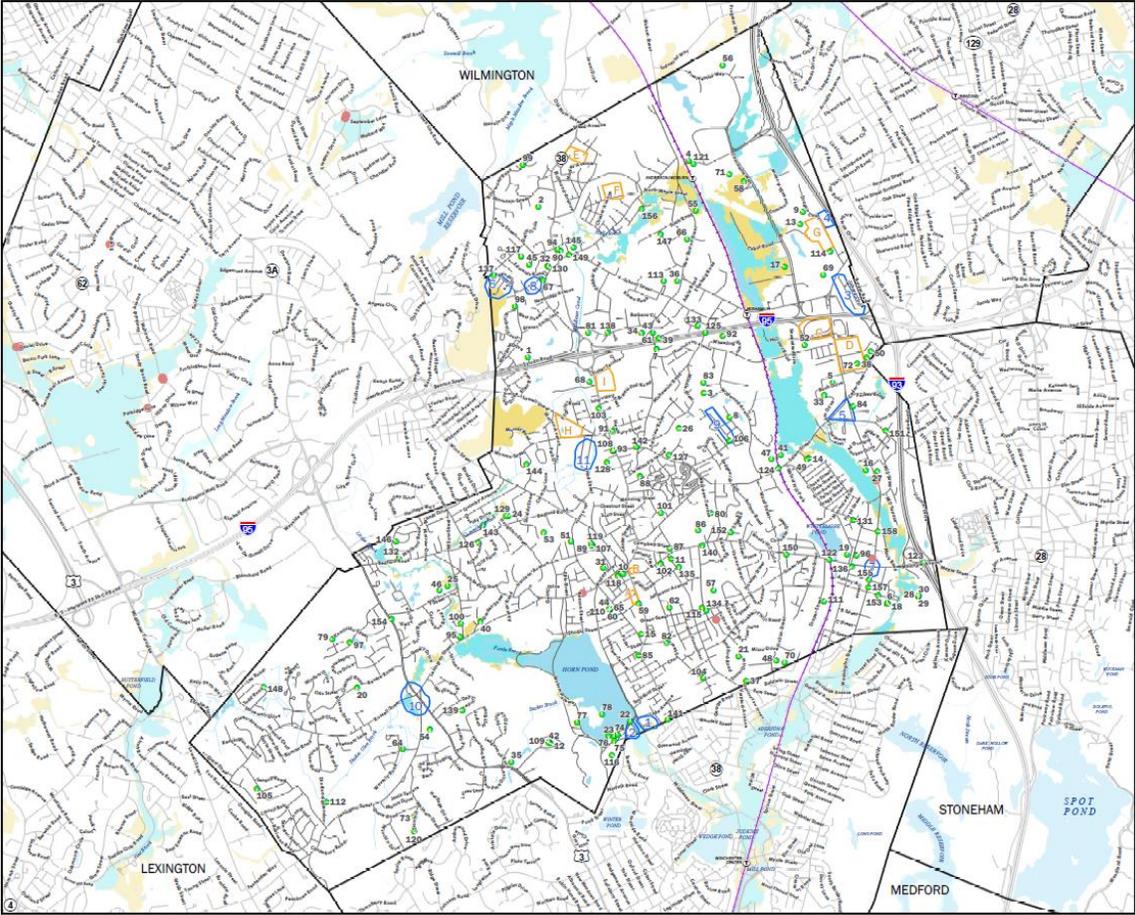


CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE



FINAL PLAN
Adopted May 5, 2016

CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE

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CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE

ACKNOWLEDGEMENTS AND CREDITS

This plan was prepared for the City of Woburn 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). The plan was funded by the City of Woburn.

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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

Planning for this Woburn Hazard Mitigation Plan update was led by the Woburn Local Hazard Mitigation Planning Committee, composed of staff from a number of different City Departments. This committee discussed where the impacts of natural hazards most affect the City, goals for addressing these impacts, and hazard mitigation measures that would benefit the City.

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 City takes to mitigate them. The City hosted two public meetings, on March 25, 2015 and June 23, 2015 and the plan was posted on the City's website for public review.

Risk Assessment

The Woburn Hazard Mitigation Plan assesses the potential impacts to the City from flooding, high winds, winter storms, brush fire, and geologic hazards. Flooding, driven by hurricanes, northeasters and other storms, clearly presents the greatest hazard to the City, with potential flooding location scattered throughout including transportation facilities such as rail and roadway infrastructure.

The Woburn Local Committee identified those areas where flooding most frequently occurs, comprising 1.23% of the City's land area, and approximately 144 buildings worth nearly an estimated \$74,423,483.

Hazard Mitigation Goals

1. Prevent and reduce the loss of life, injury and property damages resulting from all major natural hazards.
2. Identify and seek funding for measures to mitigate or eliminate each known significant flood hazard area.

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3. Integrate hazard mitigation planning as an integral factor in all relevant municipal departments, committees and boards.
 - Ensure that the Planning Department considers hazard mitigation in its review and permitting of new development.
 - Review zoning regulations to ensure that the ordinance incorporates all reasonable hazard mitigation provisions.
 - Ensure that all relevant municipal departments have the resources to continue to enforce codes and regulations related to hazard mitigation.
4. Prevent and reduce the damage to public infrastructure resulting from all hazards.
 - Begin to assess the vulnerability of municipal buildings and infrastructure to damage from an earthquake.
 - Maintain existing mitigation infrastructure in good condition.
5. Encourage the business community, major institutions and non-profits to work with the City to develop, review and implement the hazard mitigation plan.
6. Work with surrounding communities, state, regional and federal agencies to ensure regional cooperation and solutions for hazards affecting multiple communities.
 - Continue to participate in the Mystic Region REPC and Region IVA (Board of Health).
7. Ensure that future development meets federal, state and local standards for preventing and reducing the impacts of natural hazards.
8. Educate the public about natural hazards and mitigation measures that can be undertaken by property-owners.
 - Provide information on hazard mitigation activities in the languages most frequently spoken in Woburn.
9. Take maximum advantage of resources from FEMA and MEMA to educate City staff and the public about hazard mitigation.

Hazard Mitigation Strategy

The Woburn Local Committee identified a number of mitigation measures that would serve to reduce the City's vulnerability to natural hazard events. Largely these are related to maintaining the integrity of the drainage system by addressing upgrading and reconstruction issues at localized flooding locations as well as by making larger, strategic infrastructure investments. There is also a strong emphasis on boosting the general emergency planning capabilities of the City so that both hazard mitigation and emergency management can be handled efficiently and effectively.

Overall, the hazard mitigation strategy recognizes that mitigating hazards for Woburn 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 the accompanying changes to sea level and average temperatures impact the City's

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vulnerability, 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 other related plans and policies.

Plan Review and Update Process

Table 1 Plan Review and Update	
Chapter	Reviews and Updates
III – Public Participation	The Woburn Local Committee placed an emphasis on public participation for the update of 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. The first was a public forum held in conjunction with the Woburn Plan for Progress and the second was a regularly scheduled meeting of the Planning Board. The plan was also posted on the City’s website for public comment.
IV – Risk Assessment	MAPC gathered the most recently available hazard and land use data and met with City staff to identify changes in local hazard areas and development trends. City staff reviewed critical infrastructure with MAPC staff in order to create an up-to-date list. MAPC also used the most recently available version of HAZUS and assessed the potential impacts of flooding using the latest data.
V - Goals	The Hazard Mitigation Goals were reviewed and endorsed by the Local Hazard Mitigation Committee.
VI – Hazard Mitigation Strategy	The list of existing mitigation measures was updated to reflect current mitigation activities in the City. Mitigation measures from the 2007 plan were reviewed and assessed as to whether they were completed, on-going, or deferred. The Local Committee determined whether to carry forward measures into the 2015 plan update or delete them. The Committee re-prioritized all of these measures based on current conditions.
VII-- Plan Adoption & Maintenance	This section of the plan was updated with a new on-going plan implementation review and five year update process that will assist the City in incorporating hazard mitigation issues into other City planning and regulatory review processes and better prepare the City to update the plan

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As indicated on Table 26, Woburn made some progress on implementing mitigation measures identified in the 2007 Hazard Mitigation Plan. The City has completed the Montvale Avenue-Jefferson Avenue stream dredging project. Several projects that were not completed will also be continued into this plan update, including drainage projects for Hart Street and Washington Street. A number of new mitigation measures are included that were not in the 2007 plan.

Moving forward into the next five year plan implementation period there will be many more opportunities to incorporate hazard mitigation into the Town's decision making processes.

Though not formally done in the 2007 Plan, the City will document any actions taken within this iteration of the Hazard Mitigation Plan on challenges met and actions successfully adopted as part of the ongoing plan maintenance to be conducted by the Woburn Hazard Mitigation Implementation Team, as described in Section VII, Plan Adoption and Maintenance.

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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 continue 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).

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 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 City of Woburn has experienced 16 natural hazards that triggered federal or state disaster declarations since 1991. These are listed in Table 2 below. The vast majority of these events involved flooding.

Table 2. Previous Federal/State Disaster Declarations		
Disaster Name (Date of Event)	Type of Federal Assistance Provided	Declared Areas in MA
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)

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Table 2. Previous Federal/State Disaster Declarations		
Disaster Name (Date of Event)	Type of Federal Assistance Provided	Declared Areas in MA
No-Name Storm (October 1991)	FEMA Public Assistance Project Grants	Counties of Barnstable, Bristol, Dukes, Essex, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk
	FEMA Individual Household Program	Counties of Barnstable, Bristol, Dukes, Essex, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk
	Hazard Mitigation Grant Program	Counties of Barnstable, Bristol, Dukes, Essex, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk
March Blizzard (March 1993)	FEMA Public Assistance Project Grants	Statewide
January Blizzard (January 1996)	FEMA Public Assistance Project Grants	Statewide
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
(1997)	Community Development Block Grant-HUD	Counties of Essex, Middlesex, Norfolk, Plymouth, Suffolk
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
	Community Development Block Grant-HUD	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

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Table 2. Previous Federal/State Disaster Declarations		
Disaster Name (Date of Event)	Type of Federal Assistance Provided	Declared Areas in MA
	Hazard Mitigation Grant Program	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester (16 projects)
February Snowstorm (Feb 17-18, 2003)	FEMA Public Assistance Project Grants	Statewide
January Blizzard (January 22-23, 2005)	FEMA Public Assistance Project Grants	Statewide
Hurricane Katrina (August 29, 2005)	FEMA Public Assistance Project Grants	Statewide
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
Hurricane Sandy (October 27-30, 2012)	FEMA Public Assistance	Statewide
Severe snowstorm and Flooding (February 8-09, 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 City has not received any funding from FEMA under the Hazard Mitigation Grant Program (HMGP).

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Community Profile

The City of Woburn occupies 13.1 miles of the Fells Upland and is a suburban industrial city located along the upper Mystic Valley. Incorporated in 1642, Woburn became an early manufacturing center, tanning leather and making shoes. Production was large enough so that during the King Philip's Wars, town taxes were partially paid in shoes. The smallpox epidemic of 1675 cut deeply into the town's population.

The Middlesex Canal from Boston opened in 1803 and the Boston and Lowell Railroad in 1835. Woburn continued to make boots and shoes and in 1855 made \$280,000 in footwear, but by 1865 there had been a shift away from manufacturing shoes and toward the production of leather. In that year alone, the tanneries of Woburn shipped \$1.7 million of leather and Woburn was at the head of the tanning industry in the country. Immigrants from Ireland, Nova Scotia and Canada moved to Woburn to take the jobs in the tanneries and in 1884, 26 large tanneries employed 1500 men producing \$4.5 million worth of leather. Henry Thayer of Woburn originated chrome tanning, which took the place of bark tanning, in 1901. The tanyards clearly supplemented the city's subsistence farming from the earliest settlement times. By 1915 there was some diversification in the city's economy and residents were making ice cream, machine tools, mops and paper boxes among other things. Woburn developed as an early English town settlement and has a notable early burying ground. Suburban growth began in the mid-19th century and has continued.

(Narrative based on information provided by the Massachusetts Historic Commission).

The City maintains a website at <http://www.cityofwoburn.com/>

Table3. Woburn Characteristics, 2010

Population = 38,120

- 16.5% are under the age 15
- 15.9 are over age 65
- 31.5% speak English less than "very well" (over age 5)
- 0.8% live in group quarters
- 6.8% of households have no vehicle

Number of Occupied Housing Units = 15,524

- 39% are renter-occupied housing units
- 26.4% of housing units were built prior to 1940

Source: U.S. Census, 2010, American Community Survey 2013

III. PLANNING PROCESS AND 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 Committees, two public meetings hosted by the City, posting of the plan to the City’s website, and invitations sent to neighboring cities and towns, City boards and commissions, 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, July 1, 2008. 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. In plan updates, the process described below allows staff to bring the most recent hazard information into the plan, including new hazard occurrence data, changes to a municipality’s existing mitigation measures, and progress made on actions identified in previous plans.



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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, which is collected. These maps can be found in Appendix B.
2. Assess the Risks and 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.

Incorporation of Other Existing Plans and Studies

The Plan incorporates information from a number of other previously produced plans, and studies as well as applicable regulatory documents. These include:

- City of Woburn Plan for Progress
- City of Woburn May 14-16 Flooding Event Post Incident Report prepared by the City of Woburn Engineering Department, May 25, 2006.
- City of Woburn Natural Hazard Mitigation Plan November 2007
- City of Woburn Open Space and Recreation Plan, 2015
- City of Woburn 1985 Zoning Ordinances as Amended with Amendments through February 23, 2015.
- City of Woburn 1989 Municipal Code, as Amended through February 23, 2015.
- Drainage System Improvements Cost Estimation Project, Draft Report prepared by Weston & Sampson for the City of Woburn, May 10, 2010.
- Massachusetts State Hazard Mitigation Plan.2013
- FEMA, Local Mitigation Plan Review Guide; October 1, 2011
- FEMA, Flood Insurance Rate Maps for Middlesex County, MA
- Massachusetts State Hazard Mitigation Plan.2013
- Metropolitan Area Planning Council, GIS Lab, Regional Plans and Data.
- New England Seismic Network, Boston College Weston Observatory, <http://aki.bc.edu/index.htm>
- NOAA National Climatic Data Center, <http://www.ncdc.noaa.gov/>
- Northeast States Emergency Consortium, <http://www.nesec.org/>

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- Supplemental Final Environmental Impact Report. Phase 1 Muddy River Flood Control, Water Quality and Habitat Enhancement and Historic Preservation Project.
 - USGS, National Water Information System, <http://nwis.waterdata.usgs.gov/usa/nwis>
 - US Census, 2010
3. Review Existing Mitigation – Municipalities in Middlesex County have an active history in hazard mitigation as many 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 must be documented.
 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 and 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. Typically, once FEMA has approved the plan the agency issues a conditional approval with the condition being adoption of the plan by the municipality. More information on plan adoption can be found in Chapter IX and documentation of plan adoption can be found in Appendix D.
 6. Implement and 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 IX includes more detailed information on plan implementation.

2007 Plan Implementation and Maintenance

The City has made some progress towards the implementation of the mitigation strategies from the 2007 plan. By updating this plan, the City has demonstrated its intent to continue to work on mitigating natural hazards. During the next five-year planning cycle the City will document any actions taken on challenges met and mitigation successfully adopted as part of the ongoing plan maintenance to be conducted by the Woburn Hazard Mitigation Implementation Team, as described below in Section VII, Plan Adoption and Maintenance.

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The Local Hazard Mitigation Planning Team

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. Given this role, it is important that this committee include a diverse representation of community stakeholders and knowledgeable municipal staff. The team met on January 26, 2015 and June 12, 2015.

Table 4. Woburn Local Hazard Mitigation Planning Team	
Name	Representing
Scott Galvin	Mayor
Jay Duran	Superintendent of Public Works
John E. Corey, Jr.	City Engineer
Brett Gonsalves	Assistant City Engineer
Timothy J. Ring	Fire Chief
Robert Ferullo, Jr.	Police Chief
John Fralick	Health Agent
Anthony Blazejowski	Water Treatment Plant Operator
Tina Cassidy	City Planner

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 City hosted two public meetings, one during the planning process and one after a complete draft plan was available for review.

Natural hazard mitigation plans unfortunately rarely attract much public involvement in the Boston region, unless there has been a recent hazard event. 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 or other planning initiative. With this strategy, the meeting receives widespread advertising and a guaranteed audience of the board or commission members plus those who attend the meeting. These board and commission members represent an engaged audience that is informed and up to date on many of the

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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 by phoning or emailing local staff.

The public had an opportunity to provide input to the Woburn hazard mitigation planning process during a forum held as part of the master planning initiative the “Woburn Plan for Progress” on March 25, 2015. This forum was attended by 36 individuals including the Mayor, the City Planner, the City Engineer and numerous interested residents. The second opportunity for public input was at a meeting of the Woburn Planning Board held on June 23, 2015.

Table 5. Attendance at Public Meetings	
Name	Organization or Neighborhood
First Public Meeting – March 25, 2015	
Scott Galvin	Mayor
Tina Cassidy	City Planner
Jay Corey	City Engineer
Residents	
Second Public Meeting (Planning Board) – June 23, 2015	
James Callahan	Planning Board, Chair
Carolyn Turner	Planning Board, Vice Chair
Claudia Leis Bolgen	Planning Board
David Edmonds	Planning Board
Kevin Donovan	Planning Board
Robert Doherty	Planning Board
Residents	

Other Opportunities for Public Involvement

Website

Draft copies of the Woburn Hazard Mitigation Plan update were posted on the City’s website (www.cityofwoburn.com). Members of the public could access the draft document and submit comments or questions.

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The Woburn Hazard Mitigation Planning Team was encouraged to reach out to local stakeholders that might have an interest in the Hazard Mitigation Plan including neighboring communities, agencies, businesses, nonprofits, and other interested parties. On June 22, 2015 an e-mail notice was sent to the town clerks of the neighboring municipalities inviting them to review the Hazard Mitigation Plan and submit comments to the City:

Town of Winchester
Town of Stoneham
Town of Burlington
Town of Wilmington
Town of Reading

One comment was received on the draft plan. See the comment and the City's response in Appendix D).

Public Participation

Following the adoption of the plan update, the planning team will continue to provide residents, businesses, and other stakeholders the opportunity to participate in the hazard mitigation planning process. As updates and a review of the plan are conducted by the Hazard Mitigation Implementation Team, these will be placed on the city's web site, and any meetings of the Hazard Mitigation Implementation Team will be publicly noticed in accordance with city and state open meeting laws.

A full listing of the documents incorporated in the development of this plan is included in Section VIII – List of References.

Planning Timeline Summary	
January 26, 2015	Meeting of the Woburn Local Hazard Planning Team
March 25, 2015	First Public Meeting at the Woburn Plan for Progress hazard mitigation forum.
June 12, 2015	Meeting of the Woburn Local Hazard Planning Team
June 23, 2015	Second Public Meeting
October 20, 2015	Draft Plan submitted to MEMA
January 29, 2016	Revised Draft Plan submitted to MEMA
April 13, 2016	Approval Pending Adoption issued by FEMA
May 5, 2016	Final Plan Adopted by the City

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IV. RISK ASSESSMENT

The risk assessment analyzes the potential natural hazards that could occur within the City of Woburn 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.

Update Process

In order to update Woburn's risk assessment, MAPC gathered the most recently available hazard and land use data and met with City staff to identify changes in local hazard areas and development trends. MAPC also used the most recently available version of HAZUS (described below).

Overview of Hazards and Impacts

The Massachusetts Hazard Mitigation Plan 2013 (state plan) provides an in-depth overview of natural hazards in Massachusetts. The state plan indicates that Massachusetts is subject to the following natural hazards (listed in order of frequency): floods, heavy rainstorms, nor'easters or winter storms, coastal erosion, hurricanes, tornadoes, wildfires, and earthquakes. Previous state and federal disaster declarations since 1991 are summarized in Table 2.

Table 6 summarizes the hazard risks for Woburn. 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 Commonwealth of Massachusetts State Hazard Mitigation Plan, 2010. The statewide assessment was modified to reflect local conditions in Woburn using the definitions for hazard frequency and severity listed below Table 6.

Hazard	Frequency		Severity	
	Massachusetts	Woburn	Massachusetts	Woburn
Flooding	High	High	Serious	Serious
Dam failures	Very Low	Medium	Serious	Serious
Winter storms	High	High	Minor	Minor
Ice Storms	Medium	Medium	Minor	Minor
Hurricanes	Medium	Medium	Serious	Serious
Nor'easters	High	High	Serious	Serious
Thunder Storms	High	High	Minor	Minor

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Table 6. Hazard Risks Summary				
Hazard	Frequency		Severity	
	Massachusetts	Woburn	Massachusetts	Woburn
Tornadoes	Medium	Very Low	Serious	Serious
Brush fires	Medium	Medium	Minor	Minor
Earthquakes	Very Low	Very Low	Extensive	Serious
Landslides	Low	Very Low	Minor	Minor
Extreme Temperatures	Medium	Medium	Minor	Minor
Drought	Low	Low	Minor	Minor

Source, Massachusetts State Hazard Mitigation Plan, 2013, modified for Woburn

Coastal hazards are not included since Woburn is not a coastal community and these are not a risk for the City.

Definitions used in the Commonwealth of Massachusetts State Hazard Mitigation Plan

Frequency Categorization

Very low: events that occur less frequently than once in 100 years (Less than 1% per year)

Low: events that occur from once in 50 years to once in 100 years (1% to 2% per year)

Medium: events that occur from once in 5 years to once in 50 years (2% to 20% per year)

High: events that occur more frequently than once in 5 years (Greater than 20% per year)

Severity Categorization

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

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Flood Related Hazards

Flooding was the most prevalent serious natural hazard identified by local officials in Woburn. Flooding is generally the rising or overflowing of water onto normally dry land and can be caused by hurricanes, nor'easters, severe rainstorms, and thunderstorms among other causes. Global climate change has the potential to increase the frequency and severity of rainstorms and snowstorms, which would be a continuation of trend observed over the past several decades.

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 Woburn have included:

- March 1968
- 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

Previous Occurrences and Extent of Flooding

The best available data on the previous occurrences of flooding are from the National Climatic Data Center, which are provided by county. Woburn is part of Middlesex County, for which historic flood events from 2005 through March 30, 2014 were compiled and are summarized in Table 7. Middlesex County experienced 35 flood events from 2005 –2014. No deaths or injuries were reported and the total reported property damage in the county was \$40.5 million. Of that total, \$35.2 million is attributed to the two major events of March 2010.

Date	Type	Deaths	Injuries	Property Damage
10/15/2005	Flood	0	0	125.00K
5/13/2006	Flood	0	0	5.000M
5/13/2006	Flood	0	0	0.00K
7/11/2006	Flood	0	0	2.00K

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Table 7: Middlesex County Flood Events 2005-2014				
Date	Type	Deaths	Injuries	Property Damage
10/28/2006	Flood	0	0	5.00K
4/16/2007	Flood	0	0	25.00K
2/13/2008	Flood	0	0	0.00K
5/27/2008	Flood	0	0	3.00K
6/24/2008	Flood	0	0	10.00K
6/29/2008	Flood	0	0	5.00K
8/10/2008	Flood	0	0	15.00K
8/10/2008	Flood	0	0	40.00K
9/6/2008	Flood	0	0	15.00K
12/12/2008	Flood	0	0	20.00K
3/14/2010	Flood	0	0	26.430M
3/29/2010	Flood	0	0	8.810M
4/1/2010	Flood	0	0	0.00K
8/28/2011	Flood	0	0	5.00K
10/14/2011	Flood	0	0	0.00K
6/8/2012	Flood	0	0	0.00K
6/23/2012	Flood	0	0	0.00K
6/23/2012	Flood	0	0	0.00K
6/23/2012	Flood	0	0	0.00K
6/23/2012	Flood	0	0	0.00K
6/23/2012	Flood	0	0	15.00K
7/18/2012	Flood	0	0	5.00K
10/29/2012	Flood	0	0	0.00K
6/7/2013	Flood	0	0	0.00K
7/1/2013	Flood	0	0	0.00K
7/1/2013	Flood	0	0	0.00K
7/23/2013	Flood	0	0	0.00K
9/1/2013	Flood	0	0	10.00K
3/30/2014	Flood	0	0	35.00K
3/30/2014	Flood	0	0	0.00K
3/30/2014	Flood	0	0	0.00K
TOTAL		0	0	40,510,000

(Source: NOAA NCDC)

Overview of City-Wide Flooding

Woburn is subject to two kinds of flooding: *inland/riverine flooding* where the rate of precipitation and/or amount of stormwater runoff overwhelms the capacity of natural or structured drainage systems causing overflow and *urban flooding* in which precipitation

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causes the water table to rise and leads to flooding of low-lying areas such as streets and underpasses. These types of flooding are often combined as storm events lead to large amounts of draining stormwater.

Woburn falls within the Mystic River Watershed. The watershed partially or wholly encompasses 22 communities north and west of Boston. Its headwaters begin in Reading, and form the Aberjona River which flows through Woburn and Winchester and into the upper Mystic Lake. From the lower Mystic Lake, the Mystic River flows through Arlington, Somerville, Medford, Everett, Chelsea, Charlestown, and East Boston before discharging to Boston Harbor. According to the Mystic River Watershed Association (MRWA), the Mystic River watershed is home to approximately 8% of the state's population (nearly half a million people), making the Mystic one of the most densely populated and urbanized watersheds in Massachusetts.

Aberjona River Sub-Watershed – Woburn is within the sub-watershed of the Aberjona River. The primary tributaries to the Aberjona River include Horn Pond Brook, which drains Horn Pond in Woburn, Sweetwater Brook, and Spot Pond in Stoneham.

Climate change impacts: Sea-level rise and storm surges

As an inland community, Woburn is not directly impacted by sea-level rise and storm surges. However, global climate change has led to more intense storms due to the increased moisture in the air.

Inland/Riverine and Urban Flooding

Inland/riverine flooding occurs when water overflows the banks of an existing stream or river. These flood events can cause serious damage to structures and property and can threaten the lives and safety of area residents. Large amounts of impervious area in the City's watershed increase the frequency and severity of flooding because storm water is prevented from absorbing into the ground and flows overland directly into the waterway, increasing the volume of flow. This type of flooding most often occurs within the mapped floodplain areas.

Flooding Location, Impacts and Vulnerabilities

Overview of Drainage System

Information on flood hazard areas was taken from two sources. The first was the National Flood Insurance Rate Maps. The FIRM flood zones are shown on Map 3 in Appendix B and defined below.

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Flood Insurance Rate Map Zone Definitions

Zones A1-30 and AE: Special Flood Hazard Areas subject to inundation by the 1-percent-annual-chance flood event determined by detailed methods. Base Flood Elevations are shown within these zones.

Zone A (Also known as Unnumbered A Zones): Special Flood Hazard Areas subject to inundation by the 1-percent-annual-chance flood event generally determined using approximate methodologies. Because detailed hydraulic analyses have not been performed, no Base Flood Elevations or depths are shown.

Zone AH: Areas subject to inundation by 1-percent-annual-chance shallow flooding (usually areas of ponding) where average depths are between one and three feet. Base Flood Elevations (BFEs) derived from detailed hydraulic analyses are shown in this zone.

Zone AO: Special Flood Hazard Areas subject to inundation by 1-percent-annual-chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between one and three feet. Average flood depths derived from detailed hydraulic analyses are shown in this zone.

Zone VE: Areas subject to inundation by the 1-percent-annual-chance flood event with additional hazards due to storm-induced velocity wave action. Base Flood Elevations (BFEs) derived from detailed hydraulic analyses are shown

The second source of flooding information was discussions with local officials. The Locally Identified Areas of Flooding below were identified by City staff as areas where flooding is known to occur or could occur if certain infrastructure failed. These areas do not necessarily coincide with the flood zones from the FIRM maps. They may be areas that flood due to inadequate drainage systems or other local conditions rather than location within a flood zone. The numbers correspond to the numbers on Map 8, "Locally Identified Hazard Areas".

1. **Lake Terrace and Lake Circle** – Flooding in this area affects both the roadway and homes in the area. Flooding is caused by an inadequate drainage system.
2. **Arlington Road** – Flooding in this area is caused by an inadequate drainage system.
3. **Dragon Court**- Flooding in this area is centered around a low lying area at #29. Flooding affects both homes and the roadway. There is no existing storm drain infrastructure in this area.

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4. **Washington Street near Cedar Court** – This area floods during heavy rains because of insufficient capacity in the existing storm drain system. The drainage system backs up and the excess runoff travels over Washington Street.
5. **Bartlett Drive and Pearl Street Rear** – This area floods because of an under-sized drainage system.
6. **Washington Street near Wendy's/Montvale Avenue** – Flooding in this area is caused by an under-sized storm drain system. The flooding affects both nearby homes and the roadway.
7. **Ward Street at Traverse Street** – This area floods due to a limited storm drain system and impacts homes as well as the roadways.
8. **Lillian Street near the Kennedy School** – Flooding in this area occurs behind homes on Lillian Street. The primary cause of the flooding is the location of the existing storm drain inlet.
9. **Cambridge Road** – The flooding on Cambridge Road is in the vicinity of Russell Street and is caused by insufficient capacity in the drainage system. Impacts include flooding of local businesses.
10. **Winn Street to Hart Street** – Winn Street near Hamilton Road experiences flooding of homes.
11. **Salem Street at Aberjona Drive** – This area was identified as an area where emergency access could be blocked during flood events.
12. **Bedford Road: Marlboro Road to Cambridge Street** – This is another area where emergency access can be an issue during flooding.

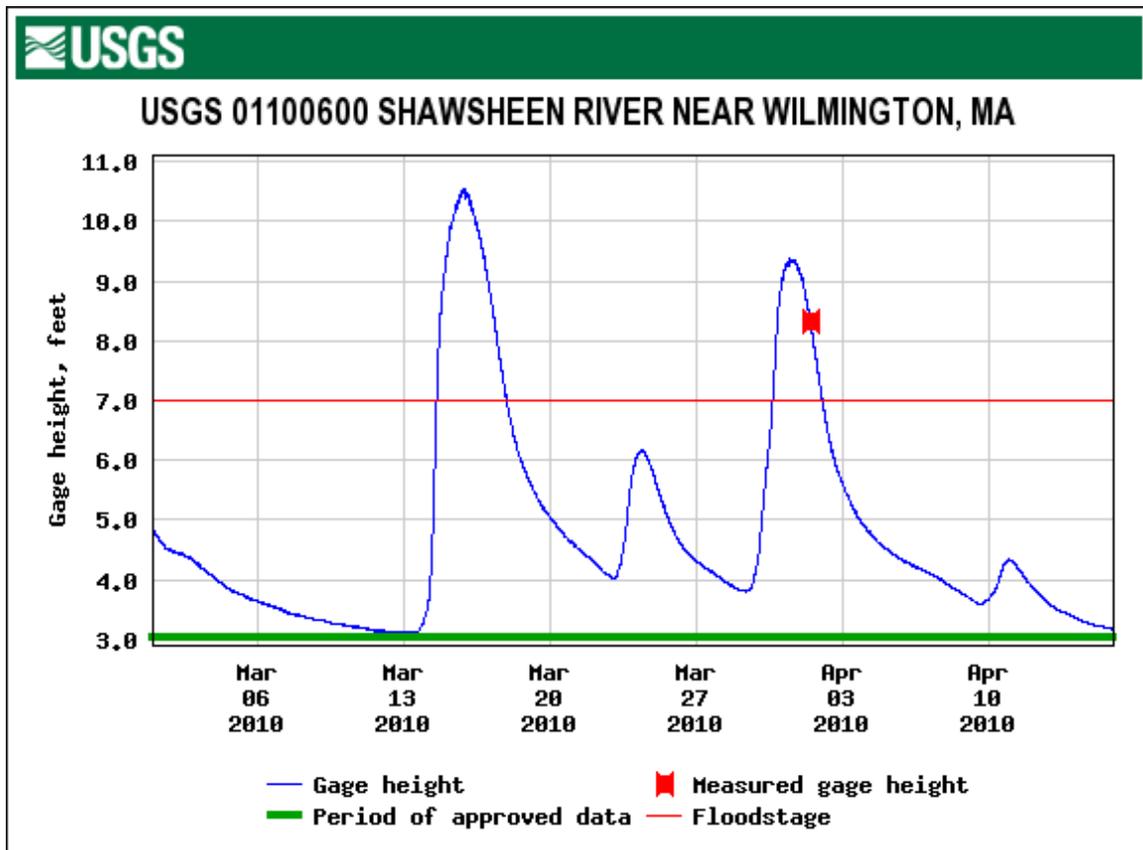
The most severe flooding since the previous plan occurred during March 2010, when a total of 14.83 inches of rainfall accumulation was recorded by the National Weather Service (NWS). The weather pattern that consisted of early springtime prevailing westerly winds that moved three successive storms, combined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

As shown in Table 7, damages from the March 2010 floods in Middlesex County totaled \$35.24 million, while total damages for all floods since 2005 totaled \$40.5 million. There were no deaths or injuries reported and the flooding events associated with property damage totaled \$25.7 million dollars. The vulnerability analysis conducted by MAPC estimates a range of damages from flooding in Woburn of \$10,025,898- \$50,129,492.

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One indication of the extent of flooding is the gage height at the nearest USGS streamflow gauging station, which is in Wilmington on the Shawsheen River. The USGS gage height, shown in Figure 1, exceeded 10 feet on March 16, 2010, and exceeded 8 feet on March 31, 2010. Flood stage at this site is 7 feet.

Figure 1 - USGS Gage Height, Shawsheen River, March 2010 Floods



Repetitive Loss Structures

Another indicator of flood risk is the number of repetitive loss structures. As defined by the Community Rating System (CRS) of 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. For more information on repetitive losses see <http://www.fema.gov/business/nfip/replps.shtm>.

There are seven repetitive loss properties in Woburn. Repetitive loss properties were not enumerated in the 2007 plan so no comparisons can be made. The seven properties include two non-residential properties, four single-family homes and one multi-family property which had three losses. Table 8 shows the breakdown of structure type by number and amount of losses between 1978 and 2010.

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Table 8. Repetitive Loss Properties Summary					
Property Type	# of Properties	Number of Claims	Building Losses	Contents Losses	Total Losses Paid
Single family	4	8	\$55,997.90	\$13,474	\$69,471.19
2-4 family	1	3	\$8,667.30	\$3,081.00	\$11,748.30
Non-residential	2	4	\$505,415.52	\$0.00	\$505,415.52
TOTAL	7	15	\$570,080.32	\$16,555	\$586,635.01

Source: Federal Emergency Management Agency, National Flood Insurance Program

Based on the record of previous occurrences flooding events in Woburn 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 per year.

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 in general is infrequent but has the potential for severe impacts.

A review with City staff and information available from the Division of Conservation and Recreation (DCR) was used to identify dams in Woburn. DCR assesses the dams using the three hazard classifications below:

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

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

Horn Pond Dam – Horn Pond is approximately 120 acres and has a watershed area of 10 square miles. The primary outlet control structure is controlled by a weir and a slide gate with a secondary emergency riprap spillway that handles elevated water levels. The spillway is located on the southerly side of Horn Pond and enters Horn Pond Brook which flows through the Town of Winchester.

In severe weather events and in anticipation of a rainfall of 4 inches or greater, the city notifies the downstream cities and towns that they will be lowering the pond to increase storm water runoff storage. When the capacity exceeds the storage volume, the pond begins to crest at elevation 42.0 (NGVD29) thus creating flooding of the local roadway and impacting the residences and apartments that directly abut Horn Pond Brook.

Horn Pond Dam is classified by the State Office of Dam Safety as being a significant hazard dam. Significant hazard dams are defined as being located where failure may cause loss of life and damage to homes, industrial or commercial facilities, secondary highways or railroads, or cause interruption of use or service of relatively important facilities. The dam was last inspected on September 7, 2006 and was deemed to be in fair condition. DCR is in the process of repairing dams on the Mystic and Aberjona Rivers and will be doing work on the Scalley Dam in the future.

The probability of future dam failure events is classified in the Massachusetts State Hazard Mitigation Plan 2013 as very low frequency, or an event that occurs less frequently than once in 100 years (less than 1% per year).

The City of Woburn and the Town of Winchester are collaborating on a project to investigate options for the renovation of Horn Pond's Scalley Dam in an effort to address regional flooding issues. The spillway outlets are not large enough to carry the amount of water contained in a large storm. The dam has been found to be structurally sound but undersized. The two communities have been working together as part of the Winchester Flood Mitigation Program, with engineering services provided by ENSR Corporation. The study indicates that the opening needs to be twice the size of the current configuration in order to have adequate control of the pond elevation as it fills and overtops during a significant storm. The dam review to be completed will include more detailed analysis of the Pond and Scalley Dam, preliminary design of the new outlet structure, and a cost analysis. The study will be funded by a grant received by the Town of Winchester. About \$50,000 of the total \$250,000 grant will go towards reviewing the dam.

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Wind Related Hazards

Wind-related hazards include hurricanes and tornadoes as well as high winds during severe rainstorms and thunderstorms. The typical wind speed in the Woburn area ranges from around 11 miles per hour to 14 over the course of the year, but independent of storm events, gusts of up to 40 mph can occur. As with many cities and towns, falling trees that result in downed power lines and power outages are an issue in Woburn. Information on wind related hazards can be found on Map 5 in Appendix B

Hurricanes and Tropical Storms

A hurricane is a violent wind and rainstorm with wind speeds of 74-200 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. Hurricanes generally occur between June and November. A tropical storm has similar characteristics, but wind speeds are below 74 miles per hour.

Between 1858 and 2013, Massachusetts has experienced approximately 35 tropical storms, eleven Category 1 hurricanes, five Category 2 hurricanes and one Category 3 hurricane. This equates to a frequency of once every six years. A hurricane or storm track is the line that delineates the path of the eye of a hurricane or tropical storm. There has been one recorded tropical storm track that passed through Woburn. The City experiences the impacts of the wind and rain of hurricanes and tropical storms regardless of whether the storm track passes through the City. The hazard mapping indicates that the 100 year wind speed is 110 miles per hour (see Map 5 in Appendix B).

Hurricanes typically have regional impacts beyond their immediate tracks, and numerous hurricanes have affected the communities of eastern Massachusetts (Table 9). A hurricane or tropical storm track is the line that delineates the path of the eye of the hurricane or storm. 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.

Table 9. Hurricane Records for Massachusetts\	
Hurricane Event	Date
Great New England Hurricane*	September 21, 1938
Great Atlantic Hurricane*	September 14-15, 1944
Hurricane Doug	September 11-12, 1950
Hurricane Carol*	August 31, 1954
Hurricane Edna*	September 11, 1954
Hurricane Diane	August 17-19, 1955

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Table 9. Hurricane Records for Massachusetts\	
Hurricane Event	Date
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
*Category 3. Source: National Oceanic and Atmospheric Administration (NOAA)	

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. The following gives an overview of the wind speeds, surges, and range of damage caused by different hurricane categories:

Scale No. (Category)	Winds(mph) Storm	Surge (ft)	Potential Damage
1	7 – 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 (NOAA)

Woburn is vulnerable to both the wind and rainfall that come with hurricanes. High winds can damage structures, bring down tree limbs and power lines, leading to blackouts and disruption of the transportation system. Rainfall associated with hurricanes can cause flooding in the city’s rivers and streams, as well as localized urban drainage flooding. The vulnerability analysis conducted using HAZUS-MH estimates \$103,228 million in damages for a Category 2 Hurricane in Woburn, and \$170,404 million for a Category 4 Hurricane. Other damages are also detailed in the analysis (see Table 22).

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

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Tornados

A tornado is a violent windstorm characterized by a narrow, violently rotating column of air that extends from the base of a thunderstorm to the ground. 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

Tornados can form from individual cells within severe thunderstorm squall lines. They can form from an isolated ‘supercell’ thunderstorm. They can be spawned by tropical cyclones or even their remnants that are passing through. Tornadoes are most common in the summer, June through August, and most form in the afternoon or evening.

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 below:

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 gusts (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, 2010

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Typically, there are 1 to 3 tornados in southern New England per year. The strongest tornado in Massachusetts history was the Worcester Tornado in 1953 (NESEC). The most recent tornado events in Massachusetts occurred in Springfield in June 2011 and in Revere in July 2014. The Springfield tornado caused significant damage and resulted in 4 deaths. The Revere tornado touched down in Chelsea just south of Route 16 (Revere Beach Parkway) and moved north into Revere’s business district along Broadway, past Revere City Hall, 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.

Although there have been no recorded tornados within the limits of the City of Woburn, since 1955 there have been 17 tornadoes in surrounding Middlesex County recorded by the Tornado History Project. Two of these were and F3 tornadoes, four were F2, and the rest were F1. These 17 tornadoes resulted in a total of one fatality and six injuries 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

Given their unpredictable track, tornadoes are a potential city-wide hazard in Woburn, although the impact of any one event is typically limited to a particular area, as was the case with the recent tornado in Revere. There have been no recorded tornadoes in Woburn, so there is no historical data with which to document damages. However, most

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structures pre-date current building codes and could be subject to damages. Generally the central portion of the city is more densely developed and would likely be subject to more damage in the event of a tornado. Evacuation 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.

Based on the record of previous occurrences since 1950, Tornado events in Woburn are a Medium frequency event as defined by the 2013 Massachusetts State Hazard Mitigation Plan. This hazard may occur from once in 5 years to once in 50 years, or a 2% to 20% chance per 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 often resulting in heavy snow, high winds, and rain. The storm radius is often as much as 1000 miles, reaching from the Carolinas to the Gulf of Maine. These storms occur most often in late fall and early winter.

Sustained wind speeds of 20-40 mph are common during a nor'easter with short-term wind speeds gusting up to 50-60 mph. Nor'easters are among winter's most ferocious storms. These strong areas of low pressure often form either in the Gulf of Mexico or off the east coast in the Atlantic Ocean. The low will then either move up the east coast into New England or out to sea. These winter weather events are notorious for producing heavy snow, rain, and oversized waves, often causing beach erosion and structural damage. Wind gusts associated with these storms can exceed hurricane force in intensity. Nor'easters may also sit stationary for several days, affecting multiple tide cycles and extended heavy precipitation. The level of damage in a strong hurricane is often more severe than a nor'easter but historically, Massachusetts has suffered more damage from nor'easters because of the greater frequency of these coastal storms (1 or 2 per year). Previous occurrences of Nor'easters include the following which are listed in the Massachusetts State Hazard Mitigation Plan 2013:

February 1978	Blizzard of 1978
October 1991	Severe Coastal Storm ("Perfect Storm")
December 1992	Great Nor'easter of 1992
January 2005	Blizzard/ oreaster
October 2005	Coastal Storm/Nr'easter
April 2007	Severe Storms, Inland & Coastal Flooding/Nor'easter
January 2011	Winter Storm/Nor'easter
October 2011	Severe Storm/NoNor'easter

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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 and February 2013 were both large nor'easters that caused significant snowfall amounts.

Woburn 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 urban stormwater ponding and flooding.

The entire City of Woburn 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 city would not be subject to coastal hazards.

Based on the record of previous occurrences, nor'easters in Woburn 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 can lead to localized damage and represent a hazard risk for communities. Generally defined as a storm that includes thunder, which always accompanies lightning, a thunderstorm is a storm event featuring 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 best available data on previous occurrences of thunderstorms in Malden is for Middlesex County through the National Climatic Data Center (NCDC). Between n the years 1995 and 2014 NCDC records show 46 thunderstorm events in eastern Middlesex County (Table 11). These storms resulted in a total of \$702,000 in property damages.

Table 11. Thunderstorm Events in Middlesex County, 1995-2014

DATE	EVENT_TYPE	MAGNITUDE	DEATHS	INJURIES	DAMAGE
4/4/1995	Thunderstorm	58	0	0	0
9/14/1995	Thunderstorm	0	0	0	0
10/28/1995	Thunderstorm	0	0	0	0
7/8/1996	Thunderstorm	50	0	0	0
5/29/1998	Thunderstorm	50	0	0	0
5/31/1998	Thunderstorm	50	0	0	0
8/5/1999	Thunderstorm	50	0	0	0

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DATE	EVENT_TYPE	MAGNITUDE	DEATHS	INJURIES	DAMAGE
6/27/2000	Thunderstorm	50	0	0	0
6/30/2001	Thunderstorm	50	0	0	0
8/10/2001	Thunderstorm	50	0	0	0
6/27/2002	Thunderstorm	50	0	0	5,000
8/13/2003	Thunderstorm	50	0	0	25,000
8/22/2003	Thunderstorm	50	0	0	5,000
8/20/2004	Thunderstorm	50	0	0	15,000
8/21/2004	Thunderstorm	50	0	0	15,000
8/5/2005	Thunderstorm	50	0	0	20,000
8/14/2005	Thunderstorm	50	0	0	5,000
7/21/2006	Thunderstorm	50	0	0	35,000
7/21/2006	Thunderstorm	50	0	0	10,000
7/21/2006	Thunderstorm	50	0	0	35,000
5/16/2007	Thunderstorm	50	0	0	-
7/28/2007	Thunderstorm	50	0	0	-
6/24/2008	Thunderstorm	50	0	0	1,000
6/24/2008	Thunderstorm	50	0	0	3,000
6/24/2008	Thunderstorm	50	0	0	1,000
7/2/2008	Thunderstorm	50	0	0	5,000
8/3/2008	Thunderstorm	50	0	0	5,000
9/9/2008	Thunderstorm	50	0	0	4,000
7/31/2009	Thunderstorm	50	0	0	10,000
7/31/2009	Thunderstorm	50	0	0	5,000
6/3/2010	Thunderstorm	50	0	0	1,000
6/6/2010	Thunderstorm	50	0	0	1,000
6/6/2010	Thunderstorm	50	0	0	30,000
6/24/2010	Thunderstorm	50	0	0	15,000
8/19/2011	Thunderstorm	50	0	0	15,000
8/19/2011	Thunderstorm	50	0	0	5,000
6/8/2012	Thunderstorm	50	0	0	25,000
6/23/2012	Thunderstorm	45	0	0	5,000
7/18/2012	Thunderstorm	70	0	0	350,000
6/17/2013	Thunderstorm	45	0	0	3,000
7/7/2014	Thunderstorm	50	0	0	5,000
7/7/2014	Thunderstorm	50	0	0	25,000
7/7/2014	Thunderstorm	50	0	0	5,000
9/6/2014	Thunderstorm	50	0	0	3,000
9/6/2014	Thunderstorm	50	0	0	10,000

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DATE	EVENT_TYPE	MAGNITUDE	DEATHS	INJURIES	DAMAGE
TOTAL			0	0	\$702,000

Source: NOAA, National Climatic Data Center Magnitude refers to wind speed

Severe thunderstorms are a city-wide hazard for Woburn. The City is vulnerable to both the wind and precipitation associated with thunderstorms. 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 urban stormwater ponding and localized flooding.

Based on the record of previous occurrences, severe thunderstorms in Woburn 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 Storms

Winter storms, including blizzards, heavy snow, 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.

Blizzards and Heavy Snow

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

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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 below:

Category	NESIS	Value Description
1	1–2.499	Notable
2	2.5–3.99	Significant
3	4–5.99	Major
4	6–9.99	Crippling
5	10.0+	Extreme

Source: Massachusetts State Hazard Mitigation Plan, 2010

Since 1958 Massachusetts has experienced two Category 5 Extreme snow storms, nine Category 4 (Crippling) storms, and 13 Category 3 (Major) snow storms. 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. Historically, severe winter storms have occurred in the following years:

Table 12. Severe Winter Storm Records for Massachusetts	
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
Blizzard of 2013	February 2013
Blizzards of 2015	January & February 2015

The City of Woburn does not keep local records of winter storms. Data for Middlesex County, which includes Woburn, is the best available data to help understand previous occurrences and impacts of winter storm events. According to National Climate Data Center (NCDC) records, from 1996 to 2014 Middlesex County experienced 50 heavy snowfall events, resulting in no deaths or injuries and \$1.45 million dollars in property damage. See Table 13 for and heavy snow events and impacts in Middlesex County.

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Table 13 - Heavy Snow events and Impacts in Middlesex County 1996 –2011				
Date	Type	Deaths	Injuries	Property Damage
1/2/1996	Heavy Snow	0	0	0.00K
1/7/1996	Heavy Snow	0	0	1.400M
2/16/1996	Heavy Snow	0	0	0.00K
3/2/1996	Heavy Snow	0	0	0.00K
3/7/1996	Heavy Snow	0	0	0.00K
4/7/1996	Heavy Snow	0	0	0.00K
4/9/1996	Heavy Snow	0	0	0.00K
12/6/1996	Heavy Snow	0	0	0.00K
3/31/1997	Heavy Snow	0	0	0.00K
4/1/1997	Heavy Snow	0	0	0.00K
12/23/1997	Heavy Snow	0	0	0.00K
1/15/1998	Heavy Snow	0	0	0.00K
1/14/1999	Heavy Snow	0	0	0.00K
2/25/1999	Heavy Snow	0	0	0.00K
3/6/1999	Heavy Snow	0	0	0.00K
3/15/1999	Heavy Snow	0	0	0.00K
1/13/2000	Heavy Snow	0	0	0.00K
1/25/2000	Heavy Snow	0	0	0.00K
2/18/2000	Heavy Snow	0	0	0.00K
1/20/2001	Heavy Snow	0	0	0.00K
2/5/2001	Heavy Snow	0	0	0.00K
3/5/2001	Heavy Snow	0	0	0.00K
3/9/2001	Heavy Snow	0	0	0.00K
12/8/2001	Heavy Snow	0	0	0.00K
3/16/2004	Heavy Snow	0	0	0.00K
2/24/2005	Heavy Snow	0	0	0.00K
12/13/2007	Heavy Snow	0	0	0.00K
12/16/2007	Heavy Snow	0	0	0.00K
1/14/2008	Heavy Snow	0	0	28.00K
2/22/2008	Heavy Snow	0	0	0.00K
12/19/2008	Heavy Snow	0	0	0.00K
12/20/2008	Heavy Snow	0	0	8.00K
12/31/2008	Heavy Snow	0	0	0.00K
1/11/2009	Heavy Snow	0	0	0.00K

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Date	Type	Deaths	Injuries	Property Damage
1/18/2009	Heavy Snow	0	0	0.00K
3/2/2009	Heavy Snow	0	0	0.00K
12/20/2009	Heavy Snow	0	0	0.00K
1/18/2010	Heavy Snow	0	0	0.00K
2/16/2010	Heavy Snow	0	0	15.00K
1/26/2011	Heavy Snow	0	0	0.00K
12/29/2012	Heavy Snow	0	0	0.00K
2/8/2013	Heavy Snow	0	0	0.00K
3/7/2013	Heavy Snow	0	0	0.00K
3/18/2013	Heavy Snow	0	0	0.00K
12/14/2013	Heavy Snow	0	0	0.00K
12/17/2013	Heavy Snow	0	0	0.00K
1/2/2014	Heavy Snow	0	0	0.00K
2/5/2014	Heavy Snow	0	0	0.00K
2/13/2014	Heavy Snow	0	0	0.00K
Total	50	0	0	1.45 M

(Source: NOAA NCDC)

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 percent 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:

Description	Diameter (inches)
Pea	0.25
Marble or Mothball	0.50
Penny or Dime	0.75
Nickel	0.88

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Description	Diameter (inches)
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.

City-specific data for previous ice storm occurrences are not collected by the City of Woburn. The best available local data is for Middlesex County through the National Climatic Data Center (see Table 14). Middlesex County experienced three events from 1998 to 2008 which caused a total of \$3,155,000 in damages. No injuries or deaths were reported.

Table 14 Ice Storm Events in Middlesex County, 1998 –2008

BEGIN_DATE	EVENT_TYPE	DEATHS	INJURIES	DAMAGE
1/9/1998	Ice Storm	0	0	5,000
11/16/2002	Ice Storm	0	0	150,000
12/11/2008	Ice Storm	0	0	3,000,000
TOTAL		0	0	3,155,000

Source: NOAA, National Climatic Data Center.

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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 5 years to once in 50 years, with 2% to 20% chance of occurring each year.

Winter Storms are a City-wide hazard in Woburn. Map 6 in Appendix B displays areas of average annual snowfall, which is in the range of 48 to 72 inches per year category.

The impacts of winter storms are most significant on the transportation system. The Woburn DPW works to clear roads as requested by emergency service providers and carries on general snow removal operations. The City continues to ban on-street parking at nights during snow storm events and during snow removal to ensure that streets can be plowed and public safety vehicle access is maximized. Transit operations may also be impacted, as they were in the most recent blizzard which caused the complete closure of the MBTA system for one day and limited services on several transit lines lasting several weeks.

The City's overall vulnerability to winter storms is primarily related to restrictions to travel on roadways, temporary road closures, school closures, and potential restrictions on emergency vehicle access. Other vulnerabilities include power outages due to fallen trees and utility lines, and damage to structures due to heavy snow loads.

Based on the record of previous occurrences, winter storm events in Woburn 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).

Geologic Hazards

Geologic hazards include earthquakes, landslides, sinkhole, subsidence, and unstable soils such as fill, peat, and clay. 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 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).

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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.

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:

Richter Magnitude	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

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) and a sample of these is included in Table 15 below.

Table 15. Historical Earthquakes in Massachusetts or Surrounding Area, 1727-2013		
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

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Table 15. Historical Earthquakes in Massachusetts or Surrounding Area, 1727-2013		
Location	Date	Magnitude*
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
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

There have been no recorded earthquake epicenters within Woburn.

Liquefaction - One additional impact that is of particular concern in the Boston metropolitan area is liquefaction (see figure below). This is due to the prevalence of filled land. Liquefaction means that loosely packed, water-logged sediments lose strength and therefore move in large masses or lose bearing strength. Soil units susceptible to liquefaction include: non-engineered artificial fill, alluvial deposits, beach deposits, fluvial deposits and flood plain deposits. Non-engineered artificial fill is what is typically known locally as filled land. An earthquake with a magnitude of 5.5 or greater can trigger liquefaction.

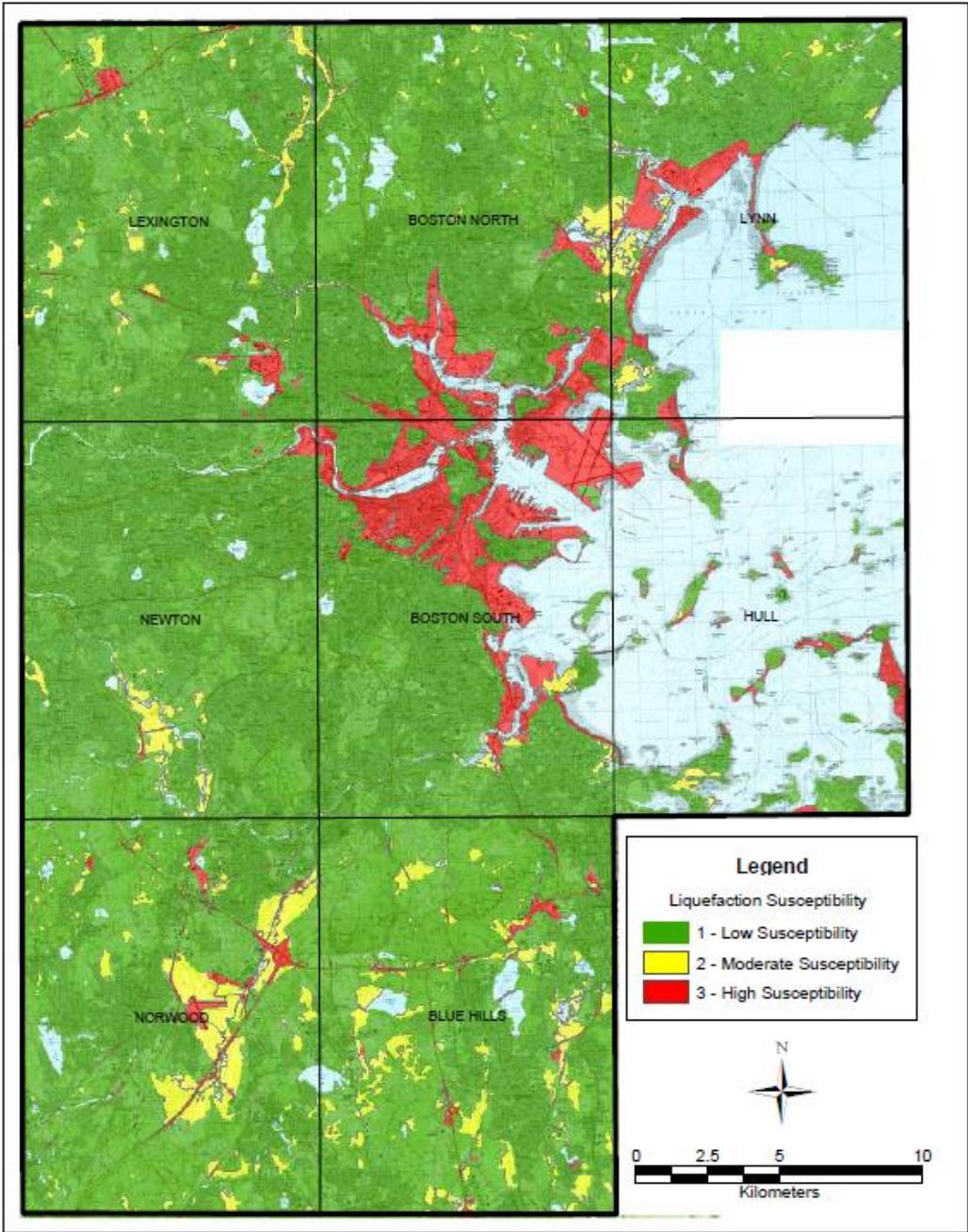
Figure 2 shows the liquefaction susceptibility of the Boston metropolitan area, and indicates that most of Woburn is classified as a low susceptibility, except for a narrow band of moderate susceptibility along the eastern side of the city. Earthquakes are a potential city-wide hazard in Woburn, although the moderate susceptibility areas would be at higher risk.

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.

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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 impacted during an earthquake.

Figure 2. Liquefaction Susceptibility of the Boston Metropolitan Area



Source: Baise, Laurie G., Rebecca B. Higgins; and Charles M. Brankman, Tufts University

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Potential earthquake damages to Woburn have been estimated using HAZUS-MH. Total damages are estimated at \$755.71 million for a 5.0 magnitude earthquake and \$6,874.71 million for a 7.0 magnitude earthquake.

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 2013 classifies earthquakes as "very low" frequency events that occur less frequently than once in 100 years, or a less than 1% per year.

The City has identified several areas where earthquakes have the potential to cause significant damage.

According to the 2007 Hazard Mitigation Plan, the city's underground water system is susceptible to earthquakes and seismic disturbances. Although Woburn has not felt any seismic activity since the mid 1960's any sudden shifts in the ground could shear or cause a rupture in the water mains. This could close roads to vehicles, pedestrians and emergency apparatus, damage properties as well as disrupt the water distribution system.

Commercial Buildings

The city has a large commercial area mainly centered in the northern portion of Woburn which has buildings in excess of 5 stories along with several public buildings that were constructed prior to 1985. This is significant since earthquake design standards were not in effect. Listed below are buildings that were constructed prior to 1985 and are 5 stories or greater.

Address	Year Built	Stories
19 Commerce Way	1964	5
59 Campbell Street	1970	7
21 Warren Avenue	1974	5
304 Cambridge Road	1979	5
Library Place	1980	5
3 Rehabilitation Way	1980	7
1 Linscott Road	1984	5
1 Mack Road	1984	5
311 Mishawum Road	1984	5
285 Mishawum Road	1985	5

Another area of concern for seismic activity is churches that have steeples. A number of these are clustered in the center of Woburn. In an earthquake, the structural integrity of

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the church steeples could be compromised thus collapsing and causing severe damage to pedestrians, vehicles and buildings within several hundred feet of the church. Some of the churches could possibly be used for shelters during emergencies, thus creating a hazardous situation inside the church during an earthquake.

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.

There is no universally accepted measure of landslide extent but it has been represented as a measure of the destructiveness of a landslide. Table 16 represents the estimated intensity for a range of landslides. For a given landslide volume, fast moving rockfalls have the highest intensity while slow moving landslides have the lowest intensity.

Table 16. 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

According to State data, the city is classified as having areas with a low risk for landslides as well having areas with a moderate risk (Appendix B - Map 4).. The western portion of

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the city has a low risk for landslides whereas the eastern portion has a moderate risk for landslides. Although potentially a city-wide hazard, there are no documented previous occurrences of landslides in Woburn. Should a landslide occur in the future in Woburn, the type and degree of impacts would be highly localized, and the city'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 Woburn.

Based on past occurrences and the Massachusetts Hazard Mitigation Plan 2013, landslides are of Very Low frequency, events that can occur less frequently than once in 100 years (less than 1% per year).

Fire Related Hazards

Brush Fires

For the purposes of this plan, 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. 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.

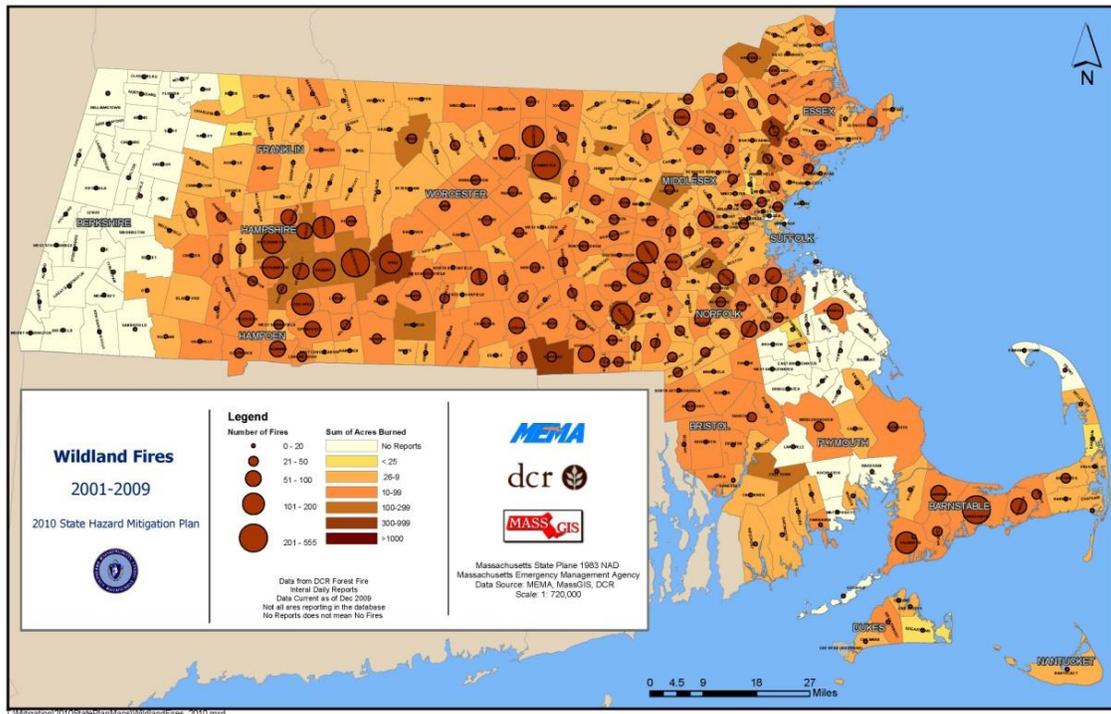
These fires present a hazard where there is the potential for them to spread into developed or inhabited areas, particularly residential areas where sufficient fuel materials might exist to allow the fire the spread into homes.

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 3 below, indicates that the wildfire extent in Woburn consists of less than 0.25 acres burned, with the City experiencing fewer than 20 recordable fires between 2001- 2009.

The City has identified an area on the westerly side of Horn Pond and just north of the Woburn Country Club golf course as a brush fire hazard area due to the numerous fires that have occurred over the years. With the numerous walking trails bisecting the area, fire hazards such as the carelessness of pedestrians with cigarettes and children playing with matches are of great concern.

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Figure 3. MA Wildfires 2001-2009



Potential vulnerabilities to wildfire include injuries and loss of human life, damage to structures and other improvements, and impacts on natural resources. Given the immediate response times to reported wildfires in Woburn, the likelihood of injuries and casualties is minimal. Smoke and air pollution from wildfires can be a health hazard, especially for sensitive populations including children, the elderly, and those with respiratory and cardiovascular diseases. Wildfire may also threaten the health and safety of those fighting the fires. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke.

Based on past occurrences and the Massachusetts Hazard Mitigation Plan 2013, brushfires are of Medium frequency, events that can occur from once in 5 years to once in 50 years (2% to 20% probability per year).

Extreme Temperatures

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 where there is prolonged period of excessively hot or cold weather.

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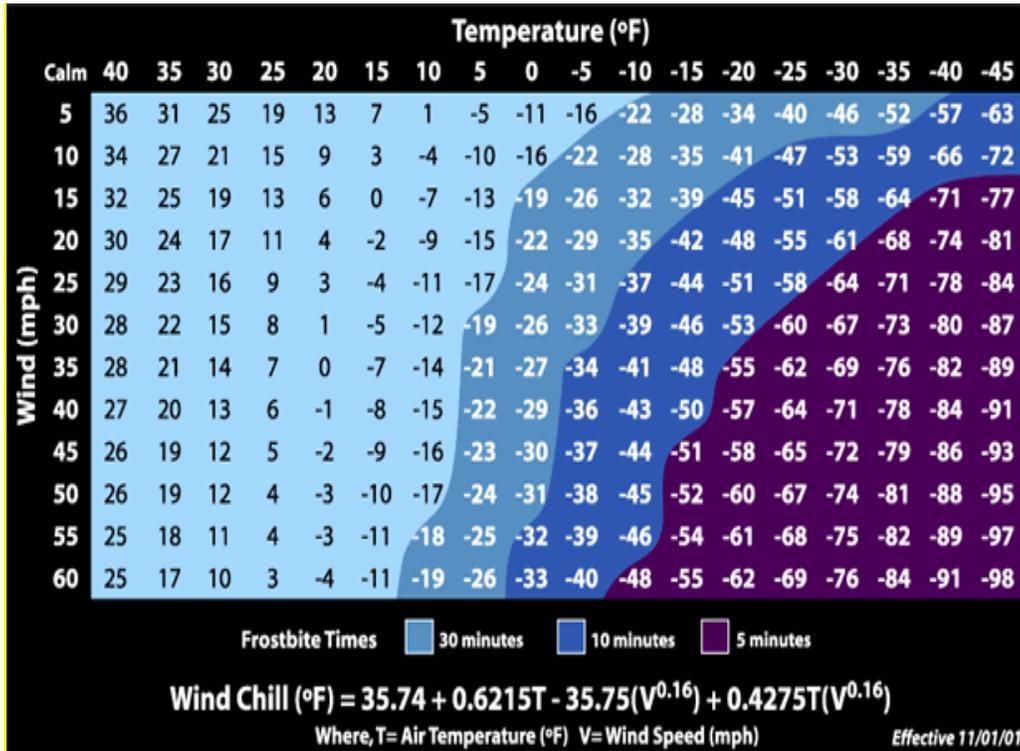
Woburn has four well-defined seasons. The seasons have several defining factors, with temperature one of the most significant. Extreme temperatures can be defined as those, which are far outside of the normal seasonal ranges for Massachusetts. The average temperatures for Massachusetts are: winter (Dec-Feb) Average = 31.8°F and summer (Jun-Aug) Average = 71°F. Extreme temperatures are a city-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 4 below.

Extreme cold is also 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.

Figure 4 - Wind Chill Temperature Index and Frostbite Risk



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.

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The City of Woburn 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 is one extreme cold event on record on February 3, 2007, which caused one death and no injuries or property damage were reported

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 NWS. These advisories are issued when the heat index (Figure 5) is forecast to exceed 100 degree Fahrenheit (F) for 2 or more hours; an excessive heat advisory is issued if forecast predicts the temperature to rise above 105 degree F.

Figure 5 Heat Index Chart

		Temperature (°F)															
		80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
Relative Humidity (%)	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.													

Extreme heat 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. Hot summer days can also worsen air pollution. With increased extreme heat,

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urban areas of the Northeast are likely to experience more days that fail to meet air quality standards.

The City does not collect data on excessive heat occurrences. The best available data is from the National Climatic Data Center (NCDC) for Middlesex County, which includes Woburn. The NCDC records indicate that on July 6, 2010 the temperature in eastern Massachusetts ranged from 100 to 106 degrees Fahrenheit. There were no reported deaths, injuries or property damage resulting from excessive heat.

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 2 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 3 to 4 inch average amounts for each month of the year. Regional monthly precipitation ranges from zero to 17 inches. Statewide annual precipitation ranges from 30 to 61 inches. Thus, in the driest calendar year (1965), the statewide precipitation total of 30 inches was 68 percent of average.

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.

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Woburn is located in the Northeast Region. In Woburn drought is a potential city-wide hazard.

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

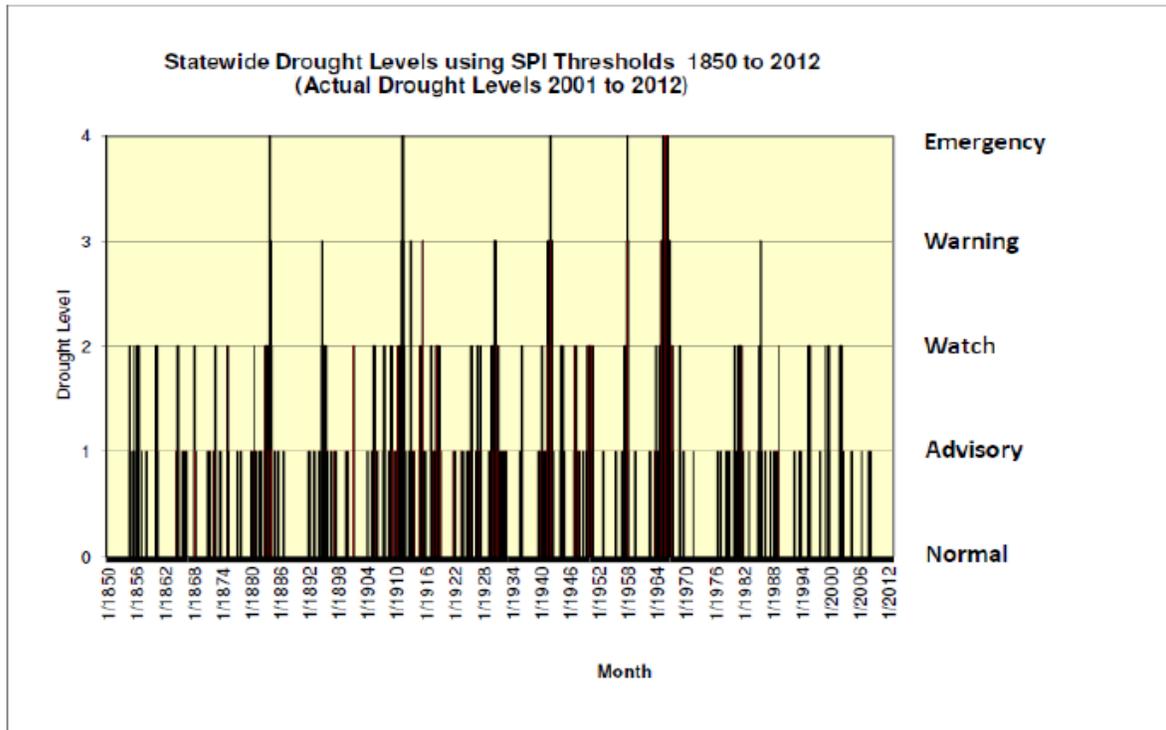
[Previous Occurrences](#)

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Woburn does not collect data relative to drought events. Because drought tends to be a regional natural 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/Islands and West).

Figure 6 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 percent of the time between 1850 and 2012. Table 17 summarizes the chronology of major droughts since the 1920's.

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



Source: Mass. State Drought Management Plan 2013

Drought Emergency

Drought emergencies have been reached infrequently, with 5 events occurring in the period between 1850 and 2012: in 1883, 1911, 1941, 1957, and 1965-1966. The 1965-1966 drought period is viewed as the most severe drought to have occurred in modern times in Massachusetts because of its long duration. On a monthly basis over the

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162-year period of record, there is a one percent chance of being in a drought Emergency.

Drought Warning

Drought Warning levels not associated with drought Emergencies have occurred four times, in 1894, 1915, 1930, and 1985. On a monthly basis over the 162-year period of record, there is a two percent chance of being in a drought Warning level.

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 and 2002. The overall frequency of being in a drought Watch is 8 percent on a monthly basis over the 162-year period of record.

Table 17 - 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.

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The state has experienced Emergency Droughts five times between 1850 and 2012. Even given that regional drought conditions may occur at a different interval than state data indicates, droughts remain primarily regional and state phenomena in Massachusetts. 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.

Land Use and Development Trends

Existing Land Use

Present day Woburn is largely a result of its early industrial history as well as its location relative to the regional transportation system. The opening of the Middlesex Canal in 1803 provided Woburn tanners with a new means of obtaining tanbark and the leather business in town boomed. The opening of the Boston & Lowell Railroad in 1835 and its Woburn Loop line in 1844 rapidly expanded the shoe making and tanning industries. The post-WWII development of Woburn was most influenced by the opening of Route 128 in 1951 and then I-93 in 1963. Woburn's location at the crossroads of these two components of the regional highway system greatly influenced new industrial, commercial and residential development beyond the historic City center.

The predominant land use in Woburn is residential. The next largest category is forest, and the third is industrial. Table 18 shows land use acreage and percentage for 2005, the most recent year for which information is available. Woburn is approaching buildout and has recently seen development on some of the remaining farms in the city.

The pace of residential development has slowed since 2010 from a high of 78 building permits for single family homes to a low of 36 in 2014. This reflects the built-out nature of the City and increasing scarcity of buildable lots.

Residential uses make up nearly 38% of the area of the City (approximately 3,081.43 acres). Commercial and industrial land uses also comprise a significant portion of the city (18.6%).

Land Use	Acres	Percentage
Crop land	62.86	0.78
Pasture	4.42	0.05
Forest	1,660.21	20.47
Wetlands	281.94	3.48
Mining	11.79	0.15
Open land	187.13	2.31

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Table 18 Land Use 2005		
Land Use	Acres	Percentage
Participation recreation	97.7	1.20
Water based recreation	2.68	0.03
Multi-family residential	518.16	6.39
High density residential	2,466.47	30.41
Low density residential	94.94	1.17
Very low density residential	2.56	0.03
Commercial	593.73	7.32
Industrial	914.99	11.28
Urban open	21.11	0.26
Transportation	289.95	3.58
Water	181.46	2.24
Powerline	157.32	1.94
Golf course	51.99	0.64
Marina	6.06	0.07
Urban public	159.13	1.96
Cemetery	74.22	0.92
Nursery	44.65	0.55
Forested wetland	215.49	2.66
Junkyards	6.47	0.08
Brushland	2.47	0.03
Total area	8,109.90	100%
Source: University of Massachusetts, Amherst Remote Sensing Project		

Economic Elements

Post-WWII development of Woburn was most influenced by the opening of Route 128 in 1951 and then I-93 in 1963. Woburn's location at the crossroads of these two components of the regional highway system greatly influenced new industrial, commercial and residential development beyond the historic City center. Access to the regional highway system has allowed commercial and industrial development to flourish.

The major local roads providing north-south access are Main Street (Route 38), Cambridge Street (Route 3), and Washington Street. The major east-west routes are Lexington Street, Montvale Avenue and Salem Street. Most of these streets contain significant local retail nodes.

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Historic, Cultural, and Natural Resource Areas

The City has many historic sites including the First and Second Burial Grounds, the Baldwin Mansion, the Rumford House, the Battle Road Conservation Area, the 1790 House, the First Congregational Church, the Middlesex Canal, the Library and the U.S. Post Office. Several of these properties are on the National Register of Historic Places.

The City has 950 acres of publicly owned open space and recreation land. This represents 11% of the total acreage of the city. The largest of these areas is Horn Pond. Horn Pond is very popular for walking with a network of trails going around the pond.

Development Trends

Under current zoning, the City of Woburn is largely built out. Much of the land area is occupied by existing residential neighborhoods, commercial centers and corridors, industrial developments and parks, schools and recreation space. The development that is occurring in the City is primarily redevelopment. Most recently, several of the remaining farms have been converted to residential subdivisions.

Development trends throughout the metropolitan region are tracked by MAPC's Development Database, which provides an inventory of new development over the last decade. The database tracks both completed developments and those currently under construction. The database includes 23 developments in the City of Woburn, of which 6 are completed and 18 are under construction or planned.

The database also includes several attributes of the new development, including site acreage, housing units, and commercial space. Four of the completed projects are housing projects, and two are commercial. Of the 18 projects currently under construction or planned, 12 are residential, four are commercial, one is mixed use, and one is a parking facility. The total 24 developments in Woburn include a total of 930 housing units and 152,697 square feet of commercial space (see Table 19).

In order to characterize any change in the city's vulnerability associated with new developments, a GIS mapping analysis was conducted which overlaid the 24 development sites with the FEMA Flood Insurance Rate Map. The analysis shows that none of the 24 developments in Woburn are located within a flood zone.

Table 19 Summary of Woburn Developments 2008-2015

DEVELOPMENTS COMPLETED 2008-2014	HOUSING UNITS	COMMERCIAL (SQ FEET)	PROJECT TYPE
Kimball Court III	175	-	Residential
159-175 Main St	-	11,200	Commercial
Wall Drive	10	-	Residential
Monarch Homes	35	-	Alzheimer's Assisted Living Residence
Robertson Way	6	-	Residential
225 Wildwood Avenue	-	23,800	Heavy manufacturing in existing building
SUBTOTAL	226	35,000	
UNDER CONSTRUCTION/PLANNED			
1 Darling Drive	12	-	12 Residential Lots
Newbridge Village at 855 Main Street	91	-	51 condo units and 40 townhouse/garden
Winning Farm	147	-	Residential
Kerrigan Way	7	-	7 single family houses
Ledges at Woburn	168	-	168-unit housing development
Russo Estates	6	-	6 single family houses
Benchmark Senior Living	87	-	87 units of senior extended care
Lord Hobo Brewery	-	47,000	Craft brewery with small retail
Dragon Court - 10 lots	20	-	2 family units on 10 lots totaling
Dave & Buster's Mishawum Road	-	47,350	Dave & Buster's store
Carlson Way	23	-	23 lot single family houses
30 Wyman St	36	-	Residential
275 Salem St	-	10,500	Commercial

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DEVELOPMENTS COMPLETED 2008-2014	HOUSING UNITS	COMMERCIAL (SQ FEET)	PROJECT TYPE
Walnut Hill Parking Deck	-	163	Multi-level structured parking garage
1071 Main Street	51	-	51 residential units in a single building
Woburn Landing	-	9,684	2 hotels and three restaurants
89 Wyman Street	4	-	4 new single family house lots
Woburn Armory	18	3,000	Mixed use, 18 residential units with 5,000 sq feet of commercial space
SUBTOTAL	704	117,697	
TOTAL ALL PROJECTS	930	152,697	

Potential Future Development

MAPC consulted with the local team to determine areas that may experience development or redevelopment in the future, defined for the purposes of this plan as a ten year time horizon. These areas are shown on Map 8, “Potential Future Development Areas” and are described below. The letter for each site corresponds to the letters on Map 8.

- A. The Armory – This building will be redeveloped into 18 residential units and 5,000 square feet of commercial space.
- B. 4 Montvale Avenue – This development will include four residential units and 2,000 square feet of commercial space.
- C. Woburn Foreign Motors – This development will include a showroom and 180,000 square feet of office space.
- D. Woburn Landing – This development will take place on the former WR Grace site and will include a hotel with three restaurants.
- E. 1071 Main Street – This development will entail 59 units of residential development.
- F. The Seaver Parcel (NELCO) – This parcel will be development into 41 townhouses.
- G. 0 Constitution Way – This development will consist of 92,000 square feet of office.
- H. The Wyman-Hurld School – The city will be building a new school to consolidate two smaller schools.
- I. New Fire Station – The City will be building a new Fire Station off of Main Street near Forest Park.

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Vulnerability Assessment

The purpose of the vulnerability assessment is to estimate the extent of potential damages from natural hazards of varying types and intensities.

Future Development in Hazard Areas

Table 20 shows the relationship of these parcels to three of the mapped hazards. 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.

Property	Flood Zone	Landslides Risk
Wyman/Hurld School	No	Low incidence
Proposed Fire Station	No	Low incidence
1071 Main Street	No	Low incidence
The Seaver Parcel/Nelco Site	No	Low incidence
Woburn Landing	No	Low incidence
Woburn Foreign Motors	No	Low incidence
0 Constitution Way	No	Low incidence
Montvale Ave.	No	Low incidence
Amory Street	No	Low incidence

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.). These facilities are listed in Table 17 and are shown on all of the maps in Appendix B.

The purpose of mapping the natural hazards and critical infrastructure is to present an overview of hazards in the community and how they relate to critical infrastructure, to better understand which facilities may be vulnerable to particular natural hazards.

Explanation of Columns in Table 21

Column 1: ID #: The first column in Table 13 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 as follows:

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.

Zones X500 (.2% annual chance) - Zone X500 is the flood insurance rate zone that correspond to the 500-year floodplains that are determined in the Flood Insurance Study (FIS) by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no BFEs (base flood elevations) or depths are shown within this zone.

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

Column 6: 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.

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Table 21: Relationship of Critical Infrastructure to Hazard Areas

PDM_ID	NAME	TYPE	Incidence of Landslides	Within FEMA Flood Zone	Locally Identified Area of Flooding	Average Annual Snow Fall
347-001	Alpha Industries	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-002	Altavesta Elementary School	School	Low incidence	No	No	H 48.1 - 72.0
347-003	Analytical Answers	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-004	Anderson Regional Transportation Center	Transportation Facility	Low incidence	No	No	H 48.1 - 72.0
347-005	Anika Therapeutics	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-006	Boston Child Development Center	School	Low incidence	No	No	H 48.1 - 72.0
347-009	Chomerics/Parker Hannafin	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-010	Woburn City Hall	Municipal Office	Low incidence	No	No	H 48.1 - 72.0
347-012	Country Club Heights	Assisted Living	Low incidence	No	No	H 48.1 - 72.0
347-013	Delta F. Corporation	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-014	Douglas Battery	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-015	Warren Avenue	Elderly Housing	Low incidence	No	No	H 48.1 - 72.0
347-016	Fuller System Inc.	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-017	General Eastern Instruments	Hazardous Materials	Low incidence	X: 0.2% Annual Chance of Flooding	No	H 48.1 - 72.0
347-018	Gentest Corp	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-019	Goodyear Elementary School	School	Low incidence	No	No	H 48.1 - 72.0
347-021	Herley-MDI	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-022	Scalley Dam	Dam	Low incidence	AE: Regulatory Floodway	Arlington Road	H 48.1 - 72.0
347-023	Horn Pond Water Treatment Facility	Water Treatment facility	Low incidence	No	No	H 48.1 - 72.0
347-024	Hurd Elementary School	School	Low incidence	No	No	H 48.1 - 72.0
347-025	Joyce Middle School	School	Low incidence	X: 0.2% Annual Chance of Flooding	No	H 48.1 - 72.0
347-026	Kennedy Middle School	School	Low incidence	No	No	H 48.1 - 72.0

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Table 21: Relationship of Critical Infrastructure to Hazard Areas

PDM_ID	NAME	TYPE	Incidence of Landslides	Within FEMA Flood Zone	Locally Identified Area of Flooding	Average Annual Snow Fall
347-027	Kindercare	School	Low incidence	No	No	H 48.1 - 72.0
347-028	Kraft Foods	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-029	Kraft General Foods	Food Manufacturer	Low incidence	No	No	H 48.1 - 72.0
347-030	Kraft General Foods	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-031	Library Park	Elderly Housing	Low incidence	No	No	H 48.1 - 72.0
347-032	Linscott Elementary School	School	Low incidence	No	No	H 48.1 - 72.0
347-033	Little Folks Day School	School	Low incidence	No	No	H 48.1 - 72.0
347-034	Little Hands Big Hearts	School	Low incidence	No	No	H 48.1 - 72.0
347-035	Launch and Learn Educare Center	School	Low incidence	No	No	H 48.1 - 72.0
347-036	Madico Inc.	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-037	Metallized Products, Inc.	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-038	Modular Genitics Inc.	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-041	Murphy's Waste Oil Services	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-042	New England Rehab	Medical Facility	Low incidence	No	No	H 48.1 - 72.0
347-044	New Horizons At Choate	Assisted Living	Low incidence	No	No	H 48.1 - 72.0
347-045	Nichols Street Extention	Elderly Housing	Low incidence	No	No	H 48.1 - 72.0
347-046	O'Brien Ice Rink	Place of Assembly	Low incidence	No	No	H 48.1 - 72.0
347-047	Organix, Inc.	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-048	PPG Finishes	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-049	Prism Science Works	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-050	Pro Science Analytical	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-051	Public Works Department	Municipal Office	Low incidence	No	No	H 48.1 - 72.0
347-052	Puddle Duck Daycare	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-053	Rag Rock Storage Tank	Water Storage Tank	Low incidence	No	No	H 48.1 - 72.0
347-054	Reeves Elementary School	School	Low incidence	No	No	H 48.1 - 72.0

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Table 21: Relationship of Critical Infrastructure to Hazard Areas						
PDM_ID	NAME	TYPE	Incidence of Landslides	Within FEMA Flood Zone	Locally Identified Area of Flooding	Average Annual Snow Fall
347-055	Rohm & Haas-Advanced Materials	Hazardous Materials	Low incidence	X: 0.2% Annual Chance of Flooding	No	H 48.1 - 72.0
347-056	Sammina (Altron)	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-057	Shamrock Elementary School	School	Low incidence	No	No	H 48.1 - 72.0
347-058	Sprint Spectrum	Hazardous Materials	Low incidence	X: 0.2% Annual Chance of Flooding	No	H 48.1 - 72.0
347-059	St. Charles	School	Low incidence	No	No	H 48.1 - 72.0
347-060	First Steps Early Learning Center	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-061	The Afterschool Club	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-065	The Warren House	Assisted Living	Low incidence	No	No	H 48.1 - 72.0
347-066	Thermo-electron Tecomet	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-067	Tidd Home	Assisted Living	Low incidence	No	No	H 48.1 - 72.0
347-068	Moppets	School	Low incidence	No	No	H 48.1 - 72.0
347-069	United States Postal Service	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-070	US Food & Drug Administration	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-071	Vaisala	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-072	Van Waters & Rogers	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-073	Waltham Street Tank	Water Storage Tank	Low incidence	No	No	H 48.1 - 72.0
347-074	Well A2	Well	Low incidence	No	No	H 48.1 - 72.0
347-075	Well B	Well	Low incidence	No	No	H 48.1 - 72.0
347-076	Well C2	Well	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	No	H 48.1 - 72.0
347-077	Well D2	Well	Low incidence	No	No	H 48.1 - 72.0
347-078	Well I	Well	Low incidence	No	No	H 48.1 - 72.0

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Table 21: Relationship of Critical Infrastructure to Hazard Areas

PDM_ID	NAME	TYPE	Incidence of Landslides	Within FEMA Flood Zone	Locally Identified Area of Flooding	Average Annual Snow Fall
347-079	Whispering Hill Tank	Water Storage Tank	Low incidence	No	No	H 48.1 - 72.0
347-080	White Elementary School	School	Low incidence	No	No	H 48.1 - 72.0
347-081	Winchester Community Health Institute	Medical Facility	Low incidence	No	No	H 48.1 - 72.0
347-082	Winfield Brooks	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-083	Woburn Creative Start Program	School	Low incidence	No	No	H 48.1 - 72.0
347-084	Woburn Elks	Place of Assembly	Low incidence	No	No	H 48.1 - 72.0
347-085	Woburn South End Fire Station	Fire Station	Low incidence	No	No	H 48.1 - 72.0
347-086	Woburn High School	School	Low incidence	No	No	H 48.1 - 72.0
347-087	Woburn Housing	Elderly Housing	Low incidence	No	No	H 48.1 - 72.0
347-088	Woburn Nursing Center	Nursing Home	Low incidence	No	No	H 48.1 - 72.0
347-089	Woburn Police Department	Police Station	Low incidence	No	No	H 48.1 - 72.0
347-090	World Of Wonder	School	Low incidence	No	No	H 48.1 - 72.0
347-091	Wyman Elementary School	School	Low incidence	No	No	H 48.1 - 72.0
347-092	Yusa Inc.	Hazardous Materials	Low incidence	No	No	H 48.1 - 72.0
347-093	East Woburn Fire Station	Fire Station	Low incidence	No	No	H 48.1 - 72.0
347-094	North Woburn Fire Station	Fire Station	Low incidence	No	No	H 48.1 - 72.0
347-095	West Side Fire Station	Fire Station	Low incidence	No	No	H 48.1 - 72.0
347-096	Fire Station	Fire Station	Low incidence	No	No	H 48.1 - 72.0
347-097	Sullivan, Nancy Daycare	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-098	Sheeran, Susan M. Daycare	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-099	Magro, Rosemary Daycare	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-100	Courtney, Diane Daycare	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-101	Chamberlain, Pauline J. Daycare	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-102	LaFlamme, Deborah L Daycare	Child Care	Low incidence	No	No	H 48.1 - 72.0

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Table 21: Relationship of Critical Infrastructure to Hazard Areas

PDM_ID	NAME	TYPE	Incidence of Landslides	Within FEMA Flood Zone	Locally Identified Area of Flooding	Average Annual Snow Fall
347-103	Serafino, Sally E. Daycare	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-104	O'Hearn, Kim L. Daycare	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-105	Fee, Susan M. Daycare	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-106	Szweda, Marie Daycare	Child Care	Low incidence	No	Lillian Street	H 48.1 - 72.0
347-107	Woburn EOC (@ Police Department)	Emergency Operations Center	Low incidence	No	No	H 48.1 - 72.0
347-108	Woburn EOC (@Fire Department)	Emergency Operations Center	Low incidence	No	No	H 48.1 - 72.0
347-109	Healthsouth New England Rehab Hospital	Hospital	Low incidence	No	No	H 48.1 - 72.0
347-110	Bournewood Caulfield Center Hospital	Hospital	Low incidence	No	No	H 48.1 - 72.0
347-111	Draper Street Sewer Pumping Station	Sewer Pumping Station	Low incidence	No	No	H 48.1 - 72.0
347-112	Dix Road Sewer Pumping Station	Sewer Pumping Station	Low incidence	No	No	H 48.1 - 72.0
347-113	Senior Center	Senior Center	Low incidence	No	No	H 48.1 - 72.0
347-114	Dragon Court Sub Station	Power Substation	Low incidence	No	No	H 48.1 - 72.0
347-115	Green Street Sub Station	Power Substation	Low incidence	No	No	H 48.1 - 72.0
347-116	Cove Street Sub Station	Power Substation	Low incidence	No	No	H 48.1 - 72.0
347-117	Webster Avenue Family Housing	Family Housing	Low incidence	No	No	H 48.1 - 72.0
347-118	Woburn District Court House	Court House	Low incidence	No	No	H 48.1 - 72.0
347-119	Woburn Police Communication Tower	Communication Tower	Low incidence	No	No	H 48.1 - 72.0
347-120	Comcast Cable Broadcast Center	Communication Tower	Low incidence	No	No	H 48.1 - 72.0
347-121	Logan Express	Transportation Facility	Low incidence	No	No	H 48.1 - 72.0
347-122	Montvale Avenue Bridge	Bridge	Low incidence	No	No	H 48.1 - 72.0
347-123	Rte 93 Bridge	Bridge	Low incidence	No	No	H 48.1 - 72.0

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Table 21: Relationship of Critical Infrastructure to Hazard Areas

PDM_ID	NAME	TYPE	Incidence of Landslides	Within FEMA Flood Zone	Locally Identified Area of Flooding	Average Annual Snow Fall
347-124	Salem Street Bridge	Bridge	Low incidence	No	No	H 48.1 - 72.0
347-125	Mishawum Road Bridge	Bridge	Low incidence	No	No	H 48.1 - 72.0
347-126	Carrie Simpson Daycare	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-127	Cantone Daycare	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-128	Boys and Girls Club ASP	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-129	Project Learn @ Hurld Elem School ASP	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-130	Project Learn @ Linscott School	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-131	Stacey Bickford Daycare	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-132	Edna Cabral Day Care	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-133	Christy Gibson Day Care	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-134	Susan Greekwood Day Care	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-135	Michelle Kenney Day Care	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-136	Tina Lentine Day Care	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-137	Kerstin Lochrie Day Care	Child Care	Low incidence	No	Pearl and Bartlett Street	H 48.1 - 72.0
347-138	Christine Mcardle Day Care	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-139	Sharon Newell Day Care	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-140	Mary Packard Day Care	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-141	Rosa Palacio Day Care	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-142	Gisela Reynosa Day Care	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-143	Marie Rodriguez Day Care	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-144	Wendy Vander Brug Day Care	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-145	Children's Center Daycare	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-007	Erin Anzivino	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-008	Maria Duffany	Child Care	Low incidence	No	No	H 48.1 - 72.0

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Table 21: Relationship of Critical Infrastructure to Hazard Areas

PDM_ID	NAME	TYPE	Incidence of Landslides	Within FEMA Flood Zone	Locally Identified Area of Flooding	Average Annual Snow Fall
347-011	Hind Chebbo	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-020	Donna Adgate	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-039	Lauren Flaherty	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-040	Lauren Burgess	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-043	After School Club	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-062	Ivanilde Dos Santos	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-064	Kris George	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-146	Kelly Barrucci	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-147	Little Sprouts	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-148	Lynn Patti Gangi	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-149	Patricia Katin	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-150	Michelle Tango	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-151	Xiaolin Wang	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-152	Paula Houle	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-153	Marlene Soler	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-154	Kimberly Higgins	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-155	Elizabeth Marquinhos	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-156	Marianne Filtzer	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-157	Margaret Hibbard	Child Care	Low incidence	No	No	H 48.1 - 72.0
347-158	Kelley Smith	Child Care	Low incidence	No	No	H 48.1 - 72.0

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Damage Assessments

An 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 City of Woburn, 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.”

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However, for the purposes of this plan, the analysis is useful. This plan is attempting to only 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. If interested, communities can build a more accurate database and further test disaster scenarios.

Estimated Damages from Hurricanes

The HAZUS software was used to model potential damages to the community from a 100 year and 500 year hurricane event; storms that are .01% and .005% 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 City, bringing the strongest winds and greatest damage potential.

Table 22. Estimated Damages from Hurricanes		
	100 Year	500 Year
Building Characteristics		
Estimated total number of buildings	11,668	11,668
Estimated total building replacement value (Year 2010 \$) (Millions of Dollars)	6,048	6,048
Building Damages		
# of buildings sustaining minor damage	1,748	2,546
# of buildings sustaining moderate damage	377	681
# of buildings sustaining severe damage	18	46
# of buildings destroyed	6	19
Population Needs		
# of households displaced	127	225
# of people seeking public shelter	26	48
Debris		
Building debris generated (tons)	16,827	24,284
Tree debris generated (tons)	3,094	4,003
# of truckloads to clear building debris	372	580
Value of Damages (Thousands of dollars)		
Total property damage	\$103,228.19	\$170,404.85
Total losses due to business interruption	\$9,830.52	\$17,748.60

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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.

Estimated Damages from Earthquakes

The HAZUS 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 23. Estimated Damages from Earthquakes		
	Magnitude 5.0	Magnitude 7.0
Building Characteristics		
Estimated total number of buildings	11,668	11,668
Estimated total building replacement value (Year 2006 \$)(Millions of dollars)	6.048	6.048
Building Damages		
# of buildings sustaining slight damage	3,258	328
# of buildings sustaining moderate damage	1,517	2,004
# of buildings sustaining extensive damage	328	3,159
# of buildings completely damaged	61	6,136
Population Needs		
# of households displaced	579	10,532
# of people seeking public shelter	297	5,361
Debris		
Building debris generated (tons)	0.14 million	1.67 million
# of truckloads to clear building debris	5,720	66,600
Value of Damages (Millions of dollars)		
Total property damage	755.71	6,874.71
Total losses due to business interruption	93.39	771.42

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Estimated Damages from Flooding

MAPC did not use HAZUS-MH to estimate flood damages in Woburn. In addition to technical difficulties with the software, the riverine module is not a reliable indicator of flooding in areas where inadequate drainage systems contribute to flooding even when those structures are not within a mapped flood zone. In lieu of using HAZUS, MAPC developed a methodology to give a rough approximation of flood damages.

Woburn is 12.95 square miles or 8,288 acres. Approximately 134 acres have been identified by local officials as areas of flooding. This amounts to 1.66 % of the land area in Woburn. The number of structures in each flood area was estimated by applying the percentage of the total land area to the number of structures (11,668) in Woburn; the same number of structures used by HAZUS for the hurricane and earthquake calculations. HAZUS uses a value of approximately \$518,000 per structure for the building replacement value. This was used to calculate the total building replacement value in each of the flood areas. The calculations were done for a low estimate of 10% building damages and a high estimate of 50% as suggested in the FEMA September 2002 publication, "State and Local Mitigation Planning how-to guides" (Page 4-13). The range of estimates for flood damages is \$10,025,898 - \$50,129,492. These calculations are not based solely on location within the floodplain or a particular type of storm (i.e. 100 year flood).

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Table 24. Estimated Damages from Flooding							
Site ID	Flood Hazard Area	Approximate Area in Acres	% of Total Land Area in Woburn	Estimated Number of Structures	Replacement Value	Low Estimate of Damages	High Estimate of Damages
1	Lake Terrace Circle	5.7	0.07%	8	\$4,123,724	\$412,372	\$2,061,862
2	Arlington Road	5.0	0.06%	7	\$3,653,644	\$365,364	\$1,826,822
3	Dragon Court	4.0	0.05%	6	\$2,945,204	\$294,520	\$1,472,602
4	Washington and Cedar Street	8.7	0.11%	12	\$6,372,888	\$637,289	\$3,186,444
5	Pearl and Barttlet Street	12.5	0.15%	18	\$9,103,761	\$910,376	\$4,551,880
6	Washington and Montvale Street	5.2	0.06%	7	\$3,827,343	\$382,734	\$1,913,671
7	Ward and Traverse Street	5.8	0.07%	8	\$4,239,479	\$423,948	\$2,119,740
8	Lillian Street	9.3	0.11%	13	\$6,783,021	\$678,302	\$3,391,510
9	Cambridge Road	17.6	0.21%	25	\$12,841,130	\$1,284,113	\$6,420,565
10	Winn Street and Hart Street	13.8	0.17%	20	\$10,104,645	\$1,010,465	\$5,052,323
11	Salem Street @ Aberjona Drive	15.2	0.2%	23	\$12,088,048	\$1,208,805	\$6,044,024
12	Bedford Road: Marlboro to Cambridge	30.9	0.4%	47	\$24,176,096	\$2,417,610	\$12,088,048
Totals							
		133.8	1.66 %	194	\$100,258,983	\$10,025,898	\$50,129,492

V. HAZARD MITIGATION GOALS

The 2007 Hazard Mitigation Plan included the following six goals:

- Improve ability to notify residents in the event of a natural disaster.
- Increase reliability of city departments and emergency shelters to function effectively during a natural disaster.
- Establish measures to reduce and/or correct each known flood hazard areas.
- Enhance the reliability of public utilities during a natural disaster.
- Increase public education.
- Expand communications with state and abutting communities.

The Woburn Local Multiple Hazard Community Planning Team met on June 12, 2015 to review these goals. Because these six goals were more focused on emergency response, MAPC presented a set of goals that were broader in scope. After some discussion, the goals listed below were endorsed by the Woburn Local Committee.

1. Prevent and reduce the loss of life, injury and property damages resulting from all major natural hazards.
2. Identify and seek funding for measures to mitigate or eliminate each known significant flood hazard area.
3. Integrate hazard mitigation planning as an integral factor in all relevant municipal departments, committees and boards.
 - Ensure that the Planning Department considers hazard mitigation in its review and permitting of new development.
 - Review zoning regulations to ensure that the ordinance incorporates all reasonable hazard mitigation provisions.
 - Ensure that all relevant municipal departments have the resources to continue to enforce codes and regulations related to hazard mitigation.
4. Prevent and reduce the damage to public infrastructure resulting from all hazards.
 - Begin to assess the vulnerability of municipal buildings and infrastructure to damage from an earthquake.
 - Maintain existing mitigation infrastructure in good condition.
5. Encourage the business community, major institutions and non-profits to work with the City to develop, review and implement the hazard mitigation plan.
6. Work with surrounding communities, state, regional and federal agencies to ensure regional cooperation and solutions for hazards affecting multiple communities.
 - Continue to participate in the Mystic Region REPC and Region IV A (Board of Health).
7. Ensure that future development meets federal, state and local standards for preventing and reducing the impacts of natural hazards.

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8. Educate the public about natural hazards and mitigation measures that can be undertaken by property-owners.
 - Provide information on hazard mitigation activities in the languages most frequently spoken in Woburn.
9. Take maximum advantage of resources from FEMA and MEMA to educate City staff and the public about hazard mitigation.

VI. HAZARD MITIGATION STRATEGY

The central component of a hazard mitigation plan is the strategy for reducing the community's vulnerabilities to natural hazard events. Responding to the analysis of risk, vulnerabilities, potential impacts, and anticipated future development, the process for developing this strategy is one of setting goals, understanding what actions the community is already taking that contribute to mitigating the effects of natural hazards and assessing where more action is needed to complement or modify existing measures. The following sections include descriptions of existing mitigation measures, a status update on mitigation measures identified in previous plans, and descriptions of proposed new mitigation measures. All mitigation measures are evaluated by their benefits and potential costs to arrive at a prioritized list of action items.

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.

<https://www.fema.gov/hazard-mitigation-grant-program>

<https://www.fema.gov/pre-disaster-mitigation-grant-program>

<https://www.fema.gov/pre-disaster-mitigation-grant-program>

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.

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- 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)

Existing Mitigation Measures

The existing protections in the City of Woburn are a combination of zoning, land use, and environmental regulations, infrastructure maintenance and drainage infrastructure improvement projects. The Town's existing mitigation measures are listed by hazard type here and are summarized in Table 25 below.

Existing Multi-Hazard Mitigation Measures

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

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. The City has an up-to-date CEMP plan that meets the state's requirements.

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.

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Regional Emergency Planning Committee (REPC) – The Mystic REPC serves as the emergency planning committee for 19 cities and towns. These include: Arlington, Burlington, Chelsea, Everett, Lynn, Lynnfield, Malden, Somerville, Melrose, North Reading, Reading, Revere, Saugus, Somerville, Stoneham, Wakefield, Winchester, Winthrop, and Woburn. The Mystic REPC's 19 member cities and towns work together to develop plans to educate, communicate, and protect their communities in case of natural and man-made emergencies. The Mystic REPC was the first regional planning committee to be certified by State of Massachusetts.

The Massachusetts Public Health Emergency Preparedness Region 4A – Woburn is a member of Region 4A, one of 15 regions within Massachusetts and is comprised of 33 cities and towns throughout the metro west area, which together form the General Coalition (GC). The Region 4A GC agrees to work collaboratively to meet the goals associated with the Centers for Disease Control and Prevention and the Massachusetts Department of Public Health Emergency Preparedness initiatives as well as other regional and local public health efforts.

Existing Flood Hazard Mitigation Measures

City Storm Drain System- All streets are swept once a year at a minimum and usually twice a year. The main roads are generally swept three or four times with some roads being done more frequently. All work is done in-house by the DPW. The DPW acquired a new street sweeper last year and feels that they have sufficient equipment at this point. Catch basin cleaning is also done annually. There are approximately 4,000 catch basins in the City. The DPW has a preventative maintenance plan and if flash floods or other storm events are forecast, they have a list of culverts and catch basins that are checked and cleaned if necessary. The DPW has three pieces of equipment and does all of the work in-house.

The City uses a combination of sand and salt to treat the roads during the winter. The City is careful to minimize the use of sand and salt on Arlington Road because of its proximity to the water supply at Horn Pond. The City also minimizes the use of salt on roads adjacent to wetlands. Salt is used primarily when there is a hilly road where safety takes precedence.

The City utilizes two areas for snow disposal. One is the ball field at the Veterans School off of School Street and the other is a smaller, satellite area at Saint Anthony's Church on Main Street. The City does not dump snow into Horn Pond because it is the City's water supply.

The City experiences approximately 25 water main breaks annually. In most years, only six of these would be considered major breaks while the remainder would be classified as

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leaks. The City is in its ninth year of a cleaning and relining program as well as replacing gates and valves. The exercise of valves and gates is done as part of the flushing program. In the past two years the DPW has been using an iPad to log in information as it undertakes this work.

The City has a Comprehensive Emergency Management Plan that covers flooding issues but primarily from a response perspective. The City restricts development under its floodplain district zoning bylaw and through the regulations of the Conservation Commission.

Zoning bylaw– The zoning ordinance for the City of Woburn contains a number of provisions that mitigate flooding problems. The relevant section of the zoning bylaw is Section 9: Floodway and Flood Plain Districts.

- Section 9.2 establishes floodway and floodplain districts as overlay districts. The boundaries of the districts are based on the Middlesex County Flood Insurance Rate Maps for the City of Woburn dated June 4, 2010.
- If a proposed use is determined to fall within the limits of the Floodway and Flood Plain district but the applicant can document that the site has been exempted by FEMA, the requirements of Section 9 do not apply.
- Section 9.4 states that there shall be no encroachments within the floodway including fill, new construction, substantial improvements and other developments.
- Within the floodplain district, no building or other structure may be erected, constructed, altered or enlarged and there shall be no dumping of trash, junk or other waste material if it restricts the floodwater flow or reduces the floodwater storage capacity. Special permits may be granted for substantial improvements to or erection of a structure the cost of which equals or exceeds fifty percent of the assessed value of the structure.
- Areas within the floodplain (but not the floodway) may be used to meet the area and yard requirements.
- Special permits may be granted for construction if it can be demonstrated that the cumulative effect of the development when combined with existing and anticipated development, will not increase the water surface elevation of the one hundred-year flood. Other special permit conditions apply.

Subdivision regulations – The Woburn Planning Board’s Land Subdivision Rules and Regulations – 1998 Edition – contain standards for drainage on subdivisions.

- The regulations require that preliminary subdivision plans show the proposed system of drainage, including adjacent natural waterways, an outline of the drainage areas of which the subdivision is a part and sufficient data to generally determine the nature of the drainage facility needs.
- Preliminary plans also need to show basic design data including peak drainage runoff rates and volumes for the 20 and 100 year storm events.
- Definitive subdivision plans need to include drainage calculations including the formulas used, drainage area, and any other information necessary for the board to check the size of any proposed drainpipes, culverts and bridges. If the

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drainage plans call for connecting into an existing drainage system, the applicant must also submit detailed calculations on the impact of the additional drainage on the existing system.

National Flood Insurance Program (NFIP) – Woburn participates in the NFIP with 49 policies in force as of August 31, 2015. FEMA maintains a database on flood insurance policies and claims. This database can be found on the FEMA website at <https://www.fema.gov/policy-claim-statistics-flood-insurance/policy-claim-statistics-flood-insurance/policy-claim-13> The following information is provided for the City of Woburn for the reporting period from January 1, 1978 through August 31, 2015. This information was not included in the 2007 plan so no comparisons can be made.

Flood insurance policies in force (as of August 31, 2015)	49
Coverage amount of flood insurance policies	\$16,423,700
Premiums paid	\$57,581
Total losses (all losses submitted regardless of the status)	45
Closed losses (Losses that have been paid)	39
Open losses (Losses that have not been paid in full)	0
CWOP losses (Losses that have been closed without payment)	6
Total payments (Total amount paid on losses)	\$843,311.03

The City 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.

Existing Dam Failure Mitigation Measures

DCR has statewide dam safety regulations which apply to the Scalley Dam at Horn Pond. These regulations mandate regular inspections based on the size of the dam and its condition. The City of Woburn has also been working with the Town of Winchester on improving dam operations.

Existing Wind Hazard Mitigation Measures

Massachusetts State Building Code - The City has adopted the Massachusetts State Building Code. The Massachusetts State Building Code contains detailed regulations regarding wind loads. The code's provisions are the most cost-effective mitigation measure against high wind situations.

Tree trimming – Under the direction of the tree warden the city maintains public shade trees within the public right-of-way. Between 2004 and 2014 the City has planted

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several hundred trees and removed about fifty dead trees. The tree warden undertakes limb removal on older public shade trees on an as needed basis if the trees pose a danger to residents. The City employs a tree foreman and two laborers that work with him on a daily basis. In order for a shade tree to be trimmed the Tree Warden must first assess the tree and then make the decision.

When EverSource (formerly NSTAR) needs to remove or trim a shade tree they will call and meet the Tree Warden on site before any work is done. EverSource also sends a plan 1 year in advance before any major work is done.

Massachusetts State Building Code – The City enforces the Massachusetts State Building Code. The Massachusetts State Building Code contains detailed regulations regarding wind loads. The code's provisions are the most cost-effective mitigation measure against tornados given the extremely low probability of occurrence. If a tornado were to occur in Woburn, damages would be extremely high due to the prevalence of older construction and the density of development.

Existing Winter Storm Hazard Mitigation Measures

Snow Removal – The DPW treats roads with salt when conditions are deemed hazardous. Typical salting operations require the deployment of 13 trucks to cover the entire City. The DPW's priority is to salt main roads and hills first, followed by the secondary and other through roads. Dead-ends and cul-de-sacs are salted last. Given the intensity of a storm, it may take up to 4 hours for a truck to apply salt to a street. Pre-treatment of major roads prior to a storm is also typical.

Due to environmental concerns and economics, the trend in snow and ice control has been to reduce the volume of sand that is mixed with salt. The DPW has phased out the use of sand. There has also been a concerted effort to reduce the volume of salt used during storms by supplementing the application of salt with chemical enhancements such as calcium chloride.

Although each snow storm varies considerably, snow removal/plowing operations typically commence when at least two inches of snow has fallen, with the expectation that more snow fall will occur. The DPW has subdivided the City into 28 distinct plow routes. Within each routes, streets are plowed and treated in order of priority, in concert with salt operations. It is extremely important that major roads remain open to vehicular traffic, especially for Emergency Services.

The DPW clears approximately 60 miles of sidewalks along major roads, in the downtown area and around schools. Currently, the City has no specific ordinance that requires

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homeowners to remove snow from the sidewalks in front of their homes; however some residents do take it upon themselves to clear the remaining sidewalks. City of Woburn ordinances do prohibit residents and others from blocking a sidewalk with snow once it has been cleared.

Existing Geologic Hazard Mitigation Measures

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.

Section 1612.2.5 sets up seismic hazard exposure groups and assigns all buildings to one of these groups according to a 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.

The 2007 Woburn Hazard Mitigation Plan states that in the event of a major earthquake, the Building Department would mobilize and begin inspections of properties based upon their seismic hazard exposure group rating. Inspections would begin with all Group III buildings.

Existing Other Hazard Mitigation Measures

Outdoor burning – Outdoor burning is regulated by the Department of Environmental Protection, which allows outdoor burning of brush, cane, forestry debris, etc. during an annual period usually from January 15th through May 1st under the supervision and control of the Fire Department. Permits are issued during the annual period each year between the hours of 9:30 AM and 2:00 PM. The Woburn Fire Department web page contains a link with more information on outdoor burning.

Development review –The Fire Department is involved in reviewing new developments.

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Table 25. Woburn Existing Mitigation Measures			
Type of Existing Mitigation Measures	Area Covered	Effectiveness/ Enforcement	Improvements/ Changes Needed
MULTIPLE HAZARDS			
Comprehensive Emergency Management Plan (CEMP)	City-wide	Emphasis is on emergency response.	None.
Massachusetts State Building Code	City-wide.	Most effective for new construction. Many buildings in the City pre-date the most recent, more stringent requirements.	None.
The Mystic Region REPC.	City-wide, Regional	Provides a forum for regional cooperation on issues related to natural and man-made disasters.	None.
MA Public Health Emergency Preparedness Region 4A	City-wide, regional	Provides a forum for regional cooperation on public health issues.	None.
FLOOD HAZARDS			
Participation in the National Flood Insurance Program.	Flood hazard areas on FIRM maps.	Effective for owners who participate in the program. However, many areas that flood are not in floodplain zones.	Encourage greater participation amongst eligible property-owners.
Maintenance of the City storm drain system	City-wide.	Effective.	None.
Maintenance of the water distribution system including relining water mains and exercising valves and gates.	City-wide.	Effective.	None.
Section 9: Floodway and Floodplain Districts of the zoning ordinance.	Mapped areas.	Effective.	None.
Subdivision regulations governing drainage, plan requirements and run-off rates.	City-wide.	Effective.	None.

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Table 25. Woburn Existing Mitigation Measures			
Type of Existing Mitigation Measures	Area Covered	Effectiveness/ Enforcement	Improvements/ Changes Needed
DAM HAZARDS			
DCR statewide dam safety regulations.	Horn Pond (Scalley Dam)	Effective.	None.
WIND HAZARDS			
Comprehensive Emergency Management Plan (CEMP)	City-wide.	Effective primarily for emergency response; less geared towards mitigation.	No changes needed; plan fulfills the requirements for a CEMP.
The Massachusetts State Building Code.	City-wide.	Effective for most situations except severe storms.	None.
Tree trimming program	City-wide.	Effective.	None.
WINTER HAZARDS			
Massachusetts State Building Code	City-wide.	Most effective for new construction. Many buildings in the City pre-date the most recent, more stringent requirements.	None.
Snow removal and plowing	City-wide.	Effective.	None.
Road treatments during snow storms.	City-wide.	Effective.	None.
GEOLOGIC HAZARDS			
The Massachusetts State Building Code	City-wide.	Effective for most situations.	None.
BRUSH FIRE HAZARDS			
State regulation of outdoor burning	City-wide.	Effective.	None.
Development review	City-wide.	Effective.	None.

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Implementation Progress on Previous Plans

At a meeting of the Woburn Hazard Mitigation Committee on June 12, 2015, City staff reviewed the mitigation measures identified in the 2007 Woburn Hazard Mitigation Plan and determined whether measures identified in the plan had been implemented or deferred. Of those measures that had been deferred, the committee evaluated whether the measure should be deleted or carried forward into the plan update. The decision on whether to delete or retain a particular measure was based on the committee’s assessment of the continued relevance or effectiveness of the measure and whether the deferral of action on the measure was due to the inability of the City to take action on the measure.

Table 26. Proposed Measures from 2007 Plan				
Mitigation Measures	Priority	Implementation Responsibility	Status	Include in 2015 Plan Update?
Washington Street –install two 18 inch drain lines connecting to a 24 inch drain.		DPW	Not yet completed.	Yes
Hart Street – Install a 24 inch drain line to reduce flooding.		DPW	Not yet completed.	Yes
Montvale Avenue-Jefferson Avenue- stream dredging.		Conservation Commission and DPW	Completed	Yes

The City has made some progress towards implementation of previously identified mitigation measures. The Montvale Avenue-Jefferson Avenue stream dredging has been completed. The remaining two projects will be carried forward into this 2015 plan update. None of the projects in the 2007 plan were prioritized, however in this plan update the two projects being carried forward from 2007 have been prioritized in the section below, along with all the new projects in this update. As shown in Table 27, the Hart Street project is assigned a low priority, and the Washington Street project is medium priority in this plan update. With the update of this plan, the City is demonstrating its commitment to continuing critical hazard mitigation activities.

2015 Hazard Mitigation Strategy

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

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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)

Proposed Hazard Mitigation Measures

Flood Hazard Mitigation Measures

The majority of the drainage improvement projects were taken from the Weston & Sampson report "Drainage System Improvements Cost Estimation – Draft Report" dated May 2010. The report included cost estimates but these estimates are 5 years old. They

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have been included in Table 27 to indicate an order of magnitude of potential costs. Two additional areas (Salem Street at Aberjona and Bedford Road) were identified during a June 12, 2015 meeting of the Local Committee.

Lake Terrace and Lake Circle Drainage Improvements – Clean, inspect and evaluate storm drain lines, manholes and catch basins. Install additional catch basins and drain manholes.

Arlington Road Drainage Improvements – Clean, inspect and evaluate storm drain lines, manholes and catch basins. Install hydrodynamic separators at four outfalls.

Dragon Court – Install 370 square feet of reinforced concrete pipe, six catch basins, two drain manholes and one flared end outfall.

Washington Street near Cedar Street – This drainage project consists of installing a parallel relief system to convey stormwater under Washington Street.

Bartlett Drive and Pearl Street Rear – This area floods due to insufficient capacity in the existing storm drain system. A relief system will be installed to convey excessive flow away from the affected area.

Washington Street near Wendy's – This project would upgrade the storm drain system to convey stormwater to a swale along the abandoned railroad bed.

Ward Street at Traverse Street - This project consists of installing an improved drain system that will convey flow from the affected area to an existing drain system on Newbridge Avenue.

Lillian Street near the Kennedy School – This project involves extending the existing drain system upstream.

Cambridge Road – This project seeks to upgrade the drainage system to handle a larger volume of flow by replacing the existing drain under Cambridge Road with a 30 inch pipe.

Hart Street – This project consists of installing a 24 inch relief line within the railroad bed and discharging behind the DPW storage facility into an existing retention area. The outlet from the retention area under Harrison Avenue will be upgraded to carry the additional runoff.

Hart Street/Winn Street -- Cleaning of the Hart Street area stream and culvert under Winn Street

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Salem Street at Aberjona Drive – This area was identified as an area where emergency access could be blocked during flood events.

Bedford Road: Marlborough to Cambridge Street – This is another area where emergency access can be an issue during flooding.

General stream maintenance- Sediment and debris and trash have decreased the hydraulic capacity of streams and drainage swales. Trash removal and dredging of approximately 10,000 linear feet is necessary.

General stream culvert maintenance – Some culverts in the City have become blocked with sediment, debris and trash. The report identifies 20 culverts in need of cleaning.

General storm drain cleaning and maintenance – Many storm drains and catch basins have been partially or completely blocked with sediment and debris. This project would involve 120,000 linear feet of storm drain pipes and 800 catch basins.

Winter Storm Hazard Mitigation Measures

Retrofit public buildings to withstand snow loads and prevent roof collapse – This potential mitigation measure is particularly timely after the severe winter of 2015. The City should have a good idea of which public buildings were most at risk and can begin the work of engineering retrofit solutions. The City has already begun an analysis of roofs in conjunction with work being done on solar installations on roofs.

Public awareness campaign – The City should increase its public awareness activities including the use of social media and written materials on winter hazards that would be available at City Hall and mailed to residents with their tax bills.

Geologic Hazard Mitigation Measures

Implement seismic upgrades to the communications center- The Public Safety building should be reviewed to determine if changes are needed in order to be brought up to seismic standards. This review would help determine and address the potential for a collapse of the communications system that would impact the City's ability to respond to emergencies after an earthquake.

Brush Fire Hazard Mitigation Measures

Consider becoming a Firewise Community – The national Firewise Communities program offers communities a structured way to undertake community-based activities to lessen the impact of brush fires.

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Purchase a brush truck – The Fire Department would like to purchase a brush truck to be better equipped to respond to brush fires.

Extreme Temperatures Hazard Mitigation Measures

Conduct a public awareness campaign about the risk of extreme temperatures – Extreme heat and cold can have impacts on residents as well as on property. Extreme heat and cold can be deadly for sensitive populations such as the elderly and extreme cold can lead to freezing pipes and damage for property-owners. A public education campaign could use print publications as well as social media to both educate residents and alert them to times when these conditions are anticipated.

Drought Hazard Mitigation Measures

Develop an ordinance to restrict the use of public water resources for non-essential uses – An ordinance is a useful tool for managing water during droughts. Such an ordinance can restrict a variety of non-essential water uses including landscaping, washing cars and filling swimming pools.

Prioritization of Mitigation Activities

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

Prioritization occurred through discussion at a meeting of the local committee and through subsequent review by committee members and public comment. Priority setting was based on local knowledge of the hazard areas, including impacts of hazard events and the extent of the area impacted and the relation of a given mitigation measure to the City's identified goals and consideration of a measure's priority in the previous plan.

Through the discussion, the local committee 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 the City currently had the technical and administrative capability to carry out the mitigation measures, whether any environmental constraints existed, and whether the City would be able to justify the costs relative to the anticipated benefits.

The table below demonstrates the prioritization. For each mitigation measure, the geographic extent of the potential benefiting area is identified as is an estimate of the

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overall benefit and cost of the measures. The benefits and costs were evaluated in terms of:

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

Costs

High	Estimated costs greater than \$50,000
Medium	Estimated costs between \$10,000 to \$50,000
Low	Estimated costs less than \$10,000 or staff time

Table 27. Mitigation Measure Prioritization

Mitigation Action	Geographic Area	Benefit	Estimated Cost ¹	Priority	Time Frame
Flood Hazard Mitigation Measures					
Drainage improvements at Arlington Road/Lake Avenue	Arlington Road	High	\$255,000	High	2015-2017
Drainage improvements Cambridge Road	Cambridge Road near Russell Street	High	\$470,000	High	2015-2017
Drainage improvements at Hart Street-24" relief line	Hart Street	Medium	\$1,045,000	Low	2015-2017
Hart St/Winn St stream and culvert cleaning	Hart Street and Winn Street	High	TBD	High	2015-2016
Drainage improvements Salem Street	Salem Street and Aberjona Drive	High	TBD	High	2015-2017

¹ Cost estimates were prepared in 2010 and would need to be updated.

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Table 27. Mitigation Measure Prioritization					
Mitigation Action	Geographic Area	Benefit	Estimated Cost¹	Priority	Time Frame
at Aberjona Dr					
Bedford Road: Marlboro to Cambridge	Bedford/Marlboro/Cambridge	High	TBD	High	2015-2017
Stream maintenance	City-wide	High	\$880,000	High	2015-2020
Stream culvert maintenance	City-wide	High	\$475,000	High	2015-2020
Storm drain cleaning and maintenance	City-wide	High	\$1,450,000	Medium	2015-2020
Drainage improvements at Lake Avenue and Lake Circle	Lake Avenue and Lake Circle	Medium	\$345,000	Medium	2017-2020
Drainage improvements at Dragon Court	Dragon Court	Medium	\$170,000	Medium	2017-2020
Drainage improvements at Washington Street	Washington St.	Medium	\$410,000	Medium	2017-2020
Drainage improvements at Bartlett Drive and Pearl Street	Bartlett Drive and Pearl Street	Medium	\$285,000	Medium	2017-2020
Drainage improvements Washington Street near Wendy's	Washington Street	Medium	\$290,000	Medium	2017-2020
Drainage improvements Ward Street at Traverse Street	Ward and Traverse Streets	Medium	\$200,000	Medium	2017-2020

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Table 27. Mitigation Measure Prioritization					
Mitigation Action	Geographic Area	Benefit	Estimated Cost¹	Priority	Time Frame
Drainage improvements Lillian Street near the Kennedy School	Kennedy School area	Medium	\$110,000	Medium	2017-2020
Winter Storm Hazard Mitigation Measures					
Retrofit public buildings to withstand snow loads	Specific locations TBD	Medium	High	Medium	2015-2020
Winter storm public awareness campaign	City-wide	Medium	Low	Medium	2015-2020
Geologic Hazard Mitigation Measures					
Implement seismic upgrades to the communications center	Site specific	Medium	High	Low	2017-2020
Brush Fire Hazard Mitigation Measures					
Consider becoming a Firewise Community	City-wide	Medium	Low	Low	2015-2020
Purchase a brush truck	City-wide	Medium	Medium	Medium	2017-2020
Extreme Temperatures Hazard Mitigation Measures					
Conduct a public awareness campaign about the risk of extreme temperatures.	City-wide	Low	Low	Low	2015-2020

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Table 27. Mitigation Measure Prioritization					
Mitigation Action	Geographic Area	Benefit	Estimated Cost¹	Priority	Time Frame
Drought Hazard Mitigation Measures					
Develop an ordinance to restrict the use of public water for non-essential uses.	City-wide	Low	Low	Low	2015-2020

Introduction to Potential Mitigation Measures (Table 28)

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 – The designation of high, medium, or low priority was done at the meeting of the Local Multiple Hazard Community Planning Team meeting. The designations reflect discussion and a general consensus developed at the meeting but could change as conditions in the community change. In determining project priorities, the local team considered potential benefits and project costs as well as the priorities for measures that were carried forward from the previous plan.

Implementation Responsibility – The designation of implementation responsibility was done by MAPC 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.

Time Frame – The time frame 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.

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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 committee 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.USnae.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.

Hazard Mitigation and Flood Mitigation Grants – This page provides information on the flood mitigation assistance grant program, the pre-disaster mitigation program and the hazard mitigation grant program.
<http://www.mass.gov/eopss/agencies/mema/hazard-mitigation/grants/>

United States Department of Agriculture- The USDA has programs by which communities can get grants for firefighting needs. See the link below for some examples.
<http://www.rd.usda.gov/newsroom/news-release/usda-invites-applications-loans-fund-community-facility-projects>

Abbreviations Used in Table 28

FEMA Mitigation Grants includes:

FMA = Flood Mitigation Assistance Program.

HMGP = Hazard Mitigation Grant Program.

PDM = Pre-Disaster Mitigation Program

ACOE = Army Corps of Engineers.

DHS/EOPS = Department of Homeland Security/Emergency Operations

EPA/DEP (SRF) = Environmental Protection Agency/Department of Environmental Protection (State Revolving Fund)

USDA = United States Department of Agriculture

Mass DOT = Massachusetts Department of Transportation

MBTA = Massachusetts Bay Transportation Authority

DCR = MA Department of Conservation and Recreation

DHCD = MA Department of Housing and Community Development

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Table 28. Woburn Potential Mitigation Measures					
Mitigation Measure	Measure Type	Implementation Responsibility	Priority	Time Frame	Potential Funding Sources
Flood Hazard Mitigation Measures					
Drainage improvements at Arlington Road/Lake Avenue	Structural	Engineering	High	2017-2020	HMGP/PDM/City
Drainage improvements at Cambridge Road	Structural	Engineering	High	2015-2017	HMGP/PDM/City
Drainage improvements at Hart Street--24" relief line	Structural	Engineering	Low	2015-2017	HMGP/PDM/City
Hart Street/Winn Street stream and culvert cleaning	Structural	Engineering	High	2015-2017	City-General Fund
Drainage improvements Salem Street at Aberjona Drive	Structural	Engineering	High	2015-2017	HMGP/PDM/City
Bedford Road: Marlboro to Cambridge	Structural	Engineering	High	2015-2017	HMGP/PDM/City
Stream maintenance	Natural resource protection	Engineering and Conservation	High	2015-2020	City/ACOE
Stream culvert maintenance	Structural	Engineering	High	2015-2020	City/ACOE
Storm drain cleaning and maintenance	Structural	Engineering	High	2015-2020	City/ACOE
Drainage improvements at Lake Avenue and Lake Circle	Structural	Engineering	Medium	2017-2020	HMGP/PDM/City
Drainage improvements at Dragon Court	Structural	Engineering	Medium	2017-2020	HMGP/PDM/City

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Table 28. Woburn Potential Mitigation Measures					
Mitigation Measure	Measure Type	Implementation Responsibility	Priority	Time Frame	Potential Funding Sources
Drainage improvements at Washington Street	Structural	Engineering	Medium	2017-2020	HMGP/PDM/City
Drainage improvements at Bartlett Drive and Pearl Street	Structural	Engineering	Medium	2017-2020	HMGP/PDM/City
Drainage improvements at Washington Street near Wendy's	Structural	Engineering	Medium	2017-2020	HMGP/PDM/City
Drainage improvements Ward Street at Traverse Street	Structural	Engineering	Medium	2017-2020	HMGP/PDM/City
Drainage improvements Lillian Street near the Kennedy School	Structural	Engineering	Medium	2017-2020	HMGP/PDM/City
Winter Storm Hazard Mitigation Measures					
Retrofit public buildings to withstand snow loads	Structural	Engineering	Medium	2015-2020	City
Winter storm public awareness campaign	Public education and awareness	Emergency Management	Medium	2015-2020	City
Geologic Hazard Mitigation Measures					
Implement seismic upgrades to the communications center	Site specific	Emergency Management	Low	2017-2020	City
Brush Fire Hazard Mitigation Measures					
Consider becoming a Firewise Community	City-wide	Fire Department	Low	2015-2020	City

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Table 28. Woburn Potential Mitigation Measures					
Mitigation Measure	Measure Type	Implementation Responsibility	Priority	Time Frame	Potential Funding Sources
Purchase a brush truck	City-wide	Fire Department	Medium	2017-2020	City
Extreme Temperatures Hazard Mitigation Measures					
Conduct a public awareness campaign about the risk of extreme temperatures.	Public education and awareness	Board of Health and Emergency Management	Low	2015-2020	City
Drought Hazard Mitigation Measures					
Develop an ordinance to restrict the use of public water for non-essential uses.	Local planning and regulations	Dept. of Public Works	Low	2015-2020	City

Local Capacity for Implementation

The City of Woburn has identified several mitigation measures that require implementation or improvements, and has the capacity within its local boards and departments to address these. The Woburn Engineering Department will address the needs for repairs and upgrades to drainage infrastructure and retrofitting public buildings for snow loads. The Fire Department will address brush fire hazards, and Emergency Management will address seismic upgrades to the communications center and public education on winter related hazards.

New Development and Infrastructure

As part of the process of developing recommendations for new mitigation measures for this plan update, the City considered the issues related to new development, redevelopment, and infrastructure needs in order limit future risks. Taking into consideration the town’s Floodplain Zoning District enforced for new development, the Subdivision Regulations enforced by the Planning Board for new development s, the enforcement of the Wetlands Protection Act by the Conservation Commission, the enforcement of the Massachusetts Building Code by the Building Department, and the Comprehensive Plan, the city determined that existing regulatory measures are taking full

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advantage of local Home Rule land use regulatory authority to minimize natural hazard impacts of development. The major priorities that emerged for the city are strategic drainage and stormwater infrastructure upgrades in the identified problem areas.

Regional and Inter-Community Considerations

Regional Issues

Some hazard mitigation issues are strictly local. The problem originates primarily within the municipality and can be solved at the municipal level (e.g., capacity issues in local drainage system). Other issues are inter-community issues that involve cooperation between two or more municipalities. There is a third level of mitigation which is regional; involving a state, regional or federal agency or an issue that involves three or more municipalities.

Regional Partners and Hazard Mitigation Coordination

In the densely developed communities of the study area, mitigating natural hazards, particularly flooding, is more than a local issue. The drainage systems that serve these communities are a complex system of storm drains, roadway drainage structures, pump stations and other facilities owned and operated by a wide array of agencies including but not limited to the City of Woburn, the Department of Conservation and Recreation (DCR), the Massachusetts Water Resources Authority (MWRA), Massachusetts Department of Transportation (MassDOT) and the Massachusetts Bay Transportation Authority (MBTA).

The planning, construction, operations and maintenance of these structures are integral to the flood 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.

State highways – The following is a list of state roads maintained by Mass Highway. The drainage systems of these roads is therefore not under the control of the City and have impacts on the potential for flooding.

- Lexington Street
- Cambridge Road
- Washington Street from Salem Street to Reading line
- Mishawum Road from Commerce Way to Washington Street
- Main Street from Middlesex Canal to Elm Street
- Main Street from Altavesta Circle to Wilmington line
- Montvale Avenue from Ranin Road to Stoneham line

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Horn Pond Dam - The City of Woburn and the Town of Winchester are collaborating on a project to investigate options for the renovation of Horn Pond's Scalley Dam in an effort to address regional flooding issues. The spillway outlets are not large enough to carry the amount of water contained in a large storm. The dam has been found to be structurally sound but undersized. The two communities have been working together as part of the Winchester Flood Mitigation Program, with engineering services provided by ENSR Corporation.

The study indicates that the opening needs to be twice the size of the current configuration in order to have adequate control of the pond elevation as it fills and overtops during a significant storm. The dam review to be completed will include more detailed analysis of the Pond and Scalley Dam, preliminary design of the new outlet structure, and a cost analysis. The study will be funded by a grant received by the Town of Winchester. About \$50,000 of the total \$250,000 grant will go towards reviewing the dam.

Climate Change

The entirety of Massachusetts, and in particular the Commonwealth's coastal cities and towns, faces potential risk from Climate Change. Many of the natural hazards that cities like Woburn have 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. For example, 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. 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.

Attempts to mitigate climate change or adapt to its potential impacts are largely outside the scope of this Hazard Mitigation Plan, which relies primarily on historic trends to assess risk and vulnerability. The potential changes to the State's storm damage profile caused by Climate Change will be well outside of historic trends, making those trends uncertain predictors of future risk and vulnerability at best. Cities, towns, Regional Planning Agencies and other regional and state agencies will need to advocate for a statewide response that includes using the best available information to map and model climate change data related to natural hazards and disseminate this information for use in hazard mitigation planning and land use policy development. In Woburn this should include a wide array of city boards and departments.

Lastly, in addition to understanding how the physical infrastructure will be impacted, it is important to identify how vulnerable populations may suffer greater impacts under future Climate Change scenarios. These populations could include the elderly, the very young,

CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE

low-income groups, immigrants and the homeless, among others, and could disproportionately suffer the effects of extreme events, like flooding and heat waves, be least-equipped to adapt. Efforts should be undertaken to identify the locations of possible vulnerable populations. This could include coordination with updates to the City's demographic data (e.g., Census data for where those 65 and over, low-income and/or are linguistically isolated are located) and collaboration with other boards that serve these population groups such as the Council on Aging Board, the Commission for Persons with Disabilities, and others.

After identifying locations, strategies should be developed and implemented to educate, engage and include these populations in hazard and emergency response planning efforts.

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CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE

VII. PLAN ADOPTION AND MAINTENANCE

Plan Adoption

The City of Woburn Hazard Mitigation Plan was adopted by the City Council on May 5, 2016. 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 some progress was made on the city's previous Hazard Mitigation Plan, 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 update, and will be structured as described below.

MAPC worked with the Woburn Hazard Mitigation Planning Team to prepare this plan. This group will continue to meet on an as-needed basis to function as the Local Hazard Mitigation Implementation Group, with the City Engineer designated as the coordinator. Additional members could be added to the local implementation group from businesses, non-profits and institutions.

The City will continue public participation during the next 5-year planning cycle. Updates and reviews of the plan will be publicly noticed in accordance with City and state open meeting laws, and the current plan will be available to the public on the City's website.

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 City Engineer, will have primary responsibility for tracking progress 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 City's approved plan status and its eligibility for FEMA mitigation grants. Because of

CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE

the time required to secure a planning grant, prepare an updated plan, and complete the approval and adoption of an updated plan, the local Hazard Mitigation Planning Team should begin the process in Year 3. This will help the City 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 update of the Woburn Hazard Mitigation Plan 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 Woburn Hazard Mitigation Plan by FEMA, the coordinator of the Hazard Mitigation Implementation Team with support from other members of the 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 during the first six (6) months following plan adoption:

- Fire / Emergency Management
- Police
- Public Works
- Engineering
- Planning and Community Development
- Recreation
- Health
- Building

Other groups that will be coordinated with include large institutions, Chambers of Commerce, land conservation organizations and watershed groups. The plans will also be

CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE

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.

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CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE

VIII. LIST OF REFERENCES

In addition to the specific reports listed below, much of the technical information for this plan came from meetings with City department heads and staff.

City of Woburn May 14-16 Flooding Event Post Incident Report prepared by the City of Woburn Engineering Department, May 25, 2006.

City of Woburn Natural Hazard Mitigation Plan Report November 2007, Woburn Engineering Department.

City of Woburn Open Space and Recreation Plan, Draft, 2015

City of Woburn 1985 Zoning Ordinances as Amended with Amendments through February 23, 2015.

City of Woburn 1989 Municipal Code, as Amended through February 23, 2015.

Drainage System Improvements Cost Estimation Project, Draft Report prepared by Weston & Sampson for the City of Woburn dated May 10, 2010.

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

FEMA Hazard Mitigation Plan Review Guide, September 2011

FEMA, Local Multi-Hazard Mitigation Planning Handbook, 2013

FEMA, Mitigation Ideas- A Resource for Reducing Risk to Natural Hazards, 2013

Massachusetts State Hazard Mitigation Plans, 2010 and 2013

MacConnell Land Use Statistics, Commonwealth of Massachusetts, 2005

Metropolitan Area Planning Council, Geographic Information Systems Lab

NOAA, National Climatic Data Center, data for Plymouth County, MA

Northeast States Emergency Consortium (NESEC)

U.S. Census, 2010

U.S. Geologic Survey, National Water Information System

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**APPENDIX A
MEETING AGENDAS**

CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE

**Local Natural Hazard Mitigation Plan
Meeting #1
City of Woburn
City Hall Engineering Conference Room
January 26, 2015 10:00 – 11:30 AM**

- 1) Welcome and Introductions**
- 2) Overview Presentation on Hazard Mitigation Planning**
- 3) Review of Project Scope**
 1. Planning Process and Community Participation
 2. Hazard Identification, Critical Facilities, and Vulnerability Analysis
 3. Assessment of Existing Mitigation Measures
 4. Hazard Mitigation Strategies
 5. Local Hazard Mitigation Plan Maintenance
 6. Local hazard Mitigation Plan Adoption and Approval
- 4) Local Team Meeting #1 (Information Gathering)**
 - a) Hazard Mitigation Planning Map Series and Digitized Ortho Photo Map
 - b) Identify Critical Facilities
 - c) Identify local hazards:
 - i) Flood Hazard Areas
 - ii) Fire Hazard Areas (brushfires./ wildfires)
 - iii) Dams
 - iv) Future Potential Development Areas
 - d) Review Plan Goals and Objectives
 - e) Discuss Public Involvement and Outreach
 - i) Identify local stakeholders
 - ii) Schedule first public meeting
- 5) Local Team Meeting #2 (Analysis and Review) – Spring 2015**
 - 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 Mitigation Measures
 - f) Review and finalize Potential Mitigation Measures
 - g) Prioritize Potential Mitigation Measures
 - h) Review draft plan
 - i) Schedule 2nd Public Meeting and outreach to stakeholders

CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE

Woburn Hazard Mitigation Plan
Local Committee Meeting #2
Friday, June 12, 2015
10:00 – 11:30 AM
Engineering Conference Room
Woburn City Hall

- 1) **Walk through of the plan**– I think it will be helpful to walk you through the plan so that you understand its structure and what information is in there prior to your full review. I will bring copies for everyone.
- 2) **Review of goals** – We will need the City to review the goals and either adopt or revise them. These are standard goals that FEMA is used to seeing in our plans.
- 3) **Review proposed hazard mitigation measures** - I have developed a list of potential mitigation measures since FEMA requires that each plan have at least one mitigation measure for each hazard. Many of these are taken from a FEMA publication “Mitigation Ideas: A Resource for Reducing Risk to Natural Hazards, January 2013. I will forward you a copy of that document and bring it with me when we meet. Selecting the potential mitigation measures is the single most important part of the plan and these are suggestions based on what I’ve heard at our meetings. If you have any projects that you think you want to submit a grant application for we will need to discuss these and make sure they are in the plan.
- 4) **June 23 meeting** – We need to discuss how much time I will have and how the evening is being structured so I can develop a Power Point presentation and have the appropriate materials ready for that night.
- 5) **Next steps** – I will outline the next steps that have to take place after the meeting on June 23.

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**APPENDIX B
HAZARD MAPPING**

CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE

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 documentation for some of the hazard maps was incomplete as well.

The map series consists of eight maps.

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

Reduced-scale copies of the map series are included in this Appendix for general reference.

Map 1: 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: Development – This map shows potential future developments, and critical infrastructure sites. MAPC consulted with City staff to determine areas that were likely to be developed or redeveloped in the future. The map also depicts current land use.

Map 3: Flood Zones – The map of flood zones used the FEMA NFIP Flood Zones as depicted on the FIRMs (Federal Insurance Rate Maps) as its source. At the time this plan was developed, these flood zones had not yet been officially adopted and were therefore considered draft. 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 Woburn are kept by the City. 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.

CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE

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. 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 and open space. 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, 2010. The critical infrastructure sites are also shown. The source of the aerial photograph is Mass GIS.

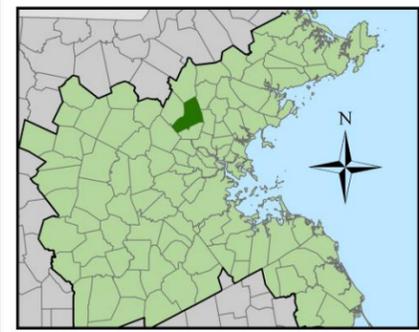
CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE



FEMA Hazard Mitigation Planning Grant
WOBURN, 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

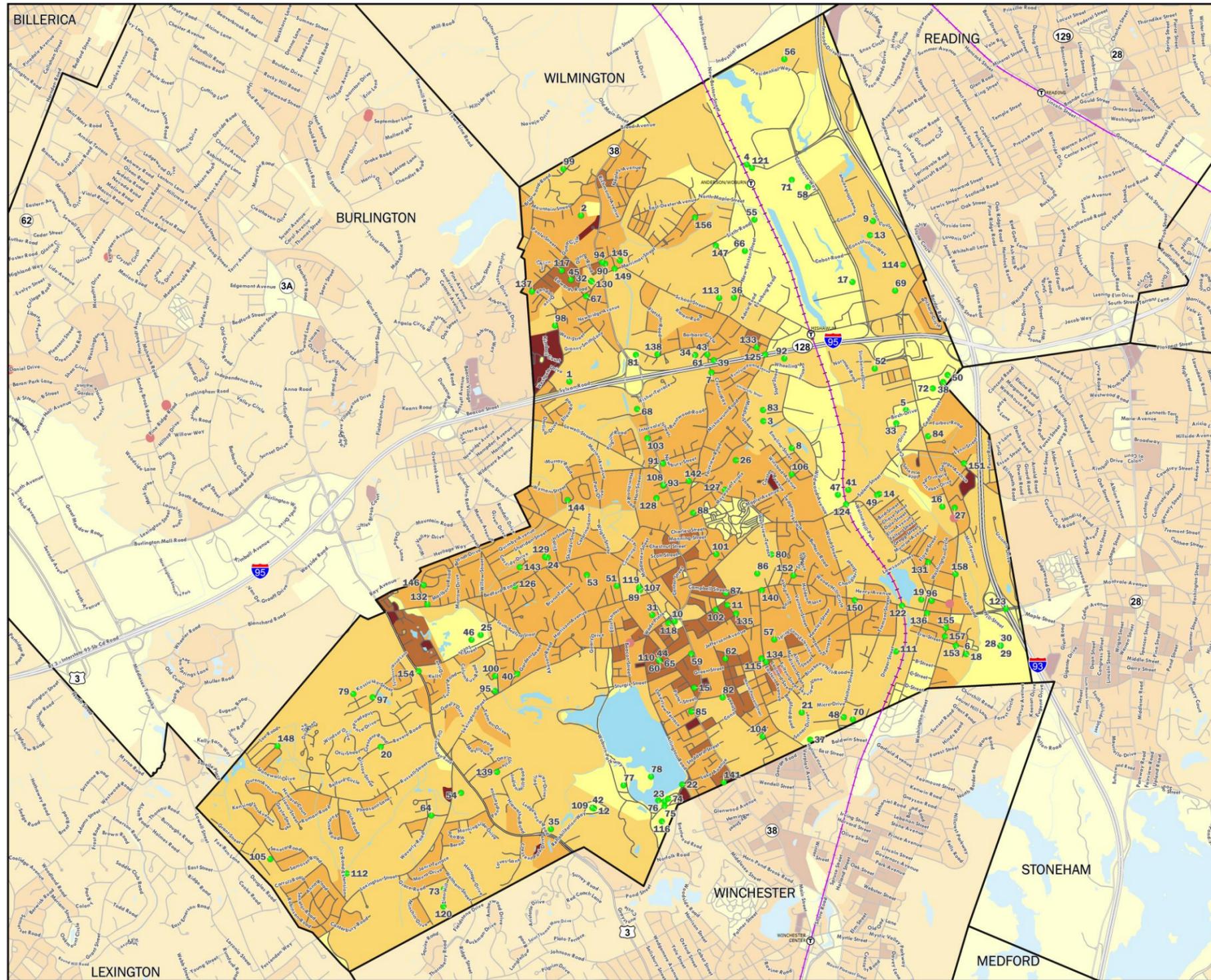


The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel-level analyses.

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)
 WOBURN, MA

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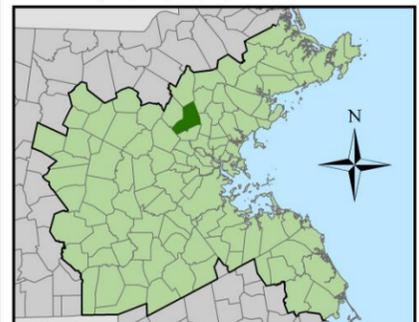
CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE



FEMA Hazard Mitigation Planning Grant
WOBURN, MA
 Map 2: Developable Land

- Sites**
- Critical Infrastructure Sites*
 - Repetitive Loss Sites
 - * See details in separate table
- Development Areas**
- 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
- All Roads**
- Interstate
 - U.S. Highway
 - State Route
 - Street
- Water Bodies**
- Water Bodies
- Train Stations**
- Ⓜ Train Stations
 - Commuter Rail Lines
 - Trains

0 0.25 0.5 Miles

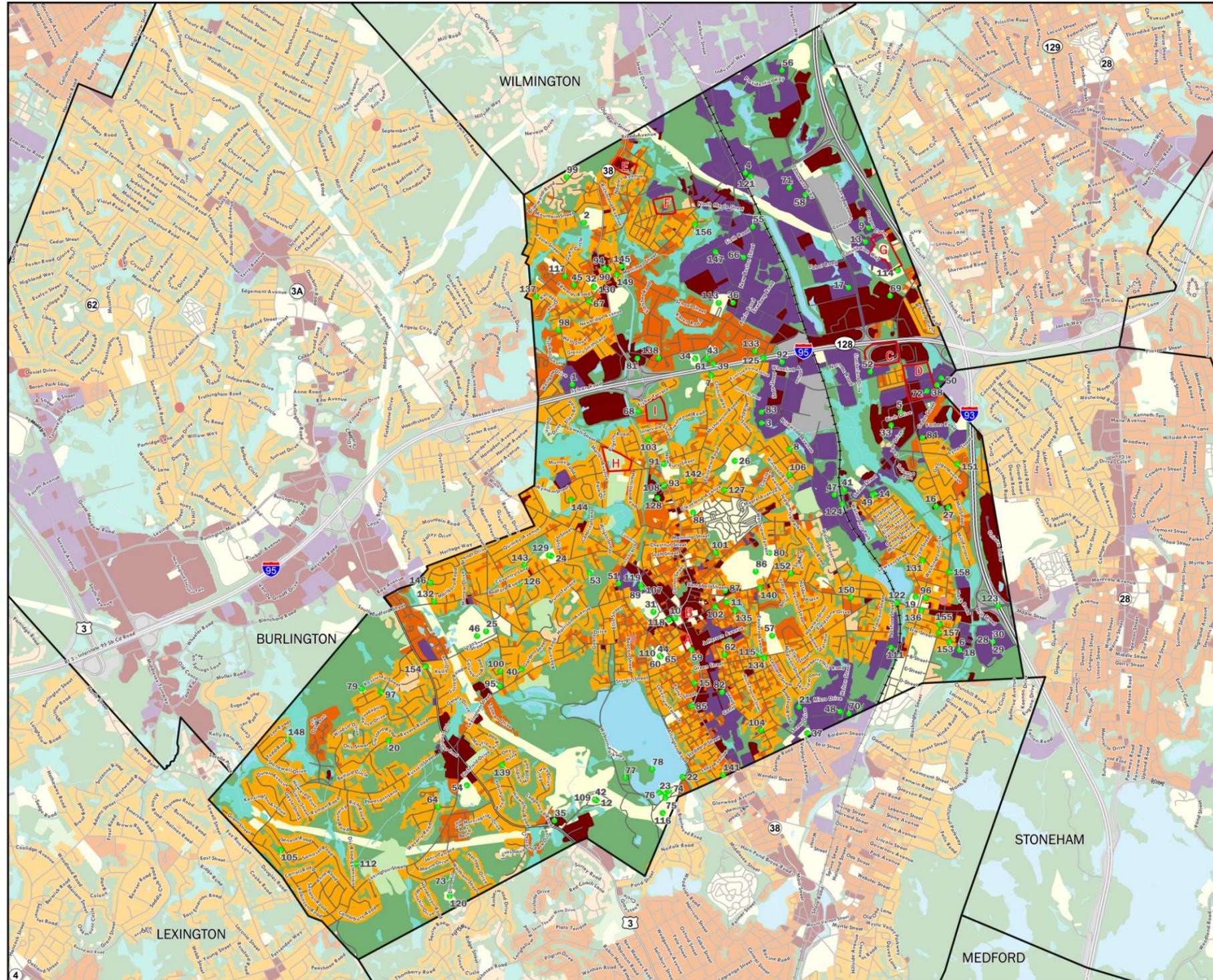


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Data Sources:
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 Northeast States Emergency Consortium (NESEC)
 Massachusetts Emergency Management Agency (MEMA)
 Federal Emergency Management Agency (FEMA)
 WOBURN, MA

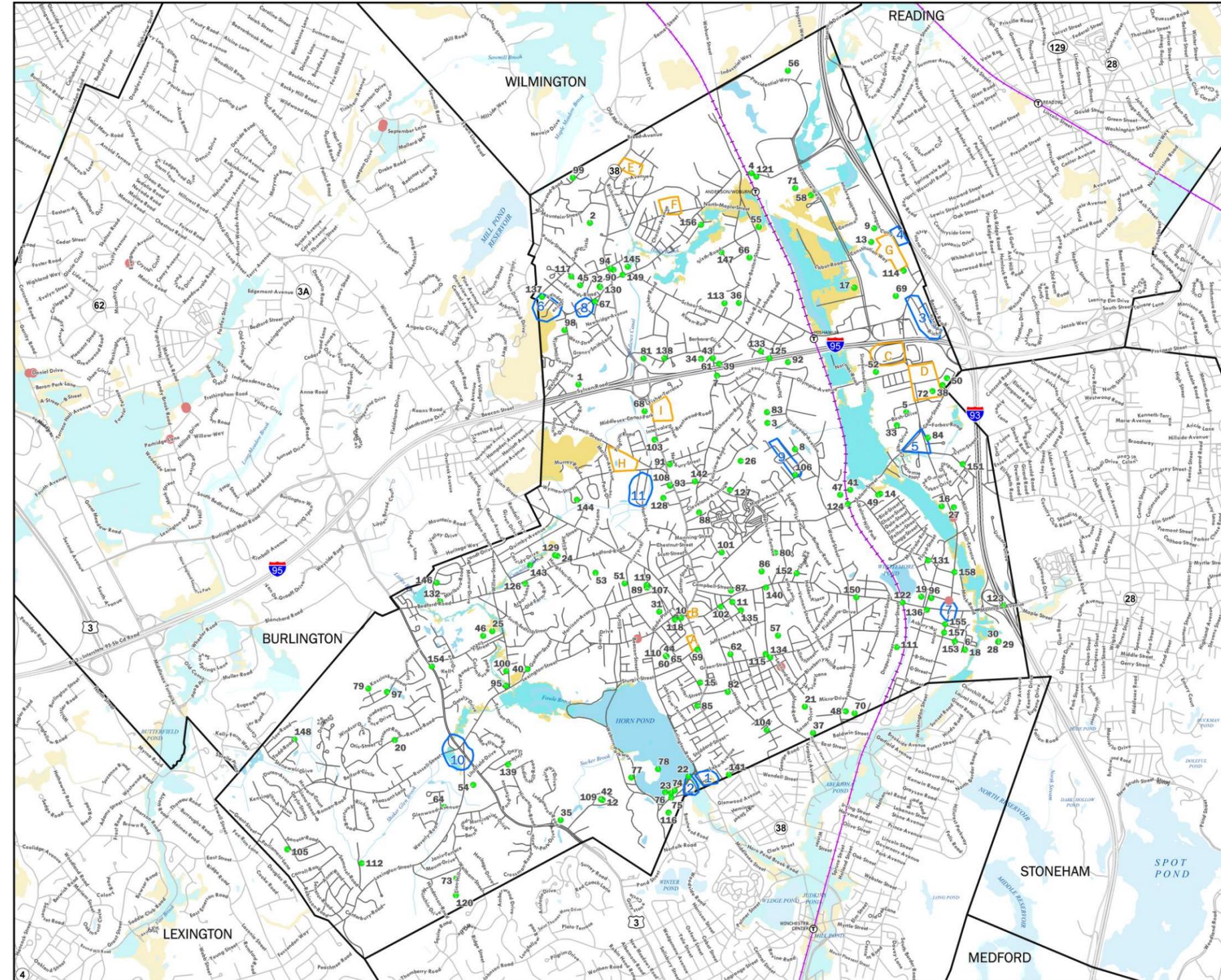
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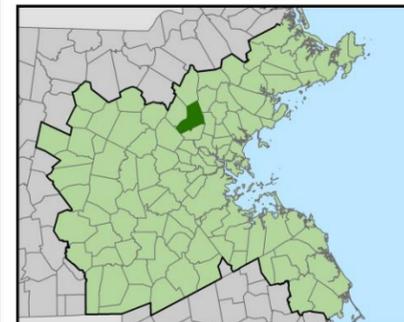


FEMA Hazard Mitigation Planning Grant
WOBURN, MA
 Map 3: Flood Zones



- Sites**
 - Critical Infrastructure Sites*
 - Repetitive Loss Sites
 - * See details in separate table
- Water Bodies**
- Flood Zones, 2013 (Annual Chance)**
 - Zone A : 1%
 - Zone AE: 1%
 - Zone AH: 1%
 - Zone AO: 1%
 - Zone VE: 1% with Velocity Hazard
 - 0.2% Annual Chance
- Locally Identified Hazard Areas***
 - ☐ Flooding
 - ☐ Development Areas
 - * See details in separate table
- Transportation**
 - Ⓣ 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)

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

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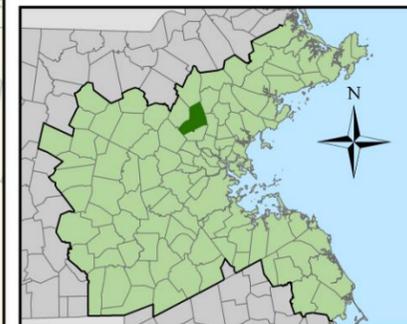


FEMA Hazard Mitigation Planning Grant
WOBURN, MA

Map 4: Earthquakes / Landslides

- Sites**
- Critical Infrastructure Sites*
 - Repetitive Loss Sites
 - * See details in separate table
- Earthquakes**
- Epicenters
- Trains**
- Train Stations
 - Commuter Rail Lines
 - Trains
- Water Bodies**
- 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

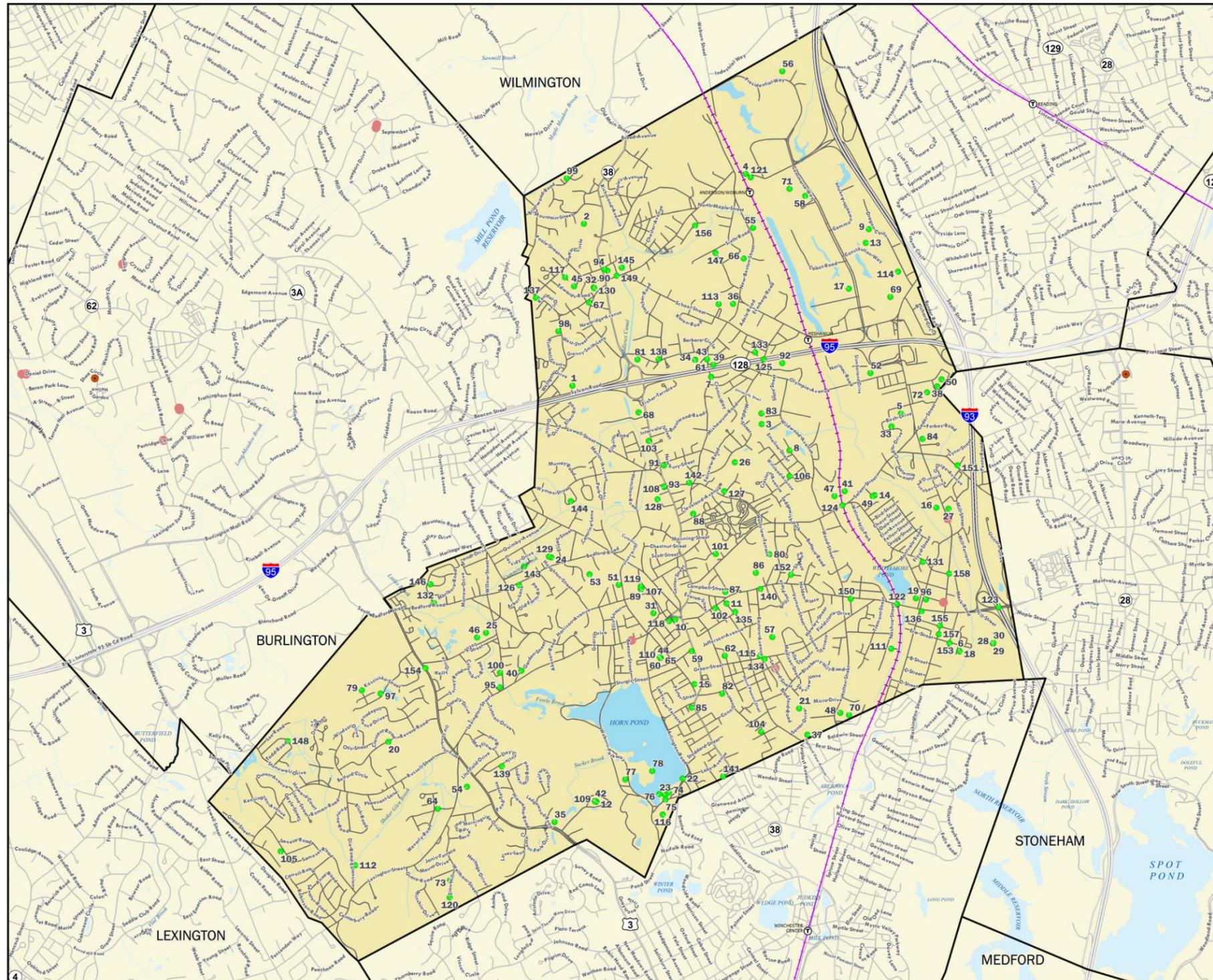


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Data Sources:
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 Federal Emergency Management Agency (FEMA)
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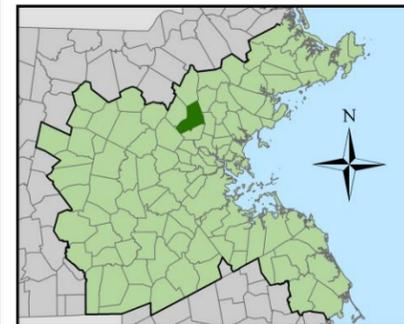
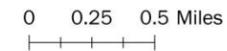
CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE



FEMA Hazard Mitigation Planning Grant
WOBURN, 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 Inundation Areas
- 100 Year Wind Speeds Miles Per Hour**
- 90 MPH
 - 100 MPH
 - 110 MPH
 - 120 MPH
 - 130 MPH
- Other Features**
- All Roads
 - Interstate
 - U.S. Highway
 - State Route
 - Street
 - Water Bodies
 - Ⓜ Train Stations
 - Commuter Rail Lines
 - Trains

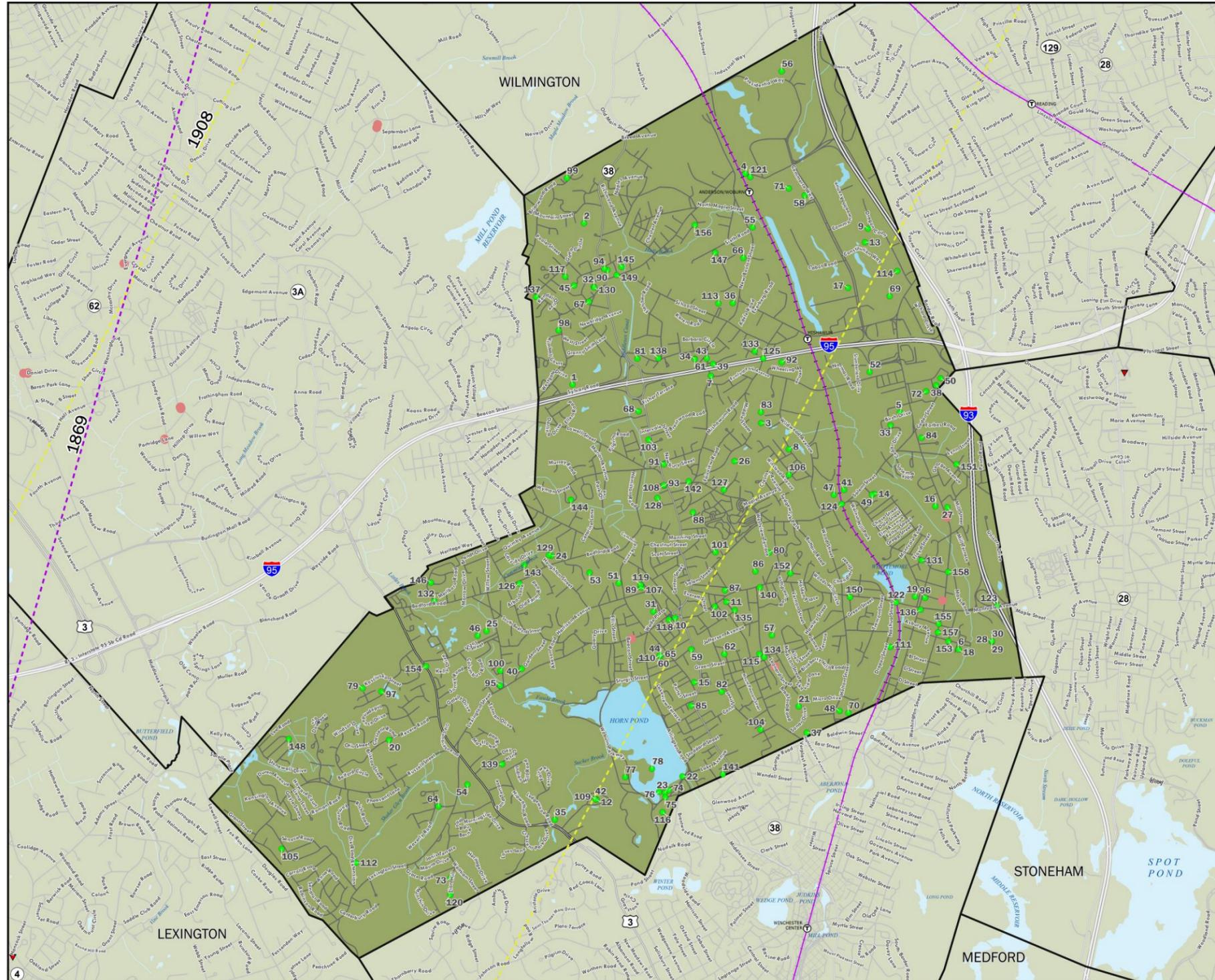


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Federal Emergency Management Agency (FEMA)
WOBURN, MA

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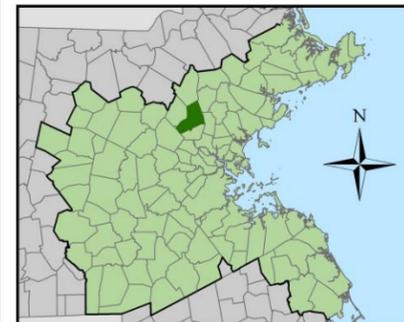
CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE



FEMA Hazard Mitigation Planning Grant
WOBURN, MA
 Map 6: Average Snowfall

- Sites**
- Critical Infrastructure Sites*
 - Repetitive Loss Sites
 - * See details in separate table
- Average Annual Snowfall**
- Light Purple: 36.1 to 48.0 inches
 - Dark Purple: 48.1 to 72.0 inches
- Water Bodies**
- Water Bodies
- Train Stations**
- Train Stations
- Commuter Rail Lines**
- Commuter Rail Lines
- Trains**
- Trains
- All Roads**
- Interstate
 - U.S. Highway
 - State Route
 - Street

0 0.25 0.5 Miles

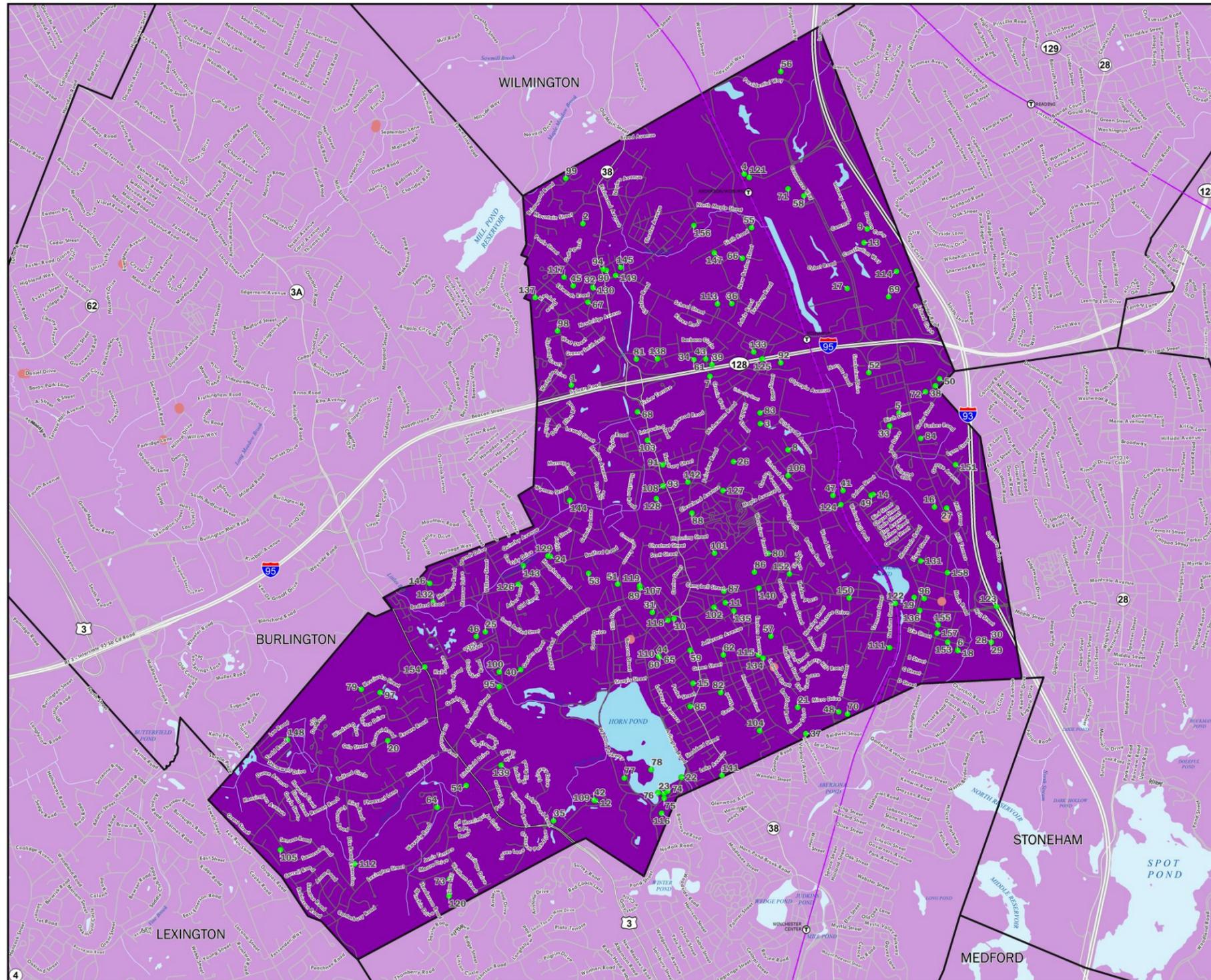


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 WOBURN, MA

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CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE



FEMA Hazard Mitigation Planning Grant
WOBURN, MA

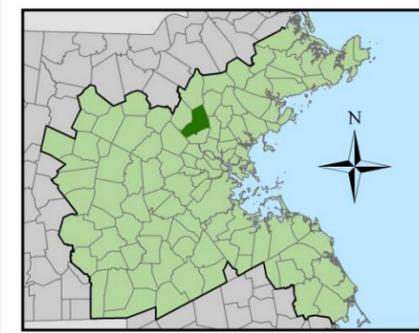
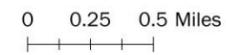
Map 7: Composite Natural Hazards

- Composite Natural Hazards**
- Low (2 Hazards)
 - Moderate (3 Hazards)
 - High (4 Hazards)
 - Very High (5 Hazards)
- Sites**
- Critical Infrastructure Sites*
 - Repetitive Loss Sites
- * See details in separate table
- Water Bodies**

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 inundation areas

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



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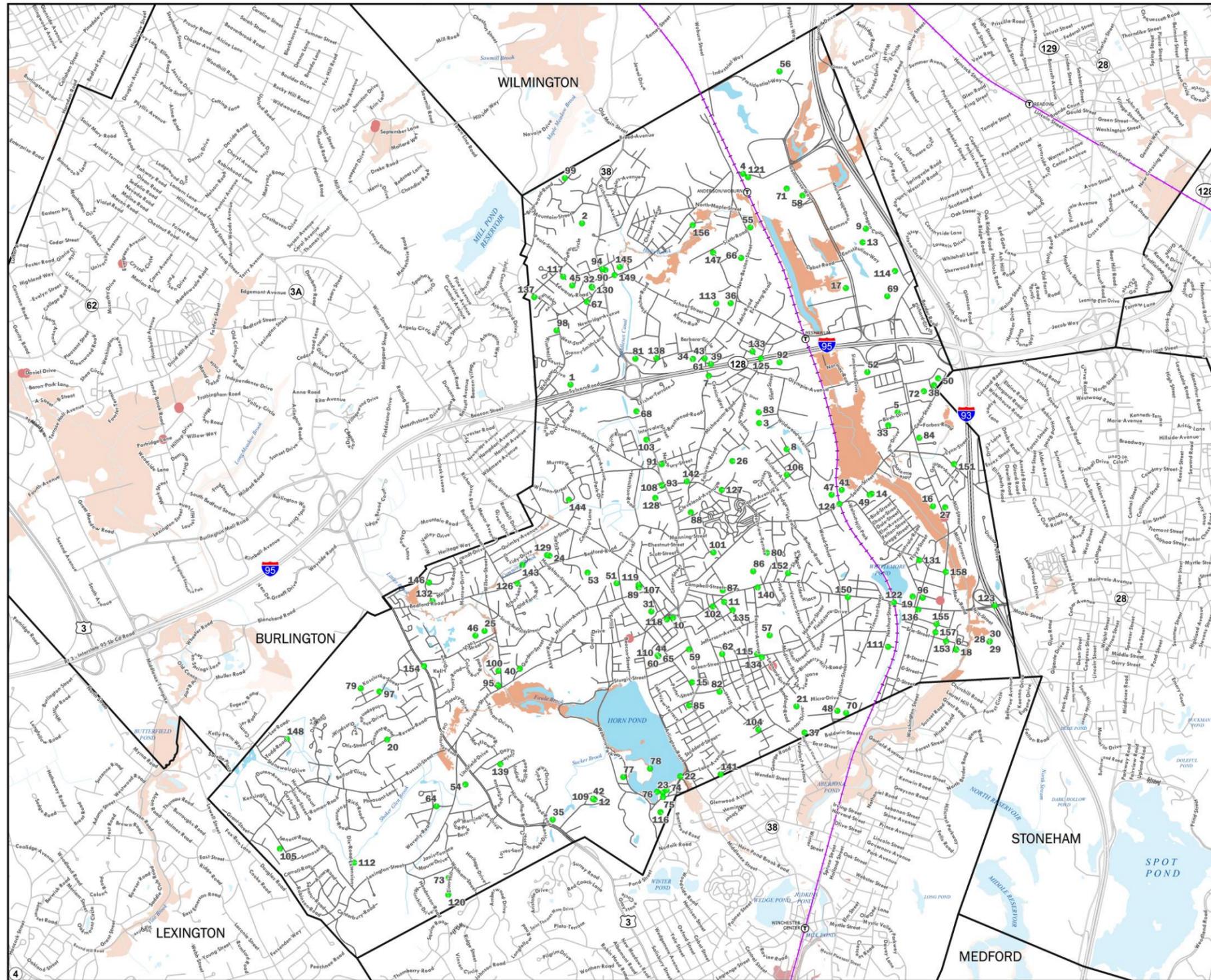
Data Sources

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) / WOBURN, MA

Path: K:\DataServices\Projects\Current_Projects\FDM\project_files\FDM_Map7.mxd
 Date: 6/4/2015



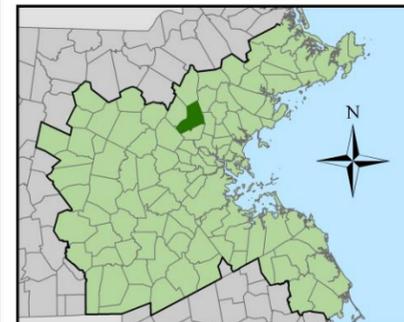
CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE



FEMA Hazard Mitigation Planning Grant
WOBURN, 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
 - Other
- Development Sites
 * See details in separate table
- Train Stations**
- Commuter Rail Lines
 - Trains
- All Roads**
- Interstate
 - U.S. Highway
 - State Route
 - Street

0 0.25 0.5 Miles

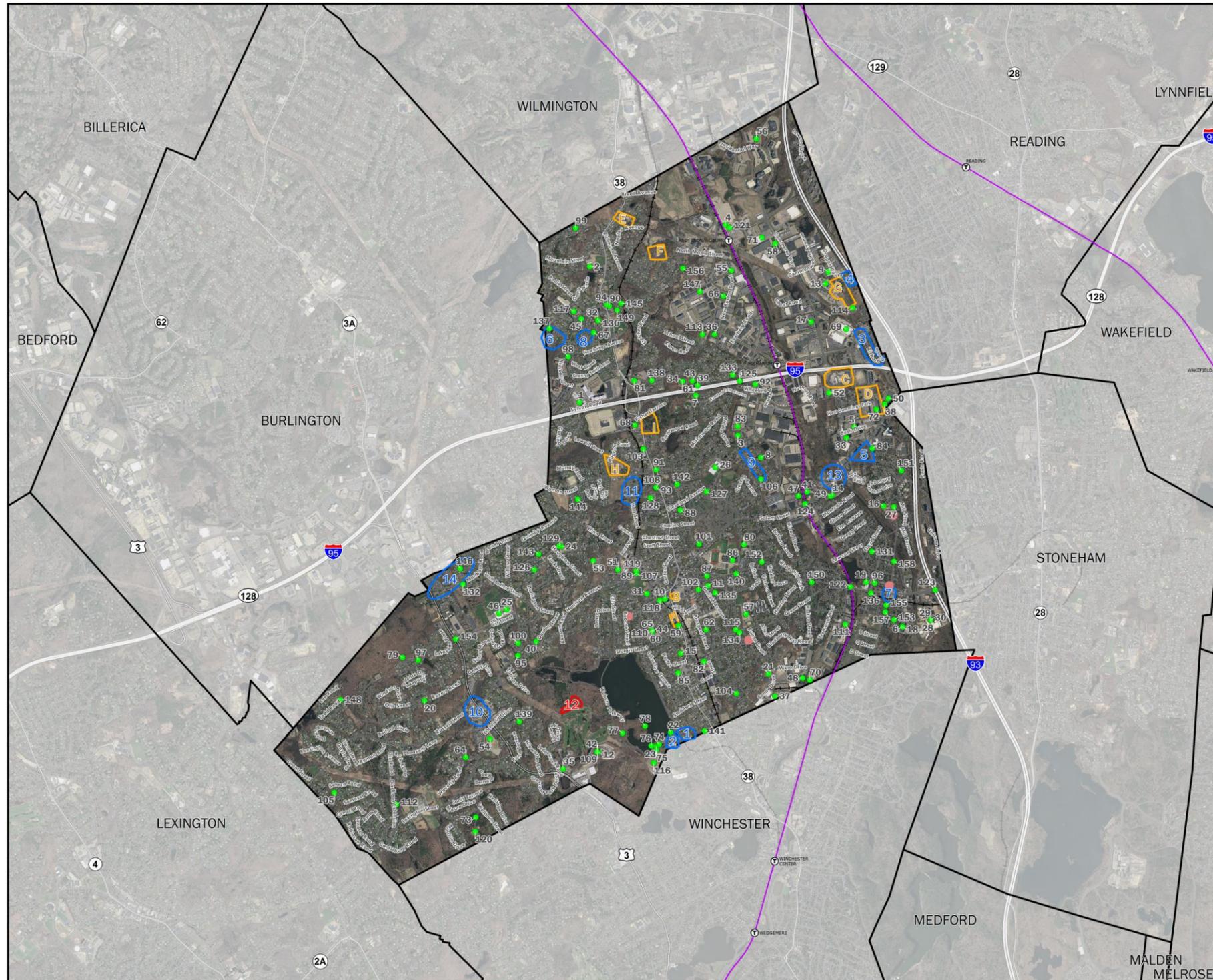


The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel-level analyses.

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)
 WOBURN, MA

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 Date: 6/16/2015



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**APPENDIX C
DOCUMENTATION OF PUBLIC PARTICIPATION**

Woburn Plan for Progress
Natural Hazards, Land Use and Transportation
Forum

7:00pm, Wednesday, March 25, 2015
Woburn High School Cafeteria
88 Montvale Ave., Woburn

Schedule of Events

7:00 Registration and Light Refreshments

7:05 Welcome- Mayor Galvin

7:10 Introduction and Agenda- Sam Cleaves, MAPC

7:15 Natural Hazard Mitigation Planning Overview- Joan Blaustein, MAPC

7:25 Land Use and Transportation Context –Sam Cleaves and Chris Kuschel, MAPC

8:05 Land Use and Transportation Table Discussions

1. Introductions around the Table

2. Land Use Discussion (20 minutes)

- a. Based on what you've heard tonight, what do you think Woburn's land use goals should be?
- b. What are the barriers to achieving these goals?
- c. What are some of the residential, downtown and commercial/industrial areas that you like or don't like?

8:25 3. Transportation Discussion (20 minutes)

- d. What should Woburn's master plan transportation goals be?
- e. Discussion of more specific transportation goals.

CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE

8:45 4.Determine priorities and recap both the land use and transportation discussion.

8:50 5.Table Discussions Report Out

The MAPC facilitator or scribe from each group will summarize and report on their group's conversation for the rest of the room to hear. The purpose of this is to identify the top priorities and themes and get the flavor of the various conversations happening around the room – where were there similarities and differences amongst the groups?

8:55 6.Natural Hazards Mapping Exercise-map areas that flood, prone to brush fires or wind damage

9:30 Adjourn

CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE



City of Woburn, Massachusetts

Planning Board

City Hall, 10 Common Street

Woburn, MA 01801

Tina Cassidy,
Planning Director

Neil Cronin, Planner

Phone: 781-897-5817 Fax: 781-897-5819

Agenda for the June 23, 2015 Planning Board Meeting

MEETING SHALL BEGIN AT 7:00 P.M.

In the City Council Chamber, City Hall, 10 Common Street, Woburn, MA

ROLL CALL of members;

APPROVAL OF MINUTES of previous meeting (June 2, 2015);

COMMUNICATIONS: a) Mayor, b) City Council, c) Commonwealth of MA, other cities and towns, d) General Communications;

SUBDIVISION APPROVAL NOT REQUIRED PLANS (ANR'S)

1. 369 Washington Street
2. Others, if any

PUBLIC HEARING: Proposed amendments to the Subdivision Rules and Regulations relative to as-built and acceptance plans and ANR filings

SUBDIVISIONS & SPECIAL PERMITS:

1. Fremont Street Extension - Scott Seaver: Set amount of bond at \$131,405, accept Tri-Partite Agreement as surety, approve HOA and easement documents, release lot for building and sale purposes
2. Highview Subdivision - Michael Santullo: Request to extend construction completion date from November 7, 2015 to November 7, 2017

PRESENTATION AND DISCUSSION: Draft Hazard Mitigation Plan for the City of Woburn / City Planner Tina Cassidy and MAPC staffer Joan Blaustein

OTHER BUSINESS:

1. Schedule next meeting/upcoming meeting agenda items (August 4, 2015)
2. Other

ADJOURN

The above items may not be presented in the order that they appear
ANY OTHER MATTER THAT MAY LEGALLY COME BEFORE THE BOARD

CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE

Notice sent to the towns of Burlington, Reading, Stoneham, Wilmington, and Winchester:

The City of Woburn and the Metropolitan Area Planning Council have been working on an update of the *Woburn Hazard Mitigation Plan*, a plan intended to reduce the City's vulnerability to the impacts of natural hazard events such as flooding and hurricanes.

A draft plan update has been developed which identifies a set of hazard mitigation measures, including structural improvements, regulatory changes for development in hazard areas, educational and outreach efforts related to natural hazards in the City, and other actions.

The draft plan update will be available for public review through October 18, 2013 on the City's web site at

<http://cityofwoburn.com/documentcenter/view/14413>

Comments and questions may be submitted in writing to Joan Blaustein at MAPC, 60 Temple Place, Boston, MA 02111, or by email to jblaustein@mapc.org. Comments should be submitted by July 7 in order to be incorporated into the final draft of the plan that will be submitted to the Massachusetts Emergency Management Agency and FEMA.

Thank you,

Joan Blaustein
Senior Regional Planner

CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE

Public Comment Received on the Draft Plan

From: anne dowd [dowdanne@yahoo.com]
Sent: Thursday, July 09, 2015 8:21 PM
To: Cassidy, Tina
Subject: comments regarding hazard mitigation plan

I have read through the draft of the City of Woburn Hazard Mitigation Plan 2015 update. I appreciate all the work that has been done. I do have a few comments that I would like to send to you.

1. On page 76 ---the city storm drain system. At least one of the new developments (Carlson Way) has complicated underground storm drainage systems. I think policies and procedures should be in place stating what department will be responsible for ensuring the streets will be swept as well as ensuring that the maintenance is done on the system. If that system fails more than one neighborhood will suffer the consequences. Although technically Carlson Way is under a Condo laws the enforcement of street cleanings and maintenance of the drainage system needs to be monitored in order for the system to work. With less and less land available more of these drainage systems will be used and need to be maintained.

Studies keep being proposed for the Middlesex Canal and Hart to Winn. I see in your plan that there is a 2015-2017 time frame. I hope that is true because the development (or overdevelopment) in the Central square area this drainage needs that to be completed to help alleviate the already high tendency for flooding.(I notice that a 24 inch drain line was proposed on the 2007 plan for Hart St....8 years later and still no drain line. At any time will MEMA or FEMA enforce proposals that Woburn puts on their mitigation goals in order to receive funding?

3. Page 22 -#10 - The plan states Winn St to Hart St-Winn St near Hamilton Road experiences flooding of homes. This is poor wording. I believe it should speak to the cleaning of the culvert. (Winn St and Hart St do not intersect) The culvert runs from Hart St to Winn St needs to be cleared. The back up from that issue not only floods homes on Hamilton Road but Hart St, Hamilton Road, Park Drive, Brae Circle and possibly parts of Colonial Road. If this culvert is cleared it may help but the Middlesex Canal should also be cleared so the water can drain from the canal to the culvert.

This culvert only drains the south side of the canal. There is no mention of clearing Cummings Brook which the North Side of the Canal drains into. This flows under Lowell St behind Frederick Drive, Murray St,(homes that have experienced flooding) under Wyman (which is clogged) through Carlson Way to Winn St meeting up previous mentioned culvert.

On page 86 I saw general stream culvert maintenance that said the report identified 20 culverts however I did not see the list of culverts.

I also didn't see listed what streams compromised the 10,000 linear feet that needed to be dredged.

CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE

I noticed that the only proposal for drought is policies on water usage. Wouldn't having more land available, less hard top, in zone II aquifer areas help to get water to the wells?

These are my comments. Thank-you for all your hard work.

Anne Dowd
43 Wyman St

The City's Responses to Public Comment Received on draft Hazard Mitigation Plan

(July 9, 2015 email from Anne Dowd to Planning Director Tina Cassidy)

The following are responses to comments made in the above-referenced correspondence received during the comment period on Woburn's draft Hazard Mitigation Plan:

City storm drain system

The design of the drainage system for the Carlson Road subdivision is somewhat unusual. While the homeowners will be responsible for maintaining the drainage system via a homeowners association, certain components of the system are within the Carlson Street right of way which will eventually become a public street.

The homeowners association is required to maintain the system in good working order, but the author's point relative to ensuring compliance with the maintenance requirement is a good one. The Woburn Planning Board will be undertaking a comprehensive review of its subdivision rules and regulations during the second part of 2016, and the issue of how to ensure compliance with maintenance standards prior system failure is one of the topics to be addressed. Options include implementation of street sweeping by the City on a regular basis, or requiring homeowners associations to provide proof of periodic street sweeping by private parties several times per year.

MEMA/FEMA funding

The commenter's point is a little unclear. If the question relates to continued eligibility for FEMA/MEMA funding, it is true an up-to-date Hazard Mitigation Plan is needed to be eligible for certain funding from these agencies. If the question relates to whether FEMA and/or MEMA would compel the City to complete the components of a hazard mitigation plan in order to receive funding, the City believes the answer is no.

List of Stream Culverts Needing Cleaning

The commenter stated she did not see in the Plan a list of the culverts noted as needing cleaning. As noted in the draft Plan, the list of culverts is contained in a May 2010 report from Weston & Sampson entitled "Drainage System Improvements Cost Estimation – Draft Report". That report is on file in the office of the Woburn Engineering Department and is available for public review.

CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE

List of Streams Needing Dredging

The commenter noted that the draft Plan mentions that approximately 10,000 linear feet of streambed requires trash removal and dredging but that there was no list of stream(s) within which this work would be required. The areas needing general stream maintenance are identified in the May 2010 Weston & Sampson report cited above. The list is shown below.

Drought policies

The commenter asked if having “more land and less hardtop” (e.g. less impervious pavement) in Zone II areas would help “get the water to the wells”. The answer is yes, to the extent that runoff from impervious areas in Zones II areas doesn’t reach the groundwater table.

SECTION A. GENERAL INFORMATION

1. Project Location:

Thirteen locations were prioritized for stream maintenance assessment and permitting. These include the following:

- (1) Area 1 - Middlesex Canal and Cummings Brook from Lowell Street to Willow Street
- (2) Area 2 - Unnamed Stream at Library Park Field parallel to North Warren Street and crossing Harrison Avenue
- (3) Area 3 - Unnamed Stream from Pigeon Road to Woburn/Winchester Town Line
- (4) Area 4 - Horn Pond Brook from Horn Pond to the Woburn/Winchester Town Line
- (5) Area 5 - Portion of Shaker Glen Brook extending from the Dix Road area to Carroll Road
- (6) Area 6 - Willow Brook extending from Rear Pearl Street to Pearl Street
- (7) Area 7 - Unnamed Stream from Fletcher Road to Alfred Street
- (8) Area 8 - Unnamed Stream/Culvert from Montvale Avenue to Garfield Avenue and from Green Street Playground area to Jefferson Avenue
- (9) Area 9 - Unnamed Stream tributary to Littles Brook and extending from Old Farm Lane to Willow Street
- (10) Area 10 - Unnamed Stream tributary to Shaker Glen Brook and extending from Revere Road to Cambridge Road
- (11) Area 11 - Unnamed Stream from Woodside Terrace to Forest Park Road to Hope Lane to Rte. 128
- (12) Area 12 - Unnamed Stream from Gettysburg Street/Todd Road Intersection to Quail Run to Stevin Drive
- (13) Area 13 - Unnamed Stream from Willow Street to Totman Drive and from Lexington Street to Totman Drive

Source: Weston & Sampson, “Drainage System Improvements Cost Estimation – Draft Report,” 2010.

**APPENDIX D
DOCUMENTATION OF PLAN ADOPTION**

CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE



RESOLVED

Be it resolved the City Council of the City of Woburn Massachusetts adopt the attached resolution regarding the City of Woburn's Hazard Mitigation Plan 2015 Update.

Certificate of Adoption
City Council
City of Woburn Massachusetts

A Resolution Adopting the City of Woburn Hazard Mitigation Plan 2015 Update

WHEREAS, the City of Woburn Massachusetts established a Committee to prepare the City of Woburn Hazard Mitigation Plan 2015 Update; and

WHEREAS, the City of Woburn Hazard Mitigation Plan 2015 Update contains several potential future projects to mitigate potential impacts from natural hazards in the City of Woburn; and

WHEREAS, duly-noticed public meetings were held by the City on March 25, 2015 and June 23, 2015; and

WHEREAS, the City of Woburn authorizes responsible departments and/or agencies to execute their responsibilities demonstrated in the plan update;

NOW, THEREFORE BE IT RESOLVED that the Woburn City Council adopts the City of Woburn Hazard Mitigation Plan 2015 update, in accordance with M.G.L. Chapter 40 section 4 or the charter and ordinances of the City of Woburn.

ADOPTED AND SIGNED this date: May 5, 2016

s/President Haggerty

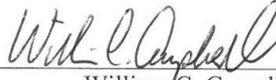
April 19, 2016
In City Council, First Reading,
Referred to Committee on Ordinances
(8 in favor, 0 opposed, 1 absent, 0 abstained)

May 3, 2016
In City Council, Second Reading, Passed to be Ordained
(9 in favor, 0 opposed, 0 absent, 0 abstained)

CITY OF WOBURN HAZARD MITIGATION PLAN 2015 UPDATE

Presented to the Mayor: May 5, 2016
Mayor's Office: May 5, 2016
Approved: s/Scott D. Galvin, Mayor

A True Copy Attest:



William C. Campbell
City Clerk and Clerk of the Council

