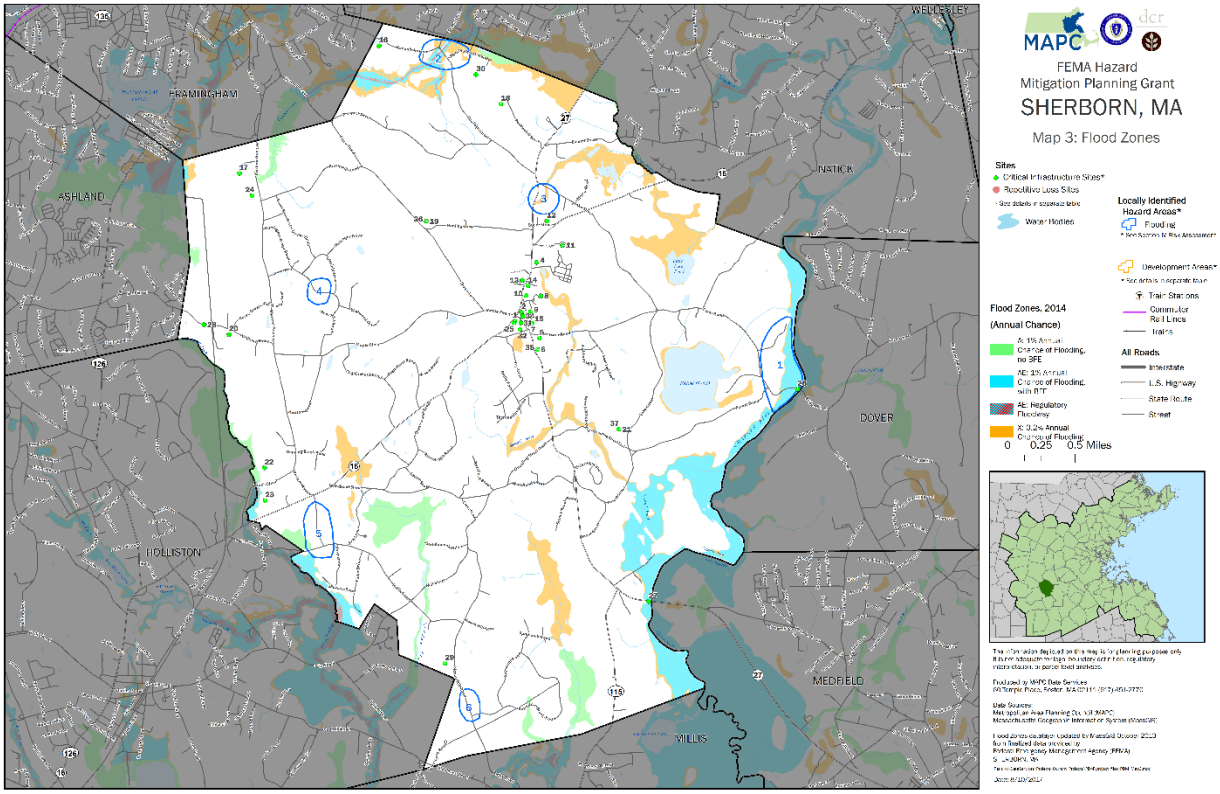
TOWN OF SHERBORN
HAZARD MITIGATION PLAN



TOWN of SHERBORN
SETTLED
1652
1674

MAPC 50 YEARS
METROPOLITAN AREA PLANNING COUNCIL
SMART GROWTH AND REGIONAL COLLABORATION

Final Plan
FEMA Approval Pending Adoption
February 7, 2019

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ACKNOWLEDGEMENTS AND CREDITS

This plan was prepared for the Town of Sherborn by the Metropolitan Area Planning Council (MAPC) under the direction of the Massachusetts Emergency Management Agency (MEMA) and the Massachusetts Department of Conservation and Recreation (DCR).

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MAPC
METROPOLITAN AREA PLANNING COUNCIL

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I EXECUTIVE SUMMARY

Hazard Mitigation planning is a proactive effort to identify actions that can be taken to reduce the dangers to life and property from natural hazard events. In the communities of the Boston region of Massachusetts, hazard mitigation planning tends to focus most on flooding, the most likely natural hazard to impact these communities. The Federal Disaster Mitigation Act of 2000 requires all municipalities that wish to be eligible to receive FEMA funding for hazard mitigation grants, to adopt a local multi-hazard mitigation plan and update this plan in five year intervals.

Planning Process

This is Sherborn's first Hazard Mitigation Plan. The planning process was led by the Sherborn Local Hazard Mitigation Planning Team, composed of staff from a number of different Town Departments. This team met on October 17, 2016; June 6, 2017; October 11, 2017; January 3, 2018; and March 19, 2018 and discussed where the impacts of natural hazards most affect the Town, goals for addressing these impacts, existing mitigation measures and new hazard mitigation measures that would benefit the Town.

Public participation in this planning process is important for improving awareness of the potential impacts of natural hazards and to build support for the actions the Town takes to mitigate them. The Town's Hazard Mitigation Planning Team hosted two public meetings, the first on May 30, 2017 and the second on July 9, 2018, and the draft plan was posted on the Town's website for public review. Key town stakeholders and neighboring communities were notified and invited to review the draft plan and submit comments. No comments were submitted to the town.

Risk Assessment

The Sherborn Hazard Mitigation Plan assesses the potential impacts to the town from flooding, high winds, winter storms, brush fire, geologic hazards, extreme temperatures, and drought. These are shown on the map series (Appendix B).

The Sherborn Local Hazard Mitigation Planning Team identified 37 Critical Facilities. These are also shown on the map series and listed in 37, identifying which facilities are located within the mapped hazard zones.

A HAZUS-MH analysis provided estimates of damages from Hurricanes of category 2 and 4 ($4.5 to $15 million), earthquakes of magnitudes 5 and 7 ($70 to $172 million), and flood damage estimates for the 100- and 500-year storms ($520,000 to $880,000).

Hazard Mitigation Goals

The Sherborn Local Hazard Mitigation Planning Team identified the following hazard mitigation goals for the Town:

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

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

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

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

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

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

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

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

Goal 9: Consider the potential impacts of future climate change. Incorporate climate sustainability and resiliency in hazard mitigation planning.

Hazard Mitigation Strategy

The Sherborn Local Hazard Mitigation Planning Team identified a number of mitigation measures that would serve to reduce the town's vulnerability to natural hazard events. These include replacing and enlarging culverts, creating a management plan for beaver dam-related issues, providing public education, and more.

Overall, the hazard mitigation strategy recognizes that mitigating hazards for Sherborn will be an ongoing process as our understanding of natural hazards and the steps that can be taken to mitigate their damages changes over time. Global climate change and a variety of other factors impact the Town's vulnerability now and in the future, and local officials will need to work together across municipal lines and with state and federal agencies in order to understand and address these changes. The Hazard Mitigation Strategy will be incorporated into the Town's other related plans and policies.

Plan Process

The process for developing Sherborn's Hazard Mitigation Plan is summarized in Table 1. Moving forward into the five year plan implementation period there will be many opportunities to incorporate hazard mitigation into the Town's decision making processes. The Town of Sherborn will document any actions taken in this iteration of the Hazard Mitigation Plan, including

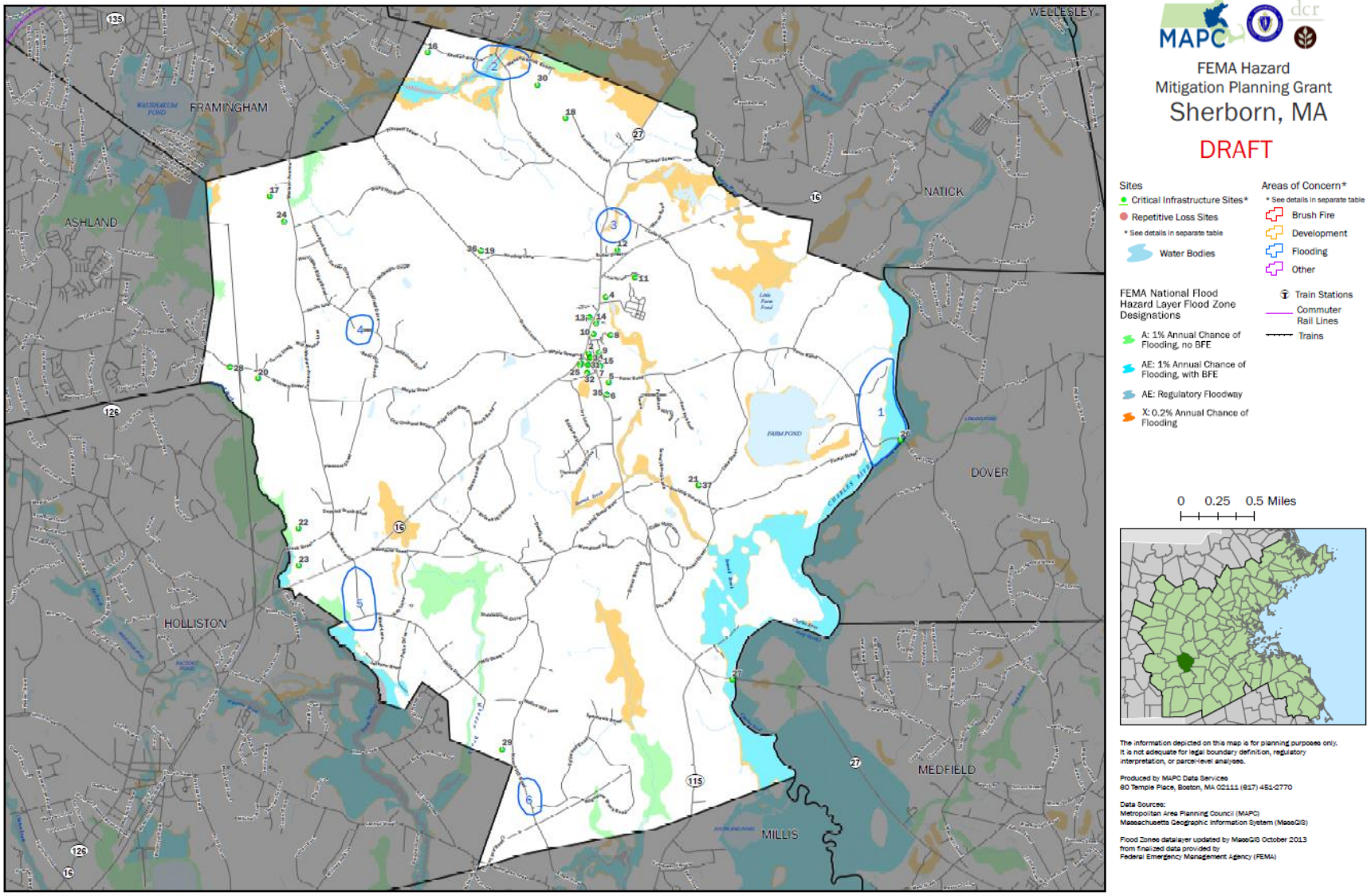
challenges met and actions successfully adopted as part of the ongoing plan maintenance to be conducted by the Sherborn Hazard Mitigation Implementation Team, as described in Section VIII, Plan Adoption and Maintenance.

Table 1: Plan Development and Process

Chapter	Reviews and Updates
III – Public Participation	The Local Hazard Mitigation Planning Team placed an emphasis on public participation for developing the Hazard Mitigation Plan, discussing strategies to enhance participation opportunities at the first local committee meeting. During plan development, the plan was discussed at two public meetings hosted by the Emergency Management Team and the Select Board. The plan was also available on the Town's website for public comment. No comments were submitted to the town.
IV – Risk Assessment	MAPC gathered the most recently available hazard and land use data and met with Town staff to identify local hazard areas and development trends. Town staff developed a list of critical infrastructure with MAPC staff in order to identify potential risks. MAPC also used the most recently available version of HAZUS to assess potential impacts of flooding, earthquakes, and hurricanes.
V – Goals	The Hazard Mitigation Goals were established and endorsed by the Sherborn Local Hazard Mitigation Planning Team.
VI – Existing Mitigation Measures	A list of existing mitigation measures was compiled to reflect current mitigation activities in the Town.
VII – Hazard Mitigation Strategy	The Plan's hazard mitigation strategy reflects both new planned measures and those that were identified as currently in place. The Local Hazard Mitigation Team prioritized all of these measures based on current conditions.
VIII – Plan Adoption & Maintenance	This section of the plan was designed with an on-going plan for implementation review and a five year update process that will assist the Town in incorporating hazard mitigation issues into other Town planning and regulatory review processes and better prepare the Town for the next comprehensive plan update.

Moving forward into the five year plan implementation period there will be many opportunities to incorporate hazard mitigation into the Town's decision making processes. The Town will document any actions taken pursuant to this Hazard Mitigation Plan as part of the ongoing plan maintenance to be conducted by the Town, as described in Section VIII, Plan Adoption and Maintenance.

Figure 1: Existing Features: Critical Facilities and Local Hazard Areas



II INTRODUCTION

Planning Requirements under the Federal Disaster Mitigation Act

The Federal Disaster Mitigation Act, passed in 2000, requires that after November 1, 2004, all municipalities that wish to be eligible to receive FEMA funding for hazard mitigation grants must adopt a local multi-hazard mitigation plan and update this plan in five year intervals. This planning requirement does not affect disaster assistance funding.

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 Department of Conservation and Recreation (DCR).

Massachusetts has taken a regional approach and has encouraged the regional planning agencies to apply for grants to prepare plans for groups of their member communities. The Metropolitan Area Planning Council (MAPC) received a grant from the Federal Emergency Management Agency (FEMA) under the Pre-Disaster Mitigation (PDM) Program, to assist the Town of Sherborn in writing its first Hazard Mitigation Plan. The local Hazard Mitigation Plan produced under this contract is designed to individually meet the requirements of the Disaster Mitigation Act for each community while listing regional concerns and hazards that impact the Town or City creating the plan.

What is a Hazard Mitigation Plan?

Natural hazard mitigation planning is the process of determining how to systematically reduce or eliminate the loss of life and property damage resulting from natural hazards such as floods, earthquakes, and hurricanes. Hazard mitigation means to permanently reduce or alleviate the losses of life, injuries, and property damage resulting from natural hazards through long-term strategies. These long-term strategies include planning, policy changes, programs, projects, and other activities.

Previous Federal/State Disasters

The Town of Sherborn has experienced 17 natural hazards that triggered federal or state disaster declarations since 1991. These are listed in Table below. The majority of these events involved flooding, while six were due to hurricanes or nor'easters, and six were due to severe winter weather.

Table 2: Previous Federal/State Disaster Declarations

DISASTER NAME (DATE OF EVENT)	TYPE OF ASSISTANCE	DECLARED AREAS
Hurricane Bob (August 1991)	FEMA Public Assistance Project Grants	Counties of Barnstable, Bristol, Dukes, Essex, Hampden, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk
	Hazard Mitigation Grant Program	Counties of Barnstable, Bristol, Dukes, Essex, Hampden, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk (16 projects)
No-Name Storm (October 1991)	FEMA Public Assistance Project Grants	Counties of Barnstable, Bristol, Dukes, Essex, Middlesex, Plymouth, Nantucket, Norfolk
	FEMA Individual Household Program	Counties of Barnstable, Bristol, Dukes, Essex, Middlesex, Plymouth, Nantucket, Norfolk
	Hazard Mitigation Grant Program	Counties of Barnstable, Bristol, Dukes, Essex, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk (10 projects)
March Blizzard (March 1993)	FEMA Public Assistance Project Grants	All 14 Counties
January Blizzard (January 1996)	FEMA Public Assistance Project Grants	All 14 Counties
October Flood (October 1996)	FEMA Public Assistance Project Grants	Counties of Essex, Middlesex, Norfolk, Plymouth, Suffolk
	FEMA Individual Household Program	Counties of Essex, Middlesex, Norfolk, Plymouth, Suffolk
	Hazard Mitigation Grant Program	Counties of Essex, Middlesex, Norfolk, Plymouth, Suffolk (36 projects)
1997	HUD Community Development Block Grant	Counties of Essex, Middlesex, Norfolk, Plymouth, Suffolk

DISASTER NAME (DATE OF EVENT)	TYPE OF ASSISTANCE	DECLARED AREAS
June Flood (June 1998)	FEMA Individual Household Program	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
	Hazard Mitigation Grant Program	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester (19 projects)
(1998)	HUD Community Development Block Grant	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
March Flood (March 2001)	FEMA Individual Household Program	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
	Hazard Mitigation Grant Program	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester (16 projects)
February Snowstorm (February 17-18, 2003)	FEMA Public Assistance Project Grants	All 14 Counties
January Blizzard (January 22-23, 2005)	FEMA Public Assistance Project Grants	All 14 Counties
Hurricane Katrina (August 29, 2005)	FEMA Public Assistance Project Grants	All 14 Counties
May Rainstorm/Flood (May 12-23, 2006)	Hazard Mitigation Grant Program	Statewide
April Nor'easter (April 15-27, 2007)	Hazard Mitigation Grant Program	Statewide
Flooding (March, 2010)	FEMA Public Assistance, FEMA Individuals and Households Program, SBA Loan	Bristol, Essex, Middlesex, Suffolk, Norfolk, Plymouth, Worcester
	Hazard Mitigation Grant Program	Statewide
Tropical Storm Irene (August 27-28, 2011)	FEMA Public Assistance	Statewide

DISASTER NAME (DATE OF EVENT)	TYPE OF ASSISTANCE	DECLARED AREAS
Hurricane Sandy (October 27-30, 2012)	FEMA Public Assistance	Statewide
Severe Snowstorm and Flooding (February 8-9, 2013)	FEMA Public Assistance; Hazard Mitigation Grant Program	Statewide
Blizzard of 2015 (January 26-28, 2015)	FEMA Public Assistance; Hazard Mitigation Grant Program	Statewide

Source: Database provided by MEMA

FEMA Funded Mitigation Projects

The Town of Sherborn has not received funding from FEMA for mitigation projects under the various Hazard Mitigation Grant Programs.

Community Profile

Sherborn, Massachusetts, is located in the southeast corner of Middlesex County between three growing metropolitan areas: Boston is eighteen miles northeast, Worcester is twenty-two miles west, and Providence is thirty miles south. Five miles long from north to south, and four miles from east to west, Sherborn has an area of sixteen square miles, or 10,328 acres. Three state numbered routes run through town (Routes 16, 27, & 115), and carry considerable amounts of commuter and commercial traffic to the larger commercial centers outside of town.

Settled in 1652 and incorporated in 1674, the town is proud of its rural heritage. This heritage is still evident in active farms and orchards, along winding tree-lined roads, and preserved in the Town Forest and other extensive public lands. When driving into Sherborn, the open fields lined with stonewalls and historic single-family homes that distinguish Sherborn's character are immediately noted. Sherborn has no industrial districts and the majority of the town is broken into one-, two-, and three-acre lot residential zones.

Open space comprises more than 50% of the town's area. Sherborn has retained its rural character principally because lands have been acquired as protected open space and because the difficulty of establishing septic systems in Sherborn's soils (e.g., high groundwater, bedrock, wetlands, and dense soils) has tended to slow growth. Sherborn relies on individual wells to supply its water and regards protection of groundwater as one of its highest priorities.

Sherborn and the towns surrounding it were primarily farming communities, although cider mills and products such as willow baskets, tools, whips, and shoes contributed to the economy in the nineteenth century. Apple trees grew well in the rocky soils, and by the 1890s one of the town's

cider mills was advertised as the largest refined cider mill in the world. Sherborn experienced a substantial period of growth and construction from the mid-1950s to the early 1970s. In the 1950s, Main Street underwent a building boom as old homes were repaired and empty lots were developed. The surrounding growing metropolitan communities saw Sherborn as a peaceful rural community to live in. Farming began to decline as people moved to Sherborn while commuting to work in the city. The influx of new residents with high tech jobs has paralleled a great reduction of active farms.

There is no MBTA, private bus service or Sherborn taxi service. Commuter Rail service is available in the neighboring towns of Ashland, Framingham, Natick, and Wellesley. Passenger and freight air service is available at Logan International Airport in Boston (twenty miles to the northeast). Express bus service to Logan Airport is also available five miles away in Framingham.

Sherborn is located in the Charles River and Sudbury River watersheds. Farm Pond, a major feature in Sherborn, is a "Great Pond," a legal term established by the Great and General Court in 1649 to indicate a natural pond that reserved fishing rights for all settlers. This statute remains in effect today; "Great Ponds," and therefore Farm Pond, must remain open to the general public for fishing. Farm Pond was also an important source for ice cutting. In the late 1800s, up to 3,000 tons of ice per year were cut and stored in several double-walled barns insulated with sawdust.

The Town is governed by a five-member Select Board and a Town Administrator and operates under the open town meeting format. The Town Administrator, appointed by the Select Board, carries out the day-to-day governing functions of the town.

There are approximately 700 jobs in Sherborn. According to 2016 American Community Survey (ACS) 5-year Estimates, 4,255 people live in Sherborn. Of the town's 1,539 housing units, about a fifth were built before 1940.

Sherborn has several unique characteristics to keep in mind while planning for natural hazards:

- Sherborn is a semi-rural community with active farms and orchards.
- Since all properties in the town have individual wells and septic systems, aquifer protection is a high priority.
- Sherborn zoning allows primarily one-, two-, and three-acre residential lots and there are no industrial districts.
- While flooding in the town is not a significant threat to lives or property, there are some problems with water inundation during high rain and storm events and during the spring snowmelt season.
- A defining characteristic of the town are its tree-lined streets. Although these trees are vulnerable to high winds and ice storms, they are a tradeoff residents are willing to have.
- In recent years, beaver dams have flooded areas and caused management issues.
- Sherborn is home to historic structures and sites that are irreplaceable and bring economic value to the town. A fifth of homes in town were built before 1940.
- Sherborn would be a good candidate for flood-related grants due to the potential impact to property, transportation emergency routes, and economic and historic resources, as well as the ability to solve the flooding problems through structural measures such as culvert

upgrades, dam and bridge upgrades, or flood proofing. The cost-benefit analysis would likely be in the town's favor.

- Much of the critical infrastructure in Sherborn is clustered near the Town Center, and in some cases near areas of floodplain. These facilities are therefore at higher risk of damage.

The Town of Sherborn maintains a website at http://sherbornma.org/

Table 3: Sherborn Characteristics

Population = 4,255 people

- 4.7% are under age 5
- 24.4% are under age 18
- 16.1% are over age 65
- 6.2% have a disability
- 1.5% over age 5 speak English less than "very well"

Number of Housing Units = 1,539

- 7.2% are renter-occupied housing units
- 19.4% of housing units were built before 1940
- 93.0% of housing units are single family homes

Source: 2016 American Community Survey 5-Year Estimates

III PLANNING PROCESS & PUBLIC PARTICIPATION

MAPC employs a six-step planning process based on FEMA's hazard mitigation planning guidance focusing on local needs and priorities, but maintaining a regional perspective matched to the scale and nature of natural hazard events. Public participation is a central component of this process, providing critical information about the local occurrence of hazards while also serving as a means to build a base of support for hazard mitigation activities. MAPC supports participation by the general public and other plan stakeholders through Local Hazard Mitigation Planning Teams, two public meetings hosted by the local Hazard Mitigation Team, posting of the plan to the Town's website, and invitations sent to neighboring communities, Town boards and commissions, the local chamber of commerce, and other local or regional entities to review the plan and provide comment.

Planning Process Summary

The six-step planning process outlined below is based on the guidance provided by FEMA in the Local Multi-Hazard Mitigation Planning Guidance. Public participation is a central element of this process, which attempts to focus on local problem areas and identify needed mitigation measures based on where gaps occur in the existing mitigation efforts of the municipality. By working on municipal hazard mitigation plans in groups of neighboring cities and towns, MAPC is able to identify regional opportunities for collaboration and facilitate communication between communities. The planning process is described in Figure 2 below.

Figure 2: Six-Step Planning Process

1. Map the Hazards – MAPC relies on data from a number of different federal, state, and local sources in order to map the areas with the potential to experience natural hazards. This mapping represents a multi-hazard assessment of the municipality and is used as a set of base maps for the remainder of the planning process. A particularly important source of information is the knowledge drawn from local municipal staff on where natural hazard impacts have occurred. These maps can be found in Appendix B.

2. Assess the Risks & Potential Damages – Working with local staff, critical facilities, infrastructure, vulnerable populations, and other features are mapped and contrasted with the hazard data from the first step to identify those that might represent particular vulnerabilities to these hazards. Land use data and development trends are also incorporated into this analysis. In addition, MAPC develops estimates of the potential impacts of certain hazard events on the community. MAPC drew on the following resources to complete the plan:

    - Town of Sherborn, General By-Laws
    - Town of Sherborn, Zoning By-Law
    - FEMA, Local Mitigation Plan Review Guide; October 1, 2011
    - FEMA, Flood Insurance Rate Maps for Middlesex County, MA, 2014
    - Massachusetts State Hazard Mitigation Plan, 2013
    - Metropolitan Area Planning Council, GIS Lab, Regional Plans and Data.
    - New England Seismic Network, Boston College Weston Observatory
    - NOAA National Centers for Environmental Information, http://www.ncdc.noaa.gov/
    - Northeast States Emergency Consortium, http://www.nesec.org/
    - US Census, 2010

3. Review Existing Mitigation – Municipalities in the Boston Metropolitan Region have an active history in hazard mitigation as most have adopted flood plain zoning districts, wetlands protection programs, and other measures as well as enforcing the State building code, which has strong provisions related to hazard resistant building requirements. All current municipal mitigation measures were documented (see Chapter VI).

4. Develop Mitigation Strategies – MAPC works with the local municipal staff to identify new mitigation measures, utilizing information gathered from the hazard identification, vulnerability assessments, and the community's existing mitigation efforts to determine where additional work is necessary to reduce the potential damages from hazard events. Additional information on the development of hazard mitigation strategies can be found in Chapter VII.

5. Plan Approval & Adoption – Once a final draft of the plan is complete it is sent to MEMA for the state level review and, following that, to FEMA for approval. Once FEMA has approved the plan, the agency issues a notice of Approval Pending Adoption, with the condition being adoption of the plan by the municipality. More information on plan adoption can be found in Chapter VIII and documentation of plan adoption can be found in Appendix D.

6. Implement & Update the Plan – Implementation is the final and most important part of any planning process. Hazard Mitigation Plans must also be updated on a five year basis making preparation for the next plan update an important on-going activity. Chapter VIII includes more detailed information on plan implementation.

The Local Multiple Hazard Community Planning Team

MAPC worked with the local community representatives to organize a Local Hazard Mitigation Planning Team for Sherborn. MAPC briefed the local representatives as to the desired composition of that team as well as the need for public participation in the local planning process.

The Local Hazard Mitigation Planning Team is central to the planning process as it is the primary body tasked with developing a mitigation strategy for the community. The local team was tasked with working with MAPC to set plan goals, provide information on the hazards that impact the town, existing mitigation measures, and helping to develop new mitigation measures for this plan. The Local Hazard Mitigation Planning Team had the following membership:

David Williams, *Town Administrator*
Diane Moores, *Assistant Town Administrator*
Erron Kinney, *Fire Chief*
Sean Killeen, *Community Maintenance and Development Director*
Richard Thompson, *Chief of Police*
Gino Carlucci, *Town Planner*
Allary Braitsch, *Conservation Administrator*
Sharon MacPherson, *Finance Director*
John McAvoy, *General Foreman*
David Bento, *Police Lieutenant*
Jim Graziano, *Police Officer*

The Local Hazard Mitigation Planning Team met on: October 17, 2016; June 6, 2017; October 11, 2017; January 3, 2018; and March 19, 2018. At the first meeting, MEMA representatives reviewed the Hazard Mitigation Planning process. The purpose of the second meeting included developing hazard mitigation goals, and gathering information on local hazard mitigation issues, and sites or areas related to these. The third meeting focused on verifying information gathered by MAPC staff and discussion of existing mitigation practices. The fourth and fifth meetings focused on developing the plan's recommendations. The agendas for these meetings are included in Appendix A.

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

Public Meetings

Public participation in the hazard mitigation planning process is important, both for plan development and for later implementation of the plan. Residents, business owners, and other community members are an excellent source for information on the historic and potential impacts of natural hazard events and particular vulnerabilities the community may face from these hazards. Their participation in this planning process also builds understanding of the concept of hazard mitigation, potentially creating support for mitigation actions taken in the future to

implement the plan. To gather this information and educate residents on hazard mitigation, the Town hosted two public meetings, one during the planning process and one after a complete draft plan was available for review.

Unless there has been a recent hazard event, natural hazard mitigation plans unfortunately rarely attract much public involvement in the Boston region. One of the best strategies for overcoming this challenge is to include discussion of the hazard mitigation plan on the agenda of an existing board or commission. With this strategy, the meeting receives widespread advertising and a guaranteed audience of the board or commission members plus those members of the public who attend the meeting. These board and commission members represent an engaged audience that is informed and up to date on many of the issues that relate to hazard mitigation planning in the locality and will likely be involved in plan implementation, making them an important audience with which to build support for hazard mitigation measures. In addition, these meetings frequently receive press coverage, expanding the audience that has the opportunity to hear the presentation and provide comment.

The public had an opportunity to provide input to the Sherborn hazard mitigation planning process during a Planning Board meeting at Sherborn Town Hall on August 15, 2017. The draft plan was also presented at a Planning Board meeting on July 9, 2018 at Sherborn Town Hall. Both meetings were publicized in accordance with the Massachusetts Public Meeting Law. See public meeting notices in Appendix C.

Local Stakeholder Involvement

The local Hazard Mitigation Planning Team was encouraged to reach out to local stakeholder that might have an interest in the Hazard Mitigation Plan including neighboring communities, agencies, businesses, nonprofits, and other interested parties. Notice was sent to the following organizations and neighboring municipalities inviting them to review the Hazard Mitigation Plan and submit comments to the Town:

- Town of Framingham
- Town of Natick
- Town of Dover
- Town of Medfield
- Town of Millis
- Town of Holliston
- Town of Ashland
- Metrowest Chamber of Commerce
- IBM Sherborn
- Aggregate Industries
- The Middlesex Corporation
- Curtiss-Wright Controls
- Donelan's Supermarkets, Inc.
- Dover Saddlery, Inc.
- Market Basket
- MRV Communications, Inc.
- Salary.com, Inc.
- Life Care Center of Nashoba Valley
- Mevion Medical System

Town Website

The draft Sherborn Hazard Mitigation Plan was posted on the Town's website after the second public meeting. Members of the public could access the draft document and submit comments or questions to the Town.

Continuing Public Participation

Following the adoption of the plan, the planning team will continue to provide residents, businesses, and other stakeholders the opportunity to learn about the hazard mitigation planning process and to contribute information that will update the town's understanding of local hazards. As updates and a review of the plan are conducted by the Sherborn Hazard Mitigation Implementation Team, they will be placed on the Town's website. Any meetings of the Hazard Mitigation Implementation Team will be publicly noticed in accordance with town and state open meeting laws.

Planning Timeline

June 6, 2017	Meeting#1 of the Sherborn Local Hazard Mitigation Planning Team
August 15, 2017	First Public Meeting with Sherborn Planning Board
October 11, 2017	Meeting#2 of the Sherborn Local Hazard Mitigation Planning Team
January 3, 2018	Meeting#3of the Sherborn Local Hazard Mitigation Planning Team
March 19, 2018	Meeting#4 of the Sherborn Local Hazard Mitigation Planning Team
July 10, 2018	Second Public Meeting with Sherborn Planning Board
August 29, 2018	Draft Plan submitted to MEMA
December 20, 2018	Revised Draft Plan submitted to MEMA
February 7, 2019	Notice of Approvable Pending Adoption received from FEMA

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IV RISK ASSESSMENT

The risk assessment analyzes the potential natural hazards that could occur within the Town of Sherborn as well as the relationship between those hazards and current land uses, potential future development, and critical infrastructure. This section also includes a vulnerability assessment that estimates the potential damages that could result from certain large scale natural hazard events.

In order to conduct Sherborn's risk assessment, MAPC gathered the most recently available hazard and land use data and met with Town staff to identify local hazard areas and development trends. MAPC also used FEMA's damage estimation software, HAZUS, which is described later in this section.

Overview of Hazards and Impacts

The Massachusetts Hazard Mitigation Plan provides an in-depth overview of natural hazards in Massachusetts. Previous state and federal disaster declarations since 1991 are summarized in Table 2. Table 4 below summarizes the hazard risks for Massachusetts and the Town of Sherborn. This evaluation takes into account the frequency of the hazard, historical records, and variations in land use. This analysis is based on the vulnerability assessment in the Massachusetts State Hazard Mitigation Plan. The statewide assessment was modified to reflect local conditions in Sherborn using the definitions for hazard frequency and severity listed below. Based on this, the Town set an overall priority for each hazard.

Table 4: Hazard Risks Summary

Hazard	Frequency		Severity	
	Massachusetts	Sherborn	Massachusetts	Sherborn
Flooding	High	High	Serious	Serious
Dam failures	Very Low	Very Low	Extensive	Extensive
Coastal Hazards	High	N/A	Serious	N/A
Tsunami	Very Low	N/A	Extensive	N/A
Hurricane/Trop Storm	Medium	Medium	Serious	Serious
Tornadoes	Medium	Low	Serious	Serious
Thunderstorms	High	High	Minor	Minor
Nor'easter	High	High	Minor	Minor
Winter-Blizzard/Snow	High	High	Minor	Minor
Winter-Ice Storms	Medium	Medium	Minor	Minor
Ice Jams	Low	N/A	Serious	N/A
Earthquakes	Very Low	Medium	Serious	Serious
Landslides	Low	Very Low	Minor	Minor
Brush fires	Medium	Medium	Minor	Serious
Major Urban Fires	Low	N/A	Minor	N/A
Extreme Temperatures	Medium	Medium	Minor	Minor
Drought	Low	Low	Minor	Minor

Source: Massachusetts State Hazard Mitigation Plan, 2013, modified for Sherborn

Of the hazards listed in the 2013 Massachusetts State Hazard Mitigation Plan, several hazard categories are not applicable to the Town of Sherborn, including: coastal hazards and tsunamis, due to the town's inland location away from the coast; and major urban fires, due to the lack of significant urban areas in close proximity to wildfire hazards that could pose a significant threat of major urban fires. In addition, The US Army Corps Ice Jam Database shows no record of ice jams in Sherborn.

Definitions Used in the Commonwealth of Massachusetts State Hazard Mitigation Plan

Frequency

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

Flood-Related Hazards

Flooding has not been a major natural hazard identified by local officials in Sherborn, however the town does contain several floodplain areas and is also subject to localized flooding. Despite the limited flooding exposure, the town has been active in implementing regulatory strategies that will serve to prevent future flooding by preserving natural capacity for stormwater infiltration. Flooding can occur during hurricanes, nor'easters, severe rainstorms and thunderstorms. Flooding is generally caused by hurricanes, nor'easters, severe rainstorms, and thunderstorms. Global climate change has the potential to exacerbate these issues over time with the potential for changing rainfall patterns leading to heavier storms.

Regionally Significant Floods

There have been a number of major floods that have affected the Metro Boston region over the last fifty years. Significant historic flood events in Sherborn have included:

- The Blizzard of 1978
- January 1979
- April 1987
- October 1991 ("The Perfect Storm")
- October 1996
- June 1998
- March 2001
- April 2004
- May 2006
- April 2007
- March 2010

Local data for previous flooding occurrences are not collected by the Town of Sherborn. The best available local data is for Middlesex County through the National Climatic Data Center (see Table 5). Middlesex County, which includes the Town of Sherborn, experienced 60 flood events from 1996 to 2016. No deaths or injuries were reported and the total reported property damage in the county was $41.9 million dollars. Of that total, $35.2 million was attributed to the two major flood events in March 2010.

Table 5: Middlesex County Flood Events, 1996-2018

Date	Deaths	Injuries	Property Damage ($)
1/29/1996	0	0	0
4/17/1996	0	0	0
9/18/1996	0	0	0
10/21/1996	0	0	0
10/22/1996	0	0	0
3/10/1998	0	0	0
3/11/1998	0	0	0
5/12/1998	0	0	0
6/14/1998	0	0	0
6/15/1998	0	0	0
6/17/1998	0	0	0
4/22/2000	0	0	0
4/23/2000	0	0	0
3/22/2001	0	0	0
3/23/2001	0	0	0
3/31/2001	0	0	0
4/1/2001	0	0	0
4/2/2004	0	0	0
4/15/2004	0	0	0
3/29/2005	0	0	0
10/15/2005	0	0	225,000
5/13/2006	0	0	5,000,000
7/11/2006	0	0	2,000
10/28/2006	0	0	5,000
4/16/2007	0	0	25,000
2/13/2008	0	0	0
5/27/2008	0	0	3,000
6/24/2008	0	0	10,000
6/29/2008	0	0	5,000
8/10/2008	0	0	15,000
8/10/2008	0	0	40,000
9/6/2008	0	0	15000
12/12/2008	0	0	20000
3/14/2010	0	0	26,430,000
3/29/2010	0	0	8,810,000

Date	Deaths	Injuries	Property Damage ($)
4/1/2010	0	0	0
8/28/2011	0	0	5,000
10/14/2011	0	0	0
6/8/2012	0	0	0
6/23/2012	0	0	15,000
7/18/2012	0	0	5,000
10/29/2012	0	0	0
6/7/2013	0	0	0
7/1/2013	0	0	0
7/23/2013	0	0	0
9/1/2013	0	0	10,000
3/30/2014	0	0	35,000
7/27/2014	0	0	0
8/31/2014	0	0	0
10/22/2014	0	0	20,000
10/23/2014	0	0	0
12/9/2014	0	0	5,000
12/9/2014	0	0	30,000
5/31/2015	0	0	0
8/4/2015	0	0	0
8/15/2015	0	0	50,000
8/15/2015	0	0	75,000
9/30/2015	0	0	0
4/6/2017	0	0	0
6/27/2017	0	0	1,000
7/12/2017	0	0	1,000,000
7/18/2017	0	0	0
8/2/2017	0	0	5,000
10/25/2017	0	0	0
10/30/2017	0	0	0
1/12/2018	0	0	0
Total	**0**	**0**	**$41,861,000**

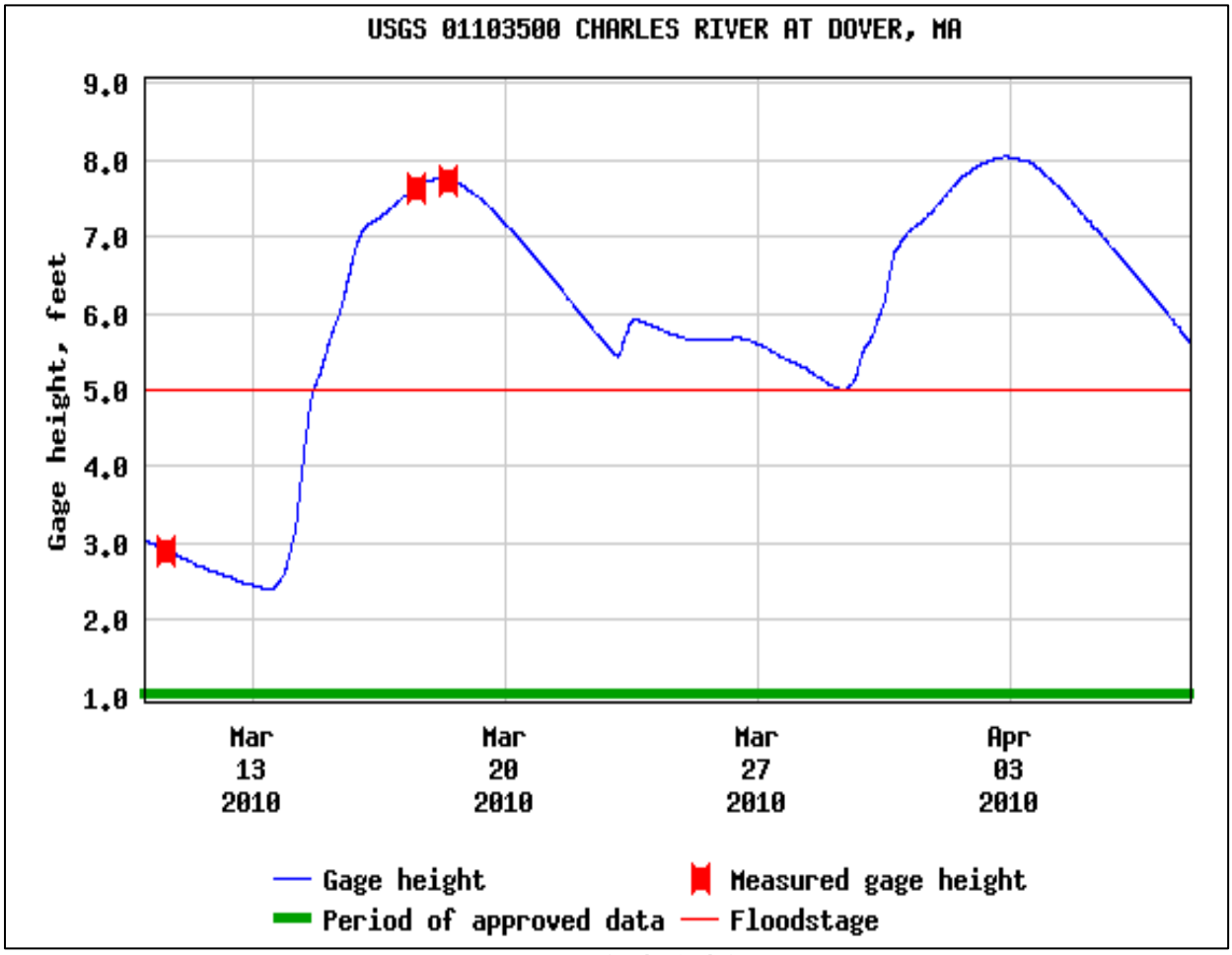
Source: NOAA, National Centers for Environmental Information

The most severe flooding in the last several decades occurred during March/April 2010, when a total of 14.83 inches of rainfall accumulation was recorded by the National Weather Service (NWS). The weather pattern that consisted of early springtime prevailing westerly winds that moved three successive storms, combined with tropical moisture from the Gulf of Mexico, across New England. Torrential rainfall caused March 2010 to be the wettest month on record.

One indication of the extent of the March 2010 flooding is the gage height at the nearest USGS streamflow gauging station, which is on the Charles River in nearby Dover. The USGS gage

height, shown in Figure 3, reached almost eight feet on March 18, 2010 and again on April 2/3. Flood stage at this gage is normally five feet.

Figure 3: USGS Flow Gage Data for Charles River, March/April 2010



Source: United States **Geological Survey 2010**

Overview of Town-Wide Flooding

Floodplain areas with a 1% annual chance of flooding are found along the southeastern border of town associated with the Charles River and its Sewall Brook tributary; along Course Brook at the northern border; along Doppinger and Dirty Meadow Brooks and Leland Mill Pond at southwest border; and along Bogastow Brook at the southern border of town. Floodplains with a 0.2% annual chance of flooding are located adjacent to Stannox Farm Creek and Sewall Brook, as well as Farm, Little Farm, and Eliot Street Ponds.

Roughly 80% of Sherborn falls within the Charles River watershed, while the remaining 20% of land in the northwest section of town is within the Sudbury River watershed. The entire Town of Sherborn is considered an aquifer recharge area and protection of groundwater is one of the Town's highest priorities. Sherborn does not have public sewer or water so residents rely on private wells and septic systems; the lack of public water and sewer has slowed development in

Sherborn. Wetlands and ledge throughout town have limited the placement of private septic systems, and therefore private wells, which must be a safe distance apart to maintain the quality of Sherborn's water supply.

Flooding in Sherborn is occasional, usually within or near floodplain areas. Damage may consist of flooding of basements, and the Fire Department may be called in to help pump out basements. In some areas of town, localized flooding occurs due to beaver activity or improperly functioning drainage infrastructure. The Sherborn Community Maintenance and Development Department has been effective at replacing outdated culverts and drainage systems.

Although Sherborn's flooding issues in the past have not been as significant as some of its nearby more developed neighbors, the town is facing new development. New impervious areas and more engineered drainage systems can bring a greater possibility of future flooding problems. Therefore, protection of open space and development controls will be critical to mitigate against future flooding. Sherborn has a history of being active in this regard.

Potential Flood Hazard Areas

Information on potential flood hazard areas was taken from two sources. The first was the National Flood Insurance Rate Maps (FIRMs). The FIRM flood zones are shown on Map 3 in Appendix B and their definitions are listed below. Mapped floodplains are primarily along the Town's river, brooks, ponds, and associated wetlands, as noted above.

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

In addition, information on areas subject to flooding was provided by local officials. The Locally Identified Areas of Flooding described in Table 6 below were identified by Town staff as areas where flooding is known to occur. All of these areas do not necessarily coincide with the flood zones from the FIRMs as some may be areas that flood due to inadequate drainage systems or

other local conditions rather than location within a flood zone. The map ID numbers correspond to the numbers on Map 8, "Local Hazard Areas."

Table 6: Locally Identified Areas of Flooding

Map ID	Name		Description
1	Farm Road/Charles River Bridge		This area experiences overflow flooding from the Charles River during heavy rain (low to medium frequency) that has damaged property. Flooding turns one home into an island.
2	Coolidge Street		This area experiences overflow flooding from Meadow Brook Stream (low frequency, high severity). The street was almost lost in 2010 due water rushing the undersized culvert and a vehicle accident that did damage to the culvert and guard rails.
3	Lake Street		This area experiences overflow flooding from Indian Brook and the main source of flooding is from beaver dams, which cause flow to go through the culvert and overtake the road.
4	Harrington Ridge Road		This road experiences flooding a few times a year after heavy rains due to water flowing out from the woods (high frequency, low severity). This area became low-lying when it was developed but there has been no property damage.
5	Western Avenue between Washington & Hollis		This road floods every spring as a farm field fills with water and goes across the road (high frequency, low severity). No property damage has been caused and the Town has not had to block off the road.
6	Nason Hill Road		This area is impacted by poor drainage and beaver activity (medium frequency, medium severity). At one point, the road had to be shut down for a few days due to beaver dams in neighboring Millis that caused Bogastow Brook to overflow. As water overtook the road, the culvert was damaged.

Repetitive Loss Structures

As defined by the National Flood Insurance Program (NFIP), a repetitive loss property is any property for which the NFIP has paid two or more flood claims of $1,000 or more in any given 10-year period since 1978. There is just one repetitive loss structures in Sherborn, a residence which experienced flood damages in 2010 and 2014. The property has received reimbursement for two claims for a total of $22,156. For more information on repetitive losses see https://www.fema.gov/txt/rebuild/repetitive_loss_faqs.txt

Potential damages from flooding in the Town of Sherborn were estimated using FEMA's HAZUS-MH program. The results, shown in Figure 40, indicate potential damages from a 100-year flood at $520,000, and from a 500-year flood at $880,000.

Sherborn experiences limited flooding and flood damage compared to most towns in the region. Nevertheless, based on the record of previous occurrences flooding events in Sherborn are a high frequency event as defined by the 2013 Massachusetts State Hazard Mitigation Plan. This hazard may occur more frequently than once in five years, or a greater than 20% chance a year.

Dams and Dam Failure

Dam failure can occur as a result of structural failure, independent of a hazard event, or as the result of the impacts of a hazard event such as flooding associated with storms or an earthquake. In the event of a dam failure, the energy of the water stored behind even a small dam can cause loss of life and property damage if there are people or buildings downstream. The number of fatalities from a dam failure depends on the amount of warning provided to the population and the number of people in the area in the path of the dam's floodwaters.

Dam failure is a highly infrequent occurrence but a severe incident could result in loss of lives and significant property damage. Since 1984, three dams have failed in or near to Massachusetts, one of which resulted in a death. There have been no recorded dam breaches in Sherborn.

According to data provided by the Massachusetts Department of Conservation and Recreation and the town, there is one dam located in Sherborn, the Leland Mill Pond Dam. The DCR dam inventory lists this dam as privately owned, however the town has taken possession of the dam. Leland Pond is an important source of water for firefighting; with a fire hydrant that covers part of the town. The town has concerns that with high rainfall the flow breaches the sides of the dam. The Town intends to conduct an inspection to determine what repairs may be needed.

DCR defines dam hazard classifications as follows:

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.

Based on the record of previous occurrences, dam failure in Sherborn is a low frequency event as defined by the 2013 Massachusetts State Hazard Mitigation Plan. This hazard may occur less frequently than once in 50 years to once in 100 years (1% to 2% per year).

Wind-Related Hazards

Wind-related hazards include hurricanes, tropical storms, and tornadoes as well as high winds during Nor'easters and thunderstorms. As with many communities, falling trees that result in downed power lines and power outages are an issue in Sherborn. Information on wind related hazards can be found on Map 5 in Appendix B

Tree damage during high winds has the potential to be a significant hazard in Sherborn. Trees can knock out power lines and block major roadways, which hinders emergency response. While Sherborn does experience downed trees that have caused power outages and roadway blockages, the town also takes pride in its tree-lined streets. Therefore, maintaining trees in a proactive fashion has been a trade-off for the tree amenities.

Hurricanes and Tropical Storms

A hurricane is a violent wind and rainstorm with wind speeds of 74 to 200 miles per hour. A hurricane is strongest as it travels over the ocean and is particularly destructive to coastal property as the storm hits the land. The Town's entire area is vulnerable to hurricanes. Hurricanes occur between June and November. A tropical storm has similar characteristics, but wind speeds are below 74 miles per hour.

A hurricane or storm track is the line that delineates the path of the eye of a hurricane or tropical storm. As shown in Map 5 in Appendix B, the following storms tracked through Sherborn in the past:

- Category 1 Hurricane in 1858
- Category 2 Hurricane in 1960
- Tropical Depression in 1988
- Tropical Storm in 1999

Sherborn experiences the impacts of hurricanes and tropical storms regardless of whether the storm track passes directly through the Town, and numerous hurricanes have affected eastern Massachusetts. Hurricanes since 1938 are shown in Table 7. The wind hazard mapping indicates that the 100 year wind speed in Sherborn is 110 miles per hour (see Appendix B).

Table 7: Hurricane Records for Massachusetts, 1938-2018

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

Source: National Oceanic and Atmospheric Administration

Hurricane intensity is measured according to the Saffir/Simpson scale, which categorizes hurricane intensity linearly based upon maximum sustained winds, barometric pressure, and storm surge potential. These are combined to estimate potential damage. Table 8 gives an overview of the wind speeds, surges, and range of damage caused by different hurricane categories.

Table 8: Saffir/Simpson Scale

Scale No. (Category)	Winds (mph)	Surge (feet)	Potential Damage
1	74 - 95	4 - 5	Minimal
2	96 - 110	6 - 8	Moderate
3	111 - 130	9 - 12	Extensive
4	131 - 155	13 - 18	Extreme
5	> 155	>18	Catastrophic

Source: National Oceanic and Atmospheric Administration

Hurricanes typically have regional impacts beyond their immediate tracks. Falling trees and branches are a significant problem because they can result in power outages when they fall on power lines or block traffic and emergency routes. Hurricanes are a town-wide hazard in Sherborn. Potential hurricane damages to Sherborn have been estimated using HAZUS-MH. Total damages are estimated at $4.5 million for a Category 2 hurricane and $15 million for a Category 4 hurricane. Other potential impacts, such as households displaced, sheltering needs, and debris generation, are detailed in Table XX.

Based on records of previous occurrences, hurricanes in Sherborn are a Medium frequency event as defined by the 2013 Massachusetts State Hazard Mitigation Plan. This hazard occurs from once in 5 years to once in 50 years, or a 2% to 20% chance per year.

Tornados

A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud. These events are spawned by thunderstorms and occasionally by hurricanes, and may occur singularly or in

multiples. They develop when cool air overrides a layer of warm air, causing the warm air to rise rapidly. Most vortices remain suspended in the atmosphere. Should they touch down, they become a force of destruction. Some ingredients for tornado formation include:

- Very strong winds in the mid and upper levels of the atmosphere
- Clockwise turning of the wind with height (from southeast at the surface to west aloft)
- Increasing wind speed with altitude 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

Tornado damage severity is measured by the Fujita Tornado Scale, in which wind speed is not measured directly but rather estimated from the amount of damage. As of February 01, 2007, the National Weather Service began rating tornados using the Enhanced Fujita-scale (EF-scale), which allows surveyors to create more precise assessments of tornado severity. The EF-scale is summarized in Table 9.

The frequency of tornadoes in eastern Massachusetts is low; on average, there are six tornadoes that touchdown somewhere in the Northeast region every year. The strongest tornado in Massachusetts history was the Worcester Tornado in 1953 (NESEC).

Table 9: 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: Massachusetts State Hazard Mitigation Plan, 2013

The most recent significant tornado events in Massachusetts were in Springfield in June 2011 and in Revere in 2014. The Springfield tornado caused significant damage and resulted in four deaths. The Revere tornado touched down in Chelsea just south of Route 16 and moved north into Revere's business district along Broadway and ended near the intersection of Routes 1 and 60. The path was approximately two miles long and 3/8 mile wide, with wind speeds up to 120 miles per hour. Approximately 65 homes had substantial damages and 13 homes and businesses were uninhabitable.

There have been no recorded tornados within the limits of the Town of Sherborn. Since 1955, there have been 16 tornadoes in surrounding Middlesex County recorded by the Tornado History Project. Two of these were F3 tornados, and four were F2. These 17 tornadoes resulted in a total of one fatality and six injuries and $38.8 million in damages, as summarized in Table 10.

Table 10: Tornado Records for Middlesex County

Date	Fujita	Fatalities	Injuries	Width	Length	Damage
10/24/1955	1	0	0	10	0.1	$500-$5000
6/19/1957	1	0	0	17	1	$5K-$50K
6/19/1957	1	0	0	100	0.5	$50-$500
7/11/1958	2	0	0	17	1.5	$50K-$500K
8/25/1958	2	0	0	50	1	$500-$5000
7/3/1961	0	0	0	10	0.5	$5K-$50K
7/18/1963	1	0	0	50	1	$5K-$50K
8/28/1965	2	0	0	10	2	$50K-$500K
7/11/1970	1	0	0	50	0.1	$5K-$50K
10/3/1970	3	1	0	60	35.4	$50K-$500K
7/1/1971	1	0	1	10	25.2	$5K-$50K
11/7/1971	1	0	0	10	0.1	$50-$500
7/21/1972	2	0	4	37	7.6	$500K-$5M
9/29/1974	3	0	1	33	0.1	$50K-$500K
7/18/1983	0	0	0	20	0.4	$50-$500
9/27/1985	1	0	0	40	0.1	$50-$500
8/7/1986	1	0	0	73	4	$50K-$500K

Source: The Tornado History Project

Buildings constructed prior to current building codes may be more vulnerable to damages caused by tornadoes. Evacuation of impacted areas may be required on short notice. Sheltering and mass feeding efforts may be required along with debris clearance, search and rescue, and emergency fire and medical services. Key routes may be blocked by downed trees and other debris, and widespread power outages are also typically associated with tornadoes.

Although tornadoes are a potential town-wide hazard in Sherborn, tornado impacts are relatively localized compared to severe storms and hurricanes. Damages from any tornado in Sherborn would greatly depend on the track of the tornado. Generally, the more densely developed area where Routes 16 and 27 converge would likely be subject to more damage in the event of a tornado than less dense areas.

Based on the record of previous occurrences since 1950, tornado events in Sherborn are a low frequency event as defined by the 2013 Massachusetts State Hazard Mitigation Plan. This hazard may occur from once in 50 years to once in 100 years, or a 1% to 2% chance a year.

Nor'easters

A northeast coastal storm, known as a nor'easter, is typically a large counter-clockwise wind circulation around a low-pressure center. Featuring strong northeasterly winds blowing in from the ocean over coastal areas, nor'easters are relatively common in the winter months in New England occurring one to two times a year. The storm radius of a nor'easter can be as much as 1,000 miles and these storms feature sustained winds of 10 to 40 mph with gusts of up to 70 mph. These

storms are accompanied by heavy rains or snows, depending on temperatures. Previous occurrences of Nor'easters include the following which are listed in the Massachusetts State Hazard Mitigation Plan 2013 are shown in Table 11.

Table 11: Nor'easter Events for Massachusetts, 1978 to 2018

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 & Coastal Flooding/Nor'easter	April 2007
Winter Storm/Nor'easter	January 2011
Severe Storm/Nor'easter	October 2011
Blizzard of 2013	February 2013
Blizzard of 2015	January 2015
Severe Storms/Nor'easters 2018	March 2018

Many of the historic flood events identified in the previous section were precipitated by nor'easters, including the "Perfect Storm" event in 1991. More recently, blizzards in December 2010, October 2011, February 2013, January 2015, and March 2018 were large nor'easters that caused significant snowfall amounts.

Sherborn is vulnerable to both the wind and precipitation that accompanies nor'easters. High winds can cause damage to structures, fallen trees, and downed power lines leading to power outages. Intense rainfall can overwhelm drainage systems causing localized flooding of rivers and streams as well as stormwater ponding and localized flooding. Fallen tree limbs as well as heavy snow accumulation and intense rainfall can impede local transportation corridors, and block access for emergency vehicles.

The entire Town of Sherborn could be at risk from the wind, rain or snow impacts from a nor'easter, depending on the track and radius of the storm, but due to its inland location the town is not subject to coastal hazards.

Based on the record of previous occurrences, nor'easters in Sherborn are high frequency events as defined by the 2013 Massachusetts State Hazard Mitigation Plan. This hazard may occur more frequently than once in 5 years (greater than 20% per year).

Severe Thunderstorms

While less severe than the other types of storms discussed, thunderstorms occur much more frequently and can lead to localized damage and thereforerepresent a hazard risk for communities. A thunderstorm typically features lightning, strong winds, and rain and/or hail. Thunderstorms sometime give rise to tornados. On average, these storms are only around 15 miles in diameter and last for about 30 minutes. A severe thunderstorm can include winds of close to 60

mph and rain sufficient to produce flooding. The town's entire area is potentially subject to severe thunderstorms.

The best available data on previous occurrences of thunderstorms in Sherborn is for Middlesex County through the National Climatic Data Center (NCDC). Between the years 2006 and 2016 NCDC records show 71 thunderstorm events in Middlesex County (Table 12). These storms resulted in a total of $1,617,000 in property damages. There were no injuries or deaths reported.

Table 12: Middlesex County Thunderstorm Events, 2006-2016

Date	Type	Magnitude*	Deaths	Injuries	Damage
4/1/2006	Thunderstorm Wind	50	0	0	8000
5/21/2006	Thunderstorm Wind	61	0	0	95000
6/23/2006	Thunderstorm Wind	50	0	0	30000
7/11/2006	Thunderstorm Wind	50	0	0	10000
7/21/2006	Thunderstorm Wind	50	0	0	35000
7/28/2006	Thunderstorm Wind	50	0	0	15000
8/2/2006	Thunderstorm Wind	50	0	0	15000
5/16/2007	Thunderstorm Wind	50	0	0	0
6/27/2007	Thunderstorm Wind	50	0	0	0
7/6/2007	Thunderstorm Wind	50	0	0	0
7/9/2007	Thunderstorm Wind	50	0	0	0
7/15/2007	Thunderstorm Wind	50	0	0	0
7/28/2007	Thunderstorm Wind	50	0	0	0
7/29/2007	Thunderstorm Wind	50	0	0	0
8/17/2007	Thunderstorm Wind	50	0	0	0
9/8/2007	Thunderstorm Wind	50	0	0	25000
5/27/2008	Thunderstorm Wind	50	0	0	8000
6/10/2008	Thunderstorm Wind	50	0	0	20000
6/23/2008	Thunderstorm Wind	50	0	0	5000
6/24/2008	Thunderstorm Wind	50	0	0	5000
6/27/2008	Thunderstorm Wind	50	0	0	5000
6/29/2008	Thunderstorm Wind	50	0	0	10000
7/1/2008	Thunderstorm Wind	50	0	0	20000
7/2/2008	Thunderstorm Wind	50	0	0	5000
7/3/2008	Thunderstorm Wind	50	0	0	15000
7/19/2008	Thunderstorm Wind	50	0	0	8000
7/20/2008	Thunderstorm Wind	50	0	0	5000
7/27/2008	Thunderstorm Wind	50	0	0	5000
8/3/2008	Thunderstorm Wind	50	0	0	5000
8/7/2008	Thunderstorm Wind	50	0	0	5000
9/9/2008	Thunderstorm Wind	50	0	0	8000
5/9/2009	Thunderstorm Wind	50	0	0	2000

Date	Type	Magnitude*	Deaths	Injuries	Damage
5/24/2009	Thunderstorm Wind	50	0	0	15000
7/7/2009	Thunderstorm Wind	50	0	0	1000
7/8/2009	Thunderstorm Wind	50	0	0	20000
7/26/2009	Thunderstorm Wind	50	0	0	15000
7/31/2009	Thunderstorm Wind	50	0	0	30000
5/4/2010	Thunderstorm Wind	50	0	0	30000
6/1/2010	Thunderstorm Wind	50	0	0	5000
6/3/2010	Thunderstorm Wind	50	0	0	20000
6/5/2010	Thunderstorm Wind	50	0	0	40000
6/6/2010	Thunderstorm Wind	50	0	0	100000
6/24/2010	Thunderstorm Wind	50	0	0	30000
7/12/2010	Thunderstorm Wind	50	0	0	50000
7/19/2010	Thunderstorm Wind	50	0	0	25000
6/1/2011	Thunderstorm Wind	50	0	0	5000
6/9/2011	Thunderstorm Wind	50	0	0	15000
8/2/2011	Thunderstorm Wind	50	0	0	1000
8/19/2011	Thunderstorm Wind	50	0	0	15000
6/8/2012	Thunderstorm Wind	50	0	0	25000
6/23/2012	Thunderstorm Wind	45	0	0	5000
7/4/2012	Thunderstorm Wind	50	0	0	10000
7/18/2012	Thunderstorm Wind	70	0	0	350000
9/7/2012	Thunderstorm Wind	50	0	0	10000
9/8/2012	Thunderstorm Wind	40	0	0	3000
6/17/2013	Thunderstorm Wind	50	0	0	25000
6/18/2013	Thunderstorm Wind	45	0	0	10000
6/24/2013	Thunderstorm Wind	45	0	0	3000
7/23/2013	Thunderstorm Wind	50	0	0	20000
7/29/2013	Thunderstorm Wind	50	0	0	5000
7/3/2014	Thunderstorm Wind	50	0	0	75000
7/7/2014	Thunderstorm Wind	87	0	0	100000
7/15/2014	Thunderstorm Wind	50	0	0	25000
7/28/2014	Thunderstorm Wind	50	0	0	50000
9/6/2014	Thunderstorm Wind	50	0	0	15000
5/28/2015	Thunderstorm Wind	45	0	0	5000
8/4/2015	Thunderstorm Wind	50	0	0	40000
8/15/2015	Thunderstorm Wind	50	0	0	25000
2/25/2016	Thunderstorm Wind	50	0	0	30000
3/17/2016	Thunderstorm Wind	45	0	0	5000
TOTAL					**1,617,000**

*Magnitude refers to maximum wind speed
Source: NOAA, National Centers for Environmental Information

Severe thunderstorms are a town-wide hazard for Sherborn. The town's vulnerability to severe thunderstorms is similar to that of Nor'easters. High winds can cause falling trees and power outages, as well as obstruction of key routes and emergency access. Heavy precipitation may also cause localized flooding, both riverine and urban drainage related.

Based on the record of previous occurrences, severe thunderstorms in Sherborn are high frequency events as defined by the 2013 Massachusetts State Hazard Mitigation Plan. This hazard may occur more frequently than once in 5 years (greater than 20% per year).

Winter Storm Hazards

Winter storms, including heavy snow, blizzards, and ice storms, are the most common and most familiar of the region's hazards that affect large geographic areas. The majority of blizzards and ice storms in the region cause more inconvenience than they do serious property damage, injuries, or deaths. However, periodically, a storm will occur which is a true disaster, and necessitates intense large-scale emergency response. The impacts of winter storms are often related to the weight of snow and ice, which can cause roof collapses and also causes tree limbs to fall. This in turn can cause property damage and potential injuries. Power outages also result from fallen trees and utility lines.

Winter storms are a potential town-wide hazard in Sherborn. The average annual snowfall in town is 36-48 inches (see Map 6 in Appendix B). The Town of Sherborn can be vulnerable to a number of public safety issues can arise during snow storms. Impassible streets are a challenge for emergency vehicles and affect residents and employers. Snow-covered sidewalks force people to walk in streets, which are already less safe due to snow, slush, puddles, and ice. Large piles of snow can also block sight lines for drivers, particularly at intersections. Not all residents are able to clear their properties, especially the elderly. Refreezing of melting snow can cause dangerous roadway conditions. In addition, transit operations may be impacted, as they were in the 2015 blizzard which caused the closure of the MBTA system for one day and limited services on several transit lines for several weeks. The Town of Sherborn provides snow plowing operations, and plowing of roads near emergency routes is a priority.

Heavy Snow and Blizzards

A blizzard is a winter snow storm with sustained or frequent wind gusts to 35 mph or more, accompanied by falling or blowing snow reducing visibility to or below ¼ 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 definition. The hazard created by the combination of snow, wind and low visibility significantly increases, however, with temperatures below 20 degrees.

Winter storms are a combination hazard because they often involve wind, ice and heavy snow fall. The National Weather Service defines "heavy snow fall" as an event generating at least 4 inches of snowfall within a 12 hour period. Winter Storms are often associated with a Nor'easter event, a large counter-clockwise wind circulation around a low-pressure center often resulting in heavy snow, high winds, and rain.

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: Extreme, Crippling, Major, Significant, and Notable. 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 largest NESIS values result from storms producing heavy snowfall over large areas that include major metropolitan centers. The NESIS categories are summarized in Table 13.

Table 13: 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: Massachusetts State Hazard Mitigation Plan, 2013

The most significant winter storm in recent history was the "Blizzard of 1978," which resulted in over 3 feet of snowfall and multiple day closures of roadways, businesses, and schools. In Sherborn blizzards and severe winter storms have occurred in the years shown in Table 14.

Table 14: Severe Winter Storm Records for Massachusetts

Storm	Date
Blizzard of 1978	February 1978
Blizzard	March 1993
Blizzard	January 1996
Severe Snow Storm	March 2001
Severe Snow Storm	December 2003
Severe Snow Storm	January 2004
Severe Snow Storm	January 2005
Severe Snow Storm	April, 2007
Severe Snow Storm	December 2010
Severe Snow Storm	January 2011
Blizzard of 2013	February 2013
Blizzard of 2015	January 2015

Source: National Oceanic and Atmospheric Administration

The Town of Sherborn does not keep local records of winter storms. Data for Middlesex County, which includes Sherborn, is the best available data to help understand previous occurrences and

impacts of heavy snow events. According to National Climate Data Center (NCDC) records, from 1996 to 2016 Middlesex County experienced 85 heavy snowfall events, resulting in no deaths, no injuries, and $4.5 million dollars in property damage. See Table 15 for and heavy snow events and impacts in Middlesex County.

Table 15: Heavy Snow Events and Impacts in Middlesex County, 1996-2016

Date	Type	Deaths	Injuries	Property Damage
1/2/1996	Heavy Snow	0	0	0
1/7/1996	Heavy Snow	0	0	1400000
1/7/1996	Heavy Snow	0	0	1500000
1/10/1996	Heavy Snow	0	0	0
1/12/1996	Heavy Snow	0	0	0
2/2/1996	Heavy Snow	0	0	0
2/16/1996	Heavy Snow	0	0	0
3/2/1996	Heavy Snow	0	0	0
3/7/1996	Heavy Snow	0	0	0
4/7/1996	Heavy Snow	0	0	0
4/9/1996	Heavy Snow	0	0	0
12/6/1996	Heavy Snow	0	0	0
12/7/1996	Heavy Snow	0	0	1360000
3/31/1997	Heavy Snow	0	0	0
4/1/1997	Heavy Snow	0	0	0
11/14/1997	Heavy Snow	0	0	0
12/23/1997	Heavy Snow	0	0	0
1/15/1998	Heavy Snow	0	0	0
1/23/1998	Heavy Snow	0	0	0
1/14/1999	Heavy Snow	0	0	0
2/25/1999	Heavy Snow	0	0	0
3/6/1999	Heavy Snow	0	0	0
3/15/1999	Heavy Snow	0	0	0
1/13/2000	Heavy Snow	0	0	0
1/25/2000	Heavy Snow	0	0	0
2/18/2000	Heavy Snow	0	0	0
12/30/2000	Heavy Snow	0	0	0
1/20/2001	Heavy Snow	0	0	0
2/5/2001	Heavy Snow	0	0	0
3/5/2001	Heavy Snow	0	0	0
3/9/2001	Heavy Snow	0	0	0
3/30/2001	Heavy Snow	0	0	0
12/8/2001	Heavy Snow	0	0	0
3/20/2002	Heavy Snow	0	0	0

Date	Type	Deaths	Injuries	Property Damage
3/16/2004	Heavy Snow	0	0	0
2/24/2005	Heavy Snow	0	0	0
12/13/2007	Heavy Snow	0	0	0
12/16/2007	Heavy Snow	0	0	0
12/19/2007	Heavy Snow	0	0	0
1/14/2008	Heavy Snow	0	0	28000
1/14/2008	Heavy Snow	0	0	20000
1/14/2008	Heavy Snow	0	0	20000
2/22/2008	Heavy Snow	0	0	0
3/1/2008	Heavy Snow	0	0	0
12/19/2008	Heavy Snow	0	0	0
12/20/2008	Heavy Snow	0	0	8000
12/21/2008	Heavy Snow	0	0	0
12/31/2008	Heavy Snow	0	0	0
1/10/2009	Heavy Snow	0	0	0
1/11/2009	Heavy Snow	0	0	0
1/18/2009	Heavy Snow	0	0	0
3/1/2009	Heavy Snow	0	0	0
3/2/2009	Heavy Snow	0	0	0
12/9/2009	Heavy Snow	0	0	15000
12/9/2009	Heavy Snow	0	0	500
12/19/2009	Heavy Snow	0	0	0
12/20/2009	Heavy Snow	0	0	0
1/18/2010	Heavy Snow	0	0	0
2/16/2010	Heavy Snow	0	0	15000
2/23/2010	Heavy Snow	0	0	8000
1/12/2011	Heavy Snow	0	0	0
1/26/2011	Heavy Snow	0	0	0
10/29/2011	Heavy Snow	0	0	30000
12/29/2012	Heavy Snow	0	0	0
2/8/2013	Heavy Snow	0	0	0
2/8/2013	Heavy Snow	0	0	0
2/23/2013	Heavy Snow	0	0	0
3/7/2013	Heavy Snow	0	0	0
3/18/2013	Heavy Snow	0	0	0
12/14/2013	Heavy Snow	0	0	0
12/17/2013	Heavy Snow	0	0	0
1/2/2014	Heavy Snow	0	0	0
1/18/2014	Heavy Snow	0	0	0
2/5/2014	Heavy Snow	0	0	0
2/13/2014	Heavy Snow	0	0	0

Date	Type	Deaths	Injuries	Property Damage
2/18/2014	Heavy Snow	0	0	0
11/26/2014	Heavy Snow	0	0	10000
1/24/2015	Heavy Snow	0	0	0
1/26/2015	Heavy Snow	0	0	0
2/2/2015	Heavy Snow	0	0	0
2/8/2015	Heavy Snow	0	0	0
2/14/2015	Heavy Snow	0	0	0
2/5/2016	Heavy Snow	0	0	70000
2/5/2016	Heavy Snow	0	0	5000
3/21/2016	Heavy Snow	0	0	0
TOTAL				**$4,500,000**

Source: NOAA, National Centers for Environmental Information

Blizzards are considered to be high frequency events based on past occurrences, as defined by the Massachusetts State Hazard Mitigation Plan, 2013. This hazard occurs more than once in five years, with a greater than 20% chance of occurring each year.

Ice Storms

The ice storm category covers a range of different weather phenomena that collectively involve rain or snow being converted to ice in the lower atmosphere leading to potentially hazardous conditions on the ground. Hail size typically refers to the diameter of the hailstones. Warnings and reports may report hail size through comparisons with real-world objects that correspond to certain diameters, shown in Table 16.

Table 16: Hail Size Comparisons

Description	Diameter (inches)
Pea	0.25
Marble or mothball	0.50
Penny or dime	0.75
Nickel	0.88
Quarter	1.00
Half dollar	1.25
Walnut or ping pong ball	1.50
Golf ball	1.75
Hen's egg	2.00
Tennis ball	2.50
Baseball	2.75
Tea cup	3.00
Grapefruit	4.00
Softball	4.50

While ice pellets and sleet are examples of these, the greatest hazard is created by freezing rain conditions, which is rain that freezes on contact with hard surfaces leading to a layer of ice on roads, walkways, trees, and other surfaces. The conditions created by freezing rain can make driving particularly dangerous and emergency response more difficult. The weight of ice on tree branches can also lead to falling branches damaging electric lines.

Town-specific data for previous ice storm occurrences are not collected by the Town of Sherborn. The best available local data is for Middlesex County through the National Climatic Data Center (see Table 17:19). Middlesex County, which includes the Town of Sherborn, experienced 45 hail events from since 2000, as shown in Table 17.

Table 17: Middlesex County Hail Events, 2000-2015

Date	Event	Magnitude*	Deaths	Injuries	Damage
7/18/2000	Hail	1	0	0	0
6/20/2001	Hail	1.75	0	0	0
7/12/2001	Hail	1.5	0	0	0
5/27/2002	Hail	0.75	0	0	0
6/2/2002	Hail	0.75	0	0	0
8/13/2003	Hail	0.75	0	0	0
7/2/2004	Hail	0.75	0	0	0
8/20/2004	Hail	0.88	0	0	0
5/21/2006	Hail	0.75	0	0	0
7/11/2006	Hail	1	0	0	0
7/28/2006	Hail	0.75	0	0	0
6/5/2007	Hail	1.25	0	0	0
6/22/2007	Hail	0.75	0	0	0
7/9/2007	Hail	1	0	0	0
7/28/2007	Hail	0.88	0	0	0
6/23/2008	Hail	0.75	0	0	0
6/24/2008	Hail	0.75	0	0	0
7/1/2008	Hail	0.88	0	0	0
7/2/2008	Hail	0.75	0	0	0
8/3/2008	Hail	0.75	0	0	0
8/7/2008	Hail	1	0	0	0
8/10/2008	Hail	0.75	0	0	0
5/24/2009	Hail	1	0	0	0
6/27/2009	Hail	0.88	0	0	0
7/7/2009	Hail	0.75	0	0	0
7/8/2009	Hail	1.75	0	0	0
5/4/2010	Hail	0.75	0	0	0
5/7/2011	Hail	0.75	0	0	0
6/1/2011	Hail	0.75	0	0	0
8/2/2011	Hail	0.75	0	0	0

Date	Event	Magnitude*	Deaths	Injuries	Damage
8/19/2011	Hail	0.75	0	0	0
3/13/2012	Hail	1.25	0	0	0
3/14/2012	Hail	1	0	0	0
6/23/2012	Hail	0.75	0	0	0
7/18/2012	Hail	1	0	0	0
10/30/2012	Hail	1	0	0	0
6/17/2013	Hail	0.75	0	0	0
5/25/2014	Hail	0.75	0	0	0
7/3/2014	Hail	1	0	0	0
8/7/2014	Hail	0.75	0	0	0
9/6/2014	Hail	0.88	0	0	0
8/4/2015	Hail	1	0	0	0
8/15/2015	Hail	0.75	0	0	0

*Magnitude refers to diameter of hail stones in inches
Source: NOAA, National Centers for Environmental Information

Ice storms are considered to be medium frequency events based on past occurrences, as defined by the Massachusetts State Hazard Mitigation Plan, 2013. This hazard occurs once in five years to once in 50 years, with 2% to 20% chance of occurring each year.

Geologic Hazards

Geologic hazards include earthquakes and landslides. Although new construction under the most recent building codes generally will be built to seismic standards, there are still many structures which pre-date the most recent building code. Information on geologic hazards in Sherborn can be found on Map 4 in Appendix B.

Earthquakes

Damage in an earthquake stems from ground motion, surface faulting, and ground failure in which weak or unstable soils, such as those composed primarily of saturated sand or silts, liquefy. The effects of an earthquake are mitigated by distance and ground materials between the epicenter and a given location. An earthquake in New England affects a much wider area than a similar earthquake in California due to New England's solid bedrock geology (NESEC).

Seismologists use a Magnitude scale (Richter Scale) to express the seismic energy released by each earthquake. The typical effects of earthquakes in various ranges are summarized in Table 18 below.

According to the State Hazard Mitigation Plan, New England experiences an average of five earthquakes per year. From 1668 to 2007, 355 earthquakes were recorded in Massachusetts (NESEC). Most have originated from the La Malbaie fault in Quebec or from the Cape Anne fault located off the coast of Rockport. The region has experienced larger earthquakes, including a

magnitude 5.0 earthquake in 1727 and a 6.0 earthquake that struck in 1755 off the coast of Cape Anne.

Table 18: Richter Scale and Effects

Richter Magnitudes	Earthquake Effects
Less than 3.5	Generally not felt, but recorded
3.5- 5.4	Often felt, but rarely causes damage
Under 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: Nevada Seismological Library (NSL), 2005

More recently, a pair of damaging earthquakes occurred near Ossipee, NH in 1940, and a 4.0 earthquake centered in Hollis, Maine in October 2012 was felt in the Boston area. Historical records of some of the more significant earthquakes in the region are shown in Table 19.

Table 19: Historical Earthquakes in Massachusetts or Surrounding Area

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
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

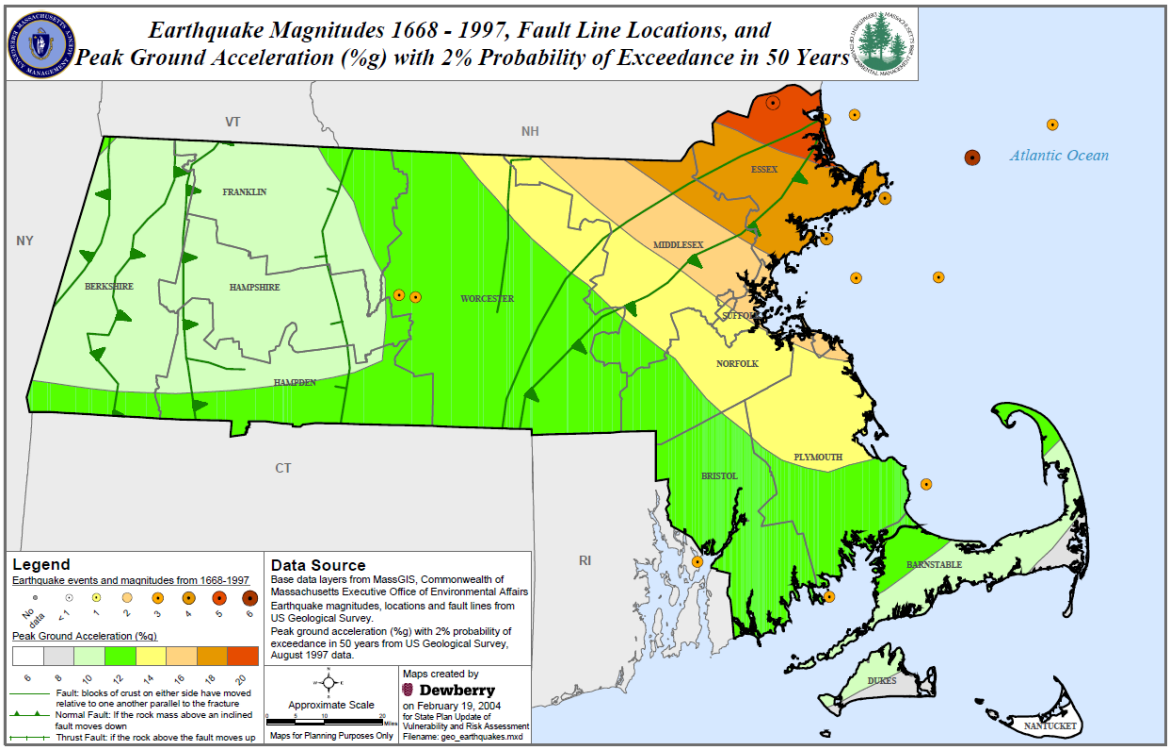
Location	Date	Magnitude
MA - Newbury	11/7/1907	NA
MA - Wareham	4/25/1924	NA
MA - Cape Ann	1/7/1925	4
MA - Nantucket	10/25/1965	NA
MA - Boston	12/27/74	2.3
VA - Mineral	8/23/11	5.8
MA - Nantucket	4/12/12	4.5
ME - Hollis	10/17/12	4.0

Source: Boston HIRA

One measure of earthquake risk is ground motion, which is measured as maximum peak horizontal acceleration, expressed as a percentage of gravity (1g). As shown in Figure 4, the range of peak ground acceleration in Massachusetts is from 10g to 20g, with a 2% probability of exceedance in 50 years. At 14g to 16g. Sherborn is in the middle part of the range for Massachusetts, making it a relatively moderate area of earthquake risk within the state, although the state as a whole is considered to have a low risk of earthquakes when compared to the rest of the country. There have been no recorded earthquake epicenters within Sherborn.

Although New England has not experienced a damaging earthquake since 1755, seismologists state that a serious earthquake occurrence is possible. There are five seismological faults in Massachusetts, but there is no discernible pattern of previous earthquakes along these fault lines.

Figure 4: Massachusetts Earthquake Probability Map



Source: Massachusetts Emergency Management Agency

Earthquakes occur without warning and may be followed by aftershocks. Many older buildings and infrastructure were constructed without specific earthquake resistant design features.

Earthquakes are a hazard with multiple impacts beyond the obvious building collapse. Buildings may suffer structural damage which may or may not be readily apparent. Earthquakes can cause major damage to roadways, making emergency response difficult. Water lines and gas lines can break, causing flooding and fires. Another potential vulnerability is equipment within structures. For example, a hospital may be structurally engineered to withstand an earthquake, but if the equipment inside the building is not properly secured, the operations at the hospital could be severely impacted during an earthquake. Earthquakes can also trigger landslides.
Earthquakes are a potential town-wide hazard in Sherborn. The Town has many older buildings that pre-date current building code which could be vulnerable in the event of a severe earthquake. Potential earthquake damages to Sherborn have been estimated using HAZUS-MH. Total building damages are estimated at $70 million for a 5.0 magnitude earthquake and $172 million for a 7.0 magnitude earthquake. Other potential impacts, such as debris generation and sheltering needs, are detailed in Figure 39.

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. The Massachusetts State Hazard Mitigation Plan classifies earthquakes as Very Low frequency events that occur less frequently than once in 100 years, or a less than 1% per year.

Landslides

According to the USGS, "The term landslide includes a wide range of ground movement, such as rock falls, deep failure of slopes, and shallow debris flows. Although gravity acting on an over steepened slope is the primary reason for a landslide, there are other contributing factors." Among the contributing factors are: erosion by rivers or ocean waves over steepened slopes; rock and soil slopes weakened through saturation by snowmelt or heavy rains; earthquakes create stresses that make weak slopes fail; and excess weight from accumulation of rain or snow, and stockpiling of rock or ore, from waste piles, or from man-made structures.

Landslides can result from human activities that destabilize an area or can occur as a secondary impact from another natural hazard such as flooding. In addition to structural damage to buildings and the blockage of transportation corridors, landslides can lead to sedimentation of water bodies. Typically, a landslide occurs when the condition of a slope changes from stable to unstable. Natural precipitation such as heavy snow accumulation, torrential rain and run-off may saturate soil creating instability enough to contribute to a landslide. The lack of vegetation and root structure that stabilizes soil can destabilize hilly terrain.

There is no universally accepted measure of landslide extent but it has been represented as a measure of the destructiveness. Table 20 summarizes the estimated intensity for a range of landslides. For a given landslide volume, fast moving rock falls have the highest intensity while slow moving landslides have the lowest intensity.

Table 20: Estimated Landslide Intensity

Estimated Volume (m^3)	Expected Landslide Velocity		
	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: *A Geomorphological Approach to the Estimation of Landslide Hazards and Risks in Umbria, Central Italy*, M. Cardinali et al, 2002

All of Sherborn is classified as having a low risk for landslides (see Map 4, Appendix B). The Town does not have records of any damages caused by landslides in Sherborn.

Should a landslide occur in the future, the type and degree of impacts would be highly localized, and the town's vulnerabilities could include damage to structures, damage to transportation and other infrastructure, and localized road closures. Injuries and casualties, while possible, would be unlikely given the low extent and impact of landslides in Sherborn.

Based on past occurrences and the Massachusetts Hazard Mitigation Plan, landslides are low frequency events that can occur once in 50 to 100 years, or a 1% to 2% chance of occurring each year).

Fire-Related Hazards

A brush fire is an uncontrolled fire occurring in a forested or grassland area. In the Boston Metro region these fires rarely grow to the size of a wildfire as seen more typically in the western U.S. As their name implies, these fires typically burn no more than the underbrush of a forested area. There are three different classes of wild fires:

- Surface fires are the most common type and burn along the floor of a forest, moving slowly and killing or damaging trees;
- Ground fires are usually started by lightning and burn on or below the forest floor;
- Crown fires spread rapidly by wind, jumping along the tops of trees.

Wildfire season can begin in March and usually ends in late November. The majority of wildfires typically occur in April and May, when most vegetation is void of any appreciable moisture, making them highly flammable. Once "green-up" takes place in late May to early June, the fire danger usually is reduced somewhat.

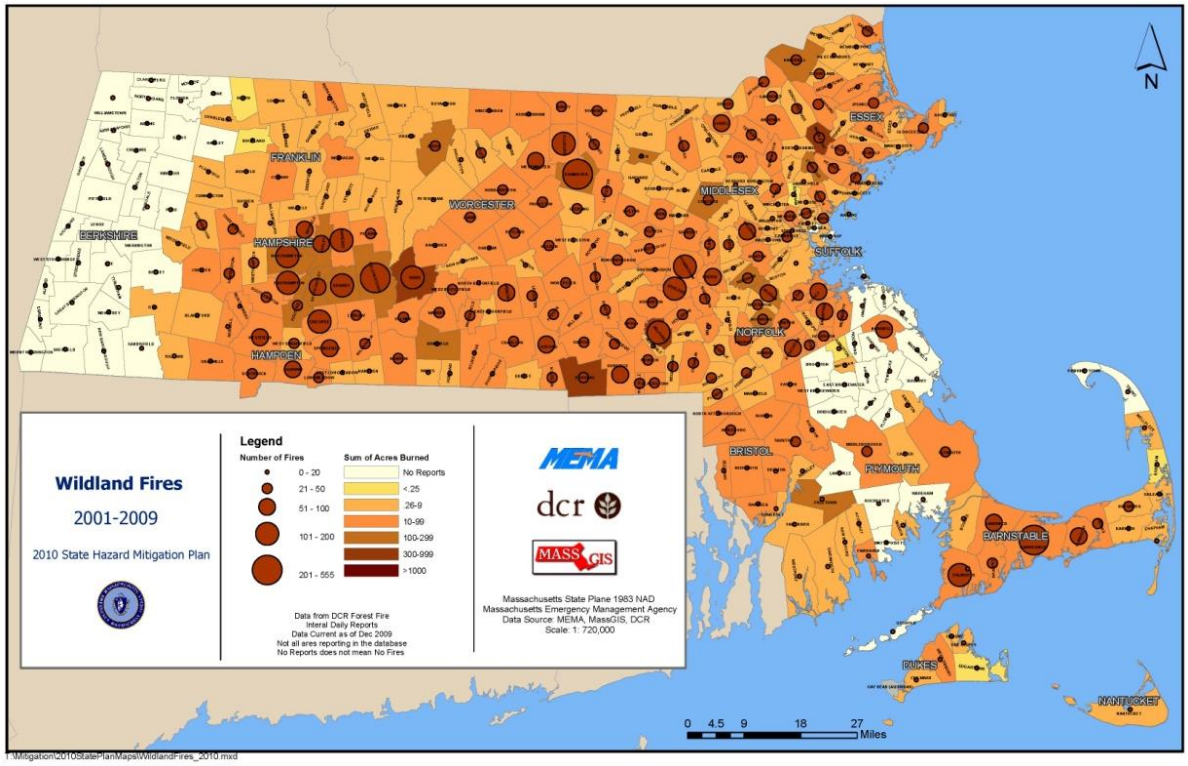
A wildfire differs greatly from other fires by its extensive size, the speed at which it can spread out from its original source, its potential to unexpectedly change direction, and its ability to jump gaps such as roads, rivers and fire breaks.

These fires can present a hazard where there is the potential for them to spread into developed or inhabited areas, particularly residential areas where sufficient fuel materials might exist to allow the fire the spread into homes. Protecting structures from fire poses special problems, and can stretch firefighting resources to the limit.

If heavy rains follow a fire, other natural disasters can occur, including landslides, mudflows, and floods. If the wild fire destroys the ground cover, then erosion becomes one of several potential problems.

Wildfires in Massachusetts are measured by the number of fires and the sum of acres burned. The most recent data available for wildfires in Massachusetts, shown in Figure 24 blow, indicates that the wildfire extent in Sherborn consists of 10 to 99 acres burned, with between 21 and 50 recordable fires from 2001 to 2009.

Figure5: Massachusetts Wildfires, 2001-2009



Source: Massachusetts State Hazard Mitigation Plan

Potential Brushfire Hazard Areas

The following areas of Town were identified as having some potential for brush fires based on the accumulation of vegetation growth. The numbers correspond to the numbers on Map 8, "Hazard Areas" In Appendix B.

- (8) Freight train tracks
- (10) Private property
- (11) Trustees of Reservation Land
- (12) Mass Audubon land/private property
- (13) Peter's Hill Conservation Land
- (14) Price Woodland Conservation Land
- (15) Barber Preservation Foundation
- (16) Town Forest
- (17) Town Forest
- (18) Town Forest
- (19) Private land
- (20) Private land
- (21) Conservation land

Potential vulnerabilities to wildfires include damage to structures and other improvements, and impacts on natural resources such as town conservation land. Smoke and air pollution from wildfires can be a health hazard, especially for sensitive populations including children, the elderly, and those with respiratory and cardiovascular diseases.

Potential damages from wildfires in Sherborn would depend on the extent and type of land affected. There could be the need for post-fire revegetation to restore burned properties, which could cost from a few thousand dollars to tens of thousands for an extensive area. However, there are no data on actual wildfire damages. to structures or injuries in fatalities in Sherborn.

Based on past occurrences and the Massachusetts Hazard Mitigation Plan 2013, brushfires are of medium frequency, events that occur from once in five years to once in 50 years (2% to 20% probability per year).

Extreme Temperature Hazards

Extreme temperatures occur when either high temperature or low temperatures relative to average local temperatures occur. These can occur for brief periods of time and be acute, or they can occur over long periods of time when there is a prolonged period of excessively hot or cold weather.

Sherborn has four well-defined seasons. The seasons have several defining factors, with temperature one of the most significant. Extreme temperatures can be defined as those, which are far outside of the normal seasonal ranges for Massachusetts. The average temperatures for Massachusetts are: winter (Dec-Feb) average = 31.8°F and summer (Jun-Aug) average = 71°F. Extreme temperatures are a town-wide hazard.

Extreme Cold

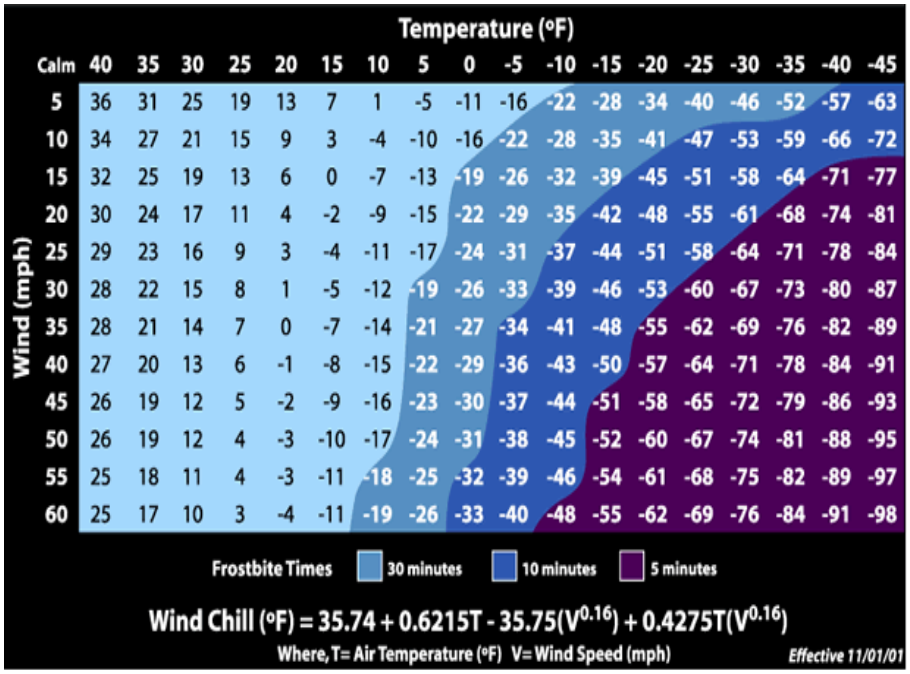
For extreme cold, temperature is typically measured using Wind Chill Temperature Index, which is provided by the National Weather Service (NWS). The latest version of the index was implemented in 2001 and it meant to show how cold conditions feel on unexposed skin. The index is provided in Figure 6 below.

Extreme cold is relative to the normal climatic lows in a region. Temperatures that drop decidedly below normal and wind speeds that increase can cause harmful wind-chill factors. The wind chill is the apparent temperature felt on exposed skin due to the combination of air temperature and wind speed.

Extreme cold is a dangerous situation that can result in health emergencies for susceptible people, such as those without shelter or who are stranded or who live in homes that are poorly insulated or without heat. The entire town is subject to extreme cold, however the elderly and people with disabilities are most vulnerable. In Sherborn, 16.1 percent of the population are over 65 and 6.2 percent of the population has a disability.

The Town of Sherborn does not collect data for previous occurrences of extreme cold. The best available local data are for Middlesex County, through the National Climatic Data Center (NCDC). There are three extreme cold events on record which caused no deaths, injuries, or property damage (see Table 21 below).

Figure 6: Wind Chill Temperature Index and Frostbit Risk



Source: National Weather Service

Table 21: Middlesex County Extreme Cold and Wind Chill Occurrences

Date	Deaths	Injuries	Damage
2/15/2015	0	0	0
2/16/2015	0	0	0
2/14/2016	0	0	0

Source: NOAA, National Centers for Environmental Information

Extreme Heat

While a heat wave for Massachusetts is defined as three or more consecutive days above 90°F. Another measure used for identifying extreme heat events is through a Heat Advisory from the National Weather Service (NWS). These advisories are issued when the heat index (Figure 7) is forecast to exceed 100 Degrees, Fahrenheit (F) for 2 or more hours; an excessive heat advisory is issued if forecast predicts the temperature to rise above105 degree F.

Figure 7: Heat Index Chart

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

Source: National Weather Service

The entire town is subject to extreme heat, however this hazard poses a potentially greater risk to the elderly, children, and people with certain medical conditions, such as heart disease. However, even young and healthy individuals can succumb to heat if they participate in strenuous physical activities during hot weather. In Sherborn children under 5 years old make up 4.7 percent of the population, and 16.1 percent are over 65 years old.

Hot summer days can also worsen air pollution. With increased extreme heat, urban areas of the Northeast are likely to experience more days that fail to meet air quality standards.

The Town of Sherborn does not collect data on excessive heat occurrences. The best available local data are for Middlesex County, through the National Climatic Data Center. From 1999 - 2016, there have been a total of 3 excessive heat events, with one reported death, no injuries, and no property damage resulting from excessive heat (see Table 22).

Table 22: Middlesex County Extreme Heat Occurrences

Date	Deaths	Injuries	Damage
7/6/2010	0	0	0
7/7/2010	0	0	0
7/5/2013	1	0	0

Source: NOAA, National Centers for Environmental Information

Extreme temperature events are projected to be medium frequency events based on past occurrences, as defined by the Massachusetts State Hazard Mitigation Plan, 2013. Both extreme cold and hot weather events occur between once in five years to once in 50 years, or a two percent to 20 percent chance of occurring each year.

Drought

Drought is a temporary irregularity in precipitation and differs from aridity since the latter is restricted to low rainfall regions and is a permanent feature of climate. Drought is a period characterized by long durations of below normal 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.

In Massachusetts, droughts are caused by the prevalence of dry northern continental air and a decrease in coastal- and tropical-cyclone activity. During the 1960's, a cool drought occurred because dry air from the north caused lower temperatures in the spring and summer of 1962-65. The northerly winds drove frontal systems to sea along the Southeast Coast and prevented the Northeastern States from receiving moisture (U.S. Geological Survey). This is considered the drought of record in Massachusetts.

Average annual precipitation in Massachusetts is 44 inches per year, with approximately three to four inch average amounts for each month of the year. Statewide annual precipitation ranges from 30 to 61 inches with regional monthly precipitation ranges between 0 to 17 inches. Thus, in the driest calendar year (1965), the statewide precipitation total of 30 inches was 68 percent of average total annual precipitation.

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. Sherborn is located in the Southeast Region. Drought is a potential town-wide hazard for the Town of Sherborn..

Five levels of drought have been developed to characterize drought severity: Normal, Advisory, Watch, Warning, and Emergency. These drought levels are based on the conditions of natural resources and are intended to provide information on the current status of water resources. The levels provide a basic framework from which to take actions to assess, communicate, and respond to drought conditions. They begin with a normal situation where data are routinely collected and distributed, move to heightened vigilance with increased data collection during an advisory, to 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 is necessary. Drought levels are used to coordinate both state agency and local response to drought situations.

As dry conditions can have a range of different impacts, a number of drought indices are available to assess these various impacts. Massachusetts uses a multi-index system that takes advantage of several of these indices to determine the severity of a given drought or extended period of dry conditions. Drought level is determined monthly based on the number of indices which have reached a given drought level. Drought levels are declared on a regional basis for each of six regions in Massachusetts. County by county or watershed-specific determinations may also be made. A determination of drought level is based on seven indices:

1. Standardized Precipitation Index (SPI) reflects soil moisture and precipitation.
2. Crop Moisture Index: (CMI) reflects soil moisture conditions for agriculture.
3. Keetch Byram Drought Index (KBDI) is designed for fire potential assessment.
4. Precipitation Index is a comparison of measured precipitation amounts to historic normal precipitation.
5. The Groundwater Level Index is based on the number of consecutive month's groundwater levels are below normal (lowest 25% of period of record).
6. The Stream flow Index is based on the number of consecutive months that stream flow levels are below normal (lowest 25% of period of record).
7. The Reservoir Index is based on the water levels of small, medium and large index reservoirs across the state, relative to normal conditions for each month.

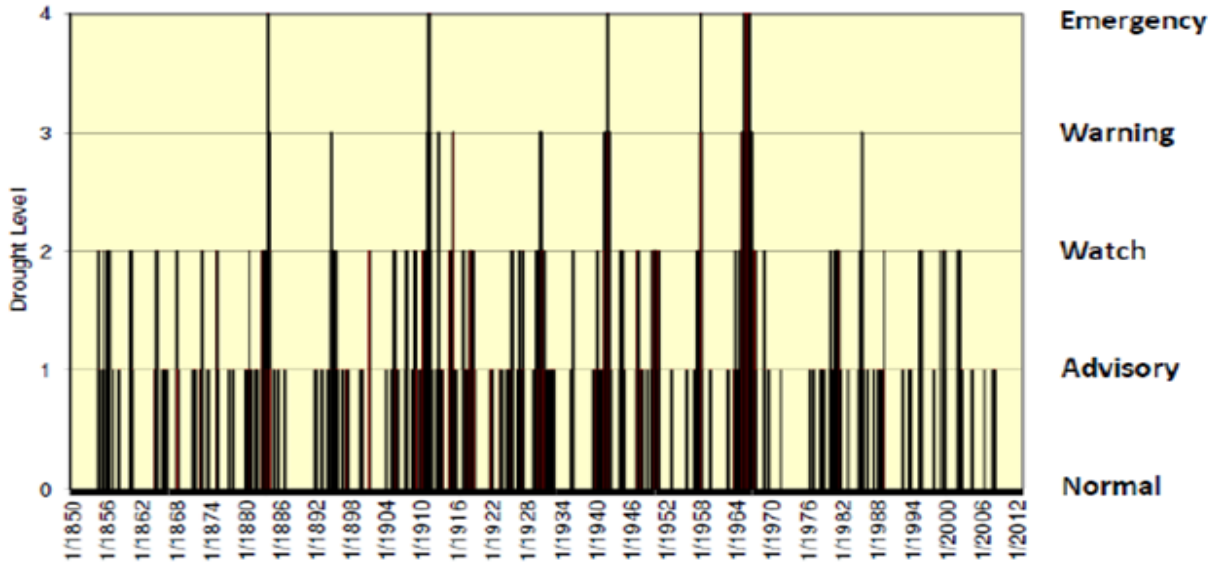
Determinations on the end of a drought or reduction of the drought level focus on two key drought indicators: precipitation and groundwater levels. These two factors have the greatest long-term impact on stream flow, water supply, reservoir levels, soil moisture and potential for forest fires.

Previous Occurrences

Sherborn does not collect data on drought events. Because drought is a regional hazard, this plan references state data as the best available data for drought. The statewide scale is a composite of six regions of the state. Regional composite precipitation values are based on monthly values from six stations, and three stations in the smaller regions (Cape Cod and the Islands).

Figure 8 depicts the incidents of drought levels' occurrence in Massachusetts from 1850 to 2012 using the Standardized Precipitation Index (SPI) parameter alone. On a monthly basis, the state would have been in a drought watch to emergency condition 11 of the time between 1850 and 2012. Table 23 below summarizes the chronology of major droughts since the 1920's.

Figure 8: Statewide Drought Levels using SPI Thresholds, 1850-2012



(Source: Mass. State Drought Management Plan 2013)

Table23: Chronology of Major Droughts in Massachusetts

Date	Area Affected	Recurrence Interval (years)	Remarks
1929-32	Statewide	10 to >50	Water-supply sources altered in 13 communities. Multistate.
	Statewide	15 to >50	More severe in eastern and extreme western Massachusetts. Multistate.
1957-59	Statewide	5 to 25	Record low water levels in observation wells, northeastern Massachusetts.
1961-69	Statewide	35 to >50	Water-supply shortages common. Record drought. Multistate.
1980-83	Statewide	10 to 30	Most severe in Ipswich and Taunton River basins; minimal effect in Nashua River basin. Multistate.
1985-88	Housatonic River Basin	25	Duration and severity unknown. Streamflow showed mixed trends elsewhere.
2016-17	Statewide	N/A	Drought declaration began in July 2016 with a Drought Watch which was upgraded to a Drought Warning in August 2016. The Central and Northeast regions were the most severely affected.

Drought Warning

Drought warning levels not associated with drought emergencies have occurred five times, in 1894, 1915, 1930, 1985, and 2016. On a monthly basis over the 162-year period of record, there is a two percent chance of being in a drought Warning level. As of July 2016, a fifth drought warning had been declared for the region that includes the Town of Sherborn. September 1, 2016 marked the sixth consecutive month of below average rainfall.

Drought Watch

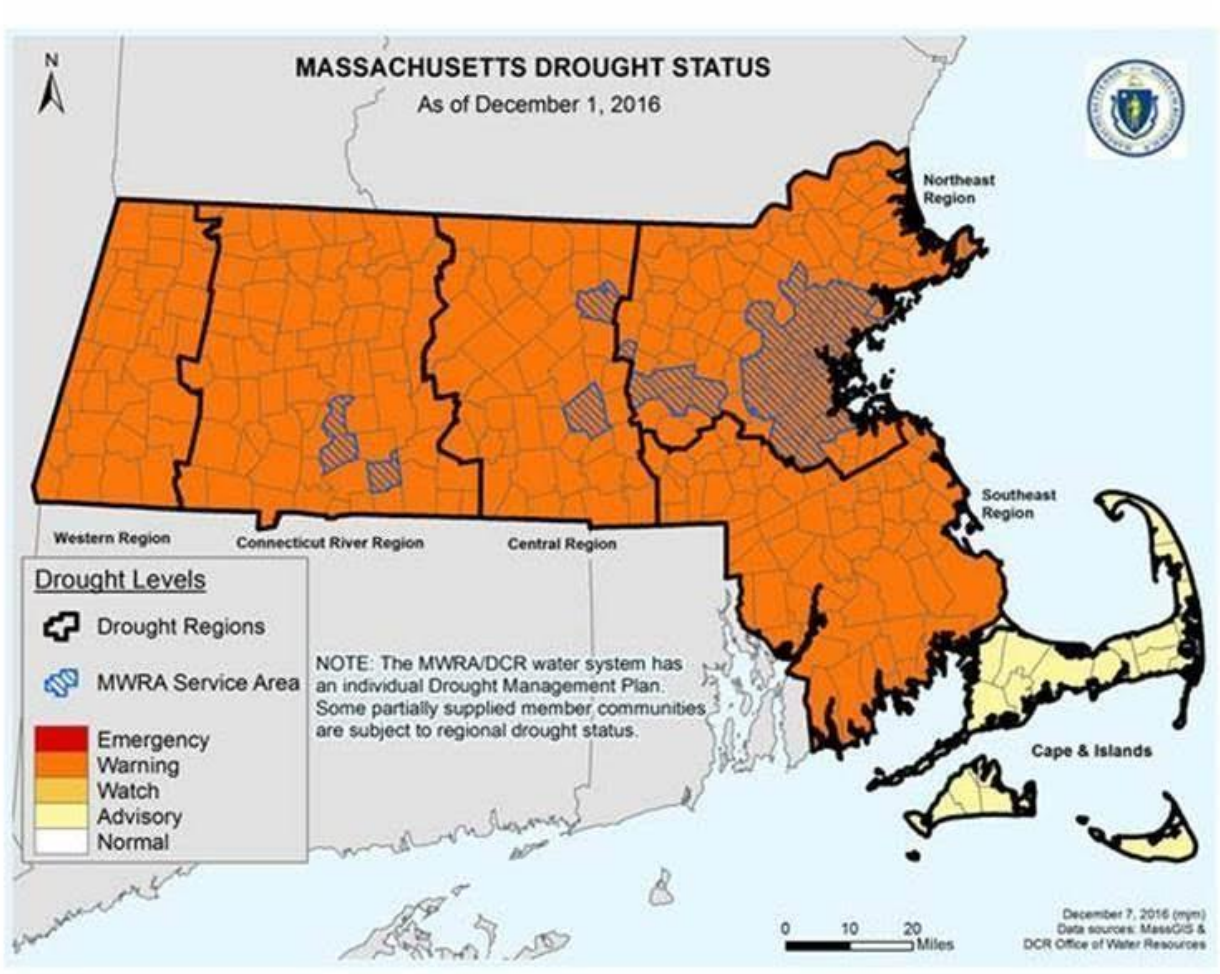
Drought watches not associated with higher levels of drought generally have occurred in three to four years per decade between 1850 and 1950. In the 1980s, there was a lengthy drought Watch level of precipitation between 1980 and 1981, followed by a drought warning in 1985. A frequency of drought watches at a rate of three years per decade resumed in the 1990s (1995, 1998, 1999). In the 2000s, Drought Watches occurred in 2001, 2002, and 2016. The overall frequency of being in a drought watch is 8% on a monthly basis over the 162-year period of record.

Drought of 2016

On July 8, 2016, Massachusetts Energy and Environmental Affairs (EEA) Secretary Matthew Beaton declared a Drought Watch for Central and Northeast Massachusetts, and a Drought Advisory for Northeast Massachusetts, which includes the Town of Sherborn. By December 2016, all regions except the Cape and Islands were listed in Drought Warning, the second highest

drought stage (see Figure 9). In early 2017 precipitation returned to a normal pattern, and by June 1, 2017 all regions of the state were listed as being in a normal condition.

Figure 9: Massachusetts Drought Status as of December 2016



Source: MA Department of Conservation and Recreation, Office of Water Resources

Under a severe long term drought the Town of Sherborn could be vulnerable to restrictions on water supply due to lowered groundwater tables that feed local wells. Potential damages of a severe drought could include losses of landscaped areas if outdoor watering is restricted and potential loss of business revenues if water supplies were severely restricted for a prolonged period. As this hazard has never occurred to such a severe degree in Sherborn, 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 a few hundred thousand to several million dollars.

Probability of Future Occurrences

The state has experienced emergency droughts five times between 1850 and 2012. Emergency Drought conditions over the 162-period of record in Massachusetts are a low frequency natural

hazard event that can occur from once in 50 years to once in 100 years (1% to 2% chance per year), as defined by the Massachusetts State Hazard Mitigation Plan, 2013.

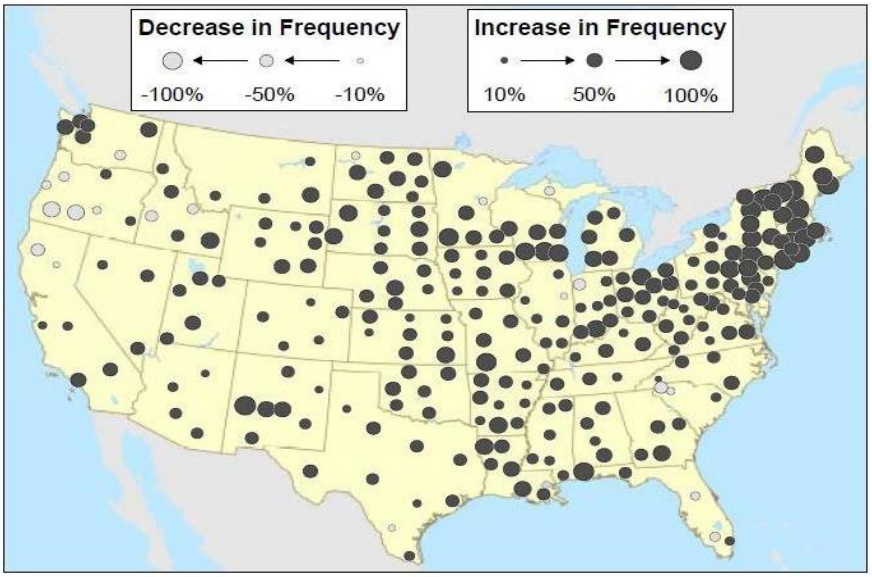
Impacts of Climate Change

Many of the natural hazards that Sherborn has historically experienced are likely to be exacerbated by climate change in future years. This is particularly true for flooding caused by extreme precipitation, and extreme heat. These are described in more detail below.

Extreme Precipitation

Sherborn's average annual precipitation is 42 inches. While total annual precipitation has not changed significantly, according to the 2012 report *When It Rains It Pours – Global Warming and the Increase in Extreme Precipitation from 1948 to 2011*, intense rainstorms and snowstorms have become more frequent and more severe over the last half century in the northeastern United States. Extreme downpours are now happening 30 percent more often nationwide than in 1948 (see Figure 10). In other words, large rain or snow storms that happened once every 12 months, on average, in the middle of the 20th century, now happen every nine months.

Figure 10: Changes in Frequency of Extreme Downpours, 1948-2011



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

Not only are these intense storm events more frequent, they are also more severe; the largest annual storms now produce 10 percent more precipitation, on average, than in 1948. In particular, the report finds that New England has experienced the greatest change with intense rain and snow storms occurring 85 percent more often than in 1948.

At the other extreme, changes in precipitation patterns and the projected future rising temperatures due to climate change will likely increase the frequency of short-term (one- to three-month) droughts and decrease stream flow during the summer.

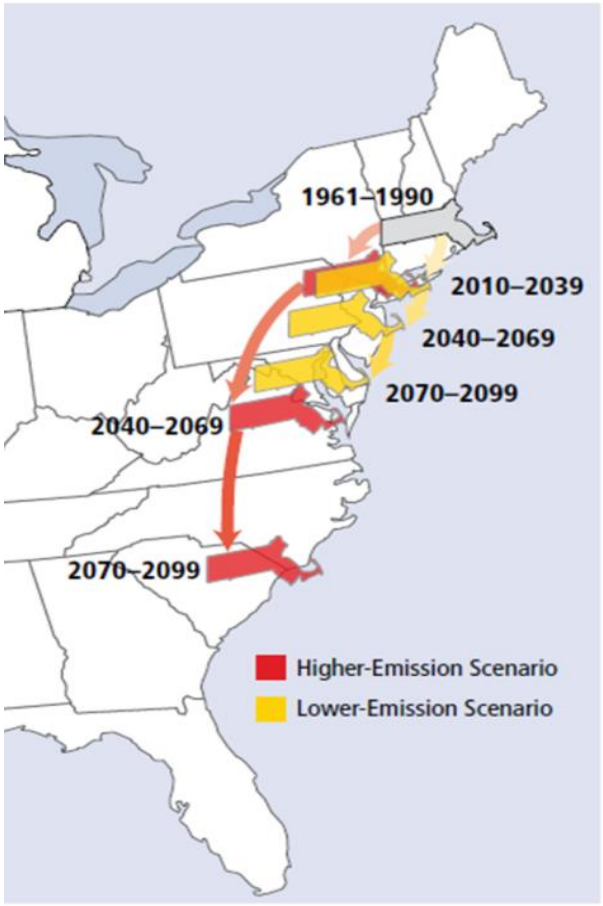
Extreme Heat

Recent temperature trends suggest greater potential impacts to come due to climate change. In the report "Confronting Climate Change in the U.S. Northeast," (2007), the Union of Concerned Scientists presented temperature projections to 2099 based on two scenarios, one with lower carbon dioxide emissions, and the other with high emissions.

Between 1961 and 1990, Boston experienced an average of 11 days per year over 90°F. That could triple to 30 days per year by 2095 under the low emissions scenario, and increase to 60 days per year under the high emissions scenario. Days over 100°F could increase from the current average of one day per year to 6 days with low emissions or 24 days with high emissions. By 2099, Massachusetts could have a climate similar to Maryland's under the low emissions scenario, and similar to the Carolinas' with high emissions (Figure 11).

Furthermore, the number of days with poor air quality could quadruple in Boston by the end of the 21st century under higher emissions scenario, or increase by half under the lower emissions scenario. These extreme temperature trends could have significant impacts on public health, particularly for those individuals with asthma and other respiratory system conditions, which typically affect the young and the old more severely.

Figure 11: Extreme Heat Scenarios



Source: Union of Concerned Scientists

Land Use and Development Trends

Existing Land Use

The most recent land use statistics available from the state are from aerial photography done in 2005. Table 24 shows the acreage and percentage of land in 23 categories. If the five residential categories are aggregated, residential uses make up 13% of the area of the town (1,343 acres). Commercial and industrial combined make up only 0.4% of the town, or 42 acres. Forest and wetlands comprise a total of 72%, or 7,434 acres.

Table 24: 2005 Land Use

Land Use Type	Acres	Percent
Crop Land, Pasture, Orchard, Nursery	907.4	8.8%
Forest	5714.0	55.3%
Non-Forested Wetlands	389.3	3.8%
Forested Wetland	1380.1	13.4%
Mining	0	0%
Open & Urban Open Land	50.6	0.5%
Participation Recreation	36.1	0.3%
Water-based Recreation	4.4	0.0%
Multi-family Residential	17.8	0.2%
High Density Residential	0	0%
Medium Density Residential	1.7	0%
Low Density Residential	849.4	8.2%
Very Low Density Residential	473.9	4.6%
Commercial	30.3	0.3%
Industrial	11.8	0.1%
Transportation	5.1	0%
Waste Disposal	1.0	0%
Powerline	108.7	1.1%
Water	236.4	2.3%
Brushland/Successional	14.6	0.1%
Urban Public	39.3	0.4%
Cemetery	13.7	0.1%
Golf Course	18.8	0.2%
Total Acres	**10,332.8**	**99.7%**

For more information on how the land use statistics were developed and the definitions of the categories, please go to http://www.mass.gov/mgis/lus.htm.

Potential Future Development

MAPC consulted with Town planning staff to determine areas that may be developed in the future, based on the Town's comprehensive planning efforts and current trends and projects. These

areas are summarized in Table 25. In order to characterize any change in the town's vulnerability associated with new developments, a GIS mapping analysis was conducted which overlaid the development sites with the FEMA Flood Insurance Rate Map. This information is provided so that planners can ensure that development proposals comply with flood plain zoning and that careful attention is paid to drainage issues. The analysis shows that only a very small portion (less than 1%) of one of the land parcels is located in Zone A (see Table 26), typically a portion of the site that is not built on.

Table 25: Potential Future Development Sites

Map ID	Name	Description
A	The Fields at Sherborn	This 32-unit (townhouses) 40B project has been permitted but it is under appeal by DEP
B	59 North Main Street	This development in permitting includes 12 units of senior housing (mix of single family homes and duplexes)
C	Coolidge Crossing	Proposed development of 88 townhouses
D	Villages at Sherborn	Conceptual stage of development for 84 apartments
E	Whitney Farms	This project in construction includes 48 units (mix of single family homes and duplexes), of which six have been built so far
F	Maybe 40B	Conceptual idea for a 40B

In addition to flood zones, Table 26 shows the relationship of these land parcels to two other mapped hazards, land slide risk and brush fire risk. None of the parcels are located in an area of high vulnerability to these hazards. Given this information, overall the potential new development would not significantly increase the Town's vulnerability to natural hazards.

Table 26: Relationship of Potential Development to Hazard Areas

Parcel	Land Slide Risk	Flood Zone	Brush Fire Risk
The Fields at Sherborn	Low	No	No
59 North Main Street	Low	No	No
Coolidge Crossing	Low	No	No
Villages at Sherborn	Low	No	No
Whitney Farms	Low	0.07% in Zone A	No
Maybe 40B	Low	No	No

Critical Infrastructure in Hazard Areas

Critical infrastructure includes facilities that are important for disaster response and evacuation (such as emergency operations centers, fire stations, water pump stations, etc.) and facilities where additional assistance might be needed during an emergency (such as nursing homes, elderly housing, day care centers, etc.). There are 37 facilities identified in Sherborn. These are listed in Table 27below and are shown on the attached maps in Appendix B.

Explanation of Columns in Table 27

Column 1: ID #: The first column in Figure 37 is an ID number which appears on the maps that are part of this plan. See Appendix B.

Column 2: Name: The second column is the name of the site. If no name appears in this column, this information was not provided to MAPC by the community.

Column 3: Type: The third column indicates what type of site it is.

Column 4: Landslide Risk: The fourth column indicates the degree of landslide risk for that site. This information came from NESEC. The landslide information shows areas with either a low susceptibility or a moderate susceptibility to landslides based on mapping of geological formations. This mapping is highly general in nature. For more information on how landslide susceptibility was mapped, refer to http://pubs.usgs.gov/pp/p1183/pp1183.html.

Column 5: FEMA Flood Zone: The fifth column addresses the risk of flooding. A "No" entry in this column means that the site is not within any of the mapped risk zones on the Flood Insurance Rate Maps (FIRM maps). If there is an entry in this column, it indicates the type of flood zone.

Column 6: Local Flooding Risk: The sixth column indicates that the facility is located in an area identified as at risk of flooding by the local hazard mitigation team.

Column 7: Snowfall. Areas designated "low" receive an annual average of 36.1 to 48.0 inches of snow. Areas designated "high" receive an annual average of 48.1 to 72 inches of snow, as shown on Map 6 in Appendix B.

Table 27: Critical Facilities and Relationship to Hazard Areas

ID #	Name	Type	Landslide Risk	FEMA Flood Zone	Local Flooding Risk	Snowfall
1	Town Hall Complex	Town Hall, Police Station, Library	No	No	No	Low
2	Community Center	Municipal	No	No	No	Low
3	Unitarian Church	Church	No	No	No	Low
4	Fire Station 1	Fire Station	No	No	No	Low
5	Fire Station 2	Fire Station	No	No	No	Low
6	St. Theresa's Church	Church	No	No	No	Low
7	Pilgrim Church	Church	No	No	No	Low
8	Woodhaven	Elder Housing	No	No	No	Low
9	Leland Farm Road	Affordable Housing	No	No	No	Low
10	Abbey Road	Elderly Housing	No	No	No	Low
11	Pine Hill Elementary School	School	No	No	No	Low
12	Community Maintenance & Development Building	DPW	No	No	No	Low
13	Business District	Business	No	No	No	Low
14	Office Building	Office	No	No	No	Low
15	Citgo Gas	Gas Station	No	No	No	Low
16	Kendall Lane	Elderly	No	No	No	Low

ID #	Name	Type	Landslide Risk	FEMA Flood Zone	Local Flooding Risk	Snowfall
		Housing				
17	Eversource Electrical Substation	Electric Substation	No	No	No	Low
18	Rockwood Street Cell Tower	Cell Tower	No	No	No	Low
19	Hunting Lane Cell Tower	Cell Tower	No	No	No	Low
20	Whitney Street Cell Tower	Cell Tower	No	No	No	Low
21	Lake Street Cell Tower	Cell Tower	No	No	No	Low
22	Brook Street Cell Tower	Cell Tower	No	No	No	Low
23	Washington Street Cell Tower	Cell Tower	No	No	No	Low
24	Kidstopia Bilingual Preschool	Daycare	No	No	No	Low
25	Town Hall Complex Well	Well	No	No	No	Low
26	Town Route Bridge	Bridge	No	AE: 1% Annual Chance of Flooding; with BFE	Farm Road/Charles River Bridge	Low
27	Charles River Bridge	Bridge	No	No	No	Low
28	Whitney Street Bridge over RR tracks	Bridge	No	No	No	Low

ID #	Name	Type	Landslide Risk	FEMA Flood Zone	Local Flooding Risk	Snowfall
29	Nason Hill Pumping Station		No	No	No	Low
30	Mass Water Authority Aqueduct	Water Source	No	No	No	Low
31	Sherborn Library	Library	No	No	No	Low
32	Sherborn Police Station	Police Station	No	No	No	Low
33	Unitarian Church Daycare	Daycare	No	No	No	Low
34	Cell Tower atop Unitarian Church	Cell Tower	No	No	No	Low
35	Cell Tower atop St. Theresa's Church	Cell Tower	No	No	No	Low
36	Emergency Radio (police/fire)	Emergency	No	No	No	Low
37	Lake Street Emergency Radio	Emergency	No	No	No	Low

Vulnerability Assessment

The purpose of the 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 hurricanes, earthquakes, and flooding. The methodology used for hurricanes and earthquakes was the HAZUS-MH software. The methodology for flooding was developed specifically to address the issue in many of the communities where flooding was not solely related to location within a floodplain.

Introduction to HAZUS-MH

HAZUS-MH (multiple-hazards) is a computer program developed by FEMA to estimate losses due to a variety of natural hazards. The following overview of HAZUS-MH is taken from the FEMA website. For more information on the HAZUS-MH software, go to: http://www.fema.gov/plan/prevent/hazus/index.shtm

> "HAZUS-MH is a nationally applicable standardized methodology and software program that contains models for estimating potential losses from earthquakes, floods, and hurricane winds. HAZUS-MH was developed by the Federal Emergency Management Agency (FEMA) under contract with the National Institute of Building Sciences (NIBS). Loss estimates produced by HAZUS-MH are based on current scientific and engineering knowledge of the effects of hurricane winds, floods and earthquakes. Estimating losses is essential to decision-making at all levels of government, providing a basis for developing and evaluating mitigation plans and policies as well as emergency preparedness, response and recovery planning.
>
> HAZUS-MH uses state-of-the-art geographic information system (GIS) software to map and display hazard data and the results of damage and economic loss estimates for buildings and infrastructure. It also allows users to estimate the impacts of hurricane winds, floods and earthquakes on populations."

There are three modules included with the HAZUS-MH software: hurricane wind, flooding, and earthquakes. There are also three levels at which HAZUS-MH can be run. Level 1 uses national baseline data and is the quickest way to begin the risk assessment process. The analysis that follows was completed using Level 1 data. Level 1 relies upon default data on building types, utilities, transportation, etc. from national databases as well as census data. While the databases include a wealth of information on the Town of Sherborn, it does not capture all relevant information. In fact, the HAZUS training manual notes that the default data is "subject to a great deal of uncertainty."

However, for the purposes of this plan, the analysis is useful. This plan is attempting to generally indicate the possible extent of damages due to certain types of natural disasters and to allow for a comparison between different types of disasters. Therefore, this analysis should be considered to be a starting point for understanding potential damages from the hazards.

Estimated Damages from Hurricanes

The HAZUS-MH software was used to model potential damages to the community from a 100 year and 500 year hurricane event; storms that are 1% and .0.2% likely to happen in a given year, and roughly equivalent to a Category 2 and Category 4 hurricane. The damages caused by these hypothetical storms were modeled as if the storm track passed directly through the Town, bringing the strongest winds and greatest damage potential.

Though there are no recorded instances of a hurricane equivalent to a 500 year storm passing through Massachusetts, this model was included in order to present a reasonable "worst case scenario" that would help planners and emergency personnel evaluate the impacts of storms that might be more likely in the future, as we enter into a period of more intense and frequent storms.

Table 28: Estimated Damages from Hurricanes

	100-Year	500-Year
Building Characteristics		
Estimated total number of buildings	1,594	
Estimated total building replacement value (2014 $)	$665,000,000	
Building Damages		
# of buildings sustaining minor damage	45	252
# of buildings sustaining moderate damage	2	34
# of buildings sustaining severe damage	0	2
# of buildings destroyed	0	1
Population Needs		
# of households displaced	0	0
# of people seeking public shelter	0	0
Debris		
Building debris generated (tons)	131	650
Tree debris generated (tons)	6,409	13,127
# of truckloads to clear building debris	72	26
Value of Damages		
Total property damage (buildings and content)	$4,537,370	$14,920,730
Total losses due to business interruption	$130,710	$661,590

Estimated Damages from Earthquakes

The HAZUS-MH earthquake module allows users to define an earthquake magnitude and model the potential damages caused by that earthquake as if its epicenter had been at the geographic center of the study area. For the purposes of this plan, two earthquakes were selected: magnitude 5.0 and a magnitude 7.0. Historically, major earthquakes are rare in New England, though a magnitude 5 event occurred in 1963.

Table 29: Estimated Damages from Earthquakes

	Magnitude 5.0	Magnitude 7.0
Building Characteristics		
Estimated total number of buildings	1,594	
Estimated total building replacement value (2014 $)	$665,000,000	
Building Damages		
# of buildings sustaining slight damage	473	510
# of buildings sustaining moderate damage	253	374
# of buildings sustaining extensive damage	67	134
# of buildings completely damaged	17	143
Population Needs		
# of households displaced	19	81
# of people seeking public shelter	10	42
Debris		
Building debris generated (tons)	10,000	40,000
# of truckloads to clear debris (@ 25 tons/truck)	440	1,640
Value of Damages		
Total property damage	$69,880,000	$172,390,000
Total losses due to business interruption	$11,640,000	$34,380,000

Estimated Damages from Flooding

The HAZUS-MH flood risk module was used to estimate damages to the municipality at the 100 and 500 return periods. These return periods correspond to flooding events that have a 1% and a 0.2% likelihood of occurring in any given year.

Table 30: Estimated Damages from Flooding

	100-Year	500-Year
Building Characteristics		
Estimated total number of buildings	1,594	
Estimated total building replacement value (2014 $)	$665,000,000	
Building Damages		
# of buildings sustaining slight damage (<10%)	1	4
# of buildings sustaining moderate damage (10-50%)	0	0
# of buildings sustaining substantial damage (>50%)	0	0
Population Needs		
# of households displaced	12	21
# of people seeking public shelter	3	5
Value of Damages		
Total property damage (buildings and content)	$520,000	$880,000
Total losses due to business interruption	$0	$0

V HAZARD MITIGATION GOALS

The Sherborn Local Hazard Mitigation Planning Team discussed and adopted the goals listed before for the Town of Sherborn. All of the goals are reflective of the Town's priorities and concerns relative to natural hazard mitigation. All of the goals are considered critical for the Town and they are not listed in order of importance.

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

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

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

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

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

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

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

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

Goal 9: Consider the potential impacts of future climate change. Incorporate climate sustainability and resiliency in hazard mitigation planning.

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VI EXISTING MITIGATION MEASURES

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

The Town's existing mitigation measures, which were in are in place today, are listed by hazard type here and are summarized in Table 31 below.

Town-Wide Flood-Related Mitigation Measures

Sherborn employs a number of practices to help minimize potential flooding and impacts from flooding, and to maintain existing drainage infrastructure. Existing town-wide mitigation measures include the following:

1. National Flood Insurance Program (NFIP): Sherborn participates in the NFIP with six policies in force as of the March 31, 2018. FEMA maintains a database on flood insurance policies and claims. This database can be found on the FEMA website at http://bsa.nfipstat.fema.gov/reports/1011.htm#MAT.

   The following information is provided for the Town of Sherborn as of 6/30/2018 –

Flood insurance policies in force	6
Coverage amount of flood insurance policies	$1,592,700
Premiums paid	$2,293
Total losses (all losses submitted regardless of the status)	6
Closed losses (Losses that have been paid)	5
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)	$34,661

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

2. Street sweeping: All streets are swept at least once per year due to the use of sand over salt in the winter. Poor draining streets can also be swept as needed following rainstorms.

3. Catch basin cleaning: The Town of Sherborn conducts catch basin cleaning once a year.

4. Roadway treatments: The Town uses a mixture of one part sand to one part salt for de-icing purposes that minimizes the amount of sand that enters catch basins and streams.

5. Zoning regulations: The Town's zoning regulations include a section on subdivisions rules and regulations, which contain a number of requirements that address flood hazard mitigation. Some of these provisions also relate to other hazards. The zoning bylaw also includes provisions for a Flood Plain District, ground water protection, site plan approval, and open space requirements. Sherborn also has Wetlands Regulations that were last updated in February 2017.

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

7. Protected open space: Sherborn has a proactive land preservation program in which hundreds of acres of open space have been protected in perpetuity.

8. Public education: The Town provides public education on stormwater through the NPDES Phase II Program.

9. Beaver activity: The Town of Sherborn makes ongoing repairs related to beaver dams through either a "beaver deceiver" or a permit from the Board of Health.

Site Specific Flood-Related Mitigation Measures

The following sites were identified by Town staff as areas that have experienced more significant flooding in the past. The numbers in this section also refer to the Areas of Concern on Map 8 in Appendix A.

1. Farm Road/Charles River Bridge: This is a medium severity flood hazard with a low to medium frequency. No existing mitigation exists but the area experiences overflow flooding from the Charles River during heavy rain that has damaged property.

2. Coolidge Street: This is a high severity, low frequency hazard due to overflow flooding for Meadow Brook Stream. The area has a culvert but it is undersized. The street was almost lost in 2010 due to water rushing the culvert and a vehicle accident that did damage to the culvert and guard rails.

3. Lake Street: This is a medium severity and frequency hazard. This area experiences overflow flooding from Indian Brook and the main source of flooding is from beaver dams, which cause flow to go through the culvert and overtake the road. A "beaver deceiver" was put in to help prevent the area from flooding.

4. Harrington Ridge Road: This is a high frequency, low severity hazard. This road experiences flooding a few times a year after heavy rains due to water flowing out from the woods. This area became low-lying when it was developed but there has been no property damage. Storm drains and culvert are currently handling the water well.

5. Western Avenue between Washington and Hollis: This is also a high frequency, low severity hazard. This road floods every spring as a farm field fills with water and goes across the road. No property damage has been caused and the Town has not had to block off the road. The Town of Sherborn does not believe it is worth mitigating at this point.

6. Nason Hill Road: This is a medium frequency and medium severity hazard. This area is impacted by poor drainage and beaver activity. At one point, the road had to be shut down for a few days due to beaver dams in neighboring Millis that caused Bogastow Brook to overflow. As water overtook the road, the existing culvert was damaged.

Dam Failure Mitigation Measures

1. DCR dam safety regulations: All dams are subject to the Division of Conservation and Recreation's dam safety regulations. The dams must be inspected regularly and reports filed with the DCR Office of Dam Safety.

2. Permits required for construction: State law requires a permit for the construction of any dam.

3. Comprehensive Emergency Management Plan: The CEMP addresses dam safety.

Wind Hazard Mitigation Measures

1. Eversource Tree Maintenance Program: Eversource, the energy provider for Sherborn, does annual tree maintenance and trimming on trees that interfere with its utility lines.

2. Public Works Tree Maintenance Program: The Town of Sherborn does tree trimming in public areas and along rights-of-ways.

Winter Hazard Mitigation Measures

1. Standard plowing operations: The Department of Public Works provides standard snow plowing operations, including salting and sanding, but with a restricted salt policy.

2. Public education: The Town of Sherborn provides information on snow operations, winter maintenance, and winter safety tips on the Town's website.

3. Snow and ice disposal: The Town's bylaw states that no person shall put any snow or ice in any public place or upon any part of a public street or sidewalk.

Brush Fire Hazard Mitigation Measures

1. Controlled open burning: Town bylaws allow controlled open burning in accordance with state regulations, but a permit is required from the Fire Chief for each day of intended burning.

2. Subdivision and site plan review: The Fire department reviews all subdivision and site plans for compliance with site access, water supply needs, and all other applicable regulations.

3. Public education: The Fire Department provides public education and safety tips on its website.

4. Fire trails: Some fire trails are maintained (mostly by volunteers) in wooded areas for firetrucks. The Community Maintenance and Development Department will soon start logging roads to provide more access.

Geologic Hazard Mitigation Measures

Earthquakes

1. Massachusetts State Building Code: The State Building Code contains a section on designing for earthquake loads (780 CMR 1612.0). Section 1612.1 states that the purpose of these provisions 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 goes on to state 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 also states that absolute safety and prevention of damage, even in an earthquake event with a reasonable probability of occurrence, cannot be achieved economically for most buildings.

2. Seismic Hazard Exposure Groups: Section 1612.2.5 sets up seismic hazard exposure groups and assigns all buildings to one of these groups according to Table 1612.2.5. Group II includes buildings which have a substantial public hazard due to occupancy or use and Group III are those buildings having essential facilities which are required for post-earthquake recovery, including fire, rescue and police stations, emergency rooms, power-generating facilities, and communications facilities.

3. Comprehensive Emergency Management Plan: The Town has an evacuation plan as specified in its CEMP.

Landslides

4. Slope stabilization requirements: The Town's subdivision rules and regulations require that all new slopes and areas disturbed by grading operations shall be topsoiled, seeded or sodded and planted to stabilize the finished ground forms and surfaces.

Existing Multi-Hazard Mitigation Measures

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

1. 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.

2. 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.

3. Local Emergency Management Planning Committee (LEPC): The LEPC consists of representatives from the Sherborn Board of Health, Police Department, and Fire Department.

4. Reverse 911: Sherborn has a reverse 911 system and names can be added to the database via the Town's website.

5. Multi-department review of developments: Multiple departments, such as Planning, Zoning, Health, Public Works, Fire, and Police, review all subdivision and site plans prior to approval.

6. Backup generators: The Police Station, Library, Town Hall, Pine Hill Elementary School, Woodhaven, and all three churches in Sherborn have backup generators that could act as shelters if necessary.

7. Public education – Emergency preparedness public education is available on the Town's website.

Table 31: Compilation of Existing Mitigation in Sherborn

Hazard	Area	Mitigation Measure
Flood-Related	Town-Wide	• Participation in the National Flood Insurance Program • Annual catch basin cleaning • Street sweeping at least annually due to use of sand over salt in winter • Flood Plain District • Wetlands regulations • Massachusetts Stormwater Policy and Stormwater Management Standards • Stormwater Requirements in Subdivision Regulations and Site Plan Review • Open Space Special Permit allowed • Protected open space and proactive land preservation programs • Public Education on stormwater through the NPDES Phase II program • Ongoing repairs related to beaver dams
	Farm Road/Charles River Bridge	This is a medium severity flood hazard with a low to medium frequency. No existing mitigation exists but the area experiences overflow flooding from the Charles River during heavy rain that has damaged property.

Hazard	Area	Mitigation Measure
	Coolidge Street	This is a high severity, low frequency hazard due to overflow flooding for Meadow Brook Stream. The area has a culvert but it is undersized. The street was almost lost in 2010 due to water rushing the culvert and a vehicle accident that did damage to the culvert and guard rails.
	Lake Street	This is a medium severity and frequency hazard. This area experiences overflow flooding from Indian Brook and the main source of flooding is from beaver dams, which cause flow to go through the culvert and overtake the road. A "beaver deceiver" was put in to help prevent the area from flooding.
	Harrington Ridge Road	This is a high frequency, low severity hazard. This road experiences flooding a few times a year after heavy rains due to water flowing out from the woods. This area became low-lying when it was developed but there has been no property damage. Storm drains and culvert are currently handling the water well.
	Western Avenue between Washington and Hollis	This is also a high frequency, low severity hazard. This road floods every spring as a farm field fills with water and goes across the road. No property damage has been caused and the Town has not had to block off the road. The Town of Sherborn does not believe it is worth mitigating at this point.
	Nason Hill Road	This is a medium frequency and medium severity hazard. This area is impacted by poor drainage and beaver activity. At one point, the road had to be shut down for a few days due to beaver dams in neighboring Millis that caused Bogastow Brook to overflow. As water overtook the road, the existing culvert was damaged.
Dams	Town-Wide	• DCR Dam Safety Regulations • Construction permits required • Comprehensive Emergency Management Plan (CEMP) addresses dam safety
Wind-Related	Town-Wide	• Tree Maintenance Program by Eversource • Tree Maintenance Program by Public Works
Winter-Related	Town-Wide	• Standard snow operations, restricted salt • Public Education on snow operations and winter maintenance on Town website • Snow and Ice Disposal Bylaw

Hazard	Area	Mitigation Measure
Fire-Related	Town-Wide	• Open burning permits required • Fire Department reviews all development plans • Fire Department provides public education and safety tips on its website • Some fire trails in wooded areas and making improvements – DPW will start logging roads which will provide access
Geologic - Earthquake	Town-Wide	• Massachusetts State Building Code and Seismic Exposure Groups • Evacuation plan in CEMP
Geologic - Landslides	Town-Wide	• Slope stabilization requirements for subdivisions
Multi-Hazard	Town-Wide	• Multi-department review of developments • Comprehensive Emergency Management Plan (CEMP) • Enforcement of State Building Code • Emergency Preparedness public education on the town website • Reverse 911 • Backup generators in Police and Fire Stations, Town Hall, Elementary School, Woodhaven (elder housing), and all three churches

Local Capacity for Implementation

Under the Massachusetts system of "Home Rule," the Town of Sherborn is authorized to adopt and from time to time amend a number of local bylaws and regulations that support the town's capabilities to mitigate natural hazards. These 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 each year at the annual Town Meeting to improve the town's capabilities, and changes to most regulations simply require a public hearing and a vote of the authorized board or commission, such as the Planning and Board or Conservation Commission.

The Town of Sherborn 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 Sherborn Community Maintenance and Development Department will address the needs for catch basin cleaning and repairs and upgrades to drainage infrastructure. The Town's Planning Board will address the updates to the Master Plan and implementation of 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.

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VII HAZARD MITIGATION STRATGY

What is Hazard Mitigation?

Hazard mitigation means to permanently reduce or alleviate the losses of life, injuries and property resulting from natural hazards through long-term strategies. These long-term strategies include planning, policy changes, education programs, infrastructure projects and other activities. FEMA currently has three mitigation grant programs: the Hazards Mitigation Grant Program (HGMP), the Pre-Disaster Mitigation program (PDM), and the Flood Mitigation Assistance (FMA) program. The three links below provide additional information on these programs.

http://www.fema.gov/government/grant/hmgp/index.shtm
http://www.fema.gov/government/grant/pdm/index.shtm
http://www.fema.gov/government/grant/fma/index.shtm

Hazard Mitigation Measures can generally be sorted into the following groups:

- 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.
  (Source: *FEMA Local Multi-Hazard Mitigation Planning Guidance*)

Regional and Inter-Community Considerations

Some hazard mitigation issues are strictly local. The problem originates primarily within the municipality and can be solved at the municipal level. Other issues are inter-community and require cooperation between two or more municipalities. There is a third level of mitigation which is regional and may involve a state, regional or federal agency or three or more municipalities.

Regional Partners

In many communities, mitigating natural hazards is more than a local issue. The facilities that serve these communities are complex systems owned and operated by a wide array of agencies, government, and private entities. In Sherborn, this includes but is not limited to the Town of Sherborn, Massachusetts Highway Department (MassHighway), and Mass Audubon. The planning, construction, operations and maintenance of these facilities are integral to the hazard mitigation efforts of communities. These agencies must be considered the communities' regional partners in hazard mitigation. These agencies also operate under the same constraints as communities do, including budgetary and staffing constraints and numerous competing priorities. In the sections that follow, the plan includes recommendations for activities to be undertaken by these other agencies. Implementation of these recommendations will require that all parties work together to develop solutions.

Introduction to Potential Mitigation Measures

Description of the Mitigation Measure – The description of each mitigation measure is brief and cost information is given only if cost data were already available from the community. The cost data represent a point in time and would need to be adjusted for inflation and for any changes or refinements in the design of a particular mitigation measure.

Priority – As described, the designation of high, medium, or low priority was done considering potential benefits and estimated project costs, as well as other factors in the STAPLEE analysis.

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

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

Potential Funding Sources – This column attempts to identify the most likely sources of funding for a specific measure. The information on potential funding sources in this table is preliminary and varies depending on a number of factors. These factors include whether or not a mitigation measure has been studied, evaluated or designed, or if it is still in the conceptual stages. MEMA and DCR assisted MAPC in reviewing the potential eligibility for hazard mitigation funding. Each

grant program and agency has specific eligibility requirements that would need to be taken into consideration. In most instances, the measure will require a number of different funding sources. Identification of a potential funding source in this table does not guarantee that a project will be eligible for, or selected for funding. Upon adoption of this plan, the local team responsible for its implementation should begin to explore the funding sources in more detail.

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

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

Massachusetts Emergency Management Agency (MEMA) – The grants page http://www.mass.gov/dem/programs/mitigate/grants.htm has a useful table that compares eligible projects for the Hazard Mitigation Grant Program and the Flood Mitigation Assistance Program.

Table 32: Recommended Mitigation Measures

Mitigation Measure	Priority	Lead Implementation	Timeframe	Estimated Cost Range	Potential Funding Sources
Flooding					
Replacement and enlargement of Coolidge Street culvert to one that is granite/ stone and 9' wide	High	Community Maintenance and Development	Years 2-5	$200,000	Town General Fund, FEMA, Ch. 90 funds
Development of a management plan with consistent strategy for dealing with beaver dam-related issues	High	Board of Health	Year 1	Staff time	N/A
Public education through Code Red and Next Door Sherborn about managing impacts from beaver dams	Medium	Board of Health	Year 2	Staff time	N/A
Replacement of undersized culvert on Lake Street to manage beaver issues	Medium	Community Maintenance and Development	Years 2-5	$100,000	Town General Fund, FEMA, Ch. 90 funds
Improvement of culvert on Western Avenue when road is repaved	Low	Community Maintenance and Development	Year 5	$30,000	Town General Fund, FEMA, Ch. 90 funds
Dams					
Inspection of Mill Pond and civil evaluation required for insurance	High	Community Maintenance and Development	Year 1	$10,000	Town General Fund
Wind Hazards					
Risk assessment of trees in town and removal of those posing a safety hazard	High	Community Maintenance and Development	Year 1	$250,000 in addition to pruning	Town General Fund
Public education about the need to remove some trees annually for safety reasons	Medium	Community Maintenance and Development	Ongoing	Staff time	N/A
Geologic Hazards (Earthquakes, Landslides)					
Structural assessment for Town Hall earthquake susceptibility	Low	Building Department	Year 4	$20,000	Town General Fund

Mitigation Measure	Priority	Lead Implementation	Timeframe	Estimated Cost Range	Potential Funding Sources
Brush Fires					
Clearing and maintenance of fire roads for access	High	Fire Department	Year 1	$30,000-$40,000	Town General Fund / Storm reimbursement
Development of program to create buffer free of leaf litter around homes for protection against a brush fire (fuel mitigation)	High	Fire Department	Year 1	Staff time	N/A
Creation of Emergency Management Plan at Woodhaven with seniors	Medium	Fire Department	Year 2	Staff time	N/A
Winter Hazards					
Exploration of alternative treatment for de-icing roads, such as pre-treating with liquid	High	CMD, Board of Health, Conservation Commission	Year 1	Staff time	N/A
Drought					
Subdivision regulation updates that requiring new developments to include a 40,000 gallon water tank	High	Planning Department	Year 1	Staff time	N/A
Extreme Temperatures					
Public education about where to go when power outages occur, such as the cooling station at Library	High	Community Maintenance and Development	Ongoing	Staff time	N/A

Process for Setting Priorities for Mitigation Measures

The last step in developing the Town's mitigation strategy is to assign a level of priority to each mitigation measure so as to guide the focus of the Town's limited resources towards those actions with the greatest potential benefit. At this stage in the process, the Local Hazard Mitigation Planning Team had limited access to detailed analyses of the cost and benefits of any given mitigation measure, so prioritization is based on the local team members' understanding of existing and potential hazard impacts and an approximate sense of the costs associated with pursuing any given mitigation measure.

Priority setting was based on local knowledge of the hazard areas, including impacts of hazard events, the extent of the area impacted, and the relation of a given mitigation measure to the k Town's goals. In addition, the local Hazard Mitigation Planning Team also took into consideration factors such as the number of homes and businesses affected, whether or not road closures occurred and what impact closures had on delivery of emergency services and the local economy, anticipated project costs, whether any environmental constraints existed, and whether the Town would be able to justify the costs relative to the anticipated benefits.

For each mitigation measure, the geographic extent of the potential benefiting area is identified as is an estimate of the overall benefit and cost of the measures. The benefits, costs, and overall priority were evaluated in terms of the following guidelines:

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

Table 33 presents the prioritization of the Town's potential hazard mitigation measures.

Table 33: Prioritization of the Hazard Mitigation Measures

Mitigation Action	Geographic Coverage	Estimated Benefit	Estimated Cost	Priority
Flood Hazard Mitigation				
Replacement and enlargement of Coolidge Street culvert to one that is granite/ stone and 9' wide	Coolidge St.	High	High	High
Development of a management plan with consistent strategy for dealing with beaver dam-related issues	Town-wide	High	Low	High
Public education through Code Red and Next Door Sherborn about managing impacts from beaver dams	Town-wide	Medium	Low	Medium
Replacement of undersized culvert on Lake Street to manage beaver issues	Lake Street	Medium	High	Medium
Improvement of culvert on Western Avenue when road is repaved	Western Ave.	Medum	Medium	Low
Dam Related				
Inspection of Mill Pond and civil evaluation required for insurance	Mill Pond Dam	High	Medium	High
Wind Mitigation Measures				
Risk assessment of trees in town and removal of those posing a safety hazard	Town-wide	High	High	High
Public education about the need to remove some trees annually for safety reasons	Town-wide	Medium	Low	Medium
Winter Storm Hazard Mitigation				
Exploration of alternative treatment for de-icing roads, such as pre-treating with liquid	Town-wide	High	Low	High
Earthquake Mitigation				
Structural assessment for Town Hall earthquake susceptibility	Town hall	Low	Medium	Low
Brushfire Mitigation				
Clearing and maintenance of fire roads for access	Town-wide	High	Medium	High
Development of program to create buffer free of leaf litter around homes for protection against a brush fire (fuel mitigation)	Town-wide	High	Low	High
Creation of Emergency Management Plan at Woodhaven with seniors	Woodhaven	Medium	Low	Medium
Extreme Temperature Mitigation				
Public education about where to go when power outages occur, such as the cooling station at Library	Town-wide	High	Low	High
Drought Mitigation				
Subdivision regulation updates that requiring new developments to include a 40,000 gallon water tank	Town-wide	High	Low	High

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VIII PLAN ADOPTION & MAINTENANCE

Plan Adoption

The Sherborn Hazard Mitigation Plan was adopted by the Select Board on [ADD DATE]. See Appendix D for documentation. The plan was approved by FEMA on [ADD DATE] for a five-year period that will expire on [ADD DATE].

Plan Maintenance

Although several of the mitigation measures from the Town's previous Hazard Mitigation Plan have been implemented, since that plan was adopted there has not been an ongoing local process to guide implementation of the plan. Such a process is needed over the next five years for the implementation of this plan, and will be structured as described below.

MAPC worked with the Sherborn Hazard Mitigation Planning Team to prepare this plan. After approval of the plan by FEMA, this group will meet to function as the Hazard Mitigation Implementation Team, with the Fire Chief designated as the coordinator. Additional members could be added to the local implementation team from businesses, non-profits and institutions. The Town will encourage public participation during the next 5-year planning cycle. As updates and a review of the plan are conducted by the Hazard Mitigation Implementation Team, these will be placed on the Town's web site, and any meetings of the Hazard Mitigation Implementation Team will be publicly noticed in accordance with town and state open meeting laws.

Implementation and Evaluation Schedule

Mid-Term Survey on Progress – The coordinator of the Hazard Mitigation Implementation Team will prepare and distribute a survey in year three of the plan. The survey will be distributed to all of the local implementation group members and other interested local stakeholders. The survey will poll the members on any changes or revisions to the plan that may be needed, progress and accomplishments for implementation, and any new hazards or problem areas that have been identified.

This information will be used to prepare a report or addendum to the local hazard mitigation plan in order to evaluate its effectiveness in meeting the plan's goals and identify areas that need to be updated in the next plan. The Hazard Mitigation Implementation Team, coordinated by the Commissioner of Public Works, will have primary responsibility for tracking progress, evaluating, and updating the plan.

Begin to Prepare for the next Plan Update – FEMA's approval of this plan is valid for five years, by which time an updated plan must be approved by FEMA in order to maintain the town's approved plan status and its eligibility for FEMA mitigation grants. Given the lead time needed to secure funding and conduct the planning process, the Hazard Mitigation Implementation Team will begin to prepare for an update of the plan in year three. This will help the Town avoid a lapse in its approved plan status and grant eligibility when the current plan expires.

The Hazard Mitigation Implementation Team will use the information from the Mid-Term progress review to identify the needs and priorities for the plan update and seek funding for the plan update process. Potential sources of funding may include FEMA Pre-Disaster Mitigation grants and the Hazard Mitigation Grant Program. Both grant programs can pay for 75% of a planning project, with a 25% local cost share required.

Prepare and Adopt an Updated Local Hazard Mitigation Plan – Once the resources have been secured to update the plan, the Hazard Mitigation Implementation Team may decide to undertake the update themselves, contract with the Metropolitan Area Planning Council to update the plan or to hire another consultant. However the Hazard Mitigation Implementation Team decides to update the plan, the group will need to review the current FEMA hazard mitigation plan guidelines for any changes. The Sherborn Hazard Mitigation Plan Update will be forwarded to MEMA and DCR for review and to FEMA for approval.

Integration of the Plans with Other Planning Initiatives

Upon approval of the Sherborn Hazard Mitigation Plan by FEMA, the Local Hazard Mitigation Team will provide all interested parties and implementing departments with a copy of the plan and will initiate a discussion regarding how the plan can be integrated into that department's ongoing work. At a minimum, the plan will be reviewed and discussed with the following departments:

- Fire
- Emergency Management
- Police
- Community Maintenance and Development
- Planning
- Conservation
- Parks, Recreation, and Community Education
- Health
- Building

Other groups that will be coordinated with include local institutions, business groups, land conservation organizations and watershed groups. The plans will also be posted on a community's website with the caveat that local team coordinator will review the plan for sensitive information that would be inappropriate for public posting. The posting of the plan on a web site will include a mechanism for citizen feedback such as an e-mail address to send comments.

The Hazard Mitigation Plan will be integrated into other town plans and policies as they are updated and renewed, including the Master Plan, Open Space Plan, Comprehensive Emergency Management Plan, and Capital Investment Program.

IX LIST OF REFERENCES

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

FEMA, Flood Risk Report, Concord River Watershed, 2/27/2013

FEMA, Flood Insurance Rate Maps for Middlesex County, MA, 2012

FEMA, Local Mitigation Plan Review Guide; October 1, 2011.

MA Emergency Management Agency, State *Hazard Mitigation Plan*, 2013

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

MA Office of Dam Safety, Inventory of Massachusetts Dams

Metropolitan Area Planning Council, Geographic Information Systems Lab

New England Seismic Network, Weston Observatory, http://aki.bc.edu/index.htm

Northeast States Emergency Consortium, website http://www.nesec.org/

NOAA, National Centers for Environmental Information, website

Town of Sherborn, General Bylaws

Town of Sherborn, Zoning Bylaws

Town of Sherborn, Subdivision Regulations

Union of Concerned Scientists, *Confronting Climate Change in the U.S. Northeast*, 2007

US Army Corps of Engineers, Ice Engineering Group, Ice Jam Database

U. S. Census, 2010, and American Community Survey, 2013

USGS, National Water Information Center, website

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APPENDIX A: LOCAL TEAM MEETINGS

Sherborn Hazard Mitigation Local Team Meeting #1
June 6, 2017
Summary of Local Planning Team Process

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1) Local Team Meeting #1 (Kickoff & MEMA Presentation)

a) MEMA overview presentation on Hazard Mitigation Planning process
b) MEMA overview of grant management
c) MAPC review of project scope, milestones, and schedule
d) Local Team membership and stakeholder identification
e) Questions and discussion

2) Local Team Meeting #2 (Information Gathering)

a) Hazard Mitigation Planning Map Series and Digital Ortho Photo Map
b) Critical Facilities Inventory and Mapping
c) Identify and map local hazard areas:
   i) Flood Hazard Areas
   ii) Fire Hazard Areas (brushfires./ wildfires)
   iii) Other hazards
d) Identify and map Potential New Development Sites
e) Review Plan Goals and Objectives
f) Prepare for Public Involvement and Outreach
   i) Identify local stakeholders
   ii) Schedule first public meeting

3) Local Team Meeting #3 (Analysis and Data Review)

a) Review and finalize Critical Facilities
b) Review and finalize local hazard identification
c) Review vulnerability analysis
d) Review Existing Mitigation Measures
e) Discuss potential recommended Mitigation Measures

4) Local Team Meeting #4 (Recommendations/Draft Plan)

a) Develop and finalize recommended Mitigation Measures
b) Prioritize recommended Mitigation Measures
c) Schedule 2nd Public Meeting and outreach to stakeholders

AGENDA

Sherborn Local Hazard Mitigation Planning Team Meeting #2

October 10, 2017 – 11:30AM
Sherborn Town Hall – Sherborn, Massachusetts

WELCOME AND INTRODUCTIONS

- Recap past meeting

REVIEW AND UPDATE MAP/LISTS

- Critical facilities
- Areas of concern/locally identified hazard areas
- New developments

DOCUMENT EXISTING MITIGATION MEASURES

- Document steps that Sherborn is already taking to mitigate potential hazards
- Review lists from similar communities and adopt for Sherborn as needed
- Start thinking about recommendations for mitigation

NEXT STEPS

- Schedule next working group meeting for November
- Schedule final public meeting for late November/early December

AGENDA

Sherborn Local Hazard Mitigation Planning Team Meeting #3

Wednesday, January 31, 2017 at 11:30am
Town Hall - Sherborn, Massachusetts

WELCOME AND INTRODUCTIONS

REVIEW EXISTING MITIGATION MEASURES

- Any updates/comments?

PROPOSE GOALS AND RECOMMENDED MITIGATION MEASURES

- Determine goals to guide plan
- Determine recommended mitigation measures - FEMA requires at least one mitigation measure for each potential hazard
- Establish priority level for mitigation measures

NEXT STEPS

- Public presentation of draft plan before the Select Board in March/April?
- Will need your assistance with stakeholder outreach

AGENDA

Sherborn Local Hazard Mitigation Planning Team Meeting #4

Monday, March 19, 2018 at 10:00am
Town Hall - Sherborn, Massachusetts

WELCOME AND INTRODUCTIONS

RECOMMENDED MITIGATION MEASURES (CONTINUED)

- Determine recommended mitigation measures - FEMA requires at least one mitigation measure for each potential hazard
- For each measure, identify lead implementation, time frame, estimated cost
- Establish priority level for mitigation measures

NEXT STEPS

- Public meeting on the draft plan before the Select Board-in May
- Will need the team's assistance to identify stakeholder contacts

APPENDIX B: HAZARD MAPPING

The MAPC GIS (Geographic Information Systems) Lab produced a series of maps for each community. Some of the data came from the Northeast States Emergency Consortium (NESEC). More information on NESEC can be found at http://www.serve.com/NESEC/. Due to the various sources for the data and varying levels of accuracy, the identification of an area as being in one of the hazard categories must be considered as a general classification that should always be supplemented with more local knowledge.

The map series consists of eight maps as described below. The maps in this appendix are necessarily reduced scale versions for general reference. Full sized higher resolution PDF's of the maps can be downloaded from the MAPC File Transfer Protocol (FTP) website at: ftp://ftp.mapc.org/Hazard_Mitigation_Plans/maps/Sherborn/

Map 1.	Population Density
Map 2.	Potential Development
Map 3.	Flood Zones
Map 4.	Earthquakes and Landslides
Map 5.	Hurricanes and Tornadoes
Map 6.	Average Snowfall
Map 7.	Composite Natural Hazards
Map 8.	Hazard Areas

Map1: Population Density – This map uses the US Census block data for 2010 and shows population density as the number of people per acre in seven categories with 60 or more people per acre representing the highest density areas.

Map 2: Land Use – This map depicts existing land use, based on the MacConnell Land Use map series from University of Massachusetts, available from MassGIS . The map displays 33 categories of land use based on interpretation of aerial photos. For more information on how the land use statistics were developed and the definitions of the categories, please go to http://www.mass.gov/mgis/lus.htm

Map 3: Flood Zones – The map of flood zones used the FEMA NFIP Flood Zones as depicted on the FIRMs (Federal Insurance Rate Maps) for Middlesex County as its source. This map is not intended for use in determining whether or not a specific property is located within a FEMA NFIP flood zone. The currently adopted FIRMS for Sherborn are kept by the Town. For more information, refer to the FEMA Map Service Center website http://www.msc.fema.gov. The definitions of the flood zones are described in detail on this site as well. The flood zone map for each community also shows critical infrastructure and repetitive loss areas.

Map 4: Earthquakes and Landslides – This information came from NESEC. For most communities, there was no data for earthquakes because only the epicenters of an earthquake are mapped.

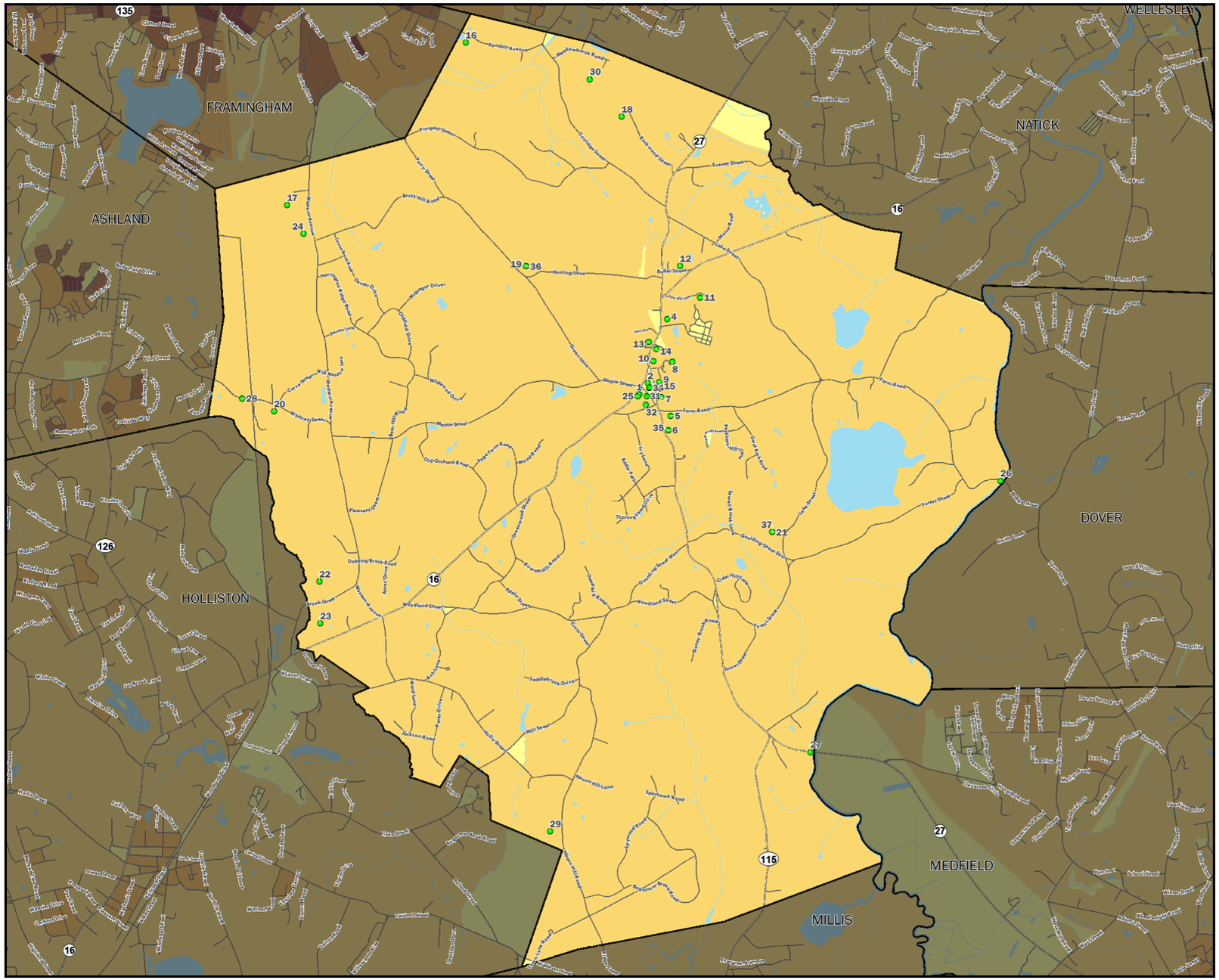
The landslide information shows areas with either a low susceptibility or a moderate susceptibility to landslides based on mapping of geological formations. This mapping is highly general in nature. For more information on how landslide susceptibility was mapped, refer to http://pubs.usgs.gov/pp/p1183/pp1183.html.

Map 5: Hurricanes and Tornadoes – This map shows a number of different items. The map includes the storm tracks for both hurricanes and tropical storms, if any occurred in this community. This information must be viewed in context. A storm track only shows where the eye of the storm passed through. In most cases, the effects of the wind and rain from these storms were felt in other communities even if the track was not within that community. This map also shows the location of tornadoes with a classification as to the level of damages. What appears on the map varies by community since not all communities experience the same wind-related events. These maps also show the 100 year wind speed.

Map 6: Average Snowfall - - This map shows the average snowfall. It also shows storm tracks for nor'easters, if any storms tracked through the community.

Map 7: Composite Natural Hazards - This map shows four categories of composite natural hazards for areas of existing development. The hazards included in this map are 100 year wind speeds of 110 mph or higher, low and moderate landslide risk, FEMA Q3 flood zones (100 year and 500 year) and hurricane surge inundation areas. Areas with only one hazard were considered to be low hazard areas. Moderate areas have two of the hazards present. High hazard areas have three hazards present and severe hazard areas have four hazards present.

Map 8: Hazard Areas – For each community, locally identified hazard areas are overlaid on an aerial photograph dated April, 2009. The source of the aerial photograph is Mass GIS. This map also shows potential future developments, and critical infrastructure sites. MAPC consulted with town staff to determine areas that were likely to be developed or redeveloped in the future.



MAPC

FEMA Hazard
Mitigation Planning Grant

SHERBORN, MA

Map 1: Population Density

Sites
- Critical Infrastructure Sites*
- Repetitive Loss Sites

* See details in separate table

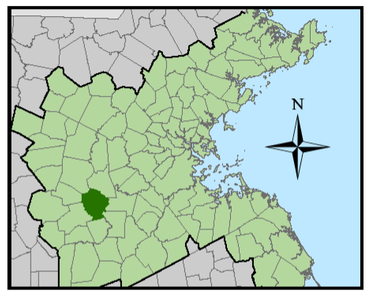
Water Bodies

Train Stations
Commuter Rail Lines
Trains

All Roads
- Interstate
- U.S. Highway
- State Route
- Street

Population Density
2010 Census Blocks
People Per Acre
- 0 or No Data
- 0.1 - 5.0
- 5.1 - 15.0
- 15.1 - 30.0
- More than 30

0 0.25 0.5 Miles



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Produced by MAPC Data Services
60 Temple Place, Boston, MA 02111 (617) 451-2770

Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Northeast States Emergency Consortium (NESEC)
Massachusetts Emergency Management Agency (MEMA)
Federal Emergency Management Agency (FEMA)
SHERBORN, MA

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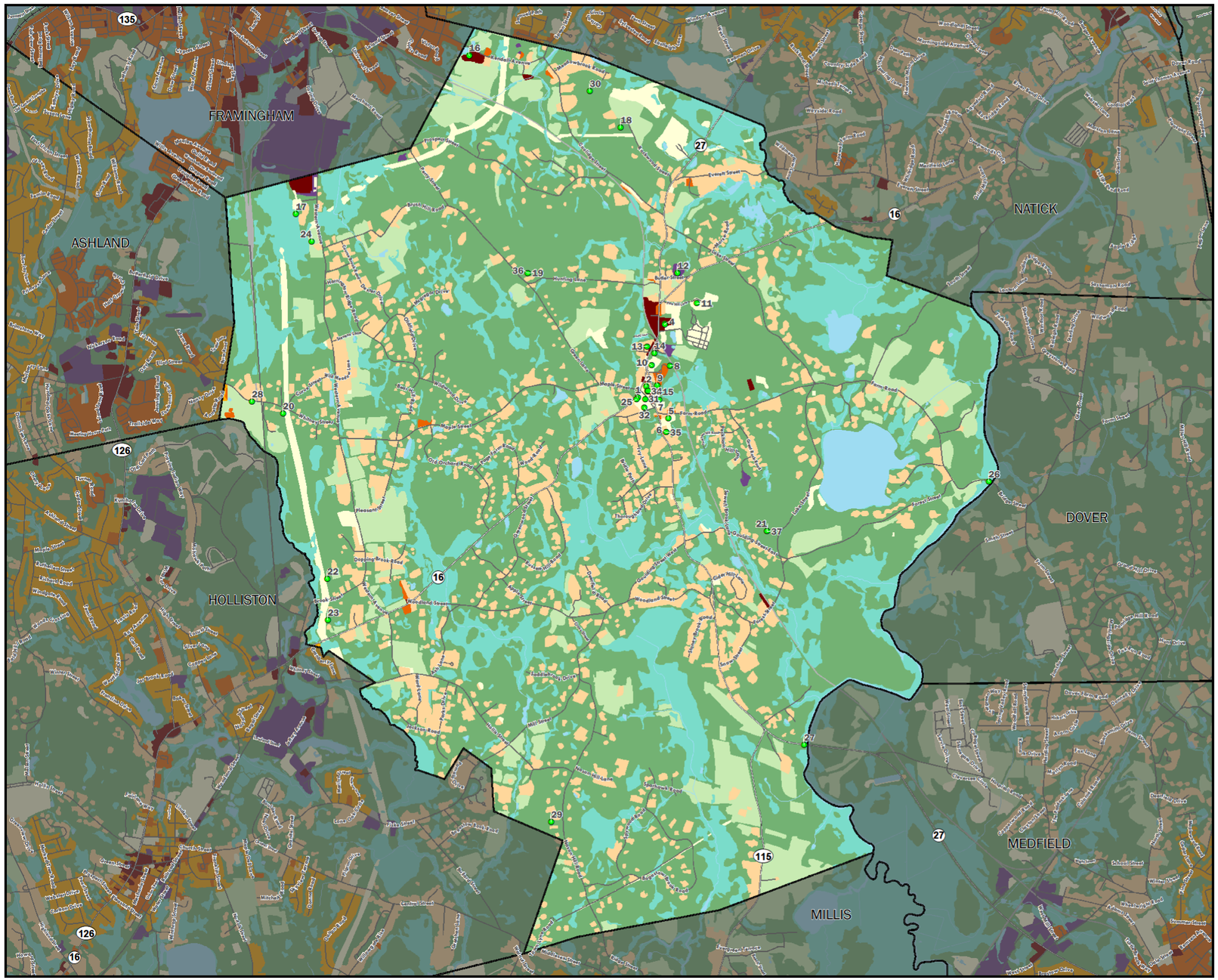


MAPC

FEMA Hazard Mitigation Planning Grant

SHERBORN, MA

Map 2: Land Use

Sites
- Critical Infrastructure Sites*
- Repetitive Loss Sites

* See details in separate table

Development Areas
* See details in separate table

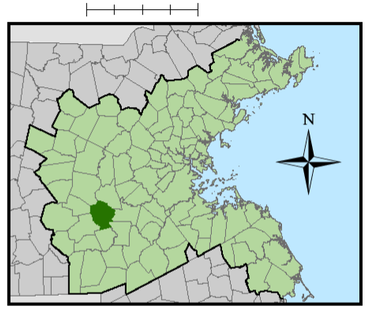
Land Use (2005)
- High Density Residential
- Medium Density Residential
- Low Density Residential
- Non-Residential Developed
- Commercial
- Industrial
- Transportation
- Agriculture
- Undeveloped
- Undeveloped Wetlands

- Train Stations
- Commuter Rail Lines
- Trains

All Roads
- Interstate
- U.S. Highway
- State Route
- Street

- Water Bodies

0 0.25 0.5 Miles



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Data Sources:
Metropolitan Area Planning Council (MAPC)
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Northeast States Emergency Consortium (NESEC)
Massachusetts Emergency Management Agency (MEMA)
Federal Emergency Management Agency (FEMA)
SHERBORN, MA

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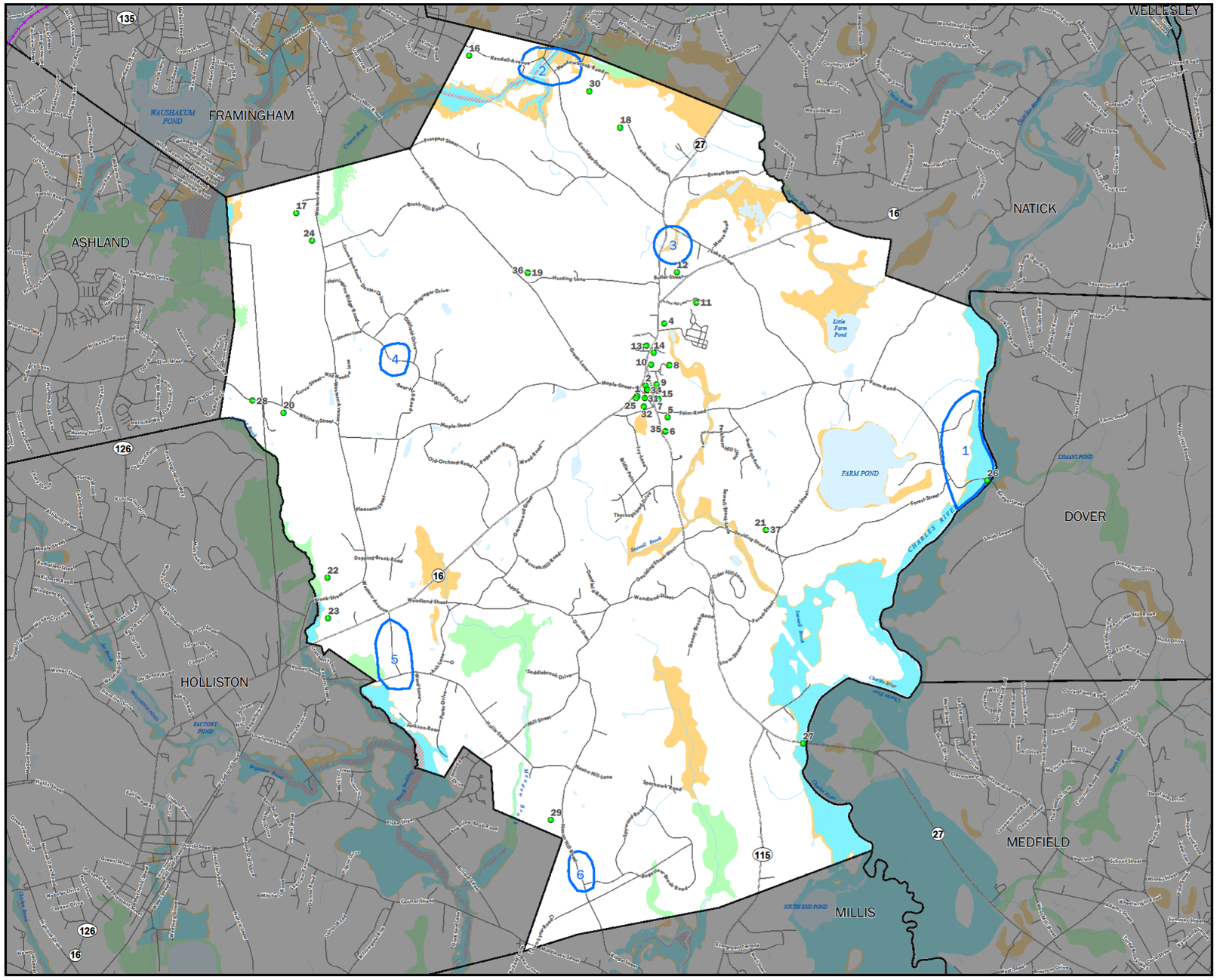


MAPC dcr

FEMA Hazard
Mitigation Planning Grant

SHERBORN, MA

Map 3: Flood Zones

Sites
- Critical Infrastructure Sites*
- Repetitive Loss Sites

* See details in separate table

Water Bodies

Locally Identified Hazard Areas*
- Flooding

* See Section IV Risk Assessment

Development Areas*

* See details in separate table

Train Stations

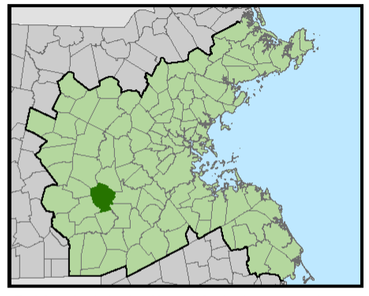
Commuter Rail Lines

Trains

Flood Zones, 2014 (Annual Chance)
- A: 1% Annual Chance of Flooding, no BFE
- AE: 1% Annual Chance of Flooding, with BFE
- AE: Regulatory Floodway
- X: 0.2% Annual Chance of Flooding

All Roads
- Interstate
- U.S. Highway
- State Route
- Street

0 0.25 0.5 Miles



The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel-level analyses.

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Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)

Flood Zones datalayer updated by MassGIS October 2013
from finalized data provided by
Federal Emergency Management Agency (FEMA)
SHERBORN, MA

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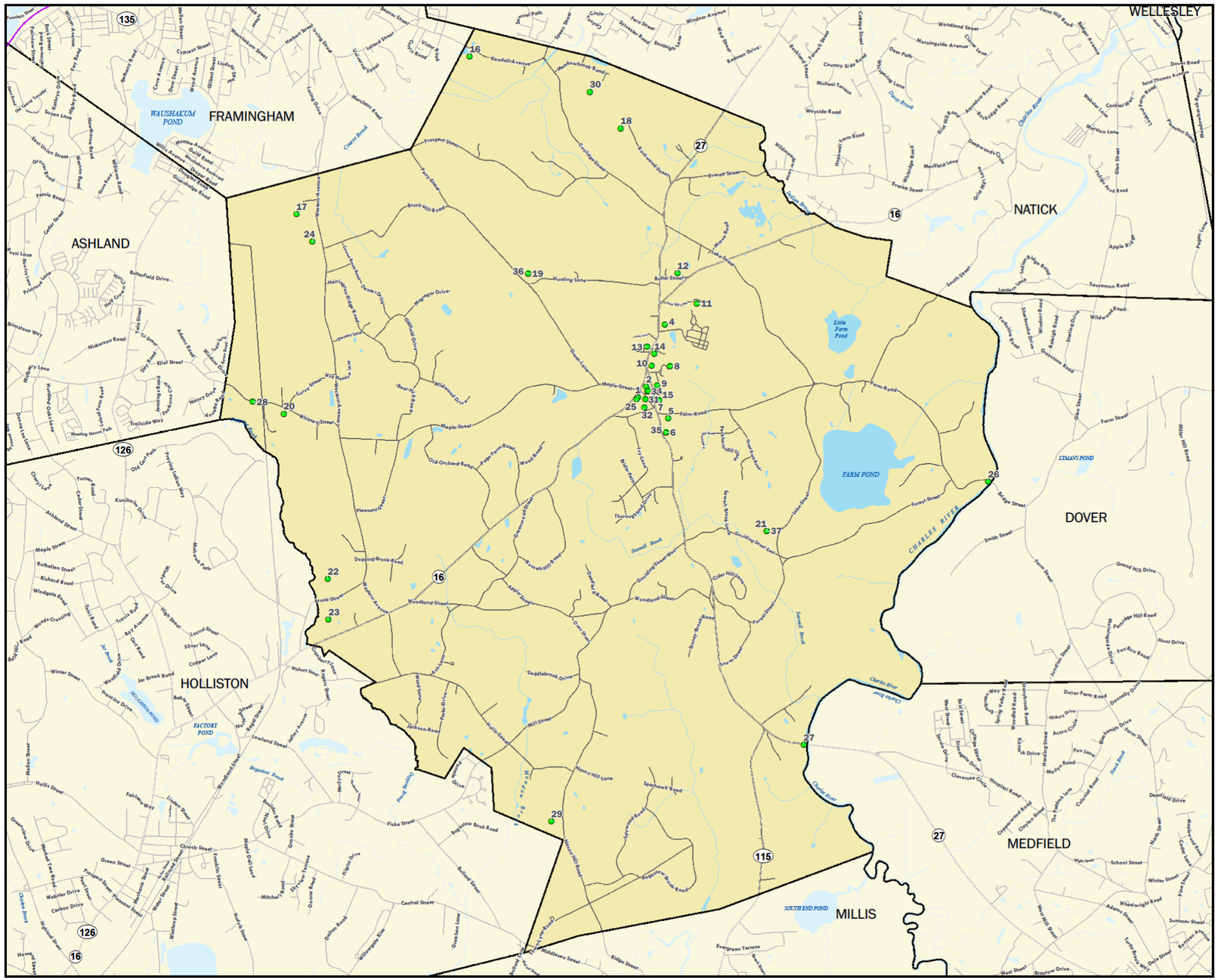


MAPC dcr

FEMA Hazard Mitigation Planning Grant

SHERBORN, MA

Map 4: Earthquakes / Landslides

Sites
- Critical Infrastructure Sites*
- Repetitive Loss Sites

* See details in separate table

Earthquakes
- Epicenters

Train Stations

Commuter Rail Lines

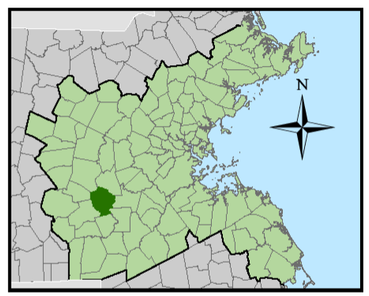
Trains

Water Bodies

All Roads
- Interstate
- U.S. Highway
- State Route
- Street

Landslides
- High landslide incidence (greater than 15% of the area is involved in landsliding)
- High susceptibility to landsliding and moderate incidence
- High susceptibility to landsliding and low incidence
- Moderate susceptibility to landsliding and low incidence
- Low landslide incidence (less than 1.5 % of the area is involved in landsliding

0 0.25 0.5 Miles



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Data Sources:
Metropolitan Area Planning Council (MAPC)
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Northeast States Emergency Consortium (NESEC)
Massachusetts Emergency Management Agency (MEMA)
Federal Emergency Management Agency (FEMA)
SHERBORN, MA

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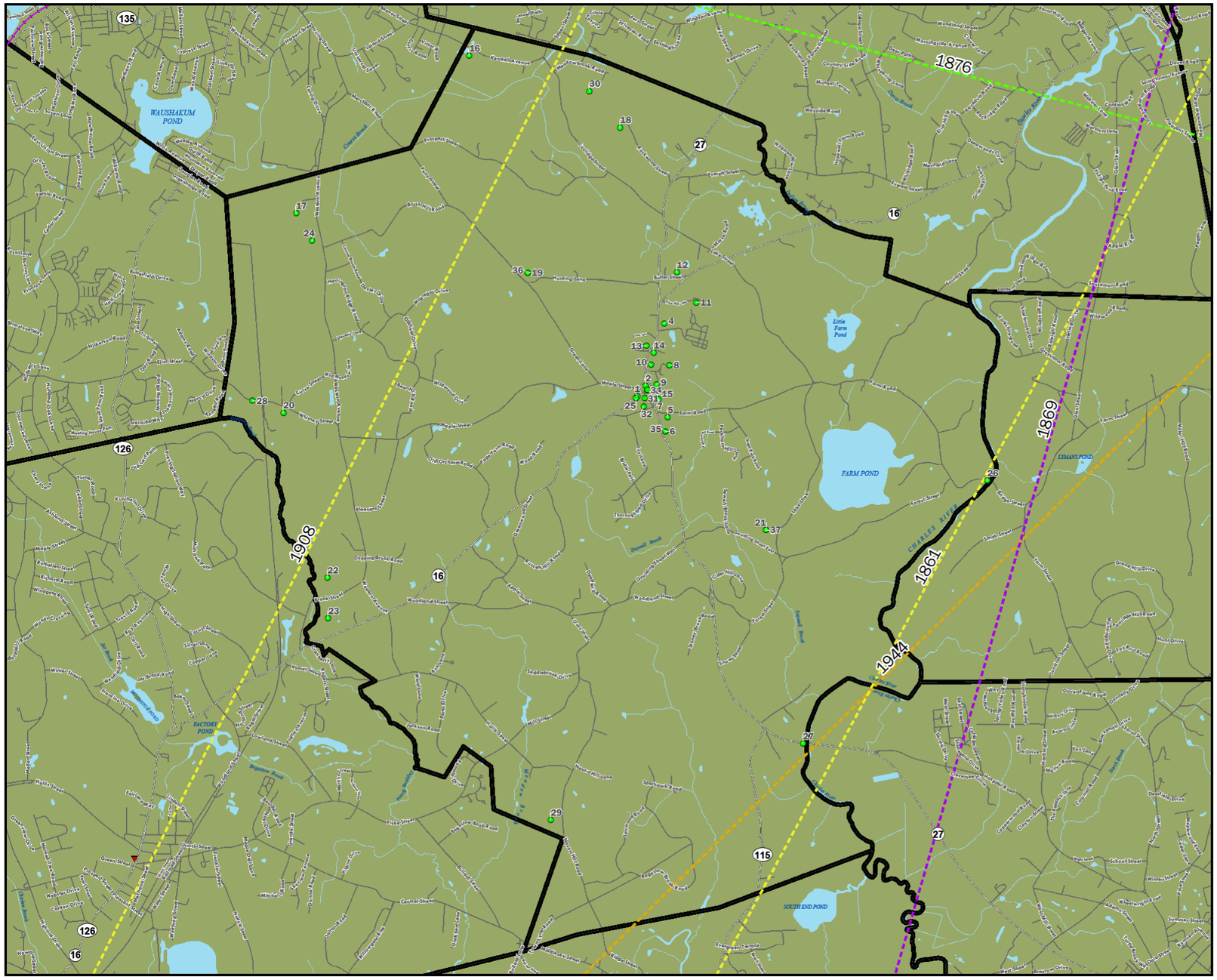


MAPC

FEMA Hazard
Mitigation Planning Grant

SHERBORN, MA

Map 5: Hurricanes / Tornadoes

Sites
- Critical Infrastructure Sites*
- Repetitive Loss Sites

* See details in separate table

Tornadoes
- Tornado

Storm Tracks
- Tropical Depression
- Tropical Storm
- Category 1 Hurricane
- Category 2 Hurricane
- Category 3 Hurricane

Year of storm noted on map

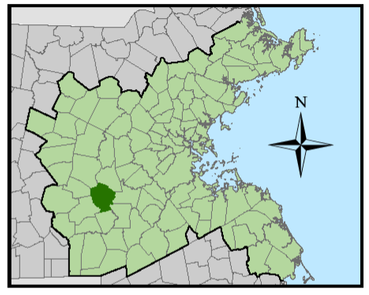
- Hurricane Surge Innudation Ares
- Train Stations
- Commuter Rail Lines
- Trains

All Roads
- Interstate
- U.S. Highway
- State Route
- Street

- Water Bodies

100 Year Wind Speeds
Miles Per Hour
- 90 MPH
- 100 MPH
- 110 MPH
- 120 MPH
- 130 MPH

0 0.25 0.5 Miles



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Data Sources:
Metropolitan Area Planning Council (MAPC)
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Massachusetts Emergency Management Agency (MEMA)
Federal Emergency Management Agency (FEMA)
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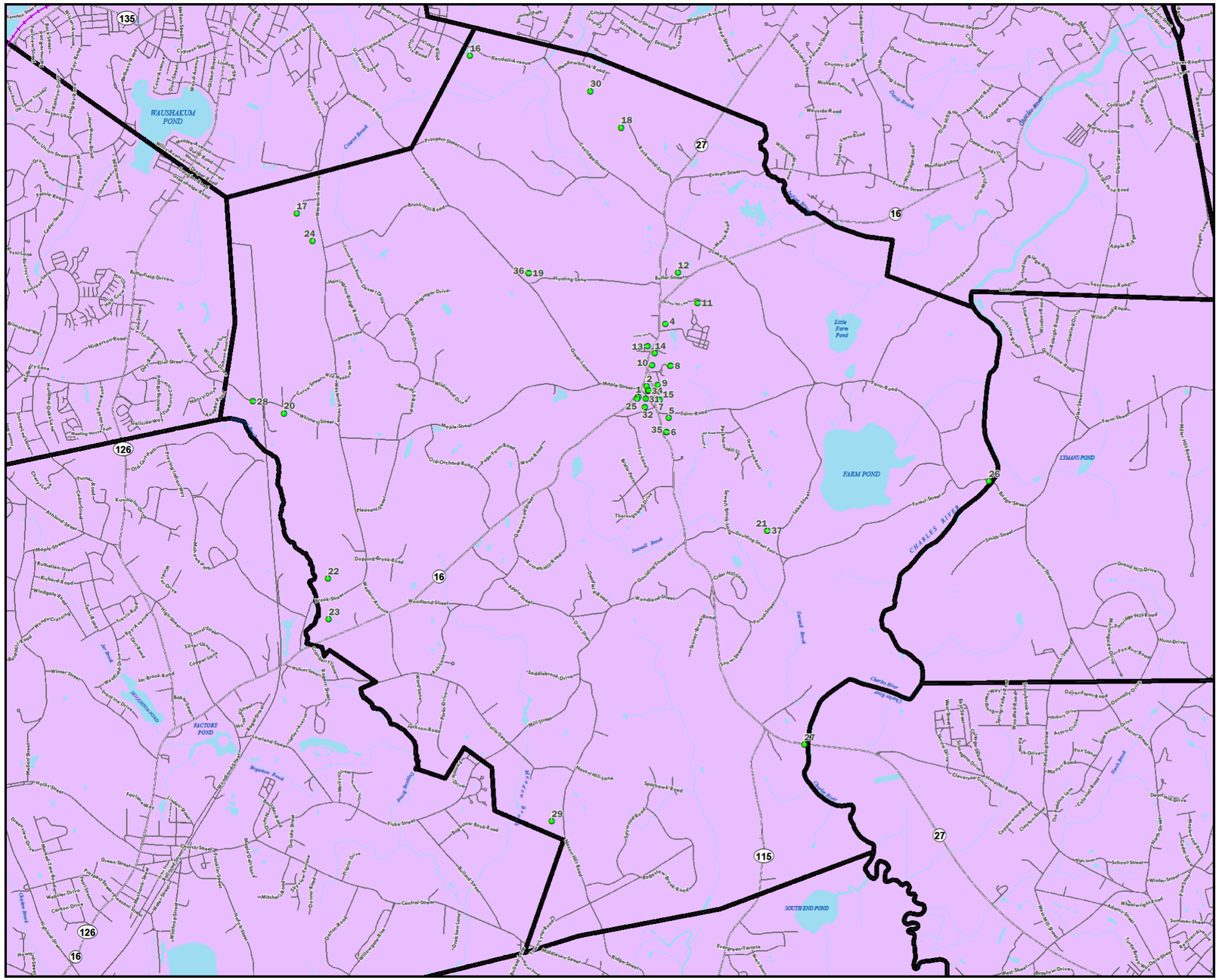

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SHERBORN, MA

Map 6: Average Snowfall

Sites
- Critical Infrastructure Sites*
- Repetitive Loss Sites

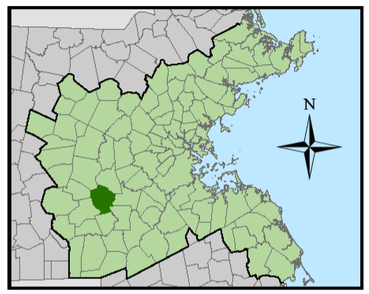
* See details in separate table

Average Annual Snowfall
- 36.1 to 48.0 inches
- 48.1 to 72.0 inches

- Water Bodies
- Train Stations
- Commuter Rail Lines
- Trains

All Roads
- Interstate
- U.S. Highway
- State Route
- Street

0 0.25 0.5 Miles



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Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Northeast States Emergency Consortium (NESEC)
Massachusetts Emergency Management Agency (MEMA)
Federal Emergency Management Agency (FEMA)
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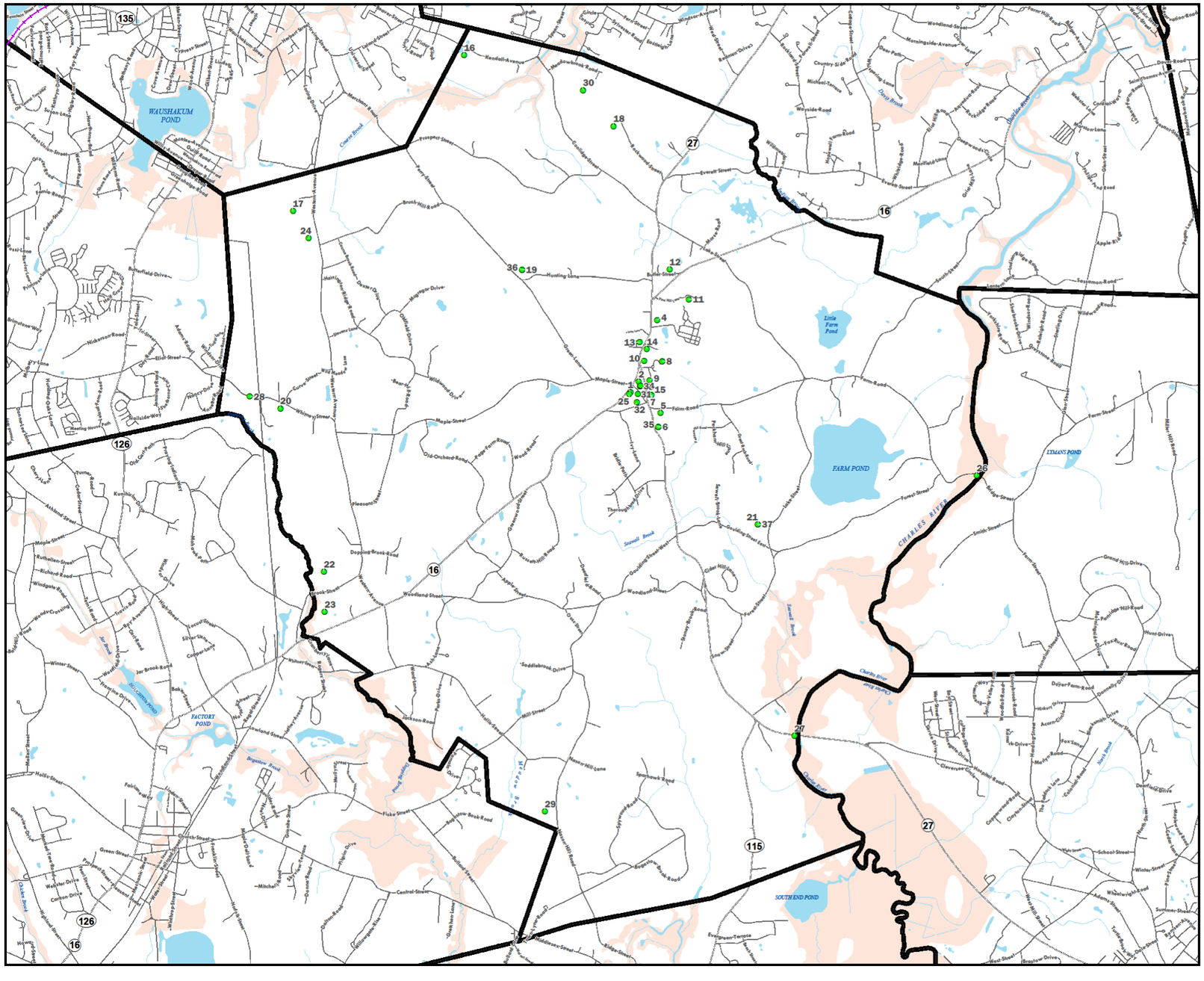
Date: 8/10/2017



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Mitigation Planning Grant

SHERBORN, MA

Map 7: Composite Natural Hazards

Composite Natural Hazards

- Low (2 Hazards)
- Moderate (3 Hazards)
- High (4 Hazards)
- Very High (5 Hazards)

Composite natural hazards shown for areas of existing development. Hazards include:

- 100 year wind speed of 110 MPH or higher
- Moderate landslide risk
- FEMA Q3 flood zones (100 year and 500 year)
- Average snowfall of 36.1" or more
- Hurricane surge innundation areas

Sites

- Critical Infrastructure Sites*
- Repetitive Loss Sites

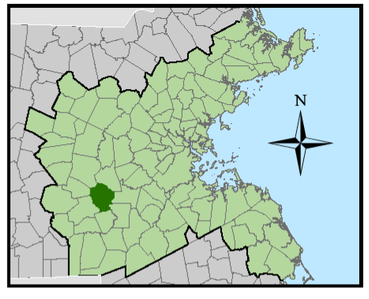
* See details in separate table

- Water Bodies

All Roads

- Interstate
- U.S. Highway
- State Route
- Street
- Train Stations
- Commuter Rail Lines
- Trains

0 0.25 0.5 Miles



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Data Sources

Composite Natural Hazard:
Wind, Landslide Risk, Snow -Northeast States Emergency Consortium (NESEC)
Flood Zones - 2013 FEMA/MassGIS
Hurricane Surge - 2013 U.S. Army Corps of Engineers, New England District

Roads/Trains: MassDOT/ CTPS

Repetitive Loss Sites: DCR/Office of Flood Hazard Management

Critical Infrastructure: Metropolitan Area Planning Council (MAPC) / SHERBORN, MA

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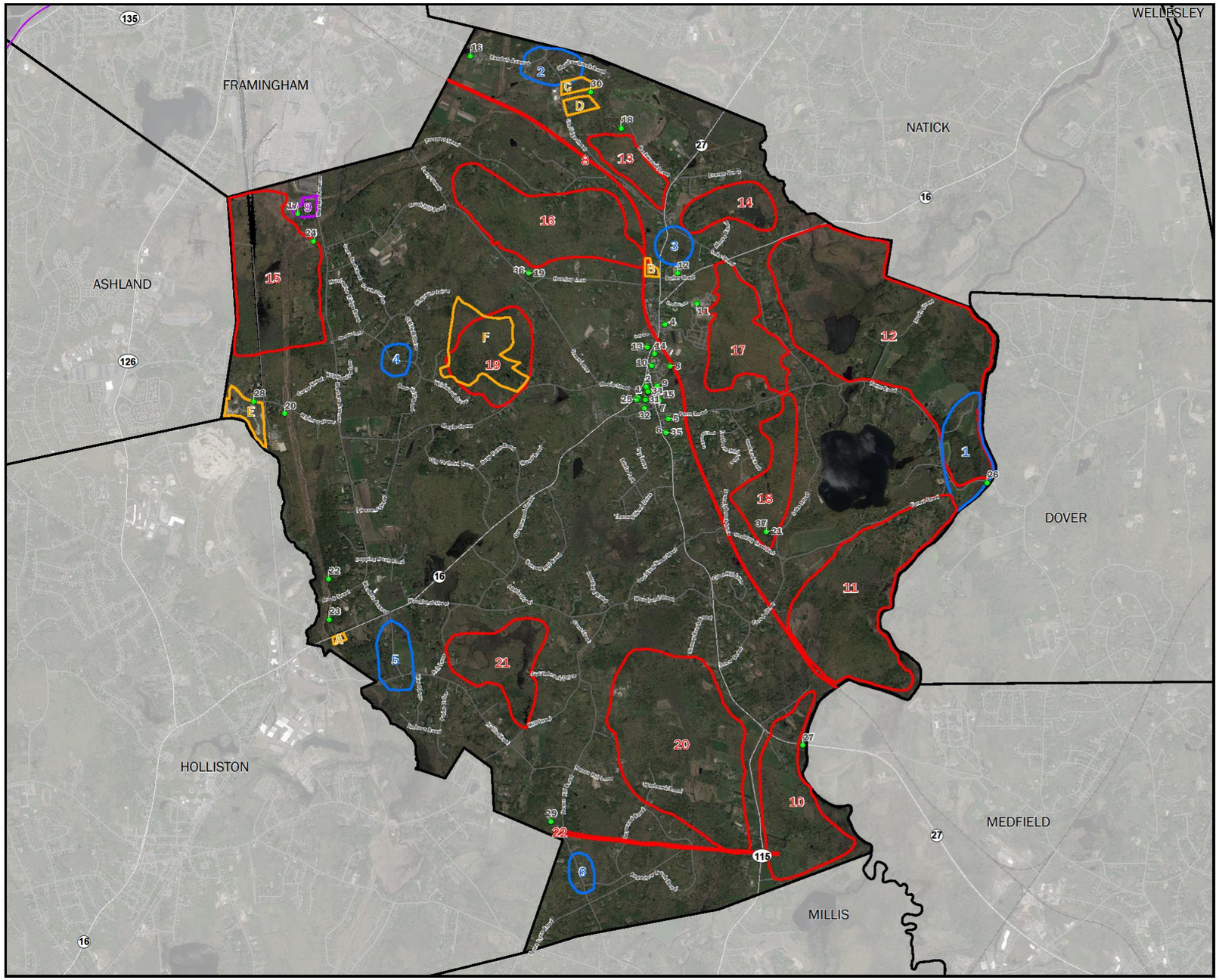
Date: 8/10/2017



MAPC dcr

FEMA Hazard
Mitigation Planning Grant

SHERBORN, MA

Map 8: Local Hazard Areas

Sites
- Critical Infrastructure Sites*
- Repetitive Loss Sites

* See details in separate table

Locally Identified Hazard Areas
- Brush Fires
- Flooding
- Drifting Snow

* See Section IV Risk Assessment

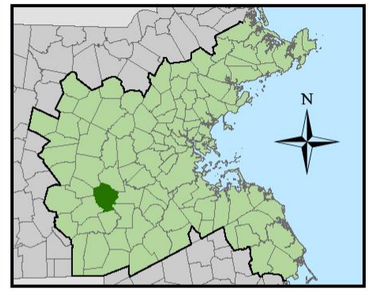
- Development Sites

* See details in separate table

- Train Stations
- Commuter Rail Lines
- Trains

All Roads
- Interstate
- U.S. Highway
- State Route
- Street

0 0.5 1 Miles



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60 Temple Place, Boston, MA 02111 (617) 451-2770

Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Northeast States Emergency Consortium (NESEC)
Massachusetts Emergency Management Agency (MEMA)
Federal Emergency Management Agency (FEMA)
Imagery © Google
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Date: 8/11/2017

APPENDIX C: PUBLIC PARTICIPATOIN

Hazard Mitigation Plan
Public Meeting

Natural hazards can have serious impacts on the Town of Sherborn and its residents…



The Sherborn Hazard Mitigation Plan is being produced to help the town reduce its vulnerability to natural hazard events such as flooding, hurricanes, and winter storms. Please join the Town for a public presentation and discussion about the Sherborn Hazard Mitigation Plan at the Planning Board meeting:

Date:	Tuesday, August 15, 2017
Time:	7:30 pm
Location:	Town Hall, Room 204B 19 Washington Street, Sherborn, MA

For more information, please contact
Emma Schnur via phone at (617) 933-0758
or email at eschnur@mapc.org

MAPC

Amanda Linehan, Communications Manager, Metropolitan Area Planning Council
617-933-0705, alinehan@mapc.org

CALENDAR LISTING / MEDIA ADVISORY

SHERBORN'S HAZARD MITIGATION PLAN TO BE DISCUSSED AT AUGUST 15 PUBLIC MEETING

Who:	Sherborn residents, business owners, representatives of non-profit organizations and institutions, and others who are interested in preventing and reducing damage from natural hazards.
What:	At the Sherborn Planning Boarding meeting on Tuesday, August 15 at 7:00 PM, a presentation will be made by the Metropolitan Area Planning Council (MAPC), which is assisting the Town on preparing its Hazard Mitigation Plan. The plan will identify natural hazards affecting Sherborn such as floods, hurricanes, winter storms, and earthquakes, as well as actions that the Town can take to reduce its vulnerability to these hazards.
When:	Tuesday, August 15, 2017, 7:00 PM
Where:	Sherborn Town Hall, 19 Washington Street, Sherborn, MA

MAPC is the regional planning agency for 101 communities in the metropolitan Boston area, promoting smart growth and regional collaboration. More information about MAPC is available at www.mapc.org.

##

Hazard Mitigation Plan
Sherborn Public Meeting

Natural hazards can have serious impacts on the Town of Sherborn and its residents and businesses



The *Sherborn Hazard Mitigation Plan* is being prrepared to help the town reduce its vulnerability to natural hazard events such as flooding, hurricanes, and winter storms. The Sherborn Planning Board is hosting a public meeting to provide an overview of the draft plan and an opportunity for questions and public input.

Date:	Tuesday, July 10, 2018
Time:	7:00 pm
Location:	Town Hall, Room 204B 19 Washington Street, Sherborn, MA

For more information, please contact
Martin Pillsbury via phone at (617) 933-0747
or email at mpillsbury@mapc.org

MAPC
METROPOLITAN AREA PLANNING COUNCIL

Amanda Linehan, Communications Manager, Metropolitan Area Planning Council
617-933-0705, alinehan@mapc.org

CALENDAR LISTING / MEDIA ADVISORY

SHERBORN'S HAZARD MITIGATION PLAN TO BE PRESENTED AT JULY 10 PUBLIC MEETING

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

What: At the Sherborn Planning Boarding meeting on Tuesday, July 10 at 7:00 PM, a presentation will be made on the draft *Sherborn Hazard Mitigation Plan* by the Metropolitan Area Planning Council (MAPC), which is assisting the Town on preparing its plan.

The draft *Sherborn Hazard Mitigation Plan* identifies natural hazards that can affect Sherborn such as floods, hurricanes, and winter storms, as well as actions that the Town can take to reduce its vulnerability to these hazards. The draft plan will be available on the Town's web site for public review until July 20.

When: Tuesday, July 10, 2018, 7:00 PM

Where: Sherborn Town Hall, 19 Washington Street, Sherborn, MA

MAPC is the regional planning agency for 101 communities in the metropolitan Boston area, promoting smart growth and regional collaboration. More information about MAPC is available at www.mapc.org.

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July 2, 2018

Felicia Hoffman, Town Clerk
Dover Town House
5 Springdale Avenue
PO Box 250
Dover, MA 02030-0250
Also via email at fhoffman@doverma.org

Dear Town Clerk,

The Town of Sherborn and the Metropolitan Area Planning Council are preparing the *Sherborn Hazard Mitigation Plan*, a plan intended to reduce the Town's vulnerability to the impacts of natural hazard events such as flooding, hurricanes, winter storms, and geologic hazards.

As part of the planning process, Sherborn's neighboring communities are being notified of a public meeting where the draft plan will be presented. The meeting will be held as follows:

Tuesday, July 10, 2018 at 7:00 pm
Sherborn Planning Board
Town Hall, Room 204A
19 Washington Street
Sherborn, MA

A flyer announcing the meeting is attached. We would appreciate if you would post this.

Comments and questions on the draft plan may be submitted at this meeting or afterwards in writing to Martin Pillsbury at mpillsbury@mapc.org, or by mail to MAPC, 60 Temple Place, Boston, MA 02111. Comments should be submitted by July 20, 2018 in order to be incorporated into the final draft of the plan.

Thank you,

Marti Pillsbury
Director of Environmental Planning

60 Temple Place, Boston, MA 02111 • 617-451-2770 • Fax 617-482-7185 • www.mapc.org

PLANNING BOARD

19 WASHINGTON STREET
SHERBORN, MASSACHUSETTS 01770

AGENDA - TOWN HALL

July 10, 2018

I. 7:00* PRESENTATION OF FINAL HAZARD MITIGATION PLAN
As a follow-up to the presentation of the preliminary Hazard Mitigation Plan last year, this is the final report which needs approval by MEMA and FEMA.

II. 7:30 HOUSING
Continued discussion of various issues related to housing including, potential new ConCom regulations addressing large septic systems and wastewater treatment plants, coordination with Housing Partnership, and Villages at Sherborn/Meadowbrook Commons.

III. 7:45* GENERAL PLAN UPDATE
Update on progress to date including roles in implementation plan tables and General Plan website.

IV. 8:00* OPEN SPACE AND RECREATION PLAN
Review of Open Space and Recreation plan draft and letter of support.

V. 8:15* ZONING ARTICLES
Continued discussion of potential zoning priorities for next year..

VI. 8:45* REGULATIONS PERTAINING TO OUTDOOR ENTERTAINMENT AND FARM EVENTS
Continued discussion of possible outdoor sound regulations to recommend to ZBA and to adopt for farm events.

VII. 9:00* OTHER BUSINESS THAT MAY COME BEFORE THE BOARD
Citizen comments, items not anticipated by the Chair 48 hours in advance, Whitney Farms, complete streets, and other potential projects and reports on meetings with other boards, etc.

VIII. 9:15* MINUTES

*Times are approximate only.
Agenda sent to Town Clerk on 6/28/18

APPENDIX D: PLAN ADOPTION

Certificate to Document Adoption of the
Hazard Mitigation Plan
By the Select Board

To be completed when plan is approved by FEMA

<TOWN LETTERHEAD>

CERTIFICATE OF ADOPTION
SELECT BOARD
TOWN OF SHERBORN, MASSACHUSETTS

A RESOLUTION ADOPTING THE
TOWN OF SHERBORN HAZARD MITIGATION PLAN

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

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

WHEREAS, duly-noticed public meetings were held by the Sherborn Planning Board on August 15, 2017 and July 10, 2018.

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

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

ADOPTED AND SIGNED this Date. _____

Name(s)

Title(s)

Signature(s)

ATTEST

APPENDIX E: PLAN APPROVAL

FEMA Letter of Approval of the Sherborn Hazard Mitigation Plan

(To be completed when plan is approved by FEMA)