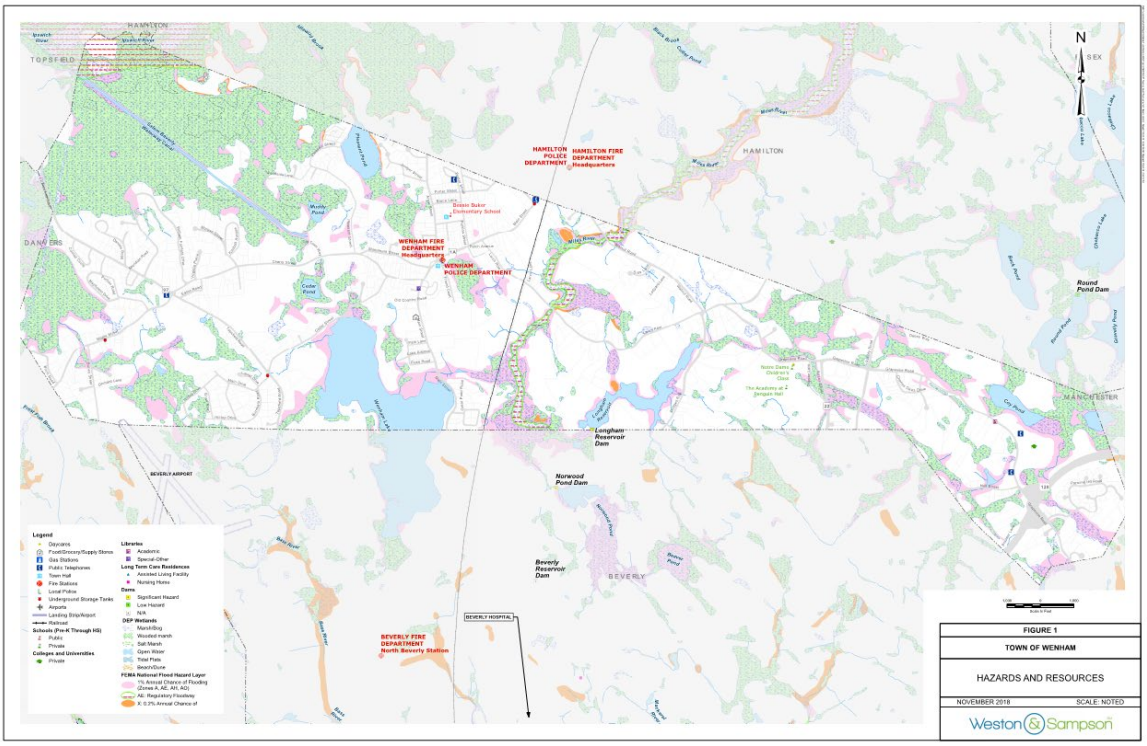
TOWN OF WENHAM
HAZARD MITIGATION PLAN and MUNICIPAL VULNERABILITY PREPAREDNESS PLAN
2019



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This plan was prepared for the Town of Wenham by Weston & Sampson (W&S) under the direction of the Massachusetts Emergency Management Agency (MEMA) and the Massachusetts Department of Conservation and Recreation (DCR).

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EXECUTIVE SUMMARY

Hazard mitigation planning is the effort to reduce loss of life and property by lessening the impacts of disasters. This is most effectively accomplished under the guidance of a long-term comprehensive plan. In Essex County and in Massachusetts, hazard mitigation planning most often focuses on flooding because flooding is the most likely natural hazard to impact these communities, including Wenham. To receive FEMA funding for hazard mitigation, the Federal Disaster Mitigation Act of 2000 requires that municipalities adopt a local Hazard Mitigation Plan (HMP) and update the plan every five years.

The Massachusetts Executive Office of Energy and Environmental Affairs' Municipal Vulnerability Preparedness (MVP) grant program helps communities plan and take action towards becoming more resilient to the impacts of climate change. The program provides MVP Planning Grants to assist municipalities in preparing for the impacts of climate change through participation in a community climate vulnerability workshop and development of a climate change action plan and MVP Action Grants to fund the implementation of priority climate change adaptation actions.

This plan provides for both a hazard mitigation planning approach, as well as incorporating MVP provisions for the City that are related to increasing resiliency associated with climate change impacts. This provides the City with a holistic assessment and implementation plan for both hazard mitigation and climate change resiliency.

Planning Process

The Wenham Hazard Mitigation Plan (HMP) was previously adopted by the Town on July 31, 2012 and was updated in 2019. The HMP update was led by the joint Wenham Municipal Vulnerability Preparedness (MVP) and HMP Core Committee ("Core Committee"; see Table 3-1). The Core Committee met on December 7, 2018, February 7, 2019, and April 19, 2019. During these meetings, the Core Committee:

- Set goals.
- Planned the public outreach to key stakeholders and the general public.
- Discussed where natural hazards would most affect the Town and possible solutions;
- Updated and revised the Town's existing mitigation measures.
- Identified high priority hazard mitigation measures could benefit the Town.

Public participation during this planning process was critical to both gaining knowledge of the vulnerable assets and the potential impacts within the Town. Public participation served as a mechanism to improve awareness and support of the proposed actions that the Core Committee identified to mitigate these hazards. An eight-hour Community Resilience Building Workshop was held to receive input from stakeholders on January 9, 2019. A second meeting was hosted as a listening session for the general public on March 21, 2019. Subsequently, the draft plan update was posted on the Town's website for public review. The Town of Wenham notified key stakeholders and neighboring communities about the opportunity to review the draft plan and submit comments. Appendix C presents additional information on outreach to stakeholders and the public.

Risk Assessment

The Wenham Hazard Mitigation Plan and Municipal Vulnerability Preparedness (HMP-MVP) Plan addresses impacts to the Town that could result from a variety of natural hazards as well as from climate change. The hazards identified and addressed include flooding, high winds, winter storms, coastal hazards, brush fires, geological hazards, extreme temperatures, and drought. Riverine and stormwater

flooding represent the greatest hazards to the Town. Areas of flooding are presented on maps in Appendix B.

The Wenham Core Committee identified 30 critical facilities. Critical facilities located within the mapped hazard zones are indicated on the map series (Appendix B) and listed in Table 2-5. The Core Committee identified the following hazard mitigation goals for the Town:

1. Prevent and reduce the loss of life, injury, public health impacts and property damages resulting from all major natural hazards.
2. Identify and seek funding for measures to mitigate or eliminate each known significant flood hazard area.
3. Integrate hazard mitigation planning as an integral factor in all relevant municipal departments, committees and boards.
4. Prevent and reduce the damage to public infrastructure resulting from all hazards.
5. Encourage the business community, major institutions and non-profits to work with the Town to develop, review and implement the hazard mitigation plan.
6. Work with surrounding communities, state, regional and federal agencies to ensure regional cooperation and solutions for hazards affecting multiple communities.
7. Ensure that future development meets federal, state and local standards for preventing and reducing the impacts of natural hazards.
8. Take maximum advantage of resources from FEMA and MEMA to educate Town staff and the public about hazard mitigation.
9. Consider the impacts of climate change and incorporate climate mitigation, adaptation, and sustainability in hazard mitigation planning.

Hazard Mitigation Strategy

The Wenham Core Committee identified several mitigation measures to reduce the Town's vulnerability to natural hazard events. These measures, listed in Table 8-2, include proposed infrastructure and drainage upgrades. Wenham's hazard mitigation strategy recognizes that mitigating hazards will be an ongoing process as mitigation measures are implemented and our understanding of natural hazards and climate change increases. Wenham will need to coordinate with neighboring municipalities and with state and federal agencies to better implement key mitigation strategies and to understand and address changes in hazards and climate. The Hazard Mitigation Strategy will be incorporated into the Town's related plans and policies.

Plan Review and Update Process

Wenham made progress on implementing mitigation measures identified in the 2012 Hazard Mitigation Plan. Several projects have been completed, including:

- Replaced the Essex Street culvert with dual 6'x6' box culverts.
- Preliminary design completed on Mill River Hull Street culvert.
- One additional DPW employee.
- The Wenham Open Space and Recreation Plan Update has received conditional approval from the State and will be resubmitted for full approval once the State's comments have been addressed.
- An additional sander has been obtained.
- A Tree Management Plan has been designed and implemented for Wenham with the assistance of Bartlett Tree Experts.

- A retention pond has been constructed at the new development on Grapevine Road, near the Beverly line. Flooding in this area is no longer an issue.
- Acquired 22 new handheld radios, three new fixed radio digital and radio mobile units, and 35 portable radios. The town is waiting on funding for the replacement of the existing 10-inch line with a new 8x10 pre-cast concrete culvert.
- The Stormwater Bylaws have been adopted.
- Continuously looking for opportunities for public outreach and education to residents on the importance of floodplain management, NFIP compliance, and development issues.
- Incorporated outfalls and catch basins into GIS database as part of the MS4 process.

Several other projects were partially completed and will be continued in this 2019 Plan Update.

Over the next five years, as the plan is being implemented, there will be many additional opportunities to incorporate hazard mitigation into the Town's decision-making processes.

The Town will document any actions taken within this iteration of the Hazard Mitigation Plan regarding challenges met and actions successfully adopted, as part of the ongoing plan maintenance to be conducted by the Wenham Hazard Mitigation Implementation Team. Plan maintenance is described further in Section 8, Plan Adoption and Maintenance.

1.0 INTRODUCTION

This section provides general background information related to the Wenham Hazard Mitigation Plan and Municipal Vulnerability Preparedness (HMP-MVP) Plan.

1.1 Planning Requirements under the Federal Disaster Mitigation Act

The purpose of the Federal Disaster Mitigation Act ("the Act"), passed in 2000, is "to reduce the loss of life and property, human suffering, economic disruption, and disaster assistance costs resulting from natural disasters." Section 322 of the Act specifically addresses mitigation planning and requires state and local governments to prepare multi-hazard mitigation plans as a precondition for receiving FEMA mitigation project grants.

Federal hazard mitigation planning and grant programs are administered by the Federal Emergency Management Agency (FEMA) in collaboration with the states. These programs are administered in Massachusetts by the Massachusetts Emergency Management Agency (MEMA) in partnership with the Massachusetts Department of Conservation and Recreation (DCR).

1.2 What is a Hazard Mitigation Plan and Municipal Vulnerability Preparedness?

Hazard mitigation is sustained action taken to reduce or eliminate the long-term risk to human life and property from hazards. Wenham has a responsibility to protect the health, safety, and welfare of its citizens through proactive mitigation policies and actions that help reduce risk and create a safer, more disaster-resilient Town. Hazard mitigation is critically important for:

- Protecting public safety and preventing loss of life and injury.
- Reducing harm to existing and future development.
- Preventing damage to a community's unique economic, cultural, and environmental assets.
- Minimizing operational downtime and accelerating recovery of government and business after disasters.
- Reducing the costs of disaster response and recovery and the exposure to risk for first responders.
- Helping accomplish other community objectives, such as leveraging capital improvements, infrastructure protection, open space preservation, and economic resiliency.

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Hazard mitigation planning uses a stepped process that includes an assessment of hazards, vulnerabilities and risks; and the development of the policies, tools and actions to mitigate those risks. This is accomplished through the participation of a wide range of stakeholders and the public, resulting in a plan for the community that will outline practical approaches to reduce long-term risks from natural hazards and disasters. Hazard mitigation is most effective when it is based on a comprehensive, long-term plan that is developed before a disaster occurs. According to the Federal Emergency Management Agency (FEMA), the purpose of mitigation planning is to identify local policies and actions that can be implemented over the long-term to reduce risk and future losses from hazards.

These mitigation policies and actions are identified based on an assessment of hazards, vulnerabilities, and risks. It is important to ensure that stakeholders and the public are an integral part of the planning process. Benefits of mitigation planning include:

- Identifying actions for risk reduction that are agreed upon by stakeholders and the public.
- Focusing resources on the greatest risks and vulnerabilities.
- Building partnerships by involving citizens, organizations, and businesses.
- Increasing education and awareness of threats and hazards, as well as their risks.
- Communicating priorities to State and Federal officials.
- Aligning risk reduction with other community objectives.

In 2017, the Massachusetts Executive Office of Energy and Environmental Affairs (EEA) initiated the Commonwealth's Municipal Vulnerability Preparedness (MVP) grant program to help communities plan and take action toward becoming more resilient to the impacts of climate change. The program provides Planning Grants to assist municipalities in preparing for the impacts of climate change through participation in a community climate vulnerability workshop and development of a climate change action plan. Communities that complete the planning grant program receive "a Certified MVP Community" designation, are then eligible for MVP Action Grants, and achieve increased standing in other state grant programs. MVP Action Grants fund the implementation of priority climate change adaptation actions that have been described in the municipality's MVP plan. The Town of Wenham received an MVP Planning Grant to simultaneously prepare an MVP plan and HMP. Many of the required steps of the MVP process also satisfy requirements for updating an HMP. As a result, the Town prepared this joint HMP-MVP Plan in accordance with FEMA guidelines for hazard mitigation planning (Title 44 Code of Regulations (CFR) 201.6) and with the Massachusetts Executive Office of Energy & Environmental Affairs' (EEA) requirements to follow the Community Resilience Building (CRB) Workshop Guidance, developed by The Nature Conservancy. This enabled Wenham to consider the impacts of climate change in its hazard mitigation planning, following the lead established by the Commonwealth when it adopted the first-ever Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2018).

1.3 Previous Federal/State Disasters

To understand the importance of hazard mitigation, it is useful to know the types and frequencies of disasters that occur in Massachusetts. Since 1991, there have been 22 storms in Massachusetts that resulted in Federal or State Disaster Declarations. Eighteen of these disaster declarations occurred in Essex County, which includes the Town of Wenham. These disasters and the related assistance are described in Table 1-1. Many of these storms caused severe flooding.

Table 1-1. Previous Federal/State Disaster Declarations

Disaster Name (Date of Event)	Disaster Number	Type of Assistance	Areas Under Declaration
Hurricane Bob August 19, 1991	DR-914	FEMA Hazard Mitigation Grant Program	Counties of Barnstable, Bristol, Dukes, Essex, Hampden, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk
Severe Coastal Storm October 30-November 2, 1991	DR-920	FEMA Hazard Mitigation Grant Program	Counties of Barnstable, Bristol, Dukes, Essex, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk

Table 1-1. Previous Federal/State Disaster Declarations

Disaster Name (Date of Event)	Disaster Number	Type of Assistance	Areas Under Declaration
Winter Coastal Storm December 11-13, 1992	DR-975	FEMA Hazard Mitigation Grant Program	Counties of Barnstable, Dukes, Essex, Plymouth, Suffolk
Blizzard January 7-13, 1996	DR-1090	No funding reported	All 14 Massachusetts Counties
Severe Storms/Flooding October 20-25, 1996	DR-1142	FEMA Hazard Mitigation Grant Program	Counties of Essex, Middlesex, Norfolk, Plymouth, Suffolk
Heavy Rain and Flooding June 13-July 6, 1998	DR-1224	FEMA Hazard Mitigation Grant Program	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
Severe Storms & Flooding March 5-April 16, 2001	DR-1364	FEMA Hazard Mitigation Grant Program	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
Flooding April 1-30, 2004	DR-1512	FEMA Individual & Households Program; FEMA Hazard Mitigation Grant Program	Essex, Middlesex, Norfolk, Suffolk, Worcester
Severe Storms and Flooding October 7-16, 2005	DR-1614	FEMA Public Assistance; FEMA Individual & Households Program; FEMA Hazard Mitigation Grant Program	All 14 Massachusetts Counties
Severe Storms and Flooding May 12-23, 2006	DR-1642	FEMA Public Assistance; FEMA Individual & Households Program; FEMA Hazard Mitigation Grant Program	Middlesex, Essex, Suffolk
Severe Storms and Inland and Coastal Flooding April 15-25, 2007	DR-1701	FEMA Public Assistance; FEMA Hazard Mitigation Grant Program	Berkshire, Franklin, Hampshire, Hampden, Essex, Plymouth, Barnstable, Dukes
Severe Winter Storm and Flooding December 11-18, 2008	DR-1813	FEMA Public Assistance; FEMA Hazard Mitigation Grant Program	All 14 Massachusetts Counties
Severe Storm and Flooding March 12-April 26, 2010	DR-1895	FEMA Public Assistance; FEMA Individual & Households Program; FEMA Hazard Mitigation Grant Program	Bristol, Essex, Middlesex, Suffolk, Norfolk, Plymouth, Worcester
Severe Winter Storm and Snowstorm January 11-12, 2011	DR-1959	FEMA Public Assistance; FEMA Hazard Mitigation Grant Program	Berkshire, Essex, Hampden, Hampshire, Middlesex, Norfolk, Suffolk
Severe Storms and Tornadoes	DR-1994	FEMA Public Assistance; FEMA Individual &	Hampden, Sturbridge, Southbridge, Worcester

Table 1-1. Previous Federal/State Disaster Declarations

Disaster Name (Date of Event)	Disaster Number	Type of Assistance	Areas Under Declaration
June 1, 2011		Households Program; FEMA Hazard Mitigation Grant Program	
Tropical Storm Irene August 27-29, 2011	DR-4028	FEMA Public Assistance; FEMA Individual & Households Program; FEMA Hazard Mitigation Grant Program	Barnstable, Berkshire, Bristol, Dukes, Franklin, Hampden, Hampshire, Norfolk, Plymouth
Severe Storm and Snowstorm October 29-30, 2011	DR-4051	FEMA Public Assistance; FEMA Public Assistance Snow Removal; FEMA Hazard Mitigation Grant Program	Berkshire, Franklin, Hampden, Hampshire, Middlesex, Worcester
Hurricane Sandy October 27-November 8, 2012	DR-4097	FEMA Public Assistance; FEMA Hazard Mitigation Grant Program	Barnstable, Bristol, Dukes, Nantucket, Plymouth, Suffolk
Severe Winter Storm, Snowstorm, and Flooding February 8-9, 2013	DR-4110	FEMA Public Assistance; FEMA Hazard Mitigation Grant Program	All 14 Massachusetts Counties
Severe Winter Storm, Snowstorm, and Flooding January 26-28, 2015	DR-4214	FEMA Public Assistance; FEMA Hazard Mitigation Grant Program	Barnstable, Bristol, Dukes, Essex, Middlesex, Nantucket, Norfolk, Plymouth, Suffolk, Worcester
Severe Winter Storm and Flooding March 2-3, 2018	DR-4372	FEMA Public Assistance; FEMA Hazard Mitigation Grant Program	Essex, Suffolk, Norfolk, Bristol, Plymouth, Barnstable, Nantucket
Severe Winter Storm and Snowstorm March 13-14, 2018	DR-4379	FEMA Public Assistance; FEMA Hazard Mitigation Grant Program	Essex, Middlesex, Norfolk, Suffolk, Worcester

Source: MEMA 2019; FEMA 2018b; MEMA and EOEEA 2018, 6-24 and Appendix B

1.4 FEMA Funded Mitigation Projects

The Town of Wenham has not received funding from FEMA for a mitigation project as part of the Hazard Mitigation Grant Program (HMGP; FEMA 2017).

Wenham participates in the National Flood Insurance Program (NFIP) (FEMA, 2018f). The NFIP is a Federal program administered by FEMA enabling property owners in participating communities to purchase insurance as a protection against flood losses in exchange for State and community floodplain management regulations that reduce future flood damages. NFIP offers flood insurance to communities that comply with the minimum standards for floodplain management.

NFIP uses a Community Rating System (CRS) to award communities that go beyond the minimum standards with lower flood insurance premiums for property owners. The incentives are awarded upon a credit system for various activities. Points are awarded to communities that prepare, adopt, implement, and update a comprehensive flood hazard mitigation plan using a Standard planning process. Wenham is not currently eligible to participate in the Community Rating System (CRS) Program.

2.0 COMMUNITY PROFILE, LAND USE AND DEVELOPMENT TRENDS

2.1 Community Profile

The Town of Wenham was originally settled in 1643, and has fortunately, retained much of its unique, historic character and tranquil, rural scenery. The Town has a total land area of 7.66 square miles (U.S. Census Bureau 2010). It is a town of many open views of farmlands, lakes, woodlands and old stone walls that accompany its winding tree-lined roads. To complement this handsome backdrop, the community is singularly fortunate to have been blessed with an active, involved citizenry, whose major goal has always been to protect what is precious from the past, while continuing to plan for future generations. Wenham is justly proud of its historic past; its present responsible and responsive local government; a wealth of dedicated and able volunteers; its nearly 300 acres of parks, playgrounds and recreational lands; and its excellent regional school system. Wenham is also home to Gordon College. Wenham voters are provided a "Free Lunch for Voters" at its traditional all-day Saturday town meeting. A walk along Wenham's lovely main street provides a timeless picture of beautiful old homes, gardens and yards, punctuated by friendly faces, residents say, giving one a general sense of connection to all that is right about New England small town life. The town maintains a website at http://www.wenhamma.gov/.

The Town is governed by a Board of Selectmen with a Town Administrator. The Town operates under the open Town meeting format. The 2017, the population was 5,246 people (U.S. Census Bureau 2017). The population of the Ipswich Basin, an area that includes Wenham, is expected to grow by 7-8% between 2010 and 2040 (Kleinfelder and MWWA 2017, 41). Demographic characteristics in Wenham that should be taken into consideration when planning for natural hazards are summarized in Table 2-1.

Table 2-1. Wenham Characteristics

5,246	Total Population
3.3 %	Under Age 5
18.0%	Under Age 18
15.8%	Over Age 65
3.3%	Under Age 65 and Person with a Disability
1.7%	Individuals Living Below the Poverty Level
1,381	Number of Housing Units
100%	Occupancy Rate
10%	Renter-Occupancy Rate
2,532	Labor Force
2.6%	Unemployment Rate
35%	Employed in Top Employment Industry (Educational Services, Health Care, and Social Assistance)

Source: U.S. Census Bureau 2017

The Town of Wenham has several unique characteristics to keep in mind while planning for natural hazards:

- Wenham is included within the Ipswich River Watershed, and the Town participates in the Ipswich River Watershed drought task force. Hazards that impact multiple towns should be addressed collaboratively.
- Wenham is a member of the Massachusetts Greenscapes Program, a coalition dedicated to promoting and protecting landscapes and water.
- Wenham's water supply comes from groundwater wells. Private wells provide water to many residences (Horsley & Witten, Inc. 2003, 4-2–4-3).
- During Wenham's MVP Workshop in January 2019, participants discussed what they felt was a lack of engagement in their community. Attendees were interested in exploring various communication tools to better notify residents about upcoming drills and extreme events.
- Statistics show that 24.65% of Wenham's population is low to moderate income (HUD 2015). Participants discussed this statistic during the MVP Workshop in January 2019. Students at Gordon College may have been included as part of this number, which would change the interpretation of the data.
- About half of Wenham's land is forested. Trees are an integral part of the Town's identity, but there is a need for maintenance and proactive strategies to help reduce power outages.
- A section of Main Street from Beverly to Hamilton has been a designated Historic District since 1972.
- Wenham would be an excellent candidate for hazard mitigation grants due to the potential impact of environmental risks to residents, property, transportation infrastructure, natural resources, and historic resources.

2.2 Existing Land Use

The Land Use Summary Statistics table displays land use in the Town of Wenham. The most recent land use statistics available are based on April 2005 digital ortho imagery. Table 2-2 displays the land use categories within Wenham, the total acreage within each of the 23 categories, as well as the percent cover of each category within the Town (See Appendix B, Map 2 of the Hazard Maps). Total residential land use makes up 13.29% of the Town's land. Commercial use makes of 0.54% of the Town's land. Recreation comprises another 0.85%, and several categories of open space combined (forest, wetlands, crop land, open land, and water) make up 77.63% of the Town.

Table 2-2. Wenham Land Use 2005

Land Use Category	Total Acres in Town	% of Total Acreage	Acres not in Flood Zone	Acres in Zone A	Acres in Zone AE	Acres in Zone X	Total Acres in Hazard	% of Land Use Category in Hazard	% of Town Area in Hazard
Brushland/ Successional	10.1	0.2%	10.1	0.0	0.0	0.0	0.0	0.0%	0.0%
Cemetery	8.0	0.2%	8.0	0.0	0.0	0.0	0.0	0.0%	0.0%
Commercial	27.9	0.5%	27.3	0.6	0.0	0.0	0.6	2.0%	0.0%
Cropland	136.3	2.6%	126.4	7.9	2.1	0.0	10.0	7.3%	0.2%
Forest	1983.0	38.1%	1662.2	197.5	114.0	9.4	320.9	16.2%	6.2%
Forested Wetland	1054.4	20.2%	150.8	313.5	586.2	3.9	903.6	85.7%	17.3%
Golf Course	87.3	1.7%	80.8	0.0	6.5	0.0	6.6	7.5%	0.1%
High Density Residential	3.0	0.1%	3.0	0.0	0.0	0.0	0.0	0.0%	0.0%
Low Density Residential	391.0	7.5%	382.3	5.1	3.4	0.2	8.6	2.2%	0.2%
Medium Density Residential	283.4	5.4%	277.2	6.0	0.1	0.1	6.2	2.2%	0.1%
Multi-Family Residential	15.3	0.3%	15.3	0.0	0.0	0.0	0.0	0.0%	0.0%
Non-Forested Wetland	303.0	5.8%	53.4	87.1	160.1	2.4	249.5	82.4%	4.8%
Nursery	21.8	0.4%	20.4	1.4	0.0	0.0	1.4	6.3%	0.0%
Open Land	97.1	1.9%	76.9	2.6	15.8	1.8	20.2	20.8%	0.4%
Orchard	5.9	0.1%	5.6	0.4	0.0	0.0	0.4	6.3%	0.0%
Participation Recreation	44.1	0.9%	38.6	5.5	0.0	0.0	5.5	12.4%	0.1%
Pasture	189.5	3.6%	180.4	7.1	1.9	0.1	9.0	4.8%	0.2%
Powerline/ Utility	6.2	0.1%	6.0	0.2	0.0	0.0	0.3	4.1%	0.0%
Transitional	19.7	0.4%	17.1	2.6	0.0	0.0	2.6	13.1%	0.1%
Transportation	41.5	0.8%	40.1	1.0	0.3	0.1	1.5	3.5%	0.0%
Urban Public/ Institutional	59.5	1.1%	47.1	12.1	0.3	0.0	12.4	20.9%	0.2%
Very Low Density Residential	156.7	3.0%	149.5	6.3	0.5	0.3	7.2	4.6%	0.1%
Water	265.8	5.1%	5.9	173.8	85.9	0.2	259.9	97.8%	5.0%
Total	**5210.4**	**100.0%**	**3384.3**	**830.6**	**977.1**	**18.4**	**1826.2**	-	-

Source: Mass GIS, McConnell Land Use

For more information on how the land use statistics were developed and the definitions of the categories, please go to https://docs.digital.mass.gov/dataset/massgis-data-land-use-2005.

2.3 Description and Economic Elements

The Town of Wenham is a historic Massachusetts town located in northeastern Massachusetts, bordered by Beverly on the south, Danvers and Topsfield on the west, Hamilton on the north, and Manchester on the east. Wenham is a tranquil, rural town with a total area of 8.09 square miles. Wenham is 22 miles north of Boston and 235 miles from New York City. The eastern end of Wenham is crossed by Massachusetts Route 128, with one exit into town. Route 1A crosses through the Town's center, Route 22 crosses through the eastern portion of the town, and Route 97 crosses the southwest corner of town. The Hamilton/Wenham MBTA stop lines on the northern border of town, which provides access to Metro Boston.

Being a small, rural town, Wenham is not home to any large businesses or commercial/industrial developments. There are many local businesses within town, with a total employment of 1,636 in 2015. There are 5,246 people living in the town of Wenham. The percentage of residents over the age of 65 is 15.8%, and 18.0% of residents are under the age of 18 (U.S. Census Bureau 2017). There is also a large student population at Gordon College, which is located in Wenham.

2.4 Recent and Potential Future Development

The Wenham Town Planner and the Department of Public Works Director met to discuss recent and potential future development within the Town. In addition, developments were identified using MAPC's MassBuilds Database, which provides an inventory of recent, future, and potential development. The database included eight residential developments in the Town of Wenham.

Also included in the MassBuilds Database are several attributes of the new development, including development acreage, number of housing units, commercial area, and project type. The developments in Wenham include a total of 44 housing units, 105,000 square feet of commercial space (see Table 2-3).

Table 2-3. Summary of Wenham Developments

Name	Year Completed	Housing Units	Commercial Square Feet	Project Type	Flood Zone	Landslide Risk
Settlers Lane	2019	7	0	Residential	No	Low
The Boulders	2007	24	0	Residential	No	Low
Middlewoods	2015	20	0	Residential	No	Low
The Academy at Penguin Hall	2016	0	105,000	Education	No	Low
Wenham Pines	Under Development	23	0	Recreation	34% located within AE	No
Total		**44**	**105,000**			

Source: Mass Builds Database, MAPC

A GIS Mapping Analysis was conducted to assess changes in the Town's vulnerability in association with new development. The analysis was done by overlaying the development sites (obtained from the town staff as well as MassBuilds) with the FEMA Flood Insurance Rate Map. The developments within the FEMA Flood Zone are identified in Table 2-4. The sites are also included in the Map Series (Appendix B), with site ID numbers indicating their location on the map.

All of the development sites are within the area of "Low Incidence" for landslides and none are within a potential brushfire area. All other natural hazards remain consistent across the town. All of Wenham is located within the zone of 48 to 72 inches of average annual snowfall. The 100-year maximum wind speed throughout the town is 110 miles per hour (Appendix B). Based upon this analysis, the potential future development in the town would not have a significant impact on the town's vulnerability to natural hazards.

Table 2-4. Potential Development in Relation to Hazard Areas

Development	Landslide Risk	Flood Zone	Brush Fire
Boulder Lane	Low incidence	11.4% located within AE	Wooded parcel, potential for fires
Wenham Country Club	Low incidence	6.5% located within AE	No
Streeter Property on Maple Street	Low incidence	10.8% located within A	A brush fire occurred in this area, potential for fires
Haley Property on Main Street	Low incidence	45.5% located within A	No
Beverly Airport	Low incidence	1.9% located within A, 4.1% located within X	No
Maple Woods on Maple Street	Low incidence	63.6% located within A	No
Spring Hill Subdivision on Dodges Row	Low incidence, however, lot is steeply sloped	No	No

New development is primarily regulated through the Zoning and General Bylaws enforced by the Planning Board and the Wetlands Act enforced by the Conservation Commission. Staff members of the Planning Department – along with many other municipal officials - provided input into the plan as participants in the Community Resilience Building Workshop (as described in Chapter 3).

2.5 Critical Infrastructure in Hazard Areas

Critical infrastructure is extremely important to a Town during a natural hazard. They can be used for disaster response, shelter, and evacuation (for example, emergency shelters, fire stations, hospitals, etc.). Critical infrastructure can also be facilities where additional assistance might be needed during an emergency (nursing homes, elderly housing, schools or daycare centers). Critical infrastructure can also include infrastructure that could be dangerous if it is compromised during a natural disaster, such as a sewage treatment plant or a site with chemical storage. There are 30 facilities identified in Wenham. These facilities are listed in Table 2-5 and are shown on the map series in Appendix B.

It is important to be aware of the location of critical infrastructure in relation to potential hazards in the community. Table 2-5 provides details in regard to the name and type of each piece of critical infrastructure. It also provides information of each potential hazard and the relation of the infrastructure to each of the hazards.

Table 2-5. Critical Infrastructure in Relation to Hazard Areas

ID	Name	Type	Landslide	Within FEMA Flood Zone	Within Locally Identified Area of Flooding	Average Annual Snow Fall*	Hurricane Surge Areas (Category#)
1	Wenham Fire Department	Fire Department	Low Susceptibility	No	Upper Larch Row and Main Street	High	0
2	Wenham Police Department	Police Department	Low Susceptibility	No	No	High	0
3	Wenham Town Hall	Municipal Office	Low Susceptibility	No	No	High	0
4	Academy at Penguin Hall	School	Low Susceptibility	No	No	High	0
5	Bessie Buker Elementary	School	Low Susceptibility	No	No	High	0
6	Mass Audubon Preschool – Grapevine Road)	School				High	0
7	Kinder Morgan Gas	Pipeline	Low Susceptibility	AE	No	High	0
8	MBTA Station	MBTA	Low Susceptibility	No	No	High	0
9	Gordon College	College	Low Susceptibility	No	No	High	0
10	Wenham Town Garage	Municipal Office	Low Susceptibility	No	No	High	0
11	Water Pump Station	Water Pump	Low Susceptibility	AE	No	High	0
12	Beverly/Salem Water Board	Municipal Office	Low Susceptibility	No	No	High	0
13	First Church of Wenham	Church	Low Susceptibility	No	No	High	0
14	Burley Street - culvert	Culvert	Low Susceptibility	No	No	High	0
15	Maple Street (at Burley Street)	Culvert	Low Susceptibility	No	Burley Street at Maple Street	High	0
16	Route 97 - 3 culverts along Audubon	Culvert	Low Susceptibility	A	Route 97 - beaver dams block railroad	High	0
17	Route 97 at Burnham Road	Culvert	Low Susceptibility	No	Burnham Road at Route 97	High	0

Table 2-5. Critical Infrastructure in Relation to Hazard Areas

ID	Name	Type	Landslide	Within FEMA Flood Zone	Within Locally Identified Area of Flooding	Average Annual Snow Fall*	Hurricane Surge Areas (Category#)
18	Cedar Street at Wenham Lake	Culvert	Low Susceptibility	A	Cedar Street culvert	High	0
19	Main St (1A) Alewife Brook (at golf course)	Culvert	Low Susceptibility	No	No	High	0
20	Larch Row - Miles River	Culvert	Low Susceptibility	AE	Larch Row flooding from Myopia Club dam	High	0
21	Walnut Road - 2 - Miles River	Culvert	Low Susceptibility	AE	Walnut Street flooding from Myopia Club dam	High	0
22	Dodges Row - Miles River	Culvert	Low Susceptibility	AE	Dodge's Row culvert	High	0
23	Grapevine Road - 4 - at Miles River	Culvert	Low Susceptibility	A	Grapevine Road culvert	High	0
24	Hull Street	Culvert	Low Susceptibility	A	Mill River at Hull Street	High	0
25	Essex Street - 2 Miles River and small	Culvert	Low Susceptibility	A	Essex Street Culvert	High	0
26	Wenham Pines (at former golf course)	Culvert				High	0
27	Beverly Hospital	Hospital Affiliation	Low Susceptibility	No	No	High	0
28	Water Storage Tank #1 at Water Garage	Water Tank	Low Susceptibility	A	No	High	0
29	Water Storage Tank #2 at Lord's Hill	Water Tank	Low Susceptibility	No	No	High	0
30	Beverly Airport	Airport				High	0

*High=48.1 - 72.0 inches

3.0 PLANNING PROCESS AND PUBLIC PARTICIPATION

This section presents the process that the Town of Wenham used to plan for hazard mitigation and climate change resilience, and how stakeholders and members of the general public were engaged in the process.

3.1 Planning Process Summary

To plan for the development of this HMP- MVP Plan, the Town of Wenham followed the process described in the Community Resilience Building Workshop Guidebook, developed by The Nature Conservancy (undated). The Guidebook presents a clear approach on how to organize the public process for mitigating the impacts of, and increasing resilience against, natural hazards and climate change. An important aspect of the natural hazard and climate change impact mitigation planning process is the discussion it promotes among community members about creating a safer, more resilient community. Developing a plan that reflects the Town of Wenham's values and priorities is likely to produce greater community support and result in greater success in implementing mitigation strategies that reduce risk.

Community Resilience Building Workshop Guidebook

The Community Resilience Building Workshop Guidebook provides a process for developing resilience action plans. The process has been implemented and successful in over one-hundred communities. The process, outlined below, is rich in information and dialogue and results in actionable plans and strong collaboration.

The Community Resilience Building Workshop Guidebook's central objectives are to:

- Define top local natural and climate-related hazards of concern;
- Identify existing and future strengthen and vulnerabilities;
- Develop prioritized actions for the Community;
- Identify immediate opportunities to collaboratively advance actions to increase resilience.

Federal regulation for mitigation plan approval requires that stakeholders and the general public are given opportunities to be involved during the planning process and in the plan's maintenance and implementation. Community members can therefore provide input that can affect the content and outcomes of the mitigation plan. The planning and outreach strategy used to develop the HMP-MVP Plan had three tiers: 1) the Core Committee, with representation from municipal leadership at the Town of Wenham, 2) stakeholders who could be vulnerable to, or provide strength against, natural hazards or climate change, and 3) the public, who live and work in the Town.

3.2 The Local Multiple Hazard Planning / MVP CORE Committee

The Town of Wenham, with support from the Planning Department and leadership from the Town Administrator's Office, convened a Core Committee to act as a steering committee for the development of the HMP-MVP Plan. The Core Committee met on December 4, 2018, February 7, 2019 and April 9, 2019; two additional meetings of the Committee are planned to review public comments and transition

to implementation of the plan's mitigation strategies. More information on these meetings is included in Appendix A.

The Core Committee established goals for the plan, provided information on hazards affecting the Town, identified critical infrastructure, identified key stakeholders, reviewed the status of existing mitigation measures, and developed proposed mitigation measures for this plan. The Core Committee developed the invitation list for the Community Resilience Building Workshop at which key stakeholders were invited to help the Town identify hazards, vulnerabilities, strengths, and proposed actions to mitigate the impacts of natural hazards and climate change. The Core Committee sought to include municipal leaders as well as politicians, representatives from local nonprofit organizations, local universities, other local jurisdictions, regional organizations, and state government. Members of the Core Committee are listed in Table 3-1.

Table 3-1. Wenham's Core Committee

Name	Affiliation
Peter Lombardi	Town Administrator
Margaret Hoffman	Planning
Jeffrey Baxter	Fire Department
Greg Bernard	Board of Health
Melissa Berry	Conservation Commission and Open Space
Robert Breaker	Police Department – Emergency Management
Jackie Bresnahan	Permitting – Building and Board of Health
Stephen Kavanagh	Fire Department
Brian Leathe	Building
Erik Mansfield	Water
Vicky Masone	Energy Manager
James Politano	Facilities
Nicci Roebuck	Administration
Bill Tyack	Public Works

The Core Committee also suggested or made available reports, maps, and other pertinent information related to natural hazards and climate change impacts in Wenham. These included:

- Town of Wenham Hazard Mitigation Plan (MAPC, 2012).
- Massachusetts Climate Change Projections (NECSC, 2018).
- Massachusetts Climate Change Adaptation Report (MA EEA, 2011).
- Massachusetts State Hazard Mitigation & Climate Change Adaptation (MEMA & EOEEA 2018)
- Local Mitigation Plan Review Guide (FEMA, 2011).
- Flood Insurance Rate Maps for Middlesex County, MA (FEMA, 2010).
- National Center for Environmental Information (NOAA).
- National Water Information System (USGS).
- Community Exposure to Potential Climate-Driven Changes to Coastal-Inundation Hazards for Six Communities in Essex County, Massachusetts (USGS, 2016).
- Decennial Census (US Census Bureau, 2010).
- American Community Survey (US Census Bureau, 2013-2017).
- Great Marsh Barriers Assessment (Wenham Aquatic Barrier Assessment Report (IRWA & NWF, 2018).

3.3 Stakeholder Involvement: Community Resilience Building Workshop

Stakeholders with subject matter expertise and local knowledge and experience, including public officials, regional organizations, neighboring communities, environmental organizations, and local institutions, were invited to engage in an eight-hour Community Resilience Building Workshop, held on January 9, 2019. During the Workshop, Weston & Sampson provided information about natural hazards and climate change. Workshop participants identified top hazards and infrastructural, societal and environmental features in the Town that are vulnerable to, or provide strength against, these challenges. Participants identified and prioritized key actions that would improve the Town's resilience to the natural and climate-related hazards. Community representatives who were invited and those who participated in the process are presented in Table 3-2.

Table 3-2. Stakeholders Invited to Attend Wenham's Community Resilience Building Workshop

	Name	Title	Affiliation
√	Peter Lombardi	Town Administrator	Administration
√	Bob Breaker	Emergency Management Director	Emergency Management & Police Department
	Tom Perkins	Police Chief	Police Department
√	Kevin DiNapoli	Police Chief	Police Department
√	Stephen Kavanagh	Fire Chief	Fire Department
√	Jeff Baxter	Fire Chief	Fire Department
√	Maribeth Ting	Nurse	Public Health
√	Greg Bernard	Health Agent	Public Health
	Jason Waldron	Facilities	School Department
	Jeff Sands	Facilities	School Department
√	Bill Tyack	Director	Department of Public Works
√	Erik Mansfield	Water Superintendent	Water Dept
√	Vicky Masone	Energy Manager	Green Communities
	Jim Politano	Director	Facilities
√	Brian Leathe	Building Inspector	Buildings
√	Jackie Bresnahan	Permitting Coord	Permitting
√	Nicci Roebuck	Administrator's Asst	Administration
√	Melissa Berry	Conservation Coordinator	Conservation
√	Margaret Hoffman	Planning Coordinator	Planning
	Sean Timmons	Recreation Director	Recreation
	Catherine Harrison	Selectman	Board of Selectman
	Jack Wilhelm	Selectman	Board of Selectman
	John Clemenzi	Selectman	Board of Selectman
	Ann Weeks	Member	Planning Board
	Don Killam	Member	Planning Board
	Dan Pasquarello	Member	Planning Board
	Virginia Rogers	Member	Planning Board

Table 3-2. Stakeholders Invited to Attend Wenham's Community Resilience Building Workshop

	Name	Title	Affiliation
	Phil Colarusso	Member	Conservation Commission
	Leo Maestranzi	Member	Conservation Commission
√	Asma Syed	Member	Conservation Commission/Open Space & Recreation Committee
	Mike Novak	Member	Conservation Commission
	Bob Burnett	Member	Conservation Commission
	Tony Feeherry	Member	Zoning Board of Appeals
	Jeremy Coffey	Member	Zoning Board of Appeals
	Chris Vance	Member	Zoning Board of Appeals
	Dana Begin	Member	Zoning Board of Appeals
	Evan Campbell	Member	Zoning Board of Appeals
√	Ernest Ashley	Member	Water Commission/ Open Space & Recreation Committee
	Tom Starr	Member	Open Space & Recreation Committee
	Jim Reynolds	Council on Aging	Director
	Dennis Curran	Member	Recreation Commission
	Len Dolan	Member	Recreation Commission
	John Cusolito	Member	Recreation Commission
	Alex Begin	Member	Finance Committee
	Mike Therrien	Member	Finance Committee
	Jim Purdy	Member	Finance Committee
	David Molitano	Member	Finance Committee
	Carrie Jelsma	Member	Finance Committee
	Bruce Blanchard	Chairman	Housing Authority
	Deb Evans	Realtor	J Barrett Realty
	Tracey Hutchinson	Realtor	Churchill Group Realty
√	Dr. Andrew Ting	Member	Board of Health
	Sam Cleaves	Senior Regional Planner	Metropolitan Area Planning Council
	Paul Mendonca	Member	Water Commission
√	Diane Dixon	Member	Water Commission
	Seth Moulton	Congressman	U.S. House of Representatives
	Bruce Tarr	State Senator	Massachusetts Senate
	Brad Hill	State Representative	Massachusetts House of Representatives
√	Michael M. Harvey	Superintendent	Wenham Public Schools
	David Polito	Chairman	School Committee
	D. Michael Lindsay	President	Gordon College
	Molly Martins	President	Penguin Academy
	Norm Tarr	General Manager	Wenham Country Club

Table 3-2. Stakeholders Invited to Attend Wenham's Community Resilience Building Workshop

	Name	Title	Affiliation
	Bruce Thibodeau	Chairman	Salem Beverly Water Supply Board
	Bradley Perron	Operations Manager	Salem Beverly Water Supply Board
√	Kristen Grubbs	Environmental Planner	Ipswich River Watershed Association
	Chris LaPointe	Greenbelt	Essex County Greenbelt Association
	Kate Bowditch	President	Essex County Greenbelt Association
	Anthony Tambone	Developer	Atlantic Tambone (Wenham Pines)
	Miriam Stason	Beverly & Wenham Farm Manager	Food Project
	Kristin Noone	Executive Director	Wenham Museum
√	Faith Hassell	Representative	National Grid
	Mike DeRosa	President	DeRosa Environmental Consulting
√	Robert Buchsbaum	Regional Scientist	Mass Audubon
	Alyson Dellisola	Communications Center Director	Essex County Reg Emergency
	Gloria Bouillon	Manager	Beverly Airport
	Joe Domelowicz	Town Manager	Hamilton
√	Samantha Grantham	Collections Manager	Wenham Museum
√	Chris Jones	Associate Vice President for Technology & Operations	Gordon College
√	Robert Pyburn	Chief	Danvers Fire Department

√ indicates invitee also attended the Workshop

Identification of Top Hazards

Workshop participants were asked to identify the four top hazards/climate change impacts that Wenham faces. They were: 1) flooding; 2) extreme temperatures (both heat and cold); 3) drought; and 4) wind, winter storms, and Nor'easters. There was extensive discussion that led to the selection of these top hazards.

Discussion about Infrastructure

Workshop participants identified key infrastructural features in Wenham that are most vulnerable to, or present strength against, natural hazards and climate change impacts (Table 3-3).

Table 3-3. Infrastructural Features and Natural Hazards/Climate Change in Wenham

Vulnerabilities	Strengths
• Schools (Buker, Penguin Hall, Gordon College),	• Buker School (largest public building, could be emergency shelter)

Table 3-3. Infrastructural Features and Natural Hazards/Climate Change in Wenham

Vulnerabilities	Strengths

• Roads and falling trees/branches and poles (i.e. Grapevine and Larch Roads)
• Flooding: stream-crossings and barriers due to bridges/ culverts/ drainage/beavers (i.e. Routes 1A and 97, Grapevine Road, Topsfield Road/Chicken Hill, Walnut, Larch Row, Cedar Street, Pleasant Pond Roads, Cherry Street, Main Street (near lake)
• Communications equipment (cell service is spotty, radio/computer systems)
• Shelter for elderly (Council on Aging, Elderly housing, over 55+ complexes)
• Water supply and infrastructure
  ○ Groundwater/aquifer protection district
  ○ Town and private wells
  ○ Infrastructure (distribution system, wells, pumping stations, storage tanks, interconnection to Beverly/ Hamilton)
• Municipal buildings (fire/police stations, Town Hall, DPW building/fueling station)
• Emergency Operations Center (Middleton)
• Wastewater collection and treatment (Eastern Wenham, Gordon College)
• Gas and electric utilities (Tennessee Gas/National Grid tank station, above-ground lines)
Salem Beverley Water Supply Board infrastructure including pumphouse and dam
	• Water supply and infrastructure
	• Gordon College
	• Municipal buildings (fire/police stations, Town Hall, DPW building)
	• Wastewater (eastern Wenham, Gordon college)
	• Underground powerlines
	  ○ Transportation
	  ○ MBTA
	• Roads
	  ○ Utilities
	  ○ Energy
	• Phone and internet

Discussion about Society and Vulnerable Populations

Workshop participants identified key societal aspects of Wenham that are most vulnerable to, or provide strength against, natural hazards and climate change impacts (Table 3-4).

Table 3-4. Societal Features and Natural Hazards/Climate Change in Wenham

Vulnerabilities	Strengths

• Vulnerable populations: knowing where they are and communications in emergency
  ○ Children (vulnerable in groups)
  ○ Elderly (60+ & 90+ years)
  ○ College students
  ○ Handicapped/special needs
  ○ Lower income (food pantry accord)
  ○ Homeless
  ○ Pets
• Lack of industry, local employment, shopping, and supplies
• Public spaces (parks, cemeteries, Pleasant Pond, Wenham canal) and cultural resources (historical association, Wenham museum)
• Town records
• Lower-level of engagement in civics, local government, community organizations
	• Elderly
	• Children
	• Town and school employees
	• College students
	• Tech savvy residents
	• Socioeconomics (income and education level)
	• Safety team
	• Public spaces (parks, cemeteries, Pleasant Pond, Wenham canal)

Discussion about the Environment

Workshop participants identified key environmental features in Wenham that are most vulnerable to, or present strength against, natural hazards and climate change impacts (Table 3-5).

Table 3-5. Environmental Features and Natural Hazards/Climate Change in Wenham

Vulnerabilities	Strengths

• Rivers/streams, lakes/ponds, wetlands
  ○ Miles River
  ○ Pleasant/Wenham Lake/canal
• Flooding (including beaver dams) and low flow
• Fisheries
• Stormwater
• Open space
• Ecosystems (vernal pools, cold water fisheries)
• Farmland
• Invasive species (insects & vector-borne diseases) and wild animal (coyotes) as threats
	• Forests and street trees
	• Water resources (wetlands, rivers/streams (Miles River), lakes/ponds (Pleasant, Wenham), groundwater)
	• Open space, open space planning, Conservation Commission, and other relevant organizations
	• Ecosystems (vernal pools, cold water fisheries)
	• Farms (Tender Crop, Reynolds, Chicken Hill)

Identification of Hazard/Climate Change Mitigation Strategies

Workshop participants focused considerable time and attention to identifying priority actions for addressing natural hazard and climate change impacts. The priority actions were then ranked in the order below. The input from the workshops was integrated throughout the HMP-MVP plan, which is described in Section 3.6 and Table 3-7.

High Priorities

- Formalize the Buker School as an emergency shelter. Ensure there is a backup power source, such as a generator, and that there is equipment, supplies, communication, and emergency manpower to manage the Buker School as an emergency shelter.
- Improve the functionality of roads, culverts, and drainage systems in Wenham. Strategies include a culvert size assessment, increasing culvert size as appropriate, maintaining culverts, beaver control, and raising roads, such as Route 97, to minimize flooding. Minimize the impacts of icing at locations such as along Route 97 just south of the Topsfield town line (called "Chicken Hill").
- Maintain road accessibility and safety and protect aboveground utilities through forest management practices. Strategies include conducting hazard tree removal, developing and implementing tree management protocol, and performing safety pruning near roadways. Replant trees to replace those removed due to safety hazards.
- Ensure effective communications town wide. Strategies include establishing redundancy in communication systems, improved cell phone coverage which may include the installation of more cell towers or other cell technology, more hazard/emergency signage, and backup power sources for communication systems. Improve emergency communication between municipal departments such as between the Public Works Department, the Fire Department, and the Police Department through the Regional Emergency Communication Center or equivalent.
- Develop strategies to protect and conserve Wenham's water supply, such as implement a drought task force or a local drought management plan, continue use of water bans to prevent excessive water use and investigate options for additional water storage.
- Incorporate climate resilience into the Town's Master Plan, regulations, bylaws and other planning tools. Regularly update municipal plans.
- Ensure redundancy of the water system through backup water sources and implementing emergency water plans.
- Continue to take a regional approach to protecting water supply through a regional study of the water supply and implementation of the study's recommendations.
- Protect the Miles River and surrounding environment. Current and increased efforts to reduce flooding, including beaver control and dredging, are needed. Additional strategies to protect the Miles River include management of overgrown vegetation, control of nutrient input to the watershed, and monitoring water quality. Collaborate with the surrounding communities of Beverly, Hamilton, and Ipswich by re-instating the Miles River Collaborative or a similar organization.
- Evaluate and update bylaws, regulations, zoning ordinances, and other planning instruments to increase resilience against the effects of climate change, including reducing the effects of flooding though Low Impact Development and stormwater management.
- Institute the position of Emergency Manager in town government.

Medium Priorities

- Improve communication with vulnerable populations, beginning with identifying the vulnerable populations in Wenham, including children and the elderly. Strategies for improving communication include determining the best outreach methods and communication preferences for the specific groups. Parents could be reached through students to simplify reverse 911.
- Educate vulnerable populations about emergency plans and emergency mitigation. This could include town-wide awareness drills about storm events, educating students about heating and cooling needs, and outreach about water resources issues.
- Improve information on where the young population is located during the day. Strategies could include conducting an inventory of the daycare centers and schools in the town and ensuring these centers have redundancy and emergency plans. Update local information with the State's list of daycares, ensuring that Emergency Management has this information.
- Improve monitoring of the elderly population. The Council on Aging and the Police Department could consider checking in on those who live alone. An evacuation plan for those who may not have personal transportation could be developed, which could include a transportation service.
- Control of invasive insects and vector borne diseases could consist of implementing an invasive species management control plan, pursuing herbicides and natural solutions to invasive species, and engaging the local community in invasive pest control.
- Protect wetlands and water resources through efforts such as control of water pollution, including septic system maintenance and stormwater management; water conservation; education; local planning; and local regulations/bylaws.
- Protect local ecosystems by removing environmental stressors, increasing connectivity of green spaces, and providing deer population management.

Additional Priorities

- Update bylaws to require underground power lines in all new developments and improvements.
- Educate property owners of the benefits of installing power lines underground and encourage them to do so.

3.4 Public Involvement: Listening Session

To gather information from the general public, educate the public on hazard mitigation and climate change, present the findings from the Community Resilience Building Workshop, and receive comments on the draft HMP-MVP Plan, the Town hosted a public listening session on March 21, 2019. The draft HMP-MVP Plan has been posted on the Town's website and public comments were received between March 22 and April 1, 2019. The public listening session was publicized in accordance with the Massachusetts Public Meeting Law (see public meeting notices in Appendix C). Key discussion points were:

The audience noted that flooding occurs near Gordon College and on Grapevine Road near the Iron Rail building (91 Grapevine Road).

The Wenham Water Use Mitigation Program [WUMP] has been implemented to collect a fee to

fund water savings projects to mitigate new water demand. The WUMP program and its fee to offset water demand are applicable to projects that: 1) require a building permit for new construction or an additional dwelling unit (including special permits for accessory apartments), 2) represent a new or increased water demand, and 3) involve residential projects of three or more dwelling units and all commercial projects.

The Town could explore opportunities for providing shelter during extreme weather at existing facilities. These include the Buker School and Gordon College. The college could potentially have the facilities to feed and house people from the community, but only when the school is not in session.

The Town already has records in place that would help for checking in on the elderly during an extreme weather event. It keeps a list of everyone 60 years and over and there is someone on staff who delivers flowers to those over 80 years old on the holidays. (This is a good way to check on their well-being.)

The tick population and associated tick-related human illnesses have exploded recently. This could be due to the warmer weather. Mosquitoes and mosquito-borne diseases are also concerning. There is concern that this condition will worsen with increasing temperatures under climate change. Public education could help to alleviate this situation.

Flooding caused by beavers should be discussed in the report. Some solutions are out of municipal control. Beavers can be trapped but they come back to areas that have fewer beavers in them. The Town should explore other solutions including beaver deceivers.

Tree planting is a priority. Most of the Town's budget for trees is for removal. There is a small amount of funding available for tree planting. This could be used to leverage three times the value spent, if used to match an MVP Action Grant.

More information about the meeting and public comments are available in Appendix A.

3.5 Continuing Public Participation

Following FEMA approval of the HMP-MVP Plan, Wenham will establish an Implementation Committee to keep the Plan current by monitoring implementation, evaluating effectiveness of mitigation strategies, and updating the plan. The Implementation Team will provide residents, businesses, and other stakeholders the opportunity to learn about natural hazard mitigation and climate change resilience planning and inform the Town's understanding of local hazards. All updates and reviews of the Plan made by the Implementation Team will be placed on the Town's web site and meetings will be publicly noticed in accordance with town and state open meeting laws. An initial list of Implementation Team membership is presented in Table 3-6.

Table 3-6. Implementation Committee

Margaret Hoffman	Committee Chair, Planning Department
Robert Breaker	Police Department – Emergency Management
Jeffrey Baxter	Fire Department
Bill Tyack	Department of Public Works
Greg Bernard	Board of Health
Erik Mansfield	Water Department

This plan addresses multiple opportunities for public outreach. It is important to make the community aware of the Hazard Mitigation Plan and accompanying mitigation measures that the Core Committee has developed. This plan discusses public outreach efforts, such as mailings, signs, and website updates. The Town is working to spread information on vector-borne diseases and preventative measures, as well as providing public outreach and education to residents on the importance of floodplain management, NFIP compliance, and development issues.

3.6 Priority Items Cross-Reference

Section 3 of this document describes items that the Core Committee and stakeholders have identified as a priority actions in their community. The rest of the document dives deeper into these priority items and presents mitigation measures developed for these items. Section 6 describes ongoing, existing mitigation measure that the Town developed and implemented. Section 7 includes the mitigation measures that were identified in the 2012 Plan, and then it identifies whether those measures are still relevant and if they will be carried over to the 2019 Hazard Mitigation Plan. Section 8 covers the Hazard Mitigation Strategy that the Town of Wenham has recommended for the future. Table 3-7 below summarizes all of the priority items that are identified in this Plan, and then the section where the mitigation measure for these priorities is covered.

Table 3-7. Wenham Cross References

Priority Items Identified in Section 3	Section 6 - Existing Mitigation Measures	Section 7 - Status of Mitigation Measures from the 2012 Plan	Section 8 - Hazard Mitigation Strategies
HIGH PRIORITY ACTIONS			
Formalize the Buker School as an emergency shelter.	Shelters and backup facilities available.	Not Completed: purchase and install generators at Buker School, Library and Senior Center.	Purchase and install generators at Buker School, Library and Senior Center.
Improve the functionality of roads, culverts, and drainage systems in Wenham.	All streets and catch basins (500) are cleaned annually. 25/75 sand/salt mix is used for winter road treatments. Drainage infrastructure/ maintenance performed using MA Chapter 90 funds.	Completed: The Essex Street Culvert was replaced in 2017/18 with dual 6'x6' box culverts. In progress: preliminary design done for larger culvert, Mill River at Hull Street. Completed: Gained back one DPW position. Catch basins are inspected regularly and cleaned/replaced when necessary. Stormwater is monitored through the MS4 permitting process. Completed. Flooding at Grapevine Road near Beverly	Replace three culverts along Route 97. Culvert replacement, Mill River at Hull Street. Continue to inspect and clean catch basins. More funding needed for culvert replacement. Culvert replacement at Dodges Row. Replace culvert and elevate road at Cedar Street.

Table 3-7. Wenham Cross References

Priority Items Identified in Section 3	Section 6 - Existing Mitigation Measures	Section 7 - Status of Mitigation Measures from the 2012 Plan	Section 8 - Hazard Mitigation Strategies
		line resolved with construction of retention pond. Not Completed: culvert replacement at Dodge's Row. Not Completed: culvert replacement at Cedar Street. Completed: access high resolution flyover data for drainage system for GIS database. In Progress: Waiting on Funding for culvert replacement at 44 Grapevine Road. In Progress: Obtained an additional sander in preparation for winter storms.	Culvert replacement at 44 Grapevine Road.
Maintain road accessibility and safety and protect aboveground utilities through forest management practices.	Outside contract for tree trimming. National Grid maintains trees within its power line corridors.	Completed. A Tree Management Plan has been designed and implemented. Not Completed: work with Beverly/Salem Water Board on creating a joint public woods safety outreach effort to reduce brush fires.	Continue implementation of the 2018 Tree Management Plan. Work with Beverly/Salem Water Board on creating a joint public woods safety outreach effort to reduce brush fires.
Ensure effective communications town wide.		Not Completed. Purchase more radios for DPW as well as a dedicated frequency.	Update emergency communications equipment: radio repeaters, fixed and hand-held radios, add a dedicated frequency for DPW.

Table 3-7. Wenham Cross References

Priority Items Identified in Section 3	Section 6 - Existing Mitigation Measures	Section 7 - Status of Mitigation Measures from the 2012 Plan	Section 8 - Hazard Mitigation Strategies
Develop strategies to protect and conserve Wenham's water supply.	Water Resources Protection Bylaw (Chap. XVIII) Water Use Restriction Bylaw (Chap. XXI)		
Incorporate climate resilience into the Town's Master Plan, regulations, bylaws and other planning tools. Regularly update municipal plans.	Subdivision Rules and Regulations Flood Plain Overlay District Site Plan Review for stormwater and erosion Aquifer Protection Overlay District Flexible Development Water Resources Protection Bylaw		Incorporate climate resilience into the Town's Master Plan update and review regulations and bylaws for opportunities to incorporate climate resilience.
Ensure redundancy of the water system through backup water sources and implementing emergency water plans.	Water Use Restriction Bylaw (Chap. XXI) Ipswich Basin Water Management Act		
Take a regional approach to protecting water supply through a regional study of the water supply and implementation of the study's recommendations.	Ipswich Basin Water Management Act		

Table 3-7. Wenham Cross References

Priority Items Identified in Section 3	Section 6 - Existing Mitigation Measures	Section 7 - Status of Mitigation Measures from the 2012 Plan	Section 8 - Hazard Mitigation Strategies
Protect the Miles River and surrounding environment. Reduce flooding through beaver control and dredging, manage overgrown vegetation, control nutrient input to the watershed, monitor water quality, and collaborate with surrounding communities.		Not completed: Complete and implement Miles River Watershed Management Plan, including a long-term beaver/beaver dam management plan, dredging, and dam removal strategies. Not completed: beaver management along Route 97 near Topsfield/Danvers lines on rail trail. Not Completed: manager beavers and dams as needed to address flooding of homes at Lake Avenue.	Complete and implement Miles River Watershed Management Plan, including a long-term beaver/beaver dam management plan, dredging, and the development of dam removal strategies. Beaver dam management along Route 97 near Topsfield/Danvers. More resources to fund flood preparation and storm response team.
Evaluate and update bylaws, regulations, zoning ordinances, and other planning instruments to increase resilience against the effects of climate change.	Subdivision Rules for drainage and maximum slope for roads Flood Plain Overlay District Site Plan Review for stormwater and erosion Aquifer Protection Overlay District Flexible Development Water Resources Protection Bylaw Earth Removal Bylaw Discharges to MS4	Completed: Draft and adopt stormwater bylaw.	

Table 3-7. Wenham Cross References

Priority Items Identified in Section 3	Section 6 - Existing Mitigation Measures	Section 7 - Status of Mitigation Measures from the 2012 Plan	Section 8 - Hazard Mitigation Strategies
	Bylaw 2001 Open Space Plan Community Preservation Act adopted in 2005 DCR Dam Safety Regulations State permits required for dam construction CEMP addresses dam safety & is up to date and include evacuation plans The Fire Department requires a written permit for outdoor burning & reviews all subdivision development plans		
Institute the position of Emergency Manager in town government.			Seeking grants or other funding solutions to fund position.
MEDIUM PRIORITY ACTIONS			
Identify and improve communication with vulnerable populations	Town has Connect CTY, a form of Reverse 911.		

Table 3-7. Wenham Cross References

Priority Items Identified in Section 3	Section 6 - Existing Mitigation Measures	Section 7 - Status of Mitigation Measures from the 2012 Plan	Section 8 - Hazard Mitigation Strategies
Educate vulnerable populations about emergency plans and emergency mitigation.		In Progress/Ongoing: Provide more public outreach and education to residents on the importance of floodplain management, NFIP compliance, and development issues.	Provide more public outreach and education to residents on the importance of floodplain management, NFIP compliance, and development issues.
Improve information on where the young and elderly populations are located during the day and improve monitoring of these populations.	Council on Aging has a list of everyone over the age of 60.		Utilize State daycare list.
Address invasive insects and vector borne diseases	Ongoing public education on mosquitos. Information is posted online regarding vector borne diseases.		Potential to add information to documents such as tax bills, water bills, and the school nurse newsletter in order to reach most residents. The Town is also planning to develop a “tick educational awareness strategy.”

Table 3-7. Wenham Cross References

Priority Items Identified in Section 3	Section 6 - Existing Mitigation Measures	Section 7 - Status of Mitigation Measures from the 2012 Plan	Section 8 - Hazard Mitigation Strategies
Protect local ecosystems by removing environmental stressors, increasing connectivity of green spaces, and providing deer population management.		In Progress: The Open Space and Recreation Plan update has received conditional approval from the state and will be resubmitted for full approval once the state's comments have been addressed. Not Completed: Lake View Golf Course and Canaan Farm were not acquired because both properties were sold.	Complete update of Wenham Open Space and Recreation Plan
ADDITIONAL PRIORITIES			
Evaluate and update bylaws to require underground power lines in all new developments and improvements.			Town is currently evaluating and updating bylaws for underground utilities in new developments.
Educate property owners of the benefits of installing power lines underground and encourage them to do so.			Building Department is working with developers for the future, and will contact National Grid about potential to create an information sheet.
STRATEGIES WITHOUT CATEGORIES			
Wenham participates in the NFIP, adopted FIRM maps, and enforces floodplain regulations. The town enforces the MA State Building Code. Town utilizes the MA Emergency Incident Command Unit. Wenham is a member of the Region One Boston Network (BAPERN).		In Progress: DPW has 20-minute response time. Need more resources for Fire Department. Not completed: develop plug-in capacity for the town's mobile generator at Police, Fire, Senior Center, Town Hall, Highway Department and First Church of Wenham Emergency Shelter.	Investigate options to make all public safety building earth-quake resistant. Install new heavy equipment storage shed in preparation for winter hazards.

Table 3-7. Wenham Cross References

Priority Items Identified in Section 3	Section 6 - Existing Mitigation Measures	Section 7 - Status of Mitigation Measures from the 2012 Plan	Section 8 - Hazard Mitigation Strategies
The town has its own Local Emergency Planning Committee. Town Hall and Fire Station share a fixed, natural gas generator. The DPW and Police facilities both have fixed natural gas generators. Multi department review of all developments.		Not Completed: Investigate options to make all public safety buildings earth-quake resistant. Not Completed: Ensure that emergency plans for hazardous facilities within Wenham are up to date and mapped.	Possible collaboration with Hamilton. Develop plug-in capacity for the town's mobile generator at Police, Fire, Senior Center, Town Hall, Highway Department and First Church of Wenham Emergency Shelter. Ensure that emergency plans for hazardous facilities within Wenham are up to date and mapped.

3.7 Planning Timeline

The HMP-MVP planning process proceed according to the timeline below.

1. Local Hazard Mitigation Planning Team / Municipal Vulnerability Preparedness Core Committee

   Meeting 1: December 4, 2018 - Plan for MVP Workshops/HMP Community Meeting
   Meeting 2: February 7, 2019 - Review MVP Priority Actions/HMP Mitigation Strategies
   Meeting 3: April 9, 2019 - Review Comments on Draft MVP Report/HMP

2. HMP Stakeholder Meetings / MVP Community Resilience Building Workshops

   8-Hour Meeting 1: January 9, 2019

3. Public Listening Session to Review Draft Plan

   Meeting: March 21, 2019
   Public Comment Period: March 22 – April 1, 2019

4.0 RISK ASSESSMENT

The risk assessment examines the natural hazards that have the potential to impact the Town of Wenham. This assessment includes a description of the type, location, and extent of natural hazards, along with information on previous occurrences. This section also includes an analysis of the vulnerability of existing and future buildings, infrastructure, and critical facilities; an estimate of the potential dollar losses to vulnerable structures; and a description of land uses and development trends.

4.1 Update Process

To update Wenham's hazard identification and risk assessment, Weston & Sampson researched and analyzed hazard and land use data, met with municipal staff, conducted an MVP workshop, and completed a GIS vulnerability analysis. The purpose of the GIS vulnerability assessment is to estimate the extent of potential damages from natural hazards of varying types and intensities. A vulnerability assessment and estimation of damages was performed for flooding through a Geographic Information System (GIS)-based exposure analysis that combined the Town's Assessor data records with available hazard data layers. These layers were used to map and illustrate hazard risk.

Definitions used in the Commonwealth of Massachusetts State Hazard Mitigation Plan

Frequency

- *Very low frequency*: events that occur less frequently than once in 100 years (less than 1% per year)
- *Low frequency*: events that occur from once in 50 years to once in 100 years (1% to 2% per year);
- *Medium frequency*: events that occur from once in 5 years to once in 50 years (2% to 20% per year);
- *High frequency*: events that occur more frequently than once in 5 years (Greater than 20% per year).

Severity

- *Minor*: Limited and scattered property damage; limited damage to public infrastructure and essential services not interrupted; limited injuries or fatalities.
- *Serious*: Scattered major property damage; some minor infrastructure damage; essential services are briefly interrupted; some injuries and/or fatalities.
- *Extensive*: Widespread major property damage; major public infrastructure damage (up to several days for repairs); essential services are interrupted from several hours to several days; many injuries and/or fatalities.
- *Catastrophic*: Property and public infrastructure destroyed; essential services stopped; numerous injuries and fatalities.

4.2 Overview of Hazards and Impacts

The 2013 Massachusetts State Hazard Mitigation Plan (MEMA and DCR 2013) and the 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan (SHMCAP; MEMA and EOEEA 2018) examine the natural hazards that have the potential to impact the Commonwealth. These plans summarize the frequency and severity of hazards of greatest concern. The frequency classification ranges from very low to high. Severity classifications are listed as a range from minor severity to catastrophic. Table 4-1 summarizes the frequency and severity of hazard risk in Wenham and the State. These frequency and severity classifications will assist the City in prioritizing mitigation actions for each hazard.

Table 4-1. Hazard Risks Summary

Hazard	Frequency		Severity	
	Massachusetts	Wenham	Massachusetts	Wenham
Flooding	High (1 flood disaster declaration event every 3 years; 43 floods per year of lesser magnitude)	High	Serious to Catastrophic	Minor to Serious
Dam Failures	Very Low	Very Low	Extensive to Catastrophic	Minor to Catastrophic
High Wind	High (43.5 events per year)	High	Minor to Extensive	Minor to Extensive
Hurricane/Tropical Storm	High (1 storm every other year)	Medium	Serious to Catastrophic	Serious
Tornadoes	High	Low	Minor to Extensive	Minor
Thunderstorms	High (20 to 30 events per year)	High	Minor to Extensive	Minor to Extensive
Nor'easter	High (1 to 4 events per year)	High	Minor to Extensive	Minor to Extensive
Snow and Blizzard	High (1 per year)	High	Minor to Extensive	Minor to Extensive
Ice Storms	High (1.5 per year)	High	Minor to Extensive	Minor to Extensive
Earthquakes	Very Low (10-15% probability of magnitude 5.0 or greater in New England in 10 years)	Very Low	Minor to Catastrophic	Minor to Extensive
Landslides	Low (once every two years in western MA)	Low	Minor to Extensive	Minor
Brush Fires	High (at least 1 per year)	Medium	Minor to Extensive	Minor to Serious
Extreme Temperatures	High (1.5 cold weather and 2 hot weather events per year)	High	Minor to Serious	Minor to Serious
Drought	High (8% chance of "Watch" level drought per	High	Minor to Serious	Minor to Serious

Table 4-1. Hazard Risks Summary

Hazard	Frequency		Severity	
	Massachusetts	Wenham	Massachusetts	Wenham
	month (recent droughts in 2016 and 1960s)			
Coastal Hazards	High (6 events per year over past 10 years)	N/A (Not a coastal community)	Serious to Extensive	N/A (Not a coastal community)
Tsunami	Very Low (1 event every 39 years on East Coast, 0 in MA)	N/A (Not a coastal community)	Extensive to Catastrophic	N/A (Not a coastal community)

Source: Table adapted from the 2018 SHMCAP and 2013 Massachusetts State Hazard Mitigation Plan, with assistance from the Town of Wenham

Not all the hazards included in the 2018 State Hazard Mitigation and Climate Adaptation Plan apply to the Town of Wenham. Given Wenham's inland location, coastal hazards and tsunamis will not impact the Town. Additionally, there are no records of ice jams occurring in Wenham (ACOE 2019).

The Core Committee and stakeholders at the CRB Workshop identified flooding, high winds, winter storms, and extreme temperatures as the top four hazards of concern.

Participants identify hazards and vulnerabilities during Wenham's MVP Workshop

4.3 Flood Related Hazards

Flooding was among the four main hazards identified by participants during Wenham's MVP workshop. Flooding can be caused by events including hurricanes, extreme precipitation, thunderstorms, and nor'easters and winter storms. Flooding can be both riverine (topping the banks of streams, rivers, ponds) and from stormwater that is not properly infiltrated into the ground. While Wenham is already experiencing the impacts of these events, climate change will likely lead to increasingly severe storms. The following sub-sections provide more information on historic flooding events, potential flood hazards, a vulnerability assessment, locally identified as areas of flooding, and information on the risk of dam failures.

4.3.1 Regionally Significant Floods

Since the 1950s, several significant floods have impacted the Boston area. Major floods that affected the Town of Wenham include the list below.

- August 1954
- March 1968
- The Blizzard of 1978
- January 1979
- April 1987
- October 1991 ("The Perfect Storm;" considered to be a 100-year storm)
- October 1996
- June 1998
- March 2001
- April 2004
- May 2006
- April 2007
- March 2010
- December 2010
- August 2011
- October 2012
- March 2013
- January 2018
- March 2018
- September 2018

4.3.2 Previous Flood Occurrences

NOAA's National Centers for Environmental Information Storm Events Database provides information on previous flood events for Essex County, which includes the Town of Wenham. Table 4-2 summarizes the 60 flood events that impacted this area between 1998 and 2018. Floods are considered "Any high flow, overflow, or inundation by water which causes damage. In general, this would mean the inundation of a normally dry area caused by an increased water level in an established watercourse, or ponding of water, that poses a threat to life or property." This does not include flash floods. Two deaths and three injuries were reported and the property damage totaled $20.698 million (not adjusted for inflation). Incredibly, flooding during March 2010 caused 60% of the total property damage reported during this time period.

Table 4-2. Essex County Flood Events, 1998--2018

Location	Date	Time	Deaths	Injuries	Property Damage ($)
WESTERN ESSEX (ZONE)	06/17/1998	17:00	0	0	0.00K
WESTERN ESSEX (ZONE)	06/18/1998	04:00	0	0	0.00K
EASTERN ESSEX (ZONE)	03/05/2001	08:00	0	0	0.00K
WESTERN ESSEX (ZONE)	04/03/2004	05:00	0	0	0.00K

Table 4-2. Essex County Flood Events, 1998--2018

Location	Date	Time	Deaths	Injuries	Property Damage ($)
WESTERN ESSEX (ZONE)	04/03/2004	12:00	0	0	0.00K
EASTERN ESSEX (ZONE)	10/15/2005	12:50	0	0	50.00K
EASTERN ESSEX (ZONE)	10/25/2005	15:26	0	0	45.00K
COUNTYWIDE	05/13/2006	10:30	2	0	7.000M
COUNTYWIDE	05/13/2006	10:30	0	0	0.00K
LYNN	07/11/2006	14:56	0	0	10.00K
PEABODY	07/28/2006	18:10	0	0	20.00K
PEABODY	03/02/2007	12:45	0	0	20.00K
HAVERHILL	04/16/2007	01:25	0	0	45.00K
HAVERHILL	02/13/2008	15:20	0	0	30.00K
LITTLE NAHANT	03/08/2008	18:00	0	0	0.00K
SALEM	08/08/2008	18:42	0	0	25.00K
TAPLEYVILLE	09/06/2008	21:54	0	0	5.00K
SOUTH ESSEX	03/14/2010	07:28	0	1	9.800M
NEWBURY	03/30/2010	11:45	0	2	3.270M
NEWBURY	04/01/2010	00:00	0	0	0.00K
LYNN	08/05/2010	15:16	0	0	7.00K
SALEM MARITIME NHS	08/25/2010	09:44	0	0	0.00K
HAWTHORNE	10/04/2011	05:28	0	0	0.00K
SOUTH LAWRENCE	10/04/2011	06:38	0	0	5.00K
TOPSFIELD	10/04/2011	11:00	0	0	300.00K
PEABODY	06/23/2012	17:04	0	0	0.00K
SOUTH LYNNFIELD	06/23/2012	17:08	0	0	0.00K
LYNN	08/10/2012	18:04	0	0	0.00K
NORTH SAUGUS	06/24/2013	19:06	0	0	5.00K
MARSH CORNER	07/01/2013	15:18	0	0	0.00K
SALEM MARITIME NHS	07/01/2013	15:20	0	0	0.00K
RIVERVIEW	07/01/2013	16:14	0	0	0.00K
SALEM MARITIME NHS	07/27/2014	13:27	0	0	0.00K
LYNN COMMON	10/23/2014	03:30	0	0	30.00K
METHUEN	10/23/2014	06:00	0	0	0.00K
(BVY)BEVERLY MUNI AR	10/23/2014	09:28	0	0	0.00K
PEABODY	12/09/2014	16:49	0	0	0.00K
SOUTH MIDDLETON	12/09/2014	16:49	0	0	0.00K
ROOTY PLAIN	12/09/2014	17:13	0	0	0.00K
SALEM MARITIME NHS	12/09/2014	20:11	0	0	0.00K
TOZIER CORNER	08/18/2015	15:21	0	0	0.00K
EAST SAUGUS	08/18/2015	15:38	0	0	0.00K
CARLETONVILLE	09/30/2015	10:13	0	0	0.00K
DEVEREUX	06/29/2016	16:15	0	0	0.00K
WEST ANDOVER	04/06/2017	19:00	0	0	0.00K
LYNNFIELD	06/27/2017	16:46	0	0	1.00K
SOUTH MIDDLETON	06/27/2017	16:47	0	0	1.00K

Table 4-2. Essex County Flood Events, 1998--2018

Location	Date	Time	Deaths	Injuries	Property Damage ($)
HAWTHORNE	07/08/2017	14:46	0	0	0.00K
SOUTH GROVELAND	07/18/2017	16:09	0	0	0.00K
LAWRENCE	09/06/2017	10:45	0	0	0.00K
LAWRENCE	09/06/2017	11:24	0	0	0.00K
SOUTH LAWRENCE	09/15/2017	16:55	0	0	10.00K
CARLETONVILLE	09/30/2017	05:05	0	0	4.00K
TAPLEYVILLE	10/25/2017	04:26	0	0	0.00K
RIVERVIEW	10/25/2017	08:00	0	0	0.00K
DANVERS	01/13/2018	03:48	0	0	5.00K
LAWRENCE	08/11/2018	13:55	0	0	10.00K
DEVEREUX	08/12/2018	07:52	0	0	0.00K
MIDDLETON	11/03/2018	06:14	0	0	0.00K
SOUTH LAWRENCE	11/03/2018	06:22	0	0	0.00K
Total			2	3	20.698M

Source: NOAA 2018a

As Table 4-2 suggests, the most severe flooding since the previous plan occurred during March 2010. During the March 14 - March 21 flood, rainfall totals reached 10 inches in eastern Massachusetts. During the March 29 - March 31 flood, rainfall totals reached 8 inches in Massachusetts.

The U.S. Geological Survey (USGS) manages a streamflow gauging station on the Ipswich River in South Middleton. The USGS gage height, shown in Figure 4-1, exceeded 7 feet on March 16, 2010 and exceeded 6 feet on March 31, 2010 (USGS 2019b).

4.3.3 Overview of the Ipswich and Miles River Watershed and Flooding

Flooding was the most prevalent natural hazard identified during the planning process, particularly as it relates to the ongoing issues of flooding and stormwater within the Ipswich River and Miles River watershed areas where Wenham is located.

The Ipswich River watershed encompasses a 155 square-mile area north of Boston in Essex and Middlesex counties. The Ipswich River extends approximately 45 miles from its westernmost headwaters in the towns of Burlington and Wilmington, northeasterly to its mouth at Essex Bay and Plum Island Sound. The Ipswich River watershed includes all or portions of 22 towns in northeastern Massachusetts. Of these, only three, Middleton, North Reading, and Topsfield, are entirely within the basin. Boxford, Hamilton, Ipswich, Lynnfield, North Andover, Wenham, and Wilmington are mostly in the basin. About half or less than half of Andover, Beverly, Burlington, Danvers, Peabody, and Reading are within the basin and less than one square mile of Billerica, Essex, Georgetown, Tewksbury, Woburn and Rowley are in the basin (Horsley & Witten, Inc. 2003, 2-2).

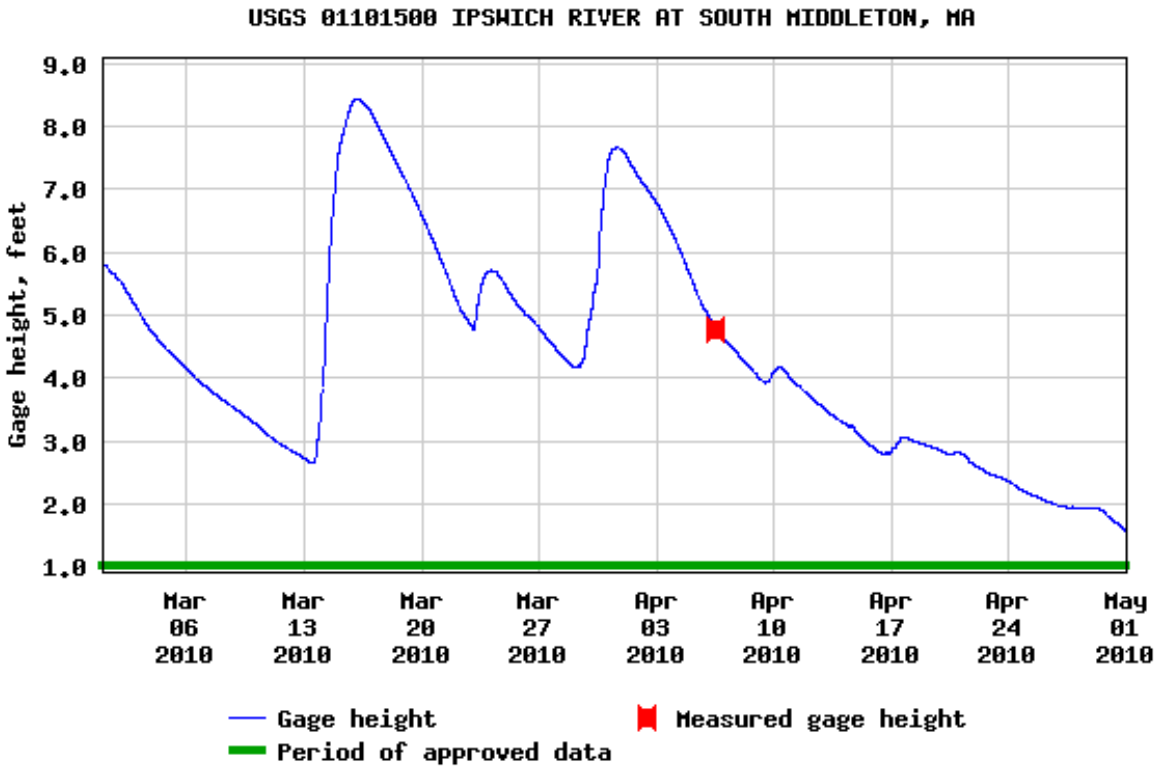


Figure 4-1. Ipswich River Gage Heights, March-April 2010
Source: USGS 2019b

The river basin can be divided into three subsections: the upper, middle and lower watersheds. The upper watershed drains 44.5 square miles to South Middleton and has a mean annual stream flow of 41 million gallons per day (mgd). The middle watershed drains 125 square miles, with a mean annual stream flow of 122 mgd). The lower watershed, below the Willowdale Dam, includes another 30 square miles of drainage area to the Ipswich Dam and its flow is not measured by a stream flow gage. Below the Ipswich Dam the river becomes tidally-influenced. Approximately 20 tributaries feed into the Ipswich River. In the upper watershed, the larger tributaries include Maple Meadow Brook, Lubbers Brook and Martins Brook. In the middle watershed, tributaries include Norris, Emerson, Boston, Fish and Howlett Brooks. In the lower watershed, the Miles River is the largest tributary. A number of tributaries, as well as the Ipswich River itself, have dams that were built to store water, power mills and/or for recreation. Three dams continue to impound sections of the river, one in Middleton and two in Ipswich. Smaller dams and remnants can be found in the main stem and tributaries (Horsley & Witten, Inc. 2003).

Restoration of the Miles River is a priority for Wenham. The river flows from Beverly through extensive wetlands before reaching the Ipswich River in Ipswich. It provides excellent riparian and wetland habitat, but faces problems including low flow velocity, nutrient inputs, and barriers to flow. Wenham replaced and enlarged three culverts previously (Grapevine Rd East, Walnut Rd, and Larch Row) damaged during the Mother's Day floods of 2006 (IRWA 2010).

The four watershed communities of Hamilton, Beverly, Ipswich and Wenham have formed the Miles River Collaborative to work together to solve these problems, and are currently seeking funding from the

US Army Corps of Engineers for a habitat restoration project. The Collaborative is also addressing beaver issues, fertilizer runoff, and undersized culverts. Ipswich River Watershed Association volunteers surveyed Miles River crossings in November 2006 in collaboration with the Massachusetts Riverways Stream Continuity Program. The Miles River has 13 road crossings and one dam.

- Longham Reservoir, created by damming the Miles River, is a major water source for the cities of Salem and Beverly. Water supply wells within the Miles River watershed are also a secondary source for Danvers and Wenham. The Myopia Hunt Club also withdraws water from the river.
- Localized flooding has occurred throughout the watershed, particularly around undersized culverts.
- Beaver activity in the river channel also raises water levels and may exacerbate flooding.
- Invasive vegetation, including purple loosestrife, is a concern. Vegetation clogs the river channel, due in part to low flow velocities and siltation, which alter the natural hydrology.
- Mass DEP has listed the Miles River as impaired because of organic enrichment due to nonpoint source pollution, low dissolved oxygen, and flow manipulation. Benthic macro invertebrates, a good indicator of habitat quality, are far below healthy levels (Mass DEP 2004; IRWA 2010).

This analysis of flood hazard areas was informed by the FEMA NFIP Flood Insurance Rate Maps (FIRMs), information from Wenham municipal staff, and stories of past flood events shared by participants during the Wenham MVP Workshop.

4.3.4 Potential Flood Hazard Areas

FEMA-designated flood zones from the NFIP FIRM are included in Map 3 in Appendix B. The definitions of these flood zones are included below.

Flood Insurance Rate Map Zone Definitions

Zone A (1% annual chance): Zone A is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the Flood Insurance Study (FIS) by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no BFEs (base flood elevations) or depths are shown within this zone. Mandatory flood insurance purchase requirements apply.

Zone AE and A1-A30 (1% annual chance): Zones AE and A1-A30 are the flood insurance rate zones that correspond to the 100-year floodplains that are determined in the FIS by detailed methods. In most instances, BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone. Mandatory flood insurance purchase requirements apply.

Zone X500 (0.2% annual chance)**:** Zone X500 is the flood insurance rate zone that corresponds to the 500-year floodplains that are determined in the Flood Insurance Study (FIS) by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no BFEs (base flood elevations) or depths are shown within this zone.

Zone VE (1% annual chance): Zone VE is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone. Mandatory flood insurance purchase requirements apply.

4.3.5 GIS Flooding Exposure Analysis

Hazard location and extent of riverine flooding was determined using the current effective FEMA Flood Insurance Rate Map (FIRM) data for Wenham dated 2017. The FIRM is the official map on which FEMA has delineated both the special flood hazard areas and the risk premium zones applicable to the community under the National Flood Insurance Program (NFIP). This includes high risk areas that have a 1 percent chance of being flooded in any year (often referred to as the "100-year floodplain"), which under the NFIP, is linked to mandatory purchase requirements for federally-backed mortgage loans. It also identifies moderate to low risk areas, defined as the area with a 0.2 percent chance of flooding in any year (often referred to as the "500-year floodplain"). For purposes of this exposure analysis, the following special flood hazard areas as identified in the Town of Wenham's current FIRMs were included:

Flood Zone AE – Regulatory Floodway
Flood Zone A (AE, AH) – 1% Annual Chance Flood Hazard
Flood Zone X (shaded) – 0.2% Annual Chance Flood Hazard

FEMA defines Flood Zone AE as the special flood hazard area where the base flood elevations are provided, Flood Zone A as special flood hazard area where no base flood elevation is provided, and Flood Zone X as areas of moderate flood hazard, usually the area between the limits of the 100-year and 500-year floods.

The Town's existing tax parcel and property value data were used to estimate the number of parcels (developed and undeveloped) and buildings located in identified hazard areas along with their respective assessed values. The parcel data set provides information about the parcel size, land use type, and assessed value among other characteristics. The parcel data was also classified into various land use types based on the Massachusetts Department of Revenue's Property Type Classification Code for Fiscal Year 2019, as described in Table 4-3 below.

Table 4-3. Wenham's Land Use Classification Based on Massachusetts Land Use Codes

Land Use Categories with Land Use Descriptions	Land Use Code
Commercial	
Bank Buildings	3410
Buildings for manufacturing operations	4000
Commercial Condominium	3421
Airport Property	3541
Discount Stores, Junior Department Stores, Department Stores	3220
General Office Buildings	3400
Golf Courses (not Ch. 61B)	3800
Golfing - areas of land arranged as a golf course (Ch. 61B, not classified as Open Space)	8050
Mixed Use (Primarily Commercial, some Residential)	0310
Mixed Use, Primarily Commercial	031R
Gas Pressure Control Stations	4280
Gasoline Service Stations - providing engine repair or maintenance services, and fuel products	3340
(formerly Commonwealth of Massachusetts. Removed June 2009.)	9010
(formerly Municipalities/Districts. Removed June 2009.)	9030
Multiple Houses on one parcel	1090

Table 4-3. Wenham's Land Use Classification Based on Massachusetts Land Use Codes

Land Use Categories with Land Use Descriptions	Land Use Code
Property Used for Postal Services	3500
Shopping Centers/Malls	3230
Small Retail and Services stores (under 10,000 sq. ft.)	325
Warehouses for storage of manufactured products	4010
Land (Other)	
Accessory Land with Improvement	1060
All land designated under Chapter 61 (not classified as Open Space)	6010
Other, Open Space	995
Potentially Developable Residential Land	1310
Productive Woodland - woodlots (Ch. 61A, not classified as Open Space)	7170
Truck Crops - vegetables (Ch. 61A, not classified as Open Space)	7120
Vacant, Conservation Organizations (Charitable Org.)	950
Public Service	
(formerly Charitable Organizations (private hospitals, etc.) Removed June 2009.)	9050
(formerly Colleges, Schools (private). Removed June 2009.)	9040
(formerly Religious Organizations. Removed June 2009.)	9060
Residential	
Apartments with more than eight units	1120
Mixed Use (Primarily Residential, some Commercial)	0130
Residential Condominium	1020
Single Family Residential	1010
Three-Family Residential	1050
Two-Family Residential	1040
Vacant Land (Developable)	
Developable Commercial Land	3900
Developable Residential Land	1300
Vacant Land (Undevelopable)	
Undevelopable Residential Land	1320

A GIS overlay analysis was conducted in which the flood hazard extent zones were overlaid with the parcel data and existing building footprint data to calculate the exposure of parcels and buildings to the flood hazards. We simply identified the parcels with buildings that are located (completely or partially) within identified hazard zones using the GIS overlay analysis (i.e., select by location using the intersect function). The number of parcels and buildings for each land use category was then totaled, along with the value of buildings and real property values associated with those parcels. These figures provide a strong indication of current hazard vulnerability, as well potential future vulnerability as it relates to vacant and potentially developable parcels.

The types and numbers of critical facilities were identified for the Town of Wenham and included in the exposure analysis (Table 4-4).

Table 4-4. Critical Infrastructure in Flood Zones

Critical Infrastructure	Total	In Flood Zone
Problem Culvert	7	6
Daycare	1	0
Community Health Center (Main and Satellite Center)	0	0
Town Hall	2	0
Assisted Living Facility	3	0
Long Term Care Residence	0	0
Fire Station	1	0
Police Station	1	0
Hospital	0	0
Schools (Pre-K through HS)	3	0
Colleges and Universities	1	0

Critical facilities were identified and mapped in GIS based on the confirmed physical location/address (information provided by Weston & Sampson). Similar to the vulnerability analysis for parcels and buildings, each was then overlaid with the identified and mappable hazard zones (FEMA Flood Zones). For purposes of this analysis it was assumed that the physical location of a critical facility within a hazard area (completely or partially) meant that it is exposed and potentially vulnerable to that specific hazard; however, it is recognized that more site-specific evaluations may be required to confirm this assumption.

As can be seen on the Critical Facilities Map (See Appendix B, Figure 4 of the Hazard Maps) and Table 4-4 below, six critical facilities are located within a flood zone. These culverts are located in close vicinity to a flood zone AE which has a 1 % annual chance of flooding.

4.3.6 Hazard Exposure Tables

The results of the vulnerability assessment conducted for Wenham's existing community assets are summarized on the following pages. These include an exposure table for those natural hazards with geographically-defined risk areas (FIRM zones). Table 4-5 below shows the exposure to buildings in flood zones by parcel type for each of the FEMA zones (Zone A, AE and X). This table shows the buildings that are located within the flood zone, the value of these buildings, and the total property value. Table 4-6 provides a detailed summary of the value of all buildings and their exposure to flood within the FIRM zones. Table 4-6 shows all property that is located within the flood zone, even if there are no buildings located in the flood zone. The value of the buildings on these parcels is then shown (even if the building is not in the flood zone) along with the total property value. Table 4-7 shows the vacant property in Wenham and how many properties are located within the flood zones. There are 1,483 developed parcels totaling $1,682,821,162 in property value located in FEMA mapped flood zones. A total of 71 buildings is located in the flood zone. Overall, 11.9% of Wenham's total property is at risk to flooding.

Table 4-5. Exposure to Buildings in Flood Zones by Parcel Type (FEMA A, AE, X)

Parcel Type Category	Number of Buildings	Building Value	Total Value
Commercial			
(formerly Commonwealth of Massachusetts. Removed June 2009.)	1	$0	$503,400
(formerly Municipalities/Districts. Removed June 2009.)	5	$962,300	$6,196,200
Mixed Use (Primarily Commercial, some Residential)	3	$134,000	$727,200
Public Service			
(formerly Colleges, Schools (private). Removed June 2009.)	15	$120,810,600	$171,765,100
Residential			
Multiple Houses on one parcel	1	$407,100	$694,700
Single Family Residential	43	$9,497,600	$20,903,200
Two-Family Residential	3	$443,600	$1,131,500
Grand Total	**71**	**$132,255,200**	**$201,921,300**

Table 4-6. Summary of the Property Value and their exposure to Flood within the FIRM

	Number of Parcels			Value of Buildings			Value of Total Property		
Land Use Category	**Total**	**Total In Hazard**	**% in Hazard**	**Total Value**	**Total Value in Hazard**	**% Value in Hazard**	**Total Value**	**Total Value in Hazard**	**% Value in Hazard**
Commercial -									
Bank Buildings	1	0	0.00%	$0	$0	0.00%	$0	$0	0.00%
Buildings for manufacturing operations	1	0	0.00%	$61,400	$0	0.00%	$768,600	$0	0.00%
Commercial Condominium	3	1	33.33%	$0	$0	0.00%	$605,200	$0	0.00%
Airport Property	1	1	100.00%	$0	$0	0.00%	$0	$0	0.00%
Discount Stores, Junior Department Stores, Department Stores	1	0	0.00%	$307,400	$0	0.00%	$523,600	$0	0.00%
General Office Buildings	1	1	100.00%	$482,800	$0	0.00%	$888,600	$0	0.00%
Golf Courses (not Ch. 61B)	1	0	0.00%	$0	$0	0.00%	$0	$0	0.00%
Golfing - areas of land arranged as a golf course (Ch. 61B, not classified as Open Space)	2	2	100.00%	$531,800	$0	0.00%	$3,683,400	$0	0.00%
Mixed Use (Primarily Commercial, some Residential)	3	0	0.00%	$821,000	$134,000	0.00%	$2,637,200	$727,200	27.57%
Mixed Use, Primarily Commercial	1	0	0.00%	$1,898,000	$0	0.00%	$3,932,000	$0	0.00%
Gas Pressure Control Stations	1	1	100.00%	$21,200	$0	0.00%	$372,900	$0	0.00%
Gasoline Service Stations - providing engine repair or maintenance services, and fuel products	1	0	0.00%	$215,100	$0	0.00%	$420,000	$0	0.00%
(formerly Commonwealth of Massachusetts. Removed June 2009.)	5	3	60.00%	$294,500	$0	0.00%	$1,280,400	$503,400	39.31%
(formerly Municipalities/Districts. Removed June 2009.)	59	31	52.54%	$99,779,300	$962,300	0.96%	$136,560,600	$6,196,200	4.53%
Multiple Houses on one parcel	22	5	22.72%	$40,798,900	$407,100	16.32%	$72,406,658	$694,700	0.95%
Property Used for Postal Services	1	0	0.00%	$131,500	$0	0.00%	$296,100	$0	0.00%
Shopping Centers/Malls	1	0	0.00%	$304,300	$0	0.00%	$541,600	$0	0.00%
Small Retail and Services stores (under 10,000 sq. ft.)	4	3	75.00%	$18,068,700	$0	0.00%	$20,963,900	$0	0.00%
Warehouses for storage of manufactured products	1	1	100.00%	$58,000	$0	0.00%	$535,388	$0	0.00%
Land (Other) -									
Accessory Land with Improvement	5	0	0.00%	$0	$0	0.00%	$22,800	$0	0.00%
All land designated under Chapter 61 (not classified as Open Space)	1	1	100.00%	$0	$0	0.00%	$0	$0	0.00%
Other, Open Space	9	0	0.00%	$0	$0	0.00%	$0	$0	0.00%
Potentially Developable Residential Land	14	7	50.00%	$0	$0	0.00%	$200,800	$0	0.00%
Productive Woodland - woodlots (Ch. 61A, not classified as Open Space)	1	0	0.00%	$0	$0	0.00%	$0	$0	0.00%
Truck Crops - vegetables (Ch. 61A, not classified as Open Space)	1	1	100.00%	$0	$0	0.00%	$0	$0	0.00%
Vacant, Conservation Organizations (Charitable Org.)	5	2	40.00%	$0	$0	0.00%	$121,800	$0	0.00%
Public Service -									
(formerly Charitable Organizations (private hospitals, etc...). Removed June 2009.)	16	13	81.25%	$1,567,000	$0	0.00%	$14,193,000	$0	0.00%
(formerly Colleges, Schools(private). Removed June 2009.)	15	10	66.67%	$292,813,100	$120,810,600	41.25%	$419,463,700	$171,765,100	40.94%
(formerly Religious Organizations. Removed June 2009.)	2	0	0.00%	$134,800	$0	0.00%	$634,400	$0	0.00%
Residential -									
Apartments with More than Eight Units	1	0	0.00%	$117,081,600	$0	0.00%	$135,792,000	$0	0.00%
Mixed Use (Primarily Residential, some Commercial)	6	0	0.00%	$3,367,900	$0	0.00%	$9,250,000	$0	0.00%
Residential Condominium	38	1	2.63%	$7,735,000	$0	0.00%	$7,735,000	$0	0.00%
Single Family Residential	1095	211	19.26%	$349,738,300	$9,497,600	2.71%	$805,854,434	$20,903,200	2.59%
Three-Family Residential	1	0	0.00%	$361,200	$0	0.00%	$903,600	$0	0.00%
Two-Family Residential	46	14	30.43%	$16,284,200	$443,600	2.72%	$38,455,982	$1,131,500	2.94%
Vacant Land (Developable) -									
Developable Commercial Land	1	0	0.00%	$0	$0	0.00%	$2,030,000	$0	0.00%
Developable Residential Land	30	11	36.67%	$0	$0	0.00%	$1,680,800	$0	0.00%
Vacant Land (Undevelopable) -									
Undevelopable Residential Land	86	30	34.88%	$0	$0	0.00%	$66,700	$0	0.00%
Total	**1,483**	**350**	**23.60%**	**$952,857,000**	**$132,255,200**	**13.87%**	**$1,682,821,162**	**$201,921,300**	**11.99%**

Wenham is partially undeveloped. An analysis of developable vacant parcels has shown that 131 parcels are remaining, with 82.98% of the total residential and 100% of the total commercial located in flood zones.

Table 4-7. Exposure of Vacant Parcels to Flooding (per Land Use Category)

Land Use Category	Number of Parcels	Land Value	Other Value	Total Value	Acres
Residential Vacancy					
Developable	30	$8,854,300	$0	$8,854,300	186.44
AE	1	$375,800	$0	$375,800	4.52
A	9	$2,889,500	$0	$2,889,500	111.42
X	0	$0	$0	$0	0
A and X	1	$215,500	$0	$215,500	26.2
Not Vulnerable	19	$5,373,500	$0	$5,373,500	44.28
Percentage in flood zone					
Potentially Developable	14	$1,459,600	$85,000	$1,544,600	98.98
AE	1	$548,300	$0	$548,300	16.59
A	6	$103,700	$0	$103,700	64.03
X	0	$0	$0	$0	0
Not Vulnerable	7	$798,300	$85,000	$883,300	18.35
Percentage in flood zone					
Undevelopable	86	$1,674,500	$4,800	$1,679,300	340.93
AE	6	$468,700	$0	$468,700	71.44
A	17	$400,600	$0	$400,600	65.44
X	0	$0	$0	$0	0
AE and X	6	$321,100	$0	$321,100	118.76
A and X	1	$129,400	$0	$129,400	41.36
Not Vulnerable	56	$317,400	$4,800	$322,200	42.45
Percentage in flood zone					
Total Vacant Residential Acres				$12,078,200	626.35
Total Acres in Flood Zone				$5,452,600	519.76
Total Percentage of Vacant Residential Acres in Flood Zone				45.14%	82.98%
Commercial Vacancy					
Developable	1	$136,500	$0	$136,500	2.38
AE	0	$0	$0	$0	0
A	0	$0	$0	$0	0
X	0	$0	$0	$0	0
Not Vulnerable	1	$136,500	$0	$136,500	2.38
Percentage in flood zone	0%				0
Potentially Developable	0	0	0	0	0

Table 4-7. Exposure of Vacant Parcels to Flooding (per Land Use Category)

Land Use Category	Number of Parcels	Land Value	Other Value	Total Value	Acres
Undevelopable	0	0	0	0	0
Total Vacant Residential Acres				$136,500	2.38
Total Acres in Flood Zone				$0	0
Total Percentage of Vacant Residential Acres in Flood Zone				100%	100%
Industrial Vacancy					
Developable	0	$0	$0	$0	0
Potentially Developable	0	$0	$0	$0	0
Undevelopable	0	$0	$0	$0	0

4.3.7 Locally Identified Areas of Flooding

Municipal staff and MVP Workshop participants helped identify local areas of flooding, which summarized in Table 4-8 below. These areas may not overlap with the FEMA-designated flood zones previously discussed.

Table 4-8. Locally Identified Areas of Flooding

ID	Location	Comments
1	Essex Street Culvert	4x6 stone box culvert at Miles River backs up during large storm events. Needs to be replaced with new 8x16 culvert.
2	Route 97 near Topsfield/Danvers lines.	Beaver Dams block railroad bed. 2 Beaver Deceivers were installed in 2008. Road needs to be raised and paved. 2x2 culvert under tracks needs to be replaced with a larger culvert.
3	Miles River, Hull Street	24-inch corrugated drain line: blocked due to beaver activity upstream even though cleaned regularly.
4	Miles River, Grapevine Road near Beverly line	Undersized 10-inch drain line needs to be replaced with 14-inch line.
5	Dam at Myopia Club	Backs up due to irrigation and creates flooding at Walnut Road and Larch Row due to water backing up from Myopia Dam and beaver dams upstream.
6	Dodge's Row	6x8 culvert needs to be replaced with an 8x10 culvert. Indirectly linked to beaver dam problems at Beverly/Salem Water Board's Longham Reservoir.
7	Homes (3-4) at Lake Avenue	Flooding due to Beverly/Salem Water Board water retention issues with homeowners and beaver dams. Mostly occurs during spring flooding.
8	Cedar Street	12-inch corrugated culvert needs to be replaced with 24-inch culvert and low part of road elevated to prevent flooding.

Table 4-8. Locally Identified Areas of Flooding

ID	Location	Comments
9	Lakeview Golf Course	Flooding due to beaver dams and Beverly Salem Water Board water retention in spring.
10	Burnham Road at Route 97	Subsurface drains were replaced in 2006 to pick up hill side drainage: OK at present.
11	Culvert at 44 Grapevine Road	Undersized 6x8 culvert needs to be replaced with 8x10. Impacts Iron Rail area, water, playing fields, cemetery, and Department of Public Works facility.
12	Larch Lane	Enon Village septic fields flooded during large storm events due to backup of Miles River. Associated with backup of water at Myopia Club dam.
13	Upper Larch Row and Main Street neighborhood	Basement flooding during larger storm events.
14	Burley Street at Maple Street	Flooding due to Brook backing up and flooding basements on Maple Street. Culverts at Burley and Maple Streets need to be cleaned and upgraded. The Burley Street catch basins were added in 2006.

4.3.8 Repetitive Loss Structures

As defined by the National Flood Insurance Program (NFIP), a repetitive loss property is any property which the NFIP has paid two or more flood claims of $1,000 or more in any given 10-year period since 1978 (FEMA and NFIP 2018a).

The 2018 State Hazard Mitigation and Climate Adaptation Plan indicates that Essex County has the second highest number of repetitive losses in Massachusetts (MEMA and EOEEA 2018, 4-23). There are no repetitive loss structures in Wenham.

Flooding events in Wenham have been classified as a High frequency event. As defined by the 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan, this hazard may occur more frequently than once in five years (a greater than 20% chance per year).

4.3.9 Dams and Dam Failure

Dam failure is defined as a collapse of an impounding structure resulting in an uncontrolled release of impounded water from a dam (DCR 2017a). Dam failures during flood events are of concern in Massachusetts, given the high density of dams constructed in the 19th century (MEMA and DCR 2013, 298).

Dams can fail due to overtopping caused by floods that exceed the capacity of the dam, deliberate acts of sabotage, structural failure of materials used in dam construction, movement and/or failure of the foundation supporting the dam, settlement and cracking of concrete or embankment dams, piping and internal erosion of soil in embankment dams, and inadequate maintenance and upkeep (MEMA and DCR 2013, 210).

Many dam failures in the United States have been secondary results of other disasters. The prominent causes are earthquakes, landslides, extreme storms, massive snowmelt, equipment malfunction, structural damage, foundation failures, and sabotage (MEMA and DCR 2013, 210).

Although dam failure does not occur frequently in Wenham, it can cause property damage, injuries, and potentially fatalities. These impacts can be at least partially mitigated through advance warning to communities impacted by a dam failure. In addition, the breach may result in erosion on the rivers and stream banks that are inundated.

Climate change may indirectly affect dam breaches for a variety of reasons. Dams are typically designed based on historic water flows and known hydrology. Climate change projections indicate that the frequency, intensity, and amount of precipitation will increase in New England. Increased precipitation may push dams over capacity. Therefore, dams will have to be monitored for safety. There are several mechanisms in place to manage increases in water, such as slowly releasing water. It is advised that these events are monitored as it can add additional stress on the dam infrastructure.

According to municipal officials and the Massachusetts Department of Conservation and Recreation (DCR), there are three dams that could impact Wenham: the Myopia Club dam, the Longham Reservoir Dam, and the Tea House Dam (Table 4-9). These are shown on the Hazard Map Series (see Appendix B).

Table 4-9. DCR Inventory of Dams in Wenham

Dam Name	Dam #	Ownership	Description	Hazard Potential
Dam at Myopia Club	N/A	Privately owned	Backs up due to irrigation and creates flooding at Walnut Road and Larch Row due to water backing up from beaver dams upstream. This is an issue tied closely to the Miles River watershed system, which Wenham is seeking to address in conjunction with surrounding communities through the Miles River Task Force. Considered to be in good condition.	Non-Jurisdictional
Longham Reservoir Dam	MA00182	Salem/Beverly Water Supply Board	In good condition.	Low
Tea House Dam	N/A	Owned by the Wenham Village Improvement Society	In good condition.	Non-Jurisdictional

Source: MA Department of Conservation and Recreation Office of Dam Safety; Coffin 2014; ACOE 2018

Wenham Lake, impounded by Longham Reservoir Dam. Photo by Elizabeth Thomsen, 2006

Of the three dams that could impact Wenham, one is considered to have a low hazard potential and two are non-jurisdictional, unregulated dams. Hazard classifications are defined by DCR as described below.

DCR Dam Hazard Classification

High: Dams located where failure or mis-operation will likely cause loss of life and serious damage to homes(s), industrial or commercial facilities, important public utilities, main highways(s) or railroad(s).

Significant: Dams located where failure or mis-operation may cause loss of life and damage home(s), industrial or commercial facilities, secondary highway(s) or railroad(s) or cause interruption of use or service of relatively important facilities.

Low: Dams located where failure or mis-operation may cause minimal property damage to others. Loss of life is not expected.

According to the Association of State Dam Safety Officials, there have been three dam failures in Massachusetts since 1984, resulting in one fatality. There has not been a dam failure in Wenham, and dam failure is classified as a low frequency event in the Town. As defined by the 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan, a low frequency hazard may occur from once in 50 years to once in 100 years (1% to 2% chance per year).

4.4 Wind Related Hazards

High winds can occur during hurricanes, tropical storms, tornadoes, nor'easters, and thunderstorms. As with many communities, falling trees that result in downed power lines and power outages are an issue in Wenham. During the MVP Workshop in January 2019, participants commented that they experience frequent wind events and power outages, even outside of the winter season. The Town of Wenham lost two school days in October 2018 due to a power outage. Wenham is 50% forest and is known for being tree-lined. So, while workshop participants recommended strategies related to reducing power outages, they also recommended ongoing tree planting and maintenance. More information on wind related hazards can be found on Map 5 in Appendix B.

4.4.1 Hurricanes and Tropical Storms

Tropical cyclones (including tropical depressions, tropical storms, and hurricanes) form over the warm waters of the Atlantic, Caribbean, and the Gulf of Mexico. A tropical storm is defined as having sustained winds from 39 to 73 mph. If sustained winds exceed 73 mph, it is categorized a hurricane. The Saffir-Simpson scale ranks hurricanes based on sustained wind speeds—from Category 1 (74 to 95 mph) to Category 5 (156 mph or more). Category 3, 4, and 5 hurricanes are considered "Major" hurricanes. Wind gusts associated with hurricanes may exceed the sustained winds and cause more severe localized damage (MEMA and DCR 2013, 323).

Hurricanes and tropical storms will impact the entire planning area. All existing and future buildings, including critical facilities, and all populations are vulnerable to hurricane and tropical storm impacts. Hurricane events have a large spatial extent and would potentially affect all of Wenham's infrastructure and buildings. Impacts include water damage in buildings from building envelope failure, business interruption, loss of communications, and power failure. Flooding is a major concern as slow-moving hurricanes can discharge tremendous amounts of rain on an area.

The official hurricane season runs from June 1 to November 30. However, storms are more likely to occur in New England during August, September, and October (MEMA and DCR 2013, 324).

The region has been impacted by hurricanes throughout its history, starting with the Great Colonial Hurricane of 1635. Between 1851 and 2010, Massachusetts experienced 11 hurricanes. This includes six category 1 hurricanes, two category 2 hurricanes, and three category 3 hurricanes (Blake, Landsea, and Gibney 2011, 21). Hurricanes that have occurred in the region since 1938 are listed in Table 4-10:

Table 4-10. Hurricane Records for Eastern Massachusetts, 1938-2012

Hurricane Event	Date
Great New England Hurricane*	September 21, 1938
Great Atlantic Hurricane*	September 14-15, 1944
Hurricane Doug	September 11-12, 1950
Hurricane Carol*	August 31, 1954
Hurricane Edna*	September 11, 1954
Hurricane Diane	August 17-19, 1955
Hurricane Donna	September 12, 1960
Hurricane Gloria	September 27, 1985
Hurricane Bob	August 19, 1991
Hurricane Earl	September 4, 2010

Table 4-10. Hurricane Records for Eastern Massachusetts, 1938-2012

Hurricane Event	Date
Tropical Storm Irene	August 28, 2011
Hurricane Sandy	October 29-30, 2012

* Category 3 Source: National Oceanic and Atmospheric Administration (NOAA)

The Saffir/Simpson scale categorizes or rates hurricanes from 1 (minimal) to 5 (catastrophic) based on their intensity. This is used to give an estimate of the potential property damage and flooding expected along the coast from a hurricane landfall. Wind speed is the determining factor in the scale, as storm surge values are highly dependent on context (MEMA and DCR 2013, 324). More information is included in Table 4-11 below.

Table 4-11. 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 are severe, there are extensive glass failures, and entire buildings could fail.

Source: MEMA and DCR 2013, page 325 (table originally created by NOAA)

The 100-year wind speed in Wenham is 110 miles per hour. There have been no recorded hurricanes or tropical storms that tracked directly through the town. However, Wenham experiences the impact of hurricanes and tropical storms even when the storm track does not pass directly through the town.

Based on a HAZUS Hurricane module, estimated damage in Wenham from hurricanes was assessed (2012 HMP). According to the State HMP, the strongest hurricane that has passed though Massachusetts was a Category 3 storm. The HAZUS assessment modeled the impacts from a category 2 hurricane and category 4 hurricane (which is a 500-year storm) passing through the Town center. There has been no storm with this force reported; this reflects the worst-case scenario with the greatest damage which can be used for planning purposes. Table 4-12 below lists estimated damage in Wenham for this worst-case scenario.

Table 4-12. Estimated Damages from Hurricanes

	Category 2	Category 4[1]
Building Characteristics		
Estimated total number of buildings	1,179	1,179
Estimated total building replacement value (Year 2002 $) (Millions of Dollars)	$405	$405
Building Damages		
# of buildings sustaining minor damage	1	110
# of buildings sustaining moderate damage	0	13
# of buildings sustaining severe damage	0	0
# of buildings destroyed	0	0
Population Needs		
# of households displaced	0	1
# of people seeking public shelter	0	0
Debris		
Building debris generated (tons)	0	3,188
Tree debris generated (tons)	0	2,837
# of truckloads to clear building debris	0	14
Value of Damages (Thousands of dollars)		
Total property damage	0	$2,548.10
Total losses due to business interruption	$.03	$254.19
[1]No Category 4 or 5 hurricanes have been recorded in New England. However, a Category 4 hurricane was included to help the communities understand the impacts of a hurricane beyond what has historically occurred in New England.		

Hurricanes in Wenham are considered a Medium frequency event. As defined by the 2018 Massachusetts State Hazard Mitigation and Adaptation Plan, this hazard occurs more frequently than once in 5 years (a greater than 20% chance per year).

4.4.2 Tornadoes

A tornado is a narrow, violently rotating column of air that extends from the base of a cloud to the ground. Tornadoes are the most violent of all atmospheric storms (MEMA and EOEEA 2018, 4-242). According to the 2018 SHMCAP, 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 be spawned by tropical cyclones or the remnants thereof, and weak tornadoes can even form from little more than a rain shower if air is converging and spinning upward. The most common months for tornadoes to occur are June, July, and August. There are exceptions: The Great

Barrington, Massachusetts tornado in 1995 occurred in May; and the Windsor Locks, Connecticut tornado in 1979 occurred in October (MEMA and EOEEA 2018, 4-244).

The Fujita Tornado Scale measures tornado severity through estimated wind speed and damage. The National Weather Service began using the Enhanced Fujita-scale (EF-scale) in 2007, which led to increasingly accurate estimates of tornado severity. Table 4-13 provides more detailed information on the EF Scale.

Table 4-13. Enhanced Fujita Scale

Fujita Scale			Derived		Operational EF Scale	
F Number	Fastest ¼ mile (mph)	3-second gust (mph)	EF Number	3-second gust (mph)	EF Number	3-second gust (mph)
0	40 – 72	45 – 78	0	65 – 85	0	65 – 85
1	73 – 112	79 – 117	1	86 – 109	1	86 – 110
2	113 – 157	118 – 161	2	110 – 137	2	111 – 135
3	158 – 207	162 – 209	3	138 – 167	3	136 – 165
4	208 – 260	210 – 261	4	168 – 199	4	166 – 200
5	261– 318	262 – 317	5	200 – 234	5	Over 200

Source: MEMA and DCR 2013, page 416

Massachusetts experiences an average of 1.7 tornadoes per year. The most tornado-prone areas of the state are the central counties. Tornadoes are comparatively rare in eastern Massachusetts and Essex County is not considered to be among the most at-risk locations (MEMA and EOEEA 2018, 4-243). The most devastating tornado in Massachusetts occurred in Worcester in 1953, killing 94 people, injuring more than 1,000 people, and causing more than $52 million in damages (more than $460 million today). The most recent tornadoes in Massachusetts occurred in 2011 in Springfield, 2014 in Revere, and 2016 in Concord (Morrison 2014; Epstein 2016).

Although there have been no recorded tornados in the Town of Wenham, there have been 11 recorded tornadoes in Essex County since 1956. No fatalities, four injuries, and $560,280 in damages were reported. Please refer to Table 4-14 for more information.

Although the whole town is vulnerable to tornadoes, damages would depend on the track of the tornado Areas with older construction and higher density development are vulnerable to greater damages. Structures built before current building codes may be more vulnerable. Evacuation, sheltering, debris clearance, distribution of food and other supplies, search and rescue, and emergency fire and medical services may be required. Critical evacuation and transportation routes may be impassable due to downed trees and debris, and recovery efforts may be complicated by power outages.

Tornado events in Wenham are considered a low frequency event. As defined by the 2018 Massachusetts State Hazard Mitigation and Adaptation Plan, this hazard may occur from once in 50 years to once in 100 years (a 1% to 2% chance per year).

Table 4-14. Tornado Records for Essex County, 1956-2018

Date	Fujita Scale	Deaths	Injuries	Property Damage $
6/13/1956	F1	0	0	2500
11/21/1956	F2	0	0	25000
12/18/1956	F1	0	0	250
7/13/1960	F0	0	0	30
7/21/1962	F1	0	3	25000
5/19/1964	F0	0	0	2500
5/19/1964	F1	0	0	2500
8/10/1965	F1	0	0	0
7/1/1968	F1	0	1	250000
7/21/1972	F1	0	0	2500
8/15/1991	F1	0	0	250000
Total		0	4	$560,280

Source: NOAA 2018a

4.4.3 Nor'easters

A nor'easter is characterized by large counter-clockwise wind circulation around a low-pressure center that often results in heavy snow, high winds, waves, and rain along the East Coast of North America. The term Nor'easter refers to their strong northeasterly winds blowing in from the ocean. These winter weather events are among the season's most ferocious storms, often causing beach erosion, flooding, and structural damage (MEMA And EOEEA 2018, 4-225).

Nor'easters generally occur on at least an annual basis, typically in late fall and early winter. Some years bring up to four nor'easter events. This is currently the most frequently occurring natural hazard in the state. The storm radius is often as much as 100 miles and sustained wind speeds of 20 to 40 mph are common, with short-term gusts of up to 50 to 60 mph. Nor'easters are commonly accompanied with a storm surge equal to or greater than two feet. High surge and winds during a hurricane can last from 6 to 12 hours, while these conditions during a nor'easter can last from 12 hours to three days (MEMA And EOEEA 2018, 4-224–4-226). Previous nor'easters include the events listed in Table 4-15 below.

Some of the historic events described in the "Flood-Related Hazards" section of this report were preceded by nor'easters, including the 1991 "Perfect Storm." The Blizzard of '78 was a notable storm. More recently, winter storms in 2015 and 2018 caused significant snowfall amounts.

The Town of Wenham is vulnerable to high winds, snow, and extreme rain during nor'easters. These impacts can lead to property damage, felled trees, power service disruptions, surcharged drainage systems, and localized flooding. These conditions can impact evacuation and transportation routes and complicate emergency response efforts. Due to its inland location, Wenham would not be subject to coastal hazards.

Nor'easters in Wenham are considered a High frequency events. As defined by the 2018 Massachusetts State Hazard Adaptation and Mitigation Plan, this hazard may occur more frequently than once in 5 years (greater than 20% chance per year).

Table 4-15. Nor'easter Events for Massachusetts, 1978 to 2015

Nor'easter Event	Date
Blizzard of 1978	February 1978
Severe Coastal Storm ("Perfect Storm")	October 1991
Great Nor'easter of 1992	December 1992
Blizzard, Nor'easter	January 2005
Coastal Storm, Nor'easter	October 2005
Severe Storms, Inland and Coastal Flooding	April 2007
Winter Storm and Nor'easter	January 2011
Severe Storm and Snowstorm	October 2011
Severe Winter Storm, Snowstorm, and Flooding	April 2013
Severe Winter Storm, Snowstorm, and Flooding	April 2015
Severe Winter Storm and Flooding	March 2018
Severe Winter Storm and Snowstorm	March 2018

Source: MEMA and DCR 2013, pages 402-406; MEMA and EOEEA 2018, Appendix B

4.4.4 Severe Thunderstorms

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 (MEMA and EOEEA 2018, 4-173).

Thunderstorms are typically less severe than other events discussed in this section. However, thunderstorms can cause local damage and are a Town-wide risk in Wenham. Thunderstorms can include lightning, strong winds, heavy rain, hail, and tornados. These storms typically last for about 30 minutes and can generate winds of up to 60 mph.

NOAA's National Centers for Environmental Information offers thunderstorm data for Essex County, which includes the Town of Wenham. Between 2008 and 2018, 150 thunderstorm events caused $1.949 million in property damages (Table 4-16). Two injuries and no deaths were reported.

Table 4-16. Essex County Thunderstorm Wind Events, 2008-2018

Location	Date	Magnitude*	Deaths	Injuries	Property Damage
HAWTHORNE	05/27/2008	50 kts. EG	0	0	2.00K
CLIFTONDALE	05/27/2008	50 kts. EG	0	0	1.00K
SALEM CGAS	06/10/2008	50 kts. EG	0	0	15.00K
METHUEN	06/10/2008	50 kts. EG	0	0	5.00K
PEABODY	06/10/2008	50 kts. EG	0	0	10.00K
SWAMPSCOTT	06/10/2008	50 kts. EG	0	0	4.00K
AMESBURY	06/22/2008	50 kts. EG	0	0	5.00K

Table 4-16. Essex County Thunderstorm Wind Events, 2008-2018

Location	Date	Magnitude*	Deaths	Injuries	Property Damage
HAVERHILL	06/27/2008	50 kts. EG	0	0	7.00K
ROWLEY	06/27/2008	50 kts. EG	0	0	0.50K
LYNN	07/01/2008	50 kts. EG	0	0	20.00K
MARBLEHEAD	07/01/2008	50 kts. EG	0	0	3.00K
PRIDES CROSSING	07/01/2008	50 kts. EG	0	0	4.00K
PRIDES CROSSING	07/02/2008	50 kts. EG	0	1	10.00K
WENHAM	07/02/2008	50 kts. EG	0	0	0.00K
HAWTHORNE	07/03/2008	50 kts. EG	0	1	3.00K
PRIDES CROSSING	07/03/2008	54 kts. EG	0	0	5.00K
SWAMPSCOTT	07/03/2008	50 kts. EG	0	0	5.00K
GLOUCESTER	07/18/2008	50 kts. EG	0	0	3.00K
PRIDES CROSSING	07/19/2008	50 kts. EG	0	0	15.00K
SALEM CGAS	09/09/2008	50 kts. EG	0	0	12.00K
SAUGUS IRON WORKS NH	09/09/2008	50 kts. EG	0	0	3.00K
MARBLEHEAD	09/09/2008	50 kts. EG	0	0	5.00K
SOUTH LAWRENCE	07/26/2009	50 kts. EG	0	0	25.00K
HAWTHORNE	07/31/2009	50 kts. EG	0	0	10.00K
PRIDES CROSSING	07/31/2009	50 kts. EG	0	0	40.00K
WEST PEABODY	07/31/2009	50 kts. EG	0	0	0.50K
GROVELAND	06/03/2010	50 kts. EG	0	0	0.00K
HAWTHORNE	06/03/2010	50 kts. EG	0	0	5.00K
SAUGUS IRON WORKS NH	06/03/2010	50 kts. EG	0	0	1.00K
WEST PEABODY	06/03/2010	50 kts. EG	0	0	15.00K
SWAMPSCOTT	06/03/2010	50 kts. EG	0	0	50.00K
SHAWSHEEN VLG	06/05/2010	50 kts. EG	0	0	50.00K
GEORGETOWN	06/05/2010	50 kts. EG	0	0	10.00K
SAUGUS IRON WORKS NH	06/06/2010	50 kts. EG	0	0	3.00K
DANVERS	06/06/2010	50 kts. EG	0	0	1.00K
LYNN	06/06/2010	52 kts. MG	0	0	75.00K
SWAMPSCOTT	06/06/2010	50 kts. EG	0	0	0.50K
SHAWSHEEN VLG	06/24/2010	50 kts. EG	0	0	50.00K
PRIDES CROSSING	06/24/2010	50 kts. EG	0	0	0.00K
LYNN	06/24/2010	50 kts. EG	0	0	15.00K
HAWTHORNE	06/24/2010	50 kts. EG	0	0	0.25K
MARBLEHEAD	06/24/2010	50 kts. EG	0	0	0.50K
HAVERHILL	07/12/2010	50 kts. EG	0	0	25.00K
GLOUCESTER	07/12/2010	50 kts. EG	0	0	5.00K
HAVERHILL	07/19/2010	50 kts. EG	0	0	25.00K
NORTH ANDOVER	06/09/2011	50 kts. EG	0	0	15.00K
LYNN	06/09/2011	50 kts. EG	0	0	15.00K
SAUGUS	06/09/2011	50 kts. EG	0	0	5.00K
TOPSFIELD	06/09/2011	50 kts. EG	0	0	15.00K
WENHAM	06/09/2011	50 kts. EG	0	0	10.00K

Table 4-16. Essex County Thunderstorm Wind Events, 2008-2018

Location	Date	Magnitude*	Deaths	Injuries	Property Damage
NEWBURY	06/09/2011	50 kts. EG	0	0	25.00K
HAWTHORNE	06/09/2011	50 kts. EG	0	0	20.00K
MANCHESTER	06/09/2011	50 kts. EG	0	0	3.00K
WEST PEABODY	06/09/2011	50 kts. EG	0	0	3.00K
AMESBURY	07/04/2011	50 kts. EG	0	0	15.00K
NEWBURYPORT	07/04/2011	50 kts. EG	0	0	10.00K
BYFIELD	07/04/2011	50 kts. EG	0	0	3.00K
GLOUCESTER	07/04/2011	50 kts. EG	0	0	3.00K
NEWBURY	07/18/2011	39 kts. EG	0	0	20.00K
LYNN	08/19/2011	50 kts. EG	0	0	5.00K
SALEM CGAS	08/19/2011	50 kts. EG	0	0	50.00K
MARBLEHEAD	08/19/2011	50 kts. EG	0	0	5.00K
NORTH SALEM	10/04/2011	50 kts. EG	0	0	10.00K
NORTH ANDOVER	06/23/2012	50 kts. EG	0	0	25.00K
EAST BOXFORD	06/23/2012	50 kts. EG	0	0	50.00K
HAWTHORNE	06/23/2012	40 kts. EG	0	0	0.50K
SOUTH GROVELAND	06/25/2012	40 kts. EG	0	0	5.00K
METHUEN	07/04/2012	50 kts. EG	0	0	5.00K
HAWTHORNE	06/24/2013	50 kts. EG	0	0	10.00K
WEST PEABODY	06/24/2013	50 kts. EG	0	0	15.00K
METHUEN	07/01/2013	50 kts. EG	0	0	3.00K
LYNN	07/01/2013	50 kts. EG	0	0	15.00K
SOUTH LAWRENCE	07/03/2014	50 kts. EG	0	0	50.00K
SAUGUS IRON WORKS NH	07/03/2014	50 kts. EG	0	0	25.00K
DEVEREUX	07/03/2014	50 kts. EG	0	0	25.00K
ANDOVER	07/15/2014	50 kts. EG	0	0	15.00K
EAST BOXFORD	07/28/2014	50 kts. EG	0	0	5.00K
HAVERHILL	07/28/2014	50 kts. EG	0	0	10.00K
AMESBURY	09/02/2014	45 kts. EG	0	0	5.00K
METHUEN	09/06/2014	50 kts. EG	0	0	3.00K
NORTH ANDOVER	09/06/2014	50 kts. EG	0	0	10.00K
NORTH ANDOVER	09/06/2014	50 kts. EG	0	0	10.00K
LAWRENCE	09/06/2014	50 kts. EG	0	0	30.00K
METHUEN	09/06/2014	50 kts. EG	0	0	10.00K
IPSWICH	09/06/2014	85 kts. EG	0	0	100.00K
EAST BOXFORD	09/06/2014	50 kts. EG	0	0	10.00K
GLOUCESTER	09/06/2014	50 kts. EG	0	0	30.00K
HAMILTON	09/06/2014	50 kts. EG	0	0	5.00K
PRIDES CROSSING	09/06/2014	50 kts. EG	0	0	25.00K
NORTH ANDOVER	09/06/2014	50 kts. EG	0	0	10.00K
WEST PEABODY	09/06/2014	50 kts. EG	0	0	5.00K
METHUEN	05/28/2015	61 kts. EG	0	0	50.00K
GEORGETOWN	05/28/2015	50 kts. EG	0	0	15.00K

Table 4-16. Essex County Thunderstorm Wind Events, 2008-2018

Location	Date	Magnitude*	Deaths	Injuries	Property Damage
ROWLEY	05/28/2015	50 kts. EG	0	0	25.00K
IPSWICH	05/28/2015	50 kts. EG	0	0	30.00K
LYNN	05/28/2015	50 kts. EG	0	0	10.00K
LYNNFIELD	05/28/2015	50 kts. EG	0	0	1.00K
NEWBURYPORT	06/23/2015	60 kts. MG	0	0	5.00K
LYNN	07/27/2015	45 kts. EG	0	0	1.00K
LYNNFIELD	08/04/2015	50 kts. EG	0	0	15.00K
PEABODY	08/04/2015	50 kts. EG	0	0	15.00K
LYNNFIELD	08/04/2015	50 kts. EG	0	0	10.00K
(BVY)BEVERLY MUNI AR	08/04/2015	50 kts. EG	0	0	5.00K
PEABODY	08/04/2015	50 kts. EG	0	0	20.00K
PRIDES CROSSING	02/25/2016	45 kts. EG	0	0	5.00K
MERRIMAC	02/25/2016	50 kts. EG	0	0	15.00K
LYNN	02/25/2016	50 kts. EG	0	0	1.00K
MARBLEHEAD	06/29/2016	50 kts. EG	0	0	25.00K
LYNN	07/01/2016	40 kts. EG	0	0	5.00K
SALEM CGAS	07/01/2016	50 kts. EG	0	0	10.00K
GROSVENOR CORNER	07/18/2016	70 kts. EG	0	0	100.00K
METHUEN	07/18/2016	40 kts. EG	0	0	5.00K
METHUEN	07/23/2016	50 kts. EG	0	0	5.00K
HAVERHILL	07/23/2016	50 kts. EG	0	0	5.00K
NEWBURY	07/23/2016	50 kts. EG	0	0	25.00K
SALISBURY	07/23/2016	50 kts. EG	0	0	15.00K
EAST BOXFORD	07/23/2016	50 kts. EG	0	0	20.00K
WEST PEABODY	07/23/2016	50 kts. EG	0	0	25.00K
TOPSFIELD	07/23/2016	50 kts. EG	0	0	35.00K
LYNN	07/23/2016	50 kts. EG	0	0	25.00K
AMESBURY	09/11/2016	50 kts. EG	0	0	5.00K
SALISBURY	09/11/2016	50 kts. EG	0	0	5.00K
MERRIMAC PORT	05/18/2017	50 kts. EG	0	0	1.00K
MARSH CORNER	05/18/2017	50 kts. EG	0	0	1.00K
MERRIMAC	05/18/2017	50 kts. EG	0	0	6.00K
IPSWICH	05/18/2017	50 kts. EG	0	0	1.00K
TAPLEYVILLE	05/18/2017	50 kts. EG	0	0	10.00K
HAVERHILL RVRSIDE AR	05/18/2017	50 kts. EG	0	0	5.00K
SOUTH PEABODY	05/18/2017	50 kts. EG	0	0	2.00K
SAUGUS	05/18/2017	50 kts. EG	0	0	3.00K
MIDDLETON	06/23/2017	50 kts. EG	0	0	5.00K
LOWELL JCT	06/23/2017	50 kts. EG	0	0	1.00K
LYNNFIELD	06/23/2017	50 kts. EG	0	0	5.00K
WEST BOXFORD	06/23/2017	50 kts. EG	0	0	1.50K
SOUTH GROVELAND	06/23/2017	50 kts. EG	0	0	12.00K
HAVERHILL RVRSIDE AR	06/23/2017	50 kts. EG	0	0	1.00K

Table 4-16. Essex County Thunderstorm Wind Events, 2008-2018

Location	Date	Magnitude*	Deaths	Injuries	Property Damage
NEWBURYPORT	06/23/2017	50 kts. EG	0	0	1.00K
BEVERLY	06/27/2017	50 kts. EG	0	0	1.00K
HAMILTON	06/27/2017	50 kts. EG	0	0	1.00K
PEABODY	06/27/2017	50 kts. EG	0	0	8.00K
GROVELAND	06/18/2018	50 kts. EG	0	0	2.00K
NEWBURYPORT	06/18/2018	50 kts. EG	0	0	2.00K
HAVERHILL ARPT	06/18/2018	50 kts. EG	0	0	5.00K
NEWBURY	06/18/2018	50 kts. EG	0	0	12.00K
NEWBURY	06/18/2018	50 kts. EG	0	0	1.50K
LINEBROOK	06/18/2018	50 kts. EG	0	0	3.00K
AMESBURY	06/18/2018	50 kts. EG	0	0	16.00K
IPSWICH	06/18/2018	50 kts. EG	0	0	5.00K
LITTLE NAHANT	09/18/2018	50 kts. EG	0	0	1.00K
SAUGUS	09/18/2018	61 kts. EG	0	0	15.00K
Total			0	2	1.949M

Source: NOAA 2018a
*Magnitude refers to maximum wind speed in knots.

Thunderstorm winds can knock down trees that cause power outages and block evacuation and transportation routes. Extreme rain during thunderstorms can cause inland flooding around waterbodies or due to surcharged drainage systems.

Severe thunderstorms are considered high frequency events in Wenham. As defined by the 2018 Massachusetts State Hazard Mitigation and Adaptation Plan, this hazard may occur more frequently than once in 5 years (greater than 20% chance per year).

4.5 Winter Storms

The entire planning area is vulnerable to the impacts of winter storm events. All current and future buildings are at risk to winter storm damage. Heavy snow loads may cause roofs and trees to collapse leading to structural damage. Additional impacts may include road closures, power outages, business interruption, business losses (i.e., due to road closures), hazardous driving conditions, frozen pipes, fires due to improper heating, and second-hand health impacts caused by shoveling (such as a heart attack). Public safety issues are also a concern, as streets and sidewalks can become difficult to pass. The town's population is also vulnerable to injuries or death caused by traffic accidents or falling trees. Vulnerable populations, such as elderly people, are at greater risk during poor travel conditions and power outages. Impassable streets can also complicate emergency response efforts during an extreme event.

Winter storms are a potential Town-wide hazard in Wenham. These events can include wind, heavy snow, blizzards, and ice storms. Blizzards and ice storms in Massachusetts can range from an inconvenience, to extreme events that cause significant impacts and require large-scale, coordinated response.

4.5.1 Heavy Snow and Blizzards

A blizzard is a winter snowstorm with sustained wind or frequent wind gusts of 35 mph or more, accompanied by falling or blowing snow that reduces visibility to or below a quarter of a mile. 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 criteria. However, the hazard created by the combination of snow, wind, and low visibility increases significantly with temperatures below 20°F. A severe blizzard is categorized as having temperatures near or below 10°F, winds exceeding 45 mph, and visibility reduced by snow to near zero (MEMA and EOEEA 2018, 4-223).

Winter storms include multiple risks, such as wind, ice, and heavy snow. The National Weather Service defines "heavy snow" as snowfall accumulating to 4" or more in 12 hours or less; or snowfall accumulating to 6" or more in 24 hours or less (NOAA 2019b). Winter storms can be combined with the Nor'easters discussed previously in the "Wind-Related Hazards" section.

There is no widely used scale to classify snowstorms. The Northeast Snowfall Impact Scale (NESIS) developed by Paul Kocin of The Weather Channel and Louis Uccellini of the National Weather Service (Kocin and Uccellini, 2004) characterizes and ranks high-impact northeast snowstorms. These storms have large areas of 10-inch snowfall accumulations and greater. NESIS has five categories, as shown in Table 4-17. The index differs from other meteorological indices in that it uses population information in addition to meteorological measurements. Thus, NESIS gives an indication of a storm's societal impacts. This scale was developed because of the impact northeast snowstorms can have on the rest of the country in terms of transportation and economics. NESIS scores are a function of the area affected by the snowstorm, the amount of snow, and the number of people living in the path of the storm. The aerial distribution of snowfall and population information are combined in an equation that calculates a NESIS score, which varies from 1 for smaller storms to over 10 for extreme storms. The raw score is converted into one of the five NESIS categories. The largest NESIS values result from storms producing heavy snowfall over large areas that include major metropolitan centers. NOAA began using the NESIS in 2005 to determine impact from snow events (MEMA and DCR 2013, 400).

Table 4-17. NESIS 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+	Extreme
Source: MEMA and EOEEA 2018		

Sixty major winter storms occurred in Massachusetts between 1953 and 2018 (MEMA and EOEEA 2018, 4-227; FEMA 2018b). The "Blizzard of 1978" was a well-known winter storm that deposited more than three feet of snow and led to multi-day closures of roads, businesses, and schools. Additional storms are included below.

February 1978	Blizzard of 1978
October 1991	Severe Coastal Storm ("Perfect Storm")
December 1992	Great Nor'easter of 1992

January 2005	Blizzard/Nor'easter
October 2005	Coastal Storm/Nor'easter
April 2007	Severe Storms, Inland & Coastal Flooding/Nor'easter
January 2011	Winter Storm/Nor'easter
October 2011	Severe Storm/Nor'easter
February 2013	Blizzard/ Nor'easter
Jaunuary 2015	Blizzard/ Nor'easter
March 2015	March 2015 Nor'easter
March 2018	March 2018 Nor'easter

Snowfall in winter 2010-11 approached the record mark with 60.3 inches measured at Logan for the season as of the end of January. Snow came in a series of severe storms, some of which included serious flooding. The current winter snowfall record in Eastern Massachusetts is 62.7 inches (MEMA and EOEEA 2018, 4-226). High snowfall amounts can lead to increased groundwater and surface water amounts, contributing to spring flooding events in Wenham and many other communities.

According to NOAA's National Centers for Environmental Information Storm Event Database, there were 56 winter storms in Essex County between 1998-2008, which resulted in over three million dollars of property damage. NOAA's National Centers for Environmental Information also offers records of heavy snow events in Essex County. Since 1998, Essex County experienced 86 heavy snowfall events that caused $133,000 dollars in property damage. No deaths or injuries were reported. Please refer to Table 4-18 for more information.

Table 4-18. Winter Storm Events and Property Damage, Essex County, 1998-2018

Location	Date	Deaths	Injuries	Property Damage ($)
EASTERN ESSEX (ZONE)	12/25/2002	0	0	15,000
WESTERN ESSEX (ZONE)	12/25/2002	0	0	15,000
WESTERN ESSEX (ZONE)	1/3/2003	0	0	0
EASTERN ESSEX (ZONE)	1/3/2003	0	0	0
EASTERN ESSEX (ZONE)	2/7/2003	0	0	0
WESTERN ESSEX (ZONE)	2/7/2003	0	0	0
EASTERN ESSEX (ZONE)	2/17/2003	0	0	0
WESTERN ESSEX (ZONE)	2/17/2003	0	0	0
EASTERN ESSEX (ZONE)	12/5/2003	0	0	0
WESTERN ESSEX (ZONE)	12/5/2003	0	0	0
WESTERN ESSEX (ZONE)	12/14/2003	0	0	0
EASTERN ESSEX (ZONE)	12/26/2004	0	0	0
WESTERN ESSEX (ZONE)	12/26/2004	0	0	0
WESTERN ESSEX (ZONE)	1/5/2005	0	0	0
EASTERN ESSEX (ZONE)	1/5/2005	0	0	0
WESTERN ESSEX (ZONE)	1/8/2005	0	0	50,000
EASTERN ESSEX (ZONE)	1/8/2005	0	0	50,000
EASTERN ESSEX (ZONE)	1/22/2005	0	0	0
WESTERN ESSEX (ZONE)	1/22/2005	0	0	0
EASTERN ESSEX (ZONE)	3/1/2005	0	0	50,000

Table 4-18. Winter Storm Events and Property Damage, Essex County, 1998-2018

Location	Date	Deaths	Injuries	Property Damage ($)
WESTERN ESSEX (ZONE)	3/1/2005	0	0	0
WESTERN ESSEX (ZONE)	3/8/2005	0	0	0
WESTERN ESSEX (ZONE)	3/12/2005	0	0	0
EASTERN ESSEX (ZONE)	10/29/2005	0	0	15,000
WESTERN ESSEX (ZONE)	2/12/2006	0	0	10,000
EASTERN ESSEX (ZONE)	2/12/2006	0	0	15,000
WESTERN ESSEX (ZONE)	2/14/2007	0	0	0
WESTERN ESSEX (ZONE)	2/14/2007	0	0	0
WESTERN ESSEX (ZONE)	3/16/2007	0	0	0
WESTERN ESSEX (ZONE)	3/16/2007	0	0	0
EASTERN ESSEX (ZONE)	12/11/2008	0	0	2,000,000
WESTERN ESSEX (ZONE)	12/26/2010	0	0	0
EASTERN ESSEX (ZONE)	12/26/2010	0	0	250,000
WESTERN ESSEX (ZONE)	1/12/2011	0	0	30,000
EASTERN ESSEX (ZONE)	1/18/2011	0	0	0
EASTERN ESSEX (ZONE)	1/21/2011	0	0	0
WESTERN ESSEX (ZONE)	1/21/2011	0	0	0
WESTERN ESSEX (ZONE)	2/1/2011	0	0	309,000
EASTERN ESSEX (ZONE)	2/1/2011	0	0	155,000
EASTERN ESSEX (ZONE)	2/27/2011	0	0	0
WESTERN ESSEX (ZONE)	1/7/2017	0	0	0
WESTERN ESSEX (ZONE)	2/9/2017	0	0	0
WESTERN ESSEX (ZONE)	2/9/2017	0	0	0
EASTERN ESSEX (ZONE)	2/12/2017	0	0	0
EASTERN ESSEX (ZONE)	2/12/2017	0	0	0
WESTERN ESSEX (ZONE)	4/1/2017	0	0	0
WESTERN ESSEX (ZONE)	12/9/2017	0	0	0
EASTERN ESSEX (ZONE)	12/9/2017	0	0	0
WESTERN ESSEX (ZONE)	1/4/2018	0	0	2,000
WESTERN ESSEX (ZONE)	1/4/2018	0	0	0
WESTERN ESSEX (ZONE)	2/17/2018	0	0	0
EASTERN ESSEX (ZONE)	2/17/2018	0	0	0
WESTERN ESSEX (ZONE)	3/7/2018	0	0	17,000
EASTERN ESSEX (ZONE)	3/7/2018	0	0	38,000
WESTERN ESSEX (ZONE)	3/13/2018	0	0	20,000
WESTERN ESSEX (ZONE)	3/13/2018	0	0	45,000
Total		0	0	$3,086,000

Source: NOAA 2018a

Blizzards are considered to be High frequency events in Wenham. As defined by the 2018 Massachusetts State Hazard Mitigation and Adaptation Plan, this hazard occurs more than once in five years (a greater than 20% annual chance of occurring).

4.5.2 Ice Storms

Ice storm conditions are defined by liquid rain falling and freezing on contact with cold objects creating ice build-ups of ¼ inch or more that can cause severe damage. An ice storm warning, now included in the criterion for a winter storm warning, is for severe icing. This is issued when 1/2 inch or more of accretion of freezing rain is expected. This may lead to dangerous walking or driving conditions and the weighing down of power lines and trees. Icy roads can also complicate emergency response efforts during an extreme event. A warning is used for winter weather conditions posing a threat to life and property. Sleet occurs when raindrops fall into subfreezing air thick enough that the raindrops refreeze into ice before hitting the ground. Sleet differs from hail: sleet is a wintertime phenomenon, while hail usually falls during thunderstorms in the spring and summer (MEMA and DCR 2013, 462). A comparison of hail sizes in shown in Table 4-19 below.

Table 4-19. Hail Size Comparisons

Description	Diameter (inches)
Pea	0.25
Marble or Mothball	0.50
Penny or Dime	0.75
Nickel	0.875
Quarter	1.00
Ping Pong Ball	1.50
Golf ball	1.75
Tennis Ball	2.50
Baseball	2.75
Tea Cup	3.00
Grapefruit	4.00
Softball	4.50

Source: NOAA 2019a

NOAA's National Centers for Environmental Information offers hail events and ice storms for Essex County. There were 66 hail events in Essex County with no events specifically reported in Wenham from 1998-2018. Ten events had hail larger than quarter size (1-inch diameter) and the largest event was tea cup size (3-inches). The total property damage was $155,000 for the past two decades. There were no deaths or injuries associated with these events. One ice storm was recorded in 2008, which caused $2.0 million dollars in property damage. No deaths or injuries were reported. Please refer to Table 4-20 for more information.

Ice storms are a potential Town-wide hazard in Wenham, as these events can impact travel and evacuation routes. Ice storms are considered Medium frequency events in Wenham. As defined by the 2018 Massachusetts State Hazard Mitigation and Adaptation Plan, this hazard occurs once in 5 years to once in 50 years (a 2% to 20% annual chance of occurring).

4.6 Geologic Hazards

Geologic hazards can include earthquakes, landslides, sinkholes, and subsidence. Town officials did not identify any local areas at particularly vulnerable to geologic hazards. Please refer to Map 4 in Appendix B for more information on geologic hazards in Wenham.

4.6.1 Earthquakes

An earthquake is the vibration, sometimes violent, of the earth's surface that follows a release of energy in the earth's crust due to fault fracture and movement. The magnitude or extent of an earthquake is a seismograph-measured value of the amplitude of the seismic waves. The Richter magnitude scale (Richter scale) was developed in 1932 as a mathematical device to compare the sizes of earthquakes. The Richter scale is the most widely known scale that measures earthquake magnitude. It has no upper limit and is not an indication of 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. Table 4-20 summarizes Richter scale magnitudes and corresponding earthquake effects (MEMA and DCR 2013, 220).

Table 4-20. Richter Scale and Effects

Richter Magnitudes	Earthquake Effects
Less than 3.5	Generally not felt, but recorded
3.6- 5.4	Often felt, but rarely causes damage
5.5 - 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 km. across where people live.
7.0- 7.9	Major earthquake. Can cause serious damage over larger areas.
8 or greater	Great earthquake. Can cause serious damage in areas several hundred meters across.

Source: Louie 1996

Earthquakes occur, albeit infrequently, in New England as compared to other parts of the country. The first recorded earthquake was noted by the Plymouth Pilgrims and other early settlers in 1638. Of the over 5,000 earthquakes recorded in the Northeast Earthquake Catalog through 2008, 1,530 occurred within the boundaries of the six New England States, with 366 earthquakes recorded for Massachusetts between 1627 and 2008. Historically, moderately damaging earthquakes strike somewhere in the region every few decades, and smaller earthquakes are felt approximately twice per year (MEMA and DCR 2013, 228-232). A summary of historic earthquakes in the Boston area is included in Table 4-21 below.

Table 4-21. Historical Earthquakes in Boston or Surrounding Area, 1727-2012

Location	Date	Magnitude
MA - Cape Ann	11/10/1727	5
MA - Cape Ann	12/29/1727	NA
MA – Cape Ann	2/10/1728	NA
MA – Cape Ann	3/30/1729	NA
MA – Cape Ann	12/9/1729	NA
MA – Cape Ann	2/20/1730	NA
MA – Cape Ann	3/9/1730	NA
MA - Boston	6/24/1741	NA
MA - Cape Ann	6/14/1744	4.7
MA - Salem	7/1/1744	NA
MA - Off Cape Ann	11/18/1755	6

Table 4-21. Historical Earthquakes in Boston or Surrounding Area, 1727-2012

Location	Date	Magnitude
MA – Off Cape Cod	11/23/1755	NA
MA - Boston	3/12/1761	4.6
MA - Off Cape Cod	2/2/1766	NA
MA - Offshore	1/2/1785	5.4
MA – Wareham/Taunton	12/25/1800	NA
MA - Woburn	10/5/1817	4.3
MA - Marblehead	8/25/1846	4.3
MA - Brewster	8/8/1847	4.2
MA - Boxford	5/12/1880	NA
MA - Newbury	11/7/1907	NA
MA - Wareham	4/25/1924	NA
MA – Cape Ann	1/7/1925	4
MA – Nantucket	10/25/1965	NA
MA – Boston	12/27/74	2.3
VA –Mineral	8/23/11	5.8
MA - Nantucket	4/12/12	4.5
ME - Hollis	10/17/12	4.0

Source: City of Boston, Natural Hazard Mitigation Plan, page 68

Earthquake risk can be measured in terms of ground motion. This metric is measured by maximum peak horizontal acceleration expressed as a percentage of gravity (%g). Peak ground acceleration in the state ranges from 10 %g to 20 %g, with a 2% probability of exceedance in 50 years. Please refer to Figure 4-2 for more information.

Wenham is in an area with a PGA of 18%g. This is a moderately high area of earthquake risk relative to the state, although the state as a whole is considered to have a low risk of earthquakes (Figure 4-2). Compared to the rest of the country, Massachusetts has a low risk of earthquakes. There have been no recorded earthquake epicenters in Wenham.

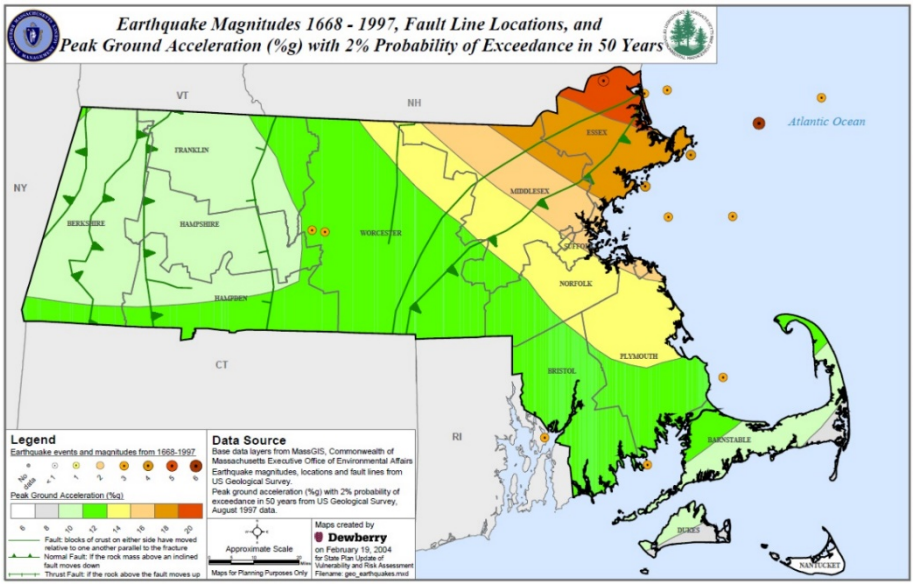


Figure 4-2. Massachusetts Earthquake Peak Ground Acceleration Map

Source: Massachusetts State Hazard Mitigation Plan

A serious earthquake in Massachusetts is possible. These events can strike without warning and can have a devastating impact on infrastructure and buildings constructed prior to earthquake resistant design considerations.

It can be assumed that all existing and future buildings and populations are at risk to an earthquake hazard. Impacts from earthquakes can be from slight to moderate building damage, to catastrophic damage and fatalities. Events may cause minor damage such as cracked plaster and chimneys, or broken windows, or major damage resulting in building collapse. Based on the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, 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." Furthermore, the time of day exposes different sectors of the community to the hazard. Earthquakes can lead to business interruptions, loss of utilities and road closures which may isolate populations. People who reside or work in unreinforced masonry buildings are vulnerable to liquefaction, the phenomenon that occurs when the strength and stiffness of a soil is reduced by earthquake.

Based on a HAZUS Earthquake module, estimated damage in Wenham from magnitude 5.0 and 7.0 earthquakes was assessed (2012 HMP). Historically, an earthquake with magnitude 5.0 occurred in 1963. This assessment assumes an earthquake epicenter at the center of the study area, which would be the worse-case scenario. Table 4-22 below lists estimated damage in Wenham for this worst-case scenario.

According to the Boston College Weston Observatory, in most parts of New England, there is a one in ten chance that a potentially damaging earthquake will occur in a 50-year time period (Kafka 2004). Earthquakes are classified as low frequency events in Wenham. As defined by the 2018 State Hazard Mitigation and Adaptation Plan, these events occur from once in 50 years to once in 100 years (1% to 2% annual chance).

Table 4-22. Estimated Damages from Earthquakes

	Magnitude 5.0	Magnitude 7.0
Building Characteristics		
Estimated total number of buildings	1179	1179
Estimated total building replacement value (Millions of $, 2002)	$405	$405
Building Damages		
# of buildings sustaining slight damage	60	387
# of buildings sustaining moderate damage	12	399
# of buildings sustaining extensive damage	1	141
# of buildings completely damaged	0	45
Population Needs		
# of households displaced	1	101
# of people seeking public shelter	0	20
Debris		
Building debris generated (tons)	Not available	Not available
# of truckloads to clear building debris		
Value of Damages (Millions of dollars)		
Total property damage	$8.68	$103.30
Total losses due to business interruption	$0.26	$11.18

4.6.2 Landslides

Landslides involve a wide range of ground movement that include rock falls, deep failure of slopes, and shallow debris flows. Gravity acting on an over-steepened slope is the primary cause of a landslide, however there are other factors that contribute to landslides. These include riverine or coastal erosion over steepened slopes; rock and soil slopes weakened through saturation by snowmelt or heavy rains; stresses from earthquake that cause weakened slopes to fail; excess weight from accumulated precipitation (rain or snow); and stockpiling of rock or ore from waste piles or man-made structures (USGS 2019a).

Landslides occur throughout the United States, causing an estimated $1 billion in damages and 25-50 deaths each year. Any area composed of very weak or fractured materials resting on a steep slope will likely experience landslides. Although the physical cause of many landslides cannot be removed, geologic investigations, good engineering practices, and effective enforcement of land-use management regulations can reduce landslide hazards (USGS 2019a). Landslides can damage buildings and infrastructure and cause sedimentation of water bodies.

Landslide are a Town-wide hazard, although there are no records of past landslides occurring in Wenham. Landslides are considered Low frequency events. These events can occur once in 50 to 100 years (a 1% to 2% annual chance of occurring). Landslide intensity can be measured in terms of destructiveness, as demonstrated by Table 4-23.

Table 4-23 Landslide Volume and Intensity

Estimated Volume	Expected Landslide Velocity		
($m^{3)}$	Fast moving landslide (Rock fall)	Rapid moving landslide (Debris flow)	Slow moving landslide (Slide)
<0.001	Slight intensity	--	--
<0.5	Medium intensity	--	--
>0.5	High intensity	--	--
<500	High intensity	Slight intensity	--
500-10,000	High intensity	Medium intensity	Slight intensity
10,000 – 50,000	Very high intensity	High intensity	Medium intensity
>500,000	--	Very high intensity	High intensity
>>500,000	--	--	Very high intensity

Source: Cardinali et al. 2002

4.7 Fire Related Hazards

Fire risk is influenced by fuel (the type of material), terrain and weather. Strong winds can exacerbate extreme fire conditions, especially wind events that persist for long periods, or ones with significant sustained wind speeds that quickly promote fire spread through the movement of embers or exposure within tree crowns. Fires can spread quickly into developed areas. Brush fires burn forest underbrush. In the Boston area, brush fires do not typically expand to the size of a wildfire. A wildfire can be defined as any non-structure fire that occurs in the vegetative wildland, including grass, shrub, leaf litter, and forested tree fuels. In general, wildfires in Massachusetts can be caused by natural events, human activity or in an intentional controlled manner, as in the case of prescribed fire. Wildfires often begin unnoticed, but spread quickly, igniting brush, trees, and homes (MEMA and DCR 2013, 252). According to the SHMCAP (Appendix B), the most recent large-scale wildfire occurred in September 1995 in the Town of Russell of Hampden County. Since wildfires are not common in Massachusetts, this plan focuses on brush and urban fires.

The State Hazard Mitigation and Climate Adaptation Plan (EEA and EOPPS, 2018) states:

> *"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 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."*

While brush fires have not had major impacts in Wenham in the past, the majority of Wenham is classified as intermix and interface areas (EEA and EOPPS, 2018, p4-176). Brush fires can lead to death and property damage. All individuals whose homes or workplaces are in wildfire hazard zones are exposed to this hazard. 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 five, people with mobility limitations, and people with low socioeconomic status (MEMA and EOEEA 2018, 4-180). Secondary effects from wildfire include contamination of reservoirs; destroyed power, gas, water, broadband, and oil transmission lines. Brush fires can also contribute to flooding as they strip slopes of vegetation, thereby exposing them to greater amounts of runoff which may cause soil erosion and ultimately the chance of flooding. Additionally, subsequent rains can worsen erosion because wildfires burn ground vegetation and ground cover.

Figure 4-3 below shows the locations of historical wildfires and the number of acres burned in Massachusetts between 2001 and 2009. Wenham has experienced between 0.26-9 acres burned, with 0-20 fires from 2001 to 2009.

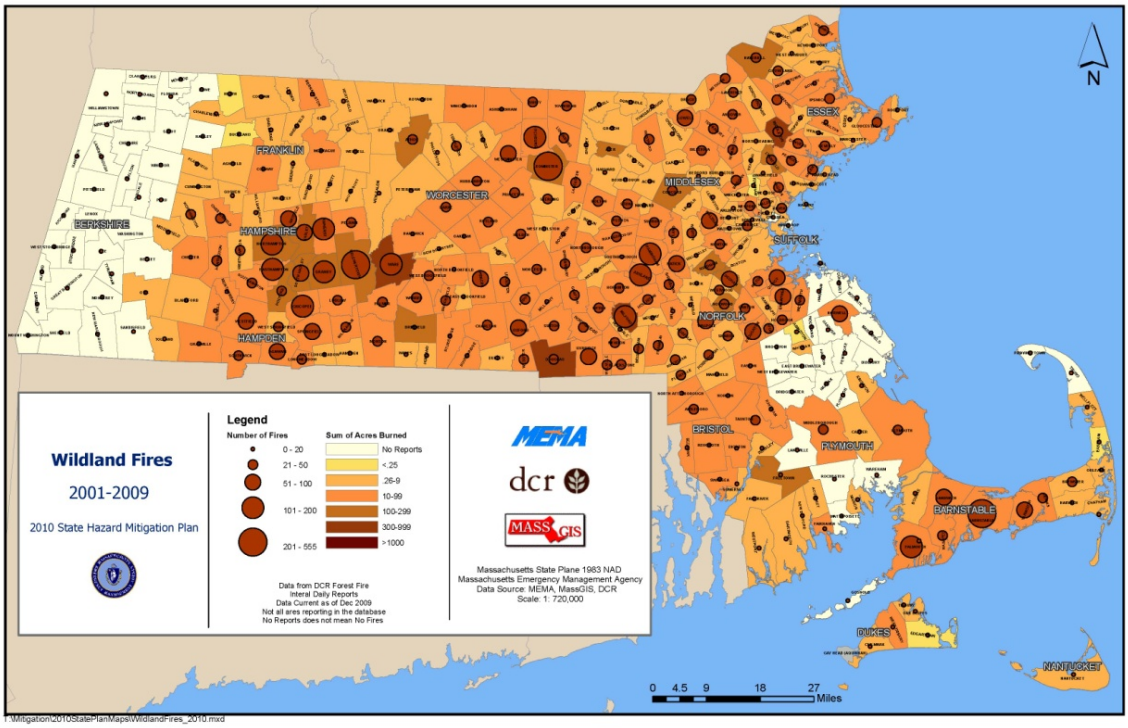


Figure 4-3. Massachusetts Wildfires 2001-2009
Source: Massachusetts State Hazard Mitigation Plan

During a 2012 interview, the Wenham Fire Chief said that the Department had responded to an average of 10 brush fires annually during the previous five years. Very few resulted in significant property damage and there were no deaths. During the MVP Workshop in January 2019, representatives from the Fire Department estimated that Wenham currently averages six brush fires per year, which can be exacerbated by high winds but are typically minor events.

There are fire prevention access and brush management issues in some of the areas associated with more frequent brush fires. The Fire Department has some dedicated forest fire apparatus but would be more effective with updated equipment.

The areas with the highest incidence of brush fires, suggesting higher vulnerability, are the Wenham Lake and Longham Reservoir areas owned by the Salem/Beverly Water Board, the MA Audubon Cedar Pond Wildlife Sanctuary and Grapevine Road lands, the MBTA Commuter Rail Right of Way, the Streeter Property, and part of the Gordon College land.

Brushfires are considered Medium frequency hazards. These events can occur from once in 5 years to once in 50 years (2% to 20% annual chance).

4.8 Extreme Temperatures

Extreme temperatures can include both temperatures over and under seasonal averages. These extreme temperature events can range from brief to lengthy.

The Boston area has four clearly-defined seasons. Extreme temperatures fall outside of the ranges typically experienced during these seasons. Boston's average winter temperature, from December to February, is 32.2°F. Boston's average summer temperature, from June to August, is 73.8°F (NOAA 2018b). Extreme temperatures are a Town-wide hazard.

4.8.1 Extreme Cold

Extremely cold temperatures are measured using the Wind Chill Temperature Index provided by the National Weather Service (NWS). The updated index was implemented in 2001and helps explain the impact of cold temperatures on unexposed skin. Figure 4-4 below provides more information.

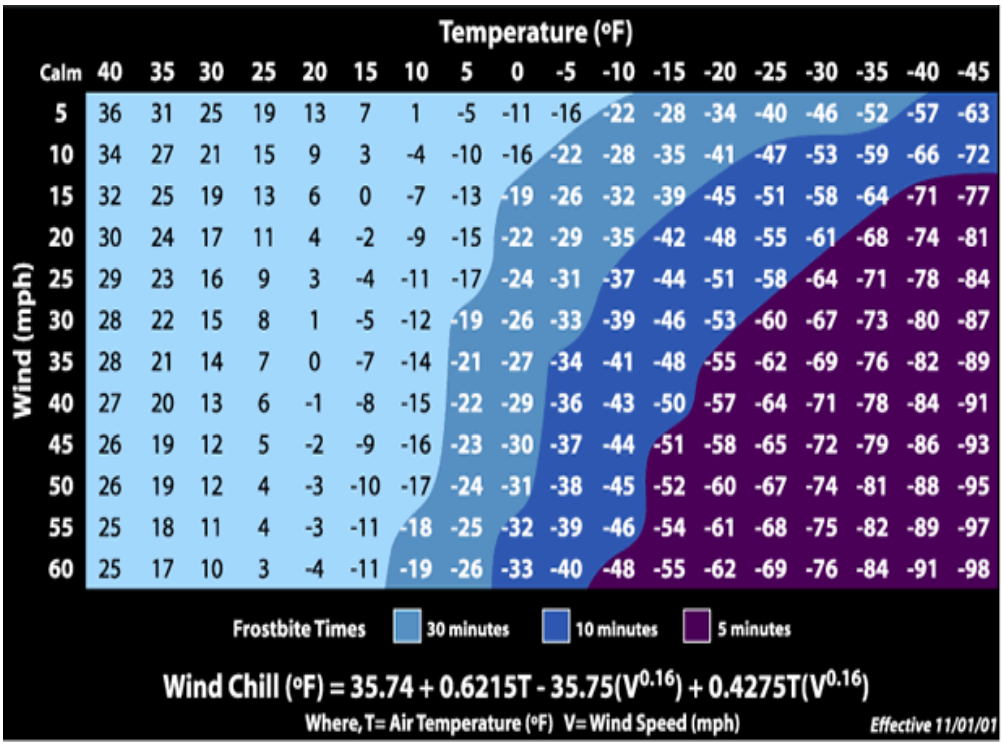


Figure 4-4. Wind Chill Temperature Index and Frostbite Risk
Source: National Weather Service

Extremely cold temperatures can create dangerous conditions for vulnerable populations like people experiencing homelessness, stranded travelers, and residents without sufficient insulation or heat. The homeless, the elderly, and people with disabilities are often most vulnerable. In Wenham, 15.8% of the population are over 65 and 3.3% of the population has a disability (U.S. Census Bureau 2017). Cold weather events can also have significant health impacts such as frostbite and hypothermia. Furthermore, power outages during cold weather may result in inappropriate use of combustion heaters, cooking appliances, and generators in poorly ventilated areas which can lead to increased risk of carbon monoxide poisoning.

NOAA's National Centers for Environmental Information provides extreme cold events data for Essex County, which includes the Town of Wenham. Between 1998 and 2018, there were four extreme cold events that caused no deaths, no injuries, and no reported property damage. Please refer to Table 4-24 for more information.

Table 4-24. Essex County Extreme Cold and Wind Chill Occurrences, 1998-2018

Date	Type	Deaths	Injuries	Damage-$
2/15/2015	Extreme Cold/Wind Chill	0	0	0
2/16/2015	Extreme Cold/Wind Chill	0	0	0
2/13/2016	Extreme Cold/Wind Chill	0	0	0
2/13/2016	Extreme Cold/Wind Chill	0	0	0

Source: NOAA 2018a

4.8.2 Extreme Heat

The NWS issues a Heat Advisory when the Heat Index (Figure 4-5) is forecast to reach 100-104° F for 2 or more hours. The NWS issues an Excessive Heat Warning if the Heat Index is forecast to reach 105°+F for 2 or more hours. Heat waves cause more fatalities in the U.S. than the total of all other meteorological events combined. In Boston, over 50 people die each year due to heat-related illnesses. From 1979-2012, excessive heat exposure caused in excess of 8,000 deaths in the United States. During this period, more people in this country died from extreme heat than from hurricanes, lightning, tornadoes, floods, and earthquakes combined. Because most heat-related deaths occur during the summer, people should be aware of who is at greatest risk and what actions can be taken to prevent a heat-related illness or death. The most vulnerable populations are the elderly, children, and people with certain medical conditions, such as heart disease. In Wenham, 15.8% of the population are over 65 and 3.3% are under age 5. However, even young and healthy individuals can succumb to heat if they participate in strenuous physical activities during hot weather. Some behaviors also put people at greater risk: drinking alcohol, taking part in strenuous outdoor physical activities in hot weather, and taking medications that impair the body's ability to regulate its temperature or that inhibit perspiration (MEMA and DCR 2013, 418; U.S. Census Bureau 2017).

Relative Humidity (%) \ Temperature (°F)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	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										

Category	Heat Index	Health Hazards
Extreme Danger	130 °F – Higher	Heat Stroke or Sunstroke is likely with continued exposure.
Danger	105 °F – 129 °F	Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.
Extreme Caution	90 °F – 105 °F	Sunstroke, muscle cramps, and/or heat exhaustions possible with prolonged exposure and/or physical activity.
Caution	80 °F – 90 °F	Fatigue possible with prolonged exposure and/or physical activity.

Figure 4-5. Heat Index Chart

During the MVP Workshop in January 2019, participants discussed public health concerns related to extreme heat. Increased temperatures can lead to a longer growing season, which in turn leads to a longer pollen season. Warmer weather can also support the migration of invasive species and lead to an increase in vector-borne diseases.

The Town of Wenham does not collect data on heat occurrences. The best available local data are for Essex County, through the National Environmental Information Center. NOAA's National Centers for Environmental Information provides extreme heat data for Essex County, which includes the Town of Wenham. Between 1998 and 2018, there were three excessive heat events and three heat events. Excessive heat are temperatures over 105° F. There were no reported deaths, injuries, or property damage. Please refer to Table 4-25 for more information.

Extreme temperatures are considered Medium frequency events. As defined by the 2018 Massachusetts State Hazard Mitigation and Adaptation Plan, these events occur between once in five years to once in 50 years (a 2% to 20% annual chance of occurring).

Table 4-25. Essex County Heat Occurrences, 1998-2018

Date	Type	Deaths	Injuries	Damage
07/06/2010	Heat	0	0	0
07/06/2010	Heat	0	0	0
07/07/2010	Heat	0	0	0
7/22/2011	Excessive Heat	0	0	0
7/01/2018	Excessive Heat	0	0	0
7/03/2018	Excessive Heat	0	0	0

Source: NOAA 2018a

4.9 Drought

Drought is an extended period of deficient precipitation. Drought conditions occur in virtually all climatic zones, yet its characteristics vary significantly from one region to another since it is relative to the normal precipitation in that region. Drought can affect agriculture, water supply, aquatic ecology, wildlife, and plant life (MEMA and DCR 2013, 421).

Average annual precipitation in Boston is 53.32 inches per year, with approximately two to five-inch average amounts for each month of the year (NOAA 2019b). Although Massachusetts is relatively small, it has a number of distinct regions that experience significantly different weather patterns and react differently to the amounts of precipitation they receive. The DCR precipitation index divides the state into six regions: Western, Central, Connecticut River Valley, Northeast, Southeast, and Cape and Islands. Wenham is located within the Northeast region (MEMA and DCR 2013, 423, 434).

Five levels of drought have been developed to characterize drought severity: Normal, Advisory, Watch, Warning, and Emergency; these correspond to Level 0 – Normal, Level 1 - Mild Drought, Level 2 - Significant Drought, Level 3 - Critical Drought (was Warning), and Level 4 - Emergency Drought (was Emergency), respectively, of the draft Drought Management Plan update. The drought levels are based on the severity of drought conditions and their impacts on natural resources and public water supplies.

The Drought Management Plan specifies the agency response and interagency coordination and communication corresponding to the various drought levels. During normal conditions, data are routinely collected and distributed. There is heightened vigilance with additional data collection during an advisory, and increased assessment and proactive education during a watch. Water restrictions might be appropriate at the watch or warning stage, depending on the capacity of each individual water supply system. A warning level indicates a severe situation and the possibility that a drought emergency may be necessary. A drought emergency is one in which mandatory water restrictions or use of emergency supplies become necessary (MEMA and DCR 2013, 423-433).

A variety of drought indices are available to assess the various impacts of dry conditions. The Commonwealth uses a multi-index system to determine the severity of a drought or extended period of dry conditions. A determination of drought level is based on seven indices: Standardized Precipitation Index, Crop Moisture Index, Keetch-Byram Drought Index (KBDI), Precipitation, Groundwater levels, Stream flow levels, and Index Reservoir levels.

Drought level is determined monthly based on the number of indices which have reached a given drought level. Most of the indices would need to be triggered in a region for a drought designation to move to a more severe level. Drought levels are declared on a regional basis for each of the six regions in Massachusetts. Drought levels may also be made county by county or be watershed-specific. Once a drought level of warning and emergency have been reached for the precipitation index, conditions must improve to those of the previous level before a determination is made to reduce the warning or emergency (MEMA and DCR 2013, 424).

4.9.1 Previous Drought Occurrences

Figure 4-6 illustrates statewide drought levels in Massachusetts from 1850 to 2012, using the Standardized Precipitation Index (SPI). Table 4-26 below summarizes a history of Massachusetts droughts between 1879 and 2017.

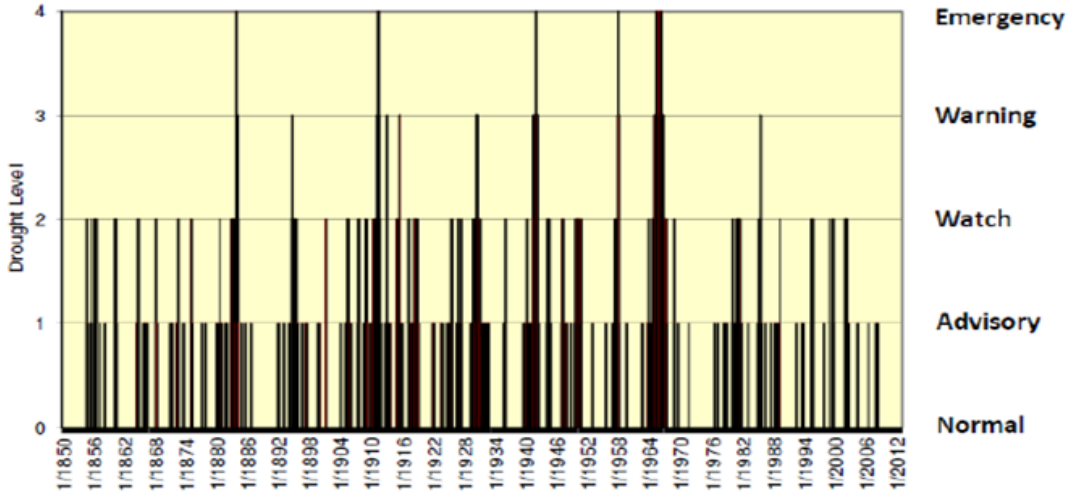


Figure 4-6 - Statewide Drought Levels using SPI Thresholds 1850 – 2012

Source: EEA and MEMA 2013, page 37

Table 4-26. Droughts in Massachusetts Based on Instrumental Records

Date	Area Affected	Recurrence Interval (years)	Remarks
1879 to 1883	–	–	–
1908 to 1912	–	–	–
1929 to 1932	Statewide	10 to >50	Water-supply sources altered in 13 communities. Multistate.
1939 to 1944	Statewide	15 to >50	More severe in eastern and extreme western Massachusetts. Multistate.
1957 to 1959	Statewide	5 to 25	Record low water levels in observation wells, northeastern Massachusetts.
1961 to 1969	Statewide	35 to >50	Water-supply shortages common. Record drought. Multistate.
1980 to 1983	Statewide	10 to 30	Most severe in Ipswich and Taunton River basins; minimal effect in Nashua River basin. Multistate.
1985 to 1988	Housatonic River Basin	25	Duration and severity unknown. Streamflow showed mixed trends elsewhere.
1995	–	–	Based on statewide average precipitation.

Table 4-26. Droughts in Massachusetts Based on Instrumental Records

Date	Area Affected	Recurrence Interval (years)	Remarks
1998 to 1999	–	–	Based on statewide average precipitation.
2001 to 2003	Statewide	–	Level 2 drought (out of 4 levels) was reached statewide for several months.
2007 to 2008	Statewide except West and Cape and Islands regions	–	Level 1 drought (out of 4 levels)
2010	Connecticut River Valley, Central and Northeast regions	–	Level 1 drought (out of 4 levels)
2014	Southeast and Cape and Islands regions	–	Level 1 drought (out of 4 levels)
2016-2017	Statewide	–	Level 3 drought (out of 4 levels).

Source: MEMA and EOEEA 2018, page 4-45

4.9.2 Drought Emergency

There are five drought emergencies on record in Massachusetts: 1883, 1911, 1941, 1957, and 1965-1966. The 1965-1966 drought is considered the most severe Massachusetts drought in modern times, given its length. On a monthly basis over the 162-year period of record, there is a one percent chance of being in a Drought Emergency (EEA and MEMA 2013, 36).

4.9.3 Drought Warning

Drought Warning levels not associated with Drought Emergencies would have occurred in 1894, 1915, 1930,1985, 2016, and 2017. On a monthly basis over the 162-year period of record, there is a two percent chance of being in a drought Warning level (EEA and MEMA 2013, 36; DCR 2017b, 1).

4.9.4 Drought Watch

Drought Watches not associated with Drought Warnings or Drought Emergencies generally would have occurred three to four times per decade between 1850 and 1950. The Drought Emergency declarations dominated the 1960s. There were no Drought Watches or above in the 1970s. In the 1980s, precipitation was at the Drought Watch level of precipitation between 1980 and 1981, another Drought Warning occurred in 1985. Drought Watches occurred at a rate of three years per decade in the 1990s (1995, 1998, 1999). In the 2000s, Drought Watches occurred in 2001 and 2002. The overall frequency of being in a Drought Watch is eight percent on a monthly basis over the 162-year period of record (EEA and MEMA 2013, 36). There were six drought watches in Massachusetts in 2002, five drought watches in 2016, and two drought watches in 2017 (DCR 2017b, 1). Figure 4-7 presents an example of drought

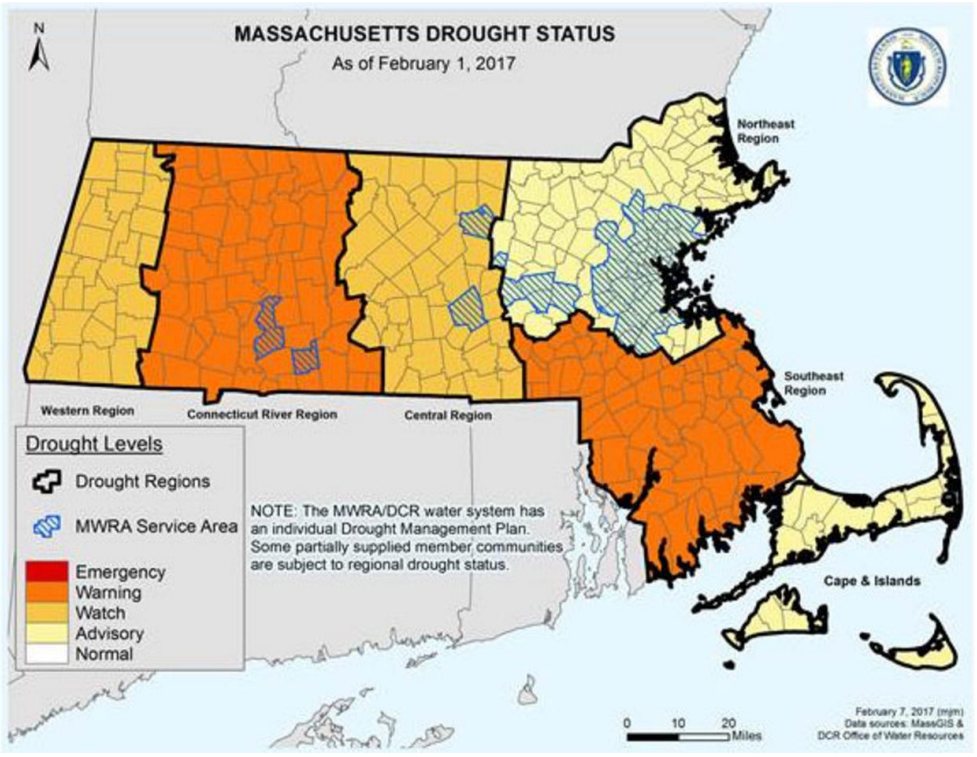


Figure 4-7: Massachusetts Drought Status, February 2017
Source: MA Department of Conservation and Recreation

conditions in the six drought regions.

Drought is a potential Town-wide hazard in Wenham. As noted previously, temperature is projected to increase and may lead to exacerbated drought conditions especially in summer and fall months. Droughts can also increase fire risk: wildfires can be caused by lightning, and a 2014 study found that the frequency of lightning strikes could increase by more than 10% for every degree Celsius of warming (MEMA and EOEEA 2018, 4-45, 4-178).

NOAA's National Centers for Environmental Information provides drought data for Essex County. This area has experienced 17 drought events since 1998, with no reported deaths, injuries, or property damage. Please refer to Table 4-27 for more information.

Table 4-27. Essex County Drought Occurrences 1998--2018				
Location	Date	Deaths	Injuries	Property Damage
EASTERN ESSEX (ZONE)	04/12/2012	0	0	0.00K
WESTERN ESSEX (ZONE)	04/12/2012	0	0	0.00K
EASTERN ESSEX (ZONE)	05/01/2012	0	0	0.00K
EASTERN ESSEX (ZONE)	07/05/2016	0	0	0.00K
WESTERN ESSEX (ZONE)	07/05/2016	0	0	0.00K
EASTERN ESSEX (ZONE)	08/01/2016	0	0	0.00K
WESTERN ESSEX (ZONE)	08/01/2016	0	0	0.00K
EASTERN ESSEX (ZONE)	09/01/2016	0	0	0.00K
WESTERN ESSEX (ZONE)	09/01/2016	0	0	0.00K
EASTERN ESSEX (ZONE)	10/01/2016	0	0	0.00K
WESTERN ESSEX (ZONE)	10/01/2016	0	0	0.00K
EASTERN ESSEX (ZONE)	11/01/2016	0	0	0.00K
WESTERN ESSEX (ZONE)	11/01/2016	0	0	0.00K
EASTERN ESSEX (ZONE)	12/01/2016	0	0	0.00K
WESTERN ESSEX (ZONE)	12/01/2016	0	0	0.00K
WESTERN ESSEX (ZONE)	01/01/2017	0	0	0.00K
EASTERN ESSEX (ZONE)	01/01/2017	0	0	0.00K
Total		0	0	0.00K

Source: NOAA 2018a

4.9.5 Probability of Future Drought Occurrences

Under a severe long-term drought, the Town of Wenham could be vulnerable to restrictions on water supply. Damage resulting from a severe drought and associated outdoor watering bans could include losses of plantings and landscaped areas and economic impacts from loss of business revenues. As this hazard has never occurred to such a severe degree in Wenham, there are no data or estimates of potential damages, but under a severe long-term drought scenario it would be reasonable to expect a range of potential damages from several hundred thousand to several millions of dollars. Another potential vulnerability of droughts could be increased risk of wildfires.

Wenham is included within the Ipswich River Watershed, and the Town participates in the Ipswich River Watershed drought task force. During the MVP workshop in January 2019, participants discussed a range of concerns related to drought. They commented that the Ipswich River is among the most stressed waterbodies, and there can be friction between Wenham and towns that don't have water restrictions. A drought that lasts longer than two years would have serious impacts on the Town and the Fire Department.

Tendercrop Farm in Wenham. Photo by David Le, The Salem News Staff Photos, 2015

Workshop participants stressed the need to prioritize planning for drought even during times when the Town is not currently experiencing a drought.

Droughts are classified as Low frequency hazards. These events can occur from once in 50 years to once in 100 years (1% to 2% annual chance).

4.10 Impacts of Climate Change

Many of the hazards that Wenham is currently experiencing could be worsened by climate change. Participants in Wenham's MVP Workshop identified drought, extreme temperatures, flooding, and strong winds and winter storms as hazards of particular concern. These are described in more detail below. Note, drought and flooding will both increase with climate change because the natural precipitation cycle will be disrupted. Under climate change, the warmer atmosphere will retain precipitation longer so that it will fall in fewer, more intense events rather than small, periodic events. This will cause more flooding and longer periods with little to no rainfall.

4.10.1 Impacts of Climate Change: Drought

During the MVP workshop, participants found that elderly residents, water infrastructure, group home residents, forests, wetlands, and the Aquifer Protection District could be negatively impacted by drought.

4.10.2 Impacts of Climate Change: Extreme Temperatures

Between 1961 and 1990, Boston experienced an average of 1 day per year in excess of 100°F. That could increase to 6 days per year by 2070, and 24 days per year by 2099. Under these conditions by the end of the century, Massachusetts's climate would more closely resemble that of Maryland or the Carolinas (refer to Figure 4-6 below).

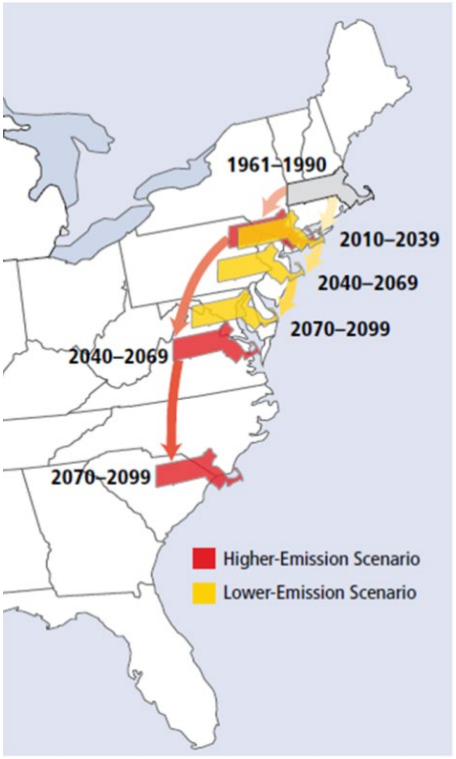


Figure 4-6 . Mass. Extreme Heat Scenarios
Source: Frumhoff et al. 2007

4.10.3 Impacts of Climate Change: Flooding

Boston's average annual precipitation is 53.32 inches (NOAA 2019b). Extreme rain and snow events are becoming increasingly common and severe particularly in the Northeast region of the country (Figure 4-7). Large rain or snow events that happened once a year in the middle of the 20th century now occur approximately every nine months. Additionally, the largest annual events now generate 10% more rain than in 1948. Regionally, New England has experienced the greatest increase in frequency of extreme rain and snow events. These events now occur 85% more frequently than they did sixty years ago (Madsen and Willcox 2012, 15-16).

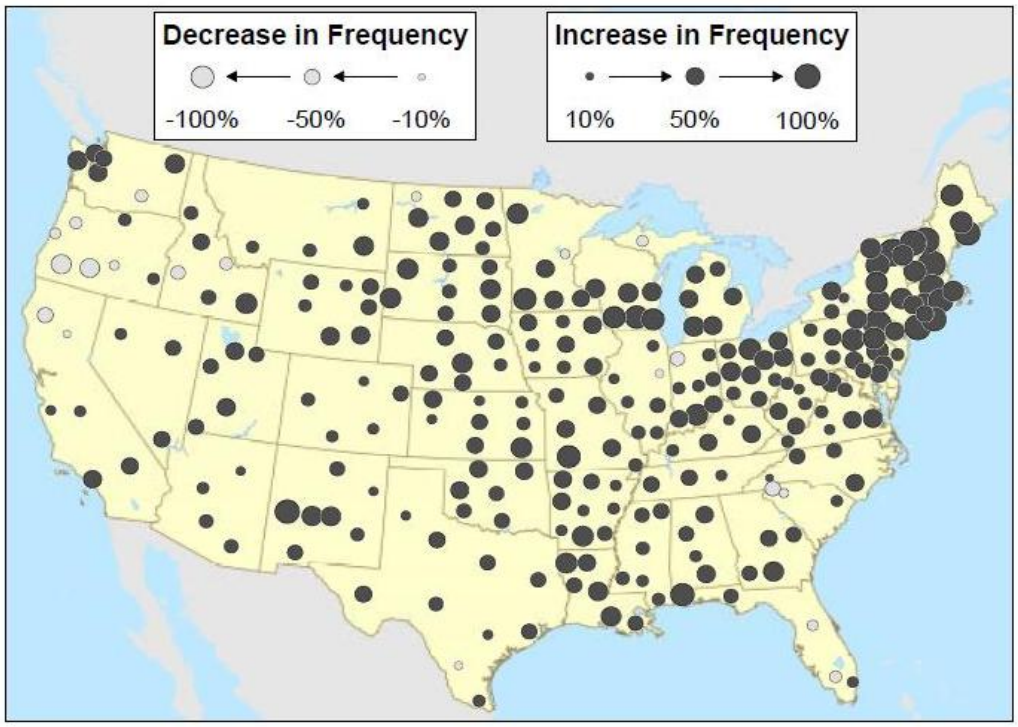


Figure 4-7. Changes in Frequency of Extreme Downpours, 1948 – 2011
Source: Madsen and Willcox 2012, page 19

There is evidence suggesting that nor'easters along the Atlantic coast are increasing in frequency and intensity. Future nor'easters may become more concentrated during the coldest winter months when atmospheric temperatures are still low enough to result in snowfall rather than rain (MEMA and EOEEA 2018, 4-224). Climate projections indicate that climate change will result in more precipitation in the winter in the Northeast, and this trend may result in more frequent or more severe winter storms.

4.10.4 Impacts of Climate Change: Strong Winds

While Wenham's current 100-year wind speed is 110 mph, climate change will likely increase the number of extreme wind events and their severity. Additionally, rising temperatures could lengthen the hurricane season and fuel stronger hurricane events. The National Climate Assessment Report notes that hurricane "intensity, frequency, and duration have all increased since the early 1980s." This source predicts continuing intensity and associated rainfall with rising temperatures. This would result in greater losses due to increased flooding, associated building damages and business interruption impacts

(Walsh and Wuebbles 2014). The anticipated increase in frequency and intensity of severe thunderstorms may also increase the risk of tornadoes (MEMA and EOEEA 2018, ES).

4.10.5 Climate Change: Winter Storms

There is evidence suggesting that nor'easters along the Atlantic coast are increasing in frequency and intensity. Future nor'easters may become more concentrated during the coldest winter months when atmospheric temperatures are still low enough to result in snowfall rather than rain (EEA and EOPSS 2018, 4-224).

Climate projections indicate that climate change will result in more precipitation during the winter in the Northeast (EEA, 2018a). This trend may result in more frequent and/or more severe winter storms.

5.0 HAZARD MITIGATION GOALS

The Wenham Core Committee reviewed and discussed the set of goals and objectives for the town of Wenham. The team endorsed the following nine goals for the Wenham Hazard Mitigation Plan 2019 Update:

1. Prevent and reduce the loss of life, injury, public health impacts and property damages resulting from all major natural hazards.

2. Identify and seek funding for measures to mitigate or eliminate each known significant flood hazard area.

3. Integrate hazard mitigation planning as an integral factor in all relevant municipal departments, committees and boards.

4. Prevent and reduce the damage to public infrastructure resulting from all hazards.

5. Encourage the business community, major institutions and non-profits to work with the Town to develop, review and implement the hazard mitigation plan.

6. Work with surrounding communities, state, regional and federal agencies to ensure regional cooperation and solutions for hazards affecting multiple communities.

7. Ensure that future development meets federal, state and local standards for preventing and reducing the impacts of natural hazards.

8. Take maximum advantage of resources from FEMA and MEMA to educate Town staff and the public about hazard mitigation.

9. Consider the potential impacts of climate change and incorporate climate mitigation, sustainability, and resilience into hazard mitigation and other Town plans and policies.

6.0 EXISTING MITIGATION MEASURES

The Town of Wenham's existing protections and capabilities are based on the Town's implementation of zoning, land use, and environmental regulations, infrastructure maintenance and drainage infrastructure improvement projects. Existing mitigation measures in Wenham are listed by hazard type here and are summarized in Table 6-2 below.

There are several mitigations measures that impact more than one hazard. These include the Comprehensive Emergency Management Plan (CEMP), the Massachusetts State Building Code and participation in a local Emergency Planning Committee.

There is ongoing public education on vector-borne diseases (primarily from mosquitos, ticks). Information is posted on signs and online.

Comprehensive Emergency Management Plan (CEMP) – Every community in Massachusetts is required to have a Comprehensive Emergency Management Plan. These plans address mitigation, preparedness, response and recovery from a variety of natural and man-made emergencies. These plans contain important information regarding flooding, dam failures and winter storms. Therefore, the CEMP is a mitigation measure that is relevant to many of the hazards discussed in this plan.

Enforcement of the State Building Code – The Massachusetts State Building Code contains many detailed regulations regarding wind loads, earthquake resistant design, flood-proofing and snow loads.

Participation in the Local Emergency Management Planning Committee (LEPC) – Wenham has its own Local Emergency Planning Committee.

6.1 Existing Flood-Hazard Mitigation Measures

Wenham minimizes potential flooding and impacts from flooding through several measures. These include:

National Flood Insurance Program (NFIP) – Wenham participates in the NFIP with 15 policies in force as of the September 30, 2018. Information about participation in the NFIP can be obtained from the MA Department of Conservation and Recreation and from FEMA's database on flood insurance policies and claims, found at https://www.fema.gov/policy-claim-statistics-flood-insurance/policy-claim-statistics-flood-insurance/policy-claim-13.
Table 6-1 is provided for the Town of Wenham:

Table 6-1. National Flood Insurance Program in Wenham

Flood insurance policies in force (as of September 30, 2018)	15
Coverage amount of flood insurance policies	$ 4,162,000
Premiums paid	$13,268
Total losses (all losses submitted regardless of the status)	2
Closed losses (Losses that have been paid)	1
Open losses (Losses that have not been paid in full)	0
CWOP losses (Losses that have been closed without payment)	1
Total payments (Total amount paid on losses)	$724.40

Floodplain Regulation – The Town of Wenham maintains up-to-date floodplain maps, enforces floodplain regulations, and provides information to property owners and builders regarding floodplains and building requirements, and thus complies with the NFIP.

Massachusetts State Building Code – The Town enforces the Massachusetts State Building Code which regulates how buildings must be designed to accommodate specific wind loads, earthquake resistant design, flood-proofing, and snow loads.

Street Sweeping – All streets are swept annually or as needed.

Catch Basin Cleaning – All of the town's approximately 500 catch basins are cleaned out annually.

Roadway Treatments – The town uses a 25/75 mixture of sand and salt. IceBan (liquid ice melt) is used in addition to or in replacement of the sand and salt mixture in particularly icy or environmentally sensitive areas.

Subdivision Rules and Regulations – The subdivision rules and regulations contain a number of requirements that address flood hazard mitigation. Some of these provisions also relate to other hazards.

Lot Drainage Section 4.6:
Development of any lot shall not cause detrimental drainage on another; drainage ROWs for drainage across or to another lot. Applicant to furnish evidence to Planning Board or Board of Health that adequate provision has been made for proper drainage of surface and underground waters.

Town of Wenham Zoning Bylaws – The zoning bylaws contain a number of requirements that address flood hazard mitigation. Some of these provisions also relate to other hazards.

Overlay and Special Districts Section 12.0:
Flood Plain Overlay District (Section 12.2)

- *Protect the public health, safety and general welfare;*
- *Protect human life and property from the hazards of periodic flooding; and*
- *Preserve the natural flood control characteristics and the flood storage capacity of the floodplains in Wenham.*

The FPOD is established as an overlay district to all other districts. Any development within the FPOD, whether structural or non-structural, shall be subject to all otherwise applicable

requirements of the underlying zoning district in which it is located, including the usual use and dimensional requirements. Any alteration of land or structure in the FPOD, except for those uses permitted by right, requires a special permit from the Planning Board and must comply with the following regulations: 780 CMR Massachusetts State Building Code, 310 CMR 10.00 MA Wetlands Act regulations, 310 CMR 13.00 Inland Wetlands Restriction Act, 310 CMR 15 Title 5 Minimum Requirements for the Subsurface Disposal of Sanitary Sewage, and Chapter XVIII of the town bylaw, the Water Resources Protection Bylaw.

Location:
The FPOD includes all special flood hazard areas within the Town of Wenham designated as Zone A, AH and AE on the Essex County Flood Insurance Rate Map (FIRM) issued by the Federal Emergency Management Agency (FEMA) for the administration of the National Flood Insurance Program (NFIP). The map panels of the Essex County FIRM that are wholly or partially within the Town of Wenham are panel numbers 25009C0406F, 25009C0408F, 25009C0409F, 25009C0426F, 25009C0427F, 25009C0428F, 25009C0429F, 25009C0433F dated July 3, 2012. The exact boundaries of the FPOD may be defined by the 100-year base flood elevations shown on the FIRM and further defined by the Essex County Flood Insurance Study (FIS) report dated July 3, 2012. The FPOD locations and boundaries also include all flood plain areas shown on the Town of Wenham Flood Plain District Zoning Map dated 1973, prepared by Essex Survey Service, Inc., Salem, MA. These areas comprise the 100-year flood plain, also known as the base flood elevation, in the Town of Wenham. The base flood means that flood which has a one percent chance of being equaled or exceeded in any given year. The FIRM and Wenham Flood Plain District Zoning Map are incorporated herein by reference and are on file with the Town Clerk Planning Board, Building Inspector, Conservation Commission, and Zoning Board of Appeals.

Aquifer Protection Overlay District (Section 12.1)
The purpose of the Aquifer Protection Overlay District (APOD) is to promote the public health by protecting, preserving, and maintaining the quality and quantity of the existing and potential ground water supplies, aquifers, and recharge areas of the Town of Wenham as present and potential sources of public water supply.
All runoff from impervious surfaces shall be recharged on the site to the maximum extent possible. The preferred method is diversion toward vegetated areas for surface infiltration.

Underground leaching facilities shall only be used where other methods are not feasible for reasons other than cost, and shall be preceded by oil, grease, and sediment traps to facilitate removal of contaminants.
Allowed uses:

- Conservation of soil, water, plants, and wildlife.
- Outdoor recreation, nature study, boating, fishing, and hunting where otherwise legally permitted.
- Foot, bicycle and/or horse paths, boat docks, and bridges.
- Normal operation and maintenance of existing water bodies and dams, splash boards, and other water control, supply, and conservation devices.
- Uses rendering impervious less than twenty percent (20%) of a lot (exclusive of wetlands and land in the Flood Plain Overlay District).
- Farming, gardening, nursery, forestry, harvesting, and grazing, provided that fertilizers, herbicides, pesticides, and other leachable materials are

not stored outdoors and are applied in accordance with Local, State and Federal regulations.

The following uses are prohibited in the APOD:

- Disposal of solid wastes, other than brush, stumps, and other organic material generated on the site.
- Storage of petroleum or other refined petroleum products (except propane and natural gas) unless secondary containment of the tank and piping is provided; with the exception of such storage tanks in existence as of the effective date of this By-Law, in which case if replaced and not enlarged, this provision shall not apply.
- The disposal of liquid or leachable wastes, except through residential septic systems. The repair and/ or expansion of septic systems existing as of the effective date of this By-Law is permitted, provided they comply with Title 5, 310 C.M.R. 15.00, et seq. and Wenham Board of Health regulations.
- New commercial and industrial uses which discharge wastewater on-site.
- Storage of road salt except in confined and covered areas.
- Dumping of snow containing de-icing chemicals which is brought in from outside the APOD.
- Animal feedlots.
- The storage of uncovered manure in quantities greater than residential landscape or gardening use.
- Mining of land except as incidental to a permitted use.
- Storage or disposal of hazardous wastes, as defined by the Hazardous Waste Regulations promulgated by the Hazardous Waste Board, the Water Resources Commission, and the Division of Water Pollution Control under the provisions of Section 27 (8), 52, 57, and 58 of Chapter 21 of the Massachusetts General Laws.
- Automotive service and repair shops, trucking and bus terminals, and junk and salvage yards.

Site Plan Review (Zoning Bylaws Section 13 – amended 2016) applies to:

- Construction, exterior alteration or exterior expansion of, or change of use within, a municipal, institutional, commercial, industrial, or residential structure with two or more dwelling units;
- Construction or expansion of a parking lot for a municipal, institutional, commercial, industrial, or residential structure with two or more dwelling units.

General Site Plan Review Environmental Standards:

- Minimize the volume of cut and fill, the number of removed trees 6" caliper or larger;
- The length of removal stone;
- The area of wetland vegetation displaced;
- The extent of stormwater flow increase from the site, soil erosion, and the threat of air and water pollution;
- Runoff must meet subdivision control regulations at a minimum.

Erosion Control Site Plan Review Standards: Design, materials, and construction processes shall be designed to avoid erosion damage, sedimentation, or uncontrolled surface water runoff by conformance with the following:

- Grading or construction which will result in final slopes of 15% or greater on 25% or more of lot area, or on 20,000 square feet or more on a single lot, even if less than 25% of lot area, shall be allowed only by special permit from the Planning Board, which shall be granted only upon demonstration that adequate provisions have been made to protect against erosion, soil instability, uncontrolled surface water runoff, or other environmental degradation. Applications and plans for such special permits shall be referred to the Conservation Commission for its advisory review.
- All such slopes exceeding 15% which result from site grading or construction activities shall either be covered with topsoil to a depth of 4 inches and planted with vegetative cover sufficient to prevent erosion or be retained by a wall constructed of masonry, reinforced concrete or treated pile or timber.
- No area or areas totaling 0.5 acres or more on any parcel or contiguous parcels in the same ownership shall have existing vegetation clear-stripped or be filled 6 inches or more so as to destroy existing vegetation unless in conjunction with agricultural activity, or unless necessarily incidental to construction on the premises under a currently valid building permit, or unless within streets which are either public or designated on an approved subdivision plan, or unless a special permit is approved by the Planning Board on condition that runoff will be controlled, erosion avoided, and either a constructed surface or cover vegetation will be provided not later than the first full spring season immediately following completion of the stripping operation. No stripped area or areas which are allowed by special permit shall remain through the winter without a soil control plan approved by the Planning Board, except in the case of agricultural activity where such temporary cover would be infeasible.
- Hillside areas, except naturally occurring ledge or bedrock outcroppings or ledge cuts, shall be retained with vegetative cover as per an approved plan.

Flexible Development (Zoning Bylaws Section 11.1)
The purpose of a Flexible Development is to:

- encourage the preservation of open land for its scenic beauty and to enhance agricultural, open space, forestry, and recreational use;
- preserve historical and archeological resources; to protect the natural environment, including the Town's varied landscapes and water resources; protect the value of real property;
- promote more sensitive siting of buildings and better overall site planning;
- perpetuate the appearance of the Town's traditional New England landscape;
- facilitate the construction and maintenance of streets, utilities, and public services in a more economical and efficient manner;
- offer an alternative to standard subdivision development;
- and/or promote the development of housing affordable to low, moderate, and median income families.

Flexible development offers an alternative to standard subdivisions by grouping housing units, preserving open space, reducing impervious area and reducing overall and peak stormwater runoff which contribute to flooding.

Water Resources Protection Bylaw Chapter XVIII: all wetland resource areas + 100' jurisdiction for any alteration require an Order of Conditions from the Conservation Commission.

Stormwater Management Bylaw Chapter XXIV (Bylaw governing discharges to the Municipal Storm Drain System) (2009): non-stormwater discharges or illicit connections to MS4 system prohibited.

Earth Removal Bylaw Chapter XII: permit required for removal of > 100 cubic yards of fill per year and > 10 yards of topsoil or sod removal per year.

Water Use Restriction Chapter XXI: protects public health and welfare and implements the Town's authority to regulate water use.

6.2 Existing Wind Hazard Mitigation Measures

Massachusetts State Building Code – The town enforces the Massachusetts State Building Code which includes protection against most wind damage and is a cost-effective mitigation measure against tornados.

Tree-trimming program – The town has a tree warden and has hired outside contractors on occasion to help with tree maintenance and also has its own tree chipper. The electrical utility company National Grid does a full tree inspection of its power line corridors every three years and takes down problem trees as needed. The town feels that this is not entirely effective as the more difficult hazardous trees are not always dealt with. Therefore, the Town has appropriated funds for tree removal and planting. In 2018, the Town of Wenham, with the help of Bartlett Tree Experts, published a comprehensive Tree Inventory and Management Plan, which involved mapping existing trees, assessing their current condition, recommending removal of trees that could become hazards, and making recommendations for future tree care (Armstrong and Ingram 2018, 6).

6.3 Existing Winter Hazard Mitigation Measures

Roadway Treatments – The town uses a 25/75 mixture of sand and salt. IceBan (liquid ice melt) is used in addition to or in replacement of the sand and salt mixture in particularly icy or environmentally sensitive areas.

Snow disposal: The Town conducts general snow and ice removal operations with its own equipment, using a 75/25 salt/sand ratio, along with IceBan, for its de-icing and traction program.

6.4 Existing Geologic Hazard Mitigation Measures

Massachusetts State Building Code – The Massachusetts State Building Code contains a section on designing for earthquake loads (780 CMR 1612.0). Section 1612.1 of the Building Code states that the purpose of this section is "to minimize the hazard to life to occupants of all buildings and non-building structures, to increase the expected performance of higher

occupancy structures as compared to ordinary structures, and to improve the capability of essential facilities to function during and after an earthquake". This section further states that due to the complexity of seismic design, the criteria presented are the minimum considered to be "prudent and economically justified" for the protection of life safety. The code acknowledges that absolute safety and prevention of damage resulting from an earthquake event cannot be achieved economically for most buildings.

Section 1612.2.5 and Table 1612.2.5 of the Massachusetts State Building Code establish seismic hazard exposure groups and assign buildings these groups. Group II includes buildings which have a substantial public hazard due to occupancy or use and Group III includes buildings with essential facilities that are required for post-earthquake recovery, including fire, rescue and police stations, emergency rooms, power-generating facilities, and communications facilities.

6.5 Existing Fire Hazard Mitigation Measures

Permits Required for Outdoor Burning – The Fire Department requires a written permit for outdoor burning, which is permitted only between January 1 and April 30.

Subdivision Review – The Fire Department is involved in reviewing all subdivision plans.

6.6 Existing Extreme Temperatures Hazard Mitigation Measures

Shade Tree Maintenance and Replacement Program: The Town maintains shade trees, removing hazardous trees and replacing them with healthy trees using the Town tree fund.

6.7 Existing Drought Hazard Mitigation Measures

Water Use Restriction Chapter XXI: protects public health and welfare and implements the Town's authority to regulate water use.

Ipswich Basin Water Management Act Coordination: Six Communities in the Ipswich Basin, in collaboration with the Massachusetts Water Works Association (MWWA) are working together to understand the current and future water supply constraints and challenges facing the Basin's municipal public water suppliers, and to identify potential regional solutions that could allow for improvement of resiliency and environmentally sustainable growth.

The Town's existing mitigation measures are summarized in Table 6-2 below.

Table 6-2. Summary of Existing Hazard Mitigation Measures

Hazard	Area	Mitigation Measures
Flood – Related	Town-Wide	A) The town participates in the National Flood Insurance Program and adopted the FIRM maps. There are 15 policies in force. The town actively enforces floodplain regulations. B) All streets and catch basins (500) are cleaned annually. C) 25/75 Sand/salt mix plus IceBan is used for winter road treatments. D) Drainage infrastructure and maintenance performed using MA Chapter 90 funds.

Table 6-2. Summary of Existing Hazard Mitigation Measures

Hazard	Area	Mitigation Measures
		E) Subdivision Rules for drainage F) Flood Plain Overlay District G) Site Plan Review for stormwater and erosion H) Aquifer Protection Overlay District I) Flexible Developments allowed J) Water Resource Protection Bylaw K) Discharges to MS4 Bylaw L) 2001 Open Space Plan M) Community Preservation Act adopted in 2005 N) Ipswich Basin Water Management Act
Wind-Related	Town-Wide	A) Outside contract for tree trimming. National Grid maintains trees within its power line corridors. B) The town enforces the MA State Building Code.
Winter-Related	Town-Wide	A) Standard snow operations with 75/25 salt/sad mix, as well as IceBan in icy or environmentally sensitive areas.
Brush Fire-Related	Town-Wide	A) The Fire Department requires a written permit for outdoor burning. B) The fire Department reviews all subdivision development plans.
Geologic - Earthquake	Town-Wide	A) The town enforces the MA State Building Code. B) Evacuation plans in CEMP C) Shelters and backup facilities available
Geologic-Landslide	Town-Wide	A) Maximum slope for subdivision roads B) Earth Removal Bylaws
Multi-Hazard	Town-Wide	A) The town enforces the MA State Building Code. B) Wenham has a Comprehensive Emergency Plan C) Town utilizes the MA Emergency Incident Command Unit. D) Town has Connect CTY, a form of Reverse 911. E) Wenham is a member of the Region One Boston Network (BAPERN). F) The town has its own Local Emergency Planning Committee. G) The Town Hall and Fire Station share a fixed, natural gas generator. The DPW and Police facilities both have fixed natural gas generators. H) Multi department review of all developments. I) The Council on Aging has a list of everyone over 60 years old.

Local Capacity for Implementation

The Town of Wenham is authorized to adopt and from time to time amend several local bylaws and regulations that support the town's capabilities to mitigate natural hazards under the Massachusetts system of "Home Rule,". Local Bylaws include: Zoning Bylaws, Subdivision and Site Plan Review Regulations, Wetlands Bylaws, Health Regulations, Public

Works regulations, and local enforcement of the State Building Code. Local Bylaws may be amended at the annual Town Meeting to improve the town's capabilities, and regulations, which are intended to help implement the Bylaws, are updated through a public hearing and a vote of the authorized board or commission, such as the Planning Board or Conservation Commission.

The Town of Wenham has recognized several existing mitigation measures that require implementation or improvements and has the capacity within its local boards and departments to address these. The Wenham Department of Public Works will address upgrades to culverts and other drainage infrastructure. The Planning Board will evaluate its Bylaws and regulations and will implement the Zoning Ordinance, Floodplain District, and Subdivision Rules and Regulations. The Conservation Commission will oversee implementation of the Wetlands Bylaw and the Open Space Plan. The Department of Public Works will work with both the Planning Board and Conservation Commission to implement and enforce the Stormwater Bylaw.

7.0 MITIGATION MEASURES FROM THE 2012 PLAN

7.1 Implementation Progress of the Previous Plan

At meetings of the Core Committee and with individual Core Committee members, Town staff reviewed the mitigation measures identified in the 2012 Wenham Hazard Mitigation Plan and determined which measure had been implemented or deferred. Of those measures that had been deferred, the Core Committee made a determination as to whether the measure should be deleted or carried forward into this Hazard Mitigation Plan 2019 Update. The Core Committee assessed the continued relevance and effectiveness of the previously proposed measures and assessed the reasons that Town was not able to take action on the measure. Table 7-1 summarizes the status of mitigation measures from the 2012 plan that are being continued in this 2019 plan update.

The Town of Wenham has taken steps to implement findings from the 2012 Hazard Mitigation Plan into the following policy, programmatic areas and plans: Wenham Open Space and Recreation Plan, Tree Management Plan, and the Miles River Watershed Management Plan.

Wenham has made progress on implementing mitigation measures identified in the 2012 Hazard Mitigation Plan, including:

- Replaced the Essex Street culvert with dual 6'x6' box culverts
- Preliminary design completed on Mill River Hull Street culvert
- One additional DPW employee.
- Wenham Open Space and Recreation Plan Update has received conditional approval from the state and will be resubmitted for full approval once the state's comments have been addressed.
- An additional sander has been obtained.
- A Tree Management Plan has been designed and implemented for Wenham with the assistance of Bartlett Tree Experts.
- A retention pond has been constructed at the new development on Grapevine Road, near the Beverly line. Flooding in this area is no longer an issue.
- The Town acquired 22 new handheld radios, three new fixed radio digital and radio mobile units, and 35 portable radios. The town is waiting on funding for the replacement of the existing 10-inch line with a new 8x10 pre-cast concrete culvert.
- The Stormwater Bylaws have been adopted.
- The town is continuously looking for opportunities for public outreach and education to residents on the importance of floodplain management, NFIP compliance, and development issues.
- The Town incorporated outfalls and catch basins into GIS database, as part of the MS4 process.

Overall, one mitigation measure from the 2012 plan will be carried forward in this 2019 plan update. Over the next five years, there will be many opportunities for the Town to incorporate hazard mitigation and climate change resilience planning into its decision-making processes. This plan will help the Town, with limited resources of staffing and funding, to prioritize the mitigation measures that it implements.

Table 7-1. Mitigation Measures from the 2012 Plan

Hazard Area/Type	Mitigation Measure in 2012 Plan	Priority in 2012 Plan	2019 Status Completed / In Progress / Not Completed	Include in 2019 Update? 2019 Priority?
High Priority				
Essex Street Culvert	4 x 6 stone box culvert at Miles River backs up during large storm events: needs to be replaced with new 8 x 10 pre-cast concrete culvert and new sidewalks. This is Wenham's top flooding and drainage infrastructure priority at present.	High	Completed: The Essex Street Culvert was replaced in 2017/18 with dual 6'x6' box culverts.	NO
Miles River Collaborative Watershed Management Plan	Complete and implement Miles River Watershed Management Plan, including a long-term beaver/beaver dam management plan, the dredging of portions of the river and the development of dam removal strategies including the possible removal of the Myopia Club Dam to help increase flood storage capacity and flows throughout the watershed.	High & NFIP	Not Completed	YES – High & NFIP
Beaver Dams block railroad bed: Route 97 near Topsfield/Danvers lines on rail trail	2 Beaver Deceivers installed in 2008: 2x2 culvert under tracks needs to be replaced with a larger culvert.	High	Not Completed. This is a beaver management problem that needs to be taken care of. A larger culvert is not needed.	YES - Medium
Mill River at Hull Street	24-inch corrugated drain line: replace with larger culvert due to	High	In Progress: Preliminary design	YES - High

Table 7-1. Mitigation Measures from the 2012 Plan

Hazard Area/Type	Mitigation Measure in 2012 Plan	Priority in 2012 Plan	2019 Status Completed / In Progress / Not Completed	Include in 2019 Update? 2019 Priority?
	beaver activity upstream.		done in 2017/18. Cost: ~$800,000	
Drainage Infrastructure Maintenance	More resources for more frequent maintenance of town-owned drainage facilities such as more frequent catch basin cleaning and replacement, culvert replacement, stormwater attenuation and treatment. 1.5 positions in DPW lost since 2009.	High	Completed: Gained back one DPW position. Catch basins are inspected regularly and cleaned/replaced when necessary. Culvert replacements rely on grants. Stormwater is monitored through the MS4 permitting process	NO
Land Protection	Complete update of Wenham Open Space and Recreation Plan.	High & NFIP	In Progress: The update has received conditional approval from the state and will be resubmitted for full approval once the state's comments have been addressed.	YES – High & NFIP
Land Protection	Acquire priority open space parcels: Lake View Golf Course and Canaan Farm.	High	Not Completed: Both properties were sold.	NO
Winter Storms	Upgrade snow removal equipment and install new heavy equipment storage shed.	High	In Progress: Obtained an additional sander.	YES – High
Winter Storms	More resources to fund better flood preparation and storm response teams.	High	In Progress: DPW has 20-minute response time. Need more	YES – Med

Table 7-1. Mitigation Measures from the 2012 Plan

Hazard Area/Type	Mitigation Measure in 2012 Plan	Priority in 2012 Plan	2019 Status Completed / In Progress / Not Completed	Include in 2019 Update? 2019 Priority?
			resources for Fire Department.	
High Winds and Hurricanes	Design and implement 10-year regional tree management and shared equipment plan with Hamilton and Ipswich.	High	Completed. A Tree Management Plan has been designed and implemented for Wenham with the assistance of Bartlett Tree Experts.	NO
Multi-hazard: power outage and communications	Update emergency communications equipment: radio repeaters, fixed and hand-held radios	High	Not Completed. Purchase more radios for DPW as well as a dedicated frequency.	YES – High Revise and combine these 3 items into town wide plan for generators
Multi-hazard: power outage and communications	Purchase and install fixed, multi-fuel generators for backup power at Buker School, Library and Senior Center. Develop plug-in capacity for the town's mobile generator at Police, Fire, Senior Center, Town Hall, Highway Department and First Church of Wenham Emergency Shelter.	High	Not Completed	YES - High
Medium Priority				
Grapevine Road near Beverly line	10-inch drain line: has been cleaned but continue to monitor for	Medium	Completed. Resolved with construction of	NO

Table 7-1. Mitigation Measures from the 2012 Plan

Hazard Area/Type	Mitigation Measure in 2012 Plan	Priority in 2012 Plan	2019 Status Completed / In Progress / Not Completed	Include in 2019 Update? 2019 Priority?
	backup problems and consider replacing with new 14-inch drain line if necessary.		retention pond at new development. Flooding is no longer an issue.	
Dodge's Row	6 x 8 culvert needs to be replaced with 8x10 culvert. Culvert needs to be replaced with new 8 x 10 culvert and new sidewalks installed.	Medium	Not Completed	YES -High
Cedar Street	12-inch corrugated culvert needs to be replaced with 24-inch culvert and low part of road elevated to prevent flooding.	Medium	Not Completed	YES – High
Homes (3-4) at Lake Avenue	Manage beavers and dams as needed.	Medium	Not Completed	NO. This area only flooded once during a 100-year storm. Dams are controlled by Beverly-Salem Water Board.
Drainage Infrastructure	To improve its drainage system record keeping capacity, locate catch basins and drainage outfalls, the town would like to have access to high resolution flyover data for its GIS database.	Medium	Completed.	NO

Table 7-1. Mitigation Measures from the 2012 Plan

Hazard Area/Type	Mitigation Measure in 2012 Plan	Priority in 2012 Plan	2019 Status Completed / In Progress / Not Completed	Include in 2019 Update? 2019 Priority?
44 Grapevine Road Culvert	Replace 10-inch line with new 8x10 pre-cast concrete culvert.	Medium	In Progress: Waiting on Funding.	YES-Med
Brush Fires	Work with Beverly/Salem Water Board on creating a joint public woods safety outreach effort to reduce brush fires	Medium	Not Completed	YES-Med
Low or Other Priority				
Flooding	Draft and adopt stormwater bylaw.	Other & NFIP	Completed	NO
Flooding	Provide more public outreach and education to residents on the importance of floodplain management, NFIP compliance, and development issues.	Other & NFIP	In Progress: Ongoing.	YES-Med
Earthquakes	Investigate options to make all public safety buildings earth-quake resistant.	Low	Not Completed	YES-Low
Multi-hazard	Ensure that emergency plans for hazardous facilities within Wenham are up to date and mapped.	Low	Not Completed	NO
Multi-hazard: power outage and communications	Ensure that all emergency plans for hazardous facilities within Wenham are up to date and mapped.	Low	Not Completed	YES-Low

8.0 HAZARD MITIGATION STRATEGY

8.1 What is Hazard Mitigation?

Hazard mitigation is the effort to reduce loss of life and property by lessening the impact of disasters. Mitigation is the phase of emergency management that is dedicated to breaking the cycle of damage, reconstruction and repeated damage through action and long-term strategies. These actions and long-term strategies can include planning, policy changes, education programs, infrastructure projects and other activities. FEMA currently has three mitigation grant programs: the Hazard Mitigation Grant Program (HGMP) (https://www.fema.gov/hazard-mitigation-grant-program), the Pre-Disaster Mitigation (PDM) program (https://www.fema.gov/pre-disaster-mitigation-grant-program), and the Flood Mitigation Assistance (FMA) program (https://www.fema.gov/flood-mitigation-assistance-grant-program).

Developing hazard mitigation plans enables state, tribal, and local governments to:

- Increase education and awareness around threats, hazards, and vulnerabilities;
- Build partnerships for risk reduction involving government, organizations, businesses, and the public;
- Identify long-term, broadly-supported strategies for risk reduction;
- Align risk reduction with other state, tribal, or community objectives;
- Identify implementation approaches that focus resources on the greatest risks and vulnerabilities; and
- Communicate priorities to potential sources of funding.

Hazard Mitigation Measures can be categorized by their different approaches to mitigating hazards. These approaches vary in terms of the types of actions taken and how those actions are administered at the local level. Measure are generally sorted into the following groups (Source: FEMA Local Multi-Hazard Mitigation Planning Guidance)

Prevention: Government administrative or regulatory actions or processes that influence the way land and buildings are developed and built. These actions also include public activities to reduce hazard losses. Examples include planning and zoning, building codes, capital improvement programs, open space preservation, and stormwater management regulations.

Property Protection: Actions that involve the modification of existing buildings or infrastructure to protect them from a hazard or removal from the hazard area. Examples include acquisition, elevation, relocation, structural retrofits, flood proofing, storm shutters, and shatter resistant glass.

Public Education & Awareness: Actions to inform and educate citizens, elected officials, and property owners about the potential risks from hazards and potential ways to mitigate them. Such actions include outreach projects, real estate disclosure, hazard information centers, and school-age and adult education programs.

Natural Resource Protection: Actions that, in addition to minimizing hazard losses also preserve or restore the functions of natural systems. These actions include sediment and erosion control, stream corridor restoration, watershed management, forest and vegetation management, and wetland restoration and preservation.

Structural Projects: Actions that involve the construction of structures to reduce the impact of a hazard. Such structures include storm water controls (e.g., culverts), floodwalls, seawalls, retaining walls, and safe rooms.

Emergency Services Protection: Actions that will protect emergency services before, during, and immediately after an occurrence. Examples of these actions include protection of warning system capability, protection of critical facilities, and protection of emergency response infrastructure.

8.1.1 Regional and Inter-Community Considerations

Several hazard mitigation issues are primarily local. The problem originates largely within the municipality and can be resolved at the municipal level. Other issues are inter-community and require a coordinated effort between two or more municipalities. Regional mitigation issues usually involve a state, regional and/or federal agency, or three or more municipalities.

Mitigation measures for the following regional issues should be considered as Wenham develops its local plan:

8.1.2 Regional Partners

Mitigating natural hazards, particularly flooding, is not confined to a local issue. The drainage systems that service communities are often complex systems of storm drains, roadway drainage infrastructure, pump stations, dams, and other facilities owned and operated by a wide variety of agencies including the Town, Massachusetts Department of Transportation (MassDOT), and the Salem Beverly Water Supply Board. The planning, construction, operation and maintenance of these structures are integral to the flood hazard mitigation efforts of communities. These agencies are the Town's regional partners in hazard mitigation efforts. These agencies also operate under the same constraints as communities do including budgetary and staffing limitations. And as all communities do, they must make decisions about numerous competing priorities. In the sections that follow, the plan provides recommendations for activities where cooperation with these other agencies will likely be necessary. In order to implement many of these mitigation measures, all parties will need to work together towards a mutually beneficial solution.

Major facilities and resources owned, operated and maintained by federal, state, regional or private entities in Wenham include:

- MBTA Commuter Rail (station on the border of Wenham and Hamilton)
- Wenham Lake and Shore Salem Beverly Water Supply Board)
- Longham Reservoir and area (Salem Beverly Water Supply Board)

- Long Hill Estate (The Trustees of Reservation)
- Mass Audubon Ipswich River Wildlife Sanctuary (Mass Audubon Society)
- Mass Audubon Cedar Pond Wildlife Sanctuary (Mass Audubon Society)
- Leaches Swamp (Greenbelt)
- J.C. Phillip's Nature Reserve (Beverly Conservation Commission)

8.1.3 New Development and Infrastructure

Hazard mitigation planning needs to consider new development and associated infrastructure in order to anticipate additional hazards that may occur with community growth. In developing recommendations for proposed mitigation measures, Wenham considered the need to limit future risks that could result from new development, redevelopment, and infrastructure needs. Through the Zoning and Bylaw changes enforced by the Planning Board and the Wetlands Act enforced by the Conservation Commission, existing regulatory measures are effectively applying local Home Rule land use regulatory authority, thus minimizing natural hazard impacts of development. Priorities for the future include addressing several critical upgrades to stormwater infrastructure and beaver management.

8.1.4 Recommended Mitigation Measures Process for Setting Priorities for Mitigation Measures

Table 8-2 represents in tabular form, the findings of the Core Committee. This table identifies the mitigation measures, the priority and implementation responsibility of the measure as well as an estimated time frame and a potential funding source. Below is a brief description of each category within the table, followed by the table itself.

Mitigation Measure – A brief description of each mitigation Cost estimates are given only if cost data was already available from the community. All cost data would need to be updated at the time of design and construction and is only provided as an estimate.

Priority – Designation of high, medium, or low priority was based on overall potential benefits, areas affected, and estimated project costs.

Implementation Responsibility – Most mitigation measures will require a multi-department approach where several Town departments share responsibility. This determination is at the discretion of the governing body of the community. The designation of implementation responsibility in the table was assigned based on general knowledge of the responsibilities of each municipal department.

Time Frame – The time frames represented below are assigned based on the complexity of the measure, the overall priority of the measure and at what stage of design and/or funding has been attained. Because the time frame for this plan is five years, the timing for all mitigation measures has been kept within this framework. The identification of time frames is not meant to prevent a community from actively seeking out and taking advantage of funding opportunities as they arise.

Potential Funding Sources – This column identifies the most likely sources of funding for a specific measure. The identification of potential funding sources in this table is

preliminary and may vary depending on numerous factors. These factors include, but are not limited to, if a mitigation measure is conceptual or has been studied, evaluated or designed. In most cases, the measure will require an assemblage of funding sources. The funding sources identified in this table are not a guarantee that a specific project will be eligible for or receive funding. Upon adoption of this plan, the local representatives responsible for implementation should begin to explore the funding sources in more detail.

Additional information on funding sources – The best way to determine eligibility for a funding source is to review the project with a staff person at the funding agency. The following websites provide an overview of programs and funding sources.

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

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

The final phase in developing the Town's mitigation strategy is to prioritize each mitigation measure to direct the Town's limited staff and resources to the highest priority measures with the greatest measurable benefit. Prioritization of the mitigation measures was based on members of the Core Committee's knowledge of existing and potential hazards and associated impacts. The Core Committee was aware of approximate associated costs with pursuing any given mitigation measure and this information was a consideration in the prioritizing.

Prioritization was established based on local knowledge of the hazard areas, including the impacts of hazard events, the extent of the impacted area, and the correlation of a specified mitigation measure to one or more of the Town's goals. In addition, the Core Committee considered other factors such as the number of homes and businesses affected, if road closures occurred and what impact those closures had on delivery of emergency services and the local economy, anticipated project costs, the existence of environmental constraints, and whether the Town could justify the costs as it relates to the anticipated benefits.
Table 8-2 presents the prioritization of the Town's potential hazard mitigation measures as well as the measures' costs and geographic extent of the potential benefit. The benefits, costs, and overall priority were evaluated using criteria in Table 8-1.

Table 8-1. Evaluation Criteria

Estimated Benefits	
High	Action will result in a significant reduction of hazard risk to people and/or property from a hazard event
Medium	Action will likely result in a moderate reduction of hazard risk to people and/or property from a hazard event
Low	Action will result in a low reduction of hazard risk to people and/or property from a hazard event
Estimated Costs	
High	Estimated costs greater than $100,000
Medium	Estimated costs between $10,000 to $100,000
Low	Estimated costs less than $10,000 and/or staff time
Priority	
High	Action very likely to have political and public support and necessary maintenance can occur following the project, and the costs seem reasonable considering likely benefits from the measure
Medium	Action may have political and public support and necessary maintenance has potential to occur following the project
Low	Not clear if action has political and public support and not certain that necessary maintenance can occur following the project

Abbreviations Used in Table 8-2

ACOE = Army Corps of Engineers.
CIP= Capital Improvement Program
CIP= Capital Improvement Plan
CZM = Coastal Zone Management
DCR = MA Department of Conservation and Recreation
DHS/EOPS = Department of Homeland Security/Emergency Operations
DEP (SRF) = Department of Environmental Protection (State Revolving Fund)
DMF = Division of Marine Fisheries
FEMA Mitigation Grants includes:
- FMA = Flood Mitigation Assistance Program.
- HMGP = Hazard Mitigation Grant Program.
- PDM = Pre-Disaster Mitigation Program

MA DOT = Massachusetts Department of Transportation
USDA = United States Department of Agriculture

Table 8-2 Recommended Mitigation Measure and Prioritization

Mitigation Measure	Geographic Coverage	Estimate Cost	Estimated Benefit	2019 Priority	Timeframe	Potential Funding Sources	Implementation Responsibility
Flooding							
1) Complete and implement Miles River Watershed Management Plan, including a long-term beaver/beaver dam management plan, such as the use of Beaver Deceivers, the dredging of portions of the river and the development of dam removal strategies including removal of the Myopia Club Dam to help increase flood storage capacity and flows throughout the watershed.	*Miles River Watershed*	High	High	High	2019-2020	Communities; ACOE; FEMA	Miles River Collaborative
2) Beaver/Beaver Dam Management. Beaver dams block railroad bed	*Route 97 near Topsfield/ Danvers*	Medium	Medium	Medium	TBD	Wenham; MADOT; FEMA	DPW/MADOT
3) Replace three culverts	*Route 97*	High	High	High	2020-2021	MADOT	Wenham Department of Public Works
4) 24-inch corrugated drain line: replace with larger culvert due to beaver activity upstream.	*Mill River at Hull Street*	High	High	High	2020-2021	Wenham; Gordon College	Wenham Department of Public Works
5) Continue to inspect and clean catch basins as needed. More funding needed for culvert replacement.	*Town-wide*	High	High	High	2019-2021	Town of Wenham	Wenham Department of Public Works

Table 8-2 Recommended Mitigation Measure and Prioritization

Mitigation Measure	Geographic Coverage	Estimate Cost	Estimated Benefit	2019 Priority	Timeframe	Potential Funding Sources	Implementation Responsibility
6) Replace existing 6 x 8 culvert with 8 x 10 culvert.	*Dodges Row*	Medium	Medium	Medium	2019-2022	Wenham; FEMA	Wenham Department of Public Works
7) Replace existing 12-inch corrugated culvert with a 24-inch culvert and elevate low part of road to prevent flooding.	*Cedar Street*	High	Medium	Medium	When road requires paving	Wenham; FEMA	Wenham Dept. of Public Works
8) Replace existing 10-inch line with new 8 x 10 pre-cast concrete culvert.	*44 Grapevine Road*	High	Medium	Medium	2020-2021	MassDOT	DPW
9) Provide more public outreach and education to residents on the importance of floodplain management NFIP compliance, and development issues.	*Town-wide*	Low	Medium	Low	ongoing	Wenham	Planning/ Conservation Commission
Wind Hazards							
10) Continue to remove hazardous trees and replace with healthy trees using the Town tree fund.	*Town-Wide*	Low/Ongoing	High	High	2019-2020	Wenham ELD, FEMA, National Grid	DPW/Conservation Commission
11) Evaluate and update bylaws to require underground power lines in all new development and improvements.	*Town-Wide*	Medium	High	Medium	2020	Wenham, National Grid	Building Department, National Grid, Developers

Table 8-2 Recommended Mitigation Measure and Prioritization

Mitigation Measure	Geographic Coverage	Estimate Cost	Estimated Benefit	2019 Priority	Timeframe	Potential Funding Sources	Implementation Responsibility
12) Educate property owners on benefits of installing power lines underground. Building department will raise this with developers and National Grid. Potential to create an info sheet for residents.	*Town-Wide*	Low	Medium	Medium	2020	Wenham	Building Department
Wildfire Hazards							
13) Work with Beverly/Salem Water Board on creating a joint public woods safety outreach effort to reduce brush fires.	*Town-Wide*	Medium	Medium	Medium	2020-2021	Wenham/BS Water Board	Fire Department
Winter Hazards							
14) Install new heavy equipment storage shed. Possible collaboration with Hamilton	*DPW*	Medium	Low	High	TBD	Wenham, FEMA	DPW
15) More resources to fund flood preparation and storm response team; find solution to fund the position of an Emergency Manager in Town government.	*Town-Wide*	Medium	High	High	TBD	Wenham	Wenham
Multi-Hazards							
16) Update emergency communications equipment: radio repeaters, fixed and hand-held radios, add a dedicated frequency for DPW.	*Town-Wide*	Medium	High	High	Ongoing	Wenham, FEMA	DPW/Police/Fire

Table 8-2 Recommended Mitigation Measure and Prioritization

Mitigation Measure	Geographic Coverage	Estimate Cost	Estimated Benefit	2019 Priority	Timeframe	Potential Funding Sources	Implementation Responsibility
17) Look for opportunities to work with Gordon College on a collaboration on a shelter.	*Gordon College*	Medium	High		2019-2022	Wenham, FEMA	DPW/College
18) Ensure that emergency plans for hazardous materials at facilities within Wenham are up to date and mapped.	*Town-Wide*	Low	Medium	Low	2019-2020	Wenham. Facilities	DPW/Planning/ Facilities
19) Improve information on where the young and elderly population is located.	*Town-Wide*	Low	Medium	Medium	Ongoing	Wenham	Schools/Council on Aging/State Daycare List
20) Address invasive insects and vector borne diseases. Potential to add information to documents such as tax bills, water bills, and the school nurse newsletter in order to reach most residents. The Town is also planning to develop a "tick educational awareness strategy."	*Town-Wide*	Low	Medium	Medium	2020	Wenham	Health Department, Planning Department
21) Incorporate climate resilience into the Town's Master Plan, regulations, bylaws and other planning tools.	*Town-Wide*	Medium	High	High	2019-2020	Wenham, EEA	Planning

9.0 PLAN ADOPTION AND MAINTENANCE

9.1 Plan Adoption

The Wenham Hazard Mitigation Plan 2019 Update was adopted by the Board of Selectmen August 20th, 2019. See Appendix D for documentation. The plan was approved by FEMA on for a five-year period that will expire on August 26, 2024.

9.2 Plan Maintenance

Weston & Sampson worked with the Wenham Core Committee to prepare this plan. After approval of the plan by FEMA, this group will meet once each year on an as-needed basis, whichever is more frequent, to function as the Local Hazard Mitigation Implementation Group. The Town should consider adding members from local businesses, non-profits and institutions. The Town will engage the public during the next 5-year planning cycle and encourage local participation whenever possible. All updates and accomplishments of the Hazard Mitigation Implementation Team and the Town, related to mitigation measure and the plan itself, will be placed on the Town's web site. All meetings of the Local Hazard Mitigation Implementation Group will be publicly noticed in accordance with town and state open meeting laws and the public will be encouraged to attend and participate.

9.3 Implementation and Evaluation Schedule

Bi-Annual Survey on Progress – The designated coordinator of the Local Hazard Mitigation Implementation Group will prepare and distribute a bi-annual survey in years two and four of the plan. The survey will be made available to all local implementation group members and any other interested local stakeholders. The survey will assist in determining any necessary changes or revisions to the plan that may be needed. In addition, it will help provide information on progress and accomplishments for implementation and any new hazards or problem areas that have been identified since the plan drafting.

The information collected through the survey will be used to formulate a report and/or addendum to the plan. It will be important to evaluate the status of measures accomplished and initiated towards meeting the plan's goals. Additionally, identifying areas that need to be updated in the next plan will need to be an ongoing process. The Hazard Mitigation Implementation Group, led by the designated coordinator, will have primary responsibility for tracking progress, evaluating, and updating the plan during the next five years and beyond.

Preparation for the Plan – FEMA's initial approval of this plan is valid for five years. During that time the Town will need to continue to track progress and identify additional or amended hazards and mitigation measures. By doing so, a plan, in order to maintain eligibility for FEMA mitigation grants, will be relatively easy since information will have been collected and updated throughout the five-year life of this plan. Given the lead time needed to secure funding and conduct the planning process, the Hazard Mitigation Implementation Group will begin drafting the full update of the plan in year four. The team will use the information from the year four biannual review, in addition to any other data and information collected, to identify the needs and priorities for the plan update. This will help the Town avoid a lapse in its approved plan status and grant eligibility when the current plan expires at the end of year five.

Potential sources of funding in the future may include FEMA Pre-Disaster Mitigation grants and the Hazard Mitigation Grant Program. Both grant programs are eligible to pay for 75% of a planning project, with a 25% local cost share requirement.

Update Preparation and Adoption – Once the resources have been secured to update the plan, the Hazard Mitigation Implementation Group will need to determine whether to undertake the update themselves or hire a consultant. If the Hazard Mitigation Implementation Group decides to update the plan themselves, the group will need to review the current FEMA hazard mitigation plan guidelines for any change in the requirements. The Wenham HMP-MVP Plan Update will be forwarded to MEMA and DCR for review and to FEMA for ultimate approval.

9.4 Integration of the Plans with Other Planning Initiatives

Upon approval of the 2019 Wenham HMP-MVP Plan by FEMA, the Core Committee will make the plan available to all interested parties and all departments with an implementation responsibility. The group will initiate a discussion with those various departments regarding how the plan can be integrated into their ongoing work. At a minimum, the plan will be reviewed and discussed with the following departments:

- Fire Department
- Emergency Management
- Police Department
- Public Works Department
- Planning
- Conservation Commission
- Board of Health
- Building

Coordination with large institutions, businesses, nonprofits, and environmental organizations will be required for successful implementation and continued updating. The adopted plan will be posted on the Town's website. Any sections of the plan containing sensitive information that would be considered inappropriate for public posting will be removed prior to posting. The posting of the plan on the Town's website will provide a mechanism for citizen feedback, such as an e-mail address for interested parties to send comments.

Appropriate sections of the HMP-MVP Plan will be integrated into other town plans, policies and documents as those are updated and renewed, including the Open Space and Recreation Plan, Comprehensive Emergency Management Plan, and Capital Investment Program.

10.0 LIST OF REFERENCES

Army Corps of Engineers (ACOE). 2019. Ice Jam Database. https://icejam.sec.usace.army.mil/ords/f?p=101:16.

Army Corps of Engineers (ACOE). 2018. "Longham Reservoir Dam." National Inventory of Dams. Accessed March 04, 2019. https://nid-test.sec.usace.army.mil/ords/f?p=105:113:1588526439400::NO:113,2:P113_RECORDID:30188.

Balch, Jennifer K., Bethany A. Bradley, John T. Abatzoglou, R. Chelsea Nagy, Emily J. Fusco, and Adam L. Mahood. 2017. "Human-started wildfires expand the fire niche across the United States." *Proceedings of the National Academy of Sciences of the United States of America (PNAS).* 114 (11) 2946-2951.

Blake, Eric S.; Landsea, Christopher W.; and Gibney, Ethan J. 2011. *The Deadliest, Costliest, and Most Intense United States Tropical Cyclones from 1851 to 2010 (and Other Frequently Requested Hurricane Facts.* NOAA Technical Memorandum NWS NHC-6. National Weather Service, National Hurricane Center. Accessed March 6, 2019. https://www.nhc.noaa.gov/pdf/nws-nhc-6.pdf.

Cardinali, M, P. Reichenback, R. Guzzetti, F. Ardizzone, G. Antonini, M. Galli, M. Cacciano, M. Castellani, P. Salvati. 2002. *A Geomorphological Approach to the Estimation of Landslide Hazards and Risks in Umbria, Central Italy*. European Geophysical Society. Natural Hazards and Earth System Sciences. 2: 57-72. https://www.nat-hazards-earth-syst-sci.net/2/57/2002/nhess-2-57-2002.pdf.

City of Boston. 2016. "Natural Hazard Mitigation Plan." MAPC, MEMA, DCR. Accessed February 28, 2019. https://www.cityofboston.gov/images_documents/Boston%20Revised%20Draft%20Hazard%20Mitigation%20Plan%202014%20Update%20%2003-31-15_tcm3-51167.pdf.

Coffin, Daniel. 2014. "Massachusetts Dam Inventory." Plum Island Research Project. Accessed February 28, 2019. http://www.plumislandresearch.org/media-library/human-interventions-at-plum-island/massachusetts-dam-inventory.

Coneco Engineers and Scientists, Inc. 2011. *Existing Drainage Analysis and Recommendations.*

Environment America Research and Policy Center. 2012. *When It Rains It Pours – Global Warming and the Increase in Extreme Precipitation.*

Epstein, David. 2016. "This Morning's Tornado in Concord, Explained." Boston.com. Accessed March 6, 2019. https://www.boston.com/weather/weather/2016/08/22/this-mornings-tornado-in-concord-explained.

Federal Emergency Management Agency (FEMA), 2014. Flood Insurance Study, Essex County Massachusetts, 2014.

Federal Emergency Management Agency (FEMA) and National Flood Insurance Program (NFIP). 2018a. Definitions: "Repetitive Loss Structure." https://www.fema.gov/national-flood-insurance-program/definitions#R.

Federal Emergency Management Agency (FEMA). 2018b. "Disasters." Webpage. Accessed November 26, 2018. www.fema.gov/disasters.

Federal Emergency Management Agency (FEMA). 2018c. "FEMA Flood Map Service Center: Welcome!" Flood Insurance Rate Map (FIRM). https://msc.fema.gov/portal/home.

Federal Emergency Management Agency (FEMA). 2018d. "Policy & Claim Statistics for Flood Insurance." Webpage. Accessed November 26, 2018. https://www.fema.gov/flood-insurance-statistics-current-month.

Federal Emergency Management Agency. 2018e. "National Flood Insurance Program Community Rating System: A Local Official's Guide to Saving Lives, Preventing Property Damage, and Reducing the Cost of Flood Insurance, FEMA B 573 / 2018 (https://www.fema.gov/media-library-data/1535126505943-439b296e7778b037d05f698f65c7891b/2018NFIP_CRS_Brochure_June_2018_508OK.pdf)

Federal Emergency Management Agency. 2018f. "Community Status Book Report – Massachusetts: Communities Participating in the National Flood Program (https://www.fema.gov/cis/MA.html).

Federal Emergency Management Agency (FEMA). 2017. "FEMA Hazard Mitigation Grant Program Dataset." Accessed March 27, 2019. Retrieved from fema.gov. https://www.fema.gov/media-library/assets/documents/28323. *

** FEMA and the Federal Government cannot vouch for the data or analyses derived from these data after the data have been retrieved from the Agency's website(s) and/or Data.gov.*

Federal Emergency Management Agency (FEMA). 2012 and 2014. Flood Insurance Rate Maps for Essex County, MA.

Federal Emergency Management Agency (FEMA). 2011 Local Mitigation Plan Review Guide.

Frumhoff, Peter C., James J. McCarthy, Jerry M. Melillo, Susanne C. Moser, Donald J. Wuebbles. 2007. Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions. Synthesis report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists (UCS). https://www.ucsusa.org/sites/default/files/legacy/assets/documents/global_warming/pdf/confronting-climate-change-in-the-u-s-northeast.pdf.

Horsley & Witten, Inc. 2003. "Ipswich River Watershed Action Plan." Accessed February 27, 2019. https://www.mass.gov/files/2017-07/Ipswich%20River%20Watershed%20Action%20Plan.pdf.

Ipswich River Watershed Association (IRWA). 2010. "Miles River Restoration Opportunities." Accessed February 27, 2019. http://ipswich-river.org/wp-content/uploads/2010/03/MilesRiver3.pdf.

Kafka, Alan L. 2004. "Why Does the Earth Quake in New England? The Science of Unexpected Earthquakes." Weston Observatory, Department of Geology and Geophysics, Boston College. Accessed March 04, 2019. http://aki.bc.edu/why_quakes.html.

Kleinfelder and Massachusetts Water Works Association (MWWA). 2017. "Ipswich Basin Water Management Act Final Report." Accessed February 27, 2019. https://lcwd.us/wp-content/uploads/sites/184/2018/11/Ipswich-River-Basin-Water-Management-Act-Final-Report-2017.pdf.

Kocin, Paul J. and Louis W. Uccellini. 2004. "A Snowfall Impact Scale Derived from Northeast Storm Snowfall Distributions." https://www.ncdc.noaa.gov/snow-and-ice/rsi/nesis.

Lipovich, Joe. 2016. *Concord Tornado Rips Through Power Lines, Leaves Over 1,000 Without Power.* Concord Patch. Accessed February 28, 2019. https://patch.com/massachusetts/concord/concord-tornado-rips-through-power-lines-leaves-over-1-000-without-power.

Louie, John N. 1996. "What is Richter Magnitude?" Nevada Seismological Laboratory. Accessed March 04, 2019. http://crack.seismo.unr.edu/ftp/pub/louie/class/100/magnitude.html.

Madsen, Travis and Nathan Willcox. 2012. *When It Rains It Pours – Global Warming and the Increase in Extreme Precipitation.* Environment America Research and Policy Center. https://environmentamerica.org/sites/environment/files/reports/When%20It%20Rains,%20It%20Pours%20vUS.pdf.

Massachusetts Department of Conservation and Recreation (DCR). 2018. Community Repetitive Loss: City of Wenham.

Massachusetts Department of Conservation and Recreation (DCR). 2017a. 302 CMR. Accessed March 6, 2019. https://www.mass.gov/files/documents/2017/10/30/302cmr10.pdf.

Massachusetts Department of Conservation and Recreation (DCR). 2017b. Recent Drought History. https://www.mass.gov/files/documents/2017/09/08/drought-status-history.pdf.

Massachusetts Emergency Management Agency (MEMA). 2019. "FEMA Public Assistance: Local, State, Tribal and Non-Profit." Accessed March 5, 2019. https://www.mass.gov/info-details/fema-public-assistance-local-state-tribal-and-non-profit#public-assistance-disaster-declarations-.

Massachusetts Emergency Management Agency (MEMA) and Department of Conservation and Recreation (DCR). 2013. *Commonwealth of Massachusetts State Hazard Mitigation Plan*.

Massachusetts Emergency Management Agency (MEMA) and Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA). 2018. *Massachusetts State Hazard Mitigation and Climate Adaptation Plan.*

Massachusetts Executive Office of Energy and Environmental Affairs (EEA) and the Massachusetts Emergency Management Agency (MEMA). 2013. Massachusetts Drought Management Plan. https://www.mass.gov/files/documents/2016/08/sj/droughtplan.pdf.

Massachusetts Executive Office of Energy and Environmental Affairs (EEA). 2011. Adaptation Advisory Committee. *Massachusetts Climate Change Adaptation Report*.

MA Geographic Information System. 2005. *McConnell Land Use Statistics*.

MA Office of Dam Safety. Inventory of Massachusetts Dams.

Metropolitan Area Planning Council. Geographic Information Systems Lab.

Metropolitan Area Planning Council. Regional Plans and Data.

Morrison, Sara. 2014. "Tornadoes of Massachusetts Past." Boston.com. Accessed March 6, 2019. https://www.boston.com/weather/untagged/2014/07/28/tornadoes-of-massachusetts-past.

National Oceanic and Atmospheric Administration (NOAA), National Weather Service. 2019a. Hail Awareness. https://www.weather.gov/cae/hail.html.

National Oceanic and Atmospheric Administration (NOAA). 2019b. National Weather Service Forecast Office: Boston, MA. "Annual Climate Report." Accessed March 04, 2019. https://w2.weather.gov/climate/index.php?wfo=box.

National Oceanic and Atmospheric Administration (NOAA). 2018a. National Centers for Environmental Information, Storm events database. https://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=25%2CMASSACHUSETTS.

National Oceanic and Atmospheric Administration (NOAA). 2018b. National Weather Service Forecast Office: Boston, MA. "Seasonal Climate Report." https://w2.weather.gov/climate/index.php?wfo=box.

Northeast States Emergency Consortium (NESEC). 2019a. "Earthquakes Hazards." Accessed March 04, 2019. http://nesec.org/earthquakes-hazards/.

Northeast States Emergency Consortium (NESEC). 2019b. "Hurricanes." Accessed February 28, 2019. http://nesec.org/hurricanes/.

Northeast States Emergency Consortium (NESEC). 2019c. "Massachusetts Earthquakes." Accessed March 04, 2019. http://nesec.org/massachusetts-earthquakes/.

Northeast States Emergency Consortium (NESEC). 2019d. "Tornadoes Hazards." Accessed February 28, 2019. http://nesec.org/tornadoes-hazards/.

Town of Wenham. Subdivision Rules and Regulations.

Town of Wenham. 2001 Open Space and Recreation Plan.

Town of Wenham. Stormwater Bylaw.

Town of Wenham. Zoning Bylaws.

United States Department of Housing and Urban Development (HUD). 2015. "Low and Moderate Income Summary Data by Local Governments, Based on 2011-2015 ACS." Accessed March 13, 2019. https://www.hudexchange.info/programs/acs-low-mod-summary-data/acs-low-mod-summary-data-local-government/.

United States Census Bureau. 2017. "Quick Facts: Wenham town, Massachusetts." Accessed February 27, 2019. https://www.census.gov/quickfacts/fact/table/wenhamtownessexcountymassachusetts,US/PST045217.

United States Census Bureau. 2013-2017. American Community Survey (ACS): 5-Year Estimates. Wenham, Massachusetts. American Fact Finder. https://www.census.gov/acs/www/data/data-tables-and-tools/data-profiles/2017/.

United States Geological Survey (USGS). 2019a. "Landslides 101." Accessed March 04, 2019. https://www.usgs.gov/natural-hazards/landslide-hazards/science/landslides-101?qt-science_center_objects=0#qt-science_center_objects.

United States Geological Survey (USGS). 2019b. "USGS 01101500 Ipswich River at South Middleton, MA." Accessed March 5, 2019. https://nwis.waterdata.usgs.gov/ma/nwis/uv/?cb_00060=on&cb_00065=on&format=gif_default&site_no=01101500&period=&begin_date=2010-03-06&end_date=2010-05-01.

United States Geological Survey (USGS). National Water Information Center. https://waterdata.usgs.gov/nwis.

Walsh, John, and Donald Wuebbles. 2014. *Climate Change Impacts in the United States: The Third National Climate Assessment.* Chapter 2: Our Changing Climate. U.S. Global Change Research Program. http://s3.amazonaws.com/nca2014/low/NCA3_Full_Report_02_Our_Changing_Climate_LowRes.pdf?download=1.

Wandle, William S. 1988-89. U.S. Geological Survey Water-Supply Paper 2375, p. 327-334. Accessed February 28, 2019. https://md.water.usgs.gov/publications/wsp-2375/ma/.

Weston Observatory, Boston College. 2019. “NESN Recent Earthquakes.” New England Seismic Network (NESN). Accessed March 04, 2019. http://aki.bc.edu/cgi-bin/NESN/recent_events.pl.

APPENDIX A

Core Committee Meetings

Town of Wenham
Municipal Vulnerability Preparedness and Hazard Mitigation Planning Grant Project
Core Team Meeting
Tuesday, December 4, 2018
9:30 am – 11:30 am

1. Introductions 5 minutes

2. Project Overview 10 minutes
   a. MVP & Hazard Mitigation Planning
      i. Municipal and stakeholder driven process
      ii. Workshop(s) to identify strengths and vulnerabilities
      iii. Matrix and report identifying MVP Key Actions/HMP Mitigation Strategies
   b. MVP Action Grants

3. Core Team Role 5 minutes
   a. Develop schedule
   b. Organize implementation of the Community Resilience Building Workshop
   c. Inform community priorities/Determine how decisions from Workshop will be used

4. Community Resilience Building Workshop/HMP Meetings 15 minutes
   a. Overview of climate projections
   b. Map of key resources/assets
   c. Discuss hazards and key features (infrastructure, society, environment)
   d. Prioritize MVP Key Actions/HMP Mitigation Strategies
   e. MVP Risk Matrix

5. Data Needs and Sources 10 minutes
   a. Interviews with municipal officials
   b. Applicable reports and materials
      i. Hazard Mitigation Plan 2012
      ii. Wenham Barriers Report, 2018
      iii. Wenham Street Tree Inventory and Management Plan, 2018
      iv. Community Exposure to Potential Climate-Driven Changes to Coastal-Inundation Hazards for Six Communities in Essex County, Massachusetts (USGS 2016)
      v. Ipswich Basin Water Management Act Planning Grant FY17 Final Report, 2017
      vi. Wenham Open Space and Recreation Plan, 2001
      vii. Emergency operation plans
      viii. What else?
   c. Critical assets and infrastructure

W&S Action Item: Review materials and incorporate into Workshop and Report(s)
Wenham Action Item: Identify and provide any additional resources

6. Workshop Participants
    a. Prepare list of workshop invitees, for example: 15 minutes
        i. Wenham Town Government (Town Administrator, Board of Selectmen, Planning, Public Works, Conservation, Health, Inspection Services, Fire, Police, Emergency Management Agency, and more)
        ii. State Government (MassDEP, State Representatives, State Senators, MAPC)
        iii. Federal Government (US Environmental Protection Agency, Army Corps of Engineers)
        iv. Institutions (Gordon College)
        v. Businesses (Chamber of Commerce, realtors, and more)
        vi. Neighborhood/Community/Environmental Groups (Ipswich River Watershed Association)
        vii. Neighboring Communities (Salem Beverly Water Board)
    b. Invitations and RSVPs
    c. Table Assignments

W&S Action Item: Draft invitation to stakeholders
Wenham Action Item: Finalize list of invitees; send invitation and track RSVPs, assign participants to tables

7. Workshop Schedule 10 minutes
    a. One 8-hour or two 4-hour meetings
    b. Weekday or weekend
    c. Day or evening

Wenham Action Item: Determine format and schedule of Workshop

8. Workshop Materials 30 minutes
    a. Draft Powerpoint
    b. Draft map for discussion at tables
    c. Other

W&S Action Item: Finalize Workshop materials based on Core Team input
Wenham Action Item: Help to fill mapping and Powerpoint gaps

9. Workshop Staffing 10 minutes
    a. Facilitators – Weston & Sampson
    b. Note-Takers – Town of Salisbury (Core Team)

W&S Action Item: Identify five table facilitators
Wenham Action Item: Identify five table note-takers

10. Wrap Up and Next Steps 10 minutes

Town of Wenham
Municipal Vulnerability Preparedness (MVP) and Hazard Mitigation Planning (HMP) Grant Project
Core Team Meeting Notes
Tuesday, December 4, 2018
9:30 am – 11:30 am

Attendance

Wenham
Peter Lombardi, Town Administrator
Margaret Hoffman, Planning
Jeffrey Baxter, Fire Department
Greg Bernard, Board of Health
Missy Berry, Conservation Commission and Open Space
Robert Breaker, Police Department – Emergency Management
Jackie Bresnahan, Permitting – Building and Board of Health
Stephen Kavanagh, Fire Department
Brian Leathe, Building
Erik Mansfield, Water
Vicky Masone, Energy Manager
James Politano, Facilities
Nicci Roebuck, Administration
Bill Tyack, Public Works

Weston & Sampson
Kathy Baskin, Project Manager

Discussion

MVP Program Overview (Kathy)

- Year 1: MVP Planning and Hazard Mitigation Planning
  - 70+ municipalities in 2017-2018
  - 80+ municipalities in 2018-2019
  - Municipal and stakeholder driven process
  - 8-hour Community Resiliency Building Workshop to identify strengths, vulnerabilities and strategies and relationship to HMP process
  - Development of Risk Matrix to identify MVP Key Actions/HMP Mitigation Strategies
- Year 2 and beyond: MVP Action Grant
  - Funding is available for implementation of Key Actions
  - MVP program ties into other funding programs; MVP certified communities receive extra points awarded on other EEA grant/loan applications

Core Team Role (Kathy)

- Core Team defines goals and develops schedule
- Organizes implementation of the Community Resilience Building Workshop, Listening Session, and HMP community and public meetings
- Determines how information and decisions from Workshop will be used
- Reviews recommendations and prioritizes Action Items

MVP Community Resilience Building Workshop/HMP Community Meetings

- Components of the Workshop are:
  - Provide an overview of climate projections
  - Use of large map depicting key resources, assets and infrastructure
  - Discussion of strengths and vulnerabilities
  - Prioritize MVP Key Actions/HMP Mitigation Strategies
  - Use of the Risk Matrix to organize ideas

Data Needs and Sources

- Reports and materials previously identified by Weston & Sampson:
  - Massachusetts Climate Change Projections (NECSC, 2018)
  - Community Exposure to Potential Climate-Driven Changes to Coastal-Inundation Hazards for Six Communities in Essex County, Massachusetts (USGS, 2016)
  - Massachusetts Climate Change Adaptation Report (MA EEA, 2011)
  - Town of Wenham Hazard Mitigation Plan (MAPC, 2012)
  - Wenham Aquatic Barrier Assessment Report (IRWA, 2018)
- Hold possible side meetings with staff that we need more input from

List of Workshop Attendees

- Margaret Hoffman is developed a preliminary list of invitees for the Workshop
- List will be screened and narrowed; Margaret will assign contact information to the invitees
- Question arose as to how to engage surrounding Towns/region and what impacts the negotiations around Emergency Dispatch will have.
- List State and Federal Agencies to invite:
  - DEP, DCR (Not sure if they have a stake in Wenham)
  - State Reps, Senators
  - Army Corp of Engineers, Ask State Rep to communicate invitations to them.
- Other suggestions included possibly inviting:
  - Miles River Collaborative – Not sure since not active in past 10 years? Hamilton, Ipswich, Beverly, Wenham
  - School nurse
  - Essex County Regional Emergency Communications Center (regional dispatch system for emergency response in Middleton)
  - Salem and Beverly Water Supply Board

Schedule

- An 8-hour one-day Workshop on a weekday from 9:00 am to 5:00 pm is preferable
- Tentatively set for Wednesday, January 9, 2019, with a back-up snow date of January 16, 2019.
- The meeting will be at the library.

Workshop Materials

- Kathy reviewed the general schedule of the workshop describing the sequence of events.
- Draft Powerpoint: The Core Team reviewed the draft workshop presentation which includes existing hazards, existing climate change, climate change projections, features that will be vulnerable or offer strength to the community under climate change, and types of actions that can be taken to alleviate impacts.
- Draft GIS Map for Discussion: The Core Team reviewed the large GIS map of the assets and vulnerabilities.

Workshop Staffing

- Weston & Sampson will provide five table facilitators for the Workshop
- The Town of Wenham will identify five table scribes/note-takers for Workshop

Wrap Up and Next Steps

- List of invitees to be finalized and invitations to be sent out for January 9 meeting.
- Send link to current HMP to all attendees
- Track everyone's hours to qualify for 120 staff hours.

Town of Wenham
Municipal Vulnerability Preparedness and Hazard Mitigation Planning Grant Project
Tuesday, December 4, 2018, 9:30 am – 11:30 am
Core Team Meeting Sign-In Sheet

Name	Affiliation	Email Address
Jeffrey Baxter	Wenham FIRE	Jbaxter@wenhamma.gov
STEPHEN B. KAVANAGH	WENHAM FIRE	SKavanagh4@WENHAMMA.GOV
Margaret Hoffman	Wenham Planning	mhoffman@wenhamma.gov
Nicci Roebuck	Administration	nroebuck@wenhamma.gov
Jackie Bresnahan	Permitting - Bldg + BOH	jbresnahan@wenhamma.gov
Robert Breaker	Wenham P.D. E.M	rbreaker@wenhamma.gov

Town of Wenham
Municipal Vulnerability Preparedness and Hazard Mitigation Planning Grant Project
Tuesday, December 4, 2018, 9:30 am – 11:30 am
Core Team Meeting Sign-In Sheet

Name	Affiliation	Email Address
Erik MANSFIELD	WATER	emansfield@wenhamma.gov
Peter Lombardi	TA	plombardi@wenhamma.gov
Missy Berry	Concom/Open Space	mberry@wenhamma.gov
James Poltano	Facilities	JPoltano@wenhamma.gov
Vicky masone	Energy manager	Vmasone@hamiltonma.gov
Bill Tyack	DPW	btyack@wenhamma.gov
BRIAN Leathe	Building off.	BLeathe@wenhamma.gov
Greg Bernard	BOH	gbernard@wenhamma.gov

Town of Wenham
Municipal Vulnerability Preparedness and Hazard Mitigation Planning Grant Project
Core Team Meeting
Thursday, February 7, 2019
10:00 am – 12:00 pm

1. Introductions — 5 minutes

2. Draft MVP/HMP Priority Actions — 20 minutes
   a. Missing Actions
   b. Order of Priority
   c. Redundancies

3. Review/Update Hazards & Critical Infrastructure of 2012 Hazard Mitigation Plan) — 45 minutes
   a. Confirm Local Areas of Flooding
   b. Identify/Confirm Critical Infrastructure
   c. Identify Future Development in Hazard Areas

4. Review/Update Mitigation Measures of 2012 Hazard Mitigation Plan — 45 minutes
   a. Review Existing Mitigation Measures
   b. Review Previous Potential Mitigation Measures
   c. Update Potential Mitigation Measures

5. Wrap Up and Next Steps — 5 minutes

Town of Wenham
Municipal Vulnerability Preparedness (MVP) and Hazard Mitigation Planning (HMP) Grant Project
Core Team Meeting Notes
Thursday, February 7, 2019
10:00 am – 12:00 pm

Attendance

Wenham
Margaret Hoffman, Planning
Melissa Berry, Conservation
Robert Breaker, Police Department – Emergency Management
Jackie Bresnahan, Permitting – Building and Board of Health
Erik Mansfield, Water
Nicci Roebuck, Administration
Bill Tyack, Public Works

Weston & Sampson
Kathy Baskin, Project Manager

Discussion

Review Draft Priority Actions from the Community Resilience Building Workshop

- The Team reviewed a draft list of the Draft MVP Report's recommended MVP Actions/Hazard Mitigation Strategies, which were developed during the January 9, 2019 Workshop, considering order of priority, redundancies, and missing Actions/Strategies.
- The Team proposed revisions to the language, fine-tuning the language to combine redundant Actions and to ensure that the Actions represented the intent of the Town and Workshop participants.
- Actions were reorganized slightly, to differentiate between High Priority, Medium Priority and Other Actions.
- Erik Mansfield will review the text related to water supply recommendations to ensure they are technically correct and reflect the department's status and needs.
- Weston & Sampson will make the suggested changes and send the revision to Margaret Hoffman for distribution.

Review/Update Hazards, Critical Infrastructure, and Mitigation Measures of 2012 Hazard Mitigation Plan

- Weston & Sampson has compiled sections of the 2012 Hazard Mitigation Plan related to hazards, critical infrastructure, current mitigation measures, and potential mitigation measures. These sections need to be updated by the Town.
- Weston & Sampson engineer Tim Deguglielmo has annotated the sections with his knowledge of the current status of these sections of the HMP needing to be updated.
- The Team offered updates to Table 5 – Relationship of Critical Infrastructure to Hazard Areas. Margaret Hoffman noted that the table's columns are out of alignment with the most right-hand column.
- The Team reviewed the previous Potential Mitigation Measures, offering updates to those related to emergency management, conservation, and community preservation.

Next Steps

- The Team will need to continue reviewing sections of the 2012 Hazard Mitigation Plan related to hazards, critical infrastructure, current mitigation measures, and potential mitigation measures. It will need to confirm local areas of flooding, identify/confirm critical infrastructure, identify future development in hazard areas, review existing mitigation measures, review previously identified potential mitigation measures, and identify new potential mitigation measures.
- Kathy Baskin set up follow-up meetings with Bill Tyack of DPW and Margaret Hoffman of Planning to continue reviewing these items.
- A Listening Session, at which the general public will have an opportunity to comment on the draft Hazard Mitigation/MVP Plan, is scheduled for Thursday, March 21, 2019 at 7:00 pm in the Selectmen's Meeting Room on the first floor of Town Hall. The meeting will be recorded for viewing on the local cable channel.

Town of Wenham
Municipal Vulnerability Preparedness and Hazard Mitigation Planning Grant Project
Thursday, February 7, 2019, 10:00 am – 12:00 pm
Core Team Meeting Sign-In Sheet

Name	Affiliation	Email Address
Jackie Bresnahan	Bldg / BOH	jbresnahan@wenhamma.gov
Missy Berry	ConCom / Open Space	mberry@wenhamma.gov
Margaret Hoffman	Planning / Zoning	mhoffman@wenhamma.gov
Bob Brenker	E.M.	rbrenker@wenhamma.gov
Erik Mansfield	WATER DEPT.	emansfield@wenhamma.gov
Bill Tyack	DPW	btyack@wenhamma.gov
Nicci Roebuck	Admin	nroebuck@wenhamma.gov
Kathy Baskin	Weston + Sampson	baskink@wseinc.com

Town of Wenham
Municipal Vulnerability Preparedness and Hazard Mitigation Planning Grant Project
Core Team Meeting
Tuesday, April 9, 2019
10:00 am – 12:00 pm

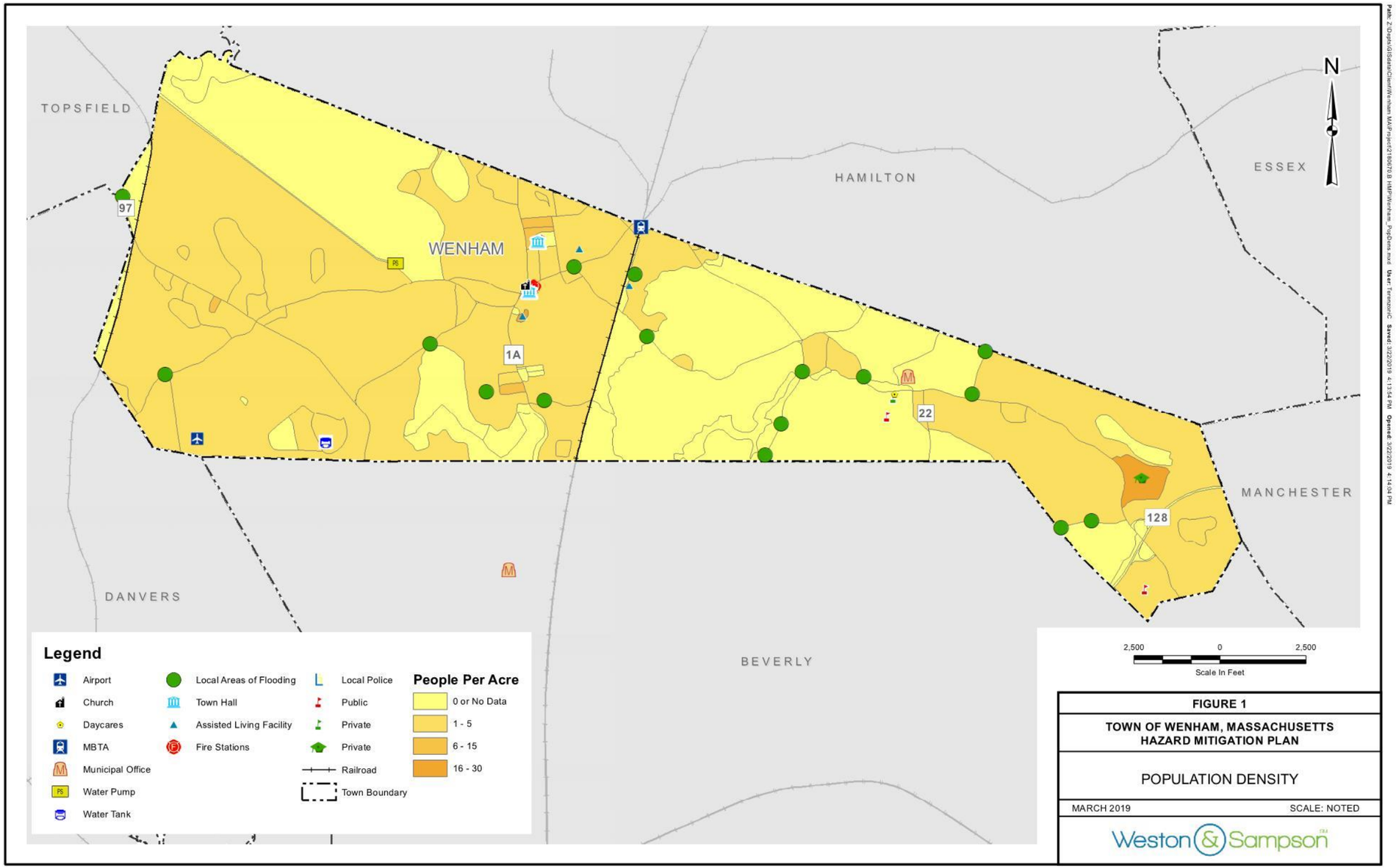
1.	Introductions	5 minutes
2.	Endorsement of Mitigation Goals	15 minutes
3.	Proposed Mitigation Strategies	45 minutes
4.	Gaps Between Workshop Recommended Actions and Proposed Strategies	20 minutes
5.	Recent and Future Development Lists	15 minutes
6.	Establish Implementation Committee	15 minutes
7.	Wrap Up and Next Steps	5 minutes

Town of Wenham
Municipal Vulnerability Preparedness and Hazard Mitigation Planning Grant Project
Tuesday, April 9, 2019, 10:00 am – 12:00 pm
Core Team Meeting Sign-In Sheet

Name	Affiliation	Email Address
Margaret Hoffman	Planning Board	mhoffman@wenhamma.gov
Bill Tyack	DPW	bTyack@wenhamma.gov
Erik Mansfield	WATER	emansfield@wenhamma.gov
Jacqueline Bresnahan	Permitting / BOH / Bldg	jbresnahan@wenhamma.gov
Amanda Kohn	W+S	Kohn.Amanda@wsinc.com
Nicci Roebuck	Administration	nroebuck@wenhamma.gov
Robert Braker	E.M. Police	rbreaker@wenhamma.gov

APPENDIX B

Hazard Maps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Daycares
MBTA
Municipal Office
Water Pump
Water Tank
Local Areas of Flooding
Town Hall
Assisted Living Facility
Fire Stations
Local Police
Public
Private
Private
Railroad
Town Boundary
People Per Acre
0 or No Data
1 - 5
6 - 15
16 - 30
2,500 0 2,500
Scale In Feet
FIGURE 1
TOWN OF WENHAM, MASSACHUSETTS
HAZARD MITIGATION PLAN
POPULATION DENSITY
MARCH 2019
SCALE: NOTED
Weston & Sampson
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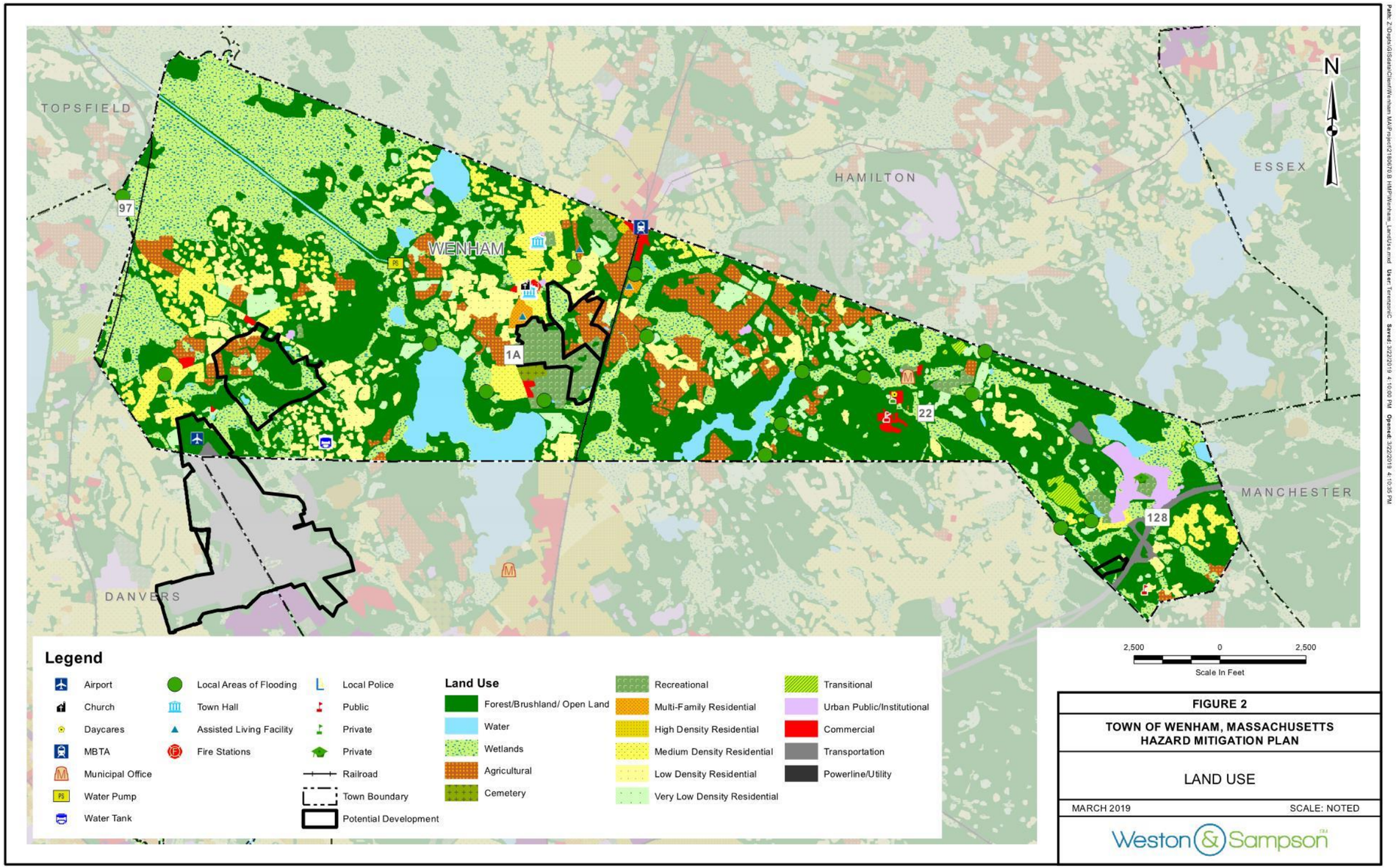
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MBTA
Municipal Office
Water Pump
Water Tank
Local Areas of Flooding
Town Hall
Assisted Living Facility
Fire Stations
Local Police
Public
Private
Private
Railroad
Town Boundary
Potential Development
Land Use
Forest/Brushland/ Open Land
Water
Wetlands
Agricultural
Cemetery
Recreational
Multi-Family Residential
High Density Residential
Medium Density Residential
Low Density Residential
Very Low Density Residential
Transitional
Urban Public/Institutional
Commercial
Transportation
Powerline/Utility
2,500
0
2,500
Scale In Feet
FIGURE 2
TOWN OF WENHAM, MASSACHUSETTS
HAZARD MITIGATION PLAN
LAND USE
MARCH 2019
SCALE: NOTED
Weston & Sampson
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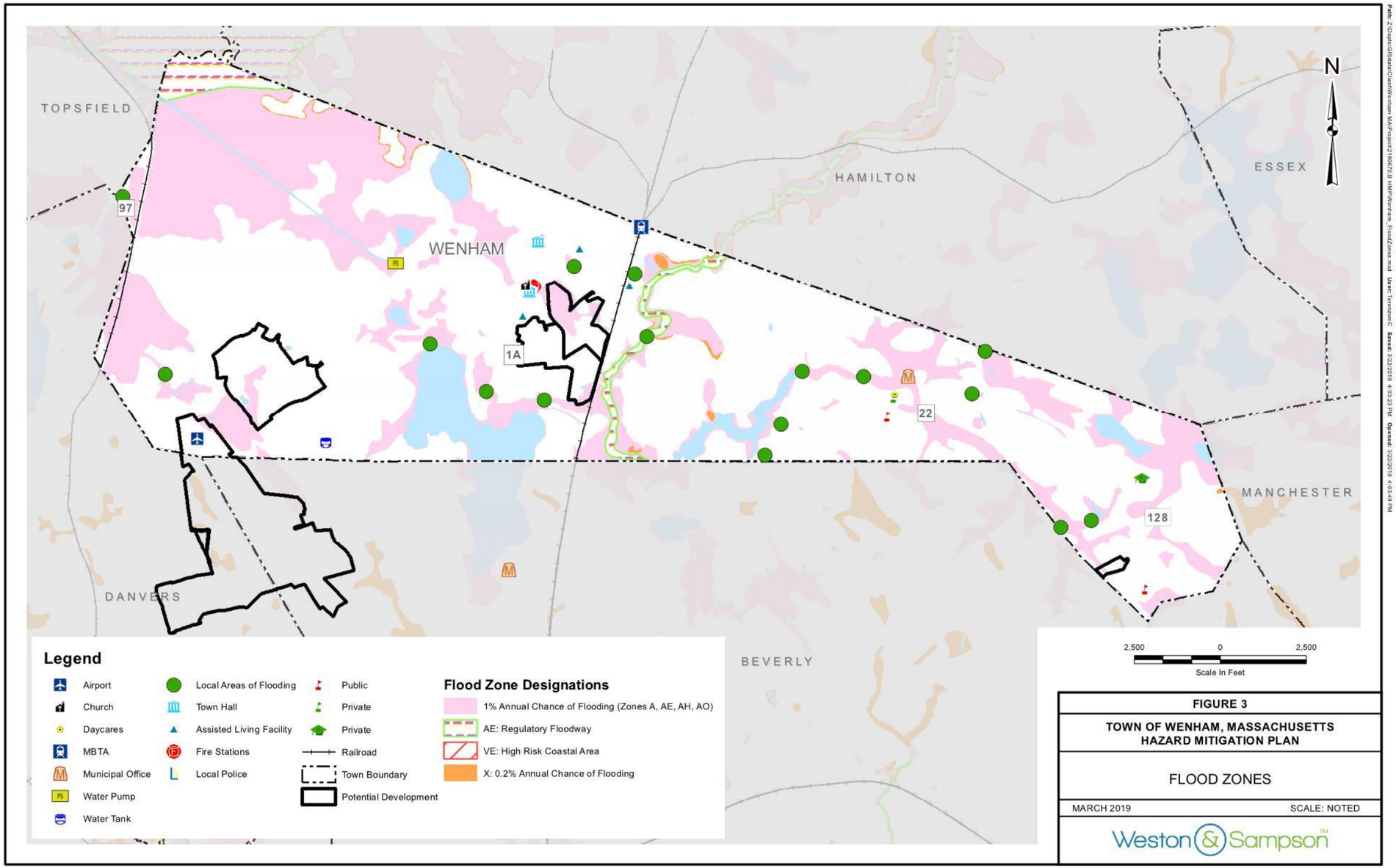
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Daycares
MBTA
Municipal Office
Water Pump
Water Tank
Local Areas of Flooding
Town Hall
Assisted Living Facility
Fire Stations
Local Police
Public
Private
Private
Railroad
Town Boundary
Potential Development
Flood Zone Designations
1% Annual Chance of Flooding (Zones A, AE, AH, AO)
AE: Regulatory Floodway
VE: High Risk Coastal Area
X: 0.2% Annual Chance of Flooding
2,500
0
2,500
Scale In Feet
FIGURE 3
TOWN OF WENHAM, MASSACHUSETTS
HAZARD MITIGATION PLAN
FLOOD ZONES
MARCH 2019
SCALE: NOTED
Weston & Sampson
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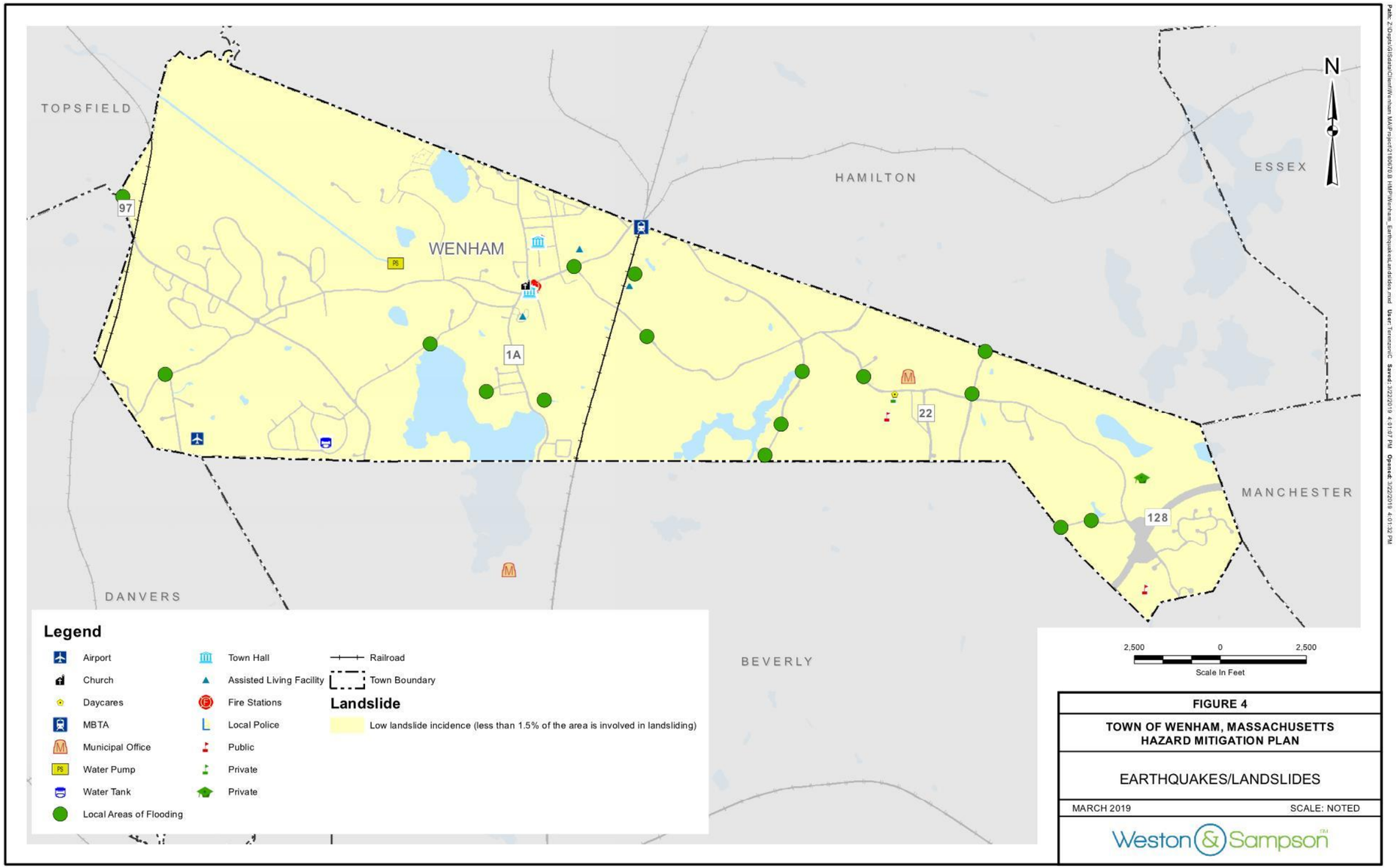
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Church
Daycares
MBTA
Municipal Office
Water Pump
Water Tank
Local Areas of Flooding
Town Hall
Assisted Living Facility
Fire Stations
Local Police
Public
Private
Private
Railroad
Town Boundary
Landslide
Low landslide incidence (less than 1.5% of the area is involved in landsliding)
2,500 0 2,500
Scale In Feet
FIGURE 4
TOWN OF WENHAM, MASSACHUSETTS
HAZARD MITIGATION PLAN
EARTHQUAKES/LANDSLIDES
MARCH 2019
SCALE: NOTED
Weston & Sampson
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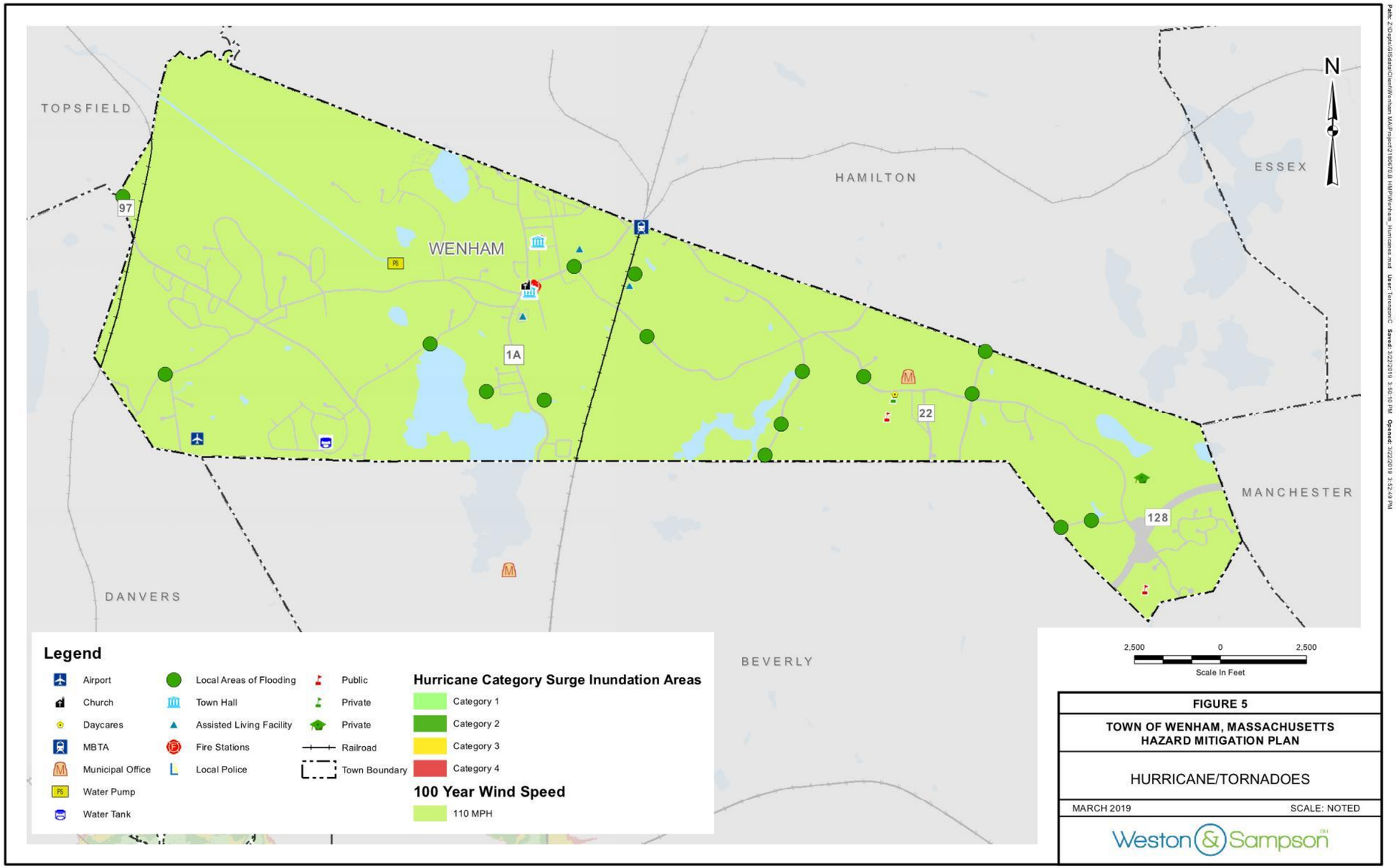
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Church
Daycares
MBTA
Municipal Office
Water Pump
Water Tank
Local Areas of Flooding
Town Hall
Assisted Living Facility
Fire Stations
Local Police
Public
Private
Private
Railroad
Town Boundary
Hurricane Category Surge Inundation Areas
Category 1
Category 2
Category 3
Category 4
100 Year Wind Speed
110 MPH
2,500
0
2,500
Scale In Feet
FIGURE 5
TOWN OF WENHAM, MASSACHUSETTS
HAZARD MITIGATION PLAN
HURRICANE/TORNADOES
MARCH 2019
SCALE: NOTED
Weston & Sampson
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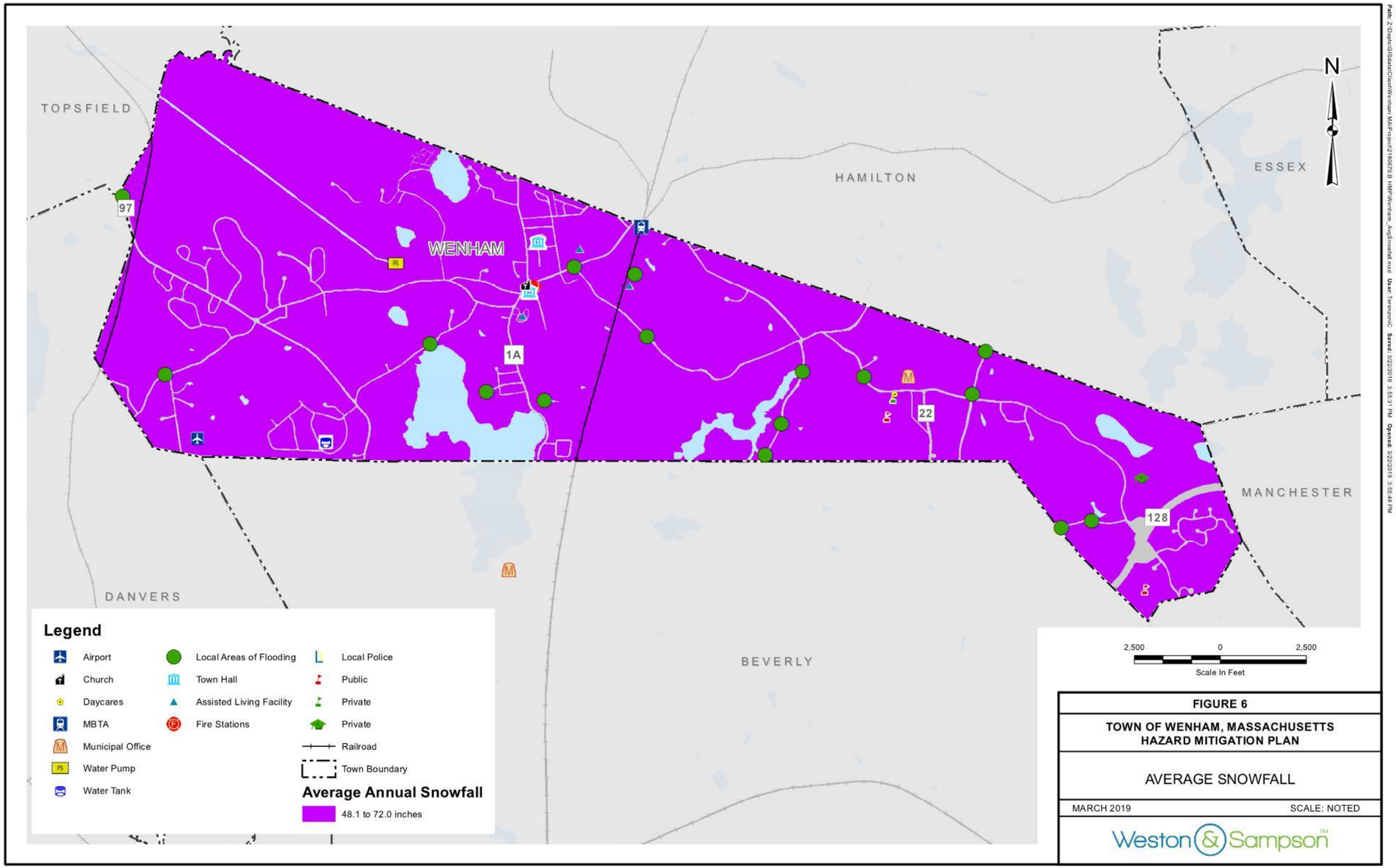
TOPSFIELD
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ESSEX
MANCHESTER
DANVERS
BEVERLY
WENHAM
97
1A
22
128
N
Legend
Airport
Church
Daycares
MBTA
Municipal Office
Water Pump
Water Tank
Local Areas of Flooding
Town Hall
Assisted Living Facility
Fire Stations
Local Police
Public
Private
Private
Railroad
Town Boundary
Average Annual Snowfall
48.1 to 72.0 inches
2,500 0 2,500
Scale In Feet
FIGURE 6
TOWN OF WENHAM, MASSACHUSETTS
HAZARD MITIGATION PLAN
AVERAGE SNOWFALL
MARCH 2019
SCALE: NOTED
Weston & Sampson
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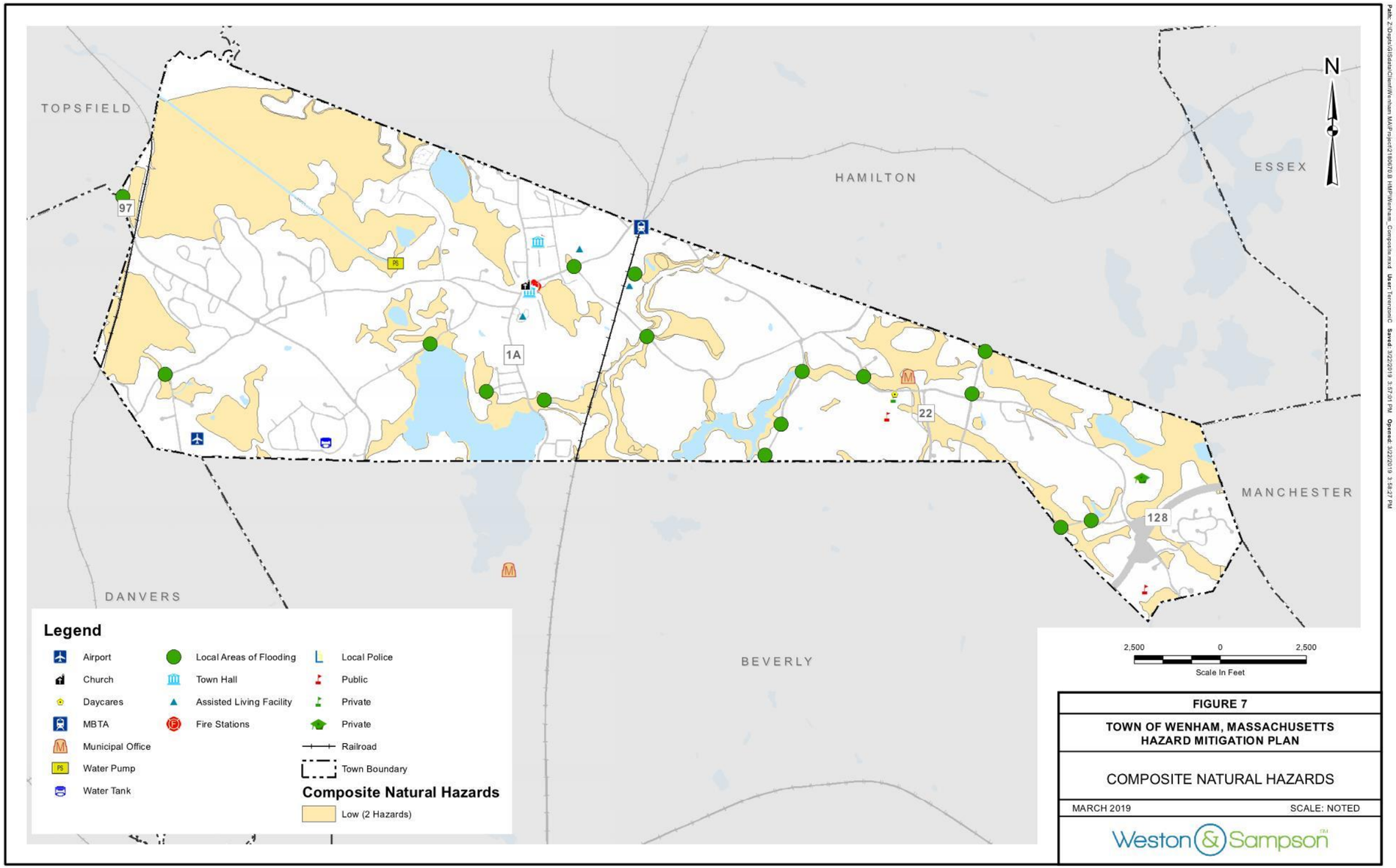
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Daycares
MBTA
Municipal Office
Water Pump
Water Tank
Local Areas of Flooding
Town Hall
Assisted Living Facility
Fire Stations
Local Police
Public
Private
Private
Railroad
Town Boundary
Composite Natural Hazards
Low (2 Hazards)
2,500 0 2,500
Scale In Feet
FIGURE 7
TOWN OF WENHAM, MASSACHUSETTS
HAZARD MITIGATION PLAN
COMPOSITE NATURAL HAZARDS
MARCH 2019
SCALE: NOTED
Weston & Sampson
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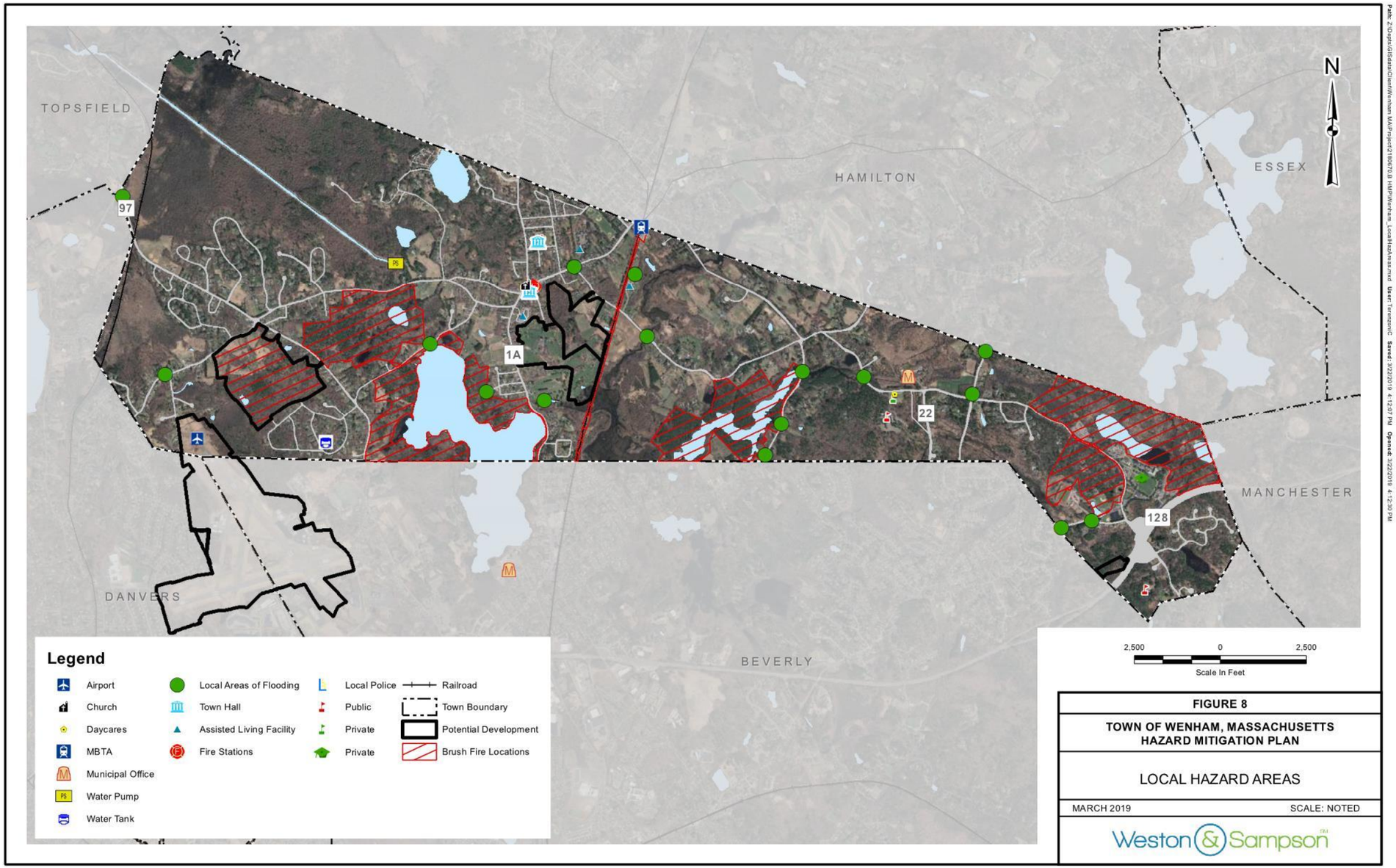
TOPSFIELD
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MANCHESTER
DANVERS
BEVERLY
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Airport
Church
Daycares
MBTA
Municipal Office
Water Pump
Water Tank
Local Areas of Flooding
Town Hall
Assisted Living Facility
Fire Stations
Local Police
Public
Private
Private
Railroad
Town Boundary
Potential Development
Brush Fire Locations
2,500
0
2,500
Scale In Feet
FIGURE 8
TOWN OF WENHAM, MASSACHUSETTS
HAZARD MITIGATION PLAN
LOCAL HAZARD AREAS
MARCH 2019
SCALE: NOTED
Weston & Sampson
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APPENDIX C

Documentation of Public Participation

Town of Wenham
Municipal Vulnerability Preparedness Planning Project
Hazard Mitigation Planning (HMP) Stakeholder Meeting &
Municipal Vulnerability Preparedness (MVP) Workshop
Hamilton Wenham Library, 14 Union Street, South Hamilton, MA
Wednesday, January 9, 2019
9:00 am – 5:00 pm

9:00 am – 9:30 am	Registration and Refreshments
9:30 am – 9:45 am	Welcome and Introductions • Peter Lombardi, Town Administrator • Margaret Hoffman, Planning Coordinator • Core Team Members • Weston & Sampson Team • Participant Introductions
9:45 am – 9:55 am	MVP / HMP Workshop Purpose and Overview • MVP Program Background • Purpose, Desired Outcomes, Objectives, Expectations • Review Agenda • Logistics
9:55 am – 10:30 am	Data Resources and Overview of Science • Hazards • Existing Climate Change • Projected Climate Change • Recent Planning Efforts • Overview of Data and Maps Being Used During Workshop
10:30 am – 10:45 am	BREAK
10:45 am – 11:10 am	Large Group Exercise #1 • Identify Major Hazards in Community • Prioritize Top Four Hazards

11:10 am – 11:25 am	Risk Matrix
	• Hazards
	• Features
	  • Infrastructure, Societal, Environmental
	  • Vulnerability or Strength
	  • Location
	  • Ownership
	• Actions

Town of Wenham
Municipal Vulnerability Preparedness Planning Project
Hazard Mitigation Planning (HMP) Stakeholder Meeting &
Municipal Vulnerability Preparedness (MVP) Workshop
Hamilton Wenham Library, 14 Union Street, South Hamilton, MA
Wednesday, January 9, 2019
9:00 am – 5:00 pm

11:25 am – 11:45 am	Small Group Exercise #1 • Infrastructure and Buildings Features • Vulnerability or Strength, Location, Ownership
11:45 am – 12:05 pm	Small Group Exercise #2 • Societal Features • Vulnerability or Strength, Location, Ownership
12:05 pm – 12:25 pm	Small Group Exercise #3 • Environmental Features • Vulnerability or Strength, Location, Ownership
12:25 pm – 1:30 pm	LUNCH
1:30 pm – 2:00 pm	HMP Mitigation Strategies/MVP Community Actions • Infrastructure • Nature-Based Solutions
2:00 pm – 2:15 pm	BREAK
2:15 pm – 3:05 pm	Small Group Exercise #4 • Define HMP Mitigation Strategies/MVP Community Actions
3:05 pm – 4:05 pm	Large Group Exercise #2 • Identify High Priority HMP Strategies/MVP Priority Actions
4:05 pm – 5:00 pm	Wrap-up and Closing Remarks

welcome

1

Community Resilience Building/ Hazard Mitigation Planning Workshop

Wenham, Massachusetts

2

Welcome & Introductions

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Wenham Introductions

Municipal Leadership

- Peter Lombardi, Town Administrator
- Margaret Hoffman, Planning Coordinator
- Core Team Members
  - Jeffrey Baxter, Fire Department
  - Greg Bernard, Board of Health
  - Missy Berry, Conservation Commission and Open Space
  - Robert Breaker, Police Department – Emergency Management
  - Jackie Bresnahan, Permitting – Building and Board of Health
  - Stephen Kavanagh, Fire Department
  - Brian Leathe, Building
  - Erik Mansfield, Water
  - Vicky Masone, Energy Manager
  - James Politano, Facilities
  - Nicci Roebuck, Administration
  - Bill Tyack, Public Works

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Weston & Sampson Introductions

Assisting with the Workshop

- Kathy Baskin, Project Manager/Facilitator
- Jim Riordan, Table Facilitator/Presenter
- Table Facilitators
  - Adria Boynton
  - Jill Getchell
  - Lydia Kifner
  - Deanna Lambert

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Participant Introductions

- Your name
- Relationship to Wenham
- Why you are here today

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Workshop Outline

Workshop-Wide
- Overview of Science & Data Resources
- Characterize Hazards

BREAK

Individual Tables
- Identify Community Features
  - Infrastructure and Buildings
  - Societal
  - Environmental

Post-Workshop
- Combine Ideas
- Prepare Report

LUNCH

Individual Tables
- Identify and Prioritize Actions

BREAK

Workshop-Wide
- Determine Overall Priority Actions

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Municipal Vulnerability Preparedness (MVP)	Hazard Mitigation Planning (HMP)
MA State Government (EEA) program: • Helps municipalities plan for climate change resiliency and implement priority projects	Federal Government (FEMA) program: • Helps municipalities reduce loss of life and property by lessening the impact of natural disasters through a long-term mitigation plan
Communities: • Define extreme weather hazards and climate change impacts • Identify key features • Determine vulnerabilities and strengths • Complete vulnerability assessments • Develop/prioritize actions • Implement key actions	Communities: • Define natural hazards (hurricanes, tornadoes, winter storms and earthquakes) • Identify key features • Determine vulnerabilities and strengths • Complete vulnerability assessments • Develop/prioritize mitigation strategies • Implement mitigation strategies

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What the MVP/HMP Program Offers

- Improved **resilience and preparedness** of natural and climate-driven hazards
- **Collaboration with stakeholders** about climate change, natural hazards and impact
- **Increased education, planning, and implementation** of priority actions/mitigation strategies

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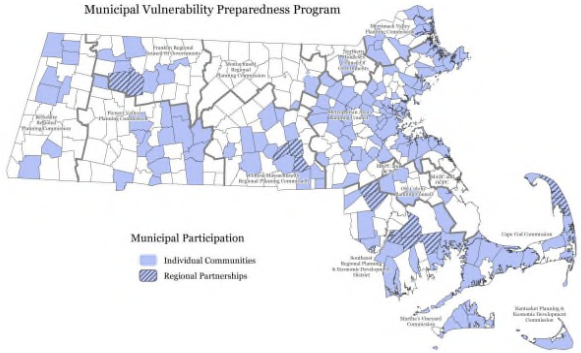
MVP: Eligible Communities

Complete MVP program; become certified; apply for MVP Action grant funding



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Data Resources & Overview of Science

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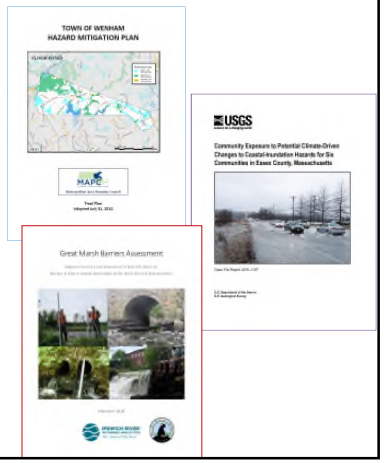
Data Resources

Lots of great work has already taken place recently!

- Massachusetts Climate Change Projections (NECSC, 2018)
- Community Exposure to Potential Climate-Driven Changes to Coastal-Inundation Hazards for Six Communities in Essex County, Massachusetts (USGS, 2016)
- Massachusetts Climate Change Adaptation Report (MA EEA, 2011)
- Town of Wenham Hazard Mitigation Plan (MAPC, 2012)
- Great Marsh Barriers Assessment (Wenham Aquatic Barrier Assessment Report) (IRWA & NWF, 2018)



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Wenham's Land Use

- Forest (51.5%)
- Wetlands (4.6%)
- Residential (11.4%)
- Commercial/Industrial (1.0%)
- Agricultural (8.3%)
- Transportation (1.1%)
- Other (15.3%)

Wenham Lake

(source: landvest.com)

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Major Natural Hazards in Wenham

Current and Future under Climate Change

Heavy Precipitation/Flooding

Severe Winter/Nor'easter

Other Severe Weather (i.e. Wind)

Hurricane

Erosion

Dam Failure

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More Major Natural Hazards

Current and Future under Climate Change

Rising Temperature/ Extreme Heat

Drought

Wildfires/Brush Fires

Landslides

Tornadoes

Earthquakes

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Heavy Precipitation

Riverine and Stormwater Flooding

- Merrimack Valley region's most frequent and costly natural disaster
- Affects infrastructure, property damage, natural resources

(https://patch.com/massachusetts/hamilton-wenham/towns-dodge-major-flood-related-problems)

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HMP 2012: Flooding Damage

Source: Town of Wenham Hazard

Table 8: Estimated Damages from Flooding				
ID	Flood Hazard Area	Replacement Value	Low Estimate of Damages	High Estimate of Damages
1	Essex Street Culvert	$1,374,044	$137,404	$687,022
2	Route 97 - beaver dams block railroad	3,091,599	309,758	1,547,799
3	Mill River at Hull Street	1,717,515	171,752	858,757
4	Mill River at Grapevine Road	1,030,533	103,053	515,267
5A	Dam at Myopia Club	1,030,533	103,053	515,267
5B	Walnut Street flooding from Myopia Club dam	1,030,533	103,053	515,267
5C	Larch Row flooding from Myopia Club dam	1,030,533	103,053	515,267
6	Grapevine Road culvert	687,022	68,702	343,511
7	Dodge's Row culvert	687,022	68,702	343,511
8	Lake Avenue homes	1,717,555	171,752	858,757
9	Cedar Street culvert	1,374,044	137,404	687,022

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HMP 2012: Flooding Damage (cont.)

Table 8: Estimated Damages from Flooding				
ID	Flood Hazard Area	Replacement Value	Low Estimate of Damages	High Estimate of Damages
10	Lakeview Golf Course	1,717,555	171,752	858,757
11	Burnham Road at Route 97	687,022	68,702	343,511
12	Culvert at 44 Grapevine Road	687,022	103,053	343,511
13	Larch Lane	1,030,533	103,053	515,267
14	Upper Larch Row and Main Street	1,374,044	137,404	687,022
15	Burley Street at Maple Street	1,717,555	171,752	858,757
16	Longham Reservoir Dam	2,748,088	274,809	1,374,044
17	Tea House Dam	1,030,533	103,053	515,267
18	Beverly/Salem Water Pump House	687,022	68,702	343,511
	Totals	$25,419,814	$2,541,981	$12,709,907

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Severe Winter/Nor'easter

- Past few decades: more rain in winter
- Example: serious damage caused by Dec 2008 ice storm
- Projected: more rainy and icy winters

(Source: https://patch.com/massachusetts/beverly/how-much-snow-can-my-roof-handle-0)

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Other Severe Weather (i.e. Wind)

- NWS Wind Advisory:
  - 31 to 39 mph for at least one hour
  - Any wind speed between 46 to 57 mph
- NWS High Wind Warning:
  - 58 mph or higher

Impacts: town resources, infrastructure, trees, private and public property

(Source: WGNS Radio)

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Hurricanes

Btw 1858-2000:
15 hurricanes hit Massachusetts

9 were Category 1,
5 were Category 2,
1 was Category 3

2012 HMP: Estimated Damages from using HAZUS Software

	Category 2	Category 4[1]
Building Characteristics		
Estimated total number of buildings	1,179	1,179
Estimated total building replacement value (Year 2002 $) (Millions of Dollars)	$405	$405
Building Damages		
# of buildings sustaining minor damage	1	110
# of buildings sustaining moderate damage	0	13
# of buildings sustaining severe damage	0	0
# of buildings destroyed	0	0
Population Needs		
# of households displaced	0	1
# of people seeking public shelter	0	0
Debris		
Building debris generated (tons)	0	3,188
Tree debris generated (tons)	0	2,837
# of truckloads to clear building debris	0	14
Value of Damages (Thousands of dollars)		
Total property damage	0	$2,548.10
Total losses due to business interruption	$.03	$254.19

[1]No Category 4 or 5 hurricanes have been recorded in New England. However, a Category 4 hurricane was included to help the communities understand the impacts of a hurricane beyond what has historically occurred in New England.

(Source: Wenham Hazard Mitigation Plan, 2012)

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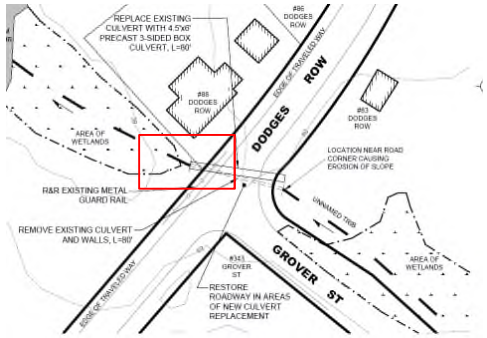
Erosion

- Caused by riverine flow & stormwater
- Increased precipitation, including winter rains, could increase erosion
- Drier soils will reduce resistance to erosion



(Source: MA Climate Change Adaptation Report, 2011)

(Source: Wenham Barriers Report, 2018)

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Dam Failure

Dams fail from:
- Structural problems independent of storm event (i.e. earthquake)
- Storm-related flooding (overspill)

Released water and energy of the water can cause loss of life and property damage downstream

3 dams (all privately owned and in good condition):
- Myopia Club Dam
- Longham Reservoir Dam
- Tea House Dam

Wenham Lake impounded by Longham Reservoir Dam

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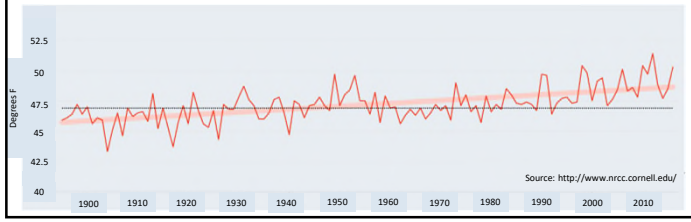
Rising Temperature/Extreme Heat

- Extreme heat can stress:
  - Vulnerable populations: over 65 years, infants, low income, language barriers
  - General population: Highest risk inland and in urban areas
  - Infrastructure: utility failure, materials stress
- Rising Temperatures can stress:
  - Individual species, ecosystems



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Drought

- Higher risk of drought in summer and fall
- Projected impacts to:
  - Water supply
  - Rivers, streams, wetlands
  - Vegetation and crops

(Source: The Daily News)

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Wildfires and Brush Fires

- 2007-2012: ~ 10 brush fires/year
- Areas with frequent brushfires:
  - Wenham Lake and Longham Reservoir areas
  - MA Audubon Cedar Pond Wildlife Sanctuary
  - MBTA commuter rail Right of Way
  - Streeter Property
  - Property of Gordon College
- Most did not cause significant property damage
- No deaths

(Source: Wenham Hazard Mitigation Plan 2012

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Geologic Related Hazards

- Types include: earthquakes, landslides, sinkholes, subsidence and unstable soil
- New England experiences an average of five earthquakes per year
- No recorded earthquake epicenters within Wenham
- Much of the development in the town predates the most recent building code that includes seismic standards
- Entire town is classified of low risk of landslides, sinkholes and subsidence

The Great New England Earthquake 1663

(Source: http://www.newenglandhistoricalsociety.com/the-great-new-england-earthquake-1663/)

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HMP 2012: Estimated Damages from Earthquakes

- Estimations developed using HAZUS-MH software
- Minimal data available
- 2 earthquakes were selected in Massachusetts history: a 1963 earthquake with a magnitude of 5.0 and an earthquake with a magnitude of 7.0.

	Magnitude 5.0	Magnitude 7.0
Building Characteristics		
Estimated total number of buildings	1179	1179
Estimated total building replacement value (Year 2002 $)(Millions of dollars)	$405	$405
Building Damages		
# of buildings sustaining slight damage	60	387
# of buildings sustaining moderate damage	12	399
# of buildings sustaining extensive damage	1	141
# of buildings completely damaged	0	45
Population Needs		
# of households displaced	1	101
# of people seeking public shelter	0	20
Debris		
Building debris generated (tons)	Not available	Not available
# of truckloads to clear building debris		
Value of Damages (Millions of dollars)		
Total property damage	$8.68	$103.30
Total losses due to business interruption	$0.26	$11.18

(Source: Wenham Hazard Mitigation Plan, 2012)

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Tornadoes

- Low frequency in Wenham
- On average (1950–2008), more than 2 per year in MA
- Weak tornadoes occur in all areas of New England
- Strongest tornadoes occur just east of the Berkshires

Hamilton, Wenham Under Tornado Watch Until 11 p.m.
The highest risk for this round of severe weather is between now and 9 p.m. with favorable conditions to spawn tornadoes until 11 p.m.
By Brooklyn Lowery, Patch Staff | Jun 23, 2015 11:23 am ET | Updated Jun 23, 2015 4:26 pm ET

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Existing Climate Change

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Increased Temperatures in Northeast

- Warmer annual temperatures - up 2°F since 1970
- Warmer winters - up 1.3°F per decade since 1970
- Decreasing winter snowpack
- Earlier flowering plants
- More frequent extreme summer heat

(http://wenham.wickedlocal.com/news/20180827/mema-weather-advisory-excessive-heat-on-way-tuesday-and-wednesday)

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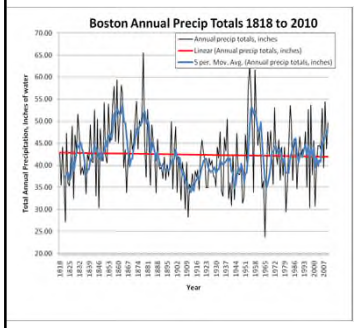
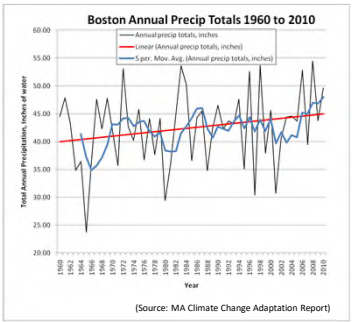
Annual Precipitation in Boston

January 1818 to December 2010





(Source: MA Climate Change Adaptation Report)

The blue line represents a five-year moving average and the red line a least squares regression.

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Change in Precipitation

6-hour, 10-year event

- 1961 = 3.2 inches
- 2015 = 3.35 inches

24-hour, 100-year event

- 1961 = 6.5 inches
- 2015 = 8.40 inches

(Sources: NOAA TP-40, 1961 and NOAA Atlas Volume 10, 2015)

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Predicted Climate Change

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Increased Temperatures/Extreme Heat

	Observed Baseline	Projected Change 2050's	Projected Change End of Century
MA Average Temp (°F)	47.6	+2.8 to +6.2	+3.8 to +10.8
Wenham Average Temp (°F)	49.5	+2.7 to +6.2	+3.6 to +10.8
Days with Temperatures Above 90°F	7	+8 to +31	+12 to +69
Days with Temperatures Above 100°F	<<1	<1 to +3	<1 to +14
Days with Temperatures Below 32°F	130	-18 to -42	-23 to -65

(Source: NECSC, 2018)

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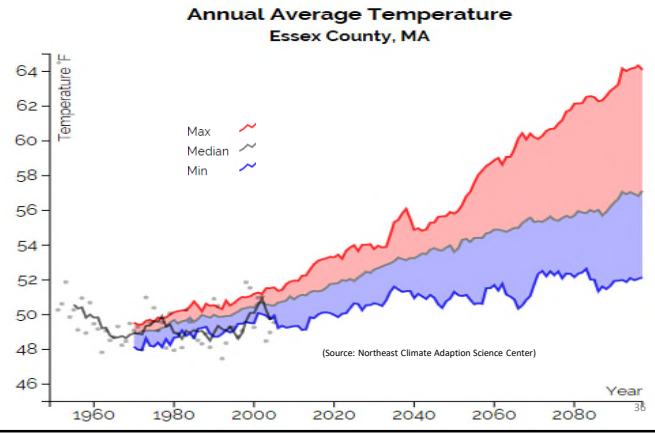
Projected: Annual Average Temperature in Essex County



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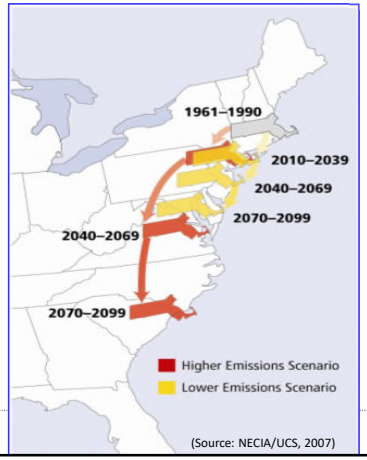
Extreme Heat

Temperatures Predicted to Increase

Winter: 15 to 40% ↑

Summer: 6 to 18% ↑



(Source: NECIA/UCS, 2007)

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Heavy Precipitation

Predicted:

- Higher winter flows and flooding
- Earlier peak flows in spring
- Extended summer low flows
- Increased flooding, polluted stormwater and wastewater discharges

(https://patch.com/massachusetts/hamilton-wenham/towns-dodge-major-flood-related-problems)

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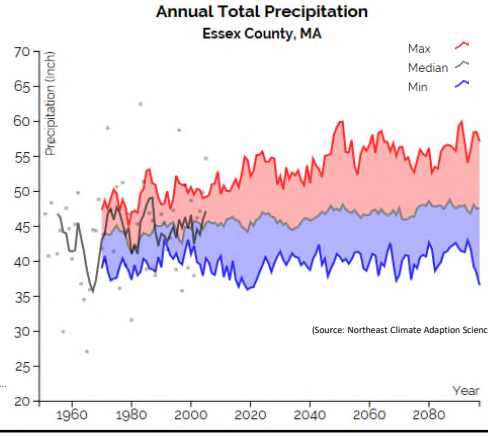
Heavy Precipitation



(Source: Northeast Climate Adaption Science Center)

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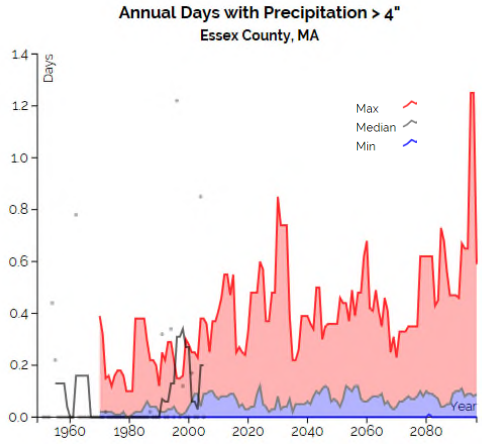
Heavy Precipitation



(Source: Northeast Climate Adaption Science Center)

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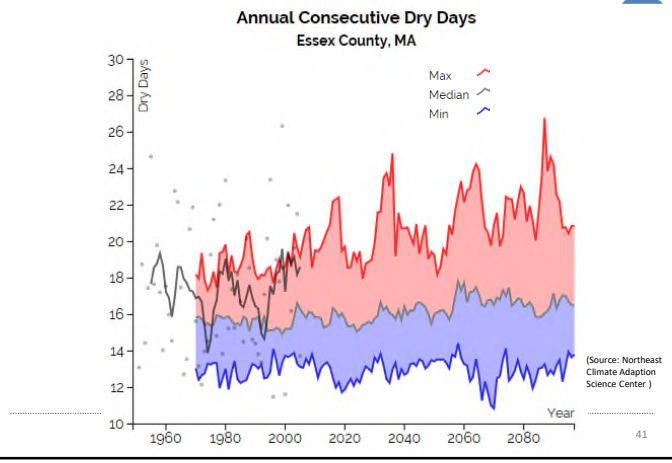
Drought



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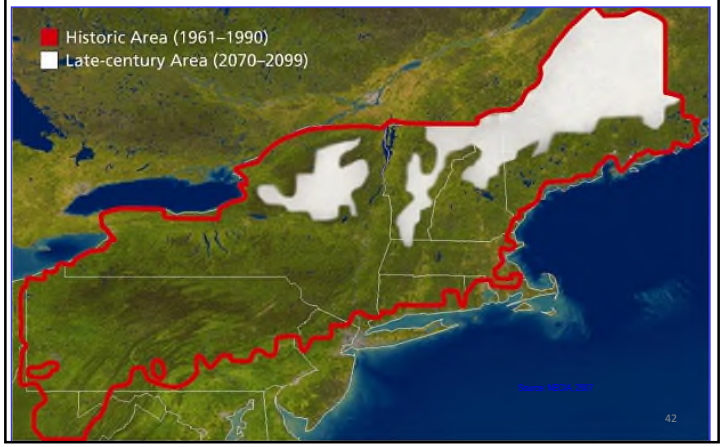
Predicted Snow Cover

(Source: UCSUSA "Confronting Climate Change in the U.S. Northeast")



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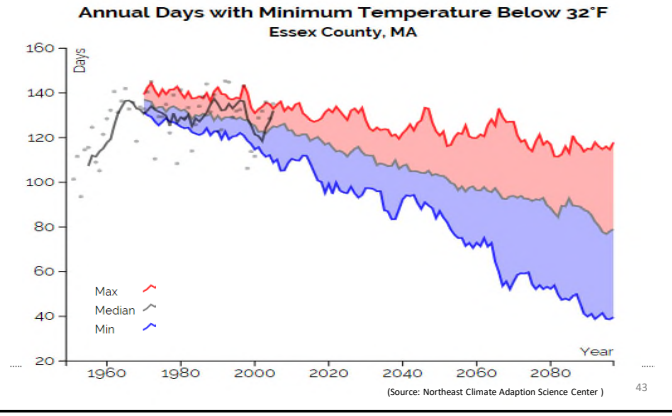
Projection: Annual Days in Essex County with Minimum Temperature Below 32°



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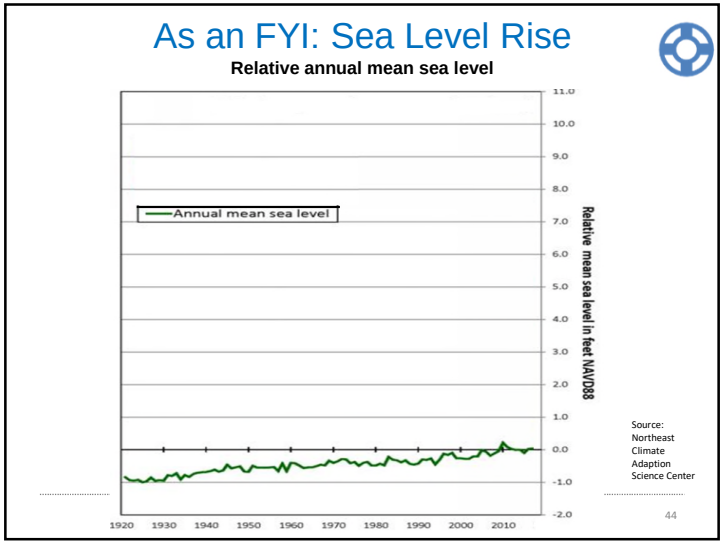
As an FYI: Sea Level Rise



44

44

As an FYI: Boston Sea Level Rise Projections

Threatens barrier buildings, infrastructure, beach and dune systems, and people

Emission Scenario	2030 (ft)	2050 (ft)	2070 (ft)	2100 (ft)
Intermediate	0.7	1.4	2.3	4.0
Intermediate-High	0.8	1.7	2.9	5.0
High	1.2	2.4	4.2	7.6
Extreme	1.4	3.1	5.4	10.2

- Increased coastal flooding
- Permanently inundated low-lying coastal areas
- Increased shoreline erosion

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(Source: Northeast Climate Adaption Science Center)

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Identify Hazards

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HMP 2012: Hazards in Wenham

Hazard	Frequency	Severity
Flooding	High	Serious
Winter Storms/ Nor'easter	High	Serious
Hurricanes	Medium	Serious- extensive
Earthquakes	Low	Catastrophic
Tornadoes	Low	Extensive
Landslides	Low	Minor
Brush Fires	Medium	Minor
Dam Failures	Low	Serious

(Source: Wenham Hazard Mitigation Plan, 2012)

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Major Natural Hazards in Wenham

Choose 4 for MVP Action Plan

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15-Minute Break!

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Risk Matrix

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Risk Matrix

Community Resilience Building Risk Matrix www.CommunityResilienceBuilding.com

H-M-L priority for action over the Short or Long term (and Ongoing)
V = Vulnerability S = Strength

Features	Location	Ownership	V or S	Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)				Priority H - M - L	Time Short Long Ongoing
Infrastructural									
Societal									
Environmental									

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Risk Matrix - Hazards

Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)				Priority	Time
				H - M - L	Short Long Ongoing

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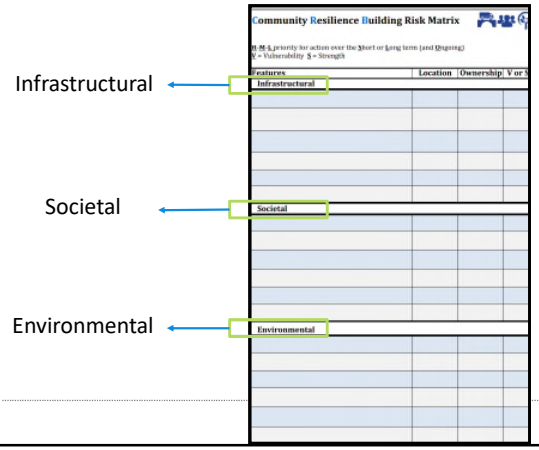
Risk Matrix- Features



53

Features in Wenham

Infrastructural, societal, and environmental features

Features — **Location** — **Ownership** — **Vulnerability or Strength**

Infrastructural
Societal
Environmental

Weston & Sampson 54

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Features in Wenham
Location

Infrastructural, societal, and environmental features

Features — **Location** — **Ownership** — **Vulnerability or Strength**

Infrastructural
Societal
Environmental

Town-wide
Multi-Neighborhood
Single-Neighborhood
Specific Location

Weston & Sampson 55

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Features in Wenham
Ownership

Infrastructural, societal, and environmental features

Features — **Location** — **Ownership** — **Vulnerability or Strength**

Infrastructural
Societal
Environmental

Town-wide
Multi-Neighborhood
Single-Neighborhood
Specific Location

State
Town
Private
Shared

Weston & Sampson 56

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Features in Wenham

Vulnerability or Strength

Infrastructural, societal, and environmental features

Features	Location	Ownership	Vulnerability or Strength
Infrastructural Societal Environmental	Town-wide Multi-Neighborhood Single-Neighborhood Specific Location	State Town Private Shared	Vulnerability Strength Both

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Infrastructure Features

58

Infrastructure

- Utilities such as electric power, gas, water, hydraulics, compressed air, municipal
- Water supply and treatment plants
- Wastewater treatment plants, sanitary & stormwater sewer systems
- Energy
- Manufacturing equipment and pollution control equipment
- Communication, data and voice computer networks
- Transportation

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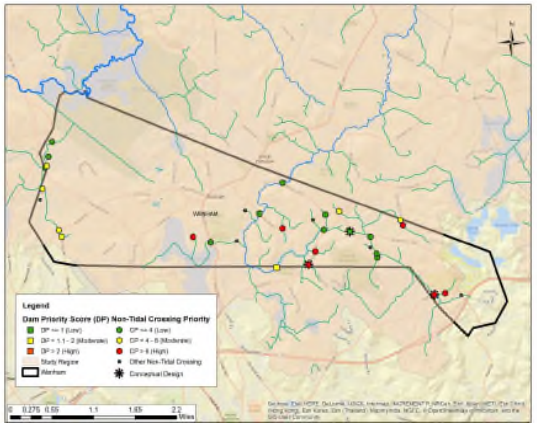
Infrastructure: Dams and Stream Crossings



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Infrastructure: Police

(Source: wenhampd.com)

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Infrastructure: Fire Department

(Source: wenhamfd.org)

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Infrastructure: Roadways

(Grapevine Road)

(Source: Google)

Weston & Sampson https://mycoast.org/reports/38427

63

Infrastructure: Bridges

(Walnut Road Bridge)

(Source: Google)

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Infrastructure: Water Supply
(Wells in Great Wenham Swamp)

(Source: Hamilton-Wenham Public Library)

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Societal Features

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Societal: Wenham's People

- Population
  - 2010 Census: 4,875
  - 2035 Projection: 6,508
- Age
  - Under age 20 = 34.8%
  - Age 65 or older = 15.4%
- Education
  - 99.2% high school
  - 67.2% Bachelors degree
- Income
  - Median household = $99,375
  - 18.82% low to moderate income
  - 2.6% below poverty level

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Societal: Wenham's Jobs

- Number of Jobs
  - 2010 Census: 1,197
  - 2040 Projection: 1,389
- 499 Businesses
  - Retail
  - Construction
  - Professional & Technical Services
  - Health Care & Social Assistance
  - College/Institution
    - Academy and Penguin Hall
    - Gordon College
    - Wenham Country Club
    - Tendercrop Farm at Canaan

Sources: Executive Office of Labor and Workforce Development; MAPC; Population: 2010 census (https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml); Population projections: UMass Donahue Institute (http://www.pep.donahue-institute.org/)

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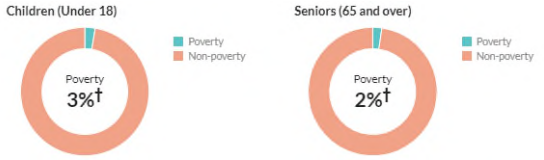
Societal: Vulnerable Populations

Elderly, low/moderate income, special income, language barriers, infirmed



18.82% of Wenham's population is low-moderate income

Sources: Censusreporter.com, ACS 2016 5-year, US Department of Housing and Urban Development, 2018): https://www.hudexchange.info/programs/acs-low-mod-summary-data/acs-low-mod-summary-data-local-government/)

69

69

Societal: Assisted Living, Senior Centers, & Seniors Living at Home

The Maples, Wenham

(Source: www.senioradvice.com/providers/view/maples-wenham-ma)

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Environmental Features

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71

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Environmental: Natural Resources

- Coldwater Streams
- Ipswich River
- Wenham Lake
- Longham Reservoir
- Pleasant Pond
- Forests
- Other Marshes & Wetlands
- Aquifers

Pleasant Pond, Wenham, MA

(Source: Town of Hamilton)

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Environmental

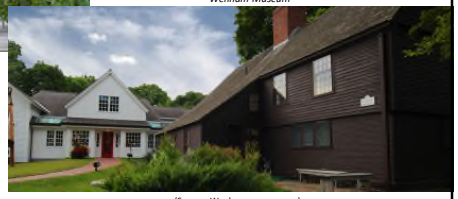
Massachusetts Audubon's Ipswich River Wildlife Sanctuary

(Source: Rootsrated.com)

Gordon College

(Source: Gordon.edu)

Wenham Museum



(Source: Wenhammuseum.org)

73

Environmental: Climate Stressors

- Drought
- Flooding
- Erosion
- Water quality/quantity impacts
- Invasive fauna and flora
- Wetland soil Impacts
- Increase in stormwater runoff
- Less groundwater recharge

(https://matowninfo.com/wenham/buyers-agaent-wenham-ma/massachusetts/#axzz5VW1Lt370)

74

Environmental: Watershed and Aquifers

- Surface water and groundwater most important resources
- Longham Reservoir and Wenham Lake are Class A public drinking water supplies
- Wenham drinking water supplies serve:
  - Beverly
  - Salem
  - part of Wenham
- Salem-Beverly Water Board owns undeveloped land near water supply sources to protect water quality

Pump station in Wenham

http://breakheartttrailrunning.blogspot.com/2015/11/salem-beverly-grand-wenham-canal-run.html

75

1-Hour Lunch

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Examples of Community Actions/ Hazard Mitigation Strategies in Wenham and Beyond

77

HMP 2012: Mitigation Measures

High Priority

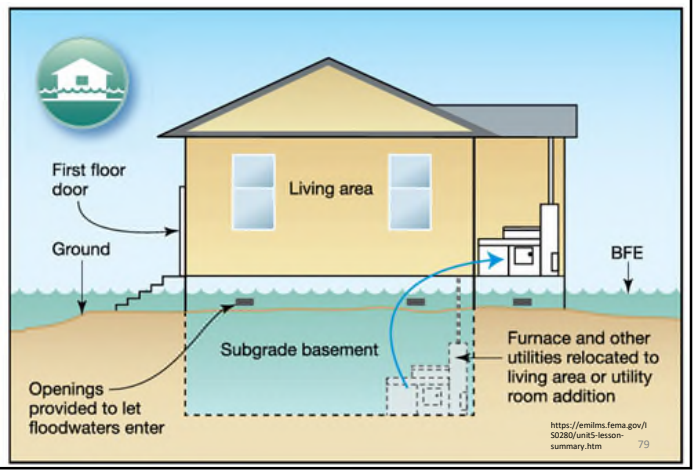
- Flooding, Drainage Infrastructure and Dams
- Land Protection
- Winter Storms
- High Winds and Hurricanes
- Power outage and communications

Medium Priority

- Flooding, Drainage Infrastructure and Dams (other locations)
- Brush Fires

78

Floodproofing



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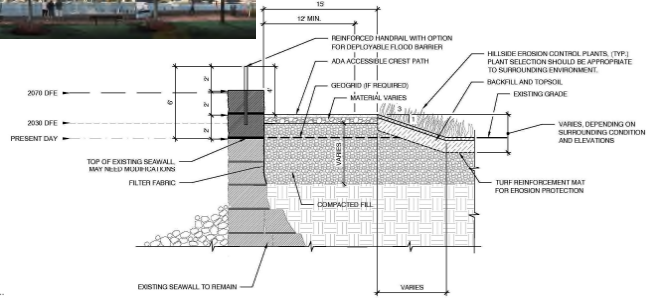
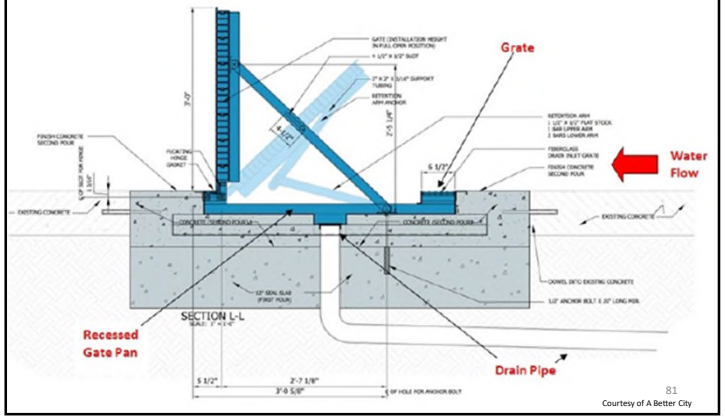
Flood Walls



80

Deployable Flood Barriers



81
Courtesy of A Better City

81

Vegetated Berms

82

82

Multi-Purpose Flood Storage

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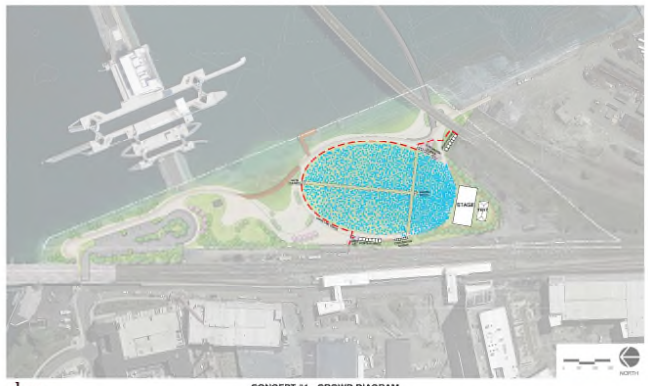
83

Landscape Design to Accommodate Water

Draw Seven Park, Somerville – Existing Conditions

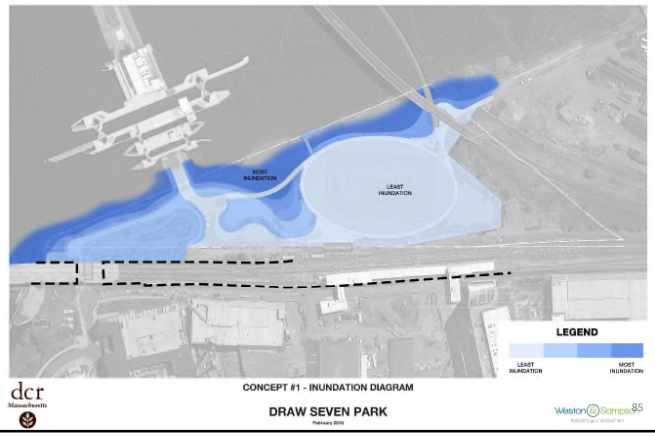


84

84

Landscape Design to Accommodate Water

Draw Seven Park, Somerville – Flooded Conditions



85

Low Impact Development (LID)

An innovative, ecosystem-based approach to land development and stormwater management

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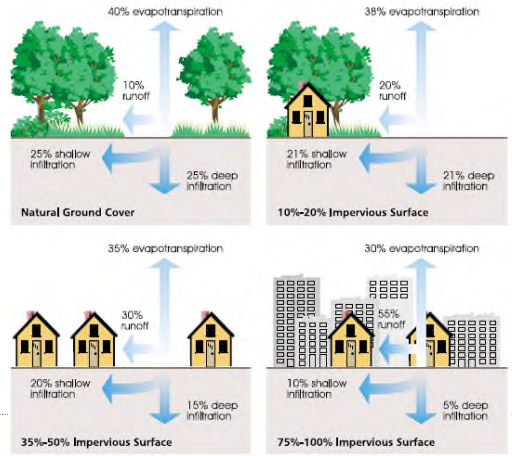
Reduce Impervious Areas



Source: Federal Stream Corridor Restoration Handbook (1998)

87

Porous Asphalt and Permeable Pavers

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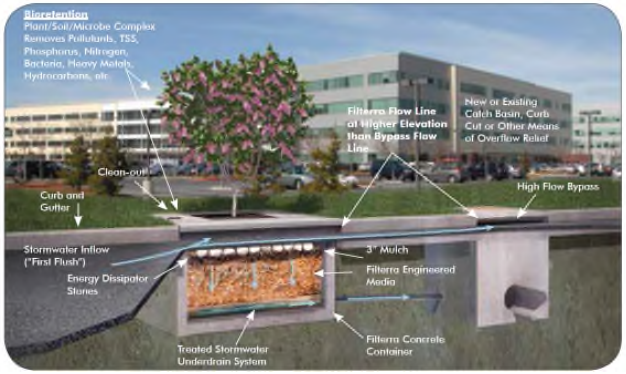
Street Trees, Tree Box Filters, Rain Gardens



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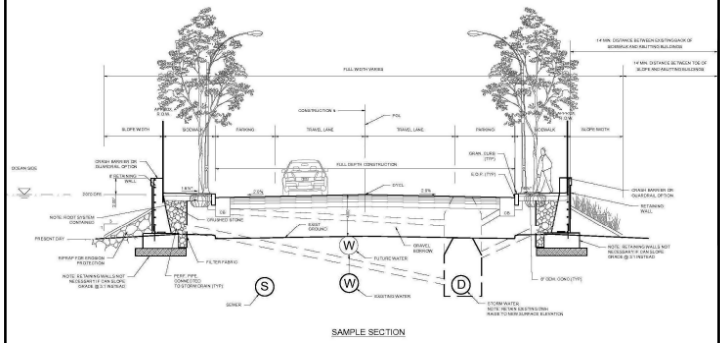
Raised Roadways



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Stormwater Detention & Retention

91

Culvert Widening to Reduce Flooding & Improve Flow and Habitat

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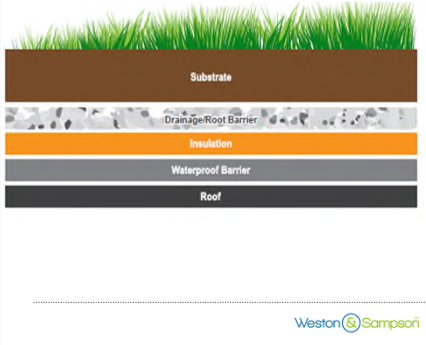
Green Roofs



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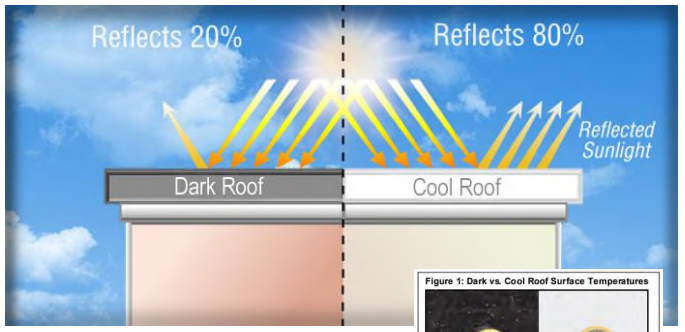
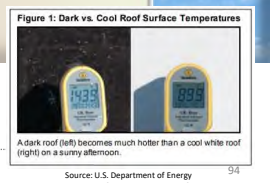
Cool Roofs



Source: Heat Island Group at Lawrence Berkeley National Laboratory



Source: U.S. Department of Energy Guidelines for Selecting Cool Roofs

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Cooling Centers

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Source: The Mercury News

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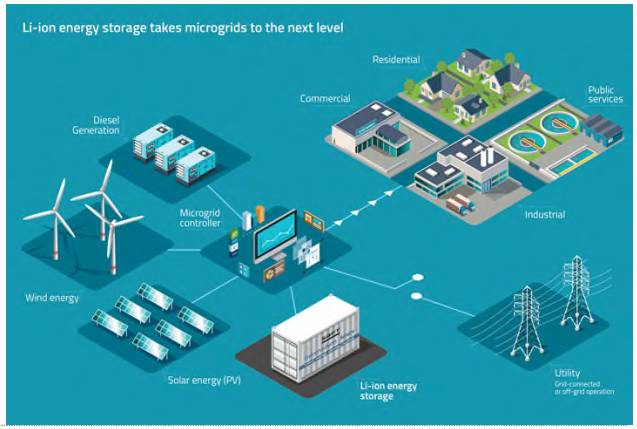
Renewable Micro-Grids



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Source: altenergymag.com

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Retrofitted Floodproof Doorways

97

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Re-Evaluate Local Regulations & Policies

98

98

15-Minute Break!

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Define Community Actions

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Identify Priority Actions

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Community Resilience Building Risk Matrix www.CommunityResilienceBuilding.com

H-M-L priority for action over the Short or Long term (and Ongoing)
V = Vulnerability S = Strength

Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

Features	Location	Ownership	V or S					Priority H - M - L	Time Short Long Ongoing
Infrastructural									
Societal									
Environmental									

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Wrap-up & Closing Remarks

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transform your environment

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HAMILTON
TOPSFIELD
DANVERS
BEVERLY AIRPORT
BEVERLY
MANCHESTER
ESSEX

Ipswich River
Ipswich River
Idlewild Brook
Black Brook
Cutler Pond
Miles River
Miles River
Miles River
Chebacco Lake
Chebacco Lake
Back Pond
Round Pond Dam
Round Pond
Gravelly Pond
Salem Beverly Waterway Canal
Pleasant Pond
Muddy Pond
Cedar Pond
Wenham Lake
Longham Reservoir
Longham Reservoir Dam
Norwood Pond Dam
Norwood Pond
Beaver Pond
Beverly Reservoir Dam
Coy Pond
Frost Fish Brook
Bass River
Bass River
Bass River
Mackerel River

HAMILTON POLICE DEPARTMENT
HAMILTON FIRE DEPARTMENT Headquarters
WENHAM FIRE DEPARTMENT Headquarters
WENHAM POLICE DEPARTMENT
BEVERLY FIRE DEPARTMENT North Beverly Station
BEVERLY HOSPITAL

Bessie Buker Elementary School
Notre Dame Children's Class
The Academy at Penguin Hall

Essex Street
Pleasant Street
Juniper Street
Porter Street
Bruce Lane
Arlene Street
Perkins Street
Main Street
Patch Avenue
Larch Lane
Larch Row
Friend Court
Old Country Road
Main Street
Patti Lane
Lake Avenue
Fiske Road
Main Street
Great Pond Road
Cedar Street
Topsfield Road
Maple Street
Birch Road
Burley Street
Orchard Lane
Laurel Drive
Main Drive
Hilltop Drive
Elliot Road
Hilltop Drive
Burnham Road
Topsfield Roads
Old Town Way
Cherry Street
Monument Street
Eaton Road
Meridian Road
Dartmouth Road
Conrad Circle
Mayflower Drive
Puritan Road
Morgan Street
William Fairfield Drive
Virginia Place
Kimball Avenue
Pleasant Street
Woodside Lane
Parkway Street
Salem Street
Walnut Road
Slab Lane
Ledgyard Lane
Walnut Road
Larch Row
Danes Way
Grapevine Road
Grapevine Road
Ridgeview Lane
Essex Street
Grapevine Road
Ridbury Road
Grapevine Road
Charles Davis Drive
Hull Street
Parsons Hill Road
Grapevine Road
Boulder Lane
Beaver Dam Road
Longham Reservoir
Wenham Lake
Great Pond Road
Topsfield Roads
Burnham Road
Hilltop Drive
Elliot Road
Laurel Drive
Main Drive
Orchard Lane
Burley Street
Birch Road
Maple Street
Topsfield Road
Cedar Street
Main Street
Patti Lane
Lake Avenue
Fiske Road
Friend Court
Old Country Road
Larch Row
Larch Lane
Perkins Street
Arlene Street
Juniper Street
Porter Street
Bruce Lane
Pleasant Street
Essex Street
Parkway Street
Woodside Lane
Salem Street
Old Town Way
Cherry Street
Monument Street
Patch Avenue
Eaton Road
Meridian Road
Dartmouth Road
Conrad Circle
Mayflower Drive
Puritan Road
Morgan Street
William Fairfield Drive
Virginia Place
Kimball Avenue
Pleasant Street
Main Street
Walnut Road
Slab Lane
Ledgyard Lane
Walnut Road
Larch Row
Danes Way
Grapevine Road
Grapevine Road
Ridgeview Lane
Essex Street
Grapevine Road
Ridbury Road
Grapevine Road
Charles Davis Drive
Hull Street
Parsons Hill Road
Grapevine Road
Boulder Lane
Beaver Dam Road

97
1A
22
128

N

1,000 0 1,000
Scale In Feet

Legend

- Daycares
- Food/Grocery/Supply Stores
- Gas Stations
- Public Telephones
- Town Hall
- Fire Stations
- Local Police
- Underground Storage Tanks
- Airports
- Landing Strip/Airport
- Railroad

Schools (Pre-K Through HS)
- Public
- Private

Colleges and Universities
- Private

Libraries
- Academic
- Special-Other

Long Term Care Residences
- Assisted Living Facility
- Nursing Home

Dams
- Significant Hazard
- Low Hazard
- N/A

DEP Wetlands
- Marsh/Bog
- Wooded marsh
- Salt Marsh
- Open Water
- Tidal Flats
- Beach/Dune

FEMA National Flood Hazard Layer
- 1% Annual Chance of Flooding (Zones A, AE, AH, AO)
- AE: Regulatory Floodway
- X: 0.2% Annual Chance of

FIGURE 1

TOWN OF WENHAM

HAZARDS AND RESOURCES

NOVEMBER 2018 SCALE: NOTED

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Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.org

H-**M**-**L** priority for action over the **S**hort or **L**ong term (and **O**ngoing)
V = Vulnerability **S** = Strength

Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

Features	Location	Ownership	V or S	DROUGHT	EXTREME TEMPS	FLOODS	WIND, WINTER STORMS, NOR'EASTERS	Priority H - M - L	Time Short Long Ongoing
Infrastructural									
ELDERLY HOUSING (OVER 55+ COMPLEXES)	TOWNWIDE	PRIVATE	V	GREEN ROOF (CURRENTLY PLANNED)	HEATING/AC →	→	BACKUP POWER	H	O
GRAPEVINE & LARCH ROADS (TREES FALL/ POLES FALL)	TOWNWIDE	TOWN	V				TREE MANAGEMENT PROGRAM ACROSS COMMUNITY, CATCHUP ON REMOVAL, PLANTING	M	O
BUKER SCHOOL (POWER OUTAGE/FLOODING LARGEST PUBLIC BUILDING- COULD BE EM. SHELTER)	TOWNWIDE	TOWN	V/S		AC, USE AS SHELTER OR EMERGENCY CENTER	IMPROVE DRAINAGE, PERMEABLES	BACKUP POWER	H	S
WATER INFRASTRUCTURE (DISTRIBUTION SYSTEM WELLS, INTERCONNECTION TO BEVERLY/HAMILTON)	TOWNWIDE	PRIVATE NATIONAL GRID	V/S	WATER CONSERVATION MEASURES		PROTECT WELLS-SANDBAGS	BACKUP POWER	H	S
COMMUNICATION (CELL SERVICE IS SPOTTY, RADIO/COMPUTER SYSTEMS)	TOWNWIDE	PRIVATE/TOWN	V				BACKUP POWER/ IMPROVE CELL COVERAGE	H	S/O
CULVERTS/DRAINAGE (BEAVER, SIZE)	TOWNWIDE	TOWN	V			INCREASE SIZE, BEAVER RELOCATION		H	S/O
Societal									
ELDERLY POPULATION	TOWNWIDE		V/S	EDUCATION, INFO SHARING, WATER CONSERVATION	HEATING & COOLING CENTERS	SHELTER	PRIORITIZE RE-ENERGY (NGRID)	H	O
COLLEGE STUDENTS	GORDON	PRIVATE	V/S	"	MODIFY ACTIVITIES	EVACUATION/EMERGENCY PLAN, SHELTER	WARN ABOUT RISKS	M	O
CHILDREN	TOWNWIDE		V	"	H/C CENTERS			M	O
SINGLE FAMILY HOMES/ RESIDENTS	TOWNWIDE		V/S	"		EDU. ABOUT OPTIONS/ NOTIFY ABOUT RISKS, INCENTIVES FOR STRATEGIES	EDUCATION ABOUT NATIONAL GRID TRIMMING TREES ON PROPERTIES	M	O
EDUCATION LEVEL	TOWNWIDE		S						
GROUP HOME RESIDENTS	5-TOWNWIDE		V	STAFF EDUCATION AND TRAINING		UP TO DATE EMERGENCY PLAN		H	O
Environmental	TWNWIDE								
WETLANDS	TOWNWIDE		V/S	RETAIN WATER (DAMS)				M	O
AQUIFER PROTECTION DISTRICT	SPECIFIC	TOWN	V	EDUCATION →	→	→	→	H	O
WELL ZONES (1+2)	SPECIFIC	TOWN	V			PROTECT FROM CONTAMINATION		H	O
INSECTS	TOWNWIDE		V		EDUCATION, SPRAYING ESSEX COUNTY MOSQUITO CONTROL	EDUCATION, REMOVE STATIC WATER, PERMEABLES		M	O
FORESTS	TOWNWIDE		V/S				EDUCATION ABOUT RECOMMENDED TREE TYPES (POWER LOSS)	H	O
WENHAM LAKE/CANAL	SPECIFIC	BEVERLY-WENHAM WATER SUPPLY	V			EDUCATION AND COORDINATION		L	O

Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.org

H-**M**-**L** priority for action over the **S**hort or **L**ong term (and **O**ngoing)
V = Vulnerability **S** = Strength

Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

Features	Location	Ownership	V or S	DROUGHT	EXTREME TEMPS	FLOODS	WIND, WINTER STORMS, NOR'EASTERS	Priority H - M - L	Time S Long O ngoing
Infrastructural									
PUBLIC UTILITES	TOWNWIDE	NGRID	V		BACKUPS OR SYSTEM REDUNDENCIES FOR PEAK DEMAND		TREE MAINTENANCE	H	O
GORDON COLLEGE	EASTERN WENHAM	PRIVATE	V/S	GREEN ROOF, COOL ROOF, RENEWABLES, IMPERIABLES, LOW-FLOW TOILETS AND SHOWERS				L	L
FIRE/POLICE STATIONS & TOWN HALL, EOC/BACKUP EOC MIDDLETON REC CENTER	TOWNWIDE	TOWN	V/S		MICROGRID		MICROGRID FOR ALL	L	L
WASTE WATER (EASTERN WENHAM, GORDON COLLEGE)	SPECIFIC TO WENHAM	CITY OF BEVERLY WATER	V/S	LOW-FLOW TOILETS, WATER CONSERVATION			BACKUP POWER	L	O/L
GAS DISTRIBUTION (TENNESSEE GAS/NGRID TANK STATION)				USE EXISTING CISTERNS		BEST QUALITY MATERIALS		L (GOOD CONDITION)	O
Societal									
Environmental									

Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.org

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V = Vulnerability **S** = Strength

Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

Features	Location	Ownership	V or S	HEAVY PRECIPITATION & FLOODING	DROUGHT	WINTER	EXTREME TEMPERATURES	Priority H - M - L	Time S Short L Long O Ongoing
Infrastructural									
TOWN WELLS/PUMPING STATIONS/TANKS	MULTIPLE	TOWN	TANKS - S PUMPS- V	VEGETATED BERMS, BRING ELEMENTS TO HIGHER ELEVATIONS, NATURAL STORAGE AT PLEASANT RD, INCREASE OUTLET HYDRAULIC CAPACITY	CONNECTION TO REGIONAL SYSTEM, ADDITIONAL TANK STORAGE	REDUNDANCY AND PUMPING CAPACITY	ONGOING HYDRANT MAINTENANCE, CONT. WATER BANS TO PREVENT EXTRA IRRIGATION/ WATER USE	H	O/L
UTILITIES - GAS, ELECTRIC, MAN-MADE	EVERYWHERE	UTILITIES	V	NO ACTION	NO ACTION	MAINTAIN STREET TREES, PARTNERING WITH UTILITIES	GENUINE FUEL PROGRAMS, POWER CONSERVATION		
GRAPEVINE RD, 97, CEDAR ST, LARCH ROW, PLEASANT POND ROADS, CHERRY ST, MAIN STREET (NEAR LAKE)	EVERYWHERE	TOWN 7 PRIVATE RDS	V	CULVERT IMPROVEMENTS	N/A	"	N/A		
CULVERTS & BRIDGES (OLD & NEW)	MULTIPLE LOCATIONS	TOWN	MOST - V SOME- S	ADDRESS UNDER-SIZED AND UNCLEA CULVERTS				H	O/S
PUMPHOUSE(S BWB) & DAM	NEAR CANAL & AT LONGHAM RD	SALEM-BEVERLEY WATER	V		DATA AND RECORDS MANAGEMENT W/ INFO TECH TOOLS				
MUNICIPAL BLDGS	DOWTOWN, IRONRAIL, BUKER SCHOOL	TOWN & HWRSD	DOWNTOWN - S IRONRAIL/BUKER - V						
COMMUNICATION INFRASTRUCTURE	ACROSS TOWN	TOWN	V	N/A	N/A	CREATE SYSTEM REDUNDANCY, NTER-OPERABILITY/ CROSS CONNECTIONS		H	S
GORDON COLLEGE	EAST WENHAM	PRIVATE	BOTH						
Societal									
STUDENTS @ GORDON	EAST WENHAM ON CAMPUS	GORDON	BOTH						
60+ & 90+ POPULATIONS	HOUSING AUTH., 55+ DEV. EVERYWHERE	PRIVATE	V	ACTIVE COA AWARENESS 7 TRANSPORTATION SYSTEM RESPONSE W/ COA/PD/FD (SHELTER IN PLACE OR EVACUATION) & ALTERNATIVE POWER SOURCES				M	O
SOCIOECONOMICS (WEALTH, EDUCATION)	EVERYWHERE	PRIVATE	S						
KIDS (UNDERSCHOOLAGE & SCHOOLAGE)	EVERYWHERE	PRIVATE	V	SHELTER IN PLACE, DRAINAGE SOLUTIONS	WORKING BUBBLERS, DESIGNATED COOLING CENTER, INDOOR RECESS OPTIONS	GENERATOR FOR BUKER, SHELTER IN SCHOOL, WEATHER RELATED CALLS	HVAC - CAPITAL PLANNING	H - GENERATOR/ M	O
LACK OF INDUSTRY & LOCAL EMPLOYMENT & SHOPPING/SUPPLIES	EVERYWHERE	PRIVATE	V						
LACK OF ENGAGEMENT IN CIVICS, LOCAL GVT, COMMUNITY ORGS.	EVERYWHERE	PRIVATE	V	DISCOVERING HOW PEOPLE WANT TO BE COMMUNICATED WITH, EDUCATION/AWARENESS/ TOWN-WIDE DRILLS WL SCHOOL KIDS ESPECIALLY				L	O/L
Environmental									
TREES (STREET TREES - INFRASTUCTURE DAMAGE, EROSION CONTROL/FOREST/SHADE/ REDUCTION OF CARBON FOOTPRINT)	EVERYWHERE	ALL	BOTH	TREE MAINT. & ADDING NEW TREES & TREES THAT ARE LOWER NEAR STREETS - CAPITAL PLANNING & ADOPT A TREE				H	O
INVASIVE SPECIES (INSECTS, PLATNS, ANIMAL	EVERYWHERE	ALL	V	ADOPT AN INVASIVE SPECIES REMOVAL, BEAVER CONTR	DROUGHT PROOF SPECIES SO INVASIVES CAN'T TAKE OVER	NATURAL SOLUTIONS (GOATS), HERBICIDING		H/M	O/S
WETLANDS & WATER BODIES	EVERYWHERE	ALL	BOTH	BEAVER CONTROL, ZONING FOR LOW IMPACT NATURAL/MANMADE STORMWATER, WATER CONSERVATION & USAGE AWARENESS		RESTORATION/REPLICATION OF WETLANDS	WATER CONSERVATION & USAGE AWARENESS	H	O
OPEN SPACE & OPEN SPACE PLANNING & CONCOM & RELEVANT ORGANIZATIONS	TOWN, SBWP, AUDUBON, PRIVATE	ALL	BOTH						
ECOSYSTEMS (BEAVERS, VERNAL POOLS, COLD WATER FISHERIES)	EVERYWHERE	ALL	BOTH	UPDATE WPA BYLAW, NATURAL PREDATORS, DRAGONFLY EX.	REMOVE STRESSORS, INCREASE RESILIENCY & CONNECTIVITY			M	L
GROUNDWATER	EVERYWHERE	ALL	BOTH	SEPTIC SYSTEM MAINT & CARE				M	L

COASTAL ADJACENT	EVERYWHERE	ALL	V					M	L

Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.org

H-**M**-**L** priority for action over the **S**hort or **L**ong term (and **O**ngoing)
V = Vulnerability **S** = Strength

Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

Features	Location	Ownership	V or S	DROUGHT	FLOODING	EXTREMES INCREASED TEMP	WIND, WINTER STORMS, NOREASTERS	Priority H - M - L	Time S Long O ngoing
Infrastructural									
ROADWAYS/1A	TOWN CENTER	STATE	V		CULVERTS ASSESSMENT, POSSIBLE GRANT FUN			H	O - IRWA
GRAPEVINE, TOPSFIELD RD/CHICKEN HILL, WALNUT, LARCH		TOWN	V		CULVERTS ASSESSMENT, POSSIBLE GRANT FUNDING		SNOW & ICE REMOVAL- CHICKEN HILL	H	
POWERLINES/ABOVE GROUN	TOWNWIDE	NATIONAL GRID	S & V				MAKE ALL POWERLINES UNDERGROUND/ REW E BYLAWS	H	L
WATER STORAGE TANKS	BURNHAM, GRAPEVINE	TOWN	S & V		IRONRAIL TANK - CERTIFY STRUCTURAL INTEGRITY		ADDRESS POWER OUTAGES	H	S
PUMPING STATION AT WENHAM CANAL	OLD TOWN WAY	SBWSB	V					H	
BUKER SCHOOL/COA PENGUIN HALL	SCHOOL ST	TOWN	V & S			FORMALIZE BUKER AS EMERGENCY STATION	GENERATOR/ CREATE DEDICATED EMERGENC E/	H	
Societal									
ELDERLY (GROUP VS. INDIDUALS)	ENON VILLAGE/ LARCH LN/ MAPLES/ BOULDERS	HOUSING AUTHORITY, PRIVATE OWNER, SINGLE FAMILY	V & S		ENON MANPOWER		COA COOLING CENTERS	M	O
HANDICAPPED/SPECIAL NEEDS	GROUP HOMES		V				EVACUATION PLAN, TRANSPORT		
SAFETY TEAM			S						
LOWER INCOME (FOOD PANTRY ACCORD)			V						
PETS			V						
GORDON COLLEGE POPULATION (COMMUNICATION BETWEEN BOTH)	GRAPVINE RD	PRIVATE	V & S						
Environmental									
GROUNDWATER/ DRINKING WATER/ HEAT/ DROUGHT TASK FORCE, TOWN & PRIVATE WELL			V	DETERMINE REGIONAL STRATEGY, DROUGHT TASK FORCE	STORAGE/ DRINKING WATER SUPPLY PLAN	CONTAMINATION TREATMENTS	WATER INFRASTRUCTURE	H	O
TREES/ FORESTS/ STREET			V & S	DRYING OUT, TREE WARDEN/ FOREST WARDEN INVENTORY	LOSS, REPLANTING W/ ADAPTABLE	MAINTAIN CANOPY, FINES	INVENTORY MAINTENANCE	H	O
WILD ANIMAL FOOD SUPPLIES - MORE BIOLOGICAL- TICKS			V						
COYOTES									
FARMLAND - (FERTILIZER)			V						
INVASIVE SPECIES/ KNOTWEED			V						

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Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

Features	Location	Ownership	V or S	DROUGHT	FLOODING	EXTREMES INCREASED TEMP	WIND, WINTER STORMS, NOREASTERS	Priority H - M - L	Time S Short L Long O Ongoing
Infrastructural									
MBTA LINE	HAMILTON/WENHAM		S						
DPW BUILDING/FUELING STATION	91 GRAPEVINE	TOWN	V		PROVIDE ACCESS/FUEL/BERMS			M	L
POLICE/FIRE/TOWN HALL/COA BLDG	TOWN CENTER	TOWN	S						
TOWN WELLS (SEPTIC SYSTEMS	PLEASANT ST	TOWN	S & V		PROVIDE ACCESS			L	O
Societal									
YOUNG CHILDREN (VULNERABLE IN GROUPS			V				SHELTERS/ SYSTEM FOR CHILDREN ALONE/ BUKER GENERATOR	H	S
COMMUNICATION IN EMERGENCY			V	REDUNDANCY FIRE, POLICE 2 WAY	SIGNAGE	REVERSE 911/ CONNECT	CELL TOWERS	H	L/O
HOMELESS			V						
TECH SAVVY RESIDENTS			S						
VULNERABLE NEIGHBORHOODS			V		IDENTIFY VULNERALE		PARSONS HILL ONE WAY IN & OUT		
Environmental									
BEAVERS			V						
MILES RIVER (LACK OF FLOW)			V		ANALYZE/ INVESTIGATE CURR EFFORTS, DREDGING, FERTILIZATIO CONTAMINATION, MYOPIA			H	L
STORMWATER/WETLANDS			V & S						
OPEN SPACE/ PROTECTED LAND (S)			V & S						

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Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

Features	Location	Ownership	V or S	DROUGHT	EXTREME TEMP	FLOOD	STRONG WIND/ NOREASTERS, WINTER STORMS	Priority H - M - L	Time Short Long Ongoing
Infrastructural									
SCHOOLS - BUKER	TOWNWIDE	TOWN/ SCHOOL DISTRICT	V & S		WHITE ROOF, AIR COND.	PUMP SYSTEM	BURY UTILITIES, GENERATOR	M	L
ROADS	TOWNWIDE	TOWN/ STATE	V & S			REPLACE CULVERTS, BEAVER CONTROL	SAFETY PRUNING	M	O
POLICE & FIRE STATIONS	SPECIFIC	TOWN	S		COOLING SPACE SETUP				
ENERGY/UTILITIES	TOWNWIDE	PRIVATE	V & S		WORKING SOLAR FIELD		HAZARD TREE REMOVALS	M	O
WATER SYSTEM	TOWNWIDE	TOWN	V & S	BACKUP SOURCES - OTHER TOWNS/ RAWWATER COLLECTION		RETENTION SYSTEM		H	O
PHONE & INTERNET	TOWNWIDE	PRIVATE	V & S						
Societal									
ELDERLY POPULATION	TOWNWIDE	PRIVATE	V	COMMUNICATION SYSTEM	COOLING/ HEATING STATIONS		SHELTER	H	O
HISTORICAL ASSOC. & WENHAM MUSEUM	SPECIFIC	PRIVATE	V			IMPROVED DRAINAGE, WALL SEALANT		H	O
PUBLIC SPACES (PARKS, CEMETARIES, PLEASANT POND, WENHAM CANAL)	TOWNWIDE	TOWN & SHARED	V & S				TREE REMOVAL		O
CHILDREN	TOWNWIDE	PRIVATE	V & S				SHELTER	H	O
TOWN & SCHOOL EMPLOYEES	TOWNWIDE	TOWN/ SCHOOL	S						O
TOWN RECORDS	SPECIFIC	TOWN	V						O
Environmental									
FORESTS/ TREES	TOWNWIDE	TOWN & PRIVATE	V & S	HAZARD TREE REMOVAL				H	O
RIVERS & STREAMS (MILES RIVER)	TOWNWIDE	TOWN & PRIVATE	V & S			VEGETATION SWALE		L	L
PONDS & LAKES (PLEASANT, WENHAM)	TOWNWIDE	TOWN & PRIVATE	V & S			BERMS, MORE SAMPLING		L	L/O
FARMS (TENDERCROP, REYNOLDS, CHICKEN HILL)	TOWNWIDE	PRIVATE	S	RAIN WATER COLLECTION				L	L
BEAVERS (GRAPEVINE RD)	TOWNWIDE	PRIVATE	V			TRAPPING		H	O
IMPERVIOUS SURFACES	TOWNWIDE	TOWN & PRIVATE	V & S			REBUILD DRAINAGE STRUCTURES, REGULATION DRAINAGES		H	O

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Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

Features	Location	Ownership	V or S	DROUGHT	EXTREME TEMP	FLOODS	WIND, WINTER STORMS, NOR' EASTERS	Priority H - M - L	Time S Long O ngoing
Infrastructural									
BUKER SCHOOL		WENHAM & REGIONAL	V/S				MANPOWER TO SERVICE SHELTER, FORMALIZE AS EMER. SHELTER, BACKUP POWER	H	S/O
ROADS/CULVERTS/DRAINAGE	TOWNWIDE	TOWN	V			CULVERT ASSESS/IMPLEMENT FINDINGS/ ASSIST COMMUN. W/ COSTS, INCREASE CULVERT SIZE, RAISE ROADS, BEAVER CONTROL, MAINTAIN CULVERTS	HAZARD TREE REMOVAL, TREE MANAGEMENT, SAFETY PRUNING	H	S/O
UTILITIES		SHARED RESPONSIBILITY	V				TREE MANAGEMENT	H	O/S
COMMUNICATIONS EQUIPMENT		SHARED -CELL & RADIOS - CELL TOWERS	V				REDUNDANCY, INTEROPERABILITY, BACKUP POWER, IMPROVED CELL COVER, IMPROVE COMM. W/ FIRE/POLICE, MORE SIGNAGE & CELL TOWERS	H	S/O
WATER SUPPLY INFRASTRUCTURE	REGIONAL	TOWN/ NEIGHBOR TOWNS	V	MANAGEMENT STRATEGY	MANAGEMENT STRATEGY	MANAGEMENT STRATEGY		H	O
POWER LINE							PUT LINES UNDERGROUND, CHANGE BYLAW TO REQUIRE UNDERGROUND	H	S/L
SIGNAGE FOR HAZARDS	TOWNWIDE/ HAZARD AREAS	TOWN	V			SIGNS	SIGNS		
ASSET MANAGEMENT (E.G. CATCH BASIN, SW INFRA.)	TOWN	TOWN	V			EXPAND EXISTING DATA MANGT. SYSTEM			
STREET TREES	TOWN	TOWN	V			REPLANTING TREES	HAZARD TREE MANAGEMENT		
Societal									
COMMUNICATION W/ VULNERABLE POPULATION, GROUP HOMES					1. IDENTIFY VULNERABLE POP. & YOUTH; 2. DETERMINE BEST OUTREACH METHODS, COMMUNICATION PREFERENCES; 3. EDUCATION AWARENESS TOWNWIDE DRILLS - STORM EVENTS; 4. REACHING PARENTS THRU STUDENTS TO SIMPLIFY REVERSE 911; 5. EDUCATE STUDENTS ON: HEATING/COOLING NEEDS; 6. GREENSCAPES - OUTREACH ON WATER RESOURCE ISSUES (INCLUDED IN 5TH GRADE CURRICULUM IN WENHAM)			H	O
CHILDREN							TOWN SHOULD BECOME AWARE OF WHERE DAYCARE CENTERS & WHAT THEIR REDUNDANCY PLANS ARE - CONSOL. INFO OF VULNERABLE POP.		O
ELDERLY (60+ & 90+ YEARS)					COUNCIL ON AGING W/ POLICE TO CHECK-IN; HAVE TRANSPORTATION SERVICE AVAILABLE, DEVELOP EVAC. PLAN			M	O
Environmental									
WELL ZONES (WATER SUPPLY)			V	STORAGE, DROUGHT TASK FORCE		PROTECT VS. CONTAMINATION PROTECTION AGAINST WIND/LOSS OF PLAN, REGIONAL STUDY OF WATER SUPPLY		H	O

MILES RIVER (BEAVER DAMS BACKUP WATER & CAUSE FLOODING)			V			INVESTIGATE CURRENT EFFORTS & NEED FOR DREDGING - WATER QUALITY CONCERNS, OVERGROWN VEG., NUTRIENT CONTROLS		H	L
INVASIVE SPECIES/INSECTS & VECTOR-BORNE DISEASES				INVAS. SPECIES MANAGE. CONTROL PLAN, HERBICIDES & NATURAL SOLUTIONS, COMMUNITY INVOLVEMENT IN CONTROL					
WETLANDS/WATERBODIES				WATER CONSERVATION, WETLAND REPLICATION					O
ECOSYSTEMS				REMOVE STRESSORS, INCREASE CONNECTIVITY, DEER MANAGEMENT					
GROUDWATER						SEPTIC SYSTEM MAINTENANCE & CARE			

Community Resilience Building Workshop/Hazard Mitigation Plan Meeting

Town of Wenham

Hamilton Wenham Library, 14 Union Street, South Hamilton, MA

Municipal Vulnerability Preparedness Program

January 9, 2018 - 9:00am to 5:00pm

Name and Affiliation	Signature	Table #
Adria Boynton, Weston & Sampson		1
Asma Syed, Con Com/OSRC		1
Bill Tyack, DPW		4
Bob Breaker, Emer Mngmnt Dir		2
Brian Leathe, Building Inspector		3
Deanna Lambert, Weston & Sampson		2
Diane Dixon, Water Commission		3 Afternoon
Dr. Andrew Ting, BoH		4
Erik Mansfield, Water Dept		1
Ernest Ashley, OSRC/Water		2
Faith Hassell, National Grid		1
Jackie Bresnahan, Permitting Coord		2
Jill Getchell, Weston & Sampson		3
Jim Politano, Facilities Director		2
Jim Riordan, Weston & Sampson		---
Kathy Baskin, Weston & Sampson		---
Kristen Grubbs, Ipswich River Watershed		3
Lydia Kifner, Weston & Sampson		4
Margaret Hoffman, Planning Coordinator		3
Melissa Berry, Conservation Coordinator		2
Michael M. Harvey, School Superintendent		1
Nicci Roebuck, Administrator's Asst		4
Peter Lombardi, Town Administrator		1
Robert Buchsbaum, Mass Audubon		4
Samantha Grantham, Wenham Museum		4
Vicky Masone, Green Communities		3
STEPHEN KAVANAGH - Fire chief		3
Jeffrey BAXter - captain		3
Chris Jones		3
Robert Pyburn		1
Diane Dixon		
Gregory P. Bernard		
Kevin DiNapoli, WPD		3

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Jackie Bresnahan, Permitting Coord		2
Jill Getchell, Weston & Sampson		3
Jim Politano, Facilities Director		2
Jim Riordan, Weston & Sampson		---
Kathy Baskin, Weston & Sampson		---
Kristen Grubbs, Ipswich River Watershed		3
Lydia Kifner, Weston & Sampson		4
Margaret Hoffman, Planning Coordinator		3
Melissa Berry, Conservation Coordinator		2
Michael M. Harvey, School Superintendent		1
Nicci Roebuck, Administrator's Asst		4
Peter Lombardi, Town Administrator		1
Robert Buchsbaum, Mass Audubon		4
Samantha Grantham, Wenham Museum		4
Vicky Masone, Green Communities		3

Community Resilience Building Workshop/Hazard Mitigation Plan Meeting

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January 9, 2018 - 9:00am to 5:00pm

Name and Affiliation	Signature	Table #
Mary Ting Wenham BOH	Mary Ting	

CALENDAR LISTING / MEDIA ADVISORY

WENHAM'S DRAFT HAZARD MITIGATION PLAN TO BE PRESENTED AT MARCH 21, 2019 PUBLIC MEETING

A meeting will be held to present an overview of Wenham's Natural Hazards Mitigation and Municipal Vulnerability Preparedness Plan and to solicit public comments.

Who: Wenham residents, business owners, representatives of non-profit organizations and institutions, and others who are interested in preventing and reducing damage from natural hazards and climate change.

What: The Wenham Planning Department will hold a public meeting to present an overview of Wenham's the draft Natural Hazards Mitigation and Municipal Vulnerability Plan. The plan will identify natural and climate change hazards affecting Wenham, including floods, winter storms, and extreme temperature. It will also present strategies that the Town can take to reduce the impacts of these hazards. When it is finalized, the Plan will be submitted to the Federal Emergency Management Agency (FEMA) for approval.

When: March 21, 2019, 7:00 PM

Where: Town Hall, 138 Main Street, Wenham, MA

Contact: Wenham Planning Department at (978) 468-5520

PUBLIC MEETING NOTICE

Town of Wenham Hazard Mitigation and Municipal Vulnerability Preparedness (MVP) Plan

Wenham's Hazard Mitigation and MVP Plan helps to reduce the Town's vulnerability to the impacts of natural hazards such as flooding, winter storms, and extreme temperatures, as well as impacts from climate change. Please join the Town's Planning Department for a presentation and discussion of the Plan's update.

Date: Thursday, March 21, 2019

Time: 7:00 pm

Location: Wenham Town Hall

Contact: Planning Department at (978) 468-5520

Town of Wenham
Municipal Vulnerability Preparedness and Hazard Mitigation Planning Grant Project
Public Listening Session
Selectmen's Room, Town Hall, 138 Main Street, Wenham, MA
Thursday, March 26, 2019
7:00 pm – 8:30 pm

Agenda

1. **Welcome and Introductions** — 5 minutes
   Margaret Hoffman, Project Manager and Planning Coordinator

2. **Overview of Municipal Vulnerability Preparedness and Hazard Mitigation Planning** — 10 minutes
   Kathy Baskin PE, Project Manager, Weston & Sampson
   Margaret Hoffman, Project Manager and Planning Coordinator

3. **Summary of Hazards, Vulnerabilities & Strengths, and Priority Actions** — 20 minutes
   Margaret Hoffman, Project Manager and Planning Coordinator

4. **Questions and Answers** — 45 minutes
   All

5. **Public Comment Period** — 5 minutes

6. **Conclusions** — 5 minutes
   Margaret Hoffman, Project Manager and Planning Coordinator

welcome

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Municipal Vulnerability Preparedness & Hazard Mitigation Planning

Workshop Findings and Priority Recommendations
&
Review of Draft Municipal Vulnerability Preparedness & Hazard Mitigation Plan

Wenham, Massachusetts
March 21, 2019

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Wenham Project Team Leadership

Municipal Leadership

- Peter Lombardi, Town Administrator
- Margaret Hoffman, Planning Coordinator
- Core Team Members
  - Jeffrey Baxter, Fire Department
  - Greg Bernard, Board of Health
  - Missy Berry, Conservation Commission and Open Space
  - Robert Breaker, Police Department – Emergency Management
  - Jackie Bresnahan, Permitting – Building and Board of Health
  - Stephen Kavanagh, Fire Department
  - Brian Leathe, Building
  - Erik Mansfield, Water
  - Vicky Masone, Energy Manager
  - James Politano, Facilities
  - Nicci Roebuck, Administration
  - Bill Tyack, Public Works

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What MVP and HMP Programs?

Massachusetts: Municipal Vulnerability Preparedness (MVP)

Plan for climate change resiliency and implement priority projects

United States: Hazard Mitigation Planning (HMP)

Reduce loss of life and property by lessening the impact of natural disasters through a long-term mitigation plan

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Definitions

Hazard – potential threat
Sun

Critical Infrastructure – valuable asset
You

Vulnerability – weakness or gap in protection
Being Outdoors

Risk – potential for loss, damage or destruction
Sunburn

Hazard + Critical Infrastructure + Vulnerability = Risk

Mitigation – reduce or eliminate risk
Sunscreen

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What MVP/HMP offers Wenham

- Preparedness for natural & climate hazards
- Collaboration with stakeholders
- Education and planning
- Grant funding for priority actions

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MVP Workshop

- Defined natural hazards (hurricanes, tornadoes, winter storms and earthquakes); climate change hazards
- Identified key features
- Determined vulnerabilities and strengths
- Developed and prioritized actions/mitigation strategies
- Next: Implement mitigation strategies

1. Engage Community → 2. Identify Hazards → 3. Assess Vulnerabilities and Strengths → 4. Develop & Prioritize Actions → 5. Take Action!

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Workshop Participants

Municipal Government
- Building Inspector
- Conservation Commission
- Emergency Management
- Health
- Facilities
- Fire
- Planning
- Police
- Permitting
- Public Works
- School
- Town Administration
- Water Commission

Environmental Groups
- Ipswich River Watershed Association
- Mass Audubon
- Green Communities

Institutions
- National Grid
- Wenham Museum

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Major Natural Hazards in Wenham
Current and Future under Climate Change

Heavy Precipitation/Flooding

Severe Winter/Nor'easter

Other Severe Weather (i.e. Wind)

Hurricane

Erosion

Dam Failure

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More Major Natural Hazards
Current and Future under Climate Change

Rising Temperature/ Extreme Heat

Drought

Wildfires/Brush Fires

Landslides

Tornadoes

Earthquakes

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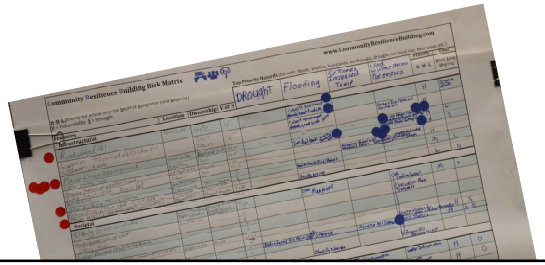
Top Hazards Identified at the Workshop

Drought

Extreme Temperatures (Heat and Cold)

Flooding

Wind, Winter Storms, Nor'easters



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Climate Change Impacts

Entire State (including Wenham)		Coastal Communities only (not Wenham)
Higher Temperatures	More Extreme Precipitation (More droughts, more floods)	~~Sea Level Rise & Coastal Surge~~

Goal: to protect infrastructure, environment, public health & safety, and economy

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Predicted Climate Change

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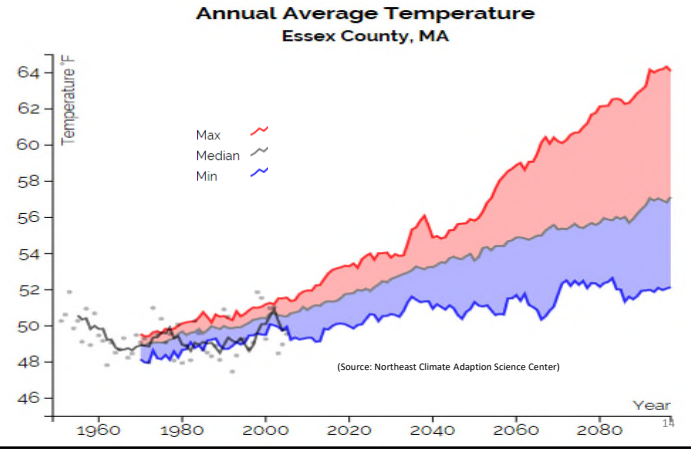
Projected: Annual Average Temperature in Essex County



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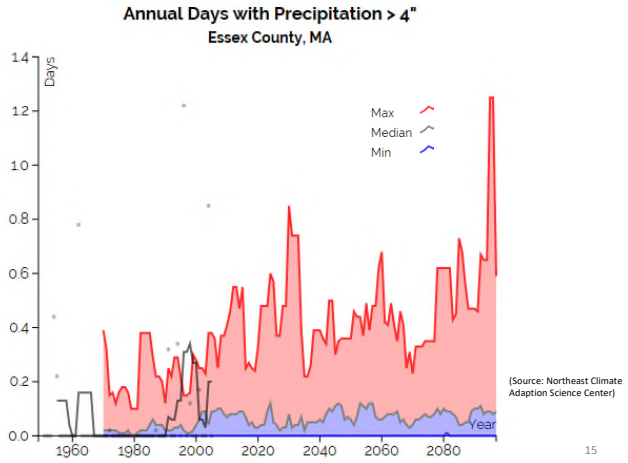
Heavy Precipitation



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Vulnerabilities

Infrastructural

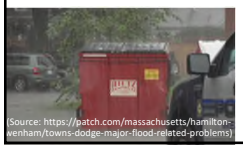
- Buker school
- Roads/ culverts/ drainage
- Utilities
- Communication equipment
- Water supply infrastructure
- Signage for hazards
- Asset management
- Street trees

Societal

- Communication with vulnerable populations, group homes
- Children
- Elderly (60+ and 90+)
- Low income
- Pets

Environmental

- Well zones (water supply)
- Miles River (Beaver dams backup water and cause flooding)
- Invasive species/ insect and vector-borne diseases
- Wetlands/waterbodies
- Ecosystems
- Groundwater


(Source: https://patch.com/massachusetts/hamilton-wenham/towns-dodge-major-flood-related-problems)

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Strengths and Assets

Infrastructural

- Buker School
- Water supply
- Gordon College
- Fire/police/Town Hall/COA
- Regional emergency operations center
- Communication network
- Transportation (roads, MBTA)
- Wastewater (eastern Wenham & Gordon College)
- Energy & communitcation utilities

Societal

- College
- Residents (elderly, children, tech

Environmental

- Water resources (wetlands, streams, lakes)
- Open space
- Forests & street trees
- Farms
- Ecosystems

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High Priority Actions

- *Emergency Shelter*: Buker School as shelter with backup generator, equipment, supplies, communication, and emergency manpower
- *Minimize Flooding*: Maintain and assess culverts, increase capacities as appropriate, control beavers, raise roads (Rte 97)
- *Forest Management*: Remove hazard trees, replant healthy trees, develop tree management protocol, prune trees near to maintain road accessibility and protect aboveground utilities
- *Ensure Communications*: Improve cell phone coverage (i.e. more cell towers or other cell technology), hazard/emergency signage, and backup power sources for communications; improve emergency communication between municipal departments

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High Priority Actions

- *Protect Water Supply*: Conserve water (i.e. drought task force, water bans, and additional water storage); ensure redundancy through backup sources and emergency plans; regional protection of water supply (study and implementation of recommendations); vegetated berms/protective barrier around wells
- *Protect Miles River/Surrounding Environ*nment: Increase efforts to reduce flooding, (i.e. beaver control and dredging); manage overgrown vegetation; control nutrient input; monitor water quality. Collaborate with Beverly, Hamilton, and Ipswich by re-instating the Miles River Collaborative
- *Planning*: Evaluate/update bylaws, regulations, zoning ordinances, and other planning instruments to increase resilience (i.e using Low Impact Development and stormwater management)
- *Emergency Management*: Consider instituting the position of Emergency Manager in town government

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Medium Priority Actions

- *Communicate with Vulnerable Populations*: Improve communications (determine best outreach methods and communication preferences); identify who the vulnerable populations are, including children and the elderly
- *Educate Vulnerable Populations and General Public*: Conduct awareness drills about storm events, educate students about heating and cooling needs, and conduct outreach about emergency plans and mitigation.

- *Determine Location of Young Children*: Determine locations of daycare centers and schools; ensure these centers have redundancy and emergency plans; update local information with the State's list of daycares

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Medium Priority Actions

- *Elderly Population*: Consider checking in on elderly who live alone; develop evacuation plan for those without transportation; consider a transportation service.

(source: landvest.com)

- *Control Invasive Species and Vector-Borne Diseases*: Consider invasive species control plan, engage community in invasive pest control
- *Protect Wetlands/Water R*esources: Control water pollution, including septic system maintenance and stormwater management; conserve water; educate; and local planning/regulations/bylaws
- *Protect Ecosystems*: Remove stressors by increasing connectivity of green spaces, and managing deer population

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Additional Priority Actions

- *Underground Power Lines*: Consider updating bylaws to require underground power lines in new developments and improvements; educate and encourage property owners to install lines underground

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Public Comments

- Comments accepted:
  - March 21, 2019 – April 1, 2019
- Send comments to Margaret Hoffman
  - Email: MHoffman@wenhamma.gov
  - Mail: Margaret R. Hoffman, AICP
    Planning Coordinator
    Town of Wenham
    138 Main Street
    Wenham, MA 01984
  - Phone: 978-468-5520 Ext. 8

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Next Steps

- March 21, 2019 Listening Session: Draft Plan
- Finalize Plan
- Send Plan to MEMA/FEMA for review and approval
- Send to the State for approval
- Apply for grants

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Thank You

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Town of Wenham
Municipal Vulnerability Preparedness and Hazard Mitigation Planning Grant Project
Public Listening Session
Selectmen's Room, Town Hall, 138 Main Street, Wenham, MA
Thursday, March 21, 2019
7:00 pm – 8:30 pm

Meeting Notes

The MVP/HMP Public Listening Session began at 7:00 pm.

Welcome and Introductions

Margaret Hoffman, Wenham's Planning Coordinator, introduced the Municipal Vulnerability Preparedness (MVP) and Hazard Mitigation Planning (HMP) Grant Project to the public. She explained that the purpose of the Listening Session was to engage the public and receive public comment on Town of Wenham's MVP/Hazard Mitigation Planning.

Municipal Vulnerability Preparedness and Hazard Mitigation Planning Overview

Kathy Baskin described the Core Team/Hazard Mitigation Planning Team, which is working under the leadership of Town Administrator Peter Lombardi. Members of the Core Team are:

Margaret Hoffman, Planning Coordinator and HMP-MVP Project Manager
Jeffrey Baxter, Fire Department
Greg Bernard, Board of Health
Melissa Berry, Conservation Commission and Open Space
Robert Breaker, Police Department – Emergency Management
Jackie Bresnahan, Permitting – Building and Board of Health
Stephen Kavanagh, Fire Department
Brian Leathe, Building
Erik Mansfield, Water
Vicky Masone, Energy Manager
James Politano, Facilities
Nicci Roebuck, Administration
Bill Tyack, Public Works

Ms. Baskin described the Massachusetts: Municipal Vulnerability Preparedness (MVP) program as a Massachusetts program that helps municipalities plan for climate change resiliency and implement priority projects. The Hazard Mitigation Planning (HMP) process is a federal program administered through FEMA and helps communities reduce loss of life and property by lessening the impact of natural disasters through a long-term mitigation plan.

The MVP Program offers Wenham:

- Preparedness for natural & climate hazards
- Collaboration with stakeholders
- Education and planning
- Grant funding for priority actions

Community Resilience Building Workshop

The Town hosted a January 9, 2019 Hazard Mitigation Stakeholder/MVP Community Resilience Building Workshop, at which attendees:

- Defined extreme weather hazards and climate change impacts
- Identified key features
- Determined vulnerabilities and strengths
- Developed and prioritized actions
- Completed vulnerability assessments
- Next: Implement key actions

The Workshop included a diverse group of participants. The Town appreciates everyone's participation. There were representatives from the following groups:

Municipal Government

- Building Inspector
- Conservation Commission
- Emergency Management
- Health
- Facilities
- Fire
- Planning
- Police
- Permitting
- Public Works
- School
- Town Administration
- Water Commission

Environmental Groups

- Ipswich River Watershed Association
- Mass Audubon
- Green Communities

Institutions

- National Grid
- Wenham Museum

Summary of Hazards, Vulnerabilities & Strengths, and Priority Actions

Ms. Baskin described the top hazards identified at the Workshop, which were: 1) flooding; 2) drought; 3) high winds, winter storms, and Nor'easters; and 4) extreme temperatures (both hot and cold). She noted that Wenham is already experiencing higher temperatures and more extreme precipitation (more floods and more droughts). These are predicted to increase with climate change. Although sea level rise is a concern along coastal Massachusetts, it is not a concern in Wenham.

Vulnerabilities identified during the Workshop were:

Infrastructural

- Buker school
- Roads/ culverts/ drainage
- Utilities
- Communication equipment
- Water supply infrastructure
- Signage for hazards
- Asset management
- Street trees

Environmental

- Well zones (water supply)
- Miles River (Beaver dams backup water and cause flooding)
- Invasive species/ insect and vector-borne diseases
- Wetlands/waterbodies
- Ecosystems
- Groundwater

Societal

- Communication with vulnerable populations, group homes
- Children
- Elderly (60+ and 90+)
- Low income
- Pets

Strengths identified during the Workshop that will help the Town move forward with resilience and hazard mitigation. They are:

Infrastructural

- Buker School
- Water supply
- Gordon College
- Fire/police/Town Hall/COA
- Regional emergency operations center
- Communication network
- Transportation (roads, MBTA)
- Wastewater (eastern Wenham & Gordon College)
- Energy & communication utilities

Environmental

- Water resources (wetlands, streams, lakes)
- Open space
- Forests & street trees
- Farms
- Ecosystems

Societal

- College
- Residents (elderly, children, tech savvy)
- Safety team
- Socioeconomics/education level

Summary of Findings Report and Priority Actions

Ms. Baskin reported on actions identified during the Workshop for increasing resilience to hazards and climate changes, as identified during the Workshop. They were:

High Priority Actions

- *Emergency Shelter*: Buker School as shelter with backup generator, equipment, supplies, communication, and emergency manpower
- *Minimize Flooding*: Maintain and assess culverts, increase capacities as appropriate, control beavers, raise roads (Route 97)
- *Forest Management*: Remove hazard trees, replant healthy trees, develop tree management protocol, prune trees near to maintain road accessibility and protect aboveground utilities
- *Ensure Communications*: Improve cell phone coverage (i.e. more cell towers or other cell technology), hazard/emergency signage, and backup power sources for communications; improve emergency communication between municipal departments
- *Protect Water Supply*: Conserve water (i.e. drought task force, water bans, and additional water storage); ensure redundancy through backup sources and emergency plans; regional protection of water supply (study and implementation of recommendations); vegetated berms/protective barrier around wells
- *Protect Miles River/Surrounding Environ*ment: Increase efforts to reduce flooding, (i.e. beaver control and dredging); manage overgrown vegetation; control nutrient input; monitor water quality. Collaborate with Beverly, Hamilton, and Ipswich by re-instating the Miles River Collaborative
- *Planning*: Evaluate/update bylaws, regulations, zoning ordinances, and other planning instruments to increase resilience (i.e. using Low Impact Development and stormwater management)
- *Emergency Management*: Consider instituting the position of Emergency Manager in town government

Medium Priority Actions

- *Communicate with Vulnerable Populations*: Improve communications (determine best outreach methods and communication preferences); identify who the vulnerable populations are, including children and the elderly
- *Educate Vulnerable Populations and General Public*: Conduct awareness drills about storm events, educate students about heating and cooling needs, and conduct outreach about emergency plans and mitigation.
- *Determine Location of Young Children*: Determine locations of daycare centers and schools; ensure these centers have redundancy and emergency plans; update local information with the State's list of daycares
- *Elderly Population*: Consider checking in on elderly who live alone; develop evacuation plan for those without transportation; consider a transportation service.
- *Control Invasive Species and Vector-Borne Diseases*: Consider invasive species control plan, engage community in invasive pest control
- *Protect Wetlands/Water R*esources: Control water pollution, including septic system maintenance and stormwater management; conserve water; educate; and local planning/regulations/bylaws
- *Protect Ecosystems*: Remove stressors by increasing connectivity of green spaces, and managing deer population

Additional Priority Actions

- *Underground Power Lines*: Consider updating bylaws to require underground power lines in new developments and improvements; educate and encourage property owners to install lines underground

Public Comments, Questions and Answers

The public engaged in a discussion throughout the presentation. Key discussion points were:

The audience noted that flooding occurs near Gordon College and on Grapevine Road near the Iron Rail building (91 Grapevine Road).

The Wenham Water Use Mitigation Program [WUMP] has been implemented to collect a fee to fund water savings projects to mitigate new water demand. The WUMP program and its fee to offset water demand are applicable to projects that: (1) require a building permit for new construction or an additional dwelling unit (including special permits for accessory apartments), (2) represent a new or increased water demand, and (3) involve residential projects of three or more dwelling units and all commercial projects.

The Town could explore opportunities for providing shelter during extreme weather at existing facilities. These include the Buker School and Gordon College. The college could potentially have the facilities to feed and house people from the community, but only when the school is not in session.

The Town already has records in place that would help for checking in on the elderly during an extreme weather event. It keeps a list of everyone 60 years and over and there is someone on staff who delivers flowers to those over 80 years old on the holidays. (This is a good way to check on their well-being.)

The tick population and associated tick-related human illnesses have exploded recently. This could be due to the warmer weather. Mosquitoes and mosquito-borne diseases are also concerning. There is concern that this condition will worsen with increasing temperatures under climate change. Public education could help to alleviate this situation.

Flooding caused by beavers should be discussed in the report. Some solutions are out of municipal control. Beavers can be trapped but they come back to areas that have fewer beavers in them. The Town should explore other solutions including beaver deceivers.

Tree planting is a priority. Most of the Town's budget for trees is for removal. There is a small amount of funding available for tree planting. This could be used to leverage three times the value spent, if used to match an MVP Action Grant.

Public Comment Period

Ms. Hoffman noted that public comments will be accepted on the draft plan, which will be posted on the town's website, between March 21, 2019 and April 1, 2019. Comments can be sent to Margaret Hoffman.

Email: MHoffman@wenhamma.gov
Mail: Margaret R. Hoffman, AICP
Planning Coordinator
Town of Wenham
138 Main Street
Wenham, MA 01984
Phone: 978-468-5520 Ext. 8

Next Steps

Next steps for the project are for the Town to finalize the Municipal Vulnerability Preparedness and Hazard Mitigation Plan and send it to MEMA for review. Comments from MEMA will be addressed and then the plan will be sent to MEMA, which will forward it to FEMA for review and approval. The Plan will then be adopted by the Town reviewed annually to assess progress toward implementation mitigation strategies. The Plan will be used as the basis for grant applications to FEMA and the MA Executive Office of Energy & Environmental affairs. The Plan will be due to be updated five years after the Town adopts it. Ms. Hoffman thanked the audience for participating.

Town of Wenham
Municipal Vulnerability Preparedness and Hazard Mitigation Planning Grant Project
Selectmen's Room, Town Hall, 138 Main Street, Wenham, MA
Thursday, March 21, 2019, 7:00 pm – 8:30 pm
Public Listening Session Sign-In Sheet

Name	Affiliation	Email	Phone	Signature
PHIL COLARUSSO	CON COMM	COLARUSSO.PHIL@EPA.GOV	978 468-3425	Phil Colarusso
Catherine Harrison	" "	charrison@wenhamma.gov	978-468-3359	
Bob Breaker	E. Management	rbreaker@wenhamma.gov	978-468-5500	
PAUL MENDONCA	WATER COMM	PAUL.E.MENDONCA@GMAIL.COM	978-468-4444	
Margaret Hoffman	Planning Coord			
Kathleen Baskin	Weston + Sampson	baskink@wseinc.com	978-278-3524	
Jackie Bresnahan	Core Team	jbresnahan@wenhamma.gov	978 468-5520 x4	
Jim Reynolds	CON	jreynolds@wenhamma.gov	468-5529	

APPENDIX D

Documentation of Plan Adoption

Town of Wenham

Town Hall
138 Main Street
Wenham, MA 01984

Board of Selectmen and Town Administrator

TEL 978-468-5520 x2 FAX 978-468-8014

CERTIFICATE OF ADOPTION
SELECT BOARD
TOWN OF WENHAM, MASSACHUSETTS

A RESOLUTION ADOPTING THE TOWN OF WENHAM HAZARD MITIGATION PLAN 2019 UPDATE

WHEREAS, the Town of Wenham established a Committee to prepare the Town of Wenham Hazard Mitigation Plan 2019 Update; and

WHEREAS, the Town of Wenham Hazard Mitigation Plan 2019 Update contains several potential future projects to mitigate potential impacts from natural hazards in the Town of Wenham, and

WHEREAS, duly-noticed public meetings were held by the WENHAM PLANNING BOARD on March 29, 2018, and the WENHAM SELECT BOARD on December 3, 2018, and

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

NOW, THEREFORE BE IT RESOLVED that the Town of WENHAM SELECT BOARD adopts the Town of Wenham Hazard Mitigation Plan 2019 Update, in accordance with M.G.L. 40 §4 or the charter and bylaws of the Town of Wenham.

ADOPTED AND SIGNED this Date. 08-20-2019

John O. Wilhelm, Chairman

John A. Clemenzi, Vice Chairman

Catherine A. Harrison, Clerk

APPENDIX E

Documentation of Plan Approval

U.S. Department of Homeland Security
FEMA Region I
99 High Street, Sixth Floor
Boston, MA 02110-2132

FEMA

SEP 10 2019

Samantha C. Phillips, Director
Massachusetts Emergency Management Agency
400 Worcester Road
Framingham, Massachusetts 01702-5399

Dear Director Phillips:

The U.S. Department of Homeland Security, Federal Emergency Management Agency (FEMA) Region I Mitigation Division has approved the Town of Wenham Hazard Mitigation Plan and Municipal Vulnerability Preparedness Plan 2019 effective **August 27, 2019** through **August 26, 2024** in accordance with the planning requirements of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), as amended, the National Flood Insurance Act of 1968, as amended, and Title 44 Code of Federal Regulations (CFR) Part 201.

With this plan approval, the jurisdiction is eligible to apply to the Massachusetts Emergency Management Agency for mitigation grants administered by FEMA. Requests for funding will be evaluated according to the eligibility requirements identified for each of these programs. A specific mitigation activity or project identified in this community's plan may not meet the eligibility requirements for FEMA funding; even eligible mitigation activities or projects are not automatically approved.

The plan must be updated and resubmitted to the FEMA Region I Mitigation Division for approval every five years to remain eligible for FEMA mitigation grant funding.

Thank you for your continued commitment and dedication to risk reduction demonstrated by preparing and adopting a strategy for reducing future disaster losses. Should you have any questions, please contact Melissa Surette at (617) 956-7559 or Melissa.Surette@fema.dhs.gov.

Sincerely,

Captain W. Russ Webster, USCG (Ret.), CEM
Regional Administrator
FEMA Region I

WRW:ms

cc: Sarah White, State Hazard Mitigation Officer, MEMA
Jeffrey Zukowski, Hazard Mitigation Planner, MEMA
Beth Dubrawski, Hazard Mitigation Contract Specialist, MEMA