (Acres)	**Warwick** (Acres)	**Land Use**	**Northfield** (Acres)	**Warwick** (Acres)
Bare Land	215	45	Agriculture	2,144	417
Cultivated	1,460	10	Commercial	297	59
Deciduous Forest	6,983	6,586	Forest	1,776	3,270
Developed Open Space	853	248	Industrial	1,448	0
Evergreen Forest	9,749	14,717	Mixed use, other	424	0
Grassland	701	362	Mixed use, primarily commercial	146	0
Impervious	540	273	Mixed use, primarily residential	1,536	2,263
Palustrine Aquatic Bed	46	40	Open land	3,733	2,295
Palustrine Emergent Wetland	229	442	Recreation	486	667
Palustrine Forested Wetland	396	615	Residential - multi-family	240	394
Palustrine Scrub/Shrub Wetland	27	88	Residential - single family	3,939	2,314
Pasture/Hay	676	382	Right-of-way	716	326
Scrub/Shrub	53	25	Tax exempt	4,553	11,783
Water	690	303	Unknown	315	244
Water and Wetlands	1,388	1,488	Water	636	104

Source: 2016 MassGIS Land Use/Land Cover data. https://docs.digital.mass.gov/dataset/massgis-data-2016-land-coverland-use

Population Characteristics

According to the U.S. Census, there are 2,997 residents in Northfield as of 2018,[2] which represents a 1% decrease from the 2010 total population of 3,303.[3] Warwick's total population remained stable within the same period, with a population of 780 in 2010, to an estimated population of 781 residents in 2018.[4]

Environmental Justice Populations

The State of Massachusetts defines an environmental justice community if any of the following conditions are met:

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[2] US Census Bureau: 2014-2018 American Community Survey (ACS) 5-Year Estimates

[3] US Census Bureau, 2010 Census

[4] Ibid.

- Block group whose annual median household income is equal to or less than 65 percent of the statewide median ($62,072 in 2010); or
- 25% or more of the residents identifying as minority; or
- 25% or more of households having no one over the age of 14 who speaks English only or very well - Limited English Proficiency (LEP)

According to these criteria, Northfield and Warwick do not currently have any environmental justice populations based on race, income, or language proficiency. More than 95% of Northfield's population is White, with the next largest racial group identified as Hispanic or Latino at 3.3% of the total population. In Warwick, nearly 95% of the population is White, and the next largest racial group identified is Hispanic or Latino at 1.9% of the total population. In terms of income, the annual median household income of Northfield ($72,083) and Warwick ($55,417) is less than the State's annual median household income of $77,378.[5] For more information, see Table 3-17: Estimated Vulnerable Populations in Northfield and Warwick in Section 3, Hazard Identification and Risk Assessment.

Current Development Trends

Current residential development occurs in the greatest density on Route 63 in Northfield Center, and on Route 78 in Warwick Center. Residential development also occurs in a low-density, decentralized pattern across both towns, with single-family homes on lots greater than a half-acre, along rural and scenic roadways. Land Use Controls have been adopted in both towns to protect open space, natural resources, and rural character while allowing for development consistent with community character that would increase tax revenue and employment opportunities in town.

The Town of Northfield has a strong interest in establishing more businesses to diversify its economic base and is committed to maintaining its rural and historic character. Limited infrastructure outside of the village and areas zoned for business uses have kept major industrial and commercial development out of the town in the past. Northfield's roadway network, community water system, and wastewater treatment plant and collection system could have a great impact on future development patterns. Water and sewer lines could be used to provide for concentrations of buildings with commercial, civic, and residential uses in the village center area. Sewer could help certain industrial uses become established. If planned, Northfield's infrastructure can be used to direct development to areas that make the most sense given the Town's priorities and the location of prime farmland soils and environmentally sensitive areas.

[5] US Census Bureau: 2014-2018 American Community Survey (ACS) 5-Year Estimates.

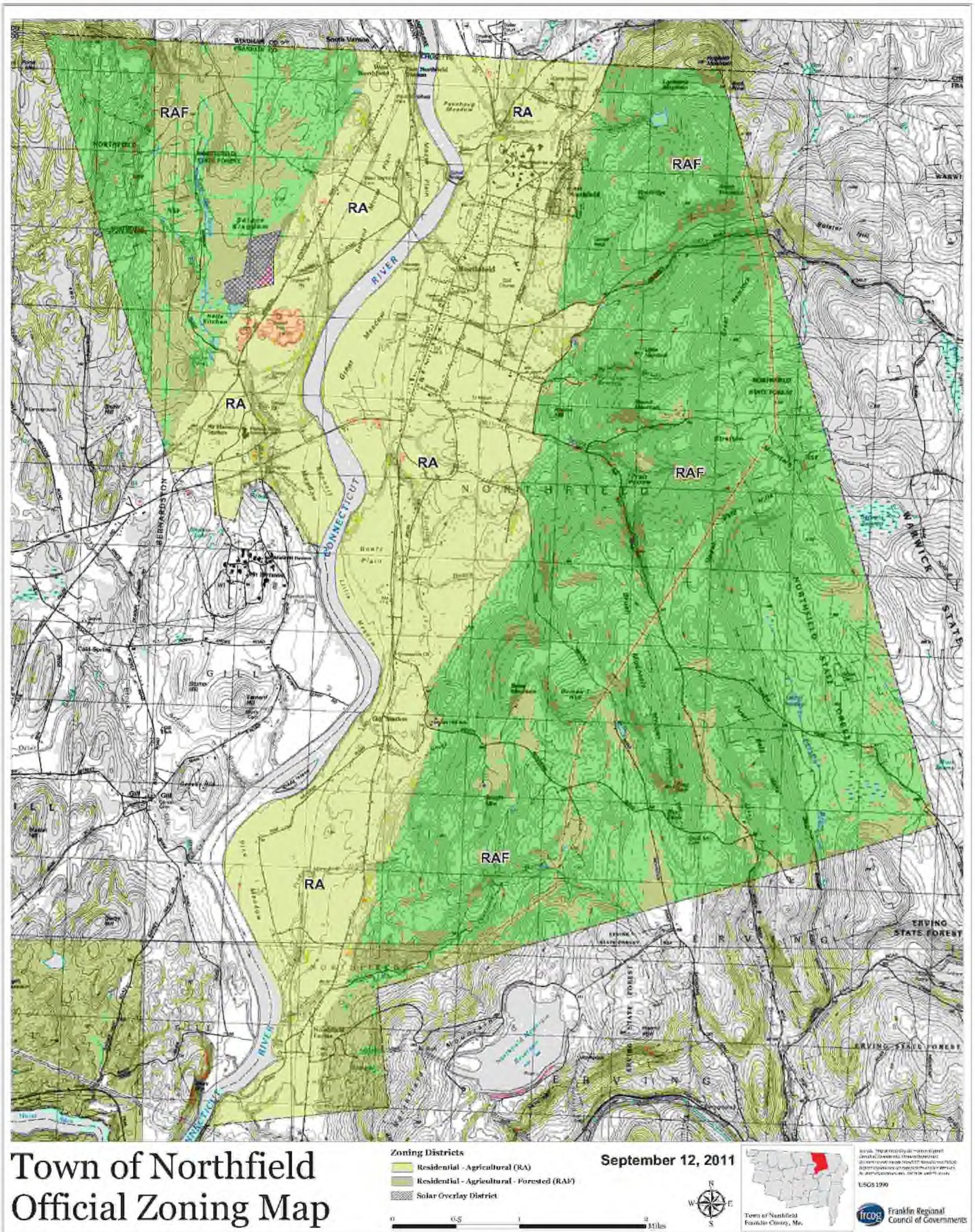
In order to support appropriate business development in town, Northfield adopted zoning bylaw and map revisions in 2017, implementing several recommendations from the 2014 Northfield Master Plan. Implementation provisions include the establishment of three new districts – Planned Development, Recreational Tourism, and Village Center – and options to include business uses on farms to help farm properties remain viable. These changes will help direct development to appropriate locations in town.

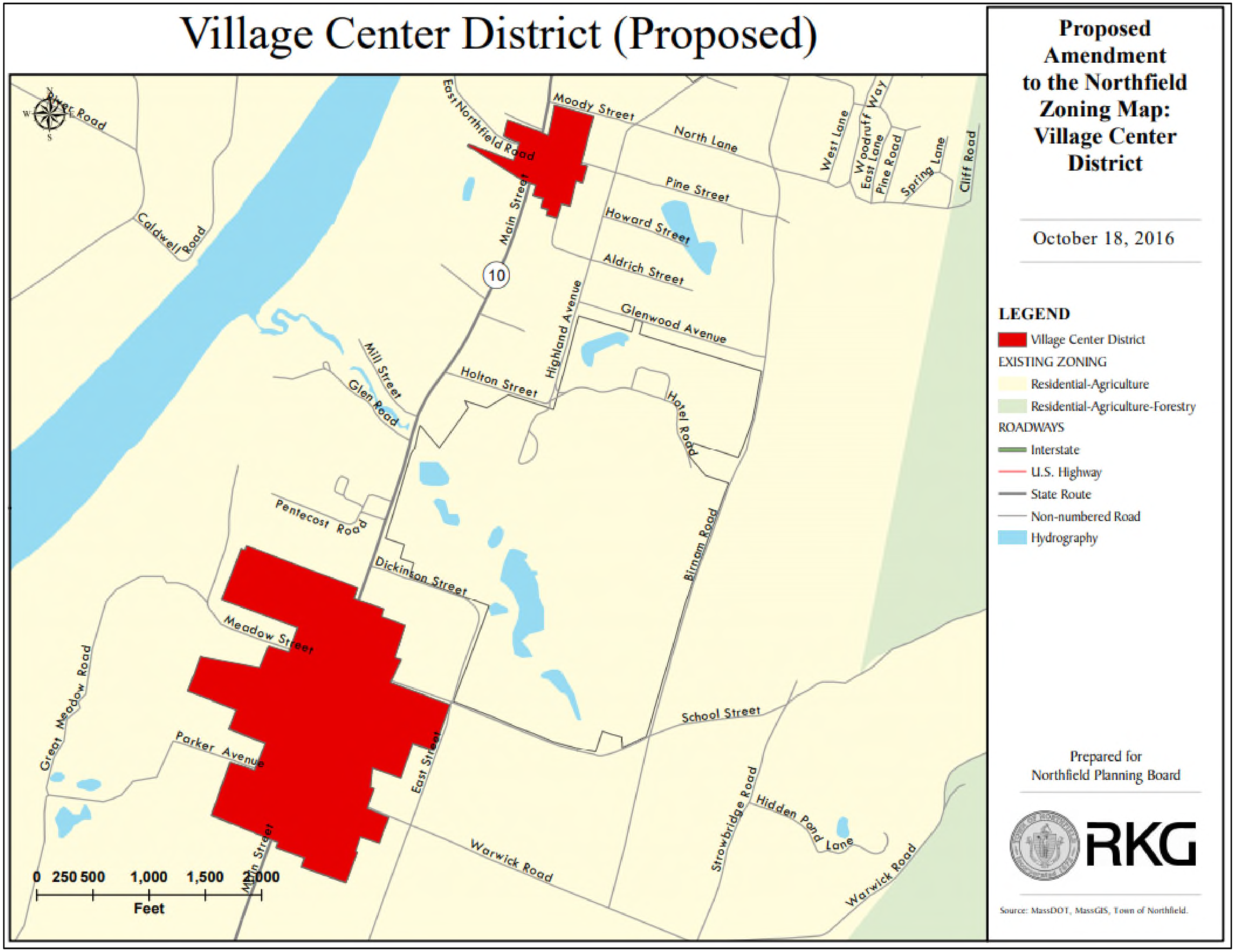
The 2014 Master Plan for Northfield states an objective to improve public services through a strategy that plans for the possibility of potential growth and considers alternative ways of extending sewer service. Actions to support this objective include:

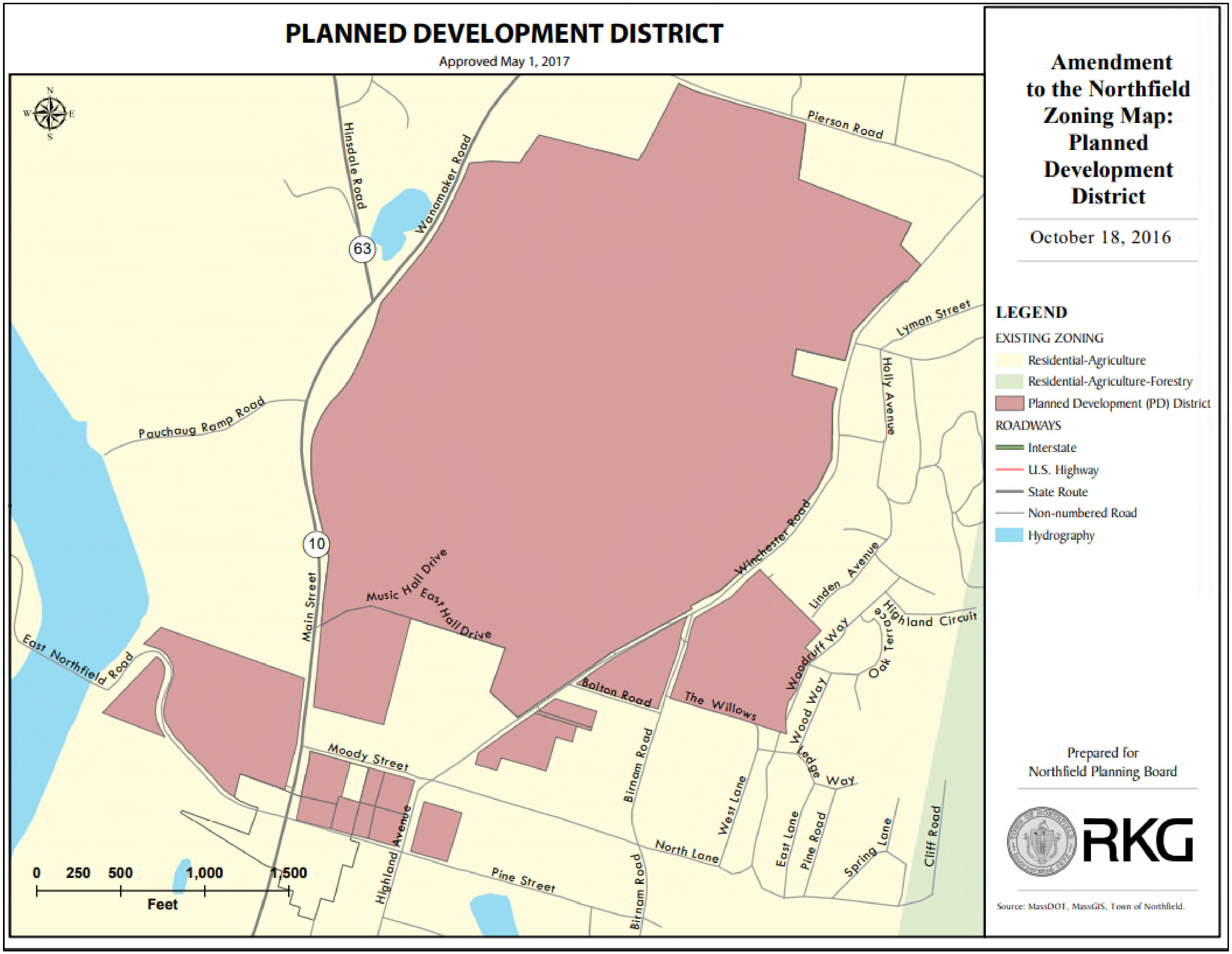
- Explore ways of increasing sewage capacity,
- Consider establishing a Sewer Enterprise Fund, and
- Consider use of on-site sewage treatment plants for large-scale commercial and/or light manufacturing or industrial uses.

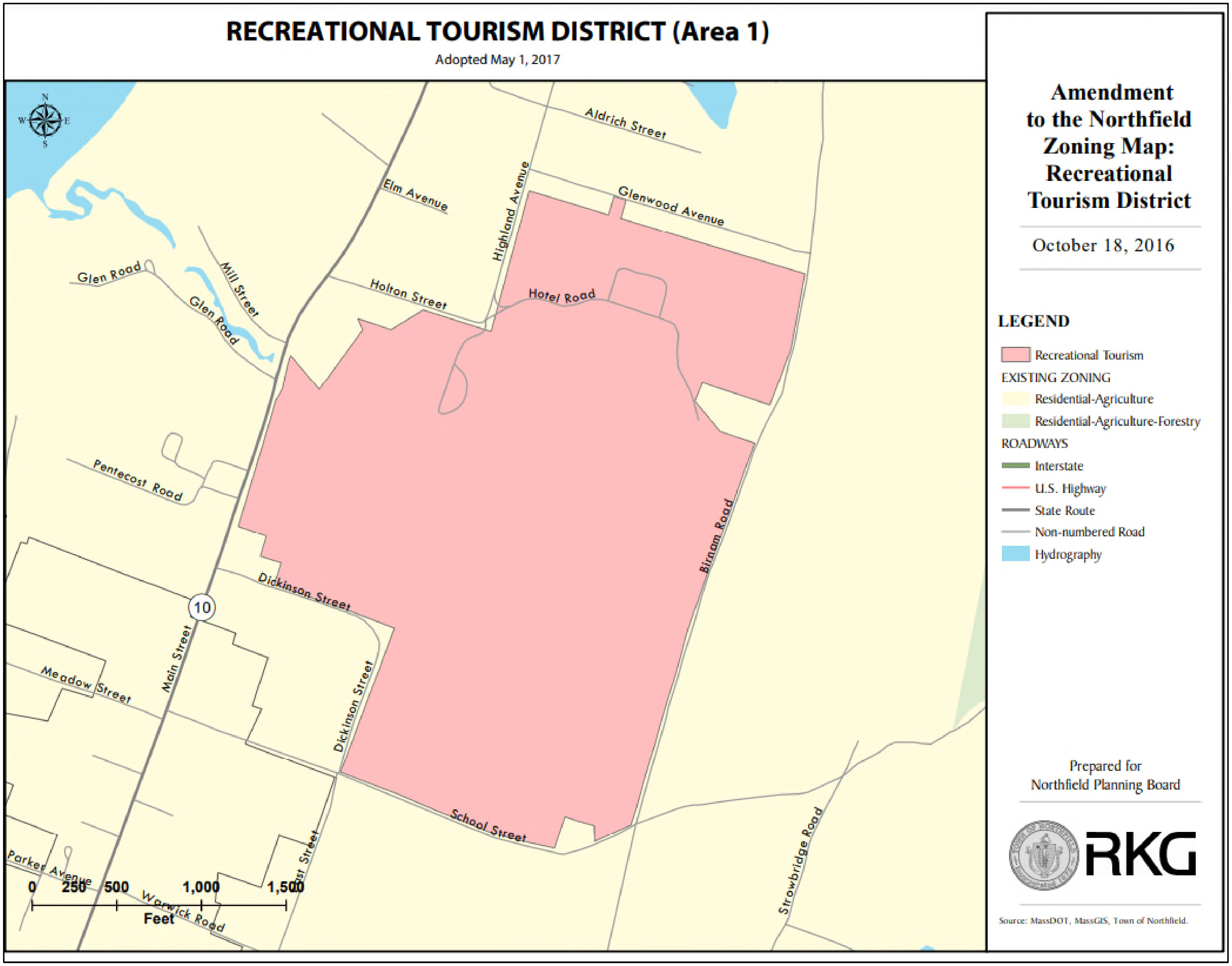
Warwick has had limited growth in recent decades, which is similar to that of the rest of Franklin County. Warwick does not have public water or sewer service, but is served entirely by on-site wells and septic systems. With 98.7 percent of Warwick residents working outside of Town[6] and a lack of small businesses outside of home-based companies, expenses incurred for community and public services must be paid for with revenues generated from taxing residential uses and open space. Warwick has a large amount of land that is protected from development. Permanently protected land, including State Forest land, makes up approximately 58% of the town. An additional 19% of land is temporarily protected through the Chapter 61 program.[7]

[6] U.S. Census Bureau Longitudinal Employer-Household Dynamics (LEHD), 2015
[7] Warwick Open Space and Recreation Plan, 2020


RAF
RA
RAF
RA
RA
RA
RAF
RAF
RA
Town of Northfield
Official Zoning Map
Zoning Districts
Residential - Agricultural (RA)
Residential - Agricultural - Forested (RAF)
Solar Overlay District
September 12, 2011
Franklin Regional Council of Governments


Village Center District (Proposed)
Proposed Amendment to the Northfield Zoning Map: Village Center District
October 18, 2016
LEGEND
Village Center District
EXISTING ZONING
Residential-Agriculture
Residential-Agriculture-Forestry
ROADWAYS
Interstate
U.S. Highway
State Route
Non-numbered Road
Hydrography
Prepared for
Northfield Planning Board
RKG
Source: MassDOT, MassGIS, Town of Northfield.
0 250 500 1,000 1,500 2,000
Feet
Moody Street
North Lane
Pine Street
Howard Street
Aldrich Street
Glenwood Avenue
Highland Avenue
Holton Street
Hotel Road
Birnam Road
School Street
Strowbridge Road
Hidden Pond Lane
Warwick Road
East Street
Main Street
East Northfield Road
Mill Street
Glen Road
Pentecost Road
Dickinson Street
Meadow Street
Parker Avenue
Great Meadow Road
Caldwell Road
West Lane
Woodruff Way
East Lane
Pine Road
Spring Lane
Cliff Road
10


PLANNED DEVELOPMENT DISTRICT
Approved May 1, 2017
Amendment to the Northfield Zoning Map: Planned Development District
October 18, 2016
LEGEND
EXISTING ZONING
Residential-Agriculture
Residential-Agriculture-Forestry
Planned Development (PD) District
ROADWAYS
Interstate
U.S. Highway
State Route
Non-numbered Road
Hydrography
Prepared for Northfield Planning Board
RKG
Source: MassDOT, MassGIS, Town of Northfield.
0 250 500 1,000 1,500
Feet
Pierson Road
Hinsdale Road
Wanamaker Road
63
Lyman Street
Holly Avenue
Pauchaug Ramp Road
10
Main Street
Music Hall Drive
East Hall Drive
Winchester Road
Linden Avenue
Highland Circuit
Oak Terrace
Woodruff Way
East Northfield Road
Bolton Road
The Willows
Wood Way
Ledge Way
Moody Street
Birnam Road
West Lane
North Lane
East Lane
Pine Road
Spring Lane
Cliff Road
Highland Avenue
Pine Street


RECREATIONAL TOURISM DISTRICT (Area 1)
Adopted May 1, 2017
Amendment to the Northfield Zoning Map: Recreational Tourism District
October 18, 2016
LEGEND
Recreational Tourism
EXISTING ZONING
Residential-Agriculture
Residential-Agriculture-Forestry
ROADWAYS
Interstate
U.S. Highway
State Route
Non-numbered Road
Hydrography
Prepared for Northfield Planning Board
RKG
Source: MassDOT, MassGIS, Town of Northfield.
Aldrich Street
Elm Avenue
Highland Avenue
Glenwood Avenue
Glen Road
Mill Street
Glen Road
Holton Street
Hotel Road
Pentecost Road
Birnam Road
Dickinson Street
10
Main Street
Meadow Street
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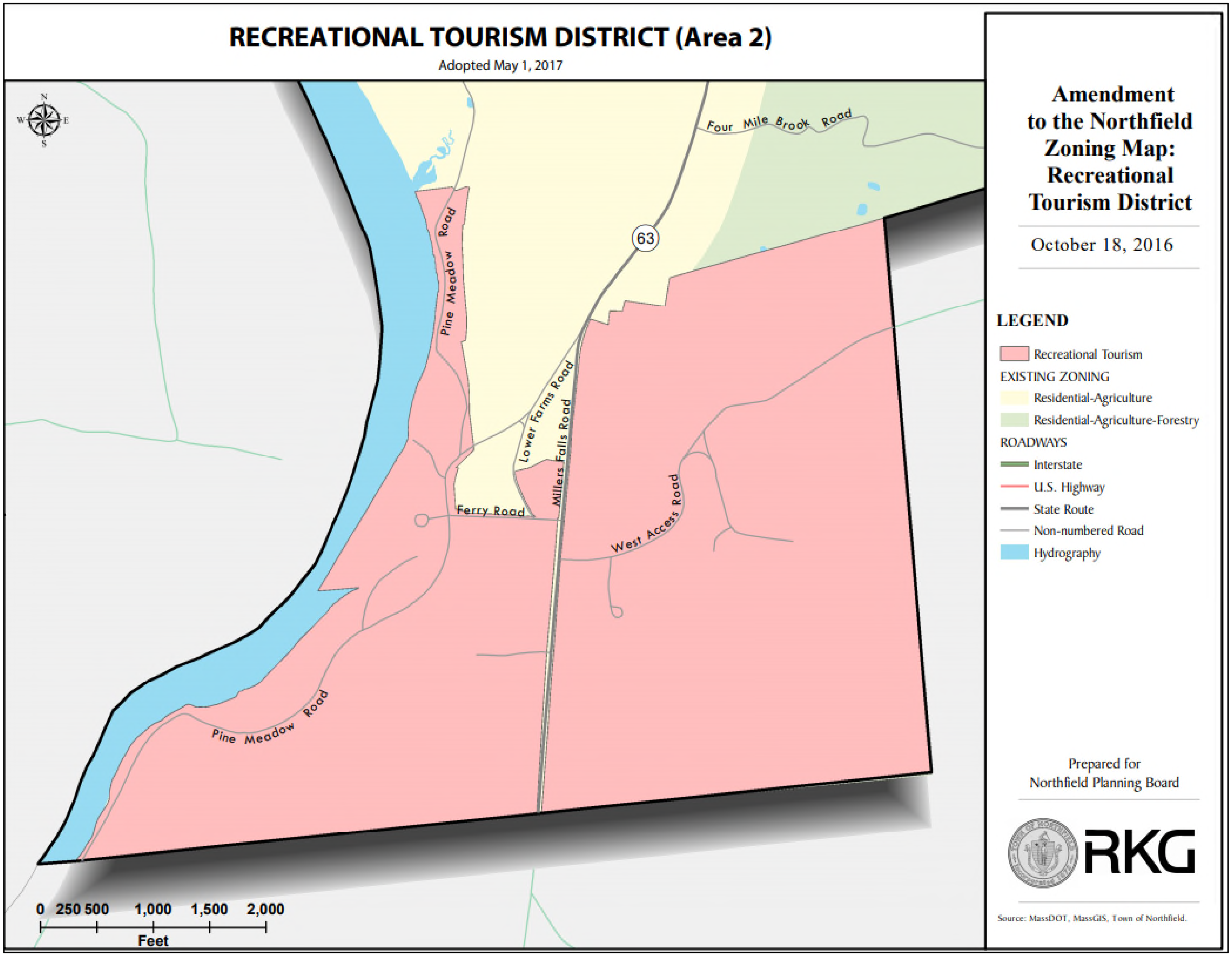
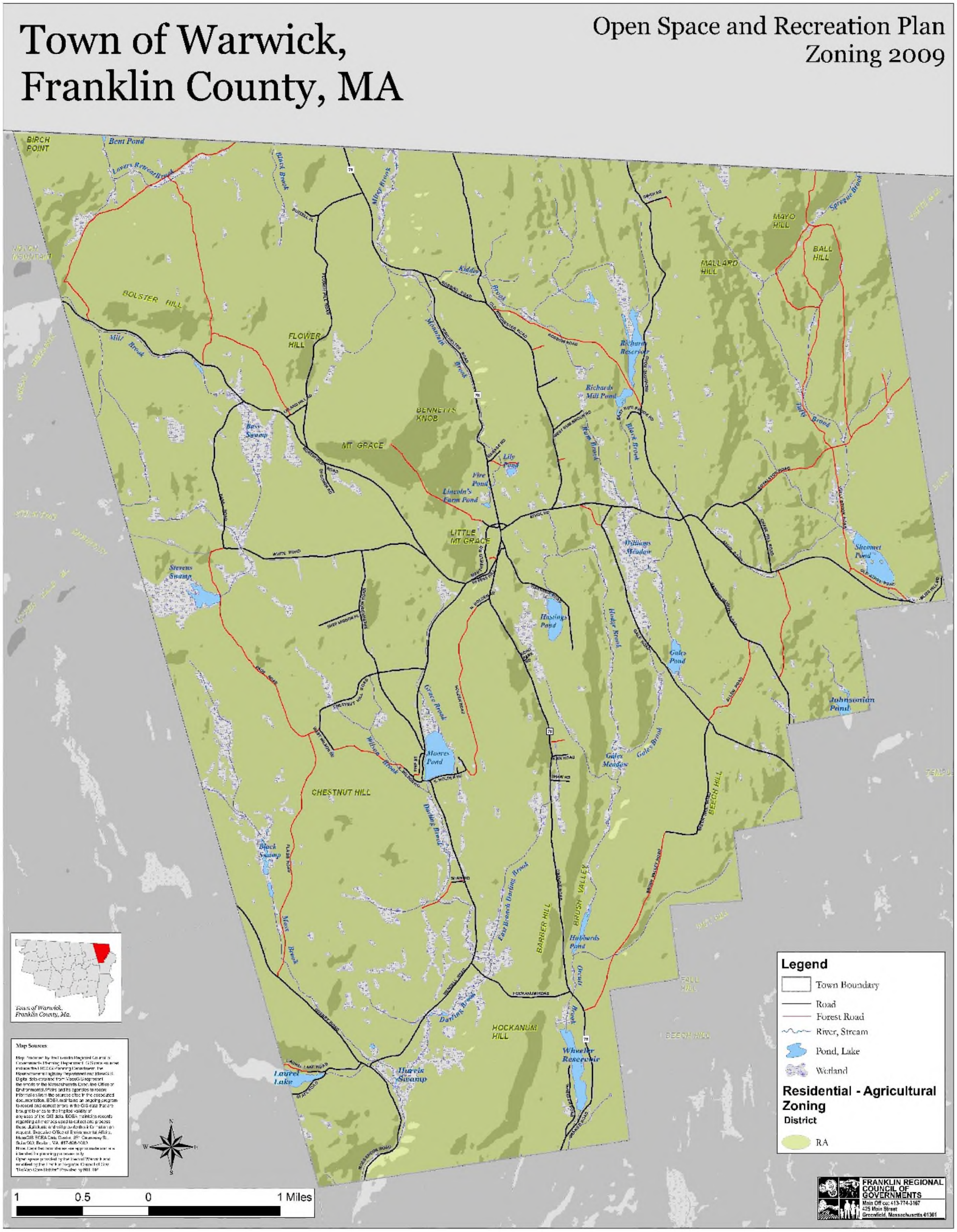
School Street
Strowbridge Road
Parker Avenue
Warwick Road
0 250 500 1,000 1,500
Feet


RECREATIONAL TOURISM DISTRICT (Area 2)
Adopted May 1, 2017
Amendment to the Northfield Zoning Map: Recreational Tourism District
October 18, 2016
LEGEND
Recreational Tourism
EXISTING ZONING
Residential-Agriculture
Residential-Agriculture-Forestry
ROADWAYS
Interstate
U.S. Highway
State Route
Non-numbered Road
Hydrography
Prepared for Northfield Planning Board
RKG
Source: MassDOT, MassGIS, Town of Northfield.
Four Mile Brook Road
Pine Meadow Road
Lower Farms Road
Millers Falls Road
Ferry Road
West Access Road
63
0 250 500 1,000 1,500 2,000
Feet


Town of Warwick,
Franklin County, MA
Open Space and Recreation Plan
Zoning 2009
BIRCH POINT
Bent Pond
MAYO HILL
BALL HILL
MALLARD HILL
BOLSTER HILL
FLOWER HILL
BENNETTS KNOB
MT GRACE
Lily Pond
Fire Pond
Lincoln's Farm Pond
LITTLE MT GRACE
Richards Reservoir
Richards Mill Pond
Stevens Swamp
Bass Swamp
Sheomet Pond
Hastings Pond
Gales Pond
Johnsonian Pond
Moores Pond
Gales Meadow
CHESTNUT HILL
BEECH HILL
Black Swamp
BARBER HILL
BRUSH VALLEY
Hubbards Pond
HOCKANUM HILL
Wheeler Reservoir
Laurel Lake
Harris Swamp
Legend
Town Boundary
Road
Forest Road
River, Stream
Pond, Lake
Wetland
Residential - Agricultural Zoning
District
RA
Town of Warwick, Franklin County, Ma.
Map Sources
1
0.5
0
1 Miles
FRANKLIN REGIONAL COUNCIL OF GOVERNMENTS

National Flood Insurance Program Status

Northfield and Warwick are participating members of the National Flood Insurance Program. Currently there are 9 flood insurance policies in effect in Northfield, for a total insurance value of $2,099,300. Northfield does not have any repetitive loss properties, and no losses have been paid. Northfield's Flood Insurance Rate Map (FIRM) is from 1980.[8] Warwick has no flood insurance policies in effect, no repetitive loss properties, and no losses paid. Warwick's Flood Insurance Rate Map (FIRM) is from 1975.[9]

Roads and Highways

The major arteries running through Northfield are Route 63 and Route 10, which connect Northfield with nearby towns and employment centers. Both Route 2 and New Hampshire Route 9 are close to Northfield and access to them is within a few miles. Route 142 also connects Northfield with Brattleboro and other points south and east. Access to I-91, Franklin County's major north/south route, is within five miles of Town on Route 63/10.

The principal highway serving Warwick is Route 78, which passes through Warwick Center and is the major north-south route running through town. It intersects with State Route 2A at its southern terminus; Route 2A connects to State Route 2, which is the major highway through northern Massachusetts. At its northern terminus Route 78 intersects with Route 10 in Winchester, New Hampshire. Also passing through Warwick Center is the east-west route of Northfield, Gale and Athol Roads. These east/west routes connect Warwick to the neighboring Towns of Northfield, Orange, and Athol. About 36 percent (20 miles) of Warwick's roads are gravel.

Rail

The two major north-south rail lines in Franklin County both travel through Northfield: the Connecticut River Main Line (owned by the Commonwealth of Massachusetts) and the NECR Main Line (owned by New England Central Railroad). There is no railroad in the Town of Warwick.

Connecticut River Main Line: This rail line is owned by the Commonwealth of Massachusetts. The Commonwealth (MassDOT) purchased the rail line in 2014 from Pan Am Railways (PAR). The Line has connections to the NECR rail line in Northfield. This line is now carrying Amtrak passenger service with a stop in Greenfield at the John W. Olver Transit Center. This service was made possible due to funding received from the 2010 American Recovery and Reinvestment Act (ARRA), which funded track improvements and passenger platform construction along the

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

[9] Ibid.

line. The track improvements also allow for greatly increased speeds along this line for freight traffic.

NECR Main Line: This rail line is owned by New England Central Railroad (NECR). The line is composed of 53 miles of right-of-way between Monson and Northfield in Massachusetts. It has a major rail facility located in Palmer in Hampden County, where it interchanges with CSX. The line also interchanges with the Connecticut River Main Line in Northfield and Montague in Franklin County. These large numbers of connections makes this line competitive with the national rail system. This line is also a major north-south corridor for the New England region, connecting Canada with Connecticut and New York. Average annual freight rail tonnages is 1.3 million tons, much of it composed of lumber products and lime slurry shipped from Canada.

While the vast majority of freight is shipped by truck in New England, MassDOT has projected that the amount of rail freight shipments will double over the next 20-30 years. This increase could have a significant impact on Northfield and Franklin County.[10] More information about hazardous materials shipped by rail is included in Man-Made Hazards in Section 3.

Public Transportation

There are no regular public transit services available to Northfield or Warwick. However, the Franklin Regional Transit Authority FRTA provides Demand Response transportation services (door-to-door transportation) for seniors, aged sixty and over, veterans, and people with disabilities in both towns.

Public Drinking Water Supply

Northfield has two public water suppliers that provide drinking water to residents and businesses in Northfield Center and Thomas Aquinas College campus and the surrounding residential neighborhood. The Northfield Water District serves a population of approximately 235 located in the village center on both sides of Main Street (Route 63). A 58 foot deep well on Sturbridge Road provides water for the district**.** A 350,000-gallon storage tank as well as the East Northfield Water Company's Grandin Reservoir serve as emergency back-up water supplies. Most of the pipes in the system were upgraded in the 1960s and 1970s; the storage tank and a pipe on Turnpike Road were added in the 1990s. The water main on Main Street experiences breaks every two-three years, and is in need of replacement. The largest user of the system is the Northfield Elementary School. The approved withdrawal limit for the well is 100,000 gallons per day, while the system average daily use is 40,000 gallons, well within the

[10] Franklin County Regional Transportation Plan, 2020. https://frcog.org/publication/view/franklin-county-regional-transportation-plan-update-2019/

approved withdrawal amount.[11]

The East Northfield Water Company serves the Thomas Aquinas College campus (formerly owned and occupied by the Northfield Mount Herman (NMH) School) and surrounding residential neighborhoods. Prior to NMH vacating its Northfield campus in 2005, the water system served a population close to 800. Now the system serves roughly 300 residents, though this number is expected to grow. The college began housing students and holding classes on campus in the fall of 2019 and expects to increase enrollment in the coming years. The 28 million gallon Grandin Reservoir was created in 1934 as the water source for the system. Other than some early expansion, there have been no major upgrades to the distribution system since it was first installed in the 1930s. A disinfection system was upgraded in 2014.[12] In 2018, above-acceptable levels of bacteria in the Grandin Reservoir were detected during eight different water quality tests, prompting the MA Department of Environmental Protection (DEP) to require a filtration system be installed at the reservoir. The spike in bacteria may be attributable to both a hot summer and runoff from heavy rain events during the testing periods.[13]

The potential cost of the filtration system (approximately $1 million) as well as debt accrued by the system over time as the number of users dropped, lead to rate hike proposals from the company in 2019. This prompted the Town to form an Ad Hoc Water Committee to review the situation and consider options for the district, which is currently a private company and not a public entity.[14] Studies of both water supply systems are needed to identify resiliency upgrades and long-term, sustainable options for operating both systems, including feasibility and implications of forming one water district.

The Town of Warwick is served almost entirely by private wells. Most residences rely on deep wells; approximately one-third to one quarter have shallow wells; and a small number depend on springs. The Town Hall and the Library are served by a water system that originates from a spring on Mount Grace. Private wells in both towns are vulnerable to power outages and drought. Wells located close to roads are also vulnerable to potential contamination from roadway runoff.

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[11] *2013 Franklin County Water and Sewer Survey*. Franklin Regional Council of Governments.
[12] Ibid.
[13] "Water company hopes to avoid $1M outlay." Marcus, Max. The Recorder. Published January 4, 2019.
[14] "Newly formed Northfield Ad Hoc Water Committee holds first meeting." DeLuca, Zach. The Recorder. Published November 8, 2019.

Sewer Service

The municipal sewer system and wastewater treatment plant serves Northfield center and the Thomas Aquinas College campus (former NMH campus). Some pipes have been replaced over time, however, inflow and infiltration (I&I) of water into the pipes and through older manholes covers, especially after heavy rain, contributes significantly to the flow at the treatment plant, which is sometimes overwhelmed. In 2020 the Town allocated funds to complete replacement or lining of roughly 500 feet of pipe, and to coat or replace 20 manholes. More pipe will need to be lined or repaired to address the I&I issues. Until recently, the system was operating at well below capacity due to the vacancy of the former NMH campus.[15] With the campus occupied again, use of the treatment system has increased. The Wastewater Treatment Plant operator anticipates that the design capacity of the plant can handle the increased use at the campus. However, continuing to address I&I in the collection system is needed to ensure the plant operates below the threshold (80% of design capacity) where expansion would be necessary.

The Northfield Wastewater Treatment Plant itself was built in 1972 and is in need of significant upgrades. According to the operator, one issue is a lack of redundancy in the treatment process. If one piece of equipment fails or there is a clog in one section, the whole system could go down. The plant does have a back-up propane generator for power outages.[16] In addition, the plant is located on the edge of the Connecticut River floodplain and is vulnerable to flooding.

In Warwick, all sewage is treated by private septic systems.

Emergency Shelters

Northfield Elementary School and the Pioneer Valley Regional School are emergency shelters in Northfield. Pioneer Valley Regional School (PVRS) has a backup generator as well as kitchen and shower facilities. The school was renovated in 2002 and is in compliance with the current earthquake standards of the Massachusetts State Building Code. Northfield Elementary School has also been identified as a shelter, and a backup power generator and wiring has been installed there for this purpose. The elementary school has kitchen facilities and its middle section was built in 1990 and is also in compliance with the current earthquake standards of the Massachusetts State Building Code. Procedures for opening, staffing, and equipping the emergency shelters on both sides of the river needs to be updated.

Warwick Elementary School is a designated Mass Care Shelter in Town. It has a generator large enough to run the critical sheltering facilities, including the kitchen and bathrooms, which have

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[15] *2013 Franklin County Water and Sewer Survey*. Franklin Regional Council of Governments.

[16] FRCOG communication with the WWTP Operator, Isaac Golding, on July 14, 2020.

showers. Staffing and operating a shelter for an extended period would be difficult for Warwick. Operationalizing the regional shelter plan is needed, along with improved residence preparedness for sheltering in place.

Natural Resources

Two regional landscape-level natural resources important in both Northfield and Warwick are abundant and contiguous forestland and watersheds. Large blocks of contiguous forestland are important regional resources for several reasons. Large blocks of forest provide clean water, air, and healthy wildlife populations. Wildlife species that require a certain amount of deep forest cover tend to migrate out of fragmenting landscapes. New house lots and subdivisions can often result in a widening of human activity, an increase in the populations of plants and animals that thrive alongside humans (i.e. raccoons and squirrels) and a reduction in the species that have larger home ranges and unique habitat needs.

Northfield, like other towns with lands upslope from the Connecticut River Valley, still contains many areas where the forests stretch to include thousands of acres that are not fragmented by development. Much of the forest in Northfield is contiguous to other forests in Erving and Warwick. Warwick's landscape is overwhelmingly forested, has exceptionally low road density and is very lightly developed. The conservation of large blocks of high quality, unfragmented forest has become a priority for regional conservation planners. The Nature Conservancy identified and mapped the best remaining forest blocks in the Eastern Region as part of their Ecoregional Planning Program. The Warwick Matrix Forest Block covers the entire town and received the highest possible ranking.

According to the 2016 MassGIS Land Cover/Land Use data, Northfield has approximately 16,731 acres of forest, which comprises 74 percent of its total land cover. Warwick has about 21,302 acres of forest, which comprises 88 percent of its total land cover. A large amount of this land is state forest and wildlife management areas with additional privately owned land permanently protected by APR, CR or as water supply lands and lands owned by conservation groups.

Water Resources

The Towns of Northfield and Warwick lie in the Connecticut River watershed, which encompasses the Millers River, Ashuelot River, and Mill Brook Basins (sub-watersheds). The Connecticut River is nationally significant. In 1991, Congress established the Silvio O. Conte National Fish and Wildlife Refuge, the only refuge in the country to encompass an entire watershed – the Connecticut River watershed in New Hampshire, Vermont, Massachusetts and Connecticut. Seven years later, in 1998, the Connecticut River became one of only fourteen rivers in the country to earn Presidential designation as an American Heritage River.

Water resources represent approximately 6 percent of the total land cover of both towns, with 1,388 acres of water and wetlands in Northfield and 1,488 acres of water and wetlands in Warwick. The Town of Warwick is home to tributaries to the Millers, Ashuelot and Connecticut Rivers, and all or parts of fourteen ponds, lakes and reservoirs – Laurel Lake, Richards and Wheeler Reservoirs, and Lily, Hastings, Moores, Hubbards, and Johnsonian Ponds. Both the Millers River and Ashuelot River (located in New Hampshire) are large rivers of statewide importance and historical significance. According to MassGIS, Warwick contains five major and six minor low-yield aquifers. There are several Flood Hazard Areas, upland streams and brooks in Warwick that have flooded during major storms and high water. These areas are likely to continue experiencing flood impacts and are discussed in greater detail in the Flooding Section of this plan.

Cultural and Historic Resources

Cultural and historic resources help define the character of a community and reflect its past. These resources may be vulnerable to natural hazards due to their location in a potential hazard area, such as a river corridor, or because of old or unstable structures.

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

Cultural and historical resources in Northfield include sites dating from the colonial period, such as Northfield's Main Street, to the nineteenth century railroads, and saw mill and grist mill sites which helped to expand the Town's economy. Northfield Mount Hermon (NMH) and the Northfield Inn were the predominant man-made features of the town for much of the 20th century and several distinctive architectural features remain. More recent structures include churches, the public library, and municipal buildings. Scenic roads and trails provide access to woods, meadows, streams, and hillside views. Such resources include major and minor trails such as the New England Trail, the Northfield State Forest trails network maintained by Northfield residents, as well as numerous old roads and logging trails. Stream corridors, wetlands, ponds, and the Connecticut River are natural areas that provide both scenic and wildlife values. Unusual natural communities and geologic features include bogs, grasslands, and meadow sanctuaries, and rocky outcrops.

Important historic resources in Northfield include:

- Main Street National Historic District (National Register of Historic Places);
- Simeon Alexander House (Millers Falls Road);
- Northfield District Schoolhouse #2 (Pine Street);
- Schell Memorial Bridge;
- King Philips Hill;
- Historic buildings along Millers Falls Road and Warwick Road;
- Various buildings and landscapes at the Thomas Aquinas College Campus and Moody Center;
- Rustic Ridge Houses;
- 88 Main Street: address of the first American Youth Hostel;
- Historic cemeteries;
- Original homestead of Calvin Swan and Dwight L. Moody
- Cellar holes in the Town Forest and in the State Forest.
- The working farms of Northfield;
- Northfield State Forest; and,
- Kidd's Island.

Cultural resources in Warwick containing historic documents and cultural artifacts include the Warwick Free Public Library and the Warwick Historical Society. The Massachusetts Cultural Resource Information System (MACRIS) lists a total of 53 areas, buildings, burial grounds, objects, and structures of cultural and/or historic significance in Warwick.[17] These include:

- Mount Grace Inn (Warwick Inn – Sheomet House – Putnam's Hotel);
- Atherton, Capt. Arlin S. House (Cobb, William House and Post Office);
- Green, Leslie W. – Francis, Howard House (Hedge, Rev. Lemuel – Reed, Rev. Samuel House);
- Goldsbury, Capt. James House;
- Warwick Historical Society (Wheelock, Col. Lemuel – Wright House);
- New England Box Company (Hanson, C. – Maynard, Nelson House);
- Erving State Forest – Laurel Lake Dam
- Warwick General Store and Post Office
- Franklin Glass Company Showroom and Storehouse and Superintendent House;
- Trinitarian Congregational Church Parsonage
- Warwick Unitarian Church
- Warwick Center Cemetery

[17] Source: Massachusetts Historical Commission, Massachusetts Cultural Resources Information System (MACRIS) Database: http://mhc-macris.net/towns.aspx.

- Stearns, Capt. Nathaniel House
- Mount Grace State Forest
- Warwick Baptist Church – Warwick Public Library
- Warwick Grist Stones
- Warwick Center

Community Facilities and Resources

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

Critical Facilities

A community's critical facilities include important municipal structures (i.e., Town Hall), emergency service structures (i.e., municipal public safety complex, shelters, and medical centers), and locations of populations that may need special assistance (i.e., nursing homes, day cares, schools, prisons) and major employers or other areas where there is a dense concentration of people. In Northfield and Warwick, the identified critical facilities include the town halls; elementary schools; and the Police and Fire stations. There are also two State-licensed home day care facilities located in Northfield (none are located in Warwick). The critical facilities are shown on the Critical Facilities and Infrastructure Maps at the end of Section 2.

2.2 IMPACTS OF CLIMATE CHANGE

Greater variation and extremes in temperature and weather due to climate change has already begun to impact Northfield and Warwick, and must be accounted for in planning for the mitigation of future hazard events. In 2017, the Commonwealth launched the Massachusetts Climate Change Clearinghouse (Resilient MA), an online gateway for policymakers, planners, and the public to identify and access climate data, maps, websites, tools, and documents on climate change adaptation and mitigation. The goal of Resilient MA is to support scientifically sound and cost-effective decision-making, and to enable users to plan and prepare for climate change impacts. Climate projections for Franklin County available through Resilient MA are summarized in this section. Additional information about the data and climate models is available on the resilient MA website: http://resilientma.org

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

Rising Temperatures

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

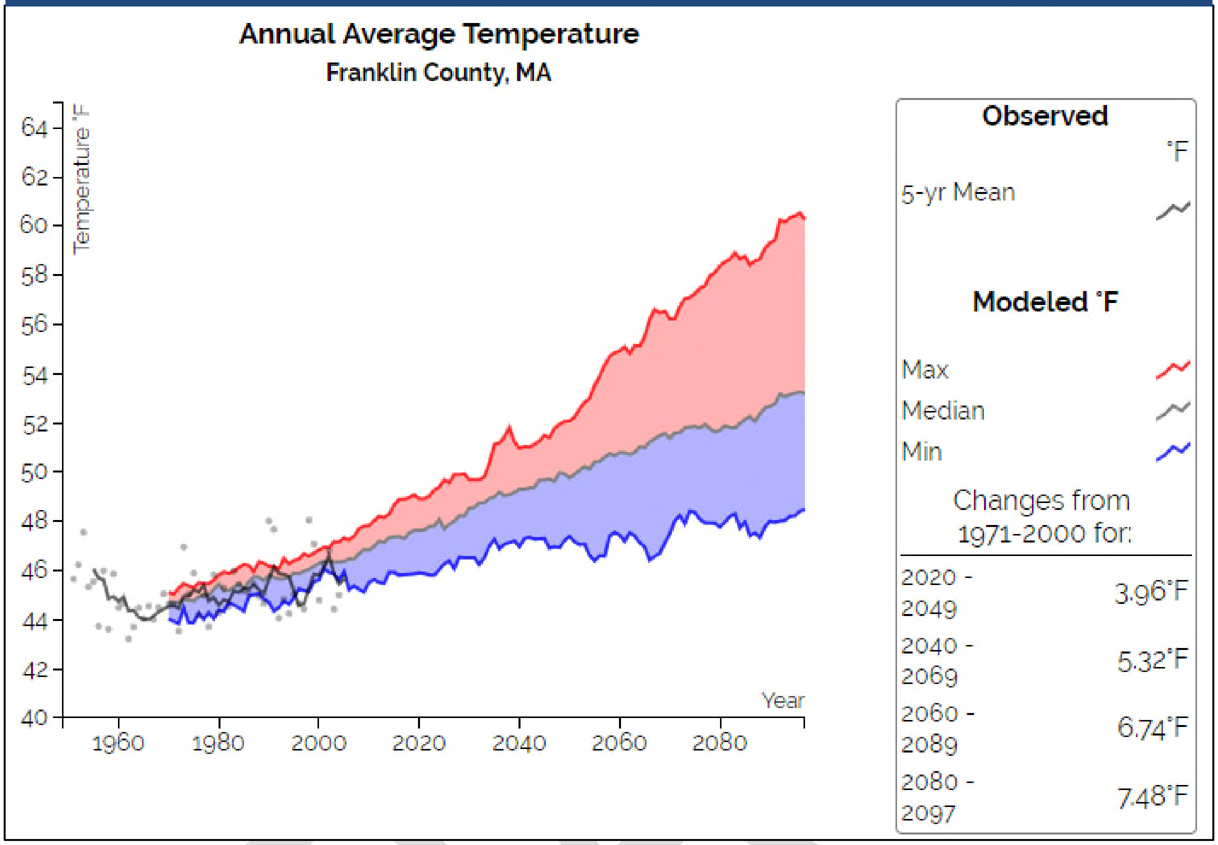
The average, maximum, and minimum temperatures in Franklin County are likely to increase significantly over the next century (resilient MA, 2018). Figure 2-2 displays the projected increase in annual temperature by mid-century and the end of this century, compared to the observed annual average temperature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

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

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

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

Figure 2-2: Projected Annual Average Temperature

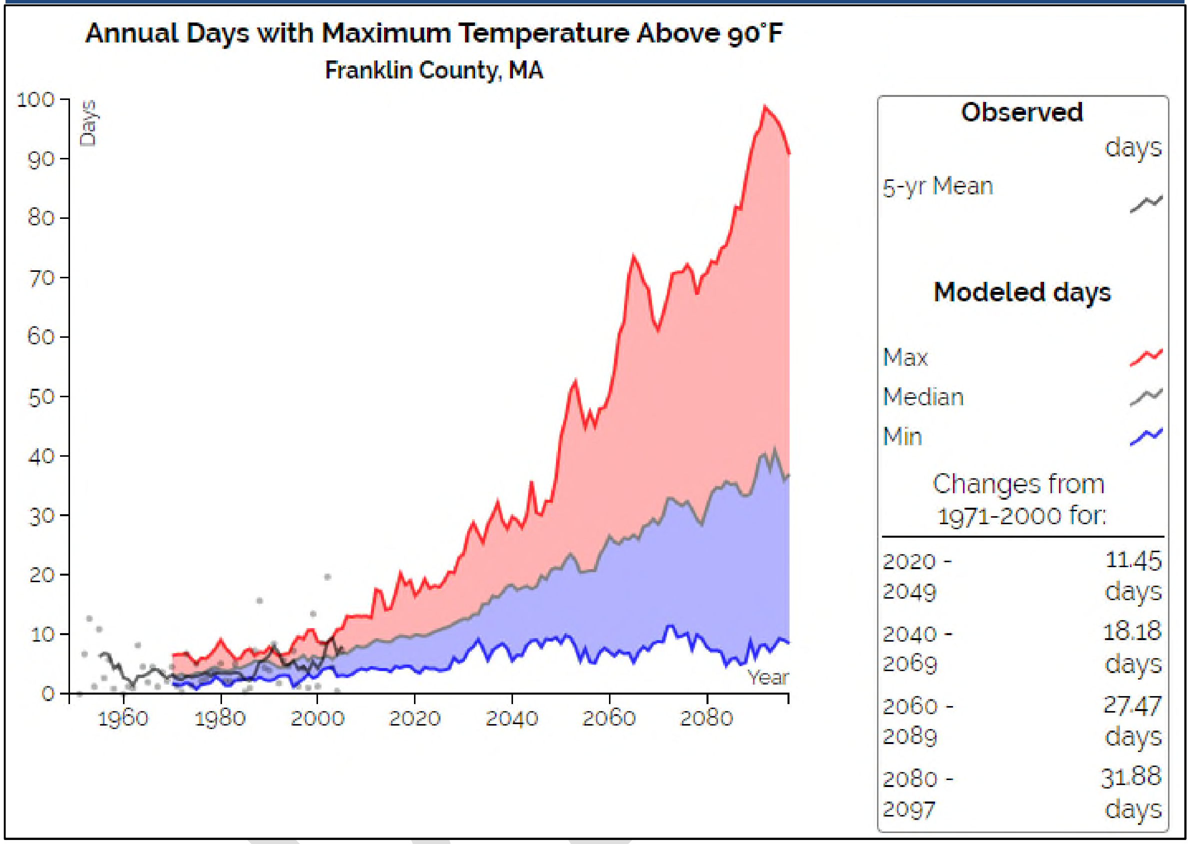


Source: Resilient MA, 2018

Winter temperatures are projected to increase at a greater rate than spring, summer, or fall. Currently Franklin County experiences an average of 169 days per year with a minimum temperature below freezing (32°F). The number of days per year with daily minimum temperatures below freezing is projected to decrease anywhere from 13 to 40 days by the 2050s, and by 15 to as many as 82 days (down to 87 days total) by the 2090s. Figure 2-2 shows annual average temperatures in Franklin County rising to approximately 53° by the end of the century, an increase of nearly 7.5°.

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

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



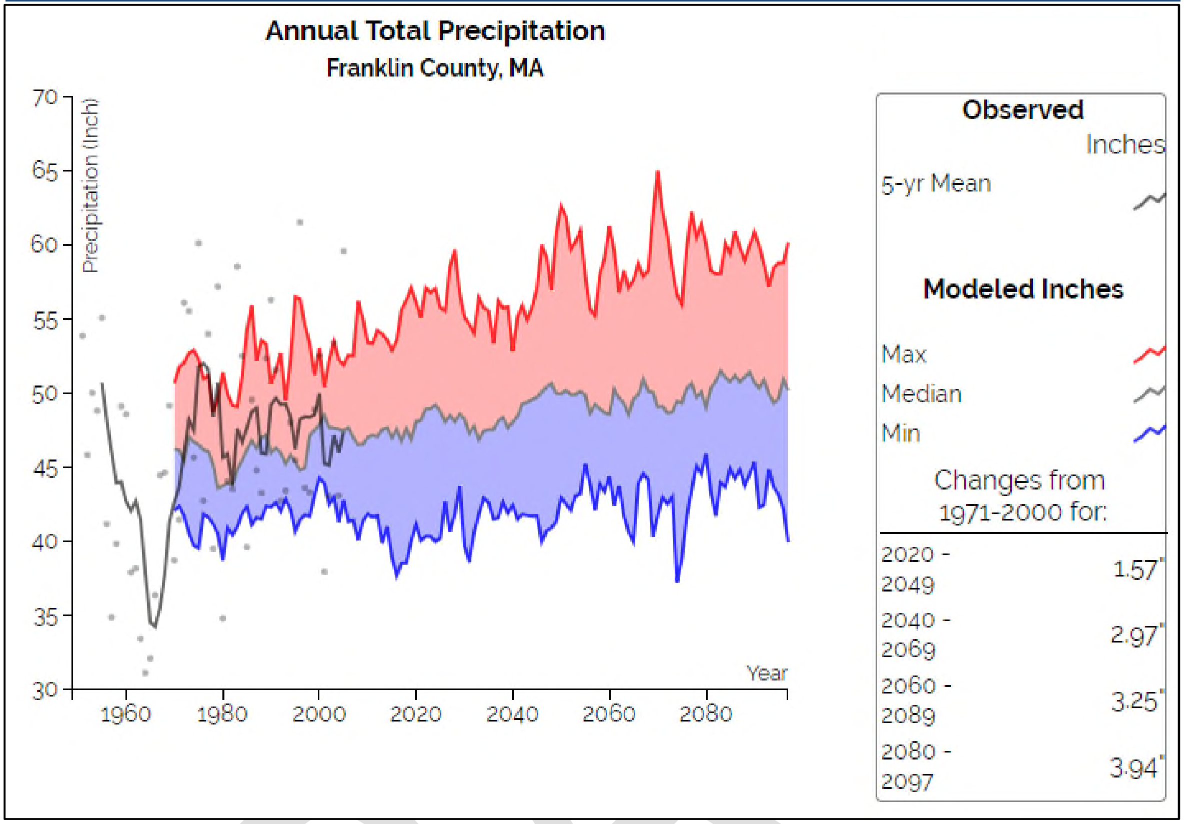
Source: Resilient MA, 2018

Changes in Precipitation

Changes in the amount, frequency, and timing of precipitation—including both rainfall and snowfall—are occurring across the globe as temperatures rise and other climate patterns shift in response. Precipitation is expected to increase over this century in Franklin County. Total annual precipitation is projected to increase by 3 inches by mid-century, and by 4 inches by the end of this century (see Figure 2-4). This will result in up to 52 inches of rain per year, compared to the 1971-2001 average annual precipitation rate of 48 inches per year in Franklin County. Precipitation during winter and spring is expected to increase, while precipitation during summer and fall is expected to decrease over this century. In general precipitation projections are more uncertain than temperature projections.[18]

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

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



Source: Resilient MA, 2018

Extreme Weather

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

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

2.3 SUMMARY OF FINDINGS

2.3.1 Northfield

The summary of findings is based on feedback from the February 2020 project kick-off meetings, from meetings with the Northfield Select Board, Planning Board, Energy Committee, and Library in the fall of 2020, and from the virtual Community Resilience Building workshops held in March 2021.

Top Hazards

- Precipitation extremes
- Severe storms and strong wind
- Manmade hazards and dam failure
- Flooding

Areas of Concern

- **Infrastructure and Facilities:** Impacts to waste water treatment plant; drinking water supply infrastructure; power lines, cell towers, roads, culverts, dams and bridges; Back-up power; Back-up emergency communication infrastructure
- **Community and Population:** Emergency notification, Emergency Action Plans; response and sheltering; power outages; home heating and cooling; insect-borne disease/ infectious disease; impacts to recreational facilities and natural resources with ecological and recreational value
- **Environment:** The Connecticut River; farmland; forest health; cold water streams and watershed resiliency; flash flooding; dam inundation areas; water quality; wetlands; invasive species and pests

Current Concerns and Challenges Presented by Hazards and Climate Change

Northfield residents and town officials have described how rain events are notably more extreme, bringing very heavy and fast precipitation that leads to hazardous flash flooding, erosion, inflow pressure on culverts, and road damage, particularly on the Town's gravel roads. Heavy rain events can also lead to riverine flooding the Connecticut River, and inflow and infiltration (I/I) into the sewer system, which are the major concerns facing the Northfield Water District, the Town's waste water treatment plant located adjacent to the river. In addition to the risk of inundation by rising water levels on the Connecticut River, the plant's actual waste water treatment process becomes overwhelmed with stormwater through I/I, which bypasses the system and causes untreated waste water to flush directly into the river. A new assessment by the State found that the waste water treatment plant is in need of over $8 million in repairs and upgrades. [19]

Northfield wastewater treatment plant at the bottom of Meadow Street.
Paul Franz, Greenfield Recorder

Managing stormwater in the Main Street historic district and surrounding vicinity has become increasingly difficult, not only due to heavy precipitation, but also because of the high water table. One resident who lives on the edge of the wetland between Pine Street and Holton Street, which is close to the Mill Brook, described enjoying watching beavers, kingfishers and great blue herons there. While many in Northfield appreciate wetlands for their beauty as well as their carbon sequestering capacity in the face of climate change, the wetlands immediately to the east of Main Street are making it difficult to keep stormwater from flooding roads, sidewalks, and parking areas, and to keep groundwater from infiltrating subsurface structures, like the basements of buildings and the sewer system.

The parking lot at Town Hall regularly floods with stormwater from rain events, and the Town is working with an engineer to design and implement stormwater BMPs retrofits. Residents nearby on Warwick Road have noted the water level from the adjacent wetland encroaching on their property. The Town will have to continue to find innovative ways to maintain public safety from flooding in the neighborhoods surrounding the historic town center while protecting the system of wetlands that is located there. Safe streets for walking, cycling, and vehicle traffic are essential to Northfield's Main Street historic district. The Town is working to implement its Complete Street Prioritization Plan and will need additional funding to complement and safeguard the transportation upgrades with stormwater BMPs to ensure its Complete Streets are not flooded streets. In particular, the Town will need green infrastructure stormwater Best Management Practices (BMPs) to address stormwater runoff on existing road surfaces and on

[19] https://www.recorder.com/a1-Northfield-wastewater-plant-needs-repairs-37386169

proposed new sidewalks in the Complete Streets Prioritization Plan for Warwick Road (Complete Streets Project #8) and Maple Street (Complete Streets Project #7).
Beavers are active at several locations across town clogging drainage systems with debris and causing local flooding and damage to roads and property. 3 miles of Old Vernon Road, Mount Hermon Station Road, and Rte. 142 could be impacted by a cascading dam failure in Sawyer Pond where beavers have constructed several large impoundments. Other locations include East Street, School Street, and the access road off of Route 10 near Old Bernardston Rd. Allowing beavers to exist and appreciating the ecological value of the wetlands that they create while mitigating the risks of flood hazards that they create continues to be a struggle.

In east Northfield where the topography is steep on the east side of the Connecticut River watershed, flashy streams are impacted by heavier precipitation events. Four Mile Brook Road is still prone to flooding from Four Mile Brook, and Caldwell Road in front of the Highway Garage and transfer station are susceptible to wash outs. The same issue is likely impacting other roads in close proximity to streams in town, including Gulf Road, Orange Road, and Warwick Road. Culverts regularly get clogged and can cause flooding and road washouts. Gulf Road is in poor condition, while Northfield Road in Warwick and Warwick Road in Northfield have many failing culverts.

Another common concern among stakeholders is the increase in the frequency and severity of storms, especially the impact of strong wind on trees, power lines, and communication infrastructure in town. On May 16, 2020, a severe thunderstorm with wind gusts of over 60 miles per hour caused significant tree damage in Northfield and across Franklin County. Another storm on September 30, 2020, caused 23 power outages in Northfield, the most of any town or city in Western Massachusetts besides Hatfield, which had 30.[20] Just one week later, on October 7, high winds brought down all three primary power lines along Route 10, trapping a man in his vehicle with live wires blocking his way in both directions. One of the wires was wedged in his trunk lid, contributing to the life-threatening nature of the situation.[21] Heavy winds can also damage cell phone and radio tower equipment. Northfield has many large trees along Main Street and central neighborhoods, many of which are aging and in need of assessment. Some town trees are falling during storms, disrupting power and internet. Trees in the public right of way elsewhere require ongoing care and maintenance which has to be coordinated with the utility company. The Town values its large trees for their air quality, temperature regulations, and scenic value, but needs to ensure that hazard trees are addressed in order to safeguard against the impacts of high wind. Undergrounding utilities in priority

[20] https://www.recorder.com/Following-Wednesday-morning-storm-Northfield-suffered-most-power-outages-36532988
[21] https://www.recorder.com/a1-high-winds-Franklin-County-36689466

locations is a preferable but often cost-prohibitive strategy.

Energy resilience is a concern for both private households and municipal buildings in Northfield. Backup power at Town Hall and Dickinson Memorial Library needs to be assessed and upgraded for the buildings to continue their vital functions during long-term power outages. Dickinson Memorial library is not only a community information hub, it also houses the Northfield Food Pantry in the basement, which is organized and managed by Unitarian Church in coordination with Amherst Survival Center for surplus food donations. At the height of the COVID-19 lockdown, volunteers filled and deliver boxes of food to people in cars two Saturdays each month during March, April and May 2020. The library opens for heating and cooling during normal hours and has extended hours during extreme temperature events. In addition, the library can provide bathroom facilities, running water, and ADA access when the power is on for operating the elevator. The library lacks backup power, and these vital functions would be curtailed during a power outage. The Northfield Senior Center located at Town Hall also provides important services both routinely and during emergencies. There is a generator for backup power at The Senior Center in the basement of Town Hall, but it would be insufficient to run the heating system for the whole building. Other Town buildings, including the Highway Garage, need to be evaluated for backup power, energy efficiency, and indoor health improvements, which should also be tied to energy resilience measures that increase on-site renewable energy generation, electrification, and back-up power capabilities.

Many homes in town do not have backup power, and residents are vulnerable to losing key household amenities like running water, heating/cooling, refrigeration, phone and internet service when the power goes out. Long-term power outages are especially challenging, and vulnerable populations are most at risk. Severe storms and strong winds are a top priority hazard in Northfield due to their increasing frequency and impact on the power and communications infrastructure serving the town. Guidance for homeowners on how to safely install residential backup power, options for on-site solar generation and battery storage, and how to access grants or rebates to reduce associated out-of-pocket costs would be helpful.

Northfield’s emergency sheltering options need to be reassessed for their readiness to provide overnight or daytime-only shelter, heating, cooling, ventilation, food and medical supplies, and sanitation. The largest potential emergency shelter, Pioneer Valley Regional School, is on the west side of the river and would be inaccessible to the majority of Northfield residents if the Route 10 bridge over the Connecticut River were to be rendered impassable. Planned energy and air quality improvements to Northfield Elementary School will make it suitable for use as a shelter, but it may be too small. There is also a need to reassess and update emergency procedures for opening emergency shelters, for participating in a Regional Sheltering Plan, and for opening and operating the EOC at Northfield Town Hall during emergencies. The COVID-19 pandemic has highlighted the need for enhanced communication. Town facilities are also in need of upgrades to improve air circulation and ventilation to help reduce the risk of infectious disease. For instance, since window inserts were installed at Dickinson Memorial Library to reduce heat loss and save on energy costs, the reduced airflow is an issue due to the COVID-19 pandemic, and a ventilation upgrade is now needed.

Northfield's emergency notification system needs to be improved. Not everyone is on the reverse 911 system, CODE RED, and a number of challenges with communications infrastructure, including spotty cell phone and internet service, means residents may lack reliable access to emergency information. The Town utilizes community liaisons between different contexts to ensure key populations are reached, however, communication could be centralized to avoid miscommunication or communication gaps between different town departments, boards, schools, and residents. There is a need to expand CODE RED to target elder adults and to improve contact between TRIAD and the Senior Center on outreach. In some cases, communication needs to be reestablished with new owners of neighboring institutions and critical facilities to foster mutual emergency preparedness, including Thomas Aquinas College, The Moody Center, and the East Northfield Water Company located in town. Institution administrations should develop a Memorandum of Understanding (MOU) with the Town that ensures public safety both on and off campus. The emergency action plan (EAP) and inundation area mapping for Grandin Reservoir needs to be shared with the Town. Northfield also needs to have updated inundation area mapping and an EAP for a dam failure at Vernon Dam, including a phone tree with town contacts, emergency procedures to follow, and strategic centers to utilize across town. According to input from town residents, Northfield used to be included in emergency preparedness activities, including practice drills, that are no longer provided since Vermont Yankee shut down. There may be other dams in Northfield's vicinity with significant or high hazard ratings, and the EAPs and emergency notification systems need to be redeveloped and tested by the Town.

Route 10 is a State Highway that shares its route with Northfield's Main Street. This means that a large number of heavy vehicles, some of them carrying hazardous materials, routinely travel within close proximity of Northfield Elementary School, some senior housing, Town offices and safety, police, fire and medical services. The transport of hazardous materials through Northfield town center, presents the risk of a manmade disaster in the vicinity of the Town's essential municipal operations and in one of its most populated areas. An updated vulnerability assessment of chemical spills in transportation settings and fixed facilities in Northfield is needed.

Warming temperatures and climate change are impacting Northfield's forest health and water quality. Invasive species and pests, no longer kept in check by cold winters, are changing forest composition, reduced forest cover over streams is harmful to cold water fish resources, forest management is more difficult with warmer winters and less frozen ground for accessing certain forested areas for logging, and land owners may be in need of education and support with implementing climate resilient management techniques in Northfield's forestland. Healthy forests provide important ecosystem services, including water filtration. Recent testing in the Grandin Reservoir, the drinking water source for the East Northfield Water Company serving the Thomas Aquinas campus, Moody Center, and a number of private residences nearby, has shown elevated levels of bacteria. The East Northfield Water Company is facing the need for installation of a costly filtration plant or the development of a new drinking water source – also costly. Funding is needed to help review current engineering assessments of East Northfield Water Company and for engineering studies to determine the Town's best options for safeguarding and managing Grandin Reservoir's water.

Specific Categories of Concerns and Challenges

Flooding and Road Washouts

The small streams and rivers in Northfield can swell quickly with stormwater brought by heavy rain. Culverts regularly get clogged with debris leading to a buildup of pressure at the culvert inlet which can lead to flooding, road damage and washouts. Undersized and failing culverts can also lead to flooding and road washouts, and the increasingly intense rain events impacting Northfield are exacerbating this major challenge.
Key areas of concern include:

- 4 Mile Brook Road
- Caldwell Road
- Gulf Road
- Northfield Road in Warwick
- Warwick Road in Northfield

In Northfield, the 100-year floodplain covers about 2,283 acres, or approximately 10 percent of the town, including an estimated 20 acres of developed residential land, less than 1 acre each of industrial use and commercial use, and 3.6 acres of public/institutional. Much of the floodplain consists of agricultural land or forest. The north end of town near the State boat ramp and the Lower Farms area along the Connecticut River are flood prone areas in Northfield.

Wetlands act as flood storage, and meadows and hayfields that are growing back into brush may be doing a better job at storing water. Identifying and implementing nature based solutions through stronger wetland and waterway protections, land conservation, and incentives for landowners to protect key areas on their land could help ensure these eco-system services continue to mitigate flooding and other climate change impacts.

Mapping of structures/roadways/infrastructure vulnerable to flooding should include the 100-year floodplain and other known flood-prone areas for both current conditions and projected precipitation levels under future climate conditions. An inventory of structures and land uses in the mapped river corridor and 100-year floodplain are needed in order to expand the risk assessment for flooding and fluvial erosion hazards and identify possible mitigation measures.

Northfield could also be impacted by dam failure at significant and high hazard dams in town, including at Grandin Reservoir, and in neighboring communities, such as Vernon Dam in Hinsdale, New Hampshire. The inundation area mapping for these dams needs to be shared with the Town of Northfield in order to inform emergency response planning.

Power Outages

Another major hazard facing Northfield is downed trees and power outages. Many households do not have a generator. A series of strong storms in 2020 caused numerous power outages within weeks of each other. Storms brought high winds that damaged town trees which fell on power lines, blocked roads, and pulled wires to the ground in town center. Northfield also has many remote locations in town where residents get isolated if trees block the road. Areas most vulnerable to power outages include town center and along main roads.

The Town and residents need to plan for long-term outages, beyond one week. The 2008 ice storm left many areas without power for up to 5 weeks and this could happen to Northfield too. A long-term sheltering plan is needed that can accommodate residents on both sides of the Connecticut River. The largest potential emergency shelter, Pioneer Valley Regional School (PVRS), is on the west side of the river and would be inaccessible to the majority of Northfield residents if the bridge were impassable. PVRS may need to be reassessed for readiness to provide long-term shelter, circulation and ventilation to help reduce the risk of infectious disease, and backup power options, including clean energy with on-site generation and storage. Planned energy and air quality improvements to Northfield Elementary School will make it suitable for use as a shelter on the east side of the river, but it may be too small. Backup power options are needed to help residents get through power outages.

Energy Resilience

Related to power outages, improving energy resilience in homes and Town buildings is a major need and challenge. There is a small solar PV array located on the south facing roof of the pavilion behind Town Hall, and the Northfield Energy Committee (NEC) has been working on upgrades to Town buildings to make them more energy efficient and properly ventilated. In 2018, NEC received Green Communities Grants to reduce energy demand and utility costs at Northfield Elementary School (NES) through building envelope and lighting improvements. A 2020 Green Communities Grant will fund additional energy conservation measures at NES that will address heating and ventilation systems, including replacement of inefficient heating controls and improved heat delivery units. In addition to making the existing equipment heat more efficiently and provide greater comfort, they will be able to accommodate future upgrades, such as air source heat pumps. The final component of the NES upgrades is the installation of heat recovery ventilators (HRV) to provide adequate year-round ventilation and improved air quality while minimizing heat loss. The selected HRV system is designed for schools, is quiet, and clinically proven to help those who struggle with allergies and asthma. The remainder of the 2020 Green Communities grant will be used to purchase and install a cold-climate air source heat pump at the Dickinson Memorial Library.

Moving forward, the Committee is interested in looking at on-site solar and battery storage as a resiliency strategy for other town buildings, assessing energy efficiency upgrades at the Town Highway Department, and ensuring that requirements associated with major facilities upgrades at the waste water treatment plant, such as a new office building and other physical plant changes are built to high energy efficiency standards, and that increased energy usage of new equipment and operational procedures and structures is managed through clean energy generation. Exploring options for newer systems that utilize the waste itself as a source for heat exchange is also of interest to the Energy Committee. Additionally, public outreach to residents with information about incentives for installing clean energy options in homes, especially combined with back-up battery storage, was also identified as a strategy.

Communication Infrastructure

Existing communication infrastructure issues and vulnerabilities could be exacerbated by hazard impacts. Town bylaws may need updating to prevent wind-related damage, protect nearby roads and utilities, and ensure regular inspection and maintenance. Adding battery back-up power to the cell tower is in process, and is expected to provide up to seven days of back-up power. There is still a need to address communication redundancy for residents. A wireless broadband solution could be implemented to help with this issue. The radio tower on Mount Grace has back-up power. Plans are in the works to replace the tower with a new, taller tower that will include emergency communication channels and back-up power. This is being done by AT&T with funding from Homeland Security.

Private Wells for drinking water

Well owners need support and guidance on how best to keep their wells safe and productive.

Northfield does not have a backup public water supply, and while the Town works to determine how best to cope with the elevated bacteria levels in Grandin Reservoir, the water supply for Thomas Aquinas College and surrounding private homes and whether to pursue a new public drinking water source, keeping residents' private wells safe and productive is vitally important. A helpful strategy in the interim is to formulate a plan for better winter road practices to help mitigate potential for road salt contamination in drinking water wells. The Town can use less salt on the roads, and there are more environmentally friendly materials, but these are expensive. The Town can also implement water conservation strategies for municipal buildings and educate residents to do the same at home.

Forest Resilience

74 percent of the land cover in Northfield is forested and contributes to a large regional greenway of contiguous forestland that provides critical habitat and supports biodiversity. Forests in Northfield will be faced with stresses due to climate change and human land management that can be expected to shape their ecology and resilience over time. Sustainable forestry practices that strike a balance between environmental protection and economic development can provide a sustainable source of wood products, increase the diversity of habitats for wildlife, provide jobs, offer places for recreation, and contribute valuable ecosystem services such as water purification. Conserving resilient forests and the linkages between them by limiting fragmentation will help plant and animal species find suitable habitats and endure the stresses of climate changes. Large, intact forested areas will also be more likely to recover from extreme events such as droughts, wind storms, ice storms, and flooding.

Maintaining healthy forests well into the future will necessitate addressing stressors like invasive species and forest pests in an effort to increase forest resiliency. Forest landowners may take both passive and active management approaches to forest stewardship. Financial incentives to conserve and manage forestland for climate resiliency and carbon sequestration and storage could help landowners maintain healthy forests in Northfield that in turn mitigate climate change and its impacts.

There is a need to promote forest stewardship practices on private and public forestlands that produce more resilient forested landscapes to reduce the risk from drought, severe weather, invasive plants and pests, and other climate change impacts.

Firstlight Power and the Connecticut River

Significant pool fluctuations on the Connecticut River related to operations of Northfield Mountain pumped storage facility are contributing to on-going streambank erosion, degradation of riparian habitat, loss of farmland, ice jams, and degradation of historic assets and recreational facilities along the river. Since the Northfield Mountain Pumped Storage Project came on-line in 1972, landowners in Northfield have watched mature trees in the riparian buffer and prime farmland soils slump and topple into the Connecticut River. Pauchaug State Boat Ramp, the most heavily used recreational boat launch located in the northeast of town requires fairly frequent dredging. FirstLight owns most of the riverbank and could be instrumental in implementing bank stabilization measures that are critically needed to mitigate on-going degradation of these environmental, cultural, and infrastructural assets. Seasonal monitoring for ice buildup and ice jams is also needed. The Town should continue working closely with the FRCOG and other local and regional stakeholders during the FERC and 401WQC permitting processes to ensure that the Town's voices are heard.

Current Strengths and Assets

Northfield has a variety of strengths to draw upon to see the community through natural hazard events. Among them are critical facilities and emergency services, institutions with key amenities that can be available through mutual aid agreements, and a network of capable volunteers and business owners willing to contribute their time and resources to help the community. Northfield also has a wealth of environmental resources, which it values and stewards with care and attention. The Town is familiar with its vulnerabilities, but also its strengths and actions to address these vulnerabilities. Participants cited several strengths and assets that help keep their community resilient in the face of climate change and other challenges. They include:

Town Hall and Emergency Operations Center (EOC): Northfield Police, EOC, and Senior Center are located at Northfield Town Hall. The Police and EOC serve Northfield and neighboring communities. Northfield EMS is paramedic level with two fully staffed 4WD ambulances. In addition to housing day-to-day municipal operations, the Town Hall provides emergency services, including emergency radio communication, emergency warming/cooling, prepared meals, charging stations, emergency drinking water, and is ADA accessible with a wheelchair elevator lift. The Building is equipped with a pellet furnace, mini-splits, and oil furnace for redundant heat supply. Electricity is essential for day-to-day operations as well as emergency services at Town Hall. The building does have a generator, but it would need to be replaced in order to serve the entire building and ensure ADA access during power outages. The Town is working with an engineer to design and implement stormwater BMPs retrofits to address flooding in the parking lot.

Emergency Response: In addition to strong EOC, Police, and EMS services with the capacity to serve Northfield residents as well as neighboring communities, Northfield is a member of the

Franklin County Cooperative Public Health Service Health District, and the Franklin County Medical Reserve Corps are organized locally. Both resources have been helpful for responding to the COVID-19 pandemic. The Town Highway and Fire Departments can coordinate with neighboring towns for support in East or West Northfield if the Route 10 Bridge cuts off local access during an emergency. The Fire Department conducts trainings to keep responders ready for a for hazardous material or chemical spills in fixed facilities and/or transportation routes in town. DCR provides trainings in Northfield for wildfire responders to locals as well as state firefighters. The Moody Center could also provide valuable emergency resources, including dining facilities, commercial kitchens, and dormitories for >100 people. Proactively utilizing and maintaining these and other regional assets strengthens Northfield's community resilience.

Town Buildings: The Energy Committee has been working to upgrade building envelopes, lighting, ventilation, and energy systems at public buildings, including Northfield Elementary School (NES) and Pioneer Valley Regional School (PVRS). Each school serves as an emergency shelters on either side of the Connecticut River, which is important should the bridge close. Dickinson Memorial Library is a sturdy stone structure, invulnerable to wind, snow, and ice, with plenty of seating, bathroom facilities, running water, heat and air conditioning, and ADA access if power is on for operating the elevator.

Societal Strengths and Assets: Participants said that strong relationships exist between the Town, businesses, and residents in Northfield, with residents and businesses always willing to help each other out, especially during emergencies. The Moody Center would like to pursue an MOU with the Town for emergency support services as well as events at Hibbert Hall for entertainment, community connection, and enrichment. Thomas Aquinas College and FirstLight Power may also be a resource for the Town in times of need. Northfield Senior Center, Food Pantry, and Council on Aging work diligently to ensure food security for elder adults and to provide emergency information, transportation, and other forms of support. The Sherriff's Department TRIAD program checks on the safety and needs of residents, especially elder adults during and after emergency events.

Environmental Awareness: Many residents of Northfield are environmentally aware and interested in environmental stewardship practices, sustainable farming, and clean energy. Northfield's Open Space Committee is proactive in the protection of local watersheds, special habitat areas, cold water streams and water resources, and contiguous forests. Dickinson Memorial Library actively promotes climate change education and awareness through book groups and community initiatives including CREW: Communities Responding to Extreme Weather, Climate Preparedness Week, 350 Massachusetts' Better Future Project, Massachusetts Voluntary Organizations Active in Disaster (VOAD), and by providing links to environmental resources on the library's website and facebook page.

2.3.2 Top Recommendations to Improve Resilience

Following Northfield's virtual MVP workshop, participants voted online on the resiliency actions brainstormed during the meeting, and then ranked all of the actions via a poll in Survey Monkey. Full results from the survey are shown in the Appendix. Poll results were consolidated as appropriate to develop Northfield's top priority recommendations as shown below. Recommendations address key vulnerabilities while building upon current strengths.

Strategies and recommendations addressing urgently needed wastewater infrastructure upgrades represent Northfield's top three (3) priority recommendations, given the critical condition of Northfield's wastewater treatment plant combined with the severe inflow and infiltration affecting the Northfield Water District. The recommendations are to:

- Seek financial assistance for nearly $8 million in required improvements urgently needed for conditions at the wastewater treatment plant to meet operating standards and address the plant's flood vulnerability.
- Seek financial assistance to implement recommended infrastructure upgrades and repairs to aging sewage pipes identified in the Town's I/I engineering report to meet EPA minimum Inflow and Infiltration requirements.
- Ensure that planned upgrades of the WWTP safeguard new and existing buildings and infrastructure associated with the treatment facility from riverine flooding.

Renewable sources of backup power at municipal buildings and critical facilities was a top priority to improve the Town's energy resilience in the face of repetitive and/or long-term power outages. The Town would like to seek funding to assess the potential for a micro grid with solar PV power and investigate small-scale battery storage on town properties. In particular, upgrading the backup power at Town Hall to power the entire building during power outages is a top priority due its vital importance during emergency situations. Residential-scale options for solar PV with small-scale battery storage as well as implementation guidance and grant funding options to purchase necessary infrastructure is needed. The town would like to include rainwater harvest infrastructure and a solar array in the development of designs for the new large emergency services building.

Developing backup and redundant communication options for residents and for town operations during hazards was a top priority for Northfield as phone and internet lines and related communications infrastructure are vulnerable to the impacts of high winds and downed trees. Many locations in town have weak cellular connectivity or no service at all.

Seeking funding to assess both water districts for solutions to help ensure that each system can meet day-to-day needs and be resilient to drought and wildfire was a top recommendation to provide the Town with the appropriate engineering assessments, hydrological studies, and technical legal support for addressing water quality issues, for understanding needed infrastructure upgrades at each water district, and for understanding the implications of establishing a second water district. Seek funding to implement needed improvements.

Upgrades to culverts and bridges that are undersized/under capacity was a top recommendation to reduce the risk of road and culvert washouts and associated road closures on the Town's evacuation routes which could isolate residents and limit access and response time for emergency responders. Funding is also needed bridge and culvert repairs, replacements, as well as necessary planning and prioritization of this work.

2.3.3 WARWICK

The summary of findings is based on feedback from the February 2020 project kick-off meetings, from meetings with the Warwick Board of Health, Energy and Building Committee, Conservation Commission, and Planning Board in the fall of 2020, the virtual Community Resilience Building workshops in February and March 2021.

Top Hazards

- Severe wind and thunderstorms
- Precipitation extremes and flooding
- Warmer / extreme temperatures
- Invasive species & pests

Areas of Concern

- **Infrastructure and Facilities:** Impacts to power lines, cell towers, roads, culverts, dams and bridges; Back-up power; Back-up emergency communication infrastructure; Water for firefighting
- **Community and Population:** Emergency notification, response and sheltering; Power outages; Home heating and cooling; Insect-borne disease/ infectious disease
- **Environment:** Forest health; Cold water streams; Flash flooding; Road salt contamination; Waterbodies and dams; Invasive species and pests

Current Concerns and Challenges Presented by Hazards and Climate Change

The most common concern among stakeholders is the increase in the frequency and severity of storms, especially the impact of strong wind on trees, power lines, and communication infrastructure in town. According to input from local residents, the 1938 hurricane blew many trees down in Warwick. There has not been a similar significant event since that time, so most trees are now at a size where they are vulnerable to blow down. A major storm could cause severe damage to forests in Warwick similar to the 1938 hurricane. Downed trees also block roads, take down power, internet and phone lines in town, and heavy winds can damage cell phone and radio tower equipment. A heavy wind event in October 2019 caused power outages in town for over a week in some areas, and access in and out of town was blocked by downed trees and wires. Communication to residents was hampered by downed wires and no internet access.

Changes in precipitation and flooding are also a concern. Warwick was largely spared from the worst impacts of Tropical Storm Irene in 2011, but residents feel the town could have experienced similar impacts as West County if the storm had stalled over Warwick. Warwick's abundant natural areas and wetlands serve as green infrastructure by slowing, absorbing, and storing flood waters. However, there are many flashy streams in Warwick due to the steep topography that are already impacted by heavier precipitation events. Flash flooding along Mill Brook on Northfield Road is causing scouring and beaver dams breaking apart, resulting in sediment shifts in the brook. This has been witnessed by a Conservation Commission member who lives on the brook, but the same issue is likely impacting other streams in town. Culverts regularly get clogged and can cause flooding and road washouts. Road salt contamination from storm water runoff has been an ongoing issue for some areas of town where drinking water wells are located close to the road. The impact of extreme precipitation on the condition of mill pond dams is a concern, especially as ponds may fill quickly during heavy precipitation events, but during dry periods, exposed natural stone dams can deteriorate.

Warwick is heavily forested, which helps mitigate the impacts of extreme heat. Nevertheless, extended periods of extreme heat is a challenge for residents who do not have air conditioning in their homes. Heating and cooling homes during extended power outages is also a major concern. The Warwick Town Hall, which can serve as a cooling or warming center, does not have back-up power. The Warwick Community School has a back-up generator, but no sheltering supplies. Warming temperatures impact forest health and water quality. Invasive species and pests, no longer kept in check by cold winters, may change forest composition in Warwick; reduction in forest cover over streams, such as die off of Hemlock, impacts cold water fish resources. Forest management activities are impacted by warmer winters too. Less frozen ground in the winter makes it difficult to access certain forested areas for logging. Firefighting access to remote forested areas is limited; improved access to water bodies is needed throughout town for firefighting.

Insect borne diseases such as Lyme disease and Eastern Equine Encephalitis (EEE) are already impacting Warwick. The Warwick Board of Health periodically places information in the Town newsletter about tick and mosquito-borne diseases, and have passed out brochures at town events that advise residents about mitigation strategies like removing standing water from yards. A communication system that can provide more timely information to residents about disease risk in town would be helpful, however.

The COVID-19 pandemic has highlighted the need for enhanced communication. Town facilities are also in need of upgrades to improve air circulation and ventilation to help reduce the risk of infectious disease. The Town recently received a Green Communities grant to improve the HVAC system at the Warwick Community School. Other Town buildings need to be evaluated for indoor health improvements, which should also be tied to energy resilience measures that increase on-site energy generation, electrification, and back-up power capabilities.

Specific Categories of Concerns and Challenges

Power Outages

The major hazards facing Warwick are downed trees and power outages. Many households do not have a generator. In October a strong storm caused a week of outage. Warwick also has many dead-end roads where residents get isolated if trees block the road.

Areas most vulnerable to power outages are on higher ground and include:

- Flower Hill Rd.
- Hockanum Rd.
- Beech Hill Rd.
- Wendell Rd.
- Shepherdson Rd.
- Hasting Heights Rd.
- Hasting Pond Rd.

The Town and residents need to plan for long-term outages, beyond one week. Remote rural areas were out of power for up to 5 weeks during the 2008 ice storm, and this could happen to Warwick too. A long-term sheltering plan is needed for the Warwick Community School. The school has a back-up generator but no sheltering supplies. A staffing plan for setting up a shelter is needed too. A “roving” generator could also help residents get through power outages.

Energy Resilience

Related to power outages, improving energy resilience in homes and Town buildings is a major need and challenge. The Warwick Energy and Buildings Committee has been working for years on improving energy efficiency in Town buildings. In addition, a small solar PV array is located at the Town Hall. Moving forward, the Committee is interested in looking at electrification options at all Town buildings, in combination with solar and battery storage, as a resiliency strategy. Outreach to residents with information about incentives for installing clean energy options in homes, especially combined with back-up battery storage, was also identified as a strategy.

Communication Infrastructure

Adding battery back-up power to the cell tower is in process, and is expected to provide up to seven days of back-up power. There is still a need to address communication redundancy for residents. A wireless broadband solution could be implemented to help with this issue. The radio tower on Mount Grace has back-up power. Plans are in the works to replace the tower with a new, taller tower that will include emergency communication channels and back-up power. This is being done by AT&T with funding from Homeland Security. The communitcation towers remain vulnerable to wildfire. Warwick now has a Code Red reverse call system. Efforts to encourage residents to sign up, and coordination with Town boards and committees on use of the system, is needed.

Flooding and Road Washouts

The small streams and rivers in Warwick can swell quickly; Mill Brook along Northfield Road is experiencing scouring, causing sediment shifts in the brook and impacting habitat. Culverts plugged with debris and causing flooding and road washouts is a major problem. The pressure that can build up behind a culvert is impressive. The Town has a back-hoe to unplug blockages, but it may not be able to unblock major blockages. Key areas of concern include:

- Winchester Road
- Wendell Road/Moss Brook
- Hockanum Road (box culvert)
- Gale Meadows on Athol and Gale Roads
- Kidder Brook on Robbins and Old Winchester Roads
- Bass Road

Flooding in general has not caused much damage to homes or buildings because there is not much development in or near the floodplain. Wetlands act as flood storage, and some former meadows and hayfields are growing back into brush and may be doing a better job at storing water. Some of these fields could potentially be reclaimed for agriculture if local demand is there. Identifying and implementing nature based solutions through stronger wetland and waterway protections, land conservation, and incentives for landowners to protect key areas on their land could help ensure these eco-system services continue to mitigate flooding and other climate change impacts.

Road Salt Contamination

Road salt contaminating drinking water wells has been an ongoing problem. The Board of Health set up a mitigation program for homeowners to test their wells. Under the program, if a homeowner tests their well and too much salt is found, then the Town will pay for a second test to see if the contamination is coming from road salt in storm water runoff. This has been an ongoing issue but the Town is now using less salt on the roads. There are more environmentally friendly materials, but these are expensive. The Town needs help to formulate a plan for better winter road practices.

Forest Resilience

Forests comprise over 20,000 acres in Warwick, roughly 90 percent of the Town's total land area. Warwick's forests contribute to a large regional greenway of contiguous forestland that provides critical habitat and supports biodiversity. Conserving resilient forests and the linkages between them will help plant and animal species move to more suitable habitats as the climate changes. Large, intact forested areas will also be more likely to recover from extreme events such as droughts, wind storms, ice storms, and flooding.

Maintaining healthy forests well into the future will necessitate addressing stressors like invasive species and forest pests in an effort to increase forest resiliency. Forest landowners may take both passive and active management approaches to forest stewardship. Financial incentives to conserve and manage forestland for climate resiliency and carbon sequestration and storage could help landowners maintain healthy forests in Warwick that in turn mitigate climate change and its impacts.

Access to some forested areas is limited and would constrain firefighting efforts in the event of a wildfire. The DCR fire town on Mt. Grace is an asset to the community – DCR can inform the Fire Department early of fires in town and can assist with response to fires. Access to water sources in town for firefighting is a concern, although mutual aid agreements are extremely helpful for receiving water trucked in from neighboring communities. Improved access to surface water sources through installation of dry hydrants would help.

Current Strengths and Assets

Communication Infrastructure Upgrades

Battery back-up power is being added to the cell tower, and is expected to provide up to seven days of back-up power; the Mt. Grace radio tower is being replaced with a new, taller tower that will include emergency communication channels and back-up power, and will have AT&T FirstNet which will create civilian cell capacity. The Town now has Code Red through the Police Department to send emergency messages to residents.

Energy Resilience

Warwick is a designated Green Community. The Warwick Energy and Buildings Committee has secured numerous grants to improve energy efficiency and move towards electrification in Town buildings, and to install a small solar PV array at Town Hall. Warwick Community School has a back-up generator.

Forest Resilience

MA DCR seasonally staffs a fire tower in Warwick on Mt. Grace, providing early warning to the Town, and assisting local fire departments with response. DCR is currently training a county wildfire crew, and can offer training to Warwick firefighters. Mutual aid agreements are in place with surrounding towns to supply water for firefighting. Many private forestland owners are actively engaged in stewardship of their land, sustaining the many benefits forests provide and supporting local forestry and wood products businesses.

Farms and Food Security

Warwick farms produce hay, beef, dairy, and other products, contributing to the local and regional food economy. Both the Town Hall and Warwick Community School have kitchens that are certified for food production. During COVID, the school has served as a free food distribution site. There are four home kitchens in Warwick that are certified for food processing.

Abundance of Protected Open Space and Natural Resources

Large protected blocks of forestland support biodiversity and species migration, carbon sequestration and storage, and serve as green infrastructure by slowing, absorbing, and storing flood waters. Warwick contains many coldwater fish resources, which provide critical habitat for coldwater fish species. There is not much development in or near the floodplain. Wetlands act as flood storage, and some former meadows and hayfields are growing back into brush and may be doing a better job at storing water.

The Town of Warwick owns over 400 acres of open space, including the Warwick Town Forest parcels, Warwick Community School, Town common, and Moores Pond Beach. Warwick has an active Open Space Committee that spearheads open space conservation projects in town. State Forests make up almost 50% of the town; Town and non-profit parcels contribute additional passive and active recreation resources; the New England Trail and the Appalachian Trail pass through town on private and public land.

Top Recommendations and Strategies to Improve Resilience

Following Warwick's virtual MVP workshops, participants ranked all of the actions via a poll in Survey Monkey. Full results from the survey are shown in the Appendix. Poll results were consolidated as appropriate to develop Warwick's top priority recommendations as shown below. Recommendations address key vulnerabilities while building upon current strengths.

Power lines: Conduct proactive tree maintenance near power lines. Work with National Grid to improve communication with the Town regarding restoration of power and when it is safe for Town departments to begin road clean-up.

Communication Towers: Encourage MA DCR to proceed with permitting the new tower on Mt. Grace to inlcude AT&T FirstNet and civilian cell capacity. Conduct proactive tree maintenance or removal of trees capable of striking communication towers. Work with the Regional Emergency Planning Committee (REPC) to develop a back-up communication plan and conduct a drill to test a situation where the Mt. Grace tower is out. Develop a back-up communication network and plan for Town communications.

Town Roads: Continue to maintain existing drainage infrastructure. Assess areas prone to washout for possible drainage improvements including stormwater Best Management Practices to protect the road, improve water quality in roadside streams and drinking water wells; prioritize areas where washouts would isolate residents.

Culverts: Assess and design drainage improvements along Northfield Road to incorporate into an upcoming re-paving project. Assess upstream areas for conservation and management strategies to slow floodwater and reduce the amount of debris carried downstream.

Cell Phone Coverage / Resident Communication Networks: Deploy civilian cell service in town as part of the AT&T FirstNet tower build on Mt. Grace. Improve the Warwick broadband network to be more dependable, making it possible for calls to be made via wifi for residents that have a phone and plan that supports it.

Roadside Wells: Develop a winter road maintenance plan that includes more environmentally friendly alternatives to road salt use.

Energy Resilience: Pursue additional energy reduction, efficiency and electrification options at Town buildings; explore installation of more solar PV on Town land or buildings, combined with battery storage; explore feasibility of a solar-powered micro-grid in the Town center.

Forest Fires: Maintain access to surface water sources for fire trucks and enhance connections with dry hydrants; maintain mutual aid agreements with neighboring towns. Continue strong relationships with MA DCR Forest Fire Control; take advantage of trainings for local firefighters to build local capacity.

Home Energy Resilience: Seek funding for housing rehabilitation grants or loans to help residents with addressing health and safety issues.

Food Security: Collaborate with the Greater Quabbin Food Alliance, the Quabbin Food Connector, and others to connect farmers, home gardeners, food pantries, processing and storage resources, distributors, and consumers, and identify local actions to respond to food insecurity needs in Warwick. Complete Board of Health approval process for designating the Warwick Community School as a food distribution site.

Town-Owned Open Space: Develop management plans for Town-owned open space with community input. Seek funding to implement management goals, such as wildlife habitat, sustainable forestry, trail development, local food production and outdoor education and recreation programs.

Open Space Protection: Identify parcels of land important to conserve or that are at risk of losing conservation values, utilizing tools such as BioMap2 and MassAudubon's MAPPR. Work with land trusts and willing landowners on premanently protecting parcels.

Invasive Species: Educate the public about invasive species and insects, and steps landowners can take to address them. Initiate a town-wide invasive species awareness day.

Streams and Brooks: Work with land trusts to implement a River Corridor easement program to conserve property within the River Corridor area. Work with Trout Unlimited, land trusts, private landowners, and DCR on assessing streams for conservation and management strategies to slow floodwaters and reduce debris, habitat destruction, and impacts to downstream infrastructure.

2.4 PROBLEM STATEMENTS

Table 2-2: Natural Hazard Problem Statements	Relevant Hazards	Relevant Towns
Electrical utilities are vulnerable to natural hazards, and when impacted, can cause repetitive and/or long-term power outages, which are a risk to the community and threaten critical facilities and infrastructure that lack backup power.	Multiple hazards	Northfield Warwick
Some municipal buildings, facilities and infrastructure, and homes in town are not up to code to withstand hazard impacts and/or are located in flood hazard areas.	Flooding, high wind events, earthquakes	Northfield Warwick
Culverts and bridges throughout town are undersized and in need of upgrades/replacements to increase their capacity and to minimize damage from hazard events.	Flooding	Northfield Warwick
Back up drinking water supply sources and agreements with surrounding towns may be needed to supply water in the event that existing sources or distribution systems are affected by a hazard.	Multiple hazards	Northfield Warwick
Water quality testing in the Grandin Reservoir, the drinking water source for the East Northfield Water Company, have shown elevated levels of bacteria, requiring the installation of a costly filtration plant or development of a new drinking water source.	Drought, extreme temperatures, heavy rain	Northfield
Municipal buildings, businesses and residents that rely on individual wells for drinking water are at risk during drought and prolonged power outages.	Multiple hazards	Northfield Warwick
Localized and chronic flooding events on several rivers and feeder brooks have been growing more serious in recent years, making roads and culverts in these areas susceptible to erosion hazards and washouts during heavy rains events. Stormwater runoff, especially from roads in hilly areas, is contributing sediment to nearby streams, affecting water quality, and roadside property, potentially impacting drinking water wells.	Flooding, hurricanes, heavy rain, severe winter storms	Northfield Warwick
Road and culvert washouts or downed trees and wires can cause closures on many of the Town's evacuation routes, isolating residents and limiting access and response time for emergency responders.	Multiple hazards	Northfield Warwick
Wind, heavy snow, ice, and extreme cold associated with severe winter storms can damage road infrastructure and make roads hazardous and difficult to keep clear of snow and debris.	Severe winter storms	Warwick
An inventory of structures and land uses in the mapped river corridor and 100-year floodplain are needed in order to expand the risk assessment for flooding and fluvial erosion hazards and identify possible mitigation measures.	Flooding, hurricanes, heavy rain	Northfield Warwick

Table 2-2: Natural Hazard Problem Statements	Relevant Hazards	Relevant Towns
The regional sheltering plan needs to be operationalized. Plans for opening, equipping and staffing shelters on both sides of the Connecticut River (PVRS on the west side and Northfield Elementary on the east side) need to be established. A plan is also needed for evacuating and sheltering large animals in advance of a disaster.	Multiple hazards	Northfield Warwick
Northfield is divided by the Connecticut River, with only one bridge to connect the east and west sides of town. Fire equipment and EMS is located on the east side of the river; Highway equipment, the regional shelter, and the hospital (in Greenfield) are on the west side of the river. If the bridge were not useable, populations on both sides of the river would be vulnerable.	Multiple hazards	Northfield
Historic assets are difficult or impossible to replace if destroyed by a natural disaster. Improvements are needed at the Historical Society building in Northfield to better protect assets.	Multiple hazards	Northfield Warwick
Town buildings should be assessed for renewable energy production and storage to improve energy resilience. Town Halls in both towns need improved back-up power to be able to operate effectively and provide vital emergency services when power is out.	Multiple hazards	Northfield Warwick
Many residents, especially seniors, individuals with certain medical conditions, and vulnerable populations, may need access to public warming and cooling centers.	Extreme temperatures	Northfield Warwick
A number of challenges with communications infrastructure, including spotty or no cell phone and internet service, means residents may lack reliable access to emergency information.	Multiple hazards	Northfield Warwick
Existing communication infrastructure is at risk to multiple hazards. Tree clearing and updating Town bylaws may be needed to prevent wind-related damage, protect nearby roads and utilities, and ensure regular inspection and maintenance.	High wind events	Northfield Warwick
There are several significant and high hazard dams within town and in upstream areas in neighboring communities where a dam breach or failure would impact the town. Regular testing of the EAPs and notification system is needed.	Dam failure	Northfield
Increased and improved access to water supply is needed for fire prevention. Improved access to forested areas is also needed.	Wildfire	Northfield Warwick
Household disaster preparedness should be encouraged, including home survival kits, evacuation procedures, and safeguarding homes and structures to better withstand hazardous weather.	Multiple hazards	Northfield Warwick
The effectiveness of the Town's emergency notification system is challenged by the vulnerability of the communications infrastructure in the	Multiple hazards	Northfield Warwick

Table 2-2: Natural Hazard Problem Statements	Relevant Hazards	Relevant Towns
area as well as low enrollment of residents**.** Residents should be reminded to sign up for reverse call / notification systems, and alternative and redundant notification systems need to be developed to reach people without cell service or internet.		
Elderly residents also need to be encouraged to enroll in Triad, especially those whom may be difficult to reach during a hazard event.	Multiple hazards	Northfield Warwick
A more formalized plan is needed to access and assist elderly, special needs, and/or disabled residents during emergencies.	Multiple hazards	Northfield Warwick
Beaver activity, including dams and altering local landscapes and vegetation, is contributing to flooding and erosion problems. Flow control devices are needed in key locations to alleviate the need for trapping.	Flooding, dam failure	Northfield Warwick
Significant pool fluctuations in the Turners Falls Power Pool are contributing to unstable riverbanks, slumping, and loss of farmland along the Connecticut River. Bank stabilization measures are needed in some areas. Seasonal monitoring for ice buildup and ice jams is also needed.	Flooding	Northfield
Riverine flooding, fluvial erosion hazards, sedimentation, and water quality issues, including nonpoint pollution is impacting the habitat and recreation value of water resources in town. River corridor area mapping, conservation, and management may be needed to protect these environmental assets.	Flooding	Northfield Warwick
There is a need to promote forest stewardship practices on private and public forestlands that produce more resilient forested landscapes to reduce risks from drought, wildfire, severe weather, invasive plants and pests, and other climate change impacts.	Multiple hazards	Northfield Warwick
Town trees in the public right of way require ongoing care and maintenance to mitigate the risk of repetitive power outages. Planting new trees to replace aging trees is needed. Coordinating this work with the utility company is a major obstacle. Undergrounding utilities in priority locations is a preferable but often cost-prohibitive strategy.	Multiple hazards	Northfield Warwick
A debris management site is needed for post-disaster debris.	Multiple hazards	Northfield Warwick
Updated vulnerability assessment, planning, and training for hazardous material or chemical spills in fixed facilities and/or transportation settings is needed.	Manmade hazards	Northfield Warwick
Updated vulnerability assessment, notification system, and response plan for a hazardous event or emergency situation at Vermont Yankee Nuclear Power Plant waste storage site is needed.	Manmade hazards	Northfield Warwick
Invasive species are becoming widespread in certain locations and displacing native flora and fauna.	Invasive Species	Northfield Warwick

Table 2-2: Natural Hazard Problem Statements	Relevant Hazards	Relevant Towns
Mosquito- and tick-borne diseases are increasing in the region.	Invasive Species, Extreme Temperatures	Northfield Warwick
The Northfield Wastewater Treatment Plant is in need of modernization to improve efficiency and increase resiliency. Inflow and infiltration of water into the system continues to be a problem, especially after heavy rains. Pipes and manhole covers need to be repaired or replaced. The plant is located near the CT River and is vulnerable to flooding.	Flooding, hurricanes, heavy rain	Northfield

3 HAZARD IDENTIFICATION AND RISK ASSESSMENT

3.1 INTRODUCTION

The following section includes a summary of disasters that have affected or could affect Northfield and Warwick. Historical research, conversations with local officials and emergency management personnel, available hazard mapping and other weather-related databases were used to develop this list.

The Core Teams referred to the *Massachusetts State Hazard Mitigation and Climate Adaptation Plan* (September 2018) as a starting point for determining the relevant hazards in Northfield and Warwick. The table below illustrates a comparison between the relevant hazards in the State plan, in Northfield and Warwick's Hazard Mitigation plans, and the Northfield and Warwick MVP Community Resilience Building Workshops.

Table 3-1: Comparison of hazards in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan and the Northfield and Warwick MVP Community Resilience Building and Hazard Mitigation Regional Plan

Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2018)	Northfield and Warwick Relevance	Northfield and Warwick MVP Top Priority Hazard
 Inland Flooding	Northfield - YES Warwick - YES	Northfield - Yes Warwick - Yes
 Drought	Northfield - YES Warwick – YES	Northfield - Yes Warwick – Yes
 Landslide	Northfield - YES Warwick – YES	Northfield - No Warwick – No
 Coastal Flooding	Northfield - NO Warwick – NO	Northfield - NO Warwick – NO

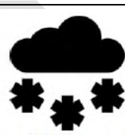
Table 3-1: Comparison of hazards in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan and the Northfield and Warwick MVP Community Resilience Building and Hazard Mitigation Regional Plan		
Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2018)	**Northfield and Warwick Relevance**	**Northfield and Warwick MVP Top Priority Hazard**
 Coastal Erosion	Northfield - NO Warwick – NO	Northfield - NO Warwick – NO
 Tsunami	Northfield - NO Warwick – NO	Northfield - NO Warwick – NO
 Average/Extreme Temperatures	Northfield - YES Warwick – YES	Northfield - No Warwick – Yes
 Wildfires	Northfield - YES Warwick – YES	Northfield - No Warwick – No
 Invasive Species	Northfield - YES Warwick – YES	Northfield - No Warwick – Yes
 Hurricanes/Tropical Storms	Northfield - YES Warwick – YES	Northfield - Yes Warwick – Yes
 Severe Winter Storm	Northfield - YES Warwick – YES	Northfield - Yes Warwick – Yes
 Tornadoes	Northfield - YES Warwick – YES	Northfield - No Warwick – No

Table 3-1: Comparison of hazards in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan and the Northfield and Warwick MVP Community Resilience Building and Hazard Mitigation Regional Plan

Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2018)	Northfield and Warwick Relevance	Northfield and Warwick MVP Top Priority Hazard
 Other Severe Weather	Northfield - YES Warwick – YES	(Dam Failure / Manmade Hazards) Northfield - Yes Warwick – Yes
 Earthquake	Northfield - YES Warwick – YES	Northfield - No Warwick – No

3.2 NATURAL HAZARD RISK ASSESSMENT METHODOLOGY

This chapter examines the hazards in the *Massachusetts State Hazard Mitigation and Climate Adaptation Plan* which are identified as likely to affect Northfield and Warwick. The analysis is organized into the following sections: Hazard Description, Location, Extent, Previous Occurrences, Probability of Future Events, Impact, and Vulnerability. A description of each of these analysis categories is provided below.

Hazard Description

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

Location

Location (Table 3-2) refers to the geographic areas within the planning area that are affected by the hazard. Some hazards affect the entire planning area universally, while others apply to a specific portion, such as a floodplain or area that is susceptible to wild fires. Classifications are based on the area that would potentially be affected by the hazard, on the following scale:

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

Extent

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

Previous Occurrences

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

Probability of Future Events

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

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

Impact

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

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

Vulnerability

Based on the above metrics, a hazard vulnerability rating was determined for each hazard. The hazard vulnerability ratings are based on a scale of 1 through 3 as follows:

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

The ranking is qualitative and is based, in part, on local knowledge of past experiences with each type of hazard, review of available data, and the work of the Core Teams. The size and impacts of a natural hazard can be unpredictable. However, many of the mitigation strategies currently in place and many of those proposed for implementation can be applied to the expected natural hazards, regardless of their unpredictability.

Table 3-5: Hazard Identification and Risk Analysis				
Type of Hazard	**Location of Occurrence**	**Probability of Future Events**	**Impact**	**Overall Hazard Vulnerability Rating**
TOWN OF NORTHFIELD				
Severe Winter Storms	Large	Very High	Limited	High
Flooding	Medium	High	Critical	High
Hurricanes / Tropical Storms	Large	Moderate	Critical	Medium

Table 3-5: Hazard Identification and Risk Analysis				
Type of Hazard	**Location of Occurrence**	**Probability of Future Events**	**Impact**	**Overall Hazard Vulnerability Rating**
Severe Thunderstorms / Wind / Microbursts	Medium	Very High	Critical	High
Extreme Temperatures	Large	High	Minor	Medium
Landslides	Isolated	Low	Limited	Low
Drought	Large	High	Critical	High
Invasive Species	Large	Very High	Limited	Medium
Dam Failure	Medium	Very Low	Catastrophic	High
Wildfires	Isolated	High	Minor	Medium
Tornadoes	Isolated	Low	Catastrophic	Medium
Earthquakes	Large	Very Low	Catastrophic	Low
TOWN OF WARWICK				
Type of Hazard	**Location of Occurrence**	**Probability of Future Events**	**Impact**	**Overall Hazard Vulnerability Rating**
Severe Winter Storms	Large	Very High	Limited	High
Flooding	Isolated	High	Limited	Medium
Hurricanes / Tropical Storms	Large	Moderate	Critical	Medium
Severe Thunderstorms / Wind / Microbursts	Medium	Very High	Critical	High
Extreme Temperatures	Large	High	Limited	High
Landslides	Isolated	Very Low	Minor	Low
Drought	Large	High	Limited	Medium
Invasive Species	Large	Very High	Limited	High

Table 3-5: Hazard Identification and Risk Analysis				
Type of Hazard	**Location of Occurrence**	**Probability of Future Events**	**Impact**	**Overall Hazard Vulnerability Rating**
Dam Failure	Isolated	Low	Limited	Low
Wildfires	Isolated	High	Limited	Low
Tornadoes	Isolated	Low	Critical	Low
Earthquakes	Medium	Very Low	Limited	Low

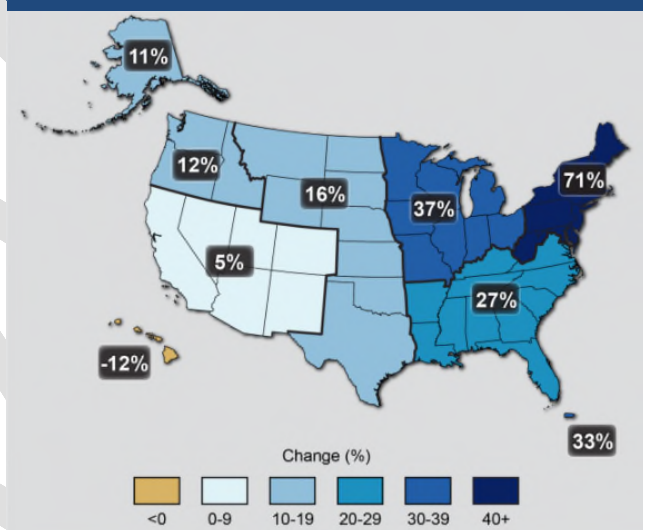
The Core Teams developed problem statements (Table 2-2) and/or a list of key issues for each hazard to summarize the vulnerability of Northfield and Warwick's structures, systems, populations and other community assets identified as vulnerable to damage and loss from a hazard event. These problem statements were used to identify the Towns' greatest vulnerabilities that will be addressed in the mitigation strategy (Section 4) and the Summary of Findings (Section 2.3).

3.3 FLOODING

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

Observed annual precipitation in Massachusetts for the last three decades was 47 inches. Total annual precipitation in Massachusetts is expected to increase between 2% to 13% by 2050, or by roughly 1 to 6 inches. In the Millers River Watershed, annual precipitation has averaged around 45 inches in recent decades. By 2050, the annual average could remain relatively the same (but occur in more heavy, short intervals) or increase by up to 12 inches a year. In general precipitation projections are more uncertain than temperature projections.[22]

Figure 3-1: Observed Change in Very Heavy Precipitation



The northeast has seen a greater increase in heavy precipitation events than the rest of the country. *Source: updated from Karl et al. 2009, Global Climate Change Impacts in the United States.*

An increase in stronger storms leads to more flooding and erosion. A shift to winter rains instead of snow will lead to more runoff, flooding, and greater storm damage along with less spring groundwater recharge. More frequent heavy precipitation events also lead to an increased risk for people who live along rivers or in their floodplains. Furthermore, residents who live outside the current flood zone could find themselves within it as the century progresses. Figure 3-2 shows potential effects of climate change on flooding from the Massachusetts State Hazard Mitigation and Climate Adaptation Plan.

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

Figure 3-2: Effects of Climate Change on Flooding

Potential Effects of Climate Change		
	CHANGES IN PRECIPITATION ➔ MORE INTENSE AND FREQUENT DOWNPOURS	More intense downpours often lead to inland flooding as soils become saturated and stop absorbing more water, river flows rise, and urban stormwater systems become overwhelmed. Flooding may occur as a result of heavy rainfall, snowmelt or coastal flooding associated with high wind and storm surge.
	EXTREME WEATHER ➔ MORE FREQUENT SEVERE STORMS	Climate change is expected to result in an increased frequency of severe storm events. This would directly increase the frequency of flooding events, and could increase the chance that subsequent precipitation will cause flooding if water stages are still elevated.
	CHANGES IN PRECIPITATION ➔ EPISODIC DROUGHTS	Vegetated ground cover has been shown to significantly reduce runoff. If drought causes vegetation to die off, this flood-mitigating capacity is diminished.

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

Hazard Description

Nationally, inland flooding causes more damage annually than any other severe weather event (U.S. Climate Resilience Toolkit, 2017). Between 2007 and 2014, the average annual cost of flood damages in Massachusetts was more than $9.1 million (NOAA, 2014). Flooding is the result of moderate precipitation over several days, intense precipitation over a short period, or melting snowpack (U.S. Climate Resilience Toolkit, 2017). Developed, impervious areas can contribute to and exacerbate flooding by concentrating and channeling stormwater runoff into nearby waterbodies. Increases in precipitation and extreme storm events from climate change are already resulting in increased flooding. Common types of flooding are described in the following subsections.

Riverine Flooding

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

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

Fluvial Erosion

Fluvial erosion is the process in which the river undercuts a bank, usually on the outside bend of a meander, causing sloughing and collapse of the riverbank. Fluvial erosion can also include scouring and down-cutting of the stream bottom, which can be a problem around bridge piers and abutments. In hillier terrain where streams may lack a floodplain, such as in many areas of Northfield and Warwick, fluvial erosion may cause more property damage than inundation. Furthermore, fluvial erosion can often occur in areas that are not part of the 100- or 500-year floodplain.

Fluvial erosion hazard (FEH) zones are mapped areas along rivers and streams that are susceptible to bank erosion caused by flash flooding. Any area within a mapped FEH zone is considered susceptible to bank erosion during a single severe flood or after many years of slow channel migration. As noted above, while the areas of the FEH zones often overlap with areas mapped within the 100-year floodplain on Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMs) or Flood Hazard Boundary Maps (FHBMs), the FIRMs or FHBMs only show areas that are likely to be inundated by floodwaters that overtop the riverbanks during a severe flood. However, much flood-related property damage and injuries is the result of bank erosion that can undermine roads, bridges, building foundations and other infrastructure. Consequently, FEH zones are sometimes outside of the 100-year floodplain shown on FIRMs or FHBMs. FEH zones can be mapped using fluvial geomorphic assessment data as well as historic data on past flood events. Both the FIRMs and FEH maps should be used in concert to understand and avoid both inundation and erosion hazards, respectively.[23]

Urban Drainage Flooding

Urban drainage flooding entails floods caused by increased water runoff due to urban

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

development and drainage systems that are not capable of conveying high flows. Drainage systems are designed to remove surface water from developed areas as quickly as possible to prevent localized flooding on streets and other urban areas. They make use of a closed conveyance system that channels water away from an urban area to surrounding streams, bypassing natural processes of water infiltration into the ground, groundwater storage, and evapotranspiration (plant water uptake and respiration). Since drainage systems reduce the amount of time the surface water takes to reach surrounding streams, flooding can occur more quickly and reach greater depths than if there were no urban development at all. In urban areas, basement, roadway, and infrastructure flooding can result in significant damage due to poor or insufficient stormwater drainage.

Ground Failures

Flooding and flood-related erosion can result from various types of ground failures, which include mud floods and mudflows, and to a much lesser degree, subsidence, liquefaction, and fluvial erosion (discussed above).

Mud floods are floods that carry large amounts of sediment, which can at times exceed 50 percent of the mass of the flood, and often occur in drainage channels and adjacent to mountainous areas. Mudflows are a specific type of landslide that contains large amounts of water and can carry debris as large as boulders. Both mudflows and mud floods result from rain falling on exposed terrain, such as terrain impacted by wildfires or logging. Mud floods and mudflows can lead to large sediment deposits in drainage channels. In addition to causing damage, these events can exacerbate subsequent flooding by filling in rivers and streams.

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

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

Ice Jam

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

Dam Failure

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

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

Additional Causes of Flooding

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

Floodplains

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

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

Active River Areas and River Corridor Mapping

Rivers and streams are dynamic systems in a constant state of change. Fluvial erosion is a natural process of wearing away of soil, vegetation, sediment, and rock through the movement of water in rivers and streams. While erosion is a natural process, the rate of erosion is affected by human alterations of river channels or land as well as changing climate. Sometimes buildings and roads are located too close to river banks and areas of active river processes, placing them at risk to erosive forces while reducing flood storage capacity in the floodplain and increasing the rate of erosion within the river corridor.

Location

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

In Northfield, the 100-year floodplain covers about 2,283 acres, or approximately 10 percent of the town, including an estimated 20 acres of developed residential land, less than 1 acre each of industrial use and commercial use, and 3.6 acres of public/institutional. Much of the floodplain consists of agricultural land or forest. The 2010 Northfield Comprehensive Emergency Management Plan identifies the north end of town near the State boat ramp and the Lower Farms area along the Connecticut River as flood prone areas in Northfield.

Warwick has about 259 floodplain acres, which is slightly less than 2 percent of the town. According to 2005 MassGIS land use data, there are 10 dwellings located on 6 acres of Warwick’s floodplain. There are no industrial or commercial uses in Warwick, and therefore, none in the floodplain. Historic and other built infrastructure in town located in the floodplain include privately owned residences, Laurel Lake and associated structures located in the Erving State Forest on Laurel Lake Road, Brush Valley Bridge on Orange Road over Orcutt Brook, structures along Gulf Brook in Mount Grace State Forest on Route 78, and the Wendell Road Bridge over Moss Brook. Given the nature of the properties and structures, it is not possible to estimate the total building value in the floodplain or the estimated losses if they were impacted by floods for specific properties.

The Warwick Flood Hazard Boundary Map (FHBM) identifies Zone A Special Flood Hazard Areas along Mountain Brook, Gale Brook, Darling Brook, and Moss Brook in Warwick. Other areas in Warwick are likely to flood, and indeed have flooded during high water. In major storms, Route 78 and Chestnut Hill Road have washed out. The Flood Plain Overlay District Bylaw was adopted in 2011 regulating land uses in all special flood hazard areas designated as Zone A on the Warwick FHBM.

In addition to the 100-year floodplain, areas upstream from major rivers play an important role in flood mitigation. Upland areas and the small tributary streams that drain them are particularly vulnerable to impacts from development, which can increase the amount of flooding downstream. These areas are critical for absorbing, infiltrating, and slowing the flow of stormwater. When these areas are left in a natural vegetated state (forested or forested floodplain), they act as “green infrastructure,” providing flood storage and mitigation through natural processes.

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

In addition, stressors to forests such as drought, extreme weather, and invasive species, can result in the loss of forest cover in upland areas. In particular, cold water streams shaded by dense hemlock stands are particularly vulnerable due to the hemlock woolly adelgid that is causing widespread mortality of these trees in the region.

Northfield Chronic Flooding Locations

The wetlands immediately to the east of Main Street in the historic town center are making it increasingly difficult to keep stormwater from flooding roads, sidewalks, and parking areas, and to keep groundwater from infiltrating subsurface structures, like the basements of buildings and the sewer system. Beavers are active at several locations nearby and contributing to flooding. The Town will have to continue to find innovative ways to maintain public safety from flooding in the neighborhoods surrounding the historic town center while protecting the system of wetlands that is located there. The Northfield Core Team identified the following areas as places that experience chronic flooding during any heavy rainstorm or when the water table is high:

Town Hall Parking Lot: Stormwater from frequent heavy rain events regularly floods the parking lot at Town Hall. The Town is working with an engineer to design and implement stormwater BMP retrofits to address flooding.

School Street: School Street is located near Mill Brook and the wetland near town center.

Warwick Road: Warwick Road crosses the wetland located in the town center, and residents on the road have noted the water level from the adjacent wetland encroaching on their property.

Glen Road: is located adjacent to Mill Brook near its confluence with the Connecticut River.

Four Mile Brook Road: Four Mile Brook Road is a 2.75 mile long gravel road located along the Four Mile Brook, a cold water tributary to the Connecticut River. Steep slopes and a narrow valley create a high stream power during heavy rain events. The presence of the road contributes to the high stream flows by concentrating runoff and transporting it to the brook. Prior to stormwater improvements, significant amounts of sediment were carried from the road to the brook, causing erosion along the road and water quality issues in the brook.

In 2005, the Franklin Regional Council of Governments (FRCOG) was awarded a 604(b) Water Quality Management Planning Grant from the Massachusetts Department of Environmental Protection (DEP) to assess the Four Mile Brook Watershed in Northfield. The project included a fluvial geomorphic assessment and development of conceptual designs to manage flow and mitigate bank erosion at several high hazard areas of Four Mile Brook adjacent to Four Mile Brook Road. Based on the assessment, a Watershed Management Plan was developed that includes recommendations for roadway improvement and stream restoration projects, as well as other Best Management Practices that will prevent erosion and nonpoint pollution in the watershed. The Four Mile Brook Watershed Management Action Plan can be found in Appendix IV.

In 2010, the Town received a grant from the MA DEP to implement stormwater Best Management Practices (BMPs) along Four Mile Brook Road. Six sites were identified for BMPs, with a goal to manage the runoff to protect the road and filter the road bed material (sediment) from the runoff before it is discharged to the ground or flows into the brook. The total project cost came to $225,000, with the town contributing 40% through in-kind staff time and Chapter 90 funds. The BMPs were designed to be simple, low cost, and low maintenance. The Highway Superintendent reported that the BMPs are working well, and that they would like to secure the additional funding that is needed to complete implementing recommendations from the Four Mile Brook Watershed Management Plan.

The Four Mile Brook Watershed Management Plan recommends implementing designs to manage flow and bank erosion in three additional high hazard areas along the brook as the next highest priority. Continuing to implement the recommendations from the plan will help mitigate future damage to the road and property from flooding events.

Glenwood Avenue:

Above left: one of the sites on Four Mile Brook Road prior to the project. Above right: The same location after installation of a rock-lined swale that collects, slows, and filters stormwater runoff from the road, helping to keep the roadway edge intact.

Warwick Chronic Flooding Locations

There are a number of rivers and feeder brooks in Warwick with the potential to cause localized and/or chronic flooding. The 2015 Hazard Mitigation Plan indicated that flooding events have been growing more serious and extending in duration in recent years. The Warwick Core Team identified the following areas as prone to washing out from flooding:

- Gale Road
- Chestnut Hill Road
- White Road
- Robbins Road
- Winchester Road
- Route 78 - culvert in the gulf

Based on these locations, flooding has an “Isolated” area of occurrence in Warwick, with less than 10% of the town affected, and a “medium” area of occurrence in Northfield, potentially impacting 10% - 50% of town.

Extent

The principal factors affecting the strength and magnitude of flood damage are flood depth and velocity. The deeper and faster that flood flows become, the more damage they can cause. Shallow flooding with high velocities can cause as much damage as deep flooding with slow velocity. This is especially true when a channel migrates over a broad floodplain, redirecting high-velocity flows and transporting debris and sediment.

The frequency and severity of flooding are measured using a discharge probability, which is the probability that a certain river discharge (flow) will be equaled or exceeded in a given year. Flood studies use historical records to determine the probability of occurrence for the different discharge levels. The flood frequency equals 100 divided by the discharge probability. For example, the 100-year discharge (discussed further in the following subsection) has a 1 percent chance of being equaled or exceeded in any given year. The “annual flood” is the greatest flood event expected to occur in a typical year. These measurements reflect statistical averages only; it is possible for two or more floods with a 100-year or higher recurrence interval to occur in a short time period. The same flood can have different recurrence intervals at different points on a river.

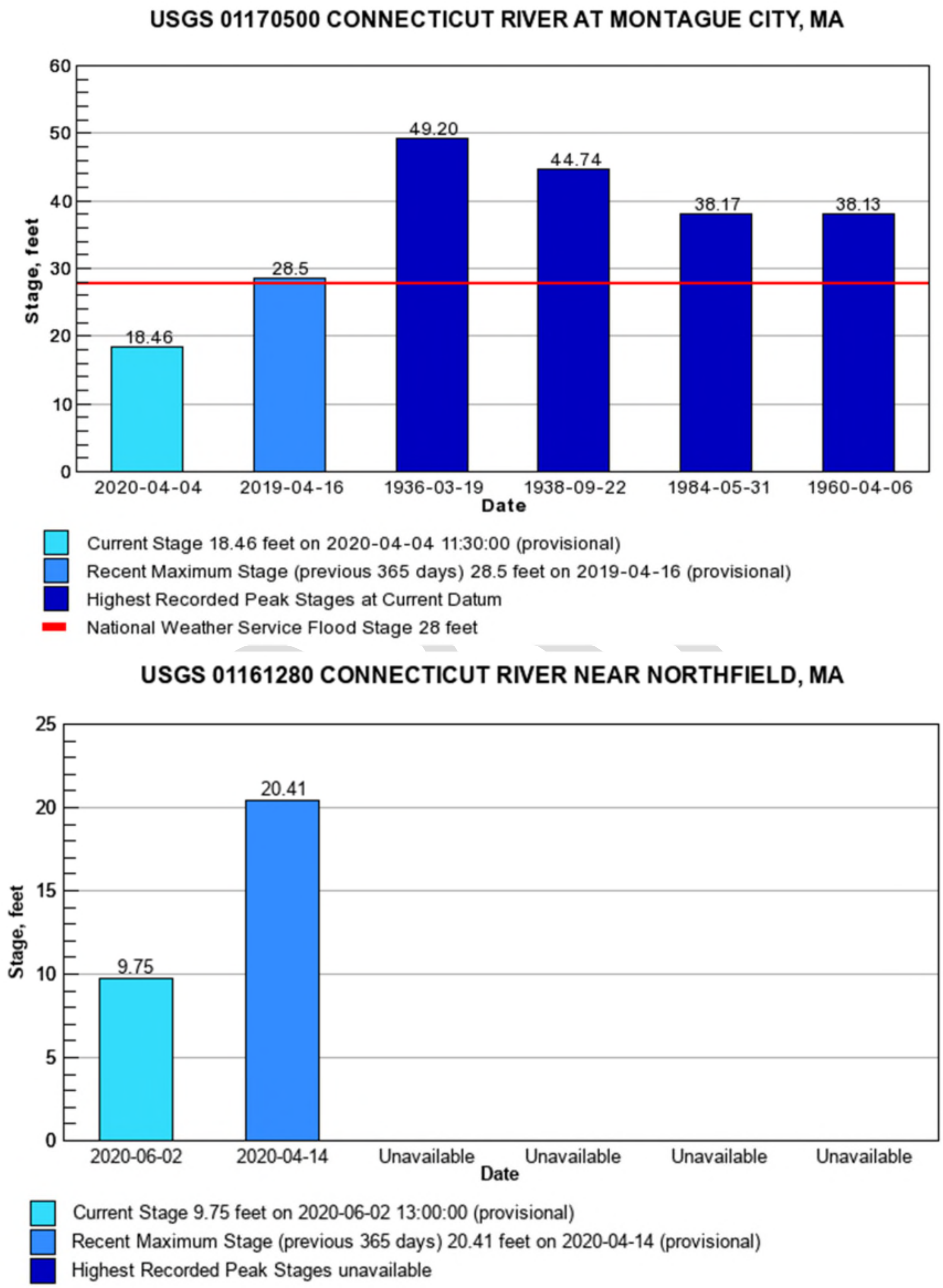
Floods can be classified as one of two types: flash floods and general floods.

Flash Floods
Flash floods are the product of heavy, localized precipitation in a short time period over a given location. Flash flooding events typically occur within minutes or hours after a period of heavy precipitation, after a dam or levee failure, or from a sudden release of water from an ice jam. Most often, flash flooding is the result of a slow-moving thunderstorm or the heavy rains from a hurricane. In rural areas, flash flooding often occurs when small streams spill over their banks. However, in urbanized areas, flash flooding is often the result of clogged storm drains (leaves and other debris) and the higher amount of impervious surface area (roadways, parking lots, roof tops).

General Floods
General flooding may last for several days or weeks and are caused by precipitation over a longer time period in a particular river basin. Excessive precipitation within a watershed of a stream or river can result in flooding particularly when development in the floodplain has obstructed the natural flow of the water and/or decreased the natural ability of the groundcover to absorb and retain surface water runoff (e.g., the loss of wetlands and the higher amounts of impervious surface area in urban areas).

Flood flows in Massachusetts are measured at numerous USGS stream gauges. The gauges operate routinely, but particular care is taken to measure flows during flood events to calibrate the stage-discharge relationships at each location and to document actual flood conditions. In the aftermath of a flood event, the USGS will typically determine the recurrence interval of the event using data from a gauge's period of historical record. Figure 3-3 shows data from the USGS gages on the Connecticut River in Northfield and near Montague City in Montague, MA (downstream of Northfield). The gage in Montague City shows the highest recorded peak stages, including five instances since 1936 when flooding exceeded the flood stage of 28 feet at this location. The most recent of these events was April 16, 2019 when the river reached 28.5 feet. Historic data is unavailable for the gage located in Northfield. The highest recorded water level in the river in the past year (as of June 2, 2020) was in April 2020 when the river reached over 20 feet.

Figure 3-3: Highest Recorded Flood Events on the Connecticut River, Northfield and Montague City



Source: USGS WaterWatch https://waterwatch.usgs.gov

The 100-Year Flood

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

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

The 500-Year Flood

The term "500-year flood" is the flood that has a 0.2 percent chance of being equaled or exceeded each year. Flood insurance purchases are not required by the Federal Government in the 500-year floodplain, but could be required by individual lenders.

Secondary Hazards

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

The section of the Connecticut River located in Northfield is part of the Turners Falls Power Pool, a 22-mile long reach of the Connecticut River between the Turners Falls Dam in Montague and the Vernon Dam in Vernon, Vermont that serves as the lower reservoir in support of the Northfield Mountain Pumped Storage Hydroelectric Project, owned by FirstLight Power Resources. The hydrodynamics of the Turners Falls Power Pool are primarily controlled by the three hydroelectric generating facilities: Turners Falls Dam, Vernon Dam, and the Northfield Mountain Pumped Storage Project. The joint operations of the Turners Falls facility and the Northfield Mountain Pumped Storage Project have resulted in larger and faster pool fluctuations, which have significantly changed the daily regime of this reach of the Connecticut River. Typical pool fluctuations average 3.5 feet per day at the dam. Much higher pool fluctuations, on the order of 9-10.5 feet at the dam, may occur over the course of the weekly pump/release cycle. Erosive forces have destabilized many sections of bank resulting in slumping and mass wasting of large sections of bank and the loss of trees and other riparian vegetation on the top of the banks.

A number of areas along the Connecticut River in Northfield have been identified as heavy erosion areas, with resulting loss of farmland. Since 1996, a variety of bioengineering techniques have been used to stabilize eroding river banks in the power pool, including locations in Northfield. The multi-phase project is being implemented through a collaboration of towns, FirstLight Power Resources, the Franklin Regional Council of Governments, the Massachusetts Department of Environmental Protection, and other local and regional stakeholders.

The Northfield Mountain Pumped Storage Project and Turners Falls Project are undergoing relicensing through the Federal Energy Regulatory Commission (FERC). A FERC license outlines the conditions under which the projects can operate and includes requirements to protect, mitigate, or enhance environmental resources impacted by the project. The FERC licenses will be valid for 30-50 years. The Connecticut River Streambank Erosion Committee (CRSEC), organized by the Franklin Regional Council of Governments (FRCOG), is actively involved in the relicensing process, reviewing reports and submitting comments to FERC.

According to the Northfield Core Team, the closure in 2014 of the Vermont Yankee nuclear power plant in Vernon, Vermont, has resulted in colder water temperatures in the Connecticut River since the plant no longer uses the river for cooling. This has led to an increased risk of ice jams along the river, which historically had been more common prior to the operation of the power plant. Ice jams have the potential of flooding farmland along the banks of the river. River ice, in conjunction with daily fluctuations of water levels due to power generation at Northfield Mountain, may also contribute to scouring of the riverbank and erosion.

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

The Warwick and Northfield Core Teams indicated that flooding and stormwater runoff from roadways has the potential to contaminate private wells located near roadways, and also negatively impacts habitat and water quality in roadside streams. Flash flooding along Mill Brook on Northfield Road in Warwick is causing scouring and sediment shifts in the brook, negatively impacting aquatic habitat. This has been witnessed by a Conservation Commission member who lives on the brook, but the same issue is likely impacting other streams in town.

In Northfield, stormwater runoff is likely one cause of elevated bacteria levels in the Grandin Reservoir that were detected during water quality testing in 2018. The reservoir serves as the drinking water source for approximately 300 residents in East Northfield and the campus of Thomas Aquinas College. The test results prompted the MA Department of Environmental Protection (DEP) to require a filtration system for the reservoir, estimated to cost $1 million. The East Northfield Water Company and the Town are exploring options for the future of East Northfield's water supply.

Previous Occurrences

The average annual precipitation for Northfield, Warwick and surrounding areas in western Massachusetts is 48 inches. Between 1996 and 2017, 17 flash floods have been reported in Franklin County (Table 3-6), resulting in $3,245,000 in property damages. No flash flood events were reported in the NOAA database during this timeframe for Warwick or Northfield.

Table 3-6: Previous Occurrences of Flash Floods in Franklin County

Year	# of Flash Flood Events	Annual Property Damage	Annual Crop Damage
1996	4	$1,800,000	$0
1998	1	$75,000	$0
2000	1	$0	$0
2003	1	$10,000	$0
2004	1	$10,000	$0
2005	3	$1,235,000	$0
2013	3	$65,000	$0

Table 3-6: Previous Occurrences of Flash Floods in Franklin County			
2014	2	$50,000	$0
2017	1	$0	$0
Total	**17**	**$3,245,000**	**$0**

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

From 1996 to 2018, 44 flood events were reported in Franklin County, resulting in total property damages worth $25,582,000 (Table 3-7). The bulk of these damages ($22,275,000) were from Tropical Storm Irene in August, 2011. No flood damages were reported in the NOAA database for Warwick or Northfield.

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

Table 3-7: Previous Occurrences of Floods in Franklin County

Year	# of Flood Events	Annual Property Damage	Annual Crop Damage
1996	7	$0	$0
1998	3	$0	$0
2001	1	$0	$0
2004	1	$0	$0
2005	2	$2,600,000	$0
2007	1	$250,000	$0
2008	3	$38,000	$0
2010	1	$150,000	$0
2011	8	$22,375,000	$0
2012	2	$0	$0
2015	10	$31,000	$0
2017	1	$1,000	$0
2018	4	$137,000	$0
Total	**44**	**$25,582,000**	**$0**

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

Snow melt, rain and ice jams caused the great flood of 1936 when the level of the Connecticut

River rose 19 feet. It caused major devastation to towns along its banks, leaving 430,000 people in Western Massachusetts homeless and causing $500 million in property damage ($6.5 billion in today's dollars).

Previous flooding events in Northfield include roads flooded after heavy rains in June 1996, though no damages were reported. Additionally, the flood damage caused by Tropical Storm Floyd in 1999 prompted the Town to seek funding from the Massachusetts Emergency Management Agency (MEMA) to clean up the worst of the storm damage. Approximately $45,000 - $50,000 was spent by the Town to clean up storm damage.

Tropical Storm Floyd dumped approximately 9 inches of rain over the Four Mile Brook watershed in the southern section of town and surrounding areas during a 24-hour period in September 1999. The brook responded by overtopping its banks and flowing down Four Mile Brook Road. The road was severely undercut and scoured by the raging water, which then deposited its load of sediment (road material, fill, etc.) into the downstream channel for an estimated distance of 1,000 linear feet. Several homes were also flooded during this storm event. During the summer of 2000, several intense rainfall events caused additional flooding, erosion and sedimentation of the brook.

Tropical Storm Floyd caused major flooding on Winchester Road in Warwick when a tree stump let go and clogged a pipe in a culvert. Other roads in town also affected by flooding during this storm included White and Leland Roads. Following Tropical Storm Floyd, the Town of Warwick received disaster relief funds from MEMA in the amount of $69,290.59.

Damage and flooding on Winchester Road from Tropical Storm Floyd on 9/17/99. Photos courtesy of the Warwick Highway Department.

On August 27 and 28 2011, Tropical Storm Irene brought heavy rain to the region, causing extensive and long term damage to Franklin County towns. According to the National Weather Service, up to 9.92 inches of rain fell during the storm, though amounts varied significantly across Franklin County. Rivers, streams, and brooks throughout the county reached and surpassed flood levels. Rising water gathered debris that clogged culverts, roads and bridges were washed out, and homes and businesses were flooded. Northfield and Warwick were spared from the worst of the damage from Tropical Storm Irene in 2011, however flooding did occur in a number of areas in both towns, including those listed above for each town in the *Location* section.

Probability of Future Events

Based on previous occurrences, the frequency of occurrence of flooding events in Northfield and Warwick is "High," with a 25% - 50% probability in any given year. Flooding frequencies for the various floodplains in Northfield and Warwick are defined by FEMA as the following:

- 10-year floodplain – 10 percent chance of flooding in any given year
- 25-year floodplain – 2.5 percent chance of flooding in any given year
- 100-year floodplain – 1 percent chance of flooding in any given year
- 500-year floodplain – 0.2 percent chance of flooding in any given year

Of all the regions in the United States, the Northeast has seen the most dramatic increase in the intensity of rainfall events. The U.S. National Climate Assessment reports that between 1958 and 2010, the Northeast saw more than a 70% increase in the amount of precipitation falling in very heavy events (defined as the heaviest 1% of all daily events). Climate projections for Massachusetts, developed by the University of Massachusetts, suggest that the frequency of high-intensity rainfall events will continue to trend upward, and the result will be an increased risk of flooding. Specifically, the annual frequency of downpours releasing more than two inches of rain per day in Massachusetts may climb from less than 1 day per year to approximately 0.9-1.5 days by 2100. Events which release over one inch during a day could climb to as high as 8-11 days per year by 2100. A single intense downpour can cause flooding and widespread damage to property and critical infrastructure. While the coastal areas in Massachusetts will experience the greatest increase in high-intensity rainfall days, some level of increase will occur in every area of Massachusetts, including Northfield and Warwick.[24]

Impact

Flooding can cause a wide range of issues, from minor nuisance roadway flooding and basement flooding to major impacts such as roadway closures. Specific damages associated

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

with flooding events include the following primary concerns:

- Blockages of roadways or bridges vital to travel and emergency response
- Breaching of dams
- Damaged or destroyed buildings and vehicles
- Uprooted trees causing power and utility outages
- Drowning, especially people trapped in cars
- Contamination of drinking water
- Dispersion of hazardous materials
- Interruption of communications and/or transportation systems, including train derailments

The impact of a flood event could be critical in Northfield, with more than 25% of property in the affected area damaged or destroyed, and possible shutdown of facilities (roads, bridges, critical facilities) for more than one week, while the impact in Warwick is likely to be limited, with potential for more than 10% of property in the affected area damaged or destroyed and a shutdown of facilities for more than 1 day.

Vulnerability

Society

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

In Northfield, the 100-year floodplain covers about 2,283 acres, or approximately 10 percent of the town, including an estimated 20 acres of developed residential land, less than 1 acre each of industrial use and commercial use, and 3.6 acres of public/institutional. Warwick has about 259 floodplain acres, which is slightly less than 2 percent of the town, and includes an estimated 6 acres of developed residential land.

Table 3-8 displays the number of dwelling units and the estimated population living in the 100-year floodplain in Northfield and Warwick. According to 2005 MassGIS Land Use data, there are 14 dwelling units located in the floodplain in Northfield, and 10 dwelling units located in the floodplain in Warwick. Using this number and each towns' average household size as of the

2018 ACS U.S. Census, it is estimated that 34 people, or 1 percent of Northfield's total population, reside in the flood hazard area. It is estimated that 23 people, or 3 percent of Warwick's total population, reside in the flood hazard area.

Table 3-8: Estimated Northfield and Warwick Population Exposed to a 1 Percent Flood Event

	Total Population	# of Dwelling Units in Flood Hazard Area	Average # of People Per Household	Estimated Population in Flood Hazard Area	% of Total Population in Flood Hazard Area
Northfield	2,997	14	2.43	34	1.1
Warwick	781	10	2.26	23	2.9

Source: 2014-2018 American Community Survey Five-Year Estimates; 2005 MassGIS Land Use data.

<u>Vulnerable Populations</u>

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

Table 3-9 estimates the number of vulnerable populations and households in Northfield. Table 3-10 estimates the number of vulnerable populations and households in Warwick. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of residents during a flood event.

Table 3-9: Estimated Vulnerable Populations in Northfield

Vulnerable Population Category	Number	Percent of Total Population*
Population Age 65 Years and Over	837	28%
Population with a Disability	627	11%
Population who Speak English Less than "Very Well"	49	2%
Vulnerable Household Category	**Number**	**Percent of Total Households***

Table 3-9: Estimated Vulnerable Populations in Northfield		
Low Income Households (annual income less than $35,000)	227	18%
Householder Age 65 Years and Over Living Alone	141	11%
Households Without Access to a Vehicle	61	5%

*Total population = 2,997; Total households = 1,234

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

Source: U.S. Census American Community Survey 2014-2018 Five-Year Estimates.

Table 3-10: Estimated Vulnerable Populations in Warwick		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	173	22%
Population with a Disability	101	11%
Population who Speak English Less than "Very Well"	18	2%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	110	32%
Householder Age 65 Years and Over Living Alone	42	12%
Households Without Access to a Vehicle	6	2%

*Total population = 781; Total households = 345

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

Source: U.S. Census American Community Survey 2014-2018 Five-Year Estimates.

<u>Health Impacts</u>

The total number of injuries and casualties resulting from typical riverine flooding is generally limited due to advance weather forecasting, blockades, and warnings. The historical record from 1996 to 2018 indicates that there have been no fatalities or injuries associated with flooding or flash flooding events in Northfield and Warwick. However, flooding can result in direct mortality to individuals in the flood zone. This hazard is particularly dangerous because even a relatively low-level flood can be more hazardous than many residents realize. For example, while 6 inches of moving water can cause adults to fall, 1 foot to 2 feet of water can sweep cars away. Downed power lines, sharp objects in the water, or fast-moving debris that may be moving in or near the water all present an immediate danger to individuals in the flood zone.

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

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

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

<u>Economic Impacts</u>

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

Damages to buildings can affect a community's economy and tax base; the following section includes an analysis of buildings in Conway that are vulnerable to flooding and their associated value.

Infrastructure

Buildings, infrastructure, and other elements of the built environment are vulnerable to inland flooding. At the site scale, buildings that are not elevated or flood-proofed and those located within the floodplain are highly vulnerable to inland flooding. These buildings are likely to become increasingly vulnerable as riverine flooding increases due to climate change (resilient MA, 2018). At a neighborhood to regional scale, highly developed areas and areas with high impervious surface coverage may be most vulnerable to flooding. Even moderate development that results in as little as 3 percent impervious cover can lead to flashier flows and river degradation, including channel deepening, widening, and instability (Vietz and Hawley, 2016).

Additionally, changes in precipitation will threaten key infrastructure assets with flood and water damage. Climate change has the potential to impact public and private services and business operations. Damage associated with flooding to business facilities, large manufacturing areas in river valleys, energy delivery and transmission, and transportation systems has economic implications for business owners as well as the state's economy in general (resilient MA, 2018). Flooding can cause direct damage to Town-owned facilities and result in roadblocks and inaccessible streets that impact the ability of public safety and emergency vehicles to respond to calls for service.

Participants in the MVP workshops expressed concern about the impacts of future flooding on undersized and failing culverts, bridges, and road infrastructure throughout the town and the Town's need to maintain, monitor, repair, and replace infrastructure. In Northfield, the WWTP on Meadow Street is located along the Connecticut River and is susceptible to inundation by rising flood waters. The workshops also identified unstable streambanks on the Connecticut River and its tributaries, and on streams in steep areas that are vulnerable to fluvial erosion and flooding, which in turn can damage road infrastructure in these areas and result in runoff from roadways that can contaminate roadside wells and habitat areas. Improving roadway drainage was identified as a high priority in order to protect the road and neighboring properties and waterbodies.

Table 3-11 shows the amount of commercial, industrial, and public/institutional land uses located in town and within the Flood Hazard Area in Northfield and Warwick. In Northfield, approximately 0.2 acres of commercial, 0.2 acres of industrial, and 3.6 acres of public/institutional land uses lie within the floodplain, accounting for less than 1 percent of commercial and industrial land uses in town and 2.4 percent of public/institutional uses in town. Warwick does not contain any commercial or Industrial land uses. The Town has 7.7 acres of public/institutional land use, however, none lie within the floodplain.

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

	Land Use	Total acres in Town	Acres in Flood Hazard Area	% of total acres in Flood Hazard Area
Northfield	Commercial	43.4	0.2	0.5%
	Industrial	17.7	0.2	0.8%
	Public/Institutional	147.5	3.6	2.4%
Warwick	Commercial	0	0	0%
	Industrial	0	0	0%
	Public/Institutional	7.7	0	0%

Source: 2005 MassGIS Land Use data.

NFIP data are useful for determining the location of areas vulnerable to flood and severe storm hazards. Table 3-12 summarizes the NFIP policies, claims, repetitive loss (RL) properties, and severe repetitive loss (SRL) properties in Northfield and Warwick associated with all flood events as of December 2018. A RL property is a property for which two or more flood insurance claims of more than $1,000 have been paid by the NFIP within any 10-year period since 1978. A SRL property is defined as one that "has incurred flood-related damage for which 4 or more separate claims payments have been paid under flood insurance coverage, with the amount of each claim payment exceeding $5,000 and with cumulative amount of such claims payments exceeding $20,000; or for which at least 2 separate claims payments have been made with the cumulative amount of such claims exceeding the reported value of the property" (FEMA). Northfield currently has nine policies in force, $0 total losses have been paid and there are no repetitive loss properties in town. Warwick has 0 policies in force, no losses paid, and no repetitive less properties.

Table 3-12: NFIP Policies, Claims, and Repetitive Loss Statistics for Northfield and Warwick							
	Number of Housing Units (2017 Estimates)	**Number of Policies in Force**	**Percent of Housing Units**	**Total Insurance in Force**	**Number of Paid Losses**	**Total Losses Paid**	**Number of Repetitive Loss Properties**
Northfield	1447	9	0.6%	$2,099,300	0	$0	0
Warwick	456	0	0%	$0	0	$0	0

Source: National Flood Insurance Program (NFIP), FEMA Region I; U.S. Census Bureau 2013-2017 American Community Survey Five-Year Estimates.

Many dams within the Commonwealth have aged past their design life. As a result, they are less resilient to hazards such as inland flooding and extreme precipitation, and may not provide adequate safety following these disasters. These structures, if impacted by disasters, can affect human health, safety, and economic activity due to increased flooding and loss of infrastructure functions. These dams require termination or restoration to improve their infrastructure and better equip them to withstand the hazards that the Commonwealth will face due to climate change. The vulnerability of Northfield and Warwick to dams impacted by climate change related disasters is discussed in detail in the Dam Failure section and in the Problem Statements in Section 2.4.

As already stated, climate change impacts, including increased frequency of extreme weather events, are expected to raise the risk of damage to transportation systems, energy-related facilities, communication systems, a wide range of structures and buildings, solid and hazardous waste facilities, and water supply and wastewater management systems. A majority of the infrastructure in Massachusetts and throughout the country has been sited and designed based on historic weather and flooding patterns. As a result, infrastructure and facilities may lack the capacity to handle greater volumes of water or the required elevation to reduce vulnerability to flooding. Examples of climate change impacts to sectors of the built environment are summarized below.

<u>Agriculture</u>

Inland flooding is likely to impact the agricultural sector. Increased river flooding is likely to cause soil erosion, soil loss, and crop damage (resilient MA, 2018). In addition, wetter springs may delay planting of crops, resulting in reduced yields.

<u>Energy</u>

Flooding can increase bank erosion and also undermine buried energy infrastructure, such as underground power, gas, and cable infrastructure. Basement flooding can destroy electrical panels and furnaces. This can result in releases of oil and hazardous wastes to floodwaters. Inland flooding can also disrupt delivery of liquid fuels.

<u>Public Health</u>
The impacts to the built environment extend into other sectors. For example, flooding may increase the vulnerability of commercial and residential buildings to toxic mold buildup, leading to health risks, as described in the Populations section of the inland flooding hazard profile. Inland flooding may also lead to contamination of well water and contamination from septic systems (DPH, 2014).

<u>Public Safety</u>
Flash flooding can have a significant impact on public safety. Fast-moving water can sweep up debris, hazardous objects, and vehicles, and carry them toward people and property. Flooding can impact the ability of emergency response personnel to reach stranded or injured people. Drownings may also occur as people attempt to drive through flooded streets or escape to higher ground.

<u>Transportation</u>
Heavy precipitation events may damage roads, bridges, and energy facilities, leading to disruptions in transportation and utility services (resilient MA, 2018). Roads may experience greater ponding, which will further impact transportation. If alternative routes are not available, damage to roads and bridges may dramatically affect commerce and public health and safety.

<u>Water Infrastructure</u>
Stormwater drainage systems and culverts that are not sized to accommodate larger storms are likely to experience flood damage as extreme precipitation events increase (resilient MA, 2018). Both culverts that are currently undersized and culverts that are appropriately sized may be overwhelmed by larger storms. Gravity-fed water and wastewater infrastructure that is located in low lying areas near rivers and reservoirs may experience increased risks. Combined sewer overflows may increase with climate change, resulting in water quality degradation and public health risks (resilient MA, 2018).

Environment
Flooding is part of the natural cycle of a balanced environment. However, severe flood events can also result in substantial damage to the environment and natural resources, particularly in areas where human development has interfered with natural flood-related processes. As described earlier in this section, severe weather events are expected to become more frequent

as a result of climate change; therefore, flooding that exceeds the adaptive capacity of natural systems may occur more often.

One common environmental effect of flooding is riverbank and soil erosion. Riverbank erosion occurs when high, fast water flows scour the edges of the river, transporting sediment downstream and reshaping the ecosystem. In addition to changing the habitat around the riverbank, this process also results in the deposition of sediment once water velocities slow. This deposition can clog riverbeds and streams, disrupting the water supply to downstream habitats. Soil erosion occurs whenever floodwaters loosen particles of topsoil and then transport them downstream, where they may be redeposited somewhere else or flushed into the ocean. Flooding can also influence soil conditions in areas where floodwaters pool for long periods of time, as continued soil submersion can cause oxygen depletion in the soil, reducing the soil quality and potentially limiting future crop production.

Flooding can also affect the health and well-being of wildlife. Animals can be directly swept away by flooding or lose their habitats to prolonged inundation. Floodwaters can also impact habitats nearby or downstream of agricultural operations by dispersing waste, pollutants, and nutrients from fertilizers. While some of these substances, particularly organic matter and nutrients, can actually increase the fertility of downstream soils, they can also result in severe impacts to aquatic habitats, such as eutrophication.

Vulnerability Summary

Based on the above analysis, Northfield has a "High" vulnerability to flooding, while Warwick has a "Medium" vulnerability to flooding. Problem statements in Section 2.4 summarize areas of greatest concern regarding the flood hazard in Northfield and Warwick.

3.4 SEVERE SNOWSTORMS / ICE STORMS

Potential Effects of Climate Change

Climate projections for Massachusetts indicate that in future decades, winter precipitation could increase annually by as much as 0.4-3.9 inches (an increase of 4-35%), but by the end of the century most of this precipitation is likely to fall as rain instead of snow. There are many human and environmental impacts that could result from this change including reduced snow cover for winter recreation and tourism, less spring snowmelt to replenish aquifers and lower spring river flows for aquatic ecosystems. Figure 3-5 show potential effects of climate change on severe winter storms from the Massachusetts State Hazard Mitigation and Climate Adaptation Plan.

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

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

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

Hazard Description

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

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

Ice Storms

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

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

Nor'easters

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

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

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

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

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

Location

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

The entire area of Northfield and Warwick is susceptible to severe snowstorms and ice storms. Because these storms occur regionally, they impact the entirety of both towns. As a result, the location of occurrence is "Large," with over 50 percent of land area affected.

Extent

Since 2005, the Regional Snowfall Index (RSI) has become the descriptor of choice for measuring winter events that impact the eastern two-thirds of the U.S. The RSI ranks snowstorm impacts on a scale system from 1 to 5 as depicted in Table 3-13. The RSI is similar to the Fujita scale for tornadoes or the Saffir-Simpson scale for hurricanes, except that it includes an additional variable: population. The RSI is based on the spatial extent of the storm, the amount of snowfall, and population.

The RSI is a regional index. Each of the six climate regions (identified by the NOAA National Centers for Environmental Information) in the eastern two-thirds of the nation has a separate index. The RSI incorporated region-specific parameters and thresholds for calculating the index. The RSI is important because, with it, a storm event and its societal impacts can be assessed within the context of a region's historical events. Snowfall thresholds in Massachusetts (in the Northeast region) are 4, 10, 20, and 30 inches of snowfall, while thresholds in the Southeast U.S. are 2, 5, 10, and 15 inches.

Table 3-13: Regional Snowfall Index Categories

Category	RSI Value	Description
1	1—3	Notable
2	2.5—3.99	Significant
3	4—5.99	Major
4	6—9.99	Crippling
5	10.0+	Extreme

Source: NOAA National Climatic Data Center

Prior to the use of the RSI, the Northeast Snowfall Impact Scale (NESIS), developed by Paul Kocin of The Weather Channel and Louis Uccellini of the National Weather Service, was used to characterize and rank high-impact northeast snowstorms with large areas of 10-inch snowfall accumulations and greater. In contrast to the RSI, which is a regional index, NESIS is a quasi-national index that is calibrated to Northeast snowstorms. NESIS has five categories, as shown in Table 3-14.

Table 3-14: Northeast Snowfall Impact Scale Categories

Category	NESIS Value	Description
1	1—2.499	Notable
2	2.5—3.99	Significant
3	4—5.99	Major

4	6—9.99	Crippling
5	10.0+	Extreme

Source: NOAA National Climatic Data Center

Previous Occurrences

New England generally experiences at least one or two severe winter storms each year with varying degrees of severity. Severe winter storms typically occur during January and February; however, they can occur from late September through late April. According to NOAA's National Climatic Data Center, there have been 80 heavy snow events in Franklin County since 1996, resulting in $15,440,000 in damages; 29 winter storm events since 2002, resulting in $1,170,000 in damages; and two ice storms have resulted in damages of $3,150,000.

On December 11, 2008, a major ice storm impacted the northeast. The hardest hit areas in southern New England were the Monadnock region of southwest New Hampshire, the Worcester Hills in central Massachusetts, and the east slopes of the Berkshires in western Massachusetts. Anywhere from half an inch to an inch of ice built up on many exposed surfaces. Combined with breezy conditions, the ice downed numerous trees, branches, and power lines which resulted in widespread power outages. More than 300,000 customers were reportedly without power in Massachusetts and an additional 300,000 were without power in the state of New Hampshire. While most people had their power restored within a week, others were still without power at Christmas (nearly 2 weeks later).

During this period, temperatures were mostly below normal and at least one major snowstorm affected the same area. At the time of this snowstorm, which dumped 7 – 12 inches of snow in eastern Franklin County and 9 – 14 inches of snow in western part of the county, over 100,000 customers were still without power in the two states combined. Two days later, on December 21, 2008, 5 – 7 inches of new snow blanketed eastern Franklin County. In Northfield, the higher elevations were impacted by the ice storm. Trees were downed and power was out in parts of the town. A shelter was opened, and the Town provided housing for the National Guard in the Town Hall for one or two nights.

Damage to the infrastructure in Massachusetts and New Hampshire amounted to roughly 80 million dollars. This amount does not include damage to private property. The extent of the damage and number of people affected prompted the governors of both Massachusetts and New Hampshire to request federal assistance. FEMA approved both requests. President Bush issued a Major Disaster Declaration for Public Assistance for seven Massachusetts counties and all of New Hampshire.

Tree damage, power outages, and closed roads from the 2008 ice storm were widespread in Northfield and Warwick. Ice storm effects in Warwick included damage on the following roads in town: Flower Hill, Shepardson, and Old Winchester Roads, as well as the roads in Warwick Center. Mount Grace suffered a high amount of downed trees. The Town received 100% reimbursement for the costs associated with the storm from FEMA (75%) and MEMA (25%), for a total of $91,048. Residents who rely upon forests for their livelihoods, including farmers who have maple sugaring operations, suffered losses due to this storm.

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

In Northfield, as of Sunday, October 30, 81% of town was without power. As of Thursday, November 3, WMECO estimated that 12% of Northfield customers were still without power.[25] A shelter was opened at the Pioneer Valley Regional School, which remained open for three days. Many trees were damaged or downed during the storm in Northfield, resulting in several months of tree work to clean up the damage.

The Town of Warwick suffered similar effects from the October 2011 snowstorm as those described above. Some residents were without power for up to 12 days. The Town has received reimbursement from FEMA for its costs associated with the storm in the amount of $18,995.61, which represents 75% of its costs, and an additional $6,331.86 from MEMA, representing the remaining 25% of the Town's costs.

Based on data available from the National Oceanic and Atmospheric Administration, there are 210 winter storms since 1900 that have registered on the RSI scale. Of these, approximately 18 storms resulted in snow falls in all or parts of Franklin County of at least 10 inches. These storms are listed in Table 3-15, in order of their RSI severity.

[25] Western Massachusetts Electric Company Outage Report, 11/3/2011.

Table 3-15: High-Impact Snowstorms in Franklin County, 1958 - 2018			
Date	RSI Value	RSI Category	RSI Classification
2/22/1969	34.0	5	Extreme
3/12/1993	22.1	5	Extreme
1/6/1996	21.7	5	Extreme
2/5/1978	18.4	5	Extreme
2/23/2010	17.8	4	Crippling
2/15/2003	14.7	4	Crippling
1/29/1966	12.3	4	Crippling
3/12/2017	10.7	4	Crippling
2/27/1947	10.6	4	Crippling
12/25/1969	10.1	4	Crippling
12/4/2003	9.4	3	Major
2/8/2013	9.2	3	Major
2/2/1961	8.3	3	Major
2/10/1983	7.9	3	Major
2/14/1958	7.9	3	Major
2/12/2007	6.9	3	Major
3/2/1960	6.9	3	Major
1/25/2015	6.2	3	Major

Source: https://www.ncdc.noaa.gov/snow-and-ice/rsi/societal-impacts

The Core Teams identified the following as storms that have impacted Northfield and Warwick in recent history and are identified in Table 3-16. On January 18, 1999, freezing rain in western Massachusetts caused severe icing of roadways, especially in the valleys of Franklin, Hampshire, and Hampden Counties. Many towns reported states of emergency. Roads were closed in many communities, including Northfield. Thunderstorms accompanied the freezing rain during the afternoon. Six to ten inches of snow fell across eastern Franklin County on November 26, 2014, bringing down trees and wires in Northfield and many surrounding towns.

Table 3-16: Recent Snow Events that Impacted Northfield and Warwick			
Date	Location	Type	Recorded Property Damages
1/18/1999	Eastern Franklin	Winter Weather	$0
11/26/2014	Eastern Franklin	Heavy Snow	$75,000

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

Probability of Future Events

Based upon the availability of records for Franklin County, the likelihood that a severe snow storm will hit Northfield and Warwick in any given year is "Very High," or a 70 to 100 percent probability in any given year.

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

Impact

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

The impact of an event would be “Limited,” with more than 10 percent of property in the affected area damaged and complete shutdown of facilities for more than 1 day possible.

Vulnerability

Society

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

Heavy snow can immobilize a region and paralyze a community, shutting down air and rail transportation, stopping the flow of supplies, and disrupting medical and emergency services. Accumulations of snow can cause buildings to collapse and knock down trees and power lines.

In rural areas, homes and farms may be isolated for days, and unprotected livestock may perish. In the mountains, heavy snow can lead to avalanches.

The impact of a severe winter storm on life, health, and safety is dependent upon several factors, including the severity of the event and whether or not adequate warning time was provided to residents. Residents may be displaced or require temporary to long-term sheltering. In addition, downed trees, damaged buildings, and debris carried by high winds can lead to injury or loss of life. The entire population of Northfield and Warwick is exposed to severe winter weather events.

Vulnerable Populations

Vulnerable populations include the elderly living alone, who are susceptible to winter hazards due to their increased risk of injury and death from falls, overexertion, and/or hypothermia from attempts to clear snow and ice, or injury and death related to power failures. In addition, severe winter weather events can reduce the ability of these populations to access emergency services. People with low socioeconomic status are more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on the net economic impact on their families. Residents with low incomes may not have access to housing or their housing may be less able to withstand cold temperatures (e.g., homes with poor insulation and heating supply).

The population over the age of 65, individuals with disabilities, and people with mobility limitations or who lack transportation are also more vulnerable because they are more likely to seek or need medical attention, which may not be available due to isolation during a winter storm event. These individuals are also more vulnerable because they may have more difficulty if evacuation becomes necessary. People with limited mobility risk becoming isolated or "snowbound" if they are unable to remove snow from their homes. Rural populations may become isolated by downed trees, blocked roadways, and power outages. Residents relying on private wells could lose access to fresh drinking water and indoor plumbing during a power outage.

Table 3-17 estimates the number of vulnerable populations and households in Northfield. Table 3-18 estimates the number of vulnerable populations and households in Warwick. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of residents during a severe winter storm event.

Table 3-17: Estimated Vulnerable Populations in Northfield		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	837	28%
Population with a Disability	627	11%
Population who Speak English Less than "Very Well"	49	2%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	227	18%
Householder Age 65 Years and Over Living Alone	141	11%
Households Without Access to a Vehicle	61	5%

*Total population = 2,997; Total households = 1,234
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2014-2018 Five-Year Estimates.

Table 3-18: Estimated Vulnerable Populations in Warwick		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	173	22%
Population with a Disability	101	11%
Population who Speak English Less than "Very Well"	18	2%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	110	32%
Householder Age 65 Years and Over Living Alone	42	12%
Households Without Access to a Vehicle	6	2%

*Total population = 781; Total households = 345
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2014-2018 Five-Year Estimates.

Health Impacts

Cold weather, which is a component of a severe winter storm, increases the risk of hypothermia and frostbite. Exposure to cold conditions can also exacerbate pre-existing respiratory and cardiovascular conditions. In addition to temperature-related dangers, however, severe winter storms also present other potential health impacts. For example, individuals may use generators in their homes if the power goes out or may use the heat system in their cars if they become trapped by snow. Without proper ventilation, both of these activities can result in carbon monoxide buildup that can be fatal. Loss of power can also lead to hypothermia. After Hurricane Sandy, the number of cases of cold exposure in New York City was three times greater than the same time period in previous years.[26] Driving during severe snow and ice conditions can also be very dangerous, as roads become slick and drivers can lose control of their vehicle. During and after winter storms, roads may be littered with debris, presenting a danger to drivers. Health impacts on people include the inability to travel to receive needed medical services and isolation in their homes. Additionally, natural gas-fueled furnaces, water heaters, and clothes dryers, and even automobile exhaust pipes, may become blocked by snow and ice, which can lead to carbon monoxide poisoning.

Economic Impacts

The entire building stock inventory in Conway is exposed to the severe winter weather hazard. In general, structural impacts include damage to roofs and building frames rather than building content. Heavy accumulations of ice can bring down trees, electrical wires, telephone poles and lines, and communication towers. Communication and power networks can be disrupted for days while utility companies work to repair the extensive damage.

Even small accumulations of ice may cause extreme hazards to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces. A specific area that is vulnerable to the winter storm hazard is the floodplain. Snow and ice melt can cause both riverine and urban flooding. The cost of snow and ice removal and repair of roads from the freeze/thaw process can drain local financial resources. The potential secondary impacts from winter storms, including loss of utilities, interruption of transportation corridors, loss of business functions, and loss of income for many individuals during business closures, also impact the local economy.

Similar to hurricanes and tropical storms, nor'easter events can greatly impact the economy, with impacts that include the loss of business functions (e.g., tourism and recreation), damage to inventories or infrastructure (the supply of fuel), relocation costs, wage losses, and rental losses due to the repair or replacement of buildings.

Infrastructure

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

All infrastructure and other elements of the built environment in Northfield and Warwick are exposed to the severe winter weather hazards. Potential structural damage to the facilities themselves may include damage to roofs and building frames. These facilities may not be fully operational if workers are unable to travel to ensure continuity of operations prior and after a severe winter event. Disruptions to key public services such as electricity, transportation, schools, and health care may become more common.[27] Table 3-19 identifies the assessed value of all residential, open space, commercial, and industrial land uses in each town, and the losses that would result from 1%, 5%, and 10% damage to this inventory as a result of a severe winter storm.

Table 3-19: Estimated Potential Loss by Tax Classification in Northfield and Warwick

	Tax Classification	Total Assessed Value FY2019	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
	Residential	$289,072,924	$2,890,729	$14,453,646	$28,907,292
	Open Space	$0	$0	$0	$0
Northfield	Commercial	$18,116,201	$181,162	$905,810	$1,811,620
	Industrial	$92,552,450	$925,525	$4,627,623	$9,255,245
	Total	**$399,741,575**	**$3,997,416**	**$19,987,079**	**$39,974,158**
	Residential	$73,910,249	$739,102	$3,695,512	$7,391,025
	Open Space	$0	$0	$0	$0
Warwick	Commercial	$1,502,073	$15,021	$75,104	$150,207
	Industrial	$0	$0	$0	$0
	Total	**$75,412,322**	**$754,123**	**$3,770,616**	**$7,541,232**

Source: Massachusetts Department of Revenue - Division of Local Services, Data Analytics and Resources Bureau, FY 2020

<u>Agriculture</u>

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.

<u>Energy</u>

Severe weather can cause power outages from trees that fall during heavy snow and strong

[27] Resilient MA 2018

wind events. Severe ice events can take down transmission and distribution lines. The severe weather can impair a utility's ability to rapidly repair and recover the system.

Public Health

Severe winter weather presents many health hazards, as previously described in the discussion of the severe winter storm/nor'easter hazard profile. Severe winter storms and events with extended power outages may overburden hospitals and emergency shelters.

Public Safety

Public safety buildings may experience direct loss (damage) from downed trees, heavy snowfall, and high winds. Full functionality of critical facilities, such as police, fire and medical facilities, is essential for response during and after a winter storm event. Because power interruptions can occur, backup power is recommended for critical facilities and infrastructure. The ability of emergency responders to respond to calls may be impaired by heavy snowfall, icy roads, and downed trees.

Transportation

Other infrastructure elements at risk for this hazard include roadways, which can be obstructed by snow and ice accumulation or by windblown debris. Additionally, over time, roadways can be damaged from the application of salt and the thermal expansion and contraction from alternating freezing and warming conditions. Other types of infrastructure, including rail, aviation, port, and waterway infrastructure (if temperatures are cold enough to cause widespread freezing), can be impacted by winter storm conditions.

Water Infrastructure

Water infrastructure that is exposed to winter conditions may freeze or be damaged by ice.

Environment

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

Vulnerability Summary

Based on the above assessment, Northfield and Warwick face a "High" vulnerability from severe snowstorms and ice storms. Severe Winter Storms / Ice Storms occur frequently in Northfield and Warwick. However, the severity of impact is minor to limited, except for impact to population, which could be critical. Problem statements in Section 2.4 summarize the areas of greatest concern regarding severe winter storms in Northfield and Warwick.

3.5 HURRICANES / TROPICAL STORMS

Potential Effects of Climate Change

A 2017 U.S. Climate Science Special Report noted that there has been an upward trend in North Atlantic hurricane activity since 1970. The report forecasts that future hurricanes formed in the North Atlantic will drop more rain and may have higher wind speeds. This is because a warmer atmosphere will hold more water, and hurricanes are efficient at wringing water out of the atmosphere and dumping it on land. When extreme storms like Tropical Storm Irene travel over inland areas, they may release large quantities of precipitation and cause rivers to overtop their banks. Irene dumped more than 10 inches of rain in western Massachusetts. Buildings floated downriver in Shelburne Falls, flooded highways were closed, and 400,000 utility customers lost power (resilient MA, 2018). Figure 3-5 displays the potential effects of climate change on hurricanes and tropical storms from the Massachusetts State Hazard Mitigation and Climate Adaptation Plan.

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

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

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

Hazard Description

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

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

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

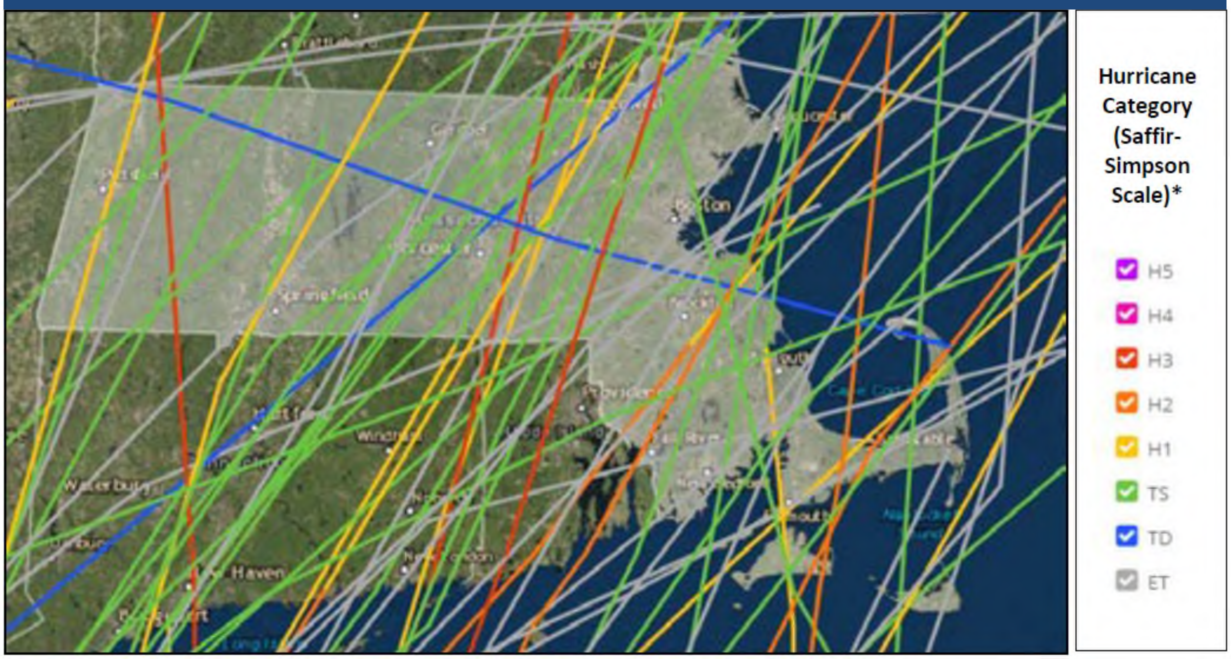
Tropical Storms
A tropical storm system is characterized by a low-pressure center and numerous thunderstorms that produce strong winds and heavy rain (winds are at a lower speed than hurricane-force winds, thus gaining its status as a tropical storm versus a hurricane). Tropical storms strengthen when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

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

Location

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

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



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

NOAA’s Historical Hurricane Tracks tool is a public interactive mapping application that displays Atlantic Basin and East-Central Pacific Basin tropical cyclone data. This interactive tool tracks tropical cyclones from 1842 to 2017. According to this resource, over the time frame tracked, 63 events categorized as an extra-tropical storm or higher occurred within 65 nautical miles of Massachusetts. The tracks of these storms are shown in Figure 3-6. As this figure shows, the paths of these storms vary across the Commonwealth, but are more likely to occur toward the coast.

Extent

Hurricanes are measured according to the Saffir-Simpson scale, which categorizes or rates hurricanes from 1 (minimal) to 5 (catastrophic) based on their intensity. This is used to give an estimate of the potential property damage and flooding expected from a hurricane landfall. Wind speed is the determining factor in the scale. All winds are assessed using the U.S. 1-minute average, meaning the highest wind that is sustained for 1 minute. The Saffir-Simpson

Scale described in Table 3-20 gives an overview of the wind speeds and range of damage caused by different hurricane categories.

Table 3-20: Saffir-Simpson Scale

Scale No. (Category)	Winds (mph)	Potential Damage
1	74 – 95	Minimal: Damage is primarily to shrubbery and trees, mobile homes, and some signs. No real damage is done to structures.
2	96 – 110	Moderate: Some trees topple; some roof coverings are damaged; and major damage is done to mobile homes.
3	111 – 130	Extensive: Large trees topple; some structural damage is done to roofs; mobile homes are destroyed; and structural damage is done to small homes and utility buildings.
4	131 – 155	Extreme: Extensive damage is done to roofs, windows, and doors; roof systems on small buildings completely fail; and some curtain walls fail.
5	> 155	Catastrophic: Roof damage is considerable and widespread; window and door damage is severe; there are extensive glass failures; and entire buildings could fail.
Additional Classifications		
Tropical Storm	39-73	NA
Tropical Depression	< 38	NA

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

Tropical storms and tropical depressions, while generally less dangerous than hurricanes, can be deadly. The winds of tropical depressions and tropical storms are usually not the greatest threat; rather, the rains, flooding, and severe weather associated with the tropical storms are what customarily cause more significant problems. Serious power outages can also be associated with these types of events. After Hurricane Irene passed through the region as a tropical storm in late August 2011, many areas of the Commonwealth were without power for more than 5 days.

While tropical storms can produce extremely powerful winds and torrential rain, they are also able to produce high waves, damaging storm surge, and tornadoes. They develop over large bodies of warm water and lose their strength if they move over land due to increased surface friction and loss of the warm ocean as an energy source. Heavy rains associated with a tropical storm, however, can produce significant flooding inland, and storm surges can produce extensive coastal flooding up to 25 miles from the coastline.

One measure of the size of a tropical cyclone is determined by measuring the distance from its center of circulation to its outermost closed isobar. If the radius is less than 2 degrees of latitude, or 138 miles, then the cyclone is "very small." A radius between 3 and 6 degrees of latitude, or 207 to 420 miles, is considered "average-sized." "Very large" tropical cyclones have a radius of greater than 8 degrees, or 552 miles.

Previous Occurrences

According to NOAA's Historical Hurricane Tracker tool, 63 hurricane or tropical storm events have occurred in the vicinity of Massachusetts between 1842 and 2016. The Commonwealth was impacted by tropical storms Jose and Phillipe in 2017. Therefore, there is an average of one storm every other year or 0.5 storms per year. Storms severe enough to receive FEMA disaster declarations, however, are far rarer, occurring every 9 years on average. The Commonwealth has not been impacted by any Category 4 or 5 hurricanes; however, Category 3 storms have historically caused widespread flooding. Winds have caused sufficient damage to impair the ability of individuals to remain in their homes.

In Massachusetts, major hurricanes occurred in 1904, 1938, 1954, 1955, 1960 and 1976, 1985, 1991 and 2010. The Great New England Hurricane of 1938, a Category 3 hurricane which occurred on September 21, 1938, was one of the most destructive and powerful storms ever to strike Southern New England. Sustained hurricane force winds occurred throughout most of Southern New England. Extensive damage occurred to roofs, trees and crops. Widespread power outages occurred, which in some areas lasted several weeks. Rainfall from this hurricane resulted in severe river flooding across sections of Massachusetts and Connecticut. The combined effects from a frontal system several days earlier and the hurricane produced rainfall of 10 to 17 inches across most of the Connecticut River Valley. This resulted in some of the worst flooding ever recorded in this area. The 1938 Hurricane affected Warwick, causing extensive damage to trees, especially along the Town's roadways.

Historic data for hurricane and tropical storm events indicate one hurricane and 17 tropical storms have been recorded in Franklin County. Hurricane Bob, a weak category 2 hurricane, made landfall in New England in August 1991. In Franklin County, Hurricane Bob caused roughly $5,555,556 in property and over $500,000 crop damages. Tropical Storm Floyd hit Massachusetts in September 1999, causing major damage in the Town of Warwick. The Highway Department documented major damage to the following roads in Town: Winchester, White, and Leland Roads. The Town received reimbursement from MEMA in the amount of $69,290.59 for its costs related to Floyd. In 2011, Tropical Storm Irene caused over $26 million in property damage in Franklin County, mostly from flooding impacts. Although Tropical Storm Irene tracked directly over the Town of Warwick, both Northfield and Warwick were spared any major damage.

Probability of Future Events

A 2017 U.S. Climate Science Special Report noted that there has been an upward trend in North Atlantic hurricane activity since 1970. The report forecasts that future hurricanes formed in the North Atlantic will drop more rain and may have higher wind speeds. This is because a warmer atmosphere will hold more water, and hurricanes are efficient at wringing water out of the atmosphere and dumping it on land.[28]

The location of Northfield and Warwick in western Massachusetts reduces the risk of extremely high winds that are associated with hurricanes, although it can experience some high wind events. Based upon past occurrences, Northfield and Warwick have a moderate probability, or a 2% - 25% chance, of experiencing a hurricane or tropical storm event in a given year.

Impact

Considering the impacts of previous hurricanes and tropical storms on Northfield and Warwick during the Vulnerability Assessment revealed that an occurrence could critically impact the Towns, with potential multiple injuries to citizens possible and with a potential of more than 25% of property damaged or destroyed.

Vulnerability

The entirety of both towns would be vulnerable to the impact of a hurricane or tropical storm. Areas prone to flooding are particularly vulnerable. Additionally high winds could impact the Town's roads, communication and energy infrastructure.

Society

Vulnerable Populations

Among the exposed populations, the most vulnerable include people with low socioeconomic status, people over the age of 65, people with medical needs, and those with low English language fluency. For example, people with low socioeconomic status are likely to consider the economic impacts of evacuation when deciding whether or not to evacuate. Individuals with medical needs may have trouble evacuating and accessing needed medical care while displaced. Those who have low English language fluency may not receive or understand the warnings to evacuate. During and after an event, rescue workers and utility workers are vulnerable to impacts from high water, swift currents, rescues, and submerged debris. Vulnerable populations may also be less likely to have adequate resources to recover from the loss of their homes and jobs or to relocate from a damaged neighborhood.

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

Table 3-21 estimates the number of vulnerable populations and households in Northfield. Table 3-22 estimates the number of vulnerable populations and households in Warwick. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of residents during a hurricane or tropical storm event.

Table 3-21: Estimated Vulnerable Populations in Northfield

Vulnerable Population Category	Number	Percent of Total Population*
Population Age 65 Years and Over	837	28%
Population with a Disability	627	11%
Population who Speak English Less than "Very Well"	49	2%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	227	18%
Householder Age 65 Years and Over Living Alone	141	11%
Households Without Access to a Vehicle	61	5%

*Total population = 2,997; Total households = 1,234

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

Source: U.S. Census American Community Survey 2014-2018 Five-Year Estimates.

Table 3-22: Estimated Vulnerable Populations in Warwick

Vulnerable Population Category	Number	Percent of Total Population*
Population Age 65 Years and Over	173	22%
Population with a Disability	101	11%
Population who Speak English Less than "Very Well"	18	2%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	110	32%
Householder Age 65 Years and Over Living Alone	42	12%
Households Without Access to a Vehicle	6	2%

*Total population = 781; Total households = 345
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2014-2018 Five-Year Estimates.

Health Impacts

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

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

Economic Impacts

In addition to the human costs that extreme storms deliver when they permanently or temporarily displace people, the repair and reconstruction costs after storm damage can be enormous for homeowners and businesses. When bridges and culverts have been washed away and roads damaged, municipal and state agencies must secure the resources for expensive recovery projects in limited municipal budgets and from Federal disaster grant programs that are increasingly over-subscribed. Electrical grid, power plants and wastewater infrastructure repair costs are all expected to increase in the future.[29]

Infrastructure

Hurricanes and tropical storms could critically impact Northfield and Warwick , with a potential of more than 25% of property in affected area damaged or destroyed. Residential and commercial buildings built along rivers may be vulnerable to severe damage. Potential structural damage to the facilities themselves may include damage to roofs and building frames. These facilities may not be fully operational if workers are unable to travel to ensure continuity of operations prior and after a severe winter event. Table 3-23 identifies the assessed value of all residential, open space, commercial, and industrial land uses in each town, and the losses that would result from 1%, 5%, and 10% damage to this inventory as a result of a hurricane or tropical storm.

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

Table 3-23: Estimated Potential Loss by Tax Classification in Northfield and Warwick					
	Tax Classification	**Total Assessed Value FY2019**	**1% Damage Loss Estimate**	**5% Damage Loss Estimate**	**10% Damage Loss Estimate**
Northfield	Residential	$289,072,924	$2,890,729	$14,453,646	$28,907,292
	Open Space	$0	$0	$0	$0
	Commercial	$18,116,201	$181,162	$905,810	$1,811,620
	Industrial	$92,552,450	$925,525	$4,627,623	$9,255,245
	Total	**$399,741,575**	**$3,997,416**	**$19,987,079**	**$39,974,158**
Warwick	Residential	$73,910,249	$739,102	$3,695,512	$7,391,025
	Open Space	$0	$0	$0	$0
	Commercial	$1,502,073	$15,021	$75,104	$150,207
	Industrial	$0	$0	$0	$0
	Total	**$75,412,322**	**$754,123**	**$3,770,616**	**$7,541,232**

Source: Massachusetts Department of Revenue - Division of Local Services, Data Analytics and Resources Bureau, FY 2020

Energy

Hurricanes and tropical storms often result in power outages and contact with damaged power lines during and after a storm, which may result in electrocution.

Public Health

Combined sewer overflows associated with heavy rainfall can release contaminants, chemicals, and pathogens directly into the environment and into water systems. If a mass outbreak of waterborne illness were to occur, hospitals and medical providers may lack the capacity to treat patients.

Public Safety

Critical infrastructure, including local and state-owned police and fire stations, other public safety buildings, and facilities that serve as emergency operation centers may experience direct loss (damage) during a hurricane or tropical storm. Emergency responders may also be exposed to hazardous situations when responding to calls. Road blockages caused by downed trees may impair travel.

Transportation

Some roads and bridges are also considered critical infrastructure, particularly those providing ingress and egress and allowing emergency vehicles access to those in need. Costly damage to roads, bridges, and rail networks may occur as a result of hurricanes.[30]

Water and Wastewater Infrastructure

Wastewater treatment centers may face elevated risks of damage and destruction from hurricanes (resilient MA, 2018). Heavy rains can lead to contamination of well water and can release contaminants from septic systems (DPH, 2014). Heavy rainfall can also overburden stormwater systems, drinking water supplies, and sewage systems.

Environment

The environmental impacts of hurricanes and tropical storms are similar to those described for other hazards, including flooding, severe winter storms and other severe weather events. As described for human health, environmental impacts can generally be divided into short-term direct impacts and long-term impacts. As the storm is occurring, flooding may disrupt normal ecosystem function and wind may fell trees and other vegetation. Additionally, wind-borne or waterborne detritus can cause mortality to animals if they are struck or transported to a non-suitable habitat.

In the longer term, impacts to natural resources and the environment as a result of hurricanes and tropical storms are generally related to changes in the physical structure of ecosystems. For example, flooding may cause scour in riverbeds and erode riverbanks, modifying the river ecosystem and depositing the scoured sediment in another location. Similarly, trees that fall during the storm may represent lost habitat for local species, or they may decompose and provide nutrients for the growth of new vegetation. If the storm spreads pollutants into natural ecosystems, contamination can disrupt food and water supplies, causing widespread and long-term population impacts on species in the area.

Vulnerability Summary

Based on the above analysis, Northfield and Warwick face a “Medium” vulnerability from hurricanes and tropical storms. The problem statements in Section 2.4 summarize the greatest areas of concern regarding hurricanes and tropical storms for Northfield and Warwick.

[30] Resilient MA 2018.

3.6 SEVERE THUNDERSTORMS / WIND / MICROBURSTS

Potential Effects of Climate Change

Climate change is expected to increase extreme weather events across the globe and in Massachusetts. Climate change leads to extreme weather because of warmer air and ocean temperatures and changing air currents. Warmer air leads to more evaporation from large water bodies and holds more moisture, so when clouds release their precipitation, there is more of it. In addition, changes in atmospheric air currents like jet streams and ocean currents can cause changes in the intensity and duration of stormy weather. While it is difficult to connect one storm to a changing climate, scientists point to the northeastern United States as one of the regions that is most vulnerable to an increase in extreme weather driven by climate change.[31]

Figure 3-7: Effects of Climate Change on Severe Thunderstorms, Wind, and Microbursts

Potential Effects of Climate Change		
	EXTREME WEATHER AND CHANGES IN PRECIPITATION ➔ MORE INTENSE AND FREQUENT THUNDERSTORMS AND DOWNPOURS	The Northeast has already experienced a larger increase in the intensity of rainfall events than any other region in the United States in the last fifty years, and this trend is expected to continue.

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

Hazard Description

A thunderstorm is a storm originating in a cumulonimbus cloud. Cumulonimbus clouds produce lightning, which locally heats the air to 50,000 degrees Celsius, which in turn produces an audible shock wave, known as thunder. Frequently during thunderstorm events, heavy rain and gusty winds are present. Less frequently, hail is present, which can become very large in size. Tornadoes can also be generated during these events. According to the National Weather Service, a thunderstorm is classified as “severe” when it produces damaging wind gusts in excess of 58 mph (50 knots), hail that is 1 inch in diameter or larger (quarter size), or a tornado.

Every thunderstorm has an updraft (rising air) and a downdraft (sinking air). Sometimes strong downdrafts known as downbursts can cause tremendous wind damage that is similar to that of a tornado. A small (less than 2.5 mile path) downburst is known as a “microburst” and a larger downburst is called a “macro-burst.” An organized, fast-moving line of microbursts traveling

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

across large areas is known as a "derecho." These occasionally occur in Massachusetts. Winds exceeding 100 mph have been measured from downbursts in Massachusetts.

Wind is air in motion relative to surface of the earth. For non-tropical events over land, the NWS issues a Wind Advisory (sustained winds of 31 to 39 mph for at least 1 hour or any gusts 46 to 57 mph) or a High Wind Warning (sustained winds 40+ mph or any gusts 58+ mph). For non-tropical events over water, the NWS issues a small craft advisory (sustained winds 25-33 knots), a gale warning (sustained winds 34-47 knots), a storm warning (sustained winds 48 to 63 knots), or a hurricane force wind warning (sustained winds 64+ knots). For tropical systems, the NWS issues a tropical storm warning for any areas (inland or coastal) that are expecting sustained winds from 39 to 73 mph. A hurricane warning is issued for any areas (inland or coastal) that are expecting sustained winds of 74 mph. Effects from high winds can include downed trees and/or power lines and damage to roofs, windows, and other structural components. High winds can cause scattered power outages. High winds are also a hazard for aircraft.

Location

When severe thunderstorms, wind, and microbursts occur, they have the potential to impact anywhere from 10% to 50% of the town.

Extent

An average thunderstorm is 15 miles across and lasts 30 minutes; severe thunderstorms can be much larger and longer. The severity of thunderstorms can vary widely, from commonplace and short-term events to large-scale storms that result in direct damage and flooding. Thunderstorms can cause hail, wind, and flooding, with widespread flooding the most common characteristic that leads to a storm being declared a disaster. The severity of flooding varies widely based both on characteristics of the storm itself and the region in which it occurs. Lightning can occasionally also present a severe hazard. Southern New England typically experiences 10 to 15 days per year with severe thunderstorms.

Microbursts are typically less than three miles across. They can last anywhere from a few seconds to several minutes. Microbursts cause damaging winds up to 170 miles per hour in strength and can be accompanied by precipitation.

Northfield and Warwick are susceptible to high winds from several types of weather events: before and after frontal systems, hurricanes and tropical storms, severe thunderstorms and tornadoes, and nor'easters. Sometimes, wind gusts of only 40 to 45 mph can cause scattered power outages from downed trees and wires. This is especially true after periods of prolonged drought or excessive rainfall, since both are situations that can weaken the root systems and make them more susceptible to the winds' effects. Winds measuring less than 30 mph are not considered to be hazardous under most circumstances. Wind speeds in a hurricane are measured using the Saffir-Simpson scale. Another scale developed for measuring wind is the Beaufort wind scale (see Figure 3-8).

Figure 3-8: Beaufort Wind Scale

Beaufort number	Wind Speed (mph)	Seaman's term		Effects on Land
0	Under 1	Calm		Calm; smoke rises vertically.
1	1-3	Light Air		Smoke drift indicates wind direction; vanes do not move.
2	4-7	Light Breeze		Wind felt on face; leaves rustle; vanes begin to move.
3	8-12	Gentle Breeze		Leaves, small twigs in constant motion; light flags extended.
4	13-18	Moderate Breeze		Dust, leaves and loose paper raised up; small branches move.
5	19-24	Fresh Breeze		Small trees begin to sway.
6	25-31	Strong Breeze		Large branches of trees in motion; whistling heard in wires.
7	32-38	Moderate Gale		Whole trees in motion; resistance felt in walking against the wind.
8	39-46	Fresh Gale		Twigs and small branches broken off trees.
9	47-54	Strong Gale		Slight structural damage occurs; slate blown from roofs.
10	55-63	Whole Gale		Seldom experienced on land; trees broken; structural damage occurs.
11	64-72	Storm		Very rarely experienced on land; usually with widespread damage.
12	73 or higher	Hurricane Force		Violence and destruction.

Source: Developed in 1805 by Sir Francis Beaufort

Previous Occurrences

Since 1996, a total of 15 high wind events occurred in Franklin County (Table 3-24), causing a total of $303,000 in property damages. High winds are defined by the National Weather Service as sustained non-convective winds of 35 knots (40 mph) or greater lasting for 1 hour or longer, or gusts of 50 knots (58 mph) or greater for any duration. The probability of future high wind events is expected to increase as a result of climate projections for the state that suggest a greater occurrence of severe weather events in the future. High wind events specifically impacting Northfield include November 2018, when trees and wires were downed on West Road and Caldwell Road, and in February 2019 when a tree was downed on Gulf Road due to high winds.

Table 3-24: High Wind Events in Franklin County			
Year	**# of High Wind Events**	**Annual Property Damage**	**Annual Crop Damage**
1996	2	$0	$0
1999	1	$0	$0
2003	2	$130,000	$0
2004	1	$30,000	$0
2005	1	$10,000	$0
2006	3	$68,000	$0
2011	1	$15,000	$0
2013	2	$35,000	$0
2018	1	$3,000	$0
2019	1	$12,000	$0
Total	**15**	**$303,000**	**$0**

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

Thunderstorm winds are defined by the National Weather Service as winds arising from convection (occurring within 30 minutes of lightning being observed or detected) with speeds of at least 50 knots (58 mph), or winds of any speed (non-severe thunderstorm winds below 50 knots) producing a fatality, injury, or damage. Northfield has experienced at least fifteen (15) thunderstorm, wind, or microburst events since 1997, and Warwick has experienced at least nine thunderstorm, wind, or microburst events in the same time period (Table 3-25). These storms resulted in downed trees and wires and caused $121,000 in property damage in Northfield and $63,000 in property damage in Warwick.

High winds from microbursts and thunderstorms are a concern to Warwick Town Officials because of the threat to communications towers and power lines. A heavy wind event in October 2019 caused power outages in town for over a week in some areas, and access in and out of town was blocked by downed trees and wires. Communication to residents was hampered by downed wires and no internet access.

Table 3-25: Severe Thunderstorm Wind Events in Northfield and Warwick				
Year	**Event**	**Annual Property Damage**	**Annual Crop Damage**	**Event Description**
NORTHFIELD				
8/16/1997	Microburst	$10,000	$0	A severe thunderstorm caused wind damage in Franklin County in Northfield. A National Weather Service survey indicated that a microburst occurred in Northfield with an estimated thunderstorm wind gust of 80 to 90 mph. All trees fell in a single direction toward the northeast. The path of the damage was about one half-mile in length and occurred on Pine Meadow Road off of Route 63. A tree fell onto a house and narrowly missed a baby sleeping in a crib. Poles and wires were downed and Route 2 was closed. A cornfield was damaged and a farm stand toppled.
5/20/1998	Hail	$0	$0	In Franklin County, trained spotters reported quarter size hail in North Leverett; dime size hail in Leverett and Northfield.
5/31/1998	Thunderstorm Wind	$0	$0	Law enforcement officials reported that trees were blown down between 5:30 PM and 6:10 PM in Shelburne Falls, Shelburne, Conway, Gill, Bernardston, Leyden, Northfield, and Warwick.
7/23/2002	Thunderstorm Wind	$8,000	$0	A line of severe thunderstorms moved across much of the Bay State during the afternoon and early evening, producing widespread wind damage.
6/26/2005	Thunderstorm Wind / Microburst Hail	$20,000	$0	Severe wind gusts brought down trees and power lines. One of the most noteworthy occurred in Northfield, where a microburst was produced from a severe thunderstorm. This microburst produced estimated wind gusts at 100 mph, or slightly higher. These wind gusts brought down 80-100 trees. The damage path stretched for approximately one mile, with the worst damage occurring on School, South, and Virnhan streets. A white pine tree three feet in diameter was brought down.
12/1/2006	Thunderstorm Wind	$3,000	$0	Trees were brought down on Warwick Avenue.
7/6/2007	Hail	$0	$0	Penny size hail.

Table 3-25: Severe Thunderstorm Wind Events in Northfield and Warwick				
Year	**Event**	**Annual Property Damage**	**Annual Crop Damage**	**Event Description**
7/20/2008	Lightning	$10,000	$0	A house on Hidden Pond Lane was struck by lightning and caught fire.
8/18/2008	Hail	$0	$0	Penny to nickel size hail.
5/26/2010	Thunderstorm Wind	$20,000	$0	Multiple trees and wires were downed by thunderstorm winds.
8/1/2011	Thunderstorm Wind, Hail	$10,000	$0	Trees and power lines along Route 142 were downed by thunderstorm winds.
8/5/2012	Thunderstorm Wind	$10,000	$0	A large tree and wires were downed on Route 142 at Wozniak Road.
7/1/2015	Thunderstorm Wind	$10,000	$0	Trees were downed onto a house and onto wires on Pierson Road. Heavy rain and some minor street flooding.
6/7/2016	Thunderstorm Wind	$5,000	$0	A tree was downed onto wires on Old Wendell Road.
2/25/2017	Thunderstorm Wind	$4,000	$0	Multiple trees and wires down.
5/15/2018	Lightning	$10,000	$0	Lightning struck a tree on Birnam Road and set the tree on fire.
6/2/2019	Thunderstorm Wind	$1,000	$0	Two large trees were down on wires on West Northfield Road.
NORTHFIELD TOTAL		**$121,000**	**$0**	
WARWICK				
8/18/1991	Thunderstorm Wind	$0	$0	Wind damage followed a path about 100 yards wide in the southern part of Northfield and then on into Warwick.
5/31/1998	Thunderstorm Wind	$0	$0	A severe thunderstorm moved through Franklin County bringing damaging winds to many communities during the late afternoon. In addition, law enforcement officials reported that trees were blown down between 5:30 PM and 6:10 PM in Shelburne Falls, Shelburne, Conway, Gill, Bernardston, Leyden, Northfield, and Warwick.
12/1/2006	Thunderstorm Wind	$3,000	$0	Thunderstorm winds downed trees and wires in Franklin and Hampden Counties, from Northfield, Gill and Greenfield to Granville and Southwick. Trees were brought down on Warwick Avenue in East Northfield.
7/6/2007	Thunderstorm Wind	$0	$0	Trees down. Cool temperatures aloft spread over Southern New England during

Table 3-25: Severe Thunderstorm Wind Events in Northfield and Warwick				
Year	Event	Annual Property Damage	Annual Crop Damage	Event Description
				the afternoon hours of the 6th. Thunderstorms developed in this airmass ahead of a weak cold front and some became severe.
5/29/2012	Microburst	ND	ND	A microburst or "straight-line wind" event came through the center of Warwick by the Fire Station and took down several trees.
9/18/2012	Strong Wind	$30,000	$0	A tree and wires were downed on Wendell Road in Warwick. A tree and wires were downed on Warwick Road in Northfield.
7/3/2014	Thunderstorm Wind	$0	$0	A tree and wires were downed on Athol Road in Warwick.
7/7/2014	Thunderstorm Wind	$0	$0	A large tree on Wendell Road was downed by thunderstorm winds.
7/7/2014	Thunderstorm Wind	$0	$0	Trees and wires along Route 28 were downed by thunderstorm winds.
9/6/2014	Thunderstorm Wind	$0	$0	A tree on Wendell Road was downed by thunderstorm winds.
6/7/2016	Thunderstorm Wind	$5,000	$0	A tree was downed onto wires on Orange Road in Warwick.
7/18/2016	Thunderstorm Wind	$25,000	$0	A tree and wires on North Holden and Orange Roads and multiple trees on Flower Hill Road were downed by thunderstorm winds.
WARWICK TOTAL		**$63,000**	**$0**	

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

Secondary hazards of thunderstorms and severe weather include lightning and hail. In Franklin County, 23 lightning events since 1997 caused a total of $835,500 in property damages (Table 3-26).

Table 3-26: Lightning Events in Franklin County			
Year	# of Lightning Events	Annual Property Damage	Annual Crop Damage
1997	1	$3,000	$0
2001	1	$20,000	$0
2002	1	$15,000	$0
2004	1	$35,000	$0
2005	1	$50,000	$0

Table 3-26: Lightning Events in Franklin County			
2008	1	$10,000	$0
2010	2	$25,000	$0
2012	1	$500,000	$0
2013	4	$49,000	$0
2014	3	$93,000	$0
2018	6	$35,500	$0
2019	1	$0	$0
Total	**23**	**$835,500**	**$0**

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

A total of 42 hail events have been reported in Franklin County since 1998 (Table 3-27). Property damage was only recorded for one event, in the amount of $5,000. One hail event in 2008 resulted in $50,000 in crop damages. Pea to marble size hail fell in a swath from Colrain to Shelburne damaging apple and peach orchards. An estimated 45 acres of apples and two to three acres of peaches were damaged by the hail.

Table 3-27: Hail Events in Franklin County			
Year	**# of Hail Events**	**Annual Property Damage**	**Annual Crop Damage**
1998	4	$0	$0
2000	1	$0	$0
2001	1	$0	$0
2003	1	$0	$0
2004	2	$0	$0
2005	3	$5,000	$0
2007	5	$0	$0
2008	7	$0	$50,000
2009	2	$0	$0
2010	4	$0	$0
2011	4	$0	$0
2012	1	$0	$0
2013	3	$0	$0
2017	3	$0	$0
2018	1	$0	$0
Total	**42**	**$5,000**	**$50,000**

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

Probability of Future Events

According to the National Weather Service, Massachusetts experiences between 20 to 30 thunderstorm days each year. Based on past occurrences, there is a “Very High” probability (50% - 100% chance) of a severe thunderstorm or winds affecting the town in a given year. Climate change is expected to increase the frequency and intensity of thunderstorms and other severe weather.

Impact

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

Vulnerability

Society

The entire population of Northfield and Warwick is considered exposed to high-wind and thunderstorm events. Downed trees, damaged buildings, and debris carried by high winds can lead to injury or loss of life. Populations located outdoors are considered at risk and more vulnerable to many storm impacts, particularly lightning strikes, compared to those who are located inside. Moving to a lower risk location will decrease a person’s vulnerability.

<u>Vulnerable Populations</u>

Socially vulnerable populations are most susceptible to severe weather based on a number of factors, including their physical and financial ability to react or respond during a hazard, and the location and construction quality of their housing. In general, vulnerable populations include people over the age of 65, the elderly living alone, people with low socioeconomic status, people with low English language fluency, people with limited mobility or a life-threatening illness, and people who lack transportation or are living in areas that are isolated from major roads. The isolation of these populations is a significant concern.

Table 3-28 estimates the number of vulnerable populations and households in Northfield. Table 3-29 estimates the number of vulnerable populations and households in Warwick. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of residents during a severe weather event.

Table 3-28: Estimated Vulnerable Populations in Northfield		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	837	28%
Population with a Disability	627	11%
Population who Speak English Less than "Very Well"	49	2%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	227	18%
Householder Age 65 Years and Over Living Alone	141	11%
Households Without Access to a Vehicle	61	5%

*Total population = 2,997; Total households = 1,234

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

Source: U.S. Census American Community Survey 2014-2018 Five-Year Estimates.

Table 3-29: Estimated Vulnerable Populations in Warwick		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	173	22%
Population with a Disability	101	11%
Population who Speak English Less than "Very Well"	18	2%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	110	32%
Householder Age 65 Years and Over Living Alone	42	12%
Households Without Access to a Vehicle	6	2%

*Total population = 781; Total households = 345

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

Source: U.S. Census American Community Survey 2014-2018 Five-Year Estimates.

Power outages can be life-threatening to those dependent on electricity for life support. Power outages may also result in inappropriate use of combustion heaters, cooking appliances and generators in indoor or poorly ventilated areas, leading to increased risks of carbon monoxide poisoning. People who work or engage in recreation outdoors are also vulnerable to severe weather.

Health Impacts

Both high winds and thunderstorms present potential safety impacts for individuals without access to shelter during these events. Extreme rainfall events can also affect raw water quality by increasing turbidity and bacteriological contaminants leading to gastrointestinal illness. Additionally, research has found that thunderstorms may cause the rate of emergency room visits for asthma to increase to 5 to 10 times the normal rate.[32] Much of this phenomenon is attributed to the stress and anxiety that many individuals, particularly children, experience during severe thunderstorms. The combination of wind, rain, and lightning from thunderstorms with pollen and mold spores can exacerbate asthma. The rapidly falling air temperatures characteristic of a thunderstorm as well as the production of nitrogen oxide gas during lightning strikes have also both been correlated with asthma.

Economic Impacts

Wind storms and severe thunderstorms events may impact the economy, including direct building losses and the cost of repairing or replacing the damage caused to the building. Additional economic impacts may include loss of business functions, water supply system damage, inventory damage, relocation costs, wage losses, and rental losses due to the repair/replacement of buildings. Agricultural losses due to lightning and the resulting fires can be extensive. Lightning can be responsible for damage to buildings; can cause electrical, forest and/or wildfires; and can damage infrastructure, such as power transmission lines and communication towers.

Recovery and clean-up costs can also be costly, resulting in further economic impacts. Prolonged obstruction of major routes due to secondary hazards such as landslides, debris, or floodwaters can disrupt the shipment of goods and other commerce. Large, prolonged storms can have negative economic impacts on an entire region.

Because of differences in building construction, residential structures are generally more susceptible to wind damage than commercial and industrial structures. Wood and masonry

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

buildings in general, regardless of their occupancy class, tend to experience more damage than concrete or steel buildings. Mobile homes are the most vulnerable to damage, even if tied down, and offer little protection to people inside.

Infrastructure

Damage to buildings is dependent upon several factors, including wind speed, storm duration, path of the storm track, and building construction. According to the Hazus wind model,[33] direct wind-induced damage (wind pressures and windborne debris) to buildings is dependent upon the performance of components and cladding, including the roof covering (shingles, tiles, membrane), roof sheathing (typically wood-frame construction only), windows, and doors, and is modeled as such. Structural wall failures can occur for masonry and wood-frame walls, and uplift of whole roof systems can occur due to failures at the roof/wall connections. Foundation failures (i.e., sliding, overturning, and uplift) can potentially take place in manufactured homes.

Massachusetts is divided into three design wind speeds for four risk categories, the limits of which are defined by the Massachusetts State Building Code (9th Edition). National wind data prepared by the American Society of Civil Engineers serve as the basis of these wind design requirements ("Minimum Design Loads for Buildings and Other Structures," American Society of Civil Engineers ASCE-7). Generally speaking, structures should be designed to withstand the total wind load of their location. Conway falls within the 90 mph wind load zone. Refer to the State Building Code (9th Edition [780 CMR] Chapter 16 Structural Design, as amended by Massachusetts) for appropriate reference wind pressures, wind forces on roofs, and similar data.

All elements of the built environment are exposed to severe weather events such as high winds and thunderstorms. Table 3-30 identifies the assessed value of all residential, open space, commercial, and industrial land uses in each town, and the losses that would result from 1%, 5%, and 10% damage to this inventory as a result of high winds or a severe thunderstorm.

Table 3-30: Estimated Potential Loss by Tax Classification in Northfield and Warwick					
	Tax Classification	**Total Assessed Value FY2019**	**1% Damage Loss Estimate**	**5% Damage Loss Estimate**	**10% Damage Loss Estimate**
Northfield	Residential	$289,072,924	$2,890,729	$14,453,646	$28,907,292
	Open Space	$0	$0	$0	$0
	Commercial	$18,116,201	$181,162	$905,810	$1,811,620

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

Table 3-30: Estimated Potential Loss by Tax Classification in Northfield and Warwick					
	Tax Classification	**Total Assessed Value FY2019**	**1% Damage Loss Estimate**	**5% Damage Loss Estimate**	**10% Damage Loss Estimate**
	Industrial	$92,552,450	$925,525	$4,627,623	$9,255,245
	Total	**$399,741,575**	**$3,997,416**	**$19,987,079**	**$39,974,158**
Warwick	Residential	$73,910,249	$739,102	$3,695,512	$7,391,025
	Open Space	$0	$0	$0	$0
	Commercial	$1,502,073	$15,021	$75,104	$150,207
	Industrial	$0	$0	$0	$0
	Total	**$75,412,322**	**$754,123**	**$3,770,616**	**$7,541,232**

Source: Massachusetts Department of Revenue - Division of Local Services, Data Analytics and Resources Bureau, FY 2020

Agriculture

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

Energy

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

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

Public Safety

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

Transportation

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

Water & Wastewater Infrastructure

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

Environment

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

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

Vulnerability Summary

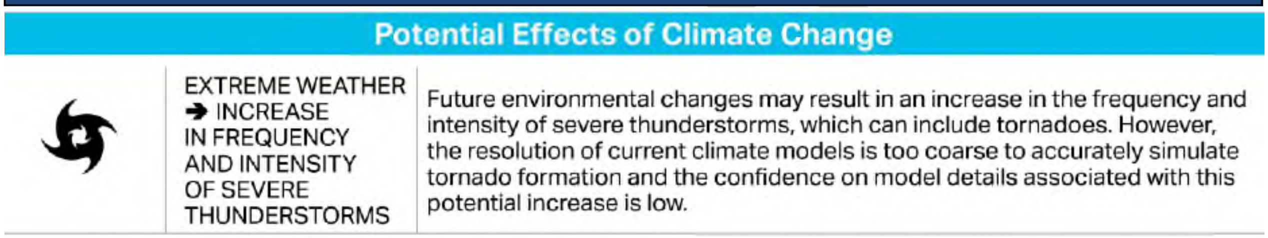
Based on the above assessment, Northfield and Warwick have a “High” vulnerability to severe thunderstorms and wind events. Thunderstorms are common in New England, and can impact property, crops, utilities and the population of Northfield and Warwick. Microbursts are less common, but can cause significant damage when they do occur. The cascade effects of severe storms include utility losses and transportation accidents and flooding. Particular areas of vulnerability include low-income and elderly populations, trailer homes, and infrastructure such as roadways and utilities that can be damaged by such storms and the low-lying areas that can be impacted by flooding. The problem statements in Section 2.4 summarize the areas of greatest concern regarding severe thunderstorms and wind events in Northfield and Warwick.

3.7 TORNADOES

Potential Impacts of Climate Change

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

Figure 3-9: Impacts of Climate Change on Tornadoes



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

Hazard Description

A tornado is a narrow, violently rotating column of air that extends from the base of a cumulonimbus cloud to the ground. The observable aspect of a tornado is the rotating column of water droplets, with dust and debris caught in the column. Tornadoes are the most violent of all atmospheric storms.

The following are common factors in tornado formation:

- Very strong winds in the middle and upper levels of the atmosphere
- Clockwise turning of the wind with height (i.e., from southeast at the surface to west aloft)
- Increasing wind speed in the lowest 10,000 feet of the atmosphere (i.e., 20 mph at the surface and 50 mph at 7,000 feet)
- Very warm, moist air near the ground, with unusually cooler air aloft
- A forcing mechanism such as a cold front or leftover weather boundary from previous shower or thunderstorm activity

Tornadoes can form from individual cells within severe thunderstorm squall lines. They can also form from an isolated supercell thunderstorm. They can be spawned by tropical cyclones or the remnants thereof, and weak tornadoes can even occur from little more than a rain shower if air is converging and spinning upward. Most tornadoes occur in the late afternoon and evening hours, when the heating is the greatest. The most common months for tornadoes to occur are June, July, and August, although the Conway, Massachusetts, tornado (2017) occurred in February.

A tornadic waterspout is a rapidly rotating column of air extending from the cloud base (typically a cumulonimbus thunderstorm) to a water surface, such as a bay or the ocean. They can be formed in the same way as regular tornadoes, or can form on a clear day with the right amount of instability and wind shear. Tornadic waterspouts can have wind speeds of 60 to 100 mph, but since they do not move very far, they can often be navigated around. They can become a threat to land if they drift onshore.

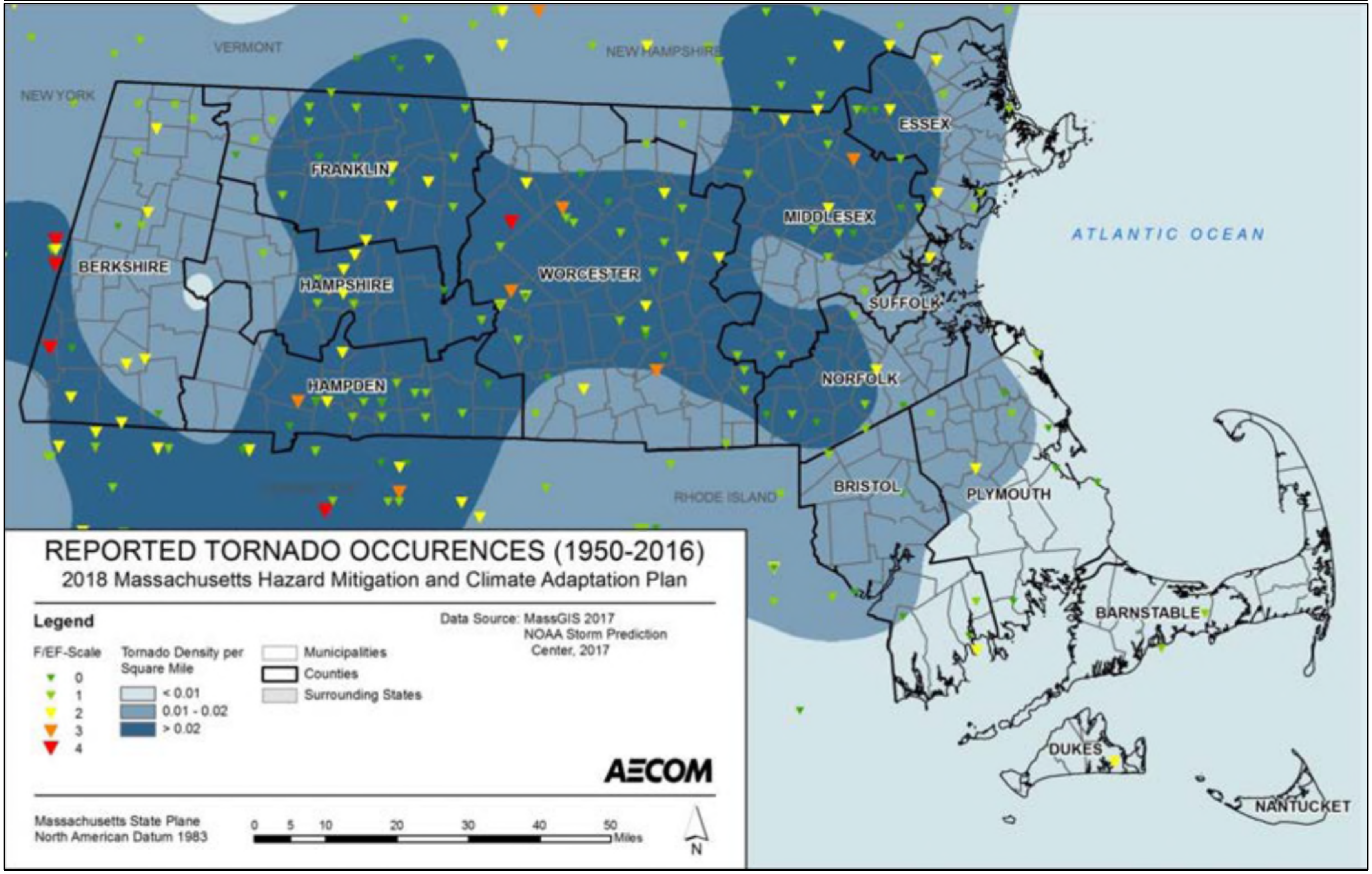
Location

Figure 3-10 illustrates the reported tornado occurrences, based on all-time initial touchdown locations across the Commonwealth as documented in the NOAA NCDC Storm Events Database. ArcGIS was used to calculate an average score per square mile. The analysis indicated that the area at greatest risk for a tornado touchdown runs from central to northeastern Massachusetts, and includes Northfield and Warwick and much of Franklin County. Tornadoes are rated as having an Area of Occurrence of "Isolated." If a tornado were to occur in Northfield and Warwick, it would likely impact less than 10% of the town.

Extent

The NWS rates tornadoes using the Enhanced Fujita scale (EF scale), which does not directly measure wind speed but rather the amount of damage created. This scale derives 3-second gusts estimated at the point of damage based on the assignment of 1 out of 8 degrees of damage to a range of different structure types. These estimates vary with height and exposure. This method is considerably more sophisticated than the original Fujita scale, and it allows surveyors to create more precise assessments of tornado severity. Figure 3-11 provides guidance from NOAA about the impacts of a storm with each rating.

Figure 3-10: Density of Reported Tornadoes per Square Mile



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

Figure 3-11: Enhanced Fujita Scale & Guide to Tornado Severity

Scale	Wind Speed Estimate		Potential damage	Example of Damage
	mph	km/h		
EF0	65–85	105–137	Minor damage. Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over. Confirmed tornadoes with no reported damage (i.e., those that remain in open fields) are always rated EF0.	
EF1	86–110	138–177	Moderate damage. Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.	
EF2	111–135	178–217	Considerable damage. Roofs torn off from well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.	
EF3	136–165	218–266	Severe damage. Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations are badly damaged.	
EF4	166–200	267–322	Devastating damage. Well-constructed and whole frame houses completely leveled; some frame homes may be swept away; cars and other large objects thrown and small missiles generated.	
EF5	>200	>322	Incredible damage. Strong-framed, well-built houses leveled off foundations and swept away; steel-reinforced concrete structures are critically damaged; tall buildings collapse or have severe structural deformations; cars, trucks, and trains can be thrown approximately 1 mile (1.6 km).	

Source: Wikipedia: https://en.wikipedia.org/wiki/Enhanced_Fujita_scale

Previous Occurrences

The most recent tornado reported in Northfield was on July 3, 1972, and was ranked F1 (Moderate Tornado) on the Fujita Scale of Tornado Intensity. The tornado was approximately three miles long and touched down on the Connecticut River to the southeast of Caldwell Road in Northfield. The extent of damage it caused is unknown. Since 1996, five tornadoes have been reported in Franklin County, in the towns of Heath (1997), Charlemont (1997), Wendell / Montague (2006), New Salem (2013) and Conway (2017). The February 2017 tornado in the center of Conway was the most destructive, impacting forests and causing major property damage to several homes, barns, and a church that subsequently had to be torn down. Miraculously, no deaths or serious injuries were reported. There have been no occurrences of a tornado in Northfield or Warwick in recent years.

Table 3-31: Tornado Events in Franklin County

Date	Severity	Property Damage	Crop Damage	Event Narrative
7/3/1997	F1	$50,000	$0	A tornado touched down just west of Number Nine Road in Heath and then skipped along a path which ended about a mile into northwest Colrain. Many large trees were uprooted or snapped at their mid levels. A silo was destroyed and part of the roof of an attached barn was peeled back. A hay tractor was flipped over with its wheels in the air. Doors to a garage were blown in and the roof was partially ripped off. The tornado affected mostly wooded terrain and did extensive tree damage when it passed through a state forest. The path width was up to 100 yards. There were no injuries.
7/3/1997	F1	$50,000	$0	A tornado touched down in the eastern part of Charlemont and travelled east causing damage to a campground. Fifteen trailers were damaged from falling trees and flying debris. Two of the trailers were severely damaged and one was destroyed with seven trees falling on top of it. Eyewitnesses reported rotation in the clouds and debris. The tornado then moved through the higher terrain of the Catamount State Forest. The path was discontinuous and ranged in width from 50 to 100 yards. The tornado path ended in the Copeland Hills section of Colrain. There were no direct injuries reported.
7/11/2006	F2	$200,000	$0	Brief F2 touchdown in Wendell and Montague
9/1/2013	EF0	$0	$0	A Massachusetts Department of Conservation and Recreation employee observed a waterspout on Quabbin Reservoir in New Salem, MA. He was able to snap two pictures of the storm, one showing a funnel and another showing the funnel extended down to the water. The waterspout was very short lived, never hit land, and did no damage and injured no

Table 3-31: Tornado Events in Franklin County				
Date	**Severity**	**Property Damage**	**Crop Damage**	**Event Narrative**
				people. Winds aloft were not conducive for tornadic development, but the environment was unstable and a surface front was moving through the region.
2/25/2017	EF1	$400,000	$0	This tornado touched down at 7:23 pm on Main Poland Road in western Conway, Massachusetts. The path width started at 50 yards, with a sharp gradient evident of damage versus no damage. Large sections of forest had thick pine trees snapped at mid-tree. Numerous power lines were downed along the path into downtown Conway. The path width grew, reaching a maximum width of 200 yards near the town hall. Several houses were severely damaged on Whately Road, southeast of the town hall. Roofs were blown off, and in one case the side walls of a house were missing with the interior of the house exposed. On Hill View Road a large barn collapsed. One injury occurred when a tree landed on a house on South Deerfield Road east of town. That was where the visible damage path ended.

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

Probability of Future Events

As highlighted in the National Climate Assessment, tornado activity in the U.S. has become more variable, and increasingly so in the last 2 decades. While the number of days per year that tornadoes occur has decreased, the number of tornadoes on these days has increased. Climate models show projections that the frequency and intensity of severe thunderstorms (which include tornadoes, hail, and winds) will increase. Based on past occurrences, there is a "Low" probability (1% - 2% chance) of a tornado affecting the town in a given year.

Impact

Tornadoes are potentially the most dangerous of local storms. If a major tornado were to strike in the populated areas of Northfield and Warwick, damage could be widespread. Fatalities could be high; many people could be displaced for an extended period of time; buildings could be damaged or destroyed; businesses could be forced to close for an extended period of time or even permanently; and routine services, such as telephone or power, could be disrupted. In Warwick, the severity of impact of a tornado event is likely "Critical," with more than 25% of property in the affected area damaged or destroyed. If a tornado were to hit the village area of Northfield, where a concentration of homes, businesses, and the Thomas Aquinas College are located, the impact could be "Catastrophic," with more than 50% of property damaged or destroyed, multiple deaths and injuries possible, and a complete shutdown of facilities for 30 days or more.

Vulnerability

Society

The entirety of Northfield and Warwick has the potential for tornado formation, and is located in the area within Massachusetts described above as having higher-than-average tornado frequency. Residents of impacted areas may be displaced or require temporary to long-term shelter due to severe weather events. In addition, downed trees, damaged buildings, and debris carried by high winds can lead to injury or loss of life.

Vulnerable Populations

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

An estimated 843 housing units in Northfield, or 60% of all housing units in town, were built prior to the 1970s when the first building code went into effect in Massachusetts. An estimated 262 housing units in Warwick, or 57% of all housing units in town, were built prior to the 1970s. There are no mobile homes located in Northfield and Warwick.[34]

Table 3-32 estimates the number of vulnerable populations and households in Northfield. Table 3-33 estimates the number of vulnerable populations and households in Warwick. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of residents during a tornado event.

Table 3-32: Estimated Vulnerable Populations in Northfield		
Vulnerable Population Category	**Number**	**Percent of Total Population***

[34] U.S. Census Bureau 2014-2018 American Community Survey five-year estimates.

Table 3-32: Estimated Vulnerable Populations in Northfield		
Population Age 65 Years and Over	837	28%
Population with a Disability	627	11%
Population who Speak English Less than "Very Well"	49	2%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	227	18%
Householder Age 65 Years and Over Living Alone	141	11%
Households Without Access to a Vehicle	61	5%

*Total population = 2,997; Total households = 1,234
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2014-2018 Five-Year Estimates.

Table 3-33: Estimated Vulnerable Populations in Warwick		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	173	22%
Population with a Disability	101	11%
Population who Speak English Less than "Very Well"	18	2%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	110	32%
Householder Age 65 Years and Over Living Alone	42	12%
Households Without Access to a Vehicle	6	2%

*Total population = 781; Total households = 345
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2014-2018 Five-Year Estimates.

Health Impacts

The primary health hazard associated with tornadoes is the threat of direct injury from flying debris or structural collapse as well as the potential for an individual to be lifted and dropped by the tornado’s winds. After the storm has subsided, tornadoes can present unique challenges to search and rescue efforts because of the extensive and widespread distribution of debris.

The distribution of hazardous materials, including asbestos-containing building materials, can present an acute health risk for personnel cleaning up after a tornado disaster and for residents in the area. The duration of exposure to contaminated material may be far longer if drinking water reservoir or groundwater aquifers are contaminated. According to the EPA, properly designed storage facilities for hazardous materials can reduce the risk of those materials being spread during a tornado. Many of the health impacts described for other types of storms, including lack of access to a hospital, carbon monoxide poisoning from generators, and mental health impacts from storm-related trauma, could occur because of tornado activity.

Economic Impacts

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

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

Infrastructure

All critical facilities and infrastructure in Northfield and Warwick are exposed to tornado events. Table 3-34 identifies the assessed value of all residential, open space, commercial, and industrial land uses in town, and the losses that would result from 1%, 5%, and 10% damage to this inventory as a result of a tornado.

Table 3-34: Estimated Potential Loss by Tax Classification in Northfield and Warwick

	Tax Classification	Total Assessed Value FY2019	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Northfield	Residential	$289,072,924	$2,890,729	$14,453,646	$28,907,292
	Open Space	$0	$0	$0	$0
	Commercial	$18,116,201	$181,162	$905,810	$1,811,620
	Industrial	$92,552,450	$925,525	$4,627,623	$9,255,245

Table 3-34: Estimated Potential Loss by Tax Classification in Northfield and Warwick					
	Tax Classification	**Total Assessed Value FY2019**	**1% Damage Loss Estimate**	**5% Damage Loss Estimate**	**10% Damage Loss Estimate**
	Total	**$399,741,575**	**$3,997,416**	**$19,987,079**	**$39,974,158**
Warwick	Residential	$73,910,249	$739,102	$3,695,512	$7,391,025
	Open Space	$0	$0	$0	$0
	Commercial	$1,502,073	$15,021	$75,104	$150,207
	Industrial	$0	$0	$0	$0
	Total	**$75,412,322**	**$754,123**	**$3,770,616**	**$7,541,232**

Source: Massachusetts Department of Revenue - Division of Local Services, Data Analytics and Resources Bureau, FY 2020

<u>Agriculture</u>

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

<u>Energy</u>

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

<u>Public Safety</u>

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

<u>Transportation</u>

Incapacity and loss of roads and bridges are the primary transportation failures resulting from tornadoes, and these failures are primarily associated with secondary hazards, such as landslide events. Tornadoes can cause significant damage to trees and power lines, blocking roads with debris, incapacitating transportation, isolating populations, and disrupting ingress and egress. Of particular concern are bridges and roads providing access to isolated areas and to the elderly. Prolonged obstruction of major routes due to secondary hazards, such as landslides, debris, or floodwaters, can disrupt the shipment of goods and other commerce. If the tornado is strong enough to transport large debris or knock out infrastructure, it can create serious impacts on power and aboveground communication lines.

Water & Wastewater Infrastructure

The hail, wind, debris, and flash flooding associated with tornadoes can cause damage to infrastructure, such as storage tanks, hydrants, residential pumping fixtures, and distribution systems. Water and wastewater utilities are also vulnerable to potential contamination due to chemical leaks from ruptured containers. Ruptured service lines in damaged buildings and broken hydrants can lead to loss of water and pressure.

Environment

Direct impacts may occur to flora and fauna small enough to be uprooted and transported by the tornado. Even if the winds are not sufficient to transport trees and other large plants, they may still uproot them, causing significant damage to the surrounding habitat. As felled trees decompose, the increased dry matter may increase the threat of wildfire in vegetated areas. Additionally, the loss of root systems increases the potential for soil erosion.

Disturbances created by blowdown events may also impact the biodiversity and composition of the forest ecosystem. Invasive plant species are often able to quickly capitalize on the resources (such as sunlight) available in disturbed and damaged ecosystems. This enables them to gain a foothold and establish quickly with less competition from native species. In addition to damaging existing ecosystems, material transported by tornadoes can also cause environmental havoc in surrounding areas. Particular challenges are presented by the possibility of asbestos-contaminated building materials or other hazardous waste being transported to natural areas or bodies of water, which could then become contaminated. Public drinking water reservoirs may also be damaged by widespread winds uprooting watershed forests and creating serious water quality disturbances.

Vulnerability Summary

Overall, Northfield has a “medium” vulnerability to tornadoes, while the less sparsely populated Warwick has a “low” vulnerability to tornadoes. Tornadoes are not common occurrences in Northfield and Warwick, but can cause significant damage when they do occur. The cascade effects of tornadoes include utility losses and transportation accidents and flooding. Losses associated with the flood hazard are discussed earlier in this section. Particular areas of vulnerability include low-income and elderly populations, mobile homes, and infrastructure such as roadways and utilities that can be damaged by such storms and the low-lying areas that can be impacted by flooding. The problem statements in Section 2.4 summarize the areas of greatest concern regarding tornadoes in Northfield and Warwick.

3.8 WILDFIRE

Potential Impacts of Climate Change

Climate change has the potential to affect multiple elements of the wildfire system: fire behavior, ignitions, fire management, and vegetation fuels. Periods of hot, dry weather create the highest fire risk. Therefore, the predicted increase in average and extreme temperatures in the Commonwealth may intensify wildfire danger by warming and drying out vegetation. A recent study published in *the Proceedings of the National Academy of Sciences* found that climate change has likely been a significant contributor to the expansion of wildfires in the western U.S., which have nearly doubled in extent in the past three decades.[35] Another study found that the frequency of lightning strikes—an occasional cause of wildfires—could increase by approximately 12 percent for every degree Celsius of warming.[36] Finally, the year-round increase in temperatures is likely to expand the duration of the fire season.

Climate change is also interacting with existing stressors to forests, making them more vulnerable to wildfire. Drought, invasive species, and extreme weather events, all can lead to more dead, downed, or dying trees, increasing the fire load in a forest.

Figure 3-12: Impacts of Climate Change on Wildfires

Potential Effects of Climate Change	
RISING TEMPERATURES AND CHANGES IN PRECIPITATION ➔ PROLONGED DROUGHT	Seasonal drought risk is projected to increase during summer and fall in the Northeast as higher temperatures lead to greater evaporation and earlier winter and spring snowmelt, coupled with more variable precipitation patterns. Drought and warmer temperatures may also heighten the risk of wildfire, by causing forested areas to dry out and become more flammable.
RISING TEMPERATURES ➔ MORE FREQUENT LIGHTNING	Research has found that the frequency of lightning strikes – an occasional cause of wildfires – could increase by approximately 12 percent for every degree Celsius of warming.

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

Hazard Description

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

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

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

quickly, igniting brush, trees, and potentially homes. The wildfire season in Massachusetts usually begins in late March and typically culminates in early June, corresponding with the driest live fuel moisture periods of the year. April is historically the month in which wildfire danger is the highest. Drought, snowpack level, and local weather conditions can impact the length of the fire season.

Fire Ecology and Wildfire Behavior

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

How a fire behaves primarily depends on the characteristics of available fuel, weather conditions, and terrain, as described below.

- Fuel:
  - Lighter fuels such as grasses, leaves, and needles quickly expel moisture and burn rapidly, while heavier fuels such as tree branches, logs, and trunks take longer to warm and ignite.
  - Snags and hazard trees, especially those that are diseased or dying, become receptive to ignition when influenced by environmental factors such as drought, low humidity, and warm temperatures.
- Weather:
  - Strong winds, especially wind events that persist for long periods or ones with significant sustained wind speeds, can exacerbate extreme fire conditions or accelerate the spread of wildfire.
  - Dry spring and summer conditions, or drought at any point of the year, increases fire risk. Similarly, the passage of a dry, cold front through the region can result in sudden wind speed increases and changes in wind direction.
  - Thunderstorms in Massachusetts are usually accompanied by rainfall; however, during periods of drought, lightning from thunderstorm cells can result in fire ignition. Thunderstorms with little or no rainfall are rare in New England but have occurred.
- Terrain:

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

The wildland-urban interface is the line, area, or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels. There are a number of reasons that the wildland-urban interface experiences an increased risk of wildfire damage. Access and fire suppression issues on private property in the wildland-urban interface can make protecting structures from wildfires difficult. This zone also faces increased risk because structures are built in densely wooded areas, so fires started on someone's property are more easily spread to the surrounding forest.

Fire is also used extensively as a land management tool to replicate natural fire cycles, and it has been used to accomplish both fire-dependent ecosystem restoration and hazard fuel mitigation objectives on federal, state, municipal, and private lands in Massachusetts since the 1980s. For example, over the past 16 years, the Massachusetts Division of Fisheries and Wildlife (MassWildlife) has used a combination of tree harvesting, shrub mowing, and prescribed burning to benefit rare species and to reduce the risk of a catastrophic wildfire in the Montague Plains Wildlife Management Area, a rare pitch pine-scrub oak forest in Montague. Approximately 880 acres have been treated since 2004 to restore woodland and shrubland habitats. MassWildlife has cooperative agreements with the Department of Conservation and Recreation and the Town of Montague Conservation Commission to restore sandplain habitats on their inholdings within the plains, and works closely with local fire departments and the DCR Bureau of Fire Control to ensure that firefighters have adequate access in the event of a wildfire and are familiar with the changes in vegetation and fuels resulting from habitat management activities.[37]

In Massachusetts, the DCR Bureau of Forest Fire Control is the state agency responsible for protecting 3.5 million acres of state, public, and private wooded land and for providing aid, assistance, and advice to the Commonwealth's cities and towns. The Bureau coordinates efforts with a number of entities, including fire departments, local law enforcement agencies, the Commonwealth's county and statewide civil defense agencies and mutual aid assistance organizations.

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[37] "Background information on Montague Plains Wildlife Management Area," MA Division of Fisheries and Wildlife, as published in the *2018 Montague Open Space and Recreation Plan*.

Bureau units respond to all fires that occur on state-owned forestland and are available to municipal fire departments for mutual assistance. Bureau firefighters are trained in the use of forestry tools, water pumps, brush breakers, and other motorized equipment, as well as in fire behavior and fire safety. Massachusetts also benefits from mutual aid agreements with other state and federal agencies. The Bureau is a member of the Northeastern Forest Fire Protection Commission, a commission organized in 1949 by the New England states, New York, and four eastern Canadian Provinces to provide resources and assistance in the event of large wildfires. Massachusetts DCR also has a long-standing cooperative agreement with the U.S. Department of Agriculture's Forest Service both for providing qualified wildfire-fighters for assistance throughout the U.S. and for receiving federal assistance within the Commonwealth. Improved coordination and management efforts seem to be reducing the average damage from wildfire events. According to the Bureau's website, in 1911, more than 34 acres were burned on average during each wildfire. As of 2017, that figure has been reduced to 1.17 acres.

Location

The ecosystems that are most susceptible to the wildfire hazard are pitch pine, scrub oak, and oak forests, as these areas contain the most flammable vegetative fuels. Other portions of the Commonwealth are also susceptible to wildfire, particularly at the urban-wildland interface. The SILVIS Lab at the University of Wisconsin-Madison Department of Forest Ecology and Management classifies exposure to wildlife hazard as "interface" or "intermix." Intermix communities are those where housing and vegetation intermingle and where the area includes more than 50 percent vegetation and has a housing density greater than one house per 16 hectares (approximately 6.5 acres). Interface communities are defined as those in the vicinity of contiguous vegetation, with more than one house per 40 acres and less than 50 percent vegetation, and within 1.5 miles of an area of more than 500 hectares (approximately 202 acres) that is more than 75 percent vegetated. These areas are shown in Figure 3-13. Inventoried assets (population, building stock, and critical facilities) were overlaid with these data to determine potential exposure and impacts related to this hazard. Northfield has several areas of "interface" and "intermix" zones within town. Warwick has several areas of "intermix" zones within town.

The Northeast Wildfire Risk Assessment Geospatial Work Group completed a geospatial analysis of fire risk in the 20-state U.S. Forest Service Northeastern Area. The assessment is comprised of three components—fuels, wildland-urban interface, and topography (slope and aspect)—that are combined using a weighted overlay to identify wildfire-prone areas where hazard mitigation practices would be most effective. Figure 3-14 illustrates the areas identified for the Commonwealth. Northfield and Warwick mostly fall within the "High" wildfire risk area. The entire area of each town is at risk for wildfire. 74 percent of Northfield and 88 percent of

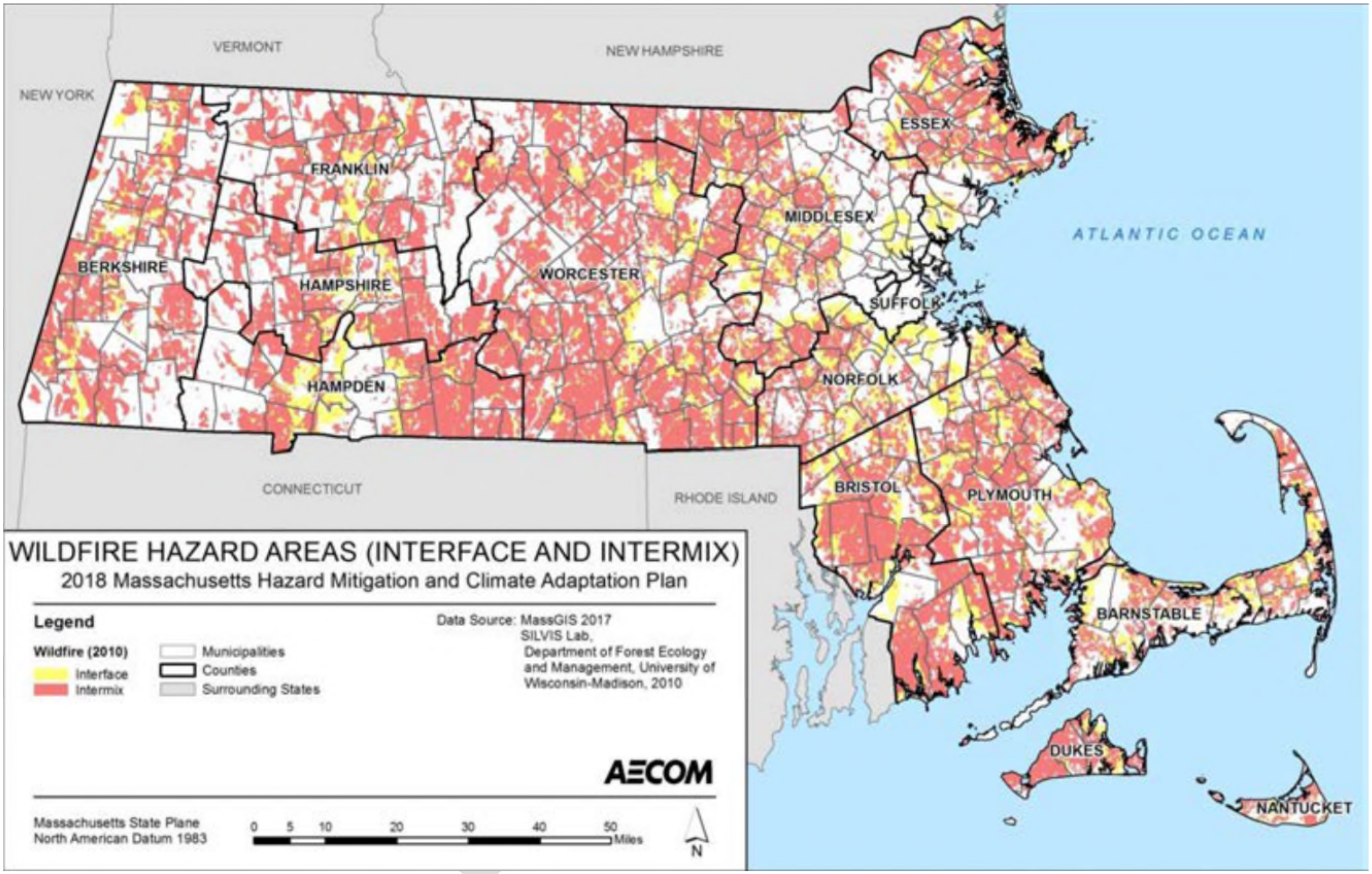
Warwick is covered by deciduous and/or evergreen forested land cover.

Early detection of wildfires is a key part of the Bureau's overall effort. Early detection is achieved by trained Bureau observers who staff the statewide network of 42 operating fire towers, including a tower in Warwick on Mount Grace. During periods of high fire danger, the Bureau conducts county-based fire patrols in forested areas. These patrols assist cities and towns in prevention efforts and allow for the quick deployment of mobile equipment for suppression of fires during their initial stage. Figure 3-15 displays the Bureau's fire control districts and fire towers in Massachusetts.

Heavily forested areas with limited access are of particular concern in Warwick and Northfield. These include areas on Mount Grace with steep slopes, and remote areas of State Forest and private forestland in both towns. In addition, both towns have access to surface water supplies to fight fires, but during times of drought, these sources may be strained or unavailable. Improvements to some water sources are also needed, such as installing dry hydrants. Mutual aid agreements are in place for surrounding towns to supply water via tanker trucks, and to assist in firefighting. DCR also provides training to local fire crews, and is currently training a county-wide wildfire response team.

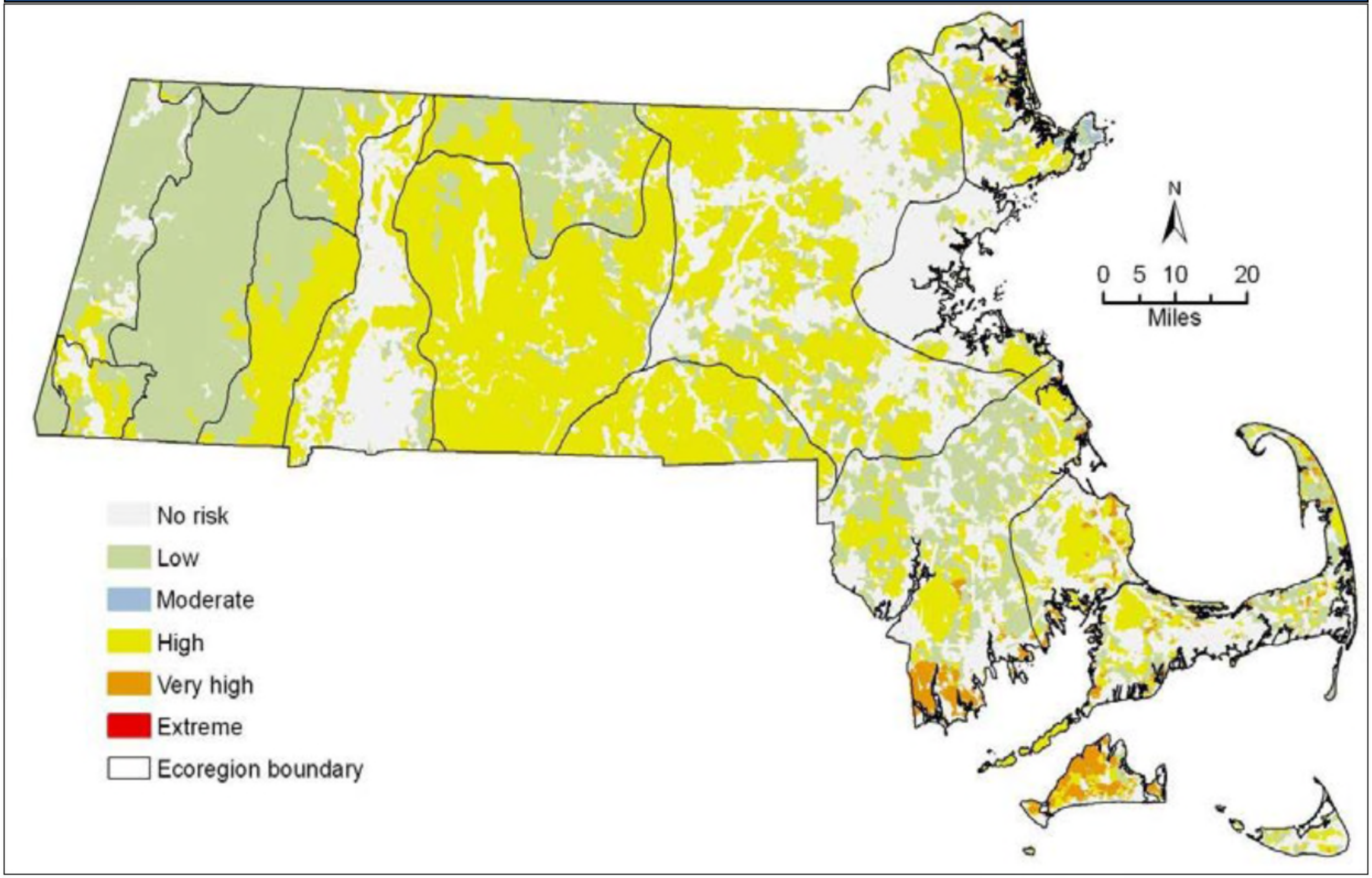
Two railroad lines pass through Northfield. These areas are prone to brush fires that are started by sparks from passing trains. Old railroad ties piled up alongside the tracks were also an issue having ignited in the past (see Previous Occurrences section). The Northfield Fire Chief reported that PAN AM was pressured to address this issue and has since picked up the unused railroad ties along the tracks in town. The Fire Chief also reported that most locomotives now have spark arrestors, and Northfield hasn't had any "track fires" in several years.

Figure 3-13: Wildland-Urban Interface and Intermix for the Commonwealth of Massachusetts



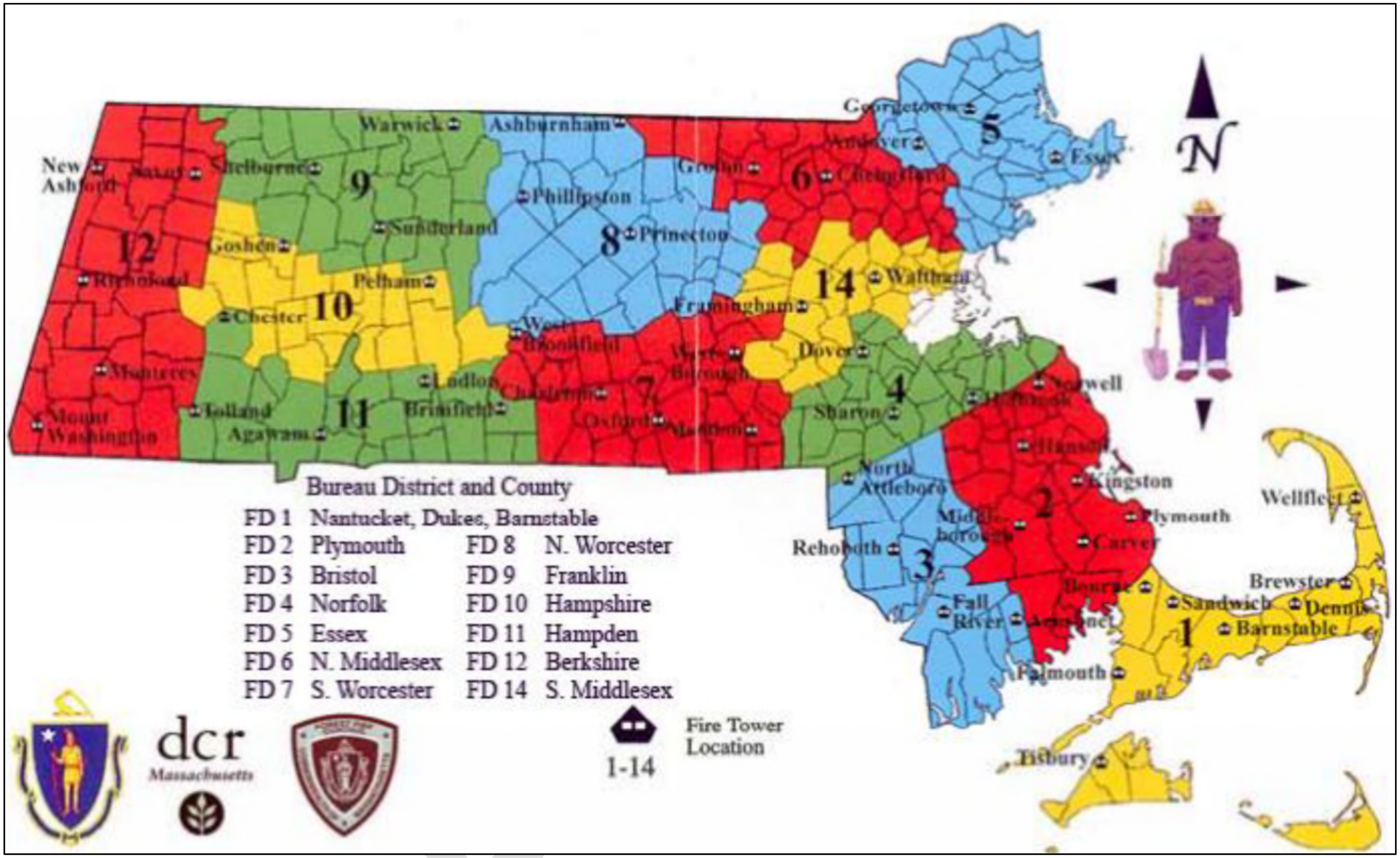
Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Figure 3-14: Wildfire Risk Areas for the Commonwealth of Massachusetts



Source: Northeast Wildfire Risk Assessment Geospatial Work Group, 2009, as presented in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, September 2018.

Figure 3-15: Massachusetts Bureau of Forest Fire Control Districts and Tower Network



Source: Massachusetts Department of Conservation and Recreation, Bureau of Forest Fire Control, 2018, as presented in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, September 2018.

Extent

The National Wildfire Coordinating Group defines seven classes of wildfires:

- Class A: 0.25 acre or less
- Class B: more than 0.25 acre, but less than 10 acres
- Class C: 10 acres or more, but less than 100 acres
- Class D: 100 acres or more, but less than 300 acres
- Class E: 300 acres or more, but less than 1,000 acres
- Class F: 1,000 acres or more, but less than 5,000 acres
- Class G: 5,000 acres or more.

Unfragmented and heavily forested areas of the state are vulnerable to wildfires, particularly during droughts. The greatest potential for significant damage to life and property from fire exists in areas designated as wildland-urban interface areas. A wildland-urban interface area defines the conditions where highly flammable vegetation is adjacent to developed areas. Fires can be classified by physical parameters such as their fireline intensity, or Byram's intensity, which is the rate of energy per unit length of the fire front (BTU [British thermal unit] per foot of fireline per second). Wildfires are also measured by their behavior, including total heat release during burnout of fuels (BTU per square foot) and whether they are crown-, ground-, or surface-burning fires. Following a fire event, the severity of the fire can be measured by the extent of mortality and survival of plant and animal life aboveground and belowground and by the loss of organic matter.[38]

If a fire breaks out and spreads rapidly, residents may need to evacuate within days or hours. A fire's peak burning period generally is between 1 p.m. and 6 p.m. Once a fire has started, fire alerting is reasonably rapid in most cases. The rapid spread of cellular and two-way radio communications in recent years has further contributed to a significant improvement in warning time.

Previous Occurrences

In the last five years (2012 – 2016) Franklin County has averaged 75 brush, tree, or lawn fires a year, with the highest reported number of fires occurring in 2016 (Figure 3-16). During 2016, Franklin County and Massachusetts experienced one of the worst droughts in the last 50 years.

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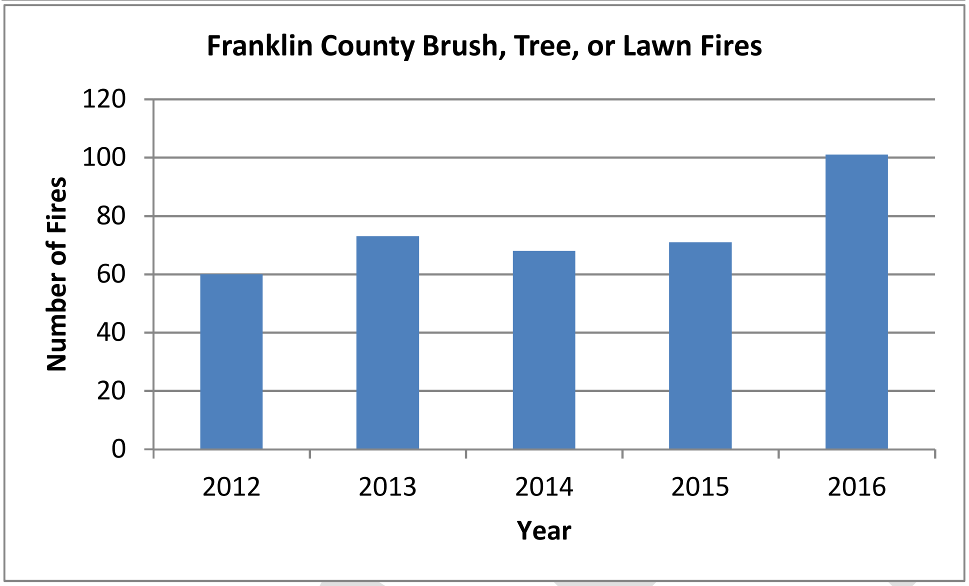
[38]National Parks Service (NPS), compiled by George Wooten. n.d. Fire and fuels management: Definitions, ambiguous terminology and references. https://www.nps.gov/olym/learn/management/upload/fire-wildfire-definitions-2.pdf

Figure 3-16: Outdoor Vegetation Fires in Franklin County 2012 - 2016



Source: Massachusetts Fire Incident Reporting System County Profiles.

Northfield and Warwick are heavily forested and therefore vulnerable to wildfires. Many brushfires are started on residential lots to clear grass, leaves, brush and other woody debris and become a problem when the homeowner can no longer control them. Lightning strikes, while relatively uncommon, are also a concern. In Northfield, a large concern is the railroad which passes through heavily forested areas. Stockpiles of old railroad ties located along the tracks in town are a major fire concern. In June 2017, assistance from numerous surrounding town fire departments was needed to fight a fire in Northfield where an estimated 1,500 railroad ties were ignited next to the railroad tracks.[39]

Probability of Future Events

It is difficult to predict the likelihood of wildfires in a probabilistic manner because a number of factors affect fire potential and because some conditions (e.g., ongoing land use development patterns, location, and fuel sources) exert changing pressure on the wildland-urban interface zone. However, based on the frequency of past occurrences, Northfield and Warwick have a "High" probability (25% - 50% chance) that it will experience a wildfire in a given year.

Impact

Unfragmented and heavily forested areas of Northfield and Warwick are vulnerable to wildfires, particularly during droughts. The greatest potential for significant damage to life and property from fire exists in areas designated as wildland-urban interface areas. A wildland-urban

[39] "Multiple towns respond to fire on railroad ties in Northfield." *The Recorder* newspaper, June 13, 2017.

interface area defines the conditions where highly flammable vegetation is adjacent to developed areas. The greatest impact in Warwick and Northfield from a wildfire is to the natural environment. Overall, the towns face a “limited” impact from wildfire, with more than 10% of the property in the affected area damaged or destroyed.

Vulnerability

Society

As demonstrated by historical wildfire events, potential losses from wildfire include human health and the lives of residents and responders. The most vulnerable populations include emergency responders and those within a short distance of the interface between the built environment and the wildland environment.

Vulnerable Populations

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

Table 3-35 estimates the number of vulnerable populations and households in Northfield. Table 3-36 estimates the number of vulnerable populations and households in Warwick. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of residents during a wildfire event.

Table 3-35: Estimated Vulnerable Populations in Northfield		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	837	28%
Population with a Disability	627	11%

Table 3-35: Estimated Vulnerable Populations in Northfield		
Population who Speak English Less than "Very Well"	49	2%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	227	18%
Householder Age 65 Years and Over Living Alone	141	11%
Households Without Access to a Vehicle	61	5%

*Total population = 2,997; Total households = 1,234

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

Source: U.S. Census American Community Survey 2014-2018 Five-Year Estimates.

Table 3-36: Estimated Vulnerable Populations in Warwick		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	173	22%
Population with a Disability	101	11%
Population who Speak English Less than "Very Well"	18	2%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	110	32%
Householder Age 65 Years and Over Living Alone	42	12%
Households Without Access to a Vehicle	6	2%

*Total population = 781; Total households = 345

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

Source: U.S. Census American Community Survey 2014-2018 Five-Year Estimates.

Health Impacts

Smoke and air pollution from wildfires can be a severe health hazard. Smoke generated by wildfire consists of visible and invisible emissions containing particulate matter (soot, tar, and minerals), gases (water vapor, carbon monoxide, carbon dioxide (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.

Economic Impacts

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

Infrastructure

For the purposes of this planning effort, all elements of the built environment located in the wildland interface and intermix areas are considered exposed to the wildfire hazard. Table 3-37 identifies the assessed value of all residential, open space, commercial, and industrial land uses in both towns, and the losses that would result from 1%, 5%, and 10% damage to this inventory as a result of a wildfire.

Table 3-37: Estimated Potential Loss by Tax Classification in Northfield and Warwick

	Tax Classification	Total Assessed Value FY2019	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Northfield	Residential	$289,072,924	$2,890,729	$14,453,646	$28,907,292
	Open Space	$0	$0	$0	$0
	Commercial	$18,116,201	$181,162	$905,810	$1,811,620
	Industrial	$92,552,450	$925,525	$4,627,623	$9,255,245
	Total	**$399,741,575**	**$3,997,416**	**$19,987,079**	**$39,974,158**
Warwick	Residential	$73,910,249	$739,102	$3,695,512	$7,391,025
	Open Space	$0	$0	$0	$0
	Commercial	$1,502,073	$15,021	$75,104	$150,207
	Industrial	$0	$0	$0	$0
	Total	**$75,412,322**	**$754,123**	**$3,770,616**	**$7,541,232**

Source: Massachusetts Department of Revenue - Division of Local Services,
Data Analytics and Resources Bureau, FY 2020

Agriculture

While Massachusetts does not experience wildfires at the same magnitude as those in western states, wildfires do occur and are a threat to the agriculture sector. The forestry industry is especially vulnerable to wildfires. Barns, other wooden structures, and animals and equipment in these facilities are also susceptible to wildfires.

Energy

Distribution lines are subject to wildfire risk because most poles are made of wood and susceptible to burning. Transmission lines are at risk to faulting during wildfires, which can result in a broad area outage. In the event of a wildfire, pipelines could provide a source of fuel and lead to a catastrophic explosion.

Public Health

As discussed in the Populations section of the wildfire hazard profile, wildfires impact air quality and public health. Widespread air quality impairment can lead to overburdened hospitals.

Public Safety

Wildfire is a threat to emergency responders and all infrastructure within the vicinity of a wildfire.

Transportation

Most road and railroads would be without damage except in the worst scenarios. However, fires can create conditions that block or prevent access, and they can isolate residents and emergency service providers. The wildfire hazard typically does not have a major direct impact on bridges, but wildfires can create conditions in which bridges are obstructed.

Water Infrastructure

In addition to potential direct losses to water infrastructure, wildfires may result in significant withdrawal of water supplies. Coupled with the increased likelihood that drought and wildfire will coincide under the future warmer temperatures associated with climate change, this withdrawal may result in regional water shortages and the need to identify new water sources.

Environment

Fire is a natural part of many ecosystems and serves important ecological purposes, including facilitating the nutrient cycling from dead and decaying matter, removing diseased plants and pests, and regenerating seeds or stimulating germination of certain plants. However, many wildfires, particularly man-made wildfires, can also have significant negative impacts on the environment. In addition to direct mortality, wildfires and the ash they generate can distort the flow of nutrients through an ecosystem, reducing the biodiversity that can be supported.

Frequent wildfires can eradicate native plant species and encourage the growth of fire-resistant invasive species. Some of these invasive species are highly flammable; therefore, their establishment in an area increases the risk of future wildfires. There are other possible feedback loops associated with this hazard. For example, every wildfire contributes to atmospheric CO_2 accumulation, thereby contributing to global warming and increasing the probability of future wildfires (as well as other hazards). There are also risks related to hazardous material releases during a wildfire. During wildfires, containers storing hazardous materials could rupture due to excessive heat and act as fuel for the fire, causing rapid spreading of the wildfire and escalating it to unmanageable levels. In addition, these materials could leak into surrounding areas, saturating soils and seeping into surface waters to cause severe and lasting environmental damage.

Vulnerability Summary

Based on the above assessment, Warwick and Northfield face a “Low” vulnerability from wildfire and brushfires. Existing and future mitigation efforts should continue to be developed and employed that will enable both towns to be prepared for these events when they occur. Wildfires can also cause utility disruption and air-quality problems. Particular areas of vulnerability include low-income and elderly populations, and residents living in the interface area adjacent to large areas of unfragmented forests. The problem statements in Section 2.4 summarize the areas of greatest concern regarding wildfires in Northfield and Warwick.

3.9 EARTHQUAKES

Potential Impacts of Climate Change

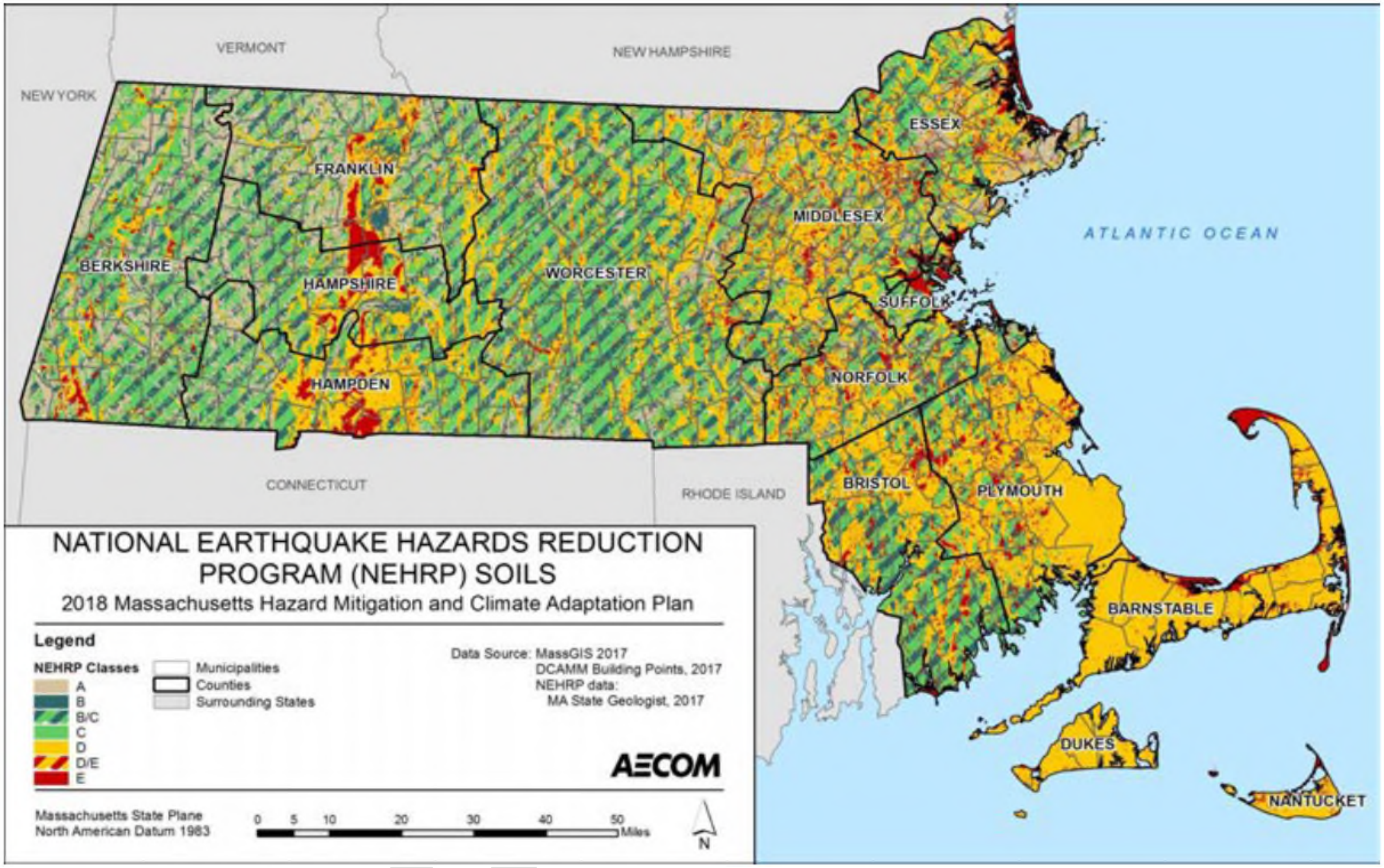
The State Hazard Mitigation and Climate Adaptation Plan does not identify any effects of climate change on the earthquake hazard in Massachusetts.

Hazard Description

An earthquake is the vibration of the Earth's surface that follows a release of energy in the Earth's crust. These earthquakes often occur along fault boundaries. As a result, areas that lie along fault boundaries—such as California, Alaska, and Japan—experience earthquakes more often than areas located within the interior portions of these plates. New England, on the other hand, experiences intraplate earthquakes because it is located deep within the interior of the North American plate. Scientists are still exploring the cause of intraplate earthquakes, and many believe these events occur along geological features that were created during ancient times and are now weaker than the surrounding areas.

Ground shaking is the primary cause of earthquake damage to man-made structures. This damage can be increased due to the fact that soft soils amplify ground shaking. A contributor to site amplification is the velocity at which the rock or soil transmits shear waves (S waves). The National Earthquake Hazards Reduction Program (NEHRP) developed five soil classifications, which are defined by their S-wave velocity, that impact the severity of an earthquake. The soil classification system ranges from A to E, where A represents hard rock that reduces ground motions from an earthquake and E represents soft soils that amplify and magnify ground shaking and increase building damage and losses. These soil types are shown in Figure 3-17.

Figure 3-17: National Earthquake Hazards Reduction Program Soil Types in Massachusetts



Note: This map should be viewed as a first-order approximation of the NEHRP soil classifications. They are not intended for site-specific engineering design or construction. The map is provided only as a guide for use in estimating potential damage from earthquakes. The maps do not guarantee or predict seismic risk or damage. However, the maps certainly provide a first step by highlighting areas that may warrant additional, site-specific investigation if high seismic risk coincides with critical facilities, utilities, or roadways. Sources: Mabee and Duncan, 2017; Preliminary NEHRP Soil Classification Map of Massachusetts, as presented in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, September 2018.

Location

New England is located in the middle of the North American Plate. One edge of the North American Plate is along the West Coast where the plate is pushing against the Pacific Ocean Plate. The eastern edge of the North American Plate is located at the middle of the Atlantic Ocean, where the plate is spreading away from the European and African Plates. New England's earthquakes appear to be the result of the cracking of the crustal rocks due to compression as the North American Plate is being very slowly squeezed by the global plate movements. As a result, New England epicenters do not follow the major mapped faults of the region, nor are they confined to particular geologic structures or terrains. Because earthquakes have been detected all over New England, seismologists suspect that a strong earthquake could be centered anywhere in the region. Furthermore, the mapped geologic faults of New England currently do not provide any indications detailing specific locations where strong earthquakes are most likely to be centered.

In addition to earthquakes occurring within the Commonwealth, earthquakes in other parts of New England can impact widespread areas. This is due in part to the fact that earthquakes in the eastern U.S. are felt over a larger area than those in the western U.S. The difference between seismic shaking in the East versus the West is primarily due to the geologic structure and rock properties that allow seismic waves to travel farther without weakening.[40]

Due to Northfield's more concentrated pattern of growth in the village area, an earthquake would result in a "medium" location of occurrence, potentially impacting 10% to 50% of town. Warwick's population is spread out sparsely throughout town. An earthquake therefore is likely to have an "isolated" area of occurrence, impacting less than 10% of town.

Extent

The location of an earthquake is commonly described by the geographic position of its epicenter and by its focal depth. The focal depth of an earthquake is the depth from the surface to the region where the earthquake's energy originates (the focus). Earthquakes with focal depths up to about 43.5 miles are classified as shallow. Earthquakes with focal depths of 43.5 to 186 miles are classified as intermediate. The focus of deep earthquakes may reach depths of more than 435 miles. The focus of most earthquakes is concentrated in the upper 20 miles of the Earth's crust. The depth to the Earth's core is about 3,960 miles, so even the deepest earthquakes originate in relatively shallow parts of the Earth's interior. The epicenter of an earthquake is the point on the Earth's surface directly above the focus.

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

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 measured value of the amplitude of the seismic waves. The Richter magnitude scale (Richter scale) was developed in 1932 as a mathematical device to compare the sizes of earthquakes. The Richter scale is the most widely known scale for measuring earthquake magnitude. It has no upper limit and is not used to express damage. An earthquake in a densely populated area, which results in many deaths and considerable damage, can have the same magnitude as an earthquake in a remote area that causes no damage.

The perceived severity of an earthquake is based on the observed effects of ground shaking on people, buildings, and natural features, and severity varies with location. Intensity is expressed by the Modified Mercalli Scale, which describes how strongly an earthquake was felt at a particular location. The Modified Mercalli Scale expresses the intensity of an earthquake's effects in a given locality in values ranging from I to XII. Seismic hazards are also expressed in terms of PGA, which is defined by USGS as "what is experienced by a particle on the ground" in terms of percent of acceleration force of gravity. More precisely, seismic hazards are described in terms of Spectral Acceleration, which is defined by USGS as "approximately what is experienced by a building, as modeled by a particle on a massless vertical rod having the same natural period of vibration as the building" in terms of percent of acceleration force of gravity (percent g). Tables 3-38 and 3-39 summarize the Richter scale magnitudes, Modified Mercalli Intensity scale, and associated damage.

Table 3-38: Richter Scale Magnitudes and Effects

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

Source: US Federal Emergency Management Agency

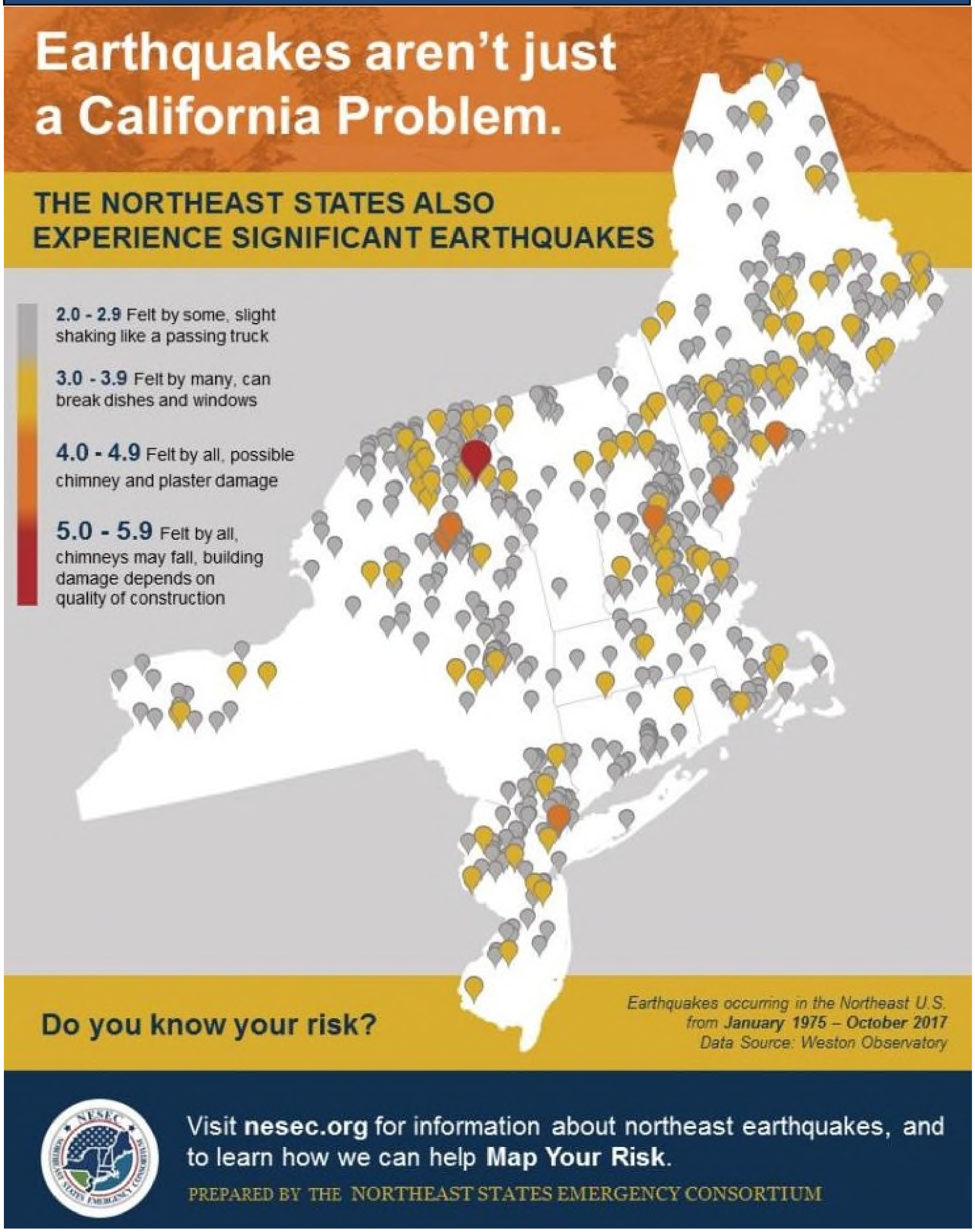
Table 3-39: Modified Mercalli Intensity Scale for and Effects			
Scale	**Intensity**	**Description of Effects**	**Corresponding Richter Scale Magnitude**
I	Instrumental	Detected only on seismographs.	
II	Feeble	Some people feel it.	< 4.2
III	Slight	Felt by people resting; like a truck rumbling by.	
IV	Moderate	Felt by people walking.	
V	Slightly Strong	Sleepers awake; church bells ring.	< 4.8
VI	Strong	Trees sway; suspended objects swing, objects fall off shelves.	< 5.4
VII	Very Strong	Mild alarm; walls crack; plaster falls.	< 6.1
VIII	Destructive	Moving cars uncontrollable; masonry fractures, poorly constructed buildings damaged.	
IX	Ruinous	Some houses collapse; ground cracks; pipes break open.	< 6.9
X	Disastrous	Ground cracks profusely; many buildings destroyed; liquefaction and landslides widespread.	< 7.3
XI	Very Disastrous	Most buildings and bridges collapse; roads, railways, pipes and cables destroyed; general triggering of other hazards.	< 8.1
XII	Catastrophic	Total destruction; trees fall; ground rises and falls in waves.	> 8.1

Source: US Federal Emergency Management Agency

Previous Occurrences

Although it is well documented that the zone of greatest seismic activity in the U.S. is along the Pacific Coast in Alaska and California, in the New England area, an average of six earthquakes are felt each year (Figure 3-18). Damaging earthquakes have taken place historically in New England (Table 3-40). According to the Weston Observatory Earthquake Catalog, 6,470 earthquakes have occurred in New England and adjacent areas. However, only 35 of these events were considered significant. The most recent earthquakes in the region that could have affected Northfield and Warwick are shown in Figure 3-18. There is no record of any damage to Northfield and Warwick as a result of these earthquakes.

Figure 3-18: Earthquakes Occurring in the Northeast from 1975 - 2017



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

Table 3-40: Northeast States Record of Historic Earthquakes			
State	**Years of Record**	**Number of Earthquakes**	**Years with Damaging Earthquakes**
Connecticut	1678 - 2016	115	1791
Maine	1766 - 2016	454	1973, 1904
Massachusetts	1668 - 2016	408	1727, 1755
New Hampshire	1638 - 2016	320	1638, 1940
Rhode Island	1766 - 2016	34	
Vermont	1843 - 2016	50	
New York	1737 - 2016	551	1737, 1929, 1944, 1983, 2002
Total Number of Earthquakes felt: 1,932			

Source: Northeast States Emergency Consortium website, http://nesec.org/earthquakes-hazards/

Probability of Future Events

Earthquakes cannot be predicted and may occur at any time. However, a 1994 report by the USGS, based on a meeting of experts at the Massachusetts Institute of Technology, provides an overall probability of occurrence. Earthquakes above magnitude 5.0 have the potential for causing damage near their epicenters, and larger magnitude earthquakes have the potential for causing damage over larger areas. This report found that the probability of a magnitude 5.0 or greater earthquake centered somewhere in New England in a 10-year period is about 10 percent to 15 percent. This probability rises to about 41 percent to 56 percent for a 50-year period. The last earthquake with a magnitude above 5.0 that was centered in New England took place in the Ossipee Mountains of New Hampshire in 1940. Based on past events, Conway has "Very Low" probability, or less than 1% chance in a given year, of being impacted by an earthquake.

Impact

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

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

Northfield faces potentially "Catastrophic" impacts from earthquakes, with more than 50% of property damaged in the affected area. In Warwick, impacts would likely be "Limited," with more than 10% of property damaged and shutdown of facilities for more than 1 day.

Vulnerability

Society

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

Vulnerable Populations

The populations most vulnerable to an earthquake event include people over the age of 65 (28% of Northfield's population, 22% of Warwick's population) and those living below the poverty level (18% of Northfield's total households, 32% of Warwick's total households). These socially vulnerable populations are most susceptible, based on a number of factors, including their physical and financial ability to react or respond during a hazard, the location and construction quality of their housing, and the inability to be self-sustaining after an incident due to a limited ability to stockpile supplies. Residents living in homes built prior to the 1970s when the State building code first went into effect, and residents living in mobile homes, are also more vulnerable to earthquakes. An estimated 843 housing units in Northfield, or 60% of all housing units in town, were built prior to the 1970s when the first building code went into effect in Massachusetts. An estimated 262 housing units in Warwick, or 57% of all housing units in town, were built prior to the 1970s. There are no mobile homes located in Northfield and Warwick.[41]

Earthen dams and levees are highly susceptible to seismic events, and the impacts of their eventual failures can be considered secondary risks for earthquakes. Due to its location on

[41] U.S. Census Bureau 2014-2018 American Community Survey five-year estimates.

both sides of the Connecticut River, and the presence of multiple high hazard dams upstream, Northfield would be particularly vulnerable in the rare event that an earthquake would trigger a dam failure upstream. There are no high hazard dams in Warwick or upstream of the town, so dam failure is less of a concern in contrast to Northfield. Specific areas of concern for both towns are discussed in more detail in the Dam Failure section.

Health Impacts

The most immediate health risk presented by the earthquake hazard is trauma-related injuries and fatalities, either from structural collapse, impacts from nonstructural items such as furniture, or the secondary effects of earthquakes, such as landslides and fires. Following a severe earthquake, health impacts related to transportation impediments and lack of access to hospitals may occur, as described for other hazards. If ground movement causes hazardous material (in storage areas or in pipelines) to enter the environment, additional health impacts could result, particularly if surface water, groundwater, or agricultural areas are contaminated.

Economic Impacts

Earthquakes also have impacts on the economy, including loss of business functions, damage to inventories, relocation costs, wage losses, and rental losses due to the repair or replacement of buildings. Lifeline-related losses include the direct repair cost for transportation and utility systems. Additionally, economic losses include the business interruption losses associated with the inability to operate a business due to the damage sustained during the earthquake as well as temporary living expenses for those displaced.

Infrastructure

All elements of the built environment in Northfield and Warwick are exposed to the earthquake hazard. Table 3-41 identifies the assessed value of all residential, open space, commercial, and industrial land uses in each town, and the losses that would result from 1%, 5%, and 10% damage to this inventory as a result of an earthquake.

Table 3-41: Estimated Potential Loss by Tax Classification in Northfield and Warwick

	Tax Classification	**Total Assessed Value FY2019**	**1% Damage Loss Estimate**	**5% Damage Loss Estimate**	**10% Damage Loss Estimate**
Northfield	Residential	$289,072,924	$2,890,729	$14,453,646	$28,907,292
	Open Space	$0	$0	$0	$0
	Commercial	$18,116,201	$181,162	$905,810	$1,811,620
	Industrial	$92,552,450	$925,525	$4,627,623	$9,255,245

Table 3-41: Estimated Potential Loss by Tax Classification in Northfield and Warwick					
	Tax Classification	Total Assessed Value FY2019	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
	Total	**$399,741,575**	**$3,997,416**	**$19,987,079**	**$39,974,158**
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	Open Space	$0	$0	$0	$0
	Commercial	$1,502,073	$15,021	$75,104	$150,207
	Industrial	$0	$0	$0	$0
	Total	**$75,412,322**	**$754,123**	**$3,770,616**	**$7,541,232**

Source: Massachusetts Department of Revenue - Division of Local Services,
Data Analytics and Resources Bureau, FY 2020

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

<u>Agriculture</u>

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.

<u>Energy</u>

Earthquakes can damage power plants, gas lines, liquid fuel storage infrastructure, transmission lines, utility poles, solar and wind infrastructure, and other elements of the energy sector. Damage to any components of the grid can result in widespread power outages.

<u>Public Health</u>

A significant earthquake may result in numerous injuries that could overburden hospitals.

<u>Public Safety</u>

Police stations, fire stations, and other public safety infrastructure can experience direct losses (damage) from earthquakes. The capability of the public safety sector is also vulnerable to damage caused by earthquakes to roads and the transportation sector.

Transportation

Earthquakes can impact many aspects of the transportation sector, including causing damage to roads, bridges, vehicles, and storage facilities and sheds. Damage to road networks and bridges can cause widespread disruption of services and impede disaster recovery and response.

Water and Wastewater Infrastructure

Due to their extensive networks of aboveground and belowground infrastructure—including pipelines, pump stations, tanks, administrative and laboratory buildings, reservoirs, chemical storage facilities, and treatment facilities—water and wastewater utilities are vulnerable to earthquakes. Additionally, sewer and water treatment facilities are often built on ground that is subject to liquefaction, increasing their vulnerability. Earthquakes can cause ruptures in storage and process tanks, breaks in pipelines, and building collapse, resulting in loss of water and loss of pressure, and contamination and disruption of drinking water services. Damage to wastewater infrastructure can lead to sewage backups and releases of untreated sewage into the environment.

Environment

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

Vulnerability Summary

Based on this analysis, Northfield and Warwick have a “Low” vulnerability to earthquakes. The problem statements in Section 2.4 summarize the areas of greatest concern regarding earthquakes in Northfield and Warwick.

3.10 DAM FAILURE

Potential Impacts of Climate Change

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

Hazard Description

Dams and levees and their associated impoundments provide many benefits to a community, such as water supply, recreation, hydroelectric power generation, and flood control. However, they also pose a potential risk to lives and property. Dam or levee failure is not a common occurrence, but dams do represent a potentially disastrous hazard. When a dam or levee fails, the potential energy of the stored water behind the dam is released rapidly. Most dam or levee failures occur when floodwaters above overtop and erode the material components of the dam. Often dam or levee breeches lead to catastrophic consequences as the water rushes in a torrent downstream, flooding an area engineers refer to as an "inundation area." The number of casualties and the amount of property damage will depend upon the timing of the warning provided to downstream residents, the number of people living or working in the inundation area, and the number of structures in the inundation area.

Many dams in Massachusetts were built during the 19th Century without the benefit of modern engineering design and construction oversight. Dams of this age can fail because of structural problems due to age and/or lack of proper maintenance, as well as from structural damage caused by an earthquake or flooding.

The Massachusetts Department of Conservation and Recreation Office of Dam Safety is the agency responsible for regulating dams in the state (M.G.L. Chapter 253, Section 44 and the implementing regulations 302 CMR 10.00). The regulations apply to dams that are in excess of 6 feet in height (regardless of storage capacity) or have more than 15 acre feet of storage capacity (regardless of height). Dam safety regulations enacted in 2005 transferred significant responsibilities for dams from the State of Massachusetts to dam owners, including the responsibility to conduct dam inspections.

Location

The Northfield CEM Plan lists only one dam in Northfield: the Grandin Reservoir Dam, a high hazard potential dam. The Grandin Reservoir Dam could affect up to an estimated 850 people if the Thomas Aquinas College campus (former Northfield Mt. Hermon School campus) is at full capacity.

The MA DCR Office of Dam Safety provided information about three dams in Northfield: Nelson Mills Pond Dam; Grandin Reservoir Dam; and Perry Pond Dam. The Nelson Mills Pond Dam is owned by the Town and is listed as a significant hazard dam. As already mentioned, the Grandin Reservoir Dam is listed as a high hazard dam, and is owned by the Northfield Mount Hermon School (NMH). NMH also owns the Perry Pond Dam, which has a low hazard designation. According to the 2005 Northfield Local Hazard Mitigation Plan, the Perry Pond Dam has been breached.

<u>Grandin Reservoir Dam</u>

The most significant of these dams is the Grandin Reservoir Dam, which is owned by Northfield Mt. Hermon School (NMH) and is situated on its former Northfield Campus, now the Thomas Aquinas College campus. This high hazard dam has a storage capacity of 28 million gallons of water, which is used as a public water supply for the East Northfield Water Company, serving the Thomas Aquinas College, Moody Center, and residents of East Northfield. According to the Facilities Department at NMH, the most recent inspection, in 2018, reported the dam to be in satisfactory condition. NMH conducts periodic maintenance at the dam to comply with inspections. The dam is inspected every two years; NMH has scheduled the next inspection of the dam for July 2020.

In 1998, the Army Corps of Engineers completed a dam failure analysis for the Grandin Reservoir Dam. The analysis focused on the impact of a dam failure to the culvert on Winchester Road, to the southwest of the reservoir. The analysis concluded that a dam breach of this type would cause flooding with appreciable property damage in one house with a possible attendant loss of life. The peak discharge would cause a maximum stage of 391.4 feet, 3.4 feet over the road. As this report was completed in 1998, it is possible that these conclusions do not adequately address the potential for damage to the residential area of East Northfield on and around Winchester Road.

An Emergency Action Plan (EAP) was created for the dam in July 2001, and was most recently updated in 2018. The EAP notes that in the event of a dam failure, residential structures would be flooded, causing appreciable damage and possible loss of life. Additionally the plan notes that the streets in the inundation area may suffer major damage, causing them to be impassable during and after the floodwaters recede. Sections of Linden Avenue, Winchester Road, Pierson Road, Route 10, and Route 63 could be inundated by the flood wave.

The Northfield Mount Hermon School, East Northfield Water Company, and the Town could conduct an exercise to test the EAP. Coordination among all partners is required to ensure the exercise is useful. The Town should also make an effort to ensure that East Northfield residents are entered into the Town's Reverse 911 system, which can alert them by telephone of the need to evacuate.

Dams Located in Other Towns that Impact Northfield

Northfield Mountain Pumped Storage Project located east of Northfield in Erving is owned and maintained by FirstLight Power Resources. The Emergency Action Plan for this facility includes inundation maps for the Northfield Main Dam and the Northwest Dike of the Northfield Mountain Reservoir in Erving. Both the dam and the dike are classified as Significant Hazards by the MA DCR Office of Dam Safety. According to inundation maps for the Northwest Dike, floodplain areas in Northfield along Four Mile Brook and the Connecticut River would be impacted by a dike failure. Upon failure, a small area of residential development would be affected. Residents would have from 18 to 50 minutes to respond to potential flooding.

Of additional concern is the Moore Dam, owned by Great River Hydro and located on the Connecticut River in the towns of Littleton, New Hampshire, and Waterford, Vermont, approximately 152 miles upstream from Northfield. According to the Emergency Action Plan, flooding caused by a failure of the dam would reach Northfield within 12 hours. Under Probable Maximum Flood conditions, flood waters would inundate farmland and residences along Caldwell Road, W. Northfield Road, Great Meadow Road, Old Bernardston Road, Route 10, including the bridge over the Connecticut River, Pine Meadow Road, and Cross Road. The Schell Memorial Bridge, due to be replaced with a new pedestrian and bicycle bridge in the next five years, could also be in danger of being damaged or destroyed if the Moore Dam were to fail.

Additional dams found upstream on the Connecticut River in neighboring states may pose a hazard to the Town of Northfield. Some publicly owned reservoirs and dams that are located upstream of Northfield include the Vernon Dam, Townshend Lake and North Springfield Lake in Vermont, and Surry Mountain Lake and Otter Brook Lake in New Hampshire .

Massachusetts Emergency Management Agency (MEMA) identifies seven dams in Warwick, all of which are designated as Low Hazard Potential:

- Wheeler Pond Dam
- Laurel Lake Dam
- Moore's Pond Dam
- Gale's Pond Dam
- Richards Reservoir Upper Dam
- Sheomet Lake Dam
- Stevens Swamp Dam

The Warwick Core Team has also listed the following dams in Warwick, but note that they do not present a threat to persons or property if breached:

- Hastings Pond Dam
- Head of Kidder Falls
- Gale Brook to Orcutt Brook Dam
- Black Brook Dam
- Rum Brook Dam
- Steven's Swamp Dam
- Mountain Brook Dam (at extension of Flower Hill Rd.)

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

Warwick's Core Team identified the possible flooding due to beaver dams as a concern. Of particular concern are the 485 culverts in town that may be subject to blockage as a result of beaver activity, resulting in flooding of the surrounding areas and potentially undermining roadways. The 2014 Committee identified a detailed list of sites where beaver dams are having a notable impact on the landscape. These include:

Athol Rd.

- Above and below culvert # 6 located East of Gale Rd. along the Rum Brook
- Above and below culvert # 7 located East of Gale Rd. along the Black Brook
- Above culvert # 8 located East of house # 321
- Above and below culverts # 35 and # 36 West of Orange Town Line along West Branch of Tully River

Bass Rd.

- Above and below culvert # 1 located South of Northfield Rd. at Bass Swamp
- Above culvert # 8 located North of State Fire Road
- End of Bass Rd. has large beaver pond and multiple dams holding back large amount of water at turnaround

Gale Rd.

- Above and under bridge located near house # 245 at Gale's Pond

Hastings Heights Rd.

- Above culvert # 3 located South of the old Allen Rd.

- Above culvert # 4 located North of Orange Town Line

Hastings Pond Rd.

- Above culvert # 1 located North of house # 73 at Hastings Pond outlet

Hockanum Rd.

- Above and below culvert # 8 located East of house # 165 along the Darling Brook

Northfield Rd.

- Above and below culverts # 46 thru # 48 located West of house # 575 going into Bass Swamp
- Along the Mill Brook across from house # 733 by culvert # 51

Orange Rd.

- Above culvert # 30 located South of house # 447
- Above culvert # 45 located South of Hockanum Rd. along the Orcutt Brook

Richmond Rd.

- Above and below culverts # 8 and # 9 located at high tension wires North of old prison camp at Richards Reservoir

Wendell Rd.

- Above and below culvert # 28 located at outlet of Moore's Pond going into Darling Brook
- Above and below culvert # 32 located South of house # 633 along Darling Brook
- Along Darling Brook located North of house # 780 by culvert #33

West Rum Brook Rd.

- Above culvert # 2 located at turnaround at end of road coming out of Stevens Swamp

White Rd.

- End of White Rd. has large beaver pond and multiple dams holding back large amount of water at turnaround

Winchester Rd.

- Above and below culvert # 20 located South of Robbins Rd.
- Below culvert # 21 located South of Robbins Rd. along the Kidder Brook
- Various beaver dams located along the Mountain Brook North of the confluence of the Mountain Brook and Kidder Brook along the western edge of Winchester Rd.

In addition to beaver dams, Warwick's Core Team identified old mill pond dams as potential concern. These dams may be located on private property. Outreach to landowners about dam maintenance, and resources for repairs or removal of dams, is needed.

Northfield's Core Team reported that beaver dams have caused flooding in several areas of town, which has resulted in damage to roads and property. Locations include Old Vernon Road, Mount Hermon Station Road, Rte. 142, East Street at School Street, Pine Street, Holton Street, and the access road off of Route 10 near Old Bernardston Road. According to the Highway

Superintendent, there is a three mile section of Old Vernon Road, as well as Mount Hermon Station Road, and Rte. 142 which could be impacted by a cascading dam failure at Sawyer Pond where beavers have currently constructed several large impoundments. Previously installed flow control devices at Sawyer Pond need to be reassessed and improved to reduce the risk of dam failure.

Extent

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

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

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

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

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

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

Previous Occurrences

Northfield and Warwick have never experienced an incidence of dam failure other than beaver dams. No dam failures or failure of beaver dams have occurred in Northfield or Warwick since the last plan.

Probability of Future Events

Currently the frequency of dam failure in Northfield is "Very Low" with a less than 1% chance of a dam failing in any given year. In Warwick, the potential for the smaller dams in town to fail is "Low," with a 1-2% chance of occurring in any given year.

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

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

Impact

A dam failure impacting Northfield is likely to have a catastrophic impact, with multiple deaths and injuries possible, more than 50% of property in the affected area damaged or destroyed, and a possible complete shutdown of facilities for 30 days or more. A dam failure in Warwick would likely have a limited impact, with very few injuries and more than 10% of property in the affected area damaged or destroyed.

Vulnerability

Dam failures, while rare, can destroy roads, structures, facilities, utilities, and impact the population of Northfield and Warwick. Existing and future mitigation efforts should continue to be developed and employed that will enable Northfield and Warwick to be prepared for these events when they occur. Particular areas of vulnerability include low-income and elderly populations, buildings in the floodplain or inundation areas, and infrastructure such as roadways and utilities that can be damaged by such events.

Society

Vulnerable Populations

The most vulnerable members of the population are those living or working within the floodplain or dam inundation areas, and in particular, those who would be unable to evacuate quickly, including people over the age of 65, households with young children under the age of 5, people with mobility limitations, people with low socioeconomic status, and people with low English fluency who may not understand emergency instructions provided in English.

Economic Impacts

Economic impacts are not limited to assets in the inundation area, but may extend to infrastructure and resources that serve a much broader area. In addition to direct damage from dam failure, economic impacts include the amount of time required to repair or replace and reopen businesses, governmental and nonprofit agencies, and industrial facilities damaged by the dam failure.[42]

Infrastructure

Structures that lie in the inundation area of each of the dams in Northfield and Warwick are vulnerable to a dam failure. Buildings located within the floodplain are also vulnerable to dam failure in Northfield and Warwick.

Environment

Examples of environmental impacts from a dam failure include:

- Pollution resulting from septic system failure, back-up of sewage systems, petroleum products, pesticides, herbicides, or solvents
- Pollution of the potable water supply or soils
- Exposure to mold or bacteria during cleanup
- Changes in land development patterns
- Changes in the configuration of streams or the floodplain

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

- Erosion, scour, and sedimentation
- Changes in downstream hydro-geomorphology
- Loss of wildlife habitat or biodiversity
- Degradation to wetlands
- Loss of topsoil or vegetative cover
- Loss of indigenous plants or animals[43]

Vulnerability Summary

Due to the presence of the Grandin Reservoir Dam, Northfield Mountain Pumped Storage Project, and additional dams found upstream on the Connecticut River, the Northfield has a "High" vulnerability from dam or levee failure. Due to the absence of significant or high hazard dams upstream of Warwick, but given the presence of extensive beaver activity in close proximity to town road infrastructure and culverts in Warwick, the Town has a "Low" vulnerability from dam or levee failure.

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

3.11 DROUGHT

Potential Impacts of Climate Change

Although total annual precipitation is anticipated to increase over the next century, seasonal precipitation is predicted to include more severe and unpredictable dry spells. More rain falling over shorter time periods will reduce groundwater recharge, even in undeveloped areas, as the ground becomes saturated and unable to absorb the same amount of water if rainfall were spread out. The effects of this trend will be exacerbated by the projected reduction in snowpack, which can serve as a significant water source during the spring melt to buffer against sporadic precipitation. Also, the snowpack melt is occurring faster than normal, resulting not only in increased flooding but a reduced period in which the melt can recharge groundwater and the amount of water naturally available during the spring growing period.

Reduced recharge can in turn affect base flow in streams that are critical to sustain ecosystems during dry periods and groundwater-based water supply systems. Reservoir-based water supply systems will also need to be assessed to determine whether they can continue to meet projected demand by adjusting their operating rules to accommodate the projected changes in precipitation patterns and associated changes in hydrology. Finally, rising temperatures will also increase evaporation, exacerbating drought conditions.

Figure 3-19: Impacts of Climate Change on Drought

Potential Effects of Climate Change	
RISING TEMPERATURES AND CHANGES IN PRECIPITATION ➔ PROLONGED DROUGHT	The frequency and intensity of droughts are projected to increase during summer and fall in the Northeast as higher temperatures lead to greater evaporation and earlier winter and spring snowmelt, and precipitation patterns become more variable and extreme.
RISING TEMPERATURES AND CHANGES IN PRECIPITATION ➔ REDUCED SNOWPACK	Due to climate change, the proportion of precipitation falling as snow and the extent of time snowpack remains are both expected to decrease. This reduces the period during which snowmelt can recharge groundwater Supplies, bolster streamflow, and provide water for the growing period.

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

Hazard Description

Droughts can vary widely in duration, severity, and local impact. They may have widespread social and economic significance that requires the response of numerous parties, including water suppliers, firefighters, farmers, and residents. Droughts are often defined as periods of deficient precipitation. How this deficiency is experienced can depend on factors such as land use change, the existence of dams, and water supply withdrawals or diversions. For example, impervious surfaces associated with development can exacerbate the effects of drought due to decreased groundwater recharge.

Drought is a natural phenomenon, but its impacts are exacerbated by the volume and rate of water withdrawn from these natural systems over time as well as the reduction in infiltration from precipitation that is available to recharge these systems. Groundwater withdrawals for drinking water can reduce groundwater levels, impacting water supplies as well as base flow (flow of groundwater) in streams. A reduction in base flow is significant, especially in times of drought, as this is often the only source of water to the stream. In extreme situations, groundwater levels can fall below stream channel bottom, and groundwater becomes disconnected from the stream, resulting in a dry channel.

Natural infiltration is reduced by impervious cover (pavement, buildings) on the land surface and by the interruption of natural small-scale drainage patterns in the landscape caused by development and drainage infrastructure. Sewer collection systems can also reduce groundwater levels when groundwater infiltrates into them. This is a common problem for wastewater collection systems in Franklin County, where many of the existing pipes were put in place over 100 years ago. Also, when drains are connected to the sanitary system, groundwater and precipitation are transported to wastewater treatment plants where effluent is typically discharged to surface water bodies and not returned to the groundwater.

Highly urbanized areas with traditional stormwater drainage systems tend to result in higher peak flood levels during rainfall events and rapid decline of groundwater levels during periods of low precipitation. Thus, the hydrology in these areas becomes more extreme during floods and droughts.[44] The importance of increasing infiltration is widely recognized, and the implementation of nature-based solutions to help address this problem is discussed further in later portions of this plan.

Location

Northfield and Warwick are in a region in Massachusetts that is more prone to severe and extreme drought based on the number of weeks these areas experienced drought conditions from 2001-2017 (Figure 3-20). Because of this hazard's regional nature, a drought would impact the entirety of both Northfield and Warwick, resulting in a "Large" location of occurrence, or more than 50 percent of total land area affected.

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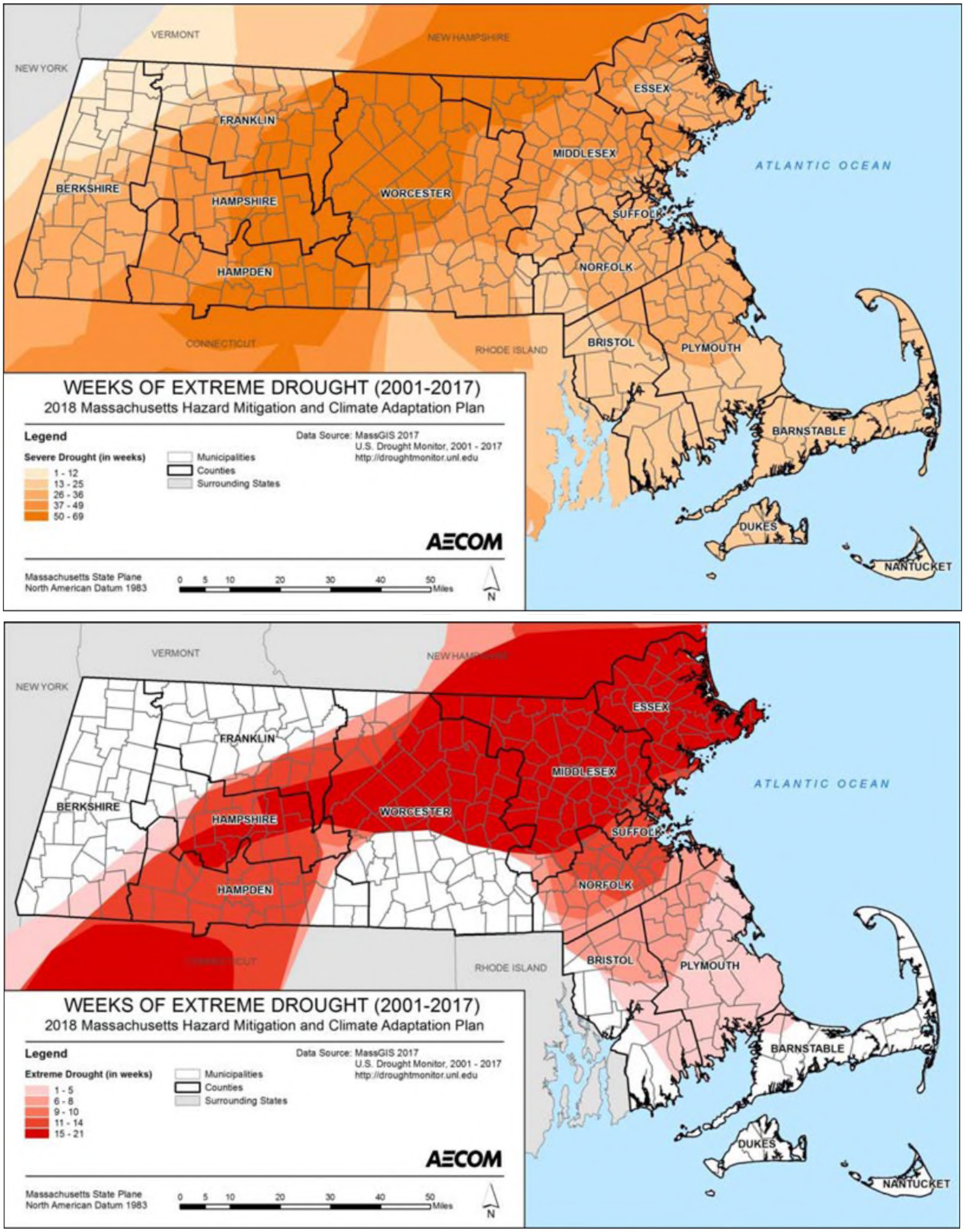
[44] ERG and Horsley Witten Group. 2017. Using Green Infrastructure to Improve Resilience in the Commonwealth of Massachusetts: Final Project Report.

Figure 3-20: Areas Experiencing Severe or Extreme Drought, 2001 - 2017



Source: U.S. Drought Monitor, 2017, as presented in the *2018 Massachusetts Hazard Mitigation and Climate Adaptation Plan.*

Extent

The severity of a drought would determine the scale of the event and would vary depending on the type of private well serving town buildings, local businesses and residents, for example shallow wells in unconsolidated materials or deep, drilled bedrock wells. Northfield's municipal water supplies could be affected by drought, as well as private wells in both Northfield and Warwick.

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

Table 3-42: U.S. Drought Monitor		
Classification	**Category**	**Description**
D0	Abnormally Dry	Going into drought: short-term dryness slowing planting, growth of crops or pastures. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered
D1	Moderate Drought	Some damage to crops, pastures; streams, reservoirs, or wells low, some water shortages developing or imminent; voluntary water-use restrictions requested
D2	Severe Drought	Crop or pasture losses likely; water shortages common; water restrictions imposed
D3	Extreme Drought	Major crop/pasture losses; widespread water shortages or restrictions
D4	Exceptional Drought	Exceptional and widespread crop/pasture losses; shortages of water in reservoirs, streams, and wells creating water emergencies

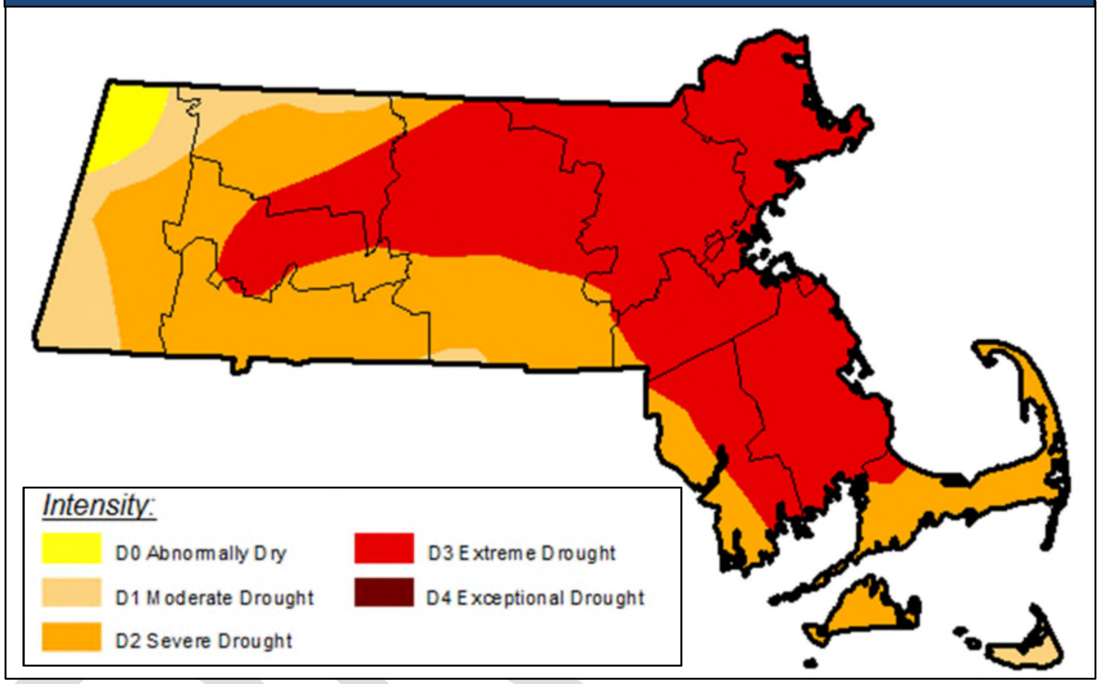
Previous Occurrences

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

Beginning in 1960 in western Massachusetts and in 1962 in eastern Massachusetts through 1969, Massachusetts experienced the most significant drought on record, according to the United States Geological Survey. The severity and duration of the drought caused significant impacts on both water supplies and agriculture. Although short or relatively minor droughts occurred over the next 50 years, the next long-term event began in March 2015, when Massachusetts began experiencing widespread abnormally dry conditions. In July 2016, based on a recommendation from the Drought Management Task Force (DMTF), the Secretary of EOEEA declared a Drought Watch for Central and Northeast Massachusetts and a Drought Advisory for Southeast Massachusetts and the Connecticut River Valley. Drought warnings were issued in five out of six drought regions of the state. Many experts stated that this drought was the worst in more than 50 years.

By September 2016, 78% of Franklin County was categorized as “severe drought” (D2) or higher, and 26% of the County was categorized as “extreme drought” (D3) (Figure 3-21).[45] By May 2017, the entire Commonwealth had returned to “normal” due to wetter-than-normal conditions in the spring of 2017.

Figure 3-21: Drought Conditions in Massachusetts on September 20, 2016



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

More recently, in 2020 the region experienced moderate to severe drought conditions during late summer and early fall. Moderate to abnormally dry conditions continued through the winter into early 2021. In Warwick, several private wells reportedly went dry during this time period.

Historically, drought has not been a significant hazard for Northfield or Warwick. Drought is no more likely to occur in Northfield and Warwick than elsewhere in the state. Drought is a concern for increasing each Town’s vulnerability to wildfire due to burn piles that blaze out of control, lightning strikes in forested land, campfires improperly managed, or arson, which can cause wildfires. Northfield and Warwick are more vulnerable to these conflagrations in times of drought and during the Spring and Fall when leaves are off the trees and the sun warms the leaf

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

litter.

Probability of Future Events
According to the 2018 Massachusetts Hazard Mitigation and Climate Adaptation Plan, on a monthly basis over the 162-year period of record from 1850 to 2012, there is a 2% chance of being in a drought warning level. As noted previously, rising temperatures and changes in precipitation due to climate change could increase the frequency of episodic droughts, like the one experienced across the Commonwealth in the summer of 2016, and in 2020. In Northfield and Warwick, drought has a "High" probability of future occurrence, or between a 25% and 50% chance of occurring in any given year.

Impact
The major impact of drought to residents would be public water supplies and private wells running dry or being contaminated due to low water levels. Farmers could be impacted economically by the extended lack of water. Drought may increase the probability of a wildfire occurring and impact availability of water supplies for firefighting. The prolonged lack of precipitation dries out soil and vegetation, which becomes increasingly prone to ignition as long as the drought persists. In Northfield, the impact of a drought on public water supplies and the farming community could be “Critical” with more than 25% property damage or disruption on quality of life. In Warwick, the impact of drought is “limited” with more than 10% of property damage and closure of facilities for more than 1 day.

Northfield and Warwick’s firefighting infrastructure may be insufficient, even in normal conditions. Firefighting capabilities could be further compromised in a drought if aquifers, fire ponds, or rivers used for pumping water are low.

Vulnerability
The number and type of impacts increase with the persistence of a drought as the effect of the precipitation deficit cascades down parts of the watershed and associated natural and socioeconomic assets. For example, a precipitation deficiency may result in a rapid depletion of soil moisture that may be discernible relatively quickly to farmers. The impact of this same precipitation deficit may not affect hydroelectric power production, drinking water supply availability, or recreational uses for many months.

Society
The entire population of Northfield and Warwick is vulnerable to drought events. However, the vulnerability of populations to this hazard can vary significantly based on water supply sources and municipal water use policies.

Vulnerable Populations

Drought conditions can cause a shortage of water for human consumption and reduce local firefighting capabilities. Public water supplies (PWS) provide water for both of these services and may struggle to meet system demands while maintaining adequate pressure for fire suppression and meeting water quality standards. The Massachusetts Department of Environmental Protection (DEP) requires all PWS to maintain an emergency preparedness plan, which is relevant for the two municipal public water supplies in Northfield. However, there is no municipal public water supply in Warwick. Individual wells provide drinking water for residents and businesses as well as the town-owned buildings in Warwick. The Town as well as homeowners and businesses are vulnerable during a drought if they are not able to find an alternate short- or long-term water supply (i.e. install a new well) or temporarily relocate in the event their well runs dry.

Health Impacts

With declining groundwater levels, residential well owners may experience dry wells or sediment in their water due to the more intense pumping required to pull water from the aquifer and to raise water from a deeper depth. Wells may also develop a concentration of pollutants, which may include nitrates and heavy metals (including uranium) depending on local geology. The loss of clean water for consumption and for sanitation may be a significant impact depending on the affected population's ability to quickly drill a deeper or a new well or to relocate to unaffected areas.

During a drought, dry soil and the increased prevalence of wildfires can increase the amount of irritants (such as pollen or smoke) in the air. Reduced air quality can have widespread deleterious health impacts, but is particularly significant to the health of individuals with pre-existing respiratory health conditions like asthma. Lowered water levels can also result in direct environmental health impacts, as the concentration of contaminants in swimmable bodies of water will increase when less water is present. Stagnant water bodies may develop and increase the prevalence of mosquito breeding, thus increasing the risk for vector-borne illnesses.

Economic Impacts

The economic impacts of drought can be substantial, and would primarily affect the agriculture, recreation and tourism, forestry, and energy sectors.

Infrastructure

Agriculture

Drier summers and intermittent droughts may strain irrigation water supplies, stress crops, and delay harvests. Insufficient irrigation will impact the availability of produce, which may result in higher demand than supply. This can drive up the price of local food. Farmers with wells that are dry are advised to contact the Massachusetts Department of Agricultural Resources to explore microloans through the Massachusetts Drought Emergency Loan Fund or to seek federal Economic Injury Disaster Loans.

Water and Wastewater Infrastructure

As noted already, drought affects both groundwater sources and smaller surface water reservoir supplies. Water supplies for drinking, agriculture, and water-dependent industries may be depleted by smaller winter snowpacks and drier summers anticipated due to climate change. Reduced precipitation during a drought means that water supplies are not replenished at a normal rate. This can lead to a reduction in groundwater levels and problems such as reduced pumping capacity or wells going dry. Shallow wells are more susceptible than deep wells. Suppliers may struggle to meet system demands while maintaining adequate water supply pressure for fire suppression requirements. Private well supplies may dry up and need to either be deepened or supplemented with water from outside sources.

Environment

Drought has a wide-ranging impact on a variety of natural systems. Some of those impacts can include the following:[46]

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

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

In addition to these direct natural resource impacts, a wildfire exacerbated by drought conditions could cause significant damage to the environment in Northfield and Warwick as well as economic damage related to the loss of valuable natural resources.

Vulnerability Summary

Based on the above assessment, Northfield has a "High" vulnerability to drought, while Warwick's vulnerability is "Medium." The problem statements in Section 2.4 summarize the areas of greatest concern regarding droughts in Northfield and Warwick.

3.12 LANDSLIDES

Potential Impacts of Climate Change

According to the 2018 *Massachusetts State Hazard Mitigation and Climate Adaptation Plan*, slope saturation by water is already a primary cause of landslides in the Commonwealth. Regional climate change models suggest that New England will likely experience warmer, wetter winters in the future as well as more frequent and intense storms throughout the year. This increase in the frequency and severity of storm events could result in more frequent soil saturation conditions, which are conducive to an increased frequency of landslides. Additionally, an overall warming trend is likely to increase the frequency and duration of droughts and wildfire, both of which could reduce the extent of vegetation throughout the Commonwealth. The loss of the soil stability provided by vegetation could also increase the probability of landslides wherever these events occur.

Figure 3-22: Impacts of Climate Change on Landslides

Potential Effects of Climate Change		
	CHANGES IN PRECIPITATION AND EXTREME WEATHER ➔ SLOPE SATURATION	Regional climate change models suggest that Massachusetts will likely experience more frequent and intense storms throughout the year. This change could result in more frequent soil saturation conditions, which are conducive to an increased frequency of landslides.
	RISING TEMPERATURES ➔ REDUCED VEGETATION EXTENT	An increased frequency of drought events is likely to reduce the extent of vegetation throughout the Commonwealth. The loss of the soil stability provided by vegetation could also increase the probability of landslides wherever these events occur.

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

Hazard Description

The term landslide includes a wide range of ground movements, such as rock falls, deep failure of slopes, and shallow debris flows. The most common types of landslides in Massachusetts include translational debris slides, rotational slides, and debris flows. Most of these events are caused by a combination of unfavorable geologic conditions (silty clay or clay layers contained in glaciomarine, glaciolacustrine, or thick till deposits), steep slopes, and/or excessive wetness leading to excess pore pressures in the subsurface. Historical landslide data for the Commonwealth suggests that most landslides are preceded by two or more months of higher than normal precipitation, followed by a single, high-intensity rainfall of several inches or more.[47] This precipitation can cause slopes to become saturated.

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

Landslides associated with slope saturation occur predominantly in areas with steep slopes underlain by glacial till or bedrock. Bedrock is relatively impermeable relative to the unconsolidated material that overlies it. Similarly, glacial till is less permeable than the soil that forms above it. Thus, there is a permeability contrast between the overlying soil and the underlying, and less permeable, unweathered till and/or bedrock. Water accumulates on this less permeable layer, increasing the pore pressure at the interface. This interface becomes a plane of weakness. If conditions are favorable, failure will occur.

Landslides are created by human activities as well, including deforestation, cultivation and construction, which destabilize already fragile slopes. Some human activities that could cause landslides include:

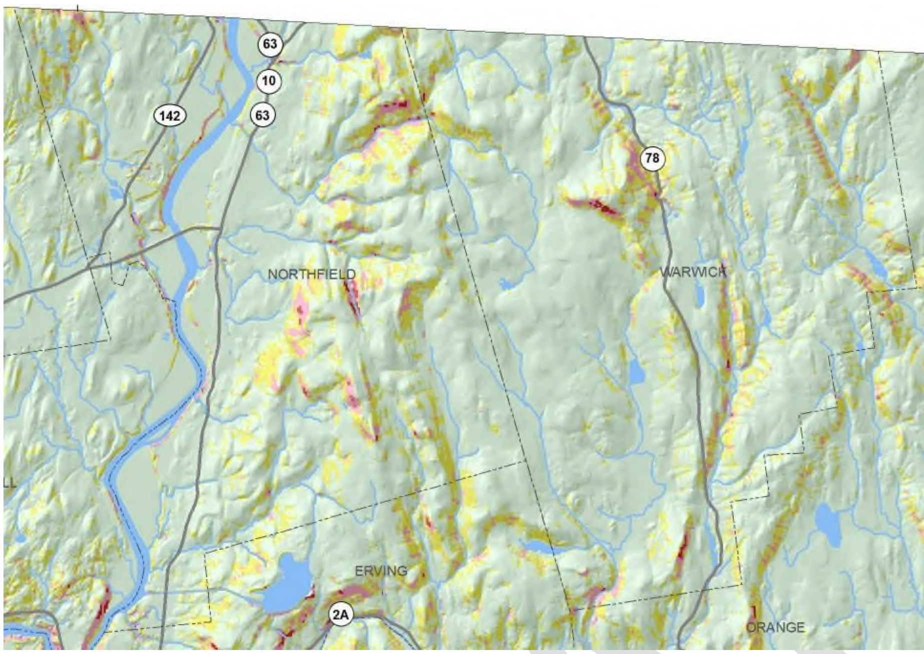
- vibrations from machinery or traffic;
- blasting;
- earthwork which alters the shape of a slope, or which imposes new loads on an existing slope;
- in shallow soils, the removal of deep-rooted vegetation that binds colluvium to bedrock; and
- construction, agricultural or forestry activities (logging)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

Location

In 2013, the Massachusetts Geological Survey prepared an updated map of potential landslide hazards for the Commonwealth (funded by FEMA's Hazard Mitigation Grant Program) to provide the public, local governments, and emergency management agencies with the location of areas where slope movements have occurred or may possibly occur in the future under conditions of prolonged moisture and high-intensity rainfall. This project was designed to provide statewide mapping and identification of landslide hazards that can be used for community level planning as well as prioritizing high-risk areas for mitigation.

Northfield and Warwick have areas in town with high and moderate landslide rankings. These areas are shown in Figure 3-23 and are mostly located along the steep slopes of the hilly terrain distributed across each town. In general, the steep topography and soils, and the presence of major waterways and upland tributaries in Northfield and Warwick are similar to surrounding towns. Northfield and Warwick have a similar amount of unstable soils as many surrounding towns.

Figure 3-23: Slope Stability Map, Northfield, Warwick and Surrounding Towns



Map Legend

Map Color Code	Predicted Stability Zone	Relative Slide Ranking[1]
(red)	Unstable	High
	Upper Threshold of Instability	
(pink)	Lower Threshold of Instability	Moderate
(yellow)	Nominally Stable	Low
	Moderately Stable	
(pale green)	Stable	Very Low

Source: Massachusetts Geologic Survey and UMass Amherst, 2013

Extent

Natural variables that contribute to the overall extent of potential landslide activity in any particular area include soil properties, topographic position and slope, and historical incidence. Predicting a landslide is difficult. As a result, estimations of the potential severity of landslides are informed by previous occurrences as well as an examination of landslide susceptibility. Information about previous landslides can provide insight as to both where landslides may occur and what types of damage may result. It is important to note, however, that landslide susceptibility only identifies areas potentially affected and does not imply a time frame when a landslide might occur. The distribution of susceptibility in Northfield and Warwick is depicted on the Slope Stability Map, with areas of higher slope instability considered to also be more susceptible to the landslide hazard.

Previous Occurrences

Erosion along the banks of the Connecticut River in Northfield has resulted in the loss of agricultural land, and bank stabilization work continues to be needed. In addition to the unstable soils along the Connecticut River, areas along Four Mile Brook and Four Mile Brook Road in Northfield are susceptible to erosion. See the Flooding section for more information. The Highway Superintendent is concerned about the potential for landslide related to beaver dam failure at Sawyer Pond. A landslide in this area could impact Old Vernon Road, Hermon

Station Road, and Route 142.

No significant landslide events have been observed in Northfield and Warwick. The location of occurrence for landslides in both towns is “isolated,” impacting less than 10% of the town.

Probability of Future Events

In general, landslides are most likely during periods of higher than average rainfall. The ground must be saturated prior to the onset of a major storm for a significant landslide to occur. Increasing heavy precipitation events will increase the risk of landslides in Northfield and Warwick. In Northfield, the probability of future landslides is “Low”, with a 1%-2% chance of occurrence in a given year. In Warwick, the probability is “Very Low” with less than a 1% chance of a landslide happening in the next year.

Impact

Homes located on lots with significant slopes (i.e., 10% or greater), or that are located at the bottom of steep slopes, are at greater risk of impacts from landslides. The impact of a landslide in Northfield could be “Limited” with more than 10% of property in the affected area damaged or destroyed. In Warwick, a landslide is likely to have a “Minor” impact, with less than 10$ of property damaged or destroyed. Route 78 in Warwick, and Gulf Road in Northfield, which are major roadways in each town, could be impacted by a landslide due to their location below some of the unstable slope areas identified in the Slope Stability Map.

Vulnerability

Society

<u>Vulnerable Populations</u>

Populations who rely on potentially impacted roads for vital transportation needs are considered to be particularly vulnerable to this hazard. In Northfield and Warwick, many residents may be vulnerable to landslides due to the fact that many homes are built on property below steep slopes, and also because both towns have limited alternative routes for accessing homes if Route 78 in Warwick or Gulf Road in Northfield were blocked by a landslide.

<u>Health Impacts</u>

People in landslide hazard zones are exposed to the risk of dying during a large-scale landslide; however, damage to infrastructure that impedes emergency access and access to health care is the largest health impact associated with this hazard. Mass movement events in the vicinity of major roads could deposit many tons of sediment and debris on top of the road. Restoring vehicular access is often a lengthy and expensive process.

Economic Impacts

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

Infrastructure

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

Agriculture

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

Energy

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

Public Health

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

Public Safety

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

Transportation

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

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

<u>Water and Wastewater Infrastructure</u>
Surface water bodies may become directly or indirectly contaminated by landslides. Landslides can block river and stream channels, which can result in upstream flooding and reduced downstream flow. This may impact the availability of drinking water. Water and wastewater infrastructure may be physically damaged by mass movements.

Environment
Landslides can affect a number of different facets of the environment, including the landscape itself, water quality, and habitat health. Following a landslide, soil and organic materials may enter streams, reducing the potability of the water and the quality of the aquatic habitat. Additionally, mass movements of sediment may result in the stripping of forest trees and soils, which in turn impacts the habitat quality of the animals that live in those forests. Flora in the area may struggle to re-establish following a significant landslide because of a lack of topsoil.

Vulnerability Summary
Based on the above assessment, Northfield and Warwick have a hazard index rating of “Low” for landslides. The problem statements in Section 2.4 summarize the areas of greatest concern regarding landslides Northfield and Warwick.

3.13 EXTREME TEMPERATURES

Potential Impacts of Climate Change

Beyond the overall warming trend associated with global warming and climate change, Conway will experience increasing days of extreme heat in the future. Generally, extreme heat is considered to be over 90 degrees Fahrenheit (°F), because at temperatures above that threshold, heat-related illnesses and mortality show a marked increase. The average summer across the Commonwealth during the years between 1971 and 2000 included 4 days over 90°F. Climate scientists project that by mid-century, the state could have a climate that resembles that of southern states today, with between 10-28 days over 90°F. By the end of the century, extreme heat could occur between 13-56 days during summer, depending on how successful we are in reducing greenhouse gas emissions.[48]

Figure 3-24: Impacts of Climate Change on Extreme Temperatures

Potential Effects of Climate Change		
	RISING TEMPERATURES ➔ HIGHER EXTREME TEMPERATURES	The average summer across the Massachusetts during the years between 1971 and 2000 included 4 days over 90°F (i.e. extreme heat days). Climate scientists project that by mid-century, the state could have a climate that resembles that of southern states today, with an additional 10-28 days over 90°F during summer. By the end of the century, extreme heat could occur between 13-56 days during summer.
	RISING TEMPERATURES ➔ HIGHER AVERAGE TEMPERATURES	Compared to an annual 1971-2000 average temperature baseline of 47.6°F, annual average temperatures in Massachusetts are projected to increase by 3.8 to 10.8 degrees (likely range) by the end of the 21st century; slightly higher in western Massachusetts.

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

Hazard Description

There is no universal definition for extreme temperatures. The term is relative to the usual weather in the region based on climatic averages. Extreme heat for Massachusetts is usually defined as a period of three or more consecutive days above 90 degrees Fahrenheit (°F), but more generally as a prolonged period of excessively hot weather, which may be accompanied by high humidity. Extreme cold is also considered relative to the normal climatic lows in a region.

Massachusetts has four seasons with several defining factors, and temperature is one of the most significant. Extreme temperatures can be defined as those that are far outside the normal ranges. The average highs and lows of the hottest and coolest months in Franklin County (using Greenfield data as a proxy) are provided in Table 3-43.

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

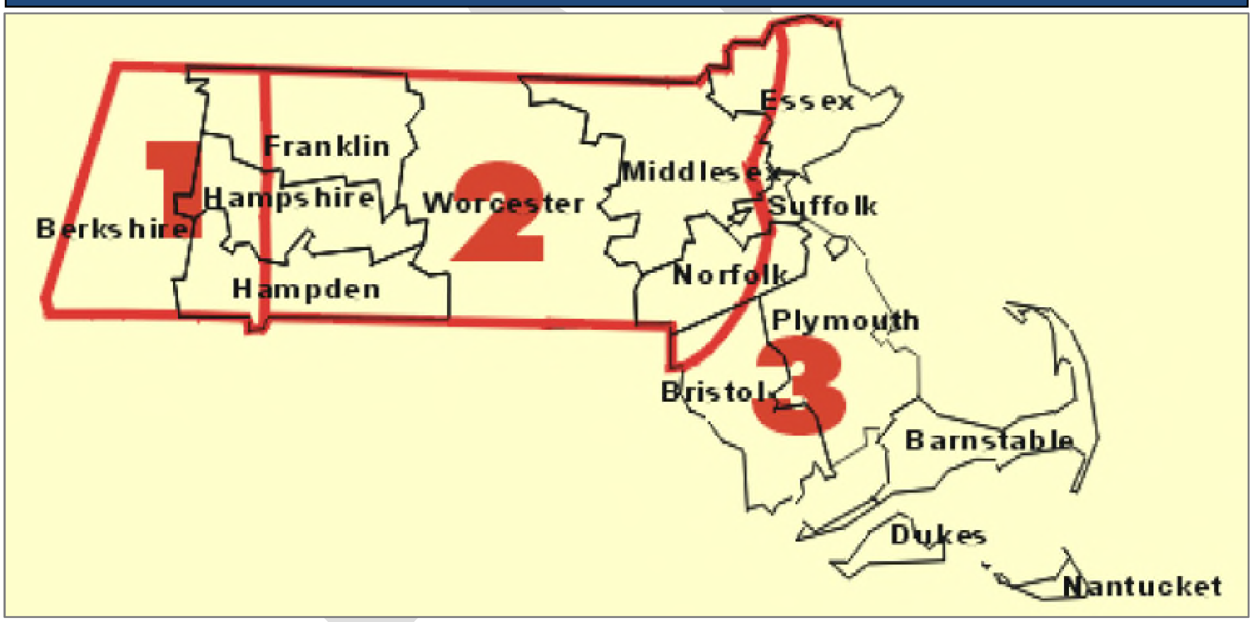
Table 3-43: Annual Average High and Low Temperatures (Greenfield)		
	July (Hottest Month)	**January (Coldest Month)**
Average High (°F)	81°	33°
Average Low (°F)	57°	12°

Note: Average temperatures are for the years 1981-2010.
Source: U.S. Climate Data.

Location

According to the NOAA, Massachusetts is made up of three climate divisions: Western, Central, and Coastal, as shown in Figure 3-25. Average annual temperatures vary slightly over the divisions, with annual average temperatures of around 46°F in the Western division (area labeled "1" in the figure), 49°F in the Central division (area labeled "2" in the figure) and 50°F in the Coastal division (area labeled "3" in the figure). Northfield and Warwick fall on the boundary between the Western and the Central climate division.

Figure 3-25: Climate Divisions in Massachusetts



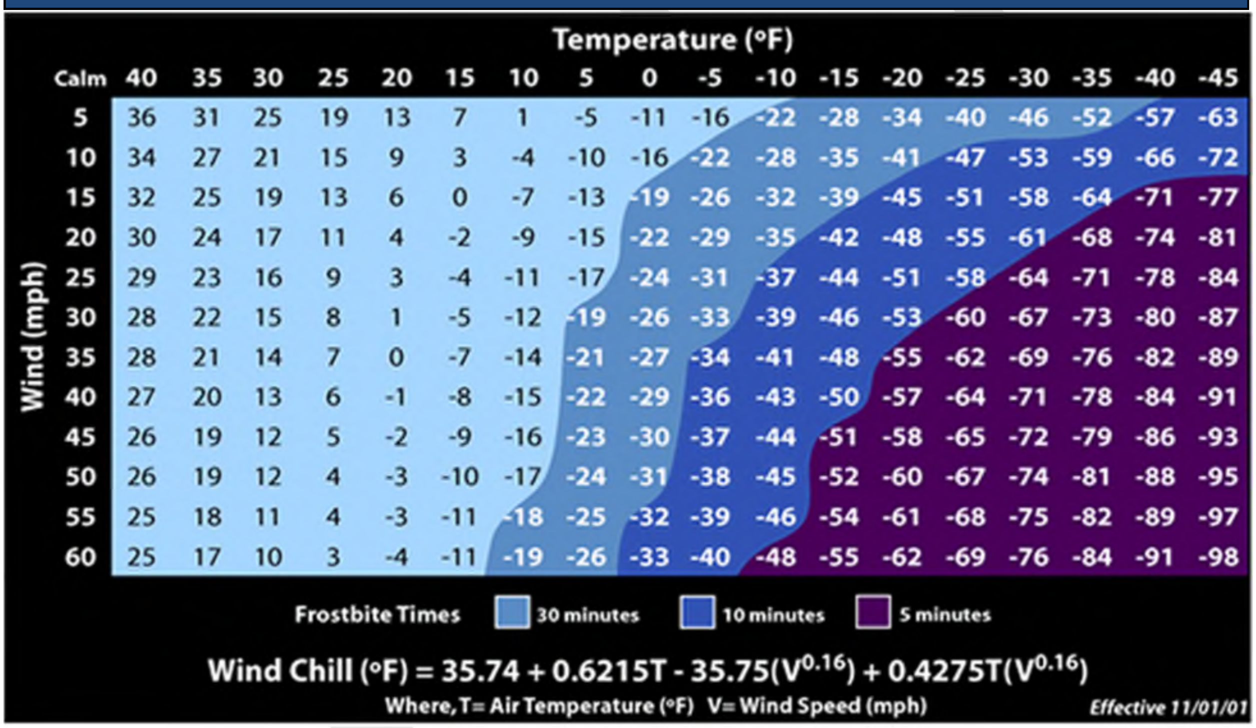
Source: NOAA, as presented in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, September 2018

Extreme temperature events occur more frequently and vary more in the inland regions of the State where temperatures are not moderated by the Atlantic Ocean. The severity of extreme heat impacts, however, is greater in densely developed urban areas like Boston than in suburban and rural areas, due to the urban "heat island" effect, described in more detail in the Impacts sub-section.

Extent

The extent (severity or magnitude) of extreme cold temperatures is generally measured through the Wind Chill Temperature Index. Wind Chill Temperature is the temperature that people and animals feel when they are outside, and it is based on the rate of heat loss from exposed skin by the effects of wind and cold. As the wind increases, the body loses heat at a faster rate, causing the skin's temperature to drop. The National Weather Service (NWS) issues a Wind Chill Advisory if the Wind Chill Index is forecast to dip to –15°F to –24°F for at least three hours, based on sustained winds (not gusts). The NWS issues a Wind Chill Warning if the Wind Chill Index is forecast to fall to –25°F or colder for at least three hours. On November 1, 2001, the NWS implemented a Wind Chill Temperature Index designed to more accurately calculate how cold air feels on human skin. Figure 3-26 shows the Wind Chill Temperature Index.

Figure 3-26: National Weather Service Wind Chill Chart



Temperature (°F)

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

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

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

Where, T = Air Temperature (°F) V = Wind Speed (mph)

Effective 11/01/01

Source: National Weather Service: https://www.weather.gov/safety/cold-wind-chill-chart

The NWS issues a Heat Advisory when the NWS Heat Index is forecast to reach 100 to 104°F for two or more hours. The NWS issues an Excessive Heat Warning if the Heat Index is forecast to reach 105°F or higher for two or more hours. The NWS Heat Index is based both on temperature and relative humidity, and describes a temperature equivalent to what a person would feel at a baseline humidity level. It is scaled to the ability of a person to lose heat to their environment. The relationship between these variables and the levels at which the NWS considers various health hazards to become relevant are shown in Figure 3-27. It is important to know that the heat index values are devised for shady, light wind conditions. Exposure to full sunshine can increase heat index values by up to 15°F. In addition, strong winds, particularly with very hot, dry air, can increase the risk of heat-related impacts.

Figure 3-27: National Weather Service Heat Index:

NWS Heat Index — Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution   Extreme Caution   Danger   Extreme Danger

Source: National Weather Service: https://www.weather.gov/safety/heat-index

Previous Occurrences

Since 1994, there have been 33 cold weather events within the Commonwealth, ranging from Cold/Wind Chill to Extreme Cold/Wind Chill events. Information on severe cold weather events in Northfield and Warwick and Franklin County was not available prior to 2015. However, detail on recent extreme events is provided below.

In February 2015, a series of snowstorms piled nearly 60 inches on the city of Boston in 3 weeks and caused recurrent blizzards across eastern Massachusetts. While Northfield, Warwick and western Massachusetts was not impacted as much from the snow, temperature gauges across the Commonwealth measured extreme cold, with wind chills as low as -31°F. Wind chills as low as 28 below zero were recorded at the Orange Municipal Airport.

In February 2016, one cold weather event broke records throughout the state. Arctic high pressure brought strong northwest winds and extremely cold wind chills to southern New

England. Wind chills as low as 38 below zero were reported in Orange.

According to the NOAA's Storm Events Database, there have been 43 warm weather events (ranging from Record Warmth/Heat to Excessive Heat events) since 1995 in Massachusetts. Excessive heat results from a combination of temperatures well above normal and high humidity. Whenever the heat index values meet or exceed locally or regionally established heat or excessive heat warning thresholds, an event is reported in the database. Information on excessive heat was not available for Northfield and Warwick or Franklin County prior to 2018.

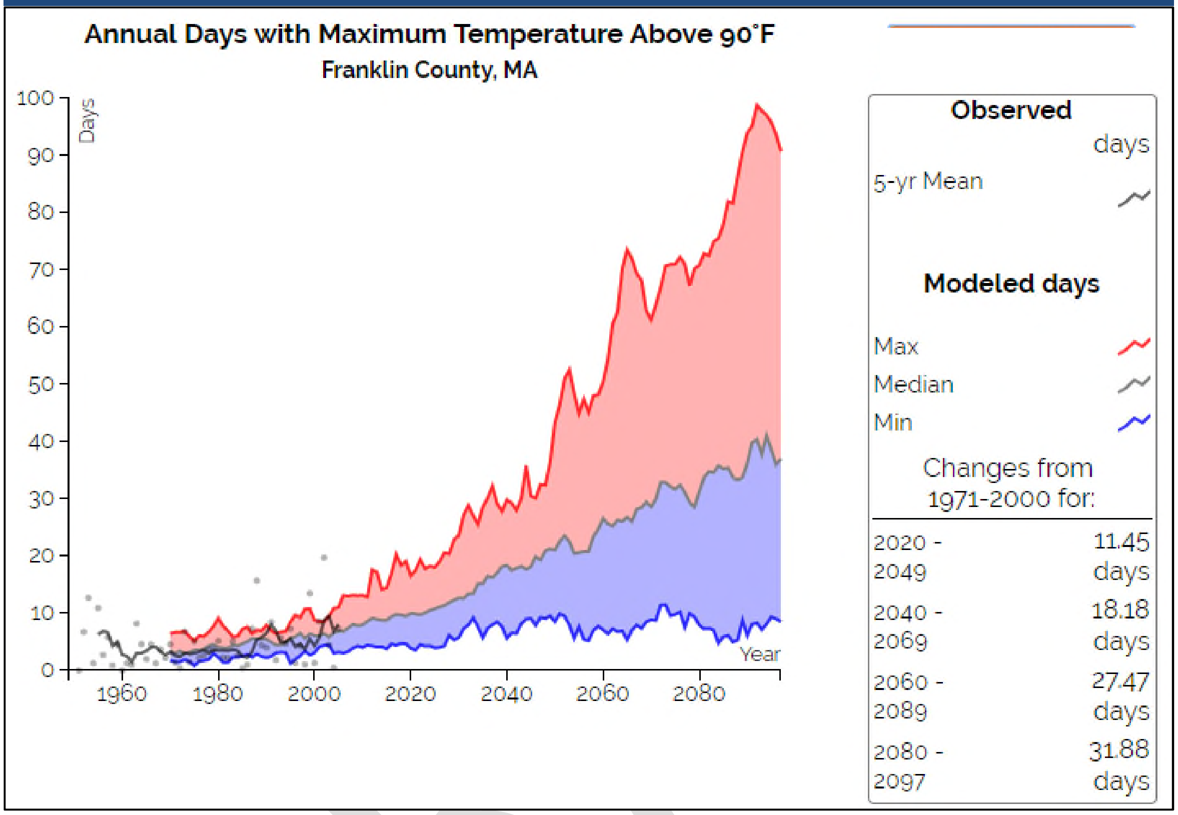
In 2012, Massachusetts temperatures broke 27 heat records. Most of these records were broken between June 20 and June 22, 2012, during the first major heat wave of the summer to hit Massachusetts and the East Coast. In July 2013, a long period of hot and humid weather occurred throughout New England. One fatality occurred on July 6, when a postal worker collapsed as the Heat Index reached 100°F. In Franklin County, excessive heat was recorded for July 1, 2018, when a heat index of 107°F was observed at the Orange Municipal Airport from 1:00 PM to 5:00 PM.

Historically, extreme temperatures have not been a significant hazard for Northfield and Warwick, and this hazard is no more likely to occur in Northfield and Warwick than elsewhere in the state.

Probability of Future Events
There are a number of climatic phenomena that determine the number of extreme weather events in a specific year. However, there are significant long-term trends in the frequency of extreme hot and cold events. In the last decade, U.S. daily record high temperatures have occurred twice as often as record lows (as compared to a nearly 1:1 ratio in the 1950s). Models suggest that this ratio could climb to 20:1 by midcentury, if GHG emissions are not significantly reduced. The data support the trends of an increased frequency of extreme hot weather events and a decreased frequency of extreme cold weather events.

The average, maximum, and minimum temperatures in Franklin County are likely to increase significantly over the next century (resilient MA, 2018). This gradual change will put long-term stress on a variety of social and natural systems, and will exacerbate the influence of discrete events. Significant increases in maximum temperatures are anticipated, particularly under a higher GHG emissions scenario. Figure 3-28 displays the projected increase in the number of days per year over 90°F. The number of days per year with daily maximum temperatures over 90°F is projected to increase by 18 days by the 2050s, and by 32 days by the end of the century (for a total of 36 days over 90°F), compared to the average observed range from 1971 to 2000 of 4 days per year. Under a high emissions scenario, however, there could be as many as 100 days with a maximum temperature above 90°F by the end of the century.

Figure 3-28: Projected Annual Days with a Maximum Temperature Above 90°F



Source: resilient MA, 2018.

In Northfield and Warwick, extreme temperatures have a “High” probability of future events, with a 25% - 50% chance of occurring in a given year.

Impact

Extreme Cold

Extreme cold is a dangerous situation that can result in health emergencies for susceptible people, such as those without shelter or who are stranded or who live in homes that are poorly insulated or without heat. Extreme cold events are events when temperatures drop well below normal in an area. Extreme cold temperatures are characterized by the ambient air temperature dropping to approximately 0°F or below.

When winter temperatures drop significantly below normal, staying warm and safe can become a challenge. Extremely cold temperatures often accompany a winter storm, which may also cause power failures and icy roads. During cold months, carbon monoxide may be high in some areas because the colder weather makes it difficult for car emission control systems to operate effectively, and temperature inversions can trap the resulting pollutants closer to the ground.

Staying indoors as much as possible can help reduce the risk of car crashes and falls on the ice, but cold weather also can present hazards indoors. Many homes may be too cold, either due to a power failure or because the heating system is not adequate for the weather. Exposure to cold temperatures, whether indoors or outside, can cause other serious or life-threatening health problems. Power outages may also result in inappropriate use of combustion heaters, cooking appliances, and generators in indoor or poorly ventilated areas, leading to increased risk of carbon monoxide poisoning or fire.

Extreme Heat

A heat wave is defined as three or more days of temperatures of 90°F or above. A basic definition of a heat wave implies that it is an extended period of unusually high atmosphere-related heat stress, which causes temporary modifications in lifestyle and which may have adverse health consequences for the affected population. Heat waves cause more fatalities in the U.S. than the total of all other meteorological events combined.

Heat impacts can be particularly significant in urban areas. Buildings, roads, and other infrastructure replace open land and vegetation. Dark-colored asphalt and roofs also absorb more of the sun’s energy. These changes cause urban areas to become warmer than the surrounding areas. This forms “islands” of higher temperatures, often referred to as “heat islands.” The term “heat island” describes built-up areas that are hotter than nearby rural or shaded areas. Heat islands occur on the surface and in the atmosphere. On a hot, sunny day, the sun can heat dry, exposed urban surfaces to temperatures 50°F to 90°F hotter than the air. Heat islands can affect communities by increasing peak energy demand during the summer, air conditioning costs, air pollution and GHG emissions, heat-related illness and death, and water quality degradation.

Extreme heat events can also have impacts on air quality. Many conditions associated with heat waves or more severe events—including high temperatures, low precipitation, strong sunlight and low wind speeds—contribute to a worsening of air quality in several ways. High temperatures can increase the production of ozone from volatile organic compounds and other aerosols. Weather patterns that bring high temperatures can also transport particulate matter air pollutants from other areas of the continent. Additionally, atmospheric inversions and low wind speeds allow polluted air to remain in one location for a prolonged period of time.

Vulnerability
The entire area of Northfield and Warwick is vulnerable to extreme temperatures.

Society

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

An additional element of vulnerability to extreme temperature events is homelessness, as homeless individuals have a limited capacity to shelter from dangerous temperatures. Two homeless people died from exposure to extreme cold in January 2019 in Greenfield.

Table 3-44 estimates the number of vulnerable populations and households in Northfield. Table 3-45 estimates the number of vulnerable populations and households in Warwick. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of residents during an extreme temperature event.

Table 3-44: Estimated Vulnerable Populations in Northfield		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	837	28%
Population with a Disability	627	11%
Population who Speak English Less than "Very Well"	49	1.6%
Vulnerable Household Category	**Number**	**Percent of Total Households***

Table 3-44: Estimated Vulnerable Populations in Northfield		
Low Income Households (annual income less than $35,000)	227	18%
Householder Age 65 Years and Over Living Alone	141	11%
Households Without Access to a Vehicle	61	5%

*Total population = 2,997; Total households = 1,234
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2014-2018 Five-Year Estimates.

Table 3-45: Estimated Vulnerable Populations in Warwick		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	173	22%
Population with a Disability	101	11%
Population who Speak English Less than "Very Well"	18	2.3%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	110	32%
Householder Age 65 Years and Over Living Alone	42	12%
Households Without Access to a Vehicle	6	2%

*Total population = 781; Total households = 345
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2014-2018 Five-Year Estimates.

<u>Health Impacts</u>

When people are exposed to extreme heat, they can suffer from potentially deadly illnesses, such as heat exhaustion and heat stroke. Heat is the leading weather-related killer in the U.S., even though most heat-related deaths are preventable through outreach and intervention. A study of heat-related deaths across Massachusetts estimated that when the temperature rises above the 85th percentile (hot: 85-86°F), 90th percentile (very hot: 87-89°F) and 95th percentile (extremely hot: 89-92°F) there are between five and seven excess deaths per day in Massachusetts. These estimates were higher for communities with high percentages of African American residents and elderly residents on days exceeding the 85th percentile.[49] A 2013 study

[49] Hattis, D. et al. 2012. The Spatial Variability of Heat-Related Mortality in Massachusetts. Applied Geography. 33(2012) pg 45-52. http://wordpress.clarku.edu/yogneva/files/2012/04/Hattis-et-al-2011-The-spatial-

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.[50] 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.[51]

Hot temperatures can contribute to deaths from heart attacks, strokes, other forms of cardiovascular disease, renal disease, and respiratory diseases such as asthma and chronic obstructive pulmonary disorder. Human bodies cool themselves primarily through sweating and through increasing blood flow to body surfaces. Heat events thus increase stress on cardiovascular, renal, and respiratory systems, and may lead to hospitalization or death in the elderly and those with pre-existing diseases.

Massachusetts has a very high prevalence of asthma: approximately 1 out of every 11 people in the state currently has asthma. In Massachusetts, poor air quality often accompanies heat events, as increased heat increases the conversion of ozone precursors in fossil fuel combustion emissions to ozone. Particulate pollution may also accompany hot weather, as the weather patterns that bring heat waves to the region may carry pollution from other areas of the continent. Poor air quality can negatively affect respiratory and cardiovascular systems, and can exacerbate asthma and trigger heart attacks.

The rate of hospital admissions for heat stress under existing conditions is shown in Figure 3-29. Between 2002 and 2012, the annual average age-adjusted rate of hospital admission for heat stress was highest in Plymouth and Suffolk Counties. Franklin County ranked among the second highest rate of 0.12-0.13 admissions per 10,000 people. As displayed in Figure 3-30, Franklin County experienced the highest annual average age-adjusted hospital admissions for heart attacks (4.29 to 4.17 per 10,000 people) during this period, along with Plymouth, Bristol, and Berkshire Counties. Hamden County had the highest annual average age emergency department visits due to asthma (see Figure 3-31), while Franklin County's rate was statistically significantly lower.

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variability-of-heat-related-mortality-in-Massachusetts.pdf

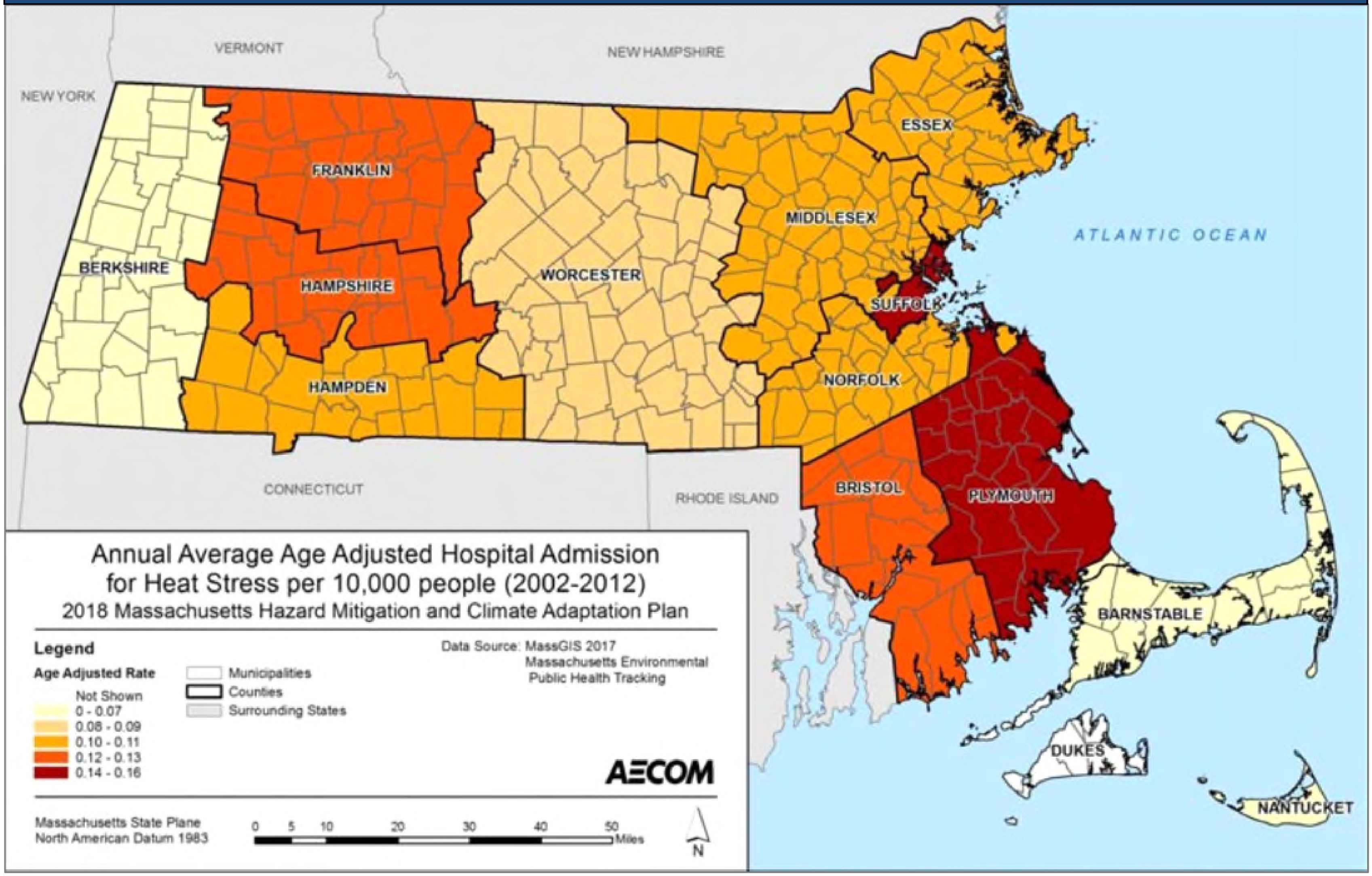
[50] Madrigano J, Mittleman MA, Baccarelli A, Goldberg R, Melly S, von Klot S, Schwartz J.Temperature, myocardial infarction, and mortality: effect modification by individual- and area-level characteristics. Epidemiology. 2013 May;24(3):439-46.

[51] Shi L. et al. 2015. Impacts of temperature and its variability on mortality in New England. Nature Climate Change. Volume 5. November 2015.

Some behaviors increase the risks of temperature-related impacts. These behaviors include voluntary actions, such as drinking alcohol or taking part in strenuous outdoor physical activities in extreme weather, but may also include necessary actions, such as taking prescribed medications that impair the body's ability to regulate its temperature or that inhibit perspiration.

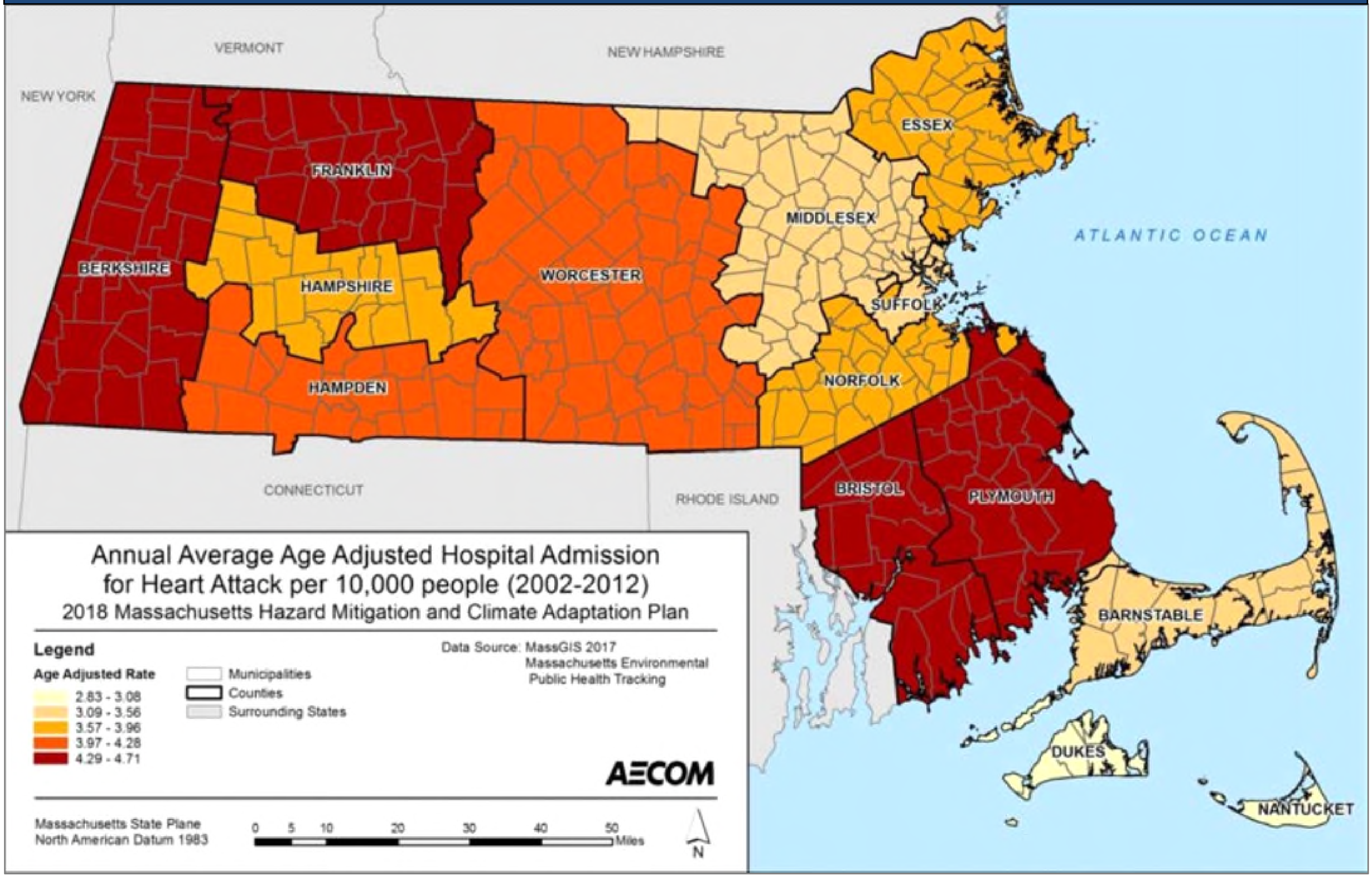
Cold-weather events can also have significant health impacts. The most immediate of these impacts are cold-related injuries, such as frostbite and hypothermia, which can become fatal if exposure to cold temperatures is prolonged. Similar to the impacts of hot weather that have already been described, cold weather can exacerbate pre-existing respiratory and cardiovascular conditions. Additionally, power outages that occur as a result of extreme temperature events can be immediately life-threatening to those dependent on electricity for life support or other medical needs. Isolation of these populations is a significant concern if extreme temperatures preclude their mobility or the functionality of systems they depend on. Power outages during cold weather may also result in inappropriate use of combustion heaters, cooking appliances, and generators in indoor or poorly ventilated areas, leading to increased risk of carbon monoxide poisoning or fires.

Figure 3-29: Rates of Heat Stress-Related Hospitalization by County



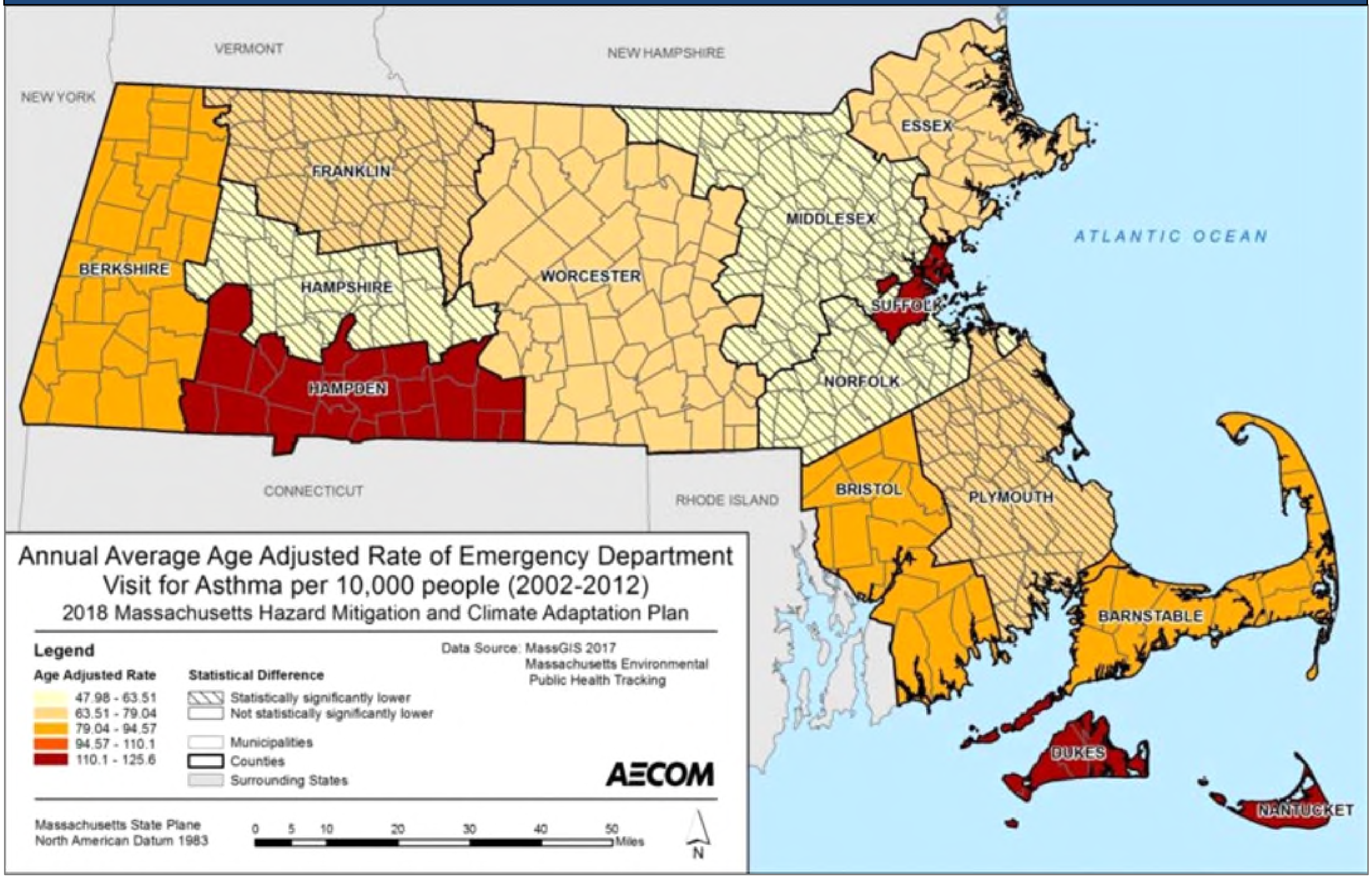
Source: Massachusetts Hazard Mitigation and Climate Adaptation Plan, September 2018.

Figure 3-30: Rates of Hospital Admissions for Heart Attacks by County



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

Figure 3-31: Rates of Emergency Department Visits Due to Asthma by County



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

Economic Impacts

Extreme temperature events also have impacts on the economy, including loss of business function and damage to and loss of inventory. Business owners may be faced with increased financial burdens due to unexpected building repairs (e.g., repairs for burst pipes), higher than normal utility bills, or business interruptions due to power failure (i.e., loss of electricity and telecommunications). Increased demand for water and electricity may result in shortages and a higher cost for these resources. Industries that rely on water for business (e.g., landscaping businesses) will also face significant impacts. There is a loss of productivity and income when the transportation sector is impacted and people and commodities cannot get to their intended destination. Businesses with employees that work outdoors (such as agricultural and construction companies) may have to reduce employees' exposure to the elements by reducing or shifting their hours to cooler or warmer periods of the day.

The agricultural industry is most directly at risk in terms of economic impact and damage due to extreme temperature and drought events. Extreme heat can result in drought and dry conditions, which directly impact livestock and crop production. Increasing average temperatures may make crops more susceptible to invasive species. Higher temperatures that result in greater concentrations of ozone negatively impact plants that are sensitive to ozone. Additionally, as described in the Environment sub-section, changing temperatures can impact the phenology.

Livestock are also impacted, as heat stress can make animals more vulnerable to disease, reduce their fertility, and decrease the rate of milk production. Additionally, scientists believe the use of parasiticides and other animal treatments may increase as the threat of invasive species and pests grows.

Infrastructure

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

Agriculture

Above average, below average, and extreme temperatures are likely to impact crops—such as apples, peaches, and maple syrup—that rely on specific temperature regimes. Unseasonably warm temperatures in early spring that are followed by freezing temperatures can result in crop loss of fruit-bearing trees. Increasing heat stress days (above 90°F) may stress livestock and some crops. More pest pressure from insects, diseases and weeds may harm crops and cause farms to increase pesticide use. Farmers may have the opportunity to introduce new crops that are viable under warmer conditions and longer growing seasons; however, a transition such as this may be costly.[52]

Energy

In addition to increasing demand for heating and cooling, periods of both hot and cold weather can stress energy infrastructure. Electricity consumption during summer may reach three times the average consumption rate of the period between 1960 and 2000; more than 25 percent of this consumption may be attributable to climate change.[53] In addition to affecting consumption rates, high temperatures can also reduce the thermal efficiency of electricity generation.

Extended-duration extreme cold can lead to energy supply concerns, as the heating sector then demands a higher percentage of the natural gas pipeline capacity. When this occurs, New England transitions electricity generation from natural gas to oil and liquid natural gas. Limited on-site oil and liquid natural gas storage as well as refueling challenges may cause energy supply concerns if the events are colder and longer in duration.

Transportation

Extreme heat has potential impacts on the design and operation of the transportation system. Impacts on the design include the instability of materials, particularly pavement, exposed to high temperatures over longer periods of time, which can cause buckling and lead to increased failures.[54] High heat can cause pavement to soften and expand, creating ruts, potholes, and jarring, and placing additional stress on bridge joints. Extreme heat may cause heat stress in materials such as asphalt and increase the frequency of repairs and replacements. Roads are also vulnerable to rapid freeze and thaw cycles, which may cause damage to road surfaces. An increase in freeze and thaw cycles can also damage bridge expansion joints.[55]

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

[52] Resilient MA: http://resilientma.org/sectors/agriculture. Accessed March 4, 2019.
[53] Massachusetts Executive Office of Energy and Environmental Affairs and the Adaptation Advisory Committee (EOEEA). 2011. Massachusetts Climate Change Adaptation Report.
[54] Massachusetts Department of Transportation (MassDOT). 2017. Assessment of Extreme Temperature Impacts on MassDOT Assets
[55] Resilient MA: http://resilientma.org/sectors/transportation. Accessed March 4, 2019.

temperatures inside the enclosure-encased equipment, such as traffic control devices and signal control systems for rail service, may result in equipment failure. Rail operations will also be impacted when mandatory speed reductions are issued in areas where tracks have been exposed to high temperatures over many days, resulting in increased transit travel time and operating costs as well as a reduction in track capacity. Finally, extreme temperatures also discourage active modes of transportation, such as bicycling and walking. This will have a secondary impact on sustainable transportation objectives and public health.

Operations are vulnerable to heat waves and associated power outages that affect electrical power supply to rail operations and to supporting ancillary assets for highway operations, such as electronic signing. Increased heat also impacts transportation workers, the viability of vegetation in rights-of-way, and vehicle washing or maintenance schedules.[56] Hot weather increases the likelihood that cars may overheat during hot weather, and also increases the deterioration rate of tires.

Water Infrastructure

Extreme temperatures do not pose as great a threat to water infrastructure as flood-related hazards, but changes in temperature can impact water infrastructure. For example, extreme heat that drives increases in air-conditioning demand can trigger power outages that disrupt water and wastewater treatment.[57] Hotter temperatures will also likely result in increased outdoor water consumption. Combined with other climate impacts such as an increase in surface water evapotranspiration, changing precipitation patterns, and groundwater recharge rates, increased water demand may challenge the capacity of water supplies and providers. Extreme heat can damage aboveground infrastructure such as tanks, reservoirs, and pump stations. Warmer temperatures can also lead to corrosion, water main breaks, and inflow and infiltration into water supplies. Extreme heat is likely to result in increased drought conditions, and this has significant implications for water infrastructure, as discussed in the Drought Section.

Extreme cold can freeze pipes, causing them to burst. This can then lead to flooding and mold inside buildings when frozen pipes thaw.

Environment

There are numerous ways in which changing temperatures will impact the natural environment. Because the species that exist in a given area have adapted to survive within a specific

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

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

temperature range, extreme temperature events can place significant stress both on individual species and the ecosystems in which they function. High-elevation spruce-fir forests, forested boreal swamp, and higher-elevation northern hardwoods are likely to be highly vulnerable to climate change. Higher summer temperatures will disrupt wetland hydrology. Paired with a higher incidence and severity of droughts, high temperatures and evapotranspiration rates could lead to habitat loss and wetlands drying out.[58] Individual extreme weather events usually have a limited long-term impact on natural systems, although unusual frost events occurring after plants begin to bloom in the spring can cause significant damage. However, the impact on natural resources of changing average temperatures and the changing frequency of extreme climate events is likely to be massive and widespread.

One significant impact of increasing temperatures may be the northern migration of plants and animals. Over time, shifting habitat may result in a geographic mismatch between the location of conservation land and the location of critical habitats and species the conserved land was designed to protect. One specific way in which average temperatures influence plant behavior is through changes in phenology, the pattern of seasonal life events in plants and animals. A recent study by the National Park Service found that of 276 parks studied, three-quarters are experiencing earlier spring conditions, as defined by the first greening of trees and first bloom of flowers, and half are experiencing an "extreme" early spring that exceeds 95% of historical conditions.[59] These changing seasonal cues can lead to ecological mismatches, as plants and animals that rely on each other for ecosystem services become "out of sync." For example, migratory birds that rely on specific food sources at specific times may reach their destinations before or after the species they feed on arrive or are in season. Additionally, invasive species tend to have more flexible phenologies than their native counterparts; therefore, shifting seasons may increase the competitiveness of present and introduced invasive species.

Wild plants and animals are also migrating away from their current habitats in search of the cooler temperatures to which they are accustomed. This is particularly pertinent for ecosystems that (like many in the northeastern U.S.) lie on the border between two biome types. For example, an examination of the Green Mountains of Vermont found a 299- to 390-foot upslope shift in the boundary between northern hardwoods and boreal forests between 1964 and 2004.[60] Such a shift is hugely significant for the species that live in this ecosystem as

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

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

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

well as for forestry companies or others who rely on the continued presence of these natural resources. Massachusetts ecosystems that are expected to be particularly vulnerable to warming temperatures include:

- Coldwater streams and fisheries
- Vernal pools
- Spruce-fir forests
- Northern hardwood (Maple-Beech-Birch) forests, which are economically important due to their role in sugar production
- Hemlock forests, particularly those with the hemlock wooly adelgid
- Urban forests, which will experience extra impacts due to the urban heat island effect

Additional impacts of warming temperatures include the increased survival and grazing damage of white-tailed deer, increased invasion rates of invasive plants, and increased survival and productivity of insect pests, which cause damage to forests.[61] As temperature increases, the length of the growing season will also increase.

Vulnerability Summary

Based on the above assessment, Northfield has a “Medium” vulnerability, and Warwick has a “High” vulnerability, to extreme temperatures. The problem statements in Section 2.4 summarize the areas of greatest concern regarding extreme temperatures for Northfield and Warwick.

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

3.14 INVASIVE SPECIES

Potential Impacts of Climate Change

A warming climate may place stress on colder-weather species while allowing non-native species accustomed to warmer climates to spread northward. This northward trend is already well documented, and is expected to accelerate in the future. Another way in which climate change may increase the frequency of natural species threat is through the possibility of climate refugees. As populations move to escape increasingly inhospitable climates, they are likely to bring along products, food, and livestock that could introduce novel (and potentially invasive) species to the areas in which they settle.

Extreme winter temperatures are also critical limiting factors for many forest pests, and warming is expected to increase their survival and lead to expansions and outbreaks. For example, in Massachusetts, it's likely that winter temperatures have been limiting the impact of hemlock wooly adelgid (Adelges tsugae), as many infested forest stands are surviving while in more southerly ranges there is near complete mortality from this pest. But the adelgid has already expanded its range with warming winter temperatures and is likely to have increased survival and higher reproductive rates in the northern portion of its range as temperatures warm, likely leading to more significant impacts on forests.[62]

Figure 3-32: Impacts of Climate Change on Invasive Species

Potential Effects of Climate Change		
	RISING TEMPERATURES ➔ WARMING CLIMATE	A warming climate may place stress on colder-weather species, while allowing non-native species accustomed to warmer climates to spread northward.
	RISING TEMPERATURES AND CHANGES IN PRECIPITATION ➔ ECOSYSTEM STRESS	Changes in precipitation and temperature combine to create new stresses for Massachusetts' unique ecosystems. For example, intense rainfall in urbanized areas can cause pollutants on roads and parking lots to get washed into nearby rivers and lakes, reducing habitat quality. As rainfall and snowfall patterns change, certain habitats and species that have specific physiological requirements may be affected. The stresses experienced by native ecosystems as a result of these changes may increase the chances of a successful invasion of non-native species.

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

Hazard Description

"Invasives" are species recently introduced to new ecosystems that cause or are likely to cause significant harm to the environment, economy, or human health. Invasives compete with native plants and wildlife for resources, disrupt beneficial relationships, spread disease, cause direct

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

mortality, and can significantly alter ecosystem function. Some of the more common invasives in Massachusetts may already be familiar - problematic invasive plants include purple loosestrife (Lythrum salicaria), Japanese barberry (Berberis thunbergi), glossy buckthorn (Frangula alnus), multiflora rose (Rosa multiflora), Japanese knotweed (Fallopia japonica), garlic mustard (Alliaria petiolata) and black locust (Robinia pseudoacacia). Invasive animals include forest pests such as the hemlock woolly adelgid (Adelgis tsugae), Asian longhorn beetle (Anoplophora glabripennis), and the emerald ash borer (Agrilus planipennis). The zebra mussel (Dreissena polymorpha) is a particularly detrimental aquatic invasive species that has recently been detected in Western Massachusetts.[63]

The Massachusetts Invasive Plant Advisory Group (MIPAG), a collaborative representing organizations and professionals concerned with the conservation of the Massachusetts landscape, is charged by the Massachusetts Executive Office of Energy and Environmental Affairs to provide recommendations to the Commonwealth to manage invasive species. MIPAG defines invasive plants as "non-native species that have spread into native or minimally managed plant systems in Massachusetts, causing economic or environmental harm by developing self- sustaining populations and becoming dominant and/or disruptive to those systems." These species have biological traits that provide them with competitive advantages over native species, particularly because in a new habitat they are not restricted by the biological controls of their native habitat. As a result, these invasive species can monopolize natural communities, displacing many native species and causing widespread economic and environmental damage. MIPAG recognized 69 plant species as "Invasive," "Likely Invasive," or "Potentially Invasive."

Massachusetts has a variety of laws and regulations in place that attempt to mitigate the impacts of these species. The Massachusetts Department of Agricultural Resources (MDAR) maintains a list of prohibited plants for the state, which includes federally noxious weeds as well as invasive plants recommended by MIPAG and approved for listing by MDAR. Species on the MDAR list are regulated with prohibitions on importation, propagation, purchase, and sale in the Commonwealth. Additionally, the Massachusetts Wetlands Protection Act (310 CMR 10.00) includes language requiring all activities covered by the Act to account for, and take steps to prevent, the introduction or propagation of invasive species.

In 2000, Massachusetts passed an Aquatic Invasive Species Management Plan, making the Commonwealth eligible for federal funds to support and implement the plan through the federal Aquatic Nuisance Prevention and Control Act. MassDEP is part of the Northeast Aquatic

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

Nuisance Species Panel, which was established under the federal Aquatic Nuisance Species Task Force. This panel allows managers and researchers to exchange information and coordinate efforts on the management of aquatic invasive species. The Commonwealth also has several resources pertaining to terrestrial invasive species, such as the Massachusetts Introduced Pest Outreach Project, although a strategic management plan has not yet been prepared for these species.

Code of Massachusetts Regulation (CMR) 330 CMR 6.0(d) requires any seed mix containing restricted noxious weeds to specify the name and number per pound on the seed label. Regulation 339 CMR 9.0 restricts the transport of currant or gooseberry species in an attempt to prevent the spread of white pine blister rust. There are also a number of state laws pertaining to invasive species. Chapters 128, 130, and 132 of Part I of the General Laws of the state include language addressing water chestnuts, green crabs, the Asian longhorn beetle, and a number of other species. These laws also include language allowing orchards and gardens to be surveyed for invasive species and for quarantines to be put into effect at any time.

Identification and monitoring is an important element in mitigating impacts from invasive species. The Outsmart Invasive Species project is a collaboration between the University of Massachusetts Amherst, the Massachusetts Department of Conservation and Recreation (MA DCR) and the Center for Invasive Species and Ecosystem Health at the University of Georgia. The goal of the project is to strengthen ongoing invasive-species monitoring efforts in Massachusetts by enlisting help from citizens. The web- and smartphone-based approach enables volunteers to identify and collect data on invasive species in their own time, with little or no hands-on training. By taking advantage of the increasing number of people equipped with iPhone or digital camera/web technology, this approach will expand the scope of invasive-species monitoring, in an effort to help control outbreaks of new or emergent invasive species that threaten our environment.[64]

Location

The damage rendered by invasive species is significant. The massive scope of this hazard means that the entirety of both Northfield and Warwick may experience impacts from these species. Furthermore, the ability of invasive species to travel far distances (either via natural mechanisms or accidental human interference) allows these species to propagate rapidly over a large geographic area. Similarly, in open freshwater ecosystems, invasive species can quickly spread once introduced, as there are generally no physical barriers to prevent establishment, outside of physiological tolerances, and multiple opportunities for transport to new locations

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

(by boats, for example).

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

Extent

Invasive species are a widespread problem in Massachusetts and throughout the country. The geographic extent of invasive species varies greatly depending on the species in question and other factors, including habitat and the range of the species. Some (such as the gypsy moth) are nearly controlled, whereas others, such as the zebra mussel, are currently adversely impacting ecosystems throughout the Commonwealth. Invasive species can be measured through monitoring and recording observances.

Previous Occurrences

The terrestrial and freshwater species listed on the MIPAG website as “Invasive” (last updated April 2016) are identified in Table 3-46. The table also includes details on the nature of the ecological and economic challenges presented by each species as well as information on where the species has been detected in Massachusetts. Nineteen of the invasive species on the list have been observed in Northfield and Warwick since 2010.

Table 3-46: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Northfield (N) Warwick(W)**
Acer platanoides L. (**Norway maple**)	A tree occurring in all regions of the state in upland and wetland habitats, and especially common in woodlands with colluvial soils. It grows in full sun to full shade. Escapes from cultivation; can form dense stands; out-competes native vegetation, including sugar maple; dispersed by water, wind and vehicles.	N, W
Aegopodium podagraria L. (**Bishop's goutweed; bishop's weed; goutweed**)	A perennial herb occurring in all regions of the state in uplands and wetlands. Grows in full sun to full shade. Escapes from cultivation; spreads aggressively by roots; forms dense colonies in flood plains.	N, W
Ailanthus altissima (P. Miller) Swingle (**Tree of heaven**)	This tree occurs in all regions of the state in upland, wetland, & coastal habitats. Grows in full sun to full shade. Spreads aggressively from root suckers, especially in disturbed areas.	
Alliaria petiolata (Bieb.) Cavara & Grande (**Garlic mustard**)	A biennial herb occurring in all regions of the state in uplands. Grows in full sun to full shade. Spreads aggressively by seed, especially in wooded areas.	N, W
Berberis thunbergii DC. (**Japanese barberry**)	A shrub occurring in all regions of the state in open and wooded uplands and wetlands. Grows in full sun to full shade. Escaping from cultivation; spread by birds; forms dense stands.	N, W
Cabomba caroliniana A.Gray (**Carolina fanwort; fanwort**)	A perennial herb occurring in all regions of the state in aquatic habitats. Common in the aquarium trade; chokes waterways.	
Celastrus orbiculatus Thunb. (**Oriental bittersweet; Asian or Asiatic bittersweet**)	A perennial vine occurring in all regions of the state in uplands. Grows in full sun to partial shade. Escaping from cultivation; berries spread by birds and humans; overwhelms and kills vegetation.	N, W
Cynanchum louiseae Kartesz & Gandhi (**Black swallow-wort, Louise's swallow-wort**)	A perennial vine occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to partial shade. Forms dense stands, out-competing native species: deadly to Monarch butterflies.	N
Elaeagnus umbellata Thunb. (**Autumn olive**)	A shrub occurring in uplands in all regions of the state. Grows in full sun. Escaping from cultivation; berries spread by birds; aggressive in open areas; has the ability to change soil.	N, W

Table 3-46: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Northfield (N) Warwick(W)**
Euonymus alatus (Thunb.) Sieb. (**Winged euonymus; Burning bush**)	A shrub occurring in all regions of the state and capable of germinating prolifically in many different habitats. It grows in full sun to full shade. Escaping from cultivation and can form dense thickets and dominate the understory; seeds are dispersed by birds.	N, W
Frangula alnus P. Mill. (**European buckthorn; glossy buckthorn**)	Shrub or tree occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Produces fruit throughout the growing season; grows in multiple habitats; forms thickets.	N, W
Hesperis matronalis L. (**Dame's rocket**)	A biennial and perennial herb occurring in all regions of the state in upland and wetland habitats. Grows in full sun to full shade. Spreads by seed; can form dense stands, particularly in flood plains.	N, W
Iris pseudacorus L. (**Yellow iris**)	A perennial herb occurring in all regions of the state in wetland habitats, primarily in flood plains. Grows in full sun to partial shade. Out-competes native plant communities.	N
Lonicera japonica Thunb. (**Japanese honeysuckle**)	A perennial vine occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Rapidly growing, dense stands climb and overwhelm native vegetation; produces many seeds that are bird dispersed; more common in southeastern Massachusetts.	
Lonicera morrowii A.Gray (**Morrow's honeysuckle**)	A shrub occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Part of a confusing hybrid complex of nonnative honeysuckles commonly planted and escaping from cultivation via bird dispersal.	N, W
Lonicera x bella Zabel [*morrowii* x *tatarica*] (**Bell's honeysuckle**)	This shrub occurs in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Part of a confusing hybrid complex of nonnative honeysuckles commonly planted and escaping from cultivation via bird dispersal.	N
Lysimachia nummularia L. (**Creeping jenny; moneywort**)	A perennial herb occurring in all regions of the state in upland and wetland habitats. Grows in full sun to full shade. Escaping from cultivation;	N, W

Table 3-46: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Northfield (N) Warwick(W)**
	problematic in flood plains, forests and wetlands; forms dense mats.	
Lythrum salicaria L. (**Purple loosestrife**)	A perennial herb or subshrub occurring in all regions of the state in upland and wetland habitats. Grows in full sun to partial shade. Escaping from cultivation; overtakes wetlands; high seed production and longevity.	N, W
Myriophyllum heterophyllum Michx. (**Variable water-milfoil; Two-leaved water-milfoil**)	A perennial herb occurring in all regions of the state in aquatic habitats. Chokes waterways, spread by humans and possibly birds.	
Myriophyllum spicatum L. (**Eurasian or European water-milfoil; spike water-milfoil**)	A perennial herb found in all regions of the state in aquatic habitats. Chokes waterways, spread by humans and possibly birds.	N
Phalaris arundinacea L. (**Reed canary-grass**)	This perennial grass occurs in all regions of the state in wetlands and open uplands. Grows in full sun to partial shade. Can form huge colonies and overwhelm wetlands; flourishes in disturbed areas; native and introduced strains; common in agricultural settings and in forage crops.	N, W
Phragmites australis (Cav.) Trin. ex Steud. subsp. australis (**Common reed**)	A perennial grass (USDA lists as subshrub, shrub) found in all regions of the state. Grows in upland and wetland habitats in full sun to full shade. Overwhelms wetlands forming huge, dense stands; flourishes in disturbed areas; native and introduced strains.	N, W
Polygonum cuspidatum Sieb. & Zucc. (**Japanese knotweed; Japanese or Mexican Bamboo**)	A perennial herbaceous subshrub or shrub occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade, but hardier in full sun. Spreads vegetatively and by seed; forms dense thickets.	N, W
Polygonum perfoliatum L. (**Mile-a-minute vine or weed; Asiatic tearthumb**)	This annual herbaceous vine is currently known to exist in several counties in MA, and has also has been found in RI and CT. Habitats include streamside, fields, and road edges in full sun to partial shade. Highly aggressive; bird and human dispersed.	
Potamogeton crispus L. (**Crisped pondweed; curly pondweed**)	A perennial herb occurring in all regions of the state in aquatic habitats. Forms dense mats in the spring and persists vegetatively.	N

Table 3-46: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Northfield (N) Warwick(W)**
Ranunculus ficaria L. (**Lesser celandine; fig buttercup**)	A perennial herb occurring on stream banks, and in lowland and uplands woods in all regions of the state. Grows in full sun to full shade. Propagates vegetatively and by seed; forms dense stands especially in riparian woodlands; an ephemeral that outcompetes native spring wildflowers.	
Rhamnus cathartica L. (**Common buckthorn**)	A shrub or tree occurring in all regions of the state in upland and wetland habitats. Grows in full sun to full shade. Produces fruit in fall; grows in multiple habitats; forms dense thickets.	N, W
Robinia pseudoacacia L. (**Black locust**)	A tree that occurs in all regions of the state in upland habitats. Grows in full sun to full shade. While the species is native to central portions of Eastern North America, it is not indigenous to Massachusetts. It has been planted throughout the state since the 1700's and is now widely naturalized. It behaves as an invasive species in areas with sandy soils.	N, W
Rosa multiflora Thunb. (**Multiflora rose**)	A perennial vine or shrub occurring in all regions of the state in upland, wetland and coastal habitats. Grows in full sun to full shade. Forms impenetrable thorny thickets that can overwhelm other vegetation; bird dispersed.	N, W
Trapa natans L. (**Water-chestnut**)	An annual herb occurring in the western, central, and eastern regions of the state in aquatic habitats. Forms dense floating mats on water.	

Source: Massachusetts Invasive Plant Advisory Group, https://www.massnrc.org/mipag/invasive.htm, and Franklin County Flora Group, 2019.

Although there are less clear-cut criteria for invasive fauna, there are a number of animals that have disrupted natural systems and inflicted economic damage on the Commonwealth, and may impact Northfield and Warwick (Table 3-47). One invasive species, the Zebra mussel, was first documented in Massachusetts in Berkshire County in 2009. Invasive fungi are also included in this table. Because of the rapidly evolving nature of the invasive species hazard, this list is not considered exhaustive.

Table 3-47: Invasive Animal and Fungi Species in Massachusetts

Species (Common Name)	Notes on Occurrence and Impact
Terrestrial Species	
Lymantria dispar dispar (**Gypsy moth** (insect))	This species was imported to Massachusetts for silk production, but escaped captivity in the 1860s. It is now found throughout the Commonwealth and has spread to parts of the Midwest. This species is considered a serious defoliator of oaks and other forest and urban trees; however, biological controls have been fairly successful against it.
Ophiostoma ulmi, Ophiostoma himal-ulmi, Ophiostoma novo-ulmi (**Dutch elm disease** (fungus))	In the 1930s, this disease arrived in Cleveland, Ohio, on infected elm logs imported from Europe. A more virulent strain arrived in the 1940s. The American elm originally ranged in all states east of Rockies, and elms were once the nation's most popular urban street tree. However, the trees have now largely disappeared from both urban and forested landscapes. It is estimated that "Dutch" elm disease has killed more than 100 million trees.
Adelges tsugae (**Hemlock woolly adelgid** (insect))	This species was introduced accidentally around 1924 and is now found from Maine to Georgia, including all of Massachusetts. It has caused up to 90% mortality in eastern hemlock species, which are important for shading trout streams and provide habitat for about 90 species of birds and mammals. It has been documented in about one-third of Massachusetts cities and towns and threatens the state's extensive Eastern Hemlock groves.
Cryphonectria parasitica (**Chestnut blight** (fungus))	This fungus was first detected in New York City in 1904. By 1926, the disease had devastated chestnuts from Maine to Alabama. Chestnuts once made up one-fourth to one-half of eastern U.S. forests, and the tree was prized for its durable wood and as a food for humans, livestock, and wildlife. Today, only stump sprouts from killed trees remain.
Anoplophora glabripennis (**Asian long-horned beetle**)	This species was discovered in Worcester in 2008. The beetle rapidly infested trees in the area, resulting in the removal of nearly 30,000 infected or high-risk trees in just 3 years.

Table 3-47: Invasive Animal and Fungi Species in Massachusetts	
Species (Common Name)	**Notes on Occurrence and Impact**
Cronartium ribicola (**White pine blister rust** (fungus))	This fungus is an aggressive and non-native pathogen that was introduced into eastern North America in 1909. Both the pine and plants in the Ribes genus (gooseberries and currants) must be present in order for the disease to complete its life cycle. The rust threatens any pines within a quarter-mile radius from infected Ribes.
Aquatic Species	
Dreissena polymorpha (**Zebra mussel**)	The first documented occurrence of zebra mussels in a Massachusetts water body occurred in Laurel Lake in July 2009. Zebra mussels can significantly alter the ecology of a water body and attach themselves to boats hulls and propellers, dock pilings, water intake pipes and aquatic animals. They are voracious eaters that can filter up to a liter of water a day per individual. This consumption can deprive young fish of crucial nutrients.

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

Probability of Future Events

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

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

Impact

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

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

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

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

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

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

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

Species roles may change as the climate changes, further complicating the management and policy response. As species ranges shift and existing inter-species relationships are broken, there is the potential that some species, including native species, may become pests because the interspecies interactions (e.g., predation, herbivory) that used to keep their population numbers in check are no longer functional.[65]

Once established, invasive species often escape notice for years or decades. Introduced species that initially escaped many decades ago are only now being recognized as invasives. Because these species can occur anywhere (on public or private property), new invasive species often escape notice until they are widespread and eradication is impractical. As a result, early and coordinated action between public and private landholders is critical to preventing widespread damage from an invasive species.

Vulnerability

Because plant and animal life is so abundant in Northfield and Warwick, the entire area of both towns is considered to be exposed to the invasive species hazard, which has the potential to cause "Limited" impacts. Areas with high amounts of plant or animal life may be at higher risk of exposure to invasive species than less vegetated areas; however, invasive species can disrupt ecosystems of all kinds.

Society

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

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

Vulnerable Populations

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

Health Impacts

Of particular concern to human health are species like the Asian tiger mosquito (Aedes albopictus). This invasive mosquito, originally from southeast and subtropical Asia has moved through the Eastern U.S. and has recently arrived in Massachusetts. Capable of spreading West Nile Virus, Equine Encephalitis, and numerous other tropical diseases, this aggressive mosquito is likely range-limited by cold winter temperatures, suitable landscape conditions (it prefers urban areas), and variation in moisture. As winter temperatures increase, the species is likely to become more prevalent in Massachusetts and throughout the Northeast, increasing the risk of serious illness for residents in summer months.[66]

Additional invasive species have negative impacts on human health. The Tree of Heaven (Ailanthus altissima)) produces powerful allelochemicals that prevent the reproduction of other species and can cause allergic reactions in humans. Similarly, due to its voracious consumption, the zebra mussel accumulates aquatic toxins, such as polychlorinated biphenyls or polyaromatic hydrocarbons, in their tissues at a rapid rate. When other organisms consume these mussels, the toxins can accumulate, resulting in potential human health impacts if humans consume these animals.

Loss of urban tree canopy from invasive species and pests can lead to higher summertime temperatures and greater vulnerability to extreme temperatures. Health impacts from extreme heat exposure is discussed in the Extreme Temperature section.

Economic Impacts

Economic impacts include the cost to control invasive species on public and private land. Individuals who are particularly vulnerable to the economic impacts of this hazard include all groups who depend on existing ecosystems in Conway for their economic success. This includes all individuals working in forestry and agriculture-related fields, as well as those whose

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

livelihoods depend on outdoor recreation activities such as hunting, hiking, or aquatic sports. Businesses catering to visitors who come to a town for outdoor recreation opportunities can also suffer from loss of business. Additionally, homeowners whose properties are adjacent to vegetated areas or waterbodies experiencing decline from an invasive species outbreak could experience decreases in property value.

Infrastructure

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

<u>Agriculture</u>

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

<u>Public Health</u>

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

<u>Transportation</u>

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

<u>Water Infrastructure</u>

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

Environment

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

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

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

- A combination of an earlier growing season, more frequent gaps in the forest canopy from wind and ice storms, and carbon dioxide fertilization will likely favor invasive plants over our native trees and forest vegetation.
- Preferential browse of native plants by larger deer populations may favor invasive species and inhibit the ability of a forest to regenerate after wind and ice storms.
- Warming temperatures favor some invasive plants, insects, and diseases, whose populations have historically been kept in check by the cold climate.
- Periods of drought weaken trees and can make them more susceptible to insects and diseases.[67]

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

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[67] Catanzaro, Paul, Anthony D'Amato, and Emily Silver Huff. *Increasing Forest Resiliency for an Uncertain Future*. University of Massachusetts Amherst, University of Vermont, USDA Forest Service. 2016

- Diminished property values
- Local and complete extinction of rare and endangered species

Vulnerability Summary

Based on the above assessment, Northfield has a “Medium” vulnerability, and Warwick has a “High” vulnerability, to Invasive species. The problem statements in Section 2.4 summarize the areas of greatest concern regarding invasive species in Northfield and Warwick.

3.15 VECTOR-BORNE DISEASES[68]

Hazard Profile

Vector-borne disease is defined by the Centers for Disease Control (CDC) as illnesses in humans that are caused by contact (being bitten by) a vector such as mosquito, tick, or flea. Examples of mosquito-borne diseases include Chikungunya, Eastern Equine Encephalitis (EEE), Zika and West Nile Virus. Examples of tick-borne disease include Lyme disease, Anaplasmosis/Ehrlichiosis, Babesiosis and Powassan.

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

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

Probability of Occurrence

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

[68] This section relies heavily on a template prepared by the Berkshire Regional Planning Commission (BRPC) for towns in their region that are working to update local hazard mitigation plans. BRPC shared this text with Carolyn Shores Ness, Board of Health and Select Board member for the Town of Deerfield. FRCOG updated available statistics for Franklin County.

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

Location

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

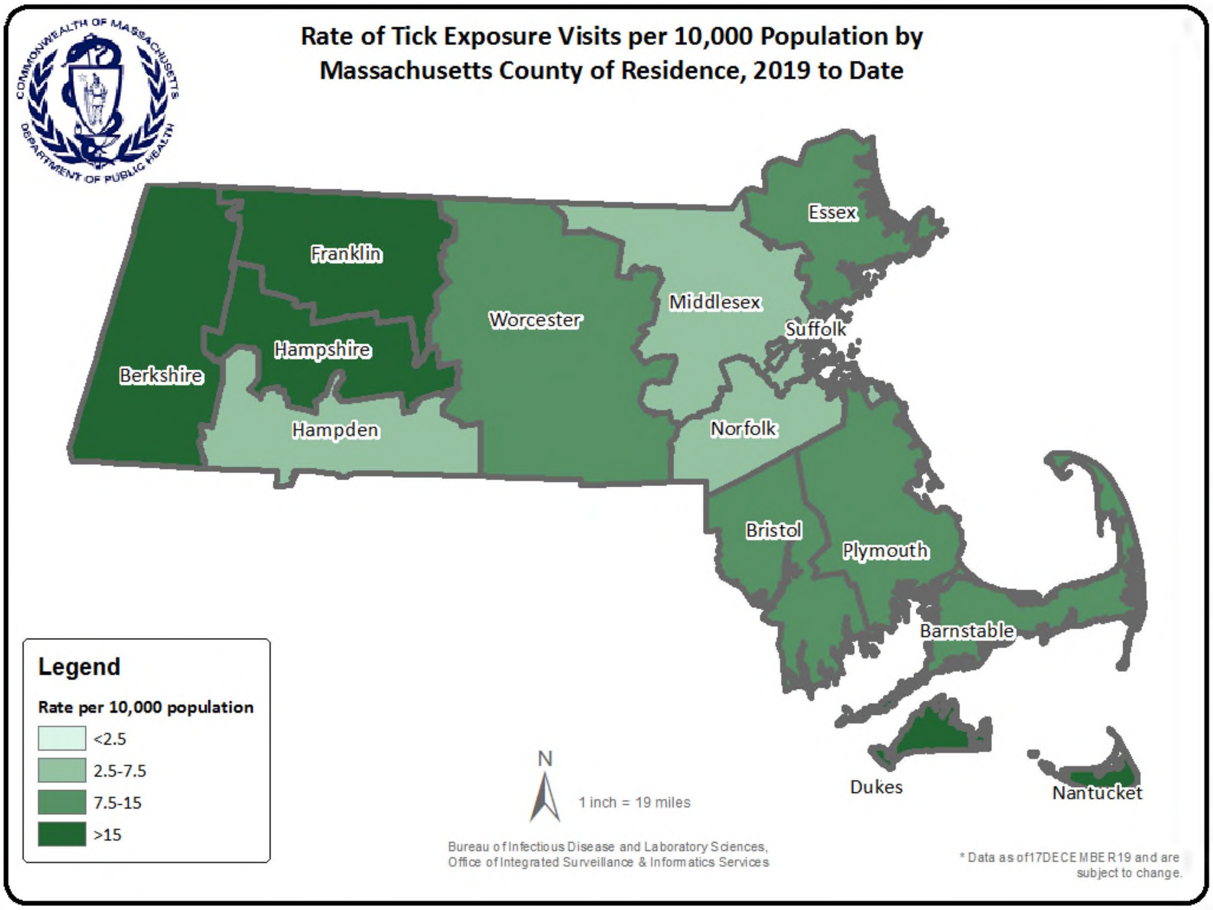
Extent

Tick-borne Illness

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

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

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



Babesiosis

- 590 confirmed and probable cases of Babesiosis were reported in Massachusetts in 2017, a 13% increase from 2016. Overall, 1,677 suspect cases of Babesiosis were investigated.
- 2 confirmed cases in Franklin County.
- Statewide, Babesiosis incidence increased from 7.9 to 9.0 cases per 100,000 residents. The incidence in Berkshire, Dukes, Hampden, Hampshire, Norfolk, Plymouth, Suffolk, and Worcester counties increased slightly. Counties with the highest incidence continued to be Barnstable, Dukes, and Nantucket.
- The majority of cases occurred in June, July and August, with only 35% of cases reporting awareness of a recent tick bite.
- People aged 60 years and older continue to be at greatest risk for clinical disease (59% of all patients identified with Babesiosis were 60 years or older) and 66% of all cases were male.

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

Human Granulocytic Anaplasmosis (HGA)

- Statewide, HGA incidence increased from 13.3 to 18.4 cases per 100,000 residents. The counties with the highest incidence are Barnstable, Berkshire, Dukes, Franklin, Nantucket and Plymouth. Berkshire County had the greatest change in incidence, from 66.3 to 133.4 cases per 100,000 residents.
- 27 confirmed cases in Franklin County.
- The majority of cases occurred in May, June, and July, with only 45% of cases reporting awareness of a recent tick bite.
- People aged 60 years and over continue to be at greatest risk for clinical disease (56% of patients identified with HGA were 60 or over) and 64% of all cases were male.
- Nearly one out of three patients with HGA (29%) was hospitalized. The symptoms most commonly reported included fever (93%), malaise (72%), and muscle aches and pain (63%). There were three fatalities.

Lyme disease

- 3,830 confirmed Lyme disease cases, and 1,770 probable cases, were reported in Massachusetts in 2014, which is a decrease of 1% from the number of confirmed and probable cases reported in 2013
- 50 confirmed cases in Franklin County in 2014.
- The highest incidence rates were among children aged 5-9 years and adults aged 65-74 years.
- The majority of cases had onsets in June, July, and August.
- 66% of confirmed cases had a reported erythema migrans (“bulls-eye”) rash.

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

- In 2019, 92 suspect Lyme
- In 2018, 76 suspect Lyme
- In 2017, 86 suspect Lyme
- Babesiosis 1 (5 were reported but 4 were revoked-determined not to be Babesiosis)
- HGA Human Granulocytic Anaplasmosis (37 total reported, 11 confirmed, 14 suspect, 1

probable and 10 revoked)

- Erlichiosis 1 (6 reported: 1 probable, 5 revoked)
- No other tick-borne illnesses reported in 2019.

Mosquito-borne Illnesses

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

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

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

Historically, clusters of human cases have occurred over a period of two to three years, with a variable number of years between clusters. In the years between these case clusters or outbreaks, isolated cases can and do occur. Outbreaks of human EEE disease in Massachusetts occurred in 1938-39, 1955-56, 1972-74, 1982-84, 1990-92, and, 2004-06. Two cases of EEE occurred in each of 2010 and 2011; one case each of these years occurred in visitors to Massachusetts. Seven human cases of EEE occurred in 2012, a single case in 2013 and no cases from 2014 - 2018.

The narrative above and the following figures are from the MA Department of Public Health's 2019 Arbovirus Surveillance and Response Plan.[69]

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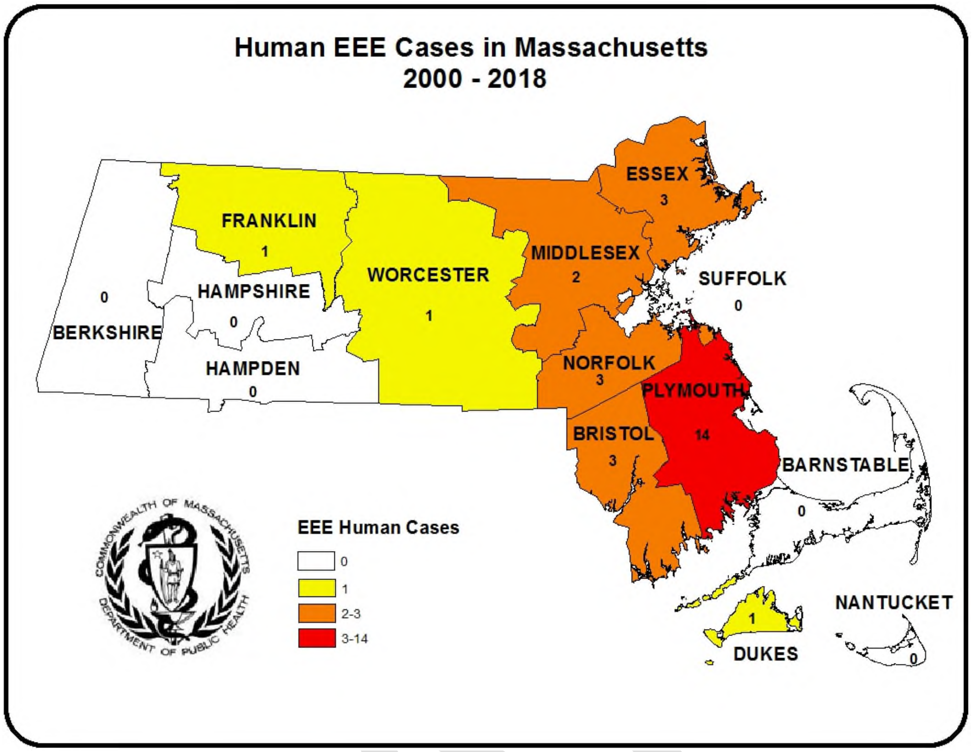
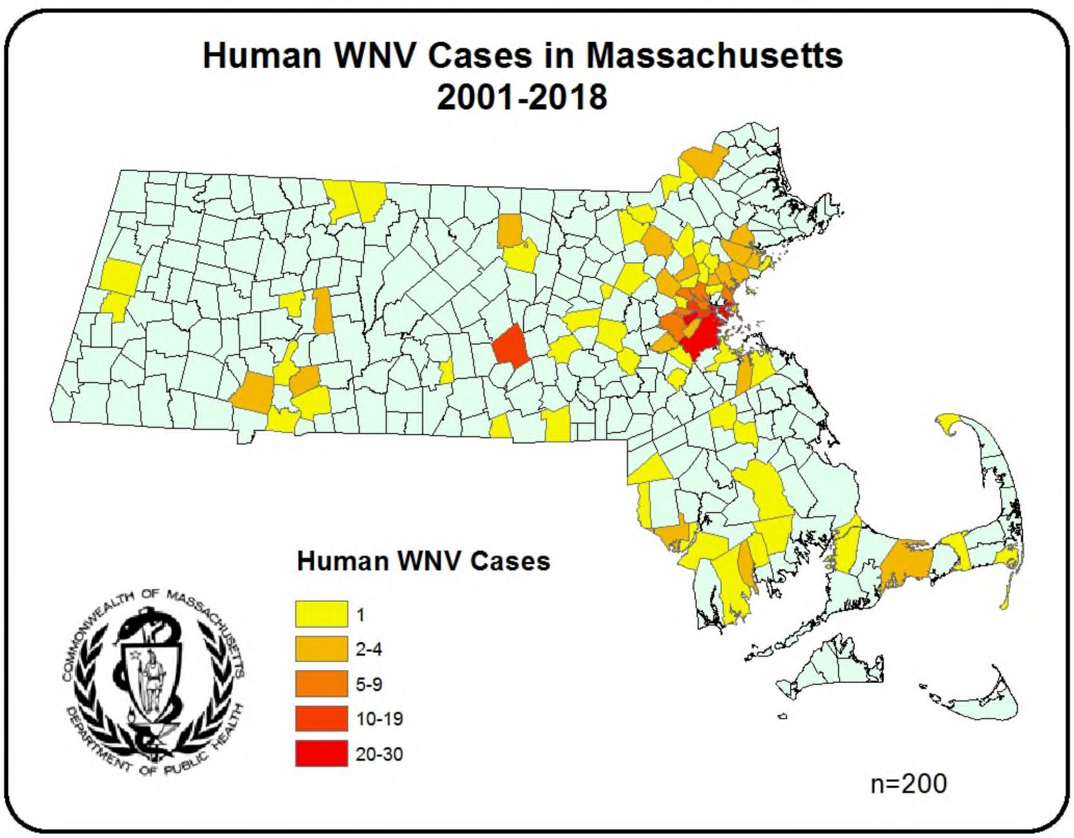
[69] https://www.mass.gov/lists/arbovirus-surveillance-plan-and-historical-data accessed March 20, 2020. Narrative





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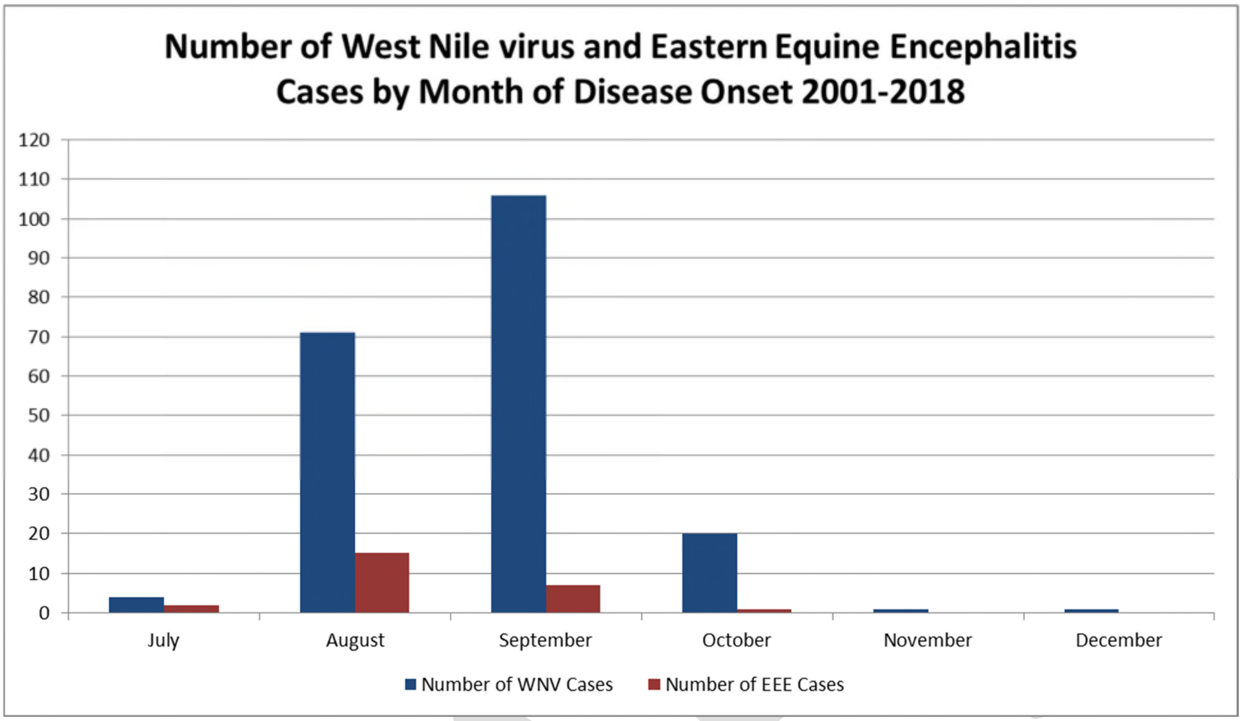

West Nile virus (WNV) first appeared in the United States in 1999. Since the initial outbreak in New York City, the virus has spread across the US from east to west. Following the identification of WNV in birds and mosquitoes in Massachusetts during the summer of 2000, MDPH arranged meetings between local, state, and federal officials, academicians, environmentalists and the public to develop recommendations to adapt the arbovirus surveillance and response plan to include activities appropriate for WNV. Four workgroups addressed the issues of surveillance, risk reduction interventions, pesticide toxicity, and communication.

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

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

2019 Arbovirus results summary

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

LAST UPDATED: November 14, 2019

Vulnerability

Society

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

Infrastructure

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

Natural Environment

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

Economy

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

Future Conditions

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

3.16 MANMADE HAZARDS

Hazard Description

Most non-natural or manmade hazards fall into two general categories: intentional acts and accidental events, although these categories can overlap. Some of the hazards included in these two categories, as defined by MEMA, consist of intentional acts such as explosive devices, biological and radiological agents, arson and cyberterrorism and accidental events such as nuclear hazards, infrastructure failure, industrial and transportation accidents. Accidental events can arise from human activities such as the manufacture, transportation, storage, and use of hazardous materials.

This plan does not address all manmade hazards that could affect Franklin County. A complete hazards vulnerability analysis was not within the scope of this update. For the purposes of this plan, non-natural hazards that are of an accidental nature were evaluated. They include industrial transportation accidents and industrial accidents in a fixed facility. New to this plan is an evaluation of cyber-security, which has become a threat of greater concern in recent years.

Hazardous Materials Definition

Hazardous materials in various forms can cause death, serious injury, long-lasting health effects, and damage to buildings, homes, and other property. Many products containing hazardous chemicals are used and stored in homes routinely. These products are also shipped daily on the nation's highways, railroads, waterways, and pipelines. Chemical manufacturers are one source of hazardous materials, but there are many others, including service stations, hospitals, and hazardous materials waste sites. Hazardous materials come in the form of explosives, flammable and combustible substances, poisons, and radioactive materials. These substances are most often released as a result of transportation accidents or because of chemical accidents in plants.

Hazardous Materials incidents have the potential to occur in every corner of the Commonwealth. A release may occur at a fixed facility or in transit. Communities with a large industrial base may be more inclined to experience a hazardous materials release due to the number of facilities that use such materials in their manufacturing process. Communities with several major roadways may be at a greater risk due to the number and frequency of trucks transporting hazardous materials.

Location and Extent

<u>Industrial Accidents - Transportation</u>

Franklin County transportation systems include road, rail, and air. Accessible and efficient freight transportation plays a vital function in the economy of the region. Most freight and goods being transported to and from Franklin County are by truck; however, a significant amount of freight that moves through the county is being hauled over the three main rail lines. Given that any freight shipped via air needs first to be trucked to an airport outside the region, air transportation is not being evaluated in this plan.

The major trucking corridors in Franklin County are Interstate 91, running north/south, and Route 2, running east/west. These two highways also represent the busiest travel corridors in the region for non-commercial traffic. Other active truck routes in the region include Routes 5/10, Route 47, Route 116, Route 63, Route 78, and Route 112. According to the Franklin County Hazardous Material Emergency Plan (HMEP), an estimated 12 or more trucks per hour travel through the region containing hazardous materials. Most of these trucks are on Interstate 91. However, approximately two vehicles per hour travel along Route 2, and up to one vehicle per hour travel along Route 10, Route 63, and Route 78 in Northfield and Warwick. In addition, the HMEP notes that all roads in the county likely have vehicles carrying hazardous materials at varying intervals.

The HMEP also identifies the hazardous materials being carried on highways. On Routes 10, 63, and 78, which travel through Northfield or Warwick, the hazardous materials regularly carried on trucks include:

- Gasoline
- Fuel oil
- Kerosene
- LPG
- Propane

Safe and efficient transportation routes for trucks traveling to and through the region are important to the region's economy and to the safety of its citizens. The safer the transportation routes are, the less likely a transportation accident will occur. In Northfield, Routes 10/63 travel through the village center. Accidents in this area are a concern due to the concentration of residences, businesses, and the elementary school.

Franklin County has two primary rail lines that carry hazardous materials to and through the county. No rail lines pass through the Town of Warwick. The New England Central Railroad, and the Connecticut River Main Line, run through Northfield. The hazardous chemicals carried by rail through the county in 2013 were:

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

The proximity of the rail lines to farmland and the Connecticut River is a concern in the event of a hazardous material spill. In addition, sparks from passing trains have caused brush fires and discarded railroad ties to catch fire. The Northfield Fire Chief reports that the ties were recently removed, which has helped mitigate the potential for fire along the tracks.

<u>Industrial Accidents – Fixed Facilities</u>

An accidental hazardous material release can occur wherever hazardous materials are manufactured, stored, transported, or used. Such releases can affect nearby populations and contaminate critical or sensitive environmental areas. Those facilities using, manufacturing, or storing toxic chemicals are required to report their locations and the quantities of the chemicals stored on-site to state and local governments. The Environmental Protection Agency's Toxics Release Inventory (TRI) contains information about more than 650 toxic chemicals that are being used, manufactured, treated, transported, or released into the environment. Northfield does not have any facilities listed on the Toxic Release Inventory. However, Northfield's Comprehensive Emergency Management (CEM) Plan identifies the First Light Power facility on Millers Falls Road, and the Department of Public Works building on Caldwell Road as facilities containing hazardous materials (Table 3-50).

Table 3-48: Hazardous Facilities in Northfield

Hazardous Facility	Location	Description of Hazard
First Light Power	99 Millers Falls Road	Sulfuric Acid, Mineral dielection fluid
DPW Headquarters	49 Caldwell Road	Diesel Fuel

Source: Northfield Comprehensive Management Plan.

The one hazardous facility in Warwick identified in the Town's Comprehensive Emergency Management Plan (eCEMP) is the DPW Highway Barn located on 15 Garage Road. Materials stored at the barn include the following maximum amounts of potentially hazardous materials: 2,000 gallons of diesel fuel stored in an above-ground tank, 250 tons of rock salt/deicing chemicals, and 600 yards of sand.

Under the Emergency Planning and Community Right-to-Know Act (EPCRA), facilities that use or store chemicals in quantities that equal or exceed established thresholds must report an annual inventory of these chemicals by March 1 of each year to the Massachusetts Emergency Management Agency (MEMA), the Franklin County Regional Emergency Planning Committee (REPC), and the Northfield Fire Department. Known as Tier II forms, the reports require basic facility identification information, employee contact information for both emergencies and non-emergencies, and information about chemicals stored or used at the facility. The information must be made available to the public. Current Tier II facilities in Northfield are identified on the Critical Facilities and Infrastructure Map, and in Table 3-51 below. There are no Tier II facilities located in Warwick.

Table 3-49: Tier II Facilities in Northfield

Tier II Facility	**Location**
Northfield Mountain Substation	Route 63
The Lane Construction Corp	216 Mount Hermon Station Road
Verizon	79 Main Street
Northfield Wastewater Treatment Plant	104 Meadow Street
Northfield Mount Hermon School	206 Main Street
Water Treatment Plant	126 Louisiana Road

Source: Massachusetts Emergency Management Agency.

In 2020 the Town of Warwick acquired the property at 355 Wendell Road for back taxes. The site was used as an illegal dump and for automobile crushing and recycling. Potential contamination includes groundwater pollution, dumped debris, and tires. The Town is working through the Franklin Regional Council of Governments' Regional Brownfields Program to conduct a Phase II environmental site assessment to collect soil samples and determine possible contamination. The Town identifies clean-up of this property as a high priority.

In addition to the above facilities, farms may store agricultural chemicals on their properties. Given that much farmland in Northfield is located in or near floodplains and their adjacent water bodies, the potential for an accidental hazardous materials spill to impact water quality is present. This plan does not include an in-depth evaluation of hazardous materials as they relate to farming. In many cases, farmers do use and store pesticides, herbicides and fertilizers on their property. In most cases, farmers are utilizing best management practices in the use and storage of agricultural chemicals and have undergone any required training and licensing if they are applying these chemicals to the land. Despite training and best management practices, an accidental release of hazardous materials can occur and potentially threaten human health and the environment. One approach that the Town could take to help prepare for a hazardous materials spill on a farm would be to become familiar with the types and quantities of chemicals stored on site at the larger farms. This would assist first responders in being adequately prepared to protect human health and prevent contamination of the environment in the event of a major spill or other accidental release of hazardous materials.

Hazardous facilities located outside of town boundaries can impact Northfield and Warwick as well. The Vermont Yankee nuclear power plant is located on the Connecticut River in Vernon, Vermont, near the Vermont/Massachusetts border. The plant is approximately 6.5 miles from the Northfield Town Hall. Warwick Town Hall is just over 11 miles from the plant. Portions of Warwick are within the 10-mile radius evacuation zone for the plant. In January 2010, the facility notified the Vermont Department of Health that samples taken in November 2009 from a ground water monitoring well on site contained tritium. This finding signals an unintended release of radioactive material into the environment. Testing has shown that contaminated groundwater has leaked into the Connecticut River, though tritium levels in the river have remained below the lower limit of detection.

On August 27, 2013, Entergy, then-owner of Vermont Yankee, announced that Vermont Yankee would cease operations at the end of 2014 for economic reasons. Vermont Yankee officially disconnected from the grid on December 29, 2014. The reactor was manually shut down without incident. Transfer of all Vermont Yankee spent fuel from the reactor to the spent fuel pool was completed on January 12, 2015. The transfer of all Vermont Yankee spent fuel to dry cask storage was completed on August 1, 2018. On December 6, 2018, the Vermont Public Utilities Commission (PUC) approved Entergy's sale of Vermont Yankee to subsidiaries of NorthStar Group Services, Inc., as a means of completing the decommissioning and site restoration on an accelerated schedule.[70]

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

Because parts of Northfield and Warwick fall within a ten mile radius of Vermont Yankee, the Towns' emergency personnel previously participated in regular trainings that evaluated shelters, evacuation procedures, traffic control, and what equipment and materials would be needed in the event of an accident at the plant. With the plant no longer in operation, these

[70] Vermont Department of Public Service: https://publicservice.vermont.gov/content/nuclear_decommissioning_citizens_advisory_panel_ndcap/history. Accessed July 6, 2019.

trainings are not provided. In addition, the Town had a nuclear planning document that was updated regularly. The plan still exists and could be used as a reference, but Vermont Yankee no longer provides support for updating the plan. These trainings helped the Town to be better prepared for a nuclear event, and also served as a basis for dealing with other emergencies.

Northfield has two public drinking water supplies, either of which could become contaminated due to manmade or natural hazard events. The same is true for private wells serving Warwick. The two water districts in Northfield provide drinking water to residents and businesses in Northfield Center and near the former Northfield Campus of NMH. Currently the two water districts are interconnected, allowing them to serve as a back-up supply to each other's customers in the event of an emergency. Both are gravity-fed, although the East Northfield Water Company does have an emergency generator for its treatment plant. The Town could consider exploring other potential back-up water supply options in case of failure of one or both existing supply systems. The Town should investigate establishing formal agreements with surrounding towns or the Pioneer Valley Regional School for supplying back-up drinking water.

Cyber Threats

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

There are many possible causes of a network failure, but most either happen because of damage to the physical network/computer system infrastructure or damage to the network in cyberspace. Physical damages are incidents that damage physical telecommunications infrastructure or server/computer hardware. Examples are a water main break above a server room, fire/lighting strike that destroys equipment, construction accident damaging buried fiber line, or power outage and other issues effecting the Internet Service Provider (ISP) that interrupts access to the internet to the town.

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

- Confidentiality: protecting a user's private information.

- Integrity: ensuring data is protected and cannot be altered by unauthorized parties.
- Availability: keeping services running and giving administration access to key networks and controls.
- Damage: irreversible damage to the computer or network operating system or "bricking" and physical, real world damages, caused by tampering with networked safety systems.
- Confidence: confidence of stakeholders in the organization that was victim of the attack.

Motives for cyber-attacks can vary tremendously, ranging from the pursuit of financial gain—the primary motivation for what is commonly referred to as "cyber-crimes" is for profit, retribution, or vandalism. Other motivations include political or social aims. Hacktivism is the act of hacking, or breaking into a computer system, for a political or social purpose. Cyber espionage is the act of obtaining secrets without permission of the holder of the information, using methods on the Internet, networks, or individual computers. [71] These threats are not only external; many acts of cyber-crime happened from current or former employees who were given network access legitimately.

For Northfield and Warwick, the most likely cyber-threat effecting the town and town departments come from malware and social engineering. These crimes pray on the vulnerable and unprepared and every individual and organization that connects a device to the internet is a potential mark.

<u>Social Engineering:</u>

Social engineering involves obtaining confidential information from individuals through deceptive means by mail, email, over the phone, and increasingly through text messages.[72] These techniques are referred to as 'Phishing'.

<u>Malware:</u>

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

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

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

Previous Occurrences

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

In July 2019, school districts across the United States were targeted by ransomware. Since 2013, there have been some 170 attacks against state and local governments and there is no sign this trend is slowing. Unlike other hazards, cyber-threats are global. Cyber-criminals don't care where you are or how small your town is. Many cyber-crimes are not perpetrated by lone criminals; they are committed by sophisticated criminal organizations and foreign governments that work around the clock looking to exploit small towns and big businesses alike.

The best way to prevent a cyber-attack is to follow best practices in cyber-security. Following these best practices will greatly mitigate the likelihood a cyber-attack is successful. The Massachusetts Executive Office of Technology Services and Security (EOTSS)[73] is the chief state program that can assist local governments with cyber-security. There are educational opportunities available throughout the region that aim to assist municipalities learn and implement these best practices.

3.17 OTHER HAZARDS

In addition to the hazards identified above, the Hazard Mitigation Team reviewed the full list of hazards listed in the Massachusetts Hazard Mitigation and Climate Adaptation Plan. Due to the location and context of Northfield and Warwick, coastal erosion, coastal flooding, and tsunamis were determined not to be a threat.

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

4 MITIGATION CAPABILITIES & STRATEGIES

4.1 NATURE-BASED SOLUTIONS FOR HAZARD MITIGATION & CLIMATE RESILIENCY

Nature-Based Solutions are actions that work with and enhance nature to help people adapt to socio-environmental challenges. They may include the conservation and restoration of natural systems, such as wetlands, forests, floodplains and rivers, to improve resiliency. NBS can be used across a watershed, a town, or on a particular site. NBS use natural systems, mimic natural processes, or work in tandem with engineering to address natural hazards like flooding, erosion and drought.

The 2018 Massachusetts Hazard Mitigation and Climate Adaptation Plan and the MVP program both place great emphasis on NBS, and multiple state and federal agencies fund projects that utilize NBS. For this plan, Low Impact Development (LID) and Green Infrastructure (GI) are included under the blanket term of NBS. Following are examples of how NBS can mitigate natural hazards and climate stressors, and protect natural resources and residents:

- Restoring and reconnecting streams to floodplains stores flood water, slows it down and reduces infrastructure damage downstream
- Designing culverts and bridges to accommodate fish and wildlife passage also makes those structures more resilient to flooding, allowing for larger volumes of water and debris to safely pass through
- Managing stormwater with small-scale infiltration techniques like rain gardens and vegetated swales recharges drinking water supplies, reduces stormwater runoff, and reduces mosquito habitat and incidents of vector-borne illness by eliminating standing pools of water following heavy rain events
- Planting trees in developed areas absorbs carbon dioxide, slows and infiltrates stormwater, and provides shade, reducing summertime heat, lowering energy costs for village residents and improving air quality by reducing smog and particulate matter
- Vegetated riparian buffers absorb and filter pollutants before they reach water sources, and reduce erosion and water velocity during high flow events

This Northfield and Warwick Community Resilience Building and Hazard Mitigation Regional Plan incorporates Nature-Based Solutions into mitigation strategies where feasible.

4.2 EXISTING AUTHORITIES POLICIES, PROGRAMS, & RESOURCES

One of the steps of this Hazard Mitigation Plan update process is to evaluate all of the Town's existing policies and practices related to natural hazards and identify potential gaps in protection.

Northfield and Warwick have most of the no cost or low cost hazard mitigation capabilities in place, such as land use zoning, and other policies and regulations that include hazard mitigation best practices, such as limitations on development in floodplains, stormwater management, tree maintenance, etc. Both towns have appropriate staff dedicated to hazard mitigation-related work for communities of their size, including a Town Administrator, Emergency Management Director, a Highway Department, and a Tree Warden. In addition to Town staff, Northfield and Warwick have volunteer Planning Boards that review all proposed developments.

Northfield has some recommended plans in place, including a 2014 Master Plan, and is currently working to update its 2013 Open Space and Recreation Plan (OSRP). Warwick recently completed the update of its Open Space and Recreation Plan (OSRP) but does not have a current Master Plan. Both Towns have very committed and dedicated volunteers who serve on Boards and Committees and in other important volunteer positions. The towns collaborate closely with surrounding communities and is party to Mutual Aid agreements through MEMA. Northfield and Warwick are member communities of the Franklin Regional Council of Governments, and participate in the Franklin County Regional Emergency Planning Committee (REPC).

Northfield and Warwick's Top Strengths and Assets

All Hazards

Participants in the Northfield and Warwick MVP Community Resilience Building workshops cited several strengths and assets that help keep their communities resilient in the face of climate change and other challenges. They include:

Communication Infrastructure Upgrades - The Mt. Grace radio tower is being replaced with a new, taller tower that will include emergency communication channels and back-up power, and AT&T FirstNet civilian cell capacity. Both Towns have reverse call systems to notify residents of emergencies.

Energy Resilience – Northfield and Warwick are both designated Green Communities. Both towns have secured numerous grants to improve energy efficiency and move towards electrification and renewable energy at Town buildings.

Forest Resilience - MA DCR seasonally staffs a fire tower in Warwick on Mt. Grace, providing early warning to both towns, and assisting local fire departments with response. Mutual aid agreements are in place with surrounding towns to supply water for firefighting.

Farms and Food Security – Farms in both towns contribute to the local and regional food economy. Both Town Halls and the Warwick Community School have kitchens that are certified for food production. During COVID, the Northfield Senior Center and the Warwick Community School served as free food distribution sites.

Abundance of Protected Open Space and Natural Resources - Large protected blocks of forestland in both towns support biodiversity and species migration, carbon sequestration and storage, and serve as green infrastructure by slowing, absorbing, and storing flood waters.

Overview of Mitigation Strategies by Hazard

An overview of the general concepts underlying mitigation strategies for each of the hazards identified in this plan is as follows:

Flooding

The key factors in flooding are the water capacity of water bodies and waterways, the regulation of waterways by flood control structures, and the preservation of flood storage areas (like floodplains) and wetlands. As more land is developed, more flood storage is demanded of the town's water bodies and waterways. FEMA has identified no flood control structures within Northfield and Warwick. Floods on the Connecticut River and portions of its major tributaries that are prone to backwater effects are controlled by nine flood control reservoirs located upstream in New Hampshire, and Vermont, and one downstream in Turners Falls.

Northfield and Warwick have adopted several land use regulations that serve to limit or regulate development in floodplains, to manage stormwater runoff, and to protect groundwater and wetland resources, the latter of which often provide important flood storage capacity. These regulations are summarized in Tables 4-1 and 4-2.

Infrastructure like dams and culverts are also in place to manage the flow of water. However, some of this infrastructure is aging and in need of replacement, or is undersized and incapable of handling heavier flows the region is experiencing due to climate change.

Severe Snowstorms / Ice Storms

Winter storms can be especially challenging for emergency management personnel even though the duration and amount of expected amount of snowfall usually is forecasted. The Massachusetts Emergency Management Agency (MEMA) serves as the primary coordinating entity in the statewide management of all types of winter storms and monitors the National Weather Service (NWS) alerting systems during periods when winter storms are expected.

To the extent that some of the damages from a winter storm can be caused by flooding, flood protection mitigation measures also assist with severe snowstorms and ice storms. The Towns have adopted the State Building Code, which ensures minimum snow load requirements for roofs on new buildings. There are no restrictions on development that are directly related to severe winter storms other than driveway design requirements that could mitigate icing and facilitate snow removal, which are summarized in Table 4-1 and Table 4-2.

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

Hurricanes and Tropical Storms

Hurricanes provide the most lead warning time of all identified hazards, because of the relative ease in predicting the storm's track and potential landfall. MEMA assumes "standby status" when a hurricane's location is 35 degrees North Latitude (Cape Hatteras) and "alert status" when the storm reaches 40 degrees North Latitude (Long Island). Even with significant warning, hurricanes cause significant damage – both due to flooding and severe wind.

The flooding associated with hurricanes can be a major source of damage to buildings, infrastructure and a potential threat to human lives. Flood protection measures can thus also be considered hurricane mitigation measures. The high winds that often accompany hurricanes can also damage buildings and infrastructure, similar to tornadoes and other strong wind events. For new or recently built structures, the primary protection against wind-related damage is construction according to the State Building Code, which addresses designing buildings to withstand high winds.

Severe Thunderstorms / Winds / Microbursts and Tornadoes

Most damage from tornadoes and severe thunderstorms come from high winds that can fell trees and electrical wires, generate hurtling debris and, possibly, hail. According to the Institute for Business and Home Safety, the wind speeds in most tornadoes are at or below design speeds that are used in current building codes, making strict adherence to building codes a primary mitigation strategy. In addition, current land development regulations, such as restrictions on the height and setbacks of telecommunications towers, can also help prevent wind damages. Regular tree maintenance and trimming around electrical wires can prevent power outages from high winds.

Wildfires / Brushfires

Seventy-four (74) percent of Northfield and eighty-eight (88) percent of Warwick is forested. A large portion of both towns is therefore at risk of fire. Wildfire and brushfire mitigation strategies involve educating people about how to prevent fires from starting, controlling burns within the town, as well as managing forests for fire prevention. One of three DCR fire towers in the region is located on Mount Grace in Warwick, providing both towns with early warning of fires.

Northfield and Warwick Fire Departments have several ongoing educational programs to educate residents on fire safety, including fire drills in the school and outreach to seniors. The Fire Departments are actively involved in teaching fire safety during Fire Prevention Week. Burn permits are issued by Shelburne Control based on air quality and weather conditions.

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

Earthquakes

Although there are five mapped seismological faults in Massachusetts, there is no discernible pattern of previous earthquakes along these faults nor is there a reliable way to predict future earthquakes along these faults or in any other areas of the state. Consequently, earthquakes are arguably the most difficult natural hazard for which to plan. Most buildings and structures in the state were constructed without specific earthquake resistant design features. In addition, earthquakes precipitate several potential devastating secondary effects such as building collapse, utility pipeline rupture, water contamination, and extended power outages. Therefore, many of the mitigation efforts for other natural hazards identified in this plan may be applicable during recovery from an earthquake in Northfield and Warwick.

Dam Failure

Dam failure is a highly infrequent occurrence, but a severe incident could prove catastrophic. In addition, dam failure most often coincides with flooding, so its impacts can be multiplied, as the additional water has nowhere to flow. The only mitigation measures currently in place are the state regulations governing the construction, inspection, and maintenance of dams, managed through the Office of Dam Safety at the Department of Conservation and Recreation. Owners of dams are responsible for hiring a qualified engineer to inspect their dams and report the results to the DCR. Owners of High Hazard Potential dams and certain Significant Hazard Potential dams are also required to prepare, maintain, and update Emergency Action Plans. Potential problems may arise if the ownership of a dam is unknown or contested. Additionally, the cost of hiring an engineer to inspect a dam or to prepare an Emergency Action Plan may be prohibitive for some owners. Nelson Mills Pond Dam and Mt. Hermon School Upper Reservoir Dam are listed as high hazard dams in Northfield. There are no high hazards dams in Warwick.

Drought

The Northeast is generally considered to be a moist region with ample rain and snow, but droughts are not uncommon. Widespread drought has occurred across the region as recently as 2016 and 2020, and before that in the early 2000s, 1980s, and mid-1960s. More frequent and severe droughts are expected as climate change continues to increase temperatures, raise evaporation rates, and dry out soils - even in spite of more precipitation and heavier rainfall events.[74]

Northfield has two public water supplies, which serve customers connected to the water utility. Businesses and residents that are not connected to water utilities in Northfield must rely on private wells for drinking water. In Warwick, business and residents throughout the town rely on individual wells for drinking water.

Forest landowners in town can be encouraged to conserve and manage their forests for climate resiliency. Strategies for promoting a resilient forest include increasing the diversity of tree species and age of trees in a forest, and promoting trees not currently threatened by pests or diseases that will thrive in a warming climate.[75]

Extreme Temperatures

A primary mitigation measure for extreme temperatures is establishing and publicizing warming or cooling centers in anticipation of extreme temperature events. Getting the word out to vulnerable populations, especially the homeless and elderly, and providing transportation is particularly important but can be challenging.

Planting and maintaining shade trees in villages and developed areas of towns can help mitigate extreme heat in these areas. Roofs and paving absorb and hold heat from the sun, making

[74] MassWildlife Climate Action Tool: https://climateactiontool.org/content/drought. Accessed March 8, 2019.
[75] Catanzaro, Paul, Anthony D'Amato, and Emily Silver Huff. *Increasing Forest Resiliency for an Uncertain Future*. University of Massachusetts Amherst, University of Vermont, USDA Forest Service. 2016

developed areas hotter during the summer than surrounding forested areas. Trees that shade these surfaces can significantly lower the temperature in a neighborhood, making it easier to be outside and reducing cooling costs for homeowners.

Invasive Species

The spread of invasive species is a serious concern as species ranges shift with a changing climate. People can also be a carrier of invasive plant species. Installing boot brushes at hiking entrances can help slow the spread of invasive species by removing seeds being carried in soil on hiking boots. Landowners can learn the top unwanted plants and look for them when out on their land, and can be encouraged to work with neighbors to control invasive exotic plants.

Before implementing any forest management, landowners should be sure to inventory for invasive exotic species. They will need to be controlled before harvesting trees and allowing sunlight into the forest, which will trigger their growth and spread. Also, the timber harvester should be required to powerwash their machines before entering the woods. Financial assistance may be available to landowners through the USDA NRCS Environmental Quality Incentives Program (EQIP) to address invasive species.[76]

In addition, Northfield and Warwick can require only native, non-invasive species be used in new development and redevelopment.

All Hazards

Pioneer Valley Regional School (PVRS) is a regional shelter serving both towns. The school was renovated in 2002, has a backup generator, kitchen and shower facilities, and is in compliance with the current earthquake standards of the Massachusetts State Building Code. Northfield Elementary School is a designated shelter in Northfield, and has a backup power generator. The elementary school has kitchen facilities and its middle section was built in 1990 and is also in compliance with the current earthquake standards of the Massachusetts State Building Code. The two schools serving as emergency shelters also addresses concerns for shelters available on both sides of the Connecticut River, in the event that flooding cuts off the east and west sides of the Town from each other.

Warwick Community School is identified as an emergency shelter in Warwick. It has a generator large enough to run the critical areas of the facility that would be needed to use it as a shelter, including the kitchen and bathrooms (which have showers). However, the town lacks sheltering supplies and staff capacity to operate a long-term emergency shelter at the school.

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

Residents would need to shelter in place or go to a regional shelter.

A regional sheltering plan that identifies regional shelter sites was completed for Franklin County with funds from the Western Region Homeland Security Advisory Council (WRHSAC). The Franklin County REPC is now working on operationalizing the plan by creating Shelter Management Teams and cost sharing agreements between towns. Northfield and Warwick officials can participate in this process to ensure its residents have clear guidance on where to shelter during an emergency.

Debris management sites in both towns need to be identified and a plan developed for addressing storm debris. The WRHSAC website has guidance for communities on disaster debris management planning.[77]

Existing Mitigation Capabilities

The Town of Northfield had numerous policies, plans, practices, programs and regulations in place that help to mitigate the impact of natural hazards in town. These various initiatives are summarized, described and assessed on the following pages and have been evaluated in the "Effectiveness" column.

Table 4-1: Existing Mitigation Capabilities in Northfield

Strategy	Capability Type	Description	Hazard	Current Effectiveness / Improvements since 2014
Parking	Regulation	The Town does not have any parking bylaws. Provides for reduced parking by Special Permit.	Flooding	Site Development Standards in General Regulations and Site Plan Review Standards address parking. Subdivision Regulations proposed in 2020 (pending formal adoption) include a checklist of required LID Site Planning and Design strategies which apply to parking and will be effective at mitigating flooding. The Town should assess their open space assets and consider adopting a bylaw to protect them from development of parking amenities.

[77] https://wrhsac.org/projects-and-initiatives/disaster-debris-management/

Table 4-1: Existing Mitigation Capabilities in Northfield				
Strategy	**Capability Type**	**Description**	**Hazard**	**Current Effectiveness / Improvements since 2014**
Special Permit	Regulation	Uses and structures subject to special permit will be viewed in relation to the characteristics of the site and shall conform wherever possible to the Principles of Rural Design, which are designed to minimize the impacts of development on the local character, neighborhood, and environment.	Flooding Erosion Landslides	Somewhat effective for mitigating or preventing localized flooding of roads and other infrastructure, impacts from stormwater runoff, erosion and landslides. Special permit should identify impacts and include flooding mitigation measures.
Definitive Plan	Regulation	Requires that subdivision design reduce, to the extent reasonably possible, flood damage. Includes several other provisions that mitigate the potential for flooding and its associated impacts. Requires a Definitive Plan for new subdivisions that shows locations of natural waterways, water bodies, wetlands, certified vernal pools, drainage courses, floodplains, significant and high hazard dam inundation areas; and shows structural details for all components of the proposed drainage systems and stormwater management facilities, including all measures for the detention, retention or infiltration of water, and descriptions of LID best management practices (BMPs). Removal, filling, or dredging of any bank, flat, marsh, meadow or swamp bordering an inland waterway is required to give written notice of intent to the Northfield Conservation Commission and the DEP.	Flooding, Landslides	Subdivision Regulations proposed in 2020 (pending formal adoption) include a checklist of required LID Site Planning and Design strategies which apply to the Definitive Plan and if implemented will be effective at mitigating flooding localized flooding of roads and other infrastructure and for controlling the impacts from stormwater runoff.
Performance Guarantee	Regulation	Performance guarantee ensures that subdividers cover the cost of construction and improvements for projects.	Flooding	Effective
Subdivision Regulations	Regulation	Section V - Design Standards requires proposed design to conform to the LID Site Planning and Design checklist and LID	Flooding	Subdivision Regulations proposed in 2020 (pending formal adoption) include a checklist of required LID Site Planning and Design strategies

Table 4-1: Existing Mitigation Capabilities in Northfield				
Strategy	**Capability Type**	**Description**	**Hazard**	**Current Effectiveness / Improvements since 2014**
		storm-water BMPs shall be designed in accordance with Northfield requirements and the MA Clean Water Toolkit and specifications of the Planning Board. Proposed subdivisions located within the 100-Year Floodplain or Special Flood Hazard Area are referred to the the Town of Northfield Zoning Bylaw.		which if implemented will be effective at mitigating localized flooding of roads and other infrastructure. Consider updating subdivision regulations with respect to watercourses and protection of natural features to reference current Wetlands Protection Act and Rivers Protection Act. Consider amending standards to address impacts of uncontrolled surface water runoff and sedimentation of streams and surface water bodies during and after site construction by requiring temporary and permanent erosion control measures. Consider requiring Impact Statements for construction beyond a certain number of lots. Review and update the Flood Plain Overlay District Zoning Bylaw in accordance with new requirements outlined in the 2020 MA Model Floodplain Bylaw. Add flood prevention and preserving the integrity of the floodplain as a stated purpose, and further restrict or eliminate new development within the 100-year floodplain and areas prone to localized flooding. Update the boundaries of the Flood Plain Overlay District in conjunction with the new FEMA floodplain maps when they are available, and add to the official zoning map.
Design Standards – Drainage		Requires drainage systems meet MA DEP Stormwater standards and Northfield's requirements and that Low Impact Development (LID) techniques should be used whenever feasible to manage stormwater within the proposed subdivision. No open water body or wetland shall be altered unless in compliance with the	Flooding	Subdivision Regulations proposed in 2020 (pending formal adoption) include a checklist of required LID Site Planning and Design strategies which if implemented will be effective at mitigating localized flooding of roads and other infrastructure.

Table 4-1: Existing Mitigation Capabilities in Northfield				
Strategy	**Capability Type**	**Description**	**Hazard**	**Current Effectiveness / Improvements since 2014**
		Massachusetts Wetlands Protection Act.		
Site Plan Review	Regulation	Plan must show existing and proposed drainage. Changes in surface drainage should not affect neighboring properties.	Flooding Erosion Landslides	Somewhat Effective. Consider requiring that site plans must show the 100-year floodplain on all plans submitted. Review and update the Flood Plain Overlay District Zoning Bylaw as outlined below.
Subdivision Review	Regulation	The fire department is involved in the review of subdivision plans.	Wildfire	Effective.
Solar Overlay District (Large Scale Solar Facilities)	Zoning Bylaw	Large Scale Ground-Mounted Solar Facilities must obtain a building permit and shall be subject to Site Plan Review before installation. Clearing of natural vegetation shall be limited to what is necessary for the construction, operation and maintenance of the large-scale ground-mounted solar photovoltaic installation or otherwise prescribed by applicable laws, regulations, and bylaws. Requires Annual Reporting to certify compliance with the requirements of the bylaw. Does not require an Operations and Maintenance Plan, including stormwater controls. Does not specify stormwater/erosion control methods.	Flooding Erosion Landslides	Semi-effective. Consider requiring stormwater and erosion control specifications in Land Clearing, Soil Erosion, and Habitat Impacts section. Removal requirements should include stabilization or re-vegetation of the site as necessary to minimize erosion. Consider adding requirements for pollinator-friendly BMPs for ground-mounted solar arrays.
Flood Plain Overlay District	Zoning Bylaw	Encroachments in the floodways which would result in any increase in flood levels are prohibited. All encroachments, including new construction, fill or substantial improvement to existing structures require professional engineer or architect certification. Certification by a professional engineer or architect is required to show no decrease in flood storage capacity or increase in flood levels. The Town follows the standards set by the Wetlands Protection	Flooding	Effective for regulating new development within the 100-year floodplain. Consider limiting new development within the 100-year floodplain. Review and update the Flood Plain Overlay District Zoning Bylaw in accordance with new requirements outlined in the 2020 MA Model Floodplain Bylaw. Add flood prevention and preserving the integrity of the floodplain as a stated purpose, and further restrict or eliminate new development within the 100-year floodplain and areas prone to localized flooding. Update the boundaries of the Flood Plain Overlay District in conjunction with the new FEMA floodplain maps

Table 4-1: Existing Mitigation Capabilities in Northfield				
Strategy	**Capability Type**	**Description**	**Hazard**	**Current Effectiveness / Improvements since 2014**
		Act.		when they are available, and add to the official zoning map. Create and distribute an educational program brochure designed to raise awareness of risks associated with building in the floodplain.
Northfield Wetlands Bylaw	Zoning Bylaw	The Town does not have any wetlands bylaws.		The Town should assess their wetlands assets and consider adopting a bylaw to manage them. When the state issues their model bylaw in 2020 or 2021, use it to review and update Northfield's bylaw.
Water Supply Protection Overlay District	Zoning Bylaw	Designed to preserve and maintain existing and potential groundwater and surface water resources within the Town. Prohibits the manufacture, disposal, use, storage, and transport of toxic or hazardous materials except for household or agricultural use.	Flooding, Landslides, Manmade Hazards	Somewhat effective for mitigating the potential for localized flooding. The Conservation Commission should review the Water Supply Overlay District regulations and make recommendations for changes. Effective in minimizing the risk of hazardous material accidents in areas containing a public drinking water source. Seek funding and technical assistance to update and digitize the Water Supply Protection District map and incorporate onto the official zoning map. Ensure that the Water Supply Protection district regulations are adequately protective, provide descriptions of the different zones, and indicate the requirements in each zones and which zones are located within Water Supply Protection district boundaries.
Removal of Natural Materials	Regulation	Regulates the removal of soil, loam, sand & gravel through a permitting process. Exempts routine farming operations and activities taking place under current building permits.	Flooding Erosion Landslides Water Pollution	Not effective for controlling localized flooding. This bylaw does not specifically address the potential for localized flooding that soil removal can cause. Add reducing or eliminating the potential for localized flooding events as a purpose of the bylaw.

Table 4-1: Existing Mitigation Capabilities in Northfield				
Strategy	**Capability Type**	**Description**	**Hazard**	**Current Effectiveness / Improvements since 2014**
		The removal of loam, earth, sand, mineral aggregate, stone or rock from a parcel of land requires a special permit except where it is incidental to the construction of an approved building, routine farming operations or construction of roads within an approved subdivision. Special Permit requires that approved vegetative cover to be established according to plan; no excavation take place less than 100 feet from the boundary of a public way or any waterway; and, no finish grade slopes exceed a grade of 2:1. No construction shall result in a change in the natural surface drainage onto abutting property.		Require mitigation of potential impacts from flooding.
Curb Cut Regulations	Regulation	Increased surface drainage onto public ways is forbidden.	Flooding	Effective/No Changes
Northfield Community Development Plan	Zoning Bylaw	Inventories natural features and environments in the Town, including many that contain floodplain areas such as wetlands, aquifer recharge areas, farms, rivers, streams, and brooks. Encourages development to locate outside certain flood-prone areas.	Flooding	Effective in establishing priorities for environmentally sensitive development that will mitigate flooding impacts. Consider zoning revisions suggested by Community Development Plan: See recommended strategy for Water Supply Protection Overlay District. Digitize the 2017 Village Center, Planned Development, Recreational Tourism 1, and Recreational Tourism 2 planning districts and incorporate onto official zoning map to make these maps more useful to the Town. Consider establishing new overlay zoning districts to help protect important natural, scenic, historic, and open space resources.
Open Space Development	Zoning Bylaw	Requires that a minimum of thirty-five percent (35%) of land tract to be developed be open space. The open space may not include wetlands, water bodies,	Flooding	Somewhat effective for controlling flooding. The Town should consider requiring that flooding prevention be more specifically addressed.

Table 4-1: Existing Mitigation Capabilities in Northfield				
Strategy	**Capability Type**	**Description**	**Hazard**	**Current Effectiveness / Improvements since 2014**
		floodplains, or slopes greater than twenty-five (25) percent.		
Four Mile Brook Watershed Assessment and Management Plan	Plan	Includes recommendations to prevent nonpoint pollution in the watershed, manage flow and mitigate bank erosion along high hazard areas of Four Mile Brook adjacent to Four Mile Brook Road.	Flooding	Effective, provided that recommendations are implemented. The Town completed recommended implementation of stormwater Best Management Practices at six sites along the brook and reported that they are effective and would like to seek funding to complete implementation of remaining recommendations from the Four Mile Brook Watershed Management Plan.
2021-2028 Town of Northfield Open Space and Recreation Plan	Plan	Inventories natural features and promotes natural resource preservation in the town, including areas in the floodplain, such as wetlands, aquifer recharge areas, farms and open space, rivers, streams and brooks.	Flooding Landslides Wildfire Drought Invasive species	Effective in identifying sensitive resource areas, including floodplains. Encourages open space and farmland preservation to provide flood storage capacity.
Participation in the National Flood Insurance Program	Program	As of 2018, there were nine (9) flood insurance policies in effect.	Flooding	Somewhat effective, provided that the town remains enrolled in the National Flood Insurance Program. The Town should evaluate whether to become a part of FEMA's Community Rating System.
Design Standards for Streets	Regulation	Requires proposed design to conform to the LID Site Planning and Design checklist which apples to roadways and requires LID stormwater BMPs shall be designed in accordance with Northfield requirements and the MA Clean WaterToolkit and specifications of the Planning Board.	Winter Storms Flooding	Subdivision Regulations proposed in 2020 (pending formal adoption) include a checklist of required LID Site Planning and Design strategies which if implemented will be effective at mitigating localized flooding of roads and other infrastructure.
Design Standards for Driveways	Regulation	Requires proposed design to conform to the LID Site Planning and Design checklist which apples to driveways and requires LID stormwater BMPs shall be designed in accordance with Northfield requirements and the MA Clean WaterToolkit and specifications of the Planning Board.	Winter Storms Flooding, Hurricanes, Tropical Storms	Subdivision Regulations proposed in 2020 (pending formal adoption) include a checklist of required LID Site Planning and Design strategies which if implemented will be effective at mitigating localized flooding of roads and other infrastructure.
Shelters	Plan	Shelters for victims of natural hazards in Northfield have been identified.	All Hazards	Effective. Ensure that identified shelters have sufficient back-up utility service in the event of primary power failure. Pioneer Valley

Table 4-1: Existing Mitigation Capabilities in Northfield

Strategy	Capability Type	Description	Hazard	Current Effectiveness / Improvements since 2014
				Regional School and Northfield Elementary School both have back-up power supplies.
Public Water Supply	Other	Public water supply sources should have backup power in case of electrical failure.	Winter Weather, T-Storms and high winds,	Effective for ensuring that utility service is uninterrupted by severe storms.
Utilities (electric and telephone)	Regulation	The Town requires all utilities to be placed underground for new subdivisions.	Winter Weather, T-Storms and high winds,	Effective for ensuring that utility service is uninterrupted by severe storms in new areas of residential development. Encourage utility companies to underground existing utility lines in locations where repetitive outages occur. Encourage utility companies to underground new utility lines. Encourage regular tree maintenance to reduce number of limbs near overhead power lines.
Zoning regulations for wireless communications facilities	Zoning Bylaw	Requires a special permit from the Zoning Board of Appeals. Wireless facilities should be set back from property lines at a distance of 150% of the height of the tower. Facilities are not permitted within 500 feet of a residential lot line.	Winter Weather, T-Storms and high winds, Hurricanes and Tropical Storms	Effective.
Burning Permits	Regulation	Residents are permitted to obtain burn permits over the phone. State police personnel provide information on safe burn practices.	Wildfire	Effective.
Fire Safety Public Education	Program	The fire department has an ongoing educational program in the schools.	Fire	Effective. Develop and distribute an educational pamphlet on fire safety and prevention.
Forestry Operations	Other	Timber harvests of more than 25 thousand board feet or 50 cords require a Cutting Plan to be submitted to the Department of Conservation and Recreation, and to the Northfield Conservation Commission.	Wildfire	Somewhat Effective. Provides the town with information on where large operations are taking place. Set up a system with the Conservation Commission to provide a copy of all cutting plans to the Fire Department when they are submitted by landowners.

Table 4-1: Existing Mitigation Capabilities in Northfield				
Strategy	**Capability Type**	**Description**	**Hazard**	**Current Effectiveness / Improvements since 2014**
				Maintain contact with the Service Forester assigned to Northfield to ensure that active Cutting Plans are being enforced.
Mobile Homes	Zoning Bylaws	Town of Northfield Zoning Bylaw prohibits mobile homes within the Town.	Winter Weather, T-Storms and high winds, Hurricanes and Tropical Storms	Does not address potential damage to existing mobile homes. Consider using Community Development Block Grant home rehabilitation funds to assist homeowners in retrofitting grandfathered mobile homes.
State Building Code	Regulation	The Town of Northfield has adopted the State Building Code.	Earthquake, Fire, High Winds	Effective.
Reverse 9-11	Program	Northfield's Emergency Alert System allows town officials to contact residents in the event of large scale accidents, natural hazards or public health emergencies. Messages can be directed to home phone, cell phone, text or email.	All Hazard	Effective.
Municipal Vulnerability Preparedness (MVP) Designation	Plan	Northfield's MVP Planning Process is underway as part of a regional planning project with the Town of Warwick and in tandem with the 2020 Hazard Mitigation Plan update. Once the plan is completed and approved, Northfield and Warwick will become designated as MVP Communities.	All Hazards	Effective.
Permits required for new dam construction	State Regulation	State law requires a permit for the construction of any dam.	Dam Failure	Effective. Ensures dams are adequately designed.
Dam Inspections	State Regulation	DCR has an inspection schedule that is based on the hazard rating of the dam (low, significant, high hazard).	Dam Failure	Very Low. The state passed a law in 2002 to shift responsibility for inspections from the state to the dam owner. The regulations have not been issued so DCR continues to inspect only the High Hazard dams. It is highly likely that the remaining dams are not being inspected according to the required schedule. Repeal the state law requiring dam owners pay for inspections.

Table 4-1: Existing Mitigation Capabilities in Northfield				
Strategy	**Capability Type**	**Description**	**Hazard**	**Current Effectiveness / Improvements since 2014**
				Adequate staff and resources should be given to DCR to ensure the inspection schedules are maintained. Map dams and Inundation Areas. Evaluate the need for Dam Inspections by the City. Incorporate Dam Safety into Development Review process.
Zoning	Regulation - Zoning Ordinance	Special Permit and/or Order of Conditions required for dams in Floodplain district or wetlands. Floodplain areas and those under the jurisdiction of the Conservation Commission.	Dam Failure	Effective
Evacuation Plans		Comprehensive evacuation plans would ensure the safety of the citizens in the event of dam failure.		Not Effective. The preparation of inundation mapping and evacuation plans is expensive for owners of dams. Owners of High Hazard Potential dams should prepare inundation area mapping and up-to-date evacuation plans in cooperation with the Town.

The Town of Warwick had numerous policies, plans, practices, programs and regulations in place that help to mitigate the impact of natural hazards in the town. These various initiatives are summarized, described and assessed on the following pages and have been evaluated in the "Effectiveness" column.

Table 4-2: Existing Mitigation Capabilities in Warwick				
Strategy	**Capability Type**	**Description**	**Hazard**	**Current Effectiveness / Improvements since 2014**
Parking	Subdivision Regulation, Zoning Bylaw	Parking for more than 3 cars requires a Special Permit; Percentage of tract to be occupied by parking is part of the Development Impact Statement required for subdivisions. Site Plan Review includes location and size of proposed parking and loading areas, driveways, walkways,pedestrian safety measures, and access and egress points.	Flooding	Effective

Table 4-2: Existing Mitigation Capabilities in Warwick				
Strategy	**Capability Type**	**Description**	**Hazard**	**Current Effectiveness / Improvements since 2014**
Subdivision Standards in the Floodplain	Subdivision Regulation	Review of subdivision proposals must determine that they will be reasonably safe from flooding; that all public and private utilities are constructed to minimize or eliminate flood damage; drainage system reduce exposure to flood hazards; and flood elevation data is provided for proposals greater than 5 lots or 5 acres, whichever is the lesser.	Flooding, Landslides	Effective
Design Standards; Protection of Natural Features; Easements; Drainage	Subdivision Regulation	Requires the preservation of all natural features including water courses, 100-year floodplains, wetlands, ponds and other water bodies, marshes, etc.	Flooding, Severe Winter Storms, Hurricanes and Tropical Storms	Effective
Required Improvements for Approved Subdivisions; Curbs and Berms; Utilities	Subdivision Regulation	Curbing required only where the Planning Board determines that special conditions of topography, drainage requirements, steep roadway grade or high traffic density so required. Otherwise, curbing is not required and the adjoining shoulder, grass plot and ditch shall be graded and treated to carry the surface water runoff adequately without erosion. All electrical, telephone, fire alarm and other wires and cables shall be installed underground unless such installation is impractical or not in the best interest of the Town.	Flooding, Winter Weather, T-Storms and high winds, Hurricanes and Tropical Storms, Wildfire	Effective
Subdivision Fire Protection	Subdivision Regulation	A Class I Subdivision (10 dwelling units or more) shall meet ISO rural fire flows of 500 gallons per minutes for 2 hours. Fire water sources shall be available for general fire fighting outside of the subdivision.	Wildfire	Effective
Procedure for Submission and Review of Plans Definitive Plan Environmental Impact Report Development Impact Statement Compliance with the Wetlands Protection Act Performance Guaranty	Subdivision Regulation	Requires that plans be prepared by a civil engineer or registered land surveyor. Class II Subdivisions of between 4 and 9 lots shall be required to submit a detailed environmental impact report with analysis of stormwater runoff, soil erosion and other land capability effects. Class I Subdivisions of 10 or more lots and all non-residential subdivisions shall be required to submit a detailed development impact statement. MGL C.131, §40, protects watercourses, ponds, floodplains or wetlands and buffer areas. Applicant shall provide a form of performance guaranty before endorsement of a Definitive Plan by the Planning Board. Civil engineer must indicate that the streets and drainage patterns, water mains, sanitary sewers, storm sewers and hydrants conform to the definitive plan.	Flooding	Effective

Table 4-2: Existing Mitigation Capabilities in Warwick				
Strategy	**Capability Type**	**Description**	**Hazard**	**Current Effectiveness / Improvements since 2014**
Site Plan Review Required Contents of a Site Plan Review Criteria	Zoning Bylaws	Required contents of a Site Plan include existing site conditions and resource areas, proposed water, septic, fire protection, and stormwater utilities, slopes, the 50-foot buffer area, and land to be protected by the Conservation Restriction. Surface drainage to limit off-site or pollution; Hazardous materials regulation. Site Plan review criteria address vehicular safety and accessibility for fire, police, and emergency vehicles; water resources protection; open spaces and pedestrian amenities; avoidance of erosion or sedimentation; existing landscape and surrounding neighborhood; impacts on wetlands, steep slopes, and hilltops; visual amenities and scenic views; unique natural or historical features; vegetation and soil removal; grade changes; underground utilities or conduits where feasible; stormwater and drainage. Drainage shall recharge groundwater to the extent practical, and surface waters flowing off-site shall not adversely affect drainage on adjacent properties or roads.	All Hazards	Effective
By-right ground-mounted solar energy systems	Zoning Bylaw	Site Plan Review is to be professionally prepared and include existing site conditions and resource areas, existing stormwater flow and slopes, surface drainage strategy to limit off-site drainage or pollution; and hazardous materials provisions to protect against hazardous releases. Requires an Operations and Maintenance Plan, including stormwater controls. Does not specify stormwater/erosion control methods	Flooding Erosion Landslides	The bylaw only applies to a Town-owned lot. Consider adding additional regulations for large-scale solar installations proposed in other areas of town. Consider outlining specific erosion and sediment control measures to make stormwater runoff mitigation capability more robust. Consider specifying that clearing of natural vegetation shall be limited to what is necessary for the construction, operation and maintenance of the large-scale ground-mounted solar photovoltaic installation.

Table 4-2: Existing Mitigation Capabilities in Warwick				
Strategy	**Capability Type**	**Description**	**Hazard**	**Current Effectiveness / Improvements since 2014**
				Require stabilization or re-vegetation of the site as necessary to minimize erosion when array is decommissioned.
Floodplain Overlay District	Zoning Bylaw	The Town has a floodplain overlay district adopted in 2011 regulating land uses in all special flood hazard areas designated as Zone A on the Warwick FHBM. Commercial and industrial uses, mobile homes on a site for longer than 6 months, storage of vehicles or equipment; dumping of trash; construction on slopes greater than 25% are prohibited. Uses allowed by Special Permit include: single family residence, duplex, or apartment; altering, dumping, filling, or removal of riverine materials or dredging; new impoundments, dams, or other water obstructions.	Flooding	Somewhat Effective. Warwick's floodplain maps date from 1975. FEMA is in the process of updating floodplain maps for Franklin County. Update the bylaw using the State's new model floodplain bylaw and revised FEMA maps, once available.
Permitted and Prohibited Uses	Zoning Bylaw	Prohibited uses include mobile homes or mobile home parks, junk yards, commercial waste disposal, hazardous or radioactive waste processing. A Special Permit is required for: uses rendering impervious more than 20% of the area of any lot, or 10,000 square feet, whichever is less; uses involving commercial transmission, manufacture or storage of high-tension electrical power, fuel oil, gasoline, natural gas or other liquefied or gaseous petroleum products; construction or alteration of surface features or contours on excessive slopes; and earth removal.	Flooding	Effective
Wetlands Bylaw	Local Bylaw	The Conservation Commission enforces the State Wetlands Protection Act in Warwick. The Town does not have a local wetlands bylaw.		Somewhat Effective. Consider adopting a local wetlands bylaw.
Erosion Control; Earth Removal; Driveways	Zoning Bylaw	The Building Inspector may require that site design, building design and construction procedures shall be modified so as to protect the site, the neighborhood and the Town against erosion, soil instability, uncontrolled surface water runoff, environmental degradation and other permanent or temporary damage caused during or after operations are completed. Prohibited to remove sod, loam, clay, sand or gravel except in connection with the construction of a structure, or when grading or developing of contiguous property, or except when pursuant to a Special Permit issued by the Zoning Board of Appeals.	Flooding Erosion Landslides	Effective

Table 4-2: Existing Mitigation Capabilities in Warwick				
Strategy	**Capability Type**	**Description**	**Hazard**	**Current Effectiveness / Improvements since 2014**
		Existing drainage ditches parallel to public or private roads shall not be obstructed by any driveway. Culverts of appropriate size and material shall be installed. Driveways shall be provided with swales and culverts allowing storm water to cross without creating erosion or washouts.		
Conservation Development	Zoning Bylaw	Encourages the preservation of historical or archaeological resources, common land for conservation, agriculture, open space, forestry and recreational use; sensitive siting of buildings and better overall site planning; better utilization of land in harmony with its natural features; more efficient provision of municipal services; protection of municipal water supplies and the value of real property. At least 35 % of the total parcel of land shall be set aside as Protected Open Space. Application must analyze water and habitat resources, slopes greater than 25%, soil types, the 100 year flood zone, prevailing winds, solar aspect diagram, land prohibited from development by legally enforceable restrictions; summarize environmental concerns relating to the proposed plan; indicate measure to prevent increased runoff, flooding, and erosion; indicate how design features integrate the proposed development into the existing landscape; and fire protection provisions.	Flooding, Wildfire, Landslides	Somewhat Effective. Consider updating with more recent best practices from MA Smart Energy / Smart Growth Toolkit and Mass Audubon including increasing the percent of required open space and providing greater flexibility in roadway design and residential dimensional requirements.[78]
(2020) Town of Warwick Open Space and Recreation Plan	Plan	Inventories natural features and promotes natural resource preservation in the town, including areas in the floodplain, such as wetlands, aquifer recharge areas, farms and open space, rivers, streams and brooks.	Flooding Landslides Wildfire Drought Invasive species	Effective in identifying sensitive resource areas, including floodplains. Encourages open space and farmland preservation to provide flood storage capacity.
Participation in the National Flood Insurance Program	Program	As of 2018, there were zero (0) flood insurance policies in effect.	Flooding	Effective

[78] https://www.massaudubon.org/our-conservation-work/advocacy/shaping-climate-resilient-communities/publications-community-resources/bylaw-review; https://www.mass.gov/smart-growth-smart-energy-toolkit-information-and-resources

Table 4-2: Existing Mitigation Capabilities in Warwick				
Strategy	**Capability Type**	**Description**	**Hazard**	**Current Effectiveness / Improvements since 2014**
Shelters	Plan	The Warwick Community School is identified as an emergency shelter in Warwick. The school has a back-up generator, but no sheltering supplies. The Town does not have the staff capacity to operate a full-time shelter.	All Hazards	Somewhat Effective. For a long-term emergency, residents will need to shelter in place or go to a regional shelter.
Burn Permits	Regulation	Residents are permitted to obtain burn permits over the phone. State police personnel provide information on safe burn practices.	Wildfire	Effective.
Fire Safety Public Education	Program	The fire department has an ongoing educational program in the schools.	Fire	Effective.
Mobile Homes	Zoning Bylaws	Mobile homes are allowed only as a temporary residence for 12 months if a home has been destroyed by fire or natural cause, or for 6 months while a permanent dwelling is under construction.	Winter Weather, T-Storms and high winds, Hurricanes and Tropical Storms	Partially Effective. Does not address potential damage to existing mobile homes. Consider using Community Development Block Grant or other funds to assist homeowners in retrofitting grandfathered mobile homes.
State Building Code	Regulation	The Town of Warwick has adopted the State Building Code.	Earthquake, Fire, High Winds	Effective.
Code Red reverse call system	Program	Warwick's Emergency Alert System allows town officials to contact residents in the event of large scale accidents, natural hazards or public health emergencies. Messages can be directed to home phone, cell phone, text or email.	All Hazard	Effective. The Town acquired a reverse call system since the 2014 Plan.
Municipal Vulnerability Preparedness (MVP) Designation	Plan	Warwick's MVP Planning Process is underway as part of a regional planning project with the Town of Northfield and in tandem with the 2020 Hazard Mitigation Plan update. Once the plan is completed and approved, Northfield and Warwick will becomes designated as MVP Communities.	All Hazards	Effective.
Permits required for new dam construction	State Regulation	State law requires a permit for the construction of any dam.	Dam Failure	Effective. Ensures dams are adequately designed.
Dam Inspections	State Regulation	DCR has an inspection schedule that is based on the hazard rating of the dam (low, significant, high hazard).	Dam Failure	Not Effective. The state passed a law in 2002 to shift responsibility for inspections from the state to the dam owner. DCR continues

Table 4-2: Existing Mitigation Capabilities in Warwick				
Strategy	**Capability Type**	**Description**	**Hazard**	**Current Effectiveness / Improvements since 2014**
				to inspect only the High Hazard dams. Adequate staff and resources should be given to DCR to ensure the inspection schedules are maintained.

4.3 HAZARD MITIGATION GOAL STATEMENTS AND ACTION PLAN

As part of the multi-hazard mitigation planning process undertaken by the Northfield and Warwick Core Teams, existing gaps in protection and possible deficiencies were identified and discussed. The Core Teams then developed general goal statements and mitigation action items that, when implemented, will help to reduce risks and future damages from multiple hazards. The goal statements, action items, Town department(s) responsible for implementation, and the proposed timeframe for implementation for each category of hazard are described below. It is important to note that Northfield and Warwick have limited capabilities and resources (especially staffing) to be able to expand and improve upon existing policies and programs when the Towns identify a need for improvement.

Hazard Mitigation Goals

Based on the findings of the Risk Assessment, public outreach, and a review of previous town plans and reports, Northfield and Warwick have developed the following goals to serve as a framework for mitigating the hazards identified in this plan:

- To provide adequate shelter, water, food and basic first aid to displaced residents in the event of a natural disaster.
- To provide adequate notification and information regarding evacuation procedures, etc., to residents in the event of a natural disaster.
- To minimize the loss of life, damage to property, and the disruption of governmental services and general business activities due to natural hazards.

Prioritization of Hazards

The Core Teams examined the results of the Risk Assessment (see Section 3) and used the results to prioritize the identified hazards. The Core Teams evaluated the natural hazards that can impact their town based on probability of occurrence, severity of impacts, and area of occurrence. The Core Teams also reviewed the towns' Existing Mitigation Strategies (Tables 4-1 and 4-2) and the work completed since the 2014 plan (Tables 4-5 and 4-7) to determine the Priority Level for each hazard.

The Committees developed problem statements and/or a list of key issues for each hazard to summarize the vulnerability of structures, systems, populations and other community assets in their town identified as vulnerable to damage and loss from a hazard event. These problem statements were used to identify the Town's greatest vulnerabilities that will be addressed in the mitigation strategy (Section 4). For the most part, those hazards receiving the highest Overall Hazard Vulnerability Rating were also assigned a Priority Level of High, as shown in Table 4-3.

Table 4-3: Hazard Priority Level Rating

	NORTHFIELD		WARWICK	
Natural Hazard	**Overall Hazard Vulnerability Rating**	**Priority Level**	**Overall Hazard Vulnerability Rating**	**Priority Level**
Severe Winter Storms	High	High	High	Medium
Flooding	High	High	Medium	High
Hurricanes / Tropical Storms	Medium	Medium	Medium	Medium
Severe Thunderstorms / Wind / Microbursts	High	High	High	High
Extreme Temperatures	Medium	Medium	High	Medium
Landslides	Low	Low	Low	Low
Drought	High	High	Medium	Medium
Invasive Species	Medium	Medium	High	High
Dam Failure	High	High	Low	Low
Wildfires	Medium	Medium	Low	Medium
Tornadoes	Medium	Medium	Low	Low
Earthquakes	Low	Low	Low	Low

Prioritization of Action Items

The Hazard Mitigation Committee identified several strategies that are currently being pursued, and other strategies that will require additional resources to implement. Strategies are based on the work of the Committee, as well as the hazard identification and risk assessment (Section 3) and the information in Tables 4-1, 4-2 and 4-4, 4-6 of this plan.

Prioritization Methodology

The Northfield and Warwick Hazard Mitigation Planning Committees reviewed and prioritized a list of mitigation strategies using the following criteria:

- **Application to high priority or multiple hazards** – Strategies are given a higher priority if they assist in the mitigation of hazards identified as high priorities (Table 4-3) or apply to several natural hazards.

- **Time required for completion** – Projects that are faster to implement, either due to the nature of the permitting process or other regulatory procedures, or because of the time it takes to secure funding, are given higher priority.

- **Estimated benefit** – Strategies which would provide the highest degree of reduction in loss of property and life are given a higher priority. This estimate is based on the Hazard Identification and Risk Assessment Chapter, particularly with regard to how much of each hazard's impact would be mitigated.

- **Cost effectiveness** – In order to maximize the effect of mitigation efforts using limited funds, priority is given to low-cost strategies. For example, regular tree maintenance is a relatively low-cost operational strategy that can significantly reduce the length of time of power outages during a winter storm. Strategies that have identified potential funding streams, such as the Hazard Mitigation Grant Program, are also given higher priority.

The following categories are used to define the priority of each mitigation strategy:

- **Low** – Strategies that would not have a significant benefit to property or people, address only one or two hazards, or would require funding and time resources that are impractical.

- **Medium** – Strategies that would have some benefit to people and property and are somewhat cost effective at reducing damage to property and people.

- **High** – Strategies that provide mitigation of high priority hazards or multiple hazards and have a large benefit that warrants their cost and time to complete.

- **Very High** – extremely beneficial projects that will greatly contribute to mitigation of high priority and multiple hazards and the protection of people and property. These projects are also given a numeric ranking within the category.

Cost Estimates

Each of the following implementation strategies is provided with a cost estimate. Projects that already have secured funding are noted as such. Where precise financial estimates are not currently available, categories were used with the following assigned dollar ranges:

- **Low** – cost less than $25,000
- **Medium** – cost between $25,000 – $100,000
- **High** – cost over $100,000

Cost estimates take into account the following resources:

- Town staff time for grant application and administration (at a rate of $25 per hour)
- Consultant design and construction cost (based on estimates for projects obtained from town and general knowledge of previous work in town)
- Town staff time for construction, maintenance, and operation activities (at a rate of $25 per hour)

Project Timeline

The timeframe for implementation of the action items are listed in the Action Plan as Year 0-1, which is the first year following plan adoption, and subsequent years after plan adoption through the 5 year life of the plan (Year 2, Year 3, Year 4 and Year 5). The Committees recognized that many mitigation action items have a timeframe that is ongoing due to either funding constraints that delay complete implementation and/or the action item should be implemented each of the five years of the plan, if possible. Therefore, a category of Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate was added.

Even when the political will exists to implement the Action Items, the fact remains that Northfield and Warwick are small towns that rely heavily on a small number of paid staff, many of whom have multiple responsibilities, and a dedicated group of volunteers who serve on town boards. However, some Action Items, when implemented by Town staff and volunteers, result in a large benefit to the community for a relatively small cost.

For larger construction projects, the towns have limited funds to hire consultants and engineers to assist them with implementation. For these projects, the Town may seek assistance through the Franklin Regional Council of Governments (FRCOG). However, the availability of FRCOG staff can be constrained by the availability of grant funding.

The 2021 Hazard Mitigation Prioritized Action Plans for Northfield and Warwick are shown in Table 4-4 and Table 4-6. 2021 Preparedness and Response Action Plans for Northfield and Warwick are shown in Table 4-8 and Table 4-9. Potential funding sources for mitigation action items are listed when known. Other potential funding sources are listed in Table 5-1 of this plan. When Town funds are listed as a source to fund hazard mitigation projects or activities, either in part (match) or in full, these funds would be obtained from the Town's "general fund."

4.4 HAZARD MITIGATION PRIORITIZED ACTION PLANS FOR NORTHFIELD AND WARWICK

Table 4-4: Prioritized Action Plan for the Town of Northfield

Action Type	Action Description	Hazards Addressed	Responsible Department / Board	Estimated Cost	Potential Funding Source	Estimated Timeframe	Benefits: Society (S) Infrastructure (I) Environment (E)	2014 Priority -------- 2020 Priority	Status
Critical Facilities & Infrastructure	Seek funding for needed bridge and culvert repairs, replacements, as well as necessary planning and prioritization of work needed on culverts and bridges throughout town that are undersized/under capacity. Prioritize vulnerable bridges and culverts on the Town's evacuation routes and where road closures result in isolating residents and limiting access and response time for emergency responders.	Flooding, Hurricanes, Tropical Storms	Select Board, Conservation Commission, Highway Department	High	Town, MEMA FMAP / PDM, MA DEP Section 319 grants	Year 0-1 with construction anticipated to be complete by Year 2	S, I, E	**Medium**	New Action Item
Critical Facilities & Infrastructure	Inventory condition and map road-side drainage culverts. Prioritize upgrades and seek funding for construction for properly designed/sized culverts that are resilient to flooding and climate change.	Flooding, Hurricanes, Tropical Storms, Microbursts, Thunderstorms	Select Board, Highway Department	High	Town, MVP, Community Compact, HMGP	Year 2 for culvert inventory project. Years 3-5 for replacement	S, I, E	**Medium**	New Action Item
Local Plans & Regulations	Seek funding to pay for technical support and engineering plans to continue to implement stormwater Best Management Practices (BMPs) on Four Mile Brook Road, identified in the Four Mile Brook Watershed Management Plan, and to move the road away from the brook at high hazard areas to reduce flooding and erosion hazards and to mitigate future damage to the road and other property from flooding.	Flooding, Hurricanes, Tropical Storms	Select Board, Conservation Commission, Highway Department, FRCOG	High	Town, MEMA FMAP / PDM, MA DEP Section 319 grants	Year 3 with construction anticipated to be complete by Year 5	S, I, E	**Medium** -------- **Medium**	Action Item carried over from 2014. In 2010, DEP awarded the Town a s.319 Nonpoint Source Pollution grant, which funded the implementation of stormwater Best Management Practices at the six priority sites identified in the assessment. Additional funding is needed to complete implementing recommendations from the Four Mile Brook Watershed Management Plan.

Table 4-4: Prioritized Action Plan for the Town of Northfield									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2014 Priority -------- 2020 Priority**	**Status**
Critical Facilities & Infrastructure	To reduce the risk to property and infrastructure during high wind events, continue to inventory Town trees, prioritize areas for tree maintenance near utility lines in town and coordinate pruning or removal of trees/limbs with Eversource's to reduce the number of limbs near overhead power lines and reduce risk to infrastructure from storms.	Severe Winter Storms, Hurricanes, Tropical Storms, Tornadoes, Microbursts, Thunderstorms	Eversource, Highway Department	Medium	Town, Eversource	Year 0-1, to be reviewed and implemented in subsequent years 2-5	S, I	**High** **High**	Action description has been updated and carried over from 2014 plan. Effective at mitigating power outages and will be continued.
Local Plans & Regulations	Review and update the Flood Plain Overlay District Zoning Bylaw in accordance with new requirements outlined in the 2020 MA Model Floodplain Bylaw. Add flood prevention and preserving the integrity of the floodplain as a stated purpose, and further restrict or eliminate new development within the 100-year floodplain and areas prone to localized flooding. Update the boundaries of the Flood Plain Overlay District in conjunction with the new FEMA floodplain maps when they are available, and add to the official zoning map.	Flooding, Hurricanes, Tropical Storms, Microbursts, Thunderstorms	Planning Board, FRCOG	Low	MVP Action Grant, Town, FRCOG, DLTA	Year 2	S, I, E	**Medium** **Medium**	Carried over and modified from 2014. Northfield's 2020 proposed Subdivision Regulations updates (pending formal adoption) require that subdivision proposals located within Flood Hazard Areas comply with the Town of Northfield Flood Plain Overlay District Zoning Bylaw. FRCOG can provide technical assistance to update the bylaw and to add the boundaries of the Flood Plain Overlay District to the official zoning map.
Local Plans & Regulations	Seek funding and technical assistance to review and revise as necessary, the following land use regulations to ensure that flood prevention and mitigation is addressed adequately: • Site Plan Review • Open Space Development • Removal of Natural Materials	Flooding, Hurricanes, Tropical Storms, Microbursts, Thunderstorms	Planning Board, Conservation Commission	Low	Town, FRCOG Local Technical Assistance, MVP	Year 0-1, to be reviewed and implemented in subsequent years 2-5	S, I, E	**Medium** **Medium**	Carried over and modified from 2014. Updates to the following land use regulations were completed with the 2020 Subdivision Regulations updates (pending formal adoption): • Definitive Subdivision Plan • Subdivision Performance Guarantee • Subdivision Design Standards and Required Improvements

Table 4-4: Prioritized Action Plan for the Town of Northfield									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2014 Priority -------- 2020 Priority**	**Status**
Local Plans & Regulations	Seek funding and technical assistance to update and digitize the Water Supply Protection District map and incorporate onto the official zoning map. Ensure that the Water Supply Protection district regulations are adequately protective, provide descriptions of the different zones, and indicate the requirements in each zones and which zones are located within Water Supply Protection district boundaries. Digitize the 2017 Village Center, Planned Development, Recreational Tourism 1, and Recreational Tourism 2 planning districts and incorporate onto official zoning map to make these maps more useful to the Town.	Flooding, Hurricanes, Tropical Storms, Microbursts, Thunderstorms	Planning Board, Conservation Commission	Low	Town, FRCOG Local Technical Assistance, MVP	Year 0-1, to be reviewed and implemented in subsequent years 2-5	S, I, E	**Medium**	New Action Item. FRCOG can provide technical assistance.
Local Plans & Regulations	Seek technical assistance to develop and adopt a Wetlands Bylaw to prevent flooding and reduce the risk of damage to the natural environment.	Flooding, Hurricanes, Tropical Storms, Microbursts, Thunderstorms	Conservation Commission	Low	Town, FRCOG, DLTA	Year 3	S, I, E	**Medium** -------- **Medium**	Action Item carried over from 2014.
Education & Awareness	Conduct public outreach to raise awareness of the risks associated with building in the floodplain, including how to access the new FEMA floodplain maps when they become available, and information on the National Flood Insurance Program (NFIP).	Flooding, Hurricanes, Tropical Storms, Microbursts, Thunderstorms	Planning Board, Conservation Commission	Low	Town, Volunteers	Year 2-5, or when new FEMA floodplain maps become available.	S, I, E	**Medium** -------- **Low**	Action Item carried over from 2014.
Critical Facilities & Infrastructure	Compile an inventory of the historic structures and landscapes in the 100 year floodplain and other known areas of flooding and fluvial erosion. Hire a consultant to determine which structures may be at most risk for flooding and options for mitigating flood risks.	Flooding, Hurricanes, Tropical Storms, Microbursts, Thunderstorms	Historical Commission, Assessors	Low-Medium	Town, MVP, Mass Historic Commission	Year 3-5	I	**Medium**	New Action Item
Local Plans & Regulations	Seek funding and technical assistance to expand and update the Vulnerability Assessment for properties located within the 100-year floodplain, using Assessors' data and new FEMA flood maps. Particular consideration should be given to determining how many housing units within the floodplain are occupied by vulnerable populations.	Flooding, Hurricanes, Tropical Storms	Planning Board, Building Inspector, FRCOG	Low	Town, Volunteers, FRCOG Local Technical Assistance	Year 4	S, I, E	**Medium** -------- **Low**	Carried over from 2004 plan, not yet started due to lack of funding and staffing capacity. May become higher priority based on the new FEMA flood maps.

Table 4-4: Prioritized Action Plan for the Town of Northfield									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2014 Priority -------- 2020 Priority**	**Status**
Local Plans & Regulations	Support local and regional, watershed-wide open space protection efforts, particularly in floodplain areas, headwater uplands, and priority sites identified in Northfield's 2021 OSRP through the use of Community Preservation Act (CPA) funds.	Flooding, Hurricanes, Tropical Storms, Microbursts, Thunderstorms	Open Space Committee, Community Preservation Committee, Select Board	High	Town, Volunteers	Year 0-1, to be reviewed and implemented in subsequent years 2-5	S, I, E	**High** / **Medium**	Carried over from 2004 plan, ongoing. In 2008 Northfield adopted the CPA, which provides local funds for open space protection. The Town completed an update to the Northfield OSRP in 2021, which identifies priorities for open space protection in town. The Town will use the OSRP and this plan as guidance for prioritizing CPA open space funding.
Critical Facilities & Infrastructure	Ensure that planned upgrades of the WWTP safeguard new and existing buildings and infrastructure associated with the treatment facility from riverine flooding on the Connecticut River. Continue seeking financial assistance for nearly $8 million in required improvements urgently needed for the plant to meet operating standards and address flood vulnerability. Seek funding to implement recommended infrastrcuture upgrades and repairs in I/I engineering report to address aging sewage pipes and WWTP conditions that are causing repeated failures to meet EPA minimum Inflow and Infiltration requirements.	Flooding, Hurricanes, Tropical Storms, Microbursts, Thunderstorms	Select Board, Sewer Commissioners	High	Town, MVP, HMPG, MassDEP	Year 0-1, to be reviewed and implemented in subsequent years 2-5	S, I, E	**High**	New Action Item
Critical Facilities & Infrastructure	Seek funding to upgrade the backup generator at Town Hall to power the entire building during power outages, including Northfield Police, EOC and Senior Center. The current backup power cannot power the entire building.	Hurricanes, Tropical Storms, Microbursts, Thunderstorms, Severe Winter Storms	Emergency Management Director, Select Board	Med	HMPG	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5) as appropriate	S, I	**High**	New Action Item
Critical Facilities & Infrastructure	Seek funding to assess potential at municipal buildings and critical facilities for solar PV power and battery storage to supplement during power outages.	Hurricanes, Tropical Storms, Microbursts, Thunderstorms, Severe Winter Storms	Emergency Management Director, Select Board	Med	Green Communities (DOER), MVP	Year 2	S, I	**High**	New Action Item

Table 4-4: Prioritized Action Plan for the Town of Northfield									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2014 Priority -------- 2020 Priority**	**Status**
Education & Awareness	Many households do not have backup power. Provide guidance on residential backup power and explore grant options.	Hurricanes, Tropical Storms, Microbursts, Thunderstorms, Severe Winter Storms	Emergency Management Director,	Low	Town, MassSaves	Year 3	S, I	**Low**	New Action Item
Critical Facilities & Infrastructure	Develop and maintain a list of areas where repetitive power outages occur. Meet with Eversource to discuss potential opportunities to underground existing utility lines in priority locations, to identify funding sources, and to develop funding applications as needed.	Hurricanes, Tropical Storms, Microbursts, Thunderstorms, Severe Winter Storms	Eversource, Emergency Management Director, Select Board, Highway Department,	Low	Eversource, Town	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5) as appropriate	S, I	**High** **Low**	Carried over from 2014 plan.
Critical Facilities & Infrastructure	Update the Subdivision Rules and Regulations to require utility lines be placed underground in new subdivisions to reduce the risk of damage to property and infrastructure from high winds and to prevent wind-related damage, protect nearby roads and utilities, and ensure regular inspection and maintenance of existing communication infrastructure.	Hurricanes, Tropical Storms, Microbursts, Thunderstorms	Planning Board	Low	Town, FRCOG Local Technical Assistance	Year 3	S, I	**Medium**	Completed in 2020 proposed Subdivision Regulations updates (pending formal adoption).
Critical Facilities & Infrastructure	Develop back up and redundant communication options for residents and for town operations during hazards in the event that phone and internet lines and related communications infrastructure is damaged by high winds and downed trees. Many locations in town have weak cellular connectivity or no service at all due to local topography.	Hurricanes, Tropical Storms, Microbursts, Thunderstorms	Planning Board, Emergency Management Director	Low-Medium	Town, FRCOG Local Technical Assistance	Year 3	S, I	**Medium**	New Action Item
Critical Facilities & Infrastructure	Utilize Community Development Block Grant (CDBG) and other funding for home rehabilitation work for low to moderate income households to bring existing homes up to code to better withstand high wind events. Work with the HRA to develop and distribute a brochure to publicize the program at the Town Hall, public events, and through the Town website and annual mailings.	Flooding, Hurricanes, Tropical Storms, Microbursts, Thunderstorms	Select Board, Franklin County Regional Housing and Redevelopment Authority (HRA)	Low	Town, CDBG	Year 3	S, I	**High** **Medium**	The Town has an agreement with the HRA to run the program on a yearly basis when funding is available. Funds are currently available to run the program in Northfield. Town can continue to apply for CDBG funds.

Table 4-4: Prioritized Action Plan for the Town of Northfield									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2014 Priority -------- 2020 Priority**	**Status**
Critical Facilities & Infrastructure; Education & Awareness	Distribute Emergency Action Plans and inundation mapping for Significant and High Hazard dams with the potential to impact Northfield to public safety officials, residents and businesses in Town, including Nelson Mills Pond Dam. Develop and rehearse dam failure evacuation and response plans. Encourage residents in dam inundation areas to enroll in Northfield's CODE RED service in order to be alerted by phone in the event of a dam failure.	Dam Failure	EMD, Police, Fire	Low	Town	Year 1 and ongoing	S, I, E	**High** / **Medium**	Carried over and modified from 2014. Town has an EAP for Northfield Mountain Reservoir Dam and can access the EAP for Grandin Reservoir Dam. Inundation maps are available for dams on the Connecticut River and the Mount Hermon Upper Reservoir Dam. Request regular dam inspections and inundation mapping for Nelson Mills Pond Dam.
Critical Facilities & Infrastructure	Evaluate locations and risk of potential flooding and dam failures associated with beaver activity, dams, and related flooding. Seek funding for technical assistance to remedy shortfalls of previously attempted beaver management solutions, including water level and flow-control devices in priority areas, and to identify alternative management solutions to reduce the need for on-going trapping.	Flooding, Hurricanes, Tropical Storms, Microbursts, Thunderstorms, Dam Failure	Highway Department Conservation Commission Select Board	Low-Medium	Town	Year 1 and ongoing for monitoring; Year 5 for investigating funding options	S, I, E	**Medium** / **Low**	This was a new action item in the 2014 plan. Progress has been made and is ongoing. Locations of existing beaver dams and beaver activity were updated for this plan.
Local Plans & Regulations	Through participation in the Connecticut River Streambank Erosion Committee, seek funding to continue to implement bank stabilization measures along the Connecticut River to reduce damages to the natural and built environment from landslides associated with flooding events.	Flooding, Dam Failure, Landslides	Select Board, Conservation Commission, Connecticut River Streambank Erosion Committee	High	Town, Volunteers, Mass DEP Section 319 grants	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5) as appropriate	S, I, E	**Medium** / **Medium**	Carried over from 2014. Since 1996, bioengineering techniques have been used in a number of areas along the Connecticut River in Northfield to stabilize eroding banks. Funding is still needed for additional projects.
Local Plans & Regulations	Revise the Site Plan Review requirements in the Zoning Bylaws to require that all new construction, regardless of size, minimize the removal of mature trees and vegetation to the extent possible, to mitigate the potential for landslides to occur.	Landslides	Planning Board	Low	Town, FRCOG Local Technical Assistance	Year 3	S, I, E	**Medium** / **Medium**	Carried over from 2014 plan. Not addressed in 2017 or 2020 regulatory updates.

Table 4-4: Prioritized Action Plan for the Town of Northfield									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2014 Priority -------- 2020 Priority**	**Status**
Local Plans & Regulations	Work with the current owner of the East Northfield Water Company to ensure regular inspections continue for the Grandin Reservoir Dam. Request and maintain dam inspection reports from the East Northfield Water Company for the dam.	Dam Failure	Emergency Management Director, Select Board, East Northfield Water Company	Low	Town, East Northfield Water Company	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5) as appropriate	S, I, E	**Medium** / **Medium**	Carried over from 2014 plan. The Town will reach out to the current owners to ensure understanding of the inspection and Emergency Action Planning requirements associated with the dam.
Critical Facilities & Infrastructure	Seek funding to assess both water districts for solutions to help ensure that each system can meet day-to-day needs and be resilient to drought, flooding and wildfire. Seek funding for engineering assessments, hydrological studies, and technical legal support for addressing water quality issues, for understanding needed infrastructure upgrades at each water district, and for understanding the implications of establishing a second water district. Seek funding to implement needed improvements.	Drought, Flooding, Wildfire	Select Board, East Northfield Water Company, Northfield Water District	High	Town, East Northfield Water Company, HMPG, MVP	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5) as appropriate	S, I, E	**High**	New Action Item
Education & Awareness	Conduct education and outreach to residents about water conservation and rainwater harvesting techniques to prevent private wells serving most homes in Northfield from running dry.	Drought	Fire Department, Conservation Commission	Low	Town	Year 3	S, I, E	**Low**	New Action Item
Education & Awareness Local Plans & Regulations	Establish regular contact with the DCR Service Forester assigned to Northfield to ensure that active Cutting Plans are being monitored, enforced and given to the Town. Implement forest stewardship practices that produce more climate resilient and stable, successional forested landscapes, which reduce the risk of fire hazards. Improve condition of access roads for firefighting. Encourage (or require) Fire Department review of Forest Cutting Plans. Work with Town Counsel to develop local regulations to require Fire Department review and oversight of logging in town. Or, amend Conservation Commission's review procedures to include review by Fire Department.	Wildfire	Fire Department, Conservation Commission, Select Board, DCR	Low	Town, Forest Land Enhancement Program, Rural Fire Assistance, National Fire Plan	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5) as appropriate	S, I, E	**Medium** / **Medium**	Action Item carried over and modified from 2014.

Table 4-4: Prioritized Action Plan for the Town of Northfield									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2014 Priority -------- 2020 Priority**	**Status**
Education & Awareness	Educate residents through materials posted on the Town website about the risk of wildfire and brushfire and how to reduce this risk by adopting general fire safety techniques. Use materials available from DCR.	Wildfire	Shelburne Control, Fire Department, DCR	Low	Town	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5) as appropriate	S, I, E	**Medium** / **Medium**	Carried over from 2004 plan. Northfield Fire Department has an ongoing educational program in the schools to teach fire safety during Fire Prevention Week. This outreach will be expanded to residents to include mitigation techniques for wildfires and brushfires. Shelburne Control provides guidance on fire safety when issuing burn permits.
Critical Facilities & Infrastructure	Seek funding to increase the staff of the Fire Department's inspection and safety unit.	Wildfire	Fire Department	Medium	Town	Year 4	S, I, E	**Low** / **Low**	Carried over from 2004 plan, not completed due to lack of funding and staffing capacity. Relevant to increased demand for inspections.
Critical Facilities & Infrastructure	Hire an engineer to inspect municipal buildings and structures to determine if they are particularly vulnerable to earthquake damage (built prior to 1975) and determine if any retrofitting measures could mitigate this vulnerability. Prioritize buildings and mitigation measures and seek funding to implement the highest priorities.	Earthquakes	Emergency Management Director, Select Board, Building Inspector	Medium-High	Town, MVP, HMGP, USDA Rural Development	Year 2	S, I	**Medium** / **Low**	Action Item updated and carried over from 2004 plan. Not completed due to lack of funding and staffing capacity.
Education & Awareness	Utilize existing resources through FEMA's Ready.gov or other sources to conduct education and outreach to schools, businesses, and residents about proper procedures to follow during and after an earthquake through the following methods: • Conduct an annual earthquake drill at the Northfield Elementary School and Pioneer Valley Regional School, and provide printouts of FEMA's *What to Do Before, During, and After an Earthquake*, or similar fact sheet, for teachers to post in classrooms. • Distribute FEMA's *Earthquake Preparedness: What Every Childcare Provider Needs to Know* booklet to all licensed childcare providers in town. Provide a link to FEMA's *Earthquake Safety Checklist* or similar resource on the Town website for residents and businesses.	Earthquakes	Emergency Management Director, Building Inspector, Select Board	Low	Town	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5) as appropriate	S	**High** / **Low**	Carried over from 2014 plan. Resources can be found at http://www.fema.gov/earthquake-publications/earthquake-publications-individuals-and-families.

Table 4-4: Prioritized Action Plan for the Town of Northfield									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2014 Priority -------- 2020 Priority**	**Status**
Education & Awareness	Participate in trainings offered by FEMA's National Earthquake Technical Assistance Program (NETAP). NETAP is designed to help state, local, and tribal governments obtain the knowledge, tools, and support that they need to plan and implement effective earthquake mitigation strategies.	Earthquakes	Building Inspector, Emergency Management Director, Select Board	Low	Town	Year 0-1, to be reviewed annually and implemented in subsequent years	S	**High** / **Low**	This Action Item was carried over from 2014 plan. Taking place as part of continued trainings.
Education & Awareness	Conduct outreach town-wide through calling and mass-mailings to encourage enrollment in the Town's CODE RED notification service. Provide technical support and suitable modalities for elder adults to access emergency communications. Utilize the Senior Center for outreach and assistance.	Multiple Hazards	Emergency Management Director	Low	Town	Year 1 and ongoing	S, E	**High** / **High**	New Action Item
Education & Awareness	Utilize the Town website to disseminate emergency preparedness materials from westernmaready.gov and other sources on what to include in a 'home survival kit,' how to prepare homes and other structures to withstand flooding and high winds, and the proper evacuation procedures to follow during a natural disaster and to enroll in the Town's CODE RED system for emergency alerts. Review materials annually and update as needed. Utilize existing resources through FEMA's Ready.gov or other sources to conduct education and outreach to schools, businesses, and residents about proper procedures to follow during hazard events, such as an earthquake.	Multiple Hazards	Emergency Management Director	Low	Town	Year 1 and ongoing	S, E	**High** / **High**	Action Item was updated and carried over from 2014. Work was completed by the Board of Health and EMD. Information was posted on the EMD's page on the Town website and is still current

Table 4-4: Prioritized Action Plan for the Town of Northfield									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2014 Priority -------- 2020 Priority**	**Status**
Critical Facilities & Infrastructure	Research pre- and post-disaster tracking systems for hazards and losses. Identify one appropriate for Northfield. Implement the program to improve the Town's hazard mitigation planning and chances of qualifying for various grants. Continue to practice the MEMA system for departments to record costs and property damages from natural hazard events, and for businesses and residents to report property damages, and farmers to report crop damages. Conduct outreach to businesses, residents, and farmers about the system and why it is important to report damages to the Town.	Multiple Hazards	Select Board, Emergency Management Director, Highway Superintendent	Low	Town, Volunteers	Year 2	S, I, E	**High** / **Low**	Ongoing from 2004 plan. The Town sends out an annual mailing to all residents with information on what local radio stations provide emergency information. The Town will supplement this information with a brochure outlining additional emergency preparedness information, and will review the materials annually and update as needed. Locate the GPS enabled digital cameras to town distributed by WRHSAC, to use to document infrastructure damages/losses and debris accumulation problems following a natural disaster.
Critical Facilities & Infrastructure	Collaborate with the Regional Emergency Planning Committee (REPC) to research appropriate vulnerability assessment models for fixed facility and transportation hazardous materials accidents or chemical spills, collect relevant data, and populate model to further prioritize manmade hazard action items.	Manmade Hazards	Emergency Management Director, REPC, FRCOG	Medium	FEMA	Year 2	S, I, E	**Medium** / **Medium**	This Action Item was carried over from 2014. Work is ongoing.
Local Plans & Regulations	Identify possible locations in Northfield and/or neighboring towns that could serve as debris management sites. Develop an MOU with local facilities for debris storage and management after a hazard event.	All Hazards	Highway Department, EMD, Select Board	Low	Town, MVP	Year 2 and ongoing	S, I, E	**High**	New Action Item. The Town has participated in the Franklin County Regional Emergency Planning Committee's (REPC) ongoing project to identify appropriate regional debris management locations.

Table 4-5: Town of Northfield Complete or Obsolete 2014 Hazard Mitigation Actions								
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**Priority in 2014 Plan**	**Current Status**
Local Plans & Regulations	Seek technical assistance to incorporate Dam Safety into Subdivision Regulations by requiring applicants to consult the Dam and Inundation Areas map during their preparation of subdivision plans. The applicant should assess the risk to the potential development from dams and supply that information along with mitigation measures to the Town as part of the review process.	Dam Failure	Emergency Management Director, Planning Board, Zoning Board of Appeals, Building Inspector	Medium	Town, FRCOG Local Technical Assistance	S, I, E	**Medium**	Completed in 2020 proposed Subdivision Regulations updates in the Application for Definitive Plan and Submittal Requirements (pending formal adoption).
Critical Facilities & Infrastructure	Monitor the rivers and streams in town for potential ice buildup and ice jams. Particular attention should be paid to any changes in ice build up on the Connecticut River after the Vermont Yankee Nuclear Power Plant ceases operation at the end of 2014.	Flooding, Ice Jams	Emergency Management Director, Highway Department	Low	Town	S, I, E	**Low**	Action Item carried over from the 2014 plan. Obsolete. Hasn't caused issues or raised river level at all.

Table 4-6: Prioritized Action Plan for the Town of Warwick									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2015 Priority -------- 2021 Priority**	**Status**
Critical Facilities & Infrastructure	Continuing to inventory, assess, and prioritize culverts in town; utilize assessment and right-sizing protocol for drainage culverts that do not cross a perennial stream (currently in pilot phase). When replacing culverts at road/stream crossings, meet the MA Stream Crossing Standards to promote fish and wildlife movement and flood resiliency, when feasible.	Flooding, Hurricanes, Tropical Storms, Thunderstorms	Highway Department, Conservation Commission	High	Town, DLTA, MEMA, MassDOT, MA DER Culvert Replacement, MassWorks, MVP	Years 1 - 5	S, I, E	High Medium	Modified from 2015 plan. MVP Action. The town has over 400 culverts. Highway Dept. working on collecting GPS coordinates for culverts. Try to upsize as working on roads. Northfield Rd. culvert will be replaced according to Stream Crossing Standards.
Critical Facilities & Infrastructure	Continue to maintain existing drainage infrastructure. Assess areas prone to washout for possible drainage improvements including stormwater Best Management Practices and streambank stabilization to protect the road, improve water quality in roadside streams and drinking water wells; prioritize areas where washouts would isolate residents.	Flooding	Highway Department, Conservation Commission	Low	Town, MassDOT, MassDEP, , Mass Works, MVP	Years 1 - 5	S, I, E	High High	Modified from 2015 plan. MVP Action. Highway Dept. continues to clear culverts and drainage infrastructure.
Critical Facilities & Infrastructure	Seek funding to undertake improvements on key sections of Winchester Road (Route 78) to improve drainage and stormwater management, taking into account climate change projections, especially in the following areas that have previously suffered flooding from major storms: • Near Mountain Brook: stabilize the brook banking along Winchester Road from Garage Road down to where Mountain Brook crosses Winchester Road and install new guardrail and upgrade the improperly designed culvert which is 42 inches at the inlet but narrows down to 38 inches on the outlet side, creating a pressure point. • Near Gulf Brook in Mount Grace State Forest needs bank stabilization near the road.	Flooding	Highway Department, Conservation Commission	High	Town, HMP, MassDOT, MassDEP, Mass Works, MVP, MA DER Culvert Replacement Program	Year 3	S, I, E	High High	Carried over from 2015 Plan. MVP Action. An improperly sized culvert resulted in a road washout in 1999. The culvert was not repaired, only the road. This is the Town's largest vulnerability but it is a high cost project.
Critical Facilities & Infrastructure	Hire an engineer to conduct a hydraulic analysis to provide prioritized recommendations for construction projects to mitigate damage from flood events in the following key areas of concern: • Wendell Road/Moss Brook • Hockanum Road (box culvert) • Gale Meadows on Athol and Gale Roads (beaver issue) • Kidder Brook on Robbins and Old Winchester Roads.	Flooding, Hurricanes, Tropical Storms	Select Board, Highway Department, Conservation Commission	High	Town, MEMA, Transportation bonds, MassDOT, MassWorks	Year 2	S, I, E	Medium Medium	Carried over from 2015 plan.

Table 4-6: Prioritized Action Plan for the Town of Warwick									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2015 Priority -------- 2021 Priority**	**Status**
Critical Facilities & Infrastructure	Hire an engineer to evaluate drainage on Chestnut Hill Road and provide recommendations for improving surface water drainage on the dirt road.	Flooding, Hurricanes, Tropical Storms	Select Board, Highway Department, Conservation Commission	High	Town, MEMA, MassDOT, MassWorks	Year 3	S, I, E	Low Low	Carried over from 2015 plan. Not more critical than other roads. Addressed one section of this road, still work to be done on other sections.
Critical Facilities & Infrastructure	Assess and design drainage improvements along Northfield Road to incorporate into an upcoming re-paving project.	Flooding	Select Board, Highway Department, Conservation Commission	High	Town, Mass DOT, MassWorks (STRAP), DER Culvert Replacement, MVP	Year 2	S, I, E	High	New MVP Action. Improvements include meeting MA Stream Crossing Standards for culvert replacement. STRAP grant is funding the project, but may not be able to cover the full cost of replacing the culvert.
Nature-Based Solutions / Critical Facilities & Infrastructure	Work with Trout Unlimited, land trusts, private landowners, and DCR on assessing streams for conservation and management strategies to slow floodwaters and reduce debris, habitat destruction, and impacts to downstream infrastructure.	Flooding	Conservation Commission, Open Space Committee, Highway Department, DCR	Low	Town, US Forest Service, NRCS, MVP	Year 4	S, I, E	Low	New MVP Action. Stream crossings could be improved but not habitually a problem.
Nature-Based Solutions	Conduct River Corridor mapping and adopt River Corridor Protection zoning to protect riverine areas. Work with land trusts to implement a River Corridor easement program to conserve property within the River Corridor area.	Flooding	Planning Board, Conservation Commission, Open Space Committee	Medium	Town, DLTA, MVP, Community One Stop for Growth	Year 5	S, I, E	Low	New MVP Action. Existing zoning protects streams and there is little development near the floodplain.
Critical Facilities & Infrastructure	Equip Town Hall, Warwick Community School, and new Fire Station with back-up power; explore installation of more solar PV on Town land or buildings, combined with battery storage; explore feasibility of a solar-powered micro-grid in the Town center.	Multiple Hazards	Select Board, Fire Department, School Committee, Buildings and Energy Committee	High	Town, MA DOER, MVP	Year 2	S	Medium	New MVP Action. Town Hall and Fire Station are not equipped with back-up power; Town facilities are in need of HVAC upgrades to improve energy resilience.

Table 4-6: Prioritized Action Plan for the Town of Warwick									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2015 Priority -------- 2021 Priority**	**Status**
Critical Facilities & Infrastructure	Consider using the Warwick Community School as a warming or cooling center during times when school is not in session. Upgrade back-up power at the school to serve critical functions.	Extreme Temperatures	EMD, Select Board, School Committee	High	Town, MEMA, MVP	Year 4	S, I	Medium	New MVP Action. Currently Town Hall can serve as a warming or cooling center but lacks back-up power.
Critical Facilities & Infrastructure / Public Awareness & Education	Implement a public education program for private well owners about proper construction methods and periodic inspections and testing to guard against contamination resulting from the infiltration of stormwater.	Flooding	Board of Health	Low	Town, Mass DEP	Years 1 - 5	S	Low / Low	Carried over from 2015 Plan. The Town established a testing program for well owners that covers the cost of a second test in the event a first test shows elevated salt levels.
Local Plans & Regulations / Nature-Based Solutions	Review and update relevant sections of the Warwick Protective Zoning Bylaws and Subdivision Regulations to require or encourage the use of Low Impact Development (LID) for stormwater management for new development and redevelopment projects.	Flooding, Hurricanes, Tropical Storms, Microbursts, Thunderstorms	Planning Board	Low	MVP, Town, DLTA, Community One Stop for Growth	Year 3	S, I, E	Medium / Medium	Modified from 2015 plan.
Local Plans & Regulations	Develop and adopt a large-scale solar PV bylaw to limit impacts on natural resources and direct this type of development to appropriate areas of town.	Multiple Hazards	Planning Board	Low	MVP, Town, DLTA, Community One Stop for Growth	Year 2	S, I, E	Medium	New MVP and OSRP Action. A by-right solar bylaw is in place for the capped landfill; current electric infrastructure does not support large scale solar.
Nature-Based Solutions	Implement the recommendations of the 2020 – 2027 Warwick Open Space and Recreation Plan, including prioritizing town sponsored land conservation projects and supporting local and regional, watershed-wide open space protection efforts.	Multiple Hazards	Open Space Committee	Low - High	Town, Volunteers, MVP, MA DCS, Land Trusts	Years 1 - 5	S, I, E	High / High	Modified from 2015 plan. MVP and OSRP Actions.
Local Plans & Regulations	Adopt a Zoning Bylaw that prevents wind damage to wireless communication facilities, and promotes appropriate siting of wireless facilities.	Hurricanes, Tropical Storms, Tornados, Microbursts, Thunderstorms	Planning Board	Low	Town, Volunteers	Year 2	S, I	High / Medium	Modified from 2015 plan.

Table 4-6: Prioritized Action Plan for the Town of Warwick									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2015 Priority -------- 2021 Priority**	**Status**
Critical Facilities & Infrastructure	Conduct proactive tree maintenance or removal of trees capable of striking communication towers. Ensure that communications and other towers located in Town are properly secured to protect them from damages resulting from high winds.	Hurricanes, Tropical Storms, Tornados, Microbursts, Thunderstorms	Town Coordinator, Highway Department, Fire Department, Conservation Commission, EMD	Medium	Town, Volunteers, DCR	Year 3	S, I	High High	Modified from 2015 plan. MVP Action
Critical Facilities & Infrastructure / Local Plans & Regulations	Encourage MA DCR to proceed with permitting the new tower on Mt. Grace to include AT&T FirstNet and civilian cell capacity. Develop a back-up communication network and plan for Town communications.	Multiple Hazards	Town Coordinator, Select Board, EMD, Fire Department, Police Department, Highway Department	High	Town, Homeland Security, MEMA, MVP	Year 2	S	High	New MVP Action. Mt. Grace radio tower is being replaced with a new, taller tower with back-up power and emergency communication channels including AT&T FirstNet
Critical Facilities & Infrastructure	Deploy civilian cell service in town as part of the AT&T FirstNet tower build on Mt. Grace. Improve the Warwick broadband network to be more dependable, making it possible for calls to be made via wifi for residents that have a phone and plan that supports it.	Multiple Hazards	Town Coordinator, Select Board	High	Town, Homeland Security, MEMA, MVP	Year 2	S	High	New MVP Action. Warwick has no cell coverage, and landlines rely on old wires that frequently have issues, leaving residents without reliable phone service. Verizon did spend $ to improve landlines.
Local Plans & Regulations / Nature-Based Solutions	Consider updates to zoning that balances conservation of open fields, farmland, forestland, streams, ponds, wetland, woods roads and trails, scenic views, and the town center with new development. Consider implementing Natural Resource Protection Zoning to protect large areas of open space with new housing development.	Flooding, Hurricanes, Tropical Storms, Microbursts, Thunderstorms	Planning Board, Conservation Commission	Low	Town, DLTA, Community One Stop for Growth	Years 1-5	S, I, E	Low	New Action identified in 2020 – 2027 OSRP.
Critical Facilities & Infrastructure	Seek funding for housing rehabilitation grants or loans to help residents with addressing health and safety issues in their homes. Assist residents with accessing existing programs and resources.	Multiple Hazards	Select Board, Franklin County Regional Housing and Redevelopment Authority (HRA)	Low	Town, CDBG, Community One Stop for Growth	Years 1 - 5	S, I	Medium	New MVP Action. The HRA administers a housing rehabilitation program for Warwick and other Franklin County towns primarily using CDBG funds.

Table 4-6: Prioritized Action Plan for the Town of Warwick									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2015 Priority -------- 2021 Priority**	**Status**
Public Education & Awareness	Periodically send out information to residents through the Town newsletter about Mass Save weatherization programs, clean energy rebates, and incentives for renewable energy and battery storage. Conduct a Warwick-style HeatSmart campaign - highlighting local heat pump case studies and connecting residents to local installers - to promote clean energy adoption in town.	Multiple Hazards	Building and Energy Committee, Town Coordinator	Low	Town, MA DOER, MA CEC, MVP	Years 1 - 5	S, E	Medium	New MVP Action. With electrical aggregation, the Town is providing residents with information on the lower electricity rate for low-income customers.
Critical Facilities & Infrastructure	Identify locations of existing beaver activity and dams. Inventory beaver damage locations and discuss mitigation options with Massachusetts Fish and Game. Investigate resources, funding, and information for addressing beaver dam issues on Town and private property.	Flooding, Hurricanes, Tropical Storms, Dam Failure	Town Coordinator, Highway Department, Emergency Management Director, Board of Health	Low-Medium	Town	Years 1 - 5	S, I, E	Medium -------- Medium	Carried over from 2015 plan. OSRP and MVP Action. Town is installing beaver deceivers where town has jurisdiction. On private land beavers are causing water levels to rise that can impact town roads.
Critical Facilities & Infrastructure	Monitor dams in town; conduct outreach to landowners on options for mitigating risks including resources for removing dams.	Dam Failure	Highway Department, Conservation Commission	Low	Town, MVP, MA DEP	Year 3	S, I, E	Medium --------	New MVP Action
Critical Facilities & Infrastructure	Identify priority areas for tree maintenance near utility lines and communication towers in town and coordinate with National Grid's to reduce the number of limbs near overhead power lines and reduce risk to infrastructure from storms.	Severe Winter Storms, Hurricanes, Tropical Storms, Tornadoes, Microbursts, Thunderstorms	National Grid, Highway Department, EMD, Select Board	Medium	Town, National Grid	Years 1 - 5	S, I	Medium -------- High	Updated and carried over from 2015 plan. MVP Action. Working with Town Forest Committee to make section of Wendell Rd. less vulnerable to trees.
Local Plans & Regulations	Maintain access to water sources for fire trucks and install dry hydrants at sources. Identify methods for increasing water storage capacity to mitigate impact to the built environment and forest resources.	Wildfire	Fire Department, Emergency Management Director	High	Town, MVP, Community One Stop for Growth	Years 1 - 5	S, I, E	High -------- High	Modified from 2015 plan. MVP and OSRP Actions.
Education & Awareness	Inventory and prioritize species threats and develop control options to minimize invasive species and pests impacts. Organize volunteer crews to implement control options. Educate the public about invasive species and their threats. Initiate a town-wide invasive species awareness day.	Invasive Species	Conservation Commission, Highway Department	Low	Town, Volunteers	Years 1 - 5	E	Medium --------	New MVP and OSRP Actions

Table 4-6: Prioritized Action Plan for the Town of Warwick									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2015 Priority -------- 2021 Priority**	**Status**
Education & Awareness	Utilize Code Red to provide timely notification to residents of mosquito-borne disease threats and precautions to take. Continue to inform residents about mitigation strategies like removing standing water from yards.	Invasive Species, Extreme Temperatures	Board of Health	Low	Town, Volunteers	Years 1 - 5	S	Medium	New MVP Action. The Board of Health provides public information on preventing mosquito and tick-borne disease. The new Code Red system is an opportunity to provide more immediate information.
Local Plans & Regulations	Consider participating in the Pioneer Valley Mosquito Control District to receive weekly monitoring of vector species and the presence of West Nile Virus and EEE via trapping, sorting, lab testing, and reporting.	Invasive Species, Extreme Temperatures	Board of Health, Select Board	Low	Town	Year 3	S	Medium	New MVP Action.
Local Plans & Regulations / Nature-Based Solutions	Encourage forest stewardship practices that produce more climate resilient and stable, successional forested landscapes and which reduce the risk of fire hazards; consider implementing a landowner incentive payment program for forestry Best Management Practices (BMPs) that promote forest health, carbon sequestration and storage, resiliency to climate change, and local wood products.	Multiple Hazards	Conservation Commission, Town Forest Committee, Fire Department, Tree Warden, Select Board	Low - High	Town, US Forest Service, DCR, MVP	Year 1 - 5	S, I, E	High	Modified from 2015 plan. MVP and OSRP Actions
Local Plans & Regulations	Encourage Fire Department review of Forest Cutting Plans. Coordinate with Conservation Commission, landowners and foresters when harvests are planned in order to improve fire access roads.	Wildfire	Fire Department, Conservation Commission	Low	Town, DCR	Years 1 - 5	S, I, E	Medium	Modified from 2015 Plan. MVP Action
Education & Awareness	Educate residents through materials posted on the Town website and distributed via the town's newsletter about the risk of wildfire and brushfire and how to reduce this risk by adopting general fire safety techniques. Work with DCR to acquire more educational signs indicating fire risk and install at Town trailheads and recreation areas. Continue to work with DCR to offer Smoky the Bear fire prevention training at the school.	Wildfire	Fire Department, Open Space Committee	Low	Town	Years 1 - 5	S, I, E	Medium -------- Medium	Modified from 2015 plan. MVP Action. Fire Safety training in done in October, but DCR staff are already booked; the Fire Dept. will work on scheduling DCR in late spring.
Local Plans & Regulations	Continue strong relationships with MA DCR Forest Fire Control; take advantage of trainings for local firefighters to build local capacity.	Wildfire	Fire Department	Low	Town	Years 1 - 5	S, I, E	Medium	New Action. MVP Action. The DCR trainings are new. The Fire Dept. is continuously training

Table 4-6: Prioritized Action Plan for the Town of Warwick									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2015 Priority -------- 2021 Priority**	**Status**
Critical Facilities & Infrastructure	Seek funding to increase the budget of the Fire Department to allow for voluntary life safety inspections and general fire safety.	Wildfire	Town Coordinator, Fire Departments	Low	Town Meeting	Year 3	S, I, E	Low Low	Carried over from 2015 plan. All public buildings are being inspected; extra funding for fire safety would be helpful.
Local Plans & Regulations	Research pre- and post-disaster tracking systems for hazards and losses. Identify one appropriate for Warwick. Implement program, which will improve the Town's hazard mitigation planning and chances of qualifying for various grants.	Multiple Hazards	Town Coordinator, Highway Department, Fire Department, Emergency Management Director	Low	Town	Years 1 - 5	S, I, E	High Medium	Carried over from 2015 plan. The Town is doing capital planning that includes roads, bridges, etc. and may be able to incorporate this into that process.
Education & Awareness	Periodically send out information to residents about how to be prepared to shelter in place, and what should be included in a "go bag" if evacuation to a shelter is required.	Multiple Hazards	Emergency Management Director	Low	Town	Years 1 - 5	S, E	High Medium	Modified from 2015 plan. MVP Action
Critical Facilities & Infrastructure	Participate in the Regional Emergency Planning Committee (REPC) trainings and exercises for fixed facility and transportation hazardous materials accidents.	Manmade Hazards	EMD, Fire Department, REPC	Low	MEMA	Years 1 - 5	S, I, E	Medium Medium	Modified from 2015 plan. The REPC typically holds at least one exercise annually.
Local Plans & Regulations	Mitigate illegal dump site which town acquired for unpaid taxes. Continue clean-up of garbage, tires, metal. Assure the problem is not worsened. Follow up on Level 1 environmental with Brownfields test boring and analysis in conjunction with FRCOG.	Manmade Hazards	Select Board, Town Coordinator	Low	Town, MA DEP, DLTA, U.S. EPA	Year 1	S, E	High 	New Action Item. The site was acquired by the Town in 2020. It previously was used for automobile storage and recycling. Clean-up has begun at the site.
Local Plans & Regulations	Identify possible locations in Warwick that could serve as debris management sites. Coordinate with state and regional agencies to identify a location(s) for the temporary storage of contaminated/ hazardous debris.	All Hazards	EMD, Select Board	Low	Town, MVP, MEMA	Year 2	S, I, E	High Low	Carried over from 2015. The Town lacks the resources to deal with hazardous debris.

Table 4-7: Town of Warwick Complete or Obsolete 2014 Hazard Mitigation Actions								
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**Priority in 2014 Plan**	**Current Status**
Local Plans & Regulations	To reduce the risk of landslides, ensure compliance with existing land use regulations (zoning bylaws, subdivision regulations, building codes) that direct development to stable slopes and soils. Protect existing development from potential landslides by ensuring that surface water and groundwater are properly managed. Update and amend, if necessary, the town's Zoning Bylaws and Subdivision Rules and Regulations to include a provision that sets limits on land clearing to maintain stable slopes to reduce the risk of landslides.	Landslides	Planning Board Building Inspector, Conservation Commission, Zoning Board of Appeals	Low	Town, Volunteers	S, I, E	**High**	Complete
Critical Facilities & Infrastructure	Enforce the State Building Code and provide training to the Building Inspector, as needed, to ensure new buildings are designed and constructed to reduce the risk of damage from high winds. Encourage the construction of new homes with basements, crawl spaces, or safe rooms to provide shelter during a hurricane or other storm event with high winds by providing information to prospective homeowners about structural designs that protect inhabitants from the effects of high winds.	Severe Winter Storms, Hurricanes, Tropical Storms, Tornadoes, Microbursts, Thunderstorms	Building Inspector	Medium	Town	S, I	**High**	Complete
Critical Facilities & Infrastructure	Maintain contact with officials at the Vermont Yankee Atomic Nuclear Electric Company's nuclear power plant located just across the border in Vernon, VT and conduct regular drills to prepare for a release of hazardous materials from the site in the final year of operations, during the decommissioning process, and in the event of continued storage of spent fuel rods on site.	Manmade Hazards	EMD, Fire Department	Low	Town, Volunteers	S, I, E	**High**	Obsolete
Critical Facilities & Infrastructure	Develop and maintain a list of areas where repetitive power outages occur. Meet with National Grid to discuss potential opportunities to underground existing utility lines in priority locations on the list. Work with National Grid to identify funding sources and to develop funding applications as needed.	Hurricanes, Tropical Storms, Tornados, Microbursts, Thunderstorms, Severe Winter Storms	Select Board, Town Coordinator, EMD, National Grid, Highway Department	High	National Grid, Town	S, I, E	Low	Obsolete – Town and utility are focusing on maintenance around lines instead of undergrounding existing wires.
Critical Facilities & Infrastructure	Monitor local streams and waterways for potential ice buildup and ice jams.	Flooding, Ice Jams	EMD, Fire Department	Low	Town	S, I, E	Low	Obsolete – no known issues in town.

5 PLAN ADOPTION AND MAINTENANCE

5.1 PLAN ADOPTION

The Franklin Regional Council of Governments (FRCOG) provided support to the Northfield and Warwick Core Team as they underwent the planning process. Town officials such as the Emergency Management Director and the Town Administrator were invaluable resources to the FRCOG and provided background and policy information and municipal documents, which were crucial to facilitating completion of the plan.

When the preliminary draft of the Northfield and Warwick Community Resilience Building and Hazard Mitigation Regional Plan was completed, copies were disseminated to the Committee for comment and approval. The Committee was comprised of representatives of Town boards and departments who bear the responsibility for implementing the action items and recommendations of the completed plan (see the list of Committee members on the front cover).

Copies of the Final Review Draft of the Plan for Northfield and Warwick were distributed to Town boards and officials, and to surrounding towns for review. Copies were made available at the Town Hall and the library, and a copy of the plan was also posted on the Town website for public review. Once reviewed and approved by MEMA, the plan was sent to the Federal Emergency Management Agency (FEMA) for their approval. FEMA approved the plan on [enter date], and on [enter date], the Northfield and Warwick Boards of Selectmen voted to adopt the plan (see Appendix C).

5.2 PLAN MAINTENANCE PROCESS

The implementation of the Northfield and Warwick Community Resilience Building and Hazard Mitigation Regional Plan will begin following its approval by MEMA and FEMA and formal adoption by the Northfield and Warwick Boards of Selectmen. Specific Town departments and boards will be responsible for ensuring the development of policies, bylaw revisions, and programs as described in the Action Plans (Table 4-3 and 4-5). The Northfield and Warwick Core Teams will oversee the implementation of the plan.

Monitoring, Evaluating, and Updating the Plan

The measure of success of the Northfield and Warwick Community Resilience Building and Hazard Mitigation Regional Plan will be the number of identified mitigation strategies implemented. In order for the Town to become more disaster resilient and better equipped to respond to natural disasters, there must be a coordinated effort between elected officials, appointed bodies, Town employees, regional and state agencies involved in disaster mitigation, and the general public.

Implementation Schedule

Annual Meetings

The Northfield and Warwick Core Teams will meet on an annual basis or as needed (i.e., following a natural or other disaster) to monitor the progress of implementation, evaluate the success or failure of implemented recommendations, and brainstorm for strategies to remove obstacles to implementation. Following these discussions, it is anticipated that the Committee may decide to reassign the roles and responsibilities for implementing mitigation strategies to different Town departments and/or revise the goals and objectives contained in the plan. At a minimum, the Committee will review and update the plan every five years. The meetings of the Core Teams will be organized and facilitated by the Northfield and Warwick Town Administrators and the Emergency Management Director.

Bi-Annual Progress Report

The Emergency Management Director will prepare and distribute a biannual progress report in years two and four of the plan. Members of the Local Planning Committee will be polled on any changes or revisions to the plan that may be needed, progress and accomplishments for implementation, failure to achieve progress, and any new hazards or problem areas that have been identified. Success or failure to implement recommendations will be evaluated differently depending on the nature of the individual Action Items being addressed, but will include, at a minimum, an analysis of the following: 1) whether or not the item has been addressed within the specified time frame; 2) whether actions have been taken by the designated responsible parties; 3) what funding sources were utilized; 4) whether or not the desired outcome has been achieved; and 4) identified barriers to implementation. This information will be used to prepare the bi-annual progress report which may be attached as an addendum, as needed, to the local hazard mitigation plan. The progress report will be distributed to all of the local implementation group members and other interested local stakeholders. The Emergency Management Director and the Committee will have primary responsibility for tracking progress and updating the plan.

Five-Year Update Preparation

During the fourth year after initial plan adoption, the Emergency Management Director will convene the Committee to begin preparations for an update of the plan, which will be required by the end of year five in order to maintain approved plan status with FEMA. The team will use the information from the annual meetings and the biannual progress reports to identify the needs and priorities for the plan update.

Updated Local Hazard Mitigation Plan – Preparation and Adoption

FEMA's approval of this plan is valid for five years, by which time an updated plan must be approved by FEMA in order to maintain the town's approved plan status and its eligibility for FEMA mitigation grants. Because of the time required to secure a planning grant, prepare an updated plan, and complete the approval and adoption of an updated plan, the local Multi-Hazard Mitigation Planning Committee should begin the process by the end of Year 3. This will help the town avoid a lapse in its approved plan status and grant eligibility when the current plan expires.

The Committee may decide to undertake the update themselves, request assistance from the Franklin Regional Council of Governments, or hire another consultant. However the Committee decides to proceed, the group will need to review the current FEMA hazard mitigation plan guidelines for any changes. The updated Northfield and Warwick Community Resilience Building and Hazard Mitigation Regional Plan will be forwarded to MEMA and to FEMA for approval.

As is the case with many Franklin County towns, Northfield and Warwick's government relies on a few public servants filling many roles, upon citizen volunteers and upon limited budgets. As such, implementation of the recommendations of this plan could be a challenge to the Committee. As the Committee meets regularly to assess progress, it should strive to identify shortfalls in staffing and funding and other issues which may hinder Plan implementation. The Committee can seek technical assistance from the Franklin Regional Council of Governments to help alleviate some of the staffing shortfalls. The Committee can also seek assistance and funding from the sources listed in Table 5-1.

Table 5-1: Potential Funding Sources for Hazard Mitigation Plan Implementation				
Program	**Type of Assistance**	**Availability**	**Managing Agency**	**Funding Source**
National Flood Insurance Program	Pre-disaster insurance	Rolling	DCR	Property Owner, FEMA
Community Assistance Program	State funds to provide assistance to communities in complying with NFIP requirements	Annually	DCR	FEMA/NFIP
Community Rating System (Part of the NFIP)	Flood insurance discounts	Rolling	DCR	Property Owner
Flood Mitigation Assistance (FMA) Program	Cost share grants for pre-disaster planning & projects	Annual	MEMA	75% FEMA/ 25% non-federal
Hazard Mitigation Grant Program (HMGP)	Post-disaster cost-share Grants	Post Disaster	MEMA	75% FEMA/ 25% non-federal
Pre-Disaster Mitigation (PDM) Program	National, competitive grant program for projects & planning	Annual	MEMA	75% FEMA/ 25% non-federal
Small Business Administration Disaster Loans	Post- disaster loans to qualified applicants	Ongoing	MEMA	Small Business Administration
Public Assistance Program	Post-disaster aid to state and local governments	Post Disaster	MEMA	FEMA/ plus a non-federal share
Dam & Seawall Repair & Removal Program	Grant and loan funds for design, permitting, and construction of repair or removal of dams	Annual	EEA	Dam and Seawall Repair or Removal Fund
Emergency Management Performance Grant (EMPG)	Funding to assist local emergency management departments in building and maintaining an all-hazards emergency preparedness system, including planning; organizational support; equipment; training; and exercises	When funds are available	MEMA	
Volunteer Fire Assistance (VFA) Program	Grants and materials to towns with less than 10,000 population for technical, financial and other assistance for forest fire related purposes, including training, Class A foam, personal protective gear, forestry tools, and other fire suppression equipment	Annual	DCR	USDA Forest Service
Federal 604b Water Quality Management Planning Grant	Funding for assessment and planning that identifies water quality problems and provides preliminary designs for Best Management Practices to address the problems	Annual	MA DEP	EPA Clean Water Act

Table 5-1: Potential Funding Sources for Hazard Mitigation Plan Implementation				
Program	**Type of Assistance**	**Availability**	**Managing Agency**	**Funding Source**
Section 319 Nonpoint Source Competitive Grant Program	Provides grants for wide variety of activities related to non-point source pollution runoff mitigation	Annual	MassDEP	EPA
Economic Development Administration Grants and Investment	Provides grants for community construction projects, which can include mitigation activities	Rolling	FRCOG	U.S. Department of Commerce, EDA
Emergency Watershed Protection	A disaster recovery program made available in emergency situations when neither the state nor the local community is able to repair a damaged watershed	Post-Disaster	NRCS MA	USDA NRCS
Agricultural Management Assistance	Funding for producers to develop or improve sources of irrigation water supply, construct new or reorganize irrigation delivery systems on existing cropland to mitigate the risk of drought	Rolling	NRCS MA	USDA NRCS
Conservation Stewardship Program	Agricultural producers and forest landowners earn payments for actively managing, maintaining, and expanding conservation activities – like cover crops, rotational grazing, ecologically-based pest management, buffer strips, and pollinator and beneficial insect habitat – while maintaining active agricultural production	Rolling	NRCS MA	USDA NRCS
Environmental Quality Incentives Program (EQIP)	Provides technical and financial assistance to forestry & agricultural producers to plan and install conservation practices that address natural resource concerns including water quality degradation, water conservation, reducing greenhouse gases, improving wildlife habitat, controlling invasive plant species, and on-farm energy conservation and efficiency.	Rolling	NRCS MA	USDA NRCS
Agricultural Lands Conservation Program (ACEP)	Provides financial and technical assistance to help conserve agricultural lands and wetlands.	Rolling	NRCS MA	USDA NRCS
Forest Stewardship Program	Supports private landowners and municipalities to manage woodlands for timber, soil and water quality, wildlife and fish habitat, and recreation	Rolling	DCR / MA Woodlands Institute	USDA Forest Service

Table 5-1: Potential Funding Sources for Hazard Mitigation Plan Implementation				
Program	**Type of Assistance**	**Availability**	**Managing Agency**	**Funding Source**
Community Forest Stewardship Implementation Grants for Municipalities	Municipalities that manage a town forest or have water supply land currently enrolled in the Forest Stewardship Program apply for 75-25 matching reimbursement grants to implement their forest stewardship plan	Rolling as funding permits	DCR	USDA Forest Service
USDA Community Facilities Direct Loan & Grant	Provides grants and loans for infrastructure and public safety development and enhancement in rural areas	Annual	USDA Rural Development MA	USDA Rural Development
Transportation Improvement Program	Prioritized, multi-year listing of transportation projects in a region that are to receive Federal funding for implementation. Projects are limited to certain roadways and are constrained by available funding for each fiscal year. Any transportation project in Franklin County that is to receive federal funding must be listed on the TIP.	Rolling	Franklin County Transportation Planning Organization / FRCOG	80% Federal / 20% State
Chapter 90 Program	Funds maintaining, repairing, improving and constructing town and county ways and bridges which qualify under the State Aid Highway Guidelines	Annual	Mass DOT	State Transportation Bond
Culvert Replacement Municipal Assistance Grant	Funds replacement of undersized, perched, and/or degraded culverts located in an area of high ecological value with better designed crossings that meet improved structural and environmental design standards and flood resiliency criteria	Annual	MA Division of Ecological Restoration	State Appropriation
MassWorks Infrastructure Program	Funds for public infrastructure such as roadways, streetscapes, water, and sewer	Annual	EOHED	State Appropriation
Municipal Small Bridge Program	5 year program (FY17 – FY21) to assist cities and towns with replacing or preserving bridges with spans between 10' and 20'	Bi-Annual	MassDOT	State Appropriation
Municipal Vulnerability Preparedness (MVP) Planning and Action Grant Programs	Funding to support cities and towns to begin the process of planning for climate change resiliency and implement priority projects; projects proposing nature-based solutions that rely on green infrastructure or conservation and enhancement of natural systems to improve community resilience are given priority for implementation funding through the MVP Action Grant	Annual	EEA	State Appropriation

Table 5-1: Potential Funding Sources for Hazard Mitigation Plan Implementation				
Program	**Type of Assistance**	**Availability**	**Managing Agency**	**Funding Source**
Land and Water Conservation Fund Grant Program	Funding for municipalities for the acquisition of parkland, development of a new park, renovation of an existing park, development of trails in an existing conservation or recreation area, or the acquisition of conservation land	Annual	EEA	National Park Service
Drinking Water Supply Protection Grant	Provides financial assistance to public water systems and municipal water departments for the purchase of land in existing Department of Environmental Protection (DEP)-approved drinking water supply protection areas, or land in estimated protection areas of identified and planned future water supply wells or intakes	Annual	EEA	EEA
Landscape Partnership Grant	Funding for large-scale (min. 500 acres), joint conservation projects completed in partnership with federal, state, and local governments, and non-profits	Annual	EEA	EEA
Conservation Partnership Grant	Funds acquisition of conservation or recreation land by non-profit entities	Annual	EEA	EEA
LAND – Local Acquisitions for Natural Diversity	Funding for municipal conservation and agricultural commissions to acquire interests in land that will be used for conservation and passive recreation purposes	Annual	EEA	EEA
PARC - Parkland Acquisitions and Renovations for Communities	Funding for municipalities to acquire parkland, build a new park, or to renovate an existing park	Annual	EEA	EEA

Table Acronym Key: DCR = MA Department of Conservation & Recreation; FEMA = Federal Emergency Management Agency; MEMA = MA Emergency Management Agency; EEA = MA Executive Office of Energy & Environmental Affairs; USDA = U.S. Department of Agriculture; NRCS = Natural Resource Conservation Service; EDA = U.S. Economic Development Administration; EPA = U.S. Environmental Protection Agency; FRCOG = Franklin Regional Council of Governments; MassDOT = MA Department of Transportation; EOHED = MA Executive Office of Housing & Economic Development

Incorporating the Plan into Existing Planning Mechanisms

2014 Northfield Multi-Hazard Mitigation Plan and 2015 Warwick Multi-Hazard Mitigation Plan

The Towns of Northfield and Warwick have taken steps to implement findings from the 2014 and 2015 Multi-Hazard Mitigation Plans into the following policy, programmatic areas and plans: the 2020 Open Space & Recreation Plans for each town and the joint 2020 Northfield and Warwick Community Resilience Building and Hazard Mitigation Regional Plan.

2020 Multi-Hazard Mitigation Plan
Upon approval of the Northfield and Warwick Community Resilience Building and Hazard Mitigation Regional Plan by FEMA, the Core Teams will provide all interested parties and implementing departments with a copy of the plan, with emphasis on Tables 4-4 and 4-6: 2020 Hazard Mitigation Prioritized Action Plans for Northfield and Warwick. The Core Teams should also consider initiating a discussion with each department on how the plan can be integrated into that department's ongoing work. At a minimum, the plan should be distributed to and reviewed with the following entities:

- Fire Department
- Emergency Management Director
- Police Department
- Public Works / Highway Department
- Planning Board
- Zoning Board of Appeals
- Conservation Commission
- Franklin County Regional Emergency Planning Committee
- Building Inspector/FCCIP
- Select Board

Some possible planning mechanisms for incorporating the Conway Multi-Hazard Mitigation Plan into existing planning mechanisms to the fullest extent possible could include:

- Incorporation of relevant Hazard Mitigation and climate change information into the Open Space and Recreation Plan. There are opportunities to discuss findings of the hazard mitigation plan and incorporate them into the Environmental Inventory and Analysis section of the OSRP and to include appropriate action items from the hazard mitigation plan in the OSRP Action Plan. The Town is planning to update its OSRP, which expires in 2020.

- Any future development of master plans and scenic byway plans could incorporate relevant material from this plan into sections such as the Natural Resources section and any action plans.
- When the Final Draft Multi-Hazard Mitigation Plan for the Town of Conway is distributed to the Town boards for their review, a letter asking each board to endorse any action item that lists that board as a responsible party would help to encourage completion of action items.
- The Planning Board could include discussions of the Multi-Hazard Mitigation Plan Action Items in one meeting annually and assess progress. Current Subdivision Rules and Regulations and Zoning Bylaws should be reviewed and revised by the EMD, Planning Board and Select Board based upon the recommendations of this plan. Technical assistance from the FRCOG may be available to assist in the modification of Conway's current Bylaws.

Continued Public Involvement

The Towns of Northfield and Warwick is dedicated to continued public involvement in the hazard mitigation planning and review process. During all phases of plan maintenance, the public will have the opportunity to provide feedback. The 2020 Plan will be maintained and available for review on the Town website through 2025. Individuals will have an opportunity to submit comments for the Plan update at any time. Any public meetings of the Core Teams will be publicized. This will provide the public an opportunity to express their concerns, opinions, or ideas about any updates/changes that are proposed to the Plan.

APPENDIX A Public Participation

APPENDIX B Certificate of Adoption

<LETTERHEAD>

CERTIFICATE OF ADOPTION

Town of Northfield, **MASSACHUSETTS**

BOARD OF SELECTMEN

A RESOLUTION ADOPTING THE Town of Northfield

MULTI-HAZARD MITIGATION PLAN

WHEREAS, the Town of Northfield established a Core Team to prepare the 2020 Northfield and Warwick Community Resilience Building and Hazard Mitigation Regional Plan; and

WHEREAS, the Town of Northfield Northfield and Warwick Community Resilience Building and Hazard Mitigation Regional Plan contains several potential future projects to mitigate potential impacts from natural hazards in the Town of Northfield, and

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

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

NOW, THEREFORE BE IT RESOLVED that the Town of Northfield BOARD OF SELECTMEN adopts the 2020 Northfield and Warwick Community Resilience Building and Hazard Mitigation Regional Plan, in accordance with M.G.L. Ch. 40.

ADOPTED AND SIGNED this Date.

Name(s)

Title(s)

Signature(s)

ATTEST

<LETTERHEAD>

CERTIFICATE OF ADOPTION

Town of Warwick, **MASSACHUSETTS**

BOARD OF SELECTMEN

A RESOLUTION ADOPTING THE Town of Warwick

MULTI-HAZARD MITIGATION PLAN

WHEREAS, the Town of Warwick established a Core Team to prepare the 2020 Northfield and Warwick Community Resilience Building and Hazard Mitigation Regional Plan; and

WHEREAS, the Town of Warwick Northfield and Warwick Community Resilience Building and Hazard Mitigation Regional Plan contains several potential future projects to mitigate potential impacts from natural hazards in the Town of Warwick, and

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

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

NOW, THEREFORE BE IT RESOLVED that the Town of Warwick BOARD OF SELECTMEN adopts the 2020 Northfield and Warwick Community Resilience Building and Hazard Mitigation Regional Plan, in accordance with M.G.L. Ch. 40.

ADOPTED AND SIGNED this Date.

Name(s)

Title(s)

Signature(s)

ATTEST